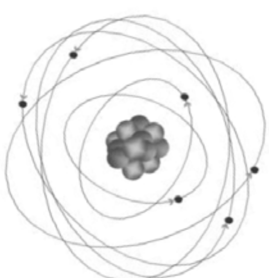
# *The HistoryMakers® ScienceMaker Toolkit*

# *Table of Contents*



# The HistoryMakers® ScienceMakers Toolkit

Dear *ScienceMakers* Toolkit Users:

In August of 2009, *The HistoryMakers*, the nation's largest African American video oral history archive, was awarded a $2.3 million three-year grant from the National Science Foundation to create *ScienceMakers*, an innovative African American media and education initiative focused on capturing and preserving the stories of African Americans in the STEM (Science, Technology, Engineering and Math) professions. *The HistoryMakers* is a national 501(c)(3) non-profit educational institution founded in 1999 committed to preserving, developing and providing easy access to an internationally recognized archival collection of thousands of African American video oral histories.

Many are unaware of the contributions of African Americans in the STEM professions. This lack of knowledge adversely affects our youth and their perceptions of the STEM professions. *ScienceMakers* will disseminate the stories of STEM professionals to youth and adult audiences through the internet, public programs and innovative uses of new technologies. We see the lives of these scientists and their careers as a gateway to greater numbers of youth pursuing STEM careers. We also hope that it will result in an increased interest and awareness of the accomplishments of African American scientists.

This 2010 ScienceMakers Toolkit is intended to be a career and educational resource and features well-known African American scientists like Lloyd Ferguson of the University of California, Berkeley and Neil deGrasse Tyson of the Hayden Planetarium in New York City. Others include James West, co-inventor of the electret microphone, and Lisa Jackson, administrator of the United States Environmental Protection Agency.

Please send all comments, questions and suggestions to info@thehistorymakers.com.

**Thank you for your support of STEM education. We hope you enjoy the ScienceMakers Toolkit. Read on and spread the word!**

Sincerely,

Julieanna Richardson
Founder & Executive Director
*The HistoryMakers*
1900 S. Michigan Avenue
Chicago, Illinois 60616

## *The HistoryMakers® ScienceMaker Toolkit*

# *Purpose & How to Use This Toolkit*

### *What is STEM?*

STEM is an acronym for:

**S**cience
**T**echnology
**E**ngineering
**M**athematics

### *What is the ScienceMakers Mission?*

The mission of *The HistoryMakers*' ScienceMakers initiative is to provide youth and adults with:

1. Exposure to successful African American STEM scientists as role models;
2. Increased knowledge about African American contributions to the STEM professions;
3. Increased information on STEM-related careers;
4. Increased awareness of STEM concepts and STEM career opportunities;
5. Improved 21st century learning skills; and
6. Inspiration for lifelong interest in science and in the STEM professions.

### *What Is A ScienceMaker?*

A ScienceMaker is:

- African American by descent.
- A person who by his/her own accomplishments has made significant contributions to research, education or some other aspect of a STEM discipline.

### *The Purpose*

The ScienceMakers Toolkit is designed to be a resource; it is not a substitute for formal science curriculum, but rather a **career resource and biographical guide to African American scientists**.

### *How to Use the ScienceMakers Toolkit*

**There are 73 ScienceMakers featured in this Toolkit.** The Toolkit is divided into eight sections including Chemistry, Computer Science, Earth Science, Engineering, Life Sciences, Mathematics, Physics, and Administration and Education. Each section contains several ScienceMaker Spotlights as well as five classroom activities.

An **Index of Activities** is included with each section as well as where they came from. Activities indicated with "1" are from *ScienceBuddies.org*, a comprehensive resource for science experiments and projects. Those indicated with "2" are from *Computer Science Unplugged*, a resource to learn about computer science without the use of a computer.

**The introduction page** for each section features a STEM field as well as possible career choices for that field. It also lists specific ScienceMakers by career and affiliation. With each name, the subjects covered in the ScienceMaker Spotlight's questions provide topics for discussion purposes.

Following each STEM introduction page are **photographs** related to that STEM field. The photographs are intended to illustrate the STEM field with events or objects with which students are familiar, and they can be used at the instructor's discretion.

**The ScienceMaker Spotlight** highlights each ScienceMaker's life and career. Each Spotlight page contains:

- Biography Table
- A ScienceMaker Biography
- Discussion Questions
- Glossary

**The Biography Table** appears at the beginning of each Spotlight page. It provides basic biographical information on each ScienceMaker. Some of the discussion questions directly relate to the biography table. For example, students can complete a map activity in which they locate all the ScienceMakers' birthplaces on a map and determine how far each is from their own location. Students can also map a ScienceMaker's educational path.

**The Biography** provides important information on each ScienceMaker's life and professional development.

**The Discussion Questions** are divided into two categories:

- **About the ScienceMaker** relates to the ScienceMaker's personal life. The first three questions ask the student to evaluate his/her life in comparison to the ScienceMaker's and think about the similarities and differences. The last question relates to the oral history process and asks the student to think about what questions they would ask the scientist.

- **About the subject matter** relates to the ScienceMaker's field of study, his or her career, or historically relevant subjects. The first two questions are designed to assess the current level of student knowledge. For example, asking "What do you think a physicist does?" allows the instructor to evaluate existing knowledge and the knowledge gained from the discussion.

**The Glossary** provides definitions for:

- Scientific terms (i.e. electron)
- STEM organizations (i.e. National Science Foundation)
- STEM careers (i.e. intern, tenured)
- Important people in science (i.e. Percy Julian)

Glossary terms are underlined in each biography. Definitions, for the most part, are written at a middle to high school level.

**The Activities**, based on the general field of study, provide hands-on demonstrations that introduce students to new STEM fields. Each activity lists an appropriate grade level for the experiment as well as its applicable National Science Content Standard. Each objective is bolded for a quick glance.

**In the back of your Toolkit, you will find:**

- ScienceMakers Oral History Guidelines
- ScienceMakers YouTube Oral History Contest Guidelines
- ScienceMakers Media Guide
- National Science Content Standards
- A list of online resources relating to the material in this Toolkit

# The HistoryMakers® ScienceMaker Toolkit

## Index of Activities

# Index of ScienceMaker Birthdays & Birthplaces



## By Birthday

| Name | Birthday | Birthplace |
|---|---|---|
| Julius Taylor | 2/15/1914 | Cape May, New Jersey |
| Lloyd Ferguson | 2/9/1918 | Oakland, California |
| Katherine Johnson | 9/26/1918 | White Sulphur Springs, Virginia |
| Robert Bragg | 9/11/1919 | Jacksonville, Florida |
| Esther A.H. Hopkins | 1926 | Stamford, Connecticut |
| Eleanor Jones | 8/10/1929 | Norfolk, Virginia |
| James West | 2/10/1931 | Farmville, Virginia |
| Lovenia DeConge-Watson | 10/3/1933 | Wickliffe, Louisiana |
| Bertram Fraser-Reid | 2/23/1934 | Coleyville, Jamaica |
| Delon Hampton | 1935 | Chicago, Illinois |
| Shirley McBay | 5/4/1935 | Bainbridge, Georgia |
| Conrad Williams | 3/1/1936 | Warsaw, North Carolina |
| William Jackson | 9/24/1936 | Birmingham, Alabama |
| Earl Shaw | 1937 | Clarksdale, Missouri |
| Reatha Clark King | 4/11/1938 | Pavo, Georgia |
| Claibourne Smith | 1939 | - |
| Joseph Johnson | 1940 | Tennessee |
| Floyd Malveaux | 1/11/1940 | Opelousas, Louisiana |
| Betty Harris | 7/29/1940 | Monroe, Louisiana |
| Frederick Oliver | 10/15/1940 | Baltimore City, Maryland |
| James Williams | 4/4/1941 | Newport News, Virginia |
| William Lupton | 5/26/1941 | Philadelphia, Pennsylvania |
| James Stith | 7/17/1941 | Alberta, Virginia |
| Marshall Jones | 8/1/1941 | Southampton, New York |
| Billy Joe Evans | 8/18/1942 | Macon, Georgia |
| Clarence Ellis | 5/11/1943 | Chicago, Illinois |
| John Haynes | 10/30/1943 | Monroe, Louisiana |
| Kennedy Reed | 5/24/1944 | Memphis, Tennessee |
| Lilia Abron | 3/8/1945 | Rockville, Maryland |
| Bryant York | 5/15/1945 | Boston, Massachusetts |
| Allen Sessoms | 1946 | - |
| Warren Buck | 2/16/1946 | Washington, District of Columbia |
| Shirley Malcom | 9/6/1946 | Birmingham, Alabama |
| Xavier Creary | 9/27/1946 | Montclair, New Jersey |
| Robert Bullard | 12/21/1946 | Elba, Alabama |
| Demetrius Venable | 10/11/1947 | Powhatan, Virginia |
| Stephen McGuire | 9/17/1948 | New Orleans, Louisiana |
| Linda Hayden | 2/4/1949 | Portsmouth, Virginia |

| | | |
|---|---|---|
| Yolanda George | 8/10/1949 | New Orleans, Louisiana |
| Jeanette Jones | 9/19/1950 | Fort Valley, Georgia |
| Carol Folt | 1951 | - |
| Gibor Basri | 5/3/1951 | New York City, New York |
| James Hubbard | 12/21/1951 | Danville, Virginia |
| Agnes Day | 7/20/1952 | Plains, Georgia |
| Keith Jackson | 9/24/1953 | Columbus, Ohio |
| Anthony Johnson | 5/23/1954 | Brooklyn, New York |
| Philip Emeagwali | 8/23/1954 | Akure, Nigeria |
| Calvin Lowe | 1955 | Roanoke Rapids, North Carolina |
| Joseph Francisco | 3/26/1955 | New Orleans, Louisiana |
| Alvin Kennedy | 6/1/1955 | Lansing, Michigan |
| Samuel Mukasa | 9/29/1955 | Maseno, Kenya |
| Sharon Haynie | 11/6/1955 | Baltimore, Maryland |
| Marc Hannah | 10/13/1956 | Chicago, Illinois |
| Akintunde Akinwande | 1957 | Offa, Nigeria |
| Emery Brown | 1957 | Ocala, Florida |
| Mark Dean | 3/2/1957 | Jefferson City, Tennessee |
| Charles Woodward | 1/23/1958 | Rochester, New York |
| Philip Phillips | 6/28/1958 | Scarborough, Tobago |
| Neil deGrasse Tyson | 10/5/1958 | New York City, New York |
| Kevin Kornegay | 3/24/1959 | Brooklyn, New York |
| Dawn Wright | 4/15/1961 | Baltimore, Maryland |
| Lisa Jackson | 2/8/1962 | Philadelphia, Pennsylvania |
| Paula Hammond | 1963 | Detroit, Michigan |
| Edward Tunstel | 11/29/1963 | Harlem, New York |
| Valerie Taylor | 1964 | - |
| Tyrone Hayes | 7/29/1967 | Columbia, South Carolina |
| Clifford Johnson | 1968 | London, England |
| Odest Jenkins | 1974 | Washington, District of Columbia |
| William Guillory | - | New Orleans, Louisiana |
| Stephen Mayo | - | Texas |
| F. Dale Morgan | - | Guyana |
| Donald Darensbourg | - | - |
| Eugene DeLoatch | - | - |



De Broglie's photon :

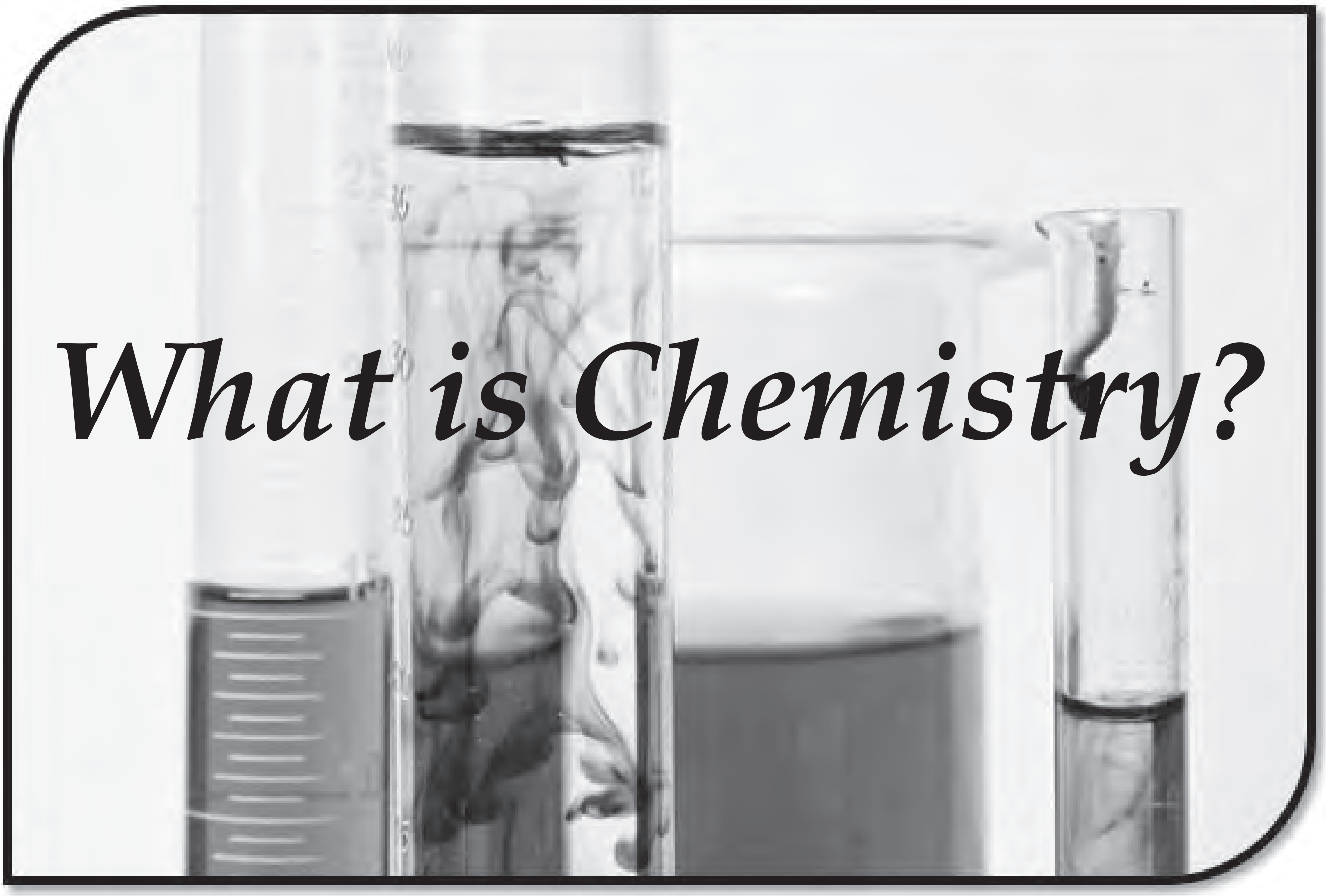
**By Birthplace** (sorted by state then city)

| Name | Birthday | Birth State | Birth City |
|---|---|---|---|
| William Jackson | 9/24/1936 | Alabama | Birmingham |
| Shirley Malcom | 9/6/1946 | Alabama | Birmingham |
| Robert Bullard | 12/21/1946 | Alabama | Elba |
| Lloyd Ferguson | 2/9/1918 | California | Oakland |
| Esther A.H. Hopkins | 1926 | Connecticut | Stamford |
| Robert Bragg | 9/11/1919 | Florida | Jacksonville |
| Emery Brown | 1957 | Florida | Ocala |
| Shirley McBay | 5/4/1935 | Georgia | Bainbridge |
| Jeanette Jones | 9/19/1950 | Georgia | Fort Valley |
| Billy Joe Evans | 8/18/1942 | Georgia | Macon |
| Reatha Clark King | 4/11/1938 | Georgia | Pavo |
| Agnes Day | 7/20/1952 | Georgia | Plains |
| Clarence Ellis | 5/11/1943 | Illinois | Chicago |
| Delon Hampton | 1935 | Illinois | Chicago |
| Marc Hannah | 10/13/1956 | Illinois | Chicago |
| Betty Harris | 7/29/1940 | Louisiana | Monroe |
| John Haynes | 10/30/1943 | Louisiana | Monroe |
| Joseph Francisco | 3/26/1955 | Louisiana | New Orleans |
| Yolanda George | 8/10/1949 | Louisiana | New Orleans |
| William Guillory | - | Louisiana | New Orleans |
| Stephen McGuire | 9/17/1948 | Louisiana | New Orleans |
| Floyd Malveaux | 1/11/1940 | Louisiana | Opelousas |
| Lovenia DeConge-Watson | 10/3/1933 | Louisiana | Wickliffe |
| Frederick Oliver | 10/15/1940 | Maryland | Baltimore City |
| Sharon Haynie | 11/6/1955 | Maryland | Baltimore |
| Dawn Wright | 4/15/1961 | Maryland | Baltimore |
| Lilia Abron | 3/8/1945 | Maryland | Rockville |
| Bryant York | 5/15/1945 | Massachusetts | Boston |
| Earl Shaw | 1937 | Missouri | Clarksdale |
| Paula Hammond | 1963 | Michigan | Detroit |
| Alvin Kennedy | 6/1/1955 | Michigan | Lansing |
| Julius Taylor | 2/15/1914 | New Jersey | Cape May |
| Xavier Creary | 9/27/1946 | New Jersey | Montclair |
| Anthony Johnson | 5/23/1954 | New York | Brooklyn |
| Kevin Kornegay | 3/24/1959 | New York | Brooklyn |
| Edward Tunstel | 11/29/1963 | New York | Harlem |
| Gibor Basri | 5/3/1951 | New York | New York City |
| Neil deGrasse Tyson | 10/5/1958 | New York | New York City |
| Charles Woodward | 1/23/1958 | New York | Rochester |
| Marshall Jones | 8/1/1941 | New York | Southampton |
| Calvin Lowe | 1955 | North Carolina | Roanoke Rapids |
| Conrad Williams | 3/1/1936 | North Carolina | Warsaw |
| Keith Jackson | 9/24/1953 | Ohio | Columbus |

| | | | |
|---|---|---|---|
| Lisa Jackson | 2/8/1962 | Pennsylvania | Philadelphia |
| William Lupton | 5/26/1941 | Pennsylvania | Philadelphia |
| Tyrone Hayes | 7/29/1967 | South Carolina | Columbia |
| Joseph Johnson | 1940 | Tennessee | - |
| Mark Dean | 3/2/1957 | Tennessee | Jefferson City |
| Kennedy Reed | 5/24/1944 | Tennessee | Memphis |
| Stephen Mayo | - | Texas | - |
| James Stith | 7/17/1941 | Virginia | Alberta |
| James Hubbard | 12/21/1951 | Virginia | Danville |
| James West | 2/10/1931 | Virginia | Farmville |
| James Williams | 4/4/1941 | Virginia | Newport News |
| Eleanor Jones | 8/10/1929 | Virginia | Norfolk |
| Linda Hayden | 2/4/1949 | Virginia | Portsmouth |
| Demetrius Venable | 10/11/1947 | Virginia | Powhatan |
| Katherine Johnson | 9/26/1918 | Virginia | White Sulphur Springs |
| Warren Buck | 2/16/1946 | - | Washington, District of Columbia |
| Odest Jenkins | 1974 | - | Washington, District of Columbia |
| Donald Darensbourg | - | - | - |
| Eugene DeLoatch | - | - | - |
| Carol Folt | 1951 | - | - |
| Claibourne Smith | 1939 | - | - |
| Allen Sessoms | 1946 | - | - |
| Valerie Taylor | 1964 | - | - |

**Foreign-born ScienceMakers:**

| Name | Birthday | Birth Country | Birth City |
|---|---|---|---|
| Clifford Johnson | 1968 | England | London |
| F. Dale Morgan | - | Guyana | - |
| Bertram Fraser-Reid | 2/23/1934 | Jamaica | Coleyville |
| Samuel Mukasa | 9/29/1955 | Kenya | Maseno |
| Philip Emeagwali | 8/23/1954 | Nigeria | Akure |
| Akintunde Akinwande | 1957 | Nigeria | Offa |
| Philip Phillips | 6/28/1958 | Tobago | Scarborough |



# What is Chemistry?

***Chemistry*** is the science of matter. Chemicals are found everywhere, from the air we breathe to the dirt under our feet. They can be as close as the dust on the floor or as far away as the matter in distant galaxies.

There are many different types of chemists. They include geochemists who study the elemental properties of the earth, food and flavor chemists who examine the chemical makeup of your food, forensic chemists who help solve crimes, and medicinal chemists who develop drugs.

**Photo credit: Horia Varlan @Flickr**

Chemistry

## *If you like chemistry, you may like the careers chosen by these people:*

| ScienceMaker | Occupation | Location | Question Topics |
|---|---|---|---|
| **Xavier Creary** | Chair of Chemistry Department | *University of Notre Dame* | Chemical reactions and the Periodic Table of Elements |
| **Donald Darensbourg** | Professor of Chemistry | *Texas A&M University* | Carbon dioxide |
| **Billy Joe Evans** | Professor Emeritus | *University of Michigan* | Magnetism and chemistry |
| **Lloyd Ferguson** | Professor Emeritus | *California State University* | Chemistry of the human body |
| **Joseph Francisco** | Professor of Chemistry | *Purdue University* | Chlorofluorocarbons and laser chemistry |
| **Bertram Fraser-Reid** | Founder | *Glycotechnology Research Institute, Inc.* | Sugars (carbohydrates) |
| **William Guillory** | Executive Director | *The Center for Creativity and Inquiry* | Photo-chemistry |
| **Betty Harris** | Chemist | *Los Alamos National Laboratory* | Chemical contamination |
| **Sharon Haynie** | Research Scientist | *Experimental Station for the Dupont Co.* | Environmentally friendly chemistry; micro-organisms and chemistry |
| **Esther Hopkins** | Laboratory Specialist | *Polaroid Corporation* | Cameras |
| **William Jackson** | Professor of Chemistry | *University of California, Davis* | Comet chemistry |
| **Alvin Kennedy** | Chair of Chemistry Department | *Morgan State University* | Polymers and plastic |
| **Reatha Clark King** | Vice President and Executive Director | *General Mills Foundation* | Thermodynamics |
| **Claibourne Smith** | Director | *WSFS Financial Corporation* | Career opportunities and education |

# Chemistry in Action



## ***Dry Ice*** ("Dry Ice Lemonade" by oskay @ Flickr)

The secret of dry ice is that it is not really ice because it is not made of water! In fact, it is the solid form of carbon dioxide. At temperatures above -69.5°F, it changes directly from a solid to a gas (without becoming a liquid) through a process called sublimation, causing the smoke in the photo. With the help of an adult, you can see this for yourself!

## ***Chocolate Chip Cookies*** ("Cookie, Anyone" by scubadive67 @ Flickr)

One of the key ingredients in cookies is baking powder. Baking powder is a leavening agent. When cookie dough is put into the oven, the baking powder contributes to a chemical reaction that produces carbon dioxide, causing the cookies to "rise" into a tasty treat.

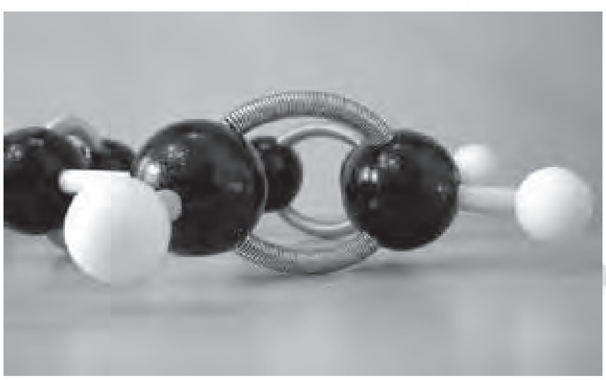
# ScienceMakers
## Spotlight: Xavier Creary

Chemistry

| Name | Xavier Creary |
|---|---|
| Birth Date | September 27, 1946 |
| Birth Place | Montclair, New Jersey |
| Education | Seton Hall University<br>Ohio State University |
| Type of Science | Organic chemistry |

## Biography

Chemist Xavier Creary was born on September 27, 1946 in Montclair, New Jersey. He was raised in New Jersey where he graduated from Seton Hall University with his B.S. degree in chemistry in 1968. After winning a $4,200 fellowship from the Goodyear Tire and Rubber Company Fund, Creary continued his studies in chemistry at Ohio State University, where he completed his Ph.D. program under the tutelage of Professor Paul Gassman in 1973.



**Carbon model photo by jurvetson @Flickr.**
Models are often used by organic chemists for the purposes of visualizing molecules.

After receiving his degree, Creary worked for one year in the laboratory of Professor Joseph Bunnett at the University of California, Santa Cruz. In 1974, Creary was invited to join the faculty of the University of Notre Dame. In 1977, he was awarded an Alfred P. Sloan Fellowship. Creary taught general chemistry courses to undergraduates as well as organic chemistry to students in advanced studies. During his career, Creary actively pursued a number of topics in the field of organic chemistry, including carbocation chemistry, electron-transfer processes, and the chemical properties and reactions of silicon-containing carbenes and free radicals. Another area of interest is the substitution mechanisms of halodiazirines. Creary has published numerous papers documenting his studies in organic chemistry. His research has been funded by the Petroleum Research Fund and the National Science Foundation (NSF).

For his accomplishments in research and education, Creary was named the Charles L. Huisking Sr. Chair in chemistry in 1994. While serving in this position, he has been honored with the Thomas P. Madden Award for Outstanding Teaching and the Kaneb Teaching Award. In 2007, he was awarded the Shilts/Leonard Award in recognition for his superb teaching at the University of Notre Dame. Creary is married to Elizabeth A. Creary.

# Discussion Questions

Chemistry

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Creary?
#2 Where was Dr. Creary born? Locate it on a map. How far away is this from where you live? Where did Dr. Creary attend college? What do you think college was like for him?
#3 How old are you? In what year was Dr. Creary your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 Dr. Creary earned a fellowship after completing his college education. Scholarships and fellowships are one way to help pay for college. Are there any scholarships available to you? What do you have to do to complete the scholarship application?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think an organic chemist does? What makes him different from another type of chemist? Would you like to be an organic chemist? Why? Why not?
#2 If you were an organic chemist, what topics would you study?
#3 Where is organic chemistry applied in your daily life?
#4 Much of Dr. Creary's work is studying chemical reactions. Generally speaking, what is a "reaction"? What is needed for a "reaction" to occur? Based on your previous answers, how would you describe a "chemical reaction"?
#5 The element of carbon is essential to Dr. Creary's work. Find carbon on a table of elements. What is its atomic number? Its mass number?
#6 Another element that Dr. Creary uses in his studies is silicon. Find silicon on a periodic table. What is its atomic number? Its mass number? How does silicon relate to carbon?

# Glossary

*Carbene*
An organic molecule containing a carbon atom with six outer shell electrons connected to two other atoms or groups of atoms.

*Carbocation*
An ion containing an excess positive charge on one or more carbon atoms.

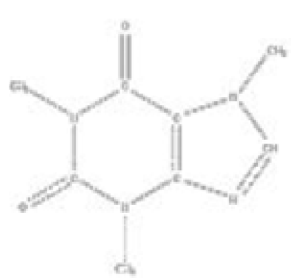
*Electron*
A subatomic particle that carries a negative electric charge and is believed to be an elementary particle. An electron has a mass that is approximately 1/1836 that of the proton.

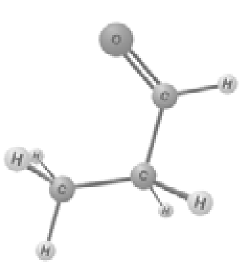
*Free radical*
An atom or group of atoms with at an unpaired electron.  It stabilizes itself by stealing an electron from a nearby molecule.

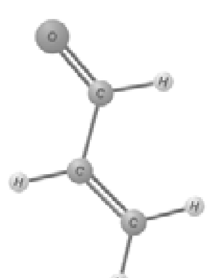
*Halodiazirine*
A class of organic molecules consisting of a carbon bound to two nitrogen atoms, which are double-bonded to each other. It also has a halogen atom (an element in Group 17 on the periodic table).

*Organic chemistry*
A discipline within chemistry that involves the scientific study of the structure, properties, composition, reactions, and preparation (by synthesis or by other means) of carbon based compounds, hydrocarbons, and their derivatives.

*National Science Foundation (NSF)*
A United States government agency that supports fundamental research and education in all the non-medical fields of science and engineering. Its medical counterpart is the National Institutes of Health.







# ScienceMakers

## Spotlight: Donald J. Darensbourg

Chemistry

| | |
|---|---|
| **Name** | Donald J. Darensbourg |
| **Education** | California State University, Los Angeles<br>University of Illinois |
| **Type of Science** | Chemistry |

## Biography

Chemist and chemistry professor Donald J. Darensbourg received his B.S. degree in chemistry from California State University, Los Angeles in 1964 and his Ph.D. degree in inorganic chemistry four years later from the University of Illinois.

Darensbourg worked at the State University of New York at Buffalo before moving to Tulane University in 1973. During his nine years at Tulane University, he was promoted to the position of full professor before joining the faculty at Texas A&M University in 1982. He conducted extensive research in the field of inorganic chemistry and published more than 330 scholarly articles pertaining to this field. He has also served as a mentor, graduating over forty-eight Ph.D. chemistry students. His areas of interest include: the organometallic chemistry of carbon dioxide, the applications of infrared spectroscopy in laboratory experiments and the utilization of carbon dioxide in the development of improved environmentally-friendly synthetic routes for the production of polycarbonates. His research has made a significant impact in many fields, including medicine, where the ability to create biodegradable medical supplies from carbon dioxide and oxetanes has become a realistic possibility.

**CO2 tank photo by House of Sims @Flickr.** CO2 and other fluids are often stored in heavy tanks with a valve that allows for controlled release of the stored gas or liquid.

Darensbourg has won numerous awards for both his teaching and research. In 1988, he received the University-level Distinguished Achievement Award in Teaching and in 1990, he was awarded the Distinguished Achievement Award in Research from the Texas A&M Association of Former Students. In March 2010, Darensbourg received the American Chemical Society (ACS) Award in Inorganic Chemistry. Darensbourg has also participated in a number of advisory boards and committees.  Since 1998, he has been a member of the International Scientific Committee's International Conference on Carbon Dioxide Utilization.  He is also a member of the National Science Foundation's (NSF) Chemistry Division and National Science Foundation Center for Chemical Innovation.  Darensbourg's research, "Organometallic chemistry of carbon dioxide pertinent to catalysis," was featured in 1991 by the Nobel Foundation's Symposium on Chemistry. Darensbourg is married to Dr. Marcetta York Darensbourg, a fellow professor at Texas A&M University.



# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Darensbourg?
#2 Where did Dr. Darensbourg attend college? What do you think college was like for him?
#3 What year did Dr. Darensbourg attend college? What was happening in the United States that year? What was happening in the world that year?
#4 Dr. Darensbourg has graduated a significant number of Ph.D. chemistry students.  What do you think this says about his role as a mentor?  Is there anyone that you consider a mentor?  How does this person help or assist you?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think an inorganic chemist does? Would you like to be an inorganic chemist? Why? Why not?
#2 If you were an inorganic chemist, topics would you study?
#3 Dr. Darensbourg's research has made a difference in several fields.  Discuss the ways in which his research has had an impact.
#4 What organisms give off carbon dioxide?  What organisms use carbon dioxide?  What would happen if the environment lost its balance between the uptake and output of carbon dioxide?
#5 Why do you think carbon dioxide is a good source of material to work with in experiments?

# Glossary



*American Chemical Society (ACS)*
A learned society (professional association) based in the United States that supports scientific inquiry in the field of chemistry.

*Biodegradable*
Able to be decomposed by natural processes.

*Carbon dioxide ($CO_2$)*
A chemical compound composed of two oxygen atoms covalently bonded to a single carbon atom. It is a gas at standard temperature and pressure and exists in the atmosphere in this state. $CO_2$ only makes up 0.038% of the atmosphere.

*Catalysis*
Acceleration of the rate of a chemical reaction that is induced by the presence of material that is chemically unchanged at the end of the reaction.

*Infrared spectroscopy*
The subset of spectroscopy that deals with the infrared region of the electromagnetic spectrum. In organic chemistry, analysis of this type of spectroscopy shows what type of bonds are present in the sample.

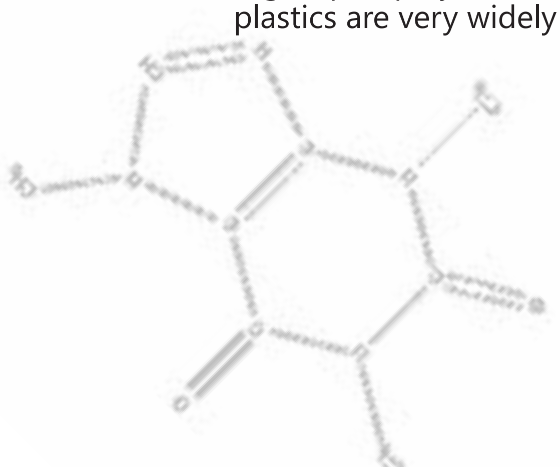
*Inorganic chemistry*
The chemistry of compounds that do not contain hydrocarbons.

*National Science Foundation (NSF)*
A United States government agency that supports fundamental research and education in all the non-medical fields of science and engineering. Its medical counterpart is the National Institutes of Health.

*Organometallic chemistry*
The study of chemical compounds containing bonds between carbon and a metal or compounds containing metal-element bonds of a largely covalent character.

*Oxytanes*
An organic compound with the molecular formula $C_3H_6O$, which has a four-membered ring with three carbon atoms and one oxygen atom. Also known as 1,3-propylene oxide.

*Polycarbonates (PC)*
A group of polymers that are easily worked, molded, and thermoformed. As such, these plastics are very widely used in modern chemistry.



# ScienceMakers
## Spotlight: Billy Joe Evans

Chemistry

| | |
|---|---|
| **Name** | Billy Joe Evans |
| **Birth Date** | August, 18, 1942 |
| **Birth Place** | Macon, Georgia |
| **Education** | Ballard High School<br>Morehouse College<br>University of Chicago |
| **Type of Science** | Chemistry |

## Biography

Chemist Billy Joe Evans was born on August 18, 1942 in Macon, Georgia. Evans grew up amidst the racism and segregation policies of the south during the 1950s. In 1959, he graduated from Ballard High School, the largest high school in Macon, Georgia. Following graduation, Evans entered Morehouse College in Atlanta, where he received his B.S. degree in chemistry in 1963. Evans went on to pursue graduate studies at the University of Chicago, where the state of Georgia paid the tuition difference between the University of Georgia and the University of Chicago. Evans received his Ph.D. degree in chemistry in 1968. His thesis was entitled: "Order-disorder phenomena and hyperfine interactions in Spinel ferrites."

**Geology photo by cogdogblog @Flickr**

After postdoctoral research work at the University of Manitoba and teaching at Howard University, Evans accepted a position on the faculty of the University of Michigan in 1970 as an assistant professor of geology and mineralogy. He then joined the chemistry department as an associate professor in 1974. Evans has continued to pursue his research in solid-state chemistry. Some of his professional interests include the design of mixed-valence compounds, naturally occurring glasses, and novel permanent magnet oxides in the construction of chemical structures. Evans is also interested in the theories of order-disorder dynamics and phase transitions. He has published over fifty scientific articles on these topics. Evans is a strong advocate for increasing the presence of African Americans in the sciences. He became Professor Emeritus at the University of Michigan in 2007.

Evans has been the recipient of many awards and prizes for his dedication to improving the quality and accessibility of higher education for all students as well as for his work in the sciences. In 1991, Evans was honored with the Statewide Distinguished Faculty Award. He received the 1997 American Chemical Society (ACS) Camille and Henry Dreyfus Award for encouraging disadvantaged students in careers in the chemical sciences. In 1998, the National Science Foundation (NSF) awarded Evans the Presidential Award for excellence in science, mathematics, and engineering.



# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Evans?
#2 Where was Dr. Evans born? Locate it on a map. How far away is this from where you live? Where did Dr. Evans attend high school? What do you think high school was like for him?
#3 How old are you? In what year was Dr. Evans your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 Dr. Evans grew up during an era of racism and the legal case *Brown v. Board of Education* was a major landmark during the time. What was the decision of the case of *Brown v. Board of Education*? When did it occur? What was the significance of this decision? How did it change things for education today?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a chemist does? Would you like to be a chemist? Why? Why not?
#2 If you were a chemist, what topics would you study?
#3 In chemistry, what are the phases (or states) of matter? What are phase transitions? What three things determine which phase matter is in?
#4 What is a "permanent" magnet? Are there materials that are not always magnetized?
#5 What is a mineral? How is a mineral different from a rock? How does mineralogy relate to geology? How do minerals relate to magnets?

# Glossary



*American Chemical Society (ACS)*
A learned society (professional association) based in the United States that supports scientific inquiry in the field of chemistry.

*Emeritus*
An adjective that is used in the title of a retired professor, bishop, or other professional.

*Ferrite*
Chemical compounds, ceramic with iron(III)oxide $Fe_2O_3$ as their principal components. Many of them are magnetic materials and they are used to make permanent magnets, ferrite cores for transformers, and other high tech applications.

*Mineralogy*
The study of chemistry, crystal structure, and physical (including optical) properties of minerals. Specific studies within mineralogy include the processes of mineral origin and formation, classification of minerals, their geographical distribution, as well as their utilization.

*National Science Foundation (NSF)*
A United States government agency that supports fundamental research and education in all the non-medical fields of science and engineering. Its medical counterpart is the National Institutes of Health.

*Order-disorder theory*
In quantum field theory and statistical mechanics in the thermodynamic limit, a system with a global symmetry can have more than one phase. For parameters where the symmetry is spontaneously broken, the system is said to be ordered. When the global symmetry is unbroken the system is disordered.

*Permanent magnet*
A magnet that retains its magnetism after being removed from a magnetic field.

*Phase transition*
A change from one state (solid or liquid or gas) to another without a change in chemical composition.

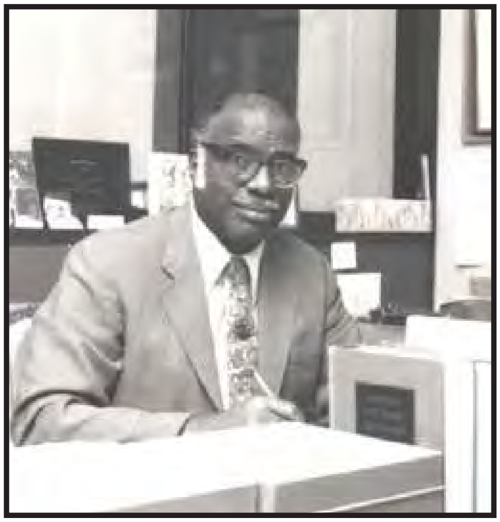
*Postdoctoral research*
Academic or scholarly research conducted by a person who has completed his or her doctoral studies, normally within a five year period. It is intended to further deepen expertise in a specialist subject, including necessary research skills and methods.

*Solid-state chemistry*
The study of the synthesis, structure, and physical properties of solid materials.

*Spinel*
A hard glassy mineral consisting of an oxide of magnesium and aluminum; occurs in various colors that are used as gemstones.

*Valence*
A measure of the number of chemical bonds formed by the atoms of a given element.

# ScienceMakers
## Spotlight: Lloyd Noel Ferguson



| | |
|---|---|
| **Name** | Lloyd Noel Ferguson |
| **Birth Date** | February 9, 1918 |
| **Birth Place** | Oakland, California |
| **Education** | University of California, Berkeley |
| **Type of Science** | Organic Chemistry |



## Biography

Chemist Lloyd Noel Ferguson was born on February 9, 1918 in Oakland, California to Noel Ferguson, a businessman, and Gwendolyn Ferguson, a house maid. Ferguson's interest in chemistry began when he was a child and built a shed in his backyard so that he could conduct experiments away from his house. Ferguson skipped two grades and although an illness kept him out of school for a year, he was able to graduate from high school in 1934, when he was only sixteen years old. After high school, Ferguson first worked with the Works Progress Administration (WPA) and then as a porter with the Southern Pacific Railway Company in order to save enough money to attend college. In 1936, Ferguson became the first in his family to attend college, earning his B.S. degree in chemistry from University of California, Berkeley in 1940. Wishing to pursue an advanced degree, Ferguson remained at the University of California, Berkeley to earn his Ph.D. degree in chemistry. During his studies, Ferguson was able to work with Dr. Melvin Calvin on a project aimed at finding a material that would release oxygen for use in submarines. The solution was a hemoglobin-like material that, when heated, releases stored oxygen. Ferguson became the first African American to receive his Ph.D. degree in chemistry from the University of California, Berkeley in 1944.

**Submarine photo by Terry Wha @Flickr.**
Dr. Ferguson designed a hemoglobin-like material that releases stored oxygen for use in submarines.

In 1945, after working at North Carolina Agricultural and Technical College for a couple years, Ferguson received an offer to join the faculty of Howard University, where he was able to both teach and conduct research. He became a full professor of chemistry at Howard University in 1955. In 1958 Ferguson became the head of the chemistry department. During his tenure, Ferguson was instrumental in building the first doctoral program in chemistry at any historically black college or university. In 1965, Ferguson joined the faculty of California State University, Los Angeles, where he chaired the department of chemistry from 1968 to 1971. Throughout his academic career, Ferguson pursued many scientific interests including: the chemistry of carbon-based molecules, the organic nature of taste sensations, and carcinogens. Ferguson has published seven textbooks and has written over fifty journal articles.

As his career matured, Ferguson fostered an interest in supporting young minority students wishing to pursue higher education and careers in science. He has developed programs such as Support of the Educationally and Economically Disadvantaged (SEED) program and the Minority Biomedical Research Program. In 1972, Ferguson also helped found the National Organization for Black Chemists and Chemical Engineers (NOBCChE). Ferguson retired from California State University, Los Angeles in 1986.

Ferguson has received much recognition for his contributions to science and education. He has a scholarship named in his honor at the California State University, Los Angeles. Additionally, he is the recipient of an honorary Ph.D. degree in chemistry from Howard University. He has served on a number of advisory boards and committees, and he was elected to participate in the prestigious American Chemical Society in 1952. Ferguson is married to Charlotte Welch, and they have raised three adult children, Lloyd, Jr., Stephen, and Lisa.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Ferguson?
#2 Where was Dr. Ferguson born? Locate it on a map. How far away is this from where you live? What are the names of his parents? Where did Dr. Ferguson attend college? What do you think college was like for him?
#3 How old are you? In what year was Dr. Ferguson your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 Dr. Ferguson has worked on some very interesting science projects. What has been your favorite project in science class? What have you learned from it?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think an organic chemist does? Would you like to be an organic chemist? Why? Why not?
#2 If you were an organic chemist, what topics would you study?
#3 Look up the definition of hemoglobin. What element is located at the center of the haem group that allows oxygen molecules or carbon dioxide molecules to bind? Why do you think the material that Dr. Ferguson designed was able to release bound oxygen when heated?
#4 One of Dr. Ferguson's scientific interests was the understanding of the nature of taste sensations. How does taste work? Which of the other four senses is most similar to taste, based on its recognition of external impetuses?

> #5 Another of Dr. Ferguson's interests was cancer-causing agents. Is there anything that is known for certain to cause cancer? If so, what is it? How would you be able to know for sure?

# Glossary



*Carcinogen*
Any substance that produces cancer.

*Hemoglobin*
The iron-containing substance in red blood cells that transports oxygen from the lungs to the rest of the body; it consists of a protein (globulin), and haem group (a porphyrin ring with an atom of iron at its center).

*National Organization for Black Chemists and Chemical Engineers (NOBCChE)*
An Ad Hoc Committee for the Professional Advancement of Black Chemists and Chemical Engineers founded by Joseph Cannon, Lloyd Ferguson, William Jackson, William Guillory, Henry McBay, Charles Merideth, and James Porter in April, 1972.

*Works Progress Administration (WPA)*
The largest New Deal agency; employed millions of people to carry out public works projects, including the construction of public buildings and roads, and operation of large arts, drama, media, and literacy programs. Re-named in 1939 as the Work Projects Administration.

# ScienceMakers
## Spotlight: Joseph S. Francisco

| | |
|---|---|
| **Name** | Joseph S. Francisco |
| **Birth Date** | March 26, 1955 |
| **Birth Place** | New Orleans, Louisiana |
| **Education** | Forest Park High School<br>University of Texas at Austin<br>Massachusetts Institute of Technology<br>Cambridge University |
| **Type of Science** | Chemistry |

## Biography

Chemist and association executive Joseph S. Francisco was born in New Orleans, Louisiana on March 26, 1955. He was raised by his grandparents, Merlin and Sarah Walker in Beaumont, Texas. Francisco's interest in studying chemistry was sparked through key mentors and his proximity to the chemical processing plants of Beaumont. He graduated from Forest Park High School in 1973 and was invited to join the engineering program at the University of Texas at Austin, where he received his B.S. degree in 1977. During his college career, Francisco gained experience in research laboratories across the country, learning about techniques in X-ray crystallography and super-conductors. After college, Francisco was hired by the Monsanto Chemical Company. He earned his Ph.D. degree in chemistry from the Massachusetts Institute of Technology (MIT) in 1983.

**MIT campus photo by Tjeerd @Flickr**

Following this, Francisco conducted research at Cambridge University for two years. He returned to the Massachusetts Institute of Technology in 1985 to teach, to continue his research in laser chemistry and to co-author a chemistry textbook. Francisco then joined the faculty of Wayne State University in 1986, where he conducted significant investigations into the chemistry and chemical reactions of chlorofluorocarbons. After holding positions on the faculty of Wayne State University for eight years, Francisco moved to Purdue University in 1995. Francisco's research group uses laser technology to study chlorofluorocarbons and the chemistry and properties of free radicals.

Francisco has been a noted figure in the chemistry field for both his research and his activity within the academic community. He served as president of the National Organization for Black Chemists and Chemical Engineers (NOBCChE) from 2005 to 2007, and he was elected president of the American Chemical Society (ACS) in 2010. Francisco has published over 400 academic papers and was named the William E. Moore Distinguished Professor at Purdue University in 2006.

# Discussion Questions

Chemistry

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Francisco?
#2 Where was Dr. Francisco born? Locate it on a map. How far away is this from where you live? What were the names of his grandparents? Where did Dr. Francisco attend high school? What do you think high school was like for him?
#3 Dr. Francisco was raised by his grandparents. What role do your grandparents play in your life? Do you see them often?
#4 How old are you? In what year was Dr. Francisco your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a chemist does? Would you like to be a chemist? Why? Why not?
#2 If you were a chemist, what topics would you study?
#3 What happens at a chemical processing plant? Is there one near you?
#4 Find chlorine and fluorine on a periodic table. How are they similar? Can you tell some properties of these elements based off of where they are located in the table?
#5 What is a chlorofluorocarbon (CFC)? Why is it potentially dangerous for the ozone layer? What catalyst serves to make the chlorofluorocarbon "active" via a photo-dissociative reaction?

# Glossary

*American Chemical Society (ACS)*
A learned society (professional association) based in the United States that supports scientific inquiry in the field of chemistry.

*Chlorofluorocarbon (CFC)*
An organic compound that contains carbon, chlorine, and fluorine and is produced as a volatile derivative of methane and ethane. It is found in many aerosol products and manufacturing processes and believed to be at least partly responsible for depleting the earth's ozone layer.

*Free radical*
An atom or group of atoms with at an unpaired electron. It stabilizes itself by stealing an electron from a nearby molecule.

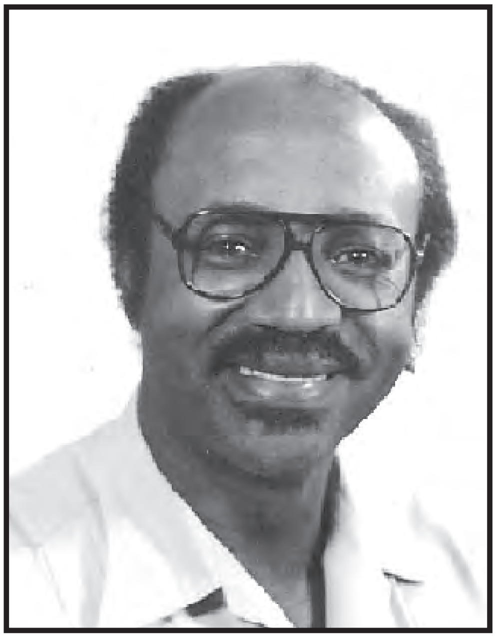
*National Organization for Black Chemists and Chemical Engineers (NOBCChE)*
An Ad Hoc Committee for the Professional Advancement of Black Chemists and Chemical Engineers founded by James Cannon, Lloyd Ferguson, William Jackson, William Guillory, Henry McBay, Charles Merideth and James Porter in April, 1972.

*Superconductor*
A substance that has no resistance to conducting an electric current. A synthetic material that has very low or no electrical resistance. Such experimental materials are being investigated in laboratories to see if they can be created at near room temperatures.

*X-ray crystallography*
The experimental science of determining the arrangement of atoms in solids utilizing x-ray technology.

# ScienceMakers
## Spotlight: Bertram Oliver Fraser-Reid

Chemistry



| | |
|---|---|
| **Name** | Bertram Oliver Fraser-Reid |
| **Birth Date** | February 23, 1934 |
| **Birth Place** | Coleyville, Jamaica |
| **Education** | Bryce Elementary School<br>Clarendon College<br>Queen's University<br>University of Alberta |
| **Type of Science** | Organic Chemistry |

## Biography

Chemist and nonprofit president Bertram Oliver Fraser-Reid was born on February 23, 1934 to William and Laura Reid in Coleyville, Jamaica. Fraser-Reid's father was the headmaster at Bryce Elementary School, the elementary school that Fraser-Reid attended. His mother died when he was only nine months old. Fraser-Reid attended Clarendon College in 1948, where he became a junior teacher. After reading a book entitled *Teach Yourself Chemistry*, Fraser-Reid became fascinated by the topic. In 1956, he decided to enroll at Queen's University in Ontario, Canada, where he received his B.S. and M.S. degrees in chemistry in 1959 and 1961, respectively. During his college career, he worked with J.K.N. Jones, an organic chemist who studied the chemistry of sugars. Fraser-Reid continued his education at the University of Alberta and completed his Ph.D. degree in 1964 with his research on the use of nuclear magnetic resonance (NMR) in determining the structure of complex molecules.

**Sugar photo by Ayelie @Flickr.**
Sugars, also known as carbohydrates, were the focus of Dr. Fraser-Reid's work.

After receiving his degree, Fraser-Reid conducted research at Imperial College in London, England. In 1966, he returned to Canada to continue his research on the chemistry of carbohydrates and to teach chemistry at the University of Waterloo. In 1980, Fraser-Reid traveled to the United States to work at the University of Maryland, where he studied the structure of potential cancer-fighting molecules. He then moved to Duke University, where he returned to his work on the chemistry of sugars. One of the most astonishing achievements of Fraser-Reid's career was demonstrating that complex organic molecules can be created from simple sugars when the proper chemical reactions are applied. Fraser-Reid's work on the chemistry of sugars opened up interesting opportunities for further research. For instance, Fraser-Reid showed that sugars can be used to construct identical copies of insect pheromones, which when sprayed on trees and crops, prevent the harmful damage of insects. There are also potential medical applications in his work, in that the molecules created by Fraser-Reid have the capability to interfere with the viral replication cycle. Such applications could provide clues as to potential cures for diseases like malaria and Acquired Immune Deficiency Syndrome (AIDS). Fraser-Reid retired from his position as professor at Duke University in 1996, and began a non-profit organization devoted to the study of the carbohydrate chemistry of tropical parasitic diseases. During his career, Fraser-Reid wrote a textbook, *Glycoscience: Chemistry and Chemical Biology*, as well as over 330 publications in academic journals.



Fraser-Reid's work has been recognized by organizations from Australia, Japan, the United Kingdom, and Canada. Among the many honors that he has received, Fraser-Reid was awarded the Musgrave Gold Medal in 2007 by the Institute of Jamaica. Fraser-Reid is married to Lillian Lawrynyuk.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Fraser-Reid?
#2 Where was Dr. Fraser-Reid born? Locate it on a map. How far away is this from where you live? What are the names of his parents? Where did Dr. Fraser-Reid attend elementary school? What do you think elementary school was like for him?
#3 How old are you? In what year was Dr. Fraser-Reid your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 How did Dr. Fraser-Reid become interested in chemistry? Why do you think the Musgrave Gold Medal is so important to Dr. Fraser-Reid?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think an organic chemist does? Would you like to be an organic chemist? Why? Why not?
#2 If you were an organic chemist, what topics would you study?
#3 What was Dr. Fraser-Reid's landmark discovery that made a large contribution to the field of organic chemistry?
#4 Look at the list of ingredients on the back of any food package and you will often find ingredients that end in the suffix "-ose." These are sugars. Find three packaged foods or drinks that contain these ingredients. List the sugars (and amount of each sugar if that information is available) you find in each food item.
#5 What are the three elements that make up a carbohydrate? How is it possible that such a large number of different sugar molecules exist when only three elements are commonly used?

# Glossary



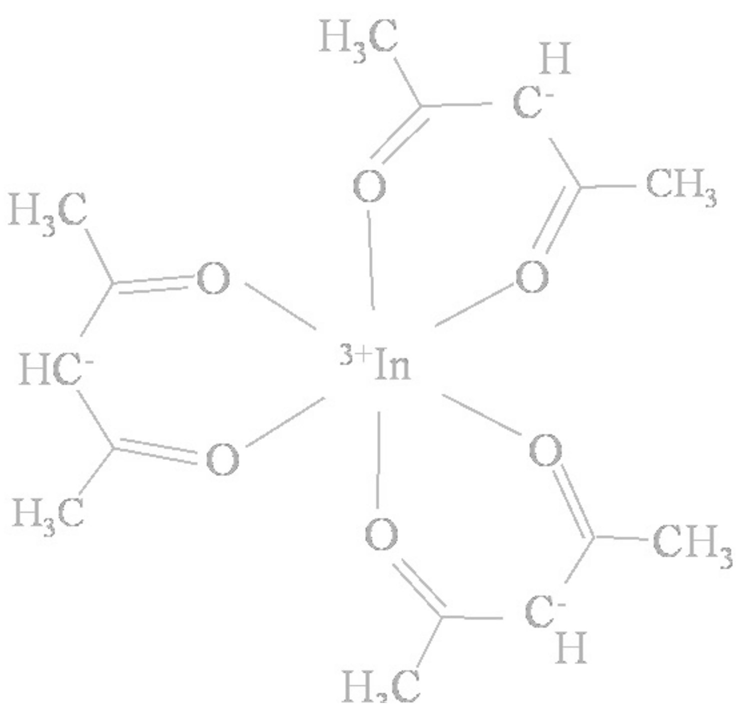
*Acquired Immune Deficiency Syndrome (AIDS)*
A disease of the human immune system caused by the human immunodeficiency virus (HIV).

*Carbohydrate*
An organic compound with the general formula $C_m(H_2O)_n$, consisting only of carbon, hydrogen and oxygen, the last two of which are in the 2:1 atom ratio. It is an essential structural component of living cells and source of energy for animals.

*Malaria*
An infectious disease caused by parasites that are transmitted through the bite of an infected mosquito.

*Nuclear magnetic resonance (NMR)*
A form of spectroscopy which depends on the absorption and emission of energy arising from the nucleus of an atom.

*Pheromones*
A chemical substance secreted externally by some animals (especially insects) that influences the physiology or behavior of other animals of the same species.



# ScienceMakers
## Spotlight: William A. Guillory



| | |
|---|---|
| **Name** | William A. Guillory |
| **Birth Place** | New Orleans, Louisiana |
| **Education** | Dillard University<br>University of California, Berkeley |
| **Type of Science** | Chemistry |

## Biography

Chemist and motivational speaker William A. Guillory was born in the housing projects of New Orleans, Louisiana. He completed his undergraduate education at Dillard University and received his B.S. degree in chemistry before earning his Ph.D. degree in chemistry from the University of California, Berkeley. Following the completion of his degree, he was offered a postdoctoral research fellowship by the National Science Foundation (NSF) to study at the Sorbonne in Paris, France.

Laser photo by orsorama @Flickr

After his fellowship, Guillory returned to the United States to conduct research and teach as a professor of chemistry at Howard University. Shortly after, he joined the faculty at Drexel University in Philadelphia. In 1973, he moved to the University of Utah. By 1977, he was named head of the chemistry department at the University of Utah, where he remained until 1980. Guillory studied the applications of lasers in chemistry, photochemistry, laser-induced fluorescence probes, and the use of other types of spectroscopy to better understand the chemistry of certain compounds. Guillory continued his work at the University of Utah until 1983 when he founded the company Innovations International, Inc. in Salt Lake City, Utah. The goal of the organization is to address problems concerning diversity and the underrepresentation of women and minorities in the workplace. Guillory has also written several motivational books, including *It's All an Illusion*, *Realizations: Personal Empowerment Through Self-*

*Awareness*, and *Tick Tock! Who Broke the Clock–The Power of Work-Life Integration*.

Guillory has received much praise for his work in both scientific research and motivational writing. He has held a number of fellowships and appointments, including the Alfred P. Sloan Fellowship and Alexander von Humboldt appointment at the University of Frankfurt.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Guillory?
#2 Where was Dr. Guillory born? Locate it on a map. How far away is this from where you live? Where did Dr. Guillory attend college?
#3 When did Dr. Guillory begin teaching at the University of Utah? What was happening in the United States that year? What was happening in the world that year?
#4 Dr. Guillory changed career paths from chemistry to motivational writing. What do you think inspired him to take up motivational writing? What types of things are motivating to you?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a chemist does? Would you like to be a chemist? Why? Why not?
#2 If you were a chemist, what topics would you study?
#3 What is photo-chemistry? Which elementary particle do you think it is named after? What are the properties of this elementary particle?
#4 Photochemical reactions are occurring all the time, for instance, exposure to light causes some chemicals to decay. Imagine that you are working with an experiment that is reactive to light hitting it. How would you get around this problem? Do you see such measures applied in everyday life?
#5 Two classic examples of the use of photochemistry in biology are the process of photosynthesis and the ability for some organisms to express bioluminescence (such as in fireflies and some jellyfish). Choose one of these examples and explain how photochemistry is involved.

# Glossary



*Fluorescence*
The emission of electromagnetic radiation by a substance that has absorbed radiation of a different wavelength. In most cases, absorption of light of a certain wavelength induces the emission of light with a larger wavelength (and lower energy).

*LASER*
An acronym for Light Amplification by Stimulated Emission of Radiation; an optical device that produces an intense monochromatic beam of coherent light.  Monochromatic light has only one wavelength—it appears to be of only one color.  Coherent light is of the same phase (i.e. there is no constructive or destructive interference of waves of light).

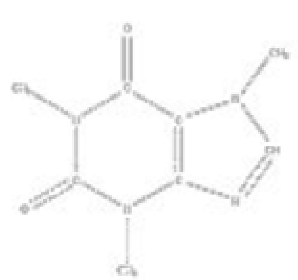
*National Science Foundation (NSF)*
A United States government agency that supports fundamental research and education in all the non-medical fields of science and engineering. Its medical counterpart is the National Institutes of Health.

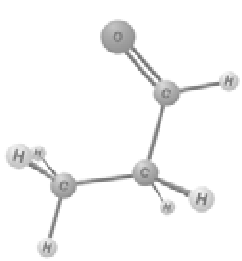
*Photochemistry*
The branch of chemistry that deals with the chemical action of light.

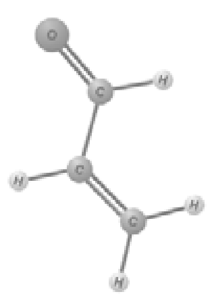
*Postdoctoral research*
Academic or scholarly research conducted by a person who has completed his or her doctoral studies, normally within a five year period. It is intended to further deepen expertise in a specialist subject, including necessary research skills and methods.

*Probe*
A device, or part of a device, used to explore, investigate or measure.

*Spectroscopy*
The study of the interaction between electromagnetic radiation and an object.  The nature of the spectroscopy is determined by the wavelength of the electromagnetic radiation used.







# ScienceMakers
## Spotlight: Betty Wright Harris



| | |
|---|---|
| **Name** | Betty Wright Harris |
| **Birth Date** | July 29, 1940 |
| **Birth Place** | Monroe, Louisiana |
| **Education** | Union Central High School<br>Southern University<br>Atlanta University<br>University of New Mexico |
| **Type of Science** | Organic Analytical Chemistry |

## Biography

Chemist Betty Wright Harris was born on July 29, 1940 in the rural Ouachita parish of Monroe, Louisiana to Henry Hudson "Jake" and Legertha Evelyn Thompson Wright. Her parents were successful farmers and until age twelve, Harris lived on the farm. In ninth grade, Harris' family bought land and built a house on the border between two school districts, and she chose to go to Union Central High School. She attended Southern University at the age of sixteen and obtained her B.S. degree in chemistry when she was nineteen. She then attended Atlanta University, where she received her M.S. degree in chemistry. Harris began her career teaching chemistry at Mississippi Valley State University, Southern University, and Colorado College.

Los Alamos, NM photo by Andrew Crow @Flickr

In 1970, Harris began working as a visiting staff member at the Los Alamos National Laboratory (LANL) in New Mexico. There, she completed research pertaining to environmental issues. Harris worked with hazardous waste cleanup and the contamination of propellants and explosives in environmental facilities. She is considered a pioneer and expert in explosives.

Harris returned to school and in 1975, she earned her Ph.D. degree from the University of New Mexico after completing a year of residence in teaching chemistry classes. She did research at Los Alamos National Laboratory and course work at the University of Wisconsin – Milwaukee.

In the mid-1980s, Harris moved to San Diego to work at Solar Turbine, Inc. as Chief of Chemical Technology. In addition to directing the laboratory efforts in the manufacturing division, Harris studied "Cold End Corrosion in Gas Turbine Engines (Centaur and GE-LM-2500), caused by $SO_2$, $SO_3$ , and $CO_2$ gases accumulating in soot deposits. She was responsible for overseeing chemical treatment vats, the parts machine shop, conducting metallographic samples, performing x-ray crystallography studies, and quality assurance of the San Diego, California natural gas supply. After two years, she returned to Los Alamos National Laboratory, where in addition to her research, she ran a student internship program. From February 2000, Dr. Harris worked for the United States Department of Energy Office of Classification through various consulting firms, Columbia Services Group, Inc., SMARTECH, Inc., and Excalibur and Associates, Inc.

Chemistry

Among Harris' accomplishments are a patent for a test that identifies minute quantities of explosives called 1,3,5-Triamino-2,4,6-trinitrobenzene (TATB). She is also the recipient of New Mexico's Governor's Trailblazer Award and helped the Girl Scouts of the United States of America create a chemistry badge. She was a member of Los Alamos National Laboratory's African American Diversity Working Group and has served as president of the New Mexico Business and Professional Women's organization. Harris was selected in 1996 for the National Science Foundation's (NSF) "Women in Science" CD-ROM. In 1999, she was featured on the Bradbury Museum's CD-ROM "Telling Our Stories: Women in Science" and received the Governor's Award for Outstanding New Mexico Women in Science. Harris lives in Maryland and is the mother of three children: Selita Harris Lucas, Jeffrey Harris (deceased), and Alloyd A. Harris, II.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Harris?
#2 Where was Dr. Harris born? Locate it on a map. How far away is this from where you live? What are the names of her parents? Where did Dr. Harris attend high school? What do you think high school was like for her?
#3 How old are you? In what year was Dr. Harris your age? What was happening in the United States that year? What was happening in the world that year? What do you think her life was like when she was your age?
#4 How does Dr. Harris's research benefit the environment?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think an organic analytical chemist does? Would you like to be this type of chemist? Why? Why not?
#2 If you were an organic analytical chemist, what topics would you study?
#3 What are the dangers of chemical contamination? Can you think of any famous examples?
#4 Is there a hazardous waste site in your area? What kinds of materials are kept there? What effects can these materials have on your health if you are exposed to them? Does the quantity of the material make a difference?

> #5 Dr. Harris developed a spot test for explosives. Spot tests are simple chemical procedures that can be used to identify a particular substance. The test can be done on a very small amount of that substance. How do you think this is accomplished? How is it known if a substance is present? What do you think is observed? Where might this test be useful?



# Glossary

*$CO_2$ (Carbon dioxide)*
A chemical compound composed of two oxygen atoms covalently bonded to a single carbon atom. It is a gas at standard temperature and pressure and exists in Earth's atmosphere in this state. $CO_2$ only makes up 0.038% of the atmosphere.

*Los Alamos National Laboratory (LANL)*
One of the largest science and technology institutions in the world that conducts multidisciplinary research on issues such as national security, outer space, renewable energy, medicine, nanotechnology, and supercomputing. It is known in particular for its role in the development of nuclear weapons during the Manhattan Project during World War II.

*Metallography*
The study of the physical structure and components of metals, typically using microscopy.

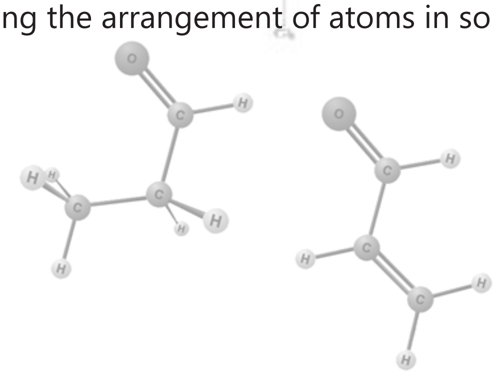
*National Science Foundation (NSF)*
A United States government agency that supports fundamental research and education in all the non-medical fields of science and engineering. Its medical counterpart is the National Institutes of Health.

*Propellant*
A material that is used to move ("propel") an object. The material is usually expelled by gas pressure. The pressure may be from a compressed gas, or a gas produced by a chemical reaction.

*$SO_2$ (Sulfur dioxide)*
A colorless toxic gas that is found in the gases from volcanoes. It is used in many manufacturing processes and present in industrial emissions. It is also thought to cause acid rain.

*$SO_3$ (Sulfur trioxide)*
In the gaseous form, this species is a significant pollutant, being the primary agent in acid rain. It is prepared on massive scales as a precursor to sulfuric acid.

*X-ray crystallography*
The experimental science of determining the arrangement of atoms in solids utilizing x-ray technology.

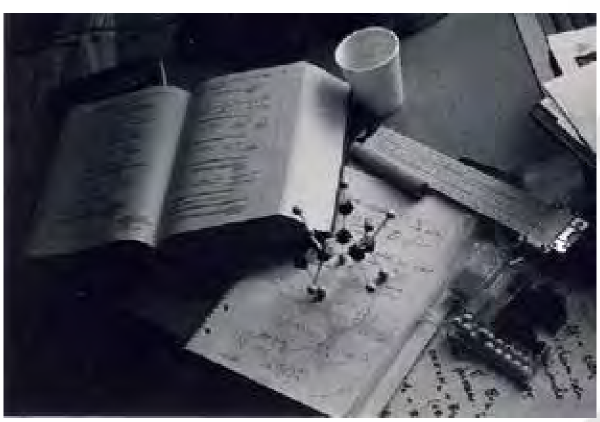


# ScienceMakers
## Spotlight: Sharon Haynie

| | |
|---|---|
| **Name** | Sharon Haynie |
| **Birth Date** | November 6, 1955 |
| **Birth Place** | Baltimore, Maryland |
| **Education** | Western High School for Girls<br>University of Pennsylvania<br>Massachusetts Institute of Technology |
| **Type of Science** | Organic Chemistry |

## Biography

Chemist Sharon Haynie was born on November 6, 1955 in Baltimore, Maryland, to Inez Penn Haynie and William H. Haynie, Jr. Haynie grew up in Baltimore, Maryland, and received her B.A. degree in biochemistry from the University of Pennsylvania in 1976. Her favorite classes during her college career were advanced inorganic chemistry and differential equations for physics. During college, Haynie had the opportunity to work in an organic chemistry laboratory, where she fell in love with the science and the academic atmosphere of the laboratory. She went on to receive her Ph.D. degree in chemistry from the Massachusetts Institute of Technology (MIT) in 1981.



**Chemistry photo by david55king @Flickr**

After working three years at Bell Laboratories in 1984, Haynie began working at E.I. du Pont de Nemours and Co. (DuPont) in the Experimental Station division. She then went on to work with the Central Research team in the Biochemical Science and Engineering Program, spending seven years with the award-winning bio-3G team. Some of her other assignments included the Vascular Graft Program and the Fibers Department Biomaterials Group. Haynie has authored and co-authored numerous patents, many of which detail processes of using environmentally friendly, bio-inspired pathways in a laboratory setting to create certain organic materials. She has conducted research in developing the synthetic materials used in vein replacements and also isolating peptides with inherent antimicrobial properties. In addition to her research, Haynie also served as an adjunct professor of chemistry at Delaware State University and the University of Delaware. She has mentored many students through a program sponsored by the American Chemical Society (ACS) Project called the Summer Educational Experience for the Disadvantaged (SEED).

Haynie has won numerous awards for her work and for her leadership in the African American scientific community. She was a member of the research team at DuPont that won the 2003 Environmental Protection Agency Presidential Green Chemistry Award for New Innovation for their project, "Microbial Production of 1,3-Propanediol." She was also elected to the position of chair of the Philadelphia Section of the American Chemical Society in 2003. Additionally, she was honored by the National Organization for the Professional Advancement of Black Chemists and Chemical Engineers (NOBCChE) with the Percy L. Julian Award in 2008. For her professional achievement in industry, Haynie was recognized by *Science Spectrum* magazine in 2006.



# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Haynie?
#2 Where was Dr. Haynie born? Locate it on a map. How far away is this from where you live? What are the names of her parents? Where did Dr. Haynie attend high school? What do you think high school was like for her?
#3 How old are you? In what year was Dr. Haynie your age? What was happening in the United States that year? What was happening in the world that year? What do you think her life was like when she was your age?
#4 Dr. Haynie worked in a laboratory during college, and she fell in love with organic chemistry. Have you had a similar experience of enjoying a class, an extracurricular activity or a work opportunity so much that you have thought about pursuing work in that field as an adult? How did your parents, grandparents, or teacher decide upon their career choices?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think an organic chemist does? Would you like to be an organic chemist? Why? Why not?
#2 If you were an organic chemist, what topics would you study?
#3 What are the advantages of using an environmentally friendly pathway to create certain organic materials?
#4 Can you think of any other ways that humans use micro-organisms to produce useable goods? Think of how some of your food is processed. What micro-organisms are used? What is made?
#5 What connections are there between organic chemistry and biology?

# Glossary



*American Chemical Society (ACS)*
A learned society (professional association) based in the United States that supports scientific inquiry in the field of chemistry.

*Bell Laboratories*
The research and development organization of Alcatel-Lucent and previously of the American Telephone & Telegraph Company (AT&T). Also known as Bell Labs and formerly known as AT&T Bell Laboratories and Bell Telephone Laboratories.

*Biochemistry*
The organic chemistry of compounds and processes occurring in living organisms.

*E.I. du Pont de Nemours & Company (DuPont)*
An American chemical company founded in July 1802 as a gunpowder mill by Eleuthère Irénée du Pont. DuPont is currently the world's second largest chemical company in terms of market capitalization and fourth in revenue. In the 20th century, DuPont led the polymer revolution by developing many highly successful materials.

*Inorganic chemistry*
The chemistry of compounds that do not contain hydrocarbons.

*Julian, Percy (1899-1975)*
An African American research chemist and a pioneer in the chemical synthesis of medicinal drugs from plants. His work would lay the foundation for the steroid drug industry's production of cortisone.

*National Organization for Black Chemists and Chemical Engineers (NOBCChE)*
An Ad Hoc Committee for the Professional Advancement of Black Chemists and Chemical Engineers founded by James Cannon, Lloyd Ferguson, William Jackson, William Guillory, Henry McBay, Charles Merideth and James Porter in April, 1972.

*Organic chemistry*
A discipline within chemistry that involves the scientific study of the structure, properties, composition, reactions, and preparation (by synthesis or by other means) of carbon based compounds, hydrocarbons, and their derivatives.

*Peptide*
Two or more amino acids (the building blocks of proteins) that are chemically linked to each other.

*Synthetic*
Man-made; not of natural origin; prepared or made artificially.

*Vascular graft*
A surgery in which tissue or organs are transplanted from a donor to a recipient that relate to vessels that conduct and circulate fluids.

# ScienceMakers Spotlight: Esther Arvilla Harrison Hopkins



| Name | Esther Arvilla Harrison Hopkins |
|---|---|
| Birth Date | 1926 |
| Birth Place | Stamford, Connecticut |
| Education | Boston University<br>Howard University<br>Yale University |
| Type of Science | Chemistry |

## Biography

Chemist, city council member, and patent attorney Esther Arvilla Harrison Hopkins was born in 1926 in Stamford, Connecticut. Working as household servants, Hopkins's parents encouraged her and her siblings to pursue their education. In 1947, Hopkins graduated from Boston University with her B.A. degree in chemistry. Just two years later, she obtained her M.S. degree in chemistry from Howard University.

Hopkins taught chemistry at Virginia State College for a short period of time before she decided to pursue research. Hopkins worked with companies such as the New England Institute for Medical Research as an assistant researcher in biophysics and the American Cyanamid's Stamford Research Laboratory as a research chemist. Hopkins studied at Yale University, where she received her second M.S. degree in chemistry and her Ph.D. degree in chemistry in 1962 and 1967, respectively. She continued her work at the American Cyanamid's Stamford Research Laboratory while she earned these degrees.


**Polaroid photo by Angel Caido @Flickr**

Following the completion of her Ph.D. program, Hopkins was hired as a supervisory research chemist with the Polaroid Corporation, where she led the Emulsion Coating and Analysis Laboratory, checking the chemical composition of the film coating for uniformity. During this time, Hopkins also developed an interest in the work of the patent department and returned to school. She received her J.D. degree from Suffolk University Law School. Hopkins retired from Polaroid Corporation in 1989 and began work as the deputy general counsel at the Massachusetts Department of Environmental

Protection. In 1999, Hopkins became the first African American selectman of Framingham, Massachusetts. She stepped down from this post in 2005, but has remained active in the community. Hopkins is married to Ewell Hopkins, a social worker and minister. They have one son, Ewell Hopkins, Jr.

# Discussion Questions



***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Hopkins?
#2 Where was Dr. Hopkins born? Locate it on a map. How far away is this from where you live? Where did Dr. Hopkins attend college? What do you think college was like for her?
#3 How old are you? In what year was Dr. Hopkins your age? What was happening in the United States that year? What was happening in the world that year? What do you think her life was like when she was your age?
#4 Besides her work as a chemist, Dr. Hopkins was active in the community. What community organizations do you participate in? What is their mission? If you or your family do not currently participate in any community organizations, what type of clubs or groups would you like to join?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a chemist does? Would you like to be a chemist? Why? Why not?
#2 If you were a chemist, what topics would you study?
#3 What is a patent? What is its purpose? For what invention or technique would you want to get a patent in your name?
#4 How does a camera that uses film work? Why would a background in chemistry be helpful for someone working with camera film? What other fields would be important in designing a camera?
#5 How does a digital camera work? How is the image stored? What parts have remained the same between the two types of camera? How has camera technology changed in the last twenty years?

# Glossary

*Emulsion*
A light-sensitive coating on paper or film that consists of fine grains of silver bromide suspended in a gelatin.

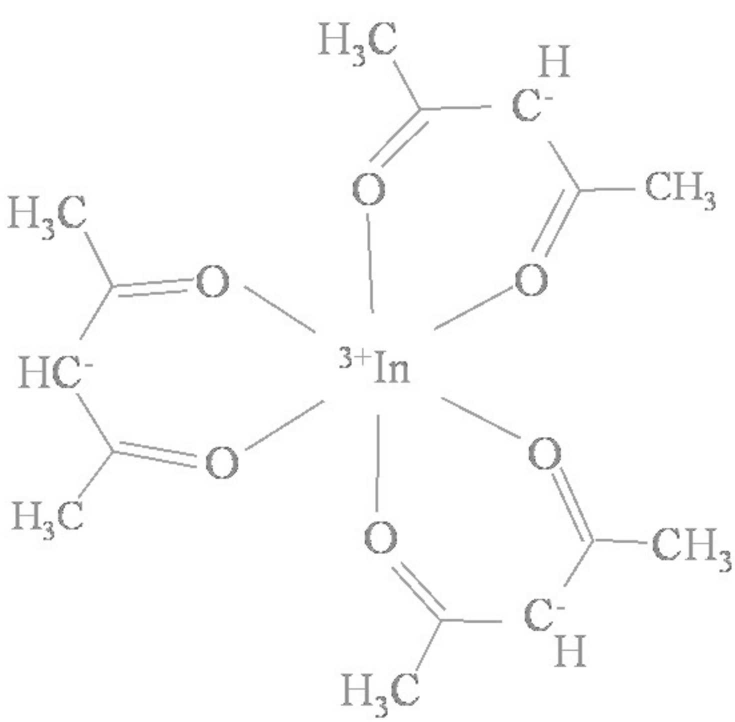
*J.D. degree ("Juris Doctor")*
A professional doctorate and first professional degree in Law.

*Patent*
A declaration issued by a government agency that declares someone the inventor of a new invention and has the privilege of stopping others from making, using or selling the claimed invention.

*Polaroid Corporation*
An international consumer electronics and eyewear company, founded in 1937 by Edwin H. Land.

*Selectman*
An elected member of a board of officials.  The term is most common in New England towns.

Chemistry



# ScienceMakers
## Spotlight: William M. Jackson

Chemistry

| Name | William M. Jackson |
|---|---|
| Birth Date | September 24, 1936 |
| Birth Place | Birmingham, Alabama |
| Education | Immaculata High School<br>Central High School<br>Morehouse College<br>Catholic University of America |
| Types of Science | Chemistry<br>Astronomy |

## Biography

Chemist William M. Jackson was born on September 24, 1936 to William and Claudia Jackson in Birmingham, Alabama. He grew up in Birmingham and Mobile, Alabama and attended Immaculata High School and Central High School. Jackson received his B.S. degree in chemistry from Morehouse College in 1956. He went on to earn his Ph.D. degree in chemistry from Catholic University of America in 1961.

**Comet McNaught photo by Forest Guardian @Flickr**

Jackson worked as a chemist at the National Bureau of Standards (NBS) from 1959 to 1961 and as a research scientist at Martin-Marietta Company in Maryland until 1963. He returned to the National Bureau of Standards as a National Academy of Sciences (NAS)-National Research Council Postdoctoral Associate for a year before he became a senior chemist at the National Aeronuatics and Space Administration (NASA) Goddard Space Flight Center (GSFC) where he worked until 1974. While at Goddard Space Flight Center, Jackson pioneered using chemical research to understand comets. He developed tunable dye lasers to study cometary radicals in the laboratory and led the first research team to use the International Ultraviolet Explorer telescope in a satellite to observe comets.

Upon leaving Goddard Space Flight Center, Jackson joined the faculty of Howard University where he taught and continued his research in the laboratory and his observations of comets. In 1985, Jackson joined the faculty of the University of California, Davis as a professor of chemistry. He was promoted to a distinguished professor and chaired the department of chemistry from 2000 to 2005. Among Jackson's research interests are photodissociation phenomena of small molecules, cometary astrochemistry and astrophysics and laser chemistry. Jackson's research group studies molecules that are relevant to the chemical make-up of comets, combustion of hydrocarbons, atmospheric chemistry and the interstellar medium.

Jackson has also been instrumental in promoting the presence of African Americans in the field of chemistry. In 1972, he was one of the original founders of the National Organization for Black Chemists and Chemical Engineers (NOBCChE). He has graduated twenty-three students with Ph.D. degrees, eleven of which were African Americans, and he instituted programs at the University of California, Davis that raised the graduate enrollment in the Ph.D. program to twelve percent of the over 200 graduate students. Jackson has received a number of awards and fellowships, including the Guggenheim Fellowship in 1989, and the 1997 Lifetime Mentor Award from the American Association for the Advancement of Science (AAAS). He is a fellow of the American Physical Society (APS), a fellow of the AAAS, and a fellow of the American Chemical Society (ACS). Jackson has published over 165 academic papers and he has one patent in his name.



# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Jackson?
#2 Where was Dr. Jackson born? Locate it on a map. How far away is this from where you live? What are the names of his parents? Where did Dr. Jackson attend high school? What do you think high school was like for him?
#3 How old are you? In what year was Dr. Jackson your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 Dr. Jackson attended a Historically Black College or University (HBCU). Are there any HBCUs near you? Which ones do you know?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think an astrochemist does? Would you like to be an astrochemist? Why? Why not?
#2 If you were an astrochemist, what topics would you study?
#3 What are the different parts of a comet? Which are the parts of a comet that we can see? Why can we see these parts? What is a comet made of?
#4 Research one particular comet. What is its name? What is its path like? How often do we see it from earth?
#5 What exists in the interstellar medium? How did these materials get there? How does the interstellar medium differ from the intergalactic medium?

# Glossary

*American Association for the Advancement of Science (AAAS)*
An international non-profit organization with the stated goals of promoting cooperation between scientists, defending scientific freedom, encouraging scientific responsibility, and supporting scientific education and science.

*American Chemical Society (ACS)*
A learned society (professional association) based in the United States that supports scientific inquiry in the field of chemistry.

*American Physical Society (APS)*
The world's second largest organization of physicists. The Society publishes more than a dozen scientific journals, including Physical Review and Physical Review Letters. It also organizes more than twenty science meetings each year.

*Astrophysics*
The study of the physics of stars, galaxies, and the interstellar medium.

*Comet*
A relatively small extraterrestrial body consisting of a frozen mass that travels around the sun in a highly elliptical orbit.

*Cometary radical*
A chemical radical (an atom or group of atoms with an unpaired electron) originating from a comet.

*Goddard Space Flight Center (GSFC)*
Goddard was NASA's first major scientific laboratory devoted entirely to the exploration of space. Located in Greenbelt, Maryland, GSFC's responsibilities include design and construction of new scientific and applications satellites, as well as tracking and communication with existing satellites.

*Hydrocarbon*
An organic compound containing only carbon and hydrogen.

*Interstellar medium*
The gas and dust that exists in open space between the stars.

*LASER*
An acronym for Light Amplification by Stimulated Emission of Radiation; an optical device that produces an intense monochromatic beam of coherent light. Monochromatic light has only one wavelength—it appears to be of only one color. Coherent light is of the same phase (i.e. there is no constructive or destructive interference of waves of light).

*National Academy of Sciences (NAS)*
A corporation in the United States whose members serve as advisers to the nation on science.

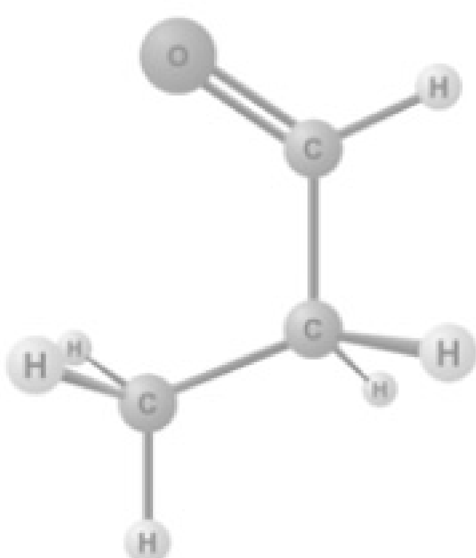
*National Aeronautics and Space Administration (NASA)*
An independent agency of the United States government responsible for aviation and spaceflight.

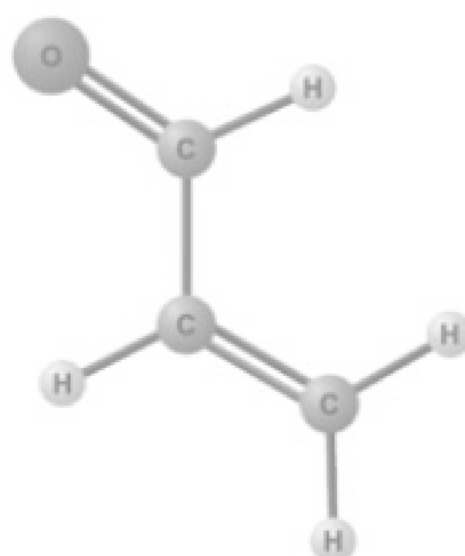
*National Bureau of Standards (NBS)*
A measurement standards laboratory.  It was renamed the National Institute of Standards and Technology (NIST) in 1989.

*National Organization for Black Chemists and Chemical Engineers (NOBCChE)*
An Ad Hoc Committee for the Professional Advancement of Black Chemists and Chemical Engineers founded by James Cannon, Lloyd Ferguson, William Jackson, William Guillory, Henry McBay, Charles Merideth and James Porter in April, 1972.

*Patent*
A declaration issued by a government agency that declares someone the inventor of a new invention and has the privilege of stopping others from making, using or selling the claimed invention.

*Photodissociation*
A chemical reaction in which a chemical compound is broken down by photons.



# ScienceMakers
## Spotlight: Alvin Preston Kennedy



| Name | Alvin Preston Kennedy |
|---|---|
| **Birth Date** | June 1, 1956 |
| **Birth Place** | Lansing, Michigan |
| **Education** | Grambling High School<br>Grambling State University<br>University of California, Berkeley |
| **Type of Science** | Chemistry |

## Biography

Chemist Alvin Preston Kennedy was born on June 1, 1956 in Lansing, Michigan to Helen and Amos Kennedy. Kennedy attended Grambling State University where he graduated with his B.S. degree in chemistry in 1978. He continued his education at the University of California, Berkeley where he was a teaching assistant for the Department of Chemistry before receiving his Ph.D. in physical chemistry in 1985.

**Bell Labs photo by kugelfish @Flickr**

After graduating, Kennedy was hired at Dow Chemical Company as a senior research chemist in central research and as a Bell Laboratories Corporate Research fellow. With Dow Chemical, he wrote sixteen internal publications. In 1989, Kennedy was promoted to project leader in central research before leaving in 1991 to become an assistant professor of chemistry at North Carolina A&T State University. Kennedy received two patents on laminates of polymers in 1993 and 1995. In 1996, he was promoted from assistant to associate professor at North Carolina A&T, and in 1998, Kennedy patented the "Resin transfer molding process for composites." Kennedy joined the faculty at Morgan State University as an associate professor of chemistry and chair of the department in 2000 and since 2002, he has been a tenured professor.

Kennedy was a National Aeronautics and Space Administration (NASA)/American Society for Engineering Education (ASEE) Research Fellow at the Marshall Space Flight Center in 1997 and 1998 and has been listed in *Who's Who Among America's Teachers*. In 2008, the National Organization for Black Chemists and Chemical Engineers (NOBCChE) named Kennedy the "Henry McBay Outstanding Teacher of the Year." Kennedy and his wife, LaToya have three adult children.

## Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Kennedy?
#2 Where was Dr. Kennedy born? Locate it on a map. How far away is this from where you live? What are the names of his parents? Where did Dr. Kennedy attend high school? What do you think high school was like for him?
#3 How old are you? In what year was Dr. Kennedy your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 The National Organization of Black Chemists and Chemical Engineers (NOBCChE) is a large, well-known organization. What is the mission of NOBCChE? How can you get involved with them? Who is Henry McBay? Why would it be an honor to receive an award named after him?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a chemist does? Would you like to be a chemist? Why? Why not?
#2 If you were a chemist, what topics would you study?
#3 Have you ever had a paper laminated before? What was the purpose of having it laminated? How does the process of lamination work?
#4 Polymers are commonly used in plastics (although the term itself actually encompasses a broad array of different molecules). See if you can find two different types of plastic made of polymers? What is the polymer called? Since a polymer is just a repeated link of single units (or monomers), what is the single unit of the polymer?
#5 What are some properties of plastics? What makes them utilizable materials? What makes them easily recyclable?

# Glossary

*American Society for Engineering Education (ASEE)*
A non-profit member association, founded in 1893, dedicated to promoting and improving engineering and engineering technology education.

*Bell Laboratories*
The research and development organization of Alcatel-Lucent and previously of the American Telephone & Telegraph Company (AT&T). Also known as Bell Labs and formerly known as AT&T Bell Laboratories and Bell Telephone Laboratories.

*Laminate*
Material formed of thin sheets glued together.

*National Aeronautics and Space Administration (NASA)*
An independent agency of the United States government responsible for aviation and spaceflight.

*National Organization for Black Chemists and Chemical Engineers (NOBCChE)*
An Ad Hoc Committee for the Professional Advancement of Black Chemists and Chemical Engineers founded by James Cannon, Lloyd Ferguson, William Jackson, William Guillory, Henry McBay, Charles Merideth and James Porter in April, 1972.

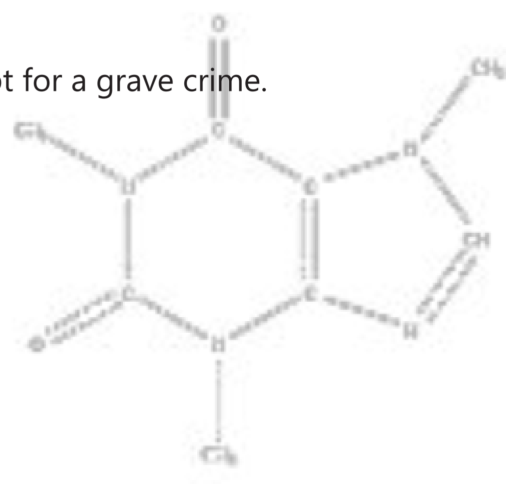
*Patent*
A declaration issued by a government agency that declares someone the inventor of a new invention and has the privilege of stopping others from making, using or selling the claimed invention.

*Physical chemistry*
The study of macroscopic, microscopic, atomic, subatomic, and particulate phenomena in chemical systems in terms of physical concepts; often dependent on the principles, practices and concepts of physics like thermodynamics, quantum chemistry, statistical mechanics and dynamics.

*Polymer*
A naturally occurring or synthetic compound consisting of large molecules made up of a linked series of repeated simple chemical units.

*Resin*
Insoluble polymeric material which allows for ready separation from liquid phase materials by filtration.

*Tenured*
Appointed for life and not subject to dismissal except for a grave crime.



# ScienceMakers
## Spotlight: Reatha Clark King



| | |
|---|---|
| **Name** | Reatha Clark King |
| **Birth Date** | April 11, 1938 |
| **Birth Place** | Pavo, Georgia |
| **Education** | Moultrie High School for Negro Youth<br>Clark College<br>University of Chicago<br>Columbia University |
| **Type of Science** | Chemistry |

Photo by Lee Prohofsky Photography

## Biography

Chemist and college president Reatha Clark King was born on April 11, 1938 in Pavo, Georgia to Willie Clark and Ola Watts Campbell. King moved with her mother to Moultrie, Georgia after her parents separated when she was in elementary school. The daughter of poorly-educated sharecroppers, King joined her family in the cotton fields throughout her childhood. She began her education in a one-room schoolhouse. In spite of her disadvantages, she excelled in school and she graduated in 1954 as valedictorian of the Moultrie High School for Negro Youth.

**University of Chicago photo by Androfire @Flickr**

King's work in school earned her a scholarship to Clark College in Atlanta, Georgia, where she enrolled in 1954. At the time, she intended to major in home economics. After taking a course with Dr. Alfred Spriggs, King decided to switch majors and pursue a career as a scientist. King received her B.S. degrees in chemistry and mathematics in 1958. During her senior year of college, King earned a Woodrow Wilson Fellowship for graduate studies, which enabled her to continue her studies in chemistry at the University of Chicago. With a focus in thermodynamics, King received her M.A. degree in chemistry in 1960 and her Ph.D. degree in physical chemistry two years later.

King moved to Washington D.C., where she worked as a project manager with the National Bureau of Standards (NBS), becoming the agency's first African American female scientist with a Ph.D. degree.

One of her first projects was to test the effects of heat on certain metal alloys. King went on to design materials that were damage-resistant to oxygen difluoride, an especially corrosive compound. Her research on this topic proved useful in some of the National Aeronautics and Space Administration's (NASA) developing projects. Also of importance to the space program was King's design of coiled tubes that allow hot liquids—such as rocket fuel—to cool. After six years with the National Bureau of Standards, King, her husband, and their two children moved to New York City where she became an assistant professor at York College. There, King quickly advanced her career, becoming a full professor and eventually the school's associate dean for academic affairs. In 1977, she moved once again to serve as president of Metropolitan State University in Minneapolis, Minnesota. Prior to her departure, King received her M.B.A. degree from Columbia University.



In 1988, King became the executive director of the General Mills Foundation and vice president of the General Mills Corporation. She retired from the company in 2002, but remained with General Mills for one more year as chair of the Foundation's board of directors. King sits on numerous boards, and has received many awards for her achievements, including the Lifetime Achievement in Philanthropy Award in 2005 from the National Center for Black Philanthropy. King is married to Dr. N. Judge King, Jr. They have raised two adult sons, N. Judge King III, and Scott Clark King.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. King?
#2 Where was Dr. King born? Locate it on a map. How far away is this from where you live? What are the names of her parents? Where did Dr. King attend high school? What do you suppose high school was like for her?
#3 How old are you? In what year was Dr. King your age? What was happening in the United States that year? What was happening in the world that year? What do you think her life was like when she was your age?
#4 King worked with her family in the cotton fields at the same time that she was studying in school. Has there ever been a time where you or someone you know has had the experience of having to work and go to school at the same time? What was it like for this person?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a chemist does? Would you like to be a chemist? Why? Why not?
#2 If you were a chemist, what topics would you study?
#3 Dr. King had a particular interest in thermochemistry. Where do you see thermochemistry applied in everyday life? If you could invent something in this field, what would you invent and why?
#4 What role does thermodynamics play in a space shuttle mission? Dr. King's accomplishments might help to give you a clue if you need a hint.

#5 If a chemical reaction releases heat, it is considered exothermic. If it takes in it (or it makes the surrounding environment cooler) it is called endothermic. Can you think of reactions that are exothermic and endothermic, or places where you think these processes might be applied?

# Glossary



*Alloy*
A metal that is a combination of two or more elements, at least one of which is a metal.

*National Aeronautics and Space Administration (NASA)*
An independent agency of the United States government responsible for aviation and spaceflight.

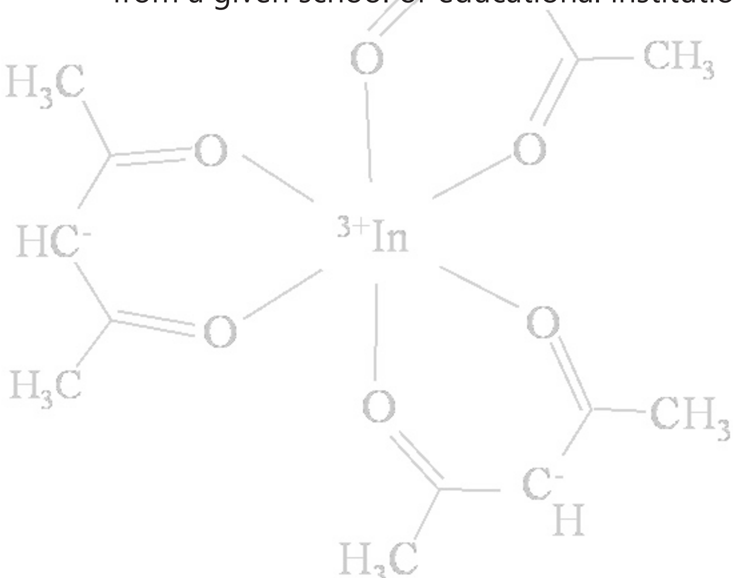
*National Bureau of Standards (NBS)*
A measurement standards laboratory. It was renamed the National Institute of Standards and Technology (NIST) in 1989.

*Oxygen difluoride*
The compound with formula $OF_2$.The molecule adopts a "V" shaped-structure like $H_2O$ but has very different properties. It is a strong oxidizer—a compound that readily donates oxygen atoms.

*Physical chemistry*
The study of macroscopic, microscopic, atomic, subatomic, and particulate phenomena in chemical systems in terms of physical concepts; often dependent on the principles, practices and concepts of physics like thermodynamics, quantum chemistry, statistical mechanics and dynamics.

*Thermodynamics*
The study of energy conversion between heat and mechanical work, and subsequently the macroscopic variables such as temperature, volume and pressure.

*Valedictorian*
An academic title typically given to the highest ranked student among the graduation class from a given school or educational institution.



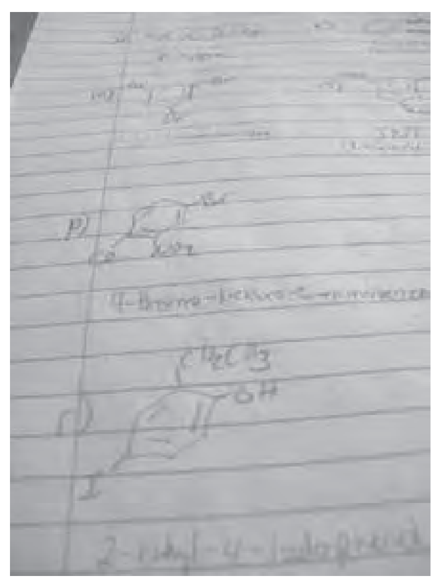
# ScienceMakers
## Spotlight: Claibourne D. Smith

| Name | Claibourne D. Smith |
| --- | --- |
| Birth Date | 1939 |
| Education | University of Denver<br>University of Oregon |
| Type of Science | Organic Chemistry |

## Biography

Chemist and college president Claibourne D. Smith was born in 1939. Smith graduated from the University of Denver with his B.S. and M.S. degrees in chemistry in 1959 and 1961, respectively. He then earned his Ph.D. degree in organic chemistry from the University of Oregon in 1964, just three years later.

Upon receiving his Ph.D. degree, Smith began his career at E.I. du Pont de Nemours & Company (DuPont). He stayed with the company for thirty-four years working on research in organic chemistry focused on the chemical properties and reactions of specific cyclic compounds. Throughout his employment, Smith held many management positions, including Director of Marketing Liaison and Vice President of Marketing in the Corporate Plans Department. He retired from the company in 1998 as Vice President of Technology and Vice Chairman of Corporation Education Aid.



**Chemistry photo by rocknroll_guitar @Flickr**

Smith has served as a member of numerous organizations and advisory boards. Most notably, after serving as the board chairman of Delaware State University, he was named the acting president of Delaware State University from 2008 to 2010. Smith was appointed to the Delaware State Board of Education in 1993, and reappointed in 1999. For his service to public education, Smith was given the Distinguished Service Award by the National Association of State Boards of Education in 2006. He also participated in the Leadership and Assistance for Science Education Reform Advisory Board. Smith lives with his wife, Roseann.

# Discussion Questions

### *About the ScienceMaker:*

#1 What was the most interesting thing you learned about Dr. Smith?
#2 Where did Dr. Smith attend college? Locate it on a map. What do you think college was like for him?
#3 How old are you? In what year was Dr. Smith your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 Several ScienceMakers have worked at E.I. du Pont de Nemours & Company. What other companies are common between the ScienceMakers?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

### *About the Subject Matter:*

#1 What do you think an organic chemist does? Would you like to be an organic chemist? Why? Why not?
#2 If you were an organic chemist, what topics would you study?
#3 Dr. Smith has been involved in many different aspects of research: student, researcher, management, director of marketing are just a few. Which of these positions would you find the most interesting?
#4 After working with a research company, Dr. Smith decided to work in politics and advisory boards. What do you think was Dr. Smith's motivation for this?
#5 For his work as an advocate for improving educational opportunities for minority students, Smith has won several awards. In what ways is education important to you? Can you find other ScienceMakers who have also advocated for improved education opportunities for African American students? Name three.

# Glossary



*Cyclic organic compound*
A compound in which a series of carbon atoms are connected to form a loop or ring. Benzene is a well known example.

*E.I. du Pont de Nemours & Company (DuPont)*
An American chemical company founded in July 1802 as a gunpowder mill by Eleuthère Irénée du Pont. DuPont is currently the world's second largest chemical company in terms of market capitalization and fourth in revenue. In the 20th century, DuPont led the polymer revolution by developing many highly successful materials.

*Organic chemistry*
A discipline within chemistry that involves the scientific study of the structure, properties, composition, reactions, and preparation (by synthesis or by other means) of carbon based compounds, hydrocarbons, and their derivatives.

# Burning Through Money



**Grade Level:** 9-12
**National Standards:** H.B.2 Structure and properties of matter
H.B.3 Chemical reactions

### *Objective*
Have you ever heard the saying, "money is burning a hole in your pocket"? **In this experiment students will see how the properties of liquids can let them light a bill on fire without burning it.**

### *Materials and Equipment*
- $1 bill (or $5 for more impressive results!)
- Rubbing alcohol
- Measuring cup
- Water
- Salt
- Metal tongs
- Matches

### *Experimental Procedure*
1. Mix the alcohol and water together in equal amounts (i.e.: if you are making two cups, use one cup alcohol and one cup water).
2. Add a small sprinkle of salt
3. Soak the bill in the solution until it is really wet
4. Using the metal tongs, pick up the bill. Do not use your hands! You'll be lighting this bill on fire! Move away from the solution too so you don't accidentally set it on fire.
5. Using a match, light the bill on fire. Watch it burn!

### *Discussion of Results*
This experiment worked partially because the bill was more like cloth than paper. Therefore, it was able to soak up the solution right away.

When the bill lit up, a chemical reaction called combustion happened. The alcohol combined with oxygen in the air and created carbon dioxide (what you breathe out) along with water. The equation is:

$$C_2H_2OH \text{ (alcohol)} + 4OH = 2CO_2 \text{ (carbon dioxide)} + 3H_2O \text{ (water)}$$

The alcohol has a higher vapor pressure than the water so it burned at a temperature too low to cause the water to completely evaporate out of the bill. The water insulated the bill from lighting on fire so only the alcohol burned. In addition, water has a high specific heat meaning the water is less likely to become hot and evaporate when it absorbs heat.

The salt gave you the cool color effect!

# Chemistry Activity on Chemical Bonds

# *Chlorofluorocarbon Attack*



**Grade Level:** 7-9
**National Standards:** H.B.3 Chemical Reactions

### *Objective*
How do chlorofluorocarbons negatively impact the environment? **In this classroom activity, students will reenact the chemical process that occurs between chlorofluorocarbons and ozone, the chemical that shields the earth from taking on too much ultraviolet (UV) radiation.**

### *Introduction*
Can the chlorine radical deplete the ozone molecules in the room? If so, how? If not, why not?

### *Materials and Equipment*
Classroom activity. Recommended: 20-25 students.
In this activity, each student will represent one atom. Designate the following in your group:

- 1 Chlorine
- All others: Oxygen molecules
    - o Game starts with oxygen students set into groups of 3. The groups of three will have to stick together throughout the whole game.
    - o At least 2 oxygen students will be on their own to start.
- 1 Carbon (teacher)

### *Experimental Procedure*
1. The game starts in an open area like a gym or a field, where the students can run around.At one end of the space the oxygen students are able to run around. This is the ozone layer.

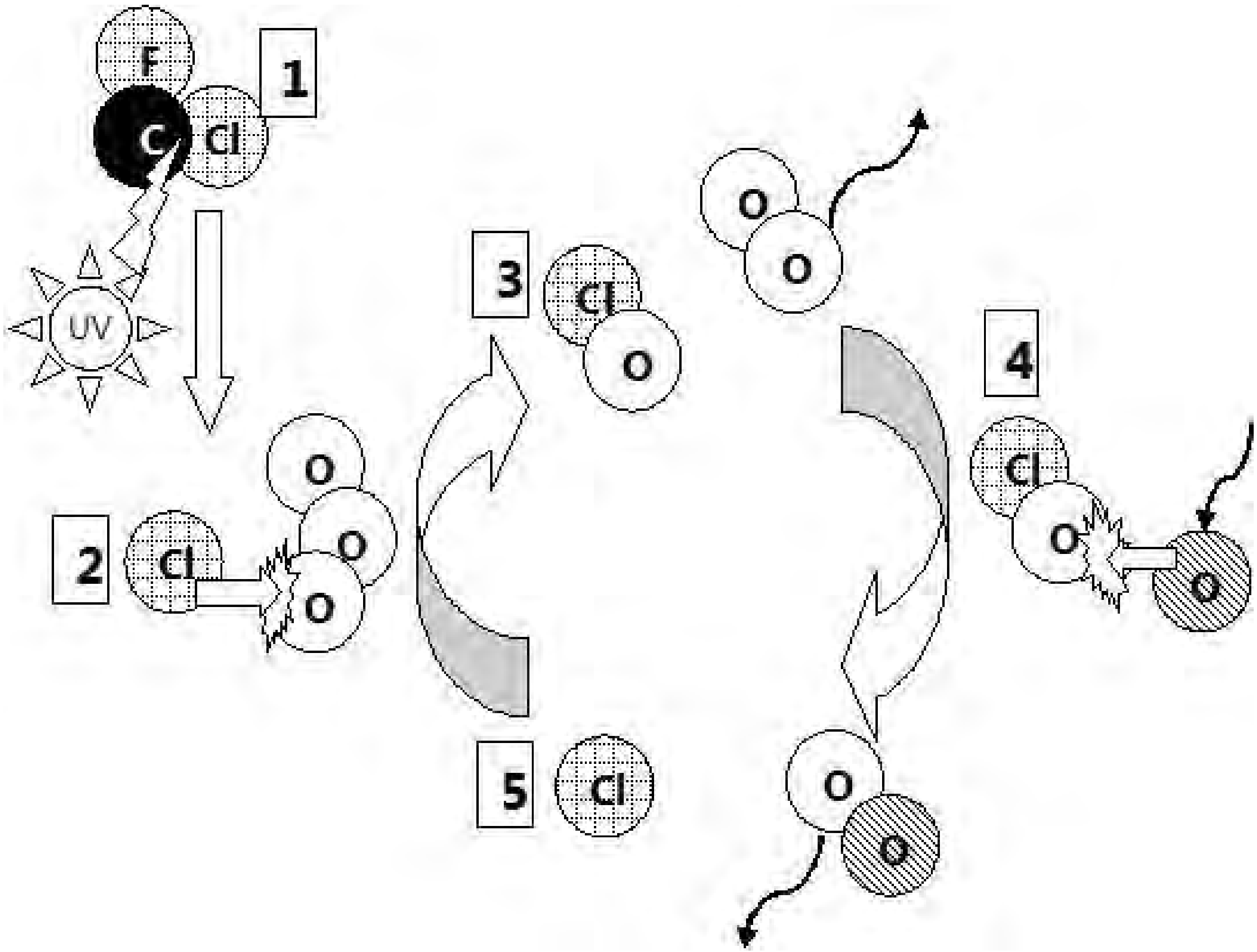
2. The teacher and the student chosen to be chlorine are at the other end of the room.

3. The teacher should explain that when UV light hits their molecule, the chlorine molecule is free to go—their chemical bond is broken.

4. The chlorine has the goal of tagging one of the groups. Once they tag a member of any group, that oxygen molecule is stuck to them and breaks away from their original group: forming $O_2$ and a halo-oxygen compound. The $O_2$ can either continue to run around, or they can sit out.

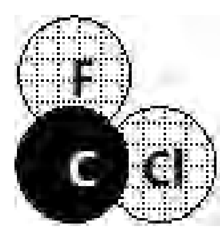
5. This is where the free oxygen molecules come in. Before the fluorine or chlorine can tag anyone else, one of the free oxygen students must tag them. Normally, the oxygen atoms would bind and form $O_2$, but it may be easier to have the free oxygen students continue their job as free oxygen.

6. Once the fluorine or chlorine has been tagged, they can go ahead to tag another group of three—but they can only tag a group of three and NOT a group of two. Repeat steps 2 through 5 until all groups of three oxygen students have been broken up.

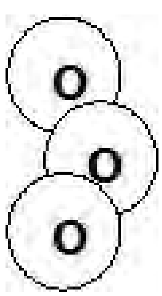



***Discussion of Results***
What happened in the end of the activity? Was your hypothesis correct? This activity is an example of a free radical reaction. In chemistry terms, “Radicals” are atoms or molecules that only have a free electron. They are highly reactive because they like to attack other molecules so that they can share electrons, making them more stable.

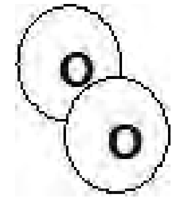
Here are some of the molecules we saw in this activity:



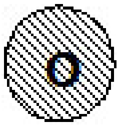

Chlorofluorocarbon (CFC): This class of molecules contains four elements: Carbon, Fluorine, Hydrogen and Carbon. As you saw in the activity, when ultraviolet light shines on the molecule, the bond between the carbon and chlorine molecules potentially breaks, causing the chlorine molecule to be released. The chlorine radical has a long-lifetime in the upper atmosphere, where it can attack susceptible ozone molecules. These molecules, although potentially harmful to the environment, are useful to appliances as refrigerants and degreasing solvents.




Ozone ($O_3$): This molecule consists of three oxygen molecules. It is not very stable and it is abundant in the upper atmosphere. The ozone layer is important to life on earth because ozone reflects damaging ultraviolet radiation that comes from the sun away from the earth’s surface.



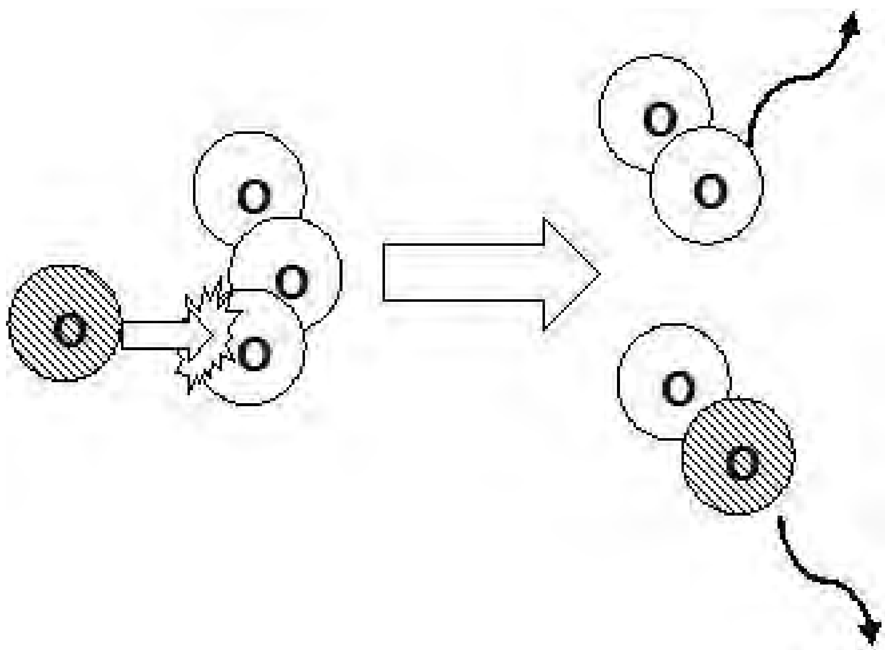

Diatomic Oxygen ($O_2$): This is the most stable form of oxygen. It consists of two oxygen atoms chemically bound together. This is the molecule that our body processes for physiological functions. This molecule is not reactive, unlike all of the other molecules in this activity.




Atomic Oxygen (O): These are the free oxygen atoms that you saw in the activity. Technically, the atomic oxygen plays more roles in the atmosphere. Like the chlorine atom that ran around tagging the ozone molecules, the atomic oxygen does the same thing, as in the diagram below. Try reenacting this process with just four oxygen molecules. What do you think is the problem of having the chlorine radical if the atomic oxygen is doing the same thing?



The problem with chlorofluorocarbons is that once the chlorine molecule is free, it can attack several ozone molecules—the process is able to repeat as seen in the cycle above. With the reaction with the atomic oxygen, the process ends in two non-reactive diatomic oxygen molecules—the atomic oxygen is not able to attack more than one ozone molecule.



# Chemistry Activity on Polymerization

## *Make Your Own Bouncy Ball*

**Grade Level:** 9-12
**National Standards:** M.B.1 Properties and changes of properties of matter

### *Objective*

Have you ever wondered how a bouncy ball is made? **In this activity, students will be making their own bouncy ball.** This procedure demonstrates the process of polymerization.

### *Introduction*

What makes up a bouncy ball? How is it made? What other questions can you ask that can be tested by making (or playing with) a bouncy ball?

### *Materials and Equipment*

- 1 tbsp. white glue
- ½ tsp. borax
- 1 tbsp. cornstarch
- 2 tbsp. warm water
- 2 plastic cups
- 2 wooden craft sticks
- Food coloring
- Zip-lock bag

### *Experimental Procedure*

1. Pour the warm water and borax powder into the one of the cups. Stir the mixture to dissolve the borax. Add food coloring if desired.
2. Pour the glue into the other cup. Add 1/2 teaspoon of the borax solution you just made and 1 tablespoon of cornstarch. Do not stir. Allow the ingredients to interact on their own for 10-15 seconds and then stir them together to fully mix.
3. The mixture should soon become difficult to stir. At this point, you can take it out of the cup and mold it into a ball. Be warned, it might be a little sticky, but the ball should solidify shortly.
4. Once you think it is ready, try bouncing your new bouncy ball.
5. You can store your plastic ball in a sealed Zip-lock bag when you are finished playing with it.
6. Clean up your work area and tools. Also be sure to wash your hands when you are done.

### *Discussion of Results*

How well does your bouncy ball work? Test it out a few times.

What is going on to form the ball? The glue contains a chemical compound called polyvinyl acetate or PVA. This is a polymer of the compound, vinyl acetate. Boron compounds, such as the borax you used in this experiment, cause the polymers to cross-link. This process is easy to imagine. Imagine that you have two linked-chains running parallel to one another. These are your polyvinyl acetate chains. Each link in the chain is a vinyl acetate monomer. When you add the boron compound, chains form connecting the existing chains, causing a giant grid-like structure of connections. As you can imagine from the example, the cross-linked compound is quite strong.

Cornstarch contains amylopectin, a polysaccharide and highly branched polymer. If you break down the word, *polysaccharide* into its component parts, you see "poly"and "saccharide" or "many carbohydrates." The amylopectin gives the ball its elasticity.

You dissolve the borax in the warm water to create the borate ions that can be used to cross-link the polyvinyl acetate chains.



***Other questions to think about:***

- Try repeating the activity, but vary the amounts of cornstarch and glue that you use. Keep track of how much you use in each trial, and what you observe once the ball is complete. Is the ball bouncier? Is it stickier? What do you think causes these observations?
- Where is boron on the periodic table? What are some of its chemical properties?
- Where else can you find amylopectin? What about polyvinyl acetate?

# Chemistry Activity on Molecules

# *Modeling with Molecules*



**Grade Level:** 9-12
**National Standards:** H.B.2 Structure and properties of matter
M.B.1 Properties and changes of properties in matter

### *Objective*

How do we picture molecules and their internal chemical bonds? **In this experiment, students will see how organic chemists use lines and letters (or rather toothpicks and colored gumdrops) to represent chemical structures.**

### *Materials and Equipment*

- 1 bag of gumdrops
- 1 box of toothpicks

### *Experimental Procedure*

1. We have four atoms that we will use: Hydrogen, Oxygen, Nitrogen, and Carbon. Assign each one a color of gumdrop in the table below. You will need the most of carbon and hydrogen.

| Element | Symbol | Color |
|---|---|---|
| Carbon | C | |
| Hydrogen | H | |
| Oxygen | O | |
| Nitrogen | N | |

2. Separate the atoms by element.
3. We will be using our atoms to build molecules. Our toothpicks will represent the chemical bonds.
4. We'll start with an easy molecule: water or $H_2O$. As is seen in the chemical formula, water has one oxygen atom and two hydrogen atoms. Grab the corresponding gumdrops and two toothpicks. Carefully insert the end of one toothpick into the oxygen atom, and the other end into a hydrogen atom. Repeat this process, inserting a second toothpick into the oxygen atom on the opposite side of the first. This is a water molecule. (To be more precise, try to approximate their bond angles by looking them up on a table. For instance, water's bond angle is 104 degrees.)
5. Here is a table containing more molecules to try:

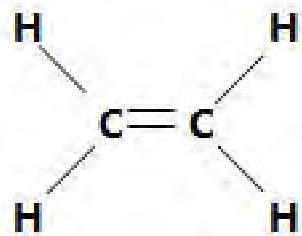
| Molecule Name | Chemical Formula | Atoms/Gumdrops | Bonds/Toothpicks |
|---|---|---|---|
| Ammonia | $NH_3$ | | |
| Methane | $CH_4$ | | |
| Carbon Dioxide | $CO_2$ | | |

Fill in the number of atoms and chemical bonds (gumdrops and toothpicks) you will need in the table above.

6. Once you have made these, we will be looking at one more type of molecule: the alkene. What makes alkenes unique is their carbon to carbon double-bonds. The simplest of these molecules is called ethylene (or ethene). Try completing the table below.

| Molecule Name | Chemical Formula | Atoms/Gumdrops | Bonds/Toothpicks |
|---|---|---|---|
| Ethylene | $C_2H_4$ | | |

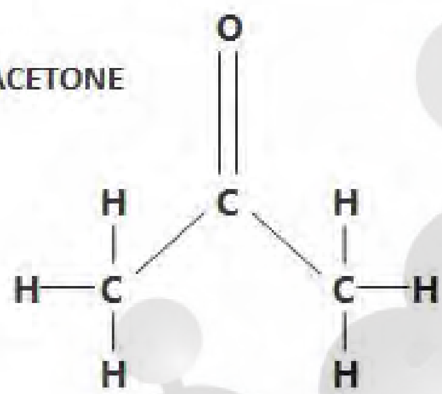
Determining the number of bonds in this molecule is kind of tricky. Ethylene has six chemical bonds total, and as you can see in the chemical formula, it has two carbon atoms and four hydrogen atoms. Ethylene is different than our previous molecules because unlike the others ethylene has two bonds between its carbons. Its chemical structure is as in the following diagram:



7. Here is one last example of a chemical structure. This is acetone, a common reagent in organic chemistry. See if you can create it using the table as in the previous example and by following the diagram below. Note the double bond between the carbon and the oxygen.

| Molecule Name | Chemical Formula | Atoms/Gumdrops | Bonds/Toothpicks |
|---|---|---|---|
| Acetone | $C_3H_6O$ | | |

ACETONE



***Discussion of Results***

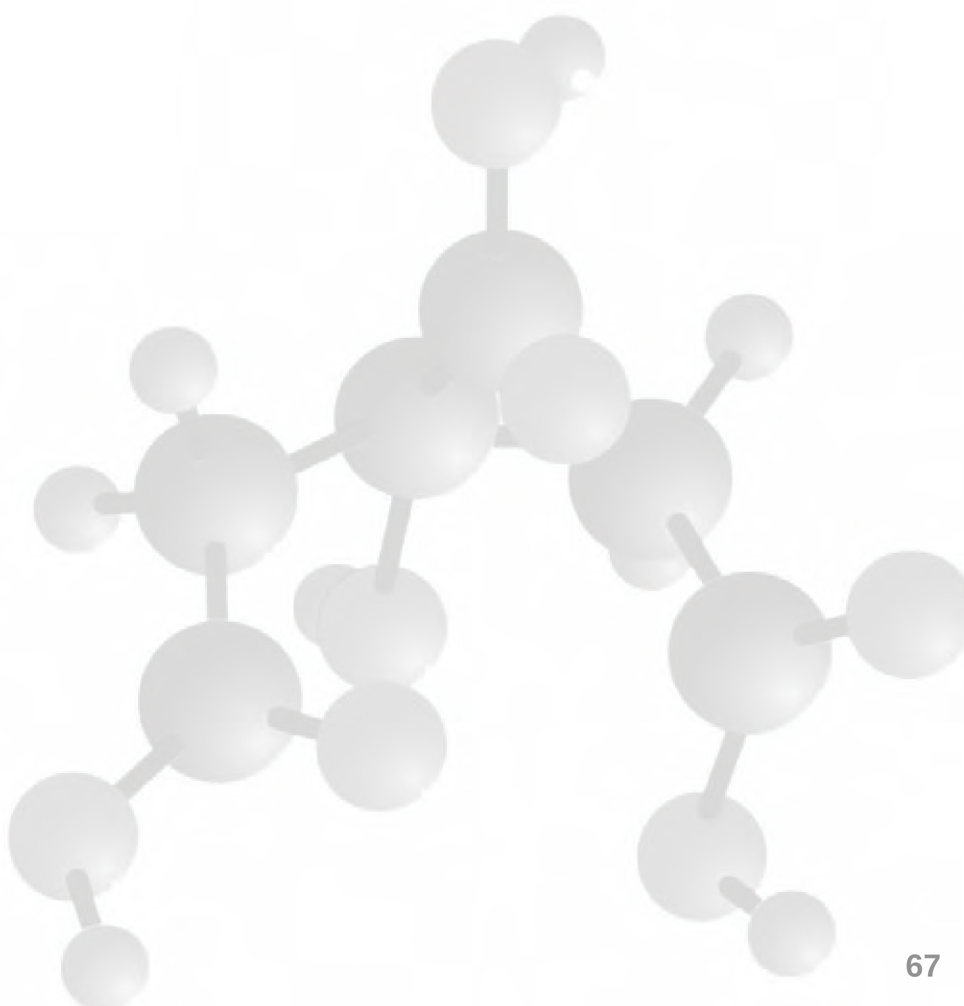
What did you learn from this activity? Is this what you expected molecular modeling to look like? How is it the same? How is it different? After this experiment, we should have three ways that we represent molecules:

1. Chemical Formula—which tells us how many of each atom are in the molecule
2. Structural drawing—Designated letters represent the elements, and lines represent chemical bonds. The structural drawing shows us how atoms are bonded on paper.
3. Model—Gumdrops of different colors are used to represent atoms of different elements and toothpicks are used to represent chemical bonds. The model gives us a 3-dimensional representation of the molecule.

### *Other questions to think about:*

- If you wanted to use Silicon in this experiment (like Xavier Creary), which element would you replace in our models?
- Which gumdrops are harder to pull apart, those with two bonds or those with a single bond? What do you think this means for the chemical properties of the molecule?
- Where do you find ammonia, methane, carbon dioxide, ethylene, and acetone in everyday life? What can they be used for?
- Look up more chemical structures in a chemistry book or online.  Try making these molecules if you have time.





Chemistry Activity on Chemical Reactions

# Putting Out A Fire With...Thin Air?

**Grade Level:** 5-9
**National Standards:** H.B.3 Chemical Reactions

### *Objective*
Have you ever considered how a fire extinguisher works? **In this experiment, students will show one of the reasons that a fire extinguisher can put out a fire.**

### *Introduction*
Read over the procedure for this experiment. What do you think will happen: after you mix the baking soda and the vinegar? After you "pour" the glass out over the candle?

### *Materials and Equipment*
- 1 tsp. baking soda
- 1 tbsp. vinegar (or lemon juice)
- 1 or 2 clear drinking glasses
- 1 lit candle

### *Experimental Procedure*
1. Light the candle, if it is not already lit.
2. "Pour" out an empty glass over the candle. Do not cover the candle or get too close to the flame. You might want to ask an adult to help with this experiment. What happens to the flame? Anything?
3. Now, tip the glass back up so it is upright. Put 1 tsp. baking soda at the bottom of the glass.
4. Pour 1 tbsp. vinegar or lemon juice into the glass. What happens? Wait for things to settle down before you go on to the next step.
5. If you have two glasses you might want to "pour" your fizzing glass into the other one without letting any liquid go into the second glass. It should look like there is nothing in the second glass.
6. Pour the empty glass over the candle. What happens now?
7. Clean up. Pour out the contents in your glasses and wash them out with tap water.

### *Discussion of Results*
What happened in this experiment? Was your hypothesis correct? What was in your "empty" glass at the end of the experiment? Was it just "air"?

When you poured the empty glass out as part of your first step, you were showing that "just air" could not put out the flame. This test is called your "negative control" test. It shows that there must have been something different the second time you tried to put out the flame. When you perform experiments, you want to minimize the differences between your trials, that way you can pinpoint what might have caused one trial to perform differently than another trial. The only thing that was prepared differently between the two trials in this experiment was the fact that you poured something into the glass after mixing baking soda and vinegar. So what happened during that process?

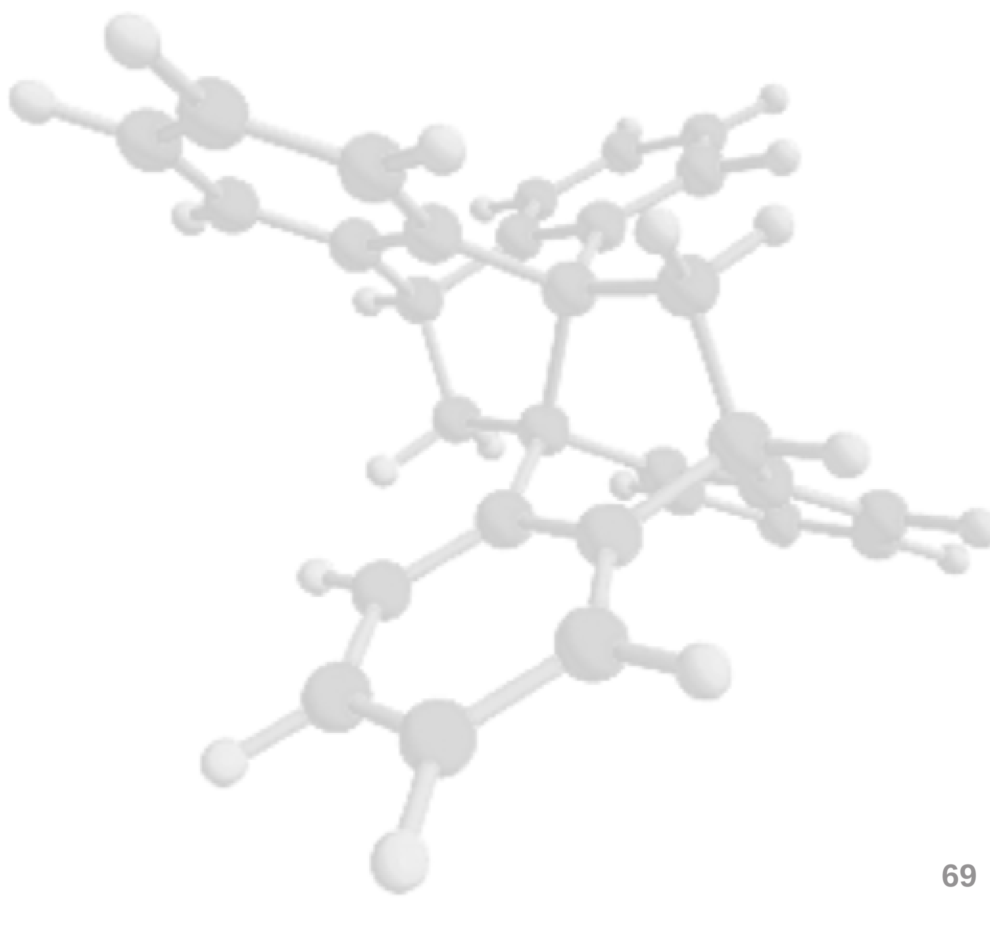
When you mixed the baking soda and vinegar, you should have noticed that the reaction mixture bubbled and fizzed, much like a carbonated soda. Much like that carbonated soda, this reaction was producing carbon dioxide. Carbon dioxide is primarily a gas, but it is significantly heavier than the air surrounding it, which allowed it to sit in the bottom of the glass and be “poured“ into the empty glass and onto the candle.

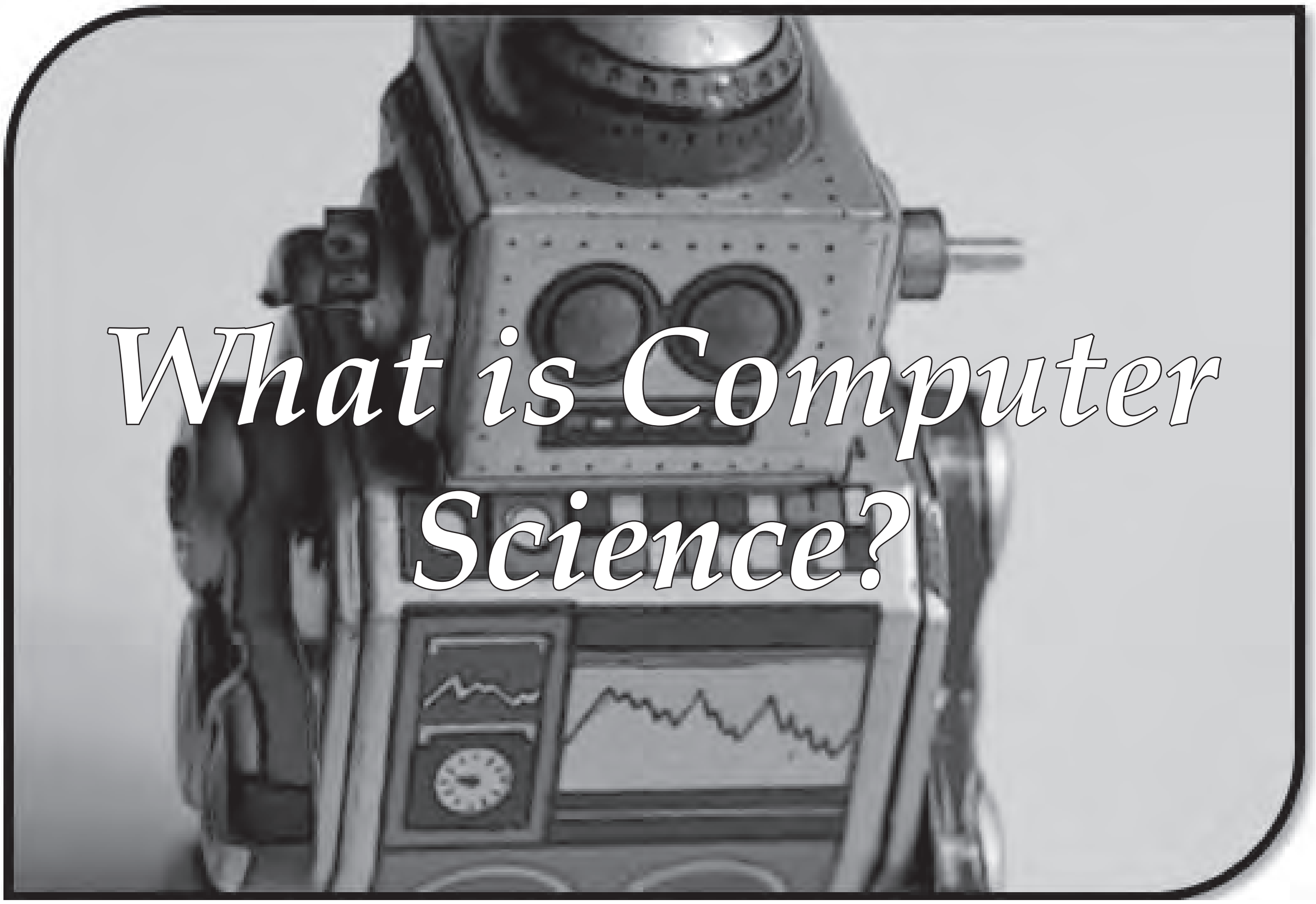
Fire needs oxygen in order to burn, so as the carbon dioxide flowed over the candle and likely settled around the base of the wick, the fire ran out of the fuel it needed to burn, and thus went out.

***Other questions to think about:***

- Without water or blowing on it, how else could you put out the candle? Think about the fuel sources a fire needs.
- What is another name for baking soda?
- What is an acid? What is a base? The reaction performed as part of this experiment is an acid-base reaction. Which of the ingredients is a base, and which is an acid?
- What is the chemical formula for Carbon dioxide? What about oxygen? Calculate their molecular mass based off of their chemical formulas.








***Computer science*** encompasses the methods and tools involved in the design of computer systems as well as the creation and implementation of algorithms, the rules that a computer program follows.

Computer scientists study how information is stored and used in computers.  This includes studying artificial intelligence in computers (like robots) or how to make computers run faster.

Photo by Sam Howzit @Flickr

## *If you like computer science, you may like the careers chosen by these people:*

| ScienceMaker | Occupation | Location | Question Topics |
|---|---|---|---|
| **Akintunde Akinwande** | Professor of Electrical Engineering & Computer Science, | *Massachusetts Institute of Technology* | Evolving technology<br>Semiconductors |
| **Mark Dean** | Vice President of Systems | *IBM Research* | Computer hardware |
| **Clarence Ellis** | Professor of Computer Science | *University of Colorado* | Computer features<br>Supercomputers |
| **Philip Emeagwali** | Computer Scientist & Engineer | | Newton's Second Law<br>Internet |
| **Marc Hannah** | Founder | *Silicon Graphics, Inc.* | Computer graphics |
| **Odest Jenkins** | Associate Professor of Computer Science | *Brown University* | Artificial Intelligence |
| **Kevin Kornegay** | Professor of Electrical and Computer Engineering | *Georgia Institute of Technology* | Computer processing and communication |
| **William Lupton** | Chair of Computer Science Department | *Morgan State University* | Computer memory<br>Database |
| **Valerie Taylor** | Department Head in Engineering | *Texas A&M University* | High performance computing<br>Nanotechnology |
| **Bryant York** | Professor of Computer Science | *Portland State University* | Accessibility of technology<br>Gaming Software |

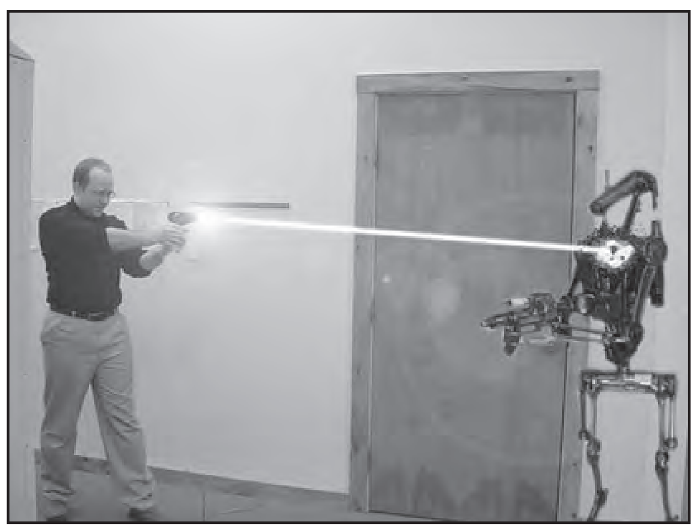
# Computer Science in Action

***Facebook*** ("Facebook Login" by jimwhimpey @ Flickr)

Facebook, launched in February of 2004, is a social networking application used to connect people to each other in a fast, easy and accessible way. This application would be impossible without the internet, a product of supercomputing.


***Special Effects*** ("Fending Off Pesky Robots" by Extra Ketchup @ Flickr)

Faster and more complex computer systems have led to the development and widespread use of sophisticated technology. This includes the dispersal of special effects programs, which at one time were used only by big-production movies. Today, even your ordinary high school teacher can fight off robots with the help of computer-generated special effects.



# ScienceMakers
## Spotlight: Akintunde Akinwande

| Name | Akintunde Akinwande |
|---|---|
| Birth Date | 1957 |
| Birth Place | Offa, Nigeria |
| Education | Government College Ibadan<br>University of Ife<br>Stanford University |
| Type of Science | Computer Science |



## Biography

Computer scientist Akintunde Akinwande was born into a family of many scholars in 1957 in Offa in Kwara State, the southwestern region of Nigeria. After attending St. Marks Primary School Offa, Akinwande's family moved to Ibadan, Nigeria, so that he could attend the same school his grandfather attended. Akinwande was educated at the Government College Ibadan before going to the University of Ife in Nigeria, where he received his B.S. degree in electrical and electronics engineering in 1978. After his undergraduate work, he moved to the United States, where he received his M.S. and Ph.D. degrees in electrical engineering from Stanford University in 1981 and 1986, respectively.

Flatscreen TV photo by Alan_D @Flickr

Upon receiving his Ph.D., Akinwande moved to Bloomington, Minnesota to work as a staff scientist at Honeywell Technology Center. There, he developed thin-film-edge field emitter arrays for use in new applications. In 1995, Akinwande joined the faculty at the Massachusetts Institute of Technology (MIT) in the Department of Electrical Engineering and Computer Science. He then became a visiting professor at the engineering department at Cambridge University and in 2002, Akinwande held a fellowship overseas at Churchill College in England. Since 2009, Akinwande has worked as a program manager at the Defense Advanced Research Projects Agency (DARPA). His research focuses on flat panel display technology, vacuum microelectronics and wide bandgap semiconductors. Akinwande is known for his demonstration of low voltage field emission arrays using the smallest reported gate aperture and radius. He is also known for his techniques to increase brightness and resolution in flat panel displays.

In 1989, Akinwande was honored with Honeywell's H.W. Sweatt Award for his technical work on the DFT processor chip and in 1996, the National Science Foundation (NSF) gave him its Career Award. He has written over 100 journal publications. Akinwande is chair of the Institute of Electrical and Electronics Engineers (IEEE) Nanotechnology Council, a fellow of the IEEE, and he has served on technical conference committees for the International Electron Device Conference and the International Vacuum Microelectronics Conference among many others.

## Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Akinwande?
#2 Where was Dr. Akinwande born? Locate it on a map. How far away is this from where you live? Where did Dr. Akinwande attend college? What do you think college was like for him?
#3 How old are you? In what year was Dr. Akinwande your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 How old was Dr. Akinwande when he came to the United States? How do you think the transition was for him?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a computer scientist does? Would you like to be a computer scientist? Why? Why not?
#2 If you were a computer scientist, what topics would you study?
#3 Flat panel displays are becoming more common in contemporary society. If you could make an invention that would improve on an already existing appliance (such as the television or radio), what would you enhance, how would you make it better, and why?
#4 Name another appliance or tool that has been upgraded in recent years. How has it been changed? What new features does the improvement bring? Are there any disadvantages to making the changes?
#5 Wide bandgaps, a topic in which Dr. Akinwande is interested with regards to semiconductors, are most often achieved using small atoms with large electronegativities. Where are the three smallest elements found on the periodic table? What is electronegativity? What three elements have the greatest electronegativities? Is there any overlap between these categories?

# Glossary

*Bandgap*
An energy range in a solid where no electron states exist. Also called an energy gap or bandgap.

*Computer science*
The study of the theoretical foundations of information and computation, and of practical techniques for their implementation and application in computer systems.

*Defense Advanced Research Projects Agency (DARPA)*
The central research and development organization for the United States Department of Defense.

*Electrical engineering*
The branch of engineering science that studies the uses of electricity and the equipment for power generation and distribution and the control of machines and communication.

*Field emission*
The emission of electrons that are stripped from parent atoms by a high electric field.

*Institute of Electrical and Electronics Engineers (IEEE)*
An international non-profit, professional organization for the advancement of technology related to electricity.

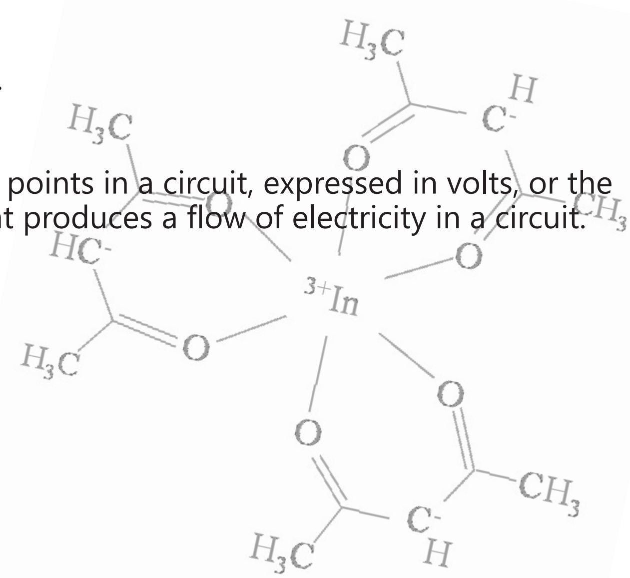
*Microelectronics*
The branch of electronics that deals with miniature components.

*National Science Foundation (NSF)*
A United States government agency that supports fundamental research and education in all the non-medical fields of science and engineering. Its medical counterpart is the National Institutes of Health.

*Semiconductor*
A material that is neither a good conductor nor a good insulator. Examples of semi-conductors are: Silicon, Boron, and Carbon.

*Vacuum*
A space that has no pressure and no molecules.

*Voltage*
The difference in electrical charge between two points in a circuit, expressed in volts, or the rate at which energy is drawn from a source that produces a flow of electricity in a circuit.



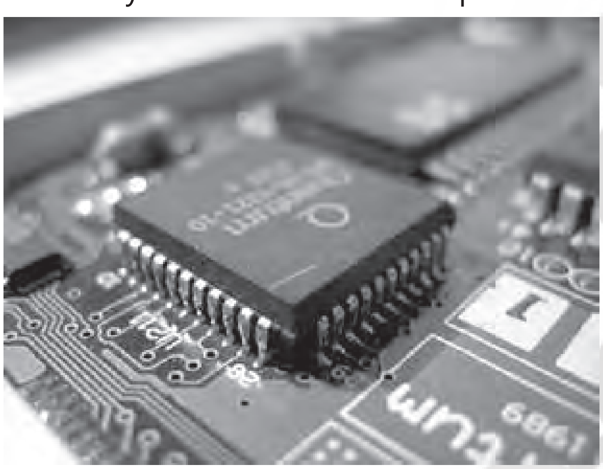
# ScienceMakers
# Spotlight: Mark E. Dean



| | |
|---|---|
| **Name** | Mark E. Dean |
| **Birth Date** | March 2, 1957 |
| **Birth Place** | Jefferson City, Tennessee |
| **Education** | Jefferson City High School<br>University of Tennessee<br>Florida Atlantic University<br>Stanford University |
| **Types of Science** | Computer Science<br>Computer Engineering<br>Electrical Engineering |

## Biography

Computer scientist, electrical engineer and inventor Mark E. Dean was born to James and Barbara Dean on March 2, 1957 in Jefferson City, Tennessee. Dean's father worked as a supervisor for the Tennessee Valley Authority Dam. Dean observed his father's work often, and his family was supportive of his academic pursuits throughout his youth. In 1979, Dean graduated from the University of Tennessee at the top of his class with his B.S. degree in electrical engineering. Dean continued to study electrical engineering at Florida Atlantic University, where he received his M.S. degree in 1982. He attended Stanford University earning a Ph.D. degree in electrical engineering in 1992.



Chip photo by Dano @Flickr

International Business Machines (IBM) hired Dean in 1980, and he worked in Florida, New York, Texas, Arizona and California. Throughout his career, he created a number of useful patents. His development teams have been responsible for such projects as the interior architecture that permits multiple electronic devices (like a printer) to be connected to a personal computer. He has also helped to establish the Blue Gene Project, a computer chip capable of running at one quadrillion floating point operations per second. This type of supercomputing technology proved useful in biomedical research, where quick and more accurate computational methods started to simulate human biology processes. In 1999, Dean helped to test the first gigahertz Complementary metal-oxide-semiconductor (CMOS) microprocessor. Throughout his career with IBM, Dean has served in various positions, including vice president for System's Research at IBM's Watson Research Center in New York, vice president of IBM's Storage Technology group and vice president of IBM Almaden Research Center in San Jose, California.

Dean has been recognized for his outstanding contributions to the development of the modern computer system. In 1995, out of 300,000 employees, Dean was one of 50 to be named an IBM fellow. He was also the first African American to receive this honor. In 1997, he was invited to join the selective National Inventors Hall of Fame. He has received honorary degrees from three colleges and universities: Wheaton College, Lincoln University, and Howard University. In 2000, he was awarded the Black Engineer of the Year Award. Just one year later, he was inducted into the National Academy of Engineering (NAE), and he was named a fellow of the Institute of Electrical and Electronics Engineers (IEEE) in 2002 and fellow of the American Academy of Arts and Sciences (AAAS) in 2004. In 2008, he was honored with the Association of Black Charities Black History Makers Immortal Award. Dean is the holder of 40 patents or patents pending, and he is married to Denise Dean.



# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Dean?
#2 Where was Dr. Dean born? Locate it on a map. How far away is this from where you live? What are the names of his parents? Where did Dr. Dean attend college? What do you think college was like for him?
#3 Find information on the Tennessee Valley Authority. What types of projects does this organization run? How do you think Dr. Dean's observations of his father's work might have influenced his career path?
#4 How old are you? In what year was Dr. Dean your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a computer scientist does? Would you like to be a computer scientist? Why? Why not?
#2 If you were a computer scientist, what topics would you study?
#3 Do you enjoy working with computers? Have you ever opened up the back of a computer? What components make up the interior of the computer?
#4 How does a computer "recognize" devices (such as a printer or keyboard) that are attached to it? What types of communication or programs are necessary between the device and the computer for the attached part to become functional?
#5 What do you think computers will be used for in the future? Using Dr. Dean's biography and work as a starting point, consider what technology will be necessary for computers to do such things in the future.

# Glossary

*American Academy of Arts and Sciences (AAAS)*
An independent policy research center that conducts multidisciplinary studies of complex and emerging problems. The Academy's elected members are leaders in the academic disciplines, the arts, business, and public affairs.

*Blue Gene Project*
An experimental parallel processing supercomputer developed by IBM that employs thousands of processors, each of which demands minimal electric current.

*Complementary metal-oxide-semiconductor (CMOS)*
Technology employing integrated field-effect transistors in a complementary symmetry arrangement, which simulates "Push/Pull" operation because of the placement of opposing-polarity devices; a technology for constructing integrated circuits. CMOS technology is used in microprocessors, microcontrollers, static RAM, and other digital logic circuits.

*Computer chip*
An integrated circuit (also known as IC, microcircuit, microchip, silicon chip, or chip) is a miniaturized electronic circuit consisting mainly of semiconductor devices, as well as passive components that has been manufactured on the surface of a thin semiconductor.



*Electrical engineering*
The branch of engineering science that studies the uses of electricity and the equipment for power generation and distribution and the control of machines and communication.

*Floating point*
The computer representation of a real number; describes a system for representing numbers that would be too large or too small to be represented as integers.

*Gigahertz*
A unit of frequency that is equal to one billion cycles per second.

*Institute of Electrical and Electronics Engineers*
An international non-profit, professional organization for the advancement of technology related to electricity.

*International Business Machines (IBM)*
One of the major mainframe computer manufacturers, as well as personal computer designer.

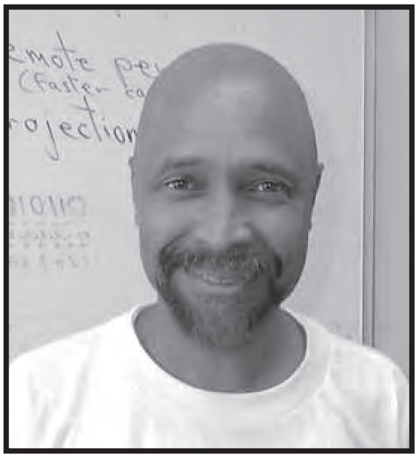
*Microprocessor*
The integrated circuit semiconductor chip that performs the bulk of the processing and controls the parts of a computer system.

*National Academy of Engineering*
A non-profit institution that operates engineering programs and encourages education and research. Election to the group is considered the highest achievement in engineering-related fields.

*Patent*
A declaration issued by a government agency that declares someone the inventor of a new invention and has the privilege of stopping others from making, using or selling the claimed invention.

*Quadrillion*
The number that is represented as a one followed by twenty-four zeros.

# ScienceMakers
## Spotlight: Clarence "Skip" Ellis




| Name | Clarence "Skip" Ellis |
|---|---|
| Birth Date | May 11, 1943 |
| Birth Place | Chicago, Illinois |
| Education | Beloit College<br>University of Illinois, Urbana-Champaign |
| Type of Science | Computer Science |

## Biography

Computer scientist Clarence Ellis was born on May 11, 1943 in Chicago, Illinois to a single mother. One of five children, Ellis began working at an insurance agency at age fifteen to help support his family. In high school, Ellis attended summer programs at several Chicago universities and upon graduation won a scholarship to Beloit College. After graduating with his B.S. degree in math and physics, Ellis attended the University of Illinois at Urbana-Champaign, where he graduated with his Ph.D. degree in computer science in 1969. Ellis was one of the first African Americans to receive a Ph.D. degree in computer science.


Computer lab photo by izzymunchted @Flickr

Ellis was hired as a supercomputer researcher at Bell Laboratories. He then moved to Xerox Corporation, where he helped introduce the concept of clicking on an image to start a program, a feature now found on most computers. He went on to work for International Business Machines (IBM), the Microelectronics and Computer Technology Corporation, Los Alamos National Laboratory (LANL), and Argonne National Laboratory. Ellis also spent time at Stanford University, the University of Texas, and the Massachusetts Institute of Technology (MIT). In 1992, Ellis joined the faculty at the University of Colorado, where he insisted on teaching general computer science classes to encourage minorities to become interested in the subject. In addition, Ellis helped develop Summer Multicultural Access to Research Training (SMART), an internship summer program. Ellis' research at the University of Colorado focused on workflow technology and computer-supported cooperative work. He has also worked to create national standards to make computers easier to use.

Ellis is the Director of the Collaboration Technology Research Group and the Institute for Cognitive Science. In 2000, he was a grant recipient from the Laboratory for New Media Strategy and Design. Ellis has published several papers on computer science topics.

# Discussion Questions

***About the ScienceMaker:***

#1 What did you find most interesting about Dr. Ellis' story?
#2 Where was Dr. Ellis born? Locate it on a map. Now locate Beloit, Wisconsin; and Champaign, Illinois. Are these very close to where Dr. Ellis grew up? How do you think he felt when he started to move further away from home later in his career?
#3 How old are you? In what year was Dr. Ellis your age? What was happening in the country that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 Dr. Ellis began working when he was just fifteen years old at an insurance company. What lessons do you think he might have learned by working there? What do you think he did as part of his job?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a computer scientist does? Would you like to be a computer scientist? Why? Why not?
#2 If you were a computer scientist, what topics would you study?
#3 A supercomputer can do many calculations very quickly. If you had access to a supercomputer, what would you have it do? Generate protein structures? Mimic physiological processes? Calculate the digits of pi? Weather forecasting? Why is supercomputing useful in these areas?
#4 Dr. Ellis is cited for having invented the option of clicking on an icon to start a program on a computer. Name a couple other "minor" features that you think people often take for granted, but make using a computer (or some other type of technology) much easier. What features would you add to make a computer easier to use?
#5 Computer technology is a very fast-paced field. Name a feature that computers did not have ten years ago, but do today. Can you name a new feature that has been added within the last five years?

# Glossary

*Argonne National Laboratory*
The first science and engineering research national laboratory in the United States. It is the largest national lab by size and scope in the Midwest. It maintains a broad portfolio in basic science research, energy storage, environmental sustainability, and national security.

*Bell Laboratories*
The research and development organization of Alcatel-Lucent and previously of the American Telephone & Telegraph Company (AT&T). Also known as Bell Labs and formerly known as AT&T Bell Laboratories and Bell Telephone Laboratories.

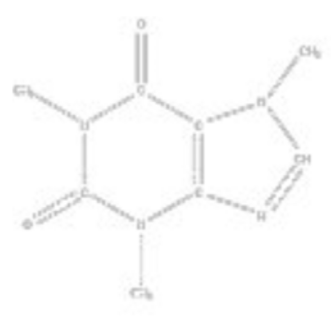
*Computer science*
The study of the theoretical foundations of information and computation, and of practical techniques for their implementation and application in computer systems.

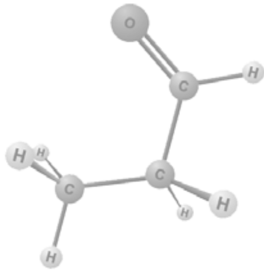
*International Business Machines (IBM)*
One of the major mainframe computer manufacturers, as well as personal computer designer.

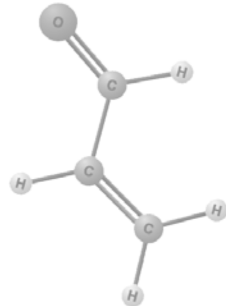
*Los Alamos National Laboratory*
One of the largest science and technology institutions in the world that conducts multidisciplinary research on issues such as national security, outer space, renewable energy, medicine, nanotechnology, and supercomputing. It is known in particular for its role in the development of nuclear weapons during the Manhattan Project.

*Supercomputer*
A mainframe computer that is one of the most powerful available at any given time.









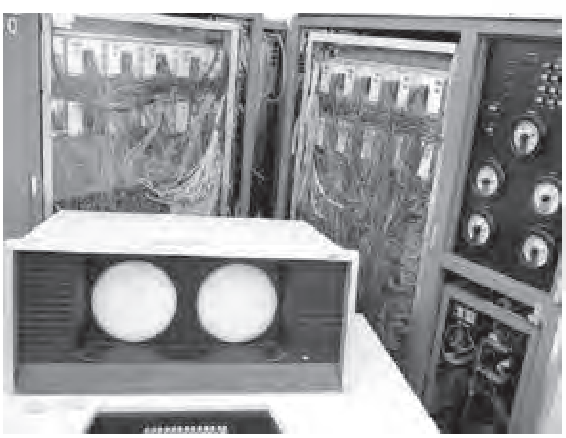
# ScienceMakers
## Spotlight: Philip Emeagwali



| | |
|---|---|
| **Name** | Philip Emeagwali |
| **Birth Date** | August 23, 1954 |
| **Birth Place** | Akure, Nigeria |
| **Education** | Oregon State University |
| **Type of Science** | Computer Science |

## Biography

Computer scientist Philip Emeagwali was born Chukwurah Emeagwali on August 23, 1954 in Akure, Nigeria to James and Agatha Emeagwali. In 1969, two years after the beginning of the Nigerian-Biafran war, Emeagwali dropped out of school and was drafted into the Biafran army. After being discharged, Emeagwali studied on his own and completed a high-school equivalency education. He took a correspondence course at the University of London before moving to the United States on a mathematics scholarship in 1973. In 1977, Emeagwali received his B.S. degree in mathematics from Oregon State University.



**Supercomputer photo by jurvetson @Flickr**

During his undergraduate education, Emeagwali worked as a civil engineer for the Wyoming Bureau of Land Reclamation. Emeagwali served as a researcher for the National Weather Service before completing his calculation achievement in 1987 with over 65,000 computer processors and a reformulation of <u>Newton's Second Law of Motion</u>. Emeagwali is credited with discovering the formula that allows <u>supercomputers</u> with a high number of <u>processors</u> to perform the world's fastest calculations – over a billion calculations per second. Emeagwali's innovative idea of connecting smaller processors to form a faster supercomputer is one of the founding principles of the <u>internet</u>, as the internet is similarly a network of millions of interconnected computers. Emeagwali is recognized as one of the key players in the creation of the internet for developing the HyperBall supercomputer that would become known as the internet.

In 1989, Emeagwali was awarded the Gordon Bell Prize for his work on an application of the CM-2 computer for oil-reservoir modeling, the first program to use a pseudo-time methodology. In 2000, President Bill Clinton cited Emeagwali as "one of the great minds of the information age." Cable News Network (CNN) has called Emeagwali "a father of the Internet" and he is also an inductee into the Gallery of History's 70 Greatest Black Achievers. He was voted the 35th greatest African of all time by *New African* magazine in 2004. In 2010, the British Broadcasting Company (BBC) interviewed Emeagwali for its "Digital Giants" series.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most compelling thing you learned about Mr. Emeagwali?
#2 Where was Mr. Emeagwali born? Locate it on a map. How far away is this from where you live? What are the names of his parents? Where did Mr. Emeagwali attend college? What do you think college was like for him?
#3 How old are you? In what year was Mr. Emeagwali your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 Mr. Emeagwali was drafted into a war when he was only fourteen. How would you feel if you were placed in his position? What do you think that was like? Research the Nigerian-Biafran Civil War. Who were the key players? What did each of the sides want? What was the result?
#5 What are other question(s) you would ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a computer scientist does? Would you like to be a computer scientist? Why? Why not?
#2 If you were a computer scientist, what topics would you study?
#3 Mr. Emeagwali says that his innovative ideas are due to years of hard work and a background in several disciplines. In what subjects do you think he must have been thoroughly trained in order to make such contributions to the development of the Internet?
#4 Mr. Emeagwali's inventions made it possible for computers to work faster than they had before. One of the achievements of this faster computer system was to reformulate Newton's Second Law. What is Newton's Second Law of Motion? In what time period did Newton formulate his Laws of Motion? Why is a reformulation of Newton's Second Law in 1987 so important?
#5 What do you use the internet for? What do you think the internet will be used for in the future that it is not already used for?

# Glossary

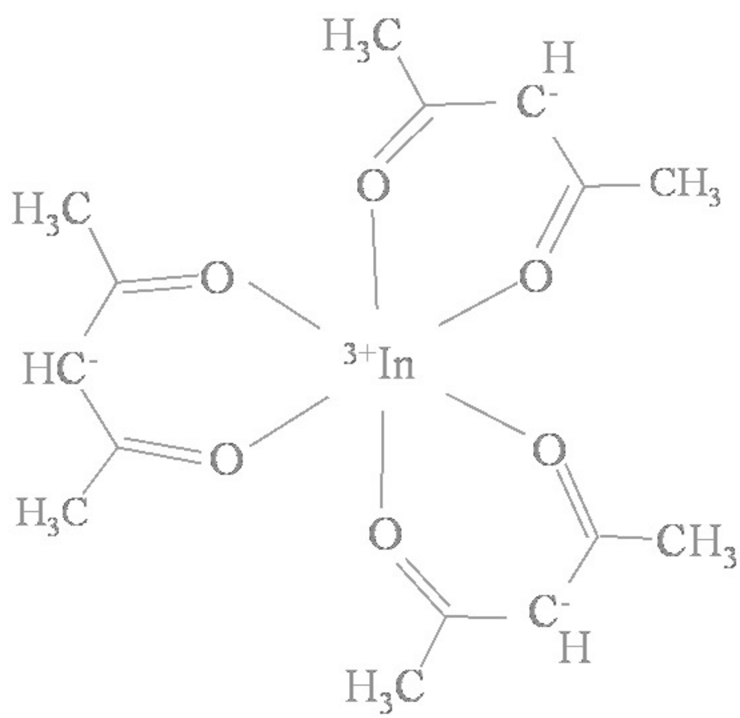
*Internet*
A global system of interconnected computer networks that use the standard Internet Protocol Suite (TCP/IP) to serve billions of users worldwide.

*Newton's Second Law of Motion*
The rate of change of momentum is proportional to the imposed force and goes in the direction of the force. A body of mass (m) subject to a force (F) undergoes an acceleration (a) that has the same direction as the force and a magnitude that is directly proportional to the force and inversely proportional to the mass, i.e., F = ma.

*Processor*
The part of a computer (a microprocessor chip) that does most of the data processing.

*Supercomputer*
A mainframe computer that is one of the most powerful available at any given time.





# ScienceMakers
## Spotlight: Marc Hannah

| | |
|---|---|
| **Name** | Marc Hannah |
| **Birth Date** | October 13, 1956 |
| **Birth Place** | Chicago, Illinois |
| **Education** | Illinois Institute of Technology<br>Stanford University |
| **Types of Science** | Computer Science<br>Electrical Engineering |

Computer Science

## Biography

Electrical engineer and computer graphics designer Marc Regis Hannah was born on October 13, 1956 in Chicago, Illinois. He attended the Illinois Institute of Technology on a scholarship awarded by Bell Laboratories. Hannah received his B.S. degree in electrical engineering in 1977 before going on to Stanford University, where he obtained his M.S. degree in 1978 and his Ph.D. degree in 1985.

**Jurassic Park photo by Scott Kinmartin @Flickr**

In 1982, Hannah co-founded Silicon Graphics Incorporated (SGI) with Jim Clark and five others, a company that went on to be well-known for its computer graphics technology. In 1986, he was named the company's principal scientist for the creation of computer programs like Personal IRIS, Indigo, Indigo2, and Indy graphics. These programs were used to create effects for movies like *Jurassic Park*, *Aladdin*, *Beauty and the Beast*, *The Hunt for Red October*, and *Field of Dreams*. George Lucas' digital effects company, Industrial Light & Magic, used Silicon Graphics Incorporated's technology to create *Terminator 2*. Hannah's programs have also been used to create television commercials and the opening introduction for *Monday Night Football*. In addition, the company's technology is used in engineering, research, and for military applications.

Hannah has sat on the Board of Directors for Magic Edge, a website designing company. He has also been profiled in *Ebony* magazine, *Electronics* magazine, *Forbes* magazine, and *PC Magazine*. In addition, Hannah has received the Professional Achievement Award from the Illinois Institute of Technology and the National Technical Association (NTA).

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Hannah?
#2 Where was Dr. Hannah born? Locate it on a map. How far away is this from where you live? Where did Dr. Hannah attend college? What do you think college was like for him?
#3 How old are you? In what year was Dr. Hannah your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 What movies do you think Dr. Hannah watched when he grew up?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a computer scientist does? Would you like to be a computer scientist? Why? Why not?
#2 If you were a computer scientist, what topics would you study?
#3 What topics did the researchers at Bell Laboratories study? Can you find other ScienceMakers who worked at Bell Laboratories?
#4 Dr. Hannah co-founded a company that worked in computer graphics technology. If you could co-found a company with anyone that would be interested in any topic, with whom would you start the company? What would the company be called? In what field or interest would it specialize?
#5 What goes into making special effects in movies? How have special effects in movies changed since the early 1990s? How has Dr. Hannah's work fueled that change? What makes computers so useful in creating special effects? How would they be created without the use of modern computers?

# Glossary

*Bell Laboratories*
The research and development organization of Alcatel-Lucent and previously of the American Telephone & Telegraph Company (AT&T).  Also known as Bell Labs and formerly known as AT&T Bell Laboratories and Bell Telephone Laboratories.

*Computer graphics*
A sub-field of computer science which studies methods for digitally synthesizing and manipulating visual content. Although the term often refers to the study of three-dimensional computer graphics, it also encompasses two-dimensional graphics and image processing.

*Effect*
An illusion produced by technical means (as in "special effect").

*Electrical engineering*
The branch of engineering science that studies the uses of electricity and the equipment for power generation and distribution and the control of machines and communication.

*National Technical Association (NTA)*
A professional association of scientists and engineers, committed to ensuring that minorities, women and youth have the skills needed for a technological workforce.

# Spotlight: Odest Chadwicke Jenkins



| Name | Odest Chadwicke Jenkins |
|---|---|
| Birth Date | 1974 |
| Birth Place | Washington, D.C. |
| Education | Alma College<br>Georgia Institute of Technology<br>University of Southern California |
| Type of Science | Computer Science |

## Biography

Computer scientist Odest Chadwicke Jenkins was born in 1974 in Washington, D.C. At Alma College, Jenkins double majored in computer science and mathematics, graduating *cum laude* in 1996. Next, he attended The Georgia Institute of Technology, receiving his M.S. degree in computer science in 1998. Jenkins then received his Ph.D. degree from the University of Southern California in 2003.


**Jenkins' book from Amazon.com**

While in school, Jenkins worked for Intel Corporation, as an intern writing software as an engineer in Computer Aided Design (CAD). He also had internships at Ford Motor Company and the University of Texas at Arlington. After obtaining his Ph.D., Jenkins received a postdoctoral research fellowship at the Robotics Research Lab at the University of Southern California. In 2004, he was hired as an assistant professor at Brown University in the computer science department, and is now an associate professor. His research focuses on human-robot interaction with an emphasis on robot learning from human demonstrations. Videos of Jenkins' current research work can be found on the brownrobotics YouTube channel.

In 2009, Jenkins co-authored the book *Creating Games: Mechanics, Content, and Technology*. He has also authored chapters for several other books, including *Data-Driven 3D Facial Animation and Human-Robot Interaction* in 2007 and *From Motor to Interaction Learning in Robots* in 2009. In 2007, Jenkins was honored with the Presidential Early Career Award for Scientists and Engineers and Office of Naval Research Young Investigator Award. In 2008, he received the Air Force Office of Scientific Research's Young Investigator Award. Jenkins was also a recipient of the National Science Foundation's (NSF) Career Award, Sloan Research Fellow by the Alfred P. Sloan Foundation, and was named a Kavli Fellow by the National Academy of Sciences (NAS) in 2009. Jenkins lives with his wife Sarah and their children Violet, Wesley, and Morgan in Providence, Rhode Island.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Jenkins?
#2 Where was Dr. Jenkins born? Locate it on a map. How far away is this from where you live? Where did Dr. Jenkins attend college? What do you think college was like for him?
#3 How old are you? In what year was Dr. Jenkins your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 Dr. Jenkins is one of the youngest ScienceMakers. What do you think you will be doing when you are his age?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a computer scientist does? Would you like to be a computer scientist? Why? Why not?
#2 If you were a computer scientist, what topics would you study?
#3 What is artificial intelligence?
#4 How would you describe a robot? Is a robot always similar to what we see in the movies or on TV? What makes a human different than a robot? Do you think we can ever design a robot that can overcome these differences? Do you think we should? Why or why not.
#5 Dr. Jenkins' work has an emphasis on robots learning from human demonstrations. What processes do you think are necessary for a robot to "learn" something? How do you learn something new?

# Glossary

*Computer Aided Design (CAD)*
The use of computer technology for the design of objects, real or virtual.

*Computer science*
The study of the theoretical foundations of information and computation, and of practical techniques for their implementation and application in computer systems.

*Intern*
A person who works in a temporary position with an emphasis on on-the-job training rather than merely employment, making it similar to an apprenticeship.

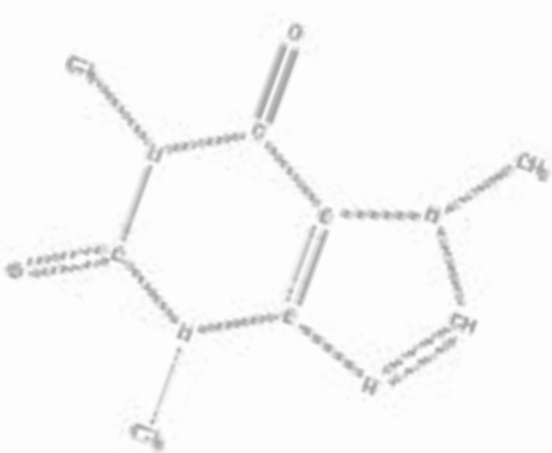
*National Academy of Sciences (NAS)*
A corporation in the United States whose members serve as advisers to the nation on science.

*National Science Foundation (NSF)*
A United States government agency that supports fundamental research and education in all the non-medical fields of science and engineering. Its medical counterpart is the National Institutes of Health.

*Postdoctoral research*
Academic or scholarly research conducted by a person who has completed his or her doctoral studies, normally within a five year period. It is intended to further deepen expertise in a specialist subject, including necessary research skills and methods.

*Robotics*
The engineering, science and technology of robots, and their design, manufacture, application, and structure. This field is related to electronics, mechanics, and software.

*Software*
A term primarily used for digitally stored data such as computer programs and other kinds of information read and written by computers.



# ScienceMakers
## Spotlight: Kevin Tyrone Kornegay



| | |
|---|---|
| **Name** | Kevin Tyrone Kornegay |
| **Birth Date** | March 24, 1959 |
| **Birth Place** | Brooklyn, New York |
| **Education** | Pratt Institute<br>University of California, Berkeley |
| **Type of Science** | Computer Science |

## Biography

Computer scientist Kevin Tyrone Kornegay was born on March 24, 1959 in Brooklyn, New York to Dorothy and Thomas Kornegay. Kornegay was one of five children in the family. He attended the Pratt Institute where he graduated with his B.S. degree in electrical engineering in 1985. During college, Kornegay held a summer internship at Bell Laboratories where he worked for a year before going to the University of California at Berkeley where he received his M.S. and Ph.D. degrees in electrical engineering and computer science in 1990 and 1992.


**Optical fibers photo by blair_25 @Flickr**

Kornegay then worked as a research staff member at the International Business Machines (IBM) T.J. Watson Research Center. In 1993, Kornegay began teaching at Polytechnic University in Brooklyn, New York before becoming an assistant professor in the School of Electrical and Computer Engineering at Purdue University in 1994. In 1997, Kornegay became the Dr. Martin L. King Visiting Professor at the Massachusetts Institute of Technology and from 1998 to 2005, he served as an assistant professor and then associate professor at Cornell University. In 2006, Kornegay joined the faculty at Georgia Institute of Technology and became the Motorola Foundation Professor in the School of Electrical and Computer Engineering. His research focused on computer chips and systems that make high-speed data transport possible through air, wire, or optical fibers.

In 1992, Kornegay wrote the chapter “Chip and Board Testing” in *Anatomy of a Silicon Compiler*.

Between 1998 and 2009, Kornegay was issued six U.S. patents for his work. In 2002, U.S. Black Engineer Magazine named him the Black Engineer of the Year and he was featured in *Science Spectrum* and *U.S. Black Engineer & Information Technology* as one of the 50 Most Important Blacks in Research Science in 2004. In 2005, the National Society of Black Engineers (NSBE) bestowed Kornegay its Golden Torch Award for Educator of the Year. Kornegay lives in Georgia and has two sons, Kevin Jr. and Justin.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Kornegay?
#2 Where was Dr. Kornegay born? Locate it on a map. How far away is this from where you live? What are the names of his parents? Where did Dr. Kornegay attend college? What do you think college was like for him?
#3 How old are you? In what year was Dr. Kornegay your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 Kornegay was one of five children. How many brothers and sisters do you have? Are they supportive of you and your interests? Are you supportive of theirs?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a computer scientist does? Would you like to be a computer scientist? Why? Why not?
#2 If you were a computer scientist, what topics would you study?
#3 What is a computer chip? What does it do?
#4 How is the speed of a computer measured? What is being measured exactly? What allows a computer to run faster?
#5 Can you think of a form of technology that transmits data through the air? What about through wire and optical fibers?

# Glossary

*Bell Laboratories*
The research and development organization of Alcatel-Lucent and previously of the American Telephone & Telegraph Company (AT&T). Also known as Bell Labs and formerly known as AT&T Bell Laboratories and Bell Telephone Laboratories.

*Computer chip*
An integrated circuit (also known as IC, microcircuit, microchip, silicon chip, or chip) is a miniaturized electronic circuit consisting mainly of semiconductor devices, as well as passive components that has been manufactured on the surface of a thin semiconductor.

*Computer science*
The study of the theoretical foundations of information and computation, and of practical techniques for their implementation and application in computer systems.

*Electrical engineering*
The branch of engineering science that studies the uses of electricity and the equipment for power generation and distribution and the control of machines and communication.

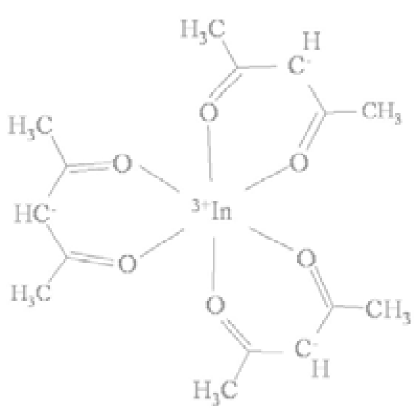
*International Business Machines (IBM)*
One of the major mainframe computer manufacturers, as well as personal computer designer.

*National Society of Black Engineers (NSBE)*
One of the largest student-run organizations in the United States centered on improving the recruitment and retention of African-American engineering students and professionals.

*Optical fibers*
A glass or plastic fiber that carries light along its length. Fiber optics is the overlap of applied science and engineering concerned with the design and application of optical fibers.

*Patent*
A declaration issued by a government agency that declares someone the inventor of a new invention and has the privilege of stopping others from making, using or selling the claimed invention.

*Silicon compiler*
A software system that takes a user's specifications and automatically generates an integrated circuit (IC). The process is sometimes referred to as hardware compilation.



# ScienceMakers
## Spotlight: William Lupton

| | |
|---|---|
| **Name** | William Lupton |
| **Birth Date** | May 26, 1941 |
| **Birth Place** | Philadelphia, Pennsylvania |
| **Education** | Central High School<br>Naval Postgraduate School<br>Louisiana State University/Columbia Pacific University |
| **Type of Science** | Computer Science |

## Biography

Computer scientist William Lupton was born on May 26, 1941 in Philadelphia, Pennsylvania. He attended Central High School, graduating in 1959. That same year, Lupton joined the United States Navy and became a sailor, eventually becoming a U.S. Naval Flight Officer and attaining the rank of Commander. He logged over 5,000 flight hours in his career and earned five Strike/Flight air medals for his combat cruises to Vietnam. In 1972, Lupton attended the Naval Postgraduate School in California where he received his B.S. and M.S. degrees in computer science. In 1980, Lupton served as chairperson of the computer science department at the United States Naval Academy. While there, he designed one of the most innovative and complete computer science major programs in the country.

US Navy airplanes photo by JLS Media @Flickr

In 1981, Lupton took a position as a Professor of Naval Science at Louisiana State University and while there earned his Ph.D. degree in expert database systems. Following his tenure at Louisiana State University in 1987, Lupton joined the faculty at Jackson State University and chaired the computer science department from 1987 to 1991. In 1991, Morgan State University invited Lupton to chair the computer science department, where he presently serves. Since 2007, Lupton has been the principal investigator (PI) of Morgan State University's Network Resources and Training Site in the Minority University-Space Interdisciplinary Network project which aims to inspire young minority scientists and engineers.

Lupton has been president of the Baltimore and National chapters of the National Technical Association (NTA) and is a member of the National Academy of Sciences (NAS). He was also the inaugural national president of the Association of the Departments of Computer Science and Engineering at Minority Institutions (ADMI). He has generated over $5 million in funding to improve science and science education. Lupton is married to Monica McKinney and has three sons, Michael, Steven, and Scott Lupton.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Lupton?
#2 Where was Dr. Lupton born? Locate it on a map. How far away is this from where you live? What are the names of his parents? Where did Dr. Lupton attend high school? What do you think high school was like for him?
#3 How old are you? In what year was Dr. Lupton your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 Dr. Lupton joined the United States Navy after high school. What are the branches of the U.S. Armed Forces? How does each keep us safe?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a computer scientist does? Would you like to be a computer scientist? Why? Why not?
#2 If you were a computer scientist, what topics would you study?
#3 Dr. Lupton's career has included work in the United States Navy and his work as a computer scientist. How has computer science been used by the United States' Armed Forces?
#4 What is a database? What is an example of something that uses a database to hold information? Think about some of the technology that you encounter every day.
#5 Look up what a 'byte' is. How much information would be in a kilobyte? A megabyte? A gigabyte?

# Glossary

*Computer science*
The study of the theoretical foundations of information and computation, and of practical techniques for their implementation and application in computer systems.

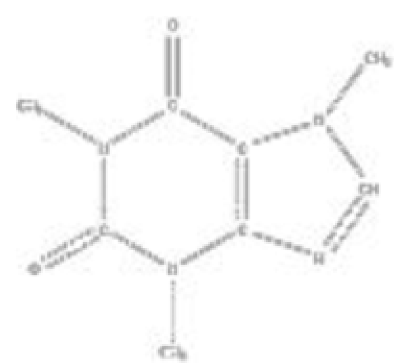
*Database*
A collection of organized information in a regular structure, usually but not necessarily in a machine-readable format accessible by a computer.

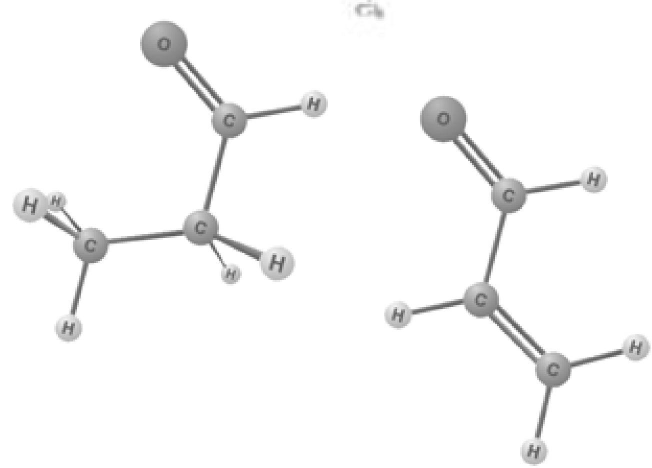
*National Academy of Science (NAS)*
A corporation in the United States whose members serve as advisers to the nation on science.

*National Technical Association (NTA)*
A professional association of scientists and engineers, committed to ensuring that minorities, women and youth have the skills needed for a technological workforce.

*Principal Investigator (PI)*
The lead scientist or engineer for a particular well-defined science (or other research) project, such as an astronomical observing campaign, laboratory study, or clinical trial.







# ScienceMakers
## Spotlight: Valerie E. Taylor



| | |
|---|---|
| **Name** | Valerie E. Taylor |
| **Birth Date** | May 24, 1963 |
| **Birth Place** | Chicago, Illinois |
| **Education** | Maria High School<br>Purdue University<br>University of California, Berkeley |
| **Types of Science** | Computer Science<br>Computer Engineering |

## Biography

Computer science and engineering professor Valerie E. Taylor was born on May 24, 1963. She attended Purdue University where she received her B.S. degree in computer and electrical engineering in 1985 and her M.S. degree in electrical engineering in 1986. She continued her education at the University of California at Berkeley where she received her Ph.D. degree in electrical engineering and computer science in 1991.

Texas A&M University photo by Kaloozer @Flickr

That same year, Taylor joined the faculty at Northwestern University as an assistant professor of electrical and computer engineering. She became an associate professor in 1997 and then a full professor in 2002. In 2003, Taylor transferred to Texas A&M University where she was named head of the Department of Computer Science and Engineering as well as the Stewart & Stevenson Professor. Since 2004, Taylor has been the Royce E. Wisenbaker Professor and head of the Department of Computer Science and Engineering. Her research interests lie in high performance computing. Taylor is currently working on "Prophesy," a database used to collect and analyze data to predict the performance on different applications on parallel systems. She has been supported by the National Science Foundation (NSF) for the "OptiPuter" and "New Approaches to Human Potential Realization through Information Technology Research" as well as the National Aeronautics and Space

Administration's (NASA) University Research, Engineering and Technology Institutes (URETI) Program for "Nanoelectronics." Currently, she is funded by the National Science Foundation to use Prophesy in conjunction with two other tools for the purpose of exploring the performance and power for applications on current parallel systems.

In 2001, Taylor received the Pathbreaker Award from the Women in Leadership at Northwestern University and the Hewlett Packard Harriet B. Rigas Education Award. The following year, Taylor was named a Young Outstanding Leader by the University of California, Berkeley's Distinguished Engineering Alumni Society. That same year she also received the Computing Research Association's (CRA) A. Nico Habermann Award for outstanding contributions aimed at increasing the numbers and/or successes of underrepresented groups in the computing research community. She has also been recognized as a Sigma Xi Distinguished Lecturer and in 2005, Taylor was given the Richard A. Tapia Achievement Award for Scientific Scholarship, Civic Science, and Diversifying Computing. Since 2008, Taylor has served on the Board of Directors for the Computing Research Association.



# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Taylor?
#2 How old are you? In what year was Dr. Taylor your age? What was happening in the United States that year? What was happening in the world that year? What do you think her life was like when she was your age?
#3 Where did Dr. Taylor attend college? Locate it on a map. How far is this from where you live? What do you think college was like for her?
#4 Dr. Taylor received a Pathbreaker Award from the Women in Leadership at Northwestern University. How would you describe a "pathbreaker"? Would you want to be one, and for what purpose?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think an electrical engineer does? Would you like to be an electrical engineer? Why? Why not?
#2 If you were an electrical engineer, what topics would you study?
#3 Why do you think there is a strong connection between electrical engineering and computer science? Can you think of another field to which electrical engineering strongly relates?
#4 What does it mean to have a "high performance" computer? Do you think these standards change? On what basis is the level of performance measured?
#5 NASA's URETI Program for "Nanoelectronics" has supported Dr. Taylor's work. What is nanotechnology? What are some other projects that are being conducted in the field of nanotechnology? For what purpose would you use nanotechnology?

# Glossary

*Computer science*
The study of the theoretical foundations of information and computation, and of practical techniques for their implementation and application in computer systems.

*Database*
A collection of organized information in a regular structure, usually but not necessarily in a machine-readable format accessible by a computer.

*Electrical engineering*
The branch of engineering science that studies the uses of electricity and the equipment for power generation and distribution and the control of machines and communication.

*High performance computing*
The class of general-purpose computers that are both faster than their commercial competitors and have sufficient central memory to store the problem sets for which they are designed.

*National Aeronautics and Space Administration (NASA)*
An independent agency of the United States government responsible for aviation and spaceflight.

*National Science Foundation (NSF)*
A United States government agency that supports fundamental research and education in all the non-medical fields of science and engineering. Its medical counterpart is the National Institutes of Health.

*Sigma Xi*
A non-profit honor society which was founded in 1886 at Cornell University by a junior faculty member and a handful of graduate students. Members elect others on the basis of their research achievements or potential.

# ScienceMakers
# Spotlight: Bryant York



| | |
|---|---|
| **Name** | Bryant York |
| **Birth Date** | May 15, 1945 |
| **Birth Place** | Boston, Massachusetts |
| **Education** | Boston Latin School<br>Brandeis University<br>Massachusetts Institute of Technology<br>University of Massachusetts at Amherst |
| **Type of Science** | Computer Science |

## Biography

Computer scientist and computer science professor Bryant York was born on May 15, 1945 to William Everett and Mabel Daves York in Boston, Massachusetts. York grew up, the third of six children, in the segregated Orchard Park Housing Project in Roxbury, Massachusetts. He attended Boston Latin School; because of his academic skill, York was selected to attend summer mathematics programs at the Massachusetts Institute of Technology (MIT). He graduated from high school in 1963 and received his B.A. degree in mathematics from Brandeis University in 1967.


IBM logo photo by Kansir @Flickr

York began work as an actuarial analyst at the John Hancock Mutual Life Insurance Co. while he worked towards his M.S. degree in management from the Massachusetts Institute of Technology in 1971. In 1974, he left work to resume his studies at the University of Massachusetts at Amherst. Two years later, he received his M.S. degree in computer science. York was offered a position working with the International Business Machines (IBM) Research Laboratories in San Jose, California. While continuing his work with IBM Research Laboratories, York completed his Ph.D. program in computer science in 1981 at the University of Massachusetts at Amherst. In 1983, York started working as a software engineer with the Digital Equipment Corporation (DEC) in the Artificial Intelligence and Technology Center. He left DEC to become an associate professor of computer science at Boston University in 1986. After spending one year as program director at the National Science Foundation (NSF), he became an associate professor and research director at Northeastern University in 1991, and a full professor and research director at Portland State University in 2001. He has continually conducted research in computer science. His research interests include computer vision, parallel algorithms, neural networks, software engineering, and computer assistance for people with disabilities.

York has received a number of awards and honors in recognition of his accomplishments. In 2006, he was named one of the 100 Most Important Blacks in Technology by the Black Engineer of the Year Awards. He was also named a Fellow of the Association for Computing Machinery in 2006 (a designation reserved for the top one percent of its members). York received the first University of Massachusetts at Amherst Alumni 2009 Outstanding Achievement Award for his contributions to society. He has also served on a number of national advisory boards and committees. York has two adult daughters, Monica and Portia, and one son, Chandler.

## Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. York?
#2 Where was Dr. York born? Locate it on a map. How far away is this from where you live? What are the names of his parents? Where did Dr. York attend high school? What do you think high school was like for him?
#3 How old are you? In what year was Dr. York your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 What kind of jobs did Dr. York have through the course of his career and how do you think those experiences impacted his research?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a computer scientist does? Would you like to be a computer scientist? Why? Why not?
#2 If you were a computer scientist, what topics would you study?
#3 What is the difference between “software” and “hardware”?
#4 Part of York’s focus in doing research has been to develop computer programs that can assist people with disabilities. If you could create an invention that would assist people with disabilities, what would it be? Who would it help?
#5 What is your favorite video game or computer game? What components go into designing a video game or computer game?

# Glossary



*Actuarial analyst*
Actuarial science applies mathematical and statistical methods to assess risk in the insurance and finance industries. Actuarial analysts are professionals who are qualified in this field.

*Computer science*
The study of the theoretical foundations of information and computation, and of practical techniques for their implementation and application in computer systems.

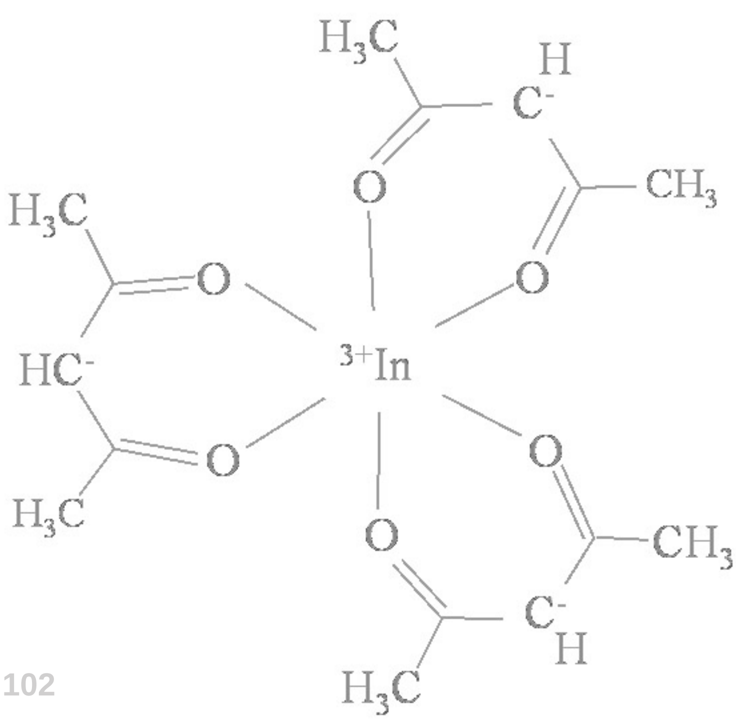
*International Business Machines (IBM)*
One of the major mainframe computer manufacturers, as well as personal computer designer.

*National Science Foundation (NSF)*
A United States government agency that supports fundamental research and education in all the non-medical fields of science and engineering. Its medical counterpart is the National Institutes of Health.

*Neural network (1)*
Computer architecture in which processors are connected in a manner suggestive of connections between neurons (i.e. it can learn by trial and error).

*Neural network (2)*
Any network of neurons or nuclei that function together to perform some function in the body.

*Software*
A term primarily used for digitally stored data such as computer programs and other kinds of information read and written by computers.



# Computer Science Activities

## From CSUnplugged.org



***Introduction***

Computer Science Unplugged is a series of learning activities that reveals a little-known secret: Computer Science isn't really about computers at all!

CS Unplugged provides an extensive collection of free resources that teach principles of Computer Science such as binary numbers, algorithms and data compression through engaging games and puzzles that use cards, string, crayons and lots of running around.

CS Unplugged is suitable for people of all ages, from elementary school to seniors, and from many countries and backgrounds. Unplugged has been used around the world for over fifteen years, in classrooms, science centers, homes, and even for holiday events in a park!

***And it's free!***

You can download Unplugged activities as individual PDF files from their pages on this site, or download a teachers' version of the collection as a single file.

***Lots more on this site.***

But it's worth browsing this site. You'll find supplementary material for each activity: videos, links, plugged-in follow-up activities, photos, feedback, curiosities and more. We're also working on links to curricula, and new material is being added regularly. Printed versions of the Unplugged material are available for purchase, and proceeds from sales are put back into the project.

(By the way we noticed that Computer Science does seem to involve computers sometimes, and many of our exercises lead on to doing activities on computers, but the Unplugged approach is a great way to get students thinking about computing before they get distracted by the technical diversions that can inhibit thinking while at the computer.)

# Count the Dots
# Binary Numbers

## Summary

Data in computers is stored and transmitted as a series of zeros and ones. How can we represent words and numbers using just these two symbols?

## Curriculum Links

- ✓ Mathematics: Number Level 2 and up. Exploring numbers in other bases. Representing numbers in base two.
- ✓ Mathematics: Algebra Level 2 and up. Continue a sequential pattern, and describe a rule for this pattern. Patterns and relationships in powers of two.

## Skills

- ✓ Counting
- ✓ Matching
- ✓ Sequencing

## Ages

- ✓ 7 and up

## Materials

- ✓ You will need to make a set of five binary cards (see page 6) for the demonstration. A4 cards with smiley face sticker dots work well.

Each child will need:

- ✓ A set of five cards.
  Copy Photocopy Master: Binary numbers (page 6) onto card and cut out.
- ✓ Worksheet Activity: Binary numbers (page 5)

There are optional extension activities, for which each child will need:

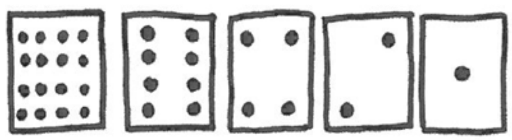
- ✓ Worksheet Activity: Working with binary (page 7)
- ✓ Worksheet Activity: Sending secret messages (page 8)
- ✓ Worksheet Activity: Fax machines and modems (page 9)
- ✓ Worksheet Activity: Counting higher than 31 (page 10)
- ✓ Worksheet Activity: More on binary numbers (page 11)

# Binary Numbers

## Introduction

Before giving out the worksheet on page 5, it can be helpful to demonstrate the principles to the whole group.

For this activity, you will need a set of five cards, as shown below, with dots on one side and nothing on the other. Choose five children to hold the demonstration cards at the front of the class. The cards should be in the following order:



## Discussion

What do you notice about the number of dots on the cards? (Each card has twice as many as the card to its right.)

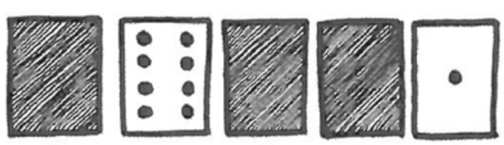
How many dots would the next card have if we carried on to the left? (32) The next…?

We can use these cards to make numbers by turning some of them face down and adding up the dots that are showing. Ask the children to make 6 (4-dot and 2-dot cards), then 15 (8-, 4-, 2- and 1-dot cards), then 21 (16, 4 and 1)…

Now try counting from zero onwards.

The rest of the class needs to look closely at how the cards change to see if they can see a pattern in how the cards flip (each card flips half as often as the one to its right). You may like to try this with more than one group.

When a binary number card is **not** showing, it is represented by a zero. When it **is** showing, it is represented by a one. This is the binary number system.



0 1 0 0 1 = 9

Ask the children to make 01001. What number is this in decimal? (9) What would 17 be in binary? (10001)

Try a few more until they understand the concept.

There are five optional follow-up extension activities, to be used for reinforcement. The children should do as many of them as they can.

# Worksheet Activity: Binary Numbers

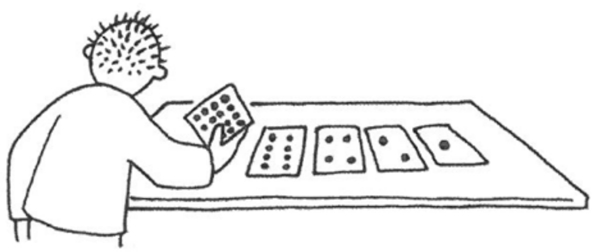
## Learning how to count

So, you thought you knew how to count? Well, here is a new way to do it!

Did you know that computers use only zero and one? Everything that you see or hear on the computer—words, pictures, numbers, movies and even sound is stored using just those two numbers! These activities will teach you how to send secret messages to your friends using exactly the same method as a computer.

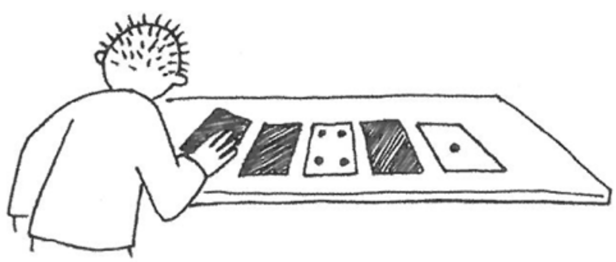
## Instructions

Cut out the cards on your sheet and lay them out with the 16-dot card on the left as shown here:



Make sure the cards are placed in exactly the same order.

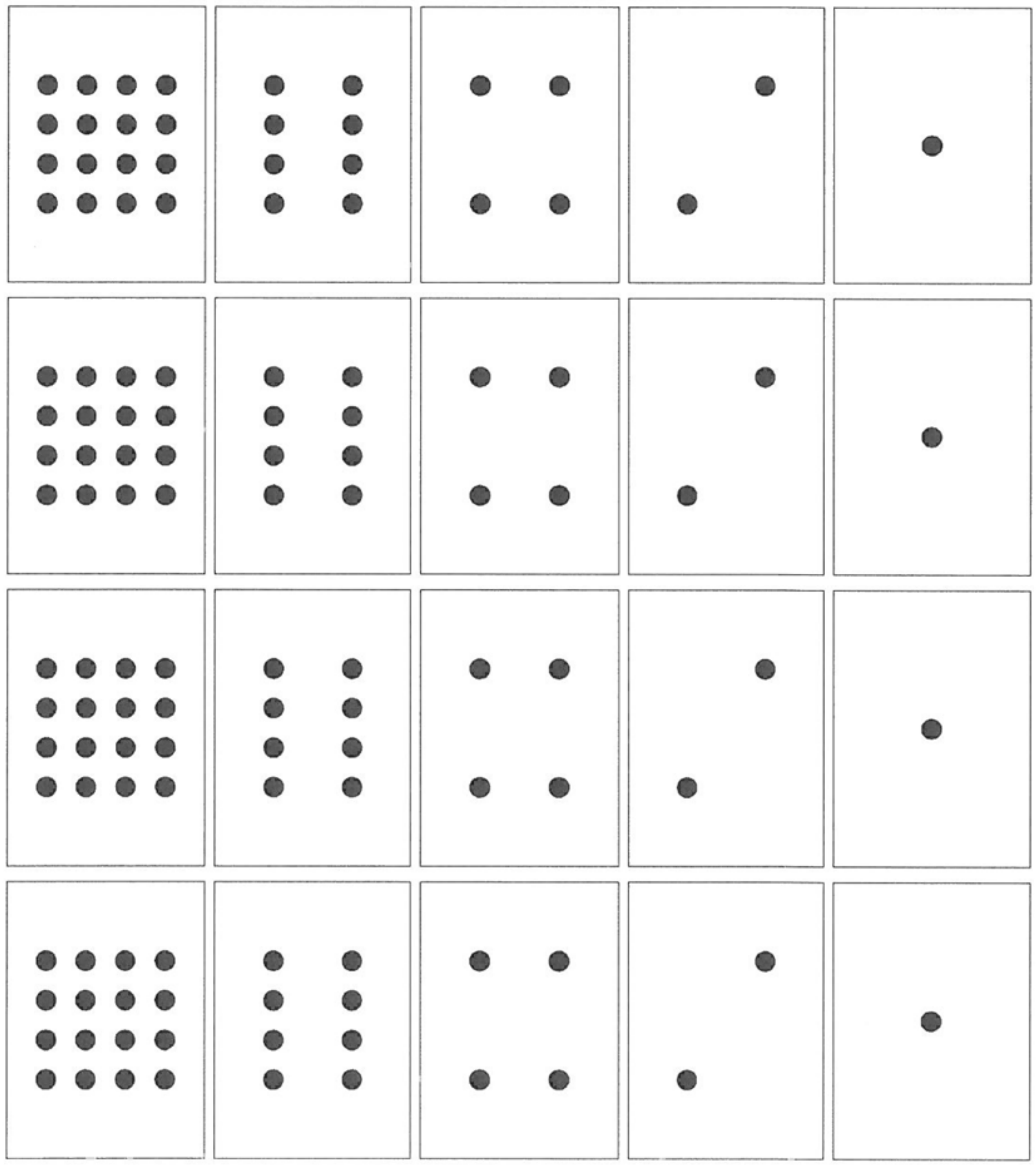
Now flip the cards so exactly 5 dots show—keep your cards in the same order!



Find out how to get 3, 12, 19. Is there more than one way to get any number? What is the biggest number you can make? What is the smallest? Is there any number you can't make between the smallest and biggest numbers?

**Extra for Experts:** Try making the numbers 1, 2, 3, 4 in order. Can you work out a logical and reliable method of flipping the cards to increase any number by one?

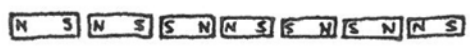
## Photocopy Master: Binary Numbers



# What's it all about?

Computers today use the binary system to represent information. It is called binary because only two different digits are used. It is also known as base two (humans normally use base 10). Each zero or one is called a *bit* (**b**inary dig**it**). A bit is usually represented in a computer's main memory by a transistor that is switched on or off, or a capacitor that is charged or discharged.

When data must be transmitted over a telephone line or radio link, high and low-pitched tones are used for the ones and zeros. On magnetic disks (floppy disks and hard disks) and tapes, bits are represented by the direction of a magnetic field on a coated surface, either North-South or South-North.

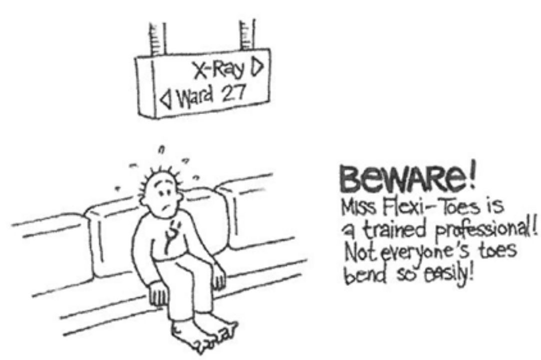



Audio CDs, CD-ROMs and DVDs store bits optically—the part of the surface corresponding to a bit either does or does not reflect light.

One bit on its own can't represent much, so they are usually grouped together in groups of eight, which can represent numbers from 0 to 255. A group of eight bits is called a byte.

The speed of a computer depends on the number of bits it can process at once. For example, a 32-bit computer can process 32-bit numbers in one operation, while a 16-bit computer must break 32-bit numbers down into smaller pieces, making it slower.

Ultimately bits and bytes are all that a computer uses to store and transmit numbers, text, and all other information. In some of the later activities we will see how other kinds of information can be represented on a computer.



# Solutions and hints

## Binary Numbers (page 5)

**3** requires cards 2 and 1
**12** requires cards 8 and 4
**19** requires cards 16, 2 and 1

There is only one way to make any number.

The biggest number you can make is 31. The smallest is 0. You can make every number in between, and each has a unique representation.

**Experts:** To increase any number by one, flip all the cards from right to left until you turn one face up.

## Working with binary (page 7)

10101 = 21, 11111 = 31

## Sending Secret Messages (page 8)

Coded message: HELP IM TRAPPED

## Counting higher than 31 (page 10)

If you add the numbers up from the beginning the sum will always be one less than the next number in the sequence.

Miss Flexi-toes can count 1024 × 1024 = 1,048,576 numbers—from 0 to 1,048,575!

## More on Binary Numbers (page 11)

When you put a zero on the right hand side of a binary number the number doubles.

All of the places containing a one are now worth twice their previous value, and so the total number doubles. (In base 10 adding a zero to the right multiplies it by 10.)

A computer needs 7 bits to store all the characters. This allows for up to 128 characters. Usually the 7 bits are stored in an 8-bit byte, with one bit wasted.

# Colour by Numbers
# Image Representation


### Summary

Computers store drawings, photographs and other pictures using only numbers. The following activity demonstrates how they can do this.


### Curriculum Links

- ✓ Mathematics: Geometry Level 2 and up. Exploring Shape and Space.

### Skills

- ✓ Counting
- ✓ Graphing

### Ages

- ✓ 7 and up

### Materials

- ✓ OHP transparency made from OHP Master: Colour by numbers (page 16)

Each child will need:

- ✓ Worksheet Activity: Kid Fax (page 17)
- ✓ Worksheet Activity: Make your own picture (page 18)

# Colour by Numbers

### Introduction

### Discussion Questions

1. What do facsimile (fax) machines do?

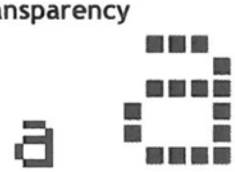
2. In what situations would computers need to store pictures? (A drawing program, a game with graphics, or a multi-media system.)

3. How can computers store pictures when they can only use numbers?

(You may like to arrange for the children to send and/or receive faxes as a preparation for this activity)



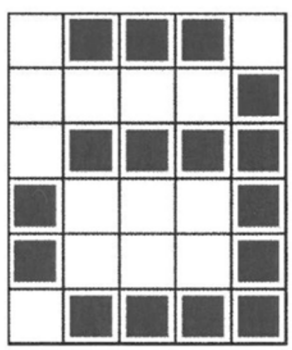
### Demonstration using OHP transparency




Computer screens are divided up into a grid of small dots called *pixels* (**pic**ture **el**ements).

In a black and white picture, each pixel is either black or white.

The letter "a" has been magnified above to show the pixels. When a computer stores a picture, all that it needs to store is which dots are black and which are white.



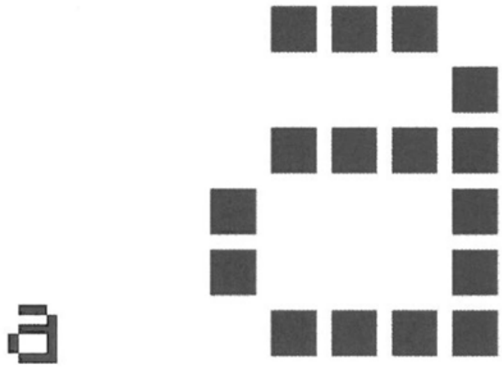
1, 3, 1
4, 1
1, 4
0, 1, 3, 1
0, 1, 3, 1
1, 4

The picture above shows us how a picture can be represented by numbers. The first line consists of one white pixel, then three black, then one white. Thus the first line is represented as 1, 3, 1.

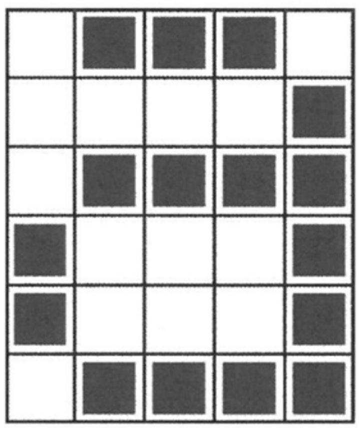
The first number always relates to the number of white pixels. If the first pixel is black the line will begin with a zero.

The worksheet on page 17 gives some pictures that the children can decode using the method just demonstrated.

## OHP Master: Colour by numbers

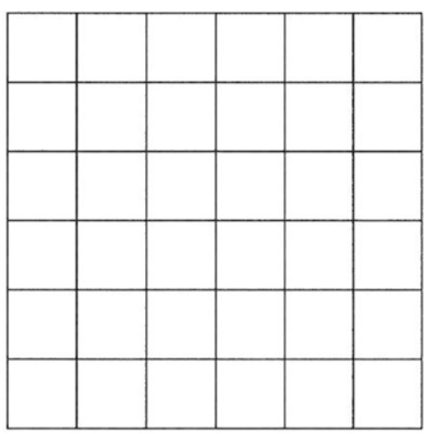


▲ A letter "a" from a computer screen and a magnified view showing the pixels that make up the image



1, 3, 1
4, 1
1, 4
0, 1, 3, 1
0, 1, 3, 1
1, 4

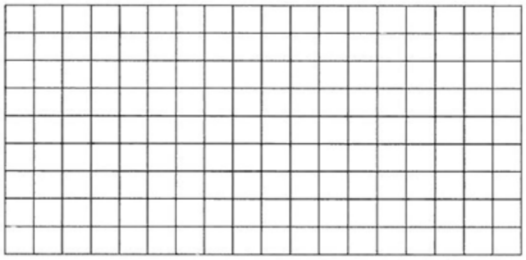
▲ The same image coded using numbers



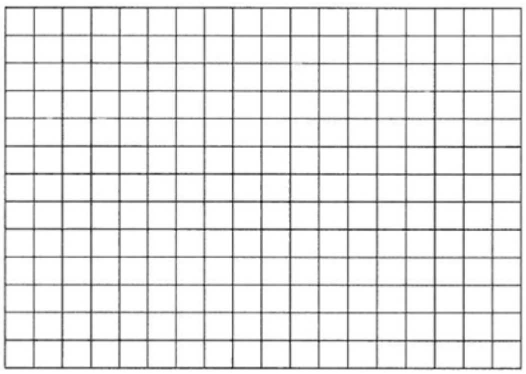
▲ Blank grid (for teaching purposes)

# Worksheet Activity: Kid Fax

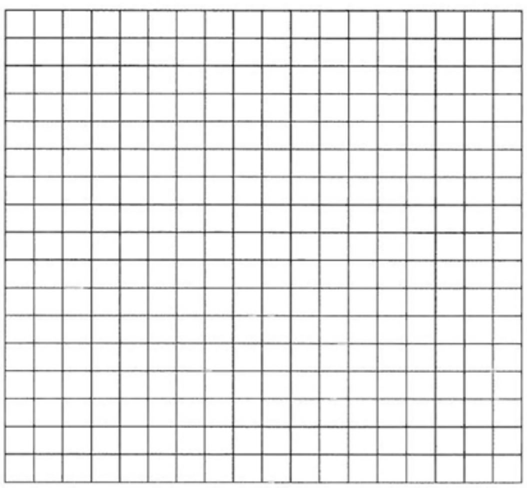
The first picture is the easiest and the last one is the most complex. It is easy to make mistakes and therefore a good idea to use a pencil to colour with and have a rubber handy!



4, 11
4, 9, 2, 1
4, 9, 2, 1
4, 11
4, 9
4, 9
5, 7
0, 17
1, 15



6, 5, 2, 3
4, 2, 5, 2, 3, 1
3, 1, 9, 1, 2, 1
3, 1, 9, 1, 1, 1
2, 1, 11, 1
2, 1, 10, 2
2, 1, 9, 1, 1, 1
2, 1, 8, 1, 2, 1
2, 1, 7, 1, 3, 1
1, 1, 1, 1, 4, 2, 3, 1
0, 1, 2, 1, 2, 2, 5, 1
0, 1, 3, 2, 5, 2
1, 3, 2, 5



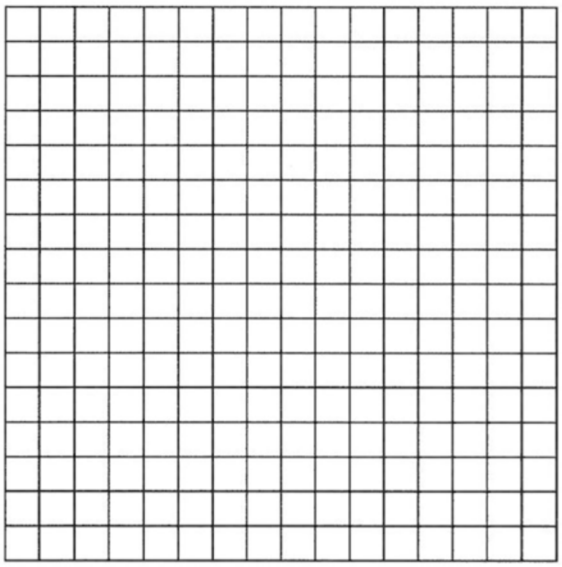
6, 2, 2, 2
5, 1, 2, 2, 2, 1
6, 6
4, 2, 6, 2
3, 1, 10, 1
2, 1, 12, 1
2, 1, 3, 1, 4, 1, 3, 1
1, 2, 12, 2
0, 1, 16, 1
0, 1, 6, 1, 2, 1, 6, 1
0, 1, 7, 2, 7, 1
1, 1, 14, 1
2, 1, 12, 1
2, 1, 5, 2, 5, 1
3, 1, 10, 1
4, 2, 6, 2
6, 6

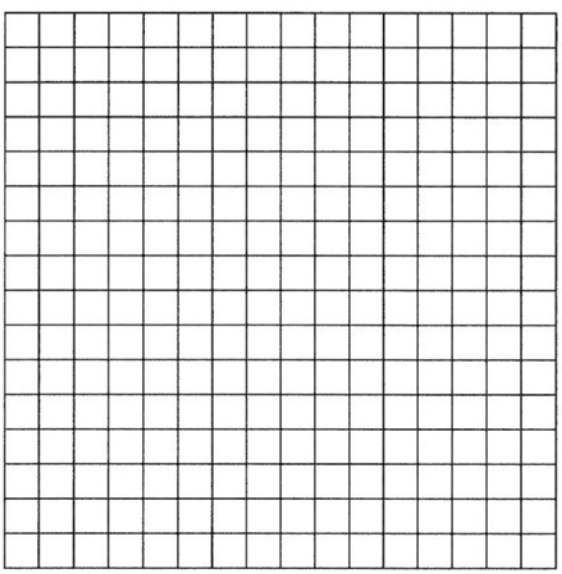
# Worksheet Activity: Make Your Own Picture

Now that you know how numbers can represent pictures, why not try making your own coded picture for a friend? Draw your picture on the top grid, and when you've finished, write the code numbers beside the bottom grid. Cut along the dotted line and give the bottom grid to a friend to colour in. (Note: you don't have to use the whole grid if you don't want to—just leave some blank lines at the bottom if your picture doesn't take up the whole grid.)

# Worksheet Activity: Make Your Own Picture

**Extra for Experts:** If you want to produce coloured images you can use a number to represent the colour (e.g. 0 is black, 1 is red, 2 is green etc.) Two numbers are now used to represent a run of pixels: the first gives the length of the run as before, and the second specifies the colour. Try making a coloured picture for a friend. Don't forget to let your friend know which number stands for which colour!





### Variations and Extensions

1. Try drawing with a sheet of tracing paper on top of the grid, so that the final image can be viewed without the grid. The image will be clearer.

2. Instead of colouring the grid the children could use squares of sticky paper, or place objects, on a larger grid.

### Discussion Point

There is usually a limit to the length of a run of pixels because the length is being represented as a binary number. How would you represent a run of twelve black pixels if you could only use numbers up to seven? (A good way is to code a run of seven black pixels, followed by a run of zero white, then a run of five black.)

# What's it all about?

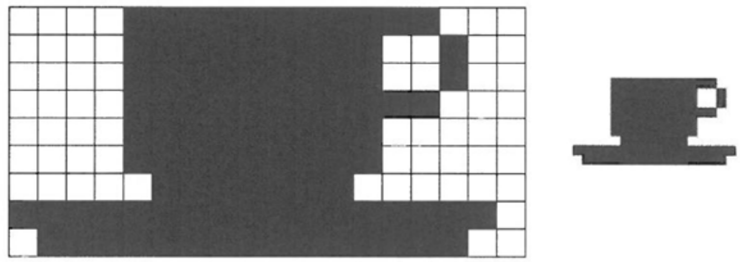
A fax machine is really just a simple computer that scans a black and white page into about 1000 × 2000 pixels, which are sent using a modem to another fax machine, which prints the pixels out on a page. Often fax images have large blocks of white (e.g. margins) or black pixels (e.g. a horizontal line). Colour pictures also have a lot of repetition in them. To save on the amount of storage space needed to keep such images programmers can use a variety of compression techniques. The method used in this activity is called 'run-length coding', and is an effective way to compress images. If we didn't compress images it would take much longer to transmit pictures and require much more storage space. This would make it infeasible to send faxes or put photos on a web page. For example, fax images are generally compressed to about a seventh of their original size. Without compression they would take seven times as long to transmit!

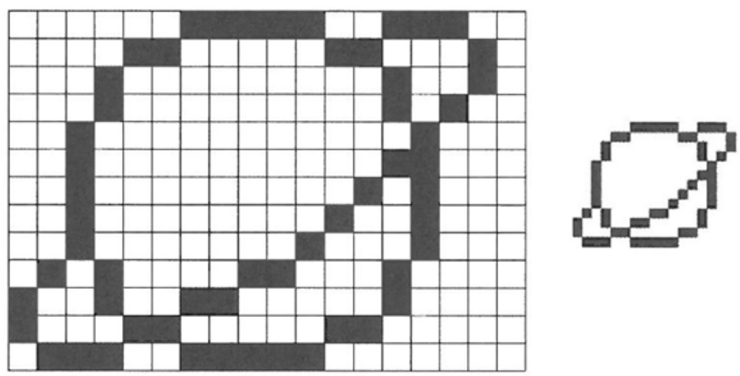
Photographs and pictures are often compressed to a tenth or even a hundredth of their original size (using a different technique). This allows many more images to be stored on a disk, and it means that viewing them over the web will take a fraction of the time.

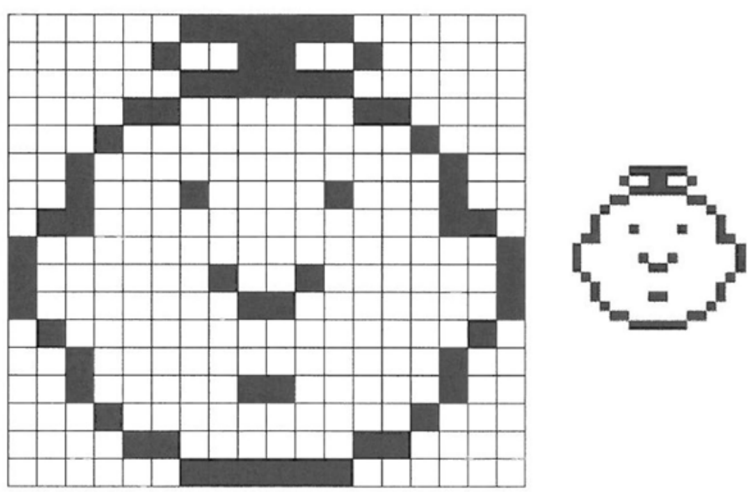
A programmer can choose which compression technique best suits the images he or she is transmitting.

# Solutions and hints

## Answers to Kid Fax Worksheet







# Card Flip Magic
# Error Detection & Correction



## Summary

When data is stored on a disk or transmitted from one computer to another, we usually assume that it doesn't get changed in the process. But sometimes things go wrong and the data is changed accidentally. This activity uses a magic trick to show how to detect when data has been corrupted, and to correct it.

## Curriculum Links

- ✓ Mathematics: Number Level 3 and up. Exploring computation and estimation.
- ✓ Algebra Level 3 and up. Exploring patterns and relationships.

## Skills

- ✓ Counting
- ✓ Recognition of odd and even numbers

## Ages

- ✓ 9 years and up

## Materials

- ✓ A set of 36 "fridge magnet" cards, coloured on one side only
- ✓ A metal board (a whiteboard works well) for the demonstration.

Each pair of children will need:

- ✓ 36 identical cards, coloured on one side only.

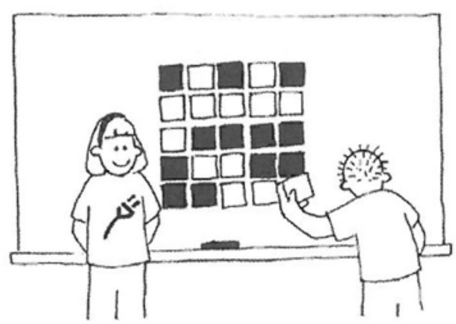
# The "Magic Trick"

### Demonstration

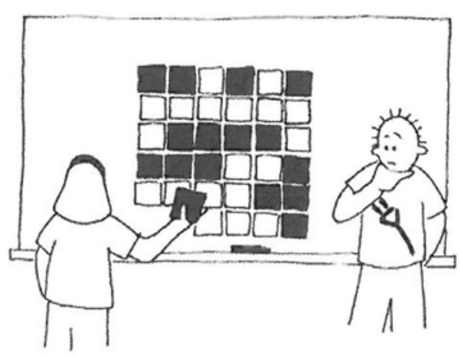
Here's your chance to be a magician!

You will need a pile of identical, two-sided cards. (To make your own cut up a large sheet of card that is coloured on one side only). For the demonstration it is easiest to use flat magnetic cards that have a different colour on each side—fridge magnets are ideal.

1. Choose a child to lay out the cards in a 5 × 5 square, with a random mixture of sides showing.



Casually add another row and column, "just to make it a bit harder".



These cards are the key to the trick. You must choose the extra cards to ensure that there is an even number of coloured cards in each row and column.

2. Get a child to flip over one card only while you cover your eyes. The row and column containing the changed card will now have an odd number of coloured cards, and this will identify the changed card.

Can the children guess how the trick is done?

### Teach the trick to the children:

1. Working in pairs, the children lay out their cards 5 × 5.

2. How many coloured cards are there in each row and column? Is it an odd or even number? Remember, 0 is an even number.

3. Now add a sixth card to each row, making sure the number of coloured cards is always even. This extra card is called a "parity" card.

4. Add a sixth row of cards along the bottom, to make the number of cards in each column an even number.

5. Now flip a card. What do you notice about the row and column? ( They will have an odd number of coloured cards.) Parity cards are used to show you when a mistake has been made.

6. Now take turns to perform the 'trick'.

### Extension Activities:

1. Try using other objects. Anything that has two 'states' is suitable. For example, you could use playing cards, coins (heads or tails) or cards with 0 or 1 printed on them (to relate to the binary system).

2. What happens if two, or more, cards are flipped? (It is not always possible to know exactly which two cards were flipped, although it is possible to tell that something has been changed. You can usually narrow it down to one of two pairs of cards. With 4 flips it is possible that all the parity bits will be correct afterwards, and so the error could go undetected.)

3. Another interesting exercise is to consider the lower right-hand card. If you choose it to be the correct one for the column above, then will it be correct for the row to its left? (The answer is yes, always.)

4. In this card exercise we have used even parity—using an even number of coloured cards. Can we do it with odd parity? (This is possible, but the lower right-hand card only works out the same for its row and column if the numbers of rows and columns are both even or both odd. For example, a 5 × 9 layout will work fine, or a 4 × 6, but a 3 × 4 layout won't.)

# A Real-Life Example for Experts!

This same checking technique is used with book codes. Published books have a ten-digit code usually found on the back cover. The tenth digit is a check digit, just like the parity bits in the exercise.

This means that if you order a book using its ISBN (International Standard Book Number), the publisher can check that you haven't made a mistake. They simply look at the checksum. That way you don't end up waiting for the wrong book!

Here's how to work out the checksum:

Multiply the first digit by ten, the second by nine, the third by eight, and so on, down to the ninth digit multiplied by two. Each of these values is then added together.

For example, the ISBN 0-13-911991-4 gives a value

$$\begin{aligned} & (0 \times 10) + (1 \times 9) + (3 \times 8) + (9 \times 7) + (1 \times 6) \\ + \; & (1 \times 5) + (9 \times 4) + (9 \times 3) + (1 \times 2) \\ = \; & 172 \end{aligned}$$

Then divide your answer by eleven. What is the remainder?

$172 \div 11 =$ 15 remainder 7

If the remainder is zero, then the checksum is zero, otherwise subtract the remainder from 11 to get the checksum.

$11 - 7 = 4$

Look back. Is this the last digit of the ISBN? Yes!

If the last digit of the ISBN wasn't a four, then we would know that a mistake had been made.

It is possible to come up with a checksum of the value of 10, which would require more than one digit. When this happens, the character X is used.

9 414942 010910

▲ A barcode (UPC) from a box of Weet-Bix™

Another example of the use of a check digit is the bar codes on grocery items. This uses a different formula. If a bar code is misread the final digit should be different from its calculated value. When this happens the scanner beeps and the checkout operator re-scans the code.

# Check that book!

## Detective Blockbuster

## Book Tracking Service, Inc.


We find and check ISBN checksums for a small fee.

Join our agency—look in your classroom or library for real ISBN codes.

### Are their checksums correct?

Sometimes errors are made.

Some of the common errors are:

- a digit has its value changed;
- two adjacent digits are swapped with each other;
- a digit is inserted in the number; and
- a digit is removed from the number

Can you find a book with the letter X for a checksum of 10? It shouldn't be too hard to find—one in every 11 should have it.

What sort of errors might occur that wouldn't be detected? Can you change a digit and still get the correct checksum? What if two digits are swapped (a common typing error)?

# What's it all about?

Imagine you are depositing $10 cash into your bank account. The teller types in the amount of the deposit, and it is sent to a central computer. But suppose some interference occurs on the line while the amount is being sent, and the code for $10 is changed to $1,000. No problem if you are the customer, but clearly a problem for the bank!

It is important to detect errors in transmitted data. So a receiving computer needs to check that the data coming to it has not been corrupted by some sort of electrical interference on the line. Sometimes the original data can be sent again when an error has been transmitted, but there are some situations when this is not feasible, for example if a disk or tape has been corrupted by exposure to magnetic or electrical radiation, by heat or by physical damage. If data is received from a deep space probe, it would be very tedious to wait for retransmission if an error had occurred! (It takes just over half an hour to get a radio signal from Jupiter when it is at its closest to Earth!)

We need to be able to recognize when the data has been corrupted *(error detection)* and to be able to reconstruct the original data *(error correction)*.

The same technique as was used in the "card flip" game is used on computers. By putting the bits into imaginary rows and columns, and adding parity bits to each row and column, we can not only detect if an error has occurred, but *where* it has occurred. The offending bit is changed back, and so we have performed error correction.

Of course computers often use more complex error control systems that are able to detect and correct multiple errors. The hard disk in a computer has a large amount of its space allocated to correcting errors so that it will work reliably even if parts of the disk fail. The systems used for this are closely related to the parity scheme.


And to finish, a joke that is better appreciated after doing this activity:

**Q:** What do you call this: "Pieces of nine, pieces of nine"?

**A:** A parroty error.

# Solutions and hints

Errors that would not be detected are those where one digit increases and another decreases. Then the sum might still be the same.

# Beat the Clock
# Sorting Networks



**Summary**

Even though computers are fast, there is a limit to how quickly they can solve problems. One way to speed things up is to use several computers to solve different parts of a problem. In this activity we use sorting networks which do several sorting comparisons at the same time.

**Curriculum Links**

✓ Mathematics: Number level 2 and up. Exploring number: Greater than, less than

**Skills**

✓ Comparing
✓ Ordering
✓ Developing algorithms
✓ Co-operative problem solving

**Ages**

✓ 7 years and up

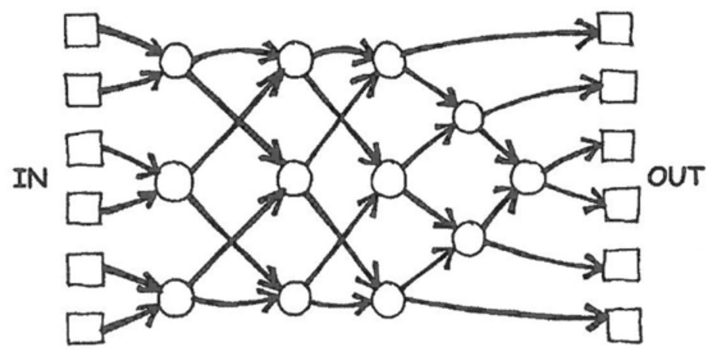
**Materials**

This is an outdoor group activity.

✓ Chalk
✓ Two sets of six cards.
Copy Photocopy Master: Sorting networks (page 73) onto card and cut out
✓ Stopwatch

# Sorting Networks

Prior to the activity use chalk to mark out this network on a court.




## Instructions for Children

This activity will show you how computers sort random numbers into order using a thing called a sorting network.

1. Organise yourselves into groups of six. Only one team uses the network at a time.

2. Each team member takes a numbered card.

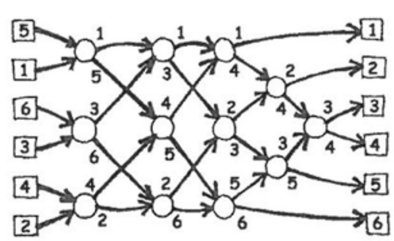
3. Each member stands in a square on the left hand (IN) side of the court. Your numbers should be in jumbled order.

4. You move along the lines marked, and when you reach a circle **you must wait for someone else to arrive.**

5. When another team member arrives in your circle compare your cards. The person with the smaller number takes the exit to their left. If you have the higher number on your card take the right exit.

6. Are you in the right order when you get to the other end of the court?

If a team makes an error the children must start again. Check that you have understood the operation of a node (circle) in the network, where the smaller value goes left and the other goes right. For example:



### Variations

1. When the children are familiar with the activity use a stopwatch to time how long each team takes to get through the network.

2. Use cards with larger numbers (e.g. the three-digit ones in the photocopy master).

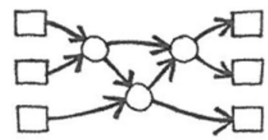
3. Make up cards with even larger numbers that will take some effort to compare, or use words and compare them alphabetically.

### Extension Activities

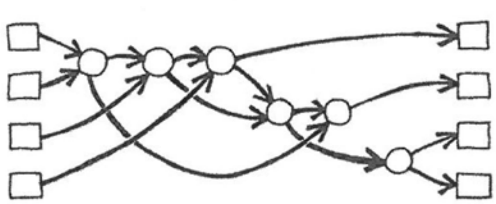
1. What happens if the smaller one goes right instead of left and vice versa? (The numbers will be sorted in reverse order.)

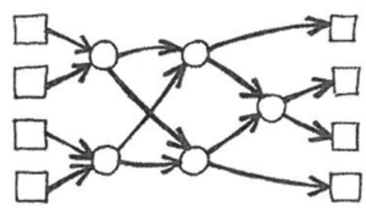
   Does it work if the network is used backwards? (It will not necessarily work, and the children should be able to find an example of an input that comes out in the wrong order.)

2. Try to design smaller or larger networks. For example, here is a network that sorts just three numbers. The children should try to come up with this on their own.



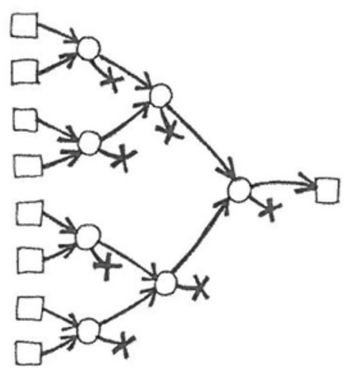
3. Below are two different networks that will sort four inputs. Which is the faster? (The second one is. Whereas the first requires all comparisons to be done serially, one after the other, the second has some being performed at the same time. The first network is an example of serial processing, whereas the second uses parallel processing to run faster.)





4. Try to make a larger sorting network.

5. Networks can also be used to find the minimum or maximum value of the inputs. For example, here is a network with eight inputs, and the single output will contain the minimum of the inputs (the other values will be left at the dead ends in the network).



6. What processes from everyday life can or can't be accelerated using parallelism? For example, cooking a meal would be a lot slower using only one cooking element, because the items would have to be cooked one after another. What jobs can be completed faster by employing more people? What jobs can't?

## Photocopy Master: Sorting networks

| | |
|---|---|
| 1 | 2 |
| 3 | 4 |
| 5 | 6 |

---

| | |
|---|---|
| 156 | 221 |
| 289 | 314 |
| 422 | 499 |

# What's it all about?

As we use computers more and more we want them to process information as quickly as possible.

One way to increase the speed of a computer is to write programs that use fewer computational steps (as shown in Activities 6 and 7).

Another way to solve problems faster is to have several computers work on different parts of the same task at the same time. For example, in the six-number sorting network, although a total of 12 comparisons are used to sort the numbers, up to three comparisons are performed simultaneously. This means that the time required will be that needed for just 5 comparison steps. This parallel network sorts the list more than twice as quickly as a system that can only perform one comparison at a time.

Not all tasks can be completed faster by using parallel computation. As an analogy, imagine one person digging a ditch ten metres long. If ten people each dug one metre of the ditch the task would be completed much faster. However, the same strategy could not be applied to a ditch ten metres deep—the second metre is not accessible until the first metre has been dug. Computer Scientists are still actively trying to find the best ways to break problems up so that they can be solved by computers working in parallel.

# The Muddy City
# Minimal Spanning Trees




## Summary

Our society is linked by many networks: telephone networks, utility supply networks, computer networks, and road networks. For a particular network there is usually some choice about where the roads, cables, or radio links can be placed. We need to find ways of efficiently linking objects in a network.


## Curriculum Links

- ✓ Mathematics: Geometry Level 2/3 and up. Exploring shape and space: Finding the shortest paths around a map

## Ages

- ✓ 9 and up

## Skills

- ✓ Problem solving

## Materials

Each child will need:

- ✓ Workshop Activity: The muddy city problem (page 78)
- ✓ Counters or squares of cardboard (approximately 40 per child)

# The Muddy City

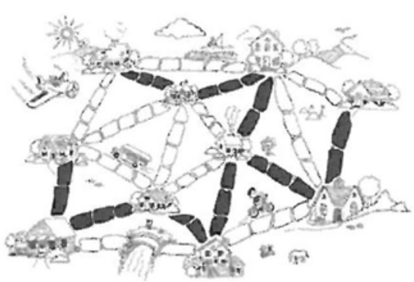
**Introduction**

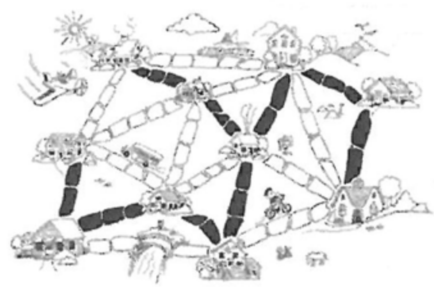
This activity will show you how computers are used to find the best solutions for real-life problems such as how to link power lines between houses. Have the children use the worksheet on page 78, which explains the 'Muddy City' problem.

**Follow-up discussion**

Share the solutions the children have found. What strategies did they use?

One good strategy to find the best solution is to start with an empty map, and gradually add counters until all of the houses are linked, adding the paths in increasing order of length, but not linking houses that are already linked. Different solutions are found if you change the order in which paths of the same length are added. Two possible solutions are shown below.





Another strategy is to start with all of the paths paved, and then remove paths you don't need. This takes much more effort, however.

Where would you find networks in real life?

Computer scientists call the representations of these networks "graphs". Real networks can be represented by a graph to solve problems such as designing the best network of roads between local cities, or aeroplane flights around the country.

There are also many other algorithms that can be applied to graphs, such as finding the shortest distance between two points, or the shortest route that visits all the points.

# Worksheet Activity: The Muddy City Problem

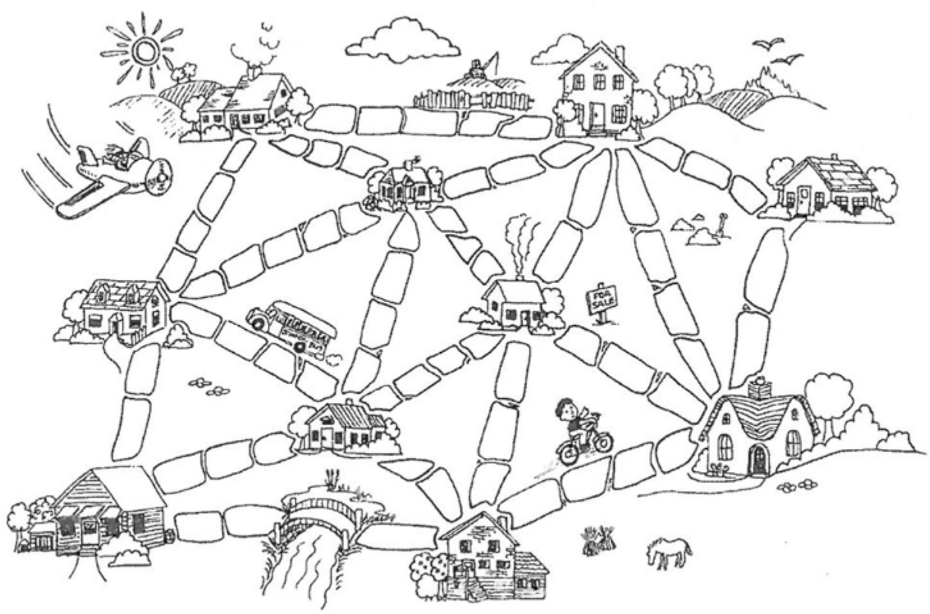
Once upon a time there was a city that had no roads. Getting around the city was particularly difficult after rainstorms because the ground became very muddy—cars got stuck in the mud and people got their boots dirty. The mayor of the city decided that some of the streets must be paved, but didn't want to spend more money than necessary because the city also wanted to build a swimming pool. The mayor therefore specified two conditions:

1. Enough streets must be paved so that it is possible for everyone to travel from their house to anyone else's house only along paved roads, and

2. The paving should cost as little as possible.

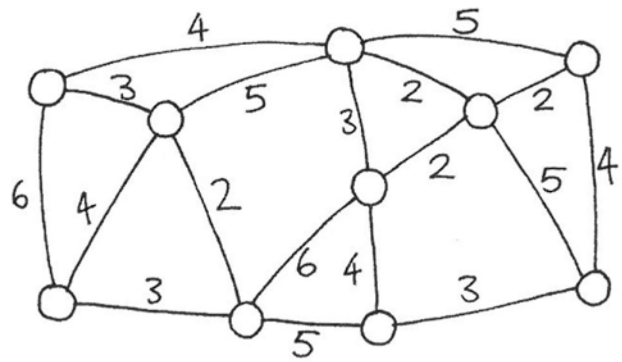
Here is the layout of the city. The number of paving stones between each house represents the cost of paving that route. Find the best route that connects all the houses, but uses as few counters (paving stones) as possible.

What strategies did you use to solve the problem?



## Variations and extensions

Here is another way of representing the cities and roads:




The houses are represented by circles, the muddy roads by lines, and the length of a road is given by the number beside the line.

Computer scientists and mathematicians often use this sort of diagram to represent these problems. They call it a *graph*. This may be confusing at first because "graph" is sometimes used in statistics to mean a chart displaying numerical data, such as a bar graph, but the graphs that computer scientists use are not related to these. The lengths do not have to be drawn to scale.

Make up some of your own muddy city problems and try them out on your friends.

Can you find out a rule to describe how many roads or connections are needed for a best solution? Does it depend on how many houses there are in the city?

# What's it all about?

Suppose you are designing how a utility such as electricity, gas, or water should be delivered to a new community. A network of wires or pipes is needed to connect all the houses to the utility company. Every house needs to be connected into the network at some point, but the route taken by the utility to get to the house doesn't really matter, just so long as a route exists.

The task of designing a network with a minimal total length is called the *minimal spanning tree* problem.

Minimal spanning trees aren't only useful in gas and power networks; they also help us solve problems in computer networks, telephone networks, oil pipelines, and airline routes. However, when deciding the best routes for people to travel, you do have to take into account how convenient the trip will be for the traveller as well as how much it will cost. No-one wants to spend hours in an aeroplane taking the long way round to a new country just because it is cheaper. The muddy city algorithm may not be much use for these networks, because it simply minimizes the *total* length of the roads or flight paths.

Minimal spanning trees are also useful as one of the steps for solving other problems on graphs, such as the "travelling salesperson problem" which tries to find the shortest route that visits every point in the network.

There are efficient algorithms (methods) for solving minimal spanning tree problems. A simple method that gives an optimal solution is to start with no connections, and add them in increasing order of size, only adding connections that join up part of the network that wasn't previously connected. This is called Kruskal's algorithm after J.B. Kruskal, who published it in 1956.

For many problems on graphs, including the "travelling salesperson problem", computer scientists are yet to find fast enough methods that find the best possible solution.

# Solutions and hints

## Variations and extensions (page 79)

How many roads or connections are needed if there are $n$ houses in the city? It turns out that an optimal solution will always have exactly $n$–1 connections in it, as this is always sufficient to link up the $n$ houses, and adding one more would create unnecessary alternative routes between houses.

# What is Environmental and Earth Science?



***Environmental and earth science*** refers to all the sciences that are related to the planet earth. It is also sometimes called geosciences. Earth science includes the study of rocks, fossils, sediment, soil, land formations, water, and other attributes of Earth and the processes that created them. Environmental science tends to study these features with a more biological or ecological approach.

Earth scientists study everything from the ocean floor to the clouds in the sky. For instance, they can look at the atmosphere and determine how carbon dioxide affects the earth's atmospheric layers or how shifting tectonic plates can cause earthquakes and volcanoes. An environmental scientist will examine these phenomena and describe how they impact life on earth, including humans.

**Photo credit: Wonderlane @Flickr**

***If you like environmental and earth science, you may like the careers chosen by these people:***

| ScienceMaker | Occupation | Location | Question Topics |
|---|---|---|---|
| **Robert Bullard** | Director | *Environmental Justice Resource Center* | Environmental justice<br>Natural disasters |
| **Lisa Jackson** | Administrator | *Environmental Protection Agency* | Environmental policy<br>Hazardous waste |
| **F. Dale Morgan** | Director | *Kuwait-MIT Center for Natural Resources and the Environment* | Geology<br>Water treatment |
| **Samuel Mukasa** | Chair of Geological Sciences Department | *University of Michigan* | Geography<br>Geological tools and techniques |
| **Dawn Wright** | Professor of Geosciences | *Oregon State University* | Ocean floor and ocean life |

# Environmental & Earth Science in Action

***Hurricane Katrina*** ("Hurricane Katrina" by au_tiger01 @ Flickr)

Hurricane Katrina formed in 2005 and caused mass destruction in the Gulf coast from Florida to Texas. In New Orleans, Louisiana the levee failed and the city was flooded. It was one of the five deadliest hurricanes to hit the United States.


***Pollution*** ("Factory Smoke" by Theodevil @ Flickr)

One of the biggest problems faced by environmental scientists is how to control the amount of pollution produced by a growing human population. Problems associated with pollution include its influence on the environment and wildlife, impact on human health, and potential role in altering the climate of the Earth.

# Spotlight: Robert Doyle Bullard

| | |
|---|---|
| **Name** | Robert Doyle Bullard |
| **Birth Date** | December 21, 1946 |
| **Birth Place** | Elba, Alabama |
| **Education** | Mulberry Heights High School<br>Alabama Agricultural and Mechanical University<br>Clark Atlanta University<br>Iowa State University |
| **Type of Science** | Environmental Science |



## Biography

Sociologist, sociology professor, author and environmental activist Robert Doyle Bullard was born on December 21, 1946 in Elba, Alabama, to Myrtle and Nehemiah Bullard. He was the fourth of five children. Growing up in Alabama during the 1950s, Bullard experienced the effects of a segregated community first-hand. After graduating from high school, Bullard went on to attend the Alabama Agricultural and Mechanical University. In 1968, he received his B.A. degree in history and government with a minor in sociology. He continued his education at Atlanta University, where he earned his M.S. degree in sociology in 1972. During his graduate studies, Bullard started his work in urban planning. He went on to complete his Ph.D. program in sociology at Iowa State University in 1976.

**Leaf photo by Epsos.de @Flickr.**

After receiving his Ph.D. degree, Bullard and his attorney wife, Linda McKeever Bullard, moved to Houston, Texas to teach at Texas Southern University. In 1978, Bullard was asked by Linda to collect data for a lawsuit, *Bean v. Southwestern Waste Corporation* she had filed in federal court involving the placement of garbage facilities in mostly black Houston neighborhoods. This was the first lawsuit that charged environmental discrimination using federal civil rights laws. This inspired Bullard to learn more about careers in the environmental field. Beyond Texas, Bullard taught at universities in Tennessee and California before returning to his alma mater, Clark Atlanta University. He was eventually named the Edmund Asa Ware Distinguished Professor of Sociology and Director of the

Environmental Justice Resource Center at Clark Atlanta University. In this position, Bullard was able to conduct research, teach and implement community outreach programs while combining his interests in sociology and environmental science.

For his work on contemporary cases of environmental justice and his active presence in the community, Bullard has been called the "Father of Environmental Justice." Bullard pioneered the cause of environmental justice through the 1970s and 1980s, and in 1994, he was instrumental in President Clinton's signing of Executive Order 12898, a legal document that defined the need for environmental justice in the United States. Bullard has delivered many presentations and has written over fifteen books detailing his research and perspectives on environmental policy. A selection of his works include: *Dumping in Dixie: Race, Class, and Environmental Quality* (1990); *Confronting Environmental Racism: Voices from the Grassroots* (1993); and *Race, Place, and Environmental Justice after Hurricane Katrina* (2009).

Among the many awards that Bullard has received, he was honored by the American Sociological Association with the William Foote Whyte Distinguished Career Award in 2007. In 2008, Bullard was named one of *Newsweek's* thirteen "Environmental Leaders of the Century."
Achievement Award for Scientific Scholarship, Civic Science, and Diversifying Computing. Since 2008, Taylor has served on the Board of Directors for the Computing Research Association.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Bullard?
#2 Where was Dr. Bullard born? Locate it on a map. How far away is this from where you live? What are the names of his parents? Where did Dr. Bullard attend high school? What do you think high school was like for him?
#3 How old are you? In what year was Dr. Bullard your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 Dr. Bullard became interested in environmental justice after his wife introduced him to the topic. What topics have people you know introduced you to?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think an environmental scientist does? Would you like to be an environmental scientist? Why? Why not?
#2 If you were an environmental scientist, what topics would you study?
#3 What subject does Bullard teach at Clark Atlanta University? How does this relate to environmental science?
#4 What is "environmental justice"? Can you think of cases where "environmental justice" has been an issue in your area?
#5 Bullard had been an advocate for assisting those in need after the destruction left by Hurricane Katrina. When did Hurricane Katrina hit the Gulf Coast of Louisiana and Mississippi? What was the aftermath?

# Glossary

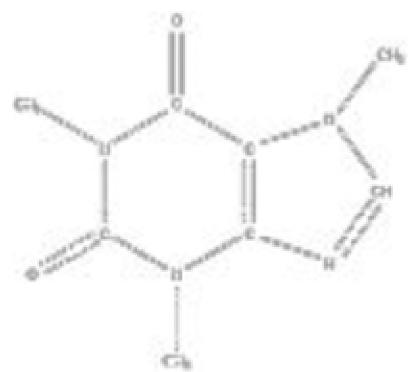
*Environmental justice*
The fair treatment of people of all races, cultures, incomes, and educational levels with respect to the development and enforcement of environmental laws, regulations, and policies.

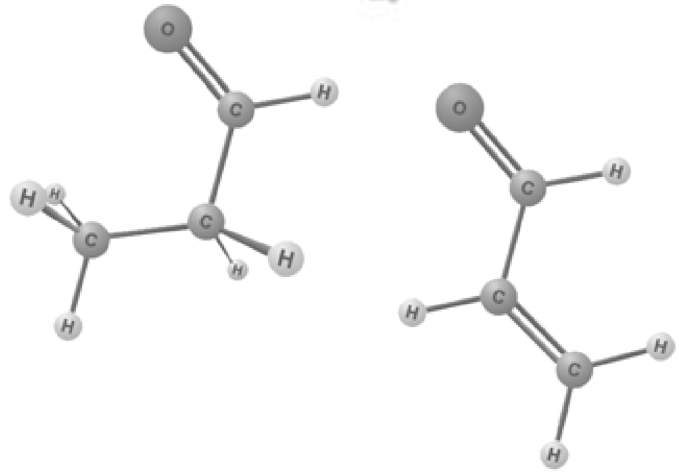
*Hurricane Katrina*
The costliest hurricane, as well as one of the five deadliest, in the history of the United States.  It hit the Gulf Coast between New Orleans, Louisiana and Gulfport, Mississippi in 2005.

*Sociology*
The study and classification of human societies.

*Whyte, William Foote*
(1914 - 2000) Sociologist chiefly known for his ethnological study in urban sociology, Street Corner Society.







# ScienceMakers
## Spotlight: Lisa P. Jackson

| | |
|---|---|
| **Name** | Lisa P. Jackson |
| **Birth Date** | February 8, 1962 |
| **Birth Place** | Philadelphia, Pennsylvania |
| **Education** | Saint Mary's Dominican High School<br>School of Chemical Engineering at Tulane University<br>Princeton University |
| **Types of Science** | Environmental Science<br>Chemical Engineering |



## Biography

Mechanical engineer, state government official and federal government official Lisa P. Jackson was born on February 8, 1962 and raised by her adoptive family in New Orleans, Louisiana. She graduated as valedictorian from Saint Mary's Dominican High School in 1979. With the aid of a scholarship from Shell Oil Company, Jackson went on to obtain her B.S. degree *summa cum laude* in mechanical engineering from the School of Chemical Engineering at Tulane University in 1983. Jackson then received her M.S. degree in chemical engineering from Princeton University in 1986.

**EPA photo by cliff1066 @Flickr**

After learning about the Love Canal incident, where public facilities were operating over former chemical dumps, and after working with Clean Sites, a non-profit organization interested in cleaning up hazardous waste sites, Jackson decided she would pursue employment with the United States Environmental Protection Agency (US EPA). She spent fifteen years working with the organization until she left to work with the New Jersey Department of Environmental Protection and Energy in 2002. Four years later, she was appointed as the New Jersey Commissioner of Environmental Protection by Governor Jon Corzine. Her efforts in New Jersey resulted in the end of bear hunting in New Jersey and a plan to reduce carbon emissions by twenty percent by 2020. In October 2008, the Governor of New Jersey appointed Jackson to the position of Chief of Staff. Her tenure in this position was cut short, when in December 2008, she was appointed by President Barack

Obama to serve as the Administrator of the United States Environmental Protection Agency. She became the first African American to hold this position. Jackson and her husband, Kenneth Jackson, have two sons, Marcus and Brian.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Mrs. Jackson?

#2 Where was Mrs. Jackson born? Locate it on a map. How far away is this from where you live? Where did Mrs. Jackson attend high school? What do you think high school was like for her?

#3 How old are you? In what year was Mrs. Jackson your age? What was happening in the United States that year? What was happening in the world that year? What do you think her life was like when she was your age?

#4 Mrs. Jackson graduated as valedictorian of her high school. What is a valedictorian? What do you think Mrs. Jackson had to do to become valedictorian?

#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think an environmental scientist does? Would you like to be an environmental scientist? Why? Why not?

#2 If you were an environmental scientist, what topics would you study?

#3 What is the significance of Mrs. Jackson being appointed to the position of administrator of the EPA? What does this agency control and how does it affect society at large?

#4 Mrs. Jackson received her degrees in mechanical and chemical engineering, but she is known mostly for her work in environmental policy. What strengths do you think a background in science gave her in her approach to environmental policy?

#5 Look up in a newspaper what types of environmental policies are being discussed in your area. If you cannot find one, try searching in a textbook or asking your parents or a teacher for a policy that has been recently passed.

# Glossary

*Hazardous waste*
Waste that poses substantial or potential threats to public health or the environment. The substances may be flammable, reactive, corrosive or toxic.

*Love Canal*
A neighborhood in Niagara Falls, New York, which became the subject of national and international attention, controversy, and eventual environmental notoriety following the discovery of 21,000 tons of toxic waste that had been buried beneath the neighborhood.

*United States Environmental Protection Agency (US EPA)*
An agency of the federal government of the United States charged to protect human health and the environment, by writing and enforcing regulations based on laws passed by Congress.

*Valedictorian*
An academic title typically given to the highest ranked student among the graduation class from a given school or educational institution.

# ScienceMakers
## Spotlight: F. Dale Morgan

| Name | F. Dale Morgan |
|---|---|
| Birth Place | Guyana, South America |
| Education | St. Joseph's College<br>Polytechnic Institute of Trinidad and Tobago<br>University of the West Indies<br>Massachusetts Institute of Technology |
| Type of Science | Geophysics |



## Biography

Geophysicist and professor F. Dale Morgan was born in Guyana in South America. Morgan also grew up in Guyana where he attended St. Stanislaus' College. He attended St. Joseph's College and the Polytechnic Institute in Trinidad. In 1970, Morgan earned his B.S. degrees in mathematics and physics from the University of the West Indies, Trinidad and Tobago. He then continued his studies at the University of the West Indies, where he earned his M.S. degree in theoretical solid state physics in 1972. His thesis was entitled: "Symmetry properties and dispersion relations in antiferromagnetic NiO and CoO."

**Haiti earthquake photo by United Nations Development Programme @Flickr**

Morgan served as a lecturer in the physics department of the University of the West Indies until 1975, when he began attending the Massachusetts Institute of Technology (MIT) with the assistance of a joint Organization of American States (OAS)/Trinidad Government Scholarship. In 1981, he graduated from the Department of Earth and Planetary Sciences at the Massachusetts Institute of Technology. His Ph.D. degree was awarded for his thesis: "Electronics of sulfide minerals: implications for induced polarization." Upon the completion of his degree, Morgan began work as a faculty member at the Massachusetts Institute of Technology. He then became a full professor of geophysics and the associate director of the Earth Resources Laboratory. Morgan's interests include geoelectromagnetism, electrokinetics, applied seismology and environmental geophysics.

In 2005, Morgan was named the co-director of the Kuwait-MIT Center for Natural Resources and the Environment, a group that aims to promote research and education outreach in the areas of energy, water, and the environment. Morgan is responsible for several projects concerning the human use and the quality of water. The projects involve investigation of oilfield production brines and the injection of treated wastewater into natural groundwater aquifers. Morgan has served on a number of advisory committees and has published many academic papers in the field of geophysics. Morgan is married to Alison Morgan.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Morgan?
#2 Where was Dr. Morgan born? Where did he attend college? Find these locations on a map. How far away is this from where you live?
#3 What year did Dr. Morgan graduate with his B.S. degree? What was happening in the United States that year? What was happening in the world that year?
#4 Dr. Morgan has lived in Guyana as well as Trinidad and Tobago, both of which are countries that have borders on the Caribbean Sea. Consider the geological features of these countries, how do you think that they might have influenced Dr. Morgan's career choice and his interest in science?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a geophysicist does? Would you like to be a geophysicist? Why? Why not?
#2 If you were a geophysicist, what topics would you study? Why do you think it is important to study geophysics?
#3 Dr. Morgan is working with an organization from Kuwait. Why do you think Dr. Morgan's studies on oilfield production brines and wastewater treatment is important for this country?
#4 What types of geological structures are around your area? Mountains? Rolling hills? Lots of lakes? Research your own area's geological history and comment on it.
#5 Dr. Morgan has a background in physics. How do you think that his knowledge of physics relates to his work in geophysics? How does it connect to Dr. Morgan's research with the Kuwait-MIT Center, which focuses primarily on water resources?

# Glossary

*Antiferromagnetism*
Magnetism when the magnetic moments of atoms or molecules align in a regular pattern with neighboring spins (on different sublattices) pointing in opposite directions.

*Aquifer*
An underground layer of earth that yields water which can be obtained from an aquifer via a well.

*Brine*
A body of water containing a high concentration of salt, often produced along with oil.

*Geoelectromagnetism*
Property of earth-materials including the forces and interactions between electrically charged particles.

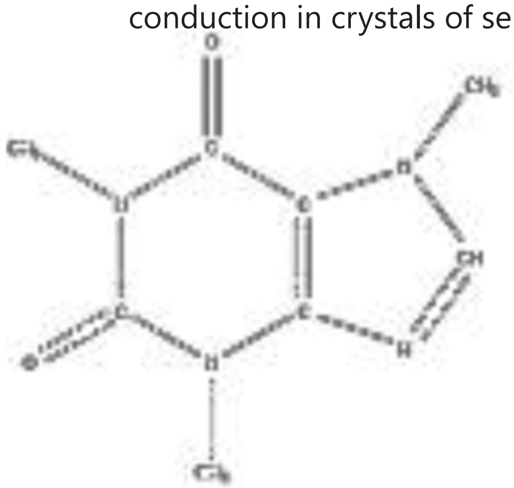
*Electrokinetics*
Any of several phenomena in which electric charge (or the flow of electric charge) causes physical movement.

*Geophysics*
The study of geology that uses physical principles to study properties of the Earth.

*Induced polarization*
A tool used for mapping in geophysical and geothermal studies. It uses the decay of an excitation voltage or variations in the Earth's resistivity measured at different low-frequency voltages to map the surface and contours of the earth.

*Seismology*
The study of earthquakes and energy waves within the earth. Seismologists study the source and the effects of earthquakes.

*Solid state physics*
The branch of physics that studies the properties of materials in the solid state such as electrical conduction in crystals of semiconductors and metals.



# ScienceMakers
## Spotlight: Samuel B. Mukasa

| | |
|---|---|
| **Name** | Samuel B. Mukasa |
| **Birth Date** | September 29, 1955 |
| **Birth Place** | Maseno, Kenya |
| **Education** | Kololo Senior Secondary School<br>University of New Hampshire<br>Ohio State University<br>University of California, Santa Barbara |
| **Types of Science** | Geology<br>Geochemistry |



## Biography

Geochemist, professor, department chair and dean Samuel B. Mukasa was born on September 29, 1955 in Maseno Kenya, of Ugandan Parents, Catherine and William Kabali. He was raised by his mother following his parents' divorce when he was six years old. He attended secondary school in Kampala, Uganda before traveling to the University of New Hampshire, where he received his B.S. degree in geology in 1977. He then received his M.S. degree in geology from Ohio State University in 1980 and his Ph.D. degree in geochemistry from the University of California, Santa Barbara in 1984.

**Monument Valley, Utah photo by Wolfgang Staudt @Flickr.**
Striking examples of geographical formations.

After working as a postdoctoral research fellow in the Isotope Geochemistry Laboratory at Lamont-Doherty Earth observatory of Columbia University, Mukasa worked as an assistant professor at the University of Florida for four years. In 1989, Mukasa started his career at the University of Michigan, becoming a full tenured professor in 1999 and department chair in 2007. In 2011, Mukasa was promoted to dean of the College of Engineering and Physical Sciences at the University of New Hampshire, his alma mater.

Throughout his career, Mukasa has been a mentor to numerous undergraduate and graduate students, as well as postdoctoral research fellows, and has published many papers on a wide variety of subjects. His research interests focus on the origin of Earth's geochemical structures and the plate tectonic evolution of the continents. He has used several techniques to further his research, including the integration of trace elements to model the petrogenesis of volcanic rocks, and the application of U/Pb and 40Ar/39Ar geochronology to unravel the tectonic evolution of mountain belts. Mukasa has also participated in several professional service organizations, including the Polar Research Board of the National Research Council, the Major Research Instrumentation Panel of the National Science Foundation (NSF), the ADVANCE Panel at NSF. He also served a two-year term as chair of the advisory board for Office of Polar Programs at NSF.

Mukasa was awarded an honorary Doctorate of Science by Nkumba University, Uganda, in April 2008. In 2010, he was elected president of the Geochemical Society, after having served as vice president for the 2008-09 term. Mukasa also holds the title of Eric J. Essene Collegiate Professor of Geological Sciences at the University of Michigan. He has garnered many research grants for his continuing research in the field of geochemistry. Additionally, through organizations such as Science and Technology Recruiting to Improve Diversity and Excellence (STRIDE), Mukasa has worked with the university community to support the growth of a diverse faculty in engineering and in science. With grants from the energy sector, he has established outreach programs in an underprivileged K-12 school system and recruitment program aimed at minority students wishing to pursue higher education. Mukasa is married to Dr. Claudia McQueen, MD, and they have one son named Christopher.



# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Mukasa?
#2 Where did Dr. Mukasa attend high school (secondary school)? Locate this on a map. How far is this from where you live? What do you think high school was like for him?
#3 How old are you? In what year was Dr. Mukasa your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 Dr. Mukasa was awarded an honorary degree by Nkumba University in Uganda. Where is Uganda? Describe the geography of Uganda.
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a geologist or geochemist does? Would you like to be either of these? Why? Why not?
#2 If you were a geologist or geochemist, what topics would you study? Why do you think it is important to study geology and geochemistry?
#3 What does the prefix "geo" mean in science terms? Can you think of any other types of scientist that has this prefix? What do they study?

#4 Consider some of the techniques geologists use in their research. For example, the Grand Canyon, is has been reportedly formed over the past 40 million years. How do you think this approximate age is determined?

#5 Many times a geochemist has to determine the chemical components of a particular rock or mineral. How is the chemical identity of an unknown mineral determined? (Hint: Think about chemical properties that help to identify different elements.) Why is knowing the chemical identity of a sample useful knowledge to have?

# Glossary

*Geochemistry*
The investigation of the chemistry of rocks.

*Geochronology*
The science of determining the absolute age of rocks, fossils, and sediments, within a certain degree of uncertainty.

*Geology*
The science and study of the solid and liquid matter that constitutes the Earth.

*Isotope geochemistry*
An aspect of geology based upon study of the relative and absolute concentrations of the elements and their isotopes in the Earth. Variations in the abundance of these isotopes, typically measured with an isotope ratio mass spectrometer or an accelerator mass spectrometer, can reveal information about the age of a rock or the source of air or water.



*National Science Foundation (NSF)*
A United States government agency that supports fundamental research and education in all the non-medical fields of science and engineering. Its medical counterpart is the National Institutes of Health.

*Petrogenesis*
A branch of petrology dealing with the origin of igneous rocks. Petrology is the branch of geology dealing with the origin, occurrence, structure and history of igneous, metamorphic, and sedimentary rocks.

*Plate tectonics*
A scientific theory which describes the large scale motions of the seven or eight major plates of earth's lithosphere.

*Postdoctoral research*
Academic or scholarly research conducted by a person who has completed his or her doctoral studies, normally within a five year period. It is intended to further deepen expertise in a specialist subject, including necessary research skills and methods.

*Tenured*
Appointed for life and not subject to dismissal except for a grave crime.

*Trace elements*
In analytical chemistry, an element in a sample that has an average concentration of less than 100 parts per million measured in atomic count, or less than 100 micrograms per gram.

# ScienceMakers
## Spotlight: Dawn Jeannine Wright

| | |
|---|---|
| **Name** | Dawn Jeannine Wright |
| **Birth Date** | April 15, 1961 |
| **Birth Place** | Baltimore, Maryland |
| **Education** | Wheaton College<br>Texas A&M University<br>University of California, Santa Barbara |
| **Type of Science** | Oceanography |



## Biography

Professor and oceanographer Dawn Jeannine Wright was born on April 15, 1961 to Jeanne and Robert Wright. Wright grew up on the island of Maui, Hawaii, fascinated by stories of adventure and discovery of the open seas. She graduated *cum laude* with her B.S. degree in geology from Wheaton College in 1983. She then earned her M.S. degree from Texas A&M University in oceanography in 1986. During her graduate studies, Wright served as a graduate research assistant and a marine laboratory specialist with the Ocean Drilling Program at Texas A&M University. Following her work as a marine laboratory specialist, Wright received her Ph.D. degree from the University of California, Santa Barbara in 1994 with her dissertation entitled "From Pattern to Process on the Deep Ocean Floor: a Geographic Information System Approach."

**Ocean floor photo by dimsis @Flickr**

The National Oceanographic and Atmospheric Administration (NOAA) hired Wright as a postdoctoral research associate following graduation. She began her teaching career in 1995 as an assistant professor in the Department of Geosciences at Oregon State University. By 2002, she was promoted to full professor. Wright is an expert on geographic information systems, and her work has focused on mapping the ocean floor in locations around the globe including: Fagatele Bay National Marine Sanctuary, in American Samoa, the East Pacific Rise in the Pacific Ocean, the Tonga Trench in the South Pacific Ocean, and the Juan de Fuca Ridge in the North Pacific Ocean. Along with her work in mapping the sea floor, Wright has assisted with a number of outreach programs, hoping to encourage more minority and female students to consider a career in the sciences. Wright has published a large number of papers detailing her investigations. She has received several awards in recognition of her work, both as a teacher and as a leading scientist in her field. She won the United States Professor of the Year for the State of Oregon in 2007, and has been listed as one of fifteen scientists featured in *Portraits of Great American Scientists*. She was also named a fellow of the American Association for the Advancement of Science (AAAS). Wright has co-authored the reference book, *Arc Marine: GIS for a Blue Planet*.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Wright?
#2 Where was Dr. Wright born? Locate it on a map. How far away is this from where you live? What are the names of her parents? Where did Dr. Wright attend college? What do you think college was like for her?
#3 How old are you? In what year was Dr. Wright your age? What was happening in the United States that year? What was happening in the world that year? What do you think her life was like when she was your age?
#4 Dr. Wright took inspiration for her field of study from her surroundings—namely, the Pacific Ocean when she was growing up on the island of Maui, Hawaii. When thinking about what you would like to do in the future, is there anything in your environment that has inspired you to consider a certain career or field of study?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think an oceanographer does? Would you like to be an oceanographer? Why? Why not?
#2 If you were an oceanographer, what topics would you study?
#3 Do you live near a large body of water, such as an ocean or a lake? What geographical features are found in this body of water? If you do not live near an ocean or lake, pick one and research it. Maps are useful when trying to find this information.
#4 You are told to map the ocean floor. How would you do it? See if you can think of at least two methods of determining the features of the ocean floor. What tools or equipment do you require?
#5 What organisms live on the ocean floor in a coral reef? What about in places like Challenger Deep in the Mariana Trench, the deepest point in the Earth's oceans? How do you think living organisms have adapted to living in both of these locations?

# Glossary

*American Association for the Advancement of Science (AAAS)*
An international non-profit organization with the stated goals of promoting cooperation between scientists, defending scientific freedom, encouraging scientific responsibility, and supporting scientific education and science.

*East Pacific Rise*
A mid-oceanic ridge, a divergent tectonic plate boundary located along the floor of the Pacific Ocean. It separates the Pacific Plate to the west from (north to south) the North American Plate, the Rivera Plate, the Cocos Plate, the Nazca Plate, and the Antarctic Plate.

*Fagatele Bay National Marine Sanctuary*
Marine sanctuary in American Samoa; the smallest, yet one of the most important marine sanctuaries as it is home to more tropical fish and marine mammals than any other U.S. marine sanctuary. It also provides a natural food source for sharks and other predators of the ocean.

*Geographic Information System (GIS)*
An interactive computer program capable of assembling, storing, analyzing and displaying information, which has been identified by location. At its most basic level, a GIS application is a computerized map (such as to Google Earth).



*Juan de Fuca Ridge*
A tectonic spreading center located off the coasts of Oregon and Washington in the United States, and the province of British Columbia in Canada.

*National Oceanic and Atmospheric Administration (NOAA)*
An agency in the Department of Commerce that maps the oceans and conserves their living resources. The NOAA predicts changes to the earth's environment, provides weather reports and forecasts concerning floods, hurricanes, and other natural disasters related to weather.

*Oceanography*
The exploration and scientific study of the oceans and ocean floor

*Pacific Ocean*
The world's largest body of water, to the east of Asia and Australasia and to the west of the Americas.

*Postdoctoral research*
Academic or scholarly research conducted by a person who has completed his or her doctoral studies, normally within a five year period. It is intended to further deepen expertise in a specialist subject, including necessary research skills and methods.

*Tonga Trench*
Located in the Pacific Ocean and is 10,882 meters (35,702 ft) deep at its deepest point, known as the ''Horizon Deep".

## Earth Science Activity on Air

# Air Particles and Air Quality

*(www.ScienceBuddies.org)*

**Grade Level:** K-5
**National Standards:** H.F.1 Personal and community health


### *Abstract*

What does the phrase, “Like a breath of fresh air,” mean to you? This common phrase can have different meanings: calming, relaxing, invigorating, energizing or CLEAN! After all, you never hear anyone say, “Like a breath of dirty air,” do you? Find out how clean the air is in this simple experiment.


### *Objective*

**In this experiment you will test the quality of air by measuring the number of air particles from different locations.**

### *Introduction*

The air we breathe has a lot to do with our health. As we breathe in fresh air, our lungs absorb oxygen from the air and pass it into our blood stream so it can be transported throughout our bodies. Oxygen is important for our whole body to have the energy it needs to survive.

It is important for all of us to have clean air to breath. People living in industrial areas are more likely to develop asthma. People who smoke are more likely to suffer from lung disease. You may have seen an example of the lungs from a smoker which are small, black and unhealthy looking. Years and years of breathing particles of tar and smoke can cause the lung tissue to develop cancer, and can even cause death.

Breathing clean air is important for keeping your lungs nice and healthy. Tiny particles of dust and soot in the air can enter your lungs when you breathe, and can block the movement of oxygen. Harmful particles can come from pollutants in the air like dust, smog, soot, smoke, and other chemicals. Because of the importance of clean air to our health, most cities keep track of air pollution by issuing smog warnings on days when there is a high level of air pollution.

How clean is the air where you live? What about around your school, where you play at the park, or where your parents go to work? Is the air at a park cleaner than air near a busy intersection? You can do a simple experiment with Vaseline to find out the answers to these questions.

### *Terms, Concepts and Questions to Start Background Research*

To do this project, you should do research that enables you to understand the following terms and concepts:

- air quality
- smog
- particles
- lungs
- asthma

## Bibliography

Here are some helpful websites:


- PBS, 2003. "PBS Now, Science and Health: Deadly Smog," Public Broadcasting Service (PBS). [accessed 3/3/2006] http://www.pbs.org/now/science/smog.html.
- EPA, 2006. "U.S. Environmental Protection Agency," U.S. EPA. [accessed: 3/3/2006] http://www.epa.gov/.
- ALA, 2004. "Defending the Clean Air Act: State of the Air 2004," American Lung Association. [accessed: 3/3/2006] http://www.lungusa.org/site/pp.asp?c=dvLUK9O0E&b=50353.


## Materials and Equipment

- Vaseline
- string
- black permanent marker
- milk carton
- hole punch
- magnifying lens
- digital camera

## Experimental Procedure

1. Save a milk carton to use for your experiment. Clean and dry the carton thoroughly before use.
2. Cut the carton into four flat pieces by cutting along the side seams of the carton. Cut each side into 3 square pieces, each piece will be approximately 3 inches long and 3 inches wide. You will have a total of 12 squares when you are done.
3. Using the hole punch, punch a hole in one corner of each square.
4. Tie a piece of string through the hole to make a loop for hanging the square up, on a tree branch for example.
5. Make a data sheet to record where you place your squares, and what data you later will collect from them:

| | | | | |
|---|---|---|---|---|
| Location: | | | | |
| Square 1 | | | | |
| Square 2 | | | | |
| Square 3 | | | | |
| TOTAL | | | | |
| Average | | | | |

6. Decide on your four locations. Good locations are: your back yard, a busy street corner, your school, a park, a shopping center, a parking lot, etc.
7. Write the name of each location in your data table. Include the cross streets (Cedar and Sacramento Street), the address (1234 Maple Street) or the name of the location (Tilden Park or Valley Mall) in your table.
8. Using your black permanent marker, draw a 1 inch by 1 inch box in the center of the white side (what used to be the inside of the carton) of each square.

9. Write the name of the location on the bottom of each square, you will use three squares for each location.
10. At each location, find a place to hang up three of your collection squares. You can hang the squares from a tree branch, sign post, light post, or any other safe landmark. If the location is busy with traffic, be sure to have an adult with you for safety.
11. Before you hang each square up, spread a thin layer of vaseline in the black box in the center of each square with your finger. Hang up the collection square.
12. Leave your collection squares for 3–5 days. It is best to leave them on days when there is no rain, so if you hear it is going to rain be sure to go and collect them even if you have not left them out for a full five days.
13. After you have waited, it is time to collect your data from the squares.
14. Revisit each location bringing your data table, magnifying glass and a digital camera.
15. Remove the squares one at a time. Each time, use your magnifying glass to count the number of visible particles you see stuck in the Vaseline inside the boxed area. Write the number in your data table.
16. Take a picture of the square. If your camera has a micro-setting for close ups, the pictures will turn out better.
17. Proceed to the next square and/or location until you have collected all of your data and filled out your data table.
18. For each location you will have collected three sets of data, so you will want to average the data to get a better result. First add together the three counts and write the answer in the "TOTAL" box. Then divide this number by 3 and write the answer in the "Average" box.
19. Now you are ready to make a graph of your data. Make a bar graph by writing a scale for the number of particles on the left side (y-axis) and then by drawing a bar up to the correct number of particles for each location. Remember to label each bar of your graph, or make a color key.
20. Print out your photos for your poster too.
21. Which sites had the most particulate matter in the air? Is this what you expected? Were each of your three counts the same or different? What do you think this tells you about the relative air quality at each location?

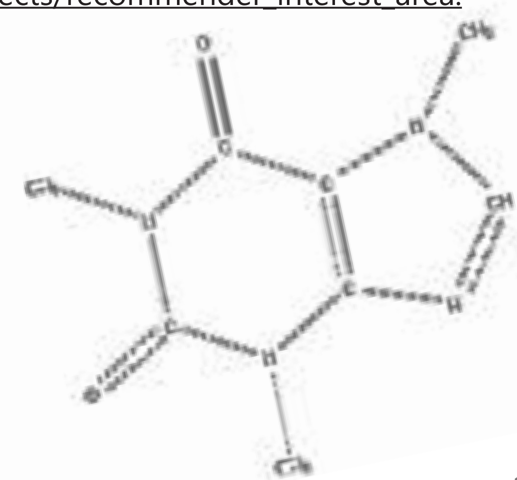


### *Variations*

- Try testing the air quality at the same location over a course of several weeks, replacing the collection squares every few days. How does the air quality change over time? Compare your data with the air quality forecast in your local newspaper; how well do they match up?
- A rainy day can be very cleansing for the air. Compare air samples before and after a rainy day; are there less particles? Where do you suppose those particles go? What does this have to do with acid rain?
- For more science project ideas in this area of science, see Environmental Science Project Ideas (http://www.sciencebuddies.org/science-fair-projects/recommender_interest_area.php?ia=EnvSci).

### *Credits*

Sara Agee, Ph.D., Science Buddies



Earth Science Activity on Environmentally Friendly Materials

# *Going Green with Packing Peanuts*



**Grade Level:** 5-8
**National Standards:** M.F.5 Science and technology in society

### *Objective*
Designing environmentally friendly materials has become popular in the last decade. One recent invention is starch-based packaging peanuts. **In this experiment, students will compare if Styrofoam and starch peanuts dissolve in two substances and which is healthier for the environment.**

### *Introduction*
In the table below, fill in the blank spots with a yes or a no if you think the packaging peanut will dissolve in the given liquid. Consider the properties of the liquids and the properties of the peanuts.

**Will the packaging peanut dissolve?**

| | Styrofoam | Starch |
|---|---|---|
| Water | | |
| Acetone | | |

### *Materials and Equipment*
- Starch-based packaging peanuts
- Styrofoam-based packaging peanuts
- Water
- Acetone (available in most drug stores)
- Safety goggles and gloves
- 2 clear beakers (or glasses)

### *Experimental Procedure*
1. Put on your safety goggles and gloves.
2. Label one glass with a "W" and one with an "A."
3. Fill the 'W" glass with enough water to cover a packaging peanut.
4. Fill the "A" glass with enough acetone to cover a packaging peanut. Never ingest the acetone and never inhale strongly near the acetone.

5. We will test the Styrofoam-based packaging peanuts first. Place one Styrofoam-based packaging peanut in each glass. Observe what happens. Record your observations in the table below.
6. Now, place one starch-based packaging peanut in each glass. Again, observe what happens and record your observations in the table below.

| | Styrofoam | Starch |
|---|---|---|
| Water | | |
| Acetone | | |

7. When you are complete with your experiment, discard any remaining peanuts and pour the liquids down the drain. Wash out your glasses thoroughly. Clean up your work-space with your gloves still on.
8. You can remove your goggles and gloves, but be sure to wash your hands really well.



### *Discussion of Results*

In this experiment you have observed the chemical property of "like dissolves like." This property refers to the polar nature of the molecules that make up the Styrofoam, the starch, the water, and the acetone.

What is polarity? Polarity is the ability of a molecule to separate positive and negative charges within the molecule. In our experiment, the polar molecules are water and starch. Water ($H_2O$), has one central oxygen atom and two hydrogen atoms bonded off of it. The oxygen atom can more readily hold onto negatively charged electrons, meaning that the molecule can separate the negative and positive charges.

A non-polar molecule does cannot separate charges in this way. The positive and negative charges are scattered throughout the molecule and cancel each other out. In our experiment, acetone and Styrofoam work in this way.

Now recall the idea of "like dissolves like." This means that:

1. A polar liquid CAN dissolve a polar solid
2. A non-polar liquid CAN dissolve a non-polar solid.
3. A non-polar liquid CANNOT dissolve a polar solid
4. A polar liquid CANNOT dissolve a non-polar solid.

***Other questions to think about:***

- Do the rules of "like dissolves like" match up with the results of your experiment?
- In what types of products are starch and acetone normally found?
- Why do think starch-based packaging peanuts are more environmentally friendly than Styrofoam-based packaging peanuts?
- Can you think of other "green" innovations that have made an existing product more environmentally friendly?
- What would happen if you warmed the water before putting in a starch-based packaging peanut? Try testing it using the same experimental set-up as above.

***Credit***

Adapted from Amy Sass.

Earth Science Activity on Earthquakes

# Investigating Mechanical Waves of an Earthquake

**Grade Level:** 6+
**National Standards:** M.D.1 Structure of the earth system

### *Objective*
How does an earthquake work like a wave? **In this experiment, students will look at the different ways in which waves propagate.** They will be asked to think about how these different waves relate to the phenomenon of earthquakes.

### *Introduction*
There are two ways waves can move: transverse and longitudinal. Which do you think relates to earthquakes? Why?

______________________________________________

______________________________________________

______________________________________________

### *Materials and Equipment*
- Slinky

### *Experimental Procedure*
1. Longitudinal waves (Primary earthquake waves):
    a. Get into groups of three. With one partner, stretch a slinky to about 5 meters in length—the slinky shouldn't sag too much, but it should not be drawn too tightly either.
    b. In these positions, either you or your partner should grab about 15 loops. While holding on to the slinky, let the extra loops go. What happens?
    c. The third partner should be watching the event to see it from the side. Let him either draw or describe what is going on.
    d. Switch places so that everyone has the chance to observe and to let the slinky go.
2. Transverse waves travel (Secondary earthquake waves):
    a. In the same group of three, you will be looking at how transverse waves travel.
    b. Again, with one partner, stretch a slinky to about 5 meters in length—the slinky shouldn't sag too much, but it should not be drawn too tightly either.
    c. You or your partner should snap your wrist to the side (or up and down) while holding the slinky. How does the slinky respond?
    d. Have the third partner observe from the side.
    e. Switch places so that everyone has the chance to observe.

### *Discussion of Results*
Was your hypothesis correct? Were you surprised that both types of waves are involved in earthquakes? The waves of earthquakes or seismic waves come in these two forms in the earth's interior. Primary waves travel rapidly through the earth's interior. Secondary waves are a bit slower.

There is another type of wave which is not explored in this activity: surface waves. Surface waves are like ripples on the surface of water and they travel in much the same way. The surface waves are much slower than the body waves that you explored in this activity, and they tend to be much more destructive.

# Earth Science Activity on The Ocean

# *Mapping the Ocean Floor with pre-SONAR Devices*

**Grade Level:** 4-7
**National Standards:** M.D.1 Structure of the earth system

### *Objective*
Have you ever thought about how the ocean floor was mapped prior to the use of SONAR? **In this activity, students will have the opportunity to experience an ocean-mapping method first-hand.**

### *Introduction*
Read ahead about the process of the activity. How efficient do you think the method of using a measured rope to determine the depth of a body of water is?

__________________________________________________________

__________________________________________________________

__________________________________________________________



### *Materials and Equipment (1 of each per student)*
- Scissors
- Tape
- Marker
- String
- Washer ring, nuts, or a nail
- Ruler
- Small pieces of wood
- Wood glue (or tape)
- Shoebox
- Piece of cardboard large enough to cover the entire shoebox (if you remove the sides of the shoebox lid, this can be used here)

### *Experimental Procedure*
Part 1: Creating your Ocean
1. With a partner, you will be designing your own ocean floor. To do this, use an open shoebox. Mark your name on the box (or give your ocean a name) so that you will remember which is yours. Also be sure to label directions (North, South, East, West) on the sides of your box.
2. Glue or tape the pieces of wood to the bottom of the shoebox. Be sure to make it so that the pieces of wood will not move very much if the box is lightly shaken.
3. With the piece of cardboard, cut a small hole (about the size of a quarter). Use this to cover your ocean.

Part 2: Determining the geography of the ocean floor
1. Switch oceans with another set of partners.
2. You will be mapping the bottom of this new ocean.

3. With your string, tie one end of the string to the washer ring, nail, or nut. Starting the tied end of the string, mark every inch, centimeter, or unit of your choice, with a permanent marker. This will serve as an anchor.
4. Without shaking the box too much, measure out even spaces where you will take measurements of the depth. This should essentially be a grid of points where you plan to find the depth. You can be as specific or as general as you want, but know that if you want a more accurate description of the ocean floor, you will want to be more specific.
5. Make a matching grid (noting which direction is which) of the ocean floor. This will serve as your ocean floor map.
6. Now, with the ocean that was given to you, drop the anchor through the cut out hole. When the washer ring reaches the bottom (you will notice that the string won't be taut), read the measurement on the string and record it in the corresponding location on your paper map.
7. Repeat step 6, getting filling in all locations on your map. Slide the cardboard cover as needed so that you can drop your anchor across the ocean.
8. After you have made all measurements, you can map this out topologically.
9. Make another grid corresponding to the ocean floor. Again, note the directions on your new grid.
10. To make this a topological map, you can make deeper locations darker than shallower spots.
11. When you are complete with your map, remove the cardboard cover and see how you and your partner did.

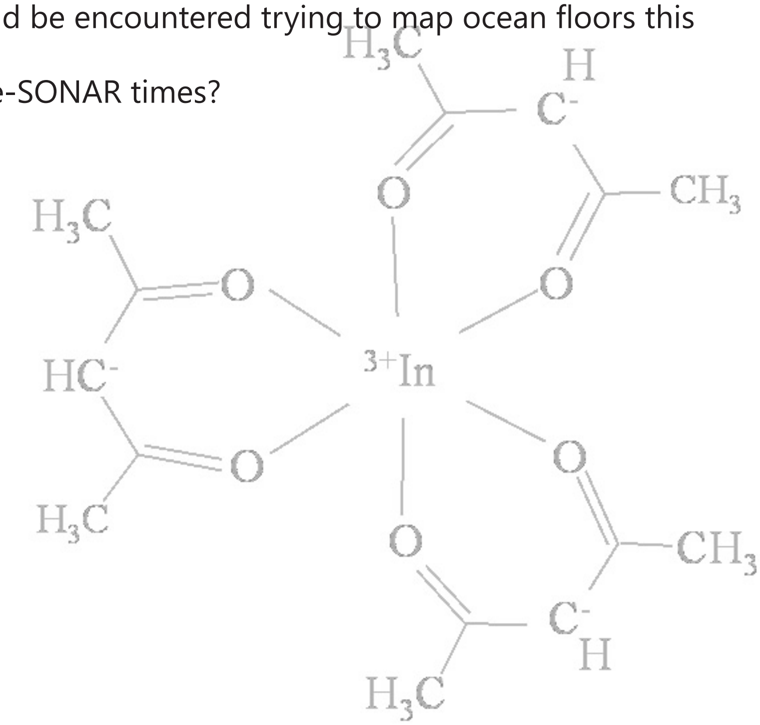
### *Discussion of Results*

How did your results compare to the actual ocean floor? Did you and your partner face any problems along the way?
In this activity, you saw how research of the ocean floor depth was conducted prior to the use and development of SONAR in the early twentieth century.



### *Other questions to think about:*

- In what ways could the activity be made easier?
- What was difficult about this process? Could you imagine mapping the entire ocean floor this way?
- What other problems do you think would be encountered trying to map ocean floors this way?
- How has technology advanced since pre-SONAR times?



# Earth Science Activity on Geotherms

# *The Power of Heat is Right Under Your Feet*

*(www.ScienceBuddies.org)*

**Grade Level:** 5-7
**National Standards:** M.D.1 Structure of the earth system


### *Abstract*

You might know that we are able to get free energy from the Sun, the wind, and water, but did you know we can get free energy from Earth itself? The temperature inside of Earth can reach 9,000°F—that kind of heat can be used to make a *lot* of energy here on the surface! This source of energy is called *geothermal energy* and it is all about taking advantage of the heat within Earth. So try this science fair project out and find out how to use the heat that lies beneath your feet!


### *Objective*

**The goal of this science fair project is to build a model of a geothermal power plant to learn more about geothermal energy.**

### *Introduction*



The word geothermal is comprised of the Greek words *geo,* meaning "earth," and *thermal* meaning "heat." Earth has four different sections: crust, mantle, outer core, and inner core. The first section, the crust, keeps us insulated from the interior heat of the earth. The crust is what we stand on every day. The second section, the mantle, starts at a depth of 1,250 miles and is semi-molten. The third section, the outer core, starts at a depth of 2,500 miles and is liquid. And finally, the inner core is solid and is made up of nickel and iron. It starts at a depth of 4,000 miles and is 9,000°F.

Many features on the crust demonstrate the heat and power within the earth: geysers, fumaroles, and mud pots, to name a few. While each is a different result of the heat from within the earth, the source of the heat is the same.

Geothermal energy is a kind of energy that is renewable and sustainable because it relies on water moving through the water cycle and the interior heat of the earth. All water on Earth is part of the global water cycle; thus, water is a renewable resource. Rainwater seeps miles into the earth. After being heated inside of the earth, the rainwater resurfaces as steam or as hot water, which ultimately lead to some of the features on the crust, mentioned above. Sometimes hot water and steam get trapped in permeable and porous rock under a layer of impermeable rock. This is called a geothermal reservoir. Geothermal reservoirs can reach temperatures of up to 700°F.

Figure 1. The Old Faithful geyser in Yellowstone National Park. (DOE/NREL, credit Joel Renner, 1997.)

Geothermal energy is obtained by tapping into a geothermal reservoir and using the hot water or steam within it to operate a turbine. As the turbine rotates, it generates electricity. These turbines are located at geothermal plants. There are three different kinds of geothermal plants: dry steam, flash steam, and binary cycle. In all cases, the plant becomes part of a cycle where hot water or steam from the reservoir comes in, creates electricity, is cooled, and is then sent back to the reservoir. When the cooled water comes back to the reservoir, it is heated and the cycle starts again. Another advantage of geothermal energy is that the power plants don't emit any greenhouse gases into the air. The only material that geothermal energy plants emit is water vapor.

In this science fair project, you will make a model of a geothermal reservoir and a geothermal energy plant. You will do an experiment to learn more about geothermal energy. Use steam and an empty can to make a pinwheel spin. You'll soon discover how much power the heat beneath your feet really has!

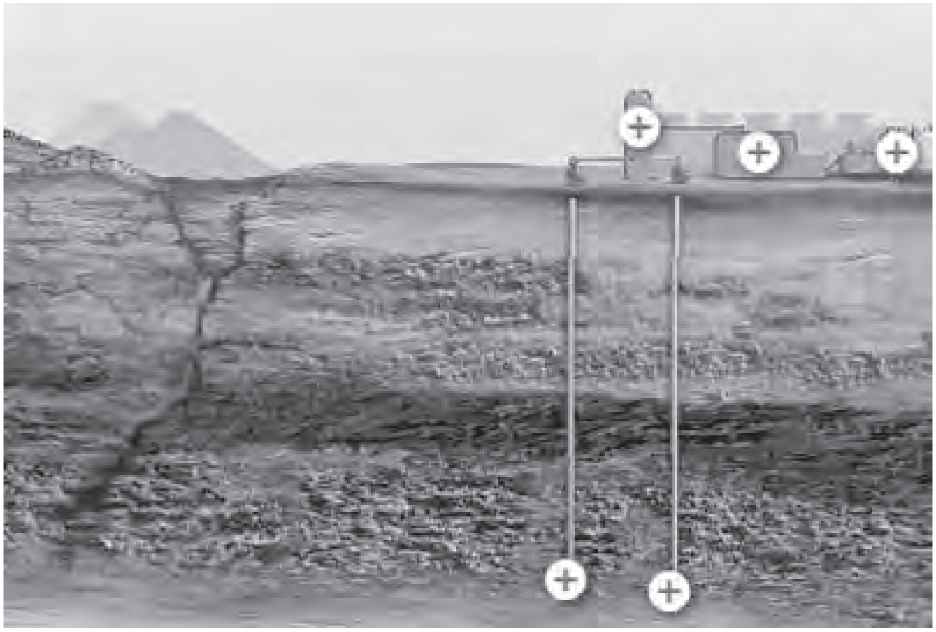


Figure 2. This screenshot is from a brief animation, courtesy of Chevron Corporation, that shows how steam is captured from beneath the ground and turned into electricity by a steam turbine. (Chevron Corporation, 2009.)



***Terms, Concepts and Questions to Start Background Research***

- Geothermal
- Crust
- Mantle
- Outer core
- Inner core
- Molten
- Geyser
- Fumarole
- Mud pot
- Renewable
- Sustainable
- Water cycle
- Permeable
- Porous
- Impermeable
- Geothermal reservoir
- Turbine
- Greenhouse gas

***Questions***

- What is geothermal energy?
- What are the different parts of the Earth?
- What are the advantages of geothermal energy? What are the disadvantages?

- What are the three different types of geothermal plants? How do they use hot water or steam to create electricity?

### *Bibliography*

The following websites have a lot of good information on geothermal energy:


- The Geothermal Education Office. (2008). Retrieved July 7, 2008, from http://www.geothermal.marin.org
- Science Clarified. (n.d.). *Geyser and hot spring.* Retrieved July 7, 2008, from http://www.scienceclarified.com/landforms/Faults-to-Mountains/Geyser-and-Hot-Spring.html


The U.S. Department of Energy's Energy Efficiency and Renewable Energy website has information on the geothermal energy, along with the history of geothermal energy in the United States.


- U.S. Department of Energy. (2006, November). *Energy Efficiency and Renewable Energy: Geothermal Technologies Program.* Retrieved July 7, 2008, from http://www1.eere.energy.gov/geothermal/geothermal_basics.html


### *Materials and Equipment*

- Clean metal can with one lid removed, 14.5-ounces; available at any grocery store
- Hammer
- Nail, 1/8-inch diameter
- Wood ruler or thin piece of wood, 12 inches long
- Rubber bands (2)
- Medium-sized pot, 3 quarts
- Aluminum foil
- Stove top
- Pinwheel, available at toy stores or novelty stores
- Permanent marker
- Timer
- Oven mitt
- Lab notebook
- Graph paper, or you can create it online by visiting Create a Graph: http://nces.ed.gov/nceskids/CreateAGraph/default.aspx

### *Experimental Procedure*

**Note: You will be working with a hot stove top. Please exercise caution when working with hot surfaces and with steam. Steam can cause painful burns.**

1. Using the hammer and nail, make a hole at the edge of the lid that is still attached. Make another hole directly opposite the first hole. Both holes should be no larger than 1/8 inch in diameter.
2. Attach the ruler, vertically, to the side of the can, using rubber bands. Position the ruler so that it is between the two holes. Make sure that the bottom edge of the ruler is flush with the bottom edge of the metal can. The can and ruler should not be tilted when placed on a flat surface. The open end of the can should be facing down. See Figure 3, below.
3. Fill your 3-quart pot with 2 quarts (or just over half full) of tap water. Take a piece of aluminum foil and place it on top of the pot. Crimp the foil down over the edges of the pot so that the water is sealed in. Take another piece of foil and place it on top of the first piece of foil. Crimp the second

Figure 3. The can and ruler assembly is a model of a geothermal power plant.

Environmental & Earth Science

piece to ensure that when the water boils, no steam can get out from the edges. The foil-covered pot models the earth. The aluminum foil is the crust, covering the heat that is within the earth.

4. Gently poke a hole in the center of the aluminum foil pieces, using the nail. Make sure that the nail goes through both layers of aluminum foil. The hole should be no larger than 1/8 inch in diameter.
5. Turn the stove top on medium to medium high and place the pot on top of the flame or hot surface. Note the setting of the stove top in your lab notebook in a data table like the one shown below. The heat setting should be hot enough to boil water; however, make sure that the water doesn't boil so heavily that water hits the foil.
6. Make one large mark on the back of the pinwheel at the base of the spokes with the permanent marker. You want to be able to see the mark clearly while the pinwheel is spinning.
7. Wait for the water to boil. When you see steam coming out of the hole and the foil cover is slightly inflated, you are ready to start the experiment.
8. Get your timer ready. Place the can and ruler on top of the hole in the foil. Let the can sit undisturbed for 30 seconds. This represents a power plant collecting steam from a reservoir in the earth.
9. Now it's time to test your model. Hold the pinwheel, facing down, above the can over both holes. See Figure 4, below. Make sure that the ruler is not in the way of the pinwheel and that the pinwheel is parallel to the can's top. If necessary, push the ruler down gently so that the can doesn't move too much. The pinwheel will start spinning. Note the height at which you are holding the pinwheel. You can use the ruler to determine the height. Write this number down in your lab notebook.
10. You're ready to start the experiment. First note the location of the mark on the back of the pinwheel. Each time you see that mark reach that location again, the pinwheel has made a complete spin. Count the number of complete spins in 20 seconds. Use the timer to keep track of time and the mark you made on the pinwheel to count the number of spins. Record the number of complete spins in 20 seconds in your lab notebook. Repeat this step two more times and record the information in your lab notebook.

Figure 4. This image shows the experimenter testing the geothermal power plant model.

11. Use the oven mitt and remove the can from the top of the pot and place it to the side. Now hold the pinwheel over the hole in the foil at the same height as in step 10. You might need a helper to hold the ruler near the pan, flush with the aluminum foil, but in the air, so you can see how high you should be holding the pinwheel. Count the number of complete spins the pinwheel makes in 20 seconds. Use the timer to keep track of time. Record the information in your lab notebook. Repeat this step two more times and record all information in your lab notebook. Holding the pinwheel over the bare foil without the can represents the power of geothermal steam from the earth without a power plant.
12. Take the pot off the flame or hot surface and let it cool down. After it has cooled down, you can leave the water that's in the pot, simply adding some more to fill the pot just past half full. Carefully undo the foil, add the water, and crimp the foil back onto the pot. Now use the nail and poke eight more holes in both aluminum foil layers around the edge of the pot.

Figure 5. Counting the number of spins over bare foil.

13. Turn on the stove top to the setting recorded in your lab notebook from step 5. Once the water is boiling and there is steam coming out of the holes, place the can and ruler on top of the hole in the middle of the foil and pot. Use your timer and let it sit there for 30 seconds. Now hold the pinwheel above the can and the two holes at the same height as recorded in your lab notebook from step 10. Count the number of complete spins that the pinwheel makes in 20 seconds. Use the timer to keep track of time. Repeat this step two more times and record all information in your lab notebook.
14. Use the oven mitt and remove the can from the pot and place it to the side. Now hold the pinwheel over the hole in the center of the foil at the same height as in step 10. Again, you might need a helper to hold the ruler near the pan, flush with the aluminum foil, but in the air, so you can see how high you should be holding the pinwheel. Get your timer ready. Count the number of complete spins the pinwheel makes in 20 seconds and write the value in your lab notebook. Repeat this step two more times and write all of the information in your lab notebook.
15. Remove the pot from the flame or hot surface and let it cool down. Repeat step 12, this time poking 12 more holes in the foil around the edge of the pot (for a total of 20 holes around the edge) and repeat steps 13-14.
16. What does poking holes around the edge of the foil do? Does it affect the number of pinwheel spins when the pinwheel is over just the foil? Does it affect the number of pinwheel spins when the pinwheel is above the can?
17. Graph the information in your lab notebook on a scatter plot. If you need help with making or understanding scatter plots or would like to build your scatter plots online, go to the following website: http://nces.ed.gov/nceskids/CreateAGraph/default.aspx.
18. Make two different scatter plots, one showing the recorded data with the can on top of the pot and one without the can on top of the foil (table on next page). For both plots, label the x-axis Holes Around the Edge and the y-axis, Average Number of Pinwheel Spins. The can on top of the foil models a geothermal power plant. What kind of conclusion can you make about how geothermal power plants work?

| Number of Holes Around the Edge | Number of Pinwheel Spins | |
|---|---|---|
| | No Can, Bare Foil | With Can on Foil |
| | | |
| | | |
| | | |
| | Average: | Average: |
| | | |
| | | |
| | | |
| | Average: | Average: |
| | | |
| | | |
| | | |
| | Average: | Average: |
| | | |
| Stove Top Setting= | Height of Pinwheel= | |

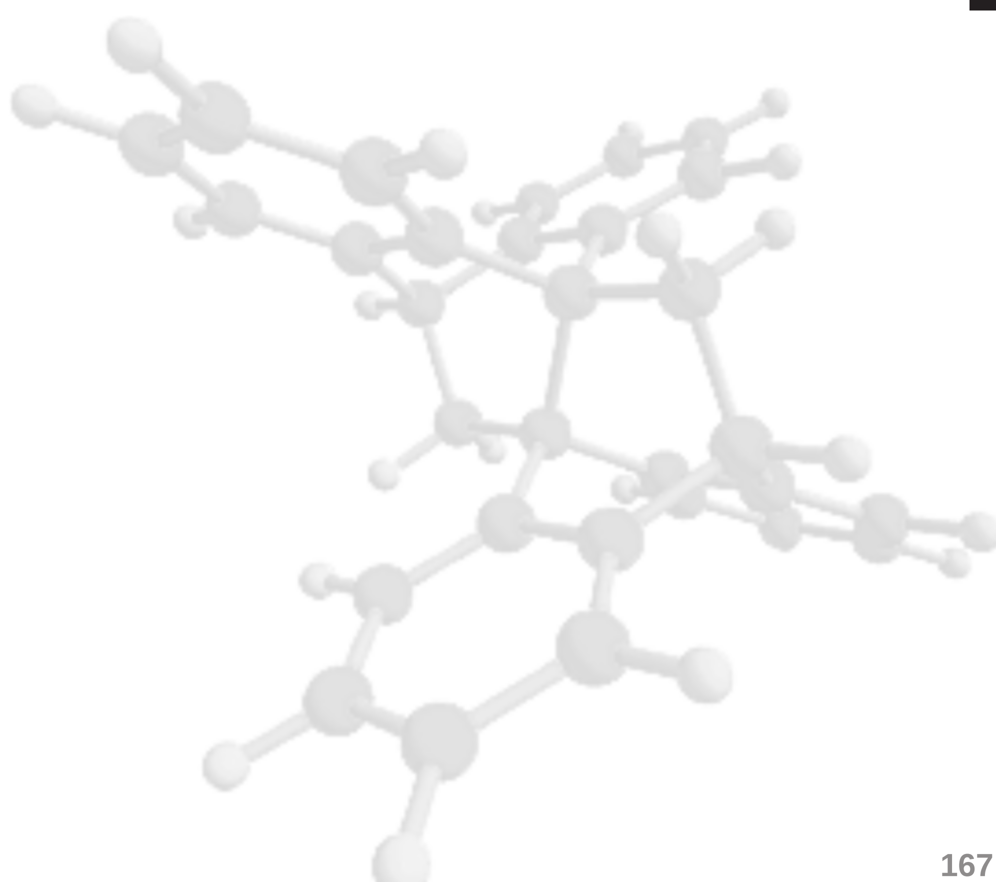
### *Variations*

- Change the height that you place the pinwheel over the can and the central hole. What kind of change do you see?
- What happens if you change the size of the can? Does this affect the number of pinwheel spins?
- For more science project ideas in this area of science, see Energy & Power Project Ideas (http://www.sciencebuddies.org/science-fair-projects/recommender_interest_area.php?ia=Energy).

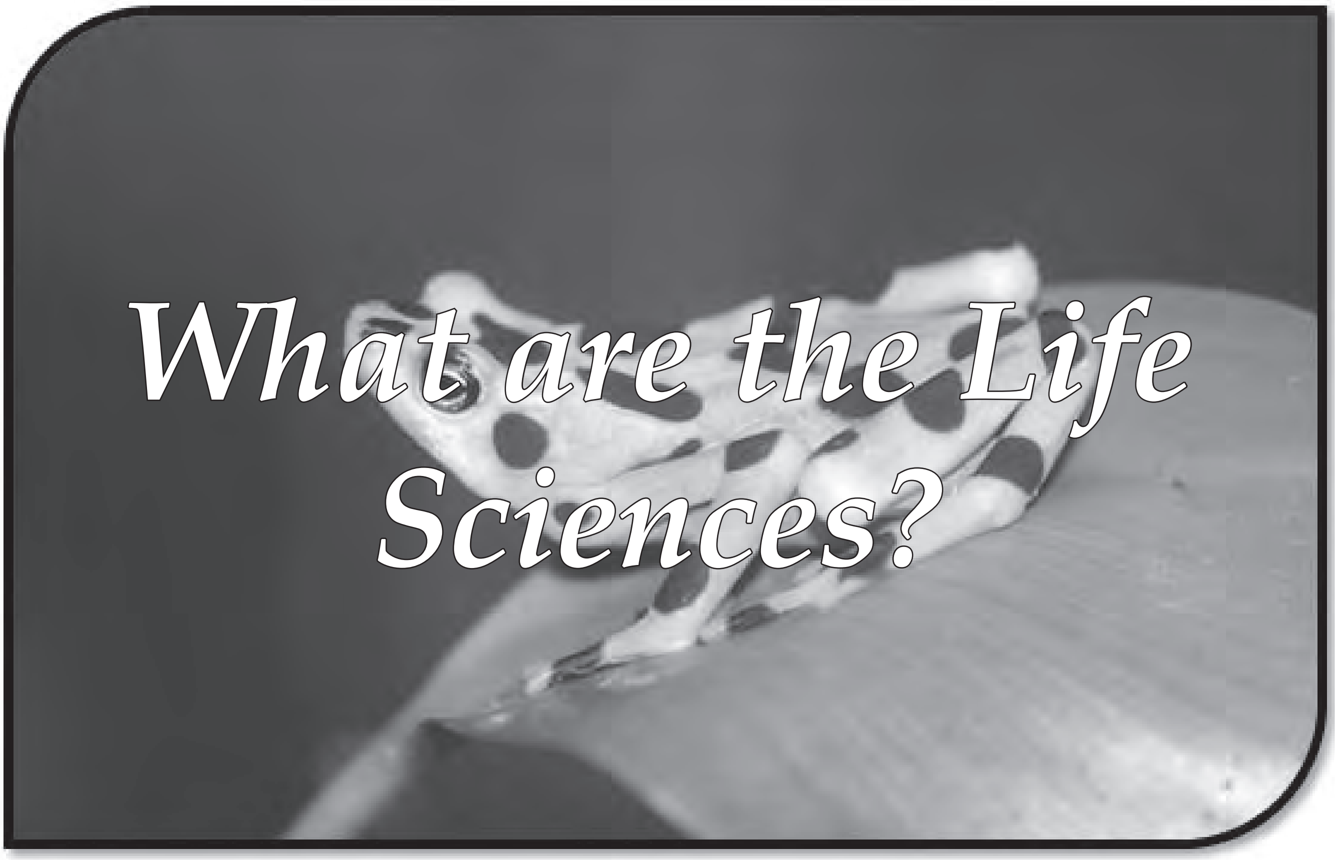
### *Credits*

Michelle Maranowski, PhD, Science Buddies





# What are the Life Sciences?



***The life sciences*** include the studies of living organisms like plants and animals, including human beings.  Biology, in particular, is concerned with the structure, function, growth, origin, evolution, and distribution of life and living things.

Life scientists include all those who look at life, from zoologists who study animals and their interactions to biochemists who elucidate protein pathways that cause biological processes.

**Photo credit: Brian Gratwicke @Flickr**

## *If you like the life sciences you may like the careers chosen by these people:*

| ScienceMaker | Occupation | Location | Question Topics |
|---|---|---|---|
| **Agnes Day** | Chair of Microbiology Department | *Howard University* | Cancer and drug resistance |
| **Carol Folt** | Professor of Biological Sciences and Provost | *Dartmouth University* | Biomagnification, metal contamination and toxins |
| **Tyrone Hayes** | Professor of Integrative Biology | *University of California, Berkeley* | Hormones and indicator species |
| **John Haynes** | Dean of Science & Mathematics | *Morehouse College* | Disease and sickle cell anemia |
| **Jeanette Jones** | Professor of Biology | *Alabama A&M University* | Fungus |
| **Floyd Malveaux** | Dean | *Howard University College of Medicine* | Allergies and asthma |
| **Stephen Mayo** | Professor of Biology & Chemistry | *California Institute of Technology* | Molecular biology |

# The Life Sciences in Action

## ***Endangered Species*** ("Giant Panda" by Jeff Kubina @ Flickr)

The giant panda is just one animal on a long list of endangered species. Endangered species are chosen because on their dwindling population size or the presence of a distinct threat in their environment which could pose a challenge to the survival of the species. Some examples of endangered species include: the blue whale, the snow leopard and the orangutan.

## ***The Human Genome Project*** ("DNA Rendering" by ynse @ Flickr)



After thirteen years of research, the Human Genome Project was completed in 2003 with the sequencing of more than 20,000 genes. The research will be useful in the medical and biological fields, particularly in the areas of evolution and immunology. Other animals that have completely sequenced genomes include: the chimpanzee (2005), the dog (2005), the chicken (2004), the house mouse (2001), the fruit fly (2000), Asian rice (2002), and Baker's yeast (1992-1997).

# ScienceMakers
## Spotlight: Agnes A. Day



| Name | Agnes A. Day |
|---|---|
| Birth Date | July 20, 1952 |
| Birth Place | Plains, Georgia |
| Education | Mainland Sr. High School<br>Bethune-Cookman College<br>Howard University |
| Type of Science | Microbiology |

## Biography

Microbiologist Agnes A. Day was born on July 20, 1952 in Plains, Georgia to Annie Lee Laster and David Laster. The youngest of thirteen children, Day was raised by her third-grade teacher, Reverend Mrs. Rosemarie Bryant. Day's interest in science began when she and her older brother would walk through the woods catching insects and animals. She learned how to ask the question "why?" during these experiences. After graduating from Mainland Sr. High School, Day attended Bethune-Cookman College in Florida where she received her B.S. degree in biology. Day then attended Howard University, graduating with her Ph.D. degree in microbiology in 1984.

**"Brown Stew Fungus?" by Roger B. @Flickr.**

After obtaining her graduate degree, Day became a research fellow in the Bone Research Branch at the National Institute of Dental Research, part of the National Institutes of Health (NIH). She left in 1988 to join the faculty at Howard University as an assistant professor. Since 1992, Day has served as a tenured associate professor of microbiology in the College of Medicine at Howard University. She also became chairman of the department of microbiology. In addition to instructing students in medicine, dentistry, pharmacy, and coordinating graduate courses, Day is known for her research on drug-resistant fungi and breast cancer health disparities.

In 1995, Day was awarded the Outstanding Research Award by the Howard University College of Medicine. She has also received the College's Kaiser-Permanente Outstanding Teaching Award, and has mentored over forty students. Day is a member of the American Association for Cancer Research and sits on its Minorities in Cancer Research and Women in Cancer Research committees. She is also a member of the American Society for Microbiology where she is a member of the Committee on Microbiological Issues which Impact Minorities (CMIIM). She also served as a consultant for the American Association for the Advancement of Science's Black Churches-Black Colleges program. Day is in demand as a science expert, having been interviewed as part of a Public Broadcasting Service (PBS) special and TheGrio's *Black History* series. In addition, she has served on numerous panels as a scientific expert in microbiology and breast cancer research.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Day?
#2 Where was Dr. Day born? Locate it on a map. How far away is this from where you live? What are the names of her parents? What do you think it was like for Dr. Day to be raised by her third grade teacher? Where did Dr. Day attend high school? What do you think high school was like for her?
#3 How old are you? In what year was Dr. Day your age? What was happening in the United States that year? What was happening in the world that year? What do you think her life was like when she was your age?
#4 In science, what is the importance of asking the question "why?"
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a microbiologist does? Would you like to be a microbiologist? Why? Why not?
#2 If you were a microbiologist, what topics would you study?
#3 What is cancer? What makes it difficult to treat? How does it spread through the body? Do you think scientists will ever discover a cure for cancer?
#4 What are some of the questions Dr. Day tries to answer about cancer? What questions would you ask?
#5 What does it mean for something to be drug-resistant? Is this a bad thing or a good thing? What would happen if the bacteria that causes strep throat (*Streptococcus pyogenes*) was drug-resistant?

# Glossary

*Cancer*
Any malignant growth or tumor caused by abnormal and uncontrolled cell division; it may spread to other parts of the body through the lymphatic system or the blood stream.

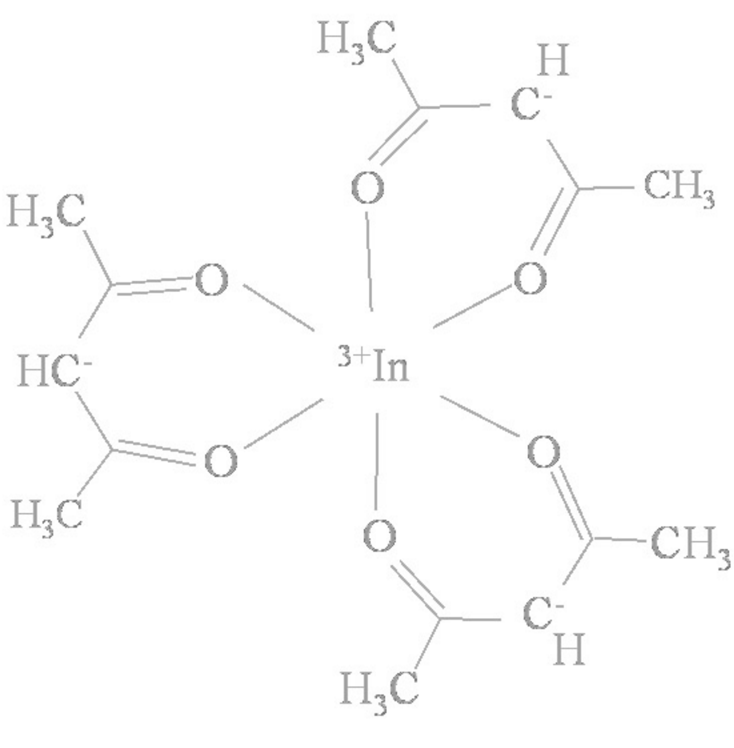
*Fungi*
The taxonomic kingdom including yeast, molds, smuts, mushrooms, and toadstools; distinct from the green plants.

*Microbiology*
The study of microorganisms, which are unicellular or cell-cluster microscopic organisms. This includes eukaryotes such as fungi and protists, and prokaryotes.

*National Institutes of Health (NIH)*
An agency in the Department of Health and Human Services whose mission is to employ science in the pursuit of knowledge to improve human health; the principal biomedical research agency of the federal government.

*Tenured*
Appointed for life and not subject to dismissal except for a grave crime.

Life Sciences



# ScienceMakers
# Spotlight: Carol L. Folt

| | |
|---|---|
| **Name** | Carol L. Folt |
| **Birth Date** | 1951 |
| **Education** | University of California, Santa Barbara<br>University of California, Davis |
| **Type of Science** | Biology |

## Biography

Environmental scientist and biology professor Carol L. Folt was born in 1951. She received her B.A. degree in aquatic biology and her M.A. degree in biology from the University of California, Santa Barbara. She then earned her Ph.D. degree in ecology from the University of California, Davis in 1982. Her dissertation was entitled, "The effects of species interactions on the feeding and mortality of zooplankton."


**"Jumping salmon" by fotoroto @Flickr.**

Upon graduation, she became a faculty member of Dartmouth College in 1983, and by 1997, Folt was a full-time professor of biological sciences. She later became associate director of the Dartmouth Toxic Metals Research Program. This program has been principally interested in examining the way that toxic metals affect ecosystems and the human population. In 2004, Folt was selected to serve as the Dean of the Faculty, and in May 2010, she was named provost of Dartmouth College. In her position as professor and researcher, Folt has served as a mentor to a number of students in both the undergraduate and graduate levels. For example, she has been a participating member in Dartmouth's Women-in-Science Project during her career at Dartmouth. Although she has taken on leadership roles in the college that demand most of her time, Folt remains active with her research projects. Her interests include: the biomagnification of metals in aquatic food webs, environmental responses in the genetic material of the water flea, restoration of the Atlantic salmon in its native environment, and information gathering and decision-making in animal behavior. Through her work, Folt has garnered over $40 million in grants and funding for her research.

Folt was awarded the John M. Manley Huntington Award for Teaching in 1991. In 2010, she was named a fellow of the American Association for the Advancement of Science (AAAS). Folt has also been an active participant in a number of professional organizations, including the Ecological Society of America and the American Society of Limnology and Oceanography. Folt is married to David Peart, who is also a professor in the Department of Biological Sciences at Dartmouth College. Folt and Peart have two children.

## Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Folt?
#2 How old are you? In what year was Dr. Folt your age? What was happening in the United States that year? What was happening in the world that year? What do you think her life was like when she was your age?
#3 Where did Dr. Folt attend college? Locate the city where you find this college on a map. How far is this from where you live? What do you think college was like for Dr. Folt?
#4 In what ways has Dr. Folt's research impacted your life? Why is it important to study the ecosystem?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think an aquatic biologist does? Would you like to be an aquatic biologist? Why? Why not?
#2 If you were an aquatic biologist, what topics would you study?
#3 What is biomagnification? Mercury in fish is a particular problem associated with biomagnification. Look up which fish tend to have higher levels of mercury stored in their bodies. Where does the mercury come from? Why is it a big problem for aquatic organisms? Where do you think the mercury enters the food chain?
#4 What are trophic levels? Research a system of trophic levels and describe it by naming organisms that belong to each trophic level. How are the trophic levels related to biomagnification?
#5 What affects does an overdose of certain metals (such as mercury) have on the body? Why are they potentially dangerous to humans when taken in large amounts? Can you find an example where the biomagnification of a specific metal or toxin in the food chain has directly impacted the human population?

# Glossary

*American Association for the Advancement of Science (AAAS)*
An international non-profit organization with the stated goals of promoting cooperation between scientists, defending scientific freedom, encouraging scientific responsibility, and supporting scientific education and science.

*Biomagnification*
The process by which certain materials accumulate in organisms that are at higher energy levels in the food chain in an ecosystem. Also known as bioamplification.

*Ecology*
The branch of biology concerned with the relations between organisms and their environment.

*Ecosystem*
A system formed by the interaction of a community of organisms with their physical environment.

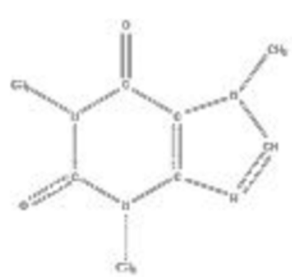
*Genetic material*
Deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). DNA and RNA store "information" through unique sequences of nucleotides, the building blocks of DNA and RNA.

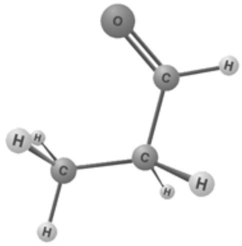
*Limnology*
The scientific study of bodies of fresh water for their biological and physical and geological properties.

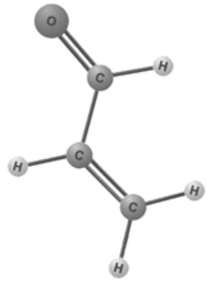
*Oceanography*
The exploration and scientific study of the oceans and ocean floor.

*Provost*
A high-ranking university administrator.

*Toxic*
Having a chemical nature that is harmful to health.







# ScienceMakers
## Spotlight: Tyrone B. Hayes

| | |
|---|---|
| **Name** | Tyrone B. Hayes |
| **Birth Date** | July 29, 1967 |
| **Birth Place** | Columbia, South Carolina |
| **Education** | Harvard University<br>University of California, Berkeley |
| **Types of Science** | Environmental Science<br>Endocrinology |

## Biography



Endocrinologist and biology professor Tyrone B. Hayes was born on July 29, 1967 in Columbia, South Carolina to Romeo and Susie Hayes. In the swamps near Columbia, Hayes first discovered his interest in science by observing how frogs morphed from tadpoles into their adult form. He earned his B.A. degree in biology in 1989 from Harvard University. His dissertation on the genetic and environmental mechanisms determining the gender of the wood frog was indicative of the research he would later pursue. Following his graduation from Harvard University, Hayes continued his studies at the University of California, Berkeley, where he received his Ph.D. degree in integrative biology in 1993 for his study of the role of hormones in mediating developmental responses to environmental changes in amphibians.

"nite time frog" by daz smith @Flickr.

Hayes worked as a National Science Foundation (NSF) postdoctoral research fellow at the University of California, Berkeley before he became an assistant professor in 1994. He was appointed to a full professorship in 2003. Hayes' scientific research continued to focus on the potential of genetic adaptation and the role of hormones in the development of the amphibian. His investigations have shown that chemical agents have the ability to negatively impact the sexual development of amphibians, even when such toxins are present in low concentrations. Hayes has taken an interest in the hormonal regulation and development of aggressive behavior. He has also been active with the National Science Foundation Review Panel since 1995, and he has served on several other advisory boards as well.

Hayes has won several awards for his teaching and his research, including the Distinguished Teaching Award from the University of California, Berkeley in 2002 and the President's Citation Award from the American Institute of Biological Science in 2004. He was also awarded the National Geographic Emerging Explorer Award and the Jennifer Altman Award in 2005.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Hayes?
#2 Where was Dr. Hayes born? Locate it on a map. How far away is this from where you live? What are the names of his parents? Where did Dr. Hayes attend college? What do you think college was like for him?
#3 How old are you? In what year was Dr. Hayes your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 How does Dr. Hayes's research help answer questions about the effect of chemicals on the environment, and on animals? Why is this important?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think an environmental scientist does? Would you like to be an environmental scientist? Why? Why not?
#2 What do you think an endocrinologist does? Would you like to be an endocrinologist? Look up the term "endocrinology" in a dictionary if you need help.
#3 If you were an endocrinologist, what topics would you study?
#4 What is a hormone? Can you name a few examples? What purpose do they serve?
#5 Why do you think Dr. Hayes chose to study frogs, rather than something like mice or insects? Is the health of frogs a good indicator of the status of the environment? Why or why not?

# Glossary

*Adaptation*
The evolutionary process whereby a population becomes better suited to its habitat. This process takes place over many generations, and is one of the basic phenomena of biology.

*Amphibian*
A class of cold-blooded vertebrates that typically living on land but breed in water; aquatic larvae undergo metamorphosis into adult form.

*Concentration*
The strength of a solution or the number of molecules of a substance in a given volume.

*Endocrinology*
The study of hormones and the glands that release them to regulate the conditions of the body.

*Genetic*
Of or relating to or produced by or being a gene.

*Hormone*
The secretion of an endocrine gland that is transmitted by the blood to the tissue on which it has a specific effect.

*National Science Foundation (NSF)*
A United States government agency that supports fundamental research and education in all the non-medical fields of science and engineering. Its medical counterpart is the National Institutes of Health.

*Postdoctoral research*
Academic or scholarly research conducted by a person who has completed his or her doctoral studies, normally within a five year period. It is intended to further deepen expertise in a specialist subject, including necessary research skills and methods.

*Toxin*
A harmful or poisonous agent.

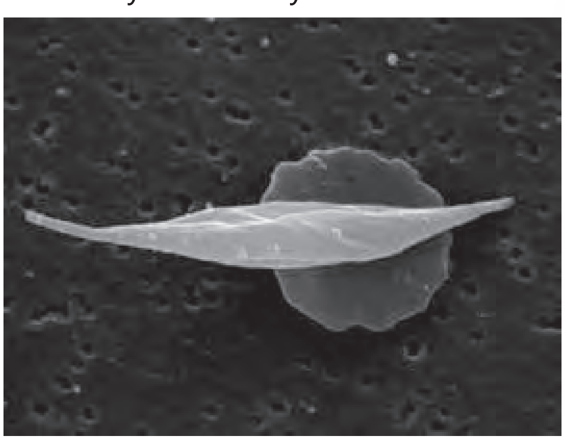
# ScienceMakers
## Spotlight: John K. "JK" Haynes

| Name | John K. "JK" Haynes |
|---|---|
| Birth Date | October 30, 1943 |
| Birth Place | Monroe, Louisiana |
| Education | Southern University Laboratory School<br>Morehouse College<br>Brown University |
| Type of Science | Biology |

## Biography



Biologist and biology professor John K. "JK" Haynes was born on October 30, 1943 in Monroe, Louisiana to John and Grace Haynes. His mother was a teacher and his father was the principal of Lincoln High School in Ruston, Louisiana. Haynes began first grade when he was four years old. When he was six, his family moved to Baton Rouge, Louisiana and Haynes began attending Southern University Laboratory School. He attended Morehouse College when he was seventeen and he received his B.S. degree in biology in 1964. Haynes aspired to attend medical school. However, a professor advised him to apply to graduate school and he went on to attend Brown University, where he obtained his Ph.D. degree in biology in 1970.



**"Sickle-cell anaemia" by ScientificRelevance.com @ Flickr.** Two red blood cells are pictured. The one in front has been affected by sickle-cell anaemia. The one behind it is a healthy blood cell.

Haynes completed his first year of <u>postdoctoral research</u> at Brown University, where he worked on <u>restriction enzymes</u>. During this time, he became interested in <u>sickle cell anemia</u>, which led to a second postdoctoral appointment in <u>biochemistry</u> at Massachusetts Institute of Technology (MIT), where he worked with Vernon Ingram, the scientist who discovered the <u>amino acid</u> difference between normal and <u>sickle cell</u> <u>hemoglobin</u>. In 1973, Haynes joined the faculty at the Meharry Medical School as a junior faculty member in the department of <u>genetics</u> and molecular medicine and the department of <u>anatomy</u>. His research was focused on why sickle cells were less deformable than normal. In 1979, he returned to

Morehouse College as an associate professor of biology as well as the director of the Office of Health Professions. As part of his work, Haynes created a program for high school students interested in medical school. Haynes has also helped recruit minority students into science with the assistance of agencies like the National Science Foundation (NSF), the Howard Hughes Medical Institute (HHMI), and the National Institutes of Health (NIH). Haynes became the endowed David E. Packard Chair in Science at Morehouse College and chairman of the biology department in 1985. In 1991, he took a sabbatical and went to Brown University to continue his work on sickle cells. Since 1999, he has served as Dean of Science and Mathematics at Morehouse College.

Under Haynes administrative leadership, new buildings for both chemistry and biology were created at Morehouse College as well as a curriculum with emphasis on lab work. Haynes has published papers on cell biology as well as on undergraduate STEM education.

## Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Haynes?
#2 Where was Dr. Haynes born? Locate it on a map. How far away is this from where you live? What are the names of his parents?
#3 How old are you? In what year was Dr. Haynes your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 Dr. Haynes began first grade at an early age. When did you begin first grade? What was it like to be starting school?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a cellular biologist does? Would you like to be a cellular biologist? Why? Why not?
#2 If you were a cellular biologist, what topics would you study?
#3 Why is there a strong connection between biology and medicine? What are the different career paths available to a person interested in biology?
#4 Sickle cell anemia is a blood condition. Can you think of other diseases that affect red blood cells? Why do you think the condition is called "sickle-cell" anemia? Look at the shape of the affected cell in the picture above for a hint.
#5 How is the body affected by sickle-cell anemia? Is there a cure? Is treatment available? How is the disease transmitted?

# Glossary

*Amino acid*
Simple organic molecules which link together in chains to form proteins.

*Anatomy*
The branch of morphology that deals with the structure of animals.

*Biochemistry*
The organic chemistry of compounds and processes occurring in living organisms.

*Cell biology*
An academic discipline that studies cells – their physiological properties, their structure, the organelles they contain, interactions with their environment, their life cycle, division and death.

*Genetics*
The branch of biology that studies heredity and variation in organisms.

*Hemoglobin*
The iron-containing substance in red blood cells that transports oxygen from the lungs to the rest of the body; it consists of a protein (globulin), and haem group (a porphyrin ring with an atom of iron at its center).

*Howard Hughes Medical Institute (HHMI)*
A nonprofit medical research organization whose mission is to support and advance biomedical research and science education in the United States.

*National Institutes of Health (NIH)*
An agency in the Department of Health and Human Services whose mission is to employ science in the pursuit of knowledge to improve human health; the principal biomedical research agency of the federal government.

*National Science Foundation (NSF)*
A United States government agency that supports fundamental research and education in all the non-medical fields of science and engineering. Its medical counterpart is the National Institutes of Health.

*Postdoctoral research*
Academic or scholarly research conducted by a person who has completed his or her doctoral studies, normally within a five year period. It is intended to further deepen expertise in a specialist subject, including necessary research skills and methods.

*Restriction enzyme*
A class of enzymes that cut DNA at specific locations identified by the nucleotide sequence.

*Sabbatical*
A period of time (usually one semester) when a faculty member is not teaching, but concentrating on his/her own education or research.

*Sickle cell*
An abnormal red blood cell that has a crescent shape and an abnormal form of hemoglobin.

*Sickle cell anemia*
A recessive genetic life-long blood disorder characterized by red blood cells that assume an abnormal, rigid, sickle shape.

# ScienceMakers
## Spotlight: Jeanette Jones

| | |
|---|---|
| **Name** | Jeanette Jones |
| **Birth Date** | September 19, 1950 |
| **Birth Place** | Fort Valley, Georgia |
| **Education** | Henry Alexander Hunt High School<br>The Fort Valley State University<br>Ohio State University |
| **Types of Science** | Biology<br>Medical Mycology |



## Biography

Biologist Jeanette Jones was born on September 19, 1950, in Peach County, Fort Valley, Georgia. She attended Fort Valley State University in Fort Valley, Georgia where she received her B.S. degree in biology education in 1972. She went on to attend The Ohio State University where she received her M.S. degree in botany/mycology specializing in medical mycology in 1973 and her Ph.D. degree in 1976.

**"wild mushrooms – Vancouver, BC" by Avi Dolgin @Flickr.**

Following graduate school, Jones was hired as an assistant professor of biology at Alabama A&M University in 1976. That same year, she became a member of the graduate faculty at the university and she was promoted to the rank of full professor of biology in 1986. While continuing in her faculty role at Alabama A&M University in 1985, Jones joined the faculty at Florida Agricultural and Mechanical University as an adjunct professor in the university's College of Pharmacy and Pharmaceutical Sciences for two summers to work on a special project with the National Aeronautics and Space Administration (NASA). In 1991, Jones served as the first female vice president for research and development for approximately seven years at Alabama A&M University. She also served as President of Alabama A&M University's Faculty Senate from 2001 to 2006. Since 2004, Jones has been director of the Center for Biomedical, Behavioral and Environmental Research.

She has also acted as consultant for federal agencies on training programs to attract women and minorities to STEM disciplines. Since 2005, Jones has served on the Research Centers in Minority Institutions' External Advisory Committee at Jackson State University in Mississippi. Her research deals with emerging biological warfare agents, aerobiology, and medical mycology.

In 1975, Jones was listed in the *World's Women Who's Who* and in 1978 she was named an Outstanding Young Woman of America. Jones has received the distinguished service award from the Beta Beta Beta National Biological Honor Society and the Significant Service Award from the NASA Space Life Sciences Training Program. In 2003, the National Institutes of Health (NIH) gave her its Extramural Associate Research Development Award. At Alabama A&M University, she has been bestowed the Outstanding Leadership Award, a Resolution for Distinguished Service from the Board of Trustees, and was named Woman of the Year in 1990 and 2006. In 1994, she was been appointed to the United States Army Science Board by the Secretary of the Army and continues in this capacity today.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Jones?
#2 How old are you? In what year was Dr. Jones your age? What was happening in the United States that year? What was happening in the world that year? What do you think her life was like when she was your age?
#3 Where did Dr. Jones attend college? In what city is this college located? Find it on a map. How far is this from where you live? What do you think college was like for Dr. Jones?
#4 Dr. Jones was listed in *World's Women Who's Who* in 1975. Who else do you think was on this list? Research and find out.
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a biologist does? Would you like to be a biologist? Why? Why not?
#2 If you were a biologist, what topics would you study?
#3 Mycology is the study of fungi. Can you name a type of fungus? Does it have any medicinal properties? What makes a fungus distinct from a plant?
#4 An aerobiologist studies organisms that rely on the wind for their movement. What are some specific organisms that an aerobiologist studies?
#5 Dr. Jones is studying how fungi might be used as agents of war. What purpose do you think fungi serve in modern warfare? Are they beneficial or harmful to those who are subjected to them?

# Glossary

*Adjunct professor*
A professor who is an assistant or subordinate to another.

*Aerobiology*
A branch of biology that studies organic particles, such as bacteria, fungal spores, very small insects, pollen grains and viruses, which are passively transported by the air.

*Biological warfare*
The use of pathogens such as viruses, bacteria, other disease-causing biological agents, or the toxins produced by them as weapons.

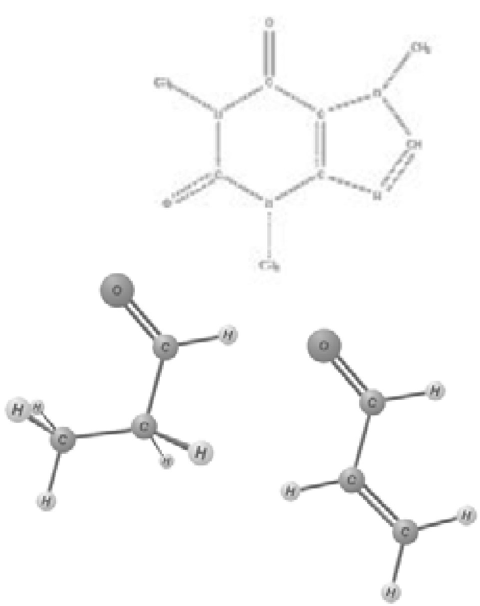
*Botany*
The scientific study of plants, including their physiology, structure, genetics, ecology, distribution, classification, and economic importance.

*Mycology*
The branch of biology concerned with the study of fungi, including their genetic and biochemical properties, their taxonomy and their use to humans.

*National Aeronautics and Space Administration (NASA)*
An independent agency of the United States government responsible for aviation and spaceflight.

*National Institutes of Health (NIH)*
An agency in the Department of Health and Human Services whose mission is to employ science in the pursuit of knowledge to improve human health; the principal biomedical research agency of the federal government.





# ScienceMakers
## Spotlight: Faloyd Joseph Malveaux

| Name | Floyd Joseph Malveaux |
|---|---|
| Birth Date | January 11, 1940 |
| Birth Place | Opelousas, Louisiana |
| Education | Holy Ghost High School<br>Creighton University<br>Loyola University<br>Michigan State University<br>Howard University<br>Washington Hospital Center<br>Johns Hopkins University |
| Types of Science | Microbiology<br>Medicine |

## Biography

Life Sciences

Allergist and physician Floyd Joseph Malveaux was born on January 11, 1940 in Opelousas, Louisiana. His mother was a math and science teacher. Malveaux did well in school, placing first in a state-wide math competition for minority high school students. He attended Creighton University in Omaha, Nebraska where he received his B.S. degree in 1961 in biological sciences. Malveaux then attended Loyola University in Chicago, where he earned his M.S. degree in biological sciences in 1964. Following his time there, Malveaux went to Michigan State University where he received his Ph.D. degree in microbiology and public health and then to Howard University where he attended medical school. Malveaux completed his postgraduate studies at Washington Hospital Center and Johns Hopkins University.

"Asthma Inhalers" by allmothers @Flickr.

During his last year as a student at Howard University, Malveaux became interested in allergies and asthma. He trained in internal medicine and allergy/clinical immunology before returning to Howard in 1978 to become an associate professor of medicine. At the Howard University College of Medicine (HUCM), Malveaux created a training program for allergists/immunologists based on his work in allergies and immunology. In 1986, Malveaux was invited to join the faculty at Johns Hopkins University, where he went on to found the Urban

Asthma and Allergy Center in Baltimore, Maryland. In 1989, he joined HUCM as Chair of the Microbiology Department. His work led to the Community Outreach for Asthma Care, a new treatment program at HUCM. In 1995, Malveaux became the dean of HUCM, forcing him to give up his clinical practice. However, he continued to conduct research on allergies and asthma. Malveaux retired from HUCM in 2005 and joined the Merck Childhood Asthma Network, Inc. as its head.

Malveaux is the recipient of several awards, including election to the Institute of Medicine of the National Academies, the National Institutes of Health's (NIH) National Research Service Award in 1991, and the Jewel Plummer Cobb Distinguished Lecture Award from Johns Hopkins in 1998. He cites one of the most rewarding aspects of his career as increasing public awareness of asthma and healthy lifestyles.to the United States Army Science Board by the Secretary of the Army and continues in this capacity today.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Malveaux?
#2 Where was Dr. Malveaux born? Locate it on a map. How far away is this from where you live? What are the names of his parents? Where did Dr. Malveaux attend college? What do you think college was like for him?
#3 How old are you? In what year was Dr. Malveaux your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 Why do you think Malveaux attended medical school? How did that change his career path? What is a Ph.D. degree? How does it differ from a M.D. degree?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a microbiologist does? Would you like to be a microbiologist? Why? Why not?
#2 If you were a microbiologist, what topics would you study?
#3 What parts of the body does asthma affect? How does a person acquire asthma? How is it treated?
#4 Are you allergic to anything? What are some of the side effects of allergies? Why do some people have allergies and others don't, or why isn't everybody allergic to the same thing?
#5 Where is the nearest medical school to you? How long does it take to earn a degree?

# Glossary

*Allergy*
A condition of hypersensitivity to a substance considered harmless to most people. Exposure to such substances causes the body to undergo a reaction, often resulting in symptoms such as difficulty breathing, swellings and rashes.

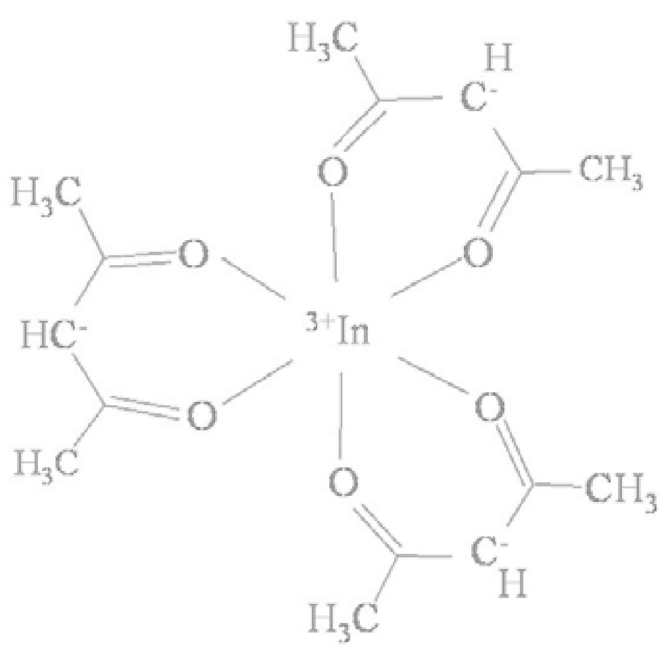
*Asthma*
A long-term respiratory condition, in which the airways may unexpectedly and suddenly narrow, often in response to an allergen, cold air, exercise, or emotional stress. Symptoms include wheezing, shortness of breath, chest tightness, and coughing.

*Immunology*
The branch of medical science that studies the body's immune system.

*Microbiology*
The study of microorganisms, which are unicellular or cell-cluster microscopic organisms. This includes eukaryotes such as fungi and protists, and prokaryotes.

*National Institutes of Health (NIH)*
An agency in the Department of Health and Human Services whose mission is to employ science in the pursuit of knowledge to improve human health; the principal biomedical research agency of the federal government.





# ScienceMakers
## Spotlight: Stephen L. Mayo

| Name | Stephen L. Mayo |
|---|---|
| Birth Place | Texas |
| Education | Pennsylvania State University<br>University of California, Berkeley<br>California Institute of Technology |
| Type of Science | Molecular Biology |

## Biography



Molecular biologist Stephen L. Mayo was born in Texas. He grew up in a military family that lived in Pennsylvania and New Jersey. He attended Pennsylvania State University, where he earned his B.S. degree in chemistry in 1983. While there, he created a protein modeling program with Dr. Roy Olofson. Mayo then attended the California Institute of Technology, where he received his Ph.D. degree in chemistry in 1987. Following graduate school, Mayo did a postdoctoral research fellowship at the University of California, Berkeley, where he developed a rule-based molecular mechanics force field.

After his postdoctoral work, Mayo cofounded Molecular Simulations Inc. (now Accelyrs). He then held another postdoctoral position in biochemistry at Stanford University School of Medicine. Mayo joined the faculty at the California Institute of Technology in 1992 as an assistant professor of biology. In addition, Mayo taught as an adjunct professor of biochemistry and molecular biology at the University of Southern California: School of Medicine in Los Angeles. He then served as an investigator in structural biology at the Howard Hughes Medical Institute (HHMI). In 1997, Mayo cofounded Xencor and sat on its scientific advisory board until 2006.

**"Calcium/calmoduin-dependent protein kinase II" by Ethan Hein @Flickr.**

Mayo's research has focused on the quantitative models of protein design and folding. He hopes to develop a systemic strategy to protein design, with the goal of creating a computer program to approach problems of protein stabilization and shape. Mayo and his colleagues were the first researchers to demonstrate that quantitative models can predict the eventual three-dimensional protein structure of a protein sequence.

In 2004, Mayo became a member of the National Academy of Sciences (NAS). He has also received a Searle Scholar Award, the Johnson Foundation Prize for adventurous and innovative research in structural biology and a Rita Allen Foundation Scholar Award.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Mayo?
#2 In what state was Dr. Mayo born? Locate it on a map. How far away is this from where you live? What are the names of his parents? Where did Dr. Mayo attend college? What do you think college was like for him?
#3 Dr. Mayo graduated from college in 1983. What was happening in the United States that year? What was happening in the world that year?
#4 Dr. Mayo grew up in a military family. A military family is often required to move as the member of the family who in the military is required to serve at different military bases. Has your family (or a friend's family) ever had to move? What was that experience like? What did you enjoy about moving? What made the process difficult?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a molecular biologist does? Would you like to be a molecular biologist? Why? Why not?
#2 If you were a molecular biologist, what topics would study?
#3 What molecules are you most familiar with? What is $H_2O$? What about $C_6H_{12}O_6$?
#4 Dr. Mayo cofounded two corporations with molecular biology as one of their primary interests. Can you think of other companies that are focused on biology? What do they produce?
#5 Look at the picture within the biography above. This is a computer generated model of a protein complex. Why do you think having a computer-simulated image is helpful?

# Glossary

*Adjunct professor*
A professor who is an assistant or subordinate to another.

*Biochemistry*
The organic chemistry of compounds and processes occurring in living organisms.

*Force field*
In the context of molecular mechanics, a force field refers to the form and parameter used to describe the potential energy of a system of particles.

*Howard Hughes Medical Institute (HHMI)*
A nonprofit medical research organization whose mission is to support and advance biomedical research and science education in the United States.

*Molecular biology*
The study of biology at a molecular level. The field overlaps with other areas of biology and chemistry, particularly genetics and biochemistry.

*Molecule*
An electrically neutral group of at least two atoms held together by very strong chemical bonds.

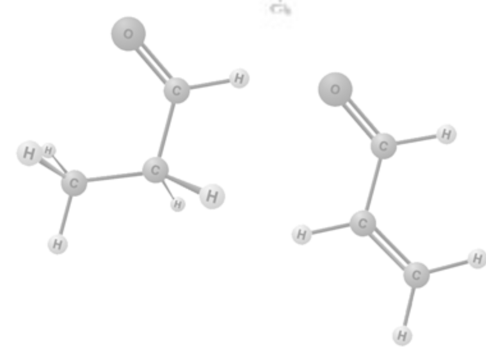
*National Academy of Sciences (NAS)*
A corporation in the United States whose members serve as advisers to the United States on science.

*Postdoctoral research*
Academic or scholarly research conducted by a person who has completed his or her doctoral studies, normally within a five year period. It is intended to further deepen expertise in a specialist subject, including necessary research skills and methods.

*Protein*
Organic compounds made of amino acids arranged in a linear chain and folded into a globular form. The amino acids in a polymer are joined together by the peptide bonds between the carboxyl and amino groups of adjacent amino acid residues.

*Protein sequence*
The order of the twenty naturally occurring amino acids that make up a particular protein.

*Protein structure*
The three-dimensional form that a protein adopts based on its given protein sequence and external conditions.



# Life Sciences Activity on Biological Toxins

# *Biomagnification*

**Grade Level:** 3-6
**National Standards:** H.C.5 Matter, energy, and organization in living systems
H.C.6 Behavior of organisms

### *Objective*
Have you ever wondered how toxins affect the ecosystems of our planet? **In this classroom activity, students will be looking at how even low levels of pollution infiltrate a biological system through a process called biomagnification.**

### *Introduction*:
Which animals are affected the most by toxins in the environment? What factors does it depend upon? Is the strongest animal in a population the most affected by toxins in the environment?

### *Materials and Equipment*
- Slips of paper or tokens. There should be a ratio of 1:3 of two different types of slips of paper or token. The color chosen for the smaller amount will represent toxins.
- 4 students to be Atlantic salmon.
- The remainder of the class will be the prey: arctic squid, sand eels, and arctic shrimp.

### *Experimental Procedure*
1. Randomly distribute the slips of paper or tokens to the prey. Each student should receive three tokens. Have the students count how many of each color they have and record it. The prey should make their tokens visible to their predators.
2. In an open space (such as a gym or field), have the prey spread out. The prey can either be asked to run around or to stand still, depending on how difficult you want to make it for the salmon to earn tokens. The three salmon stand to the side for the moment.
3. Each salmon will go individually to feast. The first salmon, being the strongest, will have the most time to gather food. He has two minutes to tag as much prey as possible. Each time he tags prey, they must hand him a token.
4. At the end of two minutes, the second salmon is free to collect as much food as possible. The second salmon has 1½ minutes.
5. The third salmon then has 1 minute.
6. The final salmon has just 30 seconds.
7. At the end of the activity, each salmon should count how many tokens he has, and how many of each color that he has collected.

### *Discussion of Results*
Return to your hypothesis. Was it correct, based on this classroom activity? If you had any unanswered questions, ask your teacher or check out your local library for more information the sometimes harmful effects of bioaccumulation.

Biomagnification, or bioamplification, is the process by which certain materials accumulate in organisms that are at higher energy levels in the food chain in an ecosystem. There are a few reasons that biomagnification occurs: the substance cannot be broken down in the environment, low rate of internal digestion within individual organisms, and increased uptake of organisms lower in the ecosystem's food chain before they can process the substance.

The strongest (or fastest) individual in a population is more likely to ingest more toxins, based on this activity.  This is because, with the greater amount food being taken in, he is more likely to take in more toxins.  Notice that in this activity it is NOT the percentage of toxins taken in, but rather the total number of toxins that make a difference.

***Other questions to think about:***

- If you were an arctic squid, a sand eel, or an arctic shrimp in this activity, how many tokens of each color did you start with?  If this were an actual ecosystem, why do you think it would be possible for you to have more or less toxins than others?  Did this make a difference on what you gave to the predator?  Did the predator know what token you would give him?
- How would biomagnification work, moving up the food chain?
- Can you think of another example where biomagnification has had detrimental effects in reality?

# Life Sciences Activity on DNA

# *DNA Candy*

**Grade Level:** 7-9
**National Standards:** H.C.1 The cell

### *Objective*

Deoxyribose Nucleic Acid (DNA) is known as the building block of life. Your DNA contains all the elements of you, from your eye color to your shoe size. **In this experiment students will learn what components make up DNA.**

### *Materials and Equipment*

- Licorice with holes through the center
- Gum drops, jelly beans, marshmallows, other small sticky candies
- Toothpicks
- String

### *Experimental Procedure*

1. Pick a color for each of the bases of DNA including guanine, cytosine, adenine, and thymine. You will use those colored candies for each base each time.

| Base | Candy Color |
|---|---|
| Guanine | |
| Cytosine | |
| Adenine | |
| Thymine | |

2. Connect your base pairs together using the toothpicks, but only those that go together in DNA.
   a. Guanine should be matched with Cytosine
   b. Adenine should be matched with Thymine
3. String the licorice together using the holes in the candy (illustrated by light gray rectangles below). This is the phosphate-sugar backbone. If you have extra small candies, you can put them in-between each licorice piece (dark gray circles below) to represent the phosphates.

4. Connect the candy pairs to the licorice using the toothpicks. Connect until you can twist the licorice to make a visible double helix.

### *Discussion of Results*

What did the toothpicks represent in the model? What about the licorice? Actual DNA contains segments called genes that store information. The bases of DNA are called nucleotides, held together with a backbone made of sugar and phosphate. Demonstrate DNA replication with your model. What are the steps?

Life Sciences Activity on Meiosis

# Marshmallow Meiosis

**Grade Level:** 8-12
**National Standards:** M.C.2 Reproduction and heredity

### *Objective*

How are physical traits determined for each individual? **In this experiment, students will be looking at how chromosomes are passed down from one generation to the next, and how these chromosomes translate into the physical traits you observe.**

This experiment will be following Mendelian genetics, which is based on dominant and recessive traits. Each physical trait you can observe (hair color, height, etc.) are determined by genes. Genes are determined by their alleles. Each organism has two alleles for each of their genes. Alleles are factors that influence the same gene, but different characteristics. For example, you might have one allele for blue eyes and one allele brown eyes, although you only have brown eyes. This is because alleles can either be coded as dominant or recessive. If a dominant gene is present, it will be observed as part of the organism's phenotype. Only if two copies of the recessive allele are present does the recessive trait become observable.

You will learn more about how genes work in this experiment. In this activity, you and a partner will create your own marshmallow creatures.

### *Introduction*

Come up with a question about inheritance patterns. Postulate an answer to this question. Which strain of marshmallow creature is the rarest? What about the most common?

### *Materials and Equipment*

- Marshmallows (large and small)
- Licorice strands
- Chocolate chips
- M&M's or Skittles
- Toothpicks
- Copy of the chromosomes below

### *Experimental Procedure*

1. Obtain a copy of the chromosomes on the page below. Cut them out.
2. Flip all of the chromosomes over so that you cannot tell what they are. Out of each pair, pick just one.
3. Now, with a partner, match up your alleles based on which trait they belong to.
4. Use the table below to create your Marshmallow creature. Note that a dominant gene is always denoted by a capital letter and a recessive gene by the lowercase letter.

| | Genotype | Phenotype |
|---|---|---|
| Body Length (big marshmallows) | $BL^A BL^A$ | 4 marshmallows |
| | $BL^A BL^B$ | 3 marshmallows |
| | $BL^B BL^B$ | 2 marshmallows |
| Legs (licorice) | LL, Ll | 6 legs |
| | Ll | 4 legs |
| Humps (small marshmallows) | $H^A H^A$ | 3 humps |
| | $H^A H^B$ | 2 humps |
| | $H^B H^B$ | 1 hump |
| Eyes (chocolate chips) | EE, Ee | 2 eyes |
| | Ee | 3 eyes |
| Nose (M&M or skittles) | NN, Nn | Red M&M |
| | Nn | Green M&M |

5. Start with the body. Use toothpicks to connect the marshmallows. Don't forget to add an extra marshmallow for the head!
6. Then move on to the legs. Stick the number of legs dictated by the genotype onto your creature's body.
7. The next step will be to add the humps. Again, use the toothpicks to add the number of small marshmallows prescribed by the genotype.
8. On the head, you will add the eyes and nose. Be sure to follow the genotype!
9. Compare your marshmallow creature to another one in the class. How are they different? How are they the same?
10. If you have time, partner up with someone else. Repeat steps 2-9. How does this creature compare to your first? Are they the same? Why or why not?

### *Discussion of Results*

In this experiment, you have seen how inheritance follows Mendelian genetics. The examples of the number of eyes, nose color, and number of legs are classic examples of the dominant/recessive inheritance patterns. Whenever a dominant allele is present in these two cases, you follow the dominant traits' characteristic.

One of Gregor Mendel's laws of inheritance is the Law of Independent Assortment. This is accounted for in this experiment when you choose your alleles. You do not choose your alleles based off of what the other chosen alleles already are. Can you think of another of Mendel's laws for inheritance?

There are two cases of co-dominance in this experiment. The examples of body length and number of humps both have two "dominant' genes, in that neither allele expresses preferably over the other when both alleles are present. Instead, when both alleles are present, a different phenotype is observed.

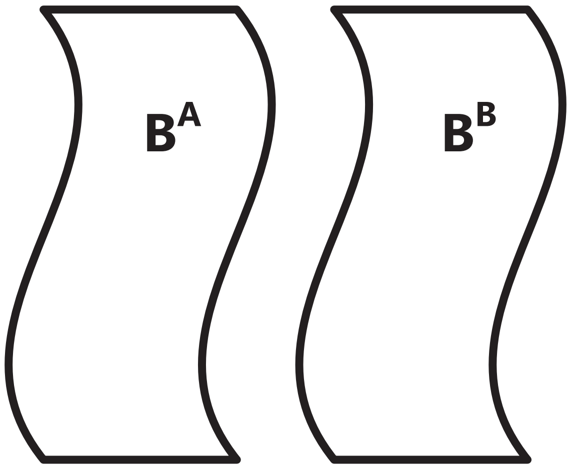
### *Other questions to think about*

- Where there any identical Marshmallow creatures?
- How many genes does the human have? What about the fruit fly?
- What other inheritance patterns exist?
- How is gender determined?

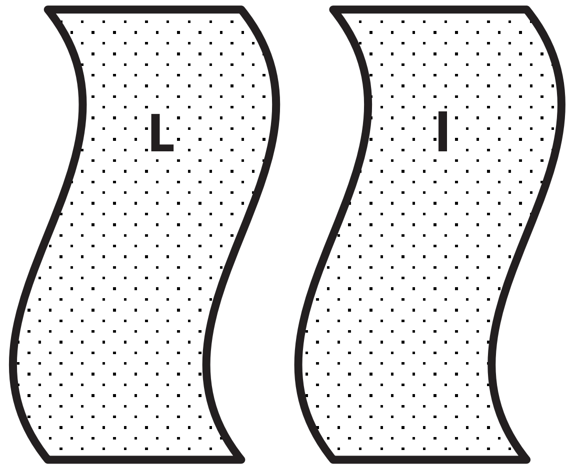
### *Credit*

Duke University's E-Bio Worksheets "Marshmallow Meiosis"

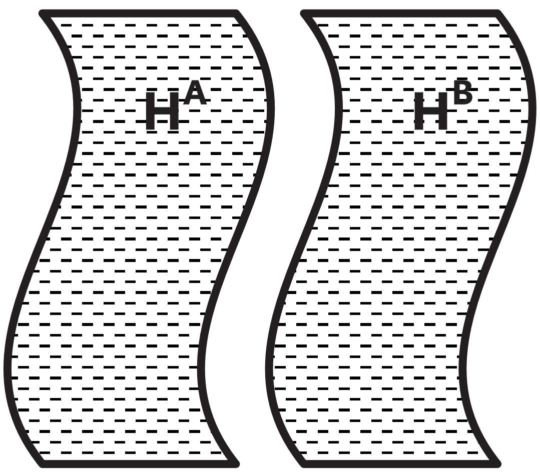
**Body Length**



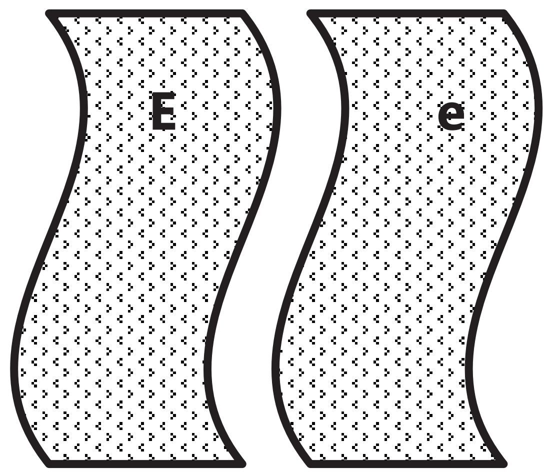

**Number of legs**



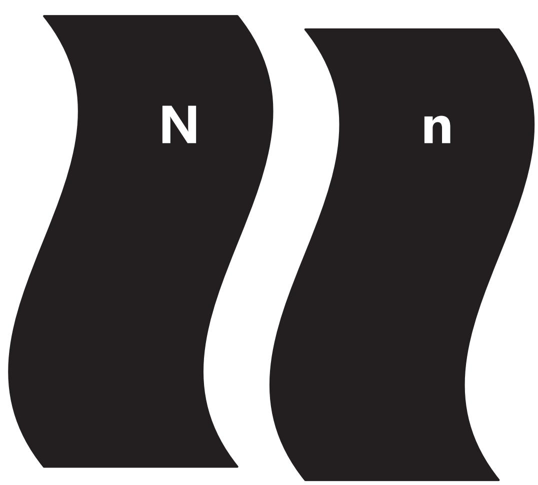

**Number of humps**




**Number of eyes**




**Nose Color**



# Fruit Power

**Grade Level:** 7-12
**National Standards:** H.B.6 Interactions of energy and matter
H.C.5 Matter, energy, and organization in living systems

### *Objective*

How do batteries work? Can anything that conducts electricity become a battery? What properties in materials allow them to conduct electrons? **This experiment will show students how to make a battery out of something as simple as a piece of fruit.**

### *Materials and Equipment*

- A lemon, lime, orange, or grapefruit
- A 2-inch copper nail
- A two-inch galvanized nail
- A two-inch Christmas tree light bulb (or other small bulb)
- Electrical tape

### *Experimental Procedure*

1. Roll the fruit on the table to soften it for a few minutes but do not break the skin of the fruit. If this happens, start over with a new piece of fruit.
2. Insert the copper nail and the galvanized nail into the fruit about two inches apart (any side will do). Push them about halfway into the fruit. Do not push the nails all the way in.
3. Remove one inch of the light insulation from the bulb lead. This may be tricky and the instructor can do this beforehand for students. There should be two bulb wires sticking out of the bulb when you are finished.
4. Carefully attach one bulb wire (called a lead) to the galvanized nail and the other to the copper nail.
5. Watch the bulb light up as soon as both wires are connected. If the light is too weak to see, try wrapping the wires more fully around the nail.



### *Discussion of Results*

Why did the battery light up? The acid in these fruits, filled with citrus, can conduct electricity. The two nails close the circuit allowing electrons to flow in a complete circle, providing energy to light the bulb. How much current do you think the battery is producing? How much current does it take to light a lightbulb (hint: check the box)? Which fruit do you think will light the bulb the strongest?

# Life Sciences Activity on Properties on Fungus

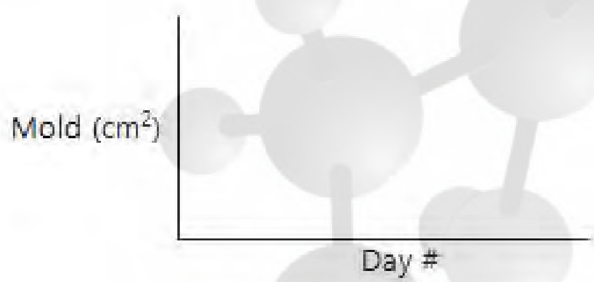
# *Growing Mold*

**Grade Level:** 2+
**National Standards:** H.C.6 Behavior of organisms
H.F.1 Personal and community health

### *Objective*
How does mold grow? What can you do to prevent it? **This experiment will show students in what conditions mold will grow best.** Mold is an important fungus that has several uses, including breaking down dead organic materials. Alexander Fleming used a type of mold fungi, to create the drug penicillin, now used to treat illness.

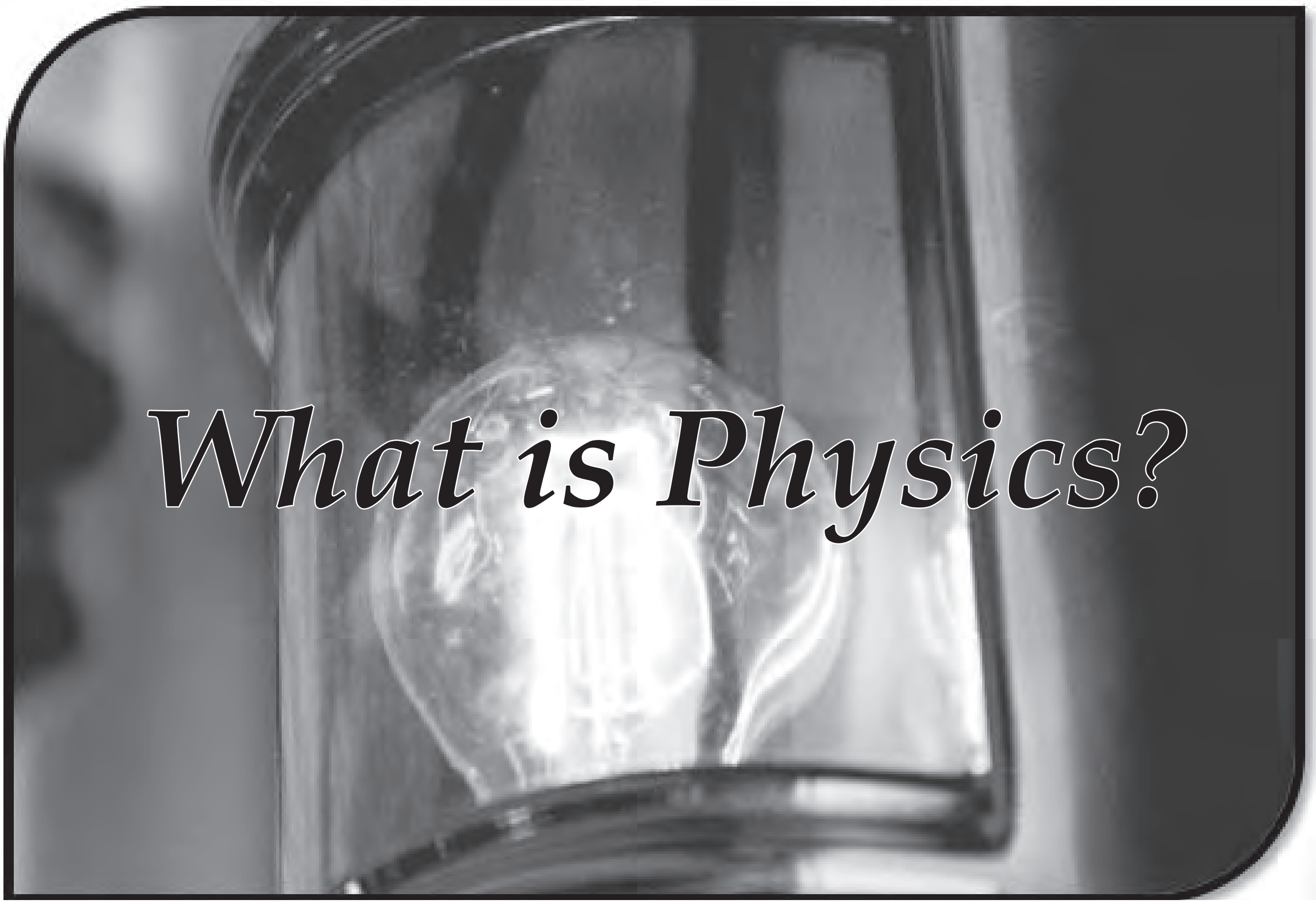
### *Materials and Equipment*
- 3 slices of bread
- Water
- 3 Ziploc bags
- 10x10 square centimeter grid
- Ruler

### *Experimental Procedure*
1. Wet one slice of bread enough to make it moist and place it in a bag. Seal the bag tightly.
2. Place the two other slices of dry bread in two separate bags and seal them as well.
3. Place the wet slice bag and one of the dry slice bags in dark places. In a closed cabinet or closet is a good place.
4. Place the other dry slice bag in the refrigerator.
5. For five days measure the square centimeters of mold on each piece of bread through the bag. Use a grid, if possible, or a ruler. If the mold covers more than half a square centimeter it is counted as 1 full centimeter. If it is less, it is counted as 0 centimeters. This will give you the area of mold on each slice of bread.
6. At the end of a week (5 days of measuring) use your final results to say what percentage of the bread was covered in mold. Make a table and a graph to plot the information.




### *Discussion of Results*
How much mold was there on the bread? Which location had the most mold? Which had the least? This information is important to food manufacturers and restaurants as moldy food is thrown away. By knowing what temperature to preserve foods at, they can make their stocks of food last longer. Sometimes, companies want to create mold such as if they are making blue cheese or soy sauce. By knowing what conditions mold likes, they can make these products faster.

# What is Physics?





***Physics*** is the science of matter and energy and the interactions between the two. Physics is comprised of topics as large as the universe and as small as elementary particles.

Physicists' ideas have led to many inventions from rocket ships to cell phones to microphones to DVD players. Physicists study a variety of topics related to matter and energy including how gravity affects objects and how electricity can light a light bulb.

Photo credit: Txd @Flickr

## *If you like physics, you may like the careers chosen by these people:*

| ScienceMaker | Occupation | Location | Question Topics |
|---|---|---|---|
| **Gibor Basri** | Professor of Astronomy | *University of California, Berkeley* | Brown dwarf stars, telescopes and space exploration |
| **Robert Bragg** | Professor Emeritus | *University of California, Berkeley* | Electromagnetic spectrum and x-ray technology |
| **Warren Buck** | Chancellor & Dean | *University of Washington* | Nuclear power and subatomic particles |
| **Anthony Johnson** | Director | *Center for Advanced Studies for Photonics Research* | Electromagnetic radiation, optics and light |
| **Joseph Johnson** | Director | *Center for Plasma Science and Technology* | Fluid dynamics and turbulence |
| **Katherine Johnson** | Research Mathematician | *NASA* | Gravity and trajectories |
| **Calvin Lowe** | Vice President of Research and Program Development | *National Institute for Aerospace* | Equilibrium, plasma, optics and light |
| **Stephen McGuire** | Chair of Physics Department | *Southern University* | Gravity, nuclear radiation |
| **Frederick Oliver** | Past-Chair of Physics Department | *Morgan State University* | Electromagnetic radiation, national physics laboratories, and radiation safety |
| **Philip Phillips** | Professor of Chemistry | *University of Illinois, Urbana-Champaign* | Fundamental forces and physical chemistry |
| **Kennedy Reed** | Physicist | *Lawrence Livermore National Laboratory* | Ions and plasma |
| **Allen Sessoms** | University President | *University of the District of Columbia* | Atoms, Large Hadron Collider |
| **Earl Shaw** | Professor of Physics | *Rutgers University* | Magnetism |
| **James Stith** | Vice President for Physics Resource Center | *American Institute of Physics* | Sound |
| **Julius Taylor** | Past-Chair of Physics Department | *Morgan State University* | Forces and collisions |
| **Neil Tyson** | Director | *Rose Planetarium* | Planetariums, Pluto, and the Solar System |
| **Demetrius Venable** | Professor of Physics & Astronomy | *Howard University* | Climate change, optics and light |
| **Conrad Williams** | Professor of Physics | *Morgan State University* | Magnetism, mentoring |
| **Charles Woodward** | Professor of Astronomy | *University of Minnesota* | Electromagnetic spectrum, telescopes and space exploration |

# Physics in Action

## Chernobyl Nuclear Power Plant

("Chernobyl NPP Units 3 & 4" by Andrzej Karoń @ Flickr)

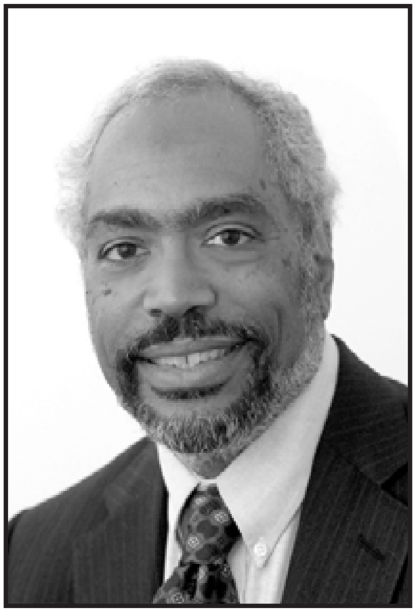
On April 26, 1986, one of the plant's reactors grew out of control and ignited. Radioactive fallout from the plant was released into the atmosphere and parts of Ukraine, Belarus, and Russia had to be evacuated. It is considered the worst nuclear power plant accident in history.

## Rollercoasters

("Rollercoaster" by Joe Jakeman @ Flickr)

Although they may seem to defy physics, rollercoaster shapes are dictated by gravity and the forces of motion.

# ScienceMakers
# Spotlight: Gibor Basri



| Name | Gibor Basri |
|---|---|
| Birth Date | May 3, 1951 |
| Birth Place | New York City, New York |
| Education | Fort Collins High School<br>Stanford University<br>University of Colorado, Boulder |
| Type of Science | Astrophysics |

## Biography

Astrophysicist Gibor Basri was born on May 3, 1951 to Saul and Phyllis Basri in New York City, New York. Basri's father was a physics professor at Colorado State University while his mother, who was Jamaican, taught dance. Basri grew up in Fort Collins, Colorado with his younger brother, David. Basri also lived in Burma and Sri Lanka when his father was on Fulbright Fellowships. As a child, Basri discovered an interest in astronomy while reading science fiction. In eighth grade, he wrote a report on his desire to become an astronomer. Basri attended Fort Collins High School before attending Stanford University, where he followed in his father's footsteps, receiving his B.S. degree in physics in 1973. He then merged his interest in astronomy with his background in physics, obtaining his Ph.D. degree in astrophysics from the University of Colorado at Boulder in 1979.

**"HD 162020 b" by Dallas1200am @ Flickr.**
HD 162020 b is a brown dwarf with a mass fifteen times that of Jupiter. It was discovered by Stephen Udry in 2002.

Basri received a chancellor's postdoctoral research fellowship at the University of California at Berkeley. He was tenured in 1988 and was named a full professor in 1994. His research has focused on star formation and stellar activity. Basri is considered a pioneer and expert on brown dwarf stars. He is best known for his work with the 10-meter Keck Telescope, which helped his team confirm the existence of brown dwarfs in 1995. From 2006 to 2007, Basri served as the acting chair for the Astronomy Department at the University of California, Berkeley. In 2007, he was named the first Vice Chancellor for Equity and Inclusion at Berkeley by Chancellor Robert J. Birgeneau which is his current title.

In 1997, Basri was awarded a Miller Research Professorship. He has written over 200 publications and his work has been cited over 8,000 times. In 2000, Basri was named a Sigma Xi Distinguished Lecturer and in 2001, he became a co-investigator on the Kepler Mission, a National Aeronautics and Space Administration (NASA) Discovery Mission designed to find extrasolar terrestrial planets. Besides his interest in science and technology education for underrepresented populations, Basri received the Chancellor's Award for Advancing Institutional Excellence in 2006 for helping University of California, Berkeley improve faculty diversity. He served on the board of the Chabot Space and Science Center, as well as the "I Have a Dream, Oakland" Foundation.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Basri?
#2 Where was Dr. Basri born? Locate it on a map. How far away is this from where you live? What are the names of his parents? Where did Dr. Basri attend high school? What do you think high school was like for him? What do you think it was like living in Burma and Sri Lanka?
#3 How old are you? In what year was Dr. Basri your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 Dr. Basri drew his inspiration to study astronomy from reading science fiction novels. What books do you enjoy reading? Is there a way the you could incorporate the topics of these books into a career in science?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think an astrophysicist does? Would you like to be an astrophysicist? Why? Why not?
#2 If you were an astrophysicist, what topics would you study?
#3 Have you ever used a telescope before? What does it do? How does it work?
#4 Dr. Basri and his team helped confirm brown dwarf stars exist. What other types of stars are there? What type of star is the sun?
#5 Do you think there is life on other planets? How would you confirm your suspicions? What kind of technology is available to you to help you test your theories?

# Glossary

*Astronomy*
The branch of physics that studies celestial bodies and the universe as a whole.

*Astrophysics*
The study of the physics of stars, galaxies, and the interstellar medium.

*Brown dwarf*
A star that is typically about the volume of the planet Jupiter, which has mass approaching that of a star, but insufficient to ignite its elements and cause it to burn as a true star.

*Chancellor*
The honorary or titular head of a university.

*Extrasolar*
A term applied to any object that exists outside the Solar System.

*Fulbright Fellowship*
A program of grants for international educational exchange for scholars, educators, graduate students and professionals, founded by United States Senator J. William Fulbright.

*National Aeronautics and Space Administration (NASA)*
An independent agency of the United States government responsible for aviation and spaceflight.

*Postdoctoral research Fellowship*
Academic or scholarly research conducted by a person who has completed his or her doctoral studies, normally within a five year period. It is intended to further deepen expertise in a specialist subject, including necessary research skills and methods.

*Sigma Xi*
A non-profit honor society which was founded in 1886 at Cornell University by a junior faculty member and a handful of graduate students. Members elect others on the basis of their research achievements or potential.

*Stellar*
Being or relating to, or resembling or emanating from stars.

*Telescope*
An instrument designed for the observation of remote objects by the collection of electromagnetic radiation. The first known practically functioning telescopes were invented in the Netherlands at the beginning of the 17th century.

*Tenured*
Appointed for life and not subject to dismissal except for a grave crime.

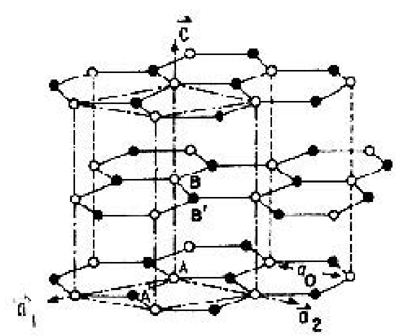
*Terrestrial*
Of or relating to land, as opposed to sea or air.

# ScienceMakers
## Spotlight: Robert Henry “Pete” Bragg, Jr.

| | |
|---|---|
| **Name** | Robert Henry “Pete” Bragg, Jr. |
| **Birth Date** | August 11, 1919 |
| **Birth Place** | Jacksonville, Florida |
| **Education** | Tilden Technical High School<br>Woodrow Wilson Junior College<br>Illinois Institute of Technology |
| **Types of Science** | Physics<br>Engineering |

## Biography

Physicist and engineer Robert Henry “Pete” Bragg, Jr. was born on August 11, 1919 in Jacksonville, Florida to Robert Henry Bragg and Lily Camille MacFarland. He had one older sister, Alberta, a younger sister, Nadine, and a younger brother, Johnny. After his parents separated, he went to live with his mother and grandmother in Memphis, Tennessee. He did well in elementary school and was encouraged by his family to move to Chicago to live with his Aunt Edna and Uncle Teddy and attend Tilden Technical High School. He attended Woodrow Wilson Junior College, a community college in Chicago, Illinois for a couple of years before he enlisted in the military during World War II. He used the money allotted to him from the G.I. Bill to attend the Illinois Institute of Technology, where he pursued a career in physics. He received his B.S. degree in physics in 1949. He then continued with graduate school under the tutelage of Frances L. Yost. His thesis was on quantum mechanical scattering theories. He graduated with his M.S. degree in 1951 from the Illinois Institute of Technology.



A diagram representing the structure that Dr. Bragg might have observed through X-ray diffraction if he looked at crystalline graphite.

After receiving his M.S. degree, Bragg was hired by the Dover Electroplating Company on the north side of Chicago, as well as the U.S. Postal Service. He then worked with the Portland Cement Association Research Laboratory for the following five years. There, he became an expert in x-ray crystallography and x-ray diffraction. He was then hired by the Armour Research Foundation at the Illinois Institute of Technology, a contract research organization, where he worked for five

Physics

years. Bragg finished his Ph.D. program at the Illinois Institute of Technology in 1960 with a degree in physics. Dr. Leonid V. Azaroff served as Bragg's mentor throughout the course of his doctorate work. After receiving his Ph.D. degree, Bragg was hired by Lockheed Martin Missile and Space, where he worked for nine years before he joined the faculty of the materials science and engineering department at University of California, Berkeley in June of 1969. Bragg served as chair of the materials science and engineering department from 1978 to 1981, the only African American to serve as a chair of the College of Engineering at University of California, Berkeley. He taught at the university and conducted research at Lawrence Berkeley National Laboratory (LBNL) until 1986. Bragg's research interests include x-ray diffraction and its application to such topics as the structure and electronic properties of carbon materials, which are used in aircraft and aerospace vehicles as well as everyday items such as golf clubs and tennis rackets. After his retirement, Bragg was awarded a Fulbright Fellowship in 1992 to conduct research for one year at the University of Ife in Nigeria. He also conducted research at the Advanced Photon Source at the Argonne National Laboratory in 1999.

Bragg's investigations in chemistry and physics have earned him numerous honors and awards throughout his career. He was named a fellow of the National Society of Black Physicists (NSBP) in 1995 and professor emeritus of the University of California, Berkeley, upon his retirement in 1987.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Bragg?
#2 Where was Dr. Bragg born? Locate it on a map. How far away is this from where you live? What are the names of his parents? Where did Dr. Bragg attend high school? What do you think high school was like for him?
#3 How old are you? In what year was Dr. Bragg your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 What was the G.I. Bill? You may have to look in a history book for the answer. This bill was also called the Serviceman's Readjustment Act of 1944. Who did it affect? Do you know anyone who was affected by the G.I. Bill? How did it support their educational aspirations?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a physicist does? Would you like to be a physicist? Why? Why not?
#2 If you were a physicist, what topics would you study?
#3 An x-ray is just like visible light in that they are both forms of electromagnetic radiation except that an x-ray is at a different energy level. The amount of energy any form of electromagnetic radiation contains is based on its frequency. If you increase the frequency, you also increase the energy. Look at an electromagnetic spectrum in a physics textbook or online. Which has more energy, the x-ray or the visible light?

#4 Have you had an x-ray before? When did you have one performed? What do you see in an x-ray? Besides its use in medicine, what else are x-rays are used for? (Hint: The above picture is an example of another use of x-rays.)

#5 One of most famous superheroes in comic book history, Superman, is known to have "X-ray vision," among other superpowers. Do you think this superpower is actually useful? Why or why not?

# Glossary

*Argonne National Laboratory*
The first science and engineering research national laboratory in the United States. It is the largest national lab by size and scope in the Midwest. It maintains a broad portfolio in basic science research, energy storage, environmental sustainability, and national security.

*Crystallography*
The experimental science of determining the arrangement of atoms in solids. In older usage, it is the scientific study of crystals.

*Diffraction*
The apparent bending of waves around small obstacles and the spreading out of waves past small openings.

*Electroplating*
A process of coating the surfaces of a metal object with a layer of a different metal through electrochemical means.

*Emeritus*
An adjective that is used in the title of a retired professor, bishop, or other professional.

*Fulbright Fellowship*
A program of grants for international educational exchange for scholars, educators, graduate students and professionals, founded by United States Senator J. William Fulbright.

*G.I. Bill*
A bill that provided college or vocational education for returning World War II veterans (commonly referred to as G.I.s) as well as one year of unemployment compensation.

*Lawrence Berkeley National Laboratory (LBNL)*
The Ernest Orlando Lawrence Berkeley National Laboratory (LBNL), is a U.S. Department of Energy (DOE) national laboratory conducting unclassified scientific research. It is located on the grounds of the University of California, Berkeley, in the Berkeley Hills above the central campus.

*National Society of Black Physicists (NSBP)*
A professional organization established in 1977 to promote the professional well-being of African American physicists and physics students within the international scientific community and the world community at large.

*Photon*
An elementary particle, and the basic “unit” of light and all other forms of electromagnetic radiation.

*Quantum mechanics*
A set of scientific principles describing the known behavior of energy and matter that predominate at the atomic and subatomic scales.

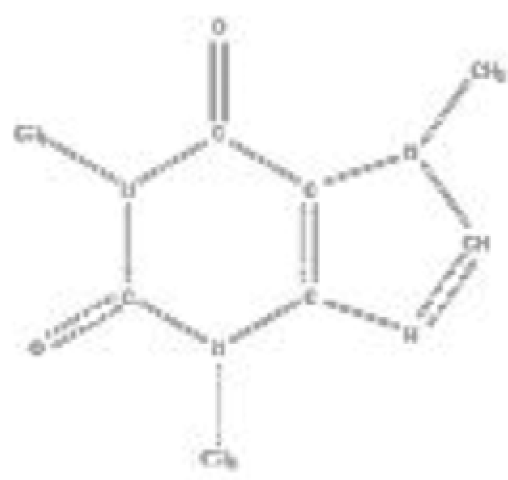
*Scattering theories*
A framework for studying and understanding the scattering of waves and particles.

*Tutelage*
Guidance; care.

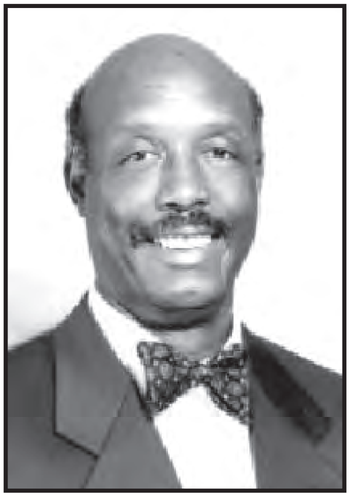
*X-ray*
A band of the electromagnetic spectrum between the ultraviolet and the gamma-ray. Photons of X-ray light are more energetic than photons in the ultraviolet but less energetic than photons in the gamma-ray.

*X-ray diffraction*
The scattering of x-rays by the atoms of a crystal; the diffraction pattern elucidates the structure of the crystal.





# ScienceMakers
## Spotlight: Warren Wesley Buck III



| | |
|---|---|
| **Name** | Warren Wesley Buck III |
| **Birth Date** | February 16, 1946 |
| **Birth Place** | Washington, D.C. |
| **Education** | Springarn High School<br>Lincoln University<br>Morgan State University<br>College of William and Mary |
| **Type of Science** | Physics |

## Biography

Physicist and chancellor Warren Wesley Buck, III was born on February 16, 1946 to Warren W. Buck, Jr. and Mildred G. Buck in Washington, D.C.  Buck grew up in Washington, D.C., and graduated from Spingarn High School in 1963.  He went on to study at Lincoln University for several years and later earned his B.S. degree in mathematics from Morgan State University in 1968.  With a focus in experimental and theoretical plasma, Buck earned his M.S. degree from the College of William and Mary in 1970.  During the 1970-1971 academic year, Buck taught mathematics at Bowie State College (now University).  Continuing his education at the College of William and Mary, Buck received his Ph.D. degree in physics with a concentration in theoretical relativistic nuclear physics in 1976.  While at the College of William and Mary, Buck was the founding president of the Black Student Organization.

**"Three Mile Island Nuclear Power Plant near Harrisburg, Pennsylvania" by Michael6076 @ Flickr.** Nuclear power is just one place where our understanding of the atom has been put to use.

Throughout his career, Buck has continued to do research in physics and has published numerous papers in academic journals.  Most of his research interests focused on nuclear and subatomic particles, including studies of the interactions between particles and anti-particles and the nature of mesons and the quark model.  Buck joined the faculty of Hampton University in 1984 after sailing on his

Physics

motorless boat for three consecutive years from Massachusetts to The Bahamas. He became a full professor at Hampton University in 1989. He also helped create the Ph.D. program in physics - the first Ph.D. degree program on the Hampton campus. Buck was a member of the team that established the science program at the Department of Energy's Jefferson Lab in Newport News, Virginia. He was also the founding director of the Nuclear/High Energy Physics Research Center of Excellence at Hampton University. In 1999, Buck was appointed chancellor and dean of the University of Washington, Bothell. He served in the position for six years. During his term, the University of Washington, Bothell became a four-year institution, and its new permanent campus was opened in the fall of 2000. Buck is also a painter, blending humanistic and physical elements in his art.

Buck has been recognized for his work as an educator and a researcher, being elected to membership in the American Physical Society (APS) and creating the popular Hampton University Graduate Studies (HUGS) summer school for nuclear physics graduate students worldwide. Buck was given the Hulon Willis Association Impact Award for his work within the African American community at the College of William and Mary. In 2001, Buck was named a "Giant in Science," by the Quality Education for Minorities (QEM) Network. Buck has worked with many advisory boards and committees, including the Committee on Education of the American Physical Society. He has also served on the board of directors of the Pacific Science Center. Buck married Cate Buck in 2006.

## Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Buck?
#2 Where was Dr. Buck born? Locate it on a map. How far away is this from where you live? What are the names of his parents? Where did Dr. Buck attend high school? What do you think high school was like for him?
#3 How old are you? In what year was Dr. Buck your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 What is the significance of developing a Ph.D. program for a university? What kind of work goes into doing this? Pick a topic in which you would want to develop a program of studies. What classes would it include?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a physicist does? Would you like to be a physicist? Why? Why not?
#2 If you were a physicist, what topics would you study?
#3 Dr. Buck's work concerns the study of subatomic particles. Can you name a few subatomic particles?
#4 How does nuclear energy work? What does nuclear energy have to do with the study of subatomic particles? What are the advantages and disadvantages of harnessing nuclear power as a source of alternative energy?
#5 What is nuclear fusion? What is nuclear fission?

# Glossary

*American Physical Society (APS)*
The world's second largest organization of physicists. The Society publishes more than a dozen scientific journals, including Physical Review and Physical Review Letters.  It also organizes more than twenty science meetings each year.

*Antiparticle*
A type of matter; most kinds of particles have a corresponding antiparticle with the same mass and opposite electric charge of the particle.

*Chancellor*
The honorary or titular head of a university.

*High energy physics*
The branch of physics that studies subatomic particles and their interactions.

*Meson*
Subatomic particles composed of one quark and one antiquark.

*Nuclear physics*
The branch of physics that studies the internal structure of atomic nuclei.

*Particle*
An atom or non-descript piece of matter (non-technical usage).

*Plasma*
A fourth state of matter distinct from solid or liquid or gas and present in stars and fusion reactors; a gas becomes a plasma when it is heated until the atoms lose all their electrons, leaving a highly electrified collection of nuclei and free electrons.

*Quality Education for Minorities (QEM) Network*
A non-profit organization based in Washington, DC, dedicated to improving the education of African Americans, Alaska Natives, American Indians, Mexican Americans, and Puerto Ricans.

*Quark*
A hypothetical elementary particle and a fundamental constituent of matter. Quarks combine to form composite particles called hadrons, the most stable of which are protons and neutrons, the components of atomic nuclei.

*Relativistic*
Term used to describe an object moving close to the speed of light.

# ScienceMakers
## Spotlight: Anthony M. Johnson

| | |
|---|---|
| **Name** | Anthony M. Johnson |
| **Birth Date** | May, 23 1954 |
| **Birth Place** | Brooklyn, New York |
| **Education** | Samuel J. Tilden, High School<br>Polytechnic Institute of New York<br>City College of New York |
| **Type of Science** | Physics |

## Biography

Physicist Anthony M. Johnson was born on May 23, 1954 in Brooklyn, New York to Helen Y. Johnson and James W. Johnson. Johnson initially wanted to study math or chemistry in college until a teacher at Samuel J. Tilden High School in Brooklyn, New York introduced him to physics. He attended the Polytechnic Institute of New York where he graduated *magna cum laude* with his B.S. degree in physics in 1975. Johnson went on to attend the City College of New York, where he received his Ph.D. degree in physics in 1981. He conducted his thesis research at Bell Laboratories in Murray Hill, New Jersey, with support from the Bell Labs Cooperative Research Fellowship Program.

**Fiber optic cabling photo by FeatheredTar @Flickr**

After completing his graduate education, Johnson began working at Bell Laboratories in Holmdel, New Jersey. He served as a member of the technical staff in the Quantum Physics and Electronics Research Department. In 1988, Johnson was promoted to distinguished member of technical staff. In 1990, he became a member of the Photonic Circuits Research Department. Between 1991 and 2000, Johnson was elevated to fellow status in the Optical Society of America (OSA), the American Physical Society (APS), the American Association for the Advancement of Science (AAAS), the Institute of Electrical and Electronics Engineers (IEEE), and the National Society of Black Physicists (NSBP). Johnson joined the faculty at the New Jersey Institute of Technology in 1995, where he served as chairperson and distinguished professor of applied physics, as well as professor of electrical and computer engineering. Since 2003, Johnson has been the Director of the Center for Advanced Studies in Photonics Research (CASPR) and a professor of physics, computer science, and electrical engineering at the University of Maryland, Baltimore County. His research focuses on ultrafast optics and optoelectronics.

Johnson has written two book chapters, is the holder of four U.S. patents, and has written nearly 70 refereed publications. He has also served as Editor-in-Chief of the journal *Optics Letters (1995-2001)*. In 1993, Johnson received the Distinguished Alumnus Award from the Polytechnic University and in 1994, he was given the Black Engineer of the Year Special Recognition Award. The American Physical Society presented Johnson with the Edward A. Bouchet Award in 1996 and in 2005, *Science Spectrum* Magazine recognized him with its Trailblazer Top Minority in Science Award. In 2002, Johnson became the first African American to serve as President of the 15,000 member Optical Society of America. The year 2010 is the fiftieth anniversary of the laser, and LaserFest designated Johnson one of the "Laser Pioneers." Johnson is married to Dr. Adrienne S. Johnson and they have three adult children, Kimberly, Justin, and Brandon.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Johnson?
#2 Where was Dr. Johnson born? Locate it on a map. How far away is this from where you live? What are the names of his parents? Where did Dr. Johnson attend high school? What do you think high school was like for him?
#3 How old are you? In what year was Dr. Johnson your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 Dr. Johnson was influenced to pursue physics by a high school teacher. Can you think of a time when a teacher influenced you to do something? How did it work out?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think an optical physicist does? Would you like to be an optical physicist? Why? Why not?
#2 If you were an optical physicist, what topics would you study?
#3 What is optics? Why might a physicist study this branch of science? If Dr. Johnson changed his mind about learning about optics, are there similar fields in physics that he might pursue?
#4 What is the speed of light? When someone says that a galaxy is ten light years away, what does this mean in terms of distance?
#5 All electromagnetic radiation travels the same speed in a vacuum. Two variables change, however. These are wavelength and frequency. What do each of these terms mean with respect to optics? How are they related with if you also consider the speed of light? Hint: compare the units of wavelength and frequency to that of velocity.

# Glossary

*American Association for the Advancement of Science (AAAS)*
An international non-profit organization with the stated goals of promoting cooperation between scientists, defending scientific freedom, encouraging scientific responsibility, and supporting scientific education and science.

*American Physical Society (APS)*
The world's second largest organization of physicists. The Society publishes more than a dozen scientific journals, including Physical Review and Physical Review Letters. It also organizes more than twenty science meetings each year.

*Bell Laboratories*
The research and development organization of Alcatel-Lucent and previously of the American Telephone & Telegraph Company (AT&T). Also known as Bell Labs and formerly known as AT&T Bell Laboratories and Bell Telephone Laboratories.

*Bouchet, Edward*
(1852 - 1918) The first African American to graduate from Yale University in 1874. He completed his dissertation in Yale University's Ph.D. program in physics in 1876.

*Circuit*
An electrical device that provides a path for electrical current to flow.

*Electronics*
The branch of physics that deals with the emission and effects of electrons and with the use of electronic devices.

*Institute of Electronics and Electrical Engineers*
An international non-profit, professional organization for the advancement of technology related to electricity.

*LASER*
An acronym for Light Amplification by Stimulated Emission of Radiation; an optical device that produces an intense monochromatic beam of coherent light. Monochromatic light has only one wavelength—it appears to be of only one color. Coherent light is of the same phase (i.e. there is no constructive or destructive interference of waves of light).

*National Society of Black Physicists (NSBP)*
A professional organization established in 1977 to promote the professional well-being of African American physicists and physics students within the international scientific community and the world community at large.

*Optical Society of America (OSA)*
A scientific society dedicated to advancing the study of light—optics and photonics—in theory and application.

*Optics*
The branch of physics which studies the behavior and properties of light, including its interactions with matter; usually describes the behavior of visible, ultraviolet, and infrared light.

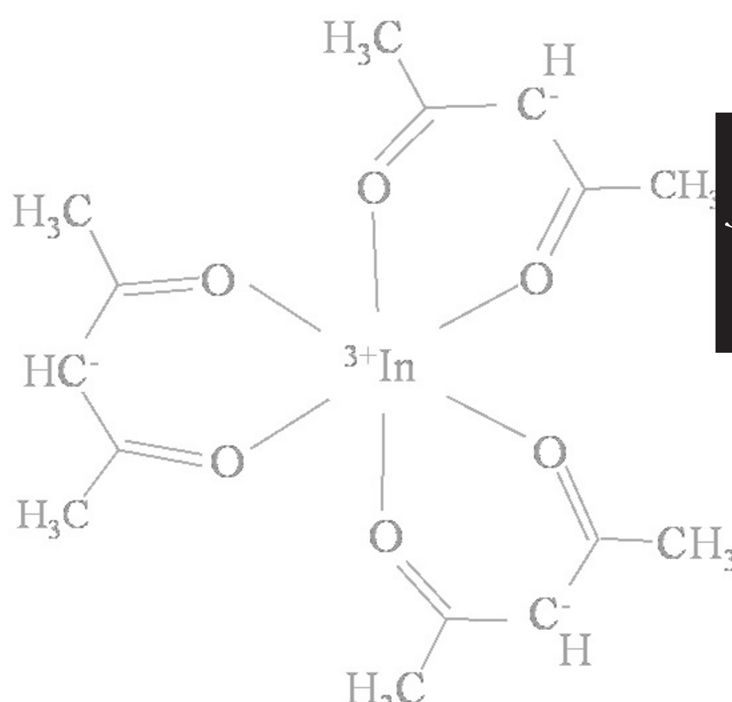
*Optoelectonics*
The study and application of electronic devices that source, detect and control light, usually considered a sub-field of photonics.

*Patent*
A declaration issued by a government agency that declares someone the inventor of a new invention and has the privilege of stopping others from making, using or selling the claimed invention.

*Photonics*
The science of photonics includes the generation, emission, transmission, modulation, signal processing, switching, amplification, detection and sensing of light.

*Quantum mechanics*
Quantum mechanics (QM) is a set of scientific principles describing the known behavior of energy and matter that predominate at the atomic and subatomic scales.

*Referee*
To review.



# ScienceMakers

## Spotlight: Joseph A. Johnson III

| | |
|---|---|
| **Name** | Joseph A. Johnson III |
| **Birth Date** | 1940 |
| **Birth Place** | Tennessee |
| **Education** | Fisk University<br>Yale University |
| **Type of Science** | Physics |

## Biography

Physicist Joseph A. Johnson III was born in 1940 in Tennessee. He attended Fisk University, where he received his B.A. degree in physics in 1960. He went on to Yale University, where he graduated with his M.S. degree in 1961 and his Ph.D. degree in 1965. During this time, Johnson was a Danforth Fellow as well as a National Science Foundation (NSF) Cooperative Fellow. In graduate school, Johnson became interested in fluid dynamics.

**"Whoosh!" by randomduck @ flickr.**
You have probably heard of turbulence when on flying on a plane. Much of Dr. Johnson's work has related to turbulence.

Following graduate school, Johnson conducted research at Sikorsky Aircraft Company and at Bell Laboratories. He also taught at Yale University, Southern University, and Rutgers University, and was named the Herbert Kayser Professor of Science and Engineering at the City College of New York. Johnson then joined the faculty at Florida Agricultural and Mechanical University (FAMU) where he is a distinguished professor of science and engineering, a professor of physics, an affiliate professor of mechanical engineering, and Director of the Center for Plasma Science and Technology (CePaST). In the past, Johnson has been Director of the National Aeronautics and Space Administration (NASA)/Florida Agricultural and Mechanical University Research Center of Nonlinear and Nonequilibrium Aeroscience and the university's Laboratory for Modern Fluid Physics. His research is focused on plasma turbulence and new methods of examining fundamental turbulence physics. In addition to his research, Johnson co-founded and was chair of the Advisory Council of the Edward Bouchet-Abdus Salam International (EBASI) Centre for Theoretical Physics Institute which aims to help advance opportunities in the discipline of physics in Africa.

In 1989, Johnson became an Associate Fellow of the American Institute of Aeronautics and Astronautics. The following year, he became a Fellow of the American Physical Society (APS) and was named a member of the Third World Academy of Sciences. He has received an honorary doctorate from Fisk University and the 1995 Edward Bouchet Award from the American Physical Society. Johnson is a member of the Sigma Xi honorary scientific society and the Naval Research Advisory Committee. He served as president of the National Society of Black Physicists (NSBP) between 1988 and 1990.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Johnson?
#2 Where was Dr. Johnson born? Locate it on a map. How far away is this from where you live?
#3 How old are you? In what year was Dr. Johnson your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 Dr. Johnson is the winner of a Bouchet Award. Who is Edward Bouchet? Why is he important to the physics community?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a physicist does? Would you like to be a physicist? Why? Why not?
#2 If you were a physicist, what topics would you study?
#3 Dr. Johnson has done research on plasma turbulence. What kind of turbulence are you familiar with? What does it mean if something is turbulent?
#4 Consider some of the properties that determine the speed and characteristics of fluid flow. What is the difference between laminar and turbulent flow? What does it mean for a fluid to be viscous? If a fluid is flowing through a pipe, is it moving faster if the pipe is narrower or wider?
#5 Fluid dynamics is the study of the properties and behavior of moving fluids. Some fields in which fluid dynamics can be applied include: acoustics, meteorology (the study of weather patterns), alternative energy, and oceanography. Pick two of these topics. How do they relate to fluid dynamics?

# Glossary

*Aeroscience*
The scientific study of the properties of objects in the air, often inclusive of object movement in the atmosphere.

*American Physical Society (APS)*
The world's second largest organization of physicists. The Society publishes more than a dozen scientific journals, including Physical Review and Physical Review Letters. It also organizes more than twenty science meetings each year.

*Bell Laboratories*
The research and development organization of Alcatel-Lucent and previously of the American Telephone & Telegraph Company (AT&T). Also known as Bell Labs and formerly known as AT&T Bell Laboratories and Bell Telephone Laboratories.

*Bouchet, Edward*
(1852 - 1918) Graduated from Yale College in 1874 and was the first African American to be elected to Phi Beta Kappa. Bouchet became the first African American to receive a Ph.D. when completed his dissertation in Yale University's Ph.D. program in physics.

*Equilibrium*
A stable situation in which forces cancel one another and there exists a balance between forces. Nonequilibrium is the opposite.

*Fluid*
A substance that continually deforms (flows) under an applied stress. All gases are fluids, but not all liquids are fluids.

*Fluid dynamics*
A sub-discipline of fluid mechanics that deals with fluid flow and the science of fluid in motion.

*Linear*
Of, in, along, or relating to a line; involving a single dimension. Nonlinear is the opposite.

*National Aeronautics and Space Administration (NASA)*
An independent agency of the United States government responsible for aviation and spaceflight.

*National Science Foundation (NSF)*
A United States government agency that supports fundamental research and education in all the non-medical fields of science and engineering. Its medical counterpart is the National Institutes of Health.

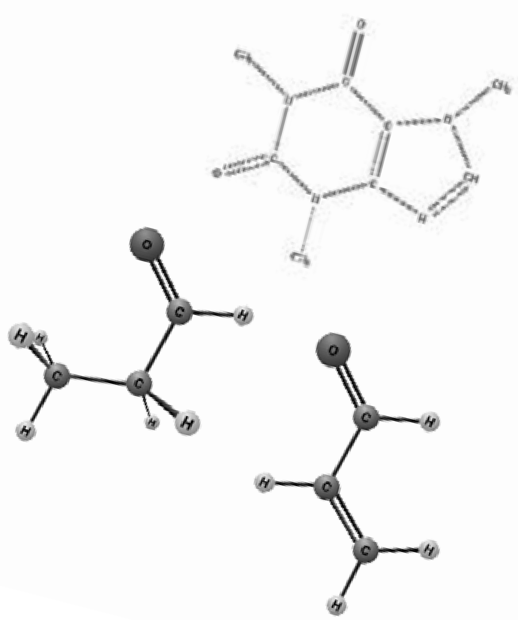
*National Society of Black Physicists (NSBP)*
A professional organization established in 1977 to promote the professional well-being of African American physicists and physics students within the international scientific community and the world community at large.

*Plasma*
A fourth state of matter distinct from solid or liquid or gas and present in stars and fusion reactors; a gas becomes a plasma when it is heated until the atoms lose all their electrons, leaving a highly electrified collection of nuclei and free electrons.

*Sigma Xi*
A non-profit honor society which was founded in 1886 at Cornell University by a junior faculty member and a handful of graduate students. Members elect others on the basis of their research achievements or potential.

*Theoretical physics*
A branch of physics which employs mathematical models and abstractions of physics in an attempt to explain natural phenomena. Its central core is mathematical physics. Sometimes mathematical physics and theoretical physics are used synonymously to refer to the latter.

*Turbulence*
Flow characterized by chaotic property changes. It is not calm or smooth.



# ScienceMakers
## Spotlight: Katherine C. G. Johnson

| | |
|---|---|
| **Name** | Katherine C. G. Johnson |
| **Birth Date** | August 26, 1918 |
| **Birth Place** | White Sulphur Springs, West Virginia |
| **Education** | West Virginia State High School<br>West Virginia State College |
| **Types of Science** | Physics<br>Mathematics |

## Biography

Physicist and mathematician Katherine C. G. Johnson was born on August 26, 1918 in White Sulphur Springs, West Virginia to Joylette and Joshua Coleman. Her mother was a teacher and her father was a farmer and janitor. From a young age, Johnson enjoyed mathematics and could figure out problems even her teachers called difficult to solve. Johnson attended West Virginia State High School, 125 miles away from her home, since all the high schools in her area were not open to African Americans. Johnson graduated from high school at age fourteen, and finished at West Virginia State College with her B.S. degree in French and mathematics by age eighteen. Dr. W.W. Schiefflin Claytor, the third African American to earn a Ph.D. degree in mathematics, created a special course in analytic geometry specifically for Johnson. In 1940, she attended West Virginia University to obtain a graduate degree and was one of the first African Americans to enroll. However, family issues kept her from completing the required courses.

**"The Moon May 4, 2009" by Lord Markus @Flickr**

After college, Johnson began teaching in elementary and high schools in Virginia and West Virginia. She taught for seventeen years in these schools. Then, at the suggestion of her family, she began working as a research mathematician at the Langley Research Center (LaRC) for the National Advisory Committee for Aeronautics (NACA). NACA later became the National Aeronautics and Space Administration (NASA). In 1953, Johnson was assigned to an all-male flight research team. Her knowledge made her invaluable to her superiors and her assertiveness won her a spot in previously all-male meetings. Upon leaving The Flight Mechanics Branch, Johnson went to the Spacecraft Controls Branch where she calculated the flight trajectory for Alan Shepard, the first American to go into space in 1959. Johnson also verified the mathematics behind John Glenn's orbit around the Earth in 1962 and calculated the flight trajectory for Apollo 11's flight to the moon in 1969. She retired from NASA in 1986.

Johnson has been the recipient of NASA's Lunar Spacecraft and Operation's Group Achievement Award. She has co-authored 26 scientific papers, and has a historically unique listing as a female co-author in a peer-reviewed NASA report. Johnson also received an Honorary Doctor of Laws from the State University of New York in Farmingdale in 1998 and in 1999, was named Outstanding Alumnus of the Year by West Virginia State College. In 2006, Johnson was awarded an honorary Doctor of Science from Capitol College of Laurel, Maryland. Johnson and her, husband Lt. Colonel James A. Johnson, live in Hampton, Virginia. They are the parents of the three grown children.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Johnson?
#2 Where was Dr. Johnson born? Locate it on a map. How far away is this from where you live? What are the names of her parents? Where did Dr. Johnson attend high school? What do you think high school was like for her?
#3 How old are you? In what year was Dr. Johnson your age? What was happening in the United States that year? What was happening in the world that year? What do you think her life was like when she was your age?
#4 Dr. Johnson was the sole female among male colleagues on her flight research team. Have you ever felt like the odd person out? How did it make you feel? How did you overcome it? How can you learn from Dr. Johnson's story?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a physicist does? Would you like to be a physicist? Why? Why not?
#2 If you were a physicist, what topics would you study?
#3 If you were calculating the trajectory of a space flight, what factors would you need to consider? Think about what forces are acting on the space shuttle at all times during the flight.
#4 One interesting flight path trajectory is termed the "free-return trajectory," in which the path of the shuttle is determined solely by the pull of gravity between the earth and the moon with limited fuel burns. Another name for the process is "slingshot around the moon." How does this work exactly? Did any of the space flight missions rely on this return method to get the astronauts back to earth safely?

#5 Dr. Johnson calculated the trajectories of some of the greatest spaceflights in American history. She did this with less computer power than a typical pocket calculator. How did she do this? What tools would you use to perform complex calculations? How did Dr. Johnson's training prepare her for this?

# Glossary

*Analytic geometry*
The study of geometry using a coordinate system and the principles of algebra and analysis.

*Apollo 11*
Space shuttle mission that landed the first humans on the Moon. Launched on July 16, 1969, the third lunar mission of NASA's Apollo Program was crewed by Commander Neil Alden Armstrong, Command Module Pilot Michael Collins, and Lunar Module Pilot Edwin Eugene 'Buzz' Aldrin, Jr.

*Glenn, John*
(1921- ) United States Astronaut who made the first orbital rocket-powered flight in 1962.

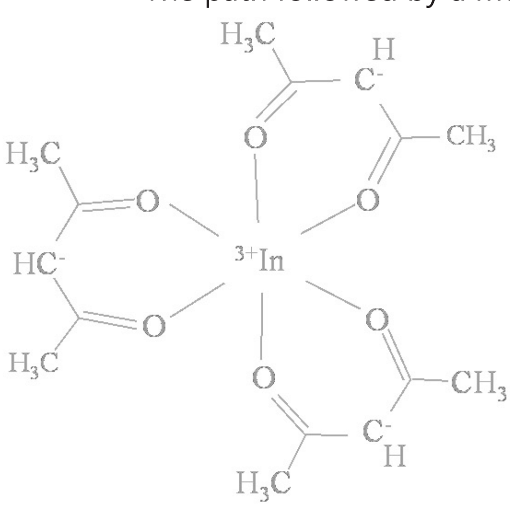
*Langley Research Center (LaRC)*
The oldest of NASA's field centers, located in Hampton, Virginia, United States.

*National Aeronautics and Space Administration (NASA)*
An independent agency of the United States government responsible for aviation and spaceflight.

*Orbit*
The elliptical path created by one celestial body as it revolves around another, like the moon around the earth.

*Shepard, Alan*
(1923-1998) The first American in space. He later commanded the Apollo 14 mission, and was the fifth person to walk on the moon.

*Trajectory*
The path followed by a moving object.

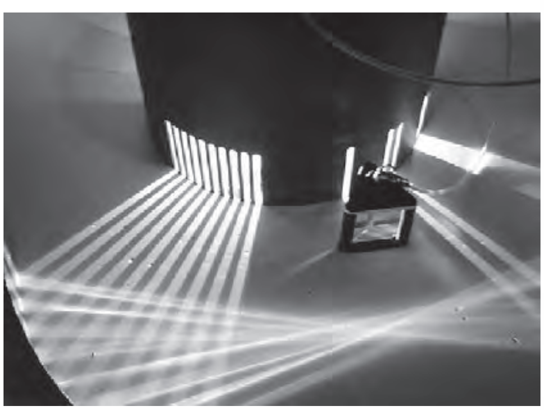


# ScienceMakers
# Spotlight: Calvin Lowe

| | |
|---|---|
| **Name** | Calvin Lowe |
| **Birth Date** | 1955 |
| **Birth Place** | Roanoke Rapids, North Carolina |
| **Education** | North Carolina A&T State University<br>Massachusetts Institute of Technology |
| **Type of Science** | Physics |

## Biography

Education administrator and physicist Calvin Lowe was born in 1955 in Roanoke Rapids, North Carolina. He received his B.S. degree from North Carolina A&T State University and his M.S. degree in plasma physics. He earned his Ph.D. degree in solid state physics from the Massachusetts Institute of Technology (MIT) in 1983.



"Fun with optics" by Monkey River Town @Flickr

Beginning in 1983, Lowe served as an associate professor of physics at the University of Kentucky. In 1987, Lowe joined the faculty at Hampton University as an associate professor and chair of the physics department. In 1992, Lowe moved to Alabama A&M State University, where he served as chair of the physics department and had a research lab focused on optics. Lowe returned to Hampton University in 1995, where he served as vice president of research and dean of the graduate college until 2000. Lowe was named the ninth president of Bowie State University in 2000, where he served until 2006. While at Bowie, Lowe served as a member of the Task Force to Study College Readiness for Disadvantaged and Capable Students. Since 2007, Lowe has worked at the National Institute of Aerospace (NIA) as its vice president of research and program development.

In addition to serving as faculty, Lowe sat on Hampton University's Board of Visitors from 2000 to 2005. He is also a former board member of the Virginia Space Grant Consortium, the Peninsula

Advanced Technology Center, the Southeastern Universities Research Association, and the Virginia Aerospace Business Consortium.  Lowe has received the Outstanding Achievement Award from the Marshall Space Flight Center (MSFC) at the National Aeronautic and Space Administration (NASA).  He has published numerous scientific papers with a focus on optical properties of materials.  Lowe lives in Maryland with his wife Tanya and their two adult children, Maya and Calvin.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Lowe?
#2 Where was Dr. Lowe born? Locate it on a map. How far away is this from where you live?
#3 How old are you? In what year was Dr. Lowe your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 Where did Dr. Lowe attend college? What do you think college was like for him?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a solid state physicist does? Would you like to be a solid state physicist? Why? Why not?
#2 If you were a solid state physicist, what topics would you study?
#3 Dr. Lowe received his B.S. and M.S. degrees in plasma physics.  Plasma is considered to be a distinct state of matter.  What are the other states of matter?  How does plasma compare to these other three in terms of relative pressure and temperature.
#4 Equilibrium is a term used to describe a situation in which all competing forces are balanced.  Often in equilibrium, the state of an observed system appears to be unchanging.  What do you think this means in a physical understanding of the word?  What does it mean in terms of chemistry?  What about biology?
#5 How do you think solid state physics and plasma physics can be used to study optics?

# Glossary

*Optics*
The branch of physics which studies the behavior and properties of light, including its interactions with matter; usually describes the behavior of visible, ultraviolet, and infrared light.

*Marshall Space Flight Center (MSFC)*
The U.S. government's civilian rocketry and spacecraft propulsion research center.

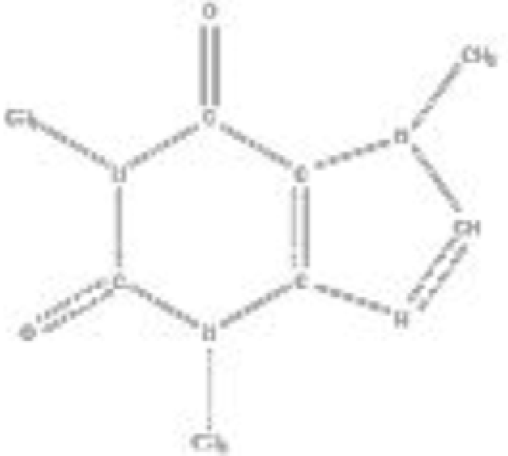
*National Aeronautics and Space Administration (NASA)*
An independent agency of the United States government responsible for aviation and spaceflight.

*National Institute of Aerospace (NIA)*
A non-profit research and graduate education institute created to conduct leading-edge aerospace and atmospheric research.

*Plasma*
A fourth state of matter distinct from solid or liquid or gas and present in stars and fusion reactors; a gas becomes a plasma when it is heated until the atoms lose all their electrons, leaving a highly electrified collection of nuclei and free electrons.

*Solid state physics*
The branch of physics that studies the properties of materials in the solid state such as electrical conduction in crystals of semiconductors and metals.





# ScienceMakers
## Spotlight: Stephen C. McGuire

| Name | Stephen C. McGuire |
|---|---|
| Birth Date | September 17, 1948 |
| Birth Place | New Orleans, Louisiana |
| Education | Joseph S. Clark High School<br>Southern University and A&M College<br>University of Rochester<br>Cornell University |
| Type of Science | Nuclear Physics |

## Biography

Physicist and physics professor Stephen C. McGuire was born on September 17, 1948 in New Orleans, Louisiana. McGuire was the first generation of his family to attend high school and college. McGuire's parents were supportive of his education and inspired him to work hard. By the time that McGuire graduated as valedictorian of his class at Joseph S. Clark Senior High in New Orleans, Louisiana, he knew that he wanted to pursue a career in physics. McGuire went on to attend Southern University and Agricultural and Mechanical College on a four-year academic scholarship. He received his B.S. degree from there in physics in 1970. McGuire continued his education at the University of Rochester, where he studied under Professor Harry W. Fulbright and graduated with his M.S. degree in nuclear physics in 1974. In 1979, McGuire obtained his Ph.D. degree from Cornell University in nuclear science with a focus on low energy neutron physics under the guidance of Professor David D. Clark.

**LIGO interferometer photo by Jim Shank @Flickr**

Between 1979 and 1982, McGuire conducted research as a staff scientist at Oak Ridge National Laboratory, served as a consultant to the National Institutes of Health (NIH) and the U.S. Department of Energy, and spent time as a physics researcher at Lawrence Livermore National Laboratory (LLNL). In 1982, McGuire joined the faculty at Alabama A&M University in the department of physics and applied physics, and he began research with the National Aeronautics and Space Administration (NASA). In 1989, he became the first African American faculty member at the endowed College of Engineering at Cornell University. McGuire then served as the Martin Luther

King, Jr. Memorial Visiting Scientist in Physics and Astronomy at Wayne State University in 1997. With research focusing on experimental nuclear physics and nuclear radiation and microelectronics, McGuire was appointed to be a visiting scientist at the Center for Neutron Research at the National Institute of Standards and Technology in 1998. Since 1999, McGuire has served as professor and chair of the department of physics at Southern University and A&M College in Baton Rouge, Louisiana. McGuire has pursued his interest in optical materials as part of the Laser Interferometer Gravitational-wave Observatory (LIGO). During his tenure with the university, McGuire helped to establish the partnership between LIGO and Southern University and A&M College, and he served as the LIGO Scientific Collaboration Principal Investigator (PI) for his campus.

McGuire was honored by NASA in 1987 with their Office of Technology Utilization Research Citation Award. One year later, McGuire participated in the First Edward A. Bouchet International Conference on Physics and Technology. In 1992, he became a charter fellow of the National Society of Black Physicists (NSBP) and in 1998, he was invited by the White House to attend a presentation by Stephen Hawking. That same year, he was also selected with ten other U.S. scientists to attend the Third Edward A. Bouchet International Conference on Physics and Technology in Botswana. McGuire is married to Saundra E. Yancy. They have two adult daughters, Carla and Stephanie.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. McGuire?
#2 Where was Dr. McGuire born? Locate it on a map. How far away is this from where you live? What are the names of his parents? Where did Dr. McGuire attend high school? What do you think high school was like for him?
#3 How old are you? In what year was Dr. McGuire your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 Dr. McGuire went to college on a scholarship. What kinds of scholarships are offered in your area? Are they science related?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a nuclear physicist does? Would you like to be a nuclear physicist? Why? Why not?
#2 If you were a nuclear physicist, what topics would you study?
#3 Where have you heard the term 'nuclear' before? What does it mean? What do you associate 'radiation' with? Why would nuclear radiation be dangerous?
#4 Look up who Stephen Hawking is. Why was he important? Why would it be an honor to be invited to one of his presentations?

#5 The development of the partnership between the Laser Interferometer Gravitational-wave Observatory (LIGO) in Livingston, Louisiana and Southern University is one of Dr. McGuire's greatest accomplishments. LIGO is attempting to observe cosmic gravitational waves through the interferometer, part of which can be seen in the picture above. If the research group at LIGO is trying to see cosmic gravitational waves, from what sources do you think the gravitational waves would be coming from?

# Glossary

*Astronomy*
The branch of physics that studies celestial bodies and the universe as a whole.

*Bouchet, Edward*
(1852 - 1918) The first African American to graduate from Yale University in 1874. He completed his dissertation in Yale University's Ph.D. program in physics in 1876.

*Consultant*
An expert who gives advice; an advisor.

*Hawking, Stephen*
(1942- ) British theoretical physicist, whose world-renowned scientific career spans over 40 years.

*Laser Interferometer Gravitational-wave Observatory (LIGO)*
A large physics experiment which is attempting to directly detect gravitational waves.

*Lawrence Livermore National Laboratory (LLNL)*
A scientific research laboratory founded by the University of California in 1952. Its principal responsibility is ensuring the safety, security and reliability of the nation's nuclear weapons through the application of advanced science, engineering and technology.

*Microelectronics*
The branch of electronics that deals with miniature components.

*National Aeronautics and Space Administration (NASA)*
An independent agency of the United States government responsible for aviation and spaceflight.

*National Institutes of Health (NIH)*
An agency in the Department of Health and Human Services whose mission is to employ science in the pursuit of knowledge to improve human health; the principal biomedical research agency of the federal government.

*National Society of Black Physicists (NSBP)*
A professional organization established in 1977 to promote the professional well-being of African American physicists and physics students within the international scientific community and the world community at large.

*Neutron*
A subatomic particle with no net electric charge and a mass slightly larger than that of a proton. They are usually found in atomic nuclei.

*Nuclear physics*
The branch of physics that studies the internal structure of atomic nuclei.

*Nuclear radiation*
Particulate and electromagnetic radiation emitted from atomic nuclei in various nuclear processes.

*Principal Investigator (PI)*
The lead scientist or engineer for a particular well-defined science (or other research) project, such as an astronomical observing campaign, laboratory study or clinical trial.

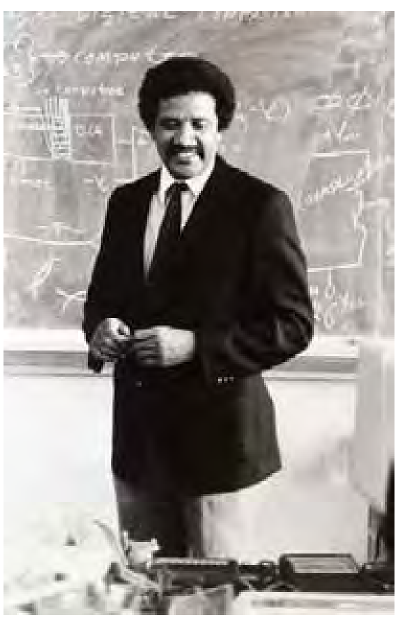
*Valedictorian*
An academic title typically given to the highest ranked student among the graduation class from a given school or educational institution.

# ScienceMakers
## Spotlight: Frederick William Oliver

| | |
|---|---|
| **Name** | Frederick William Oliver |
| **Birth Date** | October 15, 1940 |
| **Birth Place** | Baltimore City, Maryland |
| **Education** | Sollers Point High School<br>Morgan State University<br>Howard University |
| **Type of Science** | Physics |

## Biography

Physicist Frederick William Oliver was born on October 15, 1940 in Baltimore City, Maryland to Hattie and Willis Oliver. Oliver was raised on I and J Streets in an African American community located in Sparrows Point. He attended Sollers Point High School, graduating in 1958. Oliver then went to Morgan State University, where he received his B.S. degree in physics in 1962 under the mentorship of Dr. Julius Taylor. Oliver continued his education, receiving his M.S. and Ph.D. degrees from Howard University in 1965 and 1972, respectively, both in condensed matter physics. His research examines the Mossbauer Effect and its uses in spectroscopy.



(Photo from *The HistoryMakers* archive)
Dr. Oliver delivers a physics lecture
to his class.

Physics

In 1969, Oliver joined the faculty at Morgan State University as an associate professor. In 1979, Oliver became chair of the physics department at Morgan State University, taking over the position from his mentor, Dr. Julius Taylor. He served until 1995 and then again from 1999 to 2006. While at Morgan State University, Oliver held appointments with the Naval Research Laboratory (NRL), the Argonne National Laboratory, the University of Maryland, the National Aeronautics and Space Administration (NASA), Lawrence Livermore National Laboratory (LLNL), Bell Laboratories, and the Harry Diamond Laboratories. Oliver also served as the university's Radiation Safety Officer for fifteen years beginning in 1990. Since 2007, Oliver has been an appointed member of the Nuclear Regulatory Commission's

Atomic Safety and Licensing Board Panel. Oliver has published thirty-two full-length papers since 1965 and presented at numerous conferences. He has been awarded the Dr. Iva G. Jones Medallion Mantle Award and is an inducted member of Beta Kappa Chi and Sigma Pi Sigma, which are science honor societies. Oliver's most recent grant was funded by the Department of Energy for its "Educational Bridge Program." Oliver lives in Maryland with his wife Dianne and is the father of two children, Chaszetla and Chinyere.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Oliver?
#2 Where was Dr. Oliver born? Locate it on a map. How far away is this from where you live? What are the names of his parents? Where did Dr. Oliver attend high school? What do you think high school was like for him?
#3 How old are you? In what year was Dr. Oliver your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 Look up the biography of Dr. Julius Taylor (he can be found in this *ScienceMakers* Toolkit!) How would you describe him? What kind of a teacher do you think he was for Dr. Oliver?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a physicist does? Would you like to be a physicist? Why? Why not?
#2 If you were a physicist, what topics would you study?
#3 What are the responsibilities of a Radiation Safety Officer? What qualifications do you think one must have in order to become one?
#4 Dr. Oliver has worked at a number of prestigious laboratories during his career. Pick one and research some of its greatest achievements or describe what it is known for.
#5 Many spectroscopic techniques involve using different types of radiation to determine properties of matter. Can you name three types of electromagnetic radiation? Are these types of radiation used in a laboratory or hospital tests? If so, how? If not, why do you think they are not used?

# Glossary

*Argonne National Laboratory*
The first science and engineering research national laboratory in the United States. It is the largest national lab by size and scope in the Midwest. It maintains a broad portfolio in basic science research, energy storage, environmental sustainability, and national security.

*Bell Laboratories*
The research and development organization of Alcatel-Lucent and previously of the American Telephone & Telegraph Company (AT&T). Also known as Bell Labs and formerly known as AT&T Bell Laboratories and Bell Telephone Laboratories.

*Condensed matter physics*
The field of physics that deals with the macroscopic and microscopic physical properties of matter.

*Harry Diamond Laboratories (HDL)*
Research facilities that began in 1940, though that name was not given to the organization until 1962. In 1992, HDL was one of seven Army laboratories merged into a new organization, the Army Research Lab.

*Lawrence Livermore National Laboratory (LLNL)*
A scientific research laboratory founded by the University of California in 1952. Its principal responsibility is ensuring the safety, security and reliability of the nation's nuclear weapons through the application of advanced science, engineering and technology.

*Mössbauer Effect*
A physical phenomenon discovered by the German physicist Rudolf Mößbauer in 1957. It involves the absorption and scattering of photons.

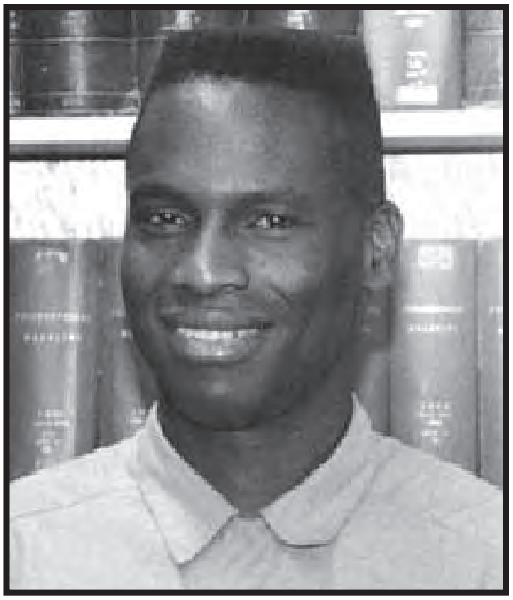
*National Aeronautics and Space Administration (NASA)*
An independent agency of the United States government responsible for aviation and spaceflight.

*Naval Research Laboratory (NRL)*
The U.S. Navy's corporate laboratory, which conducts a broadly-based multidisciplinary program of scientific research and advanced technological development directed toward maritime applications of new and improved materials, techniques, equipment, system, and ocean, atmospheric, and space sciences and related technologies.

*Radiation safety officer*
In the United States, the person within an organization responsible for the safe use of radiation and radioactive materials as well as regulatory compliance.

*Spectroscopy*
The study of the interaction between electromagnetic radiation and an object. The nature of the spectroscopy is determined by the wavelength of the electromagnetic radiation used.

# ScienceMakers
## Spotlight: Philip W. Phillips



| | |
|---|---|
| **Name** | Philip W. Phillips |
| **Birth Date** | June 28, 1958 |
| **Birth Place** | Scarborough, Tobago |
| **Education** | Walla Walla High School<br>Walla Walla University<br>University of Washington |
| **Type of Science** | Theoretical Physics |

## Biography

Physicist Philip W. Phillips was born on June 28, 1958 in Scarborough, Tobago to Carmella and Hollibert Phillips. Phillips graduated from Walla Walla High School in 1975. He then went on to earn his B.S. degrees in chemistry and mathematics in 1979 from Walla Walla University, in College Place, Washington. He continued his education at the University of Washington, where he received his Ph.D. degree in physical chemistry in 1982.

**"Floating magnet" by notydino @Flickr.** This cool trick is an example of the Meissner effect and is done by allowing the superconductor and magnet to become very cold.

Phillips has actively pursued his research interests throughout his career. He became a Miller Fellow at the University of California, Berkeley in 1982 and remained in California for two years. In 1984, Phillips was hired by the physics department at Massachusetts Institute of Technology (MIT) and became a full professor of physics. After nine years of teaching and conducting research at MIT, Phillips left to join the faculty at the University of Illinois at Urbana-Champaign in 1993 where he served as professor of physics. Phillips' interests include various topics in theoretical condensed matter. Moreover, he has invented new models for mottness. He has also examined iron-based superconductors and topological insulators. In 2009, Phillips was selected to serve a three-year term on the advisory board of the Kavli Institute of Theoretical Physics at the University of California, Santa Barbara.

Phillips has been internationally recognized for his work as an educator and an accomplished scientist. In addition to being elected to the advisory board, Phillips was elected to serve as vice-chair of the American Physical Society Nominating Committee. He was awarded the Edward A. Bouchet Award by the American Physical Society in 2000. That year, he delivered a series of lectures entitled "2e or not 2e in Strongly Repulsive Electronic Systems in 2D?" In 2002, he was named an American Physical Society Fellow for his contributions to an understanding of the field of theoretical condensed matter.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Phillips?
#2 Where was Dr. Phillips born? Locate it on a map. How far away is this from where you live?
#3 How old are you? In what year was Dr. Phillips your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 Where did Dr. Phillips attend college? What do you think college was like for him?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a theoretical physicist does? Would you like to be a theoretical physicist? Why? Why not?
#2 If you were a theoretical physicist, what topics would you study?
#3 Dr. Phillips studied chemistry and mathematics in college, then physical chemistry as part of his doctorate program. What connections exist between chemistry and physics? What do physical chemists study?
#4 If you had the opportunity to name one of your discoveries, what would you name it? Would it depend on the discovery?
#5 Physicists believe that there are four fundamental forces in the universe. Two of these are: the strong nuclear force and the weak nuclear force. These work on the level of nanoparticles and only act in a very short range. Can you think of the two others? Hint: think about what holds you to the surface of the earth, and the interaction between magnets.

# Glossary

*American Physical Society (APS)*
The world's second largest organization of physicists. The Society publishes more than a dozen scientific journals, including Physical Review and Physical Review Letters. It also organizes more than twenty science meetings each year.

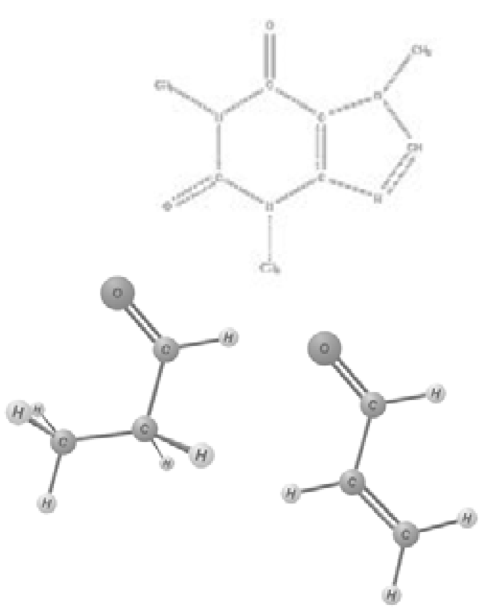
*Condensed matter*
Matter that exists in the solid or liquid phases.

*Mottness*
A term that denotes the additional ingredient, aside from antiferromagnetic ordering, which is necessary to fully describe a Mott Insulator. A Mott insulator is a class of materials that are expected to conduct electricity under conventional band theories but are insulators when measured (particularly at low temperatures).

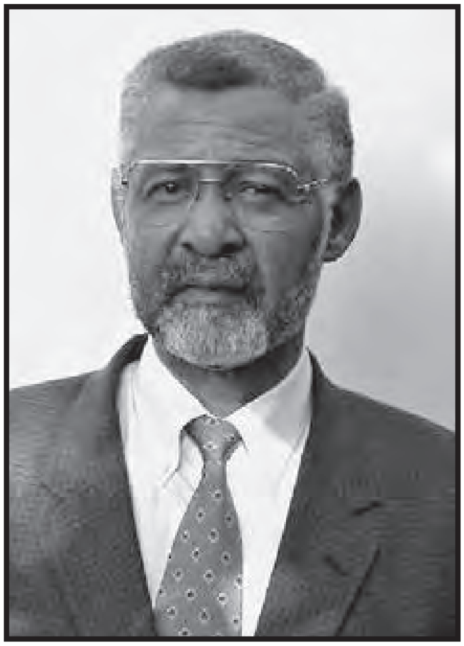
*Physical chemistry*
The study of macroscopic, microscopic, atomic, subatomic, and particulate phenomena in chemical systems in terms of physical concepts; often dependent on the principles, practices and concepts of physics like thermodynamics, quantum chemistry, statistical mechanics and dynamics.

*Superconductor*
A substance that has no resistance to conducting an electric current. A synthetic material that has very low or no electrical resistance. Such experimental materials are being investigated in laboratories to see if they can be created at near room temperatures.

*Topological insulators*
A material which is an insulator in its interior but which permits the movement of charges on its boundary.



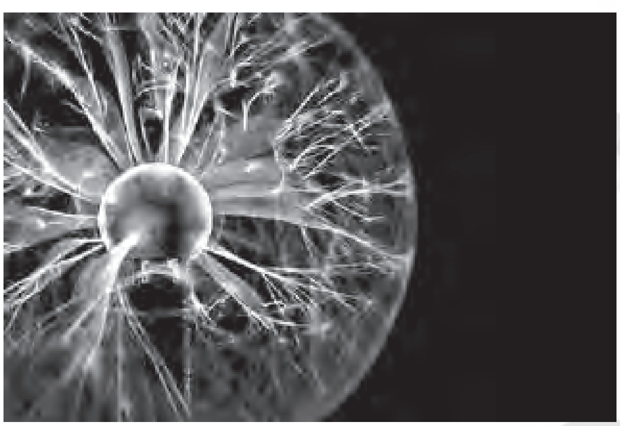
# ScienceMakers Spotlight: Kennedy Reed



| | |
|---|---|
| **Name** | Kennedy Reed |
| **Birth Date** | May 24, 1944 |
| **Birth Place** | Memphis, Tennessee |
| **Education** | Tilden Technical High School<br>Monmouth College<br>University of Wisconsin-Superior<br>University of Nebraska |
| **Type of Science** | Physics |

## Biography

Physicist Kennedy Reed was born on May 24, 1944 in Memphis, Tennessee and attended Tilden Technical High School in Chicago. He received his B.S. degree in physics from Monmouth College in Illinois in 1967, and later attended the University of Wisconsin-Superior where he received his M.S.T. degree in physics in 1971. Reed continued his education at the University of Nebraska, obtaining his Ph.D. degree in theoretical atomic physics in 1978.



**"Plasma Globe" by chasmin @Flickr**

Reed joined the faculty at Morehouse College in Atlanta, Georgia as a professor of physics in 1976. He has been a physicist at Lawrence Livermore National Laboratory (LLNL) since 1979. Reed has also been a visiting scientist at University College London in England and at the Hahn-Meitner Institute in Germany. His research has focused on theoretical studies of atomic processes in high temperature plasmas, and collisions of electrons with highly-charged ions. He is a co-founder of the National Physical Science Consortium and is the Director of the Lawrence Livermore National Laboratory Research Collaborations Program for Historically Black Colleges and Universities and Other Minority Institutions. In 2002, he was named Associate Director for Education and Outreach for the National Science Foundation (NSF) Center for Biophotonics Science and Technology at the University of California, Davis.

In 1997 and 1999, Reed worked as a visiting scientist at the University Cheikh Anta Diop in Senegal and the University of Cape Coast in Ghana through the Visiting Scholars Program of the International Center for Theoretical Physics in Trieste, Italy. He also organized U.S. visits for African physicists, resulting in exchanges of students and faculty between African and U.S. universities. In addition, Reed served as vice chair of the American Physical Society (APS) Committee on International Scientific Affairs and is Chair of the International Union of Pure and Applied Physics Commission on Physics for Development. In 2003, Reed received the American Physical Society's John Wheatley Award for his work promoting physics research and education in Africa.

Reed has published over 100 papers and is a fellow of the American Physical Society. He was president of the National Society of Black Physicists (NSBP) from 1990 to 1992, and is a member of the American Association for the Advancement of Science (AAAS) and the Optical Society of America (OSA). In 2010, Reed was honored with the Presidential Award for Excellence in Science and Engineering Mentoring.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Reed?
#2 Where was Dr. Reed born? Locate it on a map. Locate where Senegal and Ghana are in the world. How far away are they from where you live? What are the names of his parents? Where did Dr. Reed attend high school? What do you think high school was like for him?
#3 How old are you? In what year was Dr. Reed your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 Dr. Reed organized educational exchanges between Africa and the U.S. Why do you think he did this? What is the goal of an exchange program? Do you know any exchange students? Would you ever become an exchange student in a foreign country?
#5 What other question(s) would you ask if you were to interview the ScienceMaker?

***About the Subject Matter:***

#1 What do you think a physicist does? Would you like to be a physicist? Why? Why not?
#2 If you were a physicist, what topics would you study?
#3 Dr. Reed's work has focused on the studies of ions. What is an ion? What are common ionic molecules? You may have heard the saying, "opposites attract." What does that mean for ions? What happens if you bring two molecules with the same charge close together?

#4 Dr. Reed has worked with high temperature plasmas. What happens when you heat a material up? What happens to its molecules? Why is this interesting to physicists?
Note: "High temperature plasmas" means plasmas at several million degrees Celsius! The sun and other stars are examples of high temperature plasmas that occur in nature. Some of the research on these plasmas is focused on developing controlled thermonuclear fusion as a future source of energy.

#5 Research what work is done at National Ignition Facility at Lawrence Livermore National Laboratory does. How does this work affect the general public?

# Glossary

*American Association for the Advancement of Science (AAAS)*
An international non-profit organization with the stated goals of promoting cooperation between scientists, defending scientific freedom, encouraging scientific responsibility, and supporting scientific education and science.

*American Physical Society (APS)*
The world's second largest organization of physicists. The Society publishes more than a dozen scientific journals, including Physical Review and Physical Review Letters. It also organizes more than twenty science meetings each year.

*Atom*
The smallest component of an element having the chemical properties of the element.

*Biophotonics*
The study of the interaction of individual photons with biological structures.

*Electron*
A subatomic particle that carries a negative electric charge and is believed to be an elementary particle. An electron has a mass that is approximately 1/1836 that of the proton.

*Ion*
An atom or molecule in which the total number of electrons is not equal to the total number of protons, giving it a net positive or negative electrical charge.

*Lawrence Livermore National Laboratory (LLNL)*
A scientific research laboratory founded by the University of California in 1952. Its principal responsibility is ensuring the safety, security and reliability of the nation's nuclear weapons through the application of advanced science, engineering and technology.

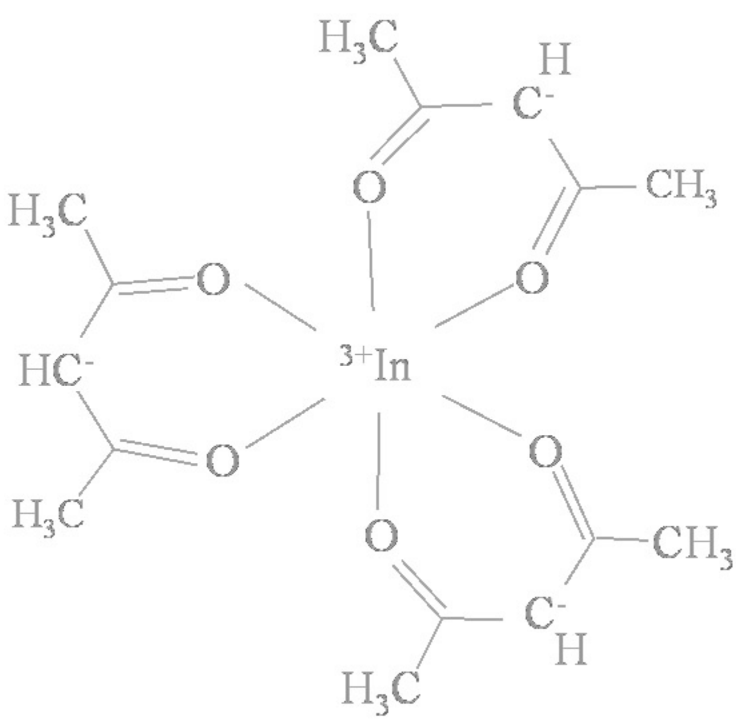
*National Science Foundation (NSF)*
A United States government agency that supports fundamental research and education in all the non-medical fields of science and engineering. Its medical counterpart is the National Institutes of Health.

*National Society of Black Physicists (NSBP)*
A professional organization established in 1977 to promote the professional well-being of African American physicists and physics students within the international scientific community and the world community at large.

*Optical Society of America (OSA)*
A scientific society dedicated to advancing the study of light—optics and photonics—in theory and application.

*Plasma*
A fourth state of matter distinct from solid or liquid or gas and present in stars and fusion reactors; a gas becomes a plasma when it is heated until the atoms lose all their electrons.

*Theoretical physics*
A branch of physics which employs mathematical models and abstractions of physics in an attempt to explain natural phenomena. Its central core is mathematical physics. Sometimes mathematical physics and theoretical physics are used synonymously to refer to the latter.

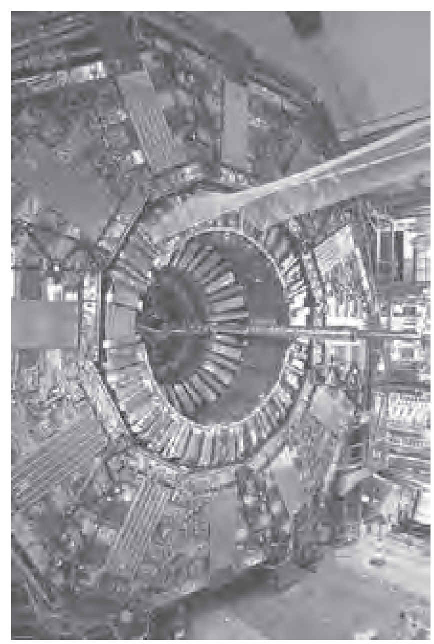


# ScienceMakers
## Spotlight: Allen Lee Sessoms

| | |
|---|---|
| **Name** | Allen Lee Sessoms |
| **Birth Date** | 1946 |
| **Education** | Union College<br>University of Washington<br>Yale University |
| **Type of Science** | Experimental Particle Physics |

## Biography

Physicist and education administrator Allen Lee Sessoms was born in 1946. He attended Union College in New York where he graduated with his B.S. degree in physics in 1968. He then attended the University of Washington, where he obtained his M.S. degree in physics the following year. Sessoms went on to Yale University where he earned his Master of Philosophy (M.Phil.) degree in physics in 1971 and his Ph.D. degree in physics in 1972. Following his graduate school work, Sessoms became a postdoctoral research associate at the Brookhaven National Laboratory (BNL) where he wrote computer programs and studied the production of quarks by high-energy protons at Fermi National Accelerator Laboratory (Fermilab).



YB-2: Muon detectors at CERN
by solarnu @Flickr



In 1973, Sessoms was hired to work as a scientific associate at the European Organization of Nuclear Research (CERN, see photo at right), where he researched quarks and similar particles. While at CERN, Sessoms became an assistant professor of physics at Harvard University. Sessoms moved to the U.S. State Department in 1980 as a senior technical advisor for the Bureau of Oceans and International Environmental and Scientific Affairs. From 1982 to 1987, Sessoms served as Director of the Office of Nuclear Technology and Safeguards in the same Bureau before becoming a Counselor for Scientific and Technological Affairs at the United States Embassy in Paris, France. Sessoms then traveled to Mexico, where he was a Minister-Counsel for Political Affairs at the United States Embassy before serving as its Deputy Chief of Mission, then the largest United States diplomatic mission in the world. In 1993, Sessoms left the United States State Department and began working as executive vice president at the University of Massachusetts system and also became its vice president for academic affairs. Following his time in Massachusetts, Sessoms was named president of Queens College, part of The City University of New York. Sessoms then spent time at Harvard University, first as a visiting scholar and then as a fellow of the Belfer Center for Science and International Affairs and as a lecturer in public policy. From 2003 to 2008, Sessoms served as the ninth president of Delaware State University prior to his appointment as president of the University of the District of Columbia. He is also a consultant to the U.S. intelligence community.

Sessoms has received a Ford Foundation Travel and Study Grant and an Alfred P. Sloan Foundation Fellowship. He has been bestowed two honorary doctorates from Union College and Soka University in Japan. Sessoms also received the Medal of Highest Honor from Soka University and the Seikyo Culture Award in Japan. In 1999, the Yale University Graduate School Association awarded him the Wilbur Lucius Cross Medal and he was named the Officier dans l'Ordre des Palmes Académiques ("Officer of the Order of Academic Palms) in France.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Sessoms?
#2 How old are you? In what year was Dr. Sessoms your age? What was happening in the country that year? What was happening in the world that year? What do you think his life was like when he was your age?
#3 Where did Dr. Sessoms attend college? In what state is this college located? Find it on a map. How far is this from where you live? What do you think college was like for Dr. Sessoms?
#4 Dr. Sessoms has traveled across the world during his career. Is this something you normally picture physicists doing? What other types of scientists do you think travel a lot?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a physicist does? Would you like to be a physicist? Why? Why not?
#2 If you were a physicist, what topics would you study?
#3 All matter is made of atoms. What are the parts of an atom? Break down the parts of an atom. What are the components of an atom and what are they made of?
#4 Several models of the atom have been developed as scientists have learned more about the atom's structure. These are: the Rutherford Model, the Bohr Model, and the Cloud Model. Pick one of these. What are the defining characteristics of the model of the atom that you have chosen? How does it compare to what is presently known about the atom?

#5 Many people have heard of CERN because it is home to the Large Hadron Collider. Research what the Large Hadron Collider does. Why is it important? How does it relate to the components of the atom?

# Glossary

*Brookhaven National Laboratory (BNL)*
A United States national laboratory located in Upton, New York on Long Island, and was formally established in 1947 at the site of Camp Upton, a former U.S. Army base.

*European Organization of Nuclear Research (CERN)*
The world's largest particle physics laboratory, situated in the suburbs of Geneva on the Franco–Swiss border. CERN's main function is to provide particle accelerators and other infrastructure needed for high-energy physics research. CERN's Large Hadron Collider is 27 km in circumference.

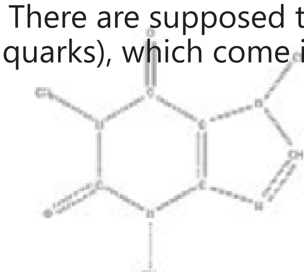
*Fermi National Accelerator Laboratory (Fermilab)*
A U.S. Department of Energy national laboratory specializing in high-energy particle physics. Fermilab's Tevatron is a landmark particle accelerator; at 3.9 miles (6.3 km) in circumference, it is the world's second largest energy particle accelerator.

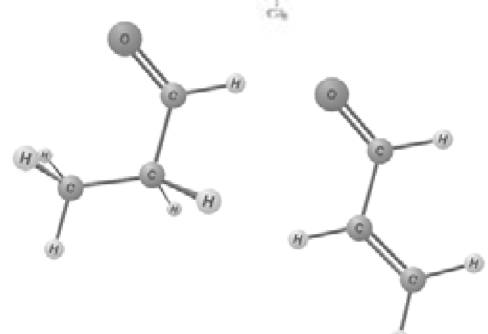
*Particle*
An atom or non-descript piece of matter (non-technical usage).

*Postdoctoral research*
Academic or scholarly research conducted by a person who has completed his or her doctoral studies, normally within a five year period. It is intended to further deepen expertise in a specialist subject, including necessary research skills and methods.

*Proton*
A subatomic particle with an electric charge of +1 elementary charge. It is found in the nucleus of each atom, along with neutrons, but is also stable by itself

*Quark*
A hypothetical fundamental particle that is smaller than the atom. There are supposed to be six flavors (the technical name for "types") of quarks (and their antiquarks), which come in pairs.



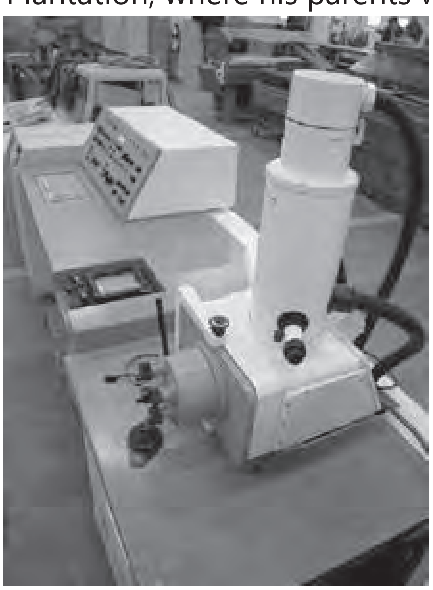


# Spotlight: Earl D. Shaw

| | |
|---|---|
| **Name** | Earl D. Shaw |
| **Birth Date** | 1937 |
| **Birth Place** | Clarksdale, Missouri |
| **Education** | Crane Technical High School<br>University of Illinois<br>Dartmouth College<br>University of California, Berkeley |
| **Type of Science** | Physics |

## Biography

Physicist Earl D. Shaw was born in 1937 in Clarksdale, Missouri. As a youth, Shaw lived on Hopson Plantation, where his parents were sharecroppers. Shaw was educated in a three-room schoolhouse by teachers without college degrees. When he was twelve years old, Shaw moved to Chicago, Illinois, where he attended Crane Technical High School. His studies in high school inspired him to pursue physics. Shaw attended the University of Illinois, where he received his B.S. degree in physics in 1960. He then went on to Dartmouth College where he obtained his M.A. degree. In 1969, Shaw graduated from the University of California at Berkeley with his Ph.D. in physics after writing his thesis: *Nuclear Relaxation in Ferromagnetic Cobalt*.



**Electron microscope photo by AMagill @Flickr**

After finishing his graduate education, Shaw worked as a research scientist at Bell Laboratories in Murray Hill, New Jersey. In 1985, after ten years of research, Shaw patented the "Free-electron amplifier device with electromagnetic radiation delay element." He also became known for his co-invention of the spin-flip Raman tunable laser. Since then, Shaw has been called the "Henry Ford of Free Electron Laser Technology." In 1991, Shaw joined the faculty of Rutgers, where he brought the far-infrared free electron laser technology he first developed at Bell Laboratories to the university. The lasers Shaw co-invented have assisted hospitals by providing radiation treatment to patients with cancer. His research is focused on enhancing the behavior of biological molecules with far-infrared radiation.

Shaw was featured in the book *Black Genius* along with his son, Alan Shaw, a professor emeritus of computer science at the University of Washington. Shaw lives in California with his wife Erin.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Shaw?
#2 Where was Dr. Shaw born? Locate it on a map. How far away is this from where you live? Where did Dr. Shaw attend high school? What do you think high school was like for him?
#3 How old are you? In what year was Dr. Shaw your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 Dr. Shaw's parents were sharecroppers—a very different occupation than the scientific career of Dr. Shaw. What do your parents do? Would you want to pursue their work? Why? Why not?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a physicist does? Would you like to be a physicist? Why? Why not?
#2 If you were a physicist, what topics would you study?
#3 The understanding of magnetism has been a key part of Dr Shaw's work. What are magnetic poles? How many poles does a magnet have? Is it possible for a magnet to be a "monopole"?
#4 A magnetic force depends upon several things. What information do you need in order to determine the magnetic force at a certain point? What do you think influences the strength of magnetic force? What makes determining the magnetic force so complex?
#5 The Free Electron Laser is just one example of a device that uses magnetism to obtain a desired effect (in this case, speeding electrons up to near the speed of light). What are other devices that you can think of that use magnetism to produce a desired effect? Think about how magnetism is used in medicine or credit cards, for example.

# Glossary

*Bell Laboratories*
The research and development organization of Alcatel-Lucent and previously of the American Telephone & Telegraph Company (AT&T). Also known as Bell Labs and formerly known as AT&T Bell Laboratories and Bell Telephone Laboratories.

*Computer science*
The study of the theoretical foundations of information and computation, and of practical techniques for their implementation and application in computer systems.

*Electromagnetic radiation*
A phenomenon that takes the form of self-propagating waves in a vacuum or in matter. Waves of energy associated with electric and magnetic fields resulting from the acceleration of an electric charge.

*Electron*
A subatomic particle that carries a negative electric charge and is believed to be an elementary particle. An electron has a mass that is approximately 1/1836 that of the proton.

*Emeritus*
An adjective that is used in the title of a retired professor, bishop, or other professional.

*Ferromagnetism*
The basic mechanism by which certain materials (such as iron) form permanent magnets, or are attracted to magnets.

*Far Infrared Radiation*
Electromagnetic radiation that approaches the region of the electromagnetic spectrum farthest from visible light, with a wavelength around 300 micrometers.

*Free Electron Laser (FEL)*
A laser that shares the same optical properties as conventional lasers such as emitting a beam consisting of coherent electromagnetic radiation which can reach high power, but uses some very different operating principles to form the beam.

*Infrared radiation (IR)*
Electromagnetic radiation consisting of light ranging from wavelength 0.7 to 300 micrometers. For reference, visible light is typically considered to be in the range of 0.4 to 0.7 micrometers. One micrometer is $1*10^{-6}$ meters or one millionth of a meter.

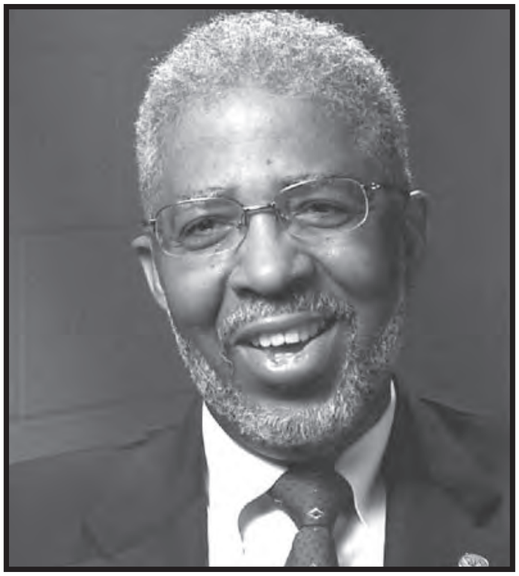


*Molecule*
An electrically neutral group of at least two atoms held together by very strong chemical bonds.

*Nuclear relaxation*
The phenomenon when a nucleus returns from an excited state to the ground state.

*Raman Effect*
The inelastic scattering of photons with subsequent change in frequency and phase. A Raman tunable device would utilize this effect to achieve a specific goal.

# ScienceMakers
# Spotlight: James Stith



| Name | James Stith |
|---|---|
| Birth Date | July 17, 1941 |
| Birth Place | Alberta, Virginia |
| Education | James Solomon Russell High School<br>Virginia State College<br>Pennsylvania State University |
| Type of Science | Physics |

## Biography

Physicist and physics professor James Stith was born on July 17, 1941 to Ruth Stith in Alberta, Virginia. Stith had three step-sisters—Wilma, Aldrena, and Joyce—and one half-sister, Juanita. Stith attended Oak Grove Elementary School and graduated from James Solomon Russell High School in 1959. It was in high school that Stith decided he wanted to pursue a career in physics.

**Dr. Stith (far right) assists young cadets with a physics demonstration at West Point.**

Stith went on to graduate from Virginia State College, earning both his B.S. and M.S. degrees in physics in 1963 and 1965, respectively. During his time at Virginia State College, Stith joined a fraternity, Alpha Phi Alpha, and worked as an instructor. In 1965, he was called to active duty in the United States Army for two years. Then, after a two-year term working with the Radio Corporation of America (RCA), Stith continued his education at Pennsylvania State University, where he earned his D.Ed. degree in physics in 1972. Following his graduation, Stith was recalled to active duty and joined the faculty of the United States Military Academy at West Point (USMA). In 1976, Stith became the first tenured African American professor at the United States Military Academy, where he continued to work until he retired from his post in 1993. Stith retired from the

United States Military Academy as a full professor of physics and from the military at the grade of Colonel. Stith then worked as a full professor of physics at Ohio State University until 1998. Following his time at Ohio State University, Stith was hired as the Vice President of the Physics Resource Center of the American Institute of Physics (AIP), a position he would hold for ten years. Stith also served on the board of the Triangle Coalition from 1999 to 2006. In 1990, He joined the advisory board for Project Kaleidoscope, an organization interested in developing and maintaining strong undergraduate programs in the scientific disciplines. Additionally, Stith has served on several advisory committees of the National Research Council throughout his career.

Stith has played an important role in increasing the role of African Americans in the physical sciences and has been recognized by the academic community for his work. In 1992, he was elected president of the American Association of Physics Teachers (AAPT), and in 2004 he was recognized as one of the "50 Most Important Blacks in Research Science" by *US Black Engineer and Information Technology Magazine*. Stith is married to Alberta Hill. They have three adult daughters: Adrienne Yvette, Andrea Lynn, and Alyssa Joy.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Stith?
#2 Where was Dr. Stith born? Locate it on a map. How far away is this from where you live? What are the names of his parents? Where did Dr. Stith attend high school? What do you think high school was like for him?
#3 How old are you? In what year was Dr. Stith your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 Stith has been a major proponent of improving education for all students. Why do you think that education is important?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a physicist does? Would you like to be a physicist? Why? Why not?
#2 If you were a physicist, what topics would you study?
#3 One of Stith's many papers was on the speed of sound in different materials at varying pressures. Use a physics book or the internet to find the speed of sound. Is this what you expected? How can you speed up the movement of sound? How can you slow it down?
#4 Which is faster, the speed of sound or the speed of light? What is the difference in their speeds?
#5 The 1979 science fiction film *Alien* used the tagline "In space no one can hear you scream." It is true that sound can travel in any medium (solid, liquid, gas, and plasma), but that it cannot travel in a vacuum. Why can sound NOT travel in a vacuum?

# Glossary

*American Association of Physics Teachers (AAPT)*
An international organization of physics educators and those with a strong interest in physics education, founded in 1931.

*American Institute of Physics (AIP)*
An international body representing physicists and publishing physics-related journals. It was founded in 1931.

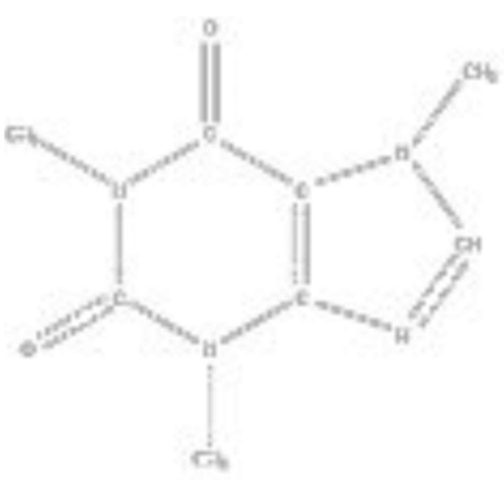
*Radio Corporation of America (RCA)*
An electronics company in existence from 1919 to 1986.

*Tenured*
Appointed for life and not subject to dismissal except for a grave crime.

*Triangle Coalition*
A non-profit organization whose mission is improve the quality and outcome of education in science, technology, engineering, and mathematics (STEM) education.

*United States Military Academy at West Point (USMA)*
A four-year coeducational federal service academy located at West Point, New York. Established in 1802, USMA is the oldest of the United States' five service academies.





# ScienceMakers
## Spotlight: Julius Henry Taylor

| Name | Julius Henry Taylor |
|---|---|
| **Birth Date** | February 15, 1914 |
| **Birth Place** | Cape May, New Jersey |
| **Education** | Middle Township High School<br>Lincoln University<br>University of Pennsylvania |
| **Type of Science** | Physics |

## Biography

Physicist Julius Henry Taylor was born on February 15, 1914 to Julia and Coleman Taylor in Cape May, New Jersey. Taylor was one of six children including Morris, Margaret, Coleman, Elizabeth, and Mildred. He attended Middle Township High School in New Jersey where he played trumpet in the band and was an avid basketball player and track star. When he graduated from high school in 1932, he did not plan to attend college. When he met Patricia Spaulding, she encouraged him to continue his studies, and the two were married in 1937. The following year, Taylor earned his A.B. degree in physics from Lincoln University in Chester County, Pennsylvania. He went on to receive his M.S. and Ph.D. degrees in solid state physics from the University of Pennsylvania.

In the 1940s, Taylor published scholarly papers under contract with the United States Navy. In 1945, he became chairman of the Department of Physics at West Virginia State College. Four years later, he joined the faculty at Morgan State University at the insistence of then-president Dr. Martin David Jenkins. Taylor began building the physics department, and became its first chairperson in 1954 after earning tenure as a professor. Taylor also started the first golf team at Morgan State University, a team that went on to win the Central Intercollegiate Athletic Association championship. A well-known golfer, Taylor continued to play eighteen holes regularly through 2009. During his years as a professor, Taylor mentored several students at Morgan State University who went on to get their Ph.D. degrees in physics including Dr. Frederick Oliver, who would later be hired as chair of the

Dr. Taylor's golf team. Dr. Taylor is pictured in the back row, second from the right.

Physics Department of Morgan State University. In 1955, Taylor served as an editor for *The Negro In Science*, a book addressing prominent African American scientists and their research. During his time at Morgan State University, Taylor served as a liaison to the National Aeronautics and Space Administration (NASA) Goddard Space Flight Center (GSFC) and the National Science Foundation (NSF), among several other scientific societies and committees. He also lectured at American University before his retirement in 1986 when he became professor emeritus at Morgan State University. After his retirement, Taylor continued to mentor students in junior and senior high schools in the Baltimore Public School System. In 1998, Taylor served as a contractor to NASA.

Taylor is the recipient of two Honorary Doctorate degrees in Science from Grambling State University and Lincoln University. In 1963, he was named Alumnus of the Year by Lincoln University and in 1976, he received a Distinguished Service Citation from the American Association of Physics Teachers (AAPT). He has been a member and president of the executive committee of the Chesapeake Section of the American Association of Physics Teachers as well as a section representative. Taylor has two children, Trena Taylor Brown and Dwight Spaulding Taylor.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Taylor?
#2 Where was Dr. Taylor born? Locate it on a map. How far away is this from where you live? What are the names of his parents? Where did Dr. Taylor attend high school? What do you think high school was like for him?
#3 How old are you? In what year was Dr. Taylor your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age? Taylor wanted to be a trumpet player before considering college. What do you think would convince you to change your mind about something important like going to college?
#4 Dr. Taylor has served as a mentor to many students. If you were going to mentor students, what subject would you teach them? How would you serve as a mentor?
#5 What other question(s) would you ask if you were to interview the ScienceMaker?

***About the Subject Matter:***

#1 What do you think a physicist does? Would you like to be a physicist? Why? Why not?
#2 If you were a physicist, what topics would you study?
#3 Dr. Taylor was an avid golfer throughout his life. The mechanics of golf are heavily dependent on knowing physics. Think of the forces that are acting on a golf ball from the moment that it is hit by the club to the moment it stops moving. Describe these forces. What forces are constant? Which is only momentary?

#4 There are a few types of collisions in physics. An *elastic collision* is one in which the total kinetic energy of the colliding bodies is conserved from before and after the interaction. An *inelastic collision* is one in which kinetic energy is not conserved (although momentum is); some of the energy is transferred to other forms of energy like heat. A *perfectly inelastic collision* is one in which the colliding objects stick together. Of these three types of collisions, how would you describe the collision between the golf ball and the head of a golf club?

#5 What factors control how far a ball is launched? Consider what happens if you have a heavier ball or if you have a heavier club, for example.

# Glossary

*American Association of Physics Teachers (AAPT)*
An international organization of physics educators and those with a strong interest in physics education, founded in 1931.

*Goddard Space Flight Center (GSFC)*
Goddard was NASA's first major scientific laboratory devoted entirely to the exploration of space. Located in Greenbelt, Maryland, GSFC's responsibilities include design and construction of new scientific and applications satellites, as well as tracking and communication with existing satellites.

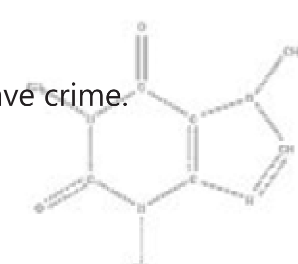
*Emeritus*
An adjective that is used in the title of a retired professor, bishop, or other professional.

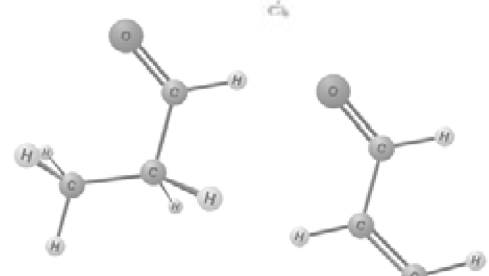
*National Aeronautics and Space Administration (NASA)*
An independent agency of the United States government responsible for aviation and spaceflight.

*National Science Foundation (NSF)*
A United States government agency that supports fundamental research and education in all the non-medical fields of science and engineering. Its medical counterpart is the National Institutes of Health.

*Solid state physics*
The branch of physics that studies the properties of materials in the solid state such as electrical conduction in crystals of semiconductors and metals.

*Tenure*
Appointment for life and not subject to dismissal except for a grave crime.





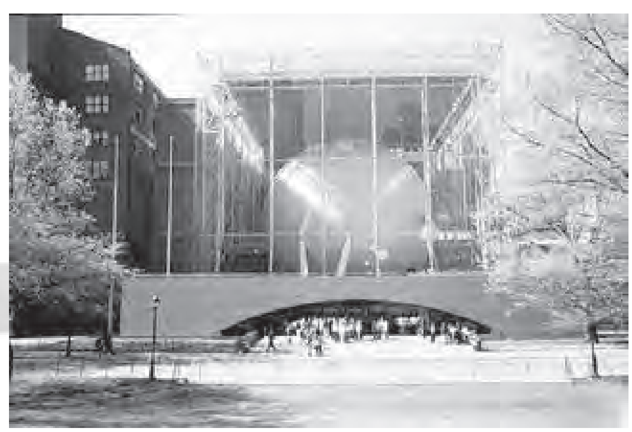
# ScienceMakers
## Spotlight: Neil deGrasse Tyson

| | |
|---|---|
| **Name** | Neil deGrasse Tyson |
| **Birth Date** | October 5, 1958 |
| **Birth Place** | New York City, New York |
| **Education** | Bronx High School of Science<br>Harvard University<br>University of Texas, Austin<br>Columbia University |
| **Type of Science** | Astrophysics |

## Biography



Astrophysicist and museum director Neil deGrasse Tyson was born on October 5, 1958 in New York City. His father, Cyril, was a sociologist and human resource commissioner while his mother, Sunchita Feliciano, was a gerontologist. Tyson grew up as the middle child of two siblings. He graduated from the Bronx High School of Science in 1976, where he was editor-in-chief of the *Physical Science Journal*. Tyson took a keen interest in astronomy as a youth after looking at the moon through binoculars from the top floor of his apartment. Tyson was noted for giving lectures on astronomy at the young age of fifteen. Astronomer and planetary scientist Carl Sagan tried to recruit Tyson to attend Cornell University, however Tyson chose Harvard University instead where he received his B.A. degree in physics in 1980. He then attended the University of Texas at Austin, where he obtained his M.A. degree in astronomy. Tyson then transferred to Columbia University to complete his Ph.D. degree in astrophysics in 1991.



**Planetarium photo by Andrew Kuchling @Flickr**

Tyson's first book was titled *Merlin's Tour of the Universe,* written in 1989. Tyson began writing the "Universe" column in *Natural History* magazine in 1995 and


NASA photo by http2007 @Flickr

in 1996, he joined the Hayden Planetarium at the American Museum of Natural History in New York as the Frederick P. Rose Director. He was featured on Public Broadcasting Service's (PBS) *Nova* "Origins," hosting the four-part miniseries in 2004. That year, he also co-authored the companion volume, *Origins: Fourteen Billion Years of Cosmic Evolution*. Tyson has served as vice president, president, and chairman of the board for the Planetary Society. In 2006, he became the host of the PBS show *Nova scienceNOW*. In 2007, Tyson was selected to be a recurring featured scientist on The History Channel's series *The Universe*. Since 2009, Tyson has hosted the radio talk show *Star Talk* with the comedian Lynne Koplitz. His latest book, published in 2009, deals with the controversy behind planet classification: *The Pluto Files: The Rise and Fall of America's Favorite Planet*.

Tyson was appointed to the Commission on the Future of the United States Aerospace Industry in 2001 by President George W. Bush. In 2004, he was selected to serve on the President's Commission on Implementation of United States Space Exploration Policy. He has also received National Aeronautics and Space Administration's (NASA) Distinguished Public Service Medal and holds honorary doctorates from ten universities. Tyson was selected as one of the 50 Most Important African Americans in Research Science in 2004 by *US Black Engineer and Information Technology Magazine* and named one of *Time Magazine*'s 100 Most Influential People of 2007. *Discover Magazine* named him one of the 50 Best Brains in Science in 2008. Tyson also holds the record for most guest appearances on *The Colbert Report* television news show.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Tyson?
#2 Where was Dr. Tyson born? Locate it on a map. How far away is this from where you live? What are the names of his parents? Where did Dr. Tyson attend high school? What do you think high school was like for him?
#3 How old are you? In what year was Dr. Tyson your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 Why do you think Dr. Tyson has shared his knowledge of astrophysics through television, books, and radio? What other forms of media are useful for talking about science?
#5 What other question(s) would you ask if you were to interview the ScienceMaker?

***About the Subject Matter:***

#1 What do you think an astrophysicist does? Would you like to be an astrophysicist? Why? Why not?
#2 If you were an astrophysicist, what topics would you study?

#5 Dr. Tyson has served as the director of the Hayden Planetarium. What is a planetarium? Is there one near you? What exhibits are usually in a planetarium?
#4 Our solar system consists of eight planets. What are the names of each of the planets, and describe their size, atmospheres, and distance from the sun. Are there planets around other stars? What are their names and around which stars do they orbit?
#5 What is Pluto currently classified as? Why is it no longer considered a planet? Should Pluto be considered a planet?

# Glossary

*Astronomy*
The branch of physics that studies celestial bodies and the universe as a whole.

*Astrophysics*
The study of the physics of stars, galaxies, and the interstellar medium.

*Gerontology*
The study of the social, psychological and biological aspects of aging.

*Hayden Planetarium*
A public planetarium located on Central Park West, New York City.

*National Aeronautics and Space Administration (NASA)*
An independent agency of the United States government responsible for aviation and spaceflight.

*Planetary Society*
A large, non-government and non-profit organization that has many research projects related to astronomy. It was founded in 1980 by Carl Sagan, Bruce Murray, and Louis Friedman, and has members from 125 countries around the world.

*Pluto*
The second-largest known dwarf planet in the Solar System (after Eris) and the tenth-largest body observed directly orbiting the Sun.

*Sagan, Carl*
(1934-1996) An American astronomer, astrophysicist, author, and highly successful popularizer of astronomy, astrophysics and other natural sciences. He pioneered exobiology and promoted the Search for Extra-Terrestrial Intelligence (SETI).

*Sociology*
The study and classification of human societies.

*Universe*
Everything we perceive to exist physically; the entirety of space and time, all forms of matter and energy.

# ScienceMakers
## Spotlight: Demetrius D. Venable

| Name | Demetrius D. Venable |
|---|---|
| Birth Date | October 11, 1947 |
| Birth Place | Powhatan, Virginia |
| Education | Pocahontas High School<br>Virginia State College<br>American University |
| Type of Science | Physics |

## Biography

Physicist Demetrius D. Venable was born on October 11, 1947 in Powhatan, Virginia. Venable's parents, J. Viola Bell Venable and James B. Venable, raised the young Venable and his two sisters. Venable attended Pocahontas Elementary School and Pocahontas High School. It was in high school that Venable first decided he wanted to pursue a career in science. He graduated from high school in 1966 and went on to study physics at Virginia State College. He received his B.S. degree in 1970. Continuing with his studies, Venable earned his M.S. and Ph.D. degrees in physics from The American University in 1972 and 1974, respectively.

**"Dunes" by Philipp Klinger @Flickr.**
Observe the cloud formations in this picture. Dr. Venable uses his background in optics to better understand weather patterns and predictability.



Upon completion of his Ph.D. program, Venable was hired by International Business Machines-East Fishkill where he studied semiconductor optical-measurement technology as a senior associate engineer. After two years of work with the company, Venable returned to academia and joined the staff of Saint Paul's College as assistant professor of physics and director of the Cooperative Physics Program. By 1978, he left Saint Paul's College to teach and conduct research at Hampton University. One of Venable's major accomplishments at Hampton, as the department chairman, was to help found the graduate program in physics there. He served in numerous positions at Hampton, eventually becoming executive vice president and provost by 1994. When he moved to Howard University in 1995, he was named the chairman of the department of physics and astronomy, a post that he would hold until 2007. During his tenure at Howard University, Venable helped to create the interdisciplinary doctorate program in atmospheric sciences. Venable was also instrumental in the development of the Howard University Beltsville Research Campus and the Raman LIDAR Program. With a specialty in optical physics, Venable has used optical techniques to study water vapor mixing ratios and atmospheric dynamics to further the goal of weather and climate predictability.

Among Venable's many awards are the National Aeronautics and Space Administration's (NASA) Distinguished Public Service Medal and the White House Initiative Science and Technology Advisory Committee's Faculty Award for Excellence in Science and Technology. Venable has also been accepted into several professional organizations, advisory boards, and committees and served as chairman of the American Institute of Physics' (AIP) Advisory Committee on Education from 1998 to 2001. He is a charter fellow of the National Society of Black Physicists (NSBP). Venable married Geri Turner in Brooklyn, New York, in 1969. They have two children, Juanita and Jessica.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Venable?
#2 Where was Dr. Venable born? Locate it on a map. How far away is this from where you live? What are the names of his parents? Where did Dr. Venable attend high school? What do you think high school was like for him?
#3 How old are you? In what year was Dr. Venable your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 Venable first decided that he wanted to pursue a career in physics during high school. Which of your classes do you enjoy the most? How can you make a career out of it? What is your path to reaching that goal?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think an optical physicist does? Would you like to be an optical physicist? Why? Why not?
#2 If you were an optical physicist, what topics would you study? What types of tools does an optical physicist use?
#3 What is the difference between reflection and refraction? Use a dictionary or a standard physics book to help.
#4 What are the climate trends in your area? Is it easier to describe your observations qualitatively or quantitatively? What is the difference between a qualitative and a quantitative observation? Do you think it makes a difference? Which way do think is more substantive? What are the pros and cons of each?
#5 In addition to optical physics, in what other ways have people studied climate change? What causes the climate to change in the first place?

# Glossary

*American Institute of Physics (AIP)*
An international body representing physicists and publishing physics-related journals. It was founded in 1931.

*Astronomy*
The branch of physics that studies celestial bodies and the universe as a whole.

*International Business Machines (IBM)*
One of the major mainframe computer manufacturers, as well as personal computer designer.

*LIDAR (LIght Detection And Ranging)*
An optical remote sensing technology that measures properties of scattered light to find range and/or other information of a distant target. The prevalent method to determine distance to an object or surface is to use laser pulses. In other words, a laser beam used to probe the lower atmosphere for solid particles (ice and snow crystals) and/or the upper atmosphere for chemicals (ozone and others).

*National Aeronautics and Space Administration (NASA)*
An independent agency of the United States government responsible for aviation and spaceflight.

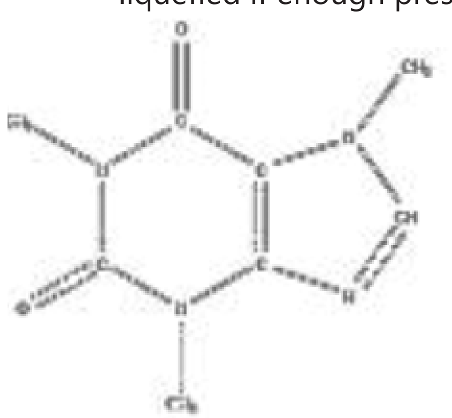
*National Society of Black Physicists (NSBP)*
A professional organization established in 1977 to promote the professional well-being of African American physicists and physics students within the international scientific community and the world community at large.

*Provost*
A high-ranking university administrator.

*Raman Spectroscopy (Raman Effect)*
A spectroscopic method that utilizes the Raman effect (the inelastic scattering of a photon) to extract information about the structure of a molecule.

*Semiconductor*
A material that is neither a good conductor nor a good insulator. Examples of semiconductors are: Silicon, Boron, and Carbon.

*Vapor*
Any substance existing in the gaseous state at a temperature lower than that of its critical point, the point when it would normally change from the liquid to gas state. Vapor can be liquefied if enough pressure is applied.



# ScienceMakers
## Spotlight: Conrad Williams

| | |
|---|---|
| **Name** | Conrad Williams |
| **Birth Date** | March 1, 1936 |
| **Birth Place** | Warsaw, North Carolina |
| **Education** | Springarn Senior High School<br>Morgan State University<br>Howard University |
| **Type of Science** | Physics |

## Biography

Physicist Conrad Williams was born on March 1, 1936 in Warsaw, North Carolina. Williams grew up on Capitol Hill in Washington, D.C., where he visited area museums, including the Smithsonian Institution. A geology curator at the Museum of Natural History helped foster his interest in the sciences; he mentored Williams and taught him about rocks and rock formations. Williams graduated from Springarn Senior High School in 1954. He then earned his B.S. degree in physics from Morgan State University in 1958. In 1960, Williams began working as a solid state physicist at the U.S. Naval Research Laboratory. By continuing his academic pursuits while working at the U.S. Naval Research Laboratory, Williams earned his M.S. degree in physics from Howard University in 1965. He continued his studies at Howard University under the guidance of Dr. Arthur N. Thorpe, and he received his Ph.D. degree in physics in 1971.

**U.S. Naval Research Laboratory photo by madmack66 @Flickr**

Williams worked at the U.S. Naval Research Laboratory for thirty-three years. He was promoted to several positions throughout his career. In 1980, he was named the program director of the college and university faculty programs, and in 1981, the associate program director of condensed matter physics and superconductivity. The following year, he was promoted to head of research in the applied magnetic section. He worked with the Naval Research Laboratory until he was hired as a physics professor at Morgan State University in 1993.

Physics

Williams has consistently contributed to the field of thin films and multilayer magnetic materials for the last five decades. His research interests focus on the physical properties of magnetism in unique compounds, such as magnetic anisotropy and magnetostriction. Williams also designed and constructed the world's first 6-Tesla high field torque magnetometer, a device that enabled him to determine the origin of the hysteretic properties that make rare-earth intermetallic compounds desirable for use in permanent magnet applications.

## Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Williams?
#2 Where was Dr. Williams born? Locate it on a map. How far away is this from where you live? Where did Dr. Williams attend high school? What do you think high school was like for him?
#3 How old are you? In what year was Dr. Williams your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 Dr. Williams worked at the U.S. Naval Research Laboratory for thirty-three years. What was going on in the world during the 1960s to the 1980s that might have impacted Williams' life and his work?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a solid state physicist does? Would you like to be a solid state physicist? Why? Why not?
#2 If you were a solid state physicist, what topics would you study?
#3 What are common properties of magnets? When a person describes an object as "magnetic," what does he mean?
#4 What are the magnetic poles? Does the earth have magnetic poles? Think about how your compass works. Which way does the compass point?
#5 The relationship between electricity and magnetism has been studied for centuries. What are Maxwell's Equations, and what do they describe? To what other physical laws do Maxwell's Equations relate?

# Glossary

*Condensed matter physics*
The field of physics that deals with the macroscopic and microscopic physical properties of matter.

*Curator*
A person who manages, administers or organizes a collection, such as those seen in a museum.

*Geology*
The science and study of the solid and liquid matter that constitutes the Earth.

*Hysteretic*
A term used to describe a system or situation in which an output value (or observation) is not a strict function of the corresponding input value (or observation), but also incorporates some lag, delay, or history dependence.

*Intermetallic compound*
Any solid material, composed of two or more metal atoms in a definite proportion, that has a definite structure which differs from those of its constituent metals.

*Magnet*
A material or object that produces a magnetic field and a force that pulls on other ferromagnetic materials like iron and attracts or repels other magnets.  Tesla are the units of magnetic fields.

*Magnetic anisotropy*
The direction dependence of a material's magnetic properties. Some magnets have no preferential direction for their magnetic moment while others will align to an axis.

*Magnetometer*
A meter to compare strengths of magnetic fields.

*Magnetostriction*
A property of magnetic materials that causes them to change their dimensions when subjected to a magnetic field.

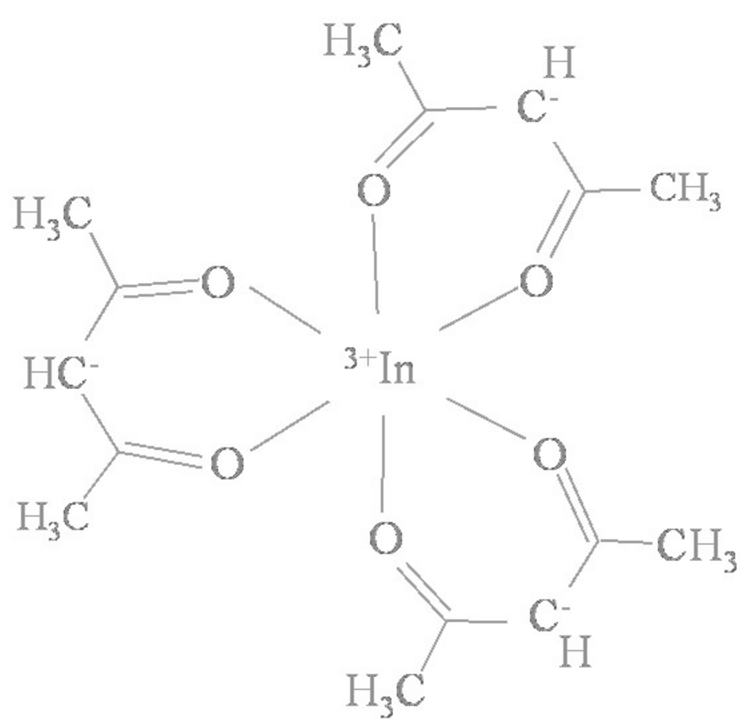
*Smithsonian Institution*
An educational and research institute and associated museum complex located in Washington, D.C.

*Solid state physics*
The branch of physics that studies the properties of materials in the solid state such as electrical conduction in crystals of semiconductors and metals.

*Superconductor*
A substance that has no resistance to conducting an electric current.  A synthetic material that has very low or no electrical resistance. Such experimental materials are being investigated in laboratories to see if they can be created at near room temperatures.

*Thin film*
Thin material layers ranging from fractions of a nanometer (monolayer) to several micrometers in thickness. Electronic semiconductor devices and optical coatings are applications that use thin films.

*Torque*
The tendency of a force to rotate an object about an axis, fulcrum, or pivot.



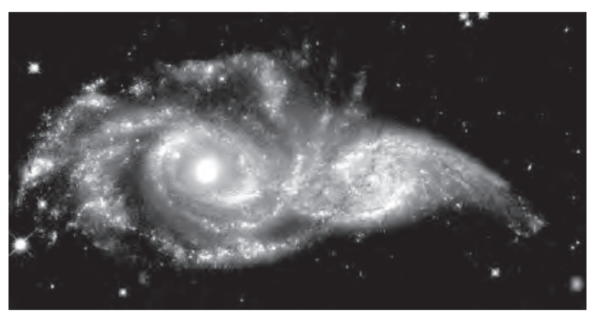

Physics

# ScienceMakers
## Spotlight: Charles E. "Chick" Woodward

| | |
|---|---|
| **Name** | Charles E. "Chick" Woodward |
| **Birth Date** | January 23, 1958 |
| **Birth Place** | Rochester, New York |
| **Education** | Dartmouth College<br>University of Rochester |
| **Types of Science** | Astronomy<br>Astrophysics |

## Biography

Astronomer and astronomy professor Charles E. "Chick" Woodward was born in, 1958. Woodward graduated from Dartmouth College in 1980 with his B.A. degree in physics. Woodward then attended the University of Rochester, where he received his M.A. degree in physics in 1982. He continued his studies at the University of Rochester where he earned his Ph.D. degree in physics and astronomy in 1987.



**"Eyes in the Sky" by NASAJPL @Flickr.** Two merging galaxies (NGC 2207 and IC 2163) are captured in this image by the Spitzer Space Telescope and Hubble Space Telescope

Woodward has held a number of positions across the country studying astrophysics. After completing his doctorate program, Woodward served as a research associate at the University of Wyoming until 1990. In 1991, he was named an assistant professor, and by 1995, an associate professor at the University of Wyoming. He was also named the director of the Wyoming Infrared and Red Buttes Observatories at the University of Wyoming in 1996. In 2000, Woodward was invited to join the staff of the Department of Physics and Astronomy at the University of Minnesota, where he was named a full professor in 2005. At the University of Minnesota, Woodward has been responsible for the university's access to the Large Binocular Telescope and Steward observatories. Throughout his career, Woodward has been involved with a number of projects, including the National Aeronautics and Space Administration (NASA) Deep Impact Space Mission, which used ground-based telescopes such as the Gemini 8-m on Mauna Kea, Hawaii and Spitzer Space Telescope infrared observations to assist in understanding the mineralogical and physical nature of comets. Woodward has also been instrumental in the development of astronomical infrared radiation array cameras, which have allowed for the studies of star formation and supernovae. Another area of interest for Woodward's research group is the study of novae dust.

Woodward's contributions to the exploration of space matter and our understanding of the universe have garnered him much recognition. Woodward has received numerous teaching awards from the University of Wyoming, as well as a number of fellowships from such prestigious organizations as the National Science Foundation (NSF) and the Smithsonian Institution. In addition, Woodward has served as a member of the American Astronomical Society and the National Society of Black Physicists (NSBP).

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Woodward?
#2 Where was Dr. Woodward born? Locate it on a map. How far away is this from where you live? What are the names of his parents?
#3 How old are you? In what year was Dr. Woodward your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 Where did Dr. Woodward attend college? What do you think college was like for him?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think an astrophysicist does? Would you like to be an astrophysicist? Why? Why not?
#2 If you were an astrophysicist, what topics would you study?
#3 What are some of the big questions in space exploration right now? What were they fifty years ago? Are they the same or are they different? What monumental event happened on July 20, 1969?
#4 What is an observatory? Have you ever been to one? Where is the closest one to you? Are there advantages to using a space telescope? Can you think of any disadvantages? Woodward used the Spitzer Space Telescope for some of his research. Can you think of other space telescopes? Check out your local library to find more information.
#5 Many of Woodward's projects have used infrared spectroscopy to observe the universe. Humans cannot see infrared light, so why do you think infrared imaging is important? What information can we gain?

# Glossary

*Astronomy*
The branch of physics that studies celestial bodies and the universe as a whole.

*Astrophysics*
The study of the physics of stars, galaxies, and the interstellar medium.

*Comet*
A relatively small extraterrestrial body consisting of a frozen mass that travels around the sun in a highly elliptical orbit.

*Deep Impact Mission*
A NASA mission in which a space probe was designed to study the composition of the comet interior of comet 9P/Tempel by releasing an impactor into the comet. The photographs showed the comet to be more dusty and less icy than had been expected.

*Infrared radiation (IR)*
Electromagnetic radiation consisting of light ranging from wavelength 0.7 to 300 micrometers. For reference, visible light is typically considered to be in the range of 0.4 to 0.7 micrometers. One micrometer is $1*10^{-6}$ meters or one millionth of a meter.

*National Aeronautics and Space Administration (NASA)*
An independent agency of the United States government responsible for aviation and spaceflight.

*National Science Foundation (NSF)*
A United States government agency that supports fundamental research and education in all the non-medical fields of science and engineering. Its medical counterpart is the National Institutes of Health.

*National Society of Black Physicists (NSBP)*
A professional organization established in 1977 to promote the professional well-being of African American physicists and physics students within the international scientific community and the world community at large.

*Nova*
A star that ejects some of its material in the form of a cloud and become more luminous in the process.

*Smithsonian Institution*
An educational and research institute and associated museum complex located in Washington, D.C.

*Spitzer Space Telescope*
Launched in 2003, the Spitzer Space Telescope is an infrared space observatory. Its liquid coolant was depleted in 2009, but the telescope is still used for certain "warm-operations" observations. The Spitzer Space Telescope has an Infrared Array Camera, an infrared spectrograph, and a Multiband Imaging Photometer.

*Telescope*
An instrument designed for the observation of remote objects by the collection of electromagnetic radiation. The first known practically functioning telescopes were invented in the Netherlands at the beginning of the 17th century.

# Physics Activity on Exploring Density

## *Coke v. Diet Coke*

**Grade Level:** 4+
**National Standards:** H.B.2 Structure and properties of matter

### *Objective*

What are the differences in coke and diet coke? **This experiment will show students how the density of two very similar objects can be different.**

### *Materials and Equipment*

- 1 can of Coke
- 1 can of Diet Coke
- Large bucket
- Water
- Sugar
- Artificial sweetener (like Nutra Sweet)

### *Experimental Procedure*

1. Look at the two cans. What is different about them? What is the same? Make two lists.

| Coke | Diet Coke |
|---|---|
| | |

2. Fill the bucket with water about halfway (enough to cover the can if you dropped it in).
3. Place the regular Coke into the water. Observe what happens.
4. Place the Diet Coke into the water. Observe what happens.
5. Write down why you think this happened.



### *Discussion of Results*

Why did one float and the other sink? Density is a measure of how much stuff is packed into a space. In this case, the Coke had sugar in it which made it more dense. On the other hand, the Diet Coke had aspartame, an artificial sweetener known as “Nutra Sweet” which requires much less to make the drink taste sweet. In fact, one 8 oz. can of Diet Coke has 125 mg of aspartame while one can of regular Coke has 39,000 mg of sugar.

Density can be measured by taking the amount of stuff (the mass) and dividing it by the amount of space (volume). For example, one classroom with one student in it is not very dense. However, one classroom with 100 students in it is very dense! The volume has not changed, but the mass has greatly increased! Water’s density is $1 g/cm^3$. Anything more dense sinks (like the Coke) and anything less dense floats (like Diet Coke).

Physics Activity on Clasical Mechanics

# Distance and Constant Acceleration

**(www.ScienceBuddies.org)**

**Grade Level:** 6-8
**National Standards:** H.B.4 Motions and forces

### *Abstract*

This project is an experiment in classical physics. You'll be following in Galileo's footsteps, and investigating Newton's laws of motion, using a metronome as your timing device. Sure, it's been done before, but if you do it yourself, you can get a firm understanding of these important concepts.

### *Objective*

**The objective of this project is to determine the relation between elapsed time and distance traveled when a moving object is under constant acceleration.**

### *Introduction*

You know from experience that when you ride your bike down a hill, it's easy to go fast. Gravity is giving you an extra push, so you don't have to do all the work with the pedals. You also know from experience that the longer the hill, the faster you go. The longer you feel that push from gravity, the faster it makes you go. Finally, you also know that the steeper the hill, the faster you go.

The maximum steepness is a sheer vertical drop—free fall—when gravity gives the biggest push of all. You wouldn't want to try that on your bicycle!

In free fall, with every passing second, gravity accelerates the object (increases its velocity) by 9.8 meters (32 feet) per second. So after one second, the object would be falling at 9.8 m/s (32 ft/s). After two seconds, the object would be falling at 19.5 m/s (64 ft/s). After three seconds, the object would be falling at 29 m/s (96 ft/s), and so on.

Measuring the speed of objects in free fall is not easy, because they fall so quickly. There is another way to make measurements of objects in motion under constant acceleration: use an inclined plane. An inclined plane is simply a ramp. You're making a hill with a constant, known slope. With a more shallow slope, the acceleration due to gravity is small, and the object will move at a speed that is more easily measured.

This project will help you make some scientific measurements of the "push" from gravity, using a marble rolling down an inclined plane, with a metronome for measuring time.

### *Terms, Concepts and Questions to Start Background Research*

To do this project, you should do research that enables you to understand the following terms and concepts:

- velocity
- acceleration
- inclined plane
- mass
- gravity

### *Questions*

- What is the formula for velocity as a function of time when an object is subject to constant acceleration?
- What is the formula for distance traveled as a function of time when an object is subject to constant accleration?

### *Bibliography*

For background information on inclined planes, see these references:
Wikipedia contributors, 2006. "Inclined Plane," Wikipedia, The Free Encyclopedia [accessed September 25, 2006] http://en.wikipedia.org/w/index.php?title=Inclined_plane&oldid=79997799.

Henderson, T., 2004. "Inclined Planes," The Physics Classroom, Glenbrook South High School, Glenview, IL [accessed September 25, 2006] http://www.glenbrook.k12.il.us/gbssci/Phys/Class/vectors/u3l3e.html.

Duffy, A. "Inclined Plane," Boston University, Interactive Physics Demonstrations [accessed September 25, 2006] http://physics.bu.edu/~duffy/semester1/c5_incline.html.

If you want to make a fancier set-up to release a steel marble electrically, see the following reference:
U.C. Regents, 1996. "Acceleration," U.C. Berkeley Physics Lecture Demonstrations [accessed September 25, 2006] http://www.mip.berkeley.edu/physics/A+0+20.html.

### *Materials and Equipment*

To do this experiment you will need the following materials and equipment:

- inclined plane
  - you'll need a flat board, about 2m long (longer is better unless you are using a video camera)
  - cut a groove straight down the middle to guide the rolling marble, *or*
  - glue a straight piece of wood along the length of the board to act as a guide;
  - mark a starting line across one end;
  - you will also need some wood blocks (about 2.5 cm thickness) to raise up one end of the board.
- tape measure (for measuring height and length of inclined plane)
- marble
- metronome
- helper
- pencil

### *Experimental Procedure*

In this experiment, the goal is to measure the distance the marble travels in equal time intervals as it rolls down an inclined plane.

1. Set up your inclined plane on a single block, so that it has a low slope. If the slope is too high, the marble will roll too fast, and it will be too hard to make accurate measurements.
2. Hold a marble in place at the starting line.
3. Use a metronome to keep track of equal time intervals.
   a. You can set the number of beats per minute that the metronome will sound.
   b. 60 beats per minute would give you one tick every second.
   c. 120 beats per minute gives you two ticks every second, or one tick every half-second.
   d. We suggest that you start with one tick every second.
4. In time with a tick, release the marble, being careful not to give it a push as you let go.
5. Have your helper mark where the marble is at the first tick after release.

6. Measure and record the distance (cm) from the starting line.
7. Repeat this 10 times.
8. Next your helper will mark where the marble is at the second tick.
9. Measure and record the distance (cm) from the starting line.
10. Repeat this 10 times.
11. Keep repeating the process for each successive tick, making 10 measurements for each tick, until the tick when the ball goes past the end of the inclined plane.
12. Calculate the average and standard deviation for the distance the marble has traveled at the end of each tick.
13. Graph the average distance traveled (y-axis) vs. time, in terms of the number of ticks (x-axis).
14. Graph the average distance traveled (y-axis) vs. time squared. Compare the two graphs.
15. Another way to see the relationship between time and distance traveled with constant acceleration is is to use the distance traveled during the first "tick" as the distance unit instead of centimeters. How many of these distance units has the ball traveled by the second tick? By the third tick? By the fourth tick? By the fifth tick?

### *Variations*

Does the mass of the marble affect its acceleration? Try the experiment with marbles of different masses. Or, even better, compare a steel marble (e.g., a pinball or a large ball bearing) with a glass marble of the same diameter. Use a gram balance to weigh each marble (you can always weigh them at the post office if you don't have a gram balance available at home or school). Is the acceleration the same or different for the marbles with different masses?

For another method of measuring distance traveled and velocity of an object rolling down an inclined plane, see the Science Buddies project, Distance and Speed of Rolling Objects Measured from Video Recordings (http://www.sciencebuddies.org/mentoring/project_ideas/Phys_p027.shtml)

Use your measurements to calculate the approximate velocity of the marble at each tick. As an example, to calculate the average velocity at the second metronome tick, take the distance the marble has traveled by the second tick, and subtract the distance the marble traveled by the previous tick. Divide the result by the amount of time per tick. Repeat this calculation for several successive time points to see how velocity changes as the marble rolls down the ramp. Make a graph of velocity (y-axis) vs. time (x-axis). Does this graph look more like the distance vs. time or the distance vs. time squared graph?

One reason a marble was chosen for this experiment was to minimize the frictional forces which counteract the acceleration of gravity. Try repeating the experiment with other rolling objects (e.g., a toy car with the same mass as the marble) or different surface treatments (e.g., smooth, waxed surface, vs. rough, sandpapered surface). Can you detect a decrease in acceleration due to increased friction?

For more advanced students:
If you have studied trigonometry, you should be able to derive a formula that describes the acceleration, $a$, of the marble as function of the angle, $\theta$, of the inclined plane (see Henderson, 2004).

If you have studied calculus, you should be able to explain both velocity and acceleration as the first and second derivatives, respectively, of distance traveled with respect to time. Conversely, you should be able to explain velocity and distance traveled at a given time as the first and second integrals, respectively, of acceleration with respect to time.

### *Credits*

Andrew Olson, Ph.D., Science Buddies

Physics Activity on The Atom

# Modeling the Elementary Particles of an Atom

**Grade Level:** 8+
**National Standards:** H.B.1 Structure of atoms

### *Objective*

Have you ever wondered what an atom looks like? **In this activity, students will explore the basic components of the atom.** You will use a few models to help get an understanding of the relative size of the subatomic particles.

### *Introduction*

Think of a question you have about the structure of the atom. For example, what components make up a nucleus? What differentiates the different elements? How big is the proton compared to the electron?

### *Materials and Equipment*

- Gumdrops or marshmallows in three colors. Suggested: green, yellow, red.
- Toothpicks
- Gallon of water
- Penny: 0.003kg

### *Experimental Procedure*

1. To begin, separate out the three colors of gumdrops.
2. Designate which color will be used for: protons, neutrons, and electrons. Record it in the table below:

| Color | Particle |
|---|---|
| | Proton (+) |
| | Neutron |
| | Electron (-) |

The proton carries a positive charge and the electron carries a negative charge. Just like a magnet, where opposite poles attract, the electromagnetic force pulls the proton and electron together.

3. We will be first modeling the simplest of atoms: the Hydrogen atom. Hydrogen is the most abundant element in the universe. Its <u>atomic number</u> is: 1. Recall that the atomic number is the number of protons in a nucleus. A hydrogen atom consists of:
   - 1 proton
   - 1 electron

The lone proton forms the nucleus of the atom. The electron would circle around the proton. Keep this one set up. You will be using it later.

4. We can form an isotope of hydrogen. An isotope of an element is any variation of the element which varies in the number of neutrons. Since the number of protons determines the identity of the atom, the number of neutrons determines its isotope characteristics. You can form an isotope of hydrogen by adding a neutron to the nucleus. This isotope of hydrogen is called deuterium and it contains:
    - 1 proton
    - 1 electron
    - 1 neutron

Use a toothpick to join together the proton and neutron gumdrops. The combined protons and neutrons form the nucleus.
Remember that in isotopes, the mass number (the number of protons and neutrons) is different, but the atomic number (the number of protons) remains the same. Thus, the mass number of deuterium is 2, and the atomic number is still 1.

5. The next molecule we will be making is the Helium atom. Helium is the second most abundant element in the universe. Its atomic number is 2 and its mass number is 4. The helium atom consists of:
    - 2 protons
    - 2 neutrons
    - 2 electrons

Carefully insert the toothpick into the 2 protons and 2 neutrons. These form the Helium nucleus. The 2 electrons circle the proton and the neutron.

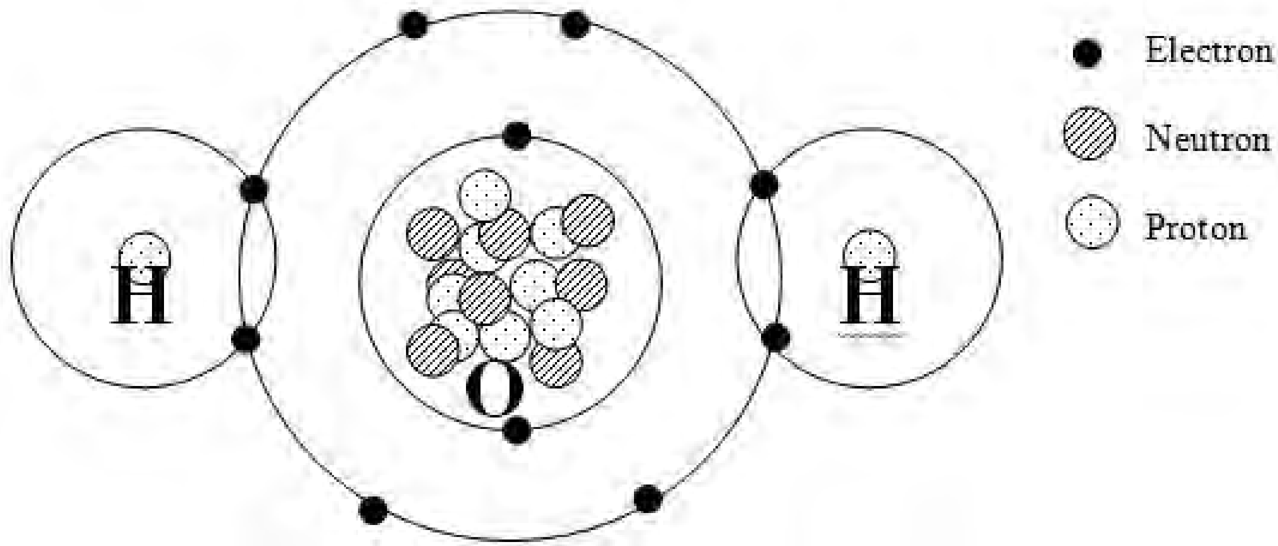
6. We'll next be making a somewhat more complex atom: the Oxygen atom. The atomic number of oxygen is 8. The Oxygen atom consists of:
    - 8 protons
    - 8 neutrons
    - 8 electrons

It will be difficult to get all the gumdrops to stick together. It may be easier to have them rest in a pile on your desk or table.
The placement of the 8 electrons on oxygen is interesting. There are two "shells" of electrons. You can represent these by using two circles. The inner, smaller circle will hold just 2 of the electron-gumdrops. The outer circle wants to hold eight electron-gumdrops in order to be stable, but you only have 6 electron-gumdrops remaining. What do you think the atom would do in order to compensate for the shortage of electrons?

7. One of the ways that atoms can become more stable is to form molecules. We will do this with Oxygen and Hydrogen to form a stable water molecule. What do we know about the molecules we will be using?
    - The oxygen wants two more electrons in its outer shell.
    - To complete their outer shell level, the hydrogen atom wants one more electron in their shell to have it completely filled.
    - We need two hydrogen atoms and one oxygen atom to make a model of water.

The solution to the problem of having complete shells is to share electrons. If the two hydrogen atoms share their one electron, they can fill the outer shell of the oxygen. Similarly, if the oxygen atom allows the hydrogen atoms to share in two of the electrons, they would also have a complete outer shell. This is the basis of the covalent chemical bond.

8. The covalent chemical bond can be modeled as in the following diagram.




9. Lastly, we will compare the relative mass of a proton to the electron. The proton has a mass of just $1.672*10^{-27}$kg. The electron has a mass of $9.109*10^{-31}$kg. The difference in magnitude between the masses of the electron and the proton is about 1,800. For comparison, hold a penny in one hand. Now hold a gallon of water in the other. This approximates the relative difference in mass of the two subatomic particles.

***Discussion of Results***
How did your hypotheses compare to what you discovered in this experiment? Are there any questions you had that were unanswered? Try looking in a chemistry book or online for more answers.

Physics Activity on Magnetism

# How the Strength of a Magnet Varies with Temperature (www.ScienceBuddies.org)

**Grade Level:** 6-8
**National Standards:** H.B.4 Motions and forces


### *Abstract*
Physicists sometimes study matter under extreme conditions. For example, think of the emptiness of interstellar space vs. the unimaginable crush of pressure at the center of a neutron star, or an object dipped in liquid nitrogen vs. the tiles on the space shuttle during re-entry. Here's an experiment on permanent magnets in "extreme kitchen" conditions that you can try at home.


### *Objective*
**The objective of this experiment is to determine whether the temperature of a magnet affects its strength.**

### *Introduction*
Magnetic fields are produced by electric currents. This could be the familiar electric current flowing in a wire, that you can measure with an ammeter. Or it could be a less familiar, microscopic current associated with electrons in atomic orbits (Nave, 2005a). Certain materials, called *ferromagnetic materials*, have unpaired electrons in their outermost atomic orbits that can become magnetically aligned over large distances (relative to the atomic scale). These regions of alignment are called *magnetic domains*.

An electric current flowing in a straight wire creates a magnetic field around the wire. The blue lines in Figure 1, below, show the orientation of such a magnetic field. Notice the "right hand" rule for determining the orientation: when the thumb of the right hand is pointing in the direction of the current, the fingers of the right hand curl in the direction of the magnetic field. You can see the effect of this magnetic field by bringing the wire close to the needle of a magnetic compass when the current is flowing. You can even make an electric current detector based on this principle (see Using a Magnet as an Electrical Current Detector.) (http://www.sciencebuddies.org/science-fair-projects/recommender_interest_area.php?ia=Elec#UsingMagnet.)

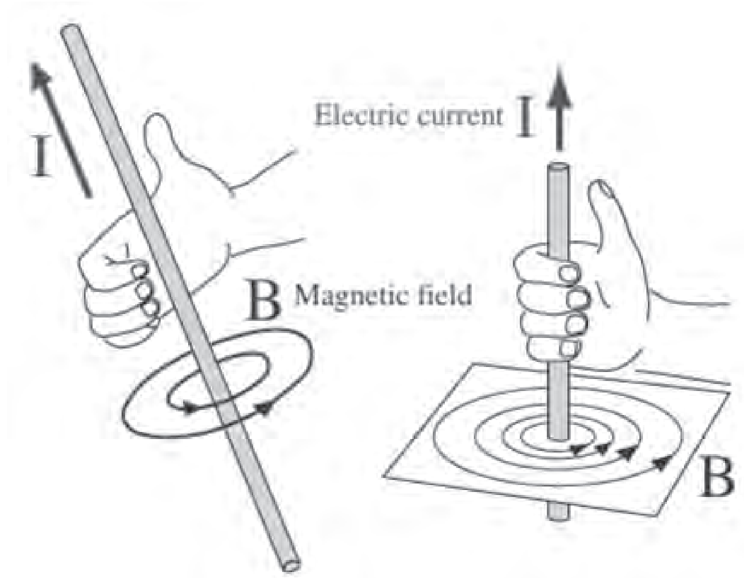



Figure 1. The illustration shows the magnetic field produced by electric current in a straight wire. When the thumb of the right hand is pointing in the direction of the current, the fingers of the right hand curl in the direction of the magnetic field (Nave, 2005f).

A current flowing through a coil of wire (the coil is also called a *solenoid*) creates a stronger magnetic field than the same current flowing through a straight wire. The magnetic field is strongest at the center of the coil. Each loop in the coil contributes additional strength to the magnetic field. The more loops, the stronger the field.

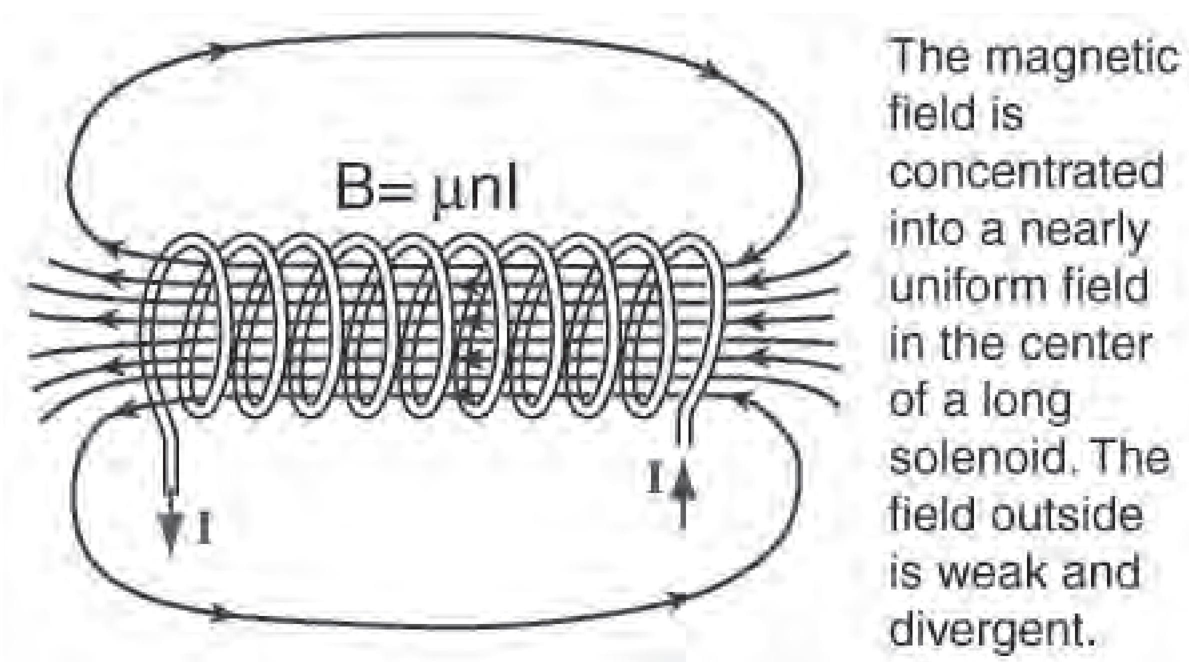



Figure 2. The illustration shows the magnetic field produced by electric current in a coil of wire (solenoid). When the fingers of the right hand curl in the direction of the current flow, the thumb of the right hand curl points in the direction of the magnetic field (i.e. thumb points toward magnetic North pole of the solenoid). (Nave, 2005g)

The magnetic field of a solenoid can be increased even further by placing a bar or rod of ferromagnetic material within the coil (*diamagnetic* and *paramagnetic* materials will also work, but will not retain a magnetic field when the current is turned off). The magnetic field from the coil strongly aligns all of the magnetic domains in the ferromagnetic material, creating a much stronger magnetic field than either the coil or the ferromagnetic material would have alone.

Permanent magnets are made from ferromagnetic materials. Ferromagnetic materials can "remember" their magnetic history. If a ferromagnetic material is exposed to a strong magnetic field, the magnetic domains within the material will retain at least some of the alignment induced by the external magnetic field.

When the temperature of a material is increased, what is happening on the atomic scale is an increase in the random motion of the atoms of which the material is made. You might think that random motion of atoms could affect the alignment of magnetic domains, so that increasing the temperature of a magnet would tend to decrease its strength. In fact, each ferromagnetic material has a *Curie tmperature* (named after Pierre Curie), above which it can no longer be magnetized. For soft iron, the Curie temperature is over 1,300°C! Your oven at home might get as hot as 260°C, so obviously 1,300°C is out of the question for a science fair experiment. But what happens to the strength of a magnet over a more approachable range of temperatures, for example from the temperature of dry ice (about −78°C) to the temperature of boiling water (+100°C)? This project shows you how to find out.

### *Terms, Concepts and Questions to Start Background Research*

To do this project, you should do research that enables you to understand the following terms and concepts:

- magnetic force,
- magnetic domain,
- ferromagnetism,
- ferromagnetic materials,
- temperature.

More advanced students may also want to study:

- diamagnetic materials,
- paramagnetic materials.

### *Questions*

- Are some magnetic materials more temperature-dependent than others?

### *Bibliography*


- Swenson, J., 2004. "Magnetic Field Strength and Low Temperature," Ask a Scientist Physics Archive, Newton BBS, Argonne National Laboratory. [accessed September 21, 2006] http://www.newton.dep.anl.gov/askasci/phy00/phy00880.htm.
- Staff, date unknown. "Magnetic Domains," Non-Destructive Testing Resource Center, Collaboration for NDT Education [accessed September 21, 2006] http://www.ndt-ed.org/EducationResources/CommunityCollege/MagParticle/Physics/MagneticDomains.htm.
- These (more advanced) articles from the HyperPhysics website offer further information about magnetism and magnetic domains:
    - Nave, C.R., 2005a. "Magnetic Field," HyperPhysics, Departments of Physics and Astronomy, Georgia State University [accessed September 21, 2006] http://hyperphysics.phy-astr.gsu.edu/hbase/magnetic/magfie.html#c1.
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- Nave, C.R., 2005f. "Magnetic Field of Current," HyperPhysics, Departments of Physics and Astronomy, Georgia State University [accessed September 21, 2006] http://hyperphysics.phy-astr.gsu.edu/hbase/magnetic/magcur.html#c1.
- Nave, C.R., 2005g. "Solenoid," HyperPhysics, Departments of Physics and Astronomy, Georgia State University [accessed September 21, 2006] http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html.

### *Materials and Equipment*

To do this experiment you will need the following materials and equipment:

- safety glasses,
- 5–10 permanent iron magnets of equal size and strength,
- thermometer (minimum range 0–100°C),
- tongs for holding magnets (preferably plastic, for minimizing heat transfer),
- dry ice (frozen $CO_2$),
- water ice,
- insulated containers to hold ice and dry ice,
- thick insulated gloves for handling dry ice,
- small pot,
- water,
- stove or hot plate for heating water,
- 2 large plastic bowls,
- at least one box of standard #1 paper clips,
  - if you have a really strong magnet, you may need more than one box,
  - test the magnet at room temperature first, and make sure that there are plenty of paper clips left over (see Experimental Procedure, below),
  - alternatives to paper clips: small steel BBs or nails.

### *Experimental Procedure*

Note: this experiment is designed for testing the temperature dependence of *permanent* magnets *not* electromagnets.

1. You will test each magnet at four different temperatures:
   a. −75°C, the temperature of dry ice (don't try to use the thermometer for this one!),
   b. 0°C, the temperature of a water ice bath,
   c. 20°C, room temperature,
   d. 100°C, the temperature of boiling water.
2. Wear safety glasses when heating, cooling, and transfering the magnets. Always use tongs for handling magnets at extreme temperatures.
3. Before measuring each magnet's strength at a given temperature, allow the magnet to equilibrate to the test temperature for at least 15 minutes.
4. To test magnetic strength, follow these steps:
   a. Use the tongs to place a magnet into a bowl filled with paper clips (or steel BB's).
   b. See how many clips (or BB's) the magnet can lift out.

c. Set the magnet and paper clips (or BB's) down in an empty plastic bowl.
d. Wait until they are safe to touch before counting the number of paper clips (or BB's).
e. Record the number in your lab notebook for each magnet and temperature tested.
f. It's a good idea to practice handling the magnets with tongs at room temperature first until you get the hang of it. Make sure your results are reproducible at room temperature before trying the experiment at extreme temperatures.

5. For each temperature, calculate the average number of objects each magnet picked up.
6. Make a graph of magnetic strength, as measured by number of objects lifted (y-axis), vs. temperature (x-axis).
7. Does magnetic strength increase, decrease, or stay the same over the temperature range you tested?

### *Variations*

- Compare the temperature dependence of magnets made of different materials (e.g., neodymium vs. iron). Do background research to find the Curie temperature and normal operating temperature range for each type of magnet you test. If necessary, adjust the temperature range for the experiment in order not to exceed the safe operating temperature range for the magnets you test.
- Here are some other Science Buddies projects related to magnetism:
  - For a more basic project, see Magnets and Charge, or The Strength of an Electromagnet.
    - (http://www.sciencebuddies.org/mentoring/project_ideas/Phys_p020.shtml)
    - (http://www.sciencebuddies.org/mentoring/project_ideas/Elec_p035.shtml)
  - You might also be interested in Spare-Change Circus: Walking Coins on a (Vertical!) 'High Wire'.
    - (http://www.sciencebuddies.org/mentoring/project_ideas/Phys_p024.shtml)
  - Finally, for a more advanced project, check out either Measure Your Magnetism or Recording on a Wire.
    - (http://www.sciencebuddies.org/mentoring/project_ideas/Elec_p030.shtml)
    - (http://www.sciencebuddies.org/mentoring/project_ideas/Elec_p015.shtml)
- For more science project ideas in this area of science, see Physics Project Ideas.
  - (http://www.sciencebuddies.org/science-fair-projects/recommender_interest_area.php?ia=Phys)

### *Credits*

Andrew Olson, Ph.D., Science Buddies

### *This project is based on:*


- Iverson, A.A., 2004. "Does the Temperature of a Magnet Affect Its Strength?" California State Science Fair Abstract [accessed September 21, 2006] http://www.usc.edu/CSSF/History/2004/Projects/J1521.pdf.
- Hoadley, R., date unknown. "Magnet Basics: What Affects the Strength of Magnets?" Magnet Man [accessed September 21, 2006] http://www.coolmagnetman.com/magstren.htm.

Physics Activity on The Speed of Light

# Measuring the Speed of Light

**Grade Level:** 7-9
**National Standards:** M.E.2 Understandings about science and technology

### *Objective*
What is the speed of light?  The speed of light is constant no matter its frequency or wavelength. **In this experiment, students will use the electromagnetic radiation from a microwave to determine the speed of light.**

### *Materials and Equipment*
- Microwave
- Microwave-safe plate.
- Mini-marshmallows
- Ruler
- Calculator

### *Experimental Procedure*
1. If your microwave has a rotating turn-table, remove it.  We want the radiation from the microwave to be hitting the same location for the duration of the experiment.
2. Cover the plate with marshmallows.
3. Put the plate of marshmallows in the microwave, and turn the microwave on for 10 seconds.
4. Check the marshmallows after 10 seconds.  Be careful, some of them may be hot.  Try not to move the marshmallows too much.
5. You should notice that the marshmallows are melted in certain places.  You do NOT want all of the marshmallows melted.  If all the marshmallows are melted, take the plate out and try again with a new batch of marshmallows for a shorter period of time.  If none of the marshmallows have started to melt, put them back in the microwave for another 10 seconds.
6. Using your ruler measure the distance between melted marshmallows in centimeters.  The distance between melted spots is half the wavelength of the microwave's electromagnetic radiation.  Take 5 measurements and record your data below.  Then find the average of your measurements.

| | **Length** |
|---|---|
| **1** | |
| **2** | |
| **3** | |
| **4** | |
| **5** | |
| **Average** | |

7. Each microwave runs at a specific frequency in Hertz (1 Hertz = 1 $sec^{-1}$). Either find a sticker on the microwave that says at what frequency it runs or look up this information online. If you cannot find the exact frequency, you can use the frequency: $2.45*10^9$ Hz. Record the frequency below. Be sure that it is in the units of (Hz).

| Frequency | |
|---|---|

Sometimes the frequency is given in units of MHz. 1MHz = $1*10^6$Hz

8. Use the equation below to calculate the speed of light based on your measurements using a microwave. What is the speed of light, according to your calculations?

**Speed of light = 2 * (average half wavelength) * (frequency of microwave)**

| Speed of light | |
|---|---|

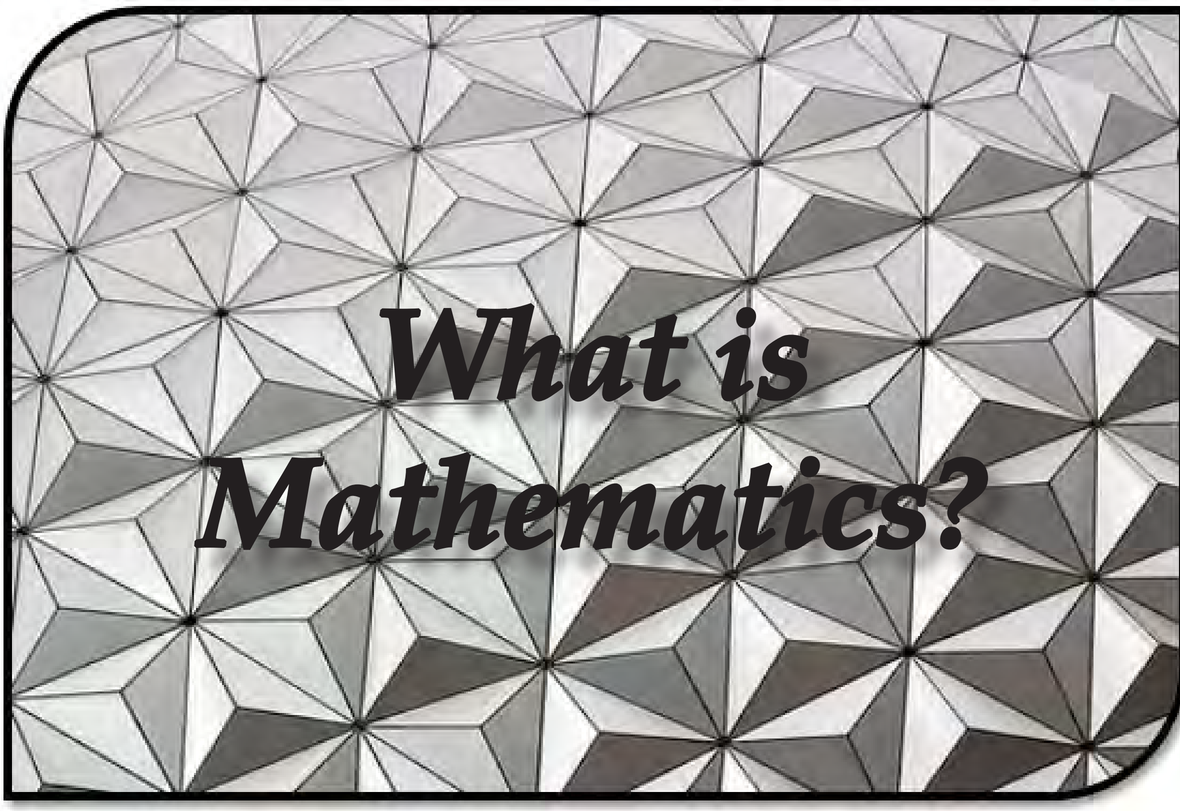
Note: Be sure that you have the proper units! Your half wavelength is measured in (cm). Your frequency is measured in (Hz). Recall that 1Hz = 1 $sec^{-1}$. When these terms are multiplied together, their units multiply, too. The units for the speed of light should be in (cm*$sec^{-1}$ or cm/sec). If you have trouble seeing this, try writing $sec^{-1}$ as the fraction: 1/sec.

### *Discussion of Results*

Find the actual speed of light in a physics textbook or online. How close is your result? What might be the source of error? In this experiment, you have determined the speed of light. You have also seen how the frequency and the wavelength of light relate to the determination of the speed of light.

### *More questions to consider:*

- Why do you take the average of several measurements between melted spots?
- What would have happened to your final result if your marshmallows had moved when you pulled your plate out of the microwave?
- What would have happened if you used giant marshmallows instead of mini-marshmallows for this experiment? Would you expect more accurate or less accurate results? Why?
- Why do we multiply by 2 in the equation to determine the speed of light?
- Why are most microwaves set to the same frequency? More specifically, why are they all around 2450MHz?
- If the frequency of the microwave were higher, what would happen to the distance between melted spots? Would it increase, decrease, or stay the same?



# What is Mathematics?

***Mathematics*** is the study of patterns, quantities, structures, and space. Mathematics is different than the natural sciences in that it relies on rational statements called "proofs" to explain phenomena rather than physical experiments.

Mathematicians approach problems with logic and use formulas to make conjectures about how the world works. Some scientists are considered mathematicians if their work influences mathematics or if their work is rooted in a mathematical approach. Mathematicians can study a diverse range of topics, including number theory, game theory, optimization, probability, statistics, and many other fields.



**Photo credit: Blue Turban Photography @Flickr**

## *If you like mathematics, you may like the careers chosen by these people:*

| ScienceMaker | Occupation | Location | Question Topics |
|---|---|---|---|
| **Emery Brown** | Professor of Health Science and Technology/ Computational Neuroscience | *Harvard Medical School* | MRI machines, statistics, neurophysiology and anesthetics |
| **Lovenia DeConge-Watson** | Professor of Mathematics | *Southern University* | Proofs |
| **Linda Hayden** | Professor of Computer Science | *Elizabeth State University* | Ice sheets, remote sensing and computer science and mathematics |
| **Clifford Johnson** | Professor of Physics & Astronomy | *University of Southern California* | String theory and mathematics |
| **Eleanor Jones** | Professor Emeritus | *Norfolk State University* | The applications of mathematics |

# Mathematics in Action

***Sports statistics*** ("Kane County Cougars Minor League Baseball" by willowbrookhotels @ Flickr)

From determining who has the fastest time in a race to calculating the highest batting average in baseball, numbers are crucial in sports players' statistics. Spectators often use the means and medians of athletes' past performances to predict how they will do in the future.

***Game shows*** ("Dramatic Music Please" by sprocket003 @ Flickr)

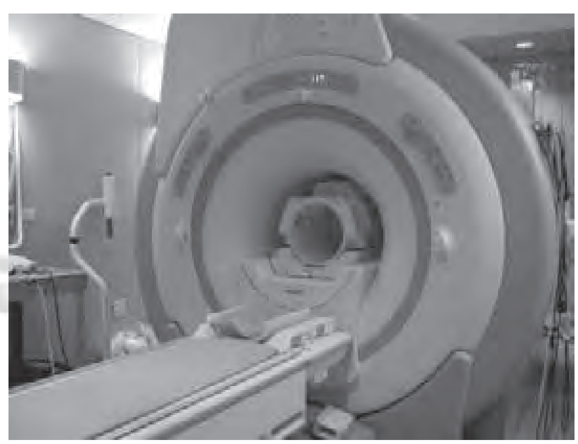
Many games depend on calculating the risk involved in making a certain move. The same holds true in popular game shows like "Deal or No Deal." What's the probability that picking the other suitcase will result in a better deal? What's the probability you'll go home without any money?

# ScienceMakers
## Spotlight: Emery Neal Brown

| | |
|---|---|
| **Name** | Emery Neal Brown |
| **Birth Date** | 1957 |
| **Birth Place** | Ocala, Florida |
| **Education** | Phillips Exeter Academy<br>Harvard University |
| **Types of Science** | Statistics<br>Anesthesiology<br>Neurophysiology |

## Biography

Statistician, anesthesiologist and neuroscientist Emery Neal Brown was born in Ocala, Florida where his parents Benjamin and Alberta Brown were junior high and high school mathematics teachers. He graduated from Phillips Exeter Academy in 1974. In 1978, Brown graduated *magna cum laude* from Harvard College with his B.A. degree in applied mathematics. Following his college education, Brown became an International Rotary fellow at the *Institut Fourier des Mathèmatiques Pures* in Grenoble, France, in 1978. He returned to Harvard Medical School (HMS) to pursue his M.D. and his Ph.D. in statistics in the Faculty of Arts and Sciences at Harvard University. He earned his A.M. degree in statistics from Harvard University in 1984. In 1987, he received his M.D. *magna cum laude* from Harvard Medical School. The year following, Brown earned his Ph.D. degree in statistics from Harvard University with his thesis entitled “Identification and Estimation of Differential Equation Models for Circadian Data.”



**“fMRI” by MacRonin47 @Flickr**
This is an fMRI machine, used to take internal pictures of the body.

Brown completed his internship in internal medicine in 1988 at the Brigham and Women’s Hospital in Boston and his residency in anesthesiology at the Massachusetts General Hospital (MGH) in 1992. Following completion of his residency he joined the anesthesiology staff in the Department of

Anesthesia at MGH and the faculty at Harvard Medical School as an instructor. In 1999, he joined the faculty of the Harvard-Massachusetts Institute of Technology (MIT), Division of Health Sciences and Technology at HMS. In 2005, Brown was named a professor of computational neuroscience and professor of health and sciences technology at MIT. In 2006, he became the Massachusetts General Hospital Professor of Anesthesia at HMS and in 2008, he was named the Warren M. Zapol Professor of Anesthesia at HMS. Brown is internationally recognized for using statistics for the development of signal processing algorithms to study how systems in the brain represent and transmit information and for his use of functional neuroimaging to study in humans how anesthetic drugs act in the brain to create the state of general anesthesia. He has developed statistical methods to: study learning and memory formation; design algorithms for neural prosthetic control; improve signal extraction from fMRI imaging time-series; localize dynamically sources of neural activity in the brain from electroencephalography (EEG) and magneto-encephalography (MEG) recordings; measure the period of the circadian pacemaker (human biological clock) and its sensitivity to light; characterize the dynamics of human heart beats in physiological and pathological states; and de-noise two-photon *in vivo* imaging data.

Brown has been recognized for his work throughout his career. In addition to being one of the most cited African American mathematicians, in 2000, Brown won the National Science Foundation (NSF) Minority Career Advancement Award, a National Institute of Mental Health Independent Scientist Award, and in 2007, an National Institutes of Health (NIH) Director's Pioneer Award. He has been named a fellow of several prominent professional organizations including the American Institute for Medical and Biological Engineering, the American Statistical Association, the American Association for the Advancement of Science (AAAS), and the Institute of Electrical and Electronics Engineers (IEEE). Brown is also a member of the Institute of Medicine of the National Academy of Sciences (NAS).

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Brown? What part of Brown's story do you find the most interesting? How would you describe him?

#2 Where was Dr. Brown born? Locate it on a map. How far away is this from where you live?

#3 How old are you? In what year was Dr. Brown your age? What was happening in the United States that year? What was happening around the world that year? What do you think his life was like when he was your age?

#4 Where did Dr. Brown attend college? What state is this located in? What do you think college was like for him?

#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What does a neurophysiologist do? Would you want to be a neurophysiologist? Why? Why not?

#2 If you were a neurophysiologist, what topics would you study? What does a statistician do? In what fields can statistics be applied?

#3 Dr. Brown applies statistics to his studies in neurophysiology. Have you ever used statistics to categorize something? How did it help? What does statistical analysis allow you to do?

#4 Have you or someone you have known had to have anesthesia for a medical procedure? What was it like? Why do some operational procedures call for anesthesia to be administered? Look up how an anesthetic works. What is the physiological process of an effective anesthesia?

#5 The picture above was taken using a Magnetic Resonance Instrument or MRI. Look up how this works. Why is it very important that the person receiving the MRI test not have any metal on?

# Glossary

*Algorithm*
An effective method for solving a problem using a finite sequence of instructions. Algorithms are used for calculation, data processing, and many other fields.

*American Association for the Advancement of Science (AAAS)*
An international non-profit organization with the stated goals of promoting cooperation between scientists, defending scientific freedom, encouraging scientific responsibility, and supporting scientific education and science.

*Anesthesia*
The loss of bodily sensation with or without loss of consciousness.

*Circadian*
Of or relating to biological processes occurring at 24-hour intervals.

*Computational neuroscience*
The study of brain function in terms of the information processing properties of the structures that make up the nervous system..

*De-noise two-photon imaging*
A fluorescence imaging technique that allows imaging of living tissue up to a very high depth, that is up to about one millimeter. The term “de-noise” refers to a signal in which background (unwanted signals) are removed.

*Differential*
In calculus, an infinitesimally small change in a variable. For example, if x is a variable, then a change in the value of x is often denoted $\Delta x$ (or $\delta x$ when this change is considered to be small).

*Electroencephalography (EEG)*
The recording of electrical activity along the scalp produced by the firing of neurons within the brain.

*Functional Magnetic Resonance Imaging (fMRI)*
A relatively new MRI technique that studies brain function. Using fMRI technology, scientists can determine which part of the central nervous system (CNS: brain and spinal cord) is active during a given task by tracking blood oxygen levels in the brain.

*In vivo*
Experimentation or processes occurring within a living organism.

*Institute of Electronics and Electrical Engineers (IEEE)*
An international non-profit, professional organization for the advancement of technology related to electricity.

*Internship*
A temporary employment position with an emphasis on on-the-job training, making it similar to an apprenticeship.

*Magneto-encephalography (MEG)*
A non-invasive diagnostic technique that directly measures the magnetic fields produced by electrical currents in the brain.

*National Academy of Sciences (NAS)*
A corporation in the United States whose members serve as advisers to the nation on science.

*National Institutes of Health (NIH)*
An agency in the Department of Health and Human Services whose mission is to employ science in the pursuit of knowledge to improve human health; the principal biomedical research agency of the federal government.

*National Science Foundation (NSF)*
A United States government agency that supports fundamental research and education in all the non-medical fields of science and engineering. Its medical counterpart is the National Institutes of Health.

*Neural*
Of or relating to the nervous system.

*Neuroimaging*
Any methodology that provides a visualization of the structure or function of elements of the nervous system, particularly the brain.

*Neuroscience*
The study of the nervous system.

*Pathology*
The study and diagnosis of disease through examination of organs, tissues, bodily fluids, and whole bodies.

*Physiology*
The science of the functioning of living systems.

*Prosthetics*
The branch of medicine dealing with the production and use of artificial body parts.

*Residency*
A stage of graduate medical training in which the physician becomes trained in a specific medical specialty.

*Statistics*
A branch of applied mathematics concerned with the collection and interpretation of quantitative data.

# ScienceMakers Spotlight: Mary Lovenia DeConge-Watson

| | |
|---|---|
| **Name** | Mary Lovenia DeConge-Watson |
| **Birth Date** | October 3, 1933 |
| **Birth Place** | Wickliffe, Louisiana |
| **Education** | Seton Hill College<br>Louisiana State University<br>St. Louis University |
| **Type of Science** | Mathematics |

## Biography

Mary Lovenia DeConge-Watson was born on October 3, 1933, in Wickliffe, Louisiana, to Adina Rodney and Alphonse Frank DeConge. Her family is Creole, and she is bilingual, speaking both English and French. In 1943, the DeConge family settled in Baton Rouge, Louisiana. Six years later, at the age of sixteen, DeConge was called to the Order of the Sisters of the Holy Family. She took her permanent vows as Sister Mary Sylvester DeConge in 1957.

Two years later, DeConge earned her B.A. degree in mathematics and French from Seton Hill College in Greensburg, Pennsylvania. She began to teach high school mathematics and French at Holy Ghost High School in Opelousas, Louisiana. In 1961, DeConge applied for and received a National Science Foundation (NSF) Academic Year award to study for a master's degree in mathematics and French, which she earned from Louisiana State University in 1962. That year, she began teaching math at Delille Junior College, and from 1964 to 1968, she attended St. Louis University and earned her Ph.D. in mathematics with a minor in French. After receiving her degree, DeConge served as assistant professor of mathematics at Loyola University of New Orleans. In 1971, she transferred to Southern University as Associate Professor of mathematics. In 1976, DeConge chose to leave the Order of the Sisters of the Holy Family. She was promoted to professor of mathematics at Southern

**The Mathematics Department at Southern University, early 1970s.**

University in Baton Rouge, Louisiana in 1982. One year later, DeConge married Roy Watson, Sr., and became Dr. Lovenia DeConge-Watson. From 1986 to 1995, DeConge-Watson served as chair and professor of mathematics at Southern University. DeConge-Watson served as Director of Modeling Integrated Mathematical Experiences (MIME) from 1993 to 2003 and retired in 2004.

From 1995 to 1998, DeConge-Watson directed the Center for Minorities in Science, Engineering, and Technology at Southern University and A&M College. Among her awards, she was the recipient of Southern University's Outstanding Chair and Department of the Year Award in 1990 and St. Louis University's Outstanding Graduate of the Graduate School of Arts and Sciences Award in 1996.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. DeConge-Watson?
#2 Where was Dr. DeConge-Watson born? Locate it on a map. How far away is this from where you live? What are the names of her parents?
#3 How old are you? In what year was Dr. DeConge-Watson your age? What was happening in the United States that year? What was happening in the world that year? What do you think her life was like when she was your age? Where did Dr. DeConge-Watson attend college? What do you think college was like for her?
#4 Dr. DeConge-Watson grew up in a bilingual household. Does your family or a friend's family speak more than one language at home? What languages? Research Louisiana's history. Why do you think that Dr. DeConge-Watson's family spoke two languages?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a mathematician does? Would you like to be a mathematician? Why? Why not?
#2 If you were a mathematician, what topics would you study?
#3 What are some common properties of mathematics that you can think of? For example, the commutative property of addition. How do you know them to be true? Do you think there is a more sound way of proving something to be true in every single case?
#4 Proofs are a common tool in mathematics. In mathematics, what is a proof? How do you go about proving something in mathematics? What information do you need to start a proof? What is the end result? Why would you want to make a thorough proof of a principle or mathematical theory?
#5 Some common phrases used in mathematical proofs are: "if and only if," and "If... then..." Try writing a couple statements incorporating these phrases. For example: "I will go to the store if and only if you go with me" and "If it is raining, then I am not going outside."

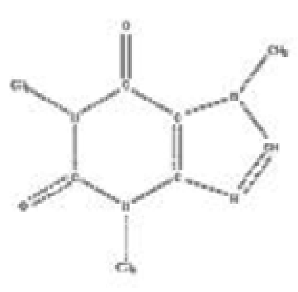
# Glossary

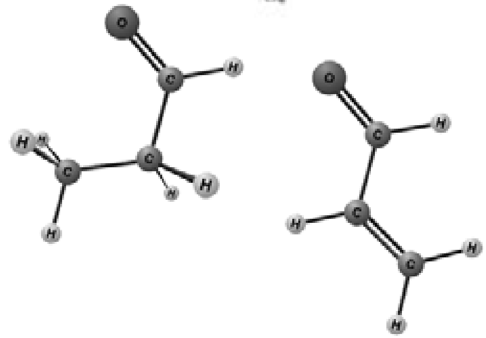
*Creole*
A person descended from French ancestors in the southern United States (especially Louisiana).

*Order of the Sisters of the Holy Family*
An order of nuns that consists of African-American women, originally based in New Orleans. The order operates schools, nursing homes, and retirement centers. There are 200 members of the order today, and it has missions in New Orleans, Washington, D.C., California, and Belize.

*Modeling Integrated Mathematical Experiences (MIME)*
A National Science Foundation Project at Southern University which offers in-service training for teachers in grades 5-12.

*National Science Foundation (NSF)*
A United States government agency that supports fundamental research and education in all the non-medical fields of science and engineering. Its medical counterpart is the National Institutes of Health.





# ScienceMakers
## Spotlight: Linda Bailey Hayden

| | |
|---|---|
| **Name** | Linda Bailey Hayden |
| **Birth Date** | February 4, 1949 |
| **Birth Place** | Portsmouth, Virginia |
| **Education** | I.C. Norcom High School<br>Virginia State University<br>University of Cincinnati<br>Old Dominion University<br>American University |
| **Types of Science** | Mathematics<br>Computer Science |

## Biography

Mathematician Linda Bailey Hayden was born on February 4, 1949 in Portsmouth, Virginia to Sarah Vaughn Bailey and Linwood Copeland Bailey Sr. Growing up, Hayden loved mathematics, particularly plotting out functions and determining their characteristics. She attended Portsmouth's Public Schools for her elementary and secondary education. Hayden was the first of her family to attend college, and her family was not surprised that she chose to concentrate her studies in math and science. Pulling together the funds that her family could provide, as well as a scholarship to cover her tuition, Hayden attended Virginia State University and graduated in 1970 with her B.S. degree in mathematics and physics. At Virginia State University, Hayden's math professors, Dr. Ruben McDaniel Jr. and Dr. Louise Hunter, made an impression on Hayden through their style and enthusiasm for the material. Hayden went on to attain her M.A. degree in math education from the University of Cincinnati just two years later.

**"Greenland Ice Sheet" by chrissy575 @Flickr.**

Hayden began her teaching career as an instructor of mathematics at the Kentucky State University in 1972 and the University of Kentucky in 1976. Three years later, she became an assistant professor of mathematics at Norfolk State University in Norfolk, Virginia. During

Mathematics

her time at Norfolk State University, she received her second M.S. degree in computer science from Old Dominion University. She then became an assistant professor of computer science at American University in 1985, where she pursued further graduate studies and received her Ph.D. degree in mathematics education in 1988. Her dissertation was entitled: "The Impact of an Intervention Program for High Ability Minority Students on Rates of High School Graduation, College enrollment, and Choice of a Quantitative Major." After a two year term at the University of the District of Columbia, Hayden moved on to become a full professor of computer science at Elizabeth State University in 1989. She has been influential in her position on the faculty of the university, particularly in the foundation and implementation of the Center of Excellence in Remote Sensing Education and Research program. One of the project's topics of interest is the cyber-infrastructure support for remote sensing of ice sheets, which is of great importance in polar science field research. Other interests of Hayden include Grid Networks and the PolarGrid Project. In addition her funding efforts have resulted in millions of dollars in scholarship and fellowship for underrepresented students in mathematics, science and technology fields.

Hayden has been the recipient of several awards recognizing her commitment to education and the sciences. She was honored with the 2003 Presidential Award for Excellence in Science, Mathematics and Engineering Mentoring by the National Science Foundation (NSF), and in 2009, she was given the National Association for Equal Opportunity in Higher Education Noble Prize. Hayden is married to Lee Vertner Hayden Jr. and they have one son, Kuchumbi Linwood Hayden.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Hayden?
#2 Where was Dr. Hayden born? Locate it on a map. How far away is this from where you live? What are the names of her parents? Where did Dr. Hayden attend high school? What do you think high school was like for her?
#3 How old are you? In what year was Dr. Hayden your age? What was happening in the United States that year? What was happening in the world that year? What do you think her life was like when she was your age?
#4 Dr. Hayden's math professor impressed her. Have you had a teacher or mentor that really made an impression on you? Were you encouraged to try something new because of that person?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a mathematician does? Would you like to be a mathematician? Why? Why not?
#2 If you were a mathematician, what topics would you study?
#3 What connections does math have to computer science? What about physics?
#4 Why is remote sensing a useful tool in science? Besides studying the ice sheets, where else could it be applied?
#5 Where are ice sheets located? What types of things would you expect to find underneath (or within) the ice sheets?

# Glossary

*Cyber-infrastructure*
The basic organizational structures needed for the proper operation of a computer network.

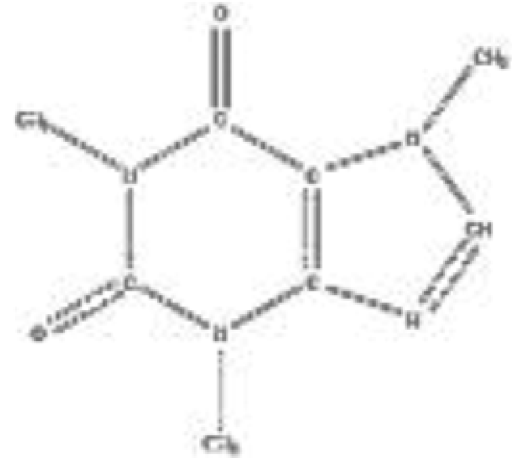
*Function*
A mathematical relation such that each element of a given set (the domain of the function) is associated with an element of another set (the range of the function).

*Grid networks*
A kind of computer network consisting of a number of (computer) systems connected in a grid topology (the configuration of a communications network).

*Ice sheet*
A mass of glacier ice that covers surrounding terrain and is greater than 50,000 km$^2$ (20,000 mile$^2$), thus also known as continental glacier.

*National Science Foundation (NSF)*
A United States government agency that supports fundamental research and education in all the non-medical fields of science and engineering. Its medical counterpart is the National Institutes of Health.

*Remote sensing*
The small or large-scale acquisition of information of an object or phenomenon, by the use of either recording or real-time sensing device(s) that are not in intimate contact with the object.



# ScienceMakers

## Spotlight: Clifford Victor Johnson

| | |
|---|---|
| **Name** | Clifford Victor Johnson |
| **Birth Date** | 1968 |
| **Birth Place** | London, England |
| **Education** | St. John Fisher High<br>Newman College<br>Imperial College at London University<br>Southampton University |
| **Types of Science** | Mathematics<br>Physics |

## Biography

Physicist and physics professor Clifford Victor Johnson was born in 1968 in London, England. Growing up, Johnson spent ten years on the Caribbean island of Montserrat, where his father worked as a telephone engineer. As a child, Johnson taught himself electronics by reading his father's books. In lieu of watching television, Johnson read electronics magazines, fixed appliances, and designed electronic projects such as radios and submarines. Due to his interest in how things worked, Johnson decided at an early age he wanted to become a scientist. He went on to receive his B.S. degree in physics from the Imperial College at London University in 1989 and his Ph.D. degree in physics from Southampton University in 1992.

USC Campus photo by cogdogblog @Flickr

After graduating, Johnson began working as a postdoctoral fellow at the Institute for Advanced Study in Princeton, New Jersey. In 1994, he moved to Princeton University. The following year, he became a postdoctoral fellow at the Kavli Institute for Theoretical Physics in Santa Barbara, California. Johnson taught as an assistant professor at the University of Kentucky between 1997 and 1999 before joining the faculty at the University of Durham, England. Since 2003, Johnson has been a professor at the University of Southern California's Department of Physics and Astronomy. In 2004, Johnson founded the African Summer Theory Institute, which held its inaugural meeting in Cape Town, South Africa.

Johnson received the National Science Foundation's (NSF) Career Award in 1997, and in 2005, he was awarded the Institute of Physics' Maxwell Medal and Prize for his work on string theory and quantum gravity. He has also been listed in the Journal of Blacks in Higher Education as the most highly cited black professor of mathematics or a related field at an American university or college. In addition to his research and teaching, Johnson communicates and explains science to the general public. He blogs, has made short films on science, written articles for magazines, and authored a book and a graphic novel. He appears on the History Channel's *The Universe* series and other channels such as Discovery, Science, National Geographic, Spike, and Comedy Central. He has been a science consultant for film, TV, radio, and theater.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Johnson?
#2 Where was Dr. Johnson born? Locate it on a map. How far away is this from where you live?
#3 How old are you? In what year was Dr. Johnson your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 Dr. Johnson was influenced at a young age by what his parents did. What do your parents do? Are you interested in those jobs?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a physicist does? Would you like to be a physicist? Why? Why not?
#2 If you were a physicist, what topics would you study?
#3 Look up what 'string theory' is. What does it mean? Why do physicists think it is important?
#4 Think of mathematical functions and the structure of shapes in geometry. What can mathematics help you to do? How are these things useful in such complex topics as string theory?
#5 Dr. Johnson works as a consultant for the Discovery Channel. Science documentaries are a good way to interest young people in science. Can you think of other ways to accomplish this?

# Glossary

*Consultant*
An expert who gives advice; an advisor.

*Electronics*
The branch of physics that deals with the emission and effects of electrons and with the use of electronic devices.

*National Science Foundation (NSF)*
A United States government agency that supports fundamental research and education in all the non-medical fields of science and engineering. Its medical counterpart is the National Institutes of Health.

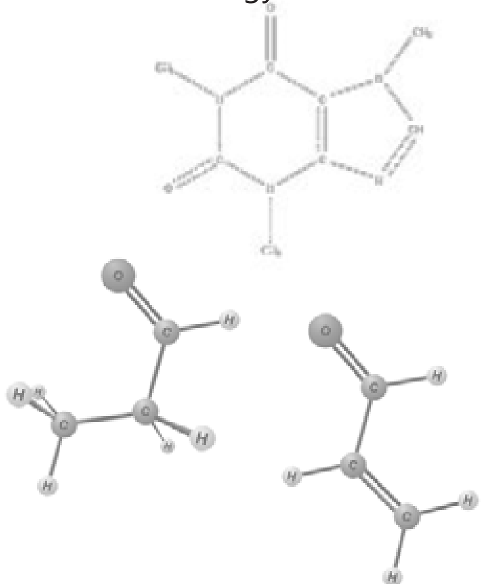
*Postdoctoral research*
Academic or scholarly research conducted by a person who has completed his or her doctoral studies, normally within a five year period. It is intended to further expertise in a specialist subject, including necessary research skills and methods.

*Quantum gravity*
The field of theoretical physics attempting to unify quantum mechanics with general relativity.

*String theory*
A theory that postulates that the identity of subatomic particles are determined by one-dimensional strings. A developing branch of quantum mechanics and general relativity with the aim of merging and reconciling the two areas of physics into a quantum theory of gravity.

*Theoretical physics*
A branch of physics which employs mathematical models and abstractions of physics in an attempt to explain natural phenomena. Its central core is mathematical physics. Sometimes mathematical physics and theoretical physics are used synonymously to refer to the latter.

*Universe*
Everything we perceive to exist physically; the entirety of space and time, all forms of matter and energy.



# ScienceMakers
# Spotlight: Eleanor Green Dawley Jones

| Name | Eleanor Green Dawley Jones |
|---|---|
| **Birth Date** | August 10, 1929 |
| **Birth Place** | Norfolk, Virginia |
| **Education** | Booker T. Washington High School<br>Howard University<br>Syracuse University |
| **Type of Science** | Mathematics |

## Biography

Mathematician Eleanor Green Dawley Jones was born on August 10, 1929 in Norfolk, Virginia. The second of six children, she was raised by her mother, Lillian Vaughn Green, who was a domestic worker and her father, George Herbert Green, who was a postal letter carrier. Jones' siblings were George, Jr., Walter, Barbara, Lillian and Mary. At the age of fifteen, Jones graduated from Booker T. Washington High School in 1945. She received a scholarship to attend Howard University and earned her B.S. degree in mathematics in 1949. She remained at Howard University to receive her M.S. degree in mathematics just one year later. After receiving her degree, Jones returned to Booker T. Washington High School as a teacher.

**"Norfolk State University Campus" by Kevin Coles @Flickr.**

After the birth of her two sons, Jones taught at Hampton University in 1955. Jones looked to African American men who had received their Ph.D. degrees as role models and decided that she also wanted to pursue a graduate degree. In 1962, she left Hampton to study mathematics at Syracuse University, where she studied under the tutelage of Dr. James Reid. She graduated from Syracuse University in 1966 as the eleventh African American woman to earn a Ph.D. degree in mathematics. Her thesis was entitled, "Abelian Groups and Their Endomorphism Rings and the Quasi-Endomorphism of Torsion-Free Abelian Groups." Upon receiving her Ph.D. degree, Jones returned to Hampton University as an associate professor of mathematics before she was offered a faculty position at Norfolk State University in Norfolk, Virginia. She began as a full professor of mathematics and chair of the math department. Jones remained an active member of the Norfolk State University faculty until she retired as professor emeritus from Norfolk University in 2003. She has three adult sons, Edward A. Dawley, III; Herbert G. Dawley; and Everett B. Jones, Jr. Herbert died in 1975.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Jones?

#2 Where was Dr. Jones born? Locate it on a map. How far away is this from where you live? What are the names of her parents? Where did Dr. Jones attend high school? What do you think high school was like for her?

#3 How old are you? In what year was Dr. Jones your age? What was happening in the United States that year? What was happening in the world that year? What do you think her life was like when she was your age? What obstacles do you think Dr. Jones had to face as she advanced in her studies of mathematics?

#4 Dr. Jones taught mathematics at her old high school. Could you imagine yourself teaching a subject at your school? What subject would you teach? How would you make an impact on your students? How would you change your school as a teacher?

#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a mathematician does? Would you like to be a mathematician? Why? Why not?

#2 If you were a mathematician, what topics would you study?

#3 There are many complicated mathematical terms in Jones' thesis title. Had you ever thought that mathematics could be so complex? What types of math can you study? What are the characteristics of these subsets of mathematics? Which do you think is the most complex?

#4 We use mathematics constantly throughout the day. How do you use math in your daily life? If we use math so often, what more is there to learn or discover in the field of mathematics? Why is this important?

#5 Why is mathematics sometimes considered to be the "purest" of all the sciences?

# Glossary

*Abelian groups*
A group in which the result of applying the group operation to two group elements does not depend on their order. For example, 1+2 =3 and 2+1 =3. Or, 1x2 = 2 and 2x1 = 2. Though the order is different, the answer is the same.

*Emeritus*
An adjective that is used in the title of a retired professor, bishop, or other professional.

*Endomorphism*
A mathematical operation which maps a mathematical object (a set or group, for example) onto itself.

*Endomorphism rings*
In abstract algebra, one associates to certain mathematical objects a ring of several internal properties which can be attributed to the object.

*Torsion*
In abstract algebra, torsion refers to a number of concepts related to elements of finite order in groups and to the failure of modules to be free.

*Tutelage*
Guidance; care.

# Mathematics Activity on Probability

# *Pick a Card, Any Card*

*(www.ScienceBuddies.org)*

**Grade Level:** K+
**National Standards:** H.F.6 Science and technology in local, national, and global challenges

### *Abstract*

No matter what your favorite card game is, we all wish we could use psychic powers to draw the card we want on our turn. You may not have psychic powers, but you might have the power of probability on your side. Do this experiment and discover how math can help you avoid the words, “Go fish!”

### *Objective*

**In this experiment you will test if the probability of drawing a particular card from a deck depends upon the number of that type of card in the deck.**

### *Introduction*

Each time you draw a card in a card game, you have a certain chance at getting the card you need to beat your opponent and win the game. Consider the game Go-Fish being played with a regular deck of playing cards. The object of the game is to win the most four of a kind sets by asking your opponent for matching cards or by drawing matching cards from the deck. At the end of the game, the player with the most sets of matched cards wins. If you want to win the game, you need to increase your chances of getting matching cards, but how?

By understanding how chance is related to math, you can learn to play with a winning strategy. For example, what if you have three kings and one queen in your hand and it is your turn to ask for a card, which one should you ask your opponent for? At first you might think that because you have more kings, you should ask for those, but it is actually better to ask for the queen! Why? Because you have a better chance of getting it!

Here is how you can figure it out: There are only four of each kind of card in the deck, so there are four kings and four queens total. If you have three kings in your hand, there is only one king left. Since only one queen is in your hand, there are three queens left. You have one chance to get a king, but three chances to get a queen out of the remaining cards. That is why you have a better chance of getting the queen than the king if you ask for it.

At first this sounds very confusing, but the more you try it you will see how it works. This strategy is based on something called *probability* which is how mathematicians study how likely an event is. There are many events that can be described by probability and math, especially in games we like to play. The chance that you will draw a certain type of card in a game of Go-Fish, the chance that you will roll a six in Chutes and Ladders or the chance that you will spin green when playing Twister are all probabilites.



The nice thing about a probability is that you can measure it by counting and using some very basic math, like addition and division. In the example above, I knew that there were four kings in a deck of cards because I can count them. I can use addition and subtraction to know how many I have left. In this experiment, you will measure the probability of drawing specific types of cards from a deck.

You will choose which cards to try for, and then measure your success at drawing the card. Which cards will be the easiest to draw? Which are the most difficult? Will your chances of drawing the card be related to how many of that card are in the deck? How can probability help you choose the right strategy?

### *Terms, Concepts and Questions to Start Background Research*

To do this type of experiment you should know what the following terms mean. Have an adult help you search the Internet, or take you to your local library to find out more!

- probability
- chance
- strategy
- likelihood

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### *Materials and Equipment*

- a deck of playing cards
- notebook
- pencil
- calculator

### *Experimental Procedure*

1. Prepare the deck of cards for your experiment. Count the cards to make sure the deck is complete (each deck should have 52 cards total). Remember to take out the jokers! Shuffle the deck three times and set aside.
2. Prepare a data table for your data. The table should include space to write all of your observations, including the name of the type of card, the number of the type of card in the deck, the number of cards drawn for each trial and space to add together and average your data. Here is an example of a data table for this experiment:

| Type of Card: | Red Cards | Black Cards | Face Cards | Spades | Kings | Queen of Hearts |
|---|---|---|---|---|---|---|
| Number in Deck: | 26 | 26 | 12 | 13 | 4 | 1 |
| Trial 1 | | | | | | |
| Trial 2 | | | | | | |
| Trial 3 | | | | | | |
| Trial... | | | | | | |
| Trial 10 | | | | | | |
| TOTALS | | | | | | |
| AVERAGES | | | | | | |

3. Choose your first type of card and write it in the first column of your data table. Count how many of that type of card there are in the deck and write this number in your table.
4. Draw cards from the top of the deck and flip them over one at a time, counting as you go. When you get to the type of card you are looking for, stop and write down the number of cards you have drawn in your table. This will be your first trial.
5. Shuffle the cards and repeat step 4 nine more times to get a total of ten trials for the first type of card.
6. Repeat steps 3–5 for each type of card you would like to test (that is, for each column in your data table).
7. Now you will want to tally up your data by adding together the number of cards drawn for the ten trials in each column. Write your answer in the "TOTALS" row. Are the numbers similar or different?
8. Next, you will want to calculate an average for each experiment. The average is a way to combine the results of all of your trials into one number, which will be useful for graphing and understanding the results of your experiment. Do this by dividing the number in each "TOTALS" box by ten, and writing the answer below in the "AVERAGES" box of the data table.
9. Now you can analyze your data by making a few graphs:
   You can use a bar graph to show the average number of cards that were drawn for each specific type of card you wanted. On the left side of the graph (Y-axis) you will put a scale for the average number of cards drawn, and on the bottom of the graph (X-axis) you will put your bars and labels. Use one bar for each type of card and draw the bar up to the corresponding number on the left (Y-axis) of the graph. Which cards were the most difficult to draw? The easiest to draw? Were there any similarities or differences between different types of cards and the likelihood that you could draw them?

   You can also make a line graph showing how the number of cards drawn compares to the number of that type of card in the deck. On the left side of the graph (Y-axis) you will put a scale for the average number of cards drawn, and on the bottom of the graph (X-axis) you will put a scale representing the number of each type of card in the deck. Did you need to draw more or less cards to choose cards that were rare compared to cards that were common?
10. Interpret your results. Did the number of each type of card present in the deck change the number number of cards it took to pick the card you wanted? Which cards were most likely to be drawn? The least likely? Did the probability of choosing a specific type of card change depending upon it's representation in the deck? Make a conclusion.

### *Variations*

A more advanced way of showing the results of your experiment would be to make histograms, which are a type of graph to show distributions. They are especially useful for visualizing probabilities. Try making a separate histogram for each type of card you tested. Do this by graphing the number of cards drawn for each trial separately in a bar graph. When all of the bars are lined up next to each other, what does the overall shape of the distribution look like?

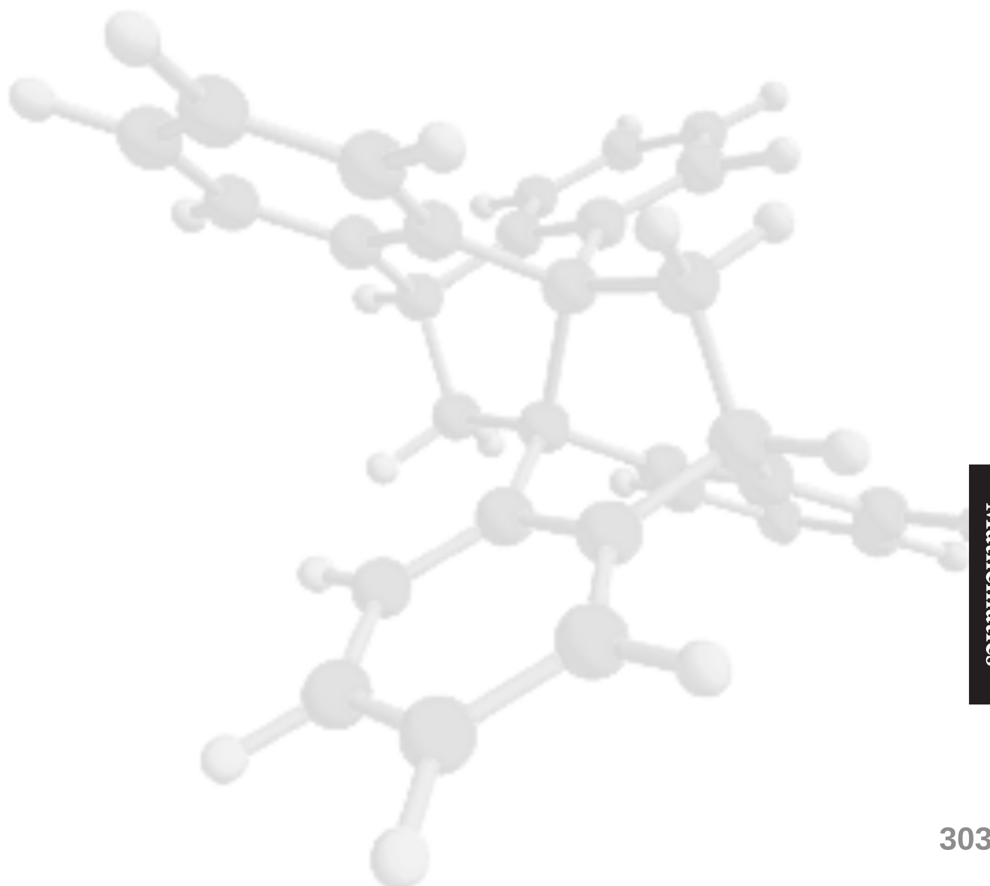
The probability of drawing a particular type of card also depends upon the number of cards drawn each time. Try another experiment to see how your chances of drawing a particular card change as you draw more cards each time. Try drawing samples of 3 cards, 5 cards, or 7 cards. Do your chances improve as more cards are taken?

Probabilities also change as cards are removed from or added to the deck. Try the experiment again, but this time remove cards from the deck before your experiment. Try using two decks of cards combined together. Does your data change? Why or why not? Try removing select cards from the deck, like taking out half of the red or black cards, before doing the experiment. Will this change your chances? What if you left the Jokers in the deck? How would this change your results?

Probabilities can change your strategies for playing a card game. Can you do an experiment to show how probabilities can help you choose cards when playing Go-Fish? What about other popular cards games like War, Memory, or Solitaire? Can you develop rules for a winning strategy? Can you invent your own card game based on probabilities?

***Credits***

Sara Agee, Ph.D., Science Buddies



# Mathematics Activity on Spatial Patterns

# *Tiling With Spidrons*

***(www.ScienceBuddies.org)***

**Grade Level:** 10-12
**National Standards:** M.E.2 Understandings about science and technology


### *Abstract*

This is a great science fair project for someone who is interested in both mathematics and art. Spidrons are geometric forms made from alternating sequences of equilateral and isosceles (30°, 30°, 120°) triangles. Spidrons were discovered and named by Daniel Erdély in the early 1970's, and have since been studied by mathematicians and artists alike. This project is a great way to learn about the mathematics and art of tiling patterns.


### *Objective*

**The goal of this science fair project is to find three or more different ways to tile the plane (i.e. an infinite two-dimensional surface) with spidron-based shapes as the tiling elements.**

### *Introduction*

Sometime in the early 1970's, Daniel Erdély was inspired to doodle a sequence of triangles inside a hexagon. He discovered that he could make a pattern of alternating equilateral and isosceles triangles, and that six of these patterns would fill the entire space inside the hexagon (Figure 1). Erdély put two of these patterns together, back-to-back to make a geometric object that he named a spidron (Figure 2).

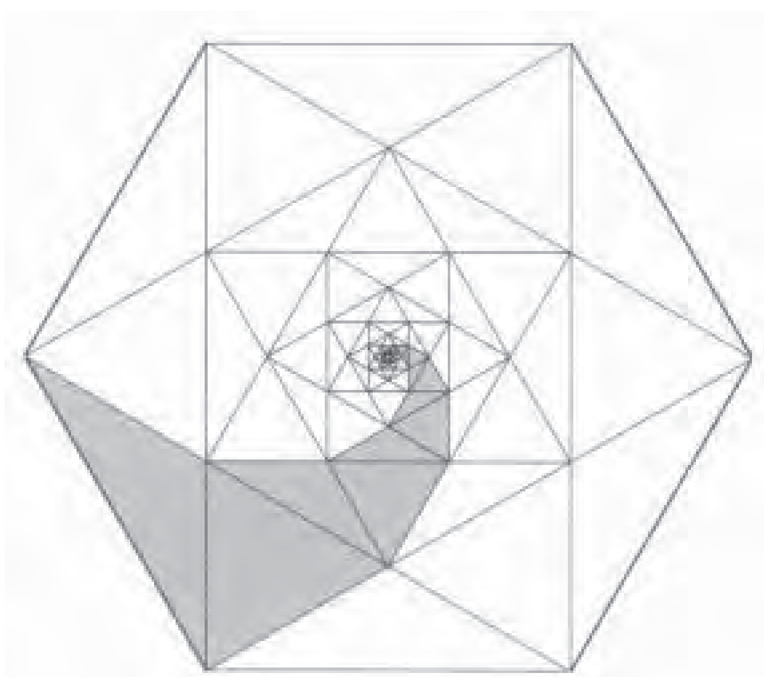


Figure 1. A single 'arm' of a spidron (blue) inscribed in a hexagon.

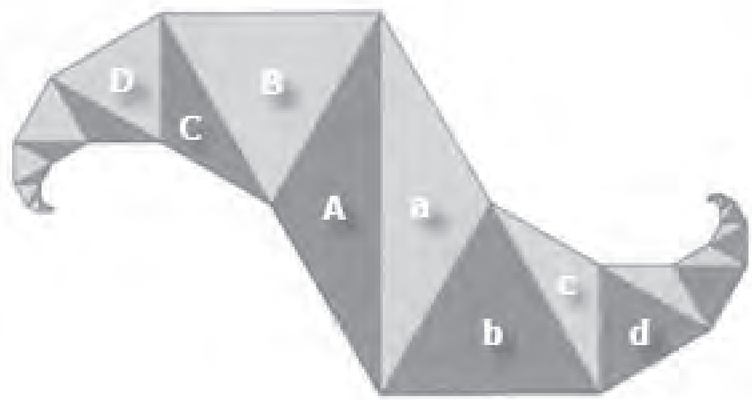



Figure 2. An example of the geometric figure that Erdély named a 'spidron.' The upper case letters show the four initial triangles in one 'arm' of the spidron. The lower case letters show the four initial triangles in the other 'arm.' Each arm consists of a sequence of alternating isosceles (A, a, C, c, etc.) and equilateral (B, b, D, d, etc.) triangles.

Erdély continued to experiment with spidrons. He realized, for example, that the sum of the areas of the sequence of triangles following an equilateral triangle in a spidron is equal to the area of the equilateral triangle itself. He also discovered many patterns for tiling two-dimensional space with spidrons, which is what you will try to do in this project. Mathematicians have a special name for tiling: *tessellation*. Tesselation has important applications in the study of crystals and quasi-crystals in chemistry and materials science. If you are interested in taking your study of spidrons to three dimensions, you will discover, as Erdély did, that spidrons have amazing properties when folded into three dimensional structures. This is a great project for someone with interests in either math or art.

### *Terms, Concepts and Questions to Start Background Research*
To do this project, you should do research that enables you to understand the following terms and concepts:

- Spidron
- Tiling (also known as tessellation)
- Symmetry

### *Questions*

- How many ways can you find to tesselate (tile) two-dimensional space with spidron arms?

### *Bibliography*
Erdely, Daniel. (n.d.). *Spidron Workbook*. Retrieved December 30, 2009, from http://edan.szinhaz.org//SpindronWorkBook/#1

edan.szinhaz.org. (n.d.) *Spidron System*. Retrieved December 30, 2009, from http://edan.szinhaz.org/SpidroNew/

Peterson, I. (2007, February). Spiraling Triangles. *Muse*. Retrieved December 30, 2009, from http://www.sciencenewsforkids.org/pages/puzzlezone/muse/muse0207.asp

Peterson, Ivars. "Swirling Seas, Crystal Balls." *ScienceNews*. Volume 170, 26 October 2006: 266-268.

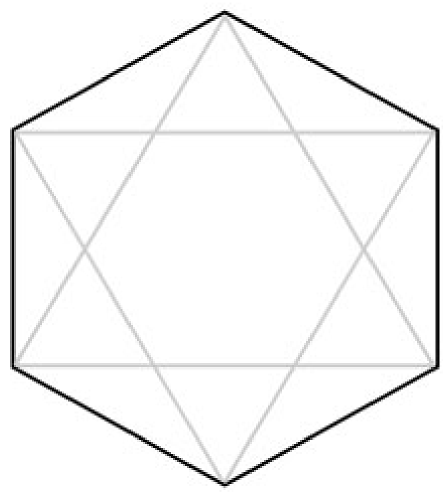
### *Materials and Equipment*

- Several sheets of colored paper
    - o Origami paper is a good choice.
    - o Colored copy paper or construction paper could also be used.
- Ruler
- Protractor
- Pencil
- Scissors
- Lab notebook

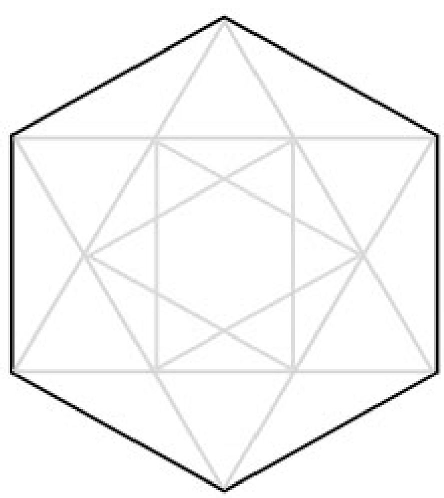
Experimental Procedure

1. Do your background research so that you are familiar with the terms, concepts, and questions, above.

2. Make a bunch of spidrons using various colors of paper. Here is a simple procedure for constructing single spidron arms (i.e., half-spidrons) by inscribing them in a regular hexagon.
    a. Draw a regular hexagon.
    b. Connect every other vertex with a straight line (gray lines in the illustration below).

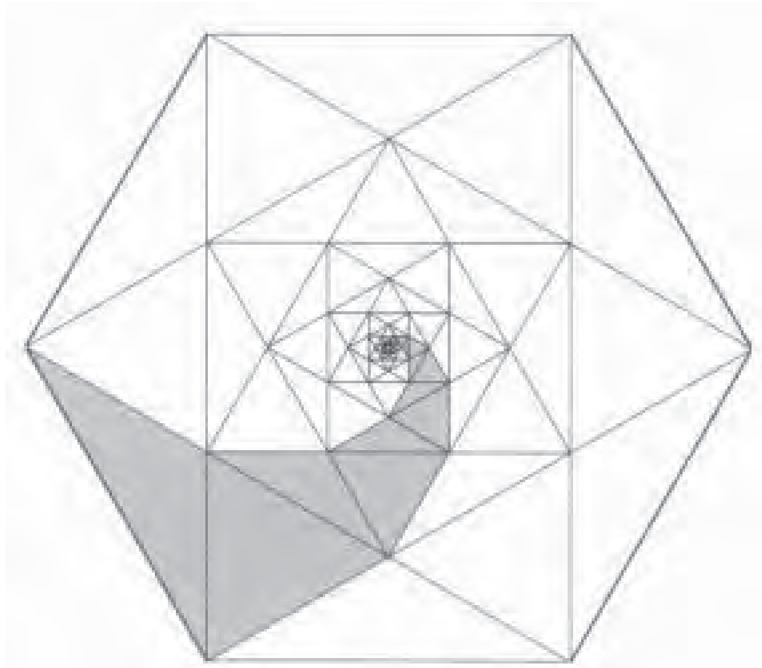


    c. The lines you draw will create a smaller regular hexagon, inside the first. Repeat the process of connecting every other vertex with a straight line (inner star below).



    d. Repeat the previous step until the inner hexagon becomes too small to continue.

e. You will be able to cut out six spidron arms (colored in blue in the illustration below) from each starting hexagon.



f. Tip: remember to make all of your starting hexagons the same size!
g. Tip: you could save time by making a spidron arm template from cardstock or cardboard, and then using this with a utility knife to cut spidron arms from colored paper. Careful with knife, and use fresh blades for best results.

3. How many different ways can you find to use the half-spidron shapes to make a repeating tiling pattern that could cover a two-dimensional plane? (Remember, simply changing colors doesn't count! You have to find different spatial arrangements of the tiling units.)

### *Variations*

For a more basic investigation of tessellation, see the Science Buddies project Tessellation: Tiling Patterns to Fill a Two-Dimensional Space (http://www.sciencebuddies.org/mentoring/project_ideas/Math_p042.shtml)

Advanced! Can you prove that the sum of the areas of the sequence of spidron triangles that follow an equilateral triangle is equal to the area of the equilateral triangle itself?

Advanced! Can you write a computer program that draws spidrons and allows the user to experiment with different spidron tiling patterns?

Advanced! One of the amazing properties of spidrons is how they can be folded up into three-dimensional shapes by making mountain and valley folds in the right places. Can you make three-dimensional polyhedra based on spidrons? Can your polyhedra be used to tile in three dimensions? If you're into origami, this could be a great project for you!

Advanced! Can you come up with an equation that describes the outline of a spidron?

### *Credits*

Andrew Olson, PhD, Science Buddies

# Mathematics Activity on Statistics

## *What is the Average Height In Your Classroom*

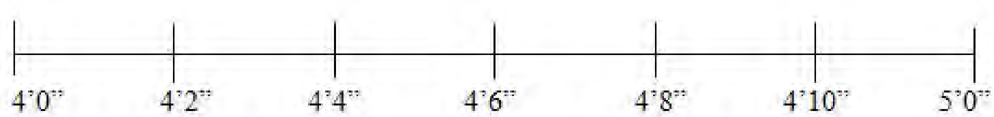
**Grade Level:** 3+
**National Standards:** H.E.2 Understandings about science and technology

### *Objective*
How can you use statistics to help you determine the correct answer? **In this experiment, students will be looking at a set of data (their classmates' heights) in order to determine if there is a trend.** Based off of a trend, they will be able to determine what the average and median heights are in the class.

### *Introduction*
How can we determine the average height of the class?

### *Materials and Equipment*
- Graph paper
- Ruler
- Colored pencils

### *Experimental Procedure*
1. This activity will require teamwork and a little bit of math.
2. First, determine how tall you are. You can figure this out by using a meter stick or by asking your parents or doctor.
3. Before you begin grouping yourself, your class will need to decide how close in height the people in your group should be. How big should the margins be? ½ inch? 1 inch? 2 inches? Your group needs to decide this before you can start to form groups. Also what are your minimum and maximum heights? Report these below:
   Step size: ______________________
   Minimum height: ______________________
   Maximum height: ______________________
4. Then, have one student prepare a line for heights along the front of the room. If you can use a blackboard, start at one end, making it a minimum height. Work your way down in equal steps until you reach the decided maximum height. The end result should look something like this:




   Note that the exact values will depend on what your class sets as the maximum height, the minimum height, and the step size.

5. Then, group yourself with other students in the class who are in your same height group.
6. Note: It is alright if no one else is in your group.
7. Once you have arranged yourselves into groups, the next step is to arrange yourselves by height. To do this, make a space at the front of the classroom. Choose one person to be your leader. In

front of the chalkboard, form a line behind that person in the designated space for your height group.
8. On the board, have someone from your group write the number of people in your height group.
9. If you have time, it might be interesting to repeat the experiment, except have only the girls go up to the board. Write the number of girls in each group. Then have the boys do the same thing.
10. Do a bar graph for each of the three groups. What trends do you notice right away?

### *Conclusions/Results*

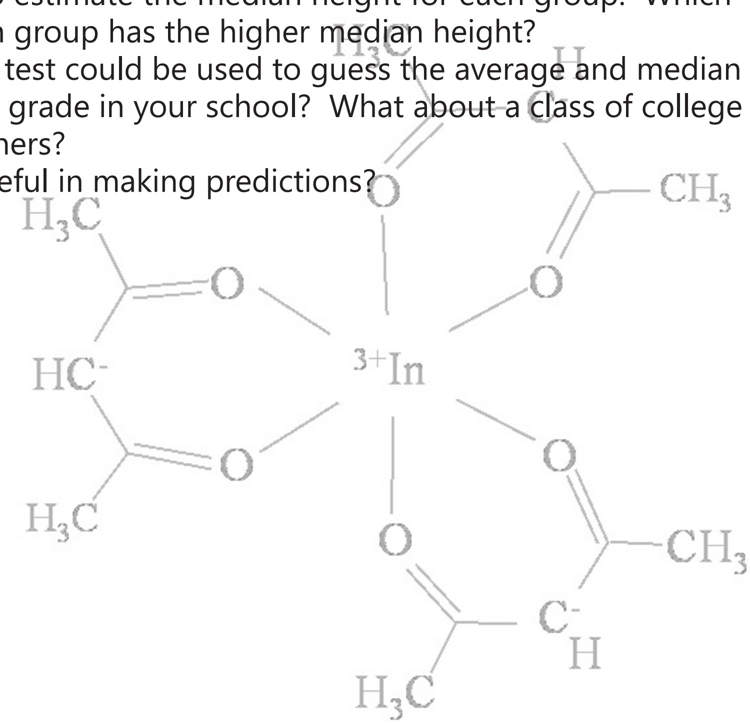
When you make the bar graph, you should visually see what was represented by having everyone line up in groups at the front of the classroom. You should notice that there tends to be a "hill" in your graph, where the number of students of average height is greater than the number of students who are shorter or taller.

This is one way in which scientists are able to make accurate predictions about what might happen in a study or a research experiment. For instance, if you had to pick one student from your classroom and without knowing who that person is, guess their height, what height would you guess? You would not choose a height represented at either end of the spectrum because there are not that many people there.

The median and the average (or mean) are two terms that can be used to describe the heights of the students in your class. The average is found by adding the height of all the students and dividing it by the number of students in the class. The median, on the other hand will give you the point where exactly half the class is below that value and exactly half the class is above that height. Try calculating both values for your entire class.
Average: ____________________
Median: ____________________

### *Questions*

- Are the average and median height for your class necessarily the same? Why can they be different? Why does the average not always reflect the height that most people are in the class?
- Compare the bar graphs for the boys and the girls. By looking at the top of the "hill" in each graph, you should be able to estimate the median height for each group. Which group is taller on average? Which group has the higher median height?
- Do you think the results from this test could be used to guess the average and median height of a classroom in the same grade in your school? What about a class of college students or a class of kindergarteners?
- Why do you think statistics are useful in making predictions?



Mathematics Activity on Probability

# The Birthday Paradox

*(www.ScienceBuddies.org)*

**Grade Level:** 5-7
**National Standards:** H.F.6 Science and technology in local, national, and global challenges


### *Abstract*
This project shows how mathematical probability sometimes contradicts our intuition. Despite the fact that there are 365 days in a year, if you survey a random group of just 23 people there is a 50:50 chance that two of them will have the same birthday. Don't believe it? Try this project and see for yourself.


### *Objective*
**The objective of this project is to prove whether or not the birthday paradox holds true by looking at random groups of 23 or more people.**

### *Introduction*
The Birthday Paradox states that in a random gathering of 23 people, there is a 50% chance that two people will have the same birthday. Is this really true?

### *Terms, Concepts and Questions to Start Background Research*
- Birthday Paradox
- Probability theory
- Converse probability

### *Bibliography*
There are a number of different sites that explain the Birthday Paradox and explain the statistics. Here is one to get you started: http://en.wikipedia.org/wiki/Birthday_paradox

### *Experimental Procedure*
1) First you will need to collect birth dates for random groups of 23 or more people. Ideally you would like to get 10-12 groups of 23 or more people so you have enough different groups to compare. Here are a couple of ways that you can find a number of randomly grouped people.
- Most schools have around 25 students in a class, so ask a teacher from each grade at your school to pass a list around each of his/her classes to collect the birth dates for students in each of his/her classes.
- Use the birth dates of players on major league baseball teams. (Note: this information can easily be found on the internet).

2) Next you will need to sort through all the birth dates you have collected and see if the Birthday Paradox holds true for the random groups of people you collected. How many of your groups have two or more people with the same birthday? Based on the birthday paradox, how many groups would you expect to find that have two people with the same birthday?

### *Variations*

- For more science project ideas in this area of science, see Pure Mathematics Project Ideas (http://www.sciencebuddies.org/science-fair-projects/recommender_interest_area.php?ia=Math).

# Mathematics Activity on Vectors

# *Vector Chess*

**Grade Level:** 8+
**National Standards:** H.F.6 Science and technology in local, national, and global challenges

### *Objective*

**The purpose of this activity is to become familiar with how vectors work.** A vector is a number of units in a given direction. You will have to work as a team if your team is going to win.

### *Introduction*

- Which team will win?
- Which piece do you think will travel the farthest away from their original position?
- Which will travel the greatest distance? Why?
- Which will travel the least distance? Why?

### *Materials and Equipment*

- Space on the floor to set up a human chessboard. A chessboard is usually 8x8 squares. Each square should be at least a couple feet in either direction.
- Nametags or signs for each of the players, designating their piece and color
- Chess board map at the back of this activity
- At least 20 students

### *Experimental Procedure*

1. Split the class in half.
2. Review the rules of chess with the class, detailing the roles and moves of each of the pieces. Have each team choose their king or queen —the person that they feel will be best able to direct the other members of the team.
3. Each student can then choose the piece that he wants to be. Remove the number of pawns as you see necessary. For example, if you have a class of 24 students, each half of the class will have 12 students—the eight power pieces and 4 pawns. Remember that all pieces play an important role in the game, so even if you are a pawn, you are an essential part to winning the game.
4. Each student is given a copy of the chess board map. They need to track down all their moves during the game.
5. Once everyone has been assigned a role, they should get in place. Pawns should figure out a strategy on where they want to be placed.
6. Point out on the board an x-axis along the horizontal field of play, and a y-axis along the vertical field of play.
7. The game is ready to begin. The king declares a move. The piece can either accept or reject the move. If the piece refuses the move, he should either suggest an alternative or explain why s/he does not wish to move. While one team is thinking about their next move, the other team should be as quiet as possible. Once the king and a piece agree on a move, the piece must declare their move.
    a. To complete the move, the piece will have to accurately describe their planned move in vectors. For instance, if a queen was going to move forward 5 spaces, the player

would say: "Queen moves 5 units in the positive y-direction." Positive and negative are relative to the team's position, so one team's positive direction is the other team's negative direction. To prevent confusion, allow both teams to state their moves in terms of their direction of movement.

   b. For a piece moving diagonally, such as a pawn or bishop, it is a bit trickier. For example, if a bishop wants to move three spaces diagonally to the upper right, he would say, "Bishop moves three units in the positive y-direction PLUS three units in the positive x-direction." The addition of vectors is important to note here.
   c. Also take note of subtracting vectors. For a piece moving diagonally 4 spaces in the upper-left direction, s/he could say either "Bishop moves four units in the positive y-direction PLUS four units in the negative y-direction." OR he could say, "Bishop moves four units in the positive y-direction MINUS four units in the positive x-direction."
   d. The knight always has to add vectors in his moves, since he is always moving in the traditional L shape.
8. Failure to say the motion correctly will result in the loss of turn for the team.
9. On their map, the student should draw a vector marking their movement. This is done by drawing an arrow that starts at their starting point and ends at the point where they stop for that turn.
10. Play continues and students should mark their motion throughout the game.
11. The game ends when one team has put the other in checkmate, or when the class period is over.
12. When the game is over, each student should do two things with their chess board map:
   a. Calculate the distance traveled using vectors. This is done by simply adding the number of units in any direction. All units should be positive (even if they were moving in the negative direction). Movement in the diagonal should be done as if adding two vectors: the horizontal and the vertical.
   b. Calculate the distance traveled from start to finish.
13. Note: It is likely that some students will not have the chance to move before they are taken out of the game. Have them follow the piece that they think will move the greatest distance overall.
14. Answers should be compiled so that students can compare their hypotheses to the answer for their classroom.

### *Discussion of Results*

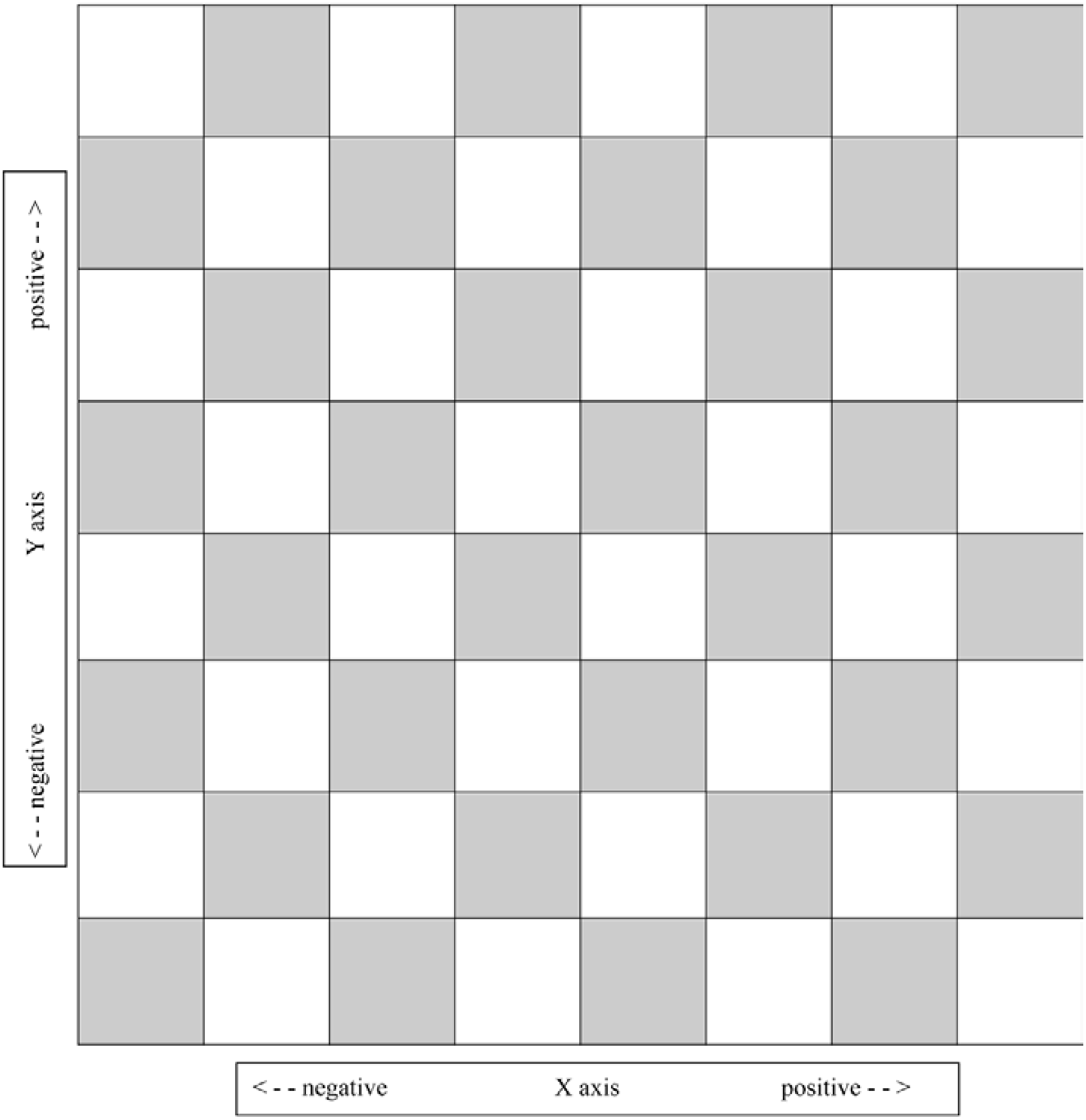
Compare the answers you found with your class' game to your initial hypothesis? Were your hypotheses correct? Do you suspect that the answers your class produced will always be the same? How could you test this?

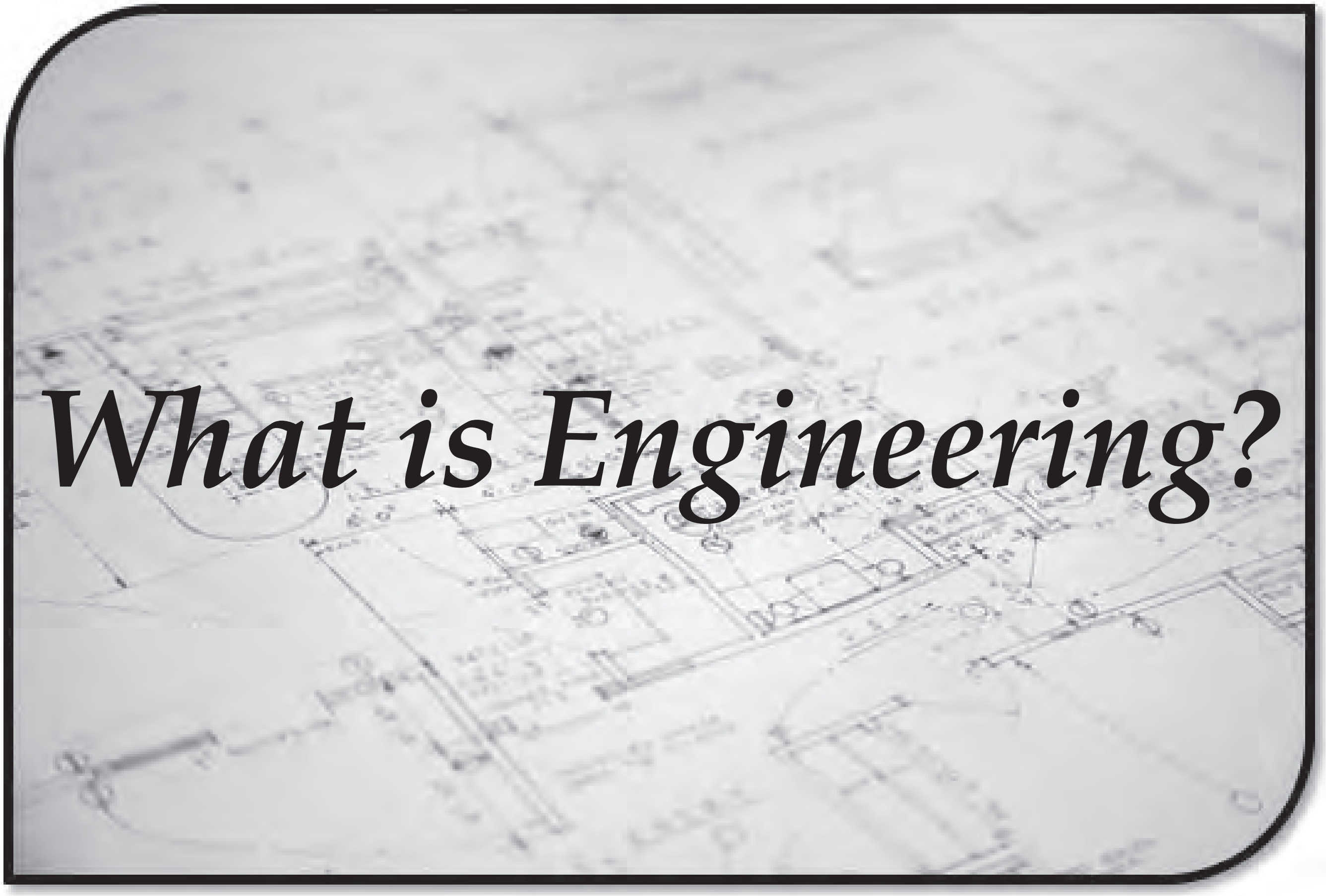
This exercise was intended to teach you about vectors. Vectors are a useful tool for understanding concepts in fields such as physics and mathematics. They can be used, for example, to describe changes in position (as you have done in this exercise), but also such things as velocity and acceleration.

### *Questions*

- What other things can you use vectors to describe? Remember that a vector has both a number and a direction.
- What is the difference between speed and velocity? Which one can be described by vectors?

**Chess Map**





# *What is Engineering?*

***Engineering*** is the practical application of scientific principles and knowledge to everyday problems, often in commercial or industrial settings.

Engineers span many different disciplines including aerospace engineers who develop plans for aircraft and spacecraft and biomedical engineers whose devices are used in medicine. Chemical engineers take raw materials and transform them into everyday forms while mechanical engineers design engines, motors and machines. There are also industrial engineers who organize the machines, people, and materials that are necessary to create products; electrical engineers who work with electrical devices like computers or cars; and civil engineers who design public facilities like roads, bridges, and parks.

**Photo credit: Will Scullin @Flickr**

## *If you like engineering, you may like the careers chosen by these people:*

| ScienceMaker | Occupation | Location | Question Topics |
|---|---|---|---|
| **Lilia Abron** | Founder & President | *PEER Consultants* | Civil and sanitary engineering |
| **Paula Hammond** | Professor of Chemical Engineering | *Massachusetts Institute of Technology* | Materials design, micelles and surface chemistry |
| **Delon Hampton** | Co-Founder | *Hampton and Associates* | Civil engineering and soil mechanics |
| **James Hubbard** | Director | *National Institute of Aerospace* | Bio-inspired design and patents |
| **Marshall Jones** | Engineer | *General Electric* | Lasers |
| **Edward Tunstel** | Senior Robotics Engineer | *NASA Jet Propulsion League* | Robotics |
| **James West** | Professor of Electrical & Computer Engineering | *Johns Hopkins University* | Microphones and sound |
| **James Williams** | Professor of Applied Mechanics | *Massachusetts Institute of Technology* | Applied mechanics, sound, and yo-yos |

# Engineering in Action

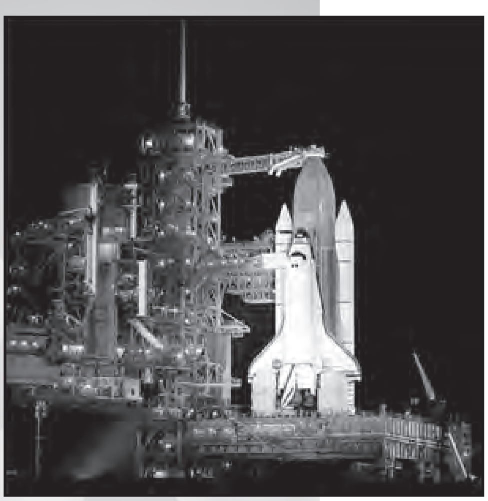
## *Tacoma Narrows Bridge Collapse*

(University of Washington Libraries, Special Collections)

The original Tacoma Narrows Bridge, a suspension bridge located in the state of Washington, collapsed on November 7, 1940. Forty mile per hour winds shook the bridge until the vibrations matched the bridge's resonance frequency. When the resonance frequency was met, the structure could not support the extreme amplitudes of the bridge's motions and it collapsed.

## *Space exploration*

("Space Shuttle Endeavour on Pad39A" by jurvetson @ Flickr)



The goals of the National Aeronautics and Space Association (NASA) have changed since its beginning in the middle of the twentieth century, but the work of engineers has re mained essential. At the beginning of the twenty-first century, the big problems in space exploration include robotic exploration of the solar system (Mars in particular) and the development of a telescope to follow in the footsteps of the Hubble Telescope.

# ScienceMakers
## Spotlight: Lilia Ann Abron

| Name | Lilia Ann Abron |
|---|---|
| Birth Date | March 8, 1945 |
| Birth Place | Rockville, Maryland |
| Education | Hamilton High School<br>Lemoyne College<br>Washington University<br>University of Iowa |
| Type of Science | Chemical Engineering |

## Biography

The first African American woman in the nation to receive her Ph.D. degree in chemical engineering, Lilia Ann Abron was born on March 8, 1945 in Memphis, Tennessee. She was born at home, instead of in a hospital. Her father was a school principal and her mother was a school teacher who taught art and geography. In addition to Abron, her parents had three other daughters. Abron is the second daughter. Abron attended Lemoyne College in Memphis, Tennessee where she received her B.S. degree in chemistry. She then attended Washington University where she earned her M.S. degree in sanitary engineering. She received her Ph.D. degree in chemical engineering from the University of Iowa in 1972.

**Pollution photo by Jim Linwood @Flickr**

Prior to beginning her own business, Abron worked for municipal government, in academia as a university professor and for several engineering firms. After receiving her M.S. degree, Abron worked for the Kansas City Water Department. She went on to become a research engineer for the Metropolitan Sanitary District of Greater Chicago. After receiving her Ph.D., Abron taught sanitary engineering at Tennessee State University, Vanderbilt University, and Howard University. In 1978, Abron founded PEER Consultants, an environmental engineering consulting firm that provides solutions to the problems of contamination of the environment. Consulting engineering firms provide advice to and solve problems for their clients, which are primarily governments and private industry.

Abron has three sons and five grandchildren. She is a member of Delta Sigma Theta Sorority and the International Women's Forum. Professionally, she is a member of the Water Environment Federation, American Water Works Association, and American Society of Civil Engineers. She also serves on the Advisory Board for the College of Engineering, University of South Florida. In 1999, Abron was the recipient of the Hancher-Finkbine Alumni Medallion from the University of Iowa, in 2001 she was awarded the Magic Hands Award by LeMoyne-Owen College, and in 2004 she was elected to the National Academy of Arts and Sciences.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Abron?
#2 Where was Dr. Abron born? Locate it on a map. How far away is this from where you live? Where did Dr. Abron attend college? What do you think college was like for her?
#3 How old are you? In what year was Dr. Abron your age? What was happening in the United States that year? What was happening in the world that year? What do you think her life was like when she was your age?
#4 Both of Dr. Abron's parents were involved in education. What do your parents do? Do you think their professions have influenced your interests?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a chemical engineer does? Would you like to be a chemical engineer? Why? Why not?
#2 If you were a chemical engineer, what topics would you study?
#3 Dr. Abron's consulting firm helps companies use resources to be less harmful to the environment. What are ways you can help the environment every day?
#4 What kind of city departments do you think need engineers? Why?
#5 Why is sanitary engineering important? If you could change one thing that would make society a bit more sanitary, what would it be? What resources would you need to carry out this plan?

# Glossary

*Chemical engineering*
The activity of applying chemistry to the solution of practical problems.

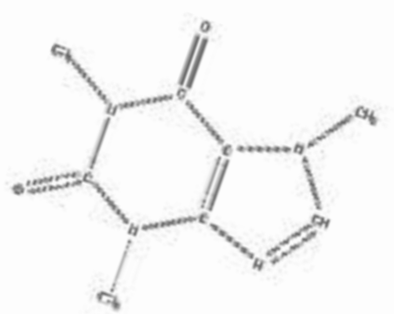
*Consultant*
An expert who gives advice, an advisor.

*Environmntal engineering*
The application of science and engineering principles to improve the environment, to provide healthy water, air, and land for human habitation and other organisms, and to remediate polluted sites.

*Geography*
The study of the physical structure and inhabitants of the Earth.

*Municipal government*
The government that operates locally and works with local issues.

*Sanitary engineering*
The application of scientific or mathematical principles to the field of sanitation, especially in regards to its effect on public health.



# ScienceMakers
## Spotlight: Paula Therese Hamond

| Name | Paula Therese Hammond |
|---|---|
| Birth Date | 1963 |
| Birth Place | Detroit, Michigan |
| Education | Massachusetts Institute of Technology<br>Georgia Institute of Technology |
| Type of Science | Chemical engineering |

## Biography

Chemical engineer and engineering professor Paula Therese Hammond was born in 1963 in Detroit, Michigan. Although she grew up wanting to become a writer, Hammond changed her mind after taking a junior high school chemistry class. She was hooked by the idea of using two materials to create a something completely different. After graduating from high school, Hammond attended Massachusetts Institute of Technology (MIT), where she obtained her B.S. degree in chemical engineering in 1984. She was then hired by Motorola in Fort Lauderdale, Florida, where she worked for two years. In 1988, Hammond earned her M.S. degree from Georgia Institute of Technology and then returned to MIT to earn her Ph.D. degree in chemical engineering in 1993.

**Army photo by US Army Africa @Flickr.**
Hammond helped found the Institute for Soldier Nanotechnologies.

Following a postdoctoral research fellowship in chemistry at Harvard University, where she became interested in surface chemistry, Hammond went on to become a faculty member of MIT. In 2003, she worked as a Radcliffe Institute Fellow, focusing on a project that allowed for the creation of polymers that form micelles in water. These isolated packages could be used to assist in drug delivery. Hammond is the Bayer Chair Professor of Chemical Engineering, and serves as its Executive Officer. Additionally, she has participated in the Koch Institute for Integrative Cancer Research at the Massachusetts Institute of Technology. She also helped found the Institute for Soldier Nanotechnologies (ISN), whose mission is to help design more functional technology for the nation's soldiers. Hammond's research interests include the nanoscale design of biomaterials, macromolecular design and synthesis, and directed assembly using surface templates. In 2010, Hammond made a research agreement with Ferrosan A/S, a pharmaceutical company, to develop a bandage that would use Hammond's technological innovations in Ferrosan's collagen bandages. Throughout her career, Hammond has served as a mentor to many graduate and undergraduate students and has published nearly 150 scholarly articles pertaining to her research in chemical engineering. She has also encouraged an increase in the presence of minority scientists and engineers at MIT by chairing the Initiative on Faculty, Race and Diversity.

Hammond has won numerous awards for her work as a scientist and as a professor. She was named the Bayer Distinguished Lecturer in 2004 and the Mark Hyman, Jr. Career Development Chair in 2003. In 2010, the Harvard Foundation awarded her the Scientist of the Year Award at the annual Albert Einstein Science Conference. Hammond has also been named one of the "Top 100 Science Stories of 2008," by *Discover* Magazine. Hammond is married to Carmon Cunningham, and they have one son, James.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Hammond?
#2 Where was Dr. Hammond born? Locate it on a map. How far away is this from where you live? Where did Dr. Hammond attend college? What do you think college was like for her?
#3 How old are you? In what year was Dr. Hammond your age? What was happening in the United States that year? What was happening in the world that year? What do you think her life was like when she was your age?
#4 Dr. Hammond was named one of the "Top 100 Science Stories of 2008." Set a goal for yourself. If you could make the "Top 100 List" for any topic in any year, what would it be for and why? What list is it? What year?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a chemical engineer does? Would you like to be a chemical engineer? Why? Why not?
#2 If you were a chemical engineer, what topics would you study?
#3 What kinds of topics do you think are part of "surface chemistry"? What happens at the interface between two substances?
#4 Dr. Hammond's lab is interested in layered nanoscale materials assembly. One way of creating a single layer is through micelles. Look up the definition of a micelle below. Recalling the property of "like dissolves like" in chemistry, how do you think micelles can be used in delivering drugs to target parts of the body if water, a polar substance, is one of the main components of the body?
#5 Dr. Hammond's multilayer coating on bandages contains antibiotics and other anti-inflammatory agents in its layers. This allows for a time-controlled release of medicine when it is applied to the body. Where else do you think this system of multilayer coatings could be used?

# Glossary

*Chemical engineering*
The activity of applying chemistry to the solution of practical problems.

*Collagen*
A protein that is the principal constituent of white fibrous connective tissue; it occurs in tendons, skin, bone, cartilage, and ligaments. It is relatively inelastic (not flexible) but has a high tensile strength (ability to resist forces of stretching).

*Macromolecule*
A very large molecule most often created by some form of polymerization. In the context of biochemistry, the term may be applied to the four conventional biopolymers (nucleic acids, proteins, carbohydrates, and lipids), as well as non-polymeric molecules with large molecular mass.

*Micelle*
In a liquid environment, micelles are essentially bubbles that trap target molecules on the inside and separate them from the external environment. The molecules that make up micelles tend to be made of two components: a polar group and a non-polar group.

*Nanoscale (nanoscopic scale)*
Structures with a length scale applicable to nanotechnology; usually cited as 1-100 nanometers.

*Polymer*
A naturally occurring or synthetic compound consisting of large molecules made up of a linked series of repeated simple chemical units.

*Postdoctoral research fellowship*
Academic or scholarly research conducted by a person who has completed his or her doctoral studies, normally within a five year period. It is intended to further expertise in a specialist subject, including necessary research skills and methods.

*Surface Chemistry*
The study of chemical phenomena that occur at the interface of two phases, including solid-liquid interfaces, solid-gas interfaces, solid-vacuum interfaces, and liquid-gas interfaces.

*Synthesis*
The process of producing a chemical compound.

*Template*
A physical object whose shape is used as a guide to make other objects.

# ScienceMakers
## Spotlight: Delon Hampton

| | |
|---|---|
| **Name** | Delon Hampton |
| **Birth Date** | 1935 |
| **Birth Place** | Chicago, Illinois |
| **Education** | University of Illinois<br>Purdue University |
| **Type of Science** | Civil Engineering |

## Biography

Civil engineer Delon Hampton was born in Chicago, Illinois. Hampton went to the University of Illinois, where he received his B.S. degree in civil engineering. He earned his M.S. and Ph.D. degrees in civil engineering from Purdue University in West Lafayette, Indiana in 1958 and 1961, respectively.

In 1961, Hampton began working as an assistant professor at Kansas State University taking leave in 1962 and 1963 to head the University of New Mexico's soil mechanics research as part of the Eric H. Wang Civil Engineering Research Facility. In 1967, Hampton became a senior research engineer at the Illinois Institute of Technology Research Institute in Chicago, Illinois. The following year, Hampton joined the faculty at Howard University as a professor of civil engineering, where he stayed until 1985.

**Civil engineers at work photo by West Point Public Affairs @Flickr**

Hampton became a partner and president of Gnaedinger, Baker, Hampton and Associates, an engineering consulting firm in Washington, D.C., in 1972 before founding Hampton and Associates as chairman and Chief Executive Officer in 1973. In 1999, Hampton became the first African American president of the American Society of Civil Engineers. Hampton has also served as a member of the U.S. Trade Advisory Committee on Africa.

Hampton has been selected as an Old Master and Distinguished Engineering Alumnus by Purdue University and received the University of Illinois Civil Engineering Alumni Association's Distinguished Alumnus Award. Hampton has received two honorary doctorate degrees and has published over forty papers. In addition, the American Society of Civil Engineers has bestowed upon Hampton its Edmund Friedman Professional Recognition Award and the James Laurie Prize. Hampton is a fellow of the American Academy of Arts and Sciences (AAAS) and has served as Councilor of the National Academy of Engineering (NAE). The American Public Transportation Association recognized him as an outstanding public transportation business member and president emeritus in 2010. He is a registered as a professional engineer in eighteen states.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Hampton?
#2 Where was Dr. Hampton born? Locate it on a map. How far away is this from where you live? Where did Dr. Hampton attend college? What do you think college was like for him?
#3 How old are you? In what year was Dr. Hampton your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 Dr. Hampton served as a professor, a researcher, and a partner before becoming CEO of his own company. Think of your dream profession. What is the path to get there? Are there alternate paths? What might they be?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a civil engineer does? Would you like to be a civil engineer? Why? Why not?
#2 If you were a civil engineer, what topics would you study?
#3 Dr. Hampton studied soil mechanics in New Mexico. Soil mechanics essentially uses the principles of engineering mechanics to predict the mechanical behavior of soils. (There is also rock mechanics). Why do you think soil mechanics is particularly of interest to civil engineers?
#4 Think of some of the aspects of your school that may have been worked on by civil engineers. The buses? The buildings? What else?
#5 What problems do you think civil engineers must consider in some place like San Francisco? What about the Gulf Coast in Mississippi? Or in the mountains of Colorado?

# Glossary

*American Academy of Arts and Sciences (AAAS)*
An independent policy research center that conducts multidisciplinary studies of complex and emerging problems. The Academy's elected members are leaders in the academic disciplines, the arts, business, and public affairs.

*Chief Executive Officer (CEO)*
The corporate executive responsible for the operations of the firm; reports to a board of directors; may appoint other managers (including a president).

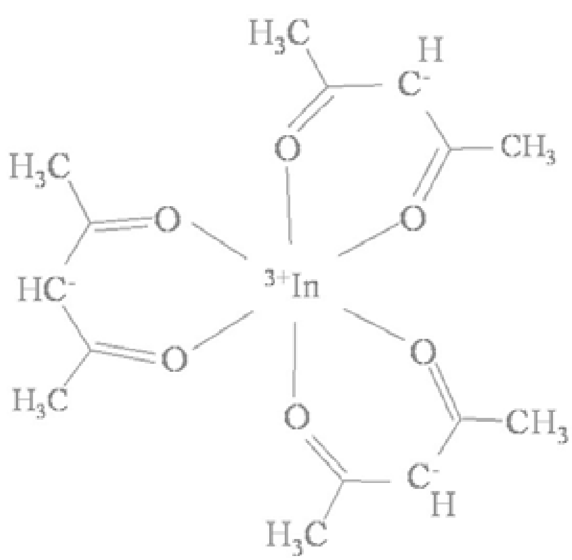
*Civil engineering*
A professional engineering discipline that deals with the design, construction and maintenance of the physical and naturally built environment, including works such as bridges, roads, canals, dams and buildings.

*Consultant*
An expert who gives advice; an advisor.

*Emeritus*
An adjective that is used in the title of a retired professor, bishop, or other professional.

*National Academy of Engineering (NAE)*
A non-profit institution that operates engineering programs and encourages education and research. Election to the group is considered the highest achievement in engineering-related fields.

*Soil mechanics*
The systematic study of the nature and behavior of soils including their classification, composition, consolidation, strength and the active and passive pressures in them.



# ScienceMakers
## Spotlight: James Edward Hubbard, Jr.

| Name | James Edward Hubbard, Jr. |
| --- | --- |
| Birth Date | December 21, 1951 |
| Birth Place | Danville, Virginia |
| Education | Baltimore Polytechnic Institute<br>Calhoon MEBA Marine Engineering School<br>Massachusetts Institute of Technology |
| Type of Science | Mechanical Engineering |

## Biography

Mechanical engineer James Edward Hubbard, Jr., was born on December 21, 1951 in Danville, Virginia. Hubbard received his engineering high school diploma in 1969 from the Baltimore Polytechnic Institute. He then attended Calhoon MEBA Marine Engineering School, where he earned his Marine Engineers License in 1971. He received his B.S., M.S., and Ph.D. degrees in mechanical engineering from Massachusetts Institute of Technology (MIT) in 1977, 1979, and 1982, respectively.

**"Walkin The Dog" by toddwshaffer @Flickr. Dr,** Hubbard developed an "In-shoe remote telemetry gait analysis system. What do you think it would say about the man in the photo's gait?

Hubbard has held an extensive list of positions as a professor and a researcher both inside and outside of academia. After receiving his Ph.D. degree, Hubbard continued his work as an assistant professor of mechanical engineering at Massachusetts Institute of Technology (MIT) until 1985, and a lecturer until 1994. In these positions, he mentored students conducting graduate and doctorate level research. Following his employment with MIT, Hubbard worked with Charles Stark Draper Laboratory, Optron Systems, Inc., Boston University Photonics Center, PhotoSense, Inc., and iProvica. In 2004, Hubbard returned to academia, becoming a full professor with the University of Maryland Aerospace Engineering Department and a Langley Distinguished professor with the National Institute of Aerospace (NIA). Throughout his career, Hubbard has produced a number of patents spanning from the "In-shoe remote telemetry gait analysis system" to the "Center of weight sensor" and "Pressure distribution characterization system." Hubbard's research has included sensors and system concepts, optoelectronics, and photonics. One of his other areas of interest is the study of adaptive structures, such as bio-inspired approaches to vehicle design.

Hubbard has garnered several awards in recognition of his work in both industrial and academic settings. In 1999, he was named the recipient of the International Society for Optical Engineering Smart Structures Product Innovation Award. In June of 2000 he was awarded the Key to the City of his hometown, Danville, Virginia, and in 2002, Hubbard was honored with the Black Engineer of the Year, President's Award. Hubbard and his wife, Adrienne, have raised three adult sons: James, Drew, and Jordan.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Hubbard?
#2 Where was Dr. Hubbard born? Locate it on a map. How far away is this from where you live? Where did Dr. Hubbard attend high school? What do you think high school was like for him?
#3 How old are you? In what year was Dr. Hubbard your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 How do Dr. Hubbard's innovations, patents, and development of sensors impact society?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a mechanical engineer does? Would you like to be a mechanical engineer? Why? Why not?
#2 If you were a mechanical engineer, what topics would you study?
#3 Dr. Hubbard has done both research and teaching. If you could do either one of these two things, which would you choose? Or would you choose to do both? Why?
#4 Three of Dr. Hubbard's patents are mentioned in his biography above. Pick one and describe how you think such a device might be used in research or everyday life.
#5 Why do you think bio-inspired approaches to vehicle design are interesting to Dr. Hubbard? Are they interesting to you? What does a bio-inspired approach to vehicle design mean exactly? If you could use a bio-inspired design to improve upon the structure of any modern appliance or machine, what would it be and why?

# Glossary

*Adaptive structures*
A mechanical structure with the ability to alter its configuration, form or properties in response to changes in the environment.

*Mechanical engineering*
The subfield of engineering concerned with designing and building machines and mechanical systems.

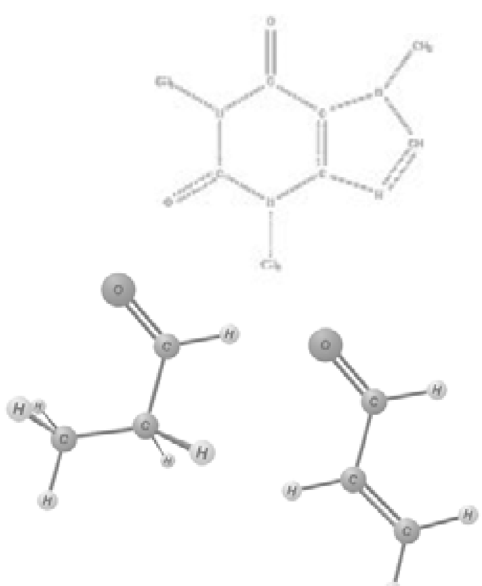
*National Institute of Aerospace (NIA)*
A non-profit research and graduate education institute created to conduct leading-edge aerospace and atmospheric research.

*Sensor*
Any device that receives a signal or stimulus (as heat or pressure or light or motion etc.) and responds to it in a distinctive manner; a detector.

*Optoelectronics*
The study and application of electronic devices that source, detect and control light, usually considered a sub-field of photonics.

*Patent*
A declaration issued by a government agency that declares someone the inventor of a new invention and has the privilege of stopping others from making, using or selling the claimed invention.

*Photonics*
The science of photonics includes the generation, emission, transmission, modulation, signal processing, switching, amplification, detection and sensing of light.



# ScienceMakers
## Spotlight: Marshall Jones

| | |
|---|---|
| **Name** | Marshall Jones |
| **Birth Date** | August 1, 1941 |
| **Birth Place** | Southampton, New York |
| **Education** | Riverhead High School<br>Mohawk Valley Community College<br>University of Michigan<br>University of Massachusetts at Amherst |
| **Type of Science** | Mechanical Engineering |

## Biography

Inventor and engineer Marshall Jones was born on August 1, 1941 to Mildred and Dallas Jones. Jones' father was enlisted in the Navy and while he was abroad during World War II, Jones, his brother, Melvin, and his mother, relocated to the duck farm of his great Aunt and Uncle in Aquebogue, New York. It was at Aquebogue Elementary School that Jones first realized his aptitude for math and science. He attended Riverhead High School and graduated with his diploma in 1960. Two years later, he received his A.A.S. degree from Mohawk Valley Community College. He then received his B.S. degree in mechanical engineering from the University of Michigan in 1965. In his graduating class, he was the only African American student in the Engineering School. Following work at Brookhaven National Laboratory (BNL), Jones went on to attend the University of Massachusetts at Amherst, where he would receive his M.S. and Ph.D. degrees in mechanical engineering in 1972 and 1974, respectively.

**Lasers photo by Qassaam @Flickr**

Jones entered into industrial research in 1974, working with General Electric Global Research in New York. Jones was one of General Electric's first scientists researching laser material processing and he soon became the manager of the Laser Technology Program. In 1982, Jones started research on high-power laser beam transmission through optical fibers. His research allowed for the passage of high power laser beams with high efficiency. Jones continued to specialize in laser technology, becoming a major pioneer in the field. His work included the use of lasers to join two dissimilar metal combinations together. This technique altered the way that lead wires in light bulbs were produced.

Jones has won a number of awards for his groundbreaking work. He was named the 1994 Black Engineer of the Year for his technical contributions to industry. One year later, he received the Distinguished Achievement Award for Professional and Community Service from the University of Massachusetts. He went on to receive the Pioneer of the Year Golden Torch Award from the National Society of Black Engineers (NSBE) in 1999. He was also elected into the National Academy of Engineering (NAE) in 2001 for his contributions to the application of high-power lasers in industry.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Jones?
#2 Where was Dr. Jones born? Locate it on a map. How far away is this from where you live? What are the names of his parents? Where did Dr. Jones attend high school? What do you think high school was like for him?
#3 How old are you? In what year was Dr. Jones your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 In the graduating class of 1965, Dr. Jones was the only African American student from the Engineering School at the University of Michigan. How do you think he felt? What events were happening the United States around this time?
#5 What other question(s) would you ask if you were to interview Dr. Jones?

***About the Subject Matter:***

#1 What do you think a mechanical engineer does? Would you like to be a mechanical engineer? Why? Why not?
#2 If you were a mechanical engineer, what topics would you study?
#3 What are qualities of the light that a laser produces? What makes lasers useful for conducting scientific experiments? Why is it extremely dangerous to look directly into a laser beam?
#4 Laser pointers come in a variety of colors, although red and green are the most common. What is the difference between red light and green light?
#5 How accurate is the portrayal of the "laser" beams that you tend to see in spy movies?

# Glossary

*Brookhaven National Laboratory (BNL)*
A United States national laboratory located in Upton, New York on Long Island, and was formally established in 1947 at the site of Camp Upton, a former U.S. Army base.

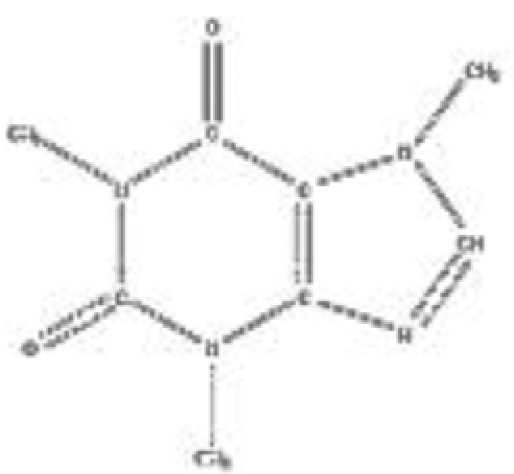
*LASER*
An acronym for Light Amplification by Stimulated Emission of Radiation; an optical device that produces an intense monochromatic beam of coherent light. Monochromatic light has only one wavelength—it appears to be of only one color. Coherent light is of the same phase (i.e. there is no constructive or destructive interference of waves of light).

*Mechanical engineering*
The subfield of engineering concerned with designing and building machines and mechanical systems.

*National Academy of Engineering (NAE)*
A non-profit institution that operates engineering programs and encourages education and research. Election to the group is considered the highest achievement in engineering-related fields.

*National Society of Black Engineers (NSBE)*
One of the largest student-run organizations in the United States centered on improving the recruitment and retention of African-American engineering students and professionals.

*Optical fibers*
A glass or plastic fiber that carries light along its length. Fiber optics is the overlap of applied science and engineering concerned with the design and application of optical fibers.



# ScienceMakers
## Spotlight: Edward Tunstel, Jr.

| | |
|---|---|
| **Name** | Edward Tunstel, Jr. |
| **Birth Date** | November 29, 1963 |
| **Birth Place** | Harlem, New York |
| **Education** | Springfield Gardens High School<br>Howard University<br>University of New Mexico |
| **Types of Science** | Electrical Engineering<br>Mechanical Engineering<br>Robotics |

## Biography

Robotics engineer and technology developer Edward Tunstel, Jr. was born on November 29, 1963 in Harlem, New York to Agnes Tunstel and Edward Tunstel, Sr. As a child, Tunstel was very interested in art, which led him to pursue an initial interest in architecture. However, after he attended a seminar held by the New York Academy of Sciences the summer of his junior year in high school, he decided to shift his focus to engineering instead due to his curiosity in learning how things worked. He graduated from Springfield Gardens High School in Queens, New York in 1981 and received his B.S. and M.E. degrees in mechanical engineering from Howard University in 1986 and 1989, respectively.

**NASA Mars rover art by Idaho National Laboratory @Flickr**

Upon his graduation from Howard University, the Jet Propulsion Laboratory (JPL) of the National Aeronautics and Space Administration (NASA) recruited Tunstel. In 1992, he was granted the JPL Minority Fellowship to further his education at the University of New Mexico, where he received his Ph.D. degree in electrical engineering in 1996. Tunstel has continued to work with the JPL following the completion of his Ph.D. program, and he has served in various roles. One of his larger projects was to serve as a Flight Systems Engineer for autonomous surface navigation of the NASA Mars Exploration Rovers. He has also served as the mobility and robotic arm lead on the Spacecraft/Rover Engineering Team for the *Spirit* and *Opportunity* rovers' surface operations on Mars. Since 1997, he worked as the Space Robotics and Autonomous Control Lead at the Johns Hopkins University Applied Physics Laboratory, where he continued to solve robotics problems for NASA. His research interests include: autonomous control systems, cooperative robotics, and mobile robot navigation.

Throughout his career, Tunstel has written a number of articles on the subject of robotics and intelligent control. He has also edited and contributed to several books related to robotics and engineering. Tunstel is a member of several professional organizations, including the Institute of Electrical and Electronics Engineers (IEEE), the National Society of Black Engineers (NSBE), and the American Institute of Aeronautics and Astronautics. He has also been honored for his contributions to the science of robotics and space exploration. Tunstel is married to Jan Harwell Tunstel.

# Discussion Questions

***About the ScienceMaker:***

#1 What was the most compelling thing you learned about Dr. Tunstel?
#2 Where was Dr. Tunstel born? Locate it on a map. How far away is this from where you live? What are the names of his parents? Where did Dr. Tunstel attend high school? What do you think high school was like for him?
#3 How old are you? In what year was Dr. Tunstel your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 Dr. Tunstel's interest in science came from his interest in art when he was young. Have you had a similar experience where one interest led into a very different topic that interests you? Ask a parent, grandparent, or teacher if they had a similar experience when choosing their career.
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a robotics engineer does? Would you like to be a robotics engineer? Why? Why not?
#2 If you were a robotics engineer, what topics would you study?
#3 What does NASA do? What projects has the organization been working on lately? What were some of their projects fifty years ago? What has happened with NASA since that time?
#4 What processes are involved in transporting a Rover to the surface of Mars? What qualities do you think the Rover must have in order to operate on the surface of Mars? Dr. Tunstel is interested in robotics. How is this related to the Mars Exploration Rovers project? What do you think his role was with this project?
#5 How does the surface of Mars compare to the surface of Earth? Is there water on Mars? Could Mars potentially support living organisms?

# Glossary

*Autonomy*
Freedom from external control and constraint in e.g. action and judgment.

*Electrical engineering*
The branch of engineering science that studies the uses of electricity and the equipment for power generation and distribution and the control of machines and communication.

*Institute of Electrical and Electronics Engineers (IEEE)*
An international non-profit, professional organization for the advancement of technology related to electricity.

*Intelligent control*
A class of robotic control techniques, that uses various artificial intelligence computing approaches.

*Jet Propulsion Laboratory (JPL)*
A federally funded research and development center. Its primary focus is the scientific study of the solar system, including exploration of the planets with automated probes.

*Mars Exploration Rover*
Any of a number of small unmanned remotely-operated vehicles sent to the planet Mars to do scientific research.

*Mechanical engineering*
The subfield of engineering concerned with designing and building machines and mechanical systems.

*National Aeronautics and Space Administration (NASA)*
An independent agency of the United States government responsible for aviation and spaceflight.

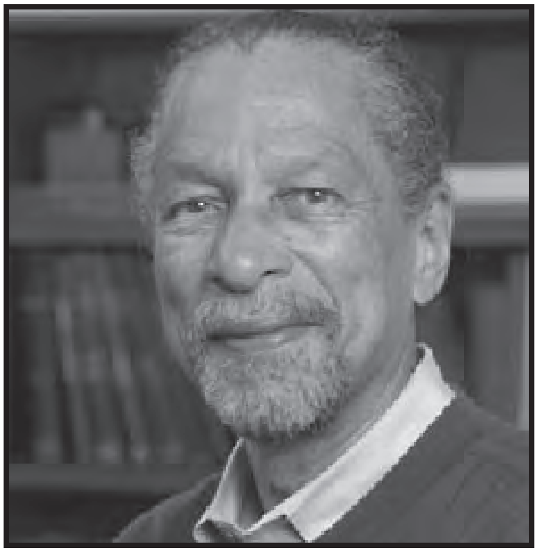
*National Society of Black Engineers (NSBE)*
One of the largest student-run organizations in the United States centered on improving the recruitment and retention of African-American engineering students and professionals.

*Opportunity (Rover)*
Mission designation MER-B (Mars Exploration Rover - B), is the second of the two rovers of NASA's ongoing Mars Exploration Rover Mission.

*Robotics*
The engineering, science and technology of robots, and their design, manufacture, application, and structure. This field is related to electronics, mechanics, and software.

*Spirit (Rover)*
Mission designation MER-A (Mars Exploration Rover - A); the first of the two rovers of NASA's ongoing Mars Exploration Rover Mission.

# ScienceMakers
## Spotlight: James Edward Maceo West



| | |
|---|---|
| **Name** | James Edward Maceo West |
| **Birth Date** | February 10, 1931 |
| **Birth Place** | Farmville, Virginia |
| **Education** | Hampton University<br>Temple University |
| **Type of Science** | Electrical Engineering |

## Biography

Inventor and physicist James Edward Maceo West was born on February 10, 1931 in Farmville, Virginia to Samuel Edward and Matilda West. He and his brother, Nathaniel, were raised in Virginia. When he was twelve years old, West learned a great deal about the properties of electricity when he worked with his cousin putting electrical wiring into homes in rural Virginia. West attended Hampton University in Virginia with the plans of going on to medical school. However, these plans changed and he transferred to Temple University in Philadelphia after serving in the Korean War where he was awarded a Purple Heart for his outstanding military service. West also changed his concentration to solid state physics. He received his B.S. degree in physics in 1957.

**"Mysupervintagemicrophone" by Lordstephen @Flickr**

West was hired at Bell Laboratories, where he began his studies to obtain his Ph.D. degree. During the second year of his doctorate program, West and a colleague, Gerhard Sessler, constructed a small microphone that did not require the use of a battery. The electret microphone replaced the carbon microphone and revolutionized communication technology. West continued developing his invention, and saw its use in such devices as hearing aids and space technology. Even in 2010, 90% of microphone technology has its foundation in West's development of the electret microphone. West retired from Lucent Technologies as a Bell Laboratories Fellow in 2001. He continued to do research at Johns Hopkins University where his research interests include, among other things, finding the new technology that will replace the electret microphone.

West's inventions and contributions to the betterment of society has garnered him a great deal of recognition. In 1999, West was selected to join the National Inventors Hall of Fame for the invention of the electret microphone. He has also received the U.S. National Medal of Technology. He has 47 U.S. patents and he has written over 100 academic papers. West has one daughter, Ellington Simone West.

## Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. West?
#2 Where was Dr. West born? Locate it on a map. How far away is this from where you live? What are the names of his parents?
#3 How old are you? In what year was Dr. West your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age? Where did Dr. West attend college? What do you suppose college was like for him?
#4 West learned about electricity by working with his uncle in wiring their homes for electricity one summer. Have you had an experience where you have learned a lot from a family member by joining them at work?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think an electrical engineer does? Would you like to be an electrical engineer? Why? Why not?
#2 If you were an electrical engineer, what topics would you study?
#3 Dr. West and Gerhard Sessler invented the electret microphone. What made this invention so important? What devices use the electret microphone?
#4 What is the difference between an electret microphone and a carbon microphone? How does a microphone work?
#5 A microphone amplifies sound. How does sound travel? Does sound travel at the same speed regardless of the material it is passing through?

# Glossary

*Bell Laboratories*
The research and development organization of Alcatel-Lucent and previously of the American Telephone & Telegraph Company (AT&T). Also known as Bell Labs and formerly known as AT&T Bell Laboratories and Bell Telephone Laboratories.

*Carbon microphone*
A sound-to-electrical signal transducer consisting of two metal plates separated by granules of carbon. One plate faces outward and acts as a diaphragm. Also known as a carbon button microphone or a carbon transmitter.

*Electret*
A dielectric material that has some electric charge; generates internal and external electric fields, and is the electrostatic equivalent of a magnet.

*Electret microphone*
A type of microphone that uses permanently-charged material.

*Electricity*
A physical phenomenon associated with stationary or moving electrons and protons.

*Order of the Purple Heart*
A United States military decoration awarded to any member of the armed forces who is wounded in action.

*Solid state physics*
The branch of physics that studies the properties of materials in the solid state such as electrical conduction in crystals of semiconductors and metals.

# ScienceMakers
## Spotlight: James H. Williams, Jr.

| | |
|---|---|
| **Name** | James H. Williams, Jr. |
| **Birth Date** | April 4, 1941 |
| **Birth Place** | Newport News, Virginia |
| **Education** | Huntington High school<br>Massachusetts Institute of Technology<br>Cambridge University |
| **Type of Science** | Mechanical Engineering |

## Biography

Mechanical engineer and engineering professor James H. Williams, Jr. was born in Newport News, Virginia on April 4, 1941 to Margaret Louise Holt and James H. Williams. Williams and his sister, Sarah Ernestine, grew up in a racially segregated neighborhood in southeastern Virginia. Performing well throughout his early education, Williams graduated from Huntington High School in 1959 and went on to attend the Massachusetts Institute of Technology (MIT), where he received his B.S. and M.S. degrees in mechanical engineering in 1967 and 1968, respectively. During the early 1960s, Williams worked as an apprentice machinist and apprentice designer at the Newport News Shipbuilding and Dry Dock Company, earning a diploma as a mechanical designer. By the time he graduated from MIT, he had been promoted to senior design engineer. Williams earned his Ph.D. degree in engineering at Cambridge University in 1970.

**"2008 California State Yo-Yo Championship"**
**by the_exploratorium @Flickr**

Williams returned to MIT as a faculty member in mechanical engineering in 1970. In 1974, Williams led a group of undergraduate students in the construction of the world's then-largest functioning yo-yo with a 26-inch bicycle wheel and a 250-foot cord. Four years later, he served as a consultant for the U.S. Federal Highway Administration and designed the first mechanized vehicle for installing plow-resistant reflective markers for highway lane delineation. Between 1980 and 1982, Williams worked with his graduate students to create the first quantitative ultrasonic nondestructive evaluation characterizations for the prediction of residual static strength and fatigue life of graphite fiber composites. In 1981, he was promoted to full professor of applied mechanics at MIT. During his career, Williams has authored hundreds of reports and articles as well as a textbook called *Fundamentals of Applied Dynamics*. Williams has served as a mentor to many students, and is a long-time advocate for increasing the presence of African Americans and other minority groups in higher education. In 1991, he led a personal demonstration by fasting every Wednesday in April outside the offices of the MIT president and provost as a call to increase the number of African American faculty members at MIT.

Williams's work in education and scientific research has earned him many awards and honors. In 1973, a short time after joining the faculty at MIT, Williams won the Everett Moore Baker Award for Outstanding Undergraduate Teaching. He has also been honored with the Jacob P. Den Hartog Distinguished Educator Award in 1981, and he was named the School of Engineering Professor of Teaching Excellence in 1991. In 1993, he was honored with the Edison Man of the Year Award and a MacVicar Faculty Fellowship.

## Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Williams?
#2 Where was Dr. Williams born? Locate it on a map. How far away is this from where you live? What are the names of his parents? Where did Dr. Williams attend high school? What do you think high school was like for him?
#3 How old are you? In what year was Dr. Williams your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 Why do you think Dr. Williams took the drastic measures he did regarding minorities in higher education? Can you think of historical examples where individuals have led demonstrations?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a mechanical engineer does? Would you like to be a mechanical engineer? Why? Why not?
#2 If you were a mechanical engineer, what topics would you study?
#3 Applied mechanics is the part of physics that studies how materials or substances respond to forces that act upon them. Can you think of examples of what a physicist interested in applied mechanics might study? Do any of these topics interest you?
#4 When Dr. Williams and his students made the 16-inch yo-yo in 1974, it was the largest that had ever been made. Have you played with a yo-yo before? How does a yo-yo work? What forces act on a yo-yo? What allows the yo-yo to come back up the string?
#5 Look up the definition of ultrasonic (or supersonic). Can humans hear noises that are ultrasonic? Why or why not?

# Glossary

*Applied mechanics*
A branch of the physical sciences and the practical application of mechanics that examines the response of solids and fluids to external forces.

*Consultant*
An expert who gives advice; an advisor.

*Dynamics*
The branch of mechanics concerned with the forces that cause motions of bodies.

*Fatigue Life*
The number of cycles of stress on a material that can be sustained prior to failure under a stated test condition.

*Graphite*
An arrangement of carbon consisting of planes of carbon atoms arranged in hexagonal arrays with the planes stacked loosely. Used as a dry lubricant, and in lead pencils.

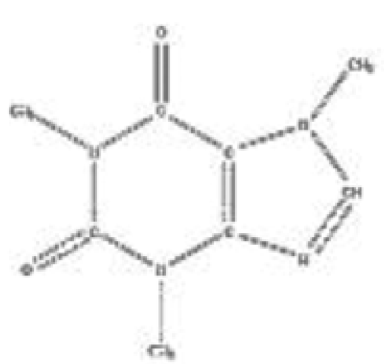
*Mechanical engineering*
The subfield of engineering concerned with designing and building machines and mechanical systems.

*Provost*
A high-ranking university administrator.

*Residual*
Remaining.

*Static Strength*
The force necessary to break a material under a slowly increasing load.

*Ultrasonic*
Having frequencies or vibrations above those of audible sound.



## Engineering Activity on Forces

# *Strong As Eggs*

**Grade Level:** 3+
**National Standards:** M.G.1 Science as a human endeavor
H.B.4 Motions and forces

### *Objective*

Why do architects often use arches to support heavy weights, like in bridges, domes, and igloos? **This experiment will show students how forces are distributed over an arch.**

### *Materials and Equipment*

- 4 eggs
- Cellophane
- 4 Telephone books

### *Experimental Procedure*

1. Carefully break off the smaller end of each of the eggs and pour out the yolks.
2. Wrap a piece of cellophane around the center of each egg.
3. Cut through the center of the cellophane to create eight dome-shaped eggshells.
4. Discard the four broken eggshells into the trash.
5. Put the four good domed eggshells on the table with the cut sides down.
6. Arrange the shells in the shape of a rectangle.
7. Guess how many books you can lay on top of the shells before they break.

### *Discussion of Results*

How many books were you able to lie? Arches can resist high pressure loads because they distribute weight horizontally as well as vertically. The top of the egg, called the crown, can support the books because their weight is distributed evenly across the entire egg arch.

### *Other questions to think about:*

- What other structures can you think of that use arches?
- What do you think might be even stronger design than an arch?

# Engineering Activity on Simple Machines

# *Which Simple Machines Do I Use The Most?*

***(www.ScienceBuddies.org)***

**Grade Level:** 1+
**National Standards:** H.B.4 Motions and forces


### *Abstract*
When you think of a machine, you probably think of computers or robots. But what if I told you that machines have been around for centuries? Would you believe me? Try this experiment to see which of these simple machines you use around your house. You might even use some of them every day!


### *Objective*
**In this experiment you will search for simple machines used in your daily life and categorize them to see which types of simple machines you use most often.**

### *Introduction*
When you have work to do, isn't it nice to have a machine do it for you? Machines make work easier by reducing the amount of effort it takes for you to do a task. Machines change the size or direction of the force required to do the task, called an applied force. The applied force causes an amount of work to be done, and the machine reduces the applied force needed to do the same amount of work saving you the effort. The amount of effort saved when using simple or complex machines is called a mechanical advantage (MA). For example, you can move a larger object by using a lever than pushing on the object by yourself because it takes less effort, like when you use a car jack to lift a car and change the tire.

Simple machines are types of machines that do work with one movement. There are 6 simple machines:

**lever** - rod that tilts on a pivot, or fulcrum, to produce a useful action at another point. Examples: pliers, seesaw, wheelbarrow, nail clippers, tweezers.

**inclined plane** - sloping surface; it reduces the effort needed to raise loads. Example: ramp.

**screw** - shaft with a thread or groove. The screw holds things together by turning and moving into surrounding material. Some gears work with a screw-like motion. Examples: boat propellers and corkscrews.

**wheel and axle** - device that turns around a fixed point to act as a rotating lever. Examples: steering wheel, faucet, wrench tightening a bolt, bike wheels, water wheel.

**pulley** - grooved wheel that turns on an axle over which a rope, chain, or belt passes. The groove fixes the rope or cable so that it won't slip off. Examples of pulleys in action: stage curtain, elevator, outdoor clothesline.

**wedge** - part of a machine with a sloping side that moves to exert force. It differs from the inclined plane by its function: the wedge forces itself between other parts. Nearly all cutting machines make use of the wedge. Examples: scissors (blades act as paired wedges), door wedge, ax, wood chisel.

Sometimes, one simple machine is not enough to complete a task. A series of simple machines can be put together in order to accomplish more complex tasks. Compound machines are two or more simple machines working together. A wheelbarrow is an example of a complex machine that uses a lever and a wheel and axle.

In this experiment, you will search for simple machines used around your house. You will categorize them according to which type(s) of simple machine(s) they are made up of. Which type of simple machine will be the most common?

### *Terms, Concepts and Questions to Start Background Research*

To do this type of experiment you should know what the following terms mean. Have an adult help you search the internet, or take you to your local library to find out more!

- lever
- inclined plane
- screw
- wedge
- pulley
- wheel and axle
- work
- force
- energy

### *Questions*

- How do simple machines work?
- What simple machines are in gadgets around my house?
- How are the elements of simple machines used together to perform a task?
- Which type of simple machine is the most common at my house? The least common?

### *Bibliography*

A very nice site explaining how simple machines can "work" for you from LEGO Education:
LEGO, 2007. "Connections: Simple Machines," LEGO Education: LEGO Group. [accessed February 3, 2007] http://www.legoeducation.com/content/item.aspx?CategoryID=94&art=14&bhcp=1

This site has some excellent photos of the basic simple machines:
MOS, 1997. "Inventor's Toolbox: The Elements of Machines," Museum of Science and The Science Learning Network. [accessed February 3, 2007] http://www.mos.org/sln/Leonardo/InventorsToolbox.html

This project was adapted from this classroom activity:
MOS, 1997. "Classroom Activity: Sketching Gadget Anatomy," Museum of Science and The Science Learning Network. [accessed February 3, 2007] http://www.mos.org/sln/Leonardo/SketchGadgetAnatomy.html

Have fun browsing through this site dedicated to the "INVENTIONS" of Rube Goldberg, whose cartoons are a humorous reminder that simple machines which do simple tasks don't have to be simple at all! Really, do check out the artwork:
Kennedy, L. 2007. "Rube Goldberg," Rube Goldberg Inc. [accessed February 3, 2007] http://www.rube-goldberg.com

### *Materials and Equipment*

- paper
- pencils with erasers
- The Inventor's Toolbox website for reference
- a selection of small machines with visible working parts (the more you have, the better):
- egg beater, cork screw, car jack, can opener, garlic press, tongs, monkey wrench, hand drill, Vise-Grips, the mechanism from a music box, wind-up toy, pencil sharpener, stapler, etc...

### *Experimental Procedure*

1. Read through the The Inventor's Toolbox to be sure that you know what simple machines are and look like.
2. Search around your house for gadgets that are built using one or more simple machines like those listed in Materials and Equipment.
3. For each gadget you find, determine which simple machines are used to make it work. Here is an example of how to use a data table to collect this type of information:

| Gadget Name | Lever | Inclined Plane | Screw | Wedge | Pulley | Wheel & Axle |
|---|---|---|---|---|---|---|
| Corkscrew | | | X | | | |
| Bottle Opener | X | | | X | | |
| etc... | | | | | | |
| Number Found | | | | | | |

4. As you look at the gadgets and try to figure out which simple machines they are made out of, it might help to draw them. Making a mechanical drawing can help you to visualize all of the parts of a gadget and how they work. Place the gadget at rest so that you can see all of the parts. Begin sketching diagrams of the machines you see in the gadget. Draw the gadget from one point of view first, and then draw it from different points of view to show all working parts. When the diagram is complete, add arrows and written notes to indicate directions of motion for each part, label the elements of machines involved, and explain connections.
5. Now add up the number of examples for each type of machine in your data table.
6. Make a bar graph of your data. On the left side of the graph (y-axis) make a number scale for the number of gadgets found. On the bottom of the graph (x-axis) write down the six different types of simple machines. Draw a bar up to the number of gadgets that you found for each type of machine.
7. Analyze your data. Which simple machines were in the most gadgets? The least?

### *Variations*

- Take this a step further by improving upon one of the gadgets you found. Can you think of a way to make it work better, or to expand its function? Make before and after mechanical drawings of your improvements and you could be on your way to a patent!
- Do you have ideas for your own gadgets? See if you can use the concept of simple machines to invent something new. Think about problems that you have around the house doing something. Can you design a machine to do it for you? Again, a good mechanical drawing is important for communicating your idea. You should also build a prototype.

- Can you design a useless invention? A famous cartoonist named Rube Goldberg (http://www.rube-goldberg.com/) made cartoons of long, tedious inventions that used many steps to do a simple task. Can you design your own Rube Goldberg machine? If you are in high school, you can even enter to win the annual Rube Goldberg Machine Contest (RGMC).
- For more science project ideas in this area of science, see Mechanical Engineering Project Ideas (http://www.sciencebuddies.org/science-fair-projects/recommender_interest_area.php?ia=ApMech).

***Credits***

Sara Agee, Ph.D., Science Buddies

# Engineering Activity on Creative Solutions

## *Newspaper Tower*

**Grade level:** 4-6
**National Standards:** M.G.1 Science as a human endeavor
H.G.1 Science as a human endeavor
H.B.4 Motions and forces

### *Objective*
Engineers often have to come up with creative solutions to problems. This experiment will test your imagination by asking how high you can build using only two sheets of newspaper. **In this experiment students will learn how creativity can lead to new engineering solutions.**

### *Materials and Equipment*
- Newspaper
- Scissors
- Tape
- Staples
- Pencils

### *Experimental Procedure*
1. Predict how high you can build a tower with only two sheets of newspaper.
2. Gather two separate sheets of newspaper.
3. Build the tallest tower possible. You can bend, cut, tear, and fold the newspaper but you can't use anything other than those sheets! This means no tape, staples, glue, etc.
4. Now try building another tower using two sheets of newspaper and 10cm of tape. Can you make it taller?
5. Turn on a fan to simulate wind. How do you need to adjust your tower so it doesn't fall over?
6. Shake the table your tower is on to simulate an earthquake. How do you need to adjust it now?
7. Place pencils on top of your tower to see how much weight it can hold. How do you need to adjust it now?

### *Discussion of Results*
How high was your tower? How did you need to adjust it for each of the conditions? These are all things a civil engineer might need to think about. Any kind of engineer requires problem-solving skills in order to adjust to new demands. Did you and your friends adjust the same way? Whose way was more effective?

### *Credit*
Adapted from PBS' "Building Big."

# Engineering Activity on Fluid Flow

## *Race Your Marbles to Discover a Liquid's Viscosity*

*(www.ScienceBuddies.org)*

**Grade Level:** 7-9
**National Standards:** H.B.2 Structure and properties of matter

### *Abstract*

How do you like your mashed potatoes? Thin and whipped smooth? Or thick and mashed into chunks? Your mouth checks out not just the taste of your food, but its viscosity, or how it flows on your tongue, every time you take a bite! In this science fair project, you'll learn what viscosity is, and how to measure it in common liquids around your home.

### *Objective*

**To determine the viscosity of common liquids by measuring the transit time of marbles through the liquids.**

### *Introduction*

On a cold winter morning, have you ever tried to squeeze some honey out of the honey bear onto your toast? It's pretty tough, huh? Honey is one of those liquids that is very sensitive to temperature. As the temperature goes down, the viscosity, or resistance to flow, goes way up and you can squeeze and squeeze all you want, but very little honey comes out. If you set the honey bear in a pan of warm water for a few minutes and try again, what happens? One little squeeze and honey comes gushing out all over your toast. The viscosity, or resistance to flow, goes way down as the temperature goes up.

As a measure of a liquid's resistance to flow, viscosity can be thought of as friction inside the liquid. If, for example, you try to ride your bike with the hand brakes on (a form of friction), it is difficult to roll the bike forward. The resistance to motion is high. Likewise, in highly viscous liquids (those with high internal friction), the resistance to *flow* is high.

Viscosity is a very important quality of liquids that scientists, engineers, and even doctors are frequently trying to measure and change. It is difficult, for example, to transport highly viscous crude oil through offshore pipelines, so scientists and engineers use a variety of methods to try and lower the oil's resistance to flow through the pipelines. Likewise, in medicine, doctors try to keep blood viscosity in the correct range. If blood is "too thick," or viscous, a patient can develop blood clots. If blood is "too thin,"or lacks viscosity, however, then the patient is at risk for bruising or bleeding events. Blood viscosity, like most things in medicine, has a happy medium.

Volcanologists (people who study volcanoes) have a big interest in viscosity, too. The viscosity of molten rock or magma determines how easily a volcano will erupt, and what shape the lava flows and resulting mountains will take on. A very thin and fluid magma erupts more easily and forms gentle mountain slopes, while a very thick magma erupts explosively and forms a fat lava flow and steep mountain slopes. So, if you see a mountain formed from a volcano, you can estimate the viscosity of the magma that formed it just by looking at the angle of its slope!

Common liquids around your house (thankfully) don't form mountain slopes though, so to measure their viscosities, you have to use some other method. One of the oldest methods is the dropped-sphere method—a glass marble or sphere of some other material is dropped into a column of a liquid. If the liquid is very viscous (imagine cold honey), it will take a long time for the marble to drop to the bottom of the column. Dropping the marble into a less viscous liquid (like water) will take much less time.

Viscosity of a liquid can be calculated from the time elapsed, provided that you know the height of the column and the densities of the sphere and the liquid. Density is a measure of how "compact" something is. It is the ratio of mass to volume, and is a measure of how much matter is packed into a space. Think of a 1-inch cube of bread. Then think of a 1-inch cube of potato. The potato is denser than the bread (there is more "stuff" in the same space). You can calculate density yourself for an object by using a scale to find out the object's mass and then dividing that by the object's volume. You can also look up the densities of many common substances, like glass, stainless steel, water, seawater, oils, etc. in materials tables.

Knowing the time it took to travel through the column of liquid, the height of the column, the density of the sphere, and the density of the liquid, you can then calculate the viscosity of the liquid with the viscosity equation:

Equation 1:

$$\text{Viscosity} = \frac{2(\Delta P)ga^2}{9v}$$

where:

- **Viscosity** is in newton-seconds per meter squared (Nsec/m2).
- **Delta (Δ) P** is the difference in density between the sphere and the liquid, and is in kilograms per meter cubed (kg/m3).
- **g** is the acceleration due to gravity and equals 9.81 meters per second squared (m/s2).
- **a** is the radius of the sphere in meters (m).
- **v** is the average velocity, defined as the distance the sphere falls, divided by the time it takes to fall in meters per second (m/s).

So, now it's time to race some marbles and see if common liquids in your home are thick or thin!

### *Terms, Concepts and Questions to Start Background Research*

- Viscosity
- Friction
- Density
- Terminal velocity
- Inverse relationship
- Direct relationship

### *Questions*

- What is liquid viscosity?
- How does viscosity change (in general) with temperature?
- Why is it important to understand viscosity?

## *Bibliography*

This source discusses what viscosity is, its importance to understanding volcanology, and how to measure viscosity in the laboratory:


- Hawai'i Space Grant College, Hawai'i Institute of Geophysics and Planetology, University of Hawai'i. (1996). *Viscosity Teacher Page*. Retrieved September 6, 2008, from http://www.spacegrant.hawaii.edu/class_acts/ViscosityTe.html


## *Materials and Equipment*

- Tall, slender drinking glasses or glass jars with straight sides, equally sized (4)
- Marker, water soluble (1)
- Ruler, preferably metric
- Glass marbles, equally sized (5)
- Safe liquids to test (4), approximately 1/2 gallon of each, such as
  - Corn syrup
  - Honey
  - Cooking or vegetable oils
  - Glycerin
  - Seawater
  - Milk
  - Water
  - Molasses
- Stopwatch
- Strainer
- Liquid dish soap
- Dish towel
- Access to sink
- Graduated cylinder, at least 1,000-mL size (1); available at science supply stores, such as Carolina Biological: www.carolina.com. Note: the larger the graduated cylinder, the easier it is to do testing.
- Lab notebook
- Helper

## *Experimental Procedure*

*Preparing Your Glasses for the Marble Race*

1. Measure down about 2 cm from the top of each glass with the ruler, and mark the 2-cm location with the water-soluble marker.
2. Fill each glass with a different test liquid, all the way up to the 2-cm mark.

*Racing Your Marbles*

1. Have a helper hold two marbles level with the tops of two glasses. You hold two marbles level with the tops of two glasses also.
2. Say, "Ready, Set, Go!" and then you and your helper should drop your marbles at the same time and see which marble hits the bottom first and which one hits the bottom last. Record your observations in your lab notebook. If you have trouble figuring out a clear winner between two liquids, race the marbles with just those liquids a second and third time after

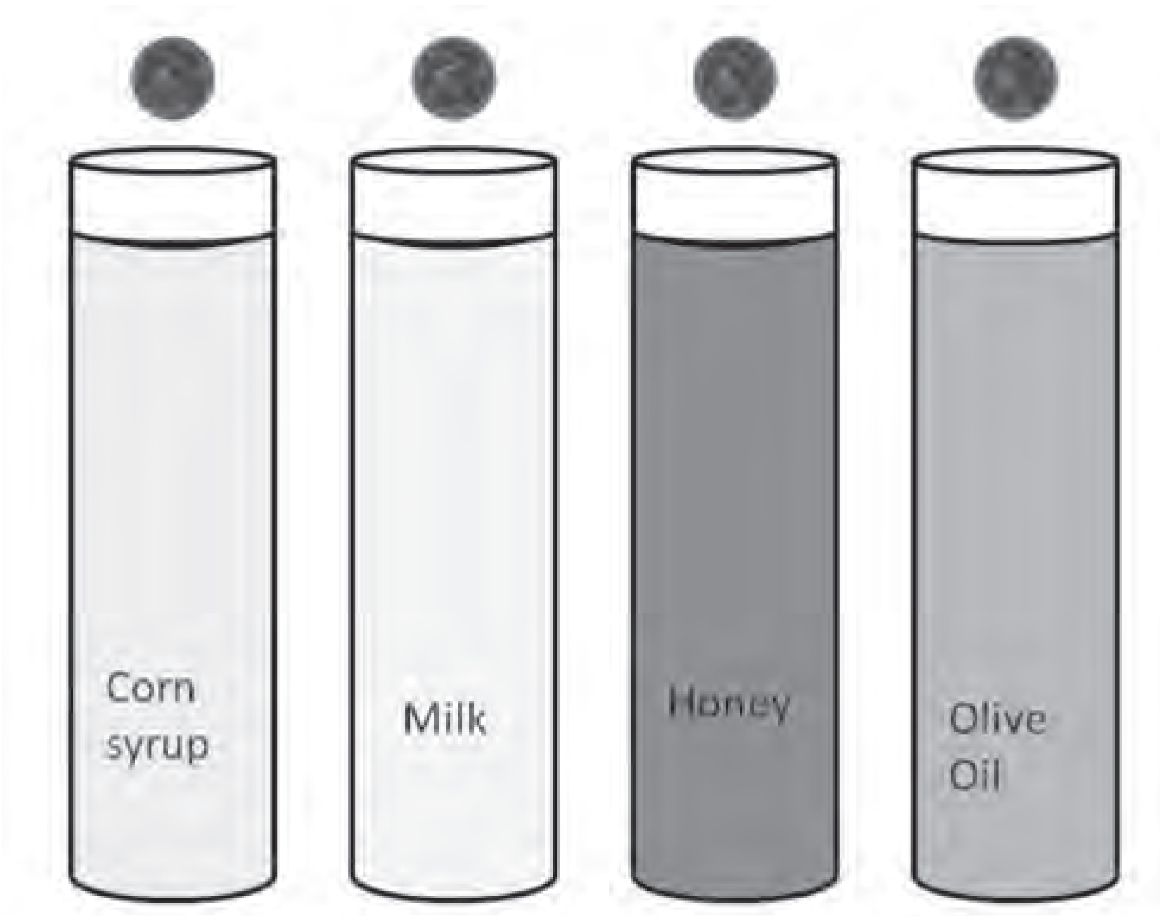



Figure 1. This drawing shows the setup of glasses and example liquids for the marble race.

first completing the next set of steps: Marble Retrieval and Cleanup.

*Marble Retrieval and Cleanup*

1. Place the strainer inside a sink or over a large bowl set inside a sink.
2. Pour the contents of each glass (the liquid and the marble) slowly into the strainer.
3. Retrieve the marbles from the strainer and wash and dry both the marbles and the glasses.

*Preparing the Graduated Cylinder to Measure the Viscosity of Each Liquid*

1. Fill the graduated cylinder up with one of the liquids to a level 5 cm below the top of the cylinder, as shown in Figure 2.
2. Measure down at least 2 cm below the surface of the liquid (as shown in Figure 2) and mark a starting line on the graduated cylinder with the marker. The starting line needs to be lower than the surface of the liquid to allow time for your marble to reach its terminal velocity before you start taking measurements.
3. Measure up from the bottom of the graduated cylinder, approximately 5 cm, and mark an ending line on the graduated cylinder with the marker. You don't want the ending line to be at the bottom of the cylinder because the marble will slow down as it approaches the bottom, due to interactions with this boundary.
4. Measure the distance between the starting point and the ending point. Record this distance in your lab notebook. This is the distance that you will use to calculate the speed of the marble as it travels through the liquid. Remember, the average speed is equal to the distance traveled, divided by the time it took to travel that distance. Now you're ready to test and get some travel times.

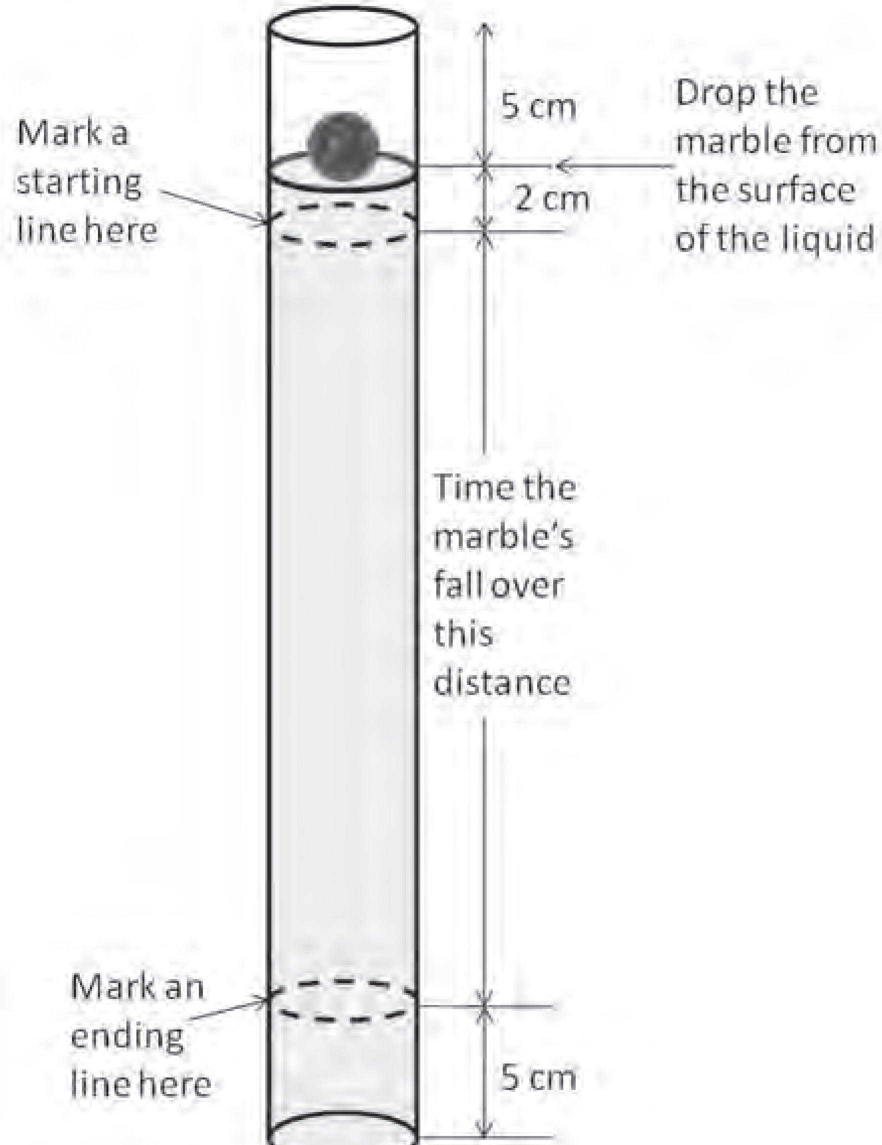



Figure 2. This drawing shows how to prepare the graduated cylinder for testing.

*Testing Your Liquids*

1. You or the helper should hold a marble at the surface of one of the liquids.
2. The other person should zero out the stopwatch.
3. The person holding the stopwatch should say "Go!" and have the other person drop the marble. As the marble passes the starting point, which was marked in the previous section, the person holding the stopwatch should start the stopwatch. As the marble passes the ending point, which was marked in the previous section, the person holding the stopwatch should stop it.
4. Record the time elapsed in a data table.
5. Repeat steps 1-4 of this section, with the same liquid and graduated cylinder, four more

Measured Time Data Table

| Liquid name | Trial 1 time (sec) | Trial 2 time (sec) | Trial 3 time (sec) | Trial 4 time (sec) | Trial 5 time (sec) | Average of times (sec) |
|---|---|---|---|---|---|---|
| Example: Corn syrup | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

times with four other marbles.

*Marble Retrieval and Cleanup*

1. Place the strainer inside a sink or over a large bowl set inside a sink.
2. Pour the contents of the graduated cylinder (the liquid and the marbles) slowly into the strainer.
3. Retrieve the marbles from the strainer and wash and dry the marbles and the graduated cylinder.
4. Repeat the experiment up to this step, starting from Preparing the Graduated Cylinder to Measure the Viscosity of Each Liquid, for the remaining test liquids.

*Analyzing Your Data Chart*

1. Calculate the average for the five time trials for each liquid and enter it in your data table.
2. Calculate the average velocity for each liquid by dividing the distance, measured in step 4 of Preparing the Graduated Cylinder to Measure the Viscosity of Each Liquid, by the average time it took to travel that distance. Record your calculation in a second data table.
3. Remember Delta P from the viscosity equation, Equation 1? Calculate Delta P, the difference in densities between the marble and each liquid, by using the table below. Record each Delta P calculation in your data table. *Note:* If you tested a liquid that is not in this table, you will have to look up its density online, or calculate the density yourself, using a scale.

Common Approximate Densities ($kg/m^3$)

| | |
|---|---|
| Water | 1000 |
| Corn syrup | 1380 |
| Molasses | 1400 |
| Honey (room temperature) | 1500 |
| Vegetable or cooking oils | 920 |
| Glycerin | 1260 |
| Ocean water | 1030 |
| Milk | 1030 |
| Glass marble | 2800 |
| Stainless steel | 7800 |

4. *If you know the diameter of your marbles,* divide the diameter by 2 to get the radius of the marbles. *If you don't know the diameter of your marbles,* measure the diameter with a ruler, and then divide by 2 to get the radius. Record the radius of your marbles in your lab notebook.
5. Calculate the viscosity of each liquid using Equation 1 from the Introduction. Record the calculations in a data table.

**Viscosity Data Table**

| Liquid name | Calculated average velocity (m/s) | Delta P ($kg/m^3$) | Viscosity (kg/meter sec) |
|---|---|---|---|
| Example: Corn syrup | | | |
| | | | |
| | | | |
| | | | |

6. Compare your viscosity test results with the marble race results. Do they match up and make sense? Did the liquids with the lowest viscosities win the race? Plot the viscosity of each liquid on the y-axis and the calculated average velocity on the x-axis. Is the relationship between viscosity and velocity inverse or direct?

Variations

- Choose one liquid and repeat the experiment using different sizes and densities of spheres. For example, try different diameters of glass marbles, stainless steel balls, or BB's. (*Note:* For your viscosity calculations, the density of a stainless steel ball bearing is 7,800 $kg/m^3$. If the diameter of any of your spheres is more than half the radius of the graduated cylinder, you should purchase a larger-diameter graduated cylinder to avoid having the spheres interact with the sides of the cylinder.) Are the velocities of the different spheres different? What about the measured viscosities from those velocities? Are they the same? Obtain some statistics, such as the standard deviation, on your measured viscosities.
- Choose a very temperature-sensitive liquid, such as honey, and evaluate how viscosity changes as a function of temperature.
- For more science project ideas in this area of science, see Chemistry Project Ideas.

***Credits***

Kristin Strong, Science Buddies
Edited by Peter Boretsky, Lockheed Martin

This project follows much of the experimental procedure outlined in the following source: Hawai'i Space Grant College, Hawai'i Institute of Geophysics and Planetology, University of Hawai'i. (1996). *Viscosity Teacher Page.* Retrieved September 6, 2008, from http://www.spacegrant.hawaii.edu/class_acts/Viscosity.html

Engineering Activity on Fluid Flow

# Race Your Marbles to Discover a Liquid's Viscosity

(www.ScienceBuddies.org)

**Grade level:** 4-7
**National Standards:** M.B.1 Properties and changes of properties in matter
H.B.2 Structure and properties of matter
M.E.2 Understandings about science and technology
H.E.2 Understandings about science and technology



### *Abstract*

Many substances are actually mixtures of different things. For example, milk, which looks like it is one substance, is actually a mixture of many different solids and liquids. Chromatography is a technique that is used to separate mixtures. **In this experiment students will study the substances that make up different inks by using paper chromatography.**


### *Objective*

The objective of this project is to use paper chromatography to analyze ink components in permanent black markers.

### *Introduction*

Matter makes up everything in the universe. Our body, the stars, computers, and coffee mugs are all made of matter. There are three different types of matter: solid, liquid, and gas. A solid is something that is normally hard (your bones, the floor under your feet, etc.), but it can also be powdery, like sugar or flour. Solids are substances that are rigid and have definite shapes. Liquids flow and assume the shape of their container; they are also difficult to compress (a powder can take the same shape as its container, but it is a collection of solids that are very small). Examples of liquids are milk, orange juice, water, and vegetable oil. Gases are around you all the time, but you may not be able to see them. The air we breathe is made up of a mixture of gases. The steam from boiling water is water's gaseous form. Gases can occupy all the parts of a container (they expand to fill their containers), and they are easily compressed.

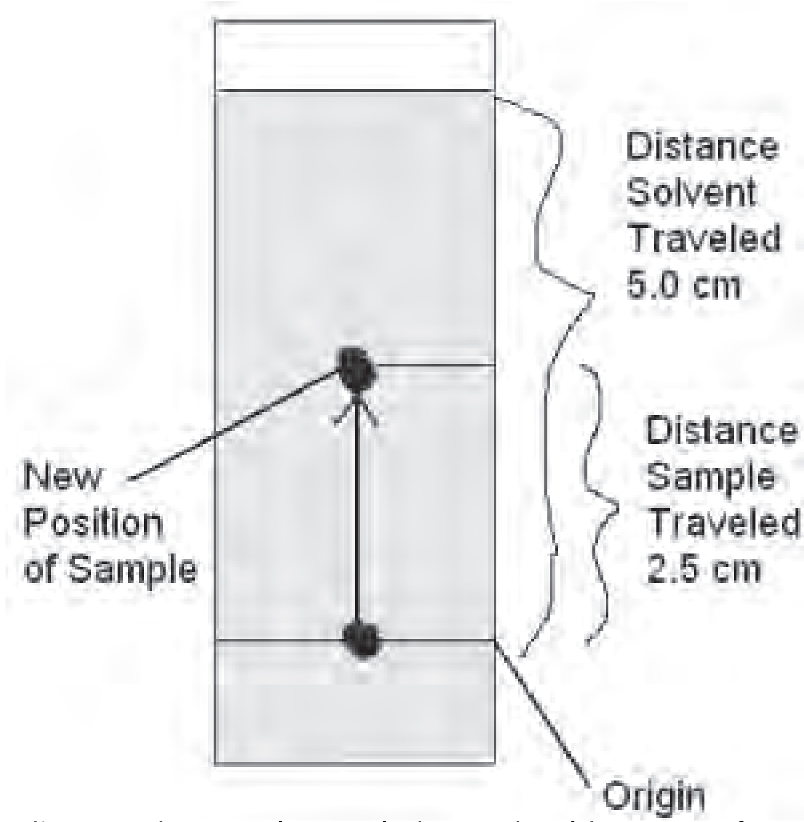
Matter is often a mixture of different substances. A heterogeneous mixture is when the mixture is made up of parts that are dissimilar (sand is a heterogeneous mixture). Homogeneous mixtures (also called solutions) are uniform in structure (milk is a homogeneous mixture). A sugar cube floating in water is a heterogeneous mixture, whereas sugar dissolved in water is a homogeneous mixture. You will determine whether the ink contained in a marker is a heterogeneous or homogeneous mixture, or just one compound.

In a mixture, the substance dissolved in another substance is called the solute. The substance doing the dissolving is called the solvent. If you dissolve sugar in water, the sugar is the solute and the water is the solvent.

For this project, you will be making a small spot with an ink marker onto a strip of paper. The bottom of this strip will then be placed in a dish of water, and the water will soak up into the paper.

The water (solvent) is the mobile phase of the chromatography system, whereas the paper is the stationary phase. These two phases are the basic principles of chromatography. Chromatography works by something called capillary action. The attraction of the water to the paper (adhesion force) is larger than the attraction of the water to itself (cohesion force), hence the water moves up the paper. The ink will also be attracted to the paper, to itself, and to the water differently, and thus a different component will move a different distance depending upon the strength of attraction to each of these objects. As an analogy, let's pretend you are at a family reunion. You enjoy giving people hugs and talking with your relatives, but your cousin does not. As you make your way to the door to leave, you give a hug to every one of your relatives, and your cousin just says "bye." So, your cousin will make it to the door more quickly than you will. You are more *attracted* to your relatives, just as some chemical samples may be more attracted to the paper than the solvent, and thus will not move up the solid phase as quickly. Your cousin is more attracted to the idea of leaving, which is like the solvent (the mobile phase).

To measure how far each component travels, we calculate the retention factor ($R_f$ value) of the sample. The $R_f$ value is the ratio between how far the component travels and the distance the solvent travels from a common starting point (the origin). If one of the sample components moves 2.5 cm up the paper and the solvent moves 5.0 cm, then the $R_f$ value is 0.5. You can use $R_f$ values to identify different components as long as the solvent, temperature, pH, and type of paper remain the same. In the image below, the light blue shading represents the solvent and the dark blue spot is the chemical sample.




When measuring the distance the sample traveled, you should measure from the origin (where the middle of the spot originally was) and then to the center of the spot in its new location.

To calculate the $R_f$ value, we use the equation:

$$R_f = \frac{\text{distance traveled by the sample component}}{\text{distance traveled by the solvent}}$$

In our example, this would be:

$$R_f = \frac{2.5 \text{ cm}}{5.0 \text{ cm}} = 0.5$$

In our example, this would be:
Note that an $R_f$ value has no units because the units of distance cancel.

Chromatography is used in many different industries and labs. The police and other investigators use chromatography to identify clues at a crime scene like blood, ink, or drugs. More accurate chromatography in combination with expensive equipment is used to make sure a food company's processes are working correctly and they are creating the right product. This type of chromatography works the same way as regular chromatography, but a scanner system in conjunction with a computer can be used to identify the different chemicals and their amounts. Chemists use chromatography in labs to track the progress of a reaction. By looking at the sample spots on the chromatography plate, they can easily find out when the products start to form and when the reactants have been used up (i.e., when the reaction is complete). Chemists and biologists also use chromatography to identify the compounds present in a sample, such as plants.

### *Terms, Concepts and Questions to Start Background Research*

- adhesion, cohesion forces
- capillary action
- stationary phase, mobile phase
- hydrophilic, hydrophobic
- $R_f$ value
- paper chromatography
- solvent
- solution

### *Questions*

1. Why do different compounds travel different distances on the piece of paper?
2. How is an $R_f$ value useful?
3. What is chromatography used for?

### *Bibliography*

Basic chemistry concepts:
http://www.chem4kids.com

Overview of liquids and capillary action:
http://encarta.msn.com/encnet/refpages/RefArticle.aspx?refid=761571486&sec=18#s18

Chromatography:
http://www.doggedresearch.com/chromo/chromatography.htm

### *Materials and Equipment*

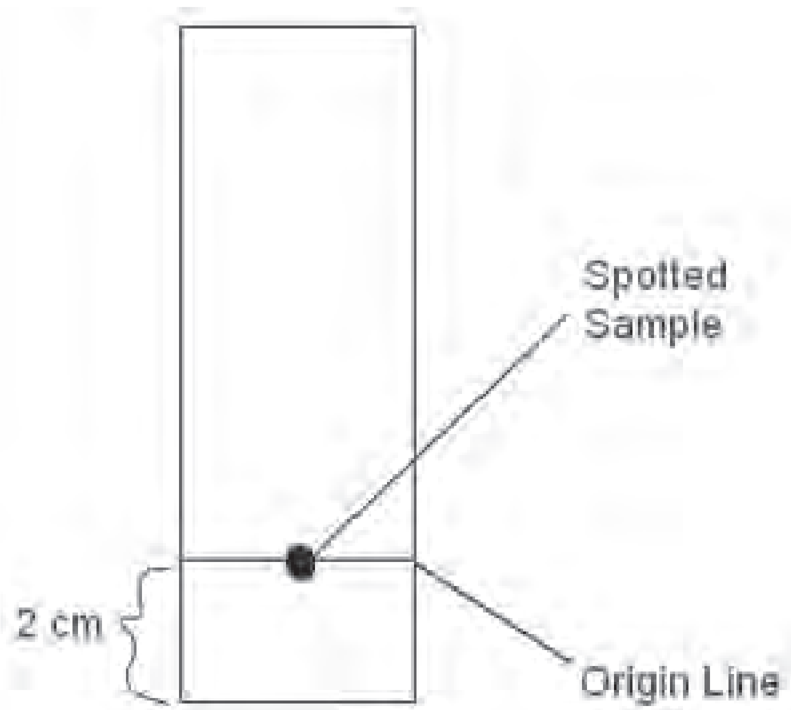
- water
- at least 15 identically sized strips of paper (5 for each pen)
  Note: chromatography paper or laboratory filter paper is preferable, but you can use a paper towel. The problem with paper towels is that they may be too absorptive and smear the ink. For more information on which papers work and which don't, see: http://www.sciencebuddies.org/mentoring/project_ideas/Chem_Chromatography_resources.shtml
- ruler
- pencils
- at least three different types of black markers (including one permanent marker), or at least three different colors of marker (including one permanent marker)
- a wide-mouth jar for the solvent

***Experimental Procedure***

Note: To make sure you can compare your results, as many of your materials as possible should remain constant. This means that the temperature, type of water used, size of paper strips, where the ink is placed onto the paper etc. should remain the same throughout the experiment.

1. Cut paper strips about one by four inches in area (they must all be the same size).

2. Take one of the paper strips and use a ruler and pencil to draw a line across it horizontally two cm from the bottom. This is the origin line (see illustration, below).

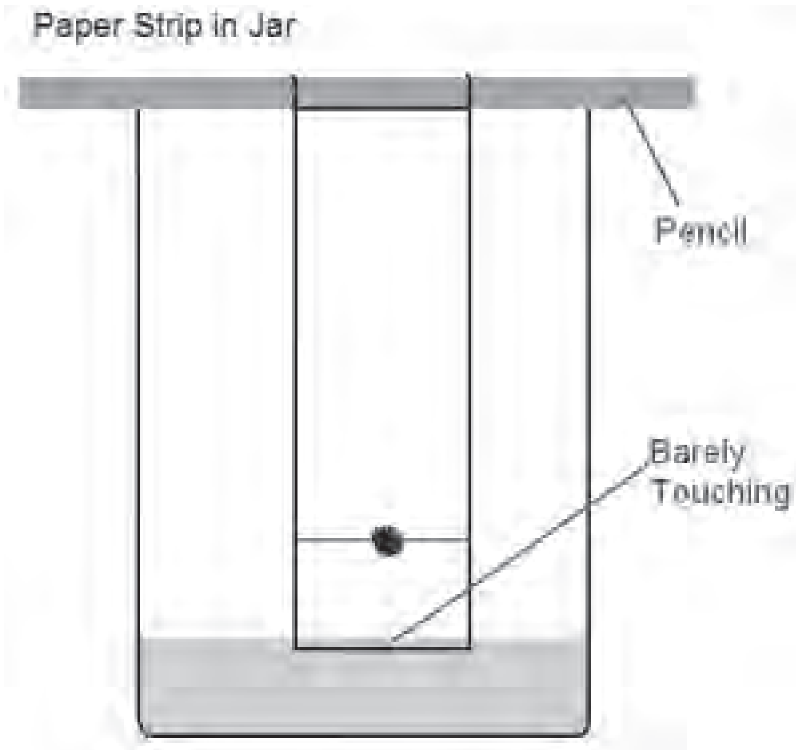



3. Pour a small amount of water into your glass (there should be barely enough for the paper strip to hang inside of the jar and just touch the water).

4. Using one of the markers, place a small dot of ink onto the line (see illustration, above).

5. Use the pencil to label the strip, so that you know which marker it represents.

6. Tape the paper to a pencil and hang it into the jar of solvent so that the bottom edge is just barely touching (see illustration, below).




7. Let the water rise up the strip until it is almost at the top.

8. Remove the strip from the jar and mark how far the solvent rose with a pencil.

9. Analyze the ink component(s):
   Measure the distance the solvent and each ink component traveled from the starting position, then calculate the $R_f$ value for each component (some of the ink components might not have moved at all!).

10. Repeat this experiment for each brand or color of marker five times.

### *Questions*
Did the different inks separate differently? By looking at the $R_f$ values, can you tell if any of the ink components from the different markers are the same?

If the ink components separated differently for each marker, why did this happen (think about the strength of attractions)?

### *Variations*
You could try using other solvents than water (or mixture of solvents) and see if the inks are separated differently (rubbing alcohol, vinegar, nail polish remover, and turpentine would be good to try). Which solvent separates the ink the best? Why? (Remember to account for attractions between chemicals.)

After buying a black light, you could try to see if any more components are visible on the paper. Some chemicals are invisible under white light, but can be seen with a black light. If you decide to do this variation, you should analyze the paper strips the same day or the next day, otherwise the spots will fade! Why are some chemicals visible under one type of light but not another? Read more here:
http://www.colorado.edu/physics/2000/waves_particles/index.html
http://www.glenbrook.k12.il.us/gbssci/Phys/Class/light/lighttoc.html

***For more advanced chromatography projects, see:***

Paper Chromatography: Advanced Version 1
http://www.sciencebuddies.org/mentoring/project_ideas/Chem_p009.shtml

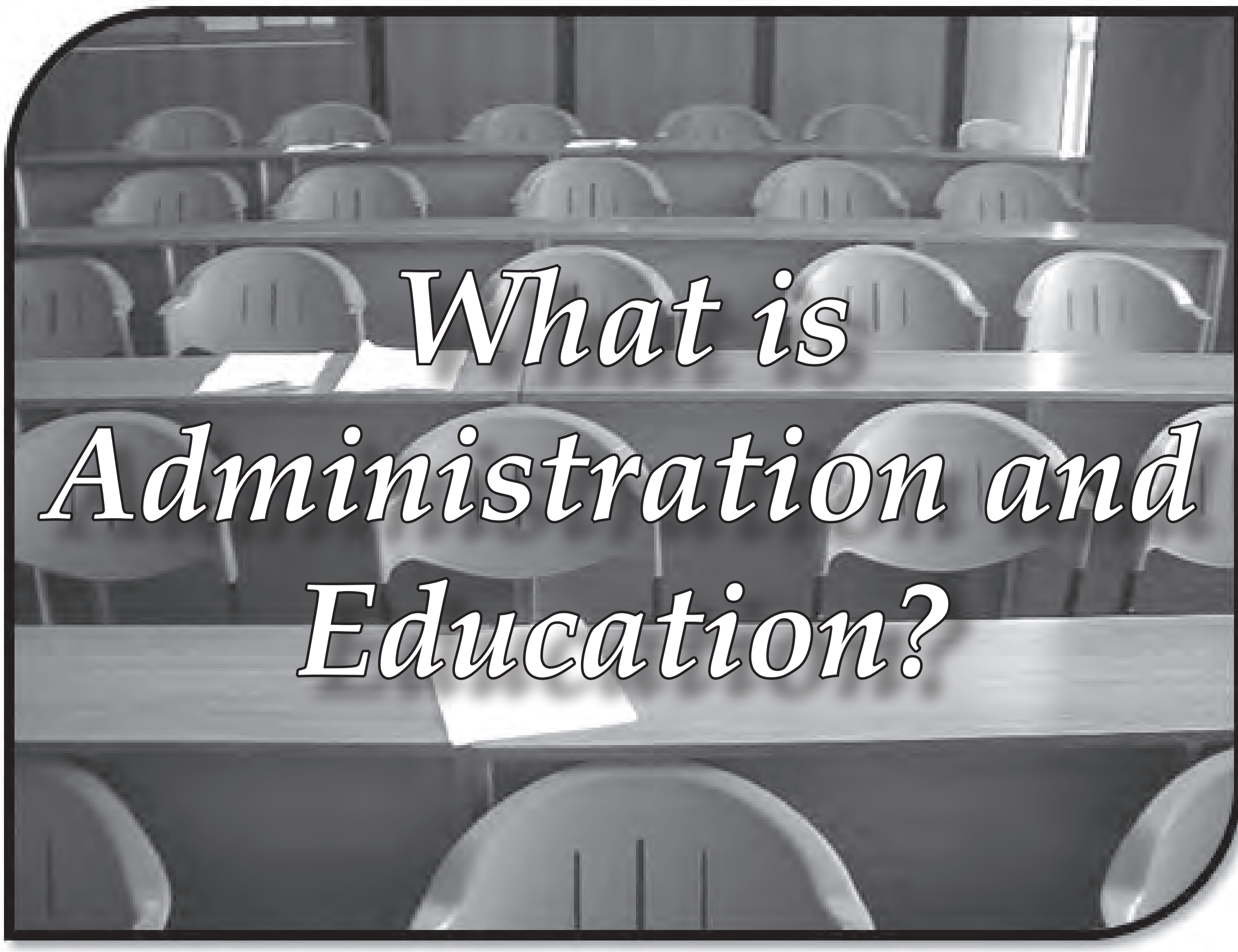
Paper Chromatography: Advanced Version 2
http://www.sciencebuddies.org/mentoring/project_ideas/Chem_p010.shtml

For more science project ideas in this area of science, see Chemistry Project Ideas:
http://www.sciencebuddies.org/science-fair-projects/recommender_interest_area.php?ia=Chem

***Credit***

Author: Amber Hess
Editor: Andrew Olson, Science Buddies

# What is Administration and Education?



***Administration and education*** encompass many of the ways that scientists have had careers outside of a laboratory or industrial setting. Many STEM professionals' careers included administration and/or education.

Some STEM professionals work for organizations like the American Association for the Advancement of Science (AAAS), whose goals are to promote the value of science and science education, or the National Science Foundation (NSF) which funds many scientific developments across the United States.

Photo credit: James Sarmiento @Flickr

***If you like administration and education, you may like the careers chosen by these people:***

| ScienceMaker | Occupation | Location | Question Topics |
|---|---|---|---|
| **Eugene DeLoatch** | Dean of School of Engineering | *Morgan State University* | Careers in electrical engineering |
| **Yolanda George** | Deputy Director | *American Association for the Advancement of Science (AAAS)* | Careers in biology and science centers |
| **Keith Jackson** | Chair of Physics Department | *Morgan State University* | Integrated circuits, nano-scale technology, and the Periodic Table of Elements |
| **Shirley Malcom** | Directorate Head | *American Association for the Advancement of Science (AAAS)* | AAAS, ecology |
| **Shirley McBay** | President | *Quality Education for Minorities Network* | Chemistry and mathematics, improving the quality of education |

# *Administration & Education in Action*



***School Bus*** ("First School Bus Ride" by tyhatch @ Flickr)


Who funds this school bus? Who decides what route they take? These questions are answered by education administrators and policymakers who were once students themselves.

***Graduation*** ("Graduation" by House Of Sims @ Flickr)

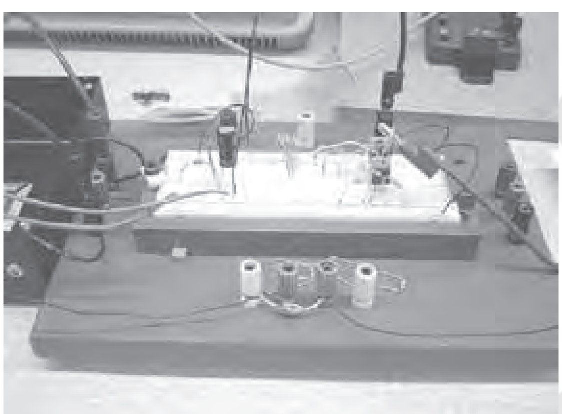
A decade into the twenty-first century, the graduation rate of African American men from high school in the United States is less than half, according to a report published by The Schott Foundation. Questions of how to go about solving such a problem continue to plague parents, students, teachers, and policy-makers alike.

# ScienceMakers
## Spotlight: Eugene DeLoatch

| | |
|---|---|
| **Name** | Eugene DeLoatch |
| **Education** | Tougaloo College<br>Lafayette College<br>Polytechnic University of Brooklyn |
| **Types of Science** | Education & Administration<br>Engineering |

## Biography

Engineering professor and education administrator Eugene DeLoatch attended secondary schools in Piermont, New York, where he was introduced to engineering by his French language teacher. DeLoatch attended Tougaloo College and Lafayette College where he graduated with B.S. degrees in mathematics and electrical engineering in 1959. He then attended the Polytechnic University of Brooklyn, receiving both his M.S. degree in electrical engineering and his Ph.D. degree in bioengineering.



**Electrical circuit photo by Mat_the_W @Flickr**

In 1975, DeLoatch joined the faculty at Howard University where he became a full professor and chairman of the Department of Electrical Engineering. DeLoatch left Howard University to establish the School of Engineering at Morgan State University in 1984. He subsequently became the first Dean and remains in that position today. Since then, Morgan State has become a leader in recruiting minority engineering students. DeLoatch has also completed research for the National Aeronautics and Space Administration (NASA), the National Science Foundation (NSF) and the National Cancer Institute. In 2001, DeLoatch was elected president of the American Society for Engineering Education. DeLoatch has served as a consultant for companies like Whirlpool Corporation and as principal investigator (PI) of the Knowledge Integration Management Center of Excellence supported by the Army Research Laboratory.

DeLoatch has been a member of the Board of Directors of the Maryland Science, Engineering and Technology Development Corporation and the Editorial Board of the American Society for Engineering Education's Journal. In 2003, DeLoatch received the Pioneer Award at the Black Engineer of the Year Awards, a banquet he helped sponsor in 1987, its inaugural year. He has also chaired the Council of Deans of Engineering of the Historically Black and Colleges and Universities and has served as a panelist at the National Institute in Science Education. He holds honorary doctorates from Lafayette College and Binghamton University.



# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. DeLoatch?
#2 What year did DeLoatch graduate from college? What was happening in the United States that year? What was happening in the world that year?
#3 Dr. DeLoatch was introduced to engineering by a teacher. Have your teachers influenced you to look at subjects you would not normally consider?
#4 How did DeLoatch combine his interest in engineering with his commitment to furthering education? Can you think of other ScienceMakers who have done similar things?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think an electrical engineer does? Would you like to be an engineer? Why? Why not?
#2 If you were an electrical engineer, what topics would you study?
#3 What kind of classes do you think Dr. DeLoatch took to prepare him for electrical engineering? What kind of classes should you take if you want to become an engineer?
#4 Dr. DeLoatch received his Ph.D. degree in bioengineering. Name an invention in bioengineering. What is its purpose? What impact has it made on society?
#5 Dr. Deloatch's work has been supported by the Army Research Laboratory. Why might the U.S. Army want to have electrical engineers on its staff? What might an electrical engineer build for them?

# Glossary

*Bioengineering*
The application of engineering principles to address challenges in the fields of biology and medicine.

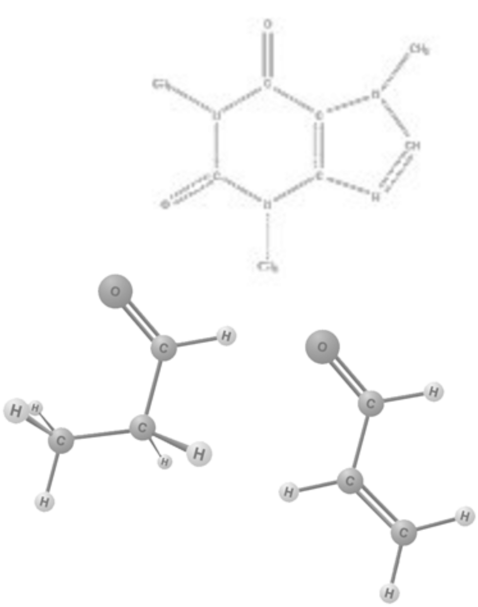
*Consultant*
An adviser.

*Electrical engineering*
The branch of engineering science that studies the uses of electricity and the equipment for power generation and distribution and the control of machines and communication.

*National Aeronautics and Space Administration (NASA)*
An independent agency of the United States government responsible for aviation and spaceflight.

*National Science Foundation (NSF)*
A United States government agency that supports fundamental research and education in all the non-medical fields of science and engineering. Its medical counterpart is the National Institutes of Health.

*Principal Investigator (PI)*
The lead scientist or engineer for a particular well-defined science (or other research) project, such as an astronomical observing campaign, laboratory study or clinical trial.



# ScienceMakers
## Spotlight: Yolanda S. George



| Name | Yolanda S. George |
|---|---|
| Birth Date | August 10, 1949 |
| Birth Place | New Orleans, Louisiana |
| Education | St. Mary's Academy<br>Xavier University<br>Clark University |
| Types of Science | Education & Administration<br>Biology |

## Biography

Education administrator Yolanda S. George was born on August 10, 1949 in New Orleans, Louisiana to Rose Lemieux and Allen Rodgers Scott. She attended St. Mary's Academy where she graduated in 1967. She continued her education at Xavier University in Louisiana, where she received her B.S. degree in biology in 1971 before attending Clark University in Georgia, where she obtained her M.S. degree in biology.


**Science Mag photo by dullhunk @ Flickr.** Science Magazine is a weekly science journal published by the AAAS, the organization where Ms. George works.

George began her career as a research biologist working in a biophysics group studying the cell cycle of cancer cells. She then moved to the University of California, Berkeley where she served as the director of a professional development program designed to encourage African Americans and other minorities to enter college and earn degrees in science and engineering. In years following, she also became the Director of Development for the Association of Science-Technology Centers (ASTC) in Washington, DC. Since 1985, George has been a Deputy Director and Program Director for the Directorate for Education and Human Resources Programs at the American Association for the Advancement of Science (AAAS), where she works to increase participation of minorities, women, and persons with disabilities in the science and engineering workforce. George also directs several other projects such as the L'Oreal USA For Women in Science Postdoctoral Awards and Vision and Change in Undergraduate Biology. She has served as a consultant for the National Science Foundation (NSF), the U.S. Department of Education, and other agencies and universities. As part of her work, George has authored science journal articles and manuals like the *In Touch with*

*Science* series and *Get into the Equation: Math and Science, Parents and Children*.

George's work has received accolades from Lawrence Livermore National Laboratory and the University of California, Berkeley. She sits on advisory boards for the Burroughs Welcome Fund Student Science Enrichment Program and the MacNeil-Leher Productions Science Reports and several other organizations.

## Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Ms. George?
#2 Where was Ms. George born? Locate it on a map. How far away is this from where you live? What are the names of her parents? Where did Ms. George attend high school? What do you think high school was like for her?
#3 How old are you? In what year was Ms. George your age? What was happening in the United States that year? What was happening in the world that year? What do you think her life was like when she was your age?
#4 Ms. George has been a proponent of building up science education opportunities for the general public. What are the science programs near you? The nearest science center? What kinds of projects do they offer? Do you think they are effective at making people interested in sciences?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 Ms. George has a scientific background in biology. What do you think a biologist does? Would you like to be a biologist? Why? Why not?
#2 If you were a biologist, what topics would you study?
#3 Ms. George started as a biologist before becoming an administrator of science education. What other kinds of careers do you think biologists could transition to?
#4 Using Ms George's life story as a resource (as well as those of other ScienceMakers), how would you go about increasing participation of minorities, women, and persons with disabilities in the science and engineering workforce?
#5 What do you like about science? How could you make this into an activity? What materials would you need?

# Glossary



*American Association for the Advancement of Science (AAAS)*
An international non-profit organization with the stated goals of promoting cooperation between scientists, defending scientific freedom, encouraging scientific responsibility, and supporting scientific education and science.

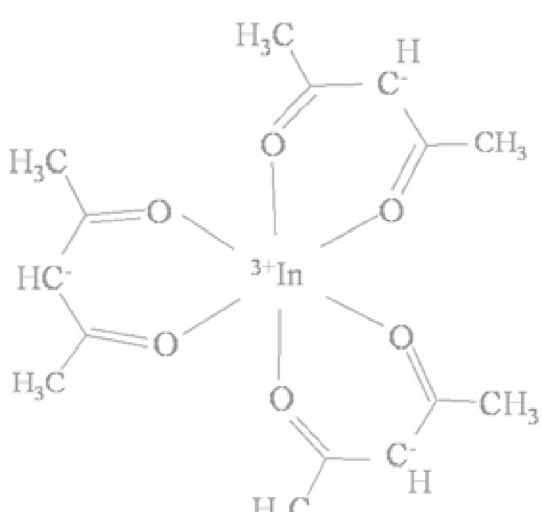
*Biophysics*
An interdisciplinary science that uses the methods of physics and physical chemistry to study biological systems. Studies included under the branches of biophysics span all levels of biological organization, from the molecular scale to whole organisms and ecosystems.

*Cancer*
Any malignant growth or tumor caused by abnormal and uncontrolled cell division; it may spread to other parts of the body through the lymphatic system or the blood stream.

*Cell cycle*
Regulated biochemical steps that cells go through involving DNA replication and cell division, usually depicted as a sequential cyclical series of events.

*Lawrence Livermore National Laboratory (LLNL)*
A scientific research laboratory founded by the University of California in 1952. Its principal responsibility is ensuring the safety, security and reliability of the nation's nuclear weapons through the application of advanced science, engineering and technology.

*National Science Foundation (NSF)*
A United States government agency that supports fundamental research and education in all the non-medical fields of science and engineering. Its medical counterpart is the National Institutes of Health.



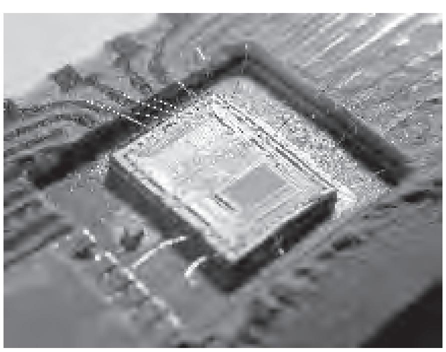
# ScienceMakers
## Spotlight: Keith Hunter Jackson

| | |
|---|---|
| **Name** | Keith Hunter Jackson |
| **Birth Date** | September 24, 1953 |
| **Birth Place** | Columbus, Ohio |
| **Education** | Morehouse College<br>Georgia Institute of Technology<br>Stanford University |
| **Types of Science** | Education & Administration<br>Physics<br>Electrical Engineering |

## Biography

Physicist Keith Hunter Jackson was born on September 24, 1953 in Columbus, Ohio to Gloria and Russell Jackson. He earned two B.S. degrees, one in physics from Morehouse College and one in electrical engineering from the Georgia Institute of Technology. Jackson then moved to California where he obtained his M.S. and Ph.D. degrees from Stanford University in 1979 and 1982, respectively.

After obtaining his graduate degrees, Jackson began working for Hewlett Packard Laboratories. He became a member of the Gate Dielectric group and developed techniques to create thin nitride films on silicon layers. In 1983, he served as a professor at Howard University, working in the Solid State Electronics group. Beginning in 1988, Jackson worked for Rockwell International (now Boeing) in the Rocketdyne division where under the Strategic Defense Initiative (SDI) program he performed research on diamond thin films, high powered chemical and Free Electron Lasers (FEL) and water-cooled optics. In 1992, Jackson began working for the Lawrence Berkeley National Laboratory as associate director of the Center for X-Ray Optics (CXRO). His research interests were in the Extreme Ultra-Violet (EVU) lithography, x-ray lithography, electroplating and injection molding. EUV lithography is the technology, which is used to build billions of nano-sized devices for use in computers and cell phones. X-ray lithography and molding is used to build micro-sized mechanical devices like micropumps, and tiny mirrors for large screen projection TV's. In 2005, Jackson became Vice President of Research and Professor of Physics at Florida Agricultural and Mechanical University (FAMU). On January 4th 2010, Jackson moved to Baltimore, Maryland and joined



Silicon integrated circuit (or silicon chip) is found in much of modern technology, including cell phones and computers.

the faculty of Morgan State University as Chair of the Department of Physics.

Jackson served as president of the National Society of Black Physicists (NSBP) from 2001 to 2006. He is also a fellow of the National Society of Black Physicists and the African Scientific Institute. In 2004, Jackson was selected as one of the 50 Most Important African Americans in Technology by *U.S. Black Engineer and Information Technology*. In addition to his published papers, Jackson has written pieces on minority physicists including "Utilization of African American Physicists in the Science & Engineering Workforce" and "The Status of the African American Physicist in the Department of Energy National Laboratories."



# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Jackson?
#2 Where was Dr. Jackson born? Locate it on a map. How far away is this from where you live? What are the names of his parents? Where did Dr. Jackson attend high school? What do you think high school was like for him?
#3 How old are you? In what year was Dr. Jackson your age? What was happening in the United States that year? What was happening in the world that year? What do you think his life was like when he was your age?
#4 Look for other scientists in this Toolkit that are a member of the National Society of Black Physicists. What do they do?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 What do you think a physicist does? Would you like to be a physicist? Why? Why not?
#2 If you were a physicist, what topics would you study?
#3 If something is nano-sized, it is very, very small. Why do you think it would be useful to make nano-sized objects?
#4 What are integrated circuits? How are they made?
#5 On the periodic table, what atomic number is silicon? Look at the elements surrounding silicon – do they have anything in common? What can you think of that is made of silicon? Why might you use silicon instead of something else?

# Glossary

*Dielectric*
An electrical insulator (does not conduct charge) that may be polarized by the action of an applied electric field.

*Electrical engineering*
The branch of engineering science that studies the uses of electricity and the equipment for power generation and distribution and the control of machines and communication.

*Electronics*
The branch of physics that deals with the emission and effects of electrons and with the use of electronic devices.

*Electroplating*
A process of coating the surfaces of a metal object with a layer of a different metal through electrochemical means.

*Extreme Ultra-Violet radiation (EUV)*
Part of the electromagnetic spectrum spanning from 120 nm down to 10 nm. Its main uses are photoelectron spectroscopy, solar imaging, and lithography.

*Free Electron Laser (FEL)*
A laser that shares the same optical properties as conventional lasers such as emitting a beam consisting of coherent electromagnetic radiation which can reach high power, but uses some very different operating principles to form the beam.

*Lawrence Berkeley National Laboratory (LBNL)*
The Ernest Orlando Lawrence Berkeley National Laboratory (LBNL), is a U.S. Department of Energy (DOE) national laboratory conducting unclassified scientific research. It is located on the grounds of the University of California, Berkeley, in the Berkeley Hills above the central campus.

*Lithography*
A method of printing from a metal or stone surface; the technique which allows for the construction of computers, video games, and even LCD TVs.

*Micropump*
Pumps with functional dimensions in the micrometer range.

*Nanoscale (nanoscopic scale)*
Structures with a length scale applicable to nanotechnology; usually cited as 1-100 nanometers.

*National Society of Black Physicists (NSBP)*
A professional organization established in 1977 to promote the professional well-being of African American physicists and physics students within the international scientific community and the world community at large.

*Nitride*
A compound containing nitrogen and a more positive element (like phosphorus or a metal).

*Optics*
The branch of physics which studies the behavior and properties of light, including its interactions with matter; usually describes the behavior of visible, ultraviolet, and infrared light.

*Strategic Defense Initiative*
A program started in 1984 to use ground and space-based lasers to protect the United States from attack by strategic nuclear ballistic missiles.

*Thin film*
Thin material layers ranging from fractions of a nanometer (monolayer) to several micrometers in thickness. Electronic semiconductor devices and optical coatings are applications that use thin films.

*X-ray*
A band of the electromagnetic spectrum between the ultraviolet and the gamma-ray. Photons of X-ray light are more energetic than photons in the ultraviolet but less energetic than photons in the gamma-ray.

# ScienceMakers
## Spotlight: Shirley Malcom

| | |
|---|---|
| **Name** | Shirley Malcom |
| **Birth Date** | September 6, 1946 |
| **Birth Place** | Birmingham, Alabama |
| **Education** | G.W. Carver High School<br>University of Washington<br>University of California, Los Angeles<br>Pennsylvania State University |
| **Types of Science** | Education & Administration<br>Zoology |

## Biography

Zoologist and education administrator Shirley Malcom knew from an early age she wanted to be a doctor. At her segregated high school she was a top student. Malcom then attended the University of Washington and graduated with her B.S. degree in zoology. Malcom went on to attend the University of California at Los Angeles where she graduated with her M.S. degree in zoology. She then attended Pennsylvania State University, receiving her Ph.D. degree in ecology.

Bill Clinton photo by Chris Denbow @Flickr

Malcom taught at both the high school and university level, including her time as an assistant professor of biology at the University of North Carolina at Wilmington. Malcom then became a program officer for the National Science Foundation's (NSF) Science Education Directorate. In 1994, Malcom became a fellow of the American Academy of Arts and Sciences (AAAS) and was appointed to the National Science Board by President Bill Clinton. She was also named to the President's Committee of Advisors on Science and Technology from 1994 until 2001. In addition, Malcom's work brought her to the American Association for the Advancement of Science (AAAS), first as head of the Association's Office of Opportunities in Science and now as the Head of the Directorate for Education and Human Resources Programs. In her current position, Malcom has worked to significantly increase opportunities for women, minorities and those with disabilities in the STEM professions.

In 1998, the University of Washington gave Malcom their Alumna Summa Laude Dignata Award, the university's highest honor. Malcom has chaired many national committees committed to scientific education and literacy. She has fifteen honorary degrees and in 2003, was given the Public Welfare Medal of the National Academy of Sciences (NAS). Malcom has authored several reports on engaging women and minorities in science and is considered a pioneer for her dedication to the issue.



# Discussion Questions

***About the ScienceMaker:***

#1 What was the most interesting thing you learned about Dr. Malcom?
#2 Where was Dr. Malcom born? Locate it on a map. How far away is this from where you live? What are the names of her parents? Where did Dr. Malcom attend high school? What do you think high school was like for her?
#3 How old are you? In what year was Dr. Malcom your age? What was happening in the United States that year? What was happening in the world that year? What do you think her life was like when she was your age?
#4 Dr. Malcom was interested in becoming a doctor. What are you interested in? Do you think you will change your mind as you get older?
#5 What other questions would you ask if you were to interview this ScienceMaker?

***About the Subject Matter:***

#1 Although she has worked most recently as an administrator of education, Dr. Malcom has a background in zoology. What do you think a zoologist does? Would you like to be a zoologist? Why? Why not?
#2 If you were a zoologist, what topics would you study?
#3 Dr. Malcom received her Ph.D. degree in ecology. What is the focus of ecology? How would you describe the ecology of your neighborhood? How is ecology different than zoology?
#4 Why do you think the president needs a Committee of Advisors on Science and Technology? What other committees does the president have?
#5 Dr. Malcom has worked with the American Academy of Arts and Science (AAAS). Research this group further. What is their goal? How do they plan to achieve this goal? Is there anything this organization does that makes an impact on you?

# Glossary

*American Academy of Arts and Science (AAAS)*
An independent policy research center that conducts multidisciplinary studies of complex and emerging problems. The Academy's elected members are leaders in the academic disciplines, the arts, business, and public affairs.

*American Association for the Advancement of Science (AAAS)*
An international non-profit organization with the stated goals of promoting cooperation between scientists, defending scientific freedom, encouraging scientific responsibility, and supporting scientific education and science.

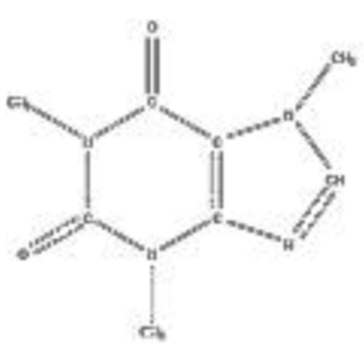
*Ecology*
The branch of biology concerned with the relations between organisms and their environment.

*National Academy of Sciences (NAS)*
A corporation in the United States whose members serve as advisers to the nation on science.

*National Science Board*
Composed of 25 members, appointed by the President and confirmed by the United States Senate, this organization represents the broad U.S. science and engineering community.

*National Science Foundation (NSF)*
A United States government agency that supports fundamental research and education in all the non-medical fields of science and engineering. Its medical counterpart is the National Institutes of Health.

*Zoology*
The branch of biology that focuses on the structure, function, behavior and evolution of animals.



# ScienceMakers

## Spotlight: Shirley Mathis McBay



| | |
|---|---|
| **Name** | Shirley Mathis McBay |
| **Birth Date** | May 4, 1935 |
| **Birth Place** | Bainbridge, Georgia |
| **Education** | Hutto High School<br>Paine College<br>Atlanta University<br>University of Georgia |
| **Types of Science** | Education & Administration<br>Mathematics |

## Biography

Mathematician Shirley Mathis McBay was born on May 4, 1935 in Bainbridge, Georgia. At a young age, McBay excelled in mathematics. She attended Paine College where she earned a B.A. degree in chemistry at age nineteen before going to Atlanta University where she obtained M.S. degrees in chemistry and mathematics. She began teaching chemistry at Spelman College in 1955 and continued until 1963. She received a United Negro College Fund fellowship in 1964 for the University of Georgia and in 1966, McBay became the first African American to earn a Ph.D. degree from the University of Georgia.

NASA program photo by NASA Goddard Photo and Video @Flickr

In 1972, McBay began working at Spelman College as an associate professor of mathematics and was promoted to Department Head of Mathematics after working to build up the department with her colleagues. In 1972, Spelman College created the Division of Natural Sciences with McBay as its division chair. As chair, McBay developed the emphasis in science and reversed the college's trend of decreasing science graduates. McBay also served as Associate Academic Dean for the College before moving to the National Science Foundation (NSF) where for five years, she served as Program Manager/ Director in the Science Education Directorate. While at the National Science Foundation, she directed two national programs to increase the number of minorities in the sciences and engineering. In 1980, McBay joined the faculty at the Massachusetts Institute of Technology (MIT) as the first African American dean for student affairs. She resigned in 1990 to become president of the Quality Education for Minorities (QEM) Network. Prior to her presidency, McBay spent three years as Director of the MIT-based QEM Project. At QEM, she served for ten years as Director of the National Aeronautics and Space Administration's (NASA) Summer Research Apprenticeship Program for High School Students.

McBay has published numerous papers on African American participation in the sciences including *The condition of African American education: Changes and challenges and Improving education for minorities*. She was also director of the Office of Minority Health's "Providing Technical Assistance to Bennett and Spelman Colleges to Prepare More Students for Biomedical and other Health-related Careers" project. She and her QEM colleagues have carried out numerous projects over the past twenty years designed to ensure that students underrepresented in science and engineering had access to a high quality education in these areas. Projects have targeted parents; high school and college students; teachers at the pre-college and college levels; and minority-serving institutions, including Tribal Colleges and Universities, Historically Black Colleges and Universities (HBCU), and Hispanic-Serving Institutions.

## Discussion Questions

### *About the ScienceMaker:*

#1 What was the most interesting thing you learned about Dr. McBay?
#2 Where was Dr. McBay born? Locate it on a map. How far away is this from where you live? What are the names of her parents? Where did Dr. McBay attend high school? What do you think high school was like for her?
#3 How old are you? In what year was Dr. McBay your age? What was happening in the United States that year? What was happening in the world that year? What do you think her life was like when she was your age?
#4 Dr. McBay has accomplished a lot of "firsts." Pick one of her firsts and describe why it is important. Who is another notable "first" that you can think of, and for what are they known?
#5 What other question(s) would you ask if you were to interview this ScienceMaker?

### *About the Subject Matter:*

#1 What do you think a mathematician does? Would you like to be a mathematician? Why? Why not?
#2 If you were a mathematician, what topics would you study?
#3 Dr. McBay earned her degrees in chemistry and mathematics. What do these subjects have in common? What could you accomplish by combining the fields of chemistry and mathematics?
#4 What is the Quality Education for Minorities Network? What is their mission statement, or what do you think it would be? What are ways that you would reach out to minority students?
#5 Dr. McBay has been an advocate for improving the number of education opportunities for minority students. Why do you think this is an important cause for Dr. McBay? What causes do you support?

# Glossary

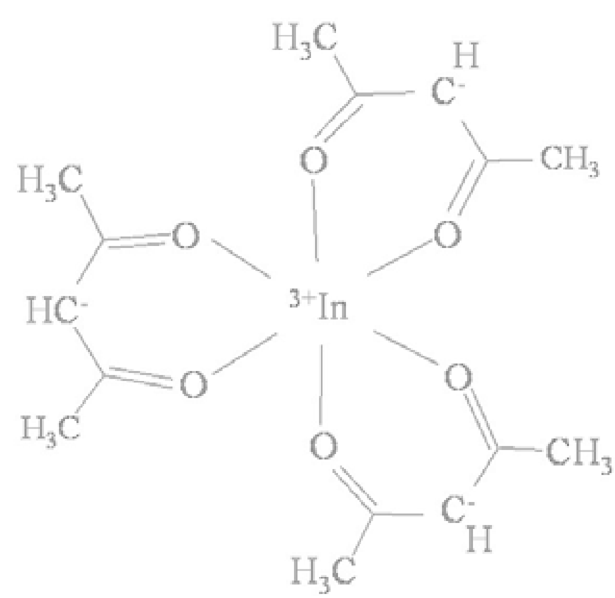


*National Aeronautics and Space Administration (NASA)*
An independent agency of the United States government responsible for aviation and spaceflight.

*National Science Foundation (NSF)*
A United States government agency that supports fundamental research and education in all the non-medical fields of science and engineering. Its medical counterpart is the National Institutes of Health.

*Quality Education for Minorities (QEM) Network*
A non-profit organization based in Washington, DC, dedicated to improving the education of African Americans, Alaska Natives, American Indians, Mexican Americans, and Puerto Ricans.

*United Negro College Fund*
An American philanthropic organization that fundraises college tuition money for black students and general scholarship funds for 39 private historically black colleges and universities.



# National Science Content Standards Alignment



The National Science Standards serve as a guide for the science standard of each state, though more specific state standards may apply. In order to make this guide as applicable as possible, we have included the National Science Standards that we feel appropriate for the content contained in the ScienceMakers Toolkit. Since the ScienceMakers program contains such a diverse body of knowledge, not every science standard will apply to every Spotlight or activity. The following is a list of standards that may apply to one or more areas of the curriculum. For the sake of clarity, individual numbers within each section have been removed, though the section labels remain intact as a reference.

**B. Physical Science - Physical science focuses on science facts, concepts, principles, theories, and models that are important for all students to know, understand, and use.**

**M.B.1 Properties and changes of properties in matter**

- Substances react chemically in characteristic ways with other substances to form new substances (compounds) with different characteristic properties. In chemical reactions, the total mass is conserved. Substances often are placed in categories or groups if they react in similar ways; metals are an example of such a group.
- Chemical elements do not break down during normal laboratory reactions involving such treatments as heating, exposure to electric current, or reaction with acids. There are more than 100 known elements that combine in a multitude of ways to produce compounds, which account for the living and nonliving substances that we encounter.

**H.B.1 Structure of atoms**

- Matter is made of minute particles called atoms, and atoms are composed of even smaller components. These components have measurable properties, such as mass and electrical charge. Each atom has a positively charged nucleus surrounded by negatively charged electrons. The electric force between the nucleus and electrons holds the atom together.
- The atom’s nucleus is composed of protons and neutrons, which are much more massive than electrons. When an element has atoms that differ in the number of neutrons, these atoms are called different isotopes of the element.
- The nuclear forces that hold the nucleus of an atom together, at nuclear distances, are usually stronger than the electric forces that would make it fly apart. Nuclear reactions convert a fraction of the mass of interacting particles into energy, and they can release much greater amounts of energy than atomic interactions. Fission is the splitting of a large nucleus into smaller pieces. Fusion is the joining of two nuclei at extremely high temperature and pressure, and is the process responsible for the energy of the sun and other stars.

- Radioactive isotopes are unstable and undergo spontaneous nuclear reactions, emitting particles and/or wavelike radiation. The decay of any one nucleus cannot be predicted, but a large group of identical nuclei decay at a predictable rate. This predictability can be used to estimate the age of materials that contain radioactive isotopes.

**H.B.2 Structure and properties of matter**

- Atoms interact with one another by transferring or sharing electrons that are furthest from the nucleus. These outer electrons govern the chemical properties of the element.
- Bonds between atoms are created when electrons are paired up by being transferred or shared. A substance composed of a single kind of atom is called an element. The atoms may be bonded together into molecules or crystalline solids. A compound is formed when two or more kinds of atoms bind together chemically.
- Solids, liquids, and gases differ in the distances and angles between molecules or atoms and therefore the energy that binds them together. In solids, the structure is nearly rigid; in liquids, molecules or atoms move around each other but do not move apart; and in gases, molecules or atoms move almost independently of each other and are mostly far apart.
- Carbon atoms can bond to one another in chains, rings, and branching networks to form a variety of structures, including synthetic polymers, oils, and the large molecules essential to life.



**H.B.3 Chemical reactions**

- Chemical reactions occur all around us, for example in health care, cooking, cosmetics, and automobiles. Complex chemical reactions involving carbon-based molecules take place constantly in every cell in our bodies.
- Chemical reactions may release or consume energy. Some reactions such as the burning of fossil fuels release large amounts of energy by losing heat and by emitting light. Light can initiate many chemical reactions such as photosynthesis and the evolution of urban smog.
- A large number of important reactions involve the transfer of either electrons (oxidation/reduction reactions) or hydrogen ions (acid/ base reactions) between reacting ions, molecules, or atoms. In other reactions, chemical bonds are broken by heat or light to form very reactive radicals with electrons ready to form new bonds. Radical reactions control many processes such as the presence of ozone and greenhouse gases in the atmosphere, burning and processing of fossil fuels, the formation of polymers, and explosions.
- Chemical reactions can take place in time periods ranging from the few femtoseconds (10-15 seconds) required for an atom to move a fraction of a chemical bond distance to geologic time scales of billions of years. Reaction rates depend on how often the reacting atoms and molecules encounter one another, the temperature, and the properties–including shape–of the reacting species.
- Catalysts, such as metal surfaces, accelerate chemical reactions. Chemical reactions in living systems are catalyzed by protein molecules called enzymes.

**H.B.4 Motions and forces**

- Objects change their motion only when a net force is applied. Laws of motion are used to calculate precisely the effects of forces on the motion of objects. The magnitude of the change in motion can be calculated using the relationship F = ma, which is independent of the nature of the force. Whenever one object exerts force on another, a force equal in magnitude and opposite in direction is exerted on the first object.

- Electricity and magnetism are two aspects of a single electromagnetic force. Moving electric charges produce magnetic forces, and moving magnets produce electric forces. These effects help students to understand electric motors and generators.

**H.B.6 Interactions of energy and matter**

- Waves, including sound and seismic waves, waves on water, and light waves, have energy and can transfer energy when they interact with matter.
- Each kind of atom or molecule can gain or lose energy only in particular discrete amounts and thus can absorb and emit light only at wavelengths corresponding to these amounts. These wavelengths can be used to identify the substance.



**C. Life Science - Life science focuses on science facts, concepts, principles, theories, and models that are important for all students to know, understand, and use.**

**M.C.1 Structure and function in living systems**

- Living systems at all levels of organization demonstrate the complementary nature of structure and function. Important levels of organization for structure and function include cells, organs, tissues, organ systems, whole organisms and ecosystems. All organisms are composed of cells–the fundamental unit of life. Most organisms are single cells; other organisms, including humans, are multicellular.
- Cells carry on the many functions needed to sustain life. They grow and divide, thereby producing more cells. This requires that they take in nutrients, which they use to provide energy for the work that cells do and to make the materials that a cell or an organism needs.
- Specialized cells perform specialized functions in multicellular organisms. Groups of specialized cells cooperate to form a tissue, such as a muscle. Different tissues are in turn grouped together to form larger functional units, called organs. Each type of cell, tissue, and organ has a distinct structure and set of functions that serve the organism as a whole.
- The human organism has systems for digestion, respiration, reproduction, circulation, excretion, movement, control, and coordination, and for protection from disease. These systems interact with one another.
- Disease is a breakdown in structures or functions of an organism. Some diseases are the result of intrinsic failures of the system. Others are the result of damage by infection by other organisms.

**M.C.2 Reproduction and heredity**

- In many species, including humans, females produce eggs and males produce sperm. Plants also reproduce sexually–the egg and sperm are produced in the flowers of flowering plants. An egg and sperm unite to begin development of a new individual. That new individual receives genetic information from its mother (via the egg) and its father (via the sperm). Sexually produced offspring never are identical to either of their parents.
- Every organism requires a set of instructions for specifying its traits. Heredity is the passage of these instructions from one generation to another.
- Hereditary information is contained in genes, located in the chromosomes of each cell. Each gene carries a single unit of information. An inherited trait of an individual

can be determined by one or by many genes, and a single gene can influence more than one trait. A human cell contains many thousands of different genes.
- The characteristics of an organism can be described in terms of a combination of traits. Some traits are inherited and others result from interactions with the environment.

**H.C.1 The cell**
- Cells have particular structures that underlie their functions. Every cell is surrounded by a membrane that separates it from the outside world. Inside the cell is a concentrated mixture of thousands of different molecules which form a variety of specialized structures that carry out such cell functions as energy production, the transport of molecules, waste disposal, the synthesis of new molecules, and the storage of genetic material.
- Most cell functions involve chemical reactions. Food molecules taken into cells react to provide the chemical constituents needed to synthesize other molecules. Both breakdown and synthesis are made possible by a large set of protein catalysts, called enzymes. The breakdown of some of the food molecules enables the cell to store energy in specific chemicals that are used to carry out the many functions of the cell.
- Cells store and use information to guide their functions. The genetic information stored in DNA is used to direct the synthesis of the thousands of proteins that each cell requires.
- Cell functions are regulated. Regulation occurs both through changes in the activity of the functions performed by proteins and through the selective expression of individual genes. This regulation allows cells to respond to their environment and to control and coordinate cell growth and division.
- Plant cells contain chloroplasts, the site of photosynthesis. Plants and many microorganisms use solar energy to combine molecules of carbon dioxide and water into complex, energy rich organic compounds and release oxygen to the environment. This process of photosynthesis provides a vital connection between the sun and the energy needs of living systems. Cells can differentiate, and complex multicellular organisms are formed as a highly organized arrangement of differentiated cells. In the development of these multicellular organisms, the progeny from a single cell form an embryo in which the cells multiply and differentiate to form the many specialized cells, tissues and organs that comprise the final organism. This differentiation is regulated through the expression of different genes.

**H.C.5 Matter, energy, and organization in living systems**
- The chemical bonds of food molecules contain energy. Energy is released when the bonds of food molecules are broken and new compounds with lower energy bonds are formed. Cells usually store this energy temporarily in phosphate bonds of a small high energy compound called ATP.

**H.C.6 Behavior of organisms**
- Multicellular animals have nervous systems that generate behavior. Nervous systems are formed from specialized cells that conduct signals rapidly through the long cell extensions that make up nerves. The nerve cells communicate with each other by secreting specific excitatory and inhibitory molecules. In sense organs, specialized cells detect light, sound, and specific chemicals and enable animals to monitor what is going on in the world around them.
- Organisms have behavioral responses to internal changes and to external stimuli. Responses to external stimuli can result from interactions with the organism's own

species and others, as well as environmental changes; these responses either can be innate or learned. The broad patterns of behavior exhibited by animals have evolved to ensure reproductive success. Animals often live in unpredictable environments, and so their behavior must be flexible enough to deal with uncertainty and change. Plants also respond to stimuli.

**D. Earth and Space Science - Earth and space science focuses on science facts, concepts, principles, theories, and models that are important for all students to know, understand, and use.**

**M.D.1 Structure of the earth system**

- Lithospheric plates on the scales of continents and oceans constantly move at rates of centimeters per year in response to movements in the mantle. Major geological events, such as earthquakes, volcanic eruptions, and mountain building, result from these plate motions.

**H.D.4 Origin and evolution of the universe**

- The origin of the universe remains one of the greatest questions in science. The "big bang" theory places the origin between 10 and 20 billion years ago, when the universe began in a hot dense state; according to this theory, the universe has been expanding ever since.
- Early in the history of the universe, matter, primarily the light atoms hydrogen and helium, clumped together by gravitational attraction to form countless trillions of stars. Billions of galaxies, each of which is a gravitationally bound cluster of billions of stars, now form most of the visible mass in the universe.

Stars produce energy from nuclear reactions, primarily the fusion of hydrogen to form helium. These and other processes in stars have led to the formation of all the other elements.

**E. Science and Technology - An understanding of science and technology establishes connections between the natural and designed world, linking science and technology.**

**M.E.2 Understandings about science and technology**

- Scientific inquiry and technological design have similarities and differences. Scientists propose explanations for questions about the natural world, and engineers propose solutions relating to human problems, needs, and aspirations. Technological solutions are temporary; technologies exist within nature and so they cannot contravene physical or biological principles; technological solutions have side effects; and technologies cost, carry risks, and provide benefits.
- Many different people in different cultures have made and continue to make contributions to science and technology.
- Science and technology are reciprocal. Science helps drive technology, as it addresses questions that demand more sophisticated instruments and provides principles for better instrumentation and technique. Technology is essential to science, because it provides instruments and techniques that enable observations of objects and phenomena that are otherwise unobservable due to factors such as quantity, distance, location, size, and speed. Technology also provides tools for investigations, inquiry and analysis.

**H.E.2 Understandings about science and technology** Scientists in different disciplines ask different questions, use different methods of investigation, and accept different types of evidence to support their explanations. Many scientific investigations require the contributions of individuals from different disciplines, including engineering. New disciplines of science, such as geophysics and biochemistry often emerge at the interface of two older disciplines.

- Science often advances with the introduction of new technologies. Solving technological problems often results in new scientific knowledge. New technologies often extend the current levels of scientific understanding and introduce new areas of research.
- Creativity, imagination, and a good knowledge base are all required in the work of science and engineering.
- Science and technology are pursued for different purposes. Scientific inquiry is driven by the desire to understand the natural world, and technological design is driven by the need to meet human needs and solve human problems. Technology, by its nature, has a more direct effect on society than science because its purpose is to solve human problems, help humans adapt, and fulfill human aspirations. Technological solutions may create new problems. Science, by its nature, answers questions that may or may not directly influence humans. Sometimes scientific advances challenge people's beliefs and practical explanations concerning various aspects of the world.
- Technological knowledge is often not made public because of patents and the financial potential of the idea or invention. Scientific knowledge is made public through presentations at professional meetings and publications in scientific journals.

**F. Science in Personal and Social Perspectives - A personal and social perceive of science helps a student to understand and act on personal and social issues. This perspective builds a foundation for future decision making.**

**M.F.5 Science and technology in society**

- Science influences society through its knowledge and world view. Scientific knowledge and the procedures used by scientists influence the way many individuals in society think about themselves, others, and the environment. The effect of science on society is neither entirely beneficial nor entirely detrimental.
- Societal challenges often inspire questions for scientific research, and social priorities often influence research priorities through the availability of funding for research. Technology influences society through its products and processes. Technology influences the quality of life and the ways people act and interact. Technological changes are often accompanied by social, political, and economic changes that can be beneficial or detrimental to individuals and to society. Social needs, attitudes, and values influence the direction of technological development.
- Science and technology have advanced through the contributions of many different people, in different cultures, at different times in history. Science and technology have contributed enormously to economic growth and productivity among societies and groups within societies. Scientists and engineers work in many different settings, including colleges and universities, businesses and industries, specific research institutes, and government agencies.
- Scientists and engineers have ethical codes requiring that human subjects involved with research be fully informed about risks and benefits associated with the research before the individuals choose to participate. This ethic extends to potential risks to communities and property. In short, prior knowledge and consent are required for research involving human subjects or potential damage to property.

- Science cannot answer all questions and technology cannot solve all human problems or meet all human needs. Students should understand the difference between scientific and other questions. They should appreciate what science and technology can reasonably contribute to society and what they cannot do. For example, new technologies often will decrease some risks and increase others.

**H.F.1 Personal and community health**

- The severity of disease symptoms is dependent on many factors, such as human resistance and the virulence of the disease-producing organism. Many diseases can be prevented, controlled, or cured. Some diseases, such as cancer, result from specific body dysfunctions and cannot be transmitted to others.

**H.F.6 Science and technology in local, national, and global challenges**

- Science and technology are essential social enterprises, but alone they can only indicate what can happen, not what should happen. The latter involves human decisions about the use of knowledge.
- Progress in science and technology can be affected by social issues and challenges. Funding priorities for specific health problems serve as examples of ways that social issues influence science and technology.
- Individuals and society must decide on proposals involving new research and the introduction of new technologies into society. Decisions involve assessment of alternatives, risks, costs, and benefits and consideration of who benefits and who suffers, who pays and gains, and what the risks are and who bears them. Students should understand the appropriateness and value of basic questions–"What can happen?"–"What are the odds?"– and "How do scientists and engineers know what will happen?"

**G. History and Nature of Science - The history and nature of science illustrates different aspects of scientific inquiry, the human aspects of science, and the role that science has played in the development of various cultures.**

**M.G.1 Science as a human endeavor**

- Women and men of various social and ethnic backgrounds–and with diverse interests, talents, qualities, and motivations–engage in the activities of science, engineering, and related fields such as the health professions. Some scientists work in teams, and some work alone, but all communicate extensively with others.
- Science requires different abilities, depending on such factors as the field of study and type of inquiry. Science is very much a human endeavor, and the work of science relies on basic human qualities, such as reasoning, insight, energy, skill, and creativity–as well as on scientific habits of mind, such as intellectual honesty, tolerance of ambiguity, skepticism, and openness to new ideas.

**M.G.3 History of science**

- Many individuals have contributed to the traditions of science. Studying some of these individuals provides further understanding of scientific inquiry, science as a human endeavor, the nature of science, and the relationships between science and society. In historical perspective, science has been practiced by different individuals in different cultures. In looking at the history of many peoples, one finds that scientists and engineers of high achievement are considered to be among the most valued contributors to their culture.

- Tracing the history of science can show how difficult it was for scientific innovators to break through the accepted ideas of their time to reach the conclusions that we currently take for granted.

**H.G.1 Science as a human endeavor**

- Individuals and teams have contributed and will continue to contribute to the scientific enterprise. Doing science or engineering can be as simple as an individual conducting field studies or as complex as hundreds of people working on a major scientific question or technological problem. Pursuing science as a career or as a hobby can be both fascinating and intellectually rewarding.
- Scientists have ethical traditions. Scientists value peer review, truthful reporting about the methods and outcomes of investigations, and making public the results of work. Violations of such norms do occur, but scientists responsible for such violations are censured by their peers.
- Scientists are influenced by societal, cultural, and personal beliefs and ways of viewing the world. Science is not separate from society but rather science is a part of society.

**H.G.3 Historical perspectives**

- In history, diverse cultures have contributed scientific knowledge and technologic inventions. Modern science began to evolve rapidly in Europe several hundred years ago. During the past two centuries, it has contributed significantly to the industrialization of Western and non-Western cultures. However, other, non-European cultures have developed scientific ideas and solved human problems through technology.
- Usually, changes in science occur as small modifications in extant knowledge. The daily work of science and engineering results in incremental advances in our understanding of the world and our ability to meet human needs and aspirations. Much can be learned about the internal workings of science and the nature of science from study of individual scientists, their daily work, and their efforts to advance scientific knowledge in their area of study.
- The historical perspective of scientific explanations demonstrates how scientific knowledge changes by evolving over time, almost always building on earlier knowledge.

# *The HistoryMakers® ScienceMaker Toolkit*

# *Oral History Guidlines*

Based on *The HistoryMakers' Becoming A HistoryMaker* Curriculum Guide



**What Is An Oral History?**

**An oral history** is a narrative about the past, spoken by a person usually during an interview. They often encompass a person's life from their earliest memory to their present day experiences. The ScienceMaker oral histories also discuss subject matter, or what kind of work the ScienceMaker did relating to their STEM field.

**What Are the Benefits of Doing Oral History In The Classroom?**

Reasons most commonly offered by teachers include:

- Makes history come alive by making a personal connection to history
- Allows students to engage in interpersonal relationship with elders
- Addresses state goals for reading, writing, listening, speaking, research and technology
- Addresses state goals for critical thinking, inference and analysis
- Places "ordinary" or unknown people into history

**How Do I Do A STEM Oral History?**

There are several steps to follow in order to do a good oral history.

**Know your topic, define your purpose and do background research.**
Find out as much as you can beforehand so that you can ask intelligent questions. Oral history does not replace basic research – excellent results will only be obtained by being prepared and basing your interview questions on knowledge you have gained already. Do your homework and know your history about the person and the subject matter. For example, you would not want to ask someone born in 1955 about his/her experience during the Great Depression. If your interviewee is an organic chemist, you would not want to ask him/her about artificial intelligence in robots.

**Write or call to request an interview.**
State why you want to interview him or her and what you want to find out about. That way, your interviewee can prepare.

**Ask informed, well-researched questions.**

1. **Prepare your questions beforehand**. Find a way to ask a question that cannot be answered "yes" or "no." These are called "open-ended" questions. Some interviews begin their question with "Tell me about your experience in..." Or "What did you do when..."

2. **Organize your questions**. Start with the basics. If you have a question that may be difficult for your interviewee to answer, wait until later in the interview when she/he is felling more comfortable and confident.
3. **Have follow-up questions in mind**, but also keep attentive to your interviewee – she/he may say something that you need clarification on or that you want them to develop further.
4. If your interviewee explains something difficult in scientific terms, you can ask them to rephrase or state in a way that a layperson would understand.

**Be aware of the setting.**

1. Try to find a quiet, comfortable place for the interview (no TVs, radios, or computers on, windows open to noisy streets, etc.)
2. Make sure your tape recorder or video camera is working. (Practice and test it beforehand and at the beginning of the interview.)
3. Keep within the limits of the time you and your interviewee have agreed to.
4. Ask your interviewee to sign a legal release form before the interview which gives you permission to use their oral history in a project.
5. Avoid interrupting or producing audible sounds such as “uh-huh” during the interview – simply nod if you want to indicate your are listening.



**After the interview:**

1. Label the tape: name of interviewee, date, place of interview, length of time for interview.
2. Write and send a thank you note to your interviewee.
3. Transcribe, or at the very least, summarize the interview while it is fresh in your mind. Creating an index of subjects covered as they occurred in the interview will also help you if you do not have the time or resources to transcribe the interviews.
4. Reflect on your performance as an interviewer. What did you do well? What could you have done better? What would you change when doing future oral histories?

# Oral History Activity Ideas

Based on *The HistoryMakers' Becoming A HistoryMaker* Curriculum Guide



**Whole Classroom Activity: Classroom Profiles**

A "profile" is a way to compile specific data from students' work that can yield new information, generate new questions, help draw conclusions. Such data could include:

a. The types of ScienceMakers students chose to study.
b. How many/who graduated from college?
c. How many/who came from (or made their mark) in the South or North, East or West of the country?
d. When did the selected ScienceMaker make the most significant contribution?
e. Your own ideas of important information to compile and display

With the data, students may communicate the compilations in the form of graphs that can be displayed in the classroom. The classroom may then synthesize data, make connections, draw conclusions, and generate new questions.

**Guess Who's Coming to Dinner**

In this project, students will work in teams to create a dinner party scene with four ScienceMakers present. Students may write an imaginary conversation among the dinner party guests (based on the information about the ScienceMakers) and dress up as their chosen ScienceMaker. Each student should guess as to who the other guests at their dinner party are, based on the conversation. Students may write a brief statement about their portrayal of the ScienceMaker, accompanied by a biography.

# Oral History Release Form for Students

Based on the University of Mary Washington's Oral History Practice Project Release Form

Thank you for participating in my oral history interview. By signing this form you are granting me permission to share video or audio from this interview with others who may use the information for scholarly and/or educational purposes including classroom feedback and personal feedback to improve my interview skills.

By giving your permission, you do not give up any copyright or performance rights that you may hold.

______________________________ ______________________________
[Signature of Interviewee] [Signature of Interviewer]

______________________________ ______________________________
[Print Name] [Date]

# YouTube SCIENCEMAKERS ORAL HISTORY CONTEST

## 1 CHOOSE A SCIENCEMAKER

Will you be physicist Kennedy Reed or biologist Agnes Day?
Maybe you'll be yourself as a future ScienceMaker!

## 2 TELL YOUR STORY

Where were you born? What do you like to do?
Show us some real science like how helium makes a balloon float or an exploding Mentos-Diet Coke rocket!

## 3 FILM YOUR VIDEO

Use the Flip camera to make your masterpiece!
Make sure we can both see and hear you.

## 4 UPLOAD TO YOUTUBE

by November 20! You can also vote on other videos on our channel: youtube.com/users/ScienceMakers1
First place wins *$300!*

The HistoryMakers.

# *The HistoryMakers® ScienceMakers*

# *YouTube Oral History Contest*

Full Guidelines, Rules & Tips




*Think you have what it takes to be a ScienceMaker?*

Show us! The ScienceMakers are African Americans who have made a significant impact on the world-wide scientific community, whether as an engineer, college biology professor, seismologist, research chemist and more. We are looking for YouTube video submissions from students with two special requirements: a passion for science, and a dream. **The ScienceMakers YouTube Oral History Contest** is **free** and **open to any student in fifth through twelfth grade at a full time U.S. public, private, or home school**. Your video can either be an imaginary interview with yourself as a scientist in the future, or an impersonation of a ScienceMaker from the ScienceMakers Toolkit. Be as creative as possible, as accurate as possible, as safe as possible, and remember to have as much fun as possible!

There are many possibilities for your video—maybe you will create technology for movie special effects like **ScienceMaker Marc Hannah**. Will you observe robot and human interactions, like **ScienceMaker Odest Jenkins**? Or study the stars and how the universe began, like **ScienceMaker Neil deGrasse Tyson**? You could even protect the environment and work for the government, like **ScienceMaker Lisa Jackson**. How will you make your contribution to science?

<u>Here's how it works:</u>

Before making your video, check with your teacher, afterschool club leader or educational leader about your video idea. With help from an adult, search the web for information about the field you plan to explore in your video. Winning videos will teach the viewer something new about science and about the ScienceMaker, and will also have an aspect of oral history—describing the life of you or the scientist and the time in which you or the scientist live.

No matter what approach you take, here are the rules that everyone must follow:

1. Before submitting your video, please **review the terms for submitting content on the YouTube website (see below)**.
2. **Choose a ScienceMaker** from the collection (either to impersonate or use as inspiration). Some sample questions to answer:
    a. Where are you from?
    b. What field are you in? What do you do every day at work?
    c. **Describe how you became a successful scientist**. Remember, being a ScienceMaker means paying attention to details and facts! As any real scientist would do, make sure you double check your results to be completely accurate in your presentation!
        i. Who inspired you to become a scientist?
        ii. What struggles did you face? How did you survive those challenges?
    d. Mention what **accomplishments** you have made.
    e. Include a **clear visual demonstration** of anything in the scientific field you have chosen.
    f. If you decide to make a video of **your future scientist self**, here are some questions for you to think about:
        i. Where did you go to school?
        ii. What science field did you choose and why?
        iii. Who inspired you? (This is where you talk about the ScienceMaker!)
        iv. What do you research? Animals? Organisms? Nature? Atoms?
        v. What new discoveries have you made?
        vi. Have you won any awards for your research?
        vii. How did you get interested in science? How old were you?
3. **No inappropriate videos will be accepted**. These men and women overcame many obstacles and challenges to become the great scientists they are today. Think about how you would want to be portrayed if you were a ScienceMaker.
4. Videos must be submitted in **English**.
5. Videos must be between **one (1) and three (3) minutes long**.
6. Students must be U.S. citizens or legal residents living within the United States or its territories.
7. Students may be 18 years of age and younger to submit a video, and must get parental permission before entering the contest.
8. Students must work with help from their teacher, afterschool club leader or other educational leader to ensure safety.
9. **The videos must be done creatively!**

To submit your video, go on www.youtube.com and create a free account if you do not already have one. Locate the ScienceMakers YouTube page (**youtube.com/users/ScienceMakers1**) and add a comment to our channel with a link to your video. You can also see our sample video and past winners online. Once a student has won, he/she cannot enter again.

### *How we choose the winner:*

The video oral history contest entries will be judged by a panel including: *The HistoryMakers* Executive Director and the Science Producer, representatives from each of the featured science centers (3-4 individuals); and a professional science association member and scientist - so make sure your science is correct!

### *Prizes:*

The winning video from each year of the contest will be featured on the ScienceMakers website, YouTube, Teacher Tube and will be shown at a public event at each of the ScienceMakers featured science centers. The top three videos will also each be awarded **cash prizes** of **$300** (first place), **$200** (second place) and **$100** (third place).

### *Time Schedule:*
The video oral history contest will be held in **2009**, **2010** and **2011**. Each year, entries must be uploaded to YouTube in the fall from **October 1st through November 30th**. Judging will occur from **December 1st through January 15th**. All valid entries will be judged by the Judging Panel (described above). Winners will be notified and winning videos posted on the website after the public programs at the end of February.

### *Things To Keep In Mind:*
- **Sound is the most important part of any video**. If we can't hear you, we can't judge your video!
- **Make a schedule** and "cast list" for your video shoot. What day will you write the script? Make the costumes? Set up the scenery? When will you practice? Who will be the cameraperson? Who will interview you?
- When shooting your video, **make sure the camera isn't too far away**. Look at the **ScienceMakers website** for good examples of a close-up face shot.
- **Test out your equipment** before shooting.
- **Edit the video once you have completed videotaping with the Flip camera.** Note: Some videos do not require editing. **Special effects and animation are welcome**, if you have experience with them, but don't go overboard! Make sure that the special effects don't overpower the scientific and biographical content of your video.
- **Pay attention to lighting**. If we can't see you, we can't judge you, either! Don't shoot your video into a light source or in front of windows.
- **We invite background music**, but it should not be so loud or distracting that it detracts from the content of your video. Background music must be appropriate—no curse words or otherwise inappropriate language is permitted, from the contestant or from the background music.
- **Film at eye level**, unless you have a special effect in mind (like filming birds up in a tree).
- **Take your time!** Remember, this video will be on YouTube for the entire world to see.



### *Terms & Conditions:*
1. By participating, contestants agree to the ScienceMakers YouTube Oral History Contest Guidelines described in this document.

2. The HistoryMakers acquires the rights to use all submitted videos for promotional purposes, including, but not limited to, such mediums as the Internet, printed or electronic marketing materials, and DVDs for sale. No royalties will be paid to the video creators on proceeds of DVD sales; however, video creators retain their rights to use, distribute and sell and their own videos without restrictions. Winning contestants will be asked to sign a waiver regarding these terms.

3. Void outside of the United States and where prohibited, taxed, or restricted by law. All federal, state, and local laws and regulations apply.

4. Videos must not contain identifying information about any person, including the entrant. Identifying information includes last name, phone number, address or email.

5. Each contestant may only submit one (1) video.

6. Winners failing to respond in a timely manner to notification of winning, or who fail to sign the waiver in a timely manner, will forfeit their prize. If a prize is forfeited, the judges will choose an alternate winner.

7. Contestants must only submit their own original work; videos must not violate copyright or in-

tellectual property rights. Videos must also not be inappropriate, defamatory or libelous.

8. Contestants agree to indemnify and hold The HistoryMakers, its assigns and licensees harmless from and against any and all third party claims, actions or proceedings of any kind and from any and all damages, liabilities, costs, and expenses relating to or arising out of any breach or alleged breach of any of the warranties, representations, or agreements of contestants hereunder.

9. By participating in this contest, winners irrevocably grant The HistoryMakers, its assigns and licensees the right to use such winner's name, likeness, biographical information, and video in any and all media for any purpose, including without limitation, advertising and/or promotional purposes as well as in, on or in connection with The HistoryMakers' website or other promotions, throughout the universe, in perpetuity, by means of any and all media and device whether now known or hereafter devised and hereby release The HistoryMakers from any liability with respect thereto.

### *YouTube Conditions:*

1. As a YouTube account holder you may submit Content to the Service, including videos and user comments. You understand that YouTube does not guarantee any confidentiality with respect to any Content you submit.

2. You shall be solely responsible for your own Content and the consequences of submitting and publishing your Content on the Service. You affirm, represent, and warrant that you own or have the necessary licenses, rights, consents, and permissions to publish Content you submit; and you license to YouTube all patent, trademark, trade secret, copyright or other proprietary rights in and to such Content for publication on the Service pursuant to these Terms of Service.

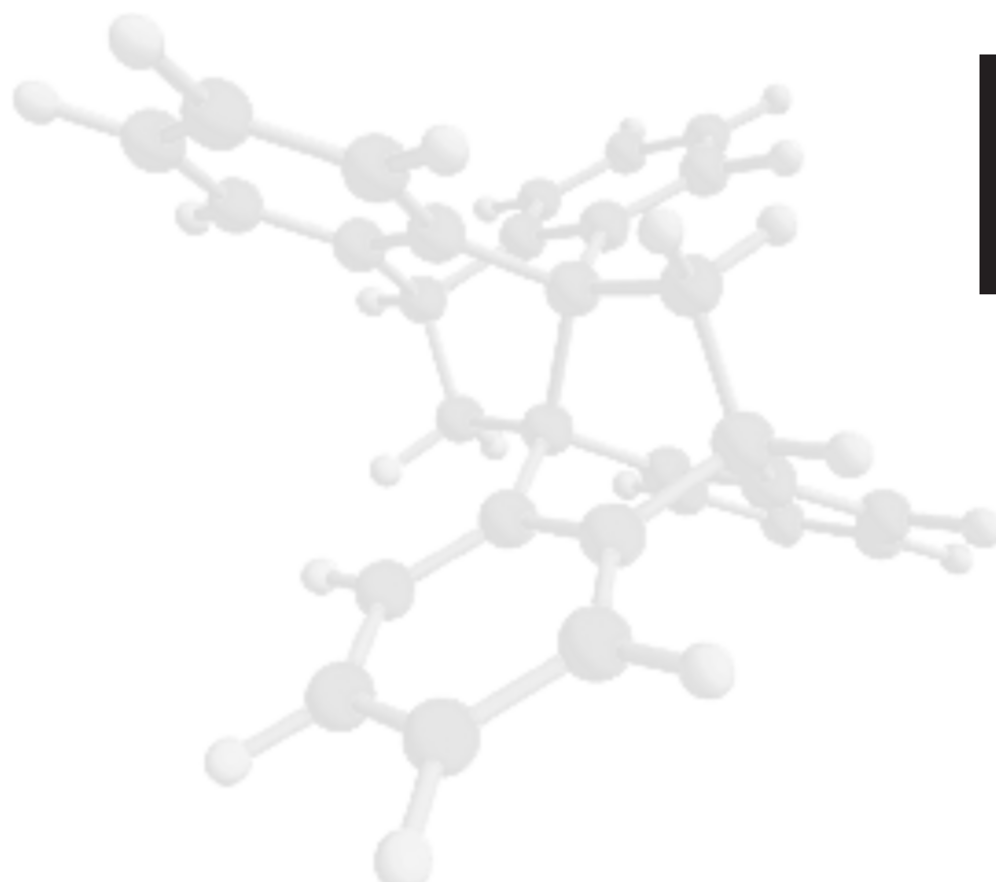
3. For clarity, you retain all of your ownership rights in your Content. However, by submitting Content to YouTube, you hereby grant YouTube a worldwide, non-exclusive, royalty-free, sublicenseable and transferable license to use, reproduce, distribute, prepare derivative works of, display, and perform the Content in connection with the Service and YouTube's (and its successors' and affiliates') business, including without limitation for promoting and redistributing part or all of the Service (and derivative works thereof) in any media formats and through any media channels. You also hereby grant each user of the Service a non-exclusive license to access your Content through the Service, and to use, reproduce, distribute, display and perform such Content as permitted through the functionality of the Service and under these Terms of Service. The above licenses granted by you in video Content you submit to the Service terminate within a commercially reasonable time after you remove or delete your videos from the Service. You understand and agree, however, that YouTube may retain, but not display, distribute, or perform, server copies of your videos that have been removed or deleted. The above licenses granted by you in user comments you submit are perpetual and irrevocable.

4. You further agree that Content you submit to the Service will not contain third party copyrighted material, or material that is subject to other third party proprietary rights, unless you have permission from the rightful owner of the material or you are otherwise legally entitled to post the material and to grant YouTube all of the license rights granted herein.

5. You further agree that you will not submit to the Service any Content or other material that is contrary to the YouTube Community Guidelines, currently found at http://www.youtube.com/t/community_guidelines, which may be updated from time to time, or contrary to applicable

local, national, and international laws and regulations.

6. YouTube does not endorse any Content submitted to the Service by any user or other licensor, or any opinion, recommendation, or advice expressed therein, and YouTube expressly disclaims any and all liability in connection with Content. YouTube does not permit copyright infringing activities and infringement of intellectual property rights on the Service, and YouTube will remove all Content if properly notified that such Content infringes on another’s intellectual property rights. YouTube reserves the right to remove Content without prior notice.



# *The HistoryMakers® ScienceMakers Toolkit*

# *Media Guide*

Publicizing and spreading the word about the *ScienceMakers* project and your involvement is important! The mission of *ScienceMakers* is to

- Expose the public to successful African Americans in a variety of Science, Technology, Engineering, and Mathematics (**STEM**) related careers as role models
- Increase awareness of STEM concepts and career opportunities, and
- Cultivate a lifelong interest in science and the STEM professions.

This media guide was created to help us spread the word.

**ScienceMakers**

Warren Washington
Atmospheric Scientist

Larry Gladney
Physicist

Shirley Ann Jackson
Physicist

## *About Us*

***ScienceMakers*** is an innovative African American media and education initiative focused on capturing and preserving the life and career stories of African Americans in the STEM professions. With your assistance, *ScienceMakers* will disseminate these stories broadly to youth, public and professional audiences using the internet (www.thehistorymakers.com), a unique digital video oral history archive (www.idvl.org/thehistorymakers), public programs, exhibits, radio, TV, print and other technologies. Over a three year period, *ScienceMakers* will become the largest collection of video oral interviews of African American scientists, resulting in an educational career and media resource for teachers, parents, students and the world at large.

**The HistoryMakers** is the single largest archival collection of its kind in the world. Our goal is to complete 5,000 interviews of both well-known and unsung African American HistoryMakers. In doing so, we want to include the stories of individual African Americans along with those of African American organizations, events, movements and periods of time that are significant to the African American community. We have completed interviews in over 80 U.S. cities and towns. Our collection houses 7,000 hours of African American testimony on videotape. The only prior methodic and wide-scale attempt to capture the testimonies of African Americans occurred in the 1930s with the recording of former slaves as a project of the Works Projects Administration (WPA). From 1936-1938, teams of writers/researchers were sent throughout the South resulting in approximately 2,300 hand-recorded interviews and some audio taped interviews. *The HistoryMakers* is the largest methodic and wide-scale collection effort since the WPA Slave Narratives Project. ScienceMakers is a project of The HistoryMakers funded by the National Science

**ScienceMakers**

Herman White
Physicist

George Carruthers
Astrophysicist

Foundation.

## *Why Advocate for ScienceMakers*

**The Need for African American Scientists**
The United States' economy depends on a strong corps of scientists and engineers, but only a small percentage of young people consider science a viable and interesting career choice. African Americans are especially underrepresented in the STEM professions.  While African Americans represent 13.4% of the U.S. population (census, May 2006), they comprise only 6.9% of our nation's STEM workforce according to the most recent NSF's Science Indicators Report (2006). In order to increase the number of African Americans, women and other minorities in the STEM professions, it is important to highlight the contributions of African American scientists as inspiring examples.

**Encouraging Youth Participation in the Sciences**
While more educational and career opportunities are open to African American youth than ever before, the most current research shows that these youth are not as prepared to enter the STEM workforce as youth from other ethnic groups. African Americans show lower high school graduation rates than the overall population, score lower on science and math achievement tests, and enroll at lower rates in AP science and math courses in high school (NSF, 2006; NAEP, 2006). The lower academic achievement of African American students and their subsequent underrepresentation in STEM professions has its roots, in part, in formal and informal learning environments, the perceptions of science as "not cool" and the "lack of appropriate role models".

Many successful STEM professionals in our collection cite an inspirational teacher, television show or even a chemistry set as the motivation for pursuing a career in the sciences. The ScienceMakers Toolkit will serve as a flexible and useful resource for teachers, science center educators and afterschool programs for helping their students catch the "science bug."

## *Getting the Word Out*

Publicizing and spreading the word about your institution's collaboration with the *ScienceMakers* project is a means of improving science education for African American students around the nation and for making others aware of the contributions of African American scientists.

**Afterschool Programs**
Many after school programs require direct contact with a group leader.  You can communicate with these types of groups through:

- E-mails
- Letters
- Telephone calls
- Meetings
- Personal visits

BOYS & GIRLS CLUBS OF AMERICA

Girl Scouts.

Before you begin any communication, prepare yourself with talking points. During the conversation, identify yourself and your connection with *ScienceMakers*. A sample description of the program is as follows:

> *ScienceMakers is intended to provide a greater understanding, interest and appreciation in the lives of those African Americans who have contributed to the field of science. Through video oral history recordings, public programs, and the ScienceMakers Toolkit the initiative seeks to reach a very wide audience. To achieve the ScienceMakers' goals, The HistoryMakers is working in cooperation with the American Association for the Advancement of Science (AAAS), ten science and technology museums, K-12 schools, colleges and universities, churches and community groups.*

After the conversation, follow-up with an email or letter and thank the group for their time.

## *The Media: Print, Radio, and TV*

Before reaching out to the media, know your organization's policy on talking to the press. Local media is a good target for press outreach.

Consider:
- Who are the major media players in your state?
- Who are the major media players in your city/town?
- Who owns these media?
- Who is your public broadcaster?
- What media outlets are most likely to run stories on K-12 education and innovative teaching methods?
- Who is of note in the social media network (i.e. Facebook, Twitter) including your own institute?

Some ideas for angles for media stories include:
- Human interest (the teacher behind the Toolkit)
- Community activity (involving school children in the *ScienceMakers* YouTube Oral History Contest)
- Event (*ScienceMakers* public program)

Print, general market, radio and television outlets to target include:
- African American-owned media
- Media with a focus on education
- Media with a focus on science

**What Media Coverage On the ScienceMakers Toolkit Can Do For You**
- Educate your local community about the ScienceMakers Toolkit
- Showcase your program as a model for other organizations
- Increase the credibility of your organization
- Help create a community of support with individuals, funders, taxpayers, etc.

**Working With the Media**
When working with journalists, it is important to be prepared ahead of time with your contact information and to have accurate information readily available as they are often working on tight deadlines. Make contact with a representative to find out what they are interested in. It is a good idea to offer them exclusive stories and help them relate your story to nationally-covered news. By building up a relationship and becoming familiar with your local media outlets as well as national and STEM-related publications, you will be better able to know what kind of stories they cover and how you can fit in.

One staff member should be designated to talk to the media and keep a log of any contact with the media. They should also be available for media calls and have a back-up spokesperson in case they are away.

Always follow-up with the media after sending a release. *However, do not be a nuisance*. Make sure the person you talk to on the phone knows that you sent a release, and ask about who to contact for more information. If your story is covered, make sure to check for inaccuracies and thank them for their time. The important thing is building a relationship with the press.

**Dos and Don'ts For the Media**

Do:

- Ask how to help media reporters
- Be available to speak for their stories, whether or not they are necessarily your story
- Make contact when you have good stories
- Offer a specific media outlet an exclusive

Don't:

- Pester the media
- Send too many stories in too short a time period
- Make public or private complaints regarding the media

**What Makes A Good ScienceMakers Story For the Media**

- The real-life story appeals to emotions, like about how ScienceMakers is encouraging youth to enter STEM fields.
- The story has a point, like underserved communities have found a tool to introduce STEM topics to students.
- The story details people rather than organizations, like individual afterschool leaders who have used the ScienceMakers Toolkit and found success
- The people identified in the story are willing to be interviewed, like the science center leader who helped arrange the public program and saw the benefit reaped by the audience.

Media Guide

**Media Releases/Media Advisories**

These should be approved by a director and include a specific contact person who will respond to inquiries and be able to answer questions about the organization or any event being held. When talking to media it is important to receive:

- The person's name
- The media outlet
- Contact information
- Deadline

These are suggested types of releases that can be used to promote your work with *ScienceMakers*.

- News Releases (time sensitive or current events)
- Feature Releases (human interest)
- Media Advisory (to invite the media to your event)
- Captioned photo

**Tips for Writing a Press Release**

- Format
  - o The header should include contact information with name, phone, and email as well as the date and "For Immediate Release."
  - o Keep it to one page.
  - o If you do use a second page, write "More" at the bottom of the first page and put all the contact information at the top of the second page as well.
  - o Put the most interesting information at the top and include a "boilerplate" (a short summary of your organization and ScienceMakers) at the bottom.
  - o Use 1.5 line spacing and 10-12pt. font.
  - o Use short paragraphs and put quotes in different paragraphs.
  - o At the end of the release, write ### to signal the end of the release.
- Style
  - o Use the active voice.
  - o Do not exaggerate your story.
  - o Spell out acronyms the first time they are used.
  - o Start with an interesting lead! It must attract the audience and compel them to keep reading.
  - o Tie in people and organizations.

This media guide also contains a sample press release (see end).

## *The Internet*

**Blogging**

An effective blog draws the reader in and offers insightful, humorous, or otherwise interesting commentary. The key components for a good blog about *ScienceMakers* include:

- Catchy title
- Example of how the *ScienceMakers* Toolkit is used
- What students learned from using the *ScienceMakers* program
- Benefit to user

For example, a blog might read:

***Making Science with ScienceMakers***

At 350 pages of African American scientists, the *ScienceMakers* Toolkit is no ordinary piece of curriculum. Inside the Toolkit, 73 scientists are classified by their Science, Technology, Engineering, or Mathematics (STEM) discipline and have their vitals (birth date, place of birth) as well as a brief biography describing how they achieved their prominent career position.

Sounds like a great resource? Yes. Makes for great teaching? Absolutely. The Toolkit, with its photos of everyday objects relating to science, makes it easy to introduce a new topic like chemistry to students with no previous experience. How do you interest students in the phases of matter? Show them how to make dry ice lemonade! What's the use of organic chemistry? Explain how chemists working at companies like the Glycotechnology Research Institute, including Dr. Bertram Fraser-Reid, use chemical reactions to change sugar into different compounds!

The *ScienceMakers* Toolkit brings both science and STEM careers to life using relatable first person stories from African American scientists. The *ScienceMakers* Toolkit is a must have for any place that claims to be a resource for students to learn more about what STEM career opportunities await them outside the classroom.

For more information, please contact The HistoryMakers at info@thehistorymakers.com or visit the website at http://www.thehistorymakers.com.

**Web 2.0 Tools**

The more concise the message, the better. Twitter and Facebook are designed to post short messages with links to more information. The ScienceMakers social networks include:

- Twitter
  - http://twitter.com/ScienceMakers
- Facebook
  - ScienceMakers2010
- YouTube
  - http://youtube.com/user/ScienceMakers1
- TeachAde
  - http://www.teachade.com/viewGroup.do?groupId=882

On **Twitter**, #hashtags are used to indicate a topic. For example, if a tweet read:

*ScienceMakers Toolkit on TeachAde! http://bit.ly/23c8 #ScienceMakers*

The hashtag might say #ScienceMakers, #TheHistoryMakers, or even #NSF. That way, if someone searches for 'ScienceMakers' as a topic, on Twitter or Google, they can see all the tweets that have been labeled under ScienceMakers. Popular hashtags are listed on the Twitter sidebar which follows the trending of different topics.

Tweeting "at" (@) someone is a useful way to get someone's attention or to link someone to another person. For example, the same tweet could also read:

*@TheHstryMakers @ScienceMakers Toolkit on TeachAde! http://bit.ly23c8*

This would indicate to both The HistoryMakers Twitter account and the ScienceMakers Twitter account that someone has mentioned them on Twitter. Likely, both TheHstryMakers and ScienceMakers account would then re-tweet that sentence to their own followers, giving both you and ScienceMakers more promotion! That tweet would read:

*RT @ScienceMakers Toolkit on TeachAde! http://bit.ly23c8*

'RT' stands for 're-tweet.' Re-tweets, @ mentions, and hashtags are important ways to gain visibility on a continually updated network like Twitter.

On **Facebook**, an update might consist of what a user is doing.  If you are using the ScienceMakers Toolkit, the message could consist of:

> *USERNAME is teaching students about Dr. Kennedy Reed with the ScienceMakers Toolkit!*

Other users can then 'like' this status or comment about the use of the Toolkit.

### *Tell Us What You Think*

We welcome your feedback!  If you have suggestions or questions about this media guide please contact us by emailing info@thehistorymakers.com.

The HistoryMakers®

CONTACT:
Your name / Organization
Phone
Email

DATE - FOR IMMEDIATE RELEASE

***[YOUR GROUP] PARTNERS WITH SCIENCEMAKERS FOR GREAT SUCCESS:***
*THE HISTORYMAKERS LEADS THE WAY IN INTERVIEWING NATION'S TOP AFRICAN AMERICAN SCIENTISTS*

**CITY, STATE – YOUR GROUP** is making a big bang of its own by showing students role models in science through *The HistoryMakers ScienceMakers* initiative. *ScienceMakers: An Innovative African American Media and Educational Initiative* is the result of a $2.3 million National Science Foundation (NSF) grant awarded to *The HistoryMakers*.

"The *ScienceMakers* initiative," said Julieanna Richardson, *The HistoryMakers* Founder & Executive Director, "is really about education, which is our core mission as an organization. Science needs to be more accessible to youth, more visible mentors are needed to encourage involvement in the sciences and more resources are needed to support the industry. With our *ScienceMakers* initiative, we are working to address those needs while ensuring that the contributions of African American scientists are not overlooked."

**YOUR GROUP** is **(using the ScienceMakers Toolkit/collaborating on a ScienceMakers public program/participating in the ScienceMakers Oral History YouTube Contest)** and working with ScienceMakers to teach youth and adults about the accomplishments of African Americans in science as well as the career opportunities available to students and how they can achieve those positions to eventually become a ScienceMaker themselves! **(Insert details of your group's specific activities here.)**

The *ScienceMakers* Toolkit, which offers training materials and teaching aids, will be distributed to schools, science centers and individuals free of charge both at the public program and year round. The public program will teach students how to conduct an oral history and give both students and adults the chance to ask questions of science, technology, engineering, and mathematics (STEM) professionals. The ScienceMakers YouTube Oral History Contest asks students to emulate an existing ScienceMaker or envision themselves as a ScienceMaker in the future and made a short video about their life to win cash and other cool prizes! Some ScienceMakers include Neil deGrasse Tyson, astrophysicist; Julius Taylor, physicist; Mark Dean, computer scientist; and Lisa Jackson, chemical engineer.

*The HistoryMakers* is a national 501(c)(3) non-profit research and educational institution dedicated to recording and preserving the personal histories of well-known and unsung African Americans. The goal is to create an archive of 5,000 interviews (30,000 hours) of professionally recorded video – creating a one-of-a–kind digital archive and a priceless educational resource. Currently, the archive houses 1,957 biographies, or 200 days worth of video footage documenting narratives and historical movements. The ScienceMakers initiative will conduct interviews with 180 notable African American scientists in the STEM professions. For more information, visit The HistoryMakers website at www.thehistorymakers.com or its digital archive with over 300 interviews at www.idvl.org/thehistorymakers.

# # #

1900 SOUTH MICHIGAN AVENUE CHICAGO ILLINOIS 60616 312.674.1900 fax 312.674.1915

12.011 *The HistoryMakers® ScienceMakers Toolkit*

# *Online Resources*

oxygen 8

Listed below are internet resources featuring games, curriculum and other ways to get students interested in STEM disciplines and careers. These sites were recommended by scientists themselves and informal science educators.

## *The HistoryMakers*

http://www.thehistorymakers.com

*The HistoryMakers* is the largest archive of videotaped African American oral histories in the United States. The organization's homepage provides links to biographies of the HistoryMakers who have been interviewed as well as updates about events and programs involving *The HistoryMakers*.


## *The HistoryMakers Digital Archive*

http://idvl.org/thehistorymakers

The archive holds 18,000 stories from 400 historically significant African Americans including seven ScienceMakers. The Digital Archive will be continually updated with the over 2,000 African Americans who have been interviewed.

## Science Buddies

http://www.sciencebuddies.org

Science Buddies has over 1000 project ideas in all areas of science. Each project includes vocabulary, questions, and other places to find more information. They also have a Topic Selection Wizard which helps students find projects uniquely suited to their interests. You can find several of their projects and experiments throughout this ScienceMakers Toolkit.


## Computer Science Unplugged

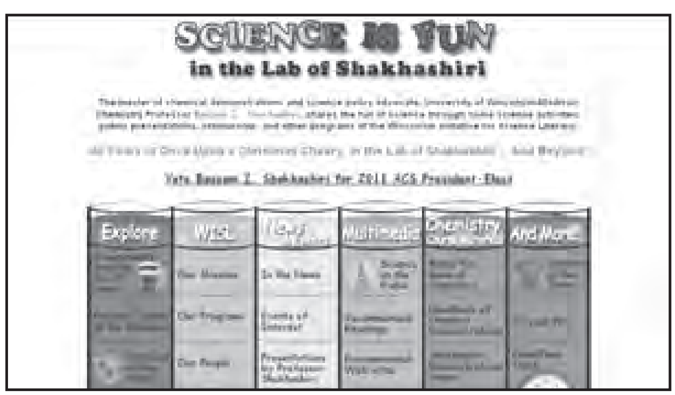
http://www.csunplugged.org

CS Unplugged features a forum as well as many other activities relating to computer science that can be completed without a computer. This is a great resource for younger students. The activities within the computer science section of this ScienceMakers Toolkit are from CS Unplugged.


## SciFun

http://www.scifun.org

SciFun is a Chemistry professor's own webpage sharing experiments that are easy to perform in the home or classroom.




Online Resources

## Science Net Links

http://www.sciencenetlinks.com

Science Net Links houses numerous lesson plans separated by grade level along with science activities and benchmarks from the federal "Race to the Top" Common Core initiative.


## Illuminations

http://illuminations.nctm.org

Illuminations is a collection of 104 online activities relating to mathematics as well as 560 lessons for preK-12 students.  They house several other links to good resources for teaching mathematics.


## Science Magazine

http://www.sciencemag.org

The premier science magazine holds career profile articles as well as a Science Careers Forum and MySciNet, "a place for scientists and students from diverse backgrounds to network and build the personal and professional connections needed to succeed in the sciences."

## *Cool Science*

http://www.hhmi.org/coolscience

Cool Science contains online virtual labs like 'The Immunology Lab,' 'The Neurophysiology Lab,' and 'The Transgenic Fly Virtual Lab.' The site also includes a virtual museum so students can see various topics from neuroscience, biology, etc.


## *BEN Portal*

http://www.biosciednet.org

BEN Portal has a wealth of education resources from BEN Collaborators managed by the AAAS. There are over 15,600 resources in 77 biology topics.


## *Middle School Teacher Portal*

http://www.msteacher2.org

MSP2 is a collection of standards-based resources in science and mathematics. It encourages collaboration between users and the sharing of resources.

## ***SMILE***

http://howtosmile.org

How To Smile is a resource based on a partnership among science and technology centers, museums, community-based organizations, and out-of-school educators.  The site contains interactive games like a roller coaster and weather waves.


## ***Compadre***

http://www.compadre.org

Compadre is a network of free online resource collections for Physics and Astronomy.