ScienceMakers DVD Toolkit Table of Contents

ScienceMakers DVD Toolkit Table of Contents 1
Index by Experiment 2-3
Introduction/How To Use this Guide 4-5
Spotlights
- Chemistry 6-41
  - Albert Antoine 6-10
  - Ralph Gardner-Chavis 11-17
  - William Lester, Jr. 18-25
  - Samuel Massie 26-30
  - Isiah M. Warner 31-36
  - Bobby L. Wilson 37-41
- Earth Science 42-54
  - Waverly Person 42-48
  - Warren M. Washington 49-54
- Life Sciences 55-130
  - Joanne Berger-Sweeney 55-58
  - Wayne Bowen 59-62
  - James Bowman 63-71
  - Edwin Cooper 72-75
  - S. Allen Counter 76-84
  - Sheila Grimes 85-91
  - Erich Jarvis 92-95
  - George Jones 96-98
  - Shawna Nesbitt 99-102
  - Roderic Pettigrew 103-106
  - Cecil Pickett 107-111
  - Welton Taylor 112-119
  - John Watson 120-124
  - Luther S. Williams 125-130
- Engineering 131-144
  - Alfred Brothers, Jr. 131-136
  - John D. Terry 137-144
- Physics 145-149
  - Clayton Bates, Jr. 145-149
  - George Campbell, Jr. 150-155
  - Darnell Diggs 156-160
  - Julian Earls 161-167
  - Larry Gladney 168-175
  - Shirley Ann Jackson 176-181
  - Walter Massey 182-188
  - Ronald E. Mickens 189-195
  - Carl Spight 196-202
  - Herman White 203-210

YouTube Contest 211-214
Media Guide 215-218
Oral History Guidelines 219-220
National Science Standards Alignment 221-228

Index of Experiments

You will notice that although each Spotlight has a specific experiment, there is a significant amount of overlap between scientific fields, and therefore experiment possibilities. The following index should prove useful. The DVD Toolkit is designed so that you can easily swap out experiments as you see fit. For example, feel free to use the “Make a Linear Accelerator” experiment instead of the “Universe Game” experiment when studying Dr. Shirley Ann Jackson. There are two version here – one by experiment, one by field.

	Experiment	Last Name	First Name	Field
1	Air Cannon	Campbell	George, Jr.	Physicist
2	Amazing Brain	Berger-Sweeney	Joanne	Neurobiologist
3	Bernoulli's Principle	Washington	Warren M.	Atmospheric Scientist
4	Blood Typing	Watson	John	Biology/Biochemist
5	Cabbage Chemistry	Warner	Isiah M.	Chemist (Analytical Chemist)
6	Can You Feel The Difference?	Jarvis	Erich	Neurobiologist
7	Candy Chromatography	Lester	William, Jr.	Chemist (Computational Chemist)
8	Collapsing Can	Diggs	Darnell	Physicist
9	Digestion Investigation	Grimes	Sheila	Veterinary Pathologist
10	Electric Motor	Terry	John D.	Electrical Engineer
11	Exploring With Sound	Pettigrew	Roderic	Radiologist
12	Floating & Sinking	White	Herman	Physicist (Particle Physics)
13	Floating Soap Bubbles	Massie	Samuel	Chemist (Organic Chemist)
14	Flying Tube	Brothers	Alfred, Jr.	Engineer (Aeronautical Engineer)
15	Gas Exchange	Pickett	Cecil	Biologist
16	Genetics: The Easy Way	Bowman	James	Geneticist and Pathologist
17	Big O’ Glass of Sunset	Bates	Clayton, Jr.	Physicist and Electrical Engineer
18	It All Starts With Cells	Williams	Luther S.	Biologist/Microbiology
19	Layered Liquids	Gardner-Chavis	Ralph	Chemist
20	Linear Accelerator	Gladney	Larry	Physicist (Particle Physics)
21	Liquefaction	Person	Waverly	Geophysicist and Seismologist
22	Liquid Fireworks	Wilson	Bobby L.	Chemist (Environmental Chemist)
23	Mapping the Homonculus	Counter	S. Allen	Neurophysiologist
24	Mentos Rocket	Antoine	Albert	Chemist
25	Pop Can Hero	Spight	Carl	Physicist
26	Reducing Risk	Cooper	Edwin	Immunobiologist
27	Rocket Balls	Earls	Julian	Physicist
28	See Your Own DNA	Jones	George	Biology/Biochemist
29	Sense of Touch	Bowen	Wayne	Neurobiologist
30	Singing Rod	Mickens	Ronald E.	Physicist and Mathematician
31	Sound Mediums	Massey	Walter	Physicist
32	Travel The Path	Nesbitt	Shawna	Cardiologist
33	Universe Game	Jackson	Shirley Ann	Physicist (Particle Physics)
34	You Make Me Sick	Taylor	Welton	Bacteriologist

Index of Experiments by Scientific Field

-	Field	Experiment	Last Name	First Name
1	Atmospheric Scientist	Bernoulli's Principle	Washington	Warren M.
2	Bacteriologist	You Make Me Sick	Taylor	Welton
3	Biologist	Gas Exchange	Pickett	Cecil
4	Biologist/Microbiology	It All Starts With Cells	Williams	Luther S.
5	Biology/Biochemist	Blood Typing	Watson	John
6	Biology/Biochemist	See Your Own DNA	Jones	George
7	Cardiologist	Travel The Path	Nesbitt	Shawna
8	Chemist	Layered Liquids	Gardner-Chavis	Ralph
9	Chemist	Mentos Rocket	Antoine	Albert
10	Chemist (Analytical Chemist)	Cabbage Chemistry	Warner	Isiah M.
11	Chemist (Computational Chemist)	Candy Chromatography	Lester	William, Jr.
12	Chemist (Environmental Chemist)	Liquid Fireworks	Wilson	Bobby L.
13	Chemist (Organic Chemist)	Floating Soap Bubbles	Massie	Samuel
14	Electrical Engineer	Electric Motor	Terry	John D.
15	Engineer (Aeronautical Engineer)	Flying Tube	Brothers	Alfred, Jr.
16	Geneticist and Pathologist	Genetics: The Easy Way	Bowman	James
17	Geophysicist and Seismologist	Liquefaction	Person	Waverly
18	Immunobiologist	Reducing Risk	Cooper	Edwin
19	Neurobiologist	Amazing Brain	Berger-Sweeney	Joanne
20	Neurobiologist	Can You Feel The Difference	Jarvis	Erich
21	Neurobiologist	Sense of Touch	Bowen	Wayne
22	Neurophysiologist	Mapping the Homonculus	Counter	S. Allen
23	Physicist	Air Cannon	Campbell	George, Jr.
24	Physicist	Collapsing Can	Diggs	Darnell
25	Physicist	Pop Can Hero	Spight	Carl
26	Physicist	Rocket Balls	Earls	Julian
27	Physicist	Sound Mediums	Massey	Walter
28	Physicist (Particle Physics)	Floating & Sinking	White	Herman
29	Physicist (Particle Physics)	Linear Accelerator	Gladney	Larry
30	Physicist (Particle Physics)	Universe Game	Jackson	Shirley Ann
31	Physicist and Electrical Engineer	Big O' Glass of Sunset	Bates	Clayton, Jr.
32	Physicist and Mathematician	Singing Rod	Mickens	Ronald E.
33	Radiologist	Exploring With Sound	Pettigrew	Roderic
34	Veterinary Pathologist	Digestion Investigation	Grimes	Sheila

Introduction – How To Use This Guide

This guide is a toolkit. Like any good toolkit, it has multiple tools within it. It is designed to be as flexible as possible. The instructor should be able to mix and match the tools to fit his or her individual lesson plans. Let's look at the individual components of the package.

There are 34 ScienceMakers in total. Each ScienceMaker has a Spotlight page within this guide. Each Spotlight page contains:

- Biography Table
- Biography of the ScienceMaker
- Discussion Questions
- Experiment
- Transcripts of the Clips

The Biography Table appears in two places: the menu of the DVD and the beginning of the Spotlight page. It is designed to provide a handy reference guide to the basic biographical information of each ScienceMaker. Some of the discussion questions directly relate to the biography table. For example, students could complete an activity in which they map all the ScienceMakers' birthplaces and how far each is from their home location. Another activity could involve putting each ScienceMaker's educational path on a map.

The Discussion Questions have been broken into two categories. The first set is related to the ScienceMaker's personal life. You will notice that several questions are repeated for each ScienceMaker; this allows for an activity combining multiple ScienceMakers and their lives. The other set of questions relates to the ScienceMaker's field of study. Again, some of the questions are similar for each ScienceMaker; these are designed to be concept-mapping questions. In other words, these questions are designed to provide a baseline knowledge before delving into the material. For example, when asked "what do you think a physicist does?" or "if you were a physicist, what questions would you study?" this provides context for the rest of the discussion. These questions allow you, the instructor, to evaluate both preexisting knowledge and knowledge gained from the discussion.

The Discussion Questions are designed to use the interview clips as a springboard into the subject matter. For example, students should be able to answer the first part of every question by watching the interview clip. The subsequent questions expand the discussion past the interview clips to the larger context surrounding the ScienceMaker, which is then applied to the students, their lives, and their futures. Some questions are designed for older students to research a particular topic, then return to the class and report. Not all questions will be appropriate for every student, nor will every experiment work well for every grade level. Rather, the Toolkit is designed so that you can easily swap components, add your own questions, or take the discussion in an entirely different direction.

The Experiment on each ScienceMaker's Spotlight page is related to his or her field of study, and it is designed to reinforce the interview and discussion portions of the lesson. In order to be as flexible as possible, any of these components can be combined with components from other Spotlight pages. Feel free to use experiments from one ScienceMaker in conjunction with another. You will notice an overlap in some fields, such as particle physics or neurobiology; to illustrate these overlaps/connections there is an Index by Experiment at the front of the Toolkit.

The Transcripts of each interview clip are provided as a reference guide for use when viewing each ScienceMaker's interview. In addition, short biographies of each ScienceMaker have also been provided.

Your Toolkit includes instructions and ideas for the YouTube contest and a Media Guide to help you publicize your use of this curriculum. Additionally, a set of Oral History Guidelines has been provided to assist you and your students. Finally, a list of educational standards from the national level has been included for your convenience. The DVD itself contains interview clips from most of the ScienceMakers. For those ScienceMakers who have not yet been interviewed, additional reading links are contained on the Spotlight page.

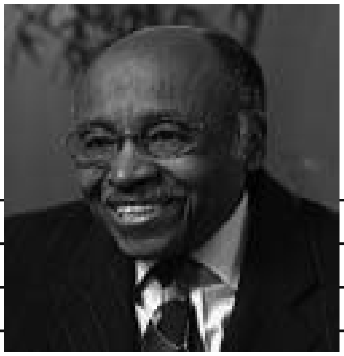
This DVD utilizes DVD@cess to allow users to access DVD-ROM content from the DVD video menus when playing the video on a computer-based DVD player. This feature is only available after installing the DVD@cess program. To install DVD@ccess:

1. Open the DVD file contents through your computer.
2. Open the DVD@ccess folder.
3. Double click on the DVD@ccess installer.
4. Follow the prompts until finished.

The additional materials can also be accessed by using the DVD as a data DVD. Simply open the DVD and then open the “written materials.pdf” file from the list of file contents on the DVD.

ScienceMakers

Spotlight: Albert Antoine



Full Name:	Albert Cornelius Antoine
Born:	January 14, 1925
Place:	New York, NY
Parents:	Wilhelmina M. Antoine
	Emmanuel E. Antoine
Spouse:	June Antoine
Education:	Townsend Harris High School - New York, NY (1941)
	City College of New York - New York, NY (B.S. Chemistry, 1945)
	Ohio State University - Columbus, OH (Ph.D. Chemistry, 1953)
Type of Science:	Chemistry
Achievements:	Research on jet and rocket propulsion for NASA
	Research on alternate fuel sources to oil

Favorites:

Color:	Purple
Food:	Grapefruit in the Morning
Time of Year:	Spring

Biography

Scientist and educator Dr. Albert Cornelius Antoine was born in New York, New York, on January 14, 1925, to Wilhelmina M. and Emmanuel E. Antoine, both of whom were natives of the British West Indies. Antoine received his elementary and secondary school education in the New York Public Schools, having attended P.S. 184 / Cooper Junior High School and Townsend Harris High School, where he earned his high school diploma in 1941. Antoine went on to earn his B.S. degree from the City College of New York and his Ph.D. in chemistry from Ohio State University. Before earning his Ph.D., Antoine was drafted into the U.S. Army in 1944 where he was trained in the Army Specialized Training Program, taking courses in civil engineering.

After his time in the Army ended, Antoine taught chemistry at the post-secondary level at Clark College in Atlanta, Georgia, during the 1953 – 1954 school year, and later taught at Cleveland State University from 1963 until 1970. From 1954 until 1983, Antoine was employed at the NASA Lewis Research Center in Cleveland, Ohio. His duties included research on jet and rocket propulsion, alternative fuels, energy research, project management and technical management for contracts and grants. From 1983 to 1996, Antoine was Senior Research Associate (College of Engineering) for Cleveland State University at NASA Lewis Research Center.

Antoine was featured in Black Contributions to the Engineering and Science Fields at the NASA Lewis Research Center, "Blacks in Science: Astrophysicist to Zoologist" by Hattie Carwell and American Men of Science. Over the course of his career, Antoine's professional activities included service on intergovernmental technical review and technical evaluating committees, membership in the American Chemical Society, and publishing and lecturing on his research.

Antoine also worked with many public service and nonprofit organizations, including the Cleveland International Program, the Council for Careers in Science, the Rotary Club and Creative Writing Workshop Projects, which was founded by his wife, June Sallee Antoine.

Discussion Questions

Personal:

1. What did you like best about listening to Dr. Antoine?

2. Where was Dr. Antoine 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. Antoine attend high school? What do you suppose high school was like for him?

3. How old are you? In what year was Dr. Antoine your age? What was happening in the country that year? What was happening in the world that year? What do you suppose his life was like when he was your age?

4. Dr. Antoine talks about his early interest in chemistry and physics. What was it that he liked? What are some of your favorite subjects? Why? What are some of your least favorite subjects? Why? **(See Clip #1)**

5. Did Dr. Antoine always know what he wanted to do as a career? What did most people expect him to become with his chemistry studies? Why did he study chemistry? Is there a specific career path that people you know expect you to follow? Do you know what you want to do for your career? What do you think you need to do to prepare for that career? **(See Clip #1)**

6. Dr. Antoine has an interesting story about segregation. What is it? Can you imagine what life was like back then? How have things changed? How have things stayed the same? **(See Clip #2)**

7. Dr. Antoine talks about his work at NACA. How does this relate to NASA? How did Dr. Antoine contribute to the space program? **(See Clip #3)**

Science:

8. What do you think a chemist does? Would you like to be a chemist? Why?

9. If you were a chemist, what kinds of questions would you study?

10. Dr. Antoine did much of his work in fuel research for jet engines. He talks about the efficiency of a fuel. What do you think he means by this? Can you think of other places where you have heard about fuel efficiency? How does fuel efficiency affect your life? How do you think it will affect your life in ten years? What kinds of things could you study to work in that field? **(See Clip #4)**

11. Dr. Antoine talks about his program to work with alternate fuel sources. What fuel sources was he studying? Why was this program abandoned? Do you think this program would be helpful now? Why? What kinds of alternate fuel sources do we use today? Can you think of anything else we could maybe use as a fuel source? How would you harness that energy? **(See Clip #5)**

12. Dr. Antoine talks about the mix of hydrogen and carbon. What is this called? Where do we get this mix today? He also began working with a mixture of carbon and something else. What was it? Did his experiment work? What did he find as his results? Why was the program finally abandoned? **(See Clip #5)**

Experiment – Mentos Rocket

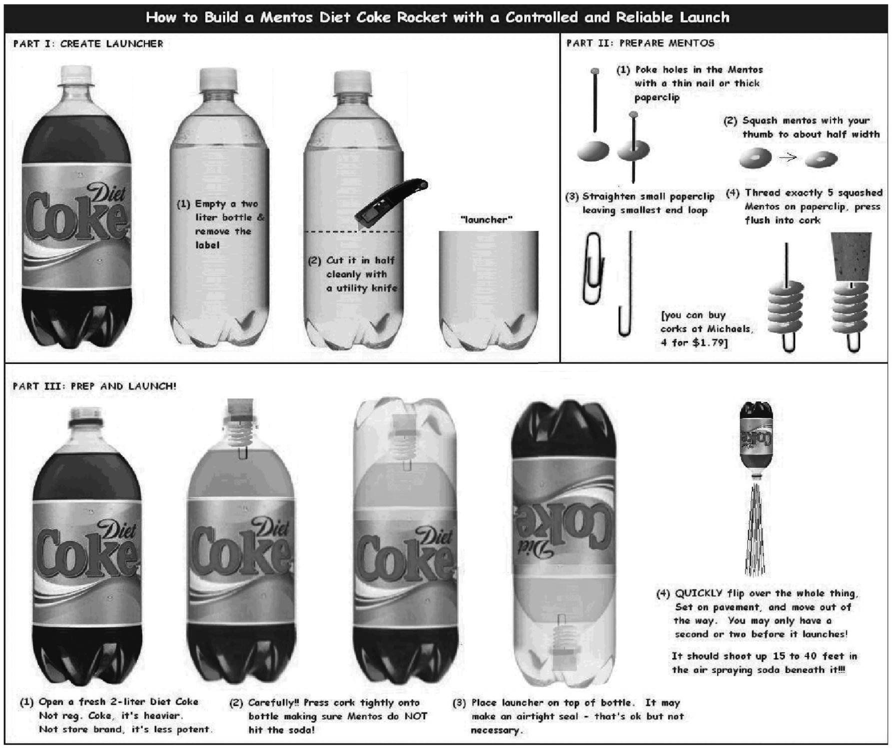
Chances are you've heard of this experiment, so here is a chance to do it for yourself. In keeping with Dr. Antoine's work with jet propulsion and rocket fuel, you will be doing the rocket version of this experiment rather than the more-well-known fountain version. Using the instructions below, from http://wtwii.files.wordpress.com, make a rocket out of a Diet Coke two liter bottle and some Mentos.

How Does It Work? From www.eepybird.com:

There has been a lot of discussion online about why Diet Coke and Mentos make such an interesting combination. What everyone can agree on is that the carbon dioxide that has been compressed into the soda escapes so rapidly that the pressure pushes the soda out of the bottle. It's like shaking a bottle before you open it, but even more dramatic.

These chemists are saying that the primary cause is physical, not chemical. Their explanation: nucleation sites. If you have a liquid that is supersaturated with gas (like soda, which is pumped full of carbon dioxide), a nucleation site is a place where the gas is able to form bubbles. Nucleation sites can be scratches on a surface or specks of dust – anywhere that you have a high surface area in a very small volume. That's where bubbles can form.

Mentos seem to be loaded with nucleation sites. In other words, there are so many microscopic nooks and crannies on the surface of a Mento that an incredible number of bubbles will form when you drop it in a bottle of soda. Since the Mentos are also heavy enough to sink, they react with the soda all the way to the bottom. The escaping bubbles quickly turn into raging foam, and the pressure builds dramatically. Before you know it, you've got a big geyser happening!



After you've had a successful launch of the Diet Coke rocket, try it again with different beverages, such as Diet Sprite, seltzer, etc., or different objects dropped in. What is the difference between these reactions?

Albert Antoine - Video Clip Transcription

Clip 1 - Sparking an Interest: I believe that my interest in chemistry particularly was sparked when I was in junior high school and some of the descriptions of chemistry and chemical reactions were just fascinating. And I was interested in science in general. Yes. I liked math and we had physics in high school, no laboratories but we had physics as a course and…I believe I just enjoyed the, that grouping of studies, math, physics and chemistry. And when I was in college, why, anyone who was studying chemistry and biology, let's say, why, the expectation was that you would be going to medical school. The idea of doing chemistry as a career was something that was foreign to our neighborhood. I didn't know any chemists…Again, people that I knew who were going to college and going on, most of them were thinking of going into medical school…So the idea of chemistry as a career was not firmly rooted in my mind 'cause people would say, "Oh, well, what are you gonna do with your studies?" I'd say, "I don't know, be an educated bum maybe," but I didn't really mean it. But I did not know of chemistry as a career and what one would do with with chemistry. I figured I would worry about that when after I finished, after I graduated.

Clip 2 - Desegregates a Lunch Counter: When I was in service in Columbus [Ohio], one day we heard a buzz going through the community, "Oh, did you hear about those soldiers that desegregated a place up on High Street?" And so we heard all this and found out they were talking about us, a group of us who had gone into a place on High Street and we were heading back to campus. This was when I was at Ohio State [University] in the service, in the Army Specialized Training Program. And we stopped at this place on High Street and ordered something to eat or drink, I don't recall. And the place was a small place. They had a few seats, and they had some stand-up counter. And anyway, we ordered our food and drink and rather than take it out to campus, we decided to eat it there. And so we did and didn't realize this was a first and evidently the providers were reluctant to say anything and so as I said, we did eat there and found out the next day that this was an accomplishment. This is Ohio, this is North, and this is segregated.

Clip 3 - Begins Work with NACA/NASA: I started at…employed at NACA, the National Advisory Committee for Aeronautics and the way I got that job…is kinda interesting. When I was here in Cleveland interviewing for the job at Industrial Rayon at which they said they wanted a, you know, a mechanical engineering background. While I was in town, I called a friend of mine who had graduated a year or so before I did from Ohio State and he was working in Cleveland at NACA and so I just called and said hello, I was in town and told him why, and he said, "Oh why don't you come out here, we're looking for people." So I did. I applied for a position there and got it and started in August of 1954, and again, this is a civilian agency of the government, the predecessor actually of NASA, but it was NACA the National Advisory Committee for Aeronautics. I was at Clark from 1953 to 1954, and then I started in 1954 at NACA as a research chemist.

Clip 4 - Jet Fuel Research: My work primarily was as a chemist. Yes, and initially it involved fuels for jet aircraft. As in all vehicle studies, you're always interested in getting better performance, more efficiency, all kinds of improvements in any mode of transportation. So, we were looking for fuels for jet aircraft that were better than the ones that were presently being used…in some cases. In one case, they were looking at different kinds of fuel, very quickly and very simply, instead of carbon and hydrogen, which is the makeup of the hydrocarbon fuels that were used in cars and aircraft and whatever. We started looking at some boron hydrogen compounds because it seemed that they might give us more efficiency, more bang for the buck in some cases. It turns out that yes, they were better in some ways, but in other ways they were not. There were too much deposits left, so that program was looked at and then dropped. The Navy was particularly interested in those fuels, so we looked at different kinds of fuels for jet aircraft other than the carbon and hydrogen fuels and then, as I said, that program was dropped because it wasn't any better.

Clip 5 - Oil Alternatives Research: And then in another program, we started looking for alternate sources of fuels. By that I mean fuels come out of the ground now, petroleum reserves. Dig an oil well. You get the oil out of it. You process it. A certain part of it goes for gasoline for cars. A certain part goes for fuels for aircraft. And a certain part goes for some other uses. Well, we had a crisis, impending crisis: that we were going to run out of petroleum fuels. What can we use? Well, one of the answers was we can use coal and oil shale. The United States has a lot of coal. It also has a lot of shale oil reserves and can we get decent aircraft fuels from these sources. Well, okay, let's get some of this out and we'll test it. As a chemist, we would analyze it. Tell the engineers how similar or how different it is from the fuels that they were using. And so, there was a program that was developed to look at fuels from alternate sources. Well, that went on for a few years until they found that, oh, we're really not as short on oil as we thought. We got enough to last for x number of years and the crisis that started off and then [oil prices] started come back down, and so that program went by the boards also because we don't need these fuels from alternate sources.

Some of my work was involved with energy research…specifically looking at batteries and fuel cells, which are sources of electricity. And the Navy was interested in the programs that we had. Well, NASA was interested also, but NASA didn't have money to support the programs. So, we were getting our support from the Department of Energy and the Department of Defense. So, my work was more for sources…for terrestrial uses and also underwater and…in some instances, because the Navy had some underwater aircraft that they wanted to develop some of these sources of energy for, and not really related to outer space. And in telling…different people they ask about that and they said, "Well, wait a minute, you're out at the space agency and…" Yes, but we do a lot of work that's not directly related to space and we were asked to do this and we respond. And it just happens that most of my work has really not been directed to any projects in outer space.

ScienceMakers

Spotlight: Ralph Gardner-Chavis

Full Name:	Ralph Alexander Gardner-Chavis
Born:	December 3, 1922
Place:	Cleveland, OH
Parents:	Vivian Hicks Gardner
	Clarence Chavous Gardner
Spouse:	Frances Bailey
Education:	John Adams High School - Cleveland, OH (1939)
	University of Illinois - Urbana-Champaign, IL (B.S. Chemistry, 1943)
	Case Western Reserve University - Cleveland, OH (M.S. Chemistry, 1952)
	Case Western Reserve University - Cleveland, OH (Ph.D. Chemistry, 1959)
Type of Science:	Chemistry
Achievements:	Research assistant on the Manhattan Project
	Worked on catalysis and molecular technology

Favorites:

Color:	Blue
Food:	Lobster
Time of Year:	Summer
Vacation Spot:	San Fransico

Biography

Scientist and educator Ralph Alexander Gardner-Chavis was born December 3, 1922, in Cleveland, Ohio, to Vivian Hicks Gardner, a teacher and housewife, and Clarence Chavous Gardner, a musician and government worker. Known throughout most of his life as Ralph Alexander Gardner, Gardner-Chavis added the Chavis surname late in his career in recognition of his relationship to John Chavis, the first African American to graduate from Princeton in 1760. Gardner-Chavis attended the Cleveland Public Schools, graduating from John Adams High School; he earned his bachelor's degree in chemistry from the University of Illinois at Urbana-Champaign in 1943. Gardner-Chavis completed his graduate studies at Case Western Reserve in Cleveland, Ohio, earning both a Master's degree and Ph.D. in chemistry in 1952 and 1959 respectively.

From 1943 to 1947, Gardner-Chavis was employed as a research assistant on the Manhattan Project, which resulted in the United States developing the atomic bomb, the use of which ended World War II in 1945. Immediately after leaving this position, Gardner-Chavis was unable to find a job as a chemist, so he worked as a waiter from 1947 to 1949. Gardner-Chavis was eventually hired as a research chemist and project leader at the Standard Oil Company in Ohio, where he remained for almost twenty years. Gardner-Chavis then took a teaching position in Cleveland State University's Chemistry Department, where he remained a full-time employee from 1968 to 1985. Gardner-Chavis later combined part-time teaching with work in the research lab of Molecular Technology Corp., a private firm where he also served as the vice president of research and on the board of directors. Gardner-Chavis went on to hold emeritus status in the CSU Chemistry Department, where he continued his research on catalysis and molecular technology, topics on which he published numerous scholarly articles.

Dr. Ralph Gardner-Chavis became a member of Kappa Alpha Psi Fraternity in 1942 and AICHE in 2001.

Discussion Questions

Personal:

1. What did you like best about listening to Dr. Gardner-Chavis?

2. Where was Dr. Gardner-Chavis 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. Gardner-Chavis attend high school? What do you suppose high school was like for him?

3. How old are you? In what year was Dr. Gardner-Chavis your age? What was happening in the country that year? What was happening in the world that year? What do you suppose his life was like when he was your age?

4. Dr. Gardner-Chavis talks about a difficult teacher that he had; describe the situation. How did he deal with it? Have you ever had a problem with a teacher? What did you do to deal with the situation? **(See Clip #1)**

5. Dr. Gardner-Chavis talks about a very frustrating time in his life. What happened? Have you ever been in a position that frustrated you? What did you do? How did you resolve the situation? **(See Clip #5)**

Science:

6. What do you think a chemist does? Would you like to be a chemist? Why?

7. If you were a chemist, what kind of questions would you study?

8. Dr. Gardner-Chavis explains how the atom bomb works. Diagram this process, paying particular attention to Einstein's equation as the demonstration of the tremendous energy that is released during nuclear fission. **(See Clip #2)**

9. Describe the tension that Dr. Gardner-Chavis discusses about the scientists working on the Manhattan Project. Have you ever been "between a rock and a hard place" about something important? How did you make your decision about how to act? If you were on the Manhattan Project, how would you have decided what to do? **(See Clip #3)**

10. Dr. Gardner-Chavis talks about the decision about what to do with the bomb once it was completed. How would you handle this decision? If you were President Truman, would you have dropped the bomb on Hiroshima? Why or why not? Would you have dropped the bomb on Nagasaki? Why or why not? How do you think the scientists who developed the bomb felt about the decision to use the bomb? How would you handle the situation? Should this situation affect decisions to do future research? Why or why not? **(See Clip #4)**

11. Dr. Gardner-Chavis talks about the work that he did with a gas interacting with a surface. What did he observe? What hypothesis did he make as a result? How did he go about proving his hypothesis? What happened? Have you ever wondered about something that you saw in the world? Did you make an educated guess as to the answer? Were you able to find out the answer? How? **(See Clip #6)**

Experiment – Layered Liquids by Dr. Basaam Shakhashiri

Have you ever heard the phrase "oil and water don't mix?" First we will test that hypothesis, then we will look at interesting combinations of several other liquids.

Oil and Water
You will need the following materials:

- 1/4 cup (60 ml) water
- 1/4 cup (60 ml) vegetable oil
- A small glass
- Food coloring

First pour the water into the glass. Add a couple of drops of food coloring and mix. Next add the oil. What do you see? Which layer is on top? Tightly cover the glass with plastic wrap or your hand (if it's big enough). While holding the glass over a sink (in case you spill), shake the glass so that the two liquids are thoroughly mixed. Set the glass down and watch what happens. Do oil and water mix?

The word "miscibility" describes how well two substances mix. Oil and water are said to be "immiscible," because they do not mix. The oil layer is on top of the water because of the difference in density of the two liquids. The density of a substance is the ratio of its mass (weight) to its volume (quantity). The oil is less dense than the water and so is on top. The next experiment examines the miscibility and density of several liquids.

Layered Liquids
You will need the following materials:

1/4 cup (60 ml) dark corn syrup or honey
1/4 cup (60 ml) dishwashing liquid
1/4 cup (60 ml) water
1/4 cup (60 ml) vegetable oil
1/4 cup (60 ml) rubbing alcohol
A tall 12 ounce (350 ml) glass or clear plastic cup
Two other cups for mixing
Food coloring

Take the 12 ounce glass. Being careful not get syrup on the side of the glass, pour the syrup into the middle of the glass. Pour enough syrup in to fill the glass 1/6 of the way. After you have added the syrup or honey, tip the glass slightly and pour an equal amount of the dishwashing liquid slowly down the side of the glass. Does the dishwashing liquid float on top of the syrup or sink to the bottom?

Next, mix a few drops of food coloring with water in one of the mixing cups. Color the rubbing alcohol a different color in another mixing cup. Be careful to add the next liquids VERY SLOWLY. They are less viscous (not as thick) and mix more easily than the previous liquids; we don't want them to mix. Tip the glass slightly, and pouring slowly down the side of the glass, add first the colored water, then the vegetable oil, and, finally, the colored rubbing alcohol.

On a piece of paper, make a sketch of the glass and its liquids, labeling the position of each liquid in your glass.

Why do the liquids stay separated? Can you think of several ways that the liquids in the glass are different? Try to describe some properties that differ in each of the liquids in the glass.

One property that is different in all of the liquids is color. Another property unique to each liquid is thickness (viscosity).

The property of the liquids that is responsible for the layering effect is density. Can you guess what the relationship is between the density of a liquid and its position in the glass?

Another property that keeps the liquids separate is that some of them are immiscible liquids, in other words they do not mix with each other. As you proved in the first experiment, oil and water are immiscible liquids. On the other hand, water and rubbing alcohol are miscible and will mix with each other. Water and the dishwashing liquid will also mix.

Stir up the liquids in the glass and watch what happens to the layers. Have any of the layers mixed (are they miscible in each other)? Wait a few minutes and look again. Have any of the other liquids separated?

Alternate procedure: Rainbow in a glass.
You will need the following materials:

Four different colors of food coloring (e.g. red, yellow, green, blue)
Five tall glasses or clear plastic cups
¾ cup (180 g) of granulated sugar
A tablespoon for measuring
1 cup (240 ml) water

In the first glass, add one tablespoon (15 g) of sugar. In the second glass, add two tablespoons of sugar, three in the third glass, and four in the last glass. Then add three tablespoons (45 ml) of water to each glass, and stir until the sugar is dissolved. If the sugar in any of the glasses will not dissolve, add one more tablespoon (15 ml) of water to all of the glasses, and stir again. When the sugar is completely dissolved, add two or three drops of red food coloring to the first glass, yellow to the second, green to the third, and blue to the last glass.

In the remaining glass we will create our rainbow. Fill the glass about a fourth of the way with the blue sugar solution. Next, carefully add the green solution to the glass. Do this by putting a spoon in the glass, just above the level of the blue solution. Slowly pour the green solution into the spoon, raising the spoon to keep it just above the level of the liquid, until the glass is half full. Add the yellow solution, and then add the red one in the same manner. What do you notice about the colored solutions?

The amount of sugar dissolved in a liquid affects its density. The blue solution has the most sugar dissolved in it and is therefore the densest. The other solutions are less dense, than the blue solution, so they float on top of it. The densities of the solutions should be very close, however, and the solutions are miscible, so you will see that the layers do not form well defined boundaries as in the first experiment. If done carefully enough, the colors should stay relatively separate from each other. What do you think will happen if you stir up the liquids in the glass?

Find this experiment online at: http://scifun.org/HomeExpts/layeredliquids.htm

<u>Ralph Gardner-Chavis - Video Clip Transcription</u>

Clip 1 - 8th Grade Arithmetic: In eighth grade arithmetic, I had this teacher named Ms. Pratt. She was a very old lady, single, spinster, and…Well, I think behind her back we called her “Ms. Pratt the Rat.” Children were seated alphabetically, and my desk was right in front of her desk. And almost every day she would find something wrong with me, or my paper had a smudge on it, or my pencil didn’t have a point, or something was wrong and she would make me stand up and she would publicly ball me out in front of the class. I was the only black in the class, so it made it doubly humiliating was the fact that since there were no other black people around, I liked the little white girl that sat next to me. Of course I never told her or anything like that, but I imagine that she knew it or at least I knew it. So it made it doubly humiliating to be treated in that manner. This kept on, day after day, and I was really getting very demoralized, not even wanting to go to school because of this. And I felt, somehow I felt that I had to deal with this problem myself. So what I did was, I decided I would look at her right dead in her eyes, and keep repeating to myself, “My God, this woman’s losing her mind right in front of my face.” And I kept saying that to myself as hard as I could and kept looking at her as fierce as hard as I could. After two days of that, she did stop…I don’t know, maybe she thought I was going to attack her or something. It was enough I guess to frighten somebody, but I was fiercely looking at her and repeating this in my head, just to myself. But I passed eighth grade arithmetic with a red seventy and the prognosis that I might as well drop out of school. I was through.

Clip 2 - How to Make an Atomic Bomb: Every uranium atom will sometime emit a neutron, and if a uranium atom…but that neutron when it is emitted has too much energy to be captured by another uranium atom. So it would just go on out. So what they do is they put the uranium rods in a thing called a moderator, which allows the neutrons to bounce around when they’re emitted and lose energy but won’t capture them. Well the two things that can be used, one thing is heavy water, made with heavy hydrogen, which is deuterium. Ordinary hydrogen contains one proton and one electron, heavy hydrogen has in the nucleus, in addition to the proton, it has one neutron. So since the proton and neutron weigh about the same, it’s twice as heavy as the ordinary hydrogen…Heavy water then, is made instead of H^2O, it’s D^2O, two Ds and an O. So that’s heavy water. So heavy water doesn’t capture neutrons very well, hardly at all, so they can use that then as a moderator to let the neutrons bounce around in the heavy water and lose energy. So when they’ve lost enough energy to be captured, they’re called thermal neutrons, and that’s the word they call them, and so then they can be captured. Well, we instead of using heavy water, we used highly purified carbon in the form of graphite. So they had blocks of graphite about a foot square on the end, and about as long as from here to the wall, that’d be about eight feet long. And they had holes drilled longitudinally in these blocks and they put the rods of uranium in there, and then let them sit there when the ones would, when they captured the neutron. When a uranium atom captures a neturon, it…into the nucleus…What it does is that it then loses an electron in the form of a high-energy beta particle, a high-energy electron. And this transforms one of the neutrons into a proton, which makes it go from the uranium, which has 92 protons, to neptunium, which has 93. Neptunium spontaneously loses another…beta particle, which is another electron converting another neutron into a proton, that goes to 94, which is plutonium. Now when plutonium picks up an electron, it then fissions, it splits into little pieces. At the same time it emits three more neutrons. But if you gathered together all the little pieces and weighed them, they would weigh less than the plutonium atom weighed. And the difference in weight, or in mass, is what’s converted into energy according to Einstein’s equation $E = mc^2$, and c is a number that’s 3 times 10 to the eighth [meters per second squared {m/s^2}], so when you square it, you get 9 times 10 to the sixteenth [meters per second squared {m/s^2}], so you can see that a tiny bit of mass converted into energy makes an awful lot of energy. And that’s what makes the bomb so fierce and so explosive and so powerful… Maybe the first one might have been equivalent to maybe 100,000 tons of TNT, some tremendous amount of energy.

Clip 3 - Manhattan Project: When I first when on the project, many people that I talked to hoped that it was really impossible to make a bomb [atomic], because we felt that mankind is much too flaky to be entrusted with such awesome power. But on the other hand, if it was possible to make one, we had to be first, before Germany, so we did work very diligently at this to try to make the bomb.

Clip 4: - Atomic Bomb Tested and Used: When they exploded the first one at Alma Gorda, New Mexico, and it worked pretty much as they'd expected. It pulverized everything around. Then they passed around a questionnaire at the laboratory there and asked us what we thought should be done. They had four…choices. A was now that we have the bomb, drop it immediately on Japan. B was now that we have the bomb, drop it on an uninhabited island and invite them to view. If they don't surrender, drop it on Japan. C was now that we have it, tell them, but don't use it. D was now that we have it, don't tell them. Don't use it. Well of course, C and D were, you know, ridiculous, but everybody that I asked, and I asked everybody that I could at the project… voted for B: drop it on the uninhabited island, 'cause we felt that that was the only right thing to do. Well, they didn't. They dropped the bomb without any warning on Hiroshima, and I think the first bomb killed 30,000 people. And then two days, two or three days later before they even had a chance to figure out what happened, they dropped the second bomb on Nagasaki, that killed 60,000. So the two together killed about 100,000 people, those are killed, that's not counting injured and the radiation damage which is apparently still prevalent in Japan.

Clip 5 - Trouble Finding Work: I expected to come back to Cleveland to go to work. One of the first places I went to was Standard Oil of Ohio. The research lab was on Cornell Road, up there by the Western Reserve, and the lady there gave me a one page piece of paper to fill out on both sides and said she would put it in a file and if an opening came, she would call me. Well, I went to every place that I could have been hired as a chemist, and I couldn't get any job…For no wage at all, there was nothing I could do and I was married at the time so I ended up waiting tables for two years, which made me very angry, of course, and I want to also point out… that in addition to working on the atom bomb, I also took courses at the University of Chicago, one given by Enrico Fermi, you know, that won the Nobel Prize and everything, and he was the one that introduced me to quantum mechanics, and in that way I had studied under Enrico Fermi, and I had taken several other courses…It was very disgusting to have had that sort of exposure academically and to have had that work experience on the atomic bomb and yet to not be able to get any job in chemistry at all when I returned.

Clip 6 - Earning his Ph.D.: What I did was, just to put it briefly was that, people had thought there were only two possible interactions of a gas with the surface of a solid. One would be a weak interaction, like the condensation of steam on the bathroom mirror, which of course is so weak an interaction that it doesn't change the water at all, it just changes the spacing between them. When they're in a liquid they're much closer together than when they were in a gas. So that was too weak to be important in catalysis. So the only other thing that other people envisioned was the idea that there was an actual bond formed between this molecule from the gas phase and that atom in the surface of the solid so that it was actually stuck on the catalyst. And so they would generate, make the catalyst, expose it to the gas and then let it sit for, say an hour or something, then they would evacuate the system to remove all the, what they call the physisorb species, these weakly bonded things, and then study the ones that were strongly bonded. Well I…since as I'd said, I felt that they didn't know what they were doing. I was determined to see everything that happened from the moment any one molecule of this gas got in contact with the surface. I wanted to try to see what it was doing. So I added a little tiny bits of gas and then ran multiple spectra, and then add a little more, and twice as much, and keep adding more and more and more until I would see the spectrum of gases…of the gas and then I would evacuate half and evacuate half and evacuate half, running multiple spectra each time so that I had as complete a record of everything that transpired.

And what I found was that there were certain…bands that the spectrum gives you bands like this, like this, well there were certain bands in the spectra that were readily removed by evacuation as if they would physisorb, the weak thing, but the vibrational frequency was quite changed from that of the gaseous molecule, as if they were chemisorbs, as if some more important, more significant reaction had occurred. So I realized I was seeing quite an anomaly, where it was looking like the two opposite things at the same time. And this of course intrigued me and also made me realize that what I was seeing was exactly what you want for catalysis, for the molecule to come from the gas phase, hit the surface, be changed, react, [and] jump right back off. And they had estimated that the enzyme carbonic enhydrase is estimated at thirty million reactions per second, so that's awful fast for getting on and off per second. So that made me realize that I had seen something of importance and so then I set about trying to identify and enlarge and to work with this…I began this work actually in ‘54 and I did the portion for my Ph.D. thesis in ‘58 and that’s when I got my really, the results. …So then I published my first paper in 1960 and of course my major professor, Dr. Petrucci, his name was on it, well he didn’t know anything about catalysis at all, so I had to explain it to him, all about it. So this put me in a good position in that I was the only one that knew what I was doing. And when it came time for my oral exam, why, one was a physicist, another was a mathematician, and the other was my major professor, the three of them. So after I talked to them, I was explaining my work and I talked about forty-five minutes and they said, “Well, that’s enough,” and I said, “Oh no, wait a minute, I’ve got a lot more to tell you.” They said, Oh no, we don’t want to hear it. No, you’ve got the Ph.D., that’s enough.” So I thought that was pretty good.

ScienceMakers

Spotlight: William Lester, Jr.

Full Name:	William Alexander Lester, Jr.
Born:	August 9, 1957
Place:	Chicago, IL
Parents:	Elizabeth Clark Lester
	William Alexander Lester, Sr.
Spouse:	Rochelle Reed
Education:	Calumet High School - Chicago, IL (1953)
	University of Chicago - Chicago, IL (B.S. Chemistry, 1958)
	University of Chicago - Chicago, IL (M.S. Theoretical Chemistry, 1959)
	Catholic University of America - Washington, D.C. (Ph.D. Chemistry, 1964)
Type of Science:	Computational Chemistry
Achievements:	Developed a new algorithm to study the energy levels of molecular close-coupling
	Research focuses on the theoretical studies of the electronic structure of the molecule

Favorites:

Color:	Black
Food:	Red Beans & Rice; Steak
Time of Year:	Spring
Vacation Spot:	Caribbean, Maui, Barbados

Biography

Distinguished theoretical chemist William Alexander Lester, Jr., was born on April 24, 1937, in Chicago, Illinois, where he attended all-black schools due to racial segregation. After World War II, Lester's family moved, and he attended a formerly all-white school; he went on to receive his B.S. degree in 1958 and his Master's degree in chemistry in 1959 from the University of Chicago. Lester obtained his Ph.D. in chemistry from the Catholic University of America in

Washington, D.C., in 1964. Lester developed his interest in science at an early age; during his senior year in high school, he used his typing skills to obtain a part-time job in the physics department of the University of Chicago, which gave him a chance to explore the potential of a future career in the sciences. Entering the University of Chicago on a history scholarship, Lester set scoring records in basketball, two of which were still standing after forty-eight years. While at Catholic University, Lester worked at the National Bureau of Standards as a member of the scientific staff; his work at the Bureau helped him to meet the requirements for his doctoral dissertation on the calculation of molecular properties. Lester obtained a postdoctoral appointment at the University of Wisconsin in Madison where he worked on the molecular collision theory. The IBM Corporation then hired Lester to work at its research laboratory in San Jose, California. Later, as the director of the National Resource for Computation in Chemistry, Lester organized and led the first unified effort in computational chemistry in the United States.

Lester later joined the faculty of the University of California at Berkeley as a professor of chemistry, where his research focused on the theoretical studies of the electronic structure of molecules. Lester's efforts at Berkeley extended the powerful quantum Monte Carlo method to a wider range of chemical problems. In 2002, Lester became the president of the Pac-10 Conference.

Throughout his career, Lester published over 200 papers in his field and was awarded numerous honors for his research and teaching. Lester held memberships in several professional organizations including the American Physical and Chemical Societies, and the American Association for the Advancement of Science. Lester also served as a fellow of the APS and of the AAAS. In addition to his professional activities, Lester remained committed to science education and sparking an interest in pursuing science careers in minority students.

Lester and his wife, Rochelle, raised two children: son, William Alexander Lester, III, and daughter, Allison L. Ramsey.

Discussion Questions

Personal:

1. What did you like best about listening to Dr. Lester?

2. Where was Dr. Lester 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. Lester attend high school? What do you suppose high school was like for him?

3. How old are you? In what year was Dr. Lester your age? What was happening in the country that year? What was happening in the world that year? What do you suppose his life was like when he was your age?

4. Dr. Lester talks about the residential segregation that was present in Chicago while he was growing up. What was blockbusting? Research this term and report back to your class. Think about your city and its neighborhoods. How many different neighborhoods are there? Even if it's not public policy, is there still racial segregation in your city today? Are there neighborhoods where certain ethnic groups live? If yes, identify these neighborhoods. How has the racial makeup of the neighborhoods changed in the last 20 years? The last 50 years? Ask your parents and grandparents what they remember. How does this change affect you? How can you affect change for the next 20 years? **(See Clip #1)**

5. Dr. Lester discusses his grandmother and her success in business. What do you know about the work that your grandparents do? If they are retired or have passed away, what kind of work did they do? How did this affect your parents? How did it affect you? Think about your family. Are there any business owners among them? If so, what kind of business? What can you learn from them about owning their own business? **(See Clip #2)**

6. Dr. Lester talks about integrating his high school. Think about your school. Estimate the racial mix of your class, your grade, and your school. Is this different from when Dr. Lester was in school? How? Research the integration of schools, both nationally and in your community. What were some of the major steps? Why was school integration so important? How does this make a difference in the way you are growing up versus Dr. Lester's experience? **(See Clip #3)**

7. Dr. Lester discusses his high school chemistry teacher. What was his name? How did he influence Dr. Lester? How did he come to suggest Dr. Lester's college choice? Did he aid Dr. Lester? How? Think about the teachers you have had. Is there a teacher who encouraged you in a particular area? Who was that teacher? What area did he or she encourage you to study? Why? Do you plan to pursue that area in college? Why or why not? **(See Clip #4)**

8. Dr. Lester was an outstanding athlete in college. Which sport? What records did he set? Does he still hold them? Why didn't he play professional basketball? What did he want to do instead? Do you play sports? If so, what do you play? How can sports help you become a well-rounded individual? How can science help you become a well-rounded individual? How can sports help you prepare for a career? How can science help you prepare for a career? **(See Clip #5)**

Science:

9. What do you think a computational chemist does? Would you like to be a computational chemist? Why?

10. If you were a computational chemist, what kinds of questions would you study?

11. Dr. Lester works to discover the structure of the atom. What are the parts of the atom? How are these parts arranged? Look at the periodic table of elements. What makes one element different from another?

12. Dr. Lester talks about trying to describe the instantaneous behavior of electrons. Think of an electron as a ball that you have thrown into the air. What happens to the ball? Can you describe its path, its position in space over time? How can you describe its exact position at a specific time? This is called its instantaneous position. Why do you suppose it would be important to know the instantaneous position of an electron? **(See Clip #6)** [Teacher's note: The better understanding we have of an electron's behavior, the better advances we can make in electronics. See Shirley Ann Jackson's interview for more on this.]

13. What was the difficulty in determining the instantaneous position of the electron? (You will have to listen closely) How did Dr. Lester solve this problem? What did this lead to? He explains the mindset of scientists who are conducting research. What is that mindset? Can you think of anyone else who might share this mindset? Give some examples. [Teacher's note: This can lead to a discussion of explorers and/or record-breaking athletes and the need to excel.] How can this mindset help you in your life? **(See Clip #6)**

14. Dr. Lester talks about the advice he gives to those he worked with at IBM. What was it? How can you put this advice into practice? Give specific examples for putting this advice into practice by the end of the school year. **(See Clip #7)**

15. Dr. Lester talks about close-coupling problems. What do these problems involve? Why are they called close-coupling problems? How did Dr. Lester make progress on this problem? What was his solution and why did it have such an impact? **(See Clip #8)**

16. Dr. Lester is currently studying photoprotection in bacteria and plants. Explain what photoprotection is. Why is it necessary? Do people have a mechanism on their bodies that offers photoprotection? What is it? [Teacher's note: This is an opportunity to discuss perspiration and its usefulness.] Dr. Lester is specifically looking at carotenoids. Research carotenoids and explain how they help plants. What are their uses to people? Find some examples of carotenoids that have an effect on people. What is Dr. Lester trying to determine? **(See Clip #9)**

Experiment – Candy Chromatography by Dr. Basaam Shakhashiri

Ever wondered why candies are different colors? Many candies contain colored dyes. Bags of M&Ms or Skittles contain candies of various colors. The labels tell us the names of the dyes used in the candies. But which dyes are used in which candies? We can answer this by dissolving the dyes out of the candies and separating them using a method called chromatography.

For this experiment you will need:

- M&M or Skittles candies (1 of each color)
- Coffee filter paper
- A tall glass
- Water
- Table salt
- A pencil (a pen or marker is not good for this experiment)
- Scissors
- A ruler
- 6 toothpicks
- Aluminum foil
- An empty 2 liter bottle with cap

Cut the coffee filter paper into a 3 inch by 3 inch (8 cm by 8 cm) square. Draw a line with the pencil about ½ inch (1 cm) from one edge of the paper. Make six dots with the pencil equally spaced along the line, leaving about 1/4 inch (0.5 cm) between the first and last dots and the edge of the paper. Below the line, use the pencil to label each dot for the different colors of candy that you have. For example, Y for yellow, G for green, BU for blue, BR for brown, etc.

Next we'll make solutions of the colors in each candy. Take an 8 inch by 4 inch (20 cm by 10 cm) piece of aluminum foil and lay it flat on a table. Place six drops of water spaced evenly along the foil. Place one color of candy on each drop. Wait about a minute for the color to come off the candy and dissolve in the water. Remove and dispose of the candies.

Now we'll put drops of the different colors onto the filter paper. Dampen the tip of one of the toothpicks in one of the colored solutions and lightly touch it to the corresponding labeled dot on your coffee filter paper. Use a light touch, so that the dot of color stays small - less than 1/16 inch (2 mm) is best. Then using a different toothpick for each color, similarly place a different color solution on each of the other five dots.

After all the color spots on the filter paper have dried, go back and repeat the process with the toothpicks to get more color on each spot. Do this three times, waiting for the spots to dry each time.

When the paper is dry, fold it in half so that it stands up on its own, with the fold standing vertically and the dots on the bottom.

Next we will make what is called a developing solution. Make sure your 2-liter bottle or milk jug is rinsed out, and add to it ⅛ teaspoon of salt and three cups of water (or use 1 cm^3 of salt and 1 liter of water). Then screw the cap on tightly and shake the contents until all of the salt is dissolved in the water. You have just made a 1% salt solution.

Now pour the salt solution into the tall glass to a depth of about ¼ inch (0.5 cm). The level of the solution should be low enough so that when you put the filter paper in, the dots will initially be above the water level. Hold the filter paper with the dots at the bottom and set it in the glass with the salt solution.

What does the salt solution do? It climbs up the paper! It seems to defy gravity, while in fact it is really moving through the paper by a process called capillary action.

As the solution climbs up the filter paper, what do you begin to see?

The color spots climb up the paper along with the salt solution, and some colors start to separate into different bands. The colors of some candies are made from more than one dye, and the colors that are mixtures separate as the bands move up the paper.

The dyes separate because some dyes stick more to the paper while other dyes are more soluble in the salt solution. These differences will lead to the dyes ending up at different heights on the paper. This process is called chromatography. (The word "chromatography" is derived from two Greek words: "chroma" meaning color and "graphein" meaning to write.) The salt solution is called the mobile phase, and the paper the stationary phase. We use the word "affinity" to refer to the tendency of the dyes to prefer one phase over the other. The dyes that travel the furthest have more affinity for the salt solution (the mobile phase); the dyes that travel the least have more affinity for the paper (the stationary phase).

When the salt solution is about ½ inch (1 cm) from the top edge of the paper, remove the paper from the solution. Lay the paper on a clean, flat surface to dry. Compare the spots from the different candies, noting similarities and differences. Which candies contained mixtures of dyes? Which ones seem to have just one dye? Can you match any of the colors on the paper with the names of the dyes on the label? Do similar colors from different candies travel up the paper the same distance?

You can do another experiment with a different type of candy. If you used Skittles the first time, repeat the experiment with M&Ms. If you used M&Ms first, try doing the experiment with Skittles. Do you get the same results for the different kinds of candy, or are they different? For example, do green M&Ms give the same results as green Skittles?

You can also use chromatography to separate the colors in products like colored markers, food coloring, and Kool-Aid. Try the experiment again using these products. What similarities and differences do you see?

Find this experiment online at: http://www.scifun.org/HomeExpts/candy.htm

William Lester, Jr. - Video Clip Transcription

Clip 1 - Residential Segregation: Well, growing up on the South Side was a lot of fun, you know, especially [in] an all-black community. When we went across Cottage Grove, 63rd and Cottage Grove, my mother would shop at the High-Lo, east of Cottage Grove we went to another world, a fair number of white folks then. So it was residential segregation of Chicago at that time, which was a primary aspect that one encountered growing up and… something which I saw as I grew up in Chicago, how the boundaries would shift. The notion of blockbusting was real, which you may recall is the aspect of city blocks shifting and realtors coming in and scaring white folks to move out so they can make money by selling homes and all that sort of thing. So that was really something I would really strongly emphasize, a colored one's existence as a young child growing up in Chicago.

Clip 2 - Memories of Grandmother: My maternal grandmother was a businesswoman, and I subsequently have gained a sense of what that meant, because she bought large homes on then South Park, now Martin Luther King Drive, and converted those to small apartments which took on the term kitchenettes, and was profitable in doing that sort of thing. She had a large apartment, and I recall the address: 5936 South Parkway, and the family one floor above were the Hansberries, Lorraine Hansberry's parents [playwright who wrote the play, *A Raisin in the Sun*] and that family and so forth, and I remember my…maternal grandmother was a successful businesswoman.

Clip 3 - Integrating High School: Calumet High School, which was the neighborhood high school for where I lived. Princeton Park had been built during World War II, and with this creation, students were being fed then into Calumet High School which did not have black students prior to the creation of this particular development. And so, my sister and I, sister Florence and I, were some of the earlier students to attend that high school. And my graduation class from that high school was 365, of which 13 were black, ten girls and three guys. There were a few more that started, but what happened to them, I don't know, but that was the nature of the racial mix that existed at that high school at the time.

Clip 4 - Chemistry Teacher: My senior year, I took chemistry as I mentioned to you, and I had Mr. Schlessinger. And [he] used to have competitions, divide the class up in two and have competitions between one side of the class and the other, and answering questions about chemistry. I used to win these things routinely, and Mr. Schlessinger suggested I should go to the Little Red School House on the Midway [Midway Plaissance], alluding to red being the schoolhouse but also the Communist influence at the University of Chicago which was there in that time frame, you know, and so forth, but that it was a good education. Not that he was Communist or anything of that sort, but he was a guy that called a spade a spade. He was very interesting, a very interesting guy and… then I did win the history scholarship and so forth. So, he was a very supportive individual. In high school, these were all white teachers at that point, and I'm sure they were instrumental in my winning a scholarship to the University of Chicago as a matter of fact, 'cause that's the only way of course, aside from grades, that such things would happened, by recommendations of teachers.

Clip 5 - College Sports: Well, the single game record was broken. I set a record of… The last record was 42 points per game. That was broken last year; somebody scored 44 at the University of Chicago. I still hold the record for the most field goals in a game, because I played in the era of two points, not two and three points. So, I had 19 field goals in a game, and also I hold the record for the highest average. I averaged 25 and a half points [25.5] my senior year, '56-'57 academic year, and made Little All-American. Little meaning that small school and that sort of thing. And the coach, the assistant coach at that point had played professional basketball back in that era said, "Well, are you interested in pros?" "Well, no, not really." It didn't pay anything. I mean, if indeed professionals earned what they earn nowadays, I would have been there in a heartbeat to try and compete for that kind of money, but at that point they made about what a second-level manager would make in some company. The money wasn't there, you know. Where there was this exotic dimension of going on to the Ph.D. and as you will see in some material I have, I indicate that this is what I wanted to do upon completion of undergrad and Master's work was to go on and teach at the university level, which happened some time later, not immediately.

Clip 6 - Electron Orbitals: It is the case that I described to you this mean field approximation, I didn't mention the name of it, it's called Hartree Fock, H-A-R-T-R-E-E, after somebody named Hartree and Fock, a Russian, F-O-C-K. Hartree Fock was the mean field approximation. The issue is: how to describe instantaneous behavior electrons by doing so-called pulsed Hartree Fock calculations. These typically took the form of what we call excitations from the determinental wave function for the system. We represented a wave function for an atom or molecule by a determinant at the smallest, or a linear combination of determinants. So, this is all orbital-based. That is, the orbitals are one-electron functions, an orbit, this is a generalization of the orbit. These determinental wave functions are mathematical representations of the behavior of individual electrons in the molecular system. But it is a fact, and this is done by Hilarus in the early days of quantum mechanics for the helium electron, a two-electron system, is that if you put in a function which depends on explicit distance between two electrons, then this can tremendously compact the representation of the wave function of the system. The reason this wasn't done routinely in other cases is that the integrals you get that you must evaluate for the expectation value of the Hamiltonian is an integral, which means you integrate over all space of the electrons of an argument, which is the complex conjugate of the wave function Hamiltonian operator times the wave function integrated over all space. So it's an average of a mathematical quantity. How you represent that wave function is what we're talking about, in terms of orbital development, or one which involves explicit correlation. And so it's the integral, the complexity of the integrals that you have to evaluate and using exponential functions for descriptions of orbitals. And in the case of explicit correlation, functions which depend upon inter-electron separation, which leads to tremendous complexity, that until that time really could not be done for systems beyond two electrons. If however, instead of using exponential functions, you use Gaussian functions, exponential of minus alpha RIJ squared, then these integrals become possible to evaluate, and this was a tremendous advance made by a fellow by the name of S.F. Boise at Cambridge, and which we did, I did, as a part of my thesis, one of the earliest publications of the explicit correlation. They've been done by some others as well, but in the States I was one of the first. And that paper even today gets referenced: my thesis work. Because it was again one of the first, and this is why I tell my students, you know, don't join the pack. You've got to try to identify a pathway which is novel and unique, which may offer then guidance to people in the field. You don't always win with this, but it's a very important dimension in terms of what you do. It's like anything. If you're the first, you may get some recognition.

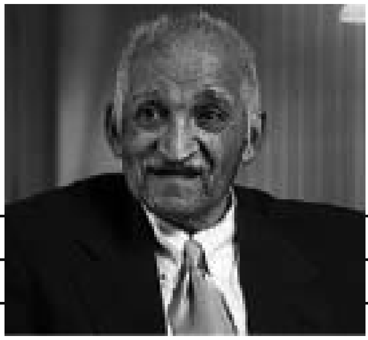
Clip 7 – Advice: Two young black scientists I met at IBM who came to apply for jobs and said, "All I want is a job," and I said, "Man, that's not the mindset. What will you bring to the table here which will be different from what we already have? What are the skills and capabilities you have developed, and you must be able to convey that." So I used to meet with them at the end of the day and sort of give them some feedback and every now and then somebody would come in with a sense of that mindset…At least the folks who left had a sense of what I was trying to convey to them in this regard.

Clip 8 - Molecular Close Coupling: The problem basically was that for [a] diatomic molecule, a molecule consisting of two atoms bound together by a bond, it rotates besides vibrating. The problem of interest here is looking at the change of rotational motion as a consequence of the atom hitting the diatomic molecule. This is a so-called close coupling problem. Why? Because the energy levels for rotation are more closely spaced together than those of vibration. In other words, you have a ground state vibrational level, a series of rotational levels, then the next vibrational level, another series of rotational levels which are going right on up. And this means then that the effect of a change in any given rotational level affects others very strongly, and that's why it's called a close coupling problem. And computationally, or in terms of mathematics, it leads to the need to solve a system of partial differential equations…It was a problem which Barnstein had indicated was too difficult a problem for a graduate student, with someone with my experience around computers that hopefully I would be able to make some headway. And I did, in part by talking to people, knowledgeable about close coupling, the same kinds of equations arise also in the scattering of electrons off of atoms, electrons off of molecules, in the mathematical formulation of each of these kinds of physical problems, the mathematics boils down to the same kind of appearance. And subsequently one has to translate these differential equations into a form that the computer would understand, and this is actually the development of an algorithm. And in that respect, I interacted with some people at the Argonne National Laboratory, which were helpful in terms of their progress regarding the electron atom problem, which I could then translate into the atom diatomic molecule problem. And [I] was able to write a code which would do the job and so as a consequence of this, I was able to compute results which subsequently became a standard against which people would test new formulations, new algorithms for solving this kind of problem. And so I had some very nice comments made about my work because of its impact on the field and the advance of the field as a consequence of this contribution.

Clip 9 - Studying Photoprotection: Actually, what I'm very excited about is one we're doing now, in which we earned a million hours of supercomputer time in order to carry out a study of photoprotection in bacteria and plants. What this is all about is…ascertaining in detail the energy transfer and energy level separations for the mechanism by which plants and bacteria are able to protect themselves from radiation. Basically what happens is that plants and bacteria absorb radiation from the sun, and this is done through antenna molecules which then end up having an energy transfer process occur, which if the system is not careful, with all this radiation coming in on a hot day, it might burn up. In point of fact carotenoids, carotenoids such as lycopene, spheroidene... beta-carotene is also a carotenoid, can carry off excess heat. Okay, they can dissipate the heat so that the bacteria chlorophyll does not become excited, leading to the formation of what we call a singlet oxygen molecule, which is a well-known detrimental molecule. So the point is, you want to avoid that, and the plants and animals can avoid that if there are carotenoids around to do this. Where we are playing a role, and this is generally well-known, is to actually compute the energy level separation. What is the amount of energy required to excited the carotenoid from its ground state to its lowest triplet and likewise the bacteria chlorophyll, the other species involved, to do the same thing, so that we know the energetics, as well as wanting to compute, which we haven't done as yet, the energy transfer matrix element, which gives you as a result the magnitude of the energy transfer rate associated with this process.

ScienceMakers

Spotlight: Samuel Massie



Full Name:	Samuel Proctor Massie, Jr.
Born:	July 3, 1919
Place:	Little Rock, AR
Parents:	Earlee Taylor Massie
	Samuel Proctor Massie, Sr.
Spouse:	Gloria Thompkins Massie
Education:	Dunbar High School - Little Rock, AR (1933)
	Agricultural Mechanical Normal College of Arkansas - Pine Bluff, AR (B.A. Chemistry, 1936)
	Fisk University - Nashville, TN (M.A. Organic Chemistry, 1940)
	Iowa State University - Ames, IA (Ph.D. Organic Chemistry, 1946)
Type of Science:	Chemistry
Achievements:	First African American professor at the United State Naval Academy, Annapolis, MD
	Named one of the 75 Premier Chemists of the 20th century

Favorites:

Color:	Navy Blue
Food:	Watermelon; Chicken
Quote:	“Do the best you can with what you have.”

Biography

Organic Chemist Samuel Proctor Massie, Jr. was born in Little Rock, Arkansas, on July 3, 1919. His mother, a teacher, and his father, a minister, instilled in him a love of education. By the age of thirteen, Massie had graduated from high school. Because he was denied admittance to the University of Arkansas due to his race, Massie went on to attend Agricultural Mechanical Normal College of Arkansas. Massie then attended Fisk University before being accepted to Iowa State University, where he received his Ph.D. in organic chemistry.

Massie attended Iowa State University at the height of World War II; during this time, he was summoned before the draft board. Massie was allowed to return to school, but he was assigned to the Manhattan Project, the program that created the first atomic bomb. After completing his Ph.D., Massie returned to Fisk University to teach; it was there that he met his future wife, Gloria. Over the years, Massie held positions at Langston University, Howard University, and the National Science Foundation. In 1963, Massie was named president of the University of North Carolina Central.

In 1966, Massie became the first African American professor at the U.S. Naval Academy; he then served as chair of the chemistry department from 1977 to 1981. In 1994, Massie retired from the Naval Academy, though he retained the title Professor Emeritus.

Massie was awarded with an NAACP Freedom Fund Award and a White House Initiative Lifetime Achievement Award. He was also named one of the seventy-five outstanding scientists in the country by Chemical and Engineering News Magazine. Massie was also involved with the Smithsonian Institute and spent more than two decades on the Maryland State Board for Community Colleges.

Samuel Massie passed away on April 10, 2005, three months after the passing of his wife, Gloria.

Discussion Questions

Personal:

1. What did you like best about listening to Dr. Massie?

2. What do you think Dr. Massie's favorite quote means? What does this tell you about him?

3. Where was Dr. Massie 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. Massie attend high school? What do you suppose high school was like for him?

4. How old are you? In what year was Dr. Massie your age? What was happening in the country that year? What was happening in the world that year? What do you suppose his life was like when he was your age?

5. Dr. Massie reflected on his lab experiences at Iowa State University. "The laboratory for the white boys was on the second floor next to the library. My laboratory was in the basement next to the rats. Separate but equal." What was the "separate but equal" attitude in the country that this exemplified? How was it challenged? When was it finally abolished? How do you think this segregation affected Dr. Massie's research? **(See Washington Post article)**

Science:

6. What do you think a chemist does? Would you like to be a chemist? Why?

7. If you were a chemist, what kinds of questions would you study?

8. Dr. Massie once said, “Many people, some of them teachers, who unconsciously make science and mathematics too difficult feel that science and mathematics are not for the common student. They are wrong. The depth of use may vary, but the principles remain understandable to all of us.” Explain this quote, using your own words. Do you agree with it? Have you ever been frustrated by science or mathematics in school? What was the source of the frustration? How do you think that teachers can make science and mathematics more accessible? What can you do to help this process? **(See Washington Post article)**

9. Dr. Massie was named one of the 75 premier chemists of the 20th century. Other scientists that shared this honor were Marie Curie, George Washington Carver, George Eastman, James Watson, and Francis Crick. Study the list. How many of these chemists have you heard of? Pick five and explain their contributions to the class. **(See List of Top 75 Chemists)**

10. Dr. Massie graduated from high school when he was thirteen years old. How old will you be when you graduate from high school? What do you think it would be like to graduate from high school at thirteen? What do you think it would be like to start college at thirteen? What problems do you think Dr. Massie faced because of his young age? What are some challenges you expect to face after you leave high school? Have you thought about attending college? If so, where? What would you study? **(See Washington Post article)**

11. Dr. Massie entered into college interested in finding a cure for a very specific ailment. What ailment was it? Who suffered from this ailment? What motivates you to pursue science? Is there a specific disease you would like to find a cure to? Is there a person in your life who you could help with your scientific knowledge? Who? How can you use science to help them? **(See Washington Post article)**

12. Dr. Massie spent most of his life as a science teacher at schools across the United States. Have you ever thought about becoming a teacher? What subject would you teach? Why? What kinds of steps should you take to become a teacher? Who can help you with that goal? **(See Washington Post article)**

13. Dr. Massie is known for his research on phenothiazine. What was it used for? Research this drug. Has it lead to any other discoveries? What kinds of advances have been made because of Dr. Massie’s work? **(See Washington Post article)**

Additional Reading:

Samuel Massie Washington Post article:
http://www.washingtonpost.com/wp-dyn/articles/A55092-2005Apr14.html

List of Top 75 Chemists: http://pubs.acs.org/cen/hotarticles/cenear/980112/top.html

Experiment – Floating Soap Bubbles by Dr. Bassam Shakhashiri

Nearly everyone has enjoyed playing with soap bubbles. These fragile spheres of soap film filled with air are both beautiful and captivating. However, few people have observed them closely or at length, because soap bubbles are fragile and very light. When you blow soap bubbles out of doors, the slightest breeze carries them away. If you blow them indoors in still air, the bubbles soon settle onto a surface and break. However, because they are very light, soap bubbles will float on a gas that is only slightly denser than the air that fills them. Such a gas is carbon dioxide. When soap bubbles settle into a container of carbon dioxide, the bubbles float on the carbon dioxide and can be examined closely. Under this close examination, soap bubbles reveal many properties that are not otherwise easily seen.

To float soap bubbles, you will need the following materials:

- Soap bubble solution
- A wand for blowing soap bubbles
- A large transparent container with an open top (an empty 38-liter [10-gallon] aquarium works nicely)
- 125 milliliters (½ cup) of baking soda (sodium bicarbonate)
- 250 milliliters (1 cup) vinegar
- Shallow glass dish to fit inside large container (such as a glass baking dish)

Set the large container on a table away from drafts and where you can easily look through its sides. Place the glass dish inside on the bottom of the large transparent container. Put 125 milliliters (½ cup) of baking soda in the glass dish. Pour 250 milliliters (1 cup) of vinegar into the dish with the baking soda. The mixture of soda and vinegar will immediately start to fizz as they react and form carbon dioxide gas. Carbon dioxide is denser than air and so it will be held in the large container as long as it is not disturbed by drafts of air over the container. Because carbon dioxide is colorless, you cannot see it inside the container. However, you will soon be able to detect its presence with soap bubbles.

After the fizzing in the dish has subsided (about a minute), gently blow several soap bubbles over the opening of the large container, so that they settle into the container. This may take a bit of practice. (Do not blow directly into the container; you will blow the carbon dioxide out of it.) When a soap bubble settles into the container it will not sink to the bottom, as it would in air. Instead, it will float on the surface of the invisible carbon dioxide in the container.

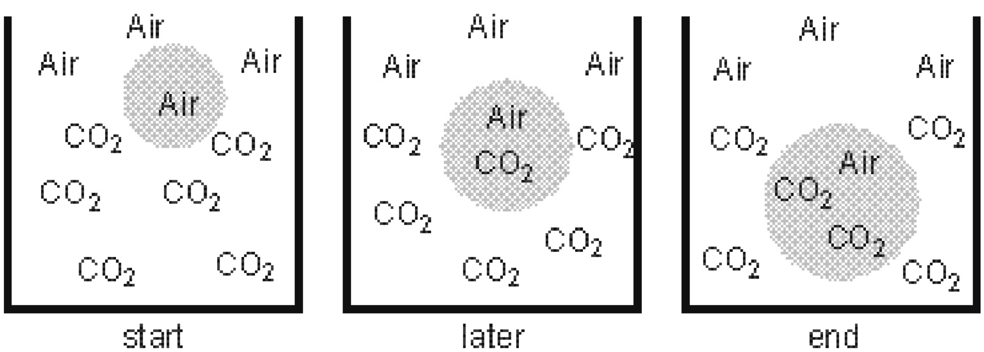
While the bubble is floating on the carbon dioxide in the container, you can observe the soap bubble closely. Note what the bubble looks like. What color is the bubble? Can you see more than one color on the bubble? Do the colors change? Notice the size of the bubble. Does its size change? Observe the position of the bubble. Does it stay at the same level in the container? Does it rise or sink?

When you have finished observing the bubbles, dispose of the mixture in the glass dish by rinsing it down the drain with water. The colors of a soap bubble come from reflections of the white light that falls on the bubble. White light, such as from the sun or from a light bulb, contains light of all colors. Light has waves, and the length of the wave, from crest to crest, determines the color of the light. When light reflects from a bubble, some of each wave reflects at the outside surface of the soap film. Some light travels through the soap film and reflects from the inside surface of the film.

Interference between waves occurs whenever waves travel through the same space. Interference occurs when two rocks are tossed near each other into a lake. Circular waves on the surface of the water spread out from where each rock entered the water. Where the crests of two waves meet, interference between the waves causes the motion of the surface of the water to increase. Where a crest and a valley meet, interference reduces the motion of the water's surface. Similar interference can occur in waves of light.

Waves of light reflected from the inner and outer surfaces of the film of a soap bubble can interfere with each other. Where the crests of the light waves reflected from the inner and outer surfaces of the film meet, the intensity of the light increases. If the crest of a wave reflected from the inner surface meets the valley of a wave from the outer surface, the intensity of the light will be diminished. Whether the crest of a wave meets another crest or a valley is determined by the length of the wave and by the thickness of the film. If the thickness of the film is a multiple of the wavelength of the light, the crests of waves reflected from the inner surface will meet the crests of waves reflected from the outer surfaces. If the thickness of the film is an odd multiple of half the wavelength, the crests of the waves reflected from the inner surface will meet the valleys of the waves reflected from the outer surface. Because the thickness of the film varies and the wavelength of the light determines its color, different areas of the bubble will have different colors. The colors of a film of oil on a wet parking lot are produced in the same way as the colors of a soap bubble.

If your soap bubbles remained floating on the carbon dioxide for more than a minute, you may have noticed that the bubbles were slowly becoming larger. You also may have noticed that the bubbles slowly sank into the container. Both the growth and the sinking of the bubbles is a result of the same process. When you blew the bubble, it was filled with air. When it settled into the container of carbon dioxide, the bubble was surrounded by this gas. The bubble grows because carbon dioxide moves into the bubble (through the soap film) faster than air moves out of the bubble. Carbon dioxide can move through the soap film more quickly than air, because it is more soluble in water than is air. (Water is the major component of the bubble-soap solution.) As the amount of carbon dioxide in the bubble increases, the bubble becomes heavier and sinks lower into the carbon dioxide in which it is floating.



CO_2 moves more easily into the bubble than air moves out.

Find this experiment online at: http://scifun.org/HomeExpts/SOAPBUBL.html

For additional information, see CHEMICAL DEMONSTRATIONS: A Handbook for Teachers of Chemistry, Volume 2, by Bassam Z. Shakhashiri, The University of Wisconsin Press, 2537 Daniels Street, Madison, Wisconsin 53704.

ScienceMakers

Spotlight: Isiah M. Warner

Full Name:	Isiah Manuel Warner
Born:	July 20, 1946
Place:	DeQuincy, LA
Parents:	Irma Warner
	Humphrey Warner
Spouse:	Della Blount
Education:	Carver High School - Bunkie, LA (1964)
	Southern University - Baton Rouge, LA (B.S. Chemistry, 1968)
	University of Washington - Seattle, WA (Ph.D. Analytical Chemistry, 1977)
Type of Science:	Chemistry
Achievements:	Served as the National Science Foundation program officer for Analytical and Surface Chemistry
	Presidential Award for Excellence in Science, Mathematics, and Engineering Mentoring

Favorites:

Color:	Blue
Food:	Thai Food
Quote:	"I am Isiah Warner, and I am a country boy from Bunkie, Louisiana."
Time of Year:	Autumn
Vacation Spot:	Europe or Africa

Biography

Chemistry professor Isiah Manuel Warner was born in DeQuincy, Louisiana, on July 20, 1946. Warner's parents, Humphrey and Irma Warner, raised him in Bunkie, Louisiana, where at age two, he drank kerosene to determine why it could produce light. Warner graduated as valedictorian from Bunkie's Carver High School in 1964; attending Southern University on a full scholarship, he graduated cum laude with his B.S. degree in chemistry in 1968. While working as a technician for Battelle Northwest, Warner earned his Ph.D. in analytical chemistry from the University of Washington in 1977.

Pursuing a career in academia, Warner served as assistant professor of chemistry at Texas A&M University from 1977 to 1982, eventually achieving tenure and a promotion to associate professor. Joining the faculty at Emory University, Warner was promoted to full professor in 1986 and served as the Samuel Candler Dobbs Professor of Chemistry from 1987 until 1992. During the 1988-89 academic year, Warner was on leave at the National Science Foundation where he served as program officer for Analytical and Surface Chemistry.
Joining the faculty of Louisiana State University (LSU) in 1992 as the Philip W. West Professor of Analytical and Environmental Chemistry, Warner became chair of the Chemistry Department and was appointed to the position of Boyd Professor in 2000.

Warner published over 230 articles in referred journals throughout the course of his career; a frequent guest lecturer, he also gave over 500 talks. Warner received five patents with another pending (as of 2004). In addition to his own speaking and publishing activities, Warner chaired over thirty doctoral theses. Recognized just as much for his work as a mentor as for his scientific activities, Warner's awards included the CASE Louisiana Teacher of the Year Award in 2000; the 2000 LSU Distinguished Faculty Award; and the 1997 Presidential Award for Excellence in Science, Mathematics, and Engineering Mentoring from President Clinton.

Warner and his wife, Della Blount Warner, raised three children.

Discussion Questions

Personal:

1. What did you like best about listening to Dr. Warner?

2. What do you think Dr. Warner's favorite quote means? What does this tell you about him?

3. Where was Dr. Warner 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. Warner attend high school? What do you suppose high school was like for him?

4. How old are you? In what year was Dr. Warner your age? What was happening in the country that year? What was happening in the world that year? What do you suppose his life was like when he was your age?

5. Dr. Warner talks about his great-great-grandfather, who was a medicine man in Africa. What is the herbalist tradition? What are some of the countries that have a rich herbalist tradition? Does that tradition survive today? Where? How has this tradition influenced modern medicine? How has it influenced Dr. Warner's own work? Research this and report back to the class. **(See Clip #1)**

6. Dr. Warner talks about his early school experience. What kind of a student was he? What was the reason for this? What happened as he progressed in his studies? What do you think was the deciding factor? How have you changed as a student throughout your school career? Are you pleased with this change? What do you think it will means for your future studies and your future career? What do you think you improve upon to achieve your goals? **(See Clip #2)**

7. Dr. Warner describes a special teacher. What was her name? What did she do that made such an impression on him? What did he take away from the experience? Have you ever had a special teacher? What did that teacher do for you? What lessons did you learn from that teacher? **(See Clip #3)**

Science:

8. What do you think a chemist does? Would you like to be a chemist? Why?

9. If you were a chemist, what kinds of questions would you study?

10. Dr. Warner talks about his first chemistry set. Why did he get it? What was so exciting to him about the chemistry set? Who else shared in the experience? What did they discover together? Dr. Warner attributes this chemistry set to launching his interest into science. Have you ever had a chemistry set? Have you ever been able play with science? Do you think science is more fun when you're not being graded? Why? How can you explore the world around you using science? **(See Clip #4)**

11. Dr. Warner had an unusual experience with science when he was two years old. What was it? What was he trying to investigate? How did he go about trying to investigate it? Have you ever had something that you wondered about? What are the kinds of things you would do to investigate those things further? **(See Biography)**

12. What was Dr. Warner's first project when he left graduate school? Explain the science behind spectroscopy. What did he use as a detector? What can you use spectroscopy for? Are there any other places we use spectroscopy today? What are they? **(See Clip #5)**

13. Dr. Warner works with chiral drugs. Explain what this means. How can chirality be useful? Why is it important to understand chirality when it comes to molecules in medicine? What are some other examples of chirality in the world around you? What can these be used for? Why is it important to know which form you are using? Why would you think it would be helpful to separate these molecules? **(See Clip #6)**

Additional Reading:
http://en.wikipedia.org/wiki/Chirality_%28chemistry%29

Experiment – Cabbage Chemistry

This experiment was developed by the Center of Science and Industry in Columbus, OH.
Description: Students become familiar with common acids and bases.

Materials:

- Red cabbage
- Cooking pot
- Knife
- Clean glass jar with lid
- Several clean, clear glasses

LIQUIDS TO TEST:

- Lemon juice
- Baking soda and water mixture
- Milk
- Vinegar
- Water
- Clear soda pop
- Windex
- Other substances as desired

Instructions:

1. Put cabbage in cooking pot and cover with cold water. Cook over medium-high heat until the water turns a deep purple-red.
2. Allow to cool. Pour liquid into jar. (The cabbage liquid can be kept in the refrigerator for several days.)
3. Pour equal amounts of liquid into each of the glasses.
4. One at a time, try adding a small amount of the materials for testing to each of the glasses.
5. Notice what happens in each glass.
6. Have the students classify the acids and bases based on common traits (can we eat them, what are they used for, etc.)

Possible Interactive Questions:
What's Going On?
The red cabbage indicator turns pink when there is an acid in it, and blue-green when there is a base in it. The indicator remains reddish-purple when there is a neutral substance in it.

pH is a measure of a substance's chemical ability to take or give hydrogen ions. Commonly, we classify substances as acids (will take hydrogen ions), bases (will give hydrogen ions), or neutrals (not willing to give or take).

What does this have to do with agriculture? One of a farmer's many jobs is being a scientist. To ensure good crops, a farmer must test the soil to make sure it is at the right pH and also to check for nutrients needed by the plants.

COSI Center of Science and Industry

Isiah M. Warner - Video Clip Transcription

Clip 1 - Family Stories: My grandmother used to tell me stories about slavery…She would tell me for example about her great-grandfather, sorry, her grandfather, would be my great-great grandfather, who was, apparently a medicine man from Africa. And, she would tell me a story about how he had all these different medicines, and there would be people from all over who would come to get treated for medicine. In those days, there weren't any cures for cancer. So, whites and blacks would come to him to be treated. So, it wasn't just like it was restricted to blacks. She would tell me stories about whites and blacks who would come to him. In fact, when I go back to Africa, there's a lot of truth to the herbalists in that they work alongside the traditional medical doctors nowadays. And Africans really believe in the herbalists, and it turns out a lot of the medicinal medicine we get from plants come from herbs in countries like Africa, South America, and that's usually some medical basis behind the use of these compounds. As a matter of fact, one of my research areas is I'm extracting some compounds that are now used in Africa for treating patients, and we're trying to find out what are the chemicals in there that might be helping.

Clip 2 - Favorite Subjects: I always liked science and mathematics. Early on, you know, I went back and looked at my grades, they were terrible when I was in first grade. Again, probably because of my emotional attachment to my mother, you know, I was very emotionally attached to my mother, didn't want to be away from her, which is part of the reason why they had to escort me to school. My grades were terrible, but as I progressed it was clear to everyone that I was the student in the class and I graduated valedictorian of my class eventually.

Clip 3 - Influential Teachers: I guess the first teacher that had an impact on me and made me believe I was something special was a teacher named Mrs. Whitcliff…She loved to hear me read. She thought my voice was so melodious. She thought I read with such eloquence that she'd have me reading before the class. I think this was fourth or fifth grade… After I'd read, she say, "Isn't his voice beautiful? Isn't he just a wonderful reader?" and the kids would be looking around saying, "What's wrong with this woman?" You know, "We don't hear anything special." But her special interest in me encouraged me also, and… I don't know why she thought I was so special, but she really thought I was special and treated me that way. And because of that also I wanted to perform better.

Clip 4 - Chemistry Set: And I just knew that I loved science, it was just something I'd… Early on, when I was about twelve years old, my father got me a chemistry set because I kept begging for a chemistry set. I don't know why. Oh, I do know why, I take it back. It was Mr. Wizard on television, I used to watch… That was my favorite show when I was growing up, Mr. Wizard, and so I wanted a chemistry set so I could do chemistry. My grandmother wouldn't let me play with it in the house. We'd have to go outside because she was afraid we'd burn the house down. But I still have fond remembrance of that chemistry set. And I was talking to a group of students recently about it and I couldn't remember exactly when we got the chemistry set so I called my brother up and said, "When did we get that chemistry set?" And he said, "Why are you asking that?" I said, "Because I was talking to a class about it." And he said, "That's amazing, I was just talking to a class about that exact same chemistry set." And so, you know, obviously it had some impact on both of us.

Clip 5 - Spectroscopy: When I left graduate school, one of the things I developed was a new instrument for measuring fluorescent spectroscopy. Fluorescence has to do with, you shine light on a molecule, and molecules give you off a different light. Both of those lights are characteristics of the molecule. The light that's absorbed, and the light that's given off. And so I developed an instrument that would measure all the light that's absorbed and given off simultaneously for all molecules at a given time. And so when I left school I started applying that instrument, I developed another instrument similar to it and started applying it to various applications. So that was the focus of my research a lot of [the] time, using that instrument to identify molecules. In fact, it was a video camera really, that I used as a detector. The image was two-dimensional. I would have a two-dimensional representation of the molecule and it would be the light that was given off as a function of exciting wavelength and emitting wavelength and that image could be plotted, you know, as a television image in two dimensions. So I could apply that to identifying molecules in pollutants, like polyaromatic hydrocarbons and different kinds of molecules. That was my first area of research.

Clip 6 - Recent Research: Since I've come here, I've started getting into the area of separation science, where I develop… Most drugs are chiral, and chirality has to do with handedness, just like my hand, my left hand and my right hand are mirror images of each other, but I can't superimpose them. There are molecules like that, that are mirror images of each other, same chemical formula and can't be superimposed. They have a special name. They're called chiral molecules, and most drugs exist in that form. They're chiral. They have two forms, one form, they're both called enantiomers. One might be called the "R" form and the other one called the "S" form. And one form might be very beneficial to you medicinally. The other form might be very detrimental to you. And there was a drug called Thalidomide, which was given to pregnant women in the 60s, and it turns out that was exactly the case. One form was beneficial; it was an anti-nausea drug. The other one was a teratogen, causing birth defects. And so women that took this drug gave birth to babies with no arms, no legs or truncated arms and legs… Not only do they look alike, but it's only in the presence of other chiral molecules that they act different. If you didn't have another chiral molecule, they would behave exactly the same. They would have the same melting point, boiling point. They would react exactly the same, but only in a chiral environment. That is, an environment where you have other molecules that are mirror images. Turns out the body is a factory for those kind of molecules; all proteins are mirror images, have mirror images because all of the amino acids have mirror images. So proteins…the body is highly selective. The body only uses pretty much L amino acids, it only uses the D form of the sugars and so the body is probably the most selective machine that you can find. So when they introduce these two forms, the body says, "I don't like this other form," and started... So what happens is, when the mother takes it, the form that was bad starts truncating blood vessels and since the blood vessel growth gets truncated, the arms can't grow and whatever depends on growing blood vessels gets truncated. Most drugs that are marketed are chiral. That's an extreme case. The less extreme case is that one has medicinal properties and the other has no properties whatsoever. And then there are other cases where they might have opposite properties. One might be good for the heart and the other one is good just as a sedative, you know. They even taste, some drugs taste different, you know. If you had different forms of sugar one might be sour or something and the other one might taste sweet. The body is able to recognize these differences because it is a chiral environment. In the normal sort of chemical reactions it doesn't matter which is which… I'm developing techniques to separate these molecules.

ScienceMakers

Spotlight: Bobby L. Wilson

Full Name:	Bobby L. Wilson
Born:	September 30, 1942
Place:	Columbus, MS
Parents:	Lilly Mae Wilson
	Johnny B. Wilson
Spouse:	Mary Ann Wilson
Education:	Hunt High School - Columbus, MS (1962)
	Alabama State University - Montgomery, AL (B.S. Chemistry, 1966)
	Southern University - Baton Rouge, LA (M.S. Chemistry, 1972)
	Michigan State University - East Lansing, MI (Ph.D. Chemistry, 1976)
Type of Science:	Chemistry
Achievements:	Developed a niobium compound later used to liquefy coal
	Published two general chemistry textbooks

Favorites:

Color:	Black
Food:	Fish
Quote:	"Everything will be just fine."
Time of Year:	Fall

Biography

Environmental chemist and college professor Bobby L. Wilson was born on September 30, 1942, in Columbus, Mississippi, the eldest child of Lilly Mae Wilson and Johnny B. Wilson. After graduating from Hunt High School in 1962, Wilson attended Alabama State University where he received his B.S. degree in chemistry. Wilson then took a teaching position at Booker T. Washington High School as a chemistry and physics teacher where he remained until he decided to continue his education in 1970. Wilson received his M.S. degree in chemistry from Southern University in Baton Rouge, Louisiana, and did his doctoral work at Michigan State University, where he received his Ph.D. in chemistry in 1976.

Wilson settled in Houston, Texas, where he became an Assistant Professor of Chemistry at the historically black Texas Southern University (TSU) in 1976. In 1978, Wilson became the regional chairman of the National Organization for the Professional Advancement of Black Chemists and Chemical Engineers (NOBCChE). After spending parts of 1982 and 1983 as a visiting research professor at Exxon's research and engineering facility in Baytown, Texas, Wilson returned to TSU to become a full professor of chemistry in 1985. One year later, Wilson began his involvement in the TSU administration, becoming an Associate Dean for the College of Arts and Sciences. By 1987, Wilson was head of the Chemistry Department, and during the 1989-1990 school year, he was the interim Dean for the College of Arts and Sciences. Wilson then became the Vice President for Academic Affairs in 1990, and in 1992, he was appointed Provost of TSU, a position he held until 1994, and again beginning in 1999. From 1996 to 1997, Wilson was the program director for the Centers of Research Excellence in Science and Technology at the National Science Foundation in Washington, D.C. Wilson was named acting President of TSU for a few months in 2006 and again in 2007.

Over the course of his career as an environmental chemist, Wilson had his research published dozens of times; published two general chemistry textbooks; gave over seventy major presentations to his peers; advised dozens of doctoral theses; held three patents; and won numerous research grants from institutions such as NASA, the Environmental Protection Agency, the Department of Energy, and the Egyptian Government. In 1998, Wilson became a member of NOBCChE's Executive Board, and in 2005, he became Chairman. Wilson also served on the Executive Board of the Texas Academy of Science.

Discussion Questions

Personal:

1. What did you like best about listening to Dr. Wilson?

2. What do you think Dr. Wilson's favorite quote means? What does this tell you about him?

3. Where was Dr. Wilson 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. Wilson attend high school? What do you suppose high school was like for him?

4. How old are you? In what year was Dr. Wilson your age? What was happening in the country that year? What was happening in the world that year? What do you suppose his life was like when he was your age?

5. What was Dr. Wilson's attitude towards school? How do you feel about school? What do you like best about it? What do you like least about it? What are you good at in school? What do you struggle with? Where kind of career will you aim for, given these things? **(See Clip #1)**

6. Dr. Wilson says that he knew he would pursue science from an early age. What influenced him in this? Why was this event so important to the American people? What did this event lead to? Do you know where you want to focus? Have you had any significant events that influenced you? What were they? What did Dr. Wilson NOT want to focus on? Why? Is there anything you know that you don't want to do? Why not? **(See Clip #2)**

7. Dr. Wilson realized something in high school and made a change in his life. What was it? Why did he do this? Have you ever been underestimated by someone? How did this feel? What did you do about it? **(See Clip #3)**

8. What did Dr. Wilson plan to study in college while he was in high school? Why couldn't he do this? What was Dr. Wilson planning on studying in college instead? How did Dr. Wilson get into chemistry once he was in college? **(See Clip #4)**

Science:

9. What do you think a chemist does? Would you like to be a chemist? Why?

10. If you were a chemist, what kinds of questions would study?

11. Dr. Wilson talks about his work. What is the difference between organic and inorganic chemistry? What are the benefits of inorganic chemistry? What are the benefits of organic chemistry? How do we use organic chemistry on a daily basis? What are some common substances that require organic chemistry? Why do you think Dr. Wilson's compounds were sensitive to air and water? Since we interact with air and water on a daily basis, have you ever considered that air and water are powerful mixtures that can react violently with compounds if not properly insulated? Give some examples of this. **(See Clip #7)**

12. Dr. Wilson talks about his niobium compound. Did he have a purpose for it when he created it? Do scientists always have to have a practical reason for the research they are conducting? Why or why not? Dr. Wilson talks about how his niobium compound was later used to liquefy coal. Can you think of other examples where pure research lead to unplanned applied technology? How has this benefited our modern way of life? **(See Clip #8)**

13. Research in chemistry is often practical in nature. This means chemists work in industries other than universities or research labs. What are some of these places? What are some ways that chemistry impacts you on a daily basis?

14. What does NOBCChE stand for? Research the organization and report back to the class. What is the benefit of an organization such as this? What do you think the value of peer support is? How do you see this played out with your peers? What inspiration can you draw from your classmates? How is this similar to professional chemists and chemical engineers?

15. Dr. Wilson talks about putting resources into education and opening up the sciences for minorities. What does he say is the biggest component in this process? Would you be more inclined to go into the sciences if there were more obvious financial assistance? Who can help you find financial assistance to go into the sciences? **(See Clip #10)**

Experiment – Liquid Fireworks

This experiment was developed by the Center of Science and Industry in Columbus, OH.
Description: As colored oil mixes with water, describe the motion of objects and conceptually describe the effects of forces on an object.

Materials:

- Small cup
- Cooking oil
- Food colors: red, blue and yellow only
- Large glass, filled full with water
- Plastic fork

Instructions:

- Fill small cup halfway with oil.
- Add 4 drops red, 4 drops blue, and 4 drops yellow food coloring to oil. Use plastic fork to break up the drops. Try not to let the color drops mix together.
- Carefully pour the mixture of oil and food colors onto the top of the water in the large glass.
- Don't stir the water! Watch closely and draw what you observe!

What's Going On?

Food color is water-based. Oil and water do not mix, but can be blended. The food color will mix with the water faster if its surface area is increased. Matter, such as water, oil, and food color, is made up of molecules, all of which are in a constant state of motion. Even without stirring the water in the container, the colors will mix and fall because of molecular motion and gravity.
At what point can you see orange, purple, or green? What is causing these colors to emerge?

COSI
Center of Science and Industry

Bobby L. Wilson - Video Clip Transcription

Clip 1 - Attitude About School: I always had a love for school, including Sunday school. Still go to Sunday school. And I always did pretty good in school. My mother never had to bother me about studying and all this stuff about… I didn't need nobody to tell me to study. I had my assignments. I did my assignments. Nobody ever said anything to me about it. My brother right under me was just the opposite, and my sister next to him was just the opposite. What I really wanted to be was… I knew I wanted to go to college. I was pretty good at math, and I loved math and science. And Sputnik came along. And so the space age had a great impact on what I thought I wanted to be. It was gonna be some kind of science.

Clip 2 - Experience in High School: I basically just went to high school, got my lesson. They put me in the shop when I first got there. Woodwork. Taught me how to build houses. How to lay bricks. So, I got some houses in Columbus that I've actually built and bricks that I've laid. And I stayed in there two years in this, what they call the shop. They didn't even have me in the college prep… And so my junior and senior year I had to do a little catching up and I had to start advising myself. After the first two years, you're in this shop, and then the second two years you're supposed to do something kind of domestic, whatever. You go off in the afternoon, go downtown and work. Well that's where I parted company with this track. And, I decided I'd go over and start taking all the math they had, and I took the chemistry in the junior year and physics in my senior year and the highest they had in math was Algebra II. So, I took Algebra I and then Geometry and then Algebra II. So, I pretty much well decided I was going to prepare my own self for college, because they were putting me in the domestic track.

Clip 3 - Knowing He Would do Science: I was fully aware and had fears and very conscious of the kind of world, you know, that we were living in. My uncle had served in the Korean Conflict, and he would come home telling me wild stories. And so, the Russians was a big fear to me, the atomic bomb or some more atomic bombs and then the hydrogen bomb, which is more powerful than the atomic bomb. And so I would spend a lot of my time envisioning, well how long can you stay in a shelter? How long will the food last? And so, I knew I was going off to college, I knew I would major in some kind of science. I knew it was not going to be biology. I did not want to be a medical doctor, because my parents used to make me stay with the older people who were sick.

So I had been turned off by sickness, like my grandmother was sick, the aunt sick, you had to babysit the sick. Well see, I didn't want to have any part of anything that had to do with biology and medicine. I knew it would be some kind of physical science.

Clip 4 - Decision to Major in Chemistry: We were standing in these lines for registration. This is how it happened, how I got into chemistry. And these long lines, you know, back in those days you'd be standing in line for days. These long lines. And so a bunch of us in the biology line, and I looked up and saw there was another line up there with nobody in the line. So, my three little buddies, the three of us, I said "Man, let's go up here and get in this short line." We walked up to Dr. McDonald and told him we wanted to register and he said, "You know this is chemistry, you're registering for the chemistry major." So, we told him, "Okay, we want to be chemistry majors then." So he asked us about our math grades, so when we told him, this was our second year, our second year in college. So, he asked about our math grades. So, once we told him our math grades, he said "Yeah, you'd be a good chemistry major." So, the three of us signed up, and we all graduated three years later with chemistry, as chemistry majors. I could have very well stayed in the biology line. I could have gotten in the math line. I really wanted to major in physics, but they didn't have a physics major. I enjoyed physics a whole lot more in high school than I did chemistry. But, 'cause… physics was just nice, but they didn't have physics majors. So, the three of us chose chemistry, and we got in that line and we became… That was the class of '66 as chemistry majors.

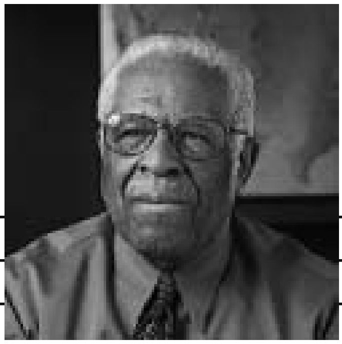
Clip 5 - Types of Chemistry: I'm what they call an inorganic chemist; I did my research in inorganic chemistry. Right now, I'm more of an environmental chemist, because it just, it's a little bit more research money available for schools like TSU in environmental chemistry and environmental science. So, we go with the money. Actually, we call it, I was just basically a synthetic chemist, just make stuff for the joy of making it. It has no use. You just make it. Synthesize it. And so, I had some niobium compound that I'd prepared and they turned out to be air sensitive so I had to do all my work in a glove box and handle all my… All my solvents had to be dried and when you say dried, had to make sure they had no water in them. If I was using let's say, benzene, I had to dry the benzene to make sure it didn't have traces of water in it because all my compounds were sensitive to water and air, so I did my work in a glove box, enjoyed making my compounds.

Clip 6 - Chemical Discoveries: It turns out that, those of us who just make stuff to say that we make it and it's the only thing of its kind in the world. Then, you publish the material. People know about it in the literature. Every once in a while, they'll find a use for it. Now it turns out that, I hadn't found no real use for the niobium compound that I made, but because I made the niobium compound and got involved with some of what we call legins…some other materials that were associated with niobium, I was able to use those, to use metals other than niobium to use catalysts to liquefy coal. And so I did some of that work at TSU. [I] actually went out to Exxon Research and Engineering in '82 on sabbatical, spent about 15 months out there and wound up with a couple of patents, but I was still using the same kind of compounds, not niobium but other metals with the same kind of material that I was making niobium compounds. And it turned out that, I could make…they could improve the colic faction.

Clip 7 - Concerns for Scientific Field: The policy makers need to really look at paying…putting enough resources in to make high education affordable to African Americans and everybody else. It's not just going to be African Americans. We talk a lot about the lack of minorities and going into the science, technology, engineering and mathematics and we got to get past just the talk. We got to put the resources in there because what I found out is that if you really put the resources there that you can find the students that are willing to come and study in these fields…I think that because of the war, that [there's] only so much money to go around and I'm hoping that this was only delayed because of that. And as soon as we get some of these other problems resolved that we can really start concentrating on the necessary resources into education.

ScienceMakers

Spotlight: Waverly Person



Full Name:	Waverly J. Person
Born:	May 1, 1927
Place:	Blackenridge, VA
Parents:	Bessie Butts
	Santee Person
Spouse:	Sarah Walker
Education:	St. Paul's High School - Lawrenceville, VA (1944)
	St. Paul's College - Lawrenceville, VA (B.S., 1949)
	American University - Washington, D.C.
	George Washington Universty - Washington, D.C.
Type of Science:	Geophysics, Seismology
Achievements:	First African American director of the United States Geological Survey's National Earthquake Information Center
	Earned the Outstanding Government Communicator Award

Favorites:

Color:	Brown
Food:	Steak & Candied Yams
Quote:	"Keep getting up."
Time of Year:	Spring

Biography

Geophysicist and seismologist Waverly J. Person was born on May 1, 1927, in Blackenridge, Virginia, to Bessie Butts and Santee Person, a farmer. After completing his B.S. degree in 1949, at St. Paul's College in Lawrenceville, Virginia, Person joined the U.S. Army. When he was honorably discharged in 1952, First Sergeant Person received Good Conduct and Asian Pacific medals.

Person married Sarah Walker in 1954 and relocated to Washington, D.C., where he performed a series of odd jobs. In 1962, Person obtained a position with the National Earthquake Information

Center, an organization designed to monitor tremors worldwide, locate earthquakes, and dispatch emergency crews. Person was intrigued by the readings on the rolls he was assigned to maintain and began to study the field in more depth; he continued to work as a technician while simultaneously studying at American University and George Washington University until 1973. Upon earning the qualifications geophysicist, Person transferred to Colorado to begin his work within his field. In 1977, he was named Director of the Colorado National Earthquake Information Center and eventually became a sought-after earthquake spokesperson for national and international media. Person went on to serve as the director of the United States Geological Survey's National Earthquake Information Center, becoming the first African American to do so.

Honors that Person earned include the Outstanding Government Communicator Award, the Meritorious Service Award from the United States Department of the Interior, and the Annual Minority Award from the Community Services Department in Boulder, Colorado. Person served as the eastern section treasurer of the Seismological Society of America and as a member of the board of directors of Boulder County Crimestoppers. Person held the positions of president and member of Flatirons Kiwanis Club in Boulder, Colorado, and as the membership retention chairman of the Rocky Mountain District.

Discussion Questions

Personal:

1. What did you like best about listening to Dr. Person?

2. What do you think Dr. Person's favorite quote means? What does this tell you about him?

3. Where was Dr. Person 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. Person attend high school? What do you suppose high school was like for him?

4. How old are you? In what year was Dr. Person your age? What was happening in the country that year? What was happening in the world that year? What do you suppose his life was like when he was your age?

5. What was school like for Dr. Person? Did he like it? What were the difficulties that he faced? How was the country different when Dr. Person was a child? Are there any similarities between then and now? What are they? **(See Clip #1)**

6. Dr. Person says that he was nosy; curious might be another way to say that. What are you curious about? Do you wonder how things work, like Dr. Person did? How can you find the answers? **(See Clip #2)**

7. Dr. Person talks about the differences that he noticed in society. What were some of those differences? Do you think that we have made enough progress since then? Why or why not? **(See Clip #2)**

8. Dr. Person talks about role models for young people who are interested in math or science. Who were the role models that Dr. Person saw? How did this change his idea of what he would become? Who are your role models? What kinds of things do they do? Why do you want to be like them? **(See Clip #3)**

9. How did Dr. Person become a geophysicist? Explain the various steps he took, especially when he changed his plans to accomplish his overall goal. What kinds of long-term goals do you have? Do you have a plan do meet those goals? What will you do if your plans don't work out? What are some ways you can change to meet your goal? **(See Clip #4)**

10. Dr. Person talks about young people today. Where does he see their focus going in terms of career goals? Do you think this is accurate? In your class, what do people want to do when they grow up? Tally the results and discuss how these numbers match up against statistics. What other opportunities do you have? What kinds of things do you like to do? What kinds of things are you good at? What kinds of jobs can you do with these likes and these skills? **(See Clip #8)**

Science:

11. What do you think a geophysicist does? Would you like to be a geophysicist? Why?

12. If you were a seismologist, what kinds of questions would you study?

13. The USGS handles earth science. What kinds of things are studied in earth science? Are there more subjects involved than Dr. Person mentions? What are they? What are the areas of earth science that are most appealing to you? **(See Clip #5)**

14. Dr. Person discusses his early earthquake detection system. What is it that it does? What are the procedures in the event of an earthquake? What are the differences between an earthquake in the U.S. and one in a different country? Dr. Person talks about sharing data. What do you think he means by this? Be specific. Why would you share scientific data? **(See Clip #6)**

15. Have you ever been in an earthquake? Where? When? How did it feel? Share your experience with the class. How do you think Dr. Person's earthquake detection system helped you?

16. Why do you think that we can't predict earthquakes? What causes earthquakes? Are there areas of the world that are more likely to have earthquakes? Why? Where are they?

17. Dr. Person talks about the Richter scale classification of earthquakes. How does the Richter scale work? Research some historic earthquakes. What was their magnitude? Why did certain types of damage occur? Is there anything we can do to minimize the damage done by an earthquake? What kinds of things can you think of to do that? **(See Clip #7)**

Experiment - Liquefaction

This experiment was developed by the Exploratorium in San Francisco, CA.

What happens to sandy or fine-grained soils when an earthquake shakes them up? Try this simple activity to find out.

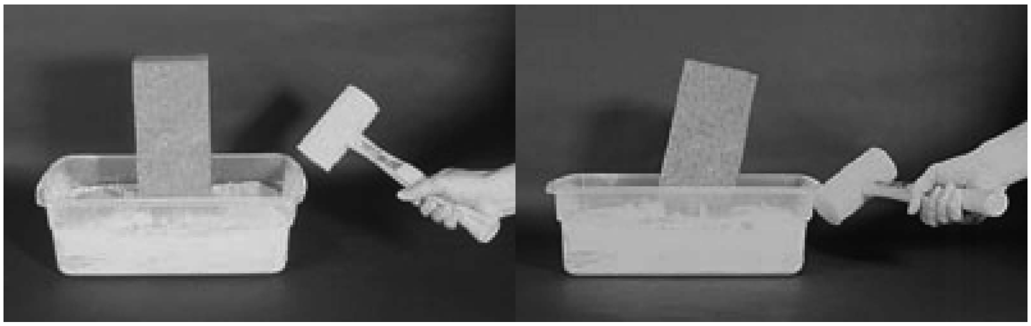
What do I need?

- Metal or heavy plastic pan—full-sized loaf pans work well
- Sand
- Water
- A smooth brick
- A rubber mallet

What do I do?

1. Fill the pan with sand—the deeper the better.
2. Put the pan on a table. Then pour in water to just below the surface of the sand.
3. Wiggle the skinny end of the brick down into the wet sand so it stands up like a building would.
4. Now, very gently, repeatedly tap the side of the pan with a mallet and notice what happens to the sand and the brick.

Earth Science



Photos: Lily Rodriguez

What's Going On?

Did the sand get all squishy? Did the brick fall over?

If a mixture of sand and water sits for a while, the sand particles will settle until they touch each other. There will be water in spaces between the particles, but the mixture will behave as a solid. When you squeeze the sand (essentially what you're doing by striking the container with the mallet) you're trying to push the sand particles closer together. To get closer to each other, the particles would have to push the water between them out of the way. That's what happens when you squeeze saturated sand in your hand, and it's what happens to the wet sand under your feet when you walk along a beach.

But that's not what happens during an earthquake. During a quake, the squeezing done by the seismic waves happens very quickly, and the water doesn't have time to flow out of the way of the sand particles. So as the particles try to move into a denser configuration, they push on the water, causing an increase in water pressure.

This increased pressure causes the forces at the contact points between the sand particles to decrease. If the water pressure is high enough, it can reduce the interparticle forces to zero, which means that the sand particles "float" away from each other. For a brief time, the sand particles are suspended in the water. This is liquefaction. The soil's loss of strength occurs because there's no contact between the particles of sand.

So What?

Many buildings in the San Francisco Bay Area are built on landfill, sand, or mud that can liquefy. Liquefaction caused much of the damage during the 1989 Loma Prieta earthquake. It has also been responsible for major destruction in other quakes, including Kobe, Japan, in 1995 and Mexico City in 1985.

Find this experiment online at: http://www.exploratorium.edu/faultline/activezone/liquefaction.html

Waverly Person - Video Clip Transcription

Clip 1 - Early school experiences: I felt real good about schooling because my parents were always was interested in us going to school. And I always wanted to go to school, but there again, we had a tough time going to school because we were working the farm. And when time came to plant and harvest, you had to stay out of school to plant and to harvest the crop. And so you missed a lot of time out of school. But I was always anxious to go to school, but sometime we had to miss a lot of time because of that. We had to get the crop in. We had to get the--that was our livelihood. We had to harvest, and we had to plant it…I was always interested in reading and writing and math and stuff like that.

Clip 2 - Childhood observations: I was always nosy. I always wanted to know what was going on. I always made an attempt to find out what was going on. And at a very young age, I began to think why were we deprived of so many things. We were paying taxes and things like that. I started to realize that at a very young age and felt that it was an injustice, and that why should we have to be subjected to this? And one of the things that really disturbed me, and this was in elementary school, was that our school would close before the white school because they say, well, they closed the school so that we could go work on the farm, and the white school would continue on. We'd close in early May, and they would close in June.

Clip 3 - Role models: I didn't have any, really inclination of any particular thing that I really wanted to do. One of the things that I somewhat leaned towards was to be a school teacher because that was a role model you'd see. You could see black school teachers, but as far as anything else, you didn't see. See, you kind of looked at them as being school teachers, and so I had an idea that that's probably what I'd want to do because that's what you see.

Clip 4 - Becoming a geophysicist: I went back to school because I had my background in math and science, so I went back to American and Joe Washington University, and I took all of the math and the science and everything that you needed to become a geophysicist, and I'm working there in it. And so I was developing more and more interest in it and everything. And I'm working the whole time. And I went on, went back and so I, I'm still a technician. And so I became qualified with everything that was needed to become a professional geophysicist, and I applied for it. The first couple of times I was turned down, not because I didn't qualify but because of my color. At that time, you had to put down what your race was. And so I got disqualified to even get on the register to be hired because my race was there, and I know what was going on. When they were doing the, the registering and, you know, looking at everything, well, automatically, I get disqualified because I'm black, okay. So I said, okay, I'm still working here, I'll keep working, and I kept working and everything. And then I kept applying. I kept applying. I'm getting experience all the time cause I had this project then that I was working on by myself, and at that time, they were building Flaming Gorge and Glenn Canyon Dam and they wanted somebody to work on that to look at what is happening here in the way of blast and what is happening with, as far as earthquakes are concerned. What happens once they start building? What happens when they put the water in and all that? And I'm working on that. So I kept applying, and so by that time, I had advanced to a grade that was higher than what I could come in as a geophysicist, and I was a higher grade. And so I applied again. And I got on the register. Okay, and then there came a time--at the time that this guy--I had developed a very close relationship with several people there. And we were, we were very, very close friends and they liked me because I did the work. And so they pushed for me. So I got the job as a geophysicist. And I had to go down from a GS-7 to a five [GS-5] to come in because they, I couldn't come in as a seven [GS-7]. I had to come in as a five [GS-5]. So I was willing to take the downgrade because the potential was there. I could see that, so I took it. And that's where I got started, and I'm still the only Afro-American.

Clip 5 - The U.S. Geological Survey: The U.S. Geological Survey is earth science. That's what we are. We are scientists, earth science in every form. That's what the U.S. Geological Survey consists of. A lot of people figure that the U.S. Geological Survey only made maps. Well, that's a big part of it, it's a mapping, but they also have the earth sciences and earthquakes is one big part of it, and geomagnetism is a big part, landslides and those kind of things. But earthquakes is one big part of the U.S. Geological Survey. Our office here and our office in Menlo Park is a big part of the U.S. Geological Survey. But it's earth science, and it's a water [quality] --you know, a lot of water, you know, the qualities of water and things like that. And parts of it also is working with dams, years ago, building dams, all those kind of--Bureau of Reclamation, and all that kind of stuff. That's, that's what the U.S. Geological Survey is all about.

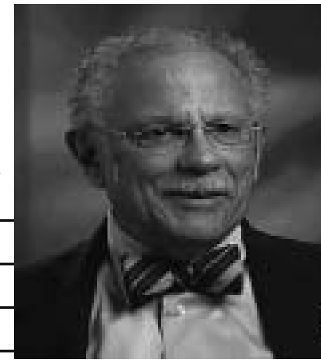
Clip 6 - Responding to earthquakes: We cannot predict, we cannot forecast earthquakes, and in the United States right now, there's no work being done on forecasting and prediction of earthquakes. So my role is--the very first thing we do is called earthquake early alerting. Now, when I say that, you think that I'm able to tell you when and where the next earthquake is gonna be. I can't do that. But what we can do, with technology today, we are the only center in the world that [can] locate [earthquakes], compute magnitudes and disseminate data on significant earthquakes worldwide. And we do that here. So that's the very first thing that we do. Any earthquake that is potentially damaging anywhere in the world, that could possibly kill people or cause damage, we're going to get the answers right now, and we're gonna pass this information on to the proper authorities, mostly to organizations that respond to disasters, and earthquakes is one of them. Get there, and begin your rescue effort. And if you get there quickly, you can rescue a lot of people. When buildings crash and come down on people, if you can get there quickly, you can get a lot of those people out alive. You can get the seriously injured to the hospital. This is after the earthquake occurs. For U.S. earthquakes, anywhere in the United States, we can have that information right here within thirty to forty minutes. We have that information, and we have a hotline here that we can reach any emergency office anywhere in the United States. And the minute that we get that information all ready, we get on the phone, and we call them and say, here is where the earthquake is, this is the location, this is the latitude, this is the longitude, this is the magnitude, and they get that. When they see that, they know the population and they know everything about it. That's when they fall into action to start rescue. If the earthquake is in a foreign country, it takes us maybe, sometimes an hour or more to get the information ready. We get it ready, and the first thing we do, once we get all that ready, we give it to our embassy or consulate in that country if we have one. And then the next place it goes, it goes to our State Department in Washington, D.C. cause they're supposed to know where all Americans are in the foreign countries. They get it, okay. Then they have all these observatories around the whole world that are cooperating with us. They are hooked into us to get our electronic mail for whatever; we locate [the] magnitude and everything. Even though they might be doing their own [research] in their country, they want to know what we got because a lot of those people are giving us data on a daily basis, real time basis, coming in by satellite. So that's the way it goes. So that is the very first thing that we do. And it's designed to try and save lives.

Clip 7 - Levels of earthquakes: A minor earthquake is 3.0 to 3.9, that's minor. A light earthquake is 4.0 to 4.9, that's light. A moderate earthquake is 5.0 to 5.9. A strong earthquake is 6.0 to 6.9. A major earthquake is 7.0 to 7.9. And a great earthquake is 8.0 and above. That's the way they classify it. And usually, when you get into the moderate earthquakes, sometimes they can have considerable damage, but in most cases--I think I know of one case in the U.S. where some people were killed, with one that was about a 5.9. Usually, you're in a magnitude of 6.0 when you get deaths in the United States, but many of the foreign countries, a lot less because their structures are not near as strong as ours here. But that's the way we classify them. And I don't have my pager on today. A pager, we carry pagers all the time that, information about these earthquakes come to us all the time. Every time it locates one, it comes to us. It buzz us. You push the button. You got it. It's coming in, all of it. And we have two people that are always on call to respond to whatever happened, and these people are experienced. They know what to do with certain magnitude earthquakes and where to go with it and all that kind of stuff. And it's my job to make sure that all of this is done and done properly.

Clip 8 - Working with young people: During the school year, all of the students from fourth grade up are allowed to tour this place. And we have all of them coming in, and we show them; we talk to them. We're trying to get the young people interested in science. And I do a lot of this in the metropolitan areas, especially in the inner city. I go in and talk to the kids and talk to them and say, look, you can do this. You can be this. If you want to do this, you got to work and do this. And so I do a lot of that…The young generation today, many of the young generation, especially Afro-Americans, they all figure they're gonna be athletes. They all figure they're gonna be professional football players. They're gonna be professional basketball players. And that's where they concentrate, okay. They see a role model. And they think they're gonna be one too. All right, the next thing they see a lot of lawyers. They see a lot of doctors. So, that's where a lot of them want to concentrate into those fields because for us, they don't see many of us. And in many cases, we don't make the money that those people make, you know, the professional [athletes]. We don't make that kind of money. There're kids today, what they're thinking about, how many bucks I'm gonna make, what kind of car am I gonna drive? I go many places to talk today to the kids. The first thing they ask me, "What kind of car you drive?" I say, "I drive a [Volkswagen] Bug." "What?" I say, yeah. So, you know, they see role models, and what they're looking at is that person out there that's making big bucks and they figure that they're gonna do it too. And you know as well as I know how many professional football players you're gonna have. How many professional basketball players you're gonna have. How many really make it, and how many don't…So, it's hard as far as science because they don't see that many role models.

ScienceMakers

Spotlight: Warren M. Washington



Full Name:	Warren Morton Washington
Born:	August 28, 1936
Place:	Portland, OR
Parents:	Dorothy Washington
	Edwin Washington
Spouse:	Mary Washington
Education:	Jefferson High School – Portland, OR (1954)
	Oregon State University – Corvallis, OR (B.S. Physics, 1958)
	Oregon State University – Corvallis, OR (M.S. Meteorology, 1960)
	Pennsylvania State University – University Park, PA (Ph.D. Meteorology, 1964)
Type of Science:	Atmospheric Science
Achievements:	Developed one of the first atmospheric computer models of the earth's climate
	Presidential Appointment to the National Science Board

Favorites:

Color:	Blue
Food:	Italian Food
Quote:	"Science is exciting."
Time of Year:	Summer
Vacation Spot	Europe (France & Italy)

Biography

Distinguished scientist Warren Morton Washington was born on August 28, 1936 in Portland, Oregon. As a high school student, Washington had a keen interest in science. After high school, he earned his B.A. degree in physics and his M.S. degree in meteorology from Oregon State University. After completing his Ph.D. in meteorology at Pennsylvania State University, Washington became a research scientist at the National Center for Atmospheric Research (NCAR) in 1963. While serving in the position of senior scientist at NCAR in 1975, Washington developed one of first atmospheric computer models of the earth's climate. Soon after, he became the head of the organization's Climate Change Research Section in the Climate and Global Dynamics Division.

As an expert in atmospheric science, climate research and computer modeling of the earth's climate, Washington received several presidential appointments. From 1978 to 1984, he served on the President's National Advisory Committee on Oceans and Atmosphere. In 1990, Washington began serving on the Secretary of Energy's Biological and Environmental Research Advisory Committee, and in 1996, he assumed the chair of the Subcommittee on Global Change. He also served on the Modernization Transition Committee and the National Centers for Environment Prediction Advisory Committee of the United States National Weather Service. In April 2000, the United States Secretary of Energy appointed Washington to the Advanced Scientific Computing Advisory Committee. He was also appointed to the National Science Board and elected chair of the organization in 2002 and 2004.

Among his many awards and recognitions, Washington received both the Le Vernier Medal of the Societe Meterologique de France and the Biological and Environmental Research Program Exceptional Service Award for atmospheric science. His induction into the National Academy of Sciences Portrait Collection of African Americans in Science, Engineering and Medicine was announced in 1997. Washington also received the Celebrating Twentieth Century Pioneers in Atmospheric Sciences Award at Howard University, and Reed College in Portland, Oregon awarded him the Vollum Award for Distinguished Accomplishment in Science and Technology. Washington held memberships in the National Academy of Engineering and the American Philosophical Society.

Washington continues to be a mentor and avid supporter of scholarly programs and outreach organizations that encourage students to enter the profession of atmospheric scientists. He lives in Denver with his wife, Mary, and family.

Discussion Questions

Personal:

1. What did you like best about listening to Dr. Washington?

2. What do you think Dr. Washington's favorite quote means? What does this tell you about him?

3. Where was Dr. Washington 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. Washington attend high school? What do you suppose high school was like for him?

4. How old are you? In what year was Dr. Washington your age? What was happening in the country that year? What was happening in the world that year? What do you suppose his life was like when he was your age?

5. Dr. Washington says that he enjoyed learning about how the world works. Do you ever wonder how things work? What kinds of things? How could you find out the answers? **(See Clip #1)**

6. Dr. Washington talks about taking hard classes, even when some of his smart friends didn't. Have you ever wanted to do something different from your friends that you thought would make you a better person? What was it? Did your friends join you? Why or why not? How did that make you feel? Are you happy with your decision? **(See Clip #3)**

7. Dr. Washington talks about a favorite teacher who helped him get excited about discovering new things. What were some of the things that excited Dr. Washington about physics? Have you ever had a teacher like that? What did they do to help you? How did that impact your life? **(See Clip #4)**

8. Dr. Washington talks about not fitting in with the people around him. Have you ever felt like you didn't fit in? Why? How did that make you feel? How did you deal with it? **(See Clip #5)**

9. Dr. Washington talks about trying to change his school because it was segregated. Is there anything you'd like to change at your school? Why? How could you go about making this change happen? **(See Clip #6)**

Science:

10. What do you think an atmospheric scientist does? Would you like to be one? Why?

11. If you were an atmospheric scientist, what kinds of questions would you study?

12. When he was younger, Dr. Washington studied the lives of scientists, much like you are doing now. Who were some of the scientists that fascinated him? Who are some of the scientists that fascinate you? Who are the five most fascinating people you can think of? Why do you like to learn about their lives? How can they teach you in your life? **(See Clip #1)**

13. Dr. Washington talks about his chemistry teacher who encouraged him to find things out for himself. Has anyone ever encouraged you to find something out for yourself? How did this make you feel? Did you find the answer? If you did, did that make you happy? If not, why not? **(See Clip #2)**

Experiment- Bernoulli's Principle by Dr. Basaam Shakhashiri

Have you ever said of someone who was talking too much, "He's just an old windbag?" Actually, windbags can be fun (think balloons), and they allow us to learn about an important property of moving air called Bernoulli's Principle.

Bouncing Balloon
For this experiment you will need:

- An electric hair dryer with circular nozzle
- A balloon
- A table tennis ball

First, blow up the balloon and tie off the end. Hold the balloon out at arm's length and let go of it. Does it stay there, or drop?

Next, hold the balloon above your head at arm's length, then blow hard at it as you let go. Can you keep the balloon in the air?

Now hold the hair dryer in one hand, turn it on, and point it up toward the ceiling. Place the balloon in the stream of moving air, and let go. Does the balloon fall to the ground or stay up? Why does this happen?

Experiment further with the hair dryer. If you tilt the nozzle slowly a little to one side, does the balloon stay in the air stream? Can you bring the nozzle back to vertical and make the balloon follow? How far can you tilt the nozzle before the balloon falls? What causes the balloon to stay in the stream of moving air?

Finally, try placing a table tennis ball in the air stream created by the hair dryer. Does it float? If your hair dryer is powerful enough, the ball will float in the stream just like the balloon. Can you place both the balloon and the table tennis ball in the air stream at the same time? Which object must be placed on top for them to both remain floating? Why is this the case?

When you first let the balloon go, it sinks because it is denser than the surrounding air. (Why do balloons filled with helium rise?) However, the balloon is just a little denser than air, so you were able to keep it from falling by blowing on the bottom of the balloon, either by mouth or with the hair dryer. The column of moving air pushes on the bottom of the balloon, forcing it to rise. The effect is the same in either case, but the hair dryer doesn't run out of breath.

But what happened when you tilted the nozzle of the hair dryer? If the balloon were simply held up by the column of air, it would have fallen down when you tilted the nozzle. Instead, the balloon followed the column of air when it moved—so something else must be happening.

The reason the balloon stays in the moving stream of air has to do with Bernoulli's Principle. Bernoulli's Principle says that the pressure decreases inside a stream of flowing air. When the balloon begins to move out of this low pressure stream, the higher pressure of the air in the room pushes it back into the moving stream. When you tilt the nozzle, the pressure in the room is still high enough to push the balloon back into the air stream, even if the moving air stream is at an angle. Eventually, at a large tilt, the force of gravity will become greater than the force of the air pressure holding the balloon in the stream, and the balloon will fall.

Let's consider an alternate explanation: could it be that the balloon is held up by the heat of the warm air from the hair dryer? This is a reasonable guess, since we know that hot air balloons float. In fact, hot air balloons have been around since 1783. Hot air balloons are able to float high in the air, because when the air inside a hot air balloon is heated, it expands, making it less dense than the surrounding air. This causes the balloon to float up to a higher altitude, where the air is less dense.

How can you test this explanation? If you can, turn off the heat on the hair dryer, and repeat the experiment. Are you able to keep the balloon afloat without the use of hot air? Actually, when you think about it, the heat from the warm dryer makes the air outside the balloon warmer than the air in the balloon. So this explanation isn't correct.

Wind Tube

For this part of the experiment, you will need a WindTube from www.teachersource.com (also available as a Bernoulli Bag from www.arborsci.com).

Stretch out the WindTube, and have someone else hold the closed end while you hold the open end. How many breaths does it take you to inflate the WindTube?

If you inflated the WindTube like most people inflate a balloon or paper bag, then it probably took a lot of breaths. If you use Bernoulli's Principle however, you can inflate the bag with a single breath!

Get all of the air out of the WindTube, and again have someone hold the closed end while you hold the open end. Hold the WindTube about a foot from your face, and hold the open end wide open. Blow one big, long breath (like you are blowing out birthday candles) straight down the middle of the WindTube and close the open end off when you are done. Did it work? How were you able to fill the WindTube with only one breath?

When you blow one breath straight down the middle, your moving breath creates a stream of low-pressure air, which pulls air from the room into the bag with it. Have you ever been on the side of the road when a big bus or truck sped by? You probably felt the rush of air that the vehicle was pulling along with it. Your breath acts in the same way when you blow into the WindTube. It pulls some of the room air with it, so that you are able to fill the entire bag with only one breath.

Daniel Bernoulli was a Swiss physicist who lived from 1700 to 1782 and did pioneering work on the motions of fluids (“hydrodynamics”). A modern application of Bernoulli’s Principle is the shape of airplane wings, which in part generate “lift” by making the air on the top of the wing move faster than the air under the wing.

For more examples of applications of Bernoulli’s Principle, with good explanations, see http://www.nasm.si.edu/exhibitions/gal109/LESSONS/TEXT/TEASERS.HTM

Find this experiment online at: http://scifun.org/HomeExpts/bernoulli.htm

Warren M. Washington - Video Clip Transcription

Clip 1 - Early interest in science: I was very curious about science…I had done reasonably good in mathematics like algebra…I just liked trying to figure out how things worked…and how to do things. And so often the books I would get would be on people like Einstein or George Washington Carver. You know, it would be…a mixture of black and white scientists and even women scientists. I was just impressed with the biographical stories…Madam Curie…on the story of her life, and I think that was impressive to me, how she was involved in the use of radium and early sort of understanding of…nuclear physics.

Clip 2 - Most influential science teacher: I think that…the most profound one was…a lady chemistry teacher who actually kind of got me started in science, I think, because she was not the type of teacher that would lecture. She would demonstrate. For example, she would put…a tennis ball into liquid nitrogen and throw it on the floor, and it would shatter. And I think I asked her, and this was probably what started me into science, [which] was I asked her why were egg yolks yellow, okay. And she says, “Find out.” Now she may have known the answer, but she… So that started me reading in the area of chemistry.

Clip 3 - Disappointment in high school: Even when I was taking science courses at Jefferson High School, algebra, trigonometry, chemistry…that many of the black students who were bright didn’t take those classes. They kind of felt, oh, that’s too hard, I don’t think, you know, they felt that they couldn’t succeed. And so I think that was a missed opportunity. I think that the teachers were there to help and work with you but some of the students just felt they didn’t have much of a dream about what they might do with their lives, and I did have that dream. I thought I could be a scientist, even in high school. And that’s why I went into physics…at college. Everybody knew physics was a hard subject to go into, but I felt I could do it, I mean, I had that kind of confidence, and it was kind of disappointing to me to see so many of my friends who didn’t have the feeling that they could succeed and do something…positive with their lives.

Clip 4 - Discovering physics: The thing that kind of clinched it for me was my senior year, and I can remember the teacher’s name was Mr. Wood. He was a physics major, I mean a physics teacher. And I just really ate up physics even more than the chemistry, because it explained how energy works. How forces work. How levers work. How the mechanical things work. How, you know, the basic things that are in our physical universe work. You can explain a lot from sort of physics principles. And in fact, I was so much impressed by physics that when I did go to college, I went as a physics major.

Clip 5 - Oregon State University: I went to Oregon State University, and there couldn’t have been more than about ten black students on the campus. I’d say seven or eight of those were on the football team. And I was living in a town called Corvallis, and Corvallis had only one black family living in that city. So you can see that it was a situation where there wasn’t…a large number of black people to interact with. So I had to kind of deal with that. And it wasn't a major problem because I'd lived in a mixed neighborhood, so I knew how to deal with everyone…But it was strange. You can imagine, because I was not only, I'm not an athlete on the football team or playing some other sport…I was involved in a hard science curriculum, physics.

Clip 6 - Segregation on campus: If you're a physics major, you don't have a lot of extracurricular activities other than studying. But I would go to the basketball games and I would…the football games and all of those things. Oregon State had a lousy football team at that time…But there was one issue that I was involved in…the students, not only the black students but a small group of us had a meeting with the president of the university…At that time, all of the sororities and fraternities…were segregated. In other words, you could not join on the sororities and so we arranged for a meeting with the president to…complain about this segregated behavior.

Clip 7 - More diversity in sciences: I didn't know there were any other African Americans. I mean normally when you show these pictures of Einstein and others who were doing physics, you don't see any black faces… Einstein, for example, in later life he didn't like to travel a lot, he had gotten every award, Nobel Prizes and all that stuff, but he was invited to Philadelphia to Lincoln University or Lincoln College, this is a black school. He accepted that and it was curious as to why did he choose to go to this little black school to give one of the few lectures in the last part of his life. And it had to do with, he felt that African Americans were treated badly in this country and it was a disgrace for the country. And he talks about it and I have quotes in the book. And so he even in 1950, 'cause I think he died in 1955, I'm not sure exactly when he had this lecture but I think it was sometime in the, like 1951 or something like that, that he gave this lecture and it was magnificent because he foresaw on the day that we're going to have to have, in physics and the sciences in general, greater diversity of students because these people were capable of learning science…Even such as great person as Albert Einstein, to take time out of his life to articulate this issue to the American people in this very famous speech that he gave, it's interesting that he was fifty years ahead of his time.

ScienceMakers

Spotlight: Joanne Berger-Sweeney

Full Name:	Joanne Eileen Berger-Sweeney
Born:	September 21, 1958
Place:	Los Angeles, CA
Parents:	Arminta Sweeney
	Paul Sweeney
Spouse:	Urs Berger
Education:	Morningside High School – Englewood, CA (1975)
	Wellesley College - Wellesley, MA (B.A. Psychobiology, 1979)
	University of California at Berkeley (Master of Public Health, 1981)
	Johns Hopkins University – Baltimore, MD (Ph.D. Neurotoxicology, 1989)
Type of Science:	Neurobiology
Achievements:	National Science Foundation Young Investigator Award
	Researches the neurobiology of learning, memory and developmental disorders

Biography

Joanne Eileen Berger-Sweeney was born on September 21, 1958 in Los Angeles, California to Paul and Arminta Sweeney. She attended Morningside High School in Englewood, California, graduating in 1975. Berger-Sweeny then attended Wellesley College in Wellesley, Massachusetts outside of Boston, where she received her B.A. degree in psychobiology in 1979. Berger-Sweeney then earned her Master of Public Health degree at the University of California at Berkeley in 1981. She remained in California for the following four years, where she worked as an environmental engineer. In 1989, Berger-Sweeney completed her doctoral studies, earning her Ph.D. degree in neurotoxicology from the Johns Hopkins University in Baltimore, Maryland. This accomplishment opened the door for her to accept a postdoctoral position at the Institute Nationale de Sante et Recherche Medicale in Paris, France.

After a two-year stint in Paris, Berger-Sweeney joined the faculty of her alma mater, Wellesley College, in 1991, where she was a key player in creating and growing the college's neuroscience degree program. Berger-Sweeney went on to become the Allene Lummis Russell Professor in Neuroscience, as well as Wellesley's Associate Dean. Berger-Sweeney also served as the director of the Society for Neuroscience's Minority Neuroscience Fellowship Program.

Berger-Sweeney's neurobiological research, mostly concerning the neurobiology of learning and memory and neurological disorders, has been published in journals such as the Journal of Neurobiology and the International Journal of Developmental Neuroscience. Berger-Sweeney's prestigious research awards include the National Science Foundation Young Investigator Award. She resides in Wellesley, Massachusetts.

Discussion Questions

Personal:

1. What was the most compelling thing you learned about Dr. Berger-Sweeney?

2. Where was Dr. Berger-Sweeney 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. Berger-Sweeney attend high school? What do you suppose high school was like for her?

3. How old are you? In what year was Dr. Berger-Sweeney your age? What was happening in the country that year? What was happening in the world that year? What do you suppose her life was like when she was your age?

4. What challenges do you think Dr. Berger-Sweeney faced as a double minority (an African American woman) in the sciences? How do you think she overcame these challenges? How is your life different because of her example?

5. Dr. Berger-Sweeney attended Wellesley College, which is an all-female school. What do you think her college experience was like? What do you think it would be like to go to a single-gender school? What are the pros and cons? Do you think your education would be more or less effective? Why? **(See Biography)**

6. Dr. Berger-Sweeney now teaches at Wellesley College. Why do you suppose she returned there? What are the advantages and disadvantages in returning to familiar locations? **(See Biography)**

Science:

7. What do you think a neurobiologist does? Would you like to be a neurobiologist? Why?

8. If you were a neurobiologist, what kinds of questions would you answer?

9. Dr. Berger-Sweeney researches the neurobiology of learning and memory. How do you learn best: reading, learning, or something else entirely? When you need to remember something, what techniques do you use? How do you think memory works? **(See Biography)**

10. Dr. Berger-Sweeney also studies neurobiological disorders. Find out what some of these disorders are and report to your class on one of them. What are the symptoms? How does it work? What are the cures, if any? Do scientists fully understand how the disease works? If not, what is the most current research? **(See Biography)**

11. Dr. Berger-Sweeney has been published in the International Journal of Developmental Neuroscience. What do you think developmental neuroscience deals with? Why do you think this is important? **(See Biography)**

12. Dr. Berger-Sweeney tries to discover how the brain works. One function of the brain, still not well understood, is the relationship between memory and the senses. What are some of the sights, sounds, and smells that you remember from your early childhood? What are some memories of events that are associated with those sensory memories? Give your group a picture of your life from the past using your sensory memories as a guide. When you describe your life, what does that remind your group about in their own lives? Why is memory so important to humans? Why do you think that certain things trigger very strong memories? Is there a way to explain this scientifically? What do you think that is?

13. Have different teams research different areas of the brain, focusing on the brain's different functions. Have each group present their findings to the class and compile a "Brain Manual."

Additional Reading

Wellesley Faculty Page - http://www.wellesley.edu/PublicAffairs/Profile/af/jbergers.html

Experiment - The Amazing Brain

This lesson was adapted from educational materials developed by the Center for the Advancement of Science Education at the Museum of Science and Industry.

Materials

- Chart Paper
- Brain Game Signs (see Activity instructions)
- Markers
- Pencils

Introduction

- *What controls every system in the body? What keeps our hearts pumping? What makes us move our muscles to lift a pencil?* The brain. Tell the students that the brain controls all of the body systems by communicating with every organ, muscle, and nerve in our bodies.

- Explain to the group that the brain relays messages to our bodies in order for us to complete tasks, whether they are as simple as blinking an eye or as complex as digesting food. The brain uses the spinal cord and nerves to keep messages running through the body, and this very complicated system is called the Nervous System.

The Brain Game

- Tell the students that they are going to re-create the Nervous System in the classroom in order to understand how this system works. Have the students stand in a straight line. Give the student at the front of the line the sign that says "Brain." Also hand them the Task Envelope and a pencil.

- Next, give a student half-way down the line the sign that says "Hand." Finally, give the student at the other end of the line the "Foot" sign.

- Ask the remaining students to think about what they represent in the Nervous System. They are the spinal cord and the nerves.

- Explain that the brain passes "messages" to the body, which travel down the spinal cord to the appropriate nerves. The students will act this system out by playing the "Brain Game."

- Instruct the “Brain” to select a task from the Task Envelope and read it silently to themselves. Then they will pass the task card to the spinal cord. The card will go down the line, with each person reading the card. Finally the card will be directed to the appropriate person, who will act out that task. The tasks include: wave, kick, jump, smile, point, and take a step. Feel free to add additional tasks.

- Sometimes the brain receives messages from part of the body that requires an immediate reaction. Give the “Hand” an Emergency Card, which tells the brain that the hand is touching something hot. The card should move up the spinal cord to the brain. When the brain reads the card, he or she should write a response and send it back to the hand.

- After the students have completed all the tasks, ask them to rejoin their tables. Ask the students to talk through how the nervous system functions. Encourage them to share their experiences during the activity.

- Ask them: *On average how long did it take to pass a message from the brain?* Tell the group that in the human body, messengers called “neurons” send messages to and from the brain at the speed of 200mph. The nervous system is incredibly quick and efficient!

The Ultimate Computer

- Now that the students have an understanding of how the brain passes messages to the body, ask the students: *In addition to moving the body and controlling the organs, what else does the brain do?* Give the students a few minutes to brainstorm ideas.

- Guide them to say that the brain: stores memories, connects to our senses (lets us know what we see, hear, smell, touch and taste), allows us to solve problems and think critically, and helps us feel and process emotions.

MUSEUM OF SCIENCE AND INDUSTRY

ScienceMakers

Spotlight: Wayne Bowen

Full Name:	Wayne Bowen
Born:	November 11, 1952
Place:	Petersburg, VA
Parents:	June Bowen
	Herbert Bowen, Jr.
Spouse:	Barbara Bowen
Education:	Baltimore City College – Baltimore MD (1970)
	Morgan State College – Baltimore, MD (B.S. Chemistry, 1974)
	Cornell University – Ithaca, NY (Ph.D. Biochemistry, 1981)
Type of Science:	Neurobiology
Achievements:	Nationally recognized leader in research on sigma receptors
	President of the NIH Black Scientists Association

Biography

Dr. Wayne Bowen was born on November 11, 1952 in Petersburg, Virginia to June and Herbert Bowen Jr. Bowen's interest in chemistry began at an early age, when he was in elementary school and liked to mix the contents of his household medicine cabinet. He attended Baltimore City College for high school, graduating in 1970. Bowen received his B.S. degree in chemistry from Morgan State College in 1974 and subsequently pursued his Ph.D. with a major in biochemistry and a minor in neurobiology from Cornell University, attaining it in 1981. Bowen received a coveted Postdoctoral Staff Fellowship at the National Institute of Mental Health in Bethesda, Maryland, where he worked for three years in the departments of biological psychiatry and clinical neuroscience before taking on an assistant professorship in biology at Brown University in 1983.

In 1991, Bowen returned to the National Institutes of Health (NIH) to take a position at the National Institute of Diabetes and Digestive and Kidney Diseases, where he became chief of the Unit on Receptor Biochemistry and Pharmacology in the Drug Design and Synthesis Section of the Laboratory of Medicinal Chemistry. He also served as President of the NIH Black Scientists Association in 2001. During his time at NIH, he would return every fall to deliver neuroscience lectures to undergraduate students; he was promoted to full professor in 2004. That same year, Bowen returned permanently to the Brown faculty as Professor of Biology in the Department of Molecular Pharmacology, Physiology, and Biotechnology in the Division of Biology and Medicine.

Today, Bowen studies a complex field that combines chemistry, biology, pharmacology, and neuroscience. He is a nationally recognized leader in research on sigma receptors—proteins in the brain and in tissues like the liver and kidney that are believed to regulate cell survival and growth. Bowen's major areas of interest include biochemical mechanisms involved in the neuronal action of opiate drugs and the biochemistry of sigma receptors in cancer cells and in the brain. Sigma receptors bind to antipsychotic drugs used in the treatment of common disorders such as schizophrenia and depression.

Discussion Questions

Personal:

1. What was the most compelling thing you learned about Dr. Bowen?

2. Where was Dr. Bowen 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. Bowen attend high school? What do you suppose high school was like for him?

3. How old are you? In what year was Dr. Bowen your age? What was happening in the country that year? What was happening in the world that year? What do you suppose his life was like when he was your age?

4. How did Dr. Bowen first become interested in chemistry? Have you ever wondered what would happen if you mixed household items together? Have you ever played with a chemistry set? Did you find it exciting? Why or why not? **(See Biography)**

5. How does Dr. Bowen feel about teaching? What does he call the process of discovery? What does he feel the balance should be between research and education? **(See Wayne Bowen's Research link)**

Science:

6. What do you think a neurobiologist does? Would you like to be a neurobiologist? Why?

7. If you were a neurobiologist, what kinds of questions would you answer?

8. Dr. Bowen researches sigma receptors. What are sigma receptors? Are there other types of receptors in the body? What are some examples? How do receptors work? Research a specific receptor and report your findings to the class. **(See Biography)**

9. Dr. Bowen's work encompasses the regulation of cell survival. What does it mean to regulate cell survival? How do cells die? Describe this process. What is "programmed cell death"? Research this phenomenon and report back to the class. How do you think this relates to Dr. Bowen's work? **(See Biography and "Death by Design")**

10. Diseases that might be impacted by Dr. Bowen's work include schizophrenia and depression. Explain how neurobiology relates to such mental illnesses as these. What are other mental illnesses facing us? Give some examples and describe the symptoms, the causes, and possible cures. **(See Biography)**

11. Have different teams research different areas of the brain, focusing on the brain's different functions. Have each group present their findings to the class and compile a "Brain Manual."

Additional Resources

There is an excellent film on programmed cell death called "Death By Design: Where Parallel Worlds Meet" (1997) by Jean-François Brunet and Peter Friedman.

Wayne Bowen's Research: http://research.brown.edu/myresearch/Wayne_Bowen

Experiment - Sense of Touch

This lesson was adapted from educational materials developed by the Center for the Advancement of Science Education at the Museum of Science and Industry.

At A Glance:

What can you feel with your fingertips? What textures can you distinguish? This activity is designed to help students explore their sense of touch by testing different textures and temperatures.

Objectives:

- Students will learn that there are different types of receptors on their skin that make up their sense of touch.
- Students will be able to make predictions about what will enhance or hinder their dermal receptors.

Advance Preparation:

Part 1: Textures

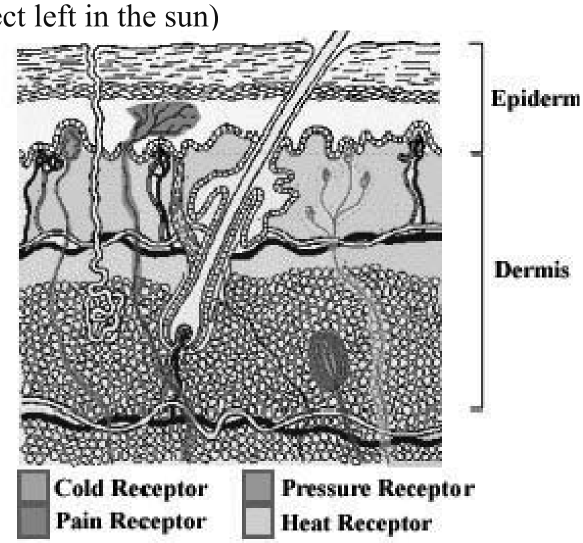
Create texture boards with different materials for students to explore. These should be a variety of different textures attached to boards for easy comparison.

Part 2: Temperatures

Prepare a cold material (e.g. an ice cube), and a warm one (e.g. an object left in the sun)

Part 3: Brain Box of Science

Collect various materials with different textures, such as sandpaper, cotton balls, marbles, different fabrics, etc. Prepare a cardboard box with openings big enough for a hand to pass through. Place items with different shapes and textures inside the box.



Materials (per group)

- A variety of materials with different textures (e.g. sandpaper, cotton balls, aluminum foil, feathers, Velcro, etc.)
- A cardboard box
- Gloves

What You Need To Know:

Your sense of touch originates in the bottom layer of your skin called the **dermis**. The dermis is filled with many small nerve endings that give you information about the things your body touches. The nerves carry the information to the spinal cord, which in turn sends signals to the brain where the feeling is registered. Nerve endings in your skin can tell you the texture of a material and whether it is hot or cold. Nerves can also sense if something is hurting you.

Above the dermis is the **epidermis**. Look at the cross-section of the skin. Notice that the pain receptors are closest to the epidermis, the temperature receptors are second, and the pressure receptors last. The information that the receptors collect from the outside of the body is passed through nerves to the spinal cord, then to the brain.

Activity:

Part 1: Textures

1. Select a texture board with 4-6 materials on it.
2. On a piece of paper, make a table with two columns. In the first column, write the name of the material.
3. Use your fingers to feel the textures of each material, and in the second column, describe those textures (you can use words like smooth, rough, bumpy, furry, soft, hard, etc.).
4. Put on a pair of gloves and touch the materials on the board again. Describe the difference.

Part 2: Temperature

1. Close your eyes and touch the two items. Aside from their texture difference, what else can you determine?
2. Put on a pair of gloves and try touching the two items again. What is the difference?
3. In addition to our sense of touch, the skin also helps regulate the body's internal temperature. How does this happen? Perspiration.
4. What is the major difference between sensing temperature through the sense of touch and "feeling" hot or cold?

Part 3: Brain Box of Science

1. We will now use a box to help you isolate the sense of touch from your other senses (especially your sense of sight and smell).
2. Explore the different items with you fingertips only. Can you tell what they are? Can you describe their texture?
3. Try exploring a different set of items with gloves on. Was it easier or harder to tell what they were?

Guiding Questions:

- What physical properties of objects can you determine with your fingertips?
- Why do you think wearing gloves makes it harder to tell the texture and the temperature of an object?

What's Happening?

Students use their fingers to discover textures and temperatures of objects. When they touch objects while wearing gloves, the nerves on their fingertips are less able to interpret the signals from the object, and thus the texture and temperature differences become less obvious to the touch.

MUSEUM OF SCIENCE AND INDUSTRY

ScienceMakers

Spotlight: James Bowman

Full Name:	James Edward Bowman, Jr.
Born:	February 5, 1923
Place:	Washington, D.C.
Parents:	Dorothy Bowman
	James Edward Bowman, Sr.
Spouse:	Barbara Bowman
Education:	Dunbar High School - Washington, D.C. (1939)
	Howard University - Washington, D.C. (B.S. Biology, 1943)
	Howard University - Washington, D.C. (M.D., 1946)
Type of Science:	Pathology, Genetics
Achievements:	Research includes hematological population genetics and genetic variation among diverse peoples
	Certification in pathologic anatomy and clinical pathology by the American Board of Pathology

Favorites:

Food:	Potato Salad, Rice & Ham
Vacation Spot:	Anywhere outside the United States

Biography

Dr. James Bowman was born on February 5, 1923, in Washington, D.C. A top expert in the fields of pathology and genetics, and Professor Emeritus in the departments of pathology and medicine at the [undergraduate] College at the University of Chicago, Bowman also served on the Committee on Genetics, the Committee on African and African American Studies and as a senior scholar for the MacLean Center for Clinical Medical Ethics.

Bowman received both his undergraduate and medical degrees from Howard University. His advanced academic training, study and fellowships, after an internship at Freedmen's Hospital in Washington, D.C., included a residency in pathology at St. Luke's Hospital in Chicago (1947-52), certification in pathologic anatomy (1951) and clinical pathology (1952) by the American Board of

Pathology, a special research fellowship in the Department of Biometry and Genetics at University College London (1961-62), and a Henry J. Kaiser Senior Fellowship at the Center for Advanced Study in the Behavioral Sciences at Stanford (1981-82).

Bowman received numerous awards and honors for his work, including several academic positions and appointments to various national and international committees, commissions and scientific teams. Bowman held memberships in various scientific societies and editorial boards. Bowman published more than ninety publications in the fields of general human genetics, hematological population genetics, genetic variation among diverse peoples and ethical, legal, and public policy issues in human genetics. Bowman and his wife, Barbara, raised one daughter, Valerie Bowman Jarrett.

Discussion Questions

Personal:

1. What did you like best about listening to Dr. Bowman?

2. Where was Dr. Bowman 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. Bowman attend high school? What do you suppose high school was like for him?

3. How old are you? In what year was Dr. Bowman your age? What was happening in the country that year? What was happening in the world that year? What do you suppose his life was like when he was your age?

4. Dr. Bowman talks abut his childhood. What sport did he play? What else did he love to do? How is your childhood similar to Dr. Bowman's? **(See Clip #1)**

5. Dr. Bowman has an unusual story about segregation and the ROTC. What was his experience? How was this similar to other stories about the Armed Forces at that time? Can you think of any others? What lessons did Dr. Bowman take away from his experience? **(See Clip #2)**

6. What was Dr. Bowman's experience in the Army after he was drafted? What are some of the advantages of wanting to pursue science in the Army? What are some of the disadvantages? Have you ever considered the educational benefits of the Armed Services? Have recent world events changed your views? Why or why not? **(See Clip #3)**

Science:

7. What do you think a pathologist does? Would you like to be a pathologist? Why?

8. If you were a pathologist, what kinds of problems would you study?

9. Dr. Bowman talks about an unusual interview process that he had. What was it? Dr. Bowman talks about doors being opened. What do you think he means by this? How can you apply this to your own life? **(See Clip #4)**

10. Dr. Bowman joined the faculty of the University of Chicago. What was unusual about this process? He also mentions that the kind of work he wasn't expecting to do in Iran led him to his job at U of C.; some might say that he was lucky. Coach Darrel Royal said, "Luck is what happens when preparation meets opportunity." How does this quote apply to Dr. Bowman? How can you apply it to your own life? **(Clip #5)**

11. Dr. Bowman works with diseases. He states that cancer will eventually be eliminated. What is his thought process behind this? What are some of the other diseases that have been wiped out in the last century? Do you think it is possible to cure cancer? How would you go about curing cancer? **(Clip #6)**

12. Dr. Bowman also works in the field of genetics. What does genetics mean? Where have you heard of genetics before? How does the study of genetics impact your life?

Experiment - Genetics: The Easy Way Developed by Yash Shah

Information for the Teacher

For several years I struggled, as a student, then as a teacher, with genetic problem solving, using the Punnett Square or the Product Rule method, and following the textbook closely. Few students succeeded in the di- or tri-hybrid problem solving. Then, one year on the chalkboard, in the process of explaining it to my students, I saw straight through it. Realizing that all calculating probability is multiplication, that multiplying 3X5X4 provides the same answer as multiplying 4X3X5, and that the Punnett Square is the same as the elementary school multiplication table, I created an alternative method to solving genetic problems quickly and accurately.

To teach this lesson a variety of strategies are used, including team and solo problem solving, lecture and demonstration, and hands-on lab exemplification. First I create hypothetical critters with their own fun gene pool; these have included either Marlings from Mars or a Recycle Critter. A Recycle Critter is created in a lab setting by students making male and female heterozygous parents with 5-8 sets of chromosomes and performing fertilization. They then build the phenotype of their Recycle Critter baby.

Next, students practice and master the six basic monohybrid problems in small groups and on the board explaining them in front of their peers. I then demonstrate solving a dihybrid problem by simply multiplying the answers of two monohybrid problems together. The preferred method is what I call the forked-line method; I prefer it since it will line up the genotypic and phenotypic ratios in a nice order, saving the time of counting through all the squares.

To do this method, one simply writes the ratio of the first cross one on top of another with some space in between, then draws n lines out from each one (n=equal to the number of possibilities in the ratio of the second cross) and writes the ratio of the second cross by each possibility of the first cross. Next, one simply multiples along the forked-line to get the final ratio; this can be done with genotypic ratios, which can be converted to phenotypic ratios, or can be done with just phenotypic ratios. To double-check the problem, make sure the sum of the ratio is equal to 4n. Furthermore, if the problem just asks for the possibility of one particular phenotype, then all one would have to multiply together are the predicted probabilities for that phenotypic combination.

Another method is to multiply the answers of the two squares together by creating a third Punnett Square; however, this time instead of gametes on the sides, the ratio of one monohybrid cross goes on one side and the ratio of the other cross goes on the other side. As I have explained in the first paragraph, I usually also tell my students how I derived these methods; this lets them see how the math they have already learned can be applied. Because the 16-square Punnett Square is in the text, and especially because my methods do not allow for one to find gamete possibilities, I also teach the textbook method. Students receive a "How-To" step-by-step handout on all methods and are given the opportunity to practice several problems.

Students quickly mastered dihybrid problems and then were challenged onto trihybrid problems, using the forked-line method. For the Recycle Critter (which had 5-8 traits), my honors students were able to calculate the percent probability of the particular phenotype they created, an octahybrid problem!

Learning was evaluated both by success with problems done as homework or teamwork and by a test. Tests were given on two levels, based on ability. The general test had monohybrid and dihybrid problems; the advanced test had mono-, di-, tri-, and tetra-hybrid problems. Students were turned on by the challenge of the work and their capability.

What made this successful can be attributed to four things: the hypothetical fun critter created, the mastery of monohybrid problems, the team-teaching, and the simplicity and ease of solving more complex genetic problems by the forked-line method, i.e., applying the rules of mathematics!

Even though this method seems so obvious and simple, it is amazing how many people do not see it. I know that such an explanation of genetic problem solving would have greatly helped me in college genetics and that many science teachers have been very thankful for it.

Recycle Critter

Objective:

The student will use recyclable trash to construct a Recycle Critter family. The student will calculate the probability of the phenotype of the offspring that two heterozygous parents produced.

Materials:

Recyclables: aluminum cans, tin cans, newspaper, plastic bottles, glass bottles and jars. Something to hold the materials together: string, tape, or glue. Blue and pink construction paper, scissors, pen

Instructions for Students

Part I: The Plan

1. In your teams, discuss what possible critter you could create with the materials provided.
2. On a sheet of paper, sketch out your design.
3. List the physical characteristics, or traits, of your critter. Your teacher will tell you how many traits, representing different kinds of genes, that your critter is required to have.
4. For each trait, list a dominant and a recessive phenotype.
5. Create a genotype symbol for each phenotype.
6. Have your teacher sign your critter plan sheet.

Part II: Constructing the Parent Critters

7. Both parents will be heterozygous for all traits. Sketch what your parents will look like.
8. Construct the two parent critters: mom and dad.

Part III: Making the Chromosomes

9. Use pink construction paper to make mom’s chromosomes.
10. Cut ___ strips of equal size (approx. 1 cm X 8 cm). Because chromosomes come in sets of two (diploid), the number of strips or chromosomes will equal two times the number of traits your critter has. (See step #3). We will pretend that the last trait is on the X sex chromosome.

11. Label your chromosomes with the appropriate allele, using the genotype symbols you designed in step #4.

12. Repeat steps #9 – 11, using blue construction paper for dad's chromosomes, with one modification. For the last trait, make one of the chromosome strips half the length of the rest. This is the Y sex chromosome and it does not get a genotype symbol (allele) written on it, since the Y chromosome is a blank. To decide whether its sister chromosome (homolog) is dominant or recessive, toss a coin or decide randomly.

Part IV: Egg, Sperm, and Fertilization

13. Turn over your chromosome sets so that the genotype symbol does not show. Do this for both mom's and dad's chromosomes.

14. Have another team member who did not see which chromosome is which randomly (with eyes shut) pick from mom's chromosomes one from each diploid set. This is the egg cell, which is haploid or half of the chromosomes of the diploid cell.

Life Science

15. Repeat, picking one of each set of dad's chromosomes. This is the _____ cell.

16. Fertilize the egg and sperm. To do this, unite the egg and sperm cells by pairing up the chromosomes so that their alleles/genotypes match. (Blue "A" or "a" matches to either pink "a" or "A".) When an egg and a sperm fertilize, a single cell called a __________ forms which grows into an embryo, then a fetus, and then a new baby. CONGRATULATIONS! You are now the proud expectant parents a new baby Recycle Critter.

17. You went in to have an amniocentesis done, where doctors draw amniotic fluid to obtain some of the baby's cells. They then can predict the baby's chromosomes and genotype. Record the new baby's genotype (What were your results in step #16). Will you have a boy or girl? _________

18. Record the new baby's phenotype. Sketch the new baby (Baby's first photo!)

19. Have your teacher sign for approval.

Part V: The Birth

20. Construct the new Recycle Critter baby.

21. Congratulations! You are now the proud parents of a healthy baby Recycle Critter! Show him or her off and be proud!

22. Now calculate the percent probability that it took for the two parents to produce that baby. Remember, follow the genetic problem solving rules you used in class. Multiply.

Teacher Tips for Recycle Critters

Adjust the number of traits / genes studied based on the learning level of the class. I base this on their response to the practice mono- and di-hybrid problems we work on in class. My honors class caught on to the method and so I challenged them to 8 genes, whereas my general biology class did 5 genes. You may even want to do 3 genes for slower students. I like to use the Recycle Critter to challenge them somewhat, so I usually do at least a trihybrid cross.

Work in cooperative teams of 3 or 4 students. Assign students a position as A, B, C, D. Assign a specific task for A, another task for B, etc. For example:

A constructs Mom
B constructs Dad
C constructs the chromosomes for Mom
D constructs the chromosomes for Dad
A makes Mom's egg by picking with eyes shut the haploid egg set of chromosomes
B makes Dad's sperm by picking with eyes shut the haploid sperm set of chromosomes
C constructs the baby
D also constructs a recycle critter (optional). A pure homozygous recessive critter would be interesting to see. This could be the older sister.
ALL students should do the calculation of the percent probability of the new baby.

Some interesting critters that my students have made include:

- aluminum can worms (Traits include color of can, number of cans, number of ring pull eyes, legs, tail or proboscis, bumps on skin).
- plastic bottle critters (Traits include arms, legs, hair color, eye color, type of nose, tail, etc.)
- newspaper monsters (Papers are cut, twisted and tied to form various traits)

You may want to restrict them solely to what we recycle, or you may want to allow them to use other miscellaneous items to create more traits.

Throw in a quick lesson about how fast things biodegrade or the benefits of recycling and the world's garbage crisis. Newspaper is a wood product and may eventually decay. Tin cans will rust and decay eventually. Aluminum will be next and will weaken and decay (but as an un-mineable source in a landfill). Plastic bottles will last forever and not decay; they are photo-sensitive, it may break down in the presence of light but will remain as small plastic beads in the soil or water supply. (What harm will this do?) Glass will not decay.

Punnett Square Method

1. Create a key box:
   - Write down the inherited traits and their dominant and recessive genotypes and phenotypes.
   - Use a different letter of the alphabet or symbol for each trait.
2. Write the phenotypic parental cross. (ie, verbally write what the problem said is to be crossed.)
3. Write the genotypic parental cross.
4. Translate the parents' phenotypes into the respective genotypes. (ie, write the symbols that fit the phenotype given, remembering that the organism is diploid and has 2 alleles/letters for each inherited trait.)
5. On the side, calculate the number of squares needed in the Punnett Square by the formula 4n, where n = number of traits in the problem (number of different letters of the alphabet).
6. Figure out all possible gametes (egg or sperm) that could be formed by meiosis for that parent. What are all the possible ways you could combine the alleles and in each case have the haploid combination, such that you have 1 allele/letter for each inherited trait? The number of possibilities will equal the number of squares down one side. Note: Some problems just ask for gamete possibilities and not for final ratios of the offspring, in which case this would be the last step.
7. Draw the squares and write in the gametes by putting the female gametes (eggs) on one side (the top, say) and the male gametes (sperm) on the other side (the left, say).

8. Fertilize the egg and sperm by combining the gametes where the row and column intersect to form the diploid offspring. Remember these are predicted possible offspring.
9. Complete the problem by writing out the genotypic ratio of the offspring. Count how many of each genotypic combination there are.
10. Translate the offspring's genotypic ratio into the phenotypic ratio and write both down.
11. If the problem asked for the percent chance that a particular phenotype or genotype could occur, calculate it as you would any percent: Number X 100%. Total
12. To double check, make sure your final ratio adds up to the total number of squares in the Punnett Square (4n).

Forked Line Method

1. Create a key box:
   - Write down the inherited traits and their dominant and recessive genotypes and phenotypes.
   - Use a different letter of the alphabet or symbol for each trait.
2. Write the phenotypic parental cross. (i.e. write what the problem said is to be crossed.)
3. Write the genotypic parental cross by translating the parents' phenotypes into the respective genotypes. (i.e. write the symbols that fit the phenotype given, remembering that the organism is diploid and has 2 alleles/letters for each inherited trait.)
4. From the genotypic parental cross, take each trait separately and cross it using a four-square Punnett Square. (Follow the Punnett Square Method Steps 4-9.)
5. Multiply all the ratios of the traits together using the forked line method. If the problem asks for genotypic ratios of the offspring (or genotypic and phenotypic ratios), you will want to multiply your genotypes together using the forked line and then translate them into phenotypes, if necessary. If it just asks for the offspring's phenotypic ratio, just multiply the phenotypes in the forked line. If the problem asks only for the percent chance for a particular phenotypic combination, then you need only to multiply that combination together and divide by the total number of squares in the Punnett Square (4n) times 100%. To do the forked line, write the first ratio vertically (on top of each other with some space in between). Draw forked lines (the number of lines is equal to the number of possibilities in the second ratio). Write the second ratio by each line. Repeat until all forks are filled. If there is a third, fourth, etc. trait crossed, draw forked lines, write the next ratio, and repeat to the bottom. When finished multiply along the forked lines to create your overall ratio.
6. To double check, make sure your final ratio adds up to the total number of squares in the Punnett Square (4n).

Find this experiment online at:
http://www.doitscience.com/2009/05/genetics-the-easy-way/

James Bowman - Video Clip Transcription

Clip 1 - Tennis and Reading: Well, I had a bicycle and I learned how to play tennis very early, and I…that was my main sport. Eventually, I became District of Columbia single tennis champion, but other than that, I had a very active boyhood…I read everything that I could, and there was a public library not far from there. And I think there's a whole wall of books that I read, just all of them, read all of them. I read mostly on weekends, and read two or three books. Had a wonderful time doing that. That I enjoyed.

Clip 2 - Segregation in the Army: We were always told that no matter what, that when you leave here, you'll be able to compete anywhere in the world, and we did. And we believed it. We had excellent professors there, too. They were very tough and many of them liked to flunk students out and it was tragic because it was during World War II and so my colleagues who didn't make it were sent overseas and died. That part was very tragic and sort of frightening because what we were when we were in the…during those times we were what we called the Army Specialized Training Program. And we were in the Army, we were Private First Class. We were reminded by our professors that if you don't make it, you'll be out of here and be sent overseas, which they were. And I graduated as First Lieutenant and after graduation we were supposed to go into the Army right away, into medical school. But at that time, the armed forces had no desire at that time to have medical officers who were Negroes and so we were discharged from the army which allowed me to continue my graduate work. I was very happy. Internship, eventually fellowship in pathology. So at that time, I did not have to go to the Army but I had many friends who were white who were our peers at other schools, and most of them were called into the Armed Training but the Negro medical officers were not. So that was an advantage of being segregated. I had no desire to go and fight for anybody else. When I think, thinking back, and all of that, I'll never forget the comment of Muhammad Ali when he was objecting going into the Army and he said that, "Well, why don't you want to go?" He said, "Nobody in that country ever called me nigger." It was wonderful, very perceptive, very perceptive. So I was fortunate but eventually I did go into the medical corps, but I did nothing but research and had a wonderful time there, too.

Clip 3 - Research in the Army: I wanted to do research, so they appointed me to the medical nutrition laboratory, which at that time was in Chicago which was very good, because at that time I was…when I was drafted into…I was head of the department of pathology at Provident Hospital, after I finished my training at St. Luke's Hospital. And then I…Then they moved the medical nutrition laboratory which I was a member to Denver, Colorado which was very nice. My wife and I had a wonderful time living in Colorado. I did nothing but research in the Army and was a 9 to 5 day, and weekends we would go to the mountains and relax and what have you. So it was a very pleasant time, and I would research. So the Army at that time was, I had no problems whatsoever. I had no desire to be regular Army, I was asked, "I said no, not for me." Since I had had ROTC experience in high school and then when I was in college I was in ROTC also. So when I was finally taken to the army I didn't have to go to basic training or anything else, I just went directly. One day I was a civilian and the next I put on a uniform and went into the laboratory to do research. So that was wonderful.

Clip 4 - Going to Iran: I happened to be at a meeting in Washington D.C., the international geographic pathology and I met a friend of mine who had been at the Armed Forces Institute of Pathology, was head of geographic pathology and he said, "What are you gonna do when you leave the Army?" And I said, "Well I was thinking of going somewhere. I was thinking of going to Africa or India or some place," and he said "Well, I heard about an excellent place in Iran. There's a new hospital that's being built and they want Americans and Iranians to open the hospital…" So my wife and I were invited out for a interview in New York at a yearly meeting they had there, and there's a large banquet and my wife and I were circulated [to] members of the board. And at the end of the dinner, they said, "Well, Dr. Bowman, we'd like to invite you and your wife to Iran." So, we said yes. And of course, everybody said, "That's the craziest thing you would do and why would you go there." Where is Iran, and what have you. I said…well, it's an opportunity and the salary wasn't bad. There's tax free, so we thought we could make it. So we… in 1955, we arrived in Iran. And it's the best thing that ever happened because that is…my work in Iran and research I did there was eventually the reason why I was invited at the University of Chicago.

Clip 5 - Job at University of Chicago: When I went to England, that is, as I said, well I was looking for soming else to do and I remembered Dr. Alving who was the…who initiated the studies of this enzyme deficiency that we were studying in Iran. And I remembered what he said. He said, "Now Dr. Bowman, when you come to Chicago, I'd like for you to see me, you know, talk to me and look me up." And so I called him up and he said "Oh, oh, I remember." He said "Come over, I want to see you." So we started chatting and chatting and chatting and then the next day he said, "You know what?" He said, he said, "We'd like to invite you to be on the faculty of the University of Chicago," which came out of the blue. I didn't expect it at all, what have you. And so he said, but, he said the chairman of the Department of Medicine - at that time the blood bank was in the Department of Medicine - and since I was a pathologist and I did all sorts of pathology, the blood bank, he said, "We need someone in the blood bank, to head the blood bank." And that, oddly enough, was in the Department of medicine and he said, "But the chairman in the Department of Medicine, Dr. Jacobson, is going to be in the International Congress of Hematology, and are you going?" I said, "Yes, I'm going there too, in Mexico." He said, "Well, he'll see you there." And so I'm in his hotel and he said, "Let's go out tomorrow, out to the pyramids," and so he took me out to the pyramids, and we talked and chatted all day long and, when we came back, he said, "Well, you know, I'd like for you to be on the faculty," just like that, I didn't have an interview or anything else. Of course well, I said something about an interview, and he said, "Well, you've been with me all day long," he said, "that's your interview," so that's how I started on the faculty of the University of Chicago.

Clip 6 - The Death of Death: I think that cancer will be a disease of the past one day. I mean, there are spectacular things going on, not only are there cures, but prevention also too. There's a tremendous amount of research going on this. One of the books that I will not write will be called "The Death of Death," in which people will no longer die…other than by accident and our own crazy things, that many of these diseases will be completely prevented or eradicated. And then of course if you have the death of death, what kind of world would this be without death? I mean, we're being philosophical about it. But one of these days it'll happen, other than by accident, and murder, and our own inhumanity to each other, it will happen. Yes. And I think that it will be that we will—I mean, after all, in my day and time, many diseases have been eradicated: polio, smallpox. Of course it may come back, you know, and what have you, and all of that, but there are things that have happened like that. I haven't, I saw smallpox in Iran, several cases of it, but you don't see it today, and so why can't we conquer all of these other things, too?

ScienceMakers

Spotlight: Edwin Cooper

Full Name:	Edwin Cooper
Born:	December 23, 1936
Place:	Oakland, TX
Parents:	Ruthesther Porche Cooper
	Edwin Ellis Cooper
Spouse:	Helene Tournaire Cooper
Education:	Jack Yates High School - Houston, TX (1953)
	Texas Southern University – Houston, TX (B.S. Biology, 1957)
	Atlanta University – Atlanta, GA (M.S. Biology, 1959)
	Brown University – Providence, RI (Ph.D. Biology, 1963)
Type of Science:	Immunobiology
Achievements:	Researches invertebrate immune systems and the evolution of neuroimmune systems
	Has taught immunology around the world

Biography

Edwin Cooper graduated *cum laude* from Texas Southern University in 1957 with his B.S. degree in biology. After studying at the Marine Biology Laboratory in Woods Hole, Massachusetts, Cooper pursued his M.S. degree in biology from Atlanta University, which he obtained in 1959. Cooper earned his Ph.D. in biology from Brown University in Providence, Rhode Island, in 1963.

Upon completing his doctorate, Cooper became an Assistant Professor of Anatomy at the University of California at Los Angeles (UCLA) School of Medicine in 1964 and attained full professorship by 1973. Cooper taught immunology around the world, beginning with an exchange program with the Instituto Politecnico Nacional in Mexico City, Mexico. Cooper received a prestigious Guggenheim fellowship to the Karolinska Institute in Stockholm, Sweden, in 1970, while maintaining his position at UCLA. Cooper went on to accept teaching fellowships at many institutions, such as the University of Complutense in Spain in 1980, the University of Tromso in Norway in 1981, the University of Reims in France in 1985, and Yamaguchi University in Japan in 1988. From 1989 to 1993, Cooper served as the vice chair for UCLA's Department of Anatomy and Cell Biology.

Cooper's research on invertebrate immune systems and the evolution of neuroimmune systems was published in several journals, including the Journal of Biological Chemistry and the Journal of Comparative Pathology. Cooper received five honorary degrees internationally, including one from his alma mater, Brown University, in 1992. Cooper was also awarded several international prizes in the sciences, such as the Alexander von Humboldt Prize in Germany, and the S.M. Nabrit Achievement Award in Science from Atlanta University.

Discussion Questions

Personal:

1. What did you like best about reading about Dr. Cooper?

2. Where was Dr. Cooper 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. Cooper attend high school? What do you suppose high school was like for him?

3. How old are you? In what year was Dr. Cooper your age? What was happening in the country that year? What was happening in the world that year? What do you suppose his life was like when he was your age?

4. Dr. Cooper's work has taken him all over the world. Where are some of the places he has worked? Find these on a map. Have you ever wanted to travel all over the world? If so, how could you make that happen? What kinds of careers would allow you to travel? What are some important skills that would allow you to travel extensively? **(See Biography)**

Science:

5. What do you think an immunobiologist does? Would you like to be a immunobiologist? Why?

6. If you were a immunobiologist, what kinds of questions would you study?

7. Dr. Cooper's research focuses on immunobiology and comparative immunology. What do you think these terms mean? Research them and present a basic definition of each to the class. **(See UCLA Faculty Page)**

8. Dr. Cooper studied briefly at the Marine Biology Laboratory in Woods Hole, Massachusetts. How did Dr. Cooper's later research into prehistoric invertebrates factor into marine biology? Are there "prehistoric invertebrates" still living today? What are some examples? Why does Dr. Cooper study prehistoric invertebrates? How does it relate to the human immune system? **(See Biography)**

9. Dr. Cooper explains his research in this way: "The human immune system still depends on its own 'prehistoric' system, but has evolved those characteristics that appeared later in fishes, amphibians, reptiles, birds and mammals. This type of immune system is adaptive, induced, specific and clonal." What does this mean? How does the evolutionary process relate the human immune system to prehistoric invertebrates. Define the terms adaptive, induced, specific and clonal as they relate to an immune system. What does Dr. Cooper hope to achieve using this premise? **(See UCLA Faculty Page)**

10. Explain briefly how the human immune system works. How is the human immune system different from the immune systems of other mammals, birds, amphibians, and reptiles. How is it different from those of plants?

Additional Resources
UCLA Faculty Page - http://www.cousinspni.org/cooper.htm

Experiment - Reducing Risk

This experiment was taken from *Science And Life Issues*, published by Lab-Aids, Inc.

How do you prevent yourself from catching an infectious disease? You know that your immune system provides you with natural defenses, but sometimes your immune system becomes overwhelmed by disease-causing microbes and you get sick. One way to reduce your risk of getting sick is by taking simple precautions, such as washing your hands before you eat. You may even use antimicrobial solutions, such as an antibacterial soap or a disinfectant, when you clean up. How effective are these products at killing germs?

You can measure the effect of different solutions on the growth of microbes. You can culture, or grow, microbes in a special dish known as a petri dish. The petri dish contains food for the organisms you are trying to culture. In classrooms, the most commonly used food is agar, a gelatin-like material that was first invented by Robert Koch. If bacteria are present, many of them will grow on the agar. It is also possible for molds and algae to grow on agar.

Materials

- For the class
    - Permanent marker(s)
    - Tape
- For each pair of students
    - 1 Sterile petri dish containing agar
    - 1 Sterile cotton swab
    - Source of bacteria
    - Solution(s) such as soap, disinfectant, preservative, etc.
    - 4-5 Paper disks (punched from filter paper or brown paper towel)
    - 1 Pair of forceps
    - 1 Pencil
    - 1 Metric ruler
    - Paper towel

Procedure

1. Use a permanent marker to put your name and class period on the bottom of your petri dish.
2. Dip your swab in the source of bacteria provided by your teacher.
3. Remove the lid of the petri dish. Use the swab to streak the bacteria onto agar. Press firmly but not too hard. Your goal is to spread the bacteria but not to break up the agar layer. Turn the dish 90 degrees and repeat.
4. Use a pencil to write the initial of the solution you are testing on a disk of filter paper (or brown paper towel).
5. Use your forceps to dip the disk in the solution. To remove excess solution, touch the edge of the disk to a clean paper towel.
6. Place the disk on the agar of your Petri dish and re-cover the dish.
7. Repeat Steps 3-6 for each solution you are testing. Be sure to leave at least 1.5 cm between the paper disks. Tape around the dish to seal it.
8. Place your Petri dish in a warm place for a few days.
9. Check the growth of microbes in the dish each day. Record if the growth of microbes has stopped in the area around the disk. If so, use a ruler to measure this space, known as the zone of inhibition.
10. Examine the control dishes set up by your teacher. Record your observations.

Analysis

1. Did the solution(s) affect the growth of bacteria on your petri dish? Explain. Be sure to compare your results to the control and to describe your evidence.
2. Share your results with the class.
   a. Did everyone who tested the same solution get the same results? Explain.
   b. How effective were the different solutions in preventing microbial growth?
   c. How might you follow up on this investigation or improve the design of this investigation?
3. Reflection: Have the results of your experiment caused you to want to change any of your behavior (such as what solutions you use to wash your hands or household surfaces)? Why or why not?

SEPUP. (2005). *Science and Life Issues*. Lawrence Hall of Science, University of California at Berkeley. Published by Lab-Aids, Inc., Ronkonkoma, NY.

ScienceMakers

Spotlight: S. Allen Counter

Full Name:	Samuel Allen Counter, Jr.
Born:	July 8, 1954
Place:	West Palm Beach, FL
Parents:	Ann Johnson Counter
	Samuel Allen Counter, Sr.
Education:	Roosevelt High School - Boynton Beach, FL (1972)
	Tennessee State University - Nashville, TN (B.S. Biology, Audiological Sciences, 1976)
	Case Western Reserve University - Cleveland, OH (Ph.D. Neurobiology, 1979)
	Karolinska Institute - Stockholm, Sweden (Doctor of Medical Science, 1989)
Type of Science:	Neurophysiology, Ethnography
Achievements:	Studies the neurobiological effects of lead and mercury exposure
	National Medical Association Hall of Fame Award

Biography

Neurophysiologist and scientific explorer Professor S. Allen Counter was born Samuel Allen Counter, Jr., on July 8, 1954, in Americus, Georgia, to Samuel Counter, Sr., and Ann Johnson Counter. Counter attended and graduated from Roosevelt High School in 1972 and went on to earn his B.S. degree in biology and audiological sciences from Tennessee State University in 1976. After earning his Ph.D. at Case Western Reserve University in 1979 and completing his postgraduate studies in neurobiology at Harvard University, Counter was appointed to the faculty of the Biology Department at Harvard.

Counter was promoted to the position of Associate Professor of Biology, and in 1981, was appointed Professor of Neurology at the Harvard Medical School. Counter then earned his Doctor of Medical Science degree from the Karolinska Institute in Stockholm, Sweden, in 1989.

As a neurophysiologist, Counter conducted research on nerve and muscle physiology, auditory physiology, and neurophysiological diagnosis of brain injuries in children and adults. Counter's scientific research also focused on the neurobiological effects of lead and mercury exposure, magnetic resonance imaging of the inner ear, balancing systems, and multiple sclerosis.

Counter also had a very active career as a scientific explorer, holding a membership in the prestigious Explorers' Club of New York. As a scientific explorer, Counter pursued his secondary academic interest, African American ethnography. In the 1970s, Counter conducted ethnographic studies among the indigenous people of Surinam (formerly Dutch Guiana) in South America. Counter's research resulted in a series of major articles on the little known rain forest descendants of seventeenth- and eighteenth-century African slaves, which appeared in national and international periodicals, including: Newsweek, Time, The New York Times, and Smithsonian magazine. In addition to his scholarly articles, Counter and colleague David Evans produced an award-winning documentary on the culture and history of the rain forest African peoples entitled, "I Shall Moulder Before I Shall Be Taken."

In 1986, Counter traveled to the northernmost settlements in Greenland on a scientific mission, where he unexpectedly discovered the eighty-year-old Inuit sons of the North Pole co-discoverers, Rear Admiral Robert E. Peary and the African American Matthew Henson, who were fathered with Inuit women during their 1906 expedition. After bringing the existence of these men to international attention, Counter organized and raised the funds to finance the journey of these sons, Anaukaq Henson and Kali Peary and twelve members of their families to the United States in May 1987 to meet their American relatives. Counter sought and gained proper recognition from the United States for Henson's contributions to Arctic exploration and co-discovery of the North Pole in 1909. Counter's work led to Henson's body being moved from his grave in the Bronx, New York, to the Arlington National Cemetery, and the U.S. Navy commissioning a U.S.N.S. oceanographic explorer ship named in Henson's honor.

In 1993, Counter initiated research studies in the interior of Ecuador, South America, where he discovered a unique group of African-descended people living high in the Andes; he later produced a documentary film on these descendants of eighteenth century slaves entitled, "Lost Africans in the Andes." From 1993 to 2000, Counter led medical teams into the Ecuadorian mountains to study health problems and provide medical services; he also conducted research to reduce the severe lead and mercury poisoning found amongst the children living in the ceramics glazing industry and gold mining areas of Ecuador.

Counter was the founding director of The Harvard Foundation, established by the president and deans of Harvard University in 1980 to improve intercultural understanding, equality, and peace among students. In September 2004, Counter was appointed Consul General of Sweden in Boston and New England by a decree from King Carl XVI Gustaf of Sweden, and Jan Eliasson, Sweden's Ambassador to the United Nations. In addition to his professional activities, Counter presented in classrooms and on television programs to increase scientific literacy among young people.

Discussion Questions

Personal:

1. What did you like best about listening to Dr. Counter?

2. Where was Dr. Counter born? Locate it on a map. How far away is this from where you live?

3. Dr. Counter talks about an opportunity that he had when he was ten years old. What was that opportunity? Who challenged him to do it? Has anyone ever challenged you to do something that you thought would be difficult? Have you ever tried something that you weren't sure you could do? What was it? What happened as a result? What does Dr. Counter say about his experience? How can that relate to you? **(See Clip #1)**

4. Dr. Counter discusses his experience with de-segregating a public beach with Mr. Willie Miller. How old was he? Can you imagine what that was like? What would you have done? How have things changed since then? How have they stayed the same? **(See Clip #2)**

5. Dr. Counter talks about a teacher who got him excited about science. What was her name? What was the specific science that Dr. Counter remembers becoming excited about? Have you ever been inspired by a teacher or other adult? What was it about them that inspired you? What did they inspire you to do? **(See Clip #3)**

6. Dr. Counter talks about an experiment that went a little wrong, leading to a very funny story. What was it? What kinds of funny stories can you remember from your own life where things got out of control because of a misunderstanding? What did Dr. Counter learn in his story? What did you learn from your own misadventure? **(See Clip #4)**

7. Dr. Counter discusses his early interest in science. Was he always good at it? What does he say was the motivation to keep learning? Have you ever found something that you had to work very hard at? Why did you do it? Do you always have to have a natural talent for something to succeed at it? Where can you put this talent to good use in your own life? **(See Clip #4)**

8. What is the achievement that Dr. Counter would like to see in his lifetime? Why do you think it does not already exist? How does this make you feel? How would you go about changing things? **(See Clip #7)**

Science:

9. What do you think a neurophysiologist does? Would you like to be a neurophysiologist? Why?

10. Dr. Counter tries to discover how the brain works. One function of the brain, still not well understood, is the relationship between memory and the senses. What are some of the sights, sounds, and smells that you remember from your early childhood? What are some memories of events that are associated with those sensory memories? Give your group a picture of your life from the past using your sensory memories as a guide. When you describe your life, what does that remind your group about in their own lives? Why is memory so important to humans? Why do you think that certain things trigger very strong memories? Is there a way to explain this scientifically? What do you think that is?

11. Dr. Counter talks about his work with MRIs. Have you ever heard of an MRI? What does MRI stand for? How does an MRI work? What are some other methods of seeing inside the body? How is an MRI different? What are the strengths and weaknesses of an MRI? **(See Clip #5)**

12. How is the MRI that Dr. Counter is using different from a standard MRI? If you could look inside someone's head, who would it be? What kinds of things would you like to see? Are these things something that can be seen on an MRI? Why or why not? **(See Clip #5)**

13. Dr. Counter's work led him to investigate the history of Robert Peary and Matthew Henson, who discovered the North Pole. Explain the significance of Dr. Counter's work in bringing this history to light. Research the story of Matthew Henson and explain why his feat was so monumental and why the lack of recognition he received for his achievement happened. What do you think it was like for the two Polar cousins, both growing up separate, then meeting their Southern relatives? **(See Clip #6)**

Experiment - Mapping the Homonculus Developed by Yash Shah

Target Audience
Secondary school students, grades 9-12

Objectives

Using two-point discrimination on the skin, students will determine the relative number of nerve endings located in the skin. By calculating the reciprocal of these measurements, the students will have the appropriate data for predicting the relative size and drawing the homunculus found on the cerebral cortex. Comparisons will be made among the homunculi of other mammals. Additional activities will show the correlation between behavior and the shape of the homunculus.

Student Prior Knowlege

1. Some background information in the structure and function of the nervous system is necessary.
2. History of phrenology as a pseudoscience.

Teacher Background

Located on the cerebral cortex is a representation of the human body called the homunculus or the' little man;' this is found on the somatosensory cortex or primary sensory cortex, immediately behind the primary motor cortex. The central sulcus, a deep groove running across the cerebrum, is located just in front of the somatosensory cortex. Neurons in this location can identify the area of the body being stimulated by the information they receive from somatic receptors in the skin and from proprioceptors in skeletal muscles. The muscle receptors transmit information about locomotion and position.

A particular body region is represented on the cortex with an area that is proportional to the number of touch receptors in the body part, not by its size. Therefore, the neurons form a geometrically distorted projection of the body surface. It should be noted that the neurons on the primary cortex are not laid down in the shape of a human, but the relative size of the areas is indicative of how sensitive the skin of that area is to touch. It can be useful for students to be able to put these parts together in a way that would represent a human. The sensory homunculus in humans has a very large face, tongue, and fingertips, therefore the student drawings will have large faces, tongues, and fingertips. Each hemisphere of the cortex receives information from the opposite side of the body.

The maps in animals and humans have been made by tactile stimulation of the skin and recording of the resultant electrical activity in the neurons of the sensory cortex. Facsimiles of these maps can be made in the classroom by using two-point discrimination to find the relative density of touch receptors in the skin. Maps are available for a number of mammals, including humans, rats, rabbits and cats.

MATERIALS

Any items with which to produce two fine points of touch

- Tooth picks
- Large paper clip bent into a horseshoe shape
- Straight pins
- Student compass (clip off the sharp point used as the pivot for the compass)
- Calipers
- Graph paper-Large squares can help guide students in estimating sizes in their drawings
- Metric rulers
- Alcohol or other disinfectant

Safety Precautions

The materials used in two-point discrimination are normal school materials but students should always be aware that everyday materials must be used carefully for personal safety. Points should be discarded or disinfected before using on another person.

PROCEDURE

Exploration

1. In a pre-lab situation, demonstrate to the students a method of two-point discrimination on the skin. Gently touch two slightly pointed objects to the skin of your forearm. It is important to apply these at the same time and to have the subject looking away from the test site.

2. Pick up the points, move them closer together and gently touch the skin of the same area again. The objects should be moved closer together until the test subject can no longer distinguish two separate points.

3. Measure the distance between the points. Have students make the measurements for one side of the body and use as much area as is feasible for your classroom setting. For example, your class may map just face, neck, arm and hand. In other settings students may volunteer to change into shorts or swim suits and a more extensive map can be made. Suggest that students randomly test the reliability of subject responses by touching with only one point.

4. The students will need to take the reciprocal of the two-point discrimination measurements before making their drawings. The areas of the skin that have many touch receptors will have a small discrimination value. To demonstrate that the skin area would be represented by a proportionally larger area on the cortex, the reciprocal must be taken. The reciprocal can be calculated by dividing the measurements into 1. If the two-point discrimination on the knee is 2.0 mm, the reciprocal would be 0.5.

5. After all calculations are made, the students should use the reciprocals as estimates to predict the relative size of the body part representations and to draw the homunculus. The smaller the distance of the two-point discrimination, the larger the reciprocal and thus the larger the body part on the homunculus will be. Have the students use the large squares on the graph paper as a guide for the approximate sizes of body parts. If the calculated reciprocals for the index finger and the thumb are 1.0 and 2.0, the thumb should be drawn twice as large as the index finger. Since each hemisphere of the cortex receives information from only one side of the body, the student drawings should be in profile.

Concept Introduction

1. When student drawings are complete, have the students compare their maps with those of students of different sex or ethnic background. If the maps have been made with care, they should be very similar.

2. Display the homunculi of other mammalian species on the overhead projector or with individual hand-outs and have the students discuss the differences among the species' representations. Representative mammalian homunculi can be found in Kandel, 1991

3. (see bibliography).

4. Introduce the anatomical and physiological terms for the nervous system which may be appropriate for the level of students in your class. A brain model could be used by the students to locate the somatosensory cortex.

Concept Application

In the application phase of the activity, divide the students into cooperative learning groups of three or four to research the answers to the focus questions. The groups should report back to the class as a whole and they should be aware that their answers may vary.

Fingertip Information for Easier Teaching

Lab preparation time– 20 to 25 minutes

Difficulties
Some students may not wish to be the subjects to be mapped. They can record and help their group analyze data.

Student Focus Questions

1. How is the pseudoscience of phrenology similar to the idea of localized function in the brain? How is it different?

2. Compare the size and shape of the rat homunculus with a typical rat body. (Kandel, 1991)

3. Why does the cat have more touch receptors around its mouth and lips than in other parts of its body? Suggest some adaptive behaviors in which this characteristic would be important.

4. Using the principles of natural selection, explain why the areas of the somatosensory cortex might be different for different species of mammals.

5. Consider the changes that modern technology might bring to the life styles of humans and predict how the shape of the human homunculus might change in the next 10,000 years.

See this experiment online at: http://www.doitscience.com/2009/05/mapping-the-homunculus/

S. Allen Counter - Video Clip Transcription

Clip 1 - Working for Small-Town Paper: We had a local teacher who was a…a very fine person in the community. Really a wonderful person, a great influence on a lot of young people, his name was Mr. Izell Hester. He had graduated from Florida A&M University, and he was the local person in Boynton who wrote for the newspaper, the county newspaper, called the Photo News. It was the black newspaper. And he decided, or he was called or whatever, to go to the military. So he went off to the military, and there was nobody to take over his column. So I recall a very brilliant grandmother saying to me, and I must have been about ten years old or something, I'm pretty sure I was about ten, "Why don't you take it over?" And I basically said, "I can't do that." She said, "Yes, you can, I've looked at your writing." And I said, "But Grandmother, Momma, I can't do that." And she said "Yes, you can. I'll even help you." So I thought about it and I had the courage to try it. So if you go back and read the Photo News back in the late fifties, you'll see that the articles are basically: Mr. John Doe and his family came to visit Boynton this weekend and met with all of his relatives for a family reunion…and a great time was had by all. I mean, most of the articles ended that way, you know, but I had a chance to write a column. I mean, I was ten years old. And the Photo News I think is still on-going in the Palm Beach County, Florida. But it was the first black paper there, and I had a chance to write for it, and I wrote the little column for Boynton and that was a real … it's those little things, that somehow your parents find a way to get you involved in that will lead to your ultimate kind of success, if you will, in life.

Clip 2 - Integrating Boynton Beach: Mr. Willie Miller was something of a civil rights leader, and he decided that whites should not keep us away from the local beaches. We had as much right to go there as did they. And he decided to lead a group of big boys, I call them big boys, a group of young men, young boys. Most of them were in junior high or high school, over to the beach for a wade-in; not a sit-in, but a wade-in, just go in the water and swim like anyone else. And I recall wanting to go and I knew my mother would never let me go, so I went anyway without telling her. And so we went over and we walked across the bridge. We went over to the section where only whites were allowed to go and I remember we walked to the beach just like any beach in the world and we, about ten of the big boys, Mr. Willie Miller and myself. They waded in and we were frightened, no question about it, and I was terribly frightened, but I was also determined to stick with the big boys there and to go into the water. We all went into the water and started to swim, and once we got in, it was delightful. But what happened was there were some two hundred or more whites on the beach or in the water. And they all came running out as if they had seen sharks and I remember being so tiny that they were running toward me and I was fearful I was going to be trampled, and one of the big boys grabbed me and held me so I wouldn't get trampled. And we went into the water and there we were swimming and we kind of stuck together in an area, and Mr. Miller was swimming. And all of a sudden within about fifteen minutes or so, white policemen came there and drew guns, and the epithets they shouted and everything, I can remember to this day. They were vicious. And they said they were gonna kill us, and of course we were frightened. But we looked at Mr. Willie Miller and he said, "Don't get out, boys, you don't have to get out, you have the right as citizens of America to swim in this water, to be here at this beach, you do not have to get out." And they were saying, "Well, if you don't get out, we're going to kill you." As we came out of the water, we followed Mr. Miller back up, you know, to the shore, and I recall seeing the mayor of the town, because he had on a white suit and a big white hat, I'll never forget. And he used a word that I'd never heard before. He said, "You boys should not be following this rabblerouser." And even at about six years old at that time, six or seven, I went, rabblerouser, I'd never heard that word before. "You boys should not follow this rabblerouser." And I remember the policemen still wanted to harm us but I recall looking up and about one hundred black citizens from our community had marched down right behind the policemen to where we were. And I remember the security that I felt at that moment, seeing all of the black people from our community coming there to defend us, to be there with us, and then we relaxed because the policemen knew, you know, at that time that they could do nothing with much of the community coming there.

Clip 3 - Good Science Teachers: I had good science teachers. I remember one woman, Ms. Julia McQueen was her name, very inspirational woman. She was a great science teacher and for some reason, she really encouraged me to study science. I think partly because she was very pretty and I remember staring at her a lot as a little boy thinking how pretty she was, and she was so bright, and she encouraged me to do science kits and biological sciences. And she would bring speakers in. I remember she brought a man in who talked to us about how airplanes lifted off the ground. And that fascinated me, about the air getting under the wing, and being able to lift the plane and it was the flow of the air and I got so fascinated about this.

Clip 4 - Experiments with a Frog: I remember that I brought a frog home and I'd read this experiment that I thought I understood. Where if you froze the frog for a certain period of time, then you could later melt the ice and restore the frog. I didn't know they were talking about liquid nitrogen, I had no access to liquid nitrogen. So I took the frog and put it in our little freezer and I had it there freezing and my mother opened it and it jumped out on her and my mother screamed. And I'll never forget I ran in the room and she was screaming and she looked at me and oh, did she give me a little whack as I ran back toward my room, saying, "don't you ever do that." I remember that very vividly because, and she later talked to me and she said, "You know, it's okay to do these experiments but don't bring them in the house like this. Go to your teacher; tell your teacher what you want to do" and so forth. But I'd either seen that, there was a show, I forget the name of the show right now, it was a science show on television, and it was something like Mr. Science or Mr. Wizard I believe it was called, something like that, and he would do these science programs and we would read these experiments. I had an interest, I didn't have a lot of talent in it, but I had an interest. And I found science teachers who were willing to teach me things about it.

Clip 5 - Using MRI for Research: I ended up doing some of my best work with a new device, an experimental magnetic resonance imaging unit…That's a unit that does basic MRIs, the kind that we get after an accident or when we're searching to examine whether there's any anomaly in the brain. But this high-field or high-strength magnetic system is one that has a much stronger resolution. In the day-to-day hospital work we use a field strength of one point five tesla, which is about as much as the government allows people to be exposed to in this magnetic device. But in this new device that I'm using, which is quite advanced, we are close to five tesla, you can't use that on humans. I've been able to study the uptake of medicines in the balance and hearing systems, I've been able to study the structural and morphological changes as a result of trauma and other sorts of things with this device, which is quite unique. In other words, you can see right through the head like a piece of glass.

Clip 6 - Matthew Henson: My grandmother had always made a little funny statement. She'd always say wherever you saw this, [pointing at his hand; referring to his skin color] this was always there helping, if not leading the way. And I got her point, if you saw this, this was also there. And she told me early on that Matthew Henson, an African American, had traveled to the North Pole with Peary [Robert E. Peary] and that he in fact had discovered the North Pole. And of course my grandmother would always give great credit to African Americans, and sometimes I thought that maybe you know she was just for our own pride, adding a little bit. But she said that to me, and I was determined to find out more. So I left the laboratory in Stockholm. I brought all of my equipment to travel to the polar regions of Greenland to meet Inuit people who had been associated. I really wanted to write the story. I again approached some scientists and doctors there to see if I could get some scientific basis for coming in. They agreed, and I ended up as I said, writing a paper on the subject…Well, when I got there, I was actually met by a translator at the military base, at Thule, which is the northernmost sort of air base that we had, and the only way to get to that part of the world. There were no regular airlines going up there. I was granted permission to get there so it was no easy task even to get there. And then I traveled about 150 or so kilometers north to the Inuit villages, and the Thule Air Base is where America watched the Soviet Union across the pole for over 50 years.

So there, I went out into the villages and I met translators who took me out, and I had the privilege of meeting Inuit people who were the descendants of Uta, the very man who traveled to the North Pole with Henson and Peary, who'd actually saved both of their lives by pulling them out of the water when they fell in. And his grandson, his great-grandson, gave me a whip, a dog whip. I still have it today. I was very proud of that, you know, and I collect things like that. And as I began to talk about the expeditions, and through my translator who had come from Thule Air Base, I was asking about Henson and they kept laughing at me, and laughing, and I was—why were they laughing so uproariously as I went into these little villages. And I asked if they knew more about Henson, and they said, "If you come with us, we will take you to the house where you will meet some people." And I got over to this house and out comes a man with dark skin, curly hair, and he says, "I am the son of Miy Paluk." And I said, "Miy Paluk?" And they explained to me that that was what they called Matthew Henson. Paluk is a kind person; it was basically Matthew, The Kind One. And so right away I started to know this man, I followed him around his seal traps. He was still in the traditional Inuit Eskimo way. He was searching for seal traps or for seals. I came to know him and he said, "You ought to meet my cousin." I had no idea who he was talking about. Turns out he meant that there was another relative, and he called him cousin because he was the son of Admiral Robert Peary. And he had grown up with him. They were adopted by two Inuit when Henson and Peary left, and they were brothers but called each other cousins. And so I came to know both of these men. They were both fathered in 1906 on Peary's ship. They were both born on Peary's ship while it was on an expedition to reach the North Pole. And the mothers were Inuit, and the son of Henson, the African American, was named Anauakaq Henson, and the son of Peary was Kali Peary.

Well I went back and forth to Greenland on a military plane, several times to see them. And they said to me at one point that they were older men and they knew they were gonna die soon. And they asked if I could help them do something they'd dreamed of since they'd been abandoned by their fathers in Greenland. They said, "Can you help us touch a relative?" And at first I kind of didn't know what that meant, but they said all their lives they'd dreamed of simply meeting a relative in the land of their fathers and just touching them, because they really felt no continuity; they really felt abandoned. And I agreed to help them, I didn't know how I was going to do it, but I came back to the U.S. and I wrote the Secretary of Defense. I wrote the president. I asked for permission to take a plan to go up and bring these people back to visit the sites of significance in their fathers' lives including Arlington National Cemetery, where Peary was buried. And short, I was granted permission and given the support of the White House, at that time, President Reagan. And I was permitted to go up and bring them to America, and when we got to Washington, D.C., they were presented flags that had flown over the capitol. They were, they met with government officials, Matthew Henson Day was proclaimed in the City of Washington. I was able to take them around, they visited the gravesites of their fathers.

And then it became clear to me what the racial discrimination of that time again did to Henson. Not only did history try to drop him out of any recognition for what he had done for his country in reaching the North Pole, which had great significance militarily, in terms of the pride of the nation, they dropped him off. And so Peary was celebrated by National Geographic. In fact, National Geographic gave Peary and others on the expedition wonderful privileges. Gave Peary a gold medal, the highest medal. Gave Bob Bartlett, another member of the expedition, their gold medal. Gave other members medals. But they wouldn't even recognize Henson. That was the nature of the racism and the supremacy felt by the people at National Geographic at that time. And I fought for years to get Henson recognition. But finally I got from the President when I realized that Henson was buried in a common grave in New York, I asked the President to permit me through a Presidential order to disinter Henson in Arlington National Cemetery—disinter him in the common cemetery, and common gravesite in Woodlawn and reinter him with full military honors at Arlington National Cemetery for what he had done for his country. I was granted permission to do that. I brought the young people back, I brought the family back from Greenland on a military jet, and there I was able to let them take part in the ceremony, and I was able to bring the old men to America to reach out and touch their relatives for the first time, both on the Henson side and on the Peary side, which is a white family in America that initially rejected even this Inuit man who at age 83 only wanted to meet a relative. But I finally persuaded them that the fair and decent thing to do would be to meet him and welcome him and he was finally welcomed in his brother's home in Augusta, Maine, his first time.

Clip 7 - Push for a Monument to Slaves: We have nothing to represent the millions of Africans and African Americans who lived and died in the helotry of slavery as we know it. And so I'd like to see in my lifetime some monument, not hidden off in some corner but on the Mall, to the contributions made to the advancement of this nation by people who were forced to work for nothing, who formed the free labor force for people who had no other basis for owning them than they were white.

ScienceMakers

Spotlight: Shelia Grimes

Full Name:	Sheila Denise Grimes
Born:	February 24, 1958
Place:	Richmond, VA
Parents:	Julia Grimes
	George Grimes
Education:	Fort Campbell High School - Fort Campbell, KY (1976)
	Tuskegee University - Tuskegee, AL (B.S./D.V.M. Veterinary Medicine, 1980)
	Michigan State University - East Lansing, MI (M.S. Veterinary Medicine, 1984)
	Michigan State University - East Lansing, MI (Ph.D. Veterinary Medicine, 1988)
Type of Science:	Veterinary Pathology
Achievements:	Section Head for the Animal Disease Diagnostic Laboratory at the Ohio Department of Agriculture

Favorites:

Color:	White
Food:	Chocolate
Time of Year:	Summer
Vacation Spot:	Alabama

Biography

Veterinary Pathologist and Section Head for the Animal Disease Diagnostic Laboratory at the Ohio Department of Agriculture Sheila Denise Grimes was born to Julia and George Grimes on February 24, 1958, in Tuskegee, Alabama. Grimes's father served in the U.S. Army, causing her family to move frequently, living on numerous military bases that included those in Germany and the State of Kentucky, where she completed high school (Fort Campbell High School in 1976). Grimes finished her undergraduate training in veterinary medicine at Tuskegee University earning her B.S. and D.V.M. (Doctor of Veterinary Medicine) degrees in 1980. Grimes went on to earn her M.S. degree in 1984 and her Ph.D. in 1988 from Michigan State University (both degrees in veterinary medicine). Grimes also taught at Michigan State University for seven years before joining the Ohio Department of Agriculture Division of Animal Industry.

Grimes spearheaded the Ohio Department of Agriculture's deer-testing program; this program was designed to detect disease in the state's white-tailed deer herd and to guard against threats to human health associated with disease among cattle and poultry.

Grimes, a published scholar and researcher, also served as a youth mentor. An avid reader, she is especially fond of the works of Zora Neale Hurston and J. California Cooper.

Discussion Questions

Personal:

1. What did you like best about listening to Dr. Grimes?

2. Where was Dr. Grimes 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. Grimes attend high school? What do you suppose high school was like for her?

3. How old are you? In what year was Dr. Grimes your age? What was happening in the country that year? What was happening in the world that year? What do you suppose her life was like when she was your age?

4. How old was Dr. Grimes when she decided to be veterinary pathologist? What led her to that decision? What kinds of things do you like? What do you like about them? What kinds of things are you good at? What careers utilize these interests and skills? Is there anything that you don't like? Why not? How can you use these dislikes to narrow down your career choices? **(See Clip #1)**

5. Describe Dr. Grimes's higher education path. What were some of her other options? Using your answers from question 4, map out a higher education path for yourself that will allow you to begin your career. Be as specific as possible. Now that you have a path, who can help you to get started on this path? **(See Clip #2)**

6. Dr. Grimes discusses inequality based on prejudices. What are her conclusions? Do you agree with her? What do you think about inequality based on race? What are other ways that people pre-judge each other? Do you ever form an opinion about someone before you talk to them? Do you think that people can change? How can you be part of this change? **(See Clip #5)**

Science:

7. What do you think a veterinary pathologist does? Would you like to be a veterinary pathologist? Why?

8. If you were a veterinary pathologist, what kinds of questions would you study?

9. Describe a typical day for Dr. Grimes. What is a necropsy? How is Dr. Grimes like a detective? Have you ever wondered how or why something happened? What was it? How did you figure it out? What are some of the tests that she runs? Why are each of these important? **(See Clip #3)**

10. Why is it important to perform a necropsy? Dr. Grimes mentions economic and personal reasons. What are some of the economic reasons? How does agriculture affect your state? What are some of your state's resources? What are some of the different areas of agricultural science that Dr. Grimes might investigate? **(See Clip #4)**

11. Dr. Grimes talks about the Tuskegee syphilis experiment. What was it? Research this experiment and report back to the class. What happened there? What were the ethical problems that this experiment brought to light? Are there any other examples in history of experimenting on people without their consent? What are they? **(Clip #6)**

12. What is it about Dr. Grimes's work that she finds exciting? What excites you? When you think of doing something as a career, what are the types of things you'd like to do every day? What kinds of careers allow you to do these things? **(See Clip #7)**

Additional Resources
"Miss Evers' Boys" starring Alfre Woodard and Laurence Fishburne. HBO Films, 1997

http://en.wikipedia.org/wiki/Tuskegee_experiment

Experiment - Digestion Investigation

This lesson was adapted from educational materials developed by the Center for the Advancement of Science Education at the Museum of Science and Industry.

Lesson Objectives:

- The students will investigate the organs in the digestive system through various activities.
- The students will prepare and conduct an experiment.
- The students will work in collaborative teams.

Materials

- Chart Paper
- Markers
- Pencils
- Masking tape
- M&M's
- Ziploc Bag
- Brown Paper Bag
- Plastic Bag
- Spray Bottle
- Sponge
- Yarn
- Scissors
- Measuring Tape
- Puzzle Pieces
- Antacids
- Plastic Containers
- Bromphenol Blue
- pH strips
- Vinegar
- pH scale
- Graduated Cylinder
- Plastic Tubing
- Water

Lesson Plan:

1. Introduction

What system is responsible for breaking down the foods and liquids that we consume? What does the Digestive System do? What are the main parts, or organs, that make up the Digestive System? The students may name organs such as stomach, esophagus, intestines, etc. After they have finished brainstorming, let them know that they are going to be able to learn first-hand what happens after a bit of food is swallowed.

2. Team Digestion

- The "piece of food" for this activity needs to be pre-made: 5 M&M's should be placed in a Ziploc bag, which should then be wrapped in paper and placed inside a small paper bag. This small paper bag should be wrapped in more paper and placed inside a plastic bag. The plastic bag should be taped closed.
- Ask for 6 volunteers. Tell them that they are going to be able to work together to recreate the digestive system. Tell the volunteers to stand in a line at the front of the room.
- Explain to the volunteers that each person will get a "Digestion Role" card to read out loud. The volunteer will read what is written in red on the card and act out the parts written in blue.
- Ask each of the volunteers to select a "Digestion Role" card at random. When everyone has a card, instruct the students to get into order of: Teeth/Saliva, Esophagus, Stomach/Gastric Juices, Small Intestine, Large Intestine, and Rectum.
- Tell the students to leave some space between the Esophagus volunteer and the stomach/Gastric Juices volunteer. The instructor should put on the "Bloodstream" sign at this point.
- When everyone is ready, tell the first person in line (Teeth/Saliva) to begin reading. Remind them to speak loudly!

Digestion Role Cards (spoken lines in bold, actions are in italics):

Teeth/Saliva – *Pick up the piece of food and begin to tear the plastic bag.* **"Teeth chew up and crush the food in our mouths, making smaller pieces for us to swallow."** *Next, with a spray bottle, spray the piece of food to moisten it well.* **"Saliva makes the food slimy and easier to swallow. It also contains chemicals, called enzymes, that start to break down the food in our mouths."** *Give the food to the esophagus.*

Esophagus – *Place the piece of food on the floor, and push the food slowly towards the stomach.* **"Food does not just fall from our mouth into the stomach, but muscles in our esophagus push the food into our stomachs. This process usually takes between 7 and 10 seconds."**

Stomach/Gastric Juices – *Take the food and tear up the bags until you can see the small Ziploc bag with the M&M's in it.* **"The stomach muscles mix and smash up the food until it is a creamy liquid." Then, using a spray bottle, spray the food. "The stomach wall releases gastric juice that contains chemicals called enzymes. Enzymes break down proteins from food."** *Hand all the food to the small intestine.*

<u>Small Intestine</u> – *Remove the small Ziploc bag with M&M's from the other bags. Find the bloodstream, and give them the Ziploc bag.* **"The small intestine uses enzymes and bacteria to further digest the food. Vitamins, minerals, and other substances used by our body will be absorbed into the bloodstream through the small intestine."** *Give the remaining food to the large intestine.*

<u>Large Intestine</u> – *Take a sponge and wipe up any water on the food or on the floor. Give the sponge to the bloodstream.* **"Water is absorbed into the bloodstream through the large intestine. The remaining food and water that cannot be used by the body continues to push through the large intestine."** *Hand the food to the rectum.*

<u>Rectum</u> – *Give the remaining unused food, and throw it into the trash can.* **"The rectum is the last stop for food in the body. Whatever the body cannot use is thrown out into the toilet."**

- If time allows, some of the other students may want to take a turn acting as a part of the digestion process. After all interested students have had the opportunity to complete this activity, spend a few minutes debriefing with them.

- As an overall group, walk through the digestive activity, and talk about the steps in the digestive system.

Questions to Ask
Is this a system? Why or why not?
What would happen if you removed on part of the process?
Why is it important for our bodies to digest food?
How long do you think it takes for food to be fully digested?
How can it take 32 hours for food to be completely digested? Where does food spend the majority of time?

Measure Your Insides

If you were to take the organs in the digestive system out of your body, stretch them out, and line them up, how long would they be? Work as a group to measure the digestive system.

Gather the supplies and decide which organ will be represented by which color. Your group will need 4 different colors of yarn, one for each organ: the esophagus, stomach, small intestine, and large intestine.

Measure out the following amounts using different colored yarn.
Esophagus = 10 inches
Stomach = 8 inches
Small Intestine = 276 inches
Large Intestine = 59 inches

Tie the ends of the yarn together so that you have one long string of different colors. Answer the following questions.

- How long is the total string?
- Are you taller or shorter than the entire string?
- Can you find something about the same height? Use the materials in the room to make a measurement.
- Is this how the digestive system looks in our bodies, one long pipeline?
- Allow the groups to talk about this activity and to share any observations they made about the digestive tract. Ask them again: *Why do you think it takes 32 hours for food to pass through the digestive system*?

- Discuss with the group that since the digestive system is almost 30 feet long, it takes food a long time to move through the system.

- Hold up the pieces of PVC pipe. Tell the group that one piece of pipe is 3 inches in diameter (across) and the other is 1 inch in diameter. Ask the group: *Which piece of pipe represents the small intestines and which represents the large intestines?*

- Explain that the large intestine is called this because it is the larger tube in the digestive system. The small intestine is much longer, but it is a smaller tube with diameter of only 1 inch, and so it is called the small intestine.

- Tell the students that in reality, both intestines are fairly big tubes and so the digestive system takes up a lot of room in our bodies. Ask the students: *How does the digestive system fit?*

- The students should say that the digestive system, especially the intestines, is scrunched up so that it all fits inside. Because the intestines are not in one straight line, it takes food a long time (32 hours) to navigate through all those twists and turns.

MUSEUM OF SCIENCE AND INDUSTRY

Sheila Grimes - Video Clip Transcription

Clip 1: - Veterinary Pathologist: Actually about ninth grade, I decided I wanted to be a veterinarian and then about the eleventh grade I decided I wanted to be a veterinary pathologist. So I was directed early on in life as to what I wanted to be…I liked medicine, and I liked science. I have no sympathy for sick people, so I knew I didn't want to go into human medicine. And I saw a television show once that had a pathologist present on the show and I thought that would be cool—I love animals, and I thought that would be cool so I decided I wanted to be a veterinary pathologist…I had some excellent female science teachers that I think helped to prepare me to go onto college.

Clip 2 - Amount of School: You can be accepted into veterinary school after two years of education or up to four years, usually it's four years of education, you have a bachelor's [degree]. But I got into veterinary school after going to school for two years and then veterinary school is four years and you receive your D.V.M. [Doctor of Veterinary Medicine], and I also got a bachelor's at the same time, and then I went on to graduate school after that…You can do an internship after veterinary school, or residency, I actually went on straight to graduate school, so I took a Ph.D. route as opposed to a residency route.

Clip 3 - Lab Work: In Ohio, I'm actually a diagnostician, so the primary responsibility that I have is a diagnostic one in that I perform necropsies, or autopsies on animals, and then I have some administrative responsibilities…Well, when I come in in the morning, if I'm on duty, which means if I'm the person performing the necropsies that day, then I will talk to the owners of the individual—owners of the animals, and discuss their case with them. A farmer might bring in an animal to us if they have pigs that have diarrhea, and the veterinarian is treating those pigs, and has been unsuccessful in treating them. So I'll take the history from that owner and see what kind of diarrhea they have. How long have they had diarrhea? Have they been treated? Has it been successful? Then the animal will be taken to the back of the lab and we'll perform a necropsy on that animal. And a necropsy is similar to an autopsy in that it's an examination of the body after it's dead. So we'll open up the carcass and look at all the internal organs, take tissues from that carcass, and then those will be prepared for a microscopic examination. So I spend a lot of time at the microscope looking at the slides, and then tests are performed in various labs, the bacteriology lab, and the virology lab, the serology lab, tie all that data together and come to a conclusion as to why the animal died.

Clip 4 - Importance of Work: Well, agriculture is a big industry. It's number one or two in the State of Ohio, and it's big in the U.S. in general. And when you have large groups of animals that become ill and you're unsuccessful in treating them, it's important to figure out what's wrong with them so you can successfully treat them because it's a big economic loss if the majority of animals in that flock or herd die. So for an economic purpose, it's essential to find out why animals are dying, what's the most appropriate therapy to treat them with. There are also individuals that may own pets that are concerned about why their pet died. You know, what type of cancer did it have?...Was it poisoned by their neighbor? So for personal reasons and economic reasons it's important to have a necropsy done.

Clip 5 - Prejudices in the World Today: It's just human nature that they're always going to have some prejudices and some racist natures, and I think there continues to be a struggle, particularly for black males. I have a brother, and he's a big gentleman. But he's a very gentle gentleman. But I realized that if he were to get on an elevator with someone, they would be concerned about being in that elevator with him even though he's the nicest person in the world. So people continue to have their prejudices, and I know several black males that feel they haven't been as successful as they could be because they're black males. I don't know that it's necessarily always that case, but I know that they feel that way and…In my lifetime, I, when I was at Michigan State I received a faculty appointment after completing graduate school. There were several black males that had received Ph.D.s prior to my completing my Ph.D. at Michigan State University, and there were positions available at that time that they could have accepted had they been offered the position, and they weren't. And I think part of it was because they were more comfortable with the black female being in that position than a black male. So I think there's still racial incidents that occur in this world, and I'm afraid that that will always be the case. I would like to think that we will have a colorblind society as Michael—as Martin Luther King wished, but I know that just based upon human nature that's going to occur. If it's not color, it's going to be hair. It's going to be body shape. It's going to be something.

Clip 6 - Tuskegee Syphilis Experiments: The U.S. had an experiment where they…Black individuals that had syphilis were not treated. They were told that they were being treated, but they actually were not treated, to see what the effects of syphilis were on the human body. So we were human guinea pigs, and many people died for a lack of treatment for a disease that was treatable. So, I know people that actually were a part of the syphilis experiment that lived to a ripe old age that received a monetary settlement because they were in that experiment, which was a horrible thing to do to people. You know, to purposely use them as human guinea pigs. That was a horrific thing to do. And Tuskegee now actually has a Center for Bioethics based upon what occurred with the Tuskegee experiment, and then us trying to ensure that that never occurs again. So, the Center for Bioethics is to ensure that that never happens to a person again, to be treated as a human guinea pig without your knowledge.

Clip 7 - Interesting Part of Job: You never know when you open up an animal exactly what you're going to find. So, it's always a mystery. [There's] something always exciting about opening up a carcass, and I mean, it may be something routine, but it may be something odd. And at least once a week, something odd comes up. And just before you came in, I actually was looking at something odd on a slide. So, there's always something new and exciting going on. A cat had some neurologic disease, and it has strange lesions in its spinal cord and its brain and it probably has more than one thing going on. But it's not a routine lesion that I would normally see. And that makes the day exciting. I mean, you have to look stuff up and learn new things.

ScienceMakers

Spotlight: Erich Jarvis

Full Name:	Erich D. Jarvis
Born:	May 6, 1965
Place:	Harlem, New York
Parents:	Sasha Valeria McCall
	James Reginald Jarvis
Spouse:	Dr. Miriam Rivas
Education:	High School of the Performing Arts – New York, NY (1983)
	Hunter College – New York, NY (B.A. Biology, Mathematics, 1988)
	Rockefeller University – New York, NY (Ph.D. Molecular Neurobiology and Animal Behavior, 1995)
Type of Science:	Neurobiology
Achievements:	Revolutionized avian neurobiology nomenclature
	Won the National Institutes of Health's Director's Pioneer Award

Biography

Neurobiology researcher Erich D. Jarvis was born on May 6, 1965, in the Harlem neighborhood of New York City to musician parents. Growing up in an artistic but poverty-stricken household, Jarvis found an early passion for dance, which led him to the famous High School of the Performing Arts to study among the brightest young artists and talent of his time.

Turning down an offer to audition for the famed African American dance company, Alvin Ailey, Jarvis chose to pursue a double major in biology and mathematics with a minor in chemistry at Hunter College in New York City, while working as a Minority Access to Research Careers (MARC) Fellow. In his undergraduate research, Jarvis studied the protein synthesis genes in bacteria. After obtaining his B.A. degree in 1988, Jarvis pursued his Ph.D. degree in molecular neurobiology and animal behavior at the Rockefeller University in New York City, where he researched song-associative learning in songbirds, research that would later become his life's work.

After completing post-doctorate research and an adjunct teaching position at Rockefeller University, Jarvis joined Duke University's faculty as an Assistant Professor in the Department of Neurobiology in 1998. At Duke, Jarvis also served as a fellow in the Department of Cognitive Neuroscience, as well as taught in many departments. These include the Center for Bioinformatics and

Computational Biology and the Developmental Biology program. Jarvis became a tenured associate professor at Duke in 2008, where he taught laboratory science for underprivileged students through the Science Outreach Program of New York.

Jarvis has been recognized as a young pioneer in his field, and his research and study of songbird neurology has won him many awards, including the National Science Foundation's highest honor for young researchers, the Alan T. Waterman award, in 2003, and the National Institute for the Humanities' Director's Pioneer Award in 2005. Jarvis was also named distinguished alumni at each of his undergraduate and graduate universities.

In 2008, Jarvis was chosen to become an Investigator for the Howard Hughes Medical Institute, one of the largest philanthropic research organizations in the country. Jarvis has been an invited contributor for several books and has published hundreds of scholarly articles in prestigious journals, including the Journal of Bacteriology and the Journal of Comparative Neurology.

Discussion Questions

Personal:

1. What was the most compelling thing you learned about Dr. Jarvis?

2. Where was Dr. Jarvis 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. Jarvis attend high school? What do you suppose high school was like for him?

3. How old are you? In what year was Dr. Jarvis your age? What was happening in the country that year? What was happening in the world that year? What do you suppose his life was like when he was your age?

4. Where did Dr. Jarvis get his inspiration to become a scientist? Give some specific examples of how this process occurred. Where do you get your inspiration to learn new things?
(See New York Times Interview)

5. Dr. Jarvis discusses his early life with his parents. What was his father like? What was his mother like? How did their divorce affect his scientific curiosity? What kinds of things did he have to overcome in order to achieve his success? **(See New York Times Interview)**

6. Dr. Jarvis has an unusual artistic background. What is it? Why do you think he chose a professional career as a scientist? Which of these fields do you prefer: the arts or the sciences? Why? Do you know anyone who is equally comfortable in the sciences and in the arts? What are the differences between the two? What are the similarities? Can you think of any skills that are equally applicable to both?
(See "Diversity in Science" Blog and Nova Interview)

7. Dr. Jarvis talks about being a "scientific artist." What does he mean by this? What are his thoughts on the compatibility of the arts and sciences? How does he say they are similar? How does he say they are different? How does this relate to your life? **(See Nova Interview)**

8. Dr. Jarvis says that there are two kinds of families in the African American community. What are they? What does he mean by this? Do you agree with him? If so, what kind of family is your family? How does your family define who you are as a person? **(See Nova Interview)**

9. What does Dr. Jarvis say about science and having fun? What is his rationale for the lifestyle that he leads? How can you model this in your own lifestyle? How does a balanced lifestyle promote success? What do you consider to be a balanced lifestyle? What does your class consider to be a balanced lifestyle? **(See Nova Interview)**

Science:

10. What do you think a neurobiologist does? Would you like to be a neurobiologist? Why?

11. If you were a neurobiologist, what kinds of questions would you study?

12. Why does Dr. Jarvis study birds as opposed to another kind of animal or humans? What are the links that he can make between bird brains and human brains? **(See Nova Interview)**

13. Dr. Jarvis studies three specific types of birds. What is the common link between them? What is he hoping to find? What does he hope is the connection to human learning? What implications does this have for diseases of language in humans? **(See New York Times Interview)**

14. Dr. Jarvis practices unusual research techniques in that he fuses molecular biology with observational fieldwork. Why is this unusual? What are the characteristics of each? What benefit can you learn from either? Why does Dr. Jarvis combine the two? **(See New York Times Interview)**

15. Dr. Jarvis talks about signals in the brain of a bird synthesizing certain genes. What does this mean? Why is it significant? What are the implications for the human brain and how it works? **(See Nova Interview)**

16. Dr. Jarvis is studying neurobiology in birds in order to help people afflicted with neurological disorders and diseases. He mentions two such diseases. What are they? Can you think of others? What are the symptoms of each? Why is it so difficult to understand neurological disorders and diseases? Do you know anyone afflicted with a disorder or disease such as these? What can you do to help that individual? **(See Nova Interview)**

17. What does "the nomenclature of avian neurobiology" mean? Why did Dr. Jarvis think it was so important to change the nomenclature? What happened when he attempted to do so? Have you ever faced a situation like this? What did you do? How did Dr. Jarvis handle the situation? What did he do especially well, according to his colleague? What was the result of the conference? **(See Nova Video)**

18. Dr. Jarvis works with a diverse group of people. How did this occur? What is his reason for doing so? How is this different from other labs? What are the benefits of working in a diverse environment? Are there any drawbacks? Look around at your class. How diverse is your class? What are the advantages and disadvantages inherent in the diversity of your class? How does this affect your learning? **(See Nova Interview)**

Additional Reading

"Diversity in Science" Blog - http://kidsndata.blogspot.com/2009/02/diversity-in-science-erich-jarvis.html

New York Times Interview - http://www.nytimes.com/2003/01/07/science/conversation-with-erich-jarvis-biologist-explores-minds-birds-that-learn-sing.html?scp=1&sq=erich+jarvis&st=nyt

Nova Interview - http://www.pbs.org/wgbh/nova/sciencenow/3214/03-jarv-nf.html

Nova Video: http://www.pbs.org/wgbh/nova/sciencenow/3214/03.html

Experiment - Can You Feel The Difference?

This experiment was taken from **Science And Life Issues**, published by Lab-Aids, Inc.

Materials

- For each pair of students
    - 1 2-point sensor
    - 2 plastic toothpicks

Safety

- Be careful when doing the touch tests. Press gently when testing, making sure to only slightly depress the skin surface.

Procedure

1. Slide 2 plastic toothpicks into the 2-point sensor on the side marked “1.5 cm.”
2. With your eyes open, investigate your sense of touch by touching the skin of your fingers, the palm of your hand, and forearm with the point of just one toothpick.
3. With your eyes open, touch your fingers, palm, and forearm with the points of both toothpicks.
4. Record your observations in your science notebook while your partner investigates his or her own sense of touch.
5. Have your partner close his or her eyes while you touch the skin on his or her fingers with either one or two toothpick points. Touch just hard enough to see that the points are barely pushing down on the skin. Randomly alternate between one and two points. Can your partner tell the difference?
6. Create a larger version of the table shown below. In the table, record your observations about your partner’s ability to tell the difference between one and two points on his or her fingers.

Table 1: Observations of Touch Sensitivity

Person Being Tested	Fingers	Palm	Forearm
(Name)			
(Name)			

7. Repeat Steps 5 and 6 on your partner’s palm and forearm.
8. Switch places and repeat Steps 5-7.
9. In your group of four, use Analysis Questions 1 and 2 to discuss your results.

Analysis

1. Which part of your arm – your fingers, palm, or forearm – was the most sensitive to touch? What data do you have to support your conclusion?
2. In your group, how many people found fingers to be the most sensitive part of their arm? How many found palms or forearms to be the most sensitive? How similar were different individuals’ responses to touch?
3. Why was it important for the person being tested to close his or her eyes?
4. Before scientists make comparisons, it is important that they perform well-designed experiments. In a well-designed experiment, all of the variables, except the one being tested, are kept the same.
    a. In your experiment, what variables did you keep the same?
    b. Were there any variables (except for the one being tested) that you could not keep the same?

SEPUP. (2005). *Science and Life Issues*. Lawrence Hall of Science, University of California at Berkeley. Published by Lab-Aids, Inc., Ronkonkoma, NY.

ScienceMakers

Spotlight: George Jones

Full Name:	George Henry Jones, Jr.
Born:	February 21, 1942
Place:	Muskogee, OK
Parents:	Bernice I. Jones
	George Henry Jones, Sr.
Education:	Manual Training High School – Muskogee, OK (1959)
	Harvard University – Cambridge, MA (B.A. Biochemical Sciences, 1963)
	University of California, Berkeley – Berkeley, CA (Ph.D. Biochemistry, 1968)
Type of Science:	Biology
Achievements:	Researches the mechanism and regulation of antibiotic synthesis in the bacteria *streptomyces*
	Received multiple National Science Foundation grants to study RNA

Biography

Dr. George Jones was born George Henry Jones, Jr. on February 21, 1942 in Muskogee, Oklahoma to George Henry Jones, Sr. and Bernice I. Jones. Jones attended Manual Training High School in Muskogee, graduating in 1959. He received his B.A. degree in biochemical sciences from Harvard University in 1963, and went on to the University of California, Berkeley, where in 1968 he earned his Ph.D. degree in biochemistry under the tutelage of Dr. C.E. Ballou.

After completing his Ph.D., Jones worked as a visiting scientist at the National Institutes of Health from 1968 to 1970. He then made an international move to the University of Geneva in Switzerland, where he completed a postdoctoral fellowship between 1970 and 1971. Upon returning to the United States, Jones took on a professorship in the Zoology Department at the University of Michigan where he worked from 1971 to 1975. In 1975, Jones moved over to the Department of Biology where he chaired the Department of Cellular and Molecular Biology from 1980 to 1982.

In 1984, Jones became professor and associate chairman for space and facilities at the University of Michigan, where he also taught in the Division of Biological Sciences and served as associate dean at the Horace H. Rackham School of Graduate Studies. Between 1986 and 1989, Jones served as a professor in the Department of Biology. He moved to Emory University in 1989 to serve as its dean in the Graduate School of Arts and Sciences and vice president for research and graduate studies. In 1990, Jones served as Emory's acting dean for one year. In 1996, Jones received the prestigious Goodrich C. White Professorship in Biology at Emory.

Jones' numerous awards include the University of Michigan International Excellence in Teaching Award and the Emory University Scholar/Teacher Award. In addition to his teaching activities, Jones held membership in several distinguished professional societies, including the American Society for Biochemistry and Molecular Biology, and the American Society for Microbiology. Jones' research covered the mechanism and regulation of antibiotic synthesis in the bacteria *streptomyces*. For this work, he received a three-year National Science Foundation Grant in 2003 to study RNA degradation and antibiotic synthesis in *streptomyces*, and another grant in 2008 to study RNA antibiotic production regulation.

Discussion Questions

Personal:

1. What was the most compelling 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 suppose high school was like for him?

3. How old are you? In what year was Dr. Jones your age? What was happening in the country that year? What was happening in the world that year? What do you suppose his life was like when he was your age?

4. Dr. Jones studied under Dr. C. E. Ballou at the University of California, Berkeley. Why was this significant? Research Dr. Ballou and explain his significance to the scientific and academic communities. **(See Biography)**

Science:

5. What do you think a biologist does? Would you like to be a biologist? Why?

6. If you were a biologist, what kinds of questions would you study?

7. What does RNA stand for? How is it different from DNA? How does RNA function? What task does RNA perform in the body? What is its relationship to DNA?

8. What is RNA degradation? Why is it a serious problem? How does Dr. Jones aim to solve this problem? **(See Biography)**

9. Dr. Jones' research focuses on a bacteria named *streptomyces*. What is *streptomyces*? Why is it significant? How has it been used in biotechnology? How is it significant to the field of medicine? **(See Biography)**

Experiment - See Your Own DNA

This lesson was adapted from educational materials developed by the Center for the Advancement of Science Education at the Museum of Science and Industry.

You will need four 8-ounce containers.

1. In one container, mix a full glass of water with 1 tablespoon of table salt.
2. In the second container, mix 2 tablespoons of water and 1 tablespoon of Liquid Dish Soap.
3. Fill the third container half full with 70% Isopropyl (rubbing) alcohol.
4. Take approximately one tablespoon of the salt-water solution from the first container and swirl it in your mouth for 30 seconds.
5. After 30 seconds spit the salt water and whatever contents are moving around in your mouth into the fourth container that was still empty.
6. Pour just enough of the spit solution to fill the top of the test tube. NOTE: Do not pour all of that swirled-spit into the test tube! The rest should be disposed of when you are finished.
7. Add 1 teaspoon of the soap-water solution to your test tube of spit. Secure your fingers around the top of the tube and move the solution around in a small circular motion for about one minute.
8. After you've rotated the spit, carefully fill the rest of the test tube with rubbing alcohol. When doing this, pour the alcohol down the inside of the test tube, so the alcohol will form a separate layer on top of the soap-spit mix. Wait about one minute, and you will see a cloud of bubbles hanging at the bottom of the layer of alcohol. Those bubbles are attached to your DNA.

By swirling the salt water in your mouth, you collected a great deal of cells from the inside of your cheeks. By spitting those cells (along with the salt water and saliva) into the test tube and mixing them with soap, you were able to break up the outer membrane and nucleus of each cell. These cell membranes and the nuclear membranes are made up of phospholipids (very similar to fats). The dish soap that you added dissolved these phospholipids, thus exposing the DNA. This DNA then floats up through the soap until it hits the alcohol solution. DNA is insoluble in cold alcohol, so it precipitates out of solution and forms the long white strands at the bottom of the layer of alcohol.

ScienceMakers

Spotlight: Shawna Nesbitt

Full Name:	Shawna Denise Nesbitt
Born:	November 10, 1963
Place:	Aliquippa, PA
Parents:	Yvonne Sarvis Smith
	Townsend Smith, Jr.
Spouse:	Thomas Nesbitt
Education:	Quigley High School – Pittsburgh, PA (1981)
	Gannon University – Erie, PA (B.S. Medicine, 1984)
	Hahnemann University School of Medicine – Philadelphia, PA (M.D., 1988)
Type of Science:	Cardiovascular Physics
Achievements:	Initiated the trial of preventing hypertension in patients with high blood pressure
	Awarded for her work on cardiovascular epidemiology and high blood pressure by the American Heart Association

Biography

Dr. Shawna Denise Nesbitt was born on November 10, 1963 in Aliquippa, Pennsylvania. Nesbitt attended Quigley High School in Pittsburgh, Pennsylvania. After graduating, she enrolled at Gannon University in Erie, Pennsylvania, where she graduated cum laude with her B.S. degree from the university's seven-year accelerated medicine program in 1984. Nesbitt then attended Hahnemann University School of Medicine in Philadelphia, Pennsylvania, where she earned her M.D. degree in 1988. Nesbitt completed her internship and residency in internal medicine at Allegheny General Hospital in Pittsburgh in 1991, and became a fellow in hypertension at the University of Michigan's Department of Internal Medicine in Ann Arbor, Michigan.

Nesbitt was hired by the University of Michigan Medical School, where she served as an instructor and then lecturer for the university's Department of Internal Medicine during the 1990s. Nesbitt went on to work as an investigator for various firms, performing research on African Americans with hypertension and renal disease, and also on the effects of quinapril on insulin resistant humans. In 1995, Nesbitt was hired by Merck & Company, Inc. to conduct a LIFE study on individuals with left ventricular hypertrophy. In 1996, Nesbitt worked for the American Heart Association as a co-investigator for a study on individuals with heterozygous familial hypercholesterolemia. Nesbitt also served as the national investigator for Astrazeneca Pharmaceuticals for a TROPHY study. Nesbitt initiated the trial of preventing hypertension in patients with high blood pressure; in addition, she worked as a manuscript reviewer for the American Journal of Hypertension and the Journal of Ethnicity and Disease.

Nesbitt received medical licensure in the states of Pennsylvania, Michigan, and Texas. The American Heart Association awarded her for her work on cardiovascular epidemiology and high blood pressure. Nesbitt also served as member on several boards, including the American College of Physicians, the American Heart Association, the American Society of Hypertension, the International Society of Hypertension in Blacks, the Association of Black Cardiologists and the National Medical Association.

In addition to her research activities, Nesbitt served as an assistant professor at the Department of Internal Medicine at the University of Texas at Southwestern Medical Center in Dallas, Texas.

Discussion Questions

Personal:

1. What was the most compelling thing you learned about Dr. Nesbitt?

2. Where was Dr. Nesbitt 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. Nesbitt attend high school? What do you suppose high school was like for her?

3. How old are you? In what year was Dr. Nesbitt your age? What was happening in the country that year? What was happening in the world that year? What do you suppose her life was like when she was your age?

4. What challenges do you think Dr. Nesbitt faced as a double minority (an African American woman) in the sciences? How do you think she overcame these challenges? How is your life different because of her example?

Science:

5. What do you think a cardiovascular physicist does? Would you like to be a cardiovascular physicist? Why?

6. If you were a cardiovascular physicist, what kinds of questions would you answer?

7. Dr. Nesbitt works with African Americans who have hypertension. What is hypertension? Why is this such a problem? Why does Dr. Nesbitt work with African Americans in particular? Do you know any one with hypertension? What is used to treat hypertension? What precautions can you take now to avoid this condition in the future? **(See Biography)**

8. Dr. Nesbitt also conducts research studying renal failure. What is renal failure? Why is this so serious? What are some of the causes of renal failure? How is renal failure usually detected? Are there different types of renal failure? How is renal failure treated? **(See Biography)**

9. Dr. Nesbitt conducted a study on individuals with left ventricular hypertrophy. What is ventricular hypertrophy? What distinguishes it from hyperplasia? Are there other types of hypertrophy? Is ventricular hypertrophy always a problem? What are some of the causes of ventricular hypertrophy? How is ventricular hypertrophy usually detected? How is ventricular hypertrophy treated? **(See Biography)**

10. Dr. Nesbitt conducted a LIFE study and a TROPHY study. Research these types of studies and report your findings to the class. What is the significance of these studies? How do these studies differ from other types of studies? How could these studies affect someone you know? **(See Biography)**

Experiment - Travel The Path

This lesson was adapted from educational materials developed by the Center for the Advancement of Science Education at the Museum of Science and Industry.

- Students will get to explore how blood travels through the body. Ask them: *Is there a certain pathway for blood to travel down? What do you think that pathway looks like?*
- Have the group talk about this pathway. Make sure they incorporate the heart in this pathway, since its primary function is to pump blood throughout the body.
- Tell the group that we know our bodies need oxygen to support our organs, but *where does the oxygen come from? How does it get into our bodies?* Ask the group to take a deep breath. What did they just breathe in? Oxygen.
- Tell the group that our organs make a waste called carbon dioxide (CO_2), that needs to be removed from our bodies. *How does our body remove carbon dioxide?* Ask the group to breathe in and then exhale. What did they just exhale? Carbon dioxide.
- Explain that one of our body parts is responsible for taking in oxygen and removing carbon dioxide: the lungs.
- Ask the group to think about how the lungs are incorporated into the pathway.
- Let the students know that they are going to act out how blood travels through this pathway in the body. They will be responsible for delivering oxygen and removing carbon dioxide.

Life Science

Leader Activity Guide

Place the "Heart Station" sign on the floor, preferably in the middle of the room. Then put the "Lung Station" signs on the floor almost directly above the heart, with some space between the heart and lungs. Next, place the "Organ Station" sign directly below the heart, but with some distance between the two stations. Finally, place a bucket on either side of the lung stations and one at the organ station.

Have a student stand with red poker chips at each "Lung Station," and have another student stand at the "Organ Station" with the blue poker chips. Tell the remaining students to line up at the Lung Stations. Explain to the students that the red chips represent blood cells that are filled with oxygen, and that these blood cells need to be delivered to the body. The blue chips represent blood cells that are carrying waste (Carbon Dioxide or CO_2) from the body and now need oxygen.

Tell the students that when they are told to go, they will:

- Pick up a red chip at either "Lung Station."
- Run to the "Heart Station."
- Make a loop around the room towards the "Organ Station."
- Drop off the red chip and pick up a blue chip at the "Organ Station."
- Run back to the "Heart Station."
- Then run to the "Lung Station," and drop off the blue chip in the bucket.
- Pick up a new red chip, and start the course all over again.
- After the students have a few minutes to run through the course, bring them back together for a brief discussion.

Questions to Ask

What was it like carrying and delivering blood cells?
Was it confusing to follow the pathway?
What happens if the blood cells fail to pick up CO_2?

MUSEUM OF SCIENCE AND INDUSTRY

ScienceMakers

Spotlight: Roderic Pettigrew

Full Name:	Roderic Pettigrew
Born:	March 26, 1951
Place:	Waynesboro, GA
Parents:	Edwina L. Pettigrew
	Cleveland William Pettigrew
Education:	Monroe High School – Albany, GA
	Morehouse College – Atlanta, GA (B.S. Physics, 1972)
	Rensselaer Polytechnic Institute – Troy, NY (M.S. Nuclear Science, 1974)
	Massachusetts Institute of Technology – Cambridge, MA (Ph.D. Applied Radiation Physics, 1977)
	University of Miami Medical School – Coral Gables, FL (M.D., 1979)
Type of Science:	Radiology
Achievements:	Clinical work and research on magnetic resonance imaging techniques
	Pioneering research involving four-dimensional imaging of the heart

Biography

Radiologist Dr. Roderic Pettigrew was born on March 26, 1951 in Waynesboro, Georgia to Cleveland William Pettigrew and Edwina L. Pettigrew, who encouraged his early childhood curiosity. Pettigrew attended Morehouse College in Atlanta after his junior year of high school on a full scholarship from Charles Merrill. Pettigrew received his B.S. degree *cum laude* in physics from Morehouse in 1972, and went on to attend graduate school at Rensselaer Polytechnic Institute, where earned his M.S. degree in nuclear science. Pettigrew then attended the Massachusetts Institute of Technology, where he earned his Ph.D. in applied radiation physics in 1977.

Pettigrew's postgraduate research led him to also pursue an accelerated medical degree at the University of Miami Medical School, and he obtained his M.D. degree in 1979. Pettigrew returned to Atlanta to complete his residency in internal medicine at Emory University. He then went to the University of California at San Diego for another internship in nuclear medicine, which he completed in 1983. After many years as a medical student and intern, Pettigrew began to perform his own clinical work and research on imaging techniques associated with magnetic resonance imaging (MRI) in 1985 with Picker International, the first company to patent the MRI.

Pettigrew returned to the Emory University School of Medicine in 1985 to become a Professor of Radiology and perform progressive research on MRI heart scanning. Pettigrew's MRI research has been published in numerous scholarly journals. He co-authored and edited "MRI of the Cardiovascular System," a reference anthology, in 1993.

Pettigrew held a teaching position at the Georgia Institute of Technology in 1995, eventually moving up to become the director of magnetic resonance research at Emory in 1995. In 2002, Pettigrew was chosen to be the first director of the National Institutes of Health Institute of Biomedical Imaging and Bioengineering, where he led the Institute's research and grant budget.

Pettigrew has been nationally lauded for his work in the field of radiology, including his membership in Phi Beta Kappa and his 1990 Most Distinguished Alumnus award from the University of Miami.

Discussion Questions

Personal:

1. What was the most compelling thing you learned about Dr. Pettigrew?

2. Where was Dr. Pettigrew 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. Pettigrew attend high school? What do you suppose high school was like for him?

3. How old are you? In what year was Dr. Pettigrew your age? What was happening in the country that year? What was happening in the world that year? What do you suppose his life was like when he was your age?

4. What role did Dr. Pettigrew's family play in helping him become a prominent scientist? How does your family help you? **(See JustGarciaHill biography)**

5. Dr. Pettigrew studied a wide variety of subjects during his education. How did he build his education in stages to become who he is today? What are some of your interests? How can you combine them into a meaningful career? **(See Biography)**

Science:

6. What do you think a radiologist does? Would you like to be a radiologist? Why?

7. If you were a radiologist, what kinds of questions would you study?

8. Dr. Pettigrew's early work involved research using magnetic resonance imaging. What is this more commonly known as? How does this technique work? What are the advantages of this technique over other imaging techniques? Why is this technology important? Where in the body is it most useful? When did magnetic resonance imaging first come into prominence?
(See NIBIB page and JustGarciaHill biography)

9. Dr. Pettigrew is known for his research regarding four-dimensional imaging of the heart. What is four-dimensional imaging? Find out how an image can be four-dimensional. Research how this technology works. Why do you think this technology is so useful? **(See NIBIB page)**

10. Dr. Pettigrew specializes in non-invasive cardiac imaging. Explain in medical terms what "non-invasive" means. Why is this such a drastic improvement over earlier procedures? Describe earlier methods of "seeing" inside the body. **(See NIBIB page)**

11. Dr. Pettigrew is the first director of the NIBIB. What does this stand for? Why is this organization significant? Research its mission and vision. Explain how it seeks to contribute to the health sciences. **(See NIBIB page)**

Additional Reading

NIBIB page - http://www.nibib.nih.gov/About/Directories/Pettigrew

JustGarciaHill biography – http://justgarciahill.org/index.php?option=com_content&view=article&id=98:pettigrew-roderic-i-md-phd&catid=6:biographies&directory=18

<u>Experiment - Exploring With Sound</u>

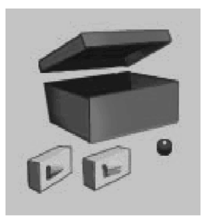
Adapted from: JASON Foundation for Education.

Objective

Use sound to figure out, or infer, the position of objects.

What You Need

- Shoe box with cover
- Tape
- Marble
- Several rectangular blocks



To Do and Observe

1. Do this experiment with a partner.

2. Tape the blocks to the inside of the bottom of the shoebox. Don't show your partner where you're taping them. Place a marble in the box. Tape the lid shut. Give the box to your partner.

3. Challenge your partner to figure out the position of the blocks by listening to the marble as it rolls inside the box.

4. Have your partner draw a map of the inside of the box. Were they right? Open the box and check. You've just created an image of something that you couldn't see.

What's Going On

Sound helps you discover the position of the blocks in the shoebox. The movements and collisions of the marble are the source of the sound. By interpreting the sounds of the marble, you can infer the position of the block.

Underwater environments are often too dark and inaccessible to permit direct visual observation. In order to "see" an underwater object, scientists use instruments that depend on energy other than reflected light. A skilled sonar operator can use the data sonar provides to infer information such as the shape and position of objects. What animals use sonar to locate objects?

In addition to sonar, doctors use sophisticated imaging techniques to "see" inside the human body without cutting it open. What are some of these techniques?

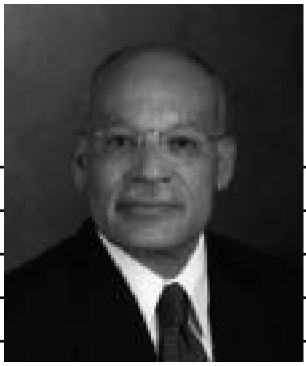
Additional Challenges

Once you've done this activity, see who can map the inside of the box the fastest. This is an excellent opportunity to discuss spatial reasoning. Try the experiment with more blocks and with less blocks. Also, try blocks on the box top and sides as well as the bottom. Challenge your partner to create a 3-dimensional map of the box.

See the original experiment online at: http://www.tryscience.org/experiments/experiments_sound_athome.html

ScienceMakers

Spotlight: Cecil Pickett



Full Name:	Cecil Pickett
Born:	October 5, 1945
Place:	Canton, IL
Parents:	Florence Pickett
	Charles Pickett
Spouse:	Shirley Pickett
Education:	Canton High School - Canton, IL (1967)
	University of California, Berkley - Berkeley, CA (B.S. Biology, 1976)
	University of California, Los Angeles - Los Angeles, CA (Ph.D. Biology, 1976)
Type of Science:	Biology, Pharmacology
Achievements:	Led discovery efforts for important and pioneering drugs for asthma, aarthritis and high cholesterol including Sinulair and Vioxx
	Named one of the 50 Most Powerful Black Executives by Fortune Magazine (2002)

Biography

Pharmaceutical researcher Cecil Pickett was born on October 5, 1945, in Canton, Illinois, to Charles Pickett, a farmer, and Florence Pickett, a homemaker. In high school, Pickett's favorite subjects were math, chemistry, and biology, which led him to major in biology at the University of California, Berkeley, where he received his B.S. degree in 1971. After completing his undergraduate studies, Pickett took on a teaching fellowship at the University of California Los Angeles, where he was a student of Dr. Joseph Cascarano and earned his Ph.D. in biology in 1976.

Upon graduating with his doctorate, Pickett became a visiting lecturer in biology at the Howard University College of Medicine before joining the staff of Merck Research Laboratories as head of research in 1978. At Merck, Pickett led the discovery efforts for important and pioneering drugs for asthma, arthritis, and high cholesterol, including Singulair and Vioxx. With Merck, Pickett transferred to Montreal, Canada, in 1988, where he headed drug discovery at the Merck Frosst Center for Therapeutic Research. In 1993, Pickett was hired to be the Executive Vice President of Discovery Research at Schering-Plough Research Institute, where he continued his reputation for innovative research and expanded the company's drug discovery program, which produced AIDS and anti-cancer pharmaceuticals. Pickett was named president of Schering-Plough in 2002, which placed him in charge of research and development for the entire company. In 2006 Pickett moved to Biogen Idec Inc. to become its President of Research and Development.

In addition to his professional career, Pickett taught at the New Jersey School of Medicine and Dentistry, and at McGill University in Montreal. Pickett's research has been widely published in prestigious journals such as the Journal of Biological Chemistry. Pickett has been recognized internationally for his work and was named one of the 50 Most Powerful Black Executives by Fortune Magazine in 2002. Pickett and his wife, Shirley, raised two daughters.

Discussion Questions

Personal:

1. What was the most compelling thing you learned about Dr. Pickett?

2. Where was Dr. Pickett 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. Pickett attend high school? What do you suppose high school was like for him?

3. How old are you? In what year was Dr. Pickett your age? What was happening in the country that year? What was happening in the world that year? What do you suppose his life was like when he was your age?

4. What were Dr. Pickett's favorite subjects in school? Why did he feel this way? What are your favorite subjects? Why do you enjoy them? What are your least favorite subjects? Why? What classes challenge you? Why? Do you think you will pursue a future career in one of these subjects? What can your teachers do to make classes more challenging and attention-grabbing? **(See answers.com biography)**

5. What extracurricular activities did Dr. Pickett participate in? What extracurricular activities do you participate in? What is your favorite? **(See answers.com biography)**

6. In 2002, Dr. Pickett was named on of the 50 Most Powerful Black Executives in America for Fortune magazine. Why do you think Dr. Pickett was seen as "powerful?" What do you think defines "power?" How can a knowledge of science give you power? How does education contribute to success and power? **(See answer.com biography)**

Science:

7. What do you think a pharmacologist does? Would you like to be a pharmacologist? Why?

8. If you were a pharmacologist, what kinds of questions would you study?

9. After Dr. Pickett left UCLA, he followed a path that was different from most biologists. What was it? Who were his mentors during this period? What advances did Dr. Pickett assist with? Have you ever followed a path that was different? Explain the situation. What was the expected path? What did you do? Look up the Robert Frost poem "Walking Through the Woods on a Snowy Evening." How could this apply to Dr. Pickett? How could it apply to you? What is a different path you could follow in the future? **(See answers.com biography)**

10. Dr. Pickett continued his research and built up a research team. What major discoveries did his group find? How do you suppose scientists work in teams? Have you ever been on a team? What about a non-sports team? What are the benefits to working on a team? What are the challenges? **(See answers.com biography)**

11. Dr. Pickett was in charge of a drug discovery program. Explain how a drug discovery program works, paying particular attention to clearly explaining any scientific concepts. How long, on average, does it take to develop a new drug? Why does the process take so long? **(See answers.com biography)**

12. Throughout his career, Dr. Pickett split his time between administrative duties, research, and academia. What is the difference between these three fields? What are specific skills in each of these fields? How do they work together? Is it important to be involved in all three? Why? Why not? Which of these three fields do you feel you would be most successful in? Why? Identify specific skills or interests of yours that typify one of these three fields. **(See answers.com biography)**

13. Dr. Pickett advocated four strategies for successful research and development at the drug company where he was the president. What are these four strategies? Do you believe these four strategies are effective? If so, why do you feel they are effective? If not, what would you do instead? Can these strategies be applied anywhere else? Where? What other strategies would you promote if you were the president of a drug discovery company? **(See answers.com biography)**

Additional Reading
Answers.com biography - http://www.answers.com/topic/cecil-pickett

Experiment - Gas Exchange

This experiment was taken from Science And Life Issues, published by Lab-Aids, Inc.

How much carbon dioxide is in your exhaled breath?

Materials

- For each group of four students
  - 1 dropper bottle of bromthymol blue (BTB) indicator
  - 5 plastic cups
  - Supply of water
- For each pair of students
  - 1 dropper bottle of 0.05 M sodium hydroxide
  - 1 dropper
  - 1 30-mL graduated cup
- For each student
  - 1 1-gallon plastic bag
  - 1 straw
  - 1 stir stick
  - Access to a wall clock or watch with a second hand

Safety

In this activity, you will be blowing through a straw into chemicals. Do not inhale through the straw! Breathe in through your nose and exhale through your mouth. If you accidentally swallow liquid, rinse your mouth thoroughly and drink plenty of water. Be sure to tell your teacher.

Procedure

Part One: Using BTB to Test for Carbon Dioxide

1. Work with your partner to add 5 mL water to each of the five large cups (A-E). Use the 30-mL graduated cup to measure the water.
2. Add 2 drops of BTB to each cup and stir
3. Create a data table to record the initial and final colors of the solutions in each cup. Record the initial colors now. Cup A will provide a control.
4. Use your dropper to bubble air into Cup B. Place the dropper into the solution and press the air out of the bulb. Before releasing the bulb, remove the tip from the solution. This will prevent uptake of solution into the dropper. (If you accidentally get solution into the dropper, simply squirt it back into Cup B.) Repeat this for 15 seconds.
5. Record the final color of the solution in Cup B in your data table.
6. Add 3 drops of 0.05 M sodium hydroxide to Cup C. Record the final color in your data table.
7. Unwrap your straw and place one end in Cup D. Take a deep breath, and then gently blow through the straw for 15 seconds. (Remember not to inhale through the straw!) Record the final color of the solution in Cup D in your data table.
8. Have your partner blow through a clean straw into Cup E for 15 seconds. (Remember not to inhale through the straw!) Record the final color in your data table.
9. Add 3 drops of sodium hydroxide to Cups D and E. In your science notebook, record any changes that you observe.
10. Work with your partner to complete Analysis Questions 1 and 2.

Part Two: Using BTB to Measure Carbon Dioxide in Exhaled Breath

11. Work with another pair of students to set up a control:
    a. Measure 10 mL of water using the 30-mL graduated cup.
    b. Add 3 drops of BTB to the graduated cup and stir.
    c. Pour the BTB solution into a large plastic cup. This solution will be the control for every member of your group.
12. Have each person in your group set up his or her own bag of BTB solution:
    a. Measure 10 mL of water using the 30-mL graduated cup.
    b. Add 3 drops of BTB to the graduated cup and stir.
    c. Pour the BTB solution into your own 1-gallon plastic bag.
13. Remove the air from your plastic bag by slowly flattening it. Be careful not to spill any of the BTB solution out of the bag. While keeping the air out of the bag, place a straw in the mouth of the bag. Make an air-tight seal by holding the mouth of the bag tightly around the straw.
14. Be sure you are sitting down. Then fill the bag with air from your lungs by blowing through the straw until the bag is fully inflated. When you finish blowing, pull out the straw. As you pull out the straw, squeeze the bag tightly shut so no air escapes.
15. Holding the bag closed, shake the bag vigorously 25 times.
16. Pour the BTB solution from the bag into a clean, empty plastic cup.
17. How much carbon dioxide is in your exhaled breath? You can find out by counting how many drops of sodium hydroxide are needed to make your BTB solution the same color as the control:

a. Add 1 drop of sodium hydroxide to your plastic cup.

b. Gently stir the solution and wait at least 10 seconds.

c. Record in your science notebook that you added 1 drop.

d. Compare the color of your solution to the control. Is it the same color as the control for at least 30 seconds?

If your answer is no, repeat Steps 17a-d. Be sure to keep track of the total number of drops!

If your answer is yes, go on to Step 18.

18. In your science notebook, record the total number of drops it took to change your solution back to the same color as the control. Then record your total on the class data table.

19. Draw a bar graph with the class results. Remember to title your graph and label the axes!

Extension 1

Do you exhale more carbon dioxide after you hold your breath? Find out by modifying and repeating Part Two of the Procedure.

Analysis

Part One: Using BTB to Test for Carbon Dioxide

1. What was the purpose of the solution in Cup A?

2. Which of the solutions in Part One contained carbon dioxide?

   a. Support your answer with evidence from your experimental results.

   b. What does this tell you about the exhaled breath of human beings?

Part Two: Using BTB to Measure Carbon Dioxide in Exhaled Breath

3. Review the class data table. What was the range of carbon dioxide in exhaled breath (as measured by drops of sodium hydroxide)?

4. Considering all the oxygen that has to get into your blood and all the carbon dioxide that has to escape from your blood, why do you think the inside of the lung is structured the way it is?

5. Were the data collected in Part One qualitative or quantitative? Explain. Were the data collected in Part Two qualitative or quantitative? Explain.

6. What are some of the important structures in the respiratory system? Explain how gases are exchanged within the respiratory system.

Extension 2

How do you think your body gets more oxygen when you exercise? Do you breathe faster (take more breaths per minute)? Or do you absorb more oxygen from the air with each breath? Use what you learned in this activity to develop an experiment to test your hypothesis.

SEPUP. (2005). *Science and Life Issues*. Lawrence Hall of Science, University of California at Berkeley. Published by Lab-Aids, Inc., Ronkonkoma, NY.

ScienceMakers

Spotlight: Welton Taylor

Full Name:	Welton Ivan Taylor
Born:	November 12, 1919
Place:	Birmingham, AL
Parents:	Cora Lee Brewer
	Federick Enlen Taylor
Spouse:	Jayne Taylor
Education:	DuSable High School - Chicago, IL (1937)
	University of Illinois - Urbana-Champaign, IL (B.A. Bacteriology, 1941)
	University of Illinois - Urbana-Champaign, IL (M.A. Bacteriology, 1947)
	University of Illinois - Urbana-Champaign, IL (Ph.D. Bacteriology, 1948)
Type of Science:	Bacteriology
Achievements:	Discovered that common antiviotics could treat gas gangrene and tetnus
	CDC in Atlanta named a bacterium, *Enterobacter taylorae*, in honor of him and a colleague

Favorites:

Color:	Red
Food:	Gumbo
Quote:	“Don’t sweat the small stuff. It’s all the small stuff.”
Time of Year:	Early Summer
Vacation Spot:	East Africa

Biography

A descendant of President Zachary Taylor, world-renowned scientist and educator Welton Ivan Taylor was born in Alabama in 1919. Shortly after his birth, Taylor’s family moved to Chicago, where his performance at DuSable High School inspired local African Americans to sponsor his undergraduate education in bacteriology at the University of Illinois. Taylor served in the first all-African American division to enter into combat in World War II; the G.I. Bill enabled him to return to his alma mater to earn his M.A. and Ph.D. degrees in bacteriology.

Taylor was appointed bacteriology instructor at the University of Illinois in 1948; he promptly discovered that common antibiotics could treat gas gangrene and tetanus, dangerous conditions that affected war victims. In 1954, the Chicago meatpacking firm Swift & Company recruited Taylor to tackle an outbreak of salmonella poisoning in baby food; he standardized his successful approach to this problem and exported it to labs world-wide. In subsequent years Taylor helped Chicago-area hospitals, healthcare organizations, and government agencies address an array of health problems. On a sojourn abroad from 1961 to 1962, Taylor collaborated with prestigious British and French scientists. Upon returning to the University of Illinois, Taylor developed methods of bacteria detection that the Food and Drug Administration relies on today. In 1985, the Centers for Disease Control in Atlanta named a bacterium, *Enterobacter taylorae*, in honor of Taylor and a British colleague.

Taylor received numerous awards and grants, and his prodigious list of publications has been a continual source of influence for scientists. In 1960, Taylor founded the Chicago chapter of the Episcopal Society for Cultural and Racial Unity, in which he remained very active. Taylor also welcomed opportunities to lecture on recent health issues that concerned him, such as increases in STDs and HIV. Taylor and his wife, Jayne, whom he married in 1945, raised two daughters, Karyn and Shelley.

Discussion Questions

Personal:

1. What did you like best about listening to Dr. Taylor?

2. What do you think Dr. Taylor's favorite quote means? What does this tell you about him?

3. 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 suppose high school was like for him?

4. How old are you? In what year was Dr. Taylor your age? What was happening in the country that year? What was happening in the world that year? What do you suppose his life was like when he was your age?

5. Dr. Taylor's family had an unusual encounter with the Ku Klux Klan. What happened? What did this mean for his family? This was similar to an event called the Great Migration. Research this event and explain how it drastically shifted the cultural makeup of the United States in the 20th Century. What were some of the short-term effects? What were the long-term effects? Did this event impact your family? How? Report your findings to the class. **(See Clip #1)**

6. What did Dr. Taylor's father say about getting a job? How does this attitude play into your education? What can you do to prepare yourself for a career? What are some things you can do to help determine what career you want? Name some individuals that can help you identify your skills and talents. What does Dr. Taylor say about cultivating skills? How did this help him in his career? **(See Clip #2)**

Science:

7. What do you think a bacteriologist does? Would you like to be a bacteriologist? Why?

8. If you were a bacteriologist, what kinds of questions would you study?

9. Dr. Taylor says that he was inspired by Louis Pasteur. Who was Louis Pasteur? What did that make him want to become? Have you ever heard of a scientist described as a detective? Why is this a fitting description? Can you think of any famous scientific detectives? What kinds of mysteries do they solve? **(See Clip #3)**

10. What was Dr. Taylor's professional nickname? How did he get this nickname? How does a bacteriologist perform his or her daily job? What are the risks inherent in studying bacteria and diseases? What are the benefits? Is there anything you like that some people think is "gross"? What is it? Why do you like it? Could it lead to a career? **(See Clip #4)**

11. Dr. Taylor also developed new procedures for immunology. What were some of those procedures? Why is this so important? **(See Clip #4)**

12. Dr. Taylor published a tremendous amount of research in a short time. What was the average? How far above this was Dr. Taylor? Research and explain the peer-review nature of scientific advancement. Why is this so critical? How would a peer-review system work in the classroom? **(See Clip #4)** [Teacher's note: This might be an excellent exercise to have students peer-review their next assignment and talk about grading criteria and standards as tools in science.]

13. Dr. Taylor talks about a particular project that he undertook for Swift and Company. Why did they need a bacteriologist? Describe their problem in detail. Dr. Taylor's role was to solve a mystery.What was the mystery? What was his final solution? Explain how this solution might have benefited similar companies. What other types of mysteries do you think a bacteriologist is called upon to solve? **(See Clip #5)**

Additional Resources
Film: "The Story of Louis Pasteur" starring Paul Muni, 1936.

Louis Pasteur: http://en.wikipedia.org/wiki/Louis_Pasteur

Experiment - You Make Me Sick!

This lesson was adapted from educational materials developed by the Center for the Advancement of Science Education at the Museum of Science and Industry.

Objective

To understand what viruses are, how they make us sick, and how we can prevent becoming ill from viruses.

Materials

- 25 small eyedroppers (or enough for each student)
- 25 orange capped test tubes
    - 23 filled with water
    - 2 filled with vinegar (black dots on the bottom)
- 25 blue capped test tubes
    - 12 filled with water
    - 13 filled with water/baking soda solution
- 5 white capped test tubes filled with vinegar
- 2 – 4 large eyedroppers
- Glo germ powder

- Glo Germ lotion
- Black light
- Soap
- Paper towels
- Kleenex
- Spray bottles
- Clorox wipes

Set Up

- Set up 25 spaces
  - Each space receives an eyedropper, an orange topped test tube, and a purple topped test tube
- Depending on the size of the class, pass out 1-3 orange test tubes with a black dot on the bottom
- At each table, two of the blue topped test tubes should have black dots on the bottom, two should not
  - At each space, sprinkle a little germ glo powder and spread it around
- Make sure there is soap and paper towel by each sink
- Put out Virus Sign
- Place on front counter:
  - Indicator with large eye dropper(s)
  - Water spray bottle and tissues
  - Glow germ lotion and black light
  - Virus test tubes and large eyedroppers
  - Clorox wipes

Life Science

What are viruses?

- Have you ever had the flu? Have you ever had a cold? The flu and colds are caused by viruses.
- Viruses are a type of microbe. Microbe is the scientific word for germ
- Microbes (microorganisms) are so small we need a microscope to see them . . .
  - They include bacteria, viruses, archaea (bacteria like), fungi, and protists (primitive algae-like amoebas). We are going to talk about the microbes bacteria and viruses
- Viruses are so small that we can pass them to other people and not even know it!
  - If one cell in our body was the size of a baseball stadium, how big would a virus be? The size of a baseball!
  - Viruses take over our cellular machinery and stop our cells from doing their normal jobs. Instead, our \ cells make copies of the virus until the whole cell is filled with viruses. The cell then bursts open and more viruses spread to the rest of our body (like a stadium of baseballs exploding!)
  - Made in plant/animal cells
  - Simple particles, a couple genes inside protein shells. So small we need a microscope to see them
  - Infect host cell (use the host's metabolic machinery) to grow and reproduce
  - Hijack cell's nucleus (command center) and instruct cells to make copies of the virus instead of what the cell normally does
  - Cell makes so many copies that it bursts open and new viral particles are released
  - We get sick because the virus stops our cells from normally functioning (which keeps us healthy)
  - There are no naturally good viruses

<u>Spread a virus</u>

- When you shake hands, you exchange microscopic particles including any viruses that might have been on your hands!

- Note: most viruses do not live long outside of a host. Most are transported directly from host to host.

- Instead of exchanging microscopic particles (which may include viruses) by shaking hands, we are going to use test tubes and eyedroppers. Divide into groups of four and exchange fluid.
  - Give each person you meet a couple drops from your test tube and have them give you a couple drops from theirs.
- What I didn't tell you is that _______ had the flu and he/she might have spread it!

- What we are going to do: a test to see who is sick with the pretend flu.
  - I am going to add a drop of pretend virus/flu detector to each test tube. If your test tube is green, you are ok and healthy. If your test tube is red, you are not ok and have the flu.
- Test patient zero first, then the rest
- NOTE: do not tell the class that the flu test is an acid/base indicator. That is not the point of the whole experiment
- We can pass viruses from person to person without even knowing it and then we get sick! It is no fun to be sick all of the time!
  - Also, some viruses can live on surfaces we touch, what can we do?
- NOTE: Once we have a virus, there isn't much we can do. Antibiotics work for bacterial infections, not viruses.

1st Line of Defense

- PREVENT SPREAD (Kleenex demo)
  - Viruses can travel through sneezes.
  - Tell the class that you have the flu, and "sneeze" on them with the spray bottle. Tell them my fake flu virus particles are now all over them and they might get sick too.
  - Fastest sneeze recorded was 102 miles per hour, so the audience might get sick too.
  - What can we do? Use a Kleenex! Repeat using Kleenex.
- Note: If you do not have a Kleenex, sneeze into your elbow – we don't shake elbows!
- PROPER HYGIENE (hand washing demo)
  - CDC: "Handwashing is the single most important means of preventing the spread of infection."
- Have several people put on fake virus lotion.
- Instruct one not to wash.
- Instruct one to wash with water.
- Instruct one to wash with soap and water.
- Instruct one to wash with soap, warm water, for a while (20 seconds . . . so "Happy Birthday" twice).
  - NOTE: depending on your audience, either have them sing "Happy Birthday" or tell them gross stories about people not washing their hands)
- Check whose hands are cleanest.
- So wash hands with soap and warm water for 20 seconds (antibacterial soap is not necessary).
  - Tell the class that regular soap is good and that antibacterial soap is bad. Why?
- It creates superbugs (kills the weak bacteria and leaves the strong bacteria).
- It doesn't kill viruses.

2nd Line of Defense

- Vaccine experiment (explain vaccines after you do the experiment)
  - Give everyone a test tube.
  - This time I have the flu and I am going to give everyone my virus (give each a squirt of vinegar).
  - Did everyone get the flu from me?
  - We are going to test again, red = sick, green = healthy.

- Why didn't some of you get sick?
- You had vaccines!

- What are vaccines?
- IMMUNIZATIONS/VACCINES
  - We have immune systems. When our immune system encounters something foreign (like a virus) it makes an antibody that is specific to the foreign particle. These antibodies fight and kill the virus.
  - But it takes time to make antibodies, so we get vaccinations.
- A vaccine is an injection of a weakened form of a virus. Our body makes antibodies and can easily fight off the virus.
- Our body then keeps a few of the antibodies around.
- When we encounter the virus (full strength) later in life after having the vaccine, our bodies can quickly copy the antibodies and fight off the virus.

MUSEUM OF SCIENCE AND INDUSTRY

Welton Taylor - Video Clip Transcription

Clip 1 - Family Moves to Chicago: My father was the first African American to have a business on Main Street downtown of Birmingham, Alabama. Taylor the Tailor. He had a tailor shop. My mother did the seamstress work. He was a tailor, trained at Talladega [College]. And he had a shop downtown. Well, my mother and my ninety-five year old cousin, who I went to see yesterday, who was twelve years old at the time, came out of the shop and were stopped at the curb because the Ku Klux Klan was walking down the street, led by three men on white horses at the front of the column. And one of the horses stumbled, and the rider was thrown. And his cap came off. And my mother looked at him and said, "I know you." And I have this on tape from my cousin. She says, "I wish you had broken your dat-blamed neck." That was not the best thing to say under the circumstances, in a crowd where a lot of people heard it, especially since the man who fell off the horse, leading the Ku Klux Klan was the banker who owned the mortgage on our house and the shop. You wouldn't have said that that was politically correct under any kind of conditions. But that's the way it worked out. Well, it wasn't long after that--I don't know the time span, but it was shortly after that, that three Klan riders came up to our back door and rapped on the door with a riding crop. My mother opened the door, and they said, "You have two weeks to get out of Alabama or be a widow." I was four months old, and my mother did not desire widowhood at that time and at that place. Two weeks to the day, we were on the Illinois Central [Railroad] headed north to Chicago.

Clip 2 - Father's Advice: "Times change, things change and people change." He says, "You fix yourself to do the job that you want to do, and the job will find you." And boy, that has been my credo. It has happened a dozens of times since then. The job will find you. So that's where I've gotten, the job has been finding me. When I went overseas for WHO [World Health Organization] and lived in Europe, and six months in France and six months in England, at the Pasteur Institute in France, working research with them, and in England, working with research at the Collindale Central Public Health Laboratory of England. I was there by request because the chief microbiologist of the World Health Organization was interested in the fact that nobody seemed to be paying any attention to salmonella problems in the United States. And they were very big in Europe, always have been. And they kill a lot of people in Europe. Here, where the food is theoretically fit to eat and the water is fit to drink. Salmonellosis is just an upset stomach, two or three days of diarrhea. You don't call the doctor. You get over it. You say, it must have been something I ate and let it go at that. But the refugee problem in Europe, salmonella hits those refugee camps. It lays people out for the dead wagon wall-to-wall. And so they wanted, since I had been publishing on that, and I was at Swift [and Company] at the time, they wanted to know about it. So they called me and asked me if I accepted, would accept a grant from the National Institutes of Health [NIH] and come over and work with them. So my father was right. The job will find you.

Clip 3 - Inspired by Louis Pasteur: He attacked problems in fields that didn't even exist. He was a chemist. So, anyway, everything I learned about Louis Pasteur, and I said, that's for me. I want to be a microbiological detective, solve problems.

Clip 4 - Work at University of Illinois:
No sooner than I got into it [position in microbiology at the University of Illinois at Urbana-Champaign], things hit the fan my first day on the job. And he said, Taylor, go down to the hospital and get a patient down there with gas gangrene. And you've worked with botulism, and that's all in the same family, *Clostridia*. Go down there, and see what you can do. I went down there, and I watched them operate on this young guy. He had been on a motorcycle accident and threw him over the handlebars and slid along in the gutter like that. And [his] wrists were all lacerated, and they were cleaning it all up. And they found that he had crepitation gas in there, it means gas gangrene had set in. And they're trying to save his hand and his arm. And so they're cleaning out the wound, and I stand there looking at them, waiting for to give me a specimen. And finally the nurse pops up and says--after it's all cleaned out, said, "Don't you think we should give microbiology a specimen?" The doctor says, "Oh, yes." And he takes a sterile swab and dips it in a nice, clean wound that's all cleaned out and gives me the swab. And my reputation was made from that moment on. I said, "I don't want the soup. I want the meat." And I dived down into the wastebasket and got one of those orange gauze pads with all the pus and corruption on it. And when I called back the next day and told them that not only did he have gas gangrene, he also had tetanus. And I said, "Look up his record and see if he's a veteran, cause if he's a veteran like me, he's been inoculated against tetanus. And that's why he's not showing the symptoms of tetanus. He's only showing gas gangrene, which he has not been inoculated for…" So as of that day, I got a nickname, Blood and Guts Taylor.

Well, it was all uphill from then--or I should say all downhill. I published at the rate of five papers a year. If nobody else got money for animals or anything else that I needed, I got it first. The department wasn't publishing five papers a year. I was publishing five papers a year by myself. I published some 20 or 30 papers with the university in the period of the next five years. And I worked out all the details on preventing gas gangrene, and now, I would say anthrax and tetanus, the wound organisms that kill, and wound botulism. And I worked at how to do it, what to do it with, and not to have to give people tetanus shots, which had antitoxin in it because people were dying of anaphylactic shock because they had had horse serum antitoxin somewhere else in their life. If they had ever had it before, you can't ever give it to them again. If they had it as children for diphtheria and you gave it to them for a wound to prevent tetanus, they died, within two or three minutes…I remember a case where the doctor was gonna do a boy that stepped on a pitchfork, farmer's kid. And it ran through his foot. They pulled the pitchfork out and sent him to the doctor. And the doctor said, "Have you ever had any other inoculations?" The kid didn't know. He said, "Well, we'll find out," gave him a little inoculation in the skin to see if there was a reaction to it. There was no reaction. He said, "Well, I'll be on the safe side anyway." I will put the, what they call atropine now; it had a different name then, to restart the heart. "I will put that syringe here full, and I'll take this one and I'll give you your shot." And he gave him a shot of tetanus antitoxin. And he pulled out the needle, and the kid was dead. Adrenaline, it's now atropine, but it was adrenaline in those days. And his adrenaline didn't do any good. The kid was dead. So that's how fast the reaction is when you go into anaphylactic shock.

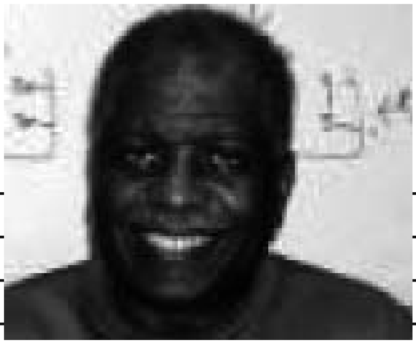
Clip 5 - Helping Swift and Company: When I found out that they were selling their salmonella, and, in livers, the way they were being processed. And every liver was contaminated with salmonella…So they said, "Taylor, go up there and find out why the livers are contaminated." And I said, "I can tell you without leaving my seat, but I said, I'll get a company car, and my kit." And I'll go up to South St. Paul, which was the largest meat packing plant in Swift and Company then. They had 240 of them, and that was the biggest. And that's where those livers were shipped from. Went up there and found that--I sampled the liver, as it came out of the cow, when they did the ventral cut on the cow and opened it up, and they took out the organs, then they have three round tubes that go down to the next floor. See, in the food industry, the cheapest form of energy is gravity. So you dump something in a hole in the floor and it slides down to the next floor. Then they take what they want off of it and dump the remains in another hole in the floor and it goes down to the next floor. By the time they get down to the basement, there's nothing left but the hides. So when they take the livers out, there was nothing wrong with the livers. Cattle don't normally have salmonellosis. Pigs, poultry [do]. Cattle don't. I tag the liver and the liver is clean as a baby's bottom. It goes down that slide to the next floor and comes out on a long table, a 20-foot long table, five feet wide. Guys working on each side, taking apart what's called the tracheal tree. It has the trachea, the lungs, the liver, the spleen, the gall bladder, etc. all attached. At the bottom of the slide, I sample the same liver that I just put my red tag and my name on. Then I dash around and come down the steps and get over there. When it comes down there, they're holding it out for me cause it's red tagged. I sample it. Every one of them had salmonella on them. Then what do they do with them? They have big bathtubs which hold maybe 600 pounds of livers. And they pull them off. They inspect them, stamp them with the government approved on it and drop them in this bathtub. And it fills up, and as it fills up, it squeezes, the weight squeezes the blood out of the liver, and by the time you get up to the top, the whole thing is swimming in blood, four inches of blood on top of the thing. Then it is taken over to the elevator and taken down to the basement to the cold room. And they have vertical, eight-foot-high racks with every foot and a half or so [there are] hooks on it. And they take them out of there and hang it on a hook, hang it on a hook, hang it on a hook. And then the next row of hooks and the next row of hooks, and the next row of hooks. Each one is dripping blood from the top and down onto the second layer. Then the two bloods down to the third layer, etc. So if you didn't have a hundred percent [contaminated], now you have a hundred percent of them contaminated.

Life Science

I said, "Your system has got to stop." [And they said], "Where are we getting the contaminate on the slides? We wash those slides down every couple of hours with Clorox solution.] I said, "Okay. Plant manager," I said, "I'm gonna have dinner, and I said about, about 8, 8:30 or 9:00 o'clock tonight, meet me at the plant with flashlights. And be sure to tell the guard so we won't get shot while we're trying to get into the plant, okay?" I met him. We walked in. I said, "Don't turn on the lights." And we just hit the flashlight beams around and we hit the lights. The eyes of rats. I says, "The rats eat the little snippets of flesh that are snipped off as a liver goes over the joints in the tube--they're open sided, they're half, halfway, the little snippets of flesh taken off of the livers as they slide over. And what's left there, the rats are climbing up on those slides at night and eating that liver. And they're depositing their thank you cards after they've had their meal. And so as long as you've got rats in the plants, you're always going to have that." And I said, "If you don't have rats, there'll probably be something else that will go around those slides later on in the day that do have salmonella, and they'll be contaminated anyway." So, I solved the problem [in his work at Swift & Company]: I devised an A-frame with the hooks on it, so that when you took the liver out of the cow on the top shelf, you put it right then and there on the A-frames, let the government inspectors inspect those livers hanging on the A-frame, and stamp them, and then put the A-frame on the elevator and take them down to the basement to the cold room, and push them up, and stack them up against the wall overnight. And then the morning, they were packed. No salmonella problem. As clean as they could be, right out of the cow.

ScienceMakers

Spotlight: John Watson



Full Name:	John A. Watson
Born:	May 21, 1940
Place:	Chicago, IL
Parents:	Catherine P. Watson
	Hosea Watson
Spouse:	Valerie M. Watson
Education:	Parker High School (now Paul Roberson) - Chicago, IL (1957)
	Illinois Institute of Technology - Chicago, IL (B.S. Biology/Biochemisry, 1964)
	University of Illinois at Chicago - Chicago, IL (Ph.D. Biochemistry, 1967)
Type of Science:	Biochemistry
Achievements:	Founding member of the Coalition for the Advancement of Blacks in Biomedical Sciences
	AAAS Lifetime Mentor Award

Biography

Dr. John A. Watson was born on May 21, 1940 in Chicago, Illinois and attended the Illinois Institute of Technology, where in 1964 he attained his B.S. degree in biology with a focus in biochemistry. He remained local for his doctoral studies and pursued his Ph.D. in biochemistry at the University of Illinois at Chicago, which he received in 1967. After completing his doctorate, Watson was a United States Public Health Service postdoctoral fellow at Brandeis University in Waltham, Massachusetts, between 1967 and 1969, after which he received an assistant professorship in the Biochemistry and Biophysics Departments at the University of California, San Francisco, the institution where he would serve in various capacities for the next four decades. In 1969, Watson was the Associate Dean for Student Affairs in the University's School of Medicine, and in 1973, he was named the Associate Dean for Admissions. He resumed teaching in the Biochemistry and Biophysics Departments from 1976 to 1984 and became a full tenured professor in 1984. Watson received the honor of Professor of Biochemistry Emeritus from the University of California in 2001.

Dr. Watson is a widely awarded educator and scientist, having received numerous fellowships including a National Science Foundation Undergraduate Summer Research Fellowship in 1963 while at Illinois Institute of Technology. In 1978 he received the UCSF's Chancellor's Award for Public Service and the Martin Luther King, Jr. Faculty Award in 1990. In 1985, the National Organization for the Professional Advancement of Black Chemists and Chemical Engineers recognized Watson with its Outstanding Teacher Award. Watson was also an American Heart Association Established Investigator between 1980 and 1985, and in 1994 the American Association for the Advancement of Science honored Watson with a Lifetime Mentor Award.

Watson holds memberships in numerous renowned professional societies, including the American Association of Oil Chemists, the National Institute of Science and the American Heart Association (Arteriosclerosis Fellow). He was also a founding member of the Coalition for the Advancement of Blacks in Biomedical Sciences. Watson has a long history of public service as well as service to the University of California, on many committees focused on not only science and minority inclusion in the sciences, but also student admissions, student life and international education issues. He has been a contributor and ad hoc reviewer for several journals including the Journal of Biological Chemistry and the Journal of Lipid Research. Watson and his wife, Valerie, raised four children.

Discussion Questions

Personal:

1. What was the most compelling thing you learned about Dr. Watson?

2. Where was Dr. Watson 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. Watson attend high school? What do you suppose high school was like for him?

3. How old are you? In what year was Dr. Watson your age? What was happening in the country that year? What was happening in the world that year? What do you suppose his life was like when he was your age?

4. Dr. Watson spent the majority of his career at the University of California, San Francisco. While many scientists move from institution to institution, Dr. Watson chose to remain in one place. Why do you think this was? What are the advantages and disadvantages of such a strategy? Do you want to live in a new place every couple of years, or would you like to stay in the same place for many years? How can this information assist you in determining your career? **(See Biography)**

5. Dr. Watson was a founding member of the Coalition for the Advancement of Blacks in Biomedical Sciences. Why do you think Dr. Watson helped form this organization? Research the organization. How has it benefited the scientific community since its formation? What are other organizations like this one? What service do they provide? Why are they necessary? What change do you think needs to be made in your school or community? What kind of an organization would you form to make these changes happen? **(See Biography)**

6. Dr. Watson has been recognized as an outstanding mentor. What is a mentor? Who inspires you? What is it about that person that you admire? How can the lessons you learn from that person help you in your career? What's the difference between a role model and a mentor? Which would you rather have? How could you seek out a role model or mentor? **(See Biography)**

Science:

7. What do you think a biochemist does? Would you like to be a biochemist? Why?

8. If you were a biochemist, what kinds of questions would you study?

9. Dr. Watson works with lipids. Lipids are a broad group of naturally occurring molecules. What does this group contain? What lipids have you heard of? Lipids can be harmful or helpful to the human body. Research some lipids and explain how they harm or help the body. **(See Science aids: Lipids)**

10. Dr. Watson has been recognized by the American Heart Association for his work with arteriosclerosis. What is arteriosclerosis? Why is this so serious? What are some of the causes of arteriosclerosis? How are riosclerosis usually detected? Are there different types of arteriosclerosis? How is arteriosclerosis treated? **(See Biography)**

Additional Reading
Science aids: Lipids - http://scienceaid.co.uk/biology/biochemistry/lipids.html

Experiment - Blood Typing

This experiment was developed by the Center of Science and Industry, Columbus, OH.

Description

Participants will distinguish between the four major blood types: A, B, AB, and O, using chemical reactions.

Concepts

Human blood can be divided into four major types: A, B, AB, and O.

Materials:

- Per Participant:
    - Creamer
    - Vinegar
    - Stir Sticks/Toothpicks
    - Typing late P
    - (5) Pipettes
    - 5) Via(s
    - (Red, Blue, and Yellow) Food Coloring

Instructions:

Provide some background information regarding human blood and the importance of blood typing, particularly its significance in surgical procedures.

James Blundell accomplished the first successful human blood transfusion in 1818. In 1900, Karl Lanstreimer observed that the blood of one individual, when mixed with the blood of another, might cause hemolysis, the visible clumping of red cells. This observation resulted in the establishment of blood typing: the distinction of four blood groups: A, B, AB, and O.

These different blood types are caused by the presence of a chemical marker-an antigen-on the surface of the type-A and type-B red blood cells. When mixed with the wrong blood type, antibodies that cause the cells to clump pick up these antigens. Someone with type-AB blood can receive any type blood with no ill effects, while people with type-O blood can only take their own type. People with type-A blood can receive A or O, and people with type-B blood can take B or O. This makes type-O blood the universal donor. Blood donors and recipients must be typed and matched very carefully before transfusions are given.

Glossary

Agglutination - the clumping together of blood cells in response to a specific antibody.

Antigen - any substance that will trigger an immune response by a host organism.

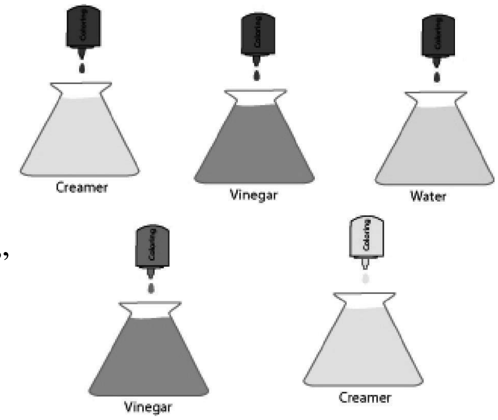
Antibodies - compounds produced by plasma cells that react with specific antigens invading a body.

Plasma - the fluid portion of blood that contains proteins and salts, in which blood cells and platelets are suspended.

Platelets - cell fragments in blood that cause clotting.

Proteins - essential constituents of all living things that are either made by the body or assimilated from food.

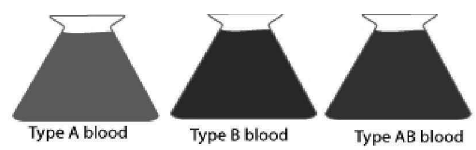
Mixing Instructions:



Creamer with Red Food Coloring to form “Type A blood”
Vinegar with Red Food Coloring to form “Type B blood”
Water with Red Food Coloring to form “Type AB blood”
Vinegar with Blue Food Coloring to form “Anti-A” (or “A Antibodies”)
Creamer with Yellow Food Coloring to form “Anti-B” (or “B Antibodies”

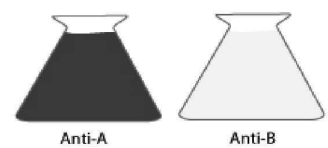
Using a pipette (or dropper,) put two large drops of blood (either A, B, or AB) into each depression of the typing plate.

Using a different pipette, add a drop of Antiserum A to Depression A. At the same time, using a different pipette, add a drop of Antiserum B to Depression B. Look for clumping—a sign that a chemical reaction is taking place. Do not add anything to the third depression; as it is your control.

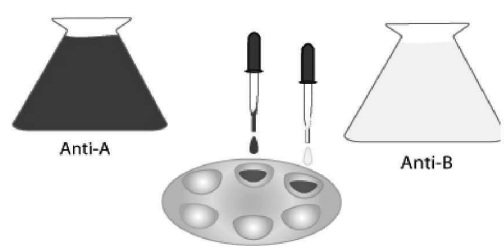


Antiserum A has a chemical that only reacts with blood type A.

Antiserum B has a chemical that only reacts with blood type B.



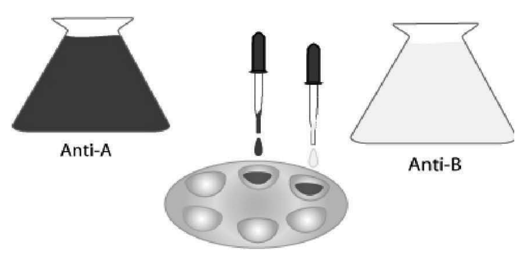
If you only get a reaction from Antiserum A, you have TYPE A blood.
If you only get a reaction from Antiserum B, you have TYPE B blood.
If they BOTH react, you have TYPE AB blood, if neither react, you have TYPE O blood.



Repeat this process for all three types of blood.

Possible Interactive Questions:

- What happened to the blood when you mixed it with the Antiserum? Why?
- How can you use these techniques to help solve a crime?



What’s Going On?

Around 1900, it was discovered that there are at least 4 different kinds of human blood. This is based on the fact that on the surface of the red blood cells there may be one or more proteins, called antigens. These antigens are called A and B. Antibodies are produced in the blood plasma against these A and B antigens and continue to be produced throughout a person’s life.

A person normally produces antibodies against the antigens that are not present on his or her red blood cells. For example, a person with antigen A on his red blood cells will produce anti-B antibodies, a person with antigen B will produce anti-A antibodies, a person with neither A or B antigens will produce both anti-A and anti-B antibodies and a person with both antigens A and B will not produce these antibodies.

The 4 blood types are known as A, B, AB and O. Blood type O (persons with neither A or B antigens) is the most common in the United States (45% of the population). Type A is found in 39% of the population. Type B is found in 12% of the population, and type AB is found in only 4% of the population.

Because of the different blood types, certain blood groups can only give or receive blood from other specific blood groups.

These blood grouping systems can help police if, for example, a rare blood type is found at a crime scene and the suspect shares that blood type. There are also distinct variations in the shape of red blood cells and other blood components that can help link a killer to the crime. Sometimes, this evidence is enough to force a confession or secure a conviction. Only a small sample of blood is needed, and many of these tests can even be done on dried bloodstains.

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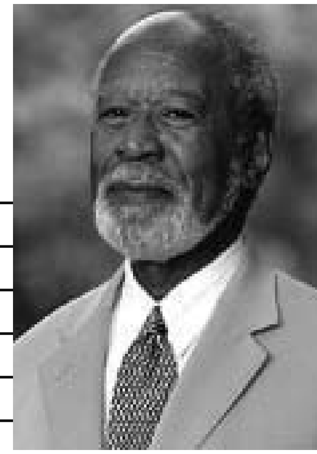
Spotlight: Luther S. Williams



Full Name:	Luther Steward Williams
Born:	August 19, 1940
Place:	Sawyerville, AL
Parents:	Mattie B. Williams
	Roosevelt Williams
Spouse:	Constance Marie Marion
Education:	Hale County Training School - Greensboro, AL (1957)
	Miles College – Fairfield, AL (B.A. Biology, 1961)
	Atlanta University – Atlanta, GA (M.S. Biology, 1963)
	Purdue University – West Lafayette, IN (Ph.D. Microbial Physiology, 1968)
Type of Science:	Biology
Achievements:	Named one of the 50 Most Important Blacks in Science Research by Spectrum Magazine
	Served as a science advisor to the White House

Biography

Scientist, educator, and administrator Dr. Luther Steward Williams earned his B.A. degree in biology with distinction from Miles College in 1961. Williams went on to Atlanta University (now Clark-Atlanta University), where he completed his M.S. degree in 1963. Williams then worked toward his Ph.D. degree in microbial physiology, which he received in 1968 from Purdue University. Williams was the recipient of an NIH predoctoral fellowship at Purdue University 1966-1968, and subsequently spent one year as an American Cancer Society postdoctoral fellow in the Department of Biochemistry at the State University of New York, Stony Brook in 1968.

Williams set himself apart as the recipient of numerous other prestigious fellowships during and after his doctoral work, with two NIH Career Development Awards at Purdue University and MIT, and NIH research grant support between 1969 and 1987; he also held an American Cancer Society Research Grant between 1969 and 1973.

Williams served as a national advisor on many federal health and science initiatives, including the original NIH Recombinant DNA National Advisory Committee from 1979-1981; the National Biotechnology Policy Board; and the U.S. Government Task Force on Women, Minorities, and the

Handicapped in Science and Technology from 1987 to 1990. From 1989 to 1990, Williams was the senior science advisor to the director at the National Science Foundation, and in 1990 he became the Foundation's assistant director of education and human resources, a position he held for nine years.

A respected science educator, Williams held numerous professorships and administrative positions at some of the most highly regarded universities in the country, including Purdue University, MIT, Washington University in St. Louis and the University of Colorado. Williams served as President of his alma mater, Atlanta University, from 1984 to 1987. In 1988, Williams was the Deputy Director of the National Institute of General Medical Sciences. In his capacity as a university graduate school administrator, Williams served as a member of the Council of Graduate Schools' Board and its committee on the Graduate Record Examination between 1981 and 1985. Williams' work in the education sector is matched by his public service efforts, as he has served as a member of the Health, Safety, and Environment Committee for the U.S. Department of Energy National Laboratories, as well serving on several of the White House's science, education and technology committees.

In 1999, Williams served as a visiting scholar at the Payson Center for International Development and Technology Transfer at Tulane University, and as Senior Vice President for Strategic Planning at Bingwa Software Company. In 2001, Williams transitioned to a post as the Director of Education and Interpretation at the Missouri Botanical Garden. In 2006, Williams was named Provost and Vice President for Academic Affairs at Tuskegee University, where he had previously been the Dean of Graduate Studies and Director of the Integrative BioSciences Ph.D. Program.

Williams authored over seventy scientific journal publications and more than twenty articles and reports addressing science, mathematics, engineering and technology education. Williams held memberships in numerous professional science organizations including the American Society for Microbiology. For his professional activities, Williams was awarded many times by universities, professional organizations, and his fraternity, Sigma Pi Phi, as well as having been named to several Who's Who lists. In 2007, Williams was appointed a member of the National Advisory Council for the National Center for Minority Health Disparity, NIH.

Discussion Questions

Personal:

1. What was the most compelling 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 suppose high school was like for him?

3. How old are you? In what year was Dr. Williams your age? What was happening in the country that year? What was happening in the world that year? What do you suppose his life was like when he was your age?

4. Dr. Williams has had a distinguished career as an administrator of several important organizations and universities. What skills would allow him to be successful as an administrator? Think about your principal. What types of skills does he or she share with Dr. Williams? **(See Biography)**

Science:

5. What do you think a biologist does? Would you like to be a biologist? Why?

6. If you were a biologist, what kinds of questions would you answer?

7. Dr. Williams has worked with the NIH. What does the NIH stand for? What does this organization do? Research and share with your class the mission and scope of the NIH. **(See Biography)**

8. Dr. Williams was awarded an American Cancer Society Research Grant. Cancer is one of the most visible types of diseases in the world today. What kinds of things would a biologist do to help cure cancer? What are some of the types of cancer you can think of? How does cancer spread? What are the methods we use to stop the spread of cancer? What are the advantages and disadvantages of each of these forms of treatment? Is there a consensus within the medical community about the best way to treat cancer? Why do you think this is? Do you know anyone who has had cancer? **(See Biography)**

9. Dr. Williams has been a science advisor to the White House. What do you think it would be like to influence science policy on a national or international level? **(See Biography)**

Experiment - It All Starts With Cells

This lesson was adapted from educational materials developed by the Center for the Advancement of Science Education at the Museum of Science and Industry.

Lesson Objectives

- The students will become familiar with different cell parts and functions.
- The students will use microscopes and will create their own slides to study cells.
- The students will work in collaborative groups.

Materials

- Cell Part Cards
- Cell Costumes
- JELL-O Cups
- Large Gumballs
- Skittles
- Pieces of Licorice
- Jelly Beans
- Jar of Sprinkles
- Fruit Roll-ups
- Spoons
- Pencils
- Microscope Slides
- Cover Slips
- Vials of Iodine
- Eyedroppers
- Toothpicks
- Onions
- Plastic Knives
- Microscope

Lesson Plan:

1. Introduction

- Tell the group that our bodies are made up of many pieces, ranging from our bones in the skeletal system to our large intestine in the digestive system. Now ask the students: *What are bones and large intestine made of?* Cells! Every living thing is made up of cells. Our bodies are made from about 10 trillion cells, which divide up into 200 different kinds of cells. So our muscles are made from muscle cells, our blood is made form blood cells, and our liver is made from liver cells. But what exactly is a cell?

2. "Cells in Costumes" Activity

- Give the students a few minutes to brainstorm in small groups what they already know about cells (parts of the cell, functions of those parts, and where cells are found).

- Encourage the groups to share their lists with the rest of the students. Look for similarities and differences in the lists.

- Tell the group that you need 8 volunteers to help represent different parts of a cell. Have the 8 students stand in front of the rest of the group, and give each volunteering student a "Cell Part" card to read out loud. Once the student has read their card, they are to put on the costume that relates to their cell part.

- Before the students read the cards, draw a picture of a cell on chart paper but leave the parts unlabeled. When each student has finished reading their card and has put on the correlating costume, label the appropriate cell part on the chart paper.

Parts of the Cell

Cell Membrane – The cell membrane is a border around the cell. The membrane is responsible for guarding the cell so that only certain things can come inside or leave the cell. So the cell membrane allows only things like oxygen, food, water, and waste to move in and out. And the membrane keeps out things that could be harmful to the cell.
**The cell membrane is the "Sheriff," put on the Sheriff's hat, bandana, and badge.

Cytoplasm – The cytoplasm is a jelly-like material that fills up the cell. The other parts of the cell are held in place by floating in the cytoplasm. The cytoplasm also provides water and nutrients that the cell needs.
**The cytoplasm is the "Chef," find the spatula, chef hat, and apron.

Endoplasmic Reticulum – The endoplasmic reticulum is a system of tiny tubes that serve as tunnels to deliver proteins to different parts of the cell. Some proteins end up being used in the cell, and other proteins are sent to the Golgi Body to be sorted and sent outside the cell.
**The endoplasmic reticulum is the "Truck Driver," find the trucker hat.

Golgi Body – The golgi body's job is to sort, package, and ship proteins and chemicals for the cell to either use or release. For example, the golgi body receives proteins from the Endoplasmic Reticulum and sends these proteins outside of the cell.
**The golgi body is the "Postal Worker," find the Postal Service hat and the stack of envelopes.

Lysosome – The lysosome is what allows the cells to digest food, old cells, or captured bacteria/viruses. The lysosome holds chemicals (called enzymes) that are released when the cell needs to digest food for energy or to get rid of waste.
**The lysosome is the "Trash Collector," find the work gloves and trash bags.

Nucleus – The nucleus directs the cell activity. It controls when the cell eats, moves, and reproduces. The nucleus is also the storage place for Deoxyribonucleic Acid (DNA), which is the blueprint for how proteins are arranged in our cells. Proteins make cells grow, control chemical reactions, and give us our uniqueness.
**The nucleus is the "Orchestra Conductor," find the conductor's gloves and the DNA sheet music.

Mitochondria – The mitochondria are responsible for converting food molecules into energy for the cell. The mitochondria break apart food molecules and release the energy from the molecules into the cell.
**The mitochondria is the "Power Plant," find the batteries and the fake food.

Ribosome – The ribosomes make proteins for the cell. Ribosomes know exactly how to make the proteins because they get a copy of the instructions from our DNA, which is stored in the nucleus of our cells. This copy is called Ribonucleic Acid (RNA).
**The ribosome is the "Carpenter," find the instructions, tool belt, and tools.

- After the students dress up in their costumes, lead the group in a brief recapping discussion. Ask the students to think about how all the parts work together in order to make the cell function. Refer to the diagram of the cell on the chart paper when discussing certain parts of the cell.

3. "Edible Cell" Activity

Now that the students have had the opportunity to learn a little about cells, tell them that they are going to make a cell . . . that they can eat!

- Give each student an individual JELL-O Gelatin snack pack. Ask them what they think the JELL-O represents in the cell (cytoplasm). Then ask what is the role of the cytoplasm.

- Then ask what represents the cell membrane (the JELL-O container) and what the cell membrane does. Next, tell the students to each pick up a large gumball and place it in the middle of the JELL-O cup. Ask the group what this gumball represents (the nucleus), and what the part of the cell does.

- Continue to walk the students through this activity so that they are adding candy to the cell that represents the various parts of the cell. Encourage the students to talk about the function of each part as they place it in the JELL-O.

Lysosomes: 2 Skittles
Golgi Body: Piece of Licorice
Mitochondria: Jelly Bean
Ribosomes: Sprinkles
Endoplasmic Reticulum: Piece of a Fruit Roll-up

- After all of the parts of the cell have been added and discussed, have the students put their edible cells aside until after the next activity.

4. "Examining Cells" Activity

**Remind the students not to eat anything for about an hour prior to this activity so that the cheek cells remain intact and can be collected.

- The students should now be somewhat familiar with the structure of the cell, and they will have the chance to study cells under a microscope. Ask the students: Even though cells are incredibly small, is there a way for us to look at cells? By using a microscope, we can study the structure of different cells. Scientists use very powerful microscopes to study cell structure, but we can still see certain parts of a cell through our microscope.

- Ask the group to think about how they could go about collecting cell samples from their own bodies. Since our bodies are made entirely out of different cells, it should be an easy task. One place to find cells easily is on the inside of our cheeks. We are constantly shedding cheek cells and growing new ones, so this is a perfect way to collect cell samples, Tell the groups to follow the guide for the next cell activity.

Activity Guide

1. Use an eyedropper to place one drop of water on a slide.
2. Take a toothpick and gently scrape the inside of your cheek. This scraping action will collect some cheek cells. Gently wipe the cells into the drop of water on the slide.
3. Using an eye dropper, place a drop of iodine on the cheek cell sample. The iodine will stain the cheek cells to make it easier to see under the microscope. Then, carefully place the plastic cover slip on top of the cells

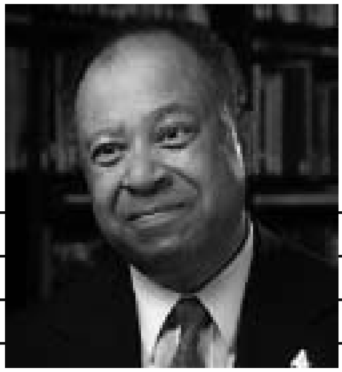
   **The water and iodine should only be between the cover slip and the slide. If there is too much liquid and the cover slip is floating over the cells, you can remove some of it by holding a piece of paper towel next to the cover slip This will soak up the excess liquid.

4. Look at the cell sample under the microscope. Make a few sketches of what you notice. Can you see any of the cell parts? What do you think that circle is inside the cell?
5. For the next part of this activity, you will work with the other students at your table to create a different cell sample. Use a toothpick to dig into a slice of onion. Try to peel off a thin clear layer of onion.
6. Follow the same steps and create a stained slide with the onion. Can you see the onion cells? Do they look the same or different than the cheek cells? Make a few drawings of what the onion cells look like under the microscope.
7. After the groups have had the chance to study cell samples, have them share what they noticed. Ask the group if they saw a large circular structure in each cell, and to identify it if they can. This circle is the cell's nucleus. Ask the students to share what they know about the nucleus and why it is important.
8. The nucleus is responsible for storing the cell's DNA, which is a very important acid in our bodies.

Museum of Science and Industry

ScienceMakers

Spotlight: Alfred Brothers, Jr.



Full Name:	Alfred Sylvester Brothers, Jr.
Born:	December 14, 1942
Place:	Boston, MA
Parents:	Edith I. Yates
	Alfred Sylvester Brothers, Sr.
Spouse:	Sanora Joy Wooden
Education:	Boston Latin School - Boston, MA (1960)
	Boston University - Boston, MA (B.S. Aeronautical Engineering, 1964)
	Golden Gate University - San Francisco, CA (M.P.A., 1976)
	Central Michigan University - Mount Pleasant, Michigan (M.P.M., 1980)
	Century University - Albuquerque, NM (Ph.D. Business Administration, 2001)
Type of Science:	Aeronautical Engineering
Achievements:	Developed the first engineering models of foreign space satellites to support the emerging United States Defense Initiative requirements
	Served as chief of the Ballistic Missile Facility Branch and Communications Sattellite Group of the United States Air Force

Favorites:

Color:	Blue
Food:	Steak
Time of Year:	Spring
Quote:	“Nothing is impossible.”

Biography

Alfred Sylvester Brothers, Jr., pilot, aeronautical engineer, and program manager, was born in Boston, Massachusetts, on December 14, 1942. He was the descendent of refugees who fled to Canada during the Revolutionary War, but later returned to settle in Boston.

Brothers graduated from Boston Latin School, the oldest high school in the nation, in 1960. He then graduated from Boston University in 1964 with his B.S. degree in aeronautical engineering. Brothers then fulfilled a childhood ambition by joining the United States Air Force, where he served for the next twenty-two years. Brothers began his Air Force career as a pilot and eventually became a top Air Force test pilot. In 1972, Brothers served in the Foreign Technology Division of Wright Patterson Air Force Base in Dayton, Ohio.

Brothers became chief of the Communications Satellite Group and chief of the Ballistic Missile Facility Branch. While there, he developed the first engineering models of foreign space satellites to support the emerging United States Defense Initiative requirements. Recognized as a national authority, Brothers authored fifteen studies and publications throughout the course of his career.

In 1976, Brothers earned his Master's in Public Administration from Golden Gate University in San Francisco, California, and in 1980, he received his Master's degree in Program Management from Central Michigan University in Mount Pleasant, Michigan. Brothers went on to become professor and department head for aerospace studies at Wright State University in Dayton, Ohio. While at Wright State, Brothers focused on encouraging the development of African American engineering students and pilot candidates. Subsequently, the graduation and commission rates for students in the AFROTC increased by 90% during Brothers' tenure. Brothers also served as adjunct professor of engineering at Indiana Institute for Technology, teaching fluid dynamics from 1991 to 1994. Brothers earned his Ph.D. in business administration from Century University in 2001 and went on to serve as Program Manager and Systems Analysis Laboratory Manager for Raytheon Systems Company, C3S, in Fort Wayne, Indiana.

In addition to his professional activities, Brothers was an active volunteer with the Boy Scouts of America and a board member of the African and African American Museum in Fort Wayne.

Discussion Questions

Personal:

1. What did you like best about listening to Dr. Brothers?

2. What do you think Dr. Brothers' favorite quote means? What does this tell you about him?

3. Where was Dr. Brothers 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. Brothers attend high school? What do you suppose high school was like for him?

4. How old are you? In what year was Dr. Brothers your age? What was happening in the country that year? What was happening in the world that year? What do you suppose his life was like when he was your age?

5. Dr. Brothers had a hard time learning math in high school though his SAT scores showed that he was capable of doing math. What caused this discrepancy? What did his teacher do to help solve the problem? Have you ever faced a situation like this? Were you able to explain your frustration to your teacher? Studies show that each person has a different style of learning. How do you learn best? Is it by reading information, hearing information, working things out with your hands, or another method? What techniques can you use to help you retain information that is tailored to your learning style? Have you communicated your learning preferences to your teacher? Have you communicated your learning preferences to your parents? What are some other ways you can communicate how you learn best? **(See Clip #1)**

6. Dr. Brothers talks about education as a lifelong pursuit. Why does he feel this is so important? He talks about the process of evolution that our world is undergoing. How can you be part of that process? **(See Clip #4)**

Science:

7. What do you think an aeronautical engineer does? Would you like to be an aeronautical engineer? Why?

8. Dr. Brothers states that he wanted to be a pilot and an aeronautical engineer. When did this start for him? Why do you think he chose this path? What was his strategy for accomplishing his goal? Have you ever considered the military as a path to education and training? Why or why not? Have you communicated this to your parents or friends? How have recent world events shaped your opinions? **(See Clip #2)**

9. Dr. Brothers talks about wanting to be involved in the design process and the production process. What is the difference between the two? Find out what the design process entails. Find out what the production process entails. What skills would you need to be a good designer? What skills would you need in order to be a good production manager? Do you have any of these skills? **(See Clip #3)**

10. Dr. Brothers talks about aeronautical engineering. What is aeronautical engineering? Understanding the forces of flight is very important in aeronautical engineering. Describe the forces of flight and how an airplane flies. What kinds of things do aeronautical engineers do? Can you think of other places where these skills might be useful? **(See Clip #4)**

11. Dr. Brothers talks about how the world is evolving. Ask your parents what some of the technological innovations that changed their lives were. For example, ask them what life was like before cell phones. Ask your grandparents what life was like before DVDs, computers, and video games. Can you imagine your life without these things? How has the world changed in your lifetime? For example, social networking sites such as Facebook and Twitter are recent phenomena. What was life like before you were able to use these sites? What kinds of things do you think your children will take for granted? How can you be part of the process of technological innovation for the next generation? **(See Clip #4)**

12. Dr. Brothers talks about young people taking an interest in engineering and mathematics. What are some of the examples he uses to illustrate this point? Have you ever had an idea and caused it to be a reality? Have you ever identified a problem and created a new solution? What does Dr. Brothers call these things? **(See Clip #5)**

13. Dr. Brothers talks about the need for visible mentors in the scientific disciplines. What do you think he means by this? Who are the visible mentors in your life? What are their careers? Are you planning to follow in any of their footsteps? Why or why not? **(See Clip #5)**

Experiment - Flying Tube

This experiment was developed by the Center of Science and Industry in Columbus, OH.

Description: A spinning paper tube generates lift as it travels forward.

Concepts: Aeronautics, Circular airfoils

Materials:

- Center tube from paper towel roll
- 5 feet of surgical rubber tubing
- 3 ft of cloth ribbon (do not use slippery ribbon)
- 2 ft of bell or iron wire
- C-clamp
- Pliers

Instructions:

1. Fold over about 1 inch of the rubber tubing and wrap it tight with a piece of wire. Twist the wire tight with the pliers and while doing so, form a loop about 1 inch in diameter in the wire.

2. Attach one end of the ribbon to the other end of the rubber tubing with a piece of wire. Twist the wire tight.

3. Slip the wire loop over the screw shaft of the C-clamp. Tighten the clamp to the end of a table.

4. Lay the tubing and ribbon across the table. Place the paper tube on top of the ribbon at its free end and roll it up snugly in the ribbon.

5. While keeping the ribbon from slipping, pull the paper tube back to stretch the rubber tubing. Release the tube. The tube will be spun as the ribbon is pulled off, while at the same time it is pulled forward by the contracting rubber tubing. With enough speed and spin, the paper tube will lift off the table and may fly a loop through the air.

What's Going On?

When the paper tube is released, two motions are imparted to it. The tube is pulled rapidly through the air and at the same time it is spun. The combination of motions generates aerodynamic lift. When seen from the side, air is made to flow over and under the tube as the tube moves forward. The tube's surface experiences a small amount of friction with the air. As it spins, the friction drags air in contact with the tube's surface around with it. On the top of the tube, the air being dragged around with the tube and the air flowing over the tube are traveling in the same direction. Below the tube, the air being dragged around the tube and the air flowing under it are traveling in opposite directions. There, the air piles up and creates a small zone of relatively high pressure. On top of the tube the pressure is lower. If the tube is moving fast enough through the air and spinning rapidly enough, the over versus under pressure difference will be greater than the weight of the tube. The tube will begin flying and it will do so as long as its air speed and rotation are maintained. This is aerodynamic lift.

Rotating airfoils have been added to the wings of some high-performance airplanes to increase lift under certain flying conditions. At least one early airplane designer unsuccessfully tried to build a plane with rotating cylinders instead of wings.

What do you think would happen if the paper tube were rotated in the opposite direction as it moved forward? Place the ribbon on top of the paper tube and wind it up turning the top of the tube away from the rubber tubing; this should wind the ribbon in the opposite direction as the first trial. What happened when you stretched and then released the rubber tubing? Did the tube have any lift? Why or why not?

Alfred Brothers, Jr. - Video Clip Transcription

Clip 1 - Influential Teachers: I was having trouble with math in high school, you know, when I just couldn't quite seem to struggle through it. But that's when the standardized tests helped. I took the SAT's, and I scored a 700 in math. And my instructor said, "Wait a minute. You can't score a 700 and have problems with my course. What's the problem?" And he also taught at night at Northeastern University. And I said, "I don't quite get the concepts as you present them." He said, "You're getting them on your own." He says, "I'll work with you, and help you, as far as that was concerned."

Clip 2 - Decision to Become a Pilot: I also joined the Air Force ROTC, and then that was the genesis of my becoming later on an Air Force Officer. And again, that four year program gave me the opportunity to learn quite a bit about the Air Force, through not only classes, but also through travel…But my decision to become a pilot was earlier than that - that was based upon my opportunity to fly in the airplane at the end of high school, also through my involvement through ROTC itself. I saw the value of it, I wanted to become an Air Force pilot, I wanted to fly jets, and that was a decision that I made. So I wanted to be both an engineer and a pilot, and work very hard to that end. [I] did reasonably well, my greatest grades were not made in undergraduate school by any stretch of the imagination, but again, the preparation was there, and again, I did graduate and move on to the Air Force. So I was commissioned as a Second Lieutenant, and went to pilot training. But the precursor to the pilot training was the flight instruction program, the F.I.P. program, that selected us in our senior year as to whether we were going to go to pilot training or not. It was a thirty hour program, done through a local airport, in a local F.B.O., as a screening program. So I got my thirty hours under my belt there, [I] pass[ed] that okay, and then headed off to pilot training down at Williams Air Force Base, Arizona.

Clip 3 - Engineering Career: Everyone kept asking me what are you going to do now? I said, "Well, I really want to get into engineering. Again, that's what I spent four years in school for, and everything else. I liked it, and I had spent a little bit of time in the Air Force doing engineering, and I said I'd like to do it again, upon retirement." And that's what brought me to Fort Wayne, Indiana, then Magnavox, and again because they had tremendous research and development and production facilities here, I said, "I'd like to design something and also be able to produce it as well." Some companies are design…some are massive production, but this company had the mixture of both of those and it was a mid-size company in which I had the opportunity to really know everyone from the secretaries all the way up to the CEO, who was stationed, who actually physically resided here. A great company and a great company to work for, I mean, in the area of communications and software development and those kinds of things, and so it was a great opportunity to start out as an engineer and shortly become a program manager, in which you're responsible for the technical direction and management of the program itself. You're the one who's responsible to attain the goals, both financial goals and schedule goals for particular government programs. And I've been doing that since that time. And it's been really an enjoyable experience.

Clip 4 - Importance of Ongoing Education: Education is a lifelong process that you never stop. You probably saw on my resume, I just got my Ph.D. and I'm just turning sixty, in that situation, in a five-year process, but it's an ongoing, education is an ongoing thing. You should never stop learning in that situation. I wouldn't necessarily say you have to pursue for the degrees, but my recommendation is continue going to school, continue to learn. Because the world is evolving so rapidly in terms of the technology and science, that it behooves you to understand the underpinnings of that technology or science. We're going to the moon, we've sent prototypes outside our solar system. Look at the Hubble Telescope and what it sees, millions of light years away. What does that mean to us? And really, we have to understand it and prepare ourselves for that understanding and also prepare our youth to understand it. The other thing I recommend to adults is: take some computer classes. If you're not computer literate, do it. Because like the telephone, that came about, and we take it for granted today. Computers will be the same way ten to fifteen years from now. We'll have gone through the generation of kids who fully understand and use it, to those who take it for granted. I think Edward [Edward Dwight] would probably tell you, the folks that landed on the moon made a great impression on us. Doesn't make a great impression on the kids any more, they just take it for granted. So consequently, life is evolving rapidly. Be part of that change, be part of that excitement. And I don't necessarily say you have to lead the excitement, by any stretch of the imagination, but you should understand what it is, and be part of the process, the discussion process.

Clip 5 - Lack of Mentors: We don't see very many mentors in the process - you don't see very many black scientists, in operation, and that's also true of black airline pilots. How many do you see? They're out there, but you don't see that many, by any stretch of the imagination, but they are there. You know, the visibility makes a difference and that's why I mention, through my scouting experience, in terms of my aviation post, that's where I was exposed to black pilots for the first time. So I could talk to people firsthand, what's the experience of flying? The kids really don't have the opportunity to fully understand and comprehend what engineering is. And engineering, like anything else, is nothing more than language. It's a way of bringing a concept into being, except it's done through formulas as far as that goes. Kids say "Well, I can't do math." I can tell them, "Yes you do, because you use money when you go shop for this, that and the other thing. You guys do math all the time, and math is a universal language, no matter where you go." It's one that's well understood. But it's just, we have made math a mystery.

ScienceMakers

Spotlight: John D. Terry

Full Name:	John David Terry
Born:	September 29, 1966
Place:	Norfolk, VA
Parent:	Deborah Kathleen Terry
Spouse:	Barbara P. Terry
Education:	Lake Taylor High School - Norfolk, VA (1984)
	Old Dominion University - Norfolk, VA (B.S. Electrical Engineering, 1988)
	Cleveland State University - Cleveland, OH (M.S. Electrical Engineering, 1993)
	Georgia Institute of Technology - Atlanta, GA (Ph.D. Electrical Engineering/Research, 1999)
Type of Science:	Electrical Engineering
Achievements:	Worked as an Experimental Research Engineer at the NASA Glenn Research Center
	Owner or co-owner of more than seventeen issued and pending patents

Favorites:

Color:	Blue
Food:	Steak
Time of Year:	Spring
Vacation Spot:	Costa Rica
Quote:	"I came. I saw. I conquered."

Biography

Electrical engineer and entrepreneur John David Terry was born on September 29, 1966, in Norfolk, Virginia. Terry was raised in the Liberty Park Housing Projects in Norfolk by his single mother, Deborah Kathleen Terry, along with two younger siblings. Terry dreamed of becoming a professional basketball player, but he had to quit his high school basketball team in order to start working part time. Terry developed a passion for technology and was encouraged by a high school guidance counselor who helped Terry win several scholarships. After high school he attended college at Old Dominion University in Norfolk, where he earned his B.S. degree in electrical engineering in 1988.

The next year, Terry was hired as an experimental research engineer at the NASA Glenn Research Center in Cleveland, Ohio. In this position, his work focused on experimental research on satellite communications. While working at NASA, Terry also attended graduate school, and in 1993, he earned his M.S. degree from Cleveland State University. A graduate fellowship from Old Dominion University allowed Terry to continue his education, and he received his Ph.D. in electrical engineering and research from Atlanta's Georgia Institute of Technology in 1999.

In 1995, Terry was hired by Texas Instruments, where he worked as a system engineer experimenting with a new type of satellite system. In 1999, Terry became a principal scientist at the Nokia Research Center in Dallas, Texas, where he worked to improve Nokia's wireless service.

In 2001, Terry founded his own company, Terry Consultants, Inc. (TCI), which specialized in helping businesses develop and apply new wireless technologies. Terry was also owner or co-owner of more than seventeen issued and pending patents. In 2004, Terry spent a year as director of WiQuest Communications with Baseband Systems Engineering, and in 2005, he co-founded Witivity, which helped customers in their use of broadband wireless technology.

Terry published two books: "Blind Adaptive Array Techniques for Mobile Satellite Communications," and "OFDM Wireless LANs: A Theoretical and Practical Guide," with Juha Heiskala. For his professional activities, Terry received a number of awards, including the 2002 Black Engineer of the Year Award for Outstanding Technical Contribution in an Industry. Terry published several articles and taught classes at Southern Methodist University, the Georgia Institute of Technology, and the University of Technology in Helsinki, Finland. Terry was also very active in the Institute of Electrical and Electronics Engineering (IEEE).

Terry and his wife, Barbara, raised three sons: Amiel, William, and Shalamar.

Discussion Questions

Personal:

1. What did you like best about listening to Dr. Terry?

2. What do you think Dr. Terry's favorite quote means? What does this tell you about him?

3. Where was Dr. Terry 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. Terry attend high school? What do you suppose high school was like for him?

4. How old are you? In what year was Dr. Terry your age? What was happening in the country that year? What was happening in the world that year? What do you suppose his life was like when he was your age?

5. Dr. Terry talks about his first introduction to problem solving. How did he first encounter algebra? What did he realize when he began studying pre-algebra in seventh grade? What does he say about having the proper training? Have you had an experience like this? How else can you apply this to your life? **(See Clip #1)**

6. Dr. Terry has unusual stories about his high school experiences. What were they? How do your experiences in school compare to those of Dr. Terry? He mentions that he felt the need to challenge \ himself. What challenges you? How do you challenge yourself? **(See Clip #2)**

7. When did Dr. Terry decide to be an electrical engineer? How does he structure his goals? What was his reward for meeting his goals? What are some of your goals? Imagine next month, next year, five years and ten years from now. What are your goals for each of those periods? How can you meet them? What are your potential challenges? How can you overcome them? **(See Clip #3)**

8. Dr. Terry downplayed much of his success until he got to NASA. How did this help him? What kind of an environment forced him to excel? How does this relate to you? How do you measure yourself? Do you take your peers into account, or are you only competing against yourself? **(See Clip #4)**

9. How did Dr. Terry come to be working at NASA? Have you heard of programs like this? What is one name for them? [Teacher's note: This provides an opening to discuss affirmative action] How successful was that group, according to Dr. Terry? What are the pros and cons of programs like this? Do you think they are helpful or harmful? Why? **(See Clip #4)**

Science:

10. What do you think an electrical engineer does? Would you like to be an electrical engineer? Why?

11. If you were an electrical engineer, what kinds of problems would you solve?

12. What was the emphasis of Dr. Terry's undergraduate work? What is this field about? How do you think it works? Can you think of places where this type of work would be useful? **(See Clip #5)**

13. What was the emphasis of Dr. Terry's graduate work in Cleveland and at NASA? What is this field about? How do you think it works? Can you think of places where this type of work would be useful? **(See Clip #5)**

14. How did Dr. Terry combine his Ph.D. work with his work at NASA? What is array signal processing? How does it work? **(See Clip #5)**

15. Dr. Terry talks about how his choice led him to be well-placed into an industry that has experienced tremendous technological growth over the last fifteen years. What are some of these technological advances? How do they impact your life? What kinds of technological innovations could you make? Where do you think the next wave of technology will happen? **(See Clip #6)**

16. Dr. Terry talks about how he was trained to think differently at Georgia Tech. What was his old way of thinking? Have you ever encountered this in school? What was he taught at Georgia Tech? Which method do you think is better? Why? Give some examples. **(See Clip #6)**

Experiment - Build an Electric Motor by Basaam Shakashiri

How does a motor change electrical energy into motion? An electric current produces a magnetic field. This magnetic field can be attracted to or repelled by a permanent magnet. This attraction or repulsion can cause movement in a wire that carries an electric current.

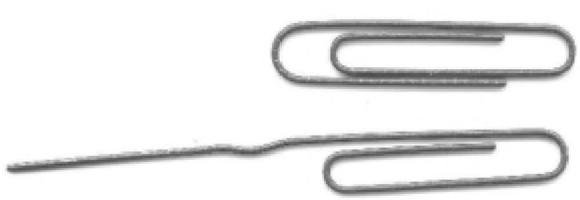
You will need the following materials:

- 1 meter (3 feet) of 22-gauge or 24-gauge solid-core insulated wire (e.g. Radio Shack catalog # 278-1215)
- 2 disk magnets (e.g. Radio Shack Catalog # 64-1888)
- 2 insulated test cables with a clip on each end (e.g. Radio Shack catalog # 278-1157) (2 pieces of above Insulated wire can also be used)
- A plastic cup
- Two large rubber bands
- Two jumbo size (2-inch) paper clips
- D-cell battery
- Wire strippers
- Waterproof marking pen
- Optional holder for D-cell (e.g. Radio Shack catalog # 270-403)

Take the 3-foot piece of insulated wire. Starting about 3 inches from the end of the wire, wrap it seven times around the D-cell battery to form a coil. Wrap the ends of the wire a couple of times around the coil to hold it together.

Use the wire strippers to remove the insulation from the two ends of the coil.

Straighten the larger loops of two paper clips.

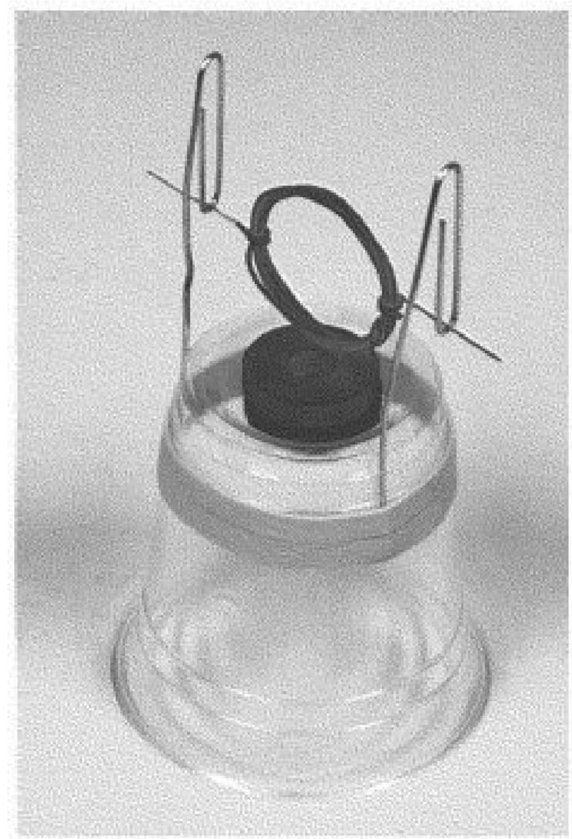


Turn the cup upside down and place a magnet on top in the center. Attach another magnet inside the cup, directly beneath the original magnet. This will create a stronger magnetic field as well as hold the top magnet in place.

Put two large rubber bands around the base of the cup.

Insert the straightened paper clips into the rubber band, so they stand upright over the bottom of the cup.

Rest the ends of the coil in the cradles formed by the paper clips. Adjust the height of the paper clips so that when the coil spins, it just clears the magnets. Adjust the coil and the clips until the coil stays balanced and centered while spinning freely on the clips. Good balance is important in getting the motor to operate well.



Once you have determined how long the projecting ends of the coil must be to rest in the paper-clip cradles, you may trim off any excess wire.

Attach one of the clip cables to each paper clip just above the rubber bands. You may need to readjust the clips to make sure the coil still spins freely.

Hold the other ends of the clip leads against the two poles of the D-cell battery. If the coil is well balanced on the clips, it will rotate to a near horizontal position. The magnetic field created by the electric current in the coil aligns itself with the magnets.

The coil may not continue to turn, because as the current continues to flow through the coil, its magnetic field stays aligned with the magnets. To get the coil to continue rotating, the current should be turned off when the coil is aligned with the magnets. This can be done by coating part of one of the bare wire ends of the coil.

Remove the coil from the paper clips. Hold the coil vertically. Use the permanent marker to paint the TOP HALF of one of the two end wires. Allow the ink to dry for a few seconds, and apply a second coat. Allow several seconds again for the ink to dry, then hang the coil on the paper clips again.

Connect the D-cell battery again, and give the coil a gentle spin. If it doesn't keep spinning on its own, check to make sure that the coil assembly is well balanced when spinning, that the projecting end has been painted with black pen as noted, and that the coil and the magnet are close to each other but do not hit each other. You might also try adjusting the distance separating the cradles. This may affect the quality of the contact between the coil and the cradles. With a little adjustment, your motor will spin rapidly when connected to the battery. (A holder for the battery will allow you to make the connections without holding them in place.)

Find this experiment online at: http://scifun.org/HomeExpts/BuildAMotor.htm

John D. Terry - Video Clip Transcription

Clip 1 - Introduction to Advanced Math: I remember at that point I first got introduced to problem solving and math, it would give us, effectively it was giving us algebra problems. I didn't know at the time they were algebra problems, I didn't have the tool set to solve them, and if you got them right, you got like ice cream, or a dollar, or something like that. And every day I would go home and diligently try and spend hours upon hours, trying to figure out these problems. And I got a fair share of them correct and sometimes I didn't, and some people just didn't care, it wasn't, like, required. But then I could really start to see that I really had an aptitude for math, mostly math, there wasn't a whole bunch of science at that time. So then when I got to the seventh grade and I was in Pre-Algebra and they started teaching us some of the tools to solve the problem, I was so excited, I went back to my sixth grade teacher to explain to him, "Oh, now I understand how you go about solving these problems, things that took me hours to do, I could solve in five minutes." And I thought that was a great achievement, you know, things that I had to puzzle out, and I thought wow, that's wonderful, you know, with the right training, it's so much more you can do than trying to figure everything out yourself. And that was a big jump for me at that time.

Engineering

Clip 2 - Achievement in High School: I got myself into physics and in the beginning of the year, you take a test, and it's like a standardized test to see where students are and then at the end of the year, you take the same test, and they see how much progress you made. And so at the end of the year, in the physics class, they said that people, well, they asked the class, you can get graded one of two ways: you can either get graded on how much you've learned, or your absolute score, and they said, it turns out the same person got the highest score either way you do it. And that was me. I got the lowest score in two different classes when I first got in there, and I got the highest score in two different classes by the end of the year. So I made the most progress and had the most absolute [score]. And in calculus, I averaged one semester, I had a hundred and five average for the semester. I wasn't working, I had lost my job, wasn't working. So, I put all my energy into math and science and so I got, you know, so I was top, top tops in the math and science. Overall I wasn't, I was nowhere close, I was like number thirty out of three hundred something students in my graduating class.

Clip 3 – Goals: I really liked electrical engineering. In fact, I had decided to be an electrical engineer in the eighth grade. I had really decided early on, and I had already planned my career out: what I needed to take and what classes I needed. So I've always been kind of in control and I've always kind of planned my life about five years ahead. I have long-term goals and short-term goals. I have goals all the way down to weekly goals and daily goals, and the way I got through school is that whenever I made my weekly goals, I would reward myself, and my reward to myself was treating myself to a banana split.

Clip 4: - NASA Program: Even though I got inducted into the National Honor Society in college, I was like only the one… I was like only two black guys in the whole induction class in my sophomore year. You know, I started to feel like I was starting to really do something that wasn't that easy to do. And you know, I really started to feel like a little bit proud of myself, but I still wanted to keep that edge. And when it was time to go to graduate school, [I thought] you know, any old clown can get a B.S. in electrical engineering, you know, and I had a job at NASA lined up…I came from Old Dominion, Old Dominion is okay for a southeast coast, but NASA people [came] from Purdue, Notre Dame, the Ohio State, University of Illinois Urbana-Champaign. All these big, big schools and here I got tossed back in that same familiar environment where I have to prove myself again, which is just the right breeding ground for me to excel. And that first year, I won an achievement award for saving the government like $300,000 for an idea that I worked on…NASA Glenn, NASA Lewis at the time I was there and that was actually a really interesting program because NASA purposely went out to create diversity in their recruitment. And so it was a whole bunch of us in [there] and there used to be a picture at the Cleveland Hopkins Airport and there was a picture of the whole group and I was the only one… I was always missing from the group because I was always working and missed the photo shoot. But that whole group of people, it's interesting, if you can ever get a copy of that and track…they went to the University of Puerto Rico. They got people from all over the country from schools up in New York. If you track the careers of that group that came into NASA at that time, myself included, all of them are doing very well, very well, but at the time, it was an unpopular decision…These kids, they just some sort of diverse, some sort of affirmative action, you know, number crunching thing. These guys will never be successful, but everybody from that group, and it was like 20 or 30 of them, because I know of at least 10 personally. Almost all of us got our Master's [degree]; some got their Ph.D.s. Some went on to become lawyers. I mean that whole group, it was a very good program, I mean, NASA should be very, very proud of themselves…I mean all of us had graduated. We had to have at least a 3.0 from our universities, it was not like they were just, you know, throwing away the Rhodes for us or anything like that. But we showed to have a lot more initiative and drive than some of the other folks.

Clip 5 - Research During School:
I was looking at a couple of schools, you know, to look at my, for my Ph.D., and I went to decent schools but I wanted to go to a top tier school, you know, you've got to understand I'm always about competition. And I always need to know where I stack up in the ranks. And so, I was looking at Purdue, Stanford and Georgia Tech and both of them, all three of those schools had a good history with graduating minorities, you know, but Stanford graduated the most minority, most minorities and Georgia Tech graduated the most African Americans with graduate degrees, and most of the minorities at Stanford were Hispanic. So, I decided, that's how I ended up picking Georgia Tech, and I went to Georgia Tech, and you know, kind of pretty much on that, you know, they have a strong school ranking and I was going into digital signal processing and so for those of you who don't know what that means, it's kind of like, it's just how you take the signals and clean them up and make them clearer. You know, when you see blurry vision and you focus in, well signal processing is like, is the science behind that. So how do you clean up signals, and make them more discernible, crisper, sometimes more audible, so to speak. That's the whole process behind digital signal processing. And Georgia Tech is number one in engineering schools in that area, so everyone goes to Georgia Tech to study that.

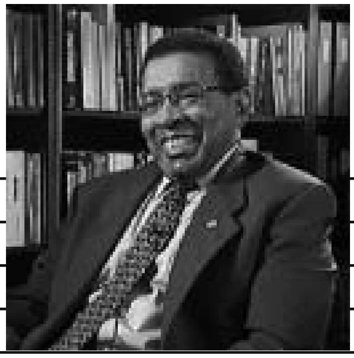
I also was, I was working in the satellite communication division at NASA, so I had to create a Ph.D. program that matches signal processing, which was my own interest, with communications and satellite communications in particular, because NASA was paying, I was on a sabbatical, I won a fellowship to go on the full sabbatical to pursue my Ph.D. so I had to make it relate to my work when I came back. And so what I did was I looked at a science that's called array signal processing and you might, what people call today MIMO technology, you know, if you go to a Best Buy, and you'll see MIMO technology which stands for, that's M-I-M-O, that's an acronym, which is multiple input, multiple output. But back in the days when I was working on my Ph.D., it was called array signal processing, and it's the same thing, it takes multiple antennaes, you know, you see these rabbit ears, everyone's seen the rabbit ears on the top of, you know, the rooftops, but instead of feeding down to a single point, each individual ear has its own individual connector and you combine them in a way to enhance the signal in a particular direction without actually having to physically steer it. So that was my Ph.D., was about taking signal processing coupled with array technology, antennae technology, with satellite communications. 'Cause I was in the satellite communications deparment, I wanted to use array signal processing, algorithms and technique that, you know, I was learning at Georgia Tech, and also coupled with the communications and so when I came out of Old Dominion, I had a signal processing emphasis.

Then I went to Cleveland where I was working for the communications department, so I took all my Master's classes in communications and, and so I'm always, I don't like to lose anything, so I wanted to program my Ph.D. to encompass all those different aspects. So I took communications, and communications and signal processing are very closely related, now in the industry. I mean, those are the two hot topics to do a lot of research and development, 'cause signal processing enhances communications, communications has applications for signal processing…and when you think about video cameras, when you think about a picture being blurred, we talk about, compression techniques, like, you know, things can be compressed and send data across in the compressed format, you know, you always, zip files, zip files are that, the same thing, hard drives use the exact same technology and the same programs, all of these are the same programs. Your CD-ROM, you know, that whole technology behind CDs and how CDs were, you know, kind of scratch resistant, you know, that you can have a scratch on a CD and the quality of the music doesn't go down. That has to do with communications and signal processing theory, so it’s a lot of aspects of our everyday life that you know, are impacted by these technologies but we’re unaware of them. And so I mean, at the time I didn’t realize how rich and fertile a feeding ground this was going to be. It was just something I was trying to put together in order to justify getting full salary and, you know, going to Georgia Tech.

Clip 6 - Time at Georgia Tech: I got there and I actually thought, this is pretty damn hard. I’m like, it was really hard, I mean, I had really grown as an engineer, I mean I was much, much better than when I first came out of Old Dominion and I was like, this is still pretty damn hard. I mean, I was, I wasn’t sure I was, it was the first time that I wasn’t sure if I was going to be able to complete it. I mean, I was really doubtful, it’s like when you try out for a team, you know, there’s some really good players out here, I don’t know if I’m going to make it, like you really don’t know. And I didn’t know if I had what it took to make the cut at Georgia Tech, I really didn’t know and up until almost ‘til I graduated, I really didn’t know, but I kept pushing hard and that’s what I wanted, I wanted to be challenged like that, I wanted to know that failure was easily imminent if I didn’t give it my hundred and ten percent, I wanted to really push myself like that. And Georgia Tech, Georgia Tech has this whole different way of teaching you to think, they teach you to think smart, you know, and in that sense, that they think that before you start writing down, my other classes, all my schools, you get credit for work, just writing down a lot of stuff, you know, whether it was cohesive or not, you just write a bunch of stuff. Georgia Tech professors, they don’t like that, that’s wasting their time. If you write a bunch of stuff, and as soon as you start deviating from what’s right, they just give it a zero. Zero it out. So it took me like almost a whole semester to get used to the whole process of the Georgia Tech way of thinking and actually, I say that’s why Georgia Tech engineers rank number one in terms of productivity and industry, they teach you to think about the problem first and try to find out what’s the essence of what you’re trying to solve. And then only once you understand the essence of what you’re trying to solve, then use the tools that they’ve given you to solve the problem.

ScienceMakers

Spotlight: Clayton Bates, Jr.



Full Name:	Clayton Wilson Bates, Jr.
Born:	September 5, 1932
Place:	New York, NY
Parents:	Arline Bates
	Clayton Wilson Bates, Sr.
Spouse:	Priscilla Bates
Education:	Brooklyn Technical High School - New York, NY (1950)
	Manhattan College - New York, NY (B.S. Electrical Engineering, 1954)
	Polytechnic Institute of Brooklyn - New York, NY (M.S. Electrical Engineering, 1956)
	Harvard University - Cambridge, MA (M.S. Electrical Engineering, 1960)
	Washington University - St. Louis, MO (Ph.D. Physics, 1966)
Type of Science:	Electrical Engineering, Physics
Achievements:	Worked on the first SEA WOLF, which was the second atmoic-powered nuclear submarine
	Worked on low-level light detection and x-ray image intensification

Favorites:

Food:	Fried Chicken
Time of Year:	Autumn
Vacation Spot:	Europe

Biography

Dr. Clayton Wilson Bates, Jr. was born on September 5, 1932, in New York City, where he attended elementary school at New York Public School 119 and middle school at New York Junior High School 43. Bates earned his high school diploma from the all-boys Brooklyn Technical High School in 1950, where he was a member of the baseball, basketball and track teams. As a young boy, he also enjoyed playing baseball and basketball in his Harlem neighborhood, where he lived with his mother and older sister, Barbara. Bates' parents, Arline and Clayton Bates, Sr., were divorced when he was a young teenager. Bates' love affair with science and engineering began early-as a youngster he enjoyed building model planes and dreamed of becoming a pilot.

From 1950 to 1954, Bates attended Manhattan College on a full academic scholarship. After receiving his B.S. degree in electrical engineering from Manhattan College, Bates earned his M.S. degree in electrical engineering from Polytechnic Institute of Brooklyn. Bates then received a fellowship from Harvard University where he earned another M.S. degree in electrical engineering in 1960. Bates went on to further his education at Washington University in St. Louis, Missouri, where he received his Ph.D. in physics in 1966.

Following his graduation, Bates worked for several engineering and scientific companies including Varian Associates, AVCO, Sylvania Electric Products, the Ford Instrument Company, and RCA; his projects ranged from low-level light detection and x-ray image intensification to the design of the nuclear reactor controls of the first SEA WOLF, the second atomic powered submarine. In 1972, Bates left Varian and accepted a position in Stanford University's Materials Science and Engineering and Electrical Department. Bates continued to work at Stanford for the next twenty-two years, where he helped to organize the Society of Black Scientists and Engineers. In 1984, Bates accepted the position of associate dean for graduate education and research at Howard University's College of Engineering, Architecture, and Computer Sciences. Throughout the course of his career, Bates authored numerous publications. Bates also continued to be committed to increasing the number of African Americans in the science and engineering fields and the number of scientific research projects at predominately black colleges and universities.

Bates and his wife, Priscilla, raised three children: Katherine, Christopher and Naomi.

Discussion Questions

Personal:

1. What did you like best about listening to Dr. Bates?

2. Where was Dr. Bates 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. Bates attend high school? What do you suppose high school was like for him?

3. How old are you? In what year was Dr. Bates your age? What was happening in the country that year? What was happening in the world that year? What do you suppose his life was like when he was your age?

4. Dr. Bates talks about taking a dream of his and figuring out how to make it come true. What was his dream? What do you dream about doing? What can you see yourself doing as an adult? **(See Clip #1)**

5. Dr. Bates talks about his obstacles. What were they? How did he get around them? What obstacles might prevent you from making your dreams come true? What can you do to get around them? **(See Clip #2)**

6. Dr. Bates also talks about failure. How did he handle failure? What was the result? Have you ever failed at something? How did you handle it? What does Dr. Bates say is the key to dealing with failure? Zig Ziglar has said, "Failure is an event, not a person." What do you think this means? How can you apply this to your life? **(See Clip #2)**

7. Why did Dr. Bates go to Washington University for his Ph.D.? Has there ever been anyone that you admired and wanted to work with? What drew you to that person? How did that person affect your life? Going forward, who are the people that you are looking to inspire you? Where do you think this will lead? Is there anyone who admires you? What can you do to point that person in a positive direction? **(See Clip #3)**

8. Dr. Bates and Dr. Walter Massey were roommates. They both achieved great things in science. Who are your close friends? What do you think your friends will achieve? Do any of your friends share the same interests as you? How can you help each other succeed? **(See Clip #3)**

Science:

9. What do you think a physicist does? Would you like to be a physicist? Why?

10. If you were a physicist, what kinds of questions would you study?

11. What do you think an electrical engineer does? Would you like to be an electrical engineer? Why?

12. If you were an electrical engineer, what kinds of problems would you solve?

13. What was Dr. Bates' proudest scientific accomplishment? Explain why this was the case. What has been your proudest achievement? Why? **(See Clip #4)**

14. Dr. Bates talks about his research. He is trying to find out how to make better detectors for infrared radiation. Though the work is progressing well, he is trying to take things in a different direction. What direction is that? Why do you think this direction is important? What could this mean for you as a future scientist? **(See Clip #5)**

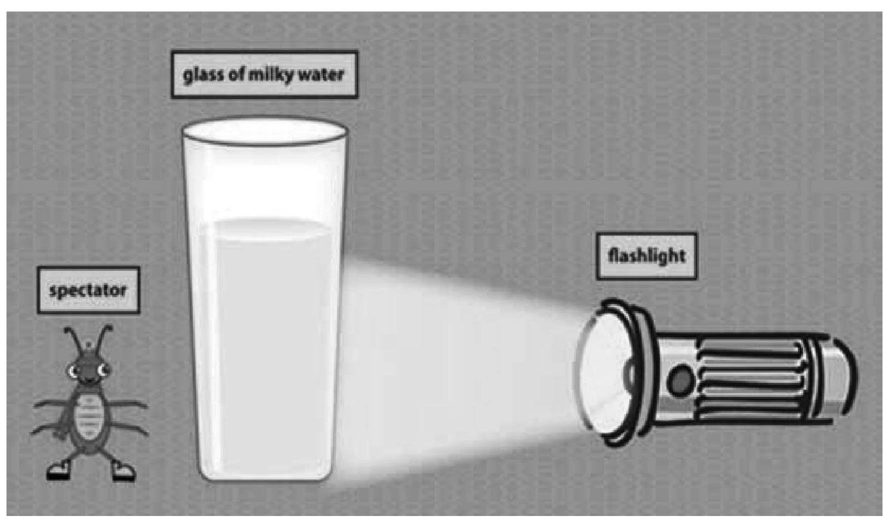
15. Dr. Bates works on developing new ways of detecting information. Other than through your eyes, how do you find out about the world? What are tools that we have today to help us "see" when our eyesight is not available? [Teacher's note: infrared, sonar, radar, radio telescopes, etc.] How do we use these tools? Are there any other ways of seeing? What happens when these tools are not enough? Can you think of other ways to gather information? How can you design equipment to take advantage of that? **(See Clip #5)**

16. Why do you think that Dr. Bates wants his research to happen at Howard University? What is an HBCU? Research the formation and background of a particular HBCU and report your findings to the class. **(See Clip #5)**

Experiment - Big O' Glass of Sunset!

This experiment was developed by Physics Central.

See why the sky is blue and a sunset is orange, all in a glass of milk!



Materials:
-Tall clear glass of water
-tablespoon of milk
-Flashlight

Instructions:
1. Stir the milk into the water.

2. Shine the flashlight from the side of the glass and observe the glass. What color is it?

3. Look directly at the flashlight through the glass. What color is it?

4. Shine the flashlight up through the bottom of the glass and look down from the top. What color do you see now?

Questions:
Imagine that the flashlight is the sun and the glass is the atmosphere when you look at them from the side. What time of day do you think this view corresponds to?

What about when you look at the flashlight from behind, or look through the bottom of the glass?

Why does the sky look blue during the day, but when you look at the sun during a sunset it looks orange?

Why do you think pollution, though very bad, makes more beautiful sunsets?

Discussion:
When light interacts with a particle, some of it is scattered while some goes through. Lord John W. S. Rayleigh (1842-1919) discovered that some colors of light are scattered more than others. In our atmosphere, blue light is scattered more than red or yellow light. During the day we don't look directly at the sun, so we are only seeing the scattered light, which is blue. However, during a sunset, when the sun is low in the sky, we are looking at it more directly. We see the yellow and orange light that is not being scattered but is passing through the atmosphere to our eyes.

In this experiment, the milk particles are doing the scattering. Just like the light from the sun, the light from the flashlight is made up of many colors. The milk in the glass is scattering the blue light but allowing the yellow and orange light to pass through. This makes the milk appear blue when looked at from the side, but yellow when looking straight at the flashlight.

Suggested Resources:
SCIENCE MADE SIMPLE, INC, Why is the Sky Blue
WhySkyBlue Enterprises, Why is the Sky Blue?
Ask A Physicist: Explain how beautiful sunrises and sunsets are the result of dust in the atmosphere?
Bibliography: Cobb, Vicki, and Cobb, Josh. Light Action!. New York: HarperCollins, 1993

See this experiment online at: http://www.physicscentral.com/experiment/physicsathome/sunset.cfm

Clayton Bates, Jr. - Video Clip Transcription

Clip 1 - Wanting to be a Pilot: I dreamed of becoming, as I said, I wanted to become a pilot, I got to designing airplanes, but I just realized at that time I had to wear corrective lenses, wear eyeglasses and they were very strict then. I knew I wasn't gonna become a pilot and so I took to building airplanes and designing them and so the dreams were to become an engineer, so it was never a question of what I was going to do or become, but just how I was going to go about doing it.

Clip 2 - Dealing with Failure: I went to Brooklyn Technical High School and you have to take an entrance examination to get into the high school and I remember I took it when I could the first time with a gentleman I still remember his name, I don't know why, my wife accuses me of remembering things that are totally useless, but Harry Waldheim was his name. Well, he passed the first time, and I didn't, I, you know, that hurt me very, very much, but I did take it the second time, the year after, did get in, and did extremely well, was very interested, graduated well ahead of, you know, Harry when he was there, I graduated about fifth in the class of over 600 students. so I did very [well]. Once I got in, it was fine, but I didn't pass the exam the first time to get in, and

I’ve never been set back by failure, I want to mention that, and that was one of the first times that that happened because I always believed in myself and what I could and couldn’t do and I knew what I wanted to do and what I liked to do and so, you know, failure’s going to happen, that is never something [that] has beaten me down into the ground, and I’ve failed a number of times, in a number of undertakings.

Clip 3 - Washington University: I got my Ph.D. from Washington University in St. Louis, and the reason I went to Washington University in St. Louis was because of a gentleman who was there that I had read about and I was interested in doing research with, and…it was very interesting because Walter Massey, who’s the president of Morehouse University, and I were roommates. It’s very interesting, at the time. And I didn’t think of it in racial terms, you know, ‘cause even when I was in engineering, I was the only, you know, black person in the class. It was science, this is what I was interested in doing and at that time I was moving more to the area in physics, you know, more so than, than engineering. And so I didn’t think of it, you know, in racial terms even though, you know, we were the only two blacks at Washington University, and we were the first two to get Ph.D.s in the department there and I don’t think they’ve had any since that time.

Clip 4 - Proudest Accomplishment: My proudest scientific accomplishment had to do with the determination of the structure of a surface that is that, you know, has applications optoelectronic applications, that has been around since the ‘20s, 1920s, and that my students and I, when I was at Stanford, we determined what that microstructure was and it has led to other work, to the work that I’m doing now. That was my, I think, my greatest scientific, in my mind, anyhow.

Clip 5 - Work at Howard University: I’m involved in some research now which has the possibility of really, you know, some cutting edge research that has a possibility of producing a new class of detectors for detecting infrared radiation and so I’m still heavily involved with that, I have students, I have a post doc, so that is my main focus at this time now, it’s just, you know, doing this research because this is, you know, as I said, I find it very interesting. I spent a fair amount of time developing the ideas and concepts for the research and am now getting as much support as I can, I can really handle. So that’s what I’m doing now, but I want this research to be done at Howard, at a black institution, something new and cutting edge, and not at a majority institution. That’s the point.

ScienceMakers

Spotlight: George Campbell, Jr.

Full Name:	George W. Campbell, Jr.
Born:	December 2, 1945
Place:	Richmond, VA
Parents:	Lillian Britt Campbell
	George W. Campbell, Sr.
Spouse:	Dr. Mary Schmidt Campbell
Education:	Central High School - Philadelphia, PA (1963)
	Drexel University - Philadelphia, PA (B.S. Physics, 1968)
	Syracuse University - Syracuse, NY (Ph.D. Theoretical Physics, 1977)
Type of Science:	Physics
Achievements:	Helped develop the third generation of telecommunication satellites
	President and CEO of the National Action Council for Minorities in Engineering (NACME)

Favorites:

Food:	Seafood
Time of Year:	All Four Seasons

Biography

Dr. George W. Campbell, Jr., was born on December 2, 1945, in Richmond, Virginia, the eldest in a family with two boys. Campbell graduated with his B.S. degree in physics in 1968 from Drexel University, where he was a Guggenheim Scholar. While at Drexel, Campbell met his future wife, Mary, whom he tutored in physics; the couple married in 1968 before both going on to graduate studies at Syracuse University. Even as impoverished graduate students, the Campbells took an interest in art and used what little disposable income they had to start their own collection. Campbell's passion for art was so strong that he once considered a career as a painter instead of a scientist.

In 1977, Campbell received his Ph.D. in theoretical physics and began working in academic positions at Syracuse University and later at Nkumbi International College in Zambia, where he taught physics and conducted research. Soon, Campbell left to take a position at AT&T Bell Laboratories, where he would stay for the next twelve years, occupying various research and design and management positions. During his time at Bell Labs, Campbell helped develop the third generation of telecommunication satellites and served as a United States delegate to the International Telecommunications Union.

After his tenure at Bell Labs, Campbell became president and CEO of the National Action Council for Minorities in Engineering (NACME), a nonprofit organization designed to open doors of opportunity for young people interested in the field of engineering. Under Campbell's leadership, NACME's public funding nearly tripled, and the organization was recognized with a U.S. Presidential Award for Excellence. In July 2000, Oxford University Press published "Access Denied: Race, Ethnicity and Scientific Enterprise," which Dr. Campbell co-edited.

On July 1, 2000, Campbell returned to academia when he became the first African American president of Cooper Union, a private university in New York City. Campbell is the recipient of numerous awards and honors. He and his wife, Dr. Mary Schmidt Campbell, the Dean of New York University's Tisch School of Arts, raised three sons, the eldest of whom, Garikai, is a professor of Mathematics at Swarthmore College.

Discussion Questions

Personal:

1. What did you like best about listening to Dr. Campbell?

2. Where was Dr. Campbell 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. Campbell attend high school? What do you suppose high school was like for him?

3. How old are you? In what year was Dr. Campbell your age? What was happening in the country that year? What was happening in the world that year? What do you suppose his life was like when he was your age?

4. Dr. Campbell talks about his experiences as a child. What was his childhood like? Was his experience what you would expect from a scientist? Why or why not? What kinds of things would you expect to learn outside of school? How can these things benefit you as a person? Dr. Campbell talks about knowing when to walk away from his life on the street. How important do you think this decision was to his success later in life? Why? **(See Clip #1)**

5. Did Dr. Campbell know that he wanted to be a physicist when he first left for college? What were some of his other interests? Why did Dr. Campbell decide to pursue physics? What are some of your interests? Do any of your interests require you to give up other things that you like? Based on your interests and your skills, what are three possible careers that you could pursue? What would you need to study in high school and/or college to prepare for these careers? **(See Clip #2)**

Science:

6. What do you think a physicist does? Would you like to be a physicist? Why?

7. If you were a physicist, what kinds of questions would you study?

8. Dr. Campbell talks about some of his interests at school. He mentions that a scientist from Bell Labs would give an annual talk and show off some of the new technological innovations. What were some of those innovations? What are some of the newest technological innovations that you can think of? How do you think they were developed? What kinds of innovations do you think will happen next? How can you be a part of that process? **(See Clip #2)**

9. Dr. Campbell explains the basis of the high-energy physics that he studies. He says that it is the quest of those in his field to find the fundamental particles (building blocks) of the universe. He briefly describes the history of this search. Do your own research on the history of particle physics and describe each major development in our understanding of the fundamental particles in the universe. **(See Clip #3)**

10. Dr. Campbell mentions being a theoretical physicist. What is the difference between a theoretical physicist and an experimental physicist? What are the benefits of basic research? **(See Clip #4)**

11. Research Bell Labs. How did it start? What were some of its greatest technological achievements? What happened to Bell Labs? Describe the effect that Bell Labs has had on our modern way of life from a technological standpoint.

12. What does NACME stand for? Research the organization and report back to the class. What is the benefit of an organization such as this? How might this organization benefit you? **(See Biography)**

Experiment - Physics in a Toroidal Vortex: Air Cannon

This experiment was developed by Physics Central.

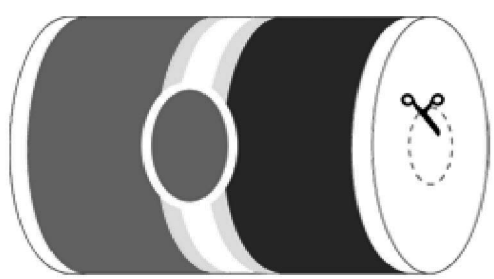
You are about to build your very own toroidal vortex generator. This device will efficiently transport air across the room in a dazzling display of fluid dynamics.

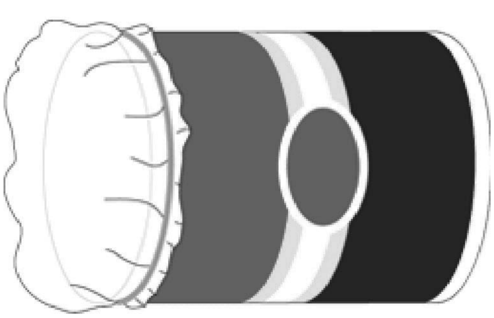
What you Need

Oatmeal container
Plastic bag
Tape
Scissors or sturdy knife (Caution: ask an adult to help you use these tools)

What to Do

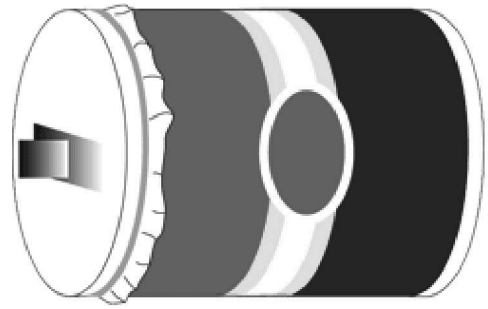
First you want to cut a hole in the bottom of the bucket or oatmeal container. Cutting a hole in the cardboard of the oatmeal container will be easier than the plastic bucket. Use the scissors to puncture a hole in the center and then cut out a circle that is 2 inches in diameter. Don't worry; the hole does not have to be perfectly circular, as you will see later.

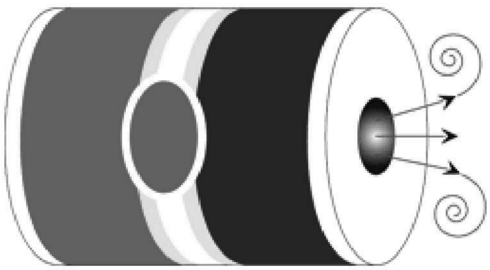




Next, tape the plastic bag over the opening opposite the hole. Make sure you tape the bag to the container so that it does not contain any air leaks. The bag should be slightly taut. The taut flexible surface of the bag is called a membrane. It is important to have fancy names when your equipment is simple. Hence, the membrane of your toroidal vortex generator sounds more sophisticated than the bag on your bucket.

Use a small piece of tape to make a handle that you can pinch with your fingers on the center of the membrane. Fold the tape so that it sticks to itself, but leave the ends free to stick to the membrane.





Now you can pull and push on the membrane. Pull back slowly and push the membrane quickly while aiming the hole towards a target. Anything flexible makes a good target: your friend's hair, posters, cats, candles (be careful with fire and hot wax, ask an adult to assist you).

What's Going On?

When the membrane thrusts a burst of air out of the hole, it displaces the surrounding air out side. The surrounding air swirls around in the shape of a twisting doughnut. The twisting doughnut will carry the original burst of air as far as 50 feet away.

The physics of moving air is called fluid dynamics. It may seem strange to call air a fluid, but the motion of gases and liquids is very similar. When a fluid twists or swirls, we call it a vortex. Again, note the advantage of using the fancy word vortex over the word swirl. Swirl is used when talking about the physics of ice cream. Can you think of where you might observe a vortex at home? Look in the bathtub, sink, or toilet. Now, our cannon generates very special vortices that differ from those found in the bathroom. They twist in the shape of a doughnut and the mathematical name for this is called a toroid. Hence, our cannon generates toroidal vortices. Vortices are amazing phenomena because the motion of the air is stable and doesn't require any outside intervention to keep it going. For instance, try blowing a burst of air with your mouth. This is an unstable burst of air that disperses by the time it reaches an arms length. A toroidal vortex, on the other hand, will travel all the way across the room. Believe it or not, the mathematics of vortices is exciting too! You will find that out when you get to college. When you get there, be sure to check the box labeled "PHYSICS" as your major.

Try This!

If you have a fog machine, then you can observe the shape of the toroidal vortex created by your air cannon. You can also put some flour inside a bucket and shake it up to simulate fog. If dry ice is available, that will work too.

See if you can use your toroidal vortex generator as smell cannon. Not all science has to be done with the eyes. Spray some perfume into the hole and see if you can send someone fragrant vortex. You can also try sending blasts of hot air or cold air.

Experiment with holes of different sizes. Will a smaller hole affect the velocity of the vortex? How small and how big can the hole be?

Experiment with holes of different shapes. Can you make a triangular fog vortex or a square?
What happens when two vortices crash into each other? Try it with a friend.

See this experiment online at: http://www.physicscentral.com/experiment/physicsathome/cannon.cfm

George Campbell, Jr. - Video Clip Transcription

Clip 1 - Street Kid: The, I was kind of a street kid, and you know, I wasn't, you know, formal, serious member of the gang like the Crips and so on today, but you know, I was in gang fights, and all those kinds of things. You know, we didn't, in those days, we didn't have high-powered weapons like they have now. I mean, we had things like top guns, where you know, you take a board and you have rubber bands and you flatten out bottle caps and you shoot people with them. We had stuff like that as weapons and so, which can hurt people, but not kill them like, like we tend to do now. So you know, I had, I learned a lot of stuff on the streets that I think also served me well. And quite frankly, I was lucky, I mean, I think there are plenty of times in the course of my career when I could have gone in a variety of different directions. I could have, you know, gotten into some things that I shouldn't have, and…and was very fortunate. One might say that I had, you know, was given certain gifts, and the confluence of fortunate events took place in the course of my life which allowed me to have the kind of opportunities that I've had.

Clip 2 - Interest in Physics:
I guess in high school I had a very intense curriculum at Central High School in Philadelphia. It was an extraordinary curriculum. We had a number of professors or teachers who had Ph.D.s and so on. You know, it was sort of Philadelphia's answer to Stuyvesant here in New York or Bronx High School of Science. And although the focus was not on science, it was a very broad academic curriculum. But we had, certainly had great math and science teachers and you know, one of the things that really stimulated my interest is that every year, once a year, we had a scientist. Philadelphia's not too far from where Bell Laboratories is and you know, in those days Bell Labs was the premier research enterprise in the world and you know, many Nobel Laureates and so on. And because Central was such a high profile academic school, Bell Labs used to send one of its physicists to, once a year, to give a gee-whiz talk on all the latest developments and technologies that were emerging from Bell Labs, and that was not too long after the transistor had been invented. The first satellites had been launched by Bell Labs. The laser had been invented there and so on, and solar cells, and so we had this spectacular performance really, by a physicist once a year who came and showed off all this, you know, solar cells mounted on little cars, and he predicted that by 1975 all cars would be powered by solar cells and so his predictions didn't all come true, but it was a wonderful talk and it certainly piqued my interest about this fascinating field of physics… And it wasn't until my junior year in college or, you know, it was a five-year program so it was really the third year that I took this modern physics course and that's when it really solidified for me that this is, this is... But I suspect that in the back of my mind I already had some inkling toward physics, even though I hadn't sort of consciously decided. Because of those kinds of early experiences. And it made a nice story for the P.R. at Bell Labs because, you know, I did wind up after my Ph.D. going to work at Bell Labs and so it was kind of, I started getting influenced, you know, black kid in the black neighborhood of Philadelphia having this influence from a Bell Lab scientist and wind up actually being there.

Clip 3 - High Energy Physics: As the energy levels in our experimental physics arena increased, new, more and more particles were being discovered, and so the objective was to try and understand the relationship of these particles, the assumption being that there are a limited number of fundamental elements, building blocks, that comprise all of the materials that exist in nature, or that one can create by various means. At one time it was thought that the atom was the fundamental building block and there were different kinds of atoms and the different atoms were elements. Then we discover that the atom in fact had protons and neutrons and electrons and so they were believed to be the fundamental building blocks and then we discovered that in fact that if you smash protons together, you found other particles and so the number of particles kept proliferating and the question was how do we organize these, what are the fundamental blocks...and how does it all fit together to yield the incredibly rich array of materials and interactions that we actually see and observe in the macroscopic world and so that was the...that's the field of theoretical physics.

Clip 4 - Going to Bell Labs: Basically theoretical physics was primarily an academic enterprise. I mean, it's not a, you know, not something an industry is interested in, except places like Bell Labs and there were very few places like Bell Labs in those days. Bell Labs, you know, AT&T, Bell System was a monopoly and it was through the existence of monopoly that Bell Labs existed. It was funded by the monopoly telephone company which allowed them to do basic research in a whole array of areas, not necessarily related to products or industrial, you know, revenue generating kinds of things. And so you know, they did basic research in astrophysics as well as things that were purely academic. I mean, it was very much an academic enterprise, parts of Bell Labs in those days. But basically, there were very few other places to do theoretical physics except the academic world. And so yeah, my expectation in doing theoretical physics, that I would remain in academia and go on to teach at a university, I wasn't even thinking about Bell Labs as a matter of fact, when I was in graduate school, it wasn't until I was basically recruited by the labs that I even gave it any consideration.

ScienceMakers

Spotlight: Darnell Diggs

Full Name:	Darnell Eugene Diggs
Born:	May 20, 1970
Place:	Tuskegee, AL
Parents:	Janie Mae Davenport Diggs
	John Diggs
Education:	Pike County High School - Petersburg, VA (1988)
	Alabama A&M University - Normal, AL (B.A. Physics, 1992)
	Michigan State University - East Lansing, MI (Ph.D. Physics, 2001)
Type of Science:	Physics
Achievements:	Works to improve polymer-based electro-optic modulators for the Air Force
	Black Engineer of the Year Award (2004)

Favorites:

Color:	Brown & Blue
Food:	Green Beans
Quote:	“I can, and I will.”
Time of Year:	Christmas
Vacation Spot:	Sydney, Australia

Biography

Research physicist Darnell Eugene Diggs was born on May 20, 1970, in Tuskegee, Alabama, to Janie Mae Davenport Diggs and John Diggs. Diggs and his twin sister were the youngest in a family of fifteen children. Diggs attended Pike County Elementary School and Pike County High School, where he was registered in advanced placement classes and played the trumpet in the school marching band.

Diggs followed in his family’s tradition by enrolling at Alabama A&M University in Normal, Alabama. While a freshman, he majored in business management and sang in the university choir. Diggs changed his major to physics at the end of his sophomore year after performing well in a physical science class; he graduated with his B.S. degree in physics in 1988. Inspired by members of the National Conference of Black Physics Students and the Society of Physics Students, of which he served as president, Diggs remained at Alabama A&M University where he earned his M.S. degree in physics in 1997. After holding internships at the University of Wisconsin and the University of Alabama in Huntsville, Diggs earned his Ph.D. degree in physics in 2001.

Diggs was hired by the United States Air Force Research Laboratory as a research physicist in 2002. There, he worked to improve polymer-based electro-optic modulators that provide critical advantages over devices made from other materials. Diggs' work proved crucial to the United States Air Force's development of new optoelectronic devices, a vital element of the country's national defense. Through his work, Diggs collaborated with Tyndall Air Force Base, Georgia Tech Research Institute, the Army Strategic Missile Command, the University of Dayton, and Alabama A&M University.

In 2004, Diggs received the Black Engineer of the Year Award in the category of Promising Scientist in Government. Science Spectrum Magazine named Diggs one of the 50 Most Important Blacks in Research Science in 2004 and a Top Minority in Science in 2005. The World Year of Physics 2005 also recognized Diggs as one of five Distinguished African American Physicists. In 2006, Diggs was invited to speak at the U.S. Air Force & Taiwan Nanoscience Initiative held in Taipei, Taiwan. In 2007, he became president of the Dayton Alumni Extension for the National Society of Black Engineers.

In addition to his activities in the sciences, Diggs also served as an ordained Elder in the Church of God in Christ.

Discussion Questions

Personal:

1. What did you like best about listening to Dr. Diggs?

2. What do you think Dr. Diggs' favorite quote means? What does this tell you about him?

3. Where was Dr. Diggs 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. Diggs attend high school? What do you suppose high school was like for him?

4. How old are you? In what year was Dr. Diggs your age? What was happening in the country that year? What was happening in the world that year? What do you suppose his life was like when he was your age?

5. How did Dr. Diggs get started in physics? Have you ever found something that you did particularly well? What was it? If not, what do you enjoy doing? How could you use that skill or talent in a career? **(See Clip #1)**

6. Dr. Diggs talks about his persistence in studying physics. What did it involve? Have you ever come across something that challenged you in a similar way? How did you handle the challenge? How did Dr. Diggs handle his challenge? What did this lead to? What is the value of doing things that are challenging for you? **(See Clip #1)**

7. Were Dr. Diggs' grades always at the top? What happened as a result? What did he do to improve the situation? Do you think that your grades tell the whole story about you academically? If so, what is that story? If not, what can you do to help your grades better reflect who you are as a student? **(See Clip #1)**

8. Who are the scientists that inspired Dr. Diggs? How did they help him? Who inspires you? What is it about that person that you admire? How can the lessons you learn from that person help you in your career? What's the difference between a role model and a mentor? Which would you rather have? How could you seek out a role model or mentor? **(See Clip #2)**

9. Dr. Diggs talks about a professor who helped explain quantum mechanics to him. Have you ever had a teacher who explained something that you were struggling with particularly well? How did this help you? **(See Clip #2)**

Science:

10. What do you think a physicist does? Would you like to be a physicist? Why?

11. If you were a physicist, what kinds of questions would you study?

12. What did Dr. Diggs do at Space Camp? Have you ever had to teach someone how to do something? What was that experience like? Would you ever teach again? What would you teach? Can you only teach in school? Where are some of the places that you have taught? **(See Clip #4)**

13. What was the subject of Dr. Diggs' Master's thesis? Explain in detail what he was studying. How could you apply this work to the real world? **(Clip #3)**

14. Dr. Diggs did his thesis working with fiber optics. Have you ever heard of fiber optics? Fiber optic cabling is possible because of Total Internal Reflection. Find out what this is and explain to the class. How do mirrors relate to fiber optics? **(See Clip #3)**

15. Dr. Diggs discusses the untapped intellectual potential within the minority community. Explain what he means by this. Why does this problem need to be solved? What are things that you can do to help solve this problem? **(See Clip #5)**

Experiment - The Collapsing Can by Dr. Bassam Shakhashiri

We are so accustomed to the pressure of the air around us that we don't even notice it. However, the air pressure is large enough to crush a soda can. You can see the air crush a can in this experiment.

For this experiment you will need:

- An empty aluminum soft-drink can
- A 2- or 3-liter (2- or 3-quart) saucepan
- A pair of kitchen tongs

Fill the saucepan with cold water. Put 15 milliliters (1 tablespoon) of water into the empty soft-drink can. Heat the can on the kitchen stove to boil the water. When the water boils, a cloud of condensed vapor will escape from the opening in the can. Allow the water to boil for about 30 seconds. Using the tongs, grasp the can and quickly invert it and dip it into the water in the pan. The can will collapse almost instantaneously.

What caused the can to collapse? When you heated the can you caused the water in it to boil. The vapor from the boiling water pushed air out of the can. When the can was filled with water vapor, you cooled it suddenly by inverting it in water. Cooling the can caused the water vapor in the can to condense, creating a partial vacuum. The extremely low pressure of the partial vacuum inside the can made it possible for the pressure of the air outside the can to crush it.

A can is crushed when the pressure outside is greater than the pressure inside, and the pressure difference is greater than the can is able to withstand. You can crush an open aluminum can with your hand. When you squeeze the can, the pressure outside becomes greater than the pressure inside. If you squeeze hard enough, the can collapses. Usually, the air pressure inside an open can is the same as the pressure outside. However, in this experiment, the air was driven out of the can and replaced by water vapor. When the water vapor condensed, the pressure inside the can became much less than the air pressure outside. Then the air outside crushed the can.

When the water vapor inside the can condensed, the can was empty. You may have expected the water in the pan to fill the can through the hole in the can. Some water from the pan may do this. However, the water cannot flow into the can fast enough to fill the can before the air outside crushes it.

CAUTION: Do not heat the can over high heat or heat the can when it is empty. This may cause the ink on the can to burn or the aluminum to melt.

For additional information:
CHEMICAL DEMONSTRATIONS: A Handbook for Teachers of Chemistry, Volume 2, by Bassam Z. Shakhashiri, The University of Wisconsin Press, 2537 Daniels Street, Madison, Wisconsin 53704.

Find this experiment online at: http://scifun.org/HomeExpts/COLLAPSE.html

Darnell Diggs - Video Clip Transcription

Physics

Clip 1 - Changing Majors: I had a physical science course with a NASA physicist, his name was Donald Hodge, and I was excelling in his course and he was like, "Are you sure you're in the right discipline?" And he was like "If I try physics, if I give you a scholarship, will you try it?" And I told him yes, and that's how I got into physics… Scholarship, but I think it's more for minority students, getting minority students into the STEM disciplines, when I say STEM, it's science, technology, engineering, math. So, it wasn't an academic scholarship but it was money available to major in physics…I didn't have physics in high school, so I didn't know what it was, I didn't know what I was declaring as a major. Then I took it and I felt it - actually I got a D on my transcript but I failed the course, but we had a comprehensive exam, and my professor was like, "Okay, whatever you make on the comprehensive exam, I will give you that grade," so I made a 61 on it and that was equivalent to a D at the time, that's what I have on my transcript. He said perhaps I need to change my major because nobody will hire anybody that's dumb…I knew I wasn't dumb, I mean, it was a different subject matter, it was a different way of thinking and going through high school, high school wasn't as difficult but physics was something different, I had to think differently so I had to sit down and you know, look inside myself and know that I could do it. But then I took it again and got a C which is really not, it was some improvement from an F to a C, then I went to the second part and got a B, then my grades started to incline.

Clip 2 - Experience with Physicists: I did not know any physicists, although I met one later on at the church I was going to. Dr. Paul Ruthford who is now an S.T., a senior scientist, which is equivalent to a general for the Army, he's a physicist, so I saw him…Then when I joined the Physics Department and started going to the National Conference of Black Physicists, National Conference of Black Physics Students, or heard of people like Shirley Ann Jackson, who was the first black woman to receive a Ph.D., it just happened to be in physics from MIT, and now she's the highest-paid college president in the nation at RPI, Rensselaer Polytechnic Institute. They had a conference, they would fly us in every year to promote African Americans in science and engineering…When I went to the conferences and saw that there is a community of African American physicists, then I knew then that is reality…I met Bill Gates, I met Keith Jackson… not the Microsoft Bill Gates, this is the black physicist, interesting hairstyle, University of Maryland, College Park, string theory guy. I met him during a tutorial on quantum mechanics and he's brilliant, as a matter of fact I always credit him in terms of helping me pass my qualifiers for the Ph.D. There's an exam you have to take in order to be a Ph.D. candidate, and you only have two tries. If you fail it, then you have to go into another discipline. But he broke quantum mechanics down so easy, it was like I couldn't believe how simple it was, and he convinced me that it really is that simple, that a lot of times people who teach it make it very difficult, so it was very simple, he was very brilliant in doing that.

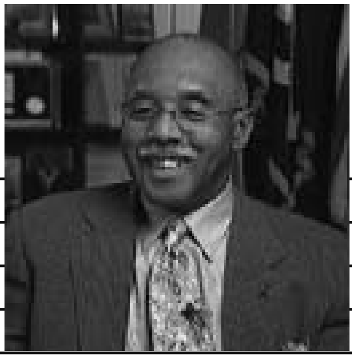
Clip 3 - Master's Thesis: My thesis was in fiber optics…I built a fiber optic temperature sensor…basically a fiber that had built a glass oven around the fiber and then we put like a bunsen burner under the glass and see as the light propagates through the heated portion of the fiber, see what it looks like on the exit end of the fiber. If you heat the fiber up, it's going to expand and contract and it's going to change. So it was a temperature sensor, sensing heat.

Clip 4 - Working at Space Camp: I was what they called at the time an educational lecturer at the Space Camp and I taught astronomy and optics and…I did telescope viewing and those types of things for the students. Taught Mars exploration, the space shuttle timeline to the kids. Taught them what it, how they eat in space. How they sleep in space. How they prepare their food. How they use the restroom. That was one of the main questions kids wanted to know. You know, those type of things…There is such a thing called, they call it the slinger, you know, when you use the restroom, if you have to use as they call the number two. You have to be strapped in because you know, the kids say, you know, what happens, these are the kids' questions, like what happens if you pass gas? Do you become a solid rocket booster? Because you're in zero gravity so you have to be strapped in, you know and held down and do your thing.

Clip 5 - Intellectual Capital: There's a great deal of intellectual capital that exists in the minority community and the, and females. I was reading on article that said if…The way we do not use the talent or the wealth that we find among women in science. The stock market wouldn't do that. It would be considered a tremendous waste. And I agree with that…It's just untapped. It's not encouraged 'cause when you talk about in the homes… Most people want their son to be a doctor, a lawyer, a teacher, a fireman, or a policeman, but you never, you rarely hear, unless they've been exposed to science, a chemist, a physicist, or you know, an engineer. I didn't know what it was.

ScienceMakers

Spotlight: Julian Earls



Full Name:	Julian Manly Earls
Born:	November 22, 1942
Place:	Portsmouth, VA
Parents:	Ida Deberry Earls
	James Earls
Spouse:	Zenobia Earls
Education:	Crestwood High School - Chesapeake, VA (1960)
	Norfolk State University - Norfolk, VA (B.S. Physics, 1964)
	University of Rochester - Rochester, NY (M.S. Radiation Biology, 1965)
	University of Michigan - Ann Arbor, MI (Ph.D. Radiation Physics, 1973)
Type of Science:	Physics
Achievements:	Director of NASA's Glenn Research Center
	Awarded the Presidential Rank of Meritorious Executive

Favorites:

Color:	Black
Food:	Lemon Meringue Pie
Time of Year:	Spring
Vacation Spot:	Los Angeles

Biography

Scientist and administrator Julian Manly Earls holds six university degrees. Earls, a native of Portsmouth, Virginia, earned his B.S. degree in physics from Norfolk State University, his M.S. degree in radiation biology from the School of Medicine and Dentistry at the University of Rochester and his Ph.D. in radiation physics from the University of Michigan. Earls was also awarded honorary degrees by the College of Aeronautics in New York, Nova Southeastern University in Florida and North Carolina A&T State University. Earls also graduated from the Harvard Business School Program for Management Development.

In 2003, Earls was appointed to the position of Director of the National Aeronautics and Space Administration's Glenn Research Center at Lewis Field in Cleveland, Ohio. In this role he was responsible for research, technology, and systems development programs in aeronautical propulsion, space propulsion, space power, space communications, and microgravity sciences. Earls managed an annual budget of approximately $773 million and oversaw a workforce of 1,920 civil service employees and 1,300 on-site support service contractors.

Earls, who began his career with NASA in 1965, has written dozens of publications for technical and educational journals, and NASA's first health physics guides. On two occasions Earls was awarded NASA medals for exceptional achievement and outstanding leadership. He was also awarded the Presidential Rank Award of Meritorious Executive.

Earls is a member of Kappa Alpha Psi Fraternity and a life member of the National Association for the Advancement of Colored People. Earls and his wife, Zenobia, reside in Beachwood, Ohio. The couple has raised two sons: Gregory and Julian, Jr. In addition to his professional activities, Earls, an avid runner, has logged over 10,000 miles and twenty-five marathons. He was given the honor of being a torchbearer for the 2002 Winter Olympic Games in Salt Lake City, Utah.

Discussion Questions

Personal:

1. What did you like best about listening to Dr. Earls?

2. Where was Dr. Earls 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. Earls attend high school? What do you suppose high school was like for him?

3. How old are you? In what year was Dr. Earls your age? What was happening in the country that year? What was happening in the world that year? What do you suppose his life was like when he was your age?

4. Dr. Earls talks about teachers that he had. Who were they? What did they teach? Why does Dr. Earls remember them? Think about a teacher you have had. What did they help to show you about the world? **(See Clip #1)**

5. Dr. Earls competed in math and science competitions between schools in Virginia. Why does he think they were so important? Have you ever competed against another school in academics? What about your class? What kinds of academic competitions are in your area? Find out more about one of them and present your findings to the class. **(See Clip #2)**

6. Dr. Earls had a very specific plan for his career and his college education. What was it? What happened instead? What did Professor Woods say to Dr. Earls about physics? Does that surprise you? Can you think of any other types of careers that share similar skills? Are there any skills you have that you think would be useful in a particular career? What are they? How can you find out which skills you will need for a career? Pick a career that interests you and report on what skills are needed to the class. **(See Clip #3)**

7. Dr. Earls talks about how he works with students. What kinds of things does he do? Do these things sound interesting? How do you relate to science and math? Do you enjoy it? If not, what would help you enjoy it more? **(See Clip #4)**

Science:

8. What do you think a physicist does? Would you like to be a physicist? Why?

9. If you were a physicist, what kinds of questions would you answer?

10. Dr. Earls talks about real-world problems that he works on with students. What is the project he describes? Many types of scientists and engineers work on something that already exists and try to make it better. Think about your neighborhood. Is there anything that could be improved, such as a road, an intersection, or a bridge? What is the problem? How could it be made better? What are the steps that you would take to fix this? **(See Clip #4)**

11. Have you ever wanted to be an astronaut? What does Dr. Earls say about the astronaut program? What kinds of people become astronauts? Do you have to be a pilot? Do you have to be in the military? What kinds of things could you study to be an astronaut? **(See Clip #5)**

12. What are Dr. Earls and NASA working on now? Do you remember the Columbia tragedy? What happened? What do you remember about it? Find out what went wrong on the shuttle and report back to the class. Ask your parents if they remember the Challenger disaster. What happened? Find out what went wrong on the shuttle and report back to the class. How are the two tragedies similar? How are they different? **(See Clip #6)**

13. Dr. Earls talks about the special ties he had to the astronauts on Columbia. What were they? Explain what micro-gravity experiments are. Why are they useful? Find examples of past micro-gravity experiments and report back to the class. **(See Clip #6)**

14. Dr. Earls talks about aeronautical engineering. What is aeronautical engineering? Understanding the forces of flight is very important in aeronautical engineering. Describe the forces of flight and how an airplane flies. What kinds of things do aeronautical engineers do? Can you think of other places where these skills might be useful? **(See Clip #4)**

Experiment - Rocket Balls: Conserving Energy but Creating Fun

This experiment was developed by Physics Central.

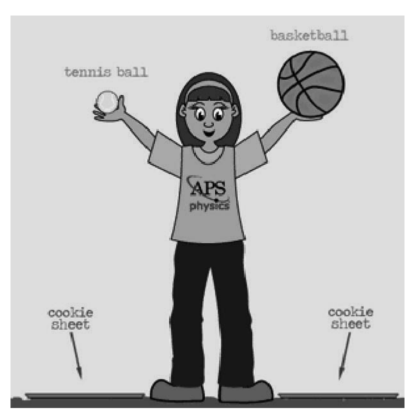
Will a ball bounce higher than it was dropped? You might say no, but come take a journey and allow a bug to tell you otherwise.

What you Need

Basketball
Tennis ball

What to Do

You are about to recreate history and defy your intuition about the laws of bouncing balls!



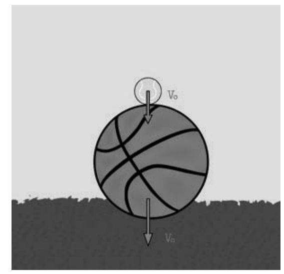
Take the basketball and the tennis ball and bounce each of them separately on a hard surface. Try bouncing them on a cookie sheet for fantastic sound effects! Listen carefully to the distinct sounds of each ball as it bounces. Your ears will play a more important role than your eyes in this experiment. Now hold the basketball in one hand and the tennis ball in the other so that they are poised at the same height above the ground. Examine each of them as you raise them high above your head. Contemplate their weight and size.

Ask gravity which ball it will pull down first. Will it be the heavy basketball or the small tennis ball? Listen to gravity and form a hypothesis.

Drum roll please! Now, release both balls at the same time. Watch, and more importantly, listen. Did you observe which ball was gravity's favorite?

The most important part of an observation is repeatability. An experiment is rarely perfect on the first try. In fact, it is never perfect. There is always some experimental error. Drop the balls several times and form a conclusion based on the average of your results.

After observing the balls drop several times, you may notice that they never bounce as high as their starting position. Why is this? Can you manage to bounce them higher than their initial height without throwing them down?

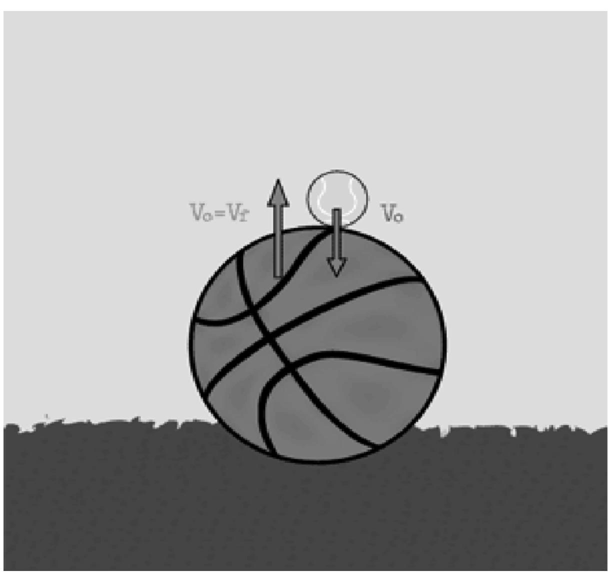


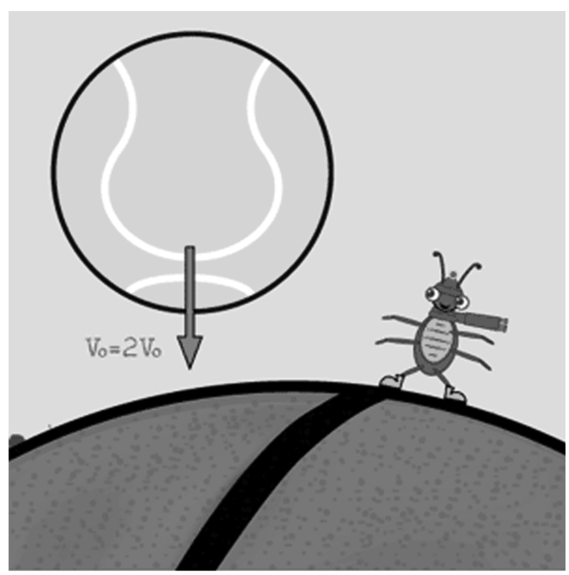
Perhaps if they worked together…

Now it is time to take this experiment outside or into a gym. Place the tennis ball on top of the basketball and gently release them together!

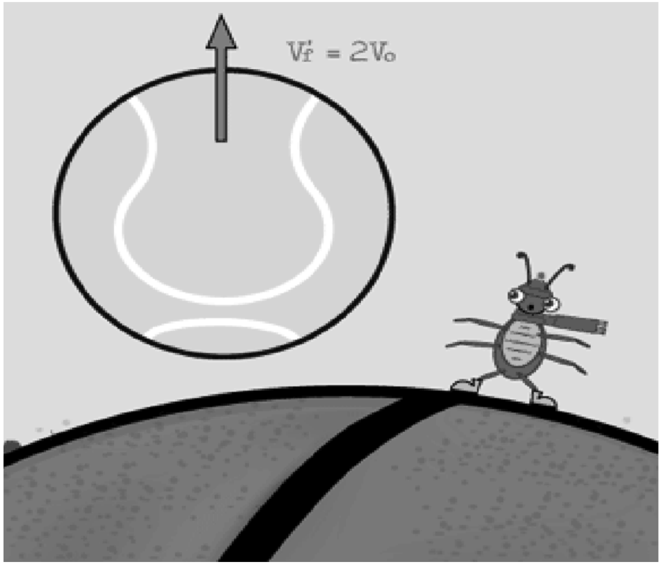
What's Going On?

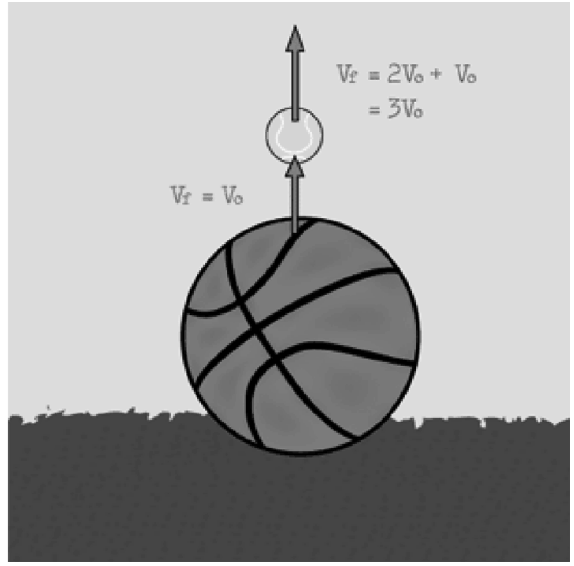
To see what happened in this super extraordinary bounce, we will need to take a journey and put ourselves in the shoes of a bug living on the basketball. (Since when do bugs wear shoes and live on basketballs? Since we started using our imagination!) From the perspective of the bug on the basketball, we fall and then bounce off the ground. Our velocity at impact is roughly 10mph. Due to the Law of Conservation of Energy, the basketball bounces up from the ground at about the same velocity that it hits the ground. (The bounce actually releases energy in the form of sound and heat. This causes the ball to bounce up negligibly slower than it impacted the ground.)





From the bug's point of view, we bounce up at about the same velocity of 10mph. At this moment, we see the tennis ball coming down upon us like a giant meteor. We brace ourselves for the impact and pause to think about how fast the tennis ball is speeding toward us. The tennis ball was falling with us the whole time at the same rate. Then we bounced first with a velocity of about 10 mph. Now this means that we are moving up from the ground at 10mph while the tennis ball is still falling down toward the ground at 10 mph. Here comes the slightly tricky part (but not really). From the bug's perspective on the basketball, we collide with the tennis ball at 20 mph-that is our up velocity plus the tennis ball's downward velocity.



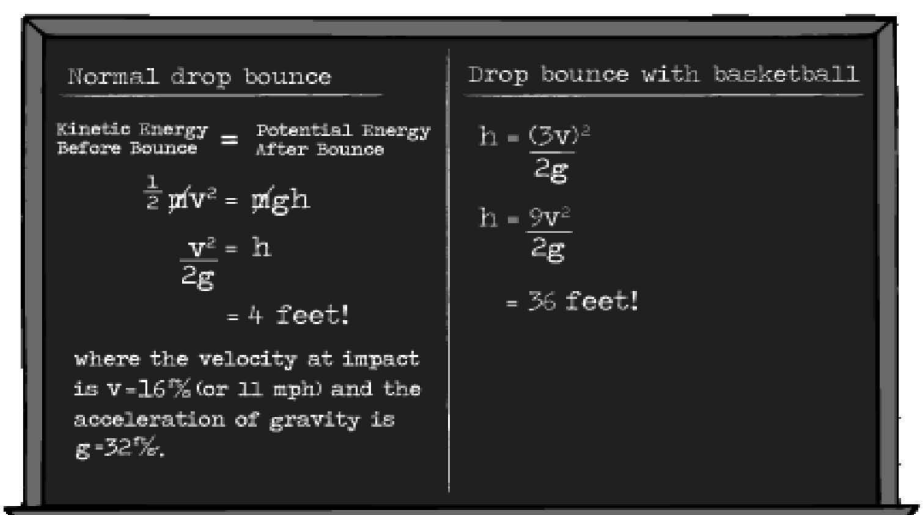


Chew on that thought for a moment and it will soon become clear. The physics of changing perspectives can be confusing. In fact, it's called relativity. Take your time. There is no need to rush. We will wait…

Welcome back. Now as we collide with the tennis ball, energy is once again conserved. This means that the tennis ball will bounce up and away from the basketball at the same velocity as during the impact (roughly 20 mph).

Let's jump back into our own shoes on the ground and conclude our observations. The basketball bounced up with some velocity (roughly 10 mph). At the same moment, the tennis ball bounced away from the basketball at twice that speed. Now putting this together, we see that the tennis ball is flying up away from the basketball at 20 mph plus the velocity of the basketball that it bounced off. This brings us to the conclusion that the tennis ball flies up into the air at 30 mph, which is three times the velocity at which it fell to the ground!

But why so high? It turns out that since the tennis ball flies up three times faster than it would without the basketball, that velocity translates into a lot of kinetic energy. As the tennis ball flies up into the air, gravity slows it down, converting all of that kinetic energy into potential energy. And the more potential energy the ball has, the higher it will go.



In the case of our current experiment, the tennis ball will fly up to nine times higher than it would without the help of the basketball.

See if you can best this value!

Try This!

Now to switch things up, you should try placing the basketball on top of the tennis ball. Will the basketball bounce higher?

Try adding a third ball, such as a ping pong ball, on top of the tennis ball. Can you figure out how fast the ping pong ball will fly up into the air?

Julian Earls - Video Clip Transcription

Clip 1 - Encouraging Teachers: I remember my fifth grade teacher was Ms. McKnight. She was the one who made me fall in love with mathematics because she used to play math games with us. She would come in with puzzles and brain teasers and made it fun. My eighth grade teacher was Ms. Louise Collard Brown, she was an English teacher and in those days she would have us diagramming English sentences and I don't even know if they still diagram sentences in classrooms anymore. But I remember the fun I had in her classroom, and then of course when I got to high school, there was my algebra teacher and I remember my shop teacher, Mr. Vick. I remember the principal of the school, Mr. Horton, and all of those teachers were special in a way.

Clip 2 - Math and Science Conferences: Now we had math and science conferences… In the State of Virginia, there was competition among all the black high schools within the state, and you would start in your school by taking tests in algebra, geometry, whatever, and then you would go from being successful there, you go to regional competition and go to state competitions. And you would actually compete with all the schools in those disciplines and you could win certificates. I had certificates that I'd won in geometry and algebra and then of course there were the science fairs as well. But there was that healthy competition among the schools that I don't even think that exists even in Virginia to this day.

Clip 3 - Decision to Major in Physics: I decided that I wanted to go to North Carolina A&T and major in electrical engineering. That was the only college that I considered. We had assembly programs as high school students and I remember the assembly program where this immaculately dressed man came in. It was one of the presenters, and I raised my hand and asked, "What do you do?" And he said he was an electrical engineer, and I said, "Well, how much money do you make?" And this was in 1956, '57, he said, "$200 a week," and I said, "That's what I want to do." Now this was probably my junior year in high school, so I decided I wanted to be an electrical engineer and my sole goal was to go to North Carolina A&T but I could not afford to go away to college. So, I ended up going to Norfolk State and they didn't have an engineering school. So I ended up majoring in physics as a result of a conversation with my major professor at that time, who turned out to be Dr. Roy Alexander Woods, who became like a second father to me. But I decided I was gonna make myself an electrical engineer by going to Norfolk State. I was going to take all the math in the math department and go to the industrial arts department and take all the courses for being an electrician and through that combination was going to make myself an electrical engineer. And I ended up taking a physics course and after the first test, he called me in, Dr. Woods, and said, "What do you plan to do?" And when I told him my plans he said, "Well, little brother, if you major in physics, you will find that physicists work as engineers quite often. But engineers do not work as physicists, so if you major in physics, that will give you more choices than even if you were an electrical engineer." And I said, okay, and that's how I ended up majoring in physics.

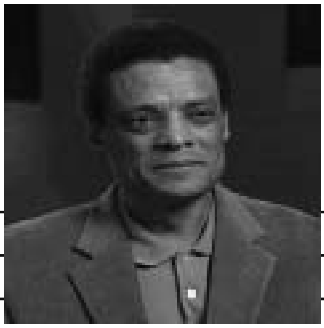
Clip 4 - Getting Youth Interested: With students, I try to get them to see that math and science can be fun. Every summer, I take all the high school students who are working here and all the college students who are working here and I take them for one day and put them together in our auditorium. And what I do is I do just like Ms. McKnight did with me, I start playing games. I'll have brain teasers, mind games that I play with them. Put them in groups, and have them laughing about some of the problems and the results that come from those, and word puzzles, and then I tell them what they can do if they stick with those math and science courses and the doors that will be open to them. I also then ask them to talk with the scientists and engineers here about what they do, and get our scientists and engineers to not put it in those lofty terms, put it in general terms that people are going to understand. For example, I try to get them to understand that in the field of aeronautics, one thing that's important is that jet engines have to be quieter because there are noise standards and people are concerned about the noise around airports. So we're trying to work on projects that will quiet jet engines such that if you're in the vicinity of the airport, that you really don't notice that the airport is there. That we confine the noise from those engines to the profile or the footprint of the airport itself. We talk about energy efficiency, how can we get these jet engines to be more fuel efficient. Those are the kinds of things that we try to do and everyone can relate to that in terms of the flow through. Trying to develop programs such that you don't have to have these delays in airports because of fog, or because of inclement weather, that you're able to have instrumentation that can see through that. Those are some real life experiences that students and everyone can get their, around which people can get their arms [around] and understand that those are the kinds of things we can do, as well as looking at space exploration which is critical to getting minorities in the astronaut program, females in the astronaut programs, and we get those astronauts to go out to the schools, especially if they're from that particular population, and let students see people who look like them, who are in these disciplines and we try to make sure that we do as much of that as we can.

Clip 5 - Astronaut Selection: When I applied for the astronaut program in 1977, there were over 8,000 applicants and they selected about 20 to 25. So, it is a very, very competitive process to become an astronaut. In fact, when I applied, it was the first time they opened up the astronaut corps up to non-pilots. Prior to that, you had to be military and you had to be a pilot. But then, they opened it up to civilians for mission specialists. So now, the technical background is a general requirement. Most of those astronauts have a Master's degree as a minimum, but they also opened it up to educated astronauts and this time, we've selected teachers who actually enter the astronaut corps and they're educator astronauts. So, they have been teachers in elementary or high schools or schools throughout the nation. They get selected and they go through the exact same training and become certified as astronauts with the intent that after they leave the astronaut corps, then they will have an impact on education and perhaps go back into the education system.

Clip 6 - Space Shuttle Columbia: We are now in the process within NASA of returning safely to flight. There was the Columbia accident investigation board that issued a report about the things we need to do to safely return to flight. We have implemented those recommendations. Just last Friday, the external tank was shipped down to Kennedy Space Center, and we're targeting an April or May time frame for returning shuttles safely to flight. But it was a great loss to the nation and to the agency and particularly for NASA Research Center because Columbia was on a science mission, unlike many of the missions that are destined for the space station for construction of the space station. This was a mission that was in lower orbit that had science experiments, what we call micro-gravity experiments, and those experiments were from NASA Glenn Research Center here in Cleveland. So those astronauts had come back and forth to Cleveland getting oriented on the experiments. So when we lost them, it was really a special blow to us because they were like family members for us with our experiments that were flying on Columbia.

ScienceMakers

Spotlight: Larry Gladney



Full Name:	Larry Donnie Gladney
Born:	August 9, 1957
Place:	Cleveland, MS
Parents:	Annie Lee Gladney
	Lucius Green Walker
Spouse:	Jacqueline Tanaka
Education:	East St. Louis High School - East St. Louis, IL (1975)
	Northwestern University - Evanston, IL (B.A. Physics, 1979)
	Stanford University - Palo Alto, CA (Ph.D. Physics, 1985)
Type of Science:	Particle Physics
Achievements:	Developed the third-level tau lepton triggers for the Collider Detector at Fermilab
	Made the first observation of an exclusive B meson decay in the Hadron Collider environment

Favorites:

Color:	Green
Food:	Fried Chicken
Time of Year:	Mid-Spring

Biography

Research physicist and professor Larry Donnie Gladney was born on August 9, 1957, in Cleveland, Mississippi, to Annie Lee Gladney and Lucius Green Walker. Raised by his mother in East St. Louis, Illinois, Gladney attended Alta Sita Elementary School and Clarke Junior High School. He graduated third in his class from East St. Louis High School in 1975. Keenly interested in the nature of matter, Gladney earned his B.A. degree in physics from Northwestern University in 1979, and he went on to Stanford University to earn his M.S. degree, then his Ph.D. in physics in 1985. Gladney pursued post-doctoral studies at the University of Pennsylvania from 1985 to 1988.

Gladney, teaching and conducting research at the University of Pennsylvania's Department of Physics in 1988, developed the third-level tau lepton triggers for the Collider Detector at Fermilab. From 1989 to 1994, Gladney served as a Presidential Young Investigator for the National Science Foundation. He was awarded a Lilly Teaching Fellowship in 1990, and by 1992, Gladney made the first observation of an exclusive B meson decay in the hadron collider environment. In 1997, Gladney received the coveted Edward A. Bouchet Award from the American Physical Society and the Martin Luther King, Jr., Lecturer Award from Wayne State University. By 2000, Gladney had been selected as the American representative to the Computing Coordinating Group for BaBar; he was then selected to head the Level 3 Trigger effort for the BaBar experiment at the SLAC PEP-II Collider. From 2003 to 2004, Gladney was a visiting scholar at the Lawrence Berkeley National Laboratory.

Gladney served as a member of the U.S. Army Science Advisory Board from 1997 to 2002. Gladney also served as a member of the High Energy Physics Advisory Panel for the Department of Energy and the National Science Foundation (NSF) in 2001, and other NSF and Department of Energy committees over the years, including Quarknet. Gladney later served as a member of the Advisory and Review Committee for the Origin and Structure of Matter project of the NSF.

Interested in the success of young people, Gladney was the recipient of the Outstanding Community Service Award from the Black Graduate Professional Students' Association at the University of Pennsylvania. Gladney was also an occasional lecturer on the subject of seeing and researching dark energy, and in 2006, appeared on a program entitled "The Three Cosmic Tenors: Exploring the Frontiers of Matter, Energy, Space and Time" with other black physicists James Gates and Herman B. White, Jr.

Discussion Questions

Personal:

1. What did you like best about listening to Dr. Gladney?

2. Where was Dr. Gladney 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. Gladney attend high school? What do you suppose high school was like for him?

3. How old are you? In what year was Dr. Gladney your age? What was happening in the country that year? What was happening in the world that year? What do you suppose his life was like when he was your age?

4. Dr. Gladney talks about flunking. What does he say was the reason? Did he deserve it? How did the situation get resolved? Have you ever flunked? How did that make you feel? What did you do about it? **(See Clip #1)**

5. Describe Dr. Gladney's "crisis" that he talks about. Why did he "hate" science? Does this make sense? How do you feel about science? Why? How did he resolve this crisis? How can you respond when you have a personal crisis? **(See Clip #2)**

6. What part did a school library play in Dr. Gladney's pursuit of physics? Do you ever go to the library? What kind of books do you read? Why? **(See Clip #2)**

Science:

7. What do you think a physicist does? Would you like to be a physicist? Why?

8. If you were a physicist, what kinds of questions would you study?

9. What was Dr. Gladney's first lesson about the culture of physics? Have you ever been in a similar situation? How did you handle it? What can you learn from Dr. Gladney's experience? **(See Clip #3)**

10. What did Dr. Gladney learn about asking for help from his first job in college? Have you ever been in a position where you didn't understand something? What did you do about it? Were you able to solve your problem? How? **(See Clip #4)**

11. What was the Manhattan Project? What significance did it play in the history of physics? In the history of the world? Dr. Gladney talks about a professor who discussed his role in the Manhattan Project. Have you ever used your knowledge to do something you knew was wrong? Has anyone ever used your knowledge for something you didn't intend? What were the consequences? What does Dr. Gladney say about knowledge like this? **(See Clip #5)**

12. Dr. Gladney discusses his thoughts on the accessibility of physics. What draws you to physics? Does anything push you away? How can you work through these two sides? **(See Clip #6)**

13. Physics is about understanding how the universe works. What is the mystery that Dr. Gladney is trying to solve about the beginning of the universe? What are two possibilities? Have you ever thought about questions like this? What are they? How would you go about trying to answer them? Can anything be known for sure? Why or why not? **(See Clip #7)**

14. What does Dr. Gladney want his legacy to be? Have you ever thought about what you will leave behind when you die? What do you want that to be? How do you want people to remember you? **(See Clip #8)**

Experiment

On the next page, view the instructions for making a linear accelerator, written by Simon Quellen Field.

See this experiment online at: http://www.kqed.org/quest/blog/2008/10/21/producers-notes-for-make-at-home-tabletop-linear-accelerator

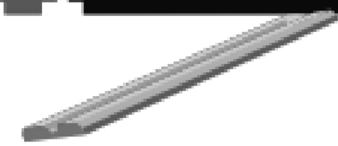
See the video: http://www.kqed.org/quest/television/make-it-at-home-tabletop-linear-accelerator

1+2+3 GAUSS RIFLE By Simon Quellen Field

A linear accelerator for studying high-energy physics costs around $ 5 billion. But you can make one for about 30 bucks with four strong magnets, a wooden ruler, some plastic tape, and nine steel balls.

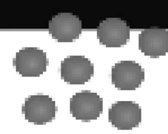
This easy project demonstrates the transfer of kinetic energy from one object to another. More importantly, it also shoots a steel ball really fast at the target of your choice. When each ball strikes the magnet in front of it, its kinetic energy is transferred to the next ball down the line. By the time the fourth ball shoots off the ruler, it possesses almost four times the energy of the first ball, which means it's moving faster, too. (The speed increase is proportional to the square root of the increase in kinetic energy.) This project takes just a few minutes to build once you have the parts, which can be ordered from *scitoys.com*.

1 GET

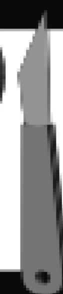


One 12" wooden ruler with a groove running through it

Four gold-plated neodymium-iron-boron magnets



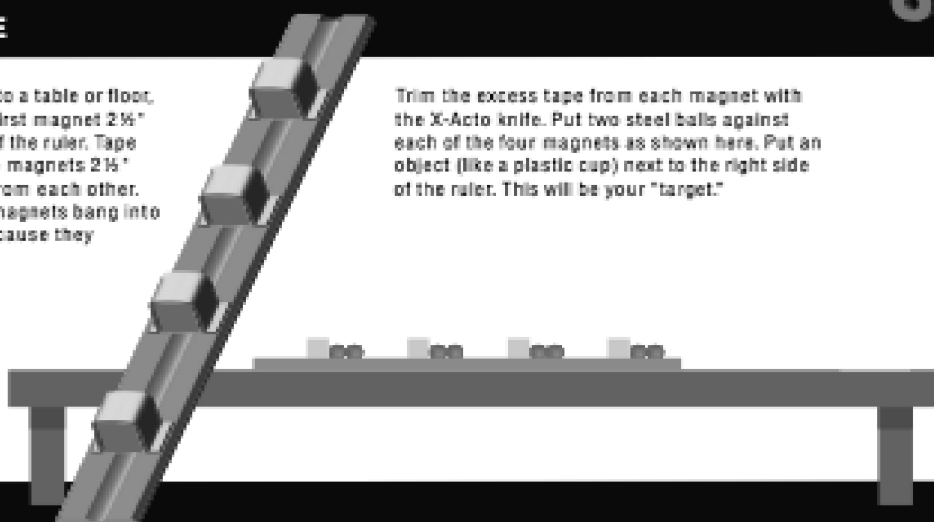
Nine $^{5}/_{8}$" diameter nickel-plated steel balls



Scotch tape and an X-Acto knife

2 MAKE

Tape the ruler to a table or floor, then tape the first magnet 2½" from the end of the ruler. Tape the other three magnets 2½" inches apart from each other. (Don't let the magnets bang into each other because they shatter easily).



Trim the excess tape from each magnet with the X-Acto knife. Put two steel balls against each of the four magnets as shown here. Put an object (like a plastic cup) next to the right side of the ruler. This will be your "target."

3 USE

Place a ball on the groove as shown. You might need to give it a gentle nudge. Once the ball hits the first magnet, the ensuing chain reaction will move too fast for you to see.

If you want to capture images of the rail gun in action, you can make a cheap high-speed camera set up like these guys did at *web.mit.edu/Damonv/Public/Doombolt*.

You can build a more powerful rail gun with a longer ruler and more magnets and balls, but at a certain point, the magnets will start to shatter.

Illustrations by Mark Frauenfelder

Physics

Larry Gladney - Video Clip Transcription

Clip 1 - Problems with a Teacher: Sixth grade…Again I had a teacher who did flunk me. By that time, I was reading at introductory college level and so she would just put “F” on my papers…Of course, I would never know why, and she told me once because the kids who were in this sort of top thirty were supposed to put on a Christmas play and she saw me hanging out with my friend Randy at the time, who was my best friend, and she saw us running around in the back behind the stage and she stopped us both and said, “I can’t believe Randy, that you’re hanging out with somebody like this. I just detest this kid. You should do much better with your friends.” And then somewhere around January, things got better. I stopped flunking and I hadn’t realized what had happened until years later when my mother said, “Well, I went down and had a talk with her.”…And after that, things got a lot better. She wouldn’t talk to me, the teacher still wouldn’t interact with me at all, but she stopped putting an “F” on everything and I wound up graduating with the highest grades for the elementary school.

Clip 2 - Decision to be a Physicist: Well, in high school, I’d already been set on the path to becoming a physicist, so. My uncle tells me I said that I wanted to be a scientist at age 3. But what I remember most about my earlier experiences with science was that I hate this. It was chemistry. It was biology. It was drawing pictures of flowers with you know, labeling the parts. And I thought, this is terrible. So, I was in real existential crisis until I went to junior high school because I loved science, but for whatever reason, all the science that they were teaching included looking through microscopes or chemistry sets and all those kinds of things. I just didn’t find very interesting. But again because of this sort of solitary approach, I would come in on the bus that would get me to school on time and it would be half an hour before classes. So, I would just go to the library and that’s where at age 13, I discovered physics and then as soon as I read my first book about what physicists do, I was hooked. Those were all the things that I wanted to study: the nature of the universe, relativity, quantum mechanics, all these things I just looked at and I immediately felt at home and thought, this is what I’ve been waiting for. It was literally for me. It was exactly like a religious epiphany. So, I came everyday to the library reading everything I could about physics and made up my mind in the 7th grade that I was going to get a Ph.D. in physics and that I was going to be a researcher, so... That didn’t waiver all the way through 8th, 9th, 10th, 11th, 12th grade. It was always very clear to me that this is my destiny and there’s not going to be anything else that’s going to satisfy me.

Clip 3 - Life Lesson at Northwestern: I think as a place, Northwestern had this aspect to it that meant that you had to be independent. You had to find your own way to stand out. And I specifically remember that I, of course I was on full financial aid. My family couldn’t contribute anything to my going to school, and part of that was the work-study program and I looked through the list of jobs and there was nothing that I thought was inter-- you know, it was checking books at the library, or working at the cafeteria and that didn’t seem interesting. And there was this one position, which was working with the physics department on a high-energy physics experiment. You would be a technician working with their electrical engineers. And I thought, well that’s great, right? What luck. And of course I go there and there’s students who were already there before me and I’m thinking well, there’s no reason they’re gonna pick me, I’m a freshman. And so I talked to the guy there, Bill Phillips, who eventually left and started his own company which actually is quite a big company now. But at that time, he was, he was the person in charge of building all the electronics and he was very unimpressed with me I think, I mean, just a freshman who comes in, you don’t know anything, don’t have any skills, don’t know anything about how to build electronics, had never done any of that kind of work, and he just said, “Well, I’ll call you.” I thought alright, well, that’s it, just “don’t call us, we’ll call you” kind of feeling to it. And after a week of course, he hadn’t called and I was thinking that I didn’t get this job, and it’s the only job I really want as a work-study student. I’ll have to do something that I really don’t have any interest in. But as I thought about it more and more, I just realized I was really angry that he said he was going to call, so he’s gotta have the bravery to tell me to my face that I didn’t get the job, that he hired somebody else. So I screwed up every ounce of courage I had and I went back to his office and poked my head in the door. And he says, "Oh, it's you. So I guess you're here for the job." And I said "Well, you never called me." And he says, "I never call anybody. Every year I pick the person for the job by whoever comes back. Usually there's only one person who's brave enough to come back a second time and that's the person I know is going to work hard enough to actually be worth the time and effort." So that was the first lesson, which is you gotta be persistent. You've gotta keep coming back, and that's the culture of physicists is that they don't give up on things.

Clip 4 - First Work-Study Assignment: So my first job was to assemble planar drift chambers, which people don't know what those are, but they're a common detector which consists of an aluminum frame with a gas bag around it and you put in ethane, which is just common cooking gas and there are very, very fine wires in the gas, so that when a subatomic particle that has an electric charge goes through, it ionizes it, and if the wires are under voltage, the charge will drift to the wire and you can sense that. Well, you need very sensitive electronics, but if you design the electronics right, you can pick that up and you can actually put a set of these through and track the path of the subatomic particle. But of course, again, I'm just starting as a freshman, I haven't had more than one college-level physics course, no calculus, I don't know anything. So my first job is I'm going to build these chambers, which I don't have any idea what any of the words you just meant were. But the professor who was in charge of the project said, "Here, I'll show you how to start," and he took me to a garage behind the physics building, and it was a room about the size of this one, and it was filled floor to ceiling with twenty foot steel beams and bales of this copper plated wire and tanks of gas. And he literally said to me, "Some assembly required," and he left. And I didn't see him again for weeks. So I was just left with this task, you either sink or swim, and luckily a graduate student, well he wasn't a graduate student at the time, but he was a technician who eventually became a graduate student and he said, "Well, you know, if you have a question you should just ask." So I said, "I have no idea how to start," and he said, "Well, look, you gotta make the chambers of a design that's gonna be about twenty feet by six feet and so you gotta learn how to cut steel beams and so, you know, you ask, right, you don't know how to cut steel? Well there are people in the shop who do, you go ask them. You don't know how to weld? Well, you go to the shop and you ask people there how to weld, or I know how to weld. You don't know electronics? Well there's the guy you work for, the electrical engineer, and you go, you ask him how to do things. But you have to be able to find out what it is you don't know, ask people how to do it, to get help, and if they don't know how to do it then you gotta figure it out."

So all four years were basically experiences like that, where I really learned how it is that people put together collaborations of hundreds of people and build these detectors that are literally three or, and now five stories high, and about four stories wide. And it's not that anybody knows how to do these things, but they, they just have the attitude that they're going to figure it out and so that part of Northwestern's experience for me was excellent. I don't see how I could've gotten that by just picking a random college like University of Illinois and trying to wind my way through, but Northwestern was small enough that you could find the right people, and they would guide you on the way.

Clip 5 - The Consequences of Physics: The people that I knew were at the tail end of the generation that created the atom bomb. And in fact, some of the people had worked on the Manhattan Project. So, their idea about what you know and what you can do with what you know was married to this very essential fact that you can destroy the world with the right facts, if you actually understand well enough what you claim to understand, you can build remarkable things. And you can also build really terrible things. But from the experience of having done it…I'm listening to one of the senior physicists there, Dr. Benoski, who had been the original director of the lab. And, hearing his stories about going to Hiroshima many years after dropping the bomb there and seeing the museum in which they had enshrined a part of the trigger for the first A-bomb, which he designed and built. So, he's looking in this…you know, among the shadows flashed into stone walls and so forth. Here's the real aspects of your work and what happens and how it can be used if you understand the physics part of it, but don't understand necessarily how it might be used once it's out in the open. And he tells the story to students like me about that as a way of saying you have to forge a very strong, again, this whole idea that you have to forge a very strong identity that says that you're not gonna live in fear of what's to come because these decisions have to made. You have the knowledge. You're going to learn more, and you have to be able to depend on yourself to make the right decisions about how to use it.

Clip 6 - Accessibility of Physics: One of the things we're realizing belatedly is that this very "throw the baby into the into the pool and see if they sink or swim" approach is really not very appropriate if you want to increase the representation by women in particular but by minorities as well. And it's because it does take that kind of strength of personality that says, we're not doing this because we want you to go away. This is what everybody has to go through because that's part of the training, this is how, this is how we do it. And I think we could certainly figure out whether that's the best way to do it, or whether or not there are ways in which we could have a, for lack of a better term, a kinder, gentler introduction that would have it accessible to more people who come from more background or more varied backgrounds. As scientists, it would be incumbent on us to try and explore as we do everything else. Is there a better way to do it? Do we really understand how it is that we lose people from the field? Do we really understand how it is that we could gain more people again from different backgrounds coming in, 'cause that's important for science, independent of what you think about what society's needs are and how many role models we need even if you didn't care about those things. If you care about the science, then you understand that without having the different points of view and the different experiences of people coming into it, the science is just not as rich. It's not as interesting, not as many new ideas get tried because people don't have the new ideas and therefore, it's an important thing to try to do almost independent of what you think the social good that comes out of just having more access to more people. You ought to do it for the good of the field.

Clip 7 - Fundamentals of the Universe: In the early history of the universe, there had to be equal amounts of matter and antimatter. We don't actually know how to create one without the other, but if I look around this room, there's all one type. It's all matter. And in fact, it would be very bad for us if there were even small specs of antimatter around because it annihilates [matter], all Star Trek fans know, it annihilates [matter] and creates a huge amount of energy. It's the equivalent of a murder mystery. The universe figured out a way to get rid of all the antimatter, and yet leave the matter behind. We don't know how that happened, and one of the things we want to explore is to understand what happened to the antimatter, and whether or not the mechanism that nature used reflects again something that's even deeper about either the mathematical aspects of the physical laws that we come to understand and sort of base our beliefs on how the universe behaves on those. Or whether or not this is just one aspect of the story of how the universe came to be. I mean, we couldn't have a universe like the one that we see, that has life in it and intelligence, if nature hadn't figured out how to do this: get rid of the antimatter. But maybe that was only one brief phase, and there isn't anything deeper about it. It's just a card trick. It might have happened with some other universes, if they happened to be existing, or maybe it only happened with ours, it's a very rare occurrence and so there's nothing deep, it's the equivalent of the existential question: it just is. But even that is a deep question. If you ask the philosophy of how likely is our universe, that's a very deep question. Einstein expressed it by saying, "I want to know whether God had any choice about how He made the universe." Once He set down these laws and they were mathematically firm, was He then constrained in that this is the only way you can make a consistent universe that makes sense and has life and intelligence in it, because there is no other way that you can logically put things together, that they actually do work or not. So, we have that as a legacy, right? Are we going to try and make a sensible universe, or are we really just going to accept what nature tells us, and not matter how preposterous it is, just decide that we are going to live with it. That's a huge philosophical question, and it's not going to be resolved probably for 10 or 20 years, if ever, into the future, because it requires us to get to the point where we either say Einstein was wrong, the universe isn't sensible and so there was a choice about how you could have made it, in that once you say that things don't have to make sense, you can choose, like making up a story, you can make up whatever story you want and you've just got to live with the final result; or if there really is some grand scheme and it all does make sense at some very fundamental level that we haven't seen yet, that would also be a great thing to expose. But we are not going to know, right? Because one of these paths, you can never prove, and the other one, well, you can say it's the most fundamental; but again, you never know that if 100 years from now somebody might discover: well there's a cellar under the basement, right, that there's something more fundamental under that.

Clip 8 - How I Want to be Remembered: When I went off to college, I was asked by one of my uncles, “So, what are you gonna do after you’re done with college?” And I said, “Well it’s...I’m going to be a physicist, absolutely clear.” And his response was, “Physicist? What kinda job is that for a nigger?” Now, he didn’t I think mean for it to be as negative as it was to me at the time, but it made me think that you know, he’s right, right? I mean, this is not a job for a nigger, but it ought to be a job for anybody who loves science, independent of what their identity is. So, I would like to be remembered as not being unusual, not being so out there, not being, you know, one of just a dozen or so who are actively working in this narrow field of particle physics. And have it not be unusual for somebody like Neil DeGrasse Tyson to say just the fact that I’m an astrophysicist. If I never did anything with my scientific career, but be an astrophysicist, that states volumes about what’s possible for black people - to not have that be a statement that needs to be made anymore, I think would be terrific.

ScienceMakers

Spotlight: Shirley Ann Jackson

Full Name:	Shirley Ann Jackson
Born:	August 5, 1946
Place:	Washington, D.C.
Parents:	Beatrice Cosby Jackson
	George Hiter Jackson
Spouse:	Morris A. Washington
Education:	Roosevelt High School - Washington, D.C. (1964)
	Massachusetts Institute of Technology - Cambridge, MA (B.S. Physics, 1968)
	Massachusetts Institute of Technology - Cambridge, MA (Ph.D. Physics, 1973)
Type of Science:	Particle Physics
Achievements:	First African American woman to receive a Ph.D. from the Massachusetts Institute of Technology
	Studied hadrons, worked on Landau theories of charge density waves and Tang-Mills gauge theories and neutrino reactions
	Inducted into the National Women's Hall of Fame

Favorites:

Color:	Red
Quote:	"Aim for the stars, so at least you can reach the treetops."
Time of Year:	Fall
Vacation Spot:	Anywhere

Biography

Physicist Shirley Ann Jackson was born on August 5, 1946, in Washington, D.C., to George Hiter Jackson and Beatrice Cosby Jackson. When Jackson was a child, her mother would read her the biography of Benjamin Banneker, an African American scientist and mathematician who helped build Washington, D.C., and her father encouraged her interest in science by assisting her with projects for school. The Space Race of the late 1950's would also have an impact on Jackson as a child, spurring her interest in scientific investigation.

Jackson attended Roosevelt High School in Washington, D.C., where she took accelerated math and science classes. Jackson graduated as valedictorian in 1964, and, encouraged by the assistant principal for boys at her high school, she applied to the Massachusetts Institute of Technology (MIT). Jackson was among the first African American students to attend the school, and in her undergraduate class she was one of only two women.

In 1973, Jackson graduated from MIT with her Ph.D. degree in theoretical elementary particle physics, the first African American woman to receive a Ph.D. in MIT's history. Jackson worked on her thesis, entitled "The Study of a Multiperipheral Model with Continued Cross-Channel Unitarity," under the direction of James Young, the first African American tenured full professor in the physics department at MIT. In 1975, the thesis was published in Annals of Physics.

After receiving her degree, Jackson got a job as a research associate in theoretical physics at the Fermi National Accelerator Laboratory, or Fermilab. While at Fermilab, Jackson studied medium to large subatomic particles, specifically hadrons, a subatomic particle with a strong nuclear force. Throughout the 1970's, Jackson would work in this area and on Landau theories of charge density waves in one- and two-dimensions, as well as Tang-Mills gauge theories and neutrino reactions.

In 1974, after two years with the Fermilab, Jackson served as visiting science associate at the European Organization for Nuclear Research in Switzerland, and worked on theories of strongly interacting elementary particles. In 1975, Jackson returned to Fermilab and was subsequently elected to the MIT Corporation's Board of Trustees. In 1976, Jackson began working on the technical staff for Bell Telephone Laboratories in theoretical physics, investigating the electronic properties of certain material that could carry a larger current than the technology that existed at the time. While at Bell, Jackson met her future husband, physicist Morris A. Washington. That same year, she was appointed Professor of Physics at Rutgers University. In 1980, Jackson became the president of the National Society of Black Physicists, and in 1985, she began serving as a member of the New Jersey Commission on Science and Technology.

In 1991, Jackson served as a professor at Rutgers while working for AT&T Bell Laboratories in Murray Hill, New Jersey. In 1995, Jackson was appointed by President Clinton to the position of chairperson of the Nuclear Regulatory Commission. In 1997, Jackson led the formation of the International Nuclear Regulators Association. In 1998, Jackson was inducted into the National Women's Hall of Fame. The following year, she became the eighteenth president of Rensselaer Polytechnic Institute. Jackson remained an advocate for women and minorities in the sciences and, since 2001, brought needed attention to the "Quiet Crisis" of America's predicted inability to innovate in the face of a looming scientific workforce shortage.

Discussion Questions

Personal:

1. What did you like best about listening to Dr. Jackson?

2. What do you think Dr. Jackson's favorite quote means? What does this tell you about her?

3. Where was Dr. Jackson 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. Jackson attend high school? What do you suppose high school was like for her?

4. How old are you? In what year was Dr. Jackson your age? What was happening in the country that year? What was happening in the world that year? What do you suppose her life was like when she was your age?

5. Dr. Jackson talks about her summertime routine. What was it? Do you have routines that you follow in the summer? What kinds of things do you do? **(See Clip #1)**

6. What kinds of things did Dr. Jackson like in school when she was young? What kinds of things do you like in school? **(See Clip #2)**

7. Dr. Jackson talks about a troubling experience that she had with a professor in Materials Science. What was her experience? Why was it troubling? Have you ever been underestimated by a person in authority? How did that make you feel? What did you do about it? **(See Clip #3)**

8. Dr. Jackson talks about her process of choosing a graduate school. What were her main criteria in choosing a school? What major event happened during her search? Do you think this affected her decision? Why did she ultimately decide to return to MIT? Have you ever had to make any major decisions? What was your process for deciding? Were you satisfied with your decision? Why or why not? **(See Clip #4)**

Science:

9. What do you think a physicist does? Would you like to be a physicist? Why?

10. If you were a physicist, what kinds of questions would you study?

11. Dr. Jackson talks about the different types of physics. What are they? What does each one cover? What kinds of things do they study? Find out and report back to the class. What kind of physics most appeals to you? Why? **(See Clip #4)**

12. How does Dr. Jackson's work relate to your cell phone or laptop? What other inventions have taken advantage of the body of knowledge that Dr. Jackson helps build? **(See Clip #5)**

13. Dr. Jackson discusses the nature of scientists in society. She points out that we value musicians highly. Who else is highly valued in our society? Why do you think scientists are not more highly valued? Why are scientists beneficial to society? What kinds of things have been possible because of scientists? Do you think we take scientists for granted? How can we change our attitudes? **(See Clip #6)**

Experiment - The Universe Game

This game was developed by the CERN Education Department.

Objective

The objective of the game is for all of the players to get from the start to the end of the spiral and out to the Universe as quickly as possible. Once everyone has finished, the game is over.

There can be two to fourteen game players. Each player chooses a different game piece that represents an elementary particle and begins with the roll of a die. A player then moves that number of spaces and follows the instruction, if any, found on that space. It may take several games before a student learns the answers to many of the questions. Therefore, be patient, pay attention to other students' answers, self-study, and engage in the discussions that arise.

Keep track of the time it takes to finish the game on a time chart in order to get an idea of how long it takes to play the game. You can also add cards with new instructions and questions to each stack and also new particles to make the game more interesting.

General Rules

Each player gets to choose a particle. All particles are placed on the start space at the beginning of the game. The players all toss the die and the one with the highest number chooses a particle and starts first. This process continues until everyone has chosen a particle playing piece and has started. Play proceeds counter-clockwise or clockwise from highest to lowest number resulting from a toss of the die. In the case of a tie, the players who tie should roll again to break the tie.

If your piece lands on a square with a word written on it, go to that stack, choose the top card, and follow that instruction. When you are done, place the card at the bottom of the pile.

If your piece lands on a square with a written instruction, follow the instruction immediately.

After answering a question from a card, place the card at the bottom of the stack to be used again. You can either advance two spaces (or the number indicated on the card) or obtain an energy card for each correct answer. You go one space backwards for each incorrect answer (unless stated otherwise on the card).

Only one die is used in the game after the initial tosses. The first player throws the die, counts the number of dots and moves his particle piece that number of spaces around the board. Players must follow the direction(s) on that space unless they have an exempt card.

When one arrives within five spaces of entering the Universe, that player must throw exactly the number of spaces needed to complete the game. Remember! S/he can only win if all players have crossed the barrier! The barrier is a simple piece of paper - not provided by us but which you can easily produce - placed with tape on the board on the square that suits you best. We suggest putting it after square 21 (starting from the Big Bang), for example, between "technology" and "accelerators," after the transition bonus jump. The "almost" winner can decide to help the other players in order for them to cross the barrier and therefore let him or her win the game.

Players may assist, upon request, another player to answer a question and can pass exempt cards to each other.

One must make it around the board in order to finish the game. The game is not won until the last player makes it around the board.

For full rules and the game board, visit: http://public-old.web.cern.ch/public-old/Content/Chapters/Education/OnlineResources/Games-en.html

Shirley Ann Jackson - Video Clip Transcription

Clip 1 - Books and Kool-Aid: I loved school. I actually liked doing housework. I liked working in the yard. And in the summers, I would love to ride my bicycle to the library, to the public library, and we could take out five books at a time. So I would always take out the maximum number of books. And what I loved about it is I could just structure my life the way I want. Now my mother was working, my sisters were doing their thing. So I used to have this routine, where I would make Kool-Aid, remember Kool-Aid? And I loved Saltines. And so I would sit in the basement and I would read half the day, sipping my Kool-Aid and eating these Saltines. Now usually in the morning in the summer, before I'd start reading, I went to take swimming lessons at a pool at Coolidge High School. Now it turns out, I never really learned to swim.

Clip 2 - Geometry Proofs: I liked doing geometry proofs. I liked solving the algebra. I loved doing trigonometry problems. I loved calculus, and I loved it just for itself. But I also liked applying it to problems. And so I love word problems where one had to apply it, and to apply it in science. So I just enjoyed it, it was, some people like to read. I like to read. I love to read. But I equally well liked doing math. And so I loved it in and of itself, as well as the ability to use it to solve problems.

Clip 3 - Materials Science: I happened to have a professor in materials science who in retrospect may have thought he was trying to help me. It was the class I had gotten the "A" in, and I got my nerve up to go ask him for a job, a summer job, and he asked me if I could cook. And I said, "Cook what?" And he says, "Well I don't really want you to cook, I just figured if you could cook, you could work with your hands. And so I'll hire you." Now earlier this same professor had told me that colored girls should learn a trade. Colored girls should learn a trade. And he used to call me and Jenny Tweedledee and Tweedledum. And so it was, there were a lot of mixed signals and I think he thought that he was trying to convince me to major in materials science and engineering because I was doing so well. But his way of suggesting it, and he probably thought that physics would be too hard or less accessible for a black female. But that really upset me…Well the summer after my freshman year, I went to work in the lab in metallurgy and materials science. I went to work for the professor who asked me if I could cook. But I got hooked and I had taken a course on the structure and properties of materials when I was a freshman, I'd done very well in the course and so on, gotten an "A"…and then MIT had an undergraduate research kind of program. They hadn't formalized it as such but you could take, you could work in a lab and get paid in the summer, which is what I did, or work for academic credit during the academic year, and so I did that, essentially the rest of the time I was at MIT.

Clip 4 - Which Physics Field to Study:
There's nuclear physics. There's high-energy physics, which is kind of an outgrowth of nuclear physics. It's sometimes referred to as elementary particle physics. And that's what my Ph.D. is actually in. There is condensed matter physics, which used to be called solid state physics. There's atomic physics. There's plasma physics. There's optical physics. There's astrophysics. And so on…I did the thesis. It was a joint thesis but it was essentially a thesis in solid state physics, condensed matter physics. And that was what I was interested in. And in particular I was interested in theoretical physics, because I had studied the Bardeen-Cooper-Schrieffer theory, the BCS theory of superconductivity. So when I went to go to apply to grad school, on the one hand I was being encouragd by my undergraduate advisor to apply to MIT and particularly if I had more, would be more interested in nuclear physics or something related to that. But then on the other, I had this interest in condensed matter or solid state physics. So I applied to schools based on what I knew. So, Bardeen, John Bardeen was at the University of Illinois. But I had been told that Illinois was not particularly friendly to African Americans…and don't ask me how I was told that, but that's what I had been told. But there was a gentleman by the name of Leo Falkoff who was at the University of Chicago who actually had worked with, had worked on many-body theory, developing that whole kind of subject that enabled the theory of superconductivity to be worked out theoretically. So then, I applied to University of Chicago because he was there. I applied to Brown because Cooper was there, to Penn [the University of Pennsylvania] because Schrieffer was there, to Harvard in applied physics because there were people there doing group theory and things related to solid state physics. To MIT, in both physics and materials science and engineering. So I got in to all these places, and then I was invited to come and visit a couple of them. I had been invited to Brown to come visit, I was invited to Penn, I already knew about MIT, obviously, and I had been back and forth to Harvard and around Harvard because of going to school in Cambridge. So I did visit Brown, and I visited Penn. And on the day I visited Penn, and was on my way back to the airport to go back to Boston, a soror was driving me to the airport and as I was being driven, the radio was on and the news, there was a newsflash that Dr. Martin Luther King, Jr. had been shot in Memphis and then a little while later, the newscaster said he had died. So that really shook us up because I was a child of the King era and even though I talked about living in a kind of a sinecure in Washington, the March on Washington occurred while I was still in high school. I was well aware of, you know, the Montgomery Bus Boycott, a lot of the activities in the South that I knew in the end led to the kinds of changes that would and did affect my life. And I also recognized that I had lived a fairly isolated life at MIT, probably half of it off the

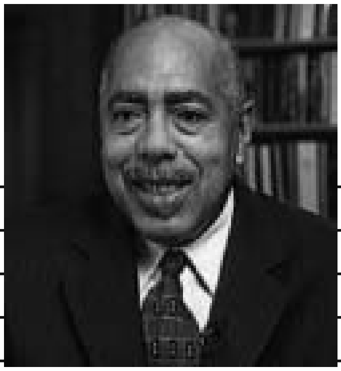
campus because of having few social outlets on the campus. I had done well academically, but it wasn't because I was part of a crowd, a group, and it was fairly isolated. In spite of all of that, I felt that MIT was clearly an important institution and I mean, that was why I had chosen to go to college there in the first place and I felt that it was important to both open the door wider for other minority kids, especially African Americans, and to try to make it more hospitable as well. And so, for this complex set of reasons, even though solid state physics wasn't a big focus at MIT at that point, it had been earlier, and it certainly is now, and it was built up after I left, it wasn't at the time. But I decided to stay, I was interested in theoretical physics but because at that point nuclear physics and elementary particle physics or high-energy physics were so important there, that is what I decided I would do. One or the other. And I started out actually thinking I would do experimental nuclear physics, but then I switched and decided to focus in elementary particle theory, or theoretical elementary particle physics.

Clip 5 - What She Does: People always want to know, well, so how does what you do relate to my cell phone, or my laptop, or whatever. Well, your cell phone or your laptop has little tiny integrated circuits, little transistors and things in it and somebody has designed those based on an understanding of how electrons move through certain materials. How they move around in two dimensions. What affects their ability to cross a distance, and so forth. When do they move if you put electrical voltage on a circuit, etc. And then people like me are the ones who are then trying to contribute to that fundamental understanding of how things work at the most elemental level. And then it builds up in layers, and so I never designed a device, but what I did was to help with creating a body of knowledge about how systems behaved in two dimensions, in layers, and what their basic electronic and optical properties are. Then somebody else takes that kind of knowledge to say, well, if something behaves like this, in a semiconductor or some other material, then what kind of device can I make out of it, a transistor or something else, a logic gate for a computer. And so on. And then it builds up from there, but long before you get there, to these chips that go into these different electronic devices that we all play around with, somebody's had to figure out the basic physics about how things operate in these chips, and that's what people like me do.

Clip 6 - Society's View of Science: See, a difficulty we have in this society is that people don't value those who do science and engineering. Partly because perhaps we don't understand what people do, partly because perhaps we're afraid of the power of science or what it could lead to. And so because of that, or because we don't understand the personality, how somebody could be so focused to spend days at a time, weeks at a time, months at a time, years, working on things, so detailed. Whether they're doing some chemical experiment, physical experiment, detailed calculations. And so I think people, because they don't understand it, they tend to put it off to the side, even as they're benefitting from what scientists and engineers do. We give great forebearance to musicians. They're very creative, and many of the most creative people are not like the everyday person walking up and down the street. But because we think we can understand it or relate to it more, we give great deference even, but we're almost afraid of people in science and engineering, so we tend to want to think that they're weird.

ScienceMakers

Spotlight: Walter Massey



Full Name:	Walter Massey
Born:	April 5, 1938
Place:	Hattiesburg, MS
Parents:	Essie Massey
	Chester Massey
Spouse:	Shirley Anne Massey
Education:	Royal Street High School - Hattiesburg, MS (1954)
	Morehouse College - Atlanta, GA (B.S. Physics, Mathematics, 1958)
	Washington University - St. Louis, MO (M.S. Physics, 1966)
	Washington University - St. Louis, MO (Ph.D. Physics, 1966)
Type of Science:	Physics
Achievements:	Served at Argonne National Laboratory as Vice President of Research
	President of Morehouse College

Favorites:

Color:	Blue
Food:	Chicken
Time of Year:	Spring
Vacation Spot:	Cape Cod

Biography

Scientist and educator Dr. Walter Massey was born on April 5, 1938, in Hattiesburg, Mississippi, to Chester and Essie Massey. Beginning his education in his hometown of Hattiesburg, Massey completed high school at sixteen, at which time he began his undergraduate studies. He went on to complete the highest levels of education, earning his B.S. degree from Morehouse College in 1958. Later, he earned his M.S. and Ph.D. degrees in physics at Washington University in 1966.

In 1993, Massey was appointed Provost and Vice President for Academic Affairs for the University of California system. In 1995, Massey returned to Morehouse College, where he served as the college's president. Massey also held physics professorships at numerous universities, including the University of Illinois, Brown University, and the University of Chicago.

Along with distinguishing himself as an educator, Massey had a long-standing relationship with Argonne National Laboratory, where he served as Vice President for Research (1984-1991) and as the Founding Chairman of the University of Chicago Development Corporation (1986-1991). In 1991, Massey was appointed Director of the National Science Foundation, where he served until 1993. Massey's career illuminates a commitment to diversity and expanding opportunities for minorities in the sciences.

In recognition of his many accomplishments, Massey was awarded over twenty honorary doctorates and numerous awards for excellence in teaching. In addition, Massey remained active in several professional organizations, including the American Academy of Arts and Sciences and the American Association for the Advancement of Science. Massey maintained a commitment to service through his affiliation with a number of civic, cultural and community organizations. Massey and his wife, Shirley Anne, raised two sons: Keith and Eric.

Discussion Questions

Personal:

1. What did you like best about listening to Dr. Massey?

2. Where was Dr. Massey 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. Massey attend high school? What do you suppose high school was like for him?

3. How old are you? In what year was Dr. Massey your age? What was happening in the country that year? What was happening in the world that year? What do you suppose his life was like when he was your age?

4. What kind of a student was Dr. Massey? What did this have to do with how smart he was? Was school difficult for him? How about you? Is school difficult for you? If so, have you talked with someone about this? How does your teacher or your parents help make it easier? If not, do your grades reflect this? Why or why not? **(See Clip #1)**

5. Why did Dr. Massey like arithmetic and mathematics as a boy? What is it that absorbs you, that you could spend hours figuring out? What could you do with this interest in the future? **(See Clip #1)**

6. How did Dr. Massey come to be at Morehouse College? How did his father initially feel about this opportunity? What made him change his mind? What do you think it would be like to start college at 16? Have does you discussed your future with your parents? How could they help you find opportunities? Besides parents, is there anyone else who could help you take advantage of opportunities? How? **(See Clip #2)**

7. Dr. Massey talks about being intimidated by the students at Morehouse when he first arrived. Why was he intimidated? How did his placement test change his opinion of himself? What does Dr. Massey say is the difference between being ignorant and being dumb? Have you ever felt "defined" by a grade? If so, was it a good thing? Why or why not? Is there a story beyond grades? How do you define yourself? Is it possible to change? How did Dr. Massey change? What can you take from his story? **(See Clip #3)**

8. Dr. Massey was told what he should and shouldn't study at Morehouse. Have you ever been told that you weren't able to do something? How did that make you feel? What did you do about it? What did Dr. Massey do about it? **(See Clip #3)**

9. Dr. Massey talks about his professors at Morehouse. How did they help him? Who inspires you? What is it about that person that you admire? How can the lessons you learn from that person help you in your career? What is the difference between a role model and a mentor? Which would you rather have? How could you seek out a role model or mentor? **(See Clip #4)**

10. There was one professor in particular who Dr. Massey credits with exposing him to a more sophisticated world. Who was it? What kinds of things did they do? When you think of culture and sophistication, what comes to mind? Do you know anyone that you would consider sophisticated? Who? What can you learn from them about the wider world of culture? **(See Clip #4)**

Science:

11. What do you think a physicist does? Would you like to be a physicist? Why?

12. If you were a physicist, what kinds of questions would you study?

13. Why is Dr. Massey excited about the way the world works? How can science be used to help study the way the world works? How does mathematics play a role in this? What kinds of statements can you make about the way the world works? Can you put it in mathematical terms? **(See Clip #5)**

14. Why was Dr. Massey drawn to physics? Have you ever thought about science that way? When you think about the world around you, what are you curious about? What questions do you have? How can you answer them? **(See Clip #3 and Clip #5)**

15. Dr. Massey explains his research at Argonne with sound and liquid helium. What can you discover about helium? How is helium used in everyday life? How does sound travel through the air? Can sound travel through liquid? Is it the same or different? **(See Clip #7)**

16. Dr. Massey and his team observed behavior that did not make sense. What was this behavior and what was it called? Why didn't it make sense? Have you ever looked at something and wondered how it worked? What did you do to answer your questions? Were you able to find out for sure or did you have to settle for an educated guess? Dr. Massey and his team solved the mystery. What was the solution and how did it work? Diagram the process. **(See Clip #7)**

Experiment - Sound Mediums, Sound Speed and Energy!

This activity was developed by the Center of Science and Industry in Columbus, Ohio.

Key Points

- Air, water or solids are necessary for vibrations to be transferred from one thing to the next and for sound to be heard.
- Whatever the vibrations transfer through is called the sound medium.
- Sound vibrations transfer at differing rates. Therefore, they have different intensities depending upon the sound medium.
- Vibrations travel most quickly in mediums where molecules are closest together and most slowly in mediums where molecules are farthest apart.

Learning Objectives

- Experiment with vibrations traveling through air, water, and solids.
- Manipulate variables and observe differences.
- Make inferences based upon the differences observed.

Materials

Per pair:

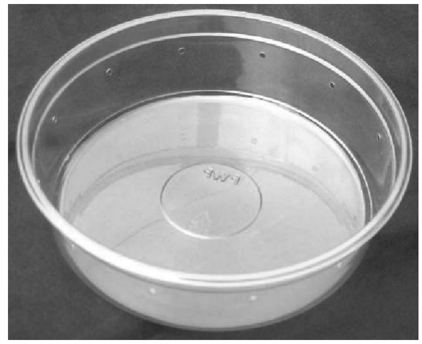
1 tuning fork
1 wooden board
1 can with balloon stretch across the top

Per demo:

1 32 oz deli cup w/water (see picture at right)
1 tuning fork

Per group of six or eight:

8 oz. deli cup w/salt



Procedures

Vibration Bump

Sounds are produced by vibrations. Vibrations are a form of energy, and this energy is transferred to whatever is close to it. The molecules of a gas, a liquid or a solid through which the sound vibrations move are set in motion. These molecules pass the energy to the molecules next to them, which pass the energy along to the molecules next to them, and so on and so forth, until the energy arrives at the inside of our ear, where it is changed into electrical impulses and sent to our brain. Our brain then interprets those impulses into the sounds we recognize.

All along the path that sound travels, the molecules themselves vibrate a lot, but they don't move very far.

Have a volunteer give the vibrating source sign to one participant and the ear sign to another participant. Now have all the participants arrange themselves in a line with one sign holder at one end and the other sign holder at the opposite end. The group will probably need to arrange itself into a semi-circle.

Explain that the people between the vibration source and the ear are molecules. When you ring the bell, the vibration source is to bump the hip of the air molecule next to it, which bumps the air molecule next to it and so on down the line until the vibration arrives at the ear. (Caution the older participants to be careful of the younger, smaller participants.) When the vibration arrives at the ear, that person will hold the sign up high in the air. There are molecules within the ear that also carry the vibration, but we are not going to go into the various parts of the ear.

Ring the bell and start the vibration. When the ear sign is up in the air, tell the participants they were great, but that sound travels a lot faster than they bumped! Repeat the bump more quickly. (Yes, everyone will probably get a little silly at this point, but the idea of speed will be made.)

Now, there was lots of energy transferred in that activity, but did any of you "molecules" move very far? Not really, and it's the same way when molecules transfer energy in the form of sound waves.

Sound travels when molecules pass along vibrations. What are the three states of matter? Can the molecules that make up these different things all vibrate? Sound has to travel through something - - air, liquid or solid - - and we call that "something" the sound medium.

While the participants are still standing in their semi-circles, have them stand a little bit closer together. Explain that they are going to do the vibration bump again. Do they think they will be able to match their speed from before? Why or why not? Repeat the bell ringing sequence. Did the vibration move as quickly as before?

Now have the participants stand even closer together without touching. How fast do they think they can do the vibration bump now?

Have the participants sit down. Ask the participants whether they think sound travels more quickly through mediums that have molecules close together or far apart. Are molecules of air close together or far apart? In what medium are the molecules closest together? (solids) Do the participants think sound travels fastest through gases, solids, or liquids?

Find a partner, and let's prove our theory about through which medium sound travels best.

Each pair needs a wooden board and a tuning fork. How many of you have ever used a tuning fork? Can you show us how to use one? Please use the edge of the sole of your shoe, rather than the floor, to set the tuning forks vibrating. Take turns listening to the sound produced by the fork.

Now, one person in each pair needs to place his or her ear on one corner of the wooden board. The other person will strike the tuning fork on his or her shoe and then place the single end of the tuning fork on the corner of the board opposite the first person's ear.

Did you hear the vibrations of the tuning fork better through the air or through the wooden board? Why?

Through the air, it takes sound about five seconds to travel one mile. That's very fast, but through water, sound can travel one mile in just over one second. I haven't seen figures on how fast sound travels through wood, but through steel, sound can go over three miles in just one second! Are the molecules in wood closer or further apart than in steel? So, would sound travel faster in wood or in steel?

When the molecules of a medium are vibrating and passing along sound waves, is there energy being passed along also?

Let's do a demo to think about this question a little more. I need you to divide yourselves into three groups around three people. We're going to do a demo together with you. Now, bend over so you can see the water really well. Don't be afraid to get up close!

Now, on the count of three, we are going to each strike our tuning forks and see if there is any energy transferred to this water. Watch closely so you can tell us what you notice! One, two, three!

(This activity, if done with more than one person, needs to be closely coordinated to keep the fun in it. As soon as you strike the tuning forks, place the forked ends just slightly into the water, holding them at about a forty-five degree angle to the water, with the fork facing away from you.)

Where did that energy come from?

Okay, let's get back in our groups and do another quick activity to prove this same point. You'll be working in pairs again, and each pair will need a can covered with a balloon, a pinch of salt and a tuning fork - who can tell me what a "pinch" is? Right, a very small amount! Place that pinch of salt onto the balloon. Take turns striking the tuning fork against your shoe and holding it very close to, but not touching, the balloon. What's happening? What's the best way to hold the tuning fork to make the salt crystals dance around? Take turns with the tuning fork and see what observations you can make. Tell me one thing that you notice. (Take several observations and play off the energy of the room.)

Walter Massey - Video Clip Transcription

Clip 1 - School and Math: I was not a bad student, but I, if you were to look at my grades, I don't think my grades would look that great except in math. School wasn't hard to me, let's put it like that, wasn't difficult, and so I did what I liked to do in school, but I never flunked anything. It wasn't, you know, it was not difficult. But I was not, I was not one of the top students…I always liked arithmetic, and always liked then mathematics, I liked it because you could, you could absorb yourself in it, solving mathematical problems was a way of sort of, I don't mean I wanted deliberately to get away but it was almost like reading, just totally occupied your mind to solve a difficult--does, of course--difficult mathematical problem. When you're young, anything is difficult. So I liked figuring out the math and I could just sit and you know, figure out math problems all day, it was like some people with crossword puzzles I guess, it was something I liked to do.

Clip 2 - Going to Morehouse as a Student: Morehouse was part of a group of schools, I think three of them. The Ford Foundation chose to experiment…to see if they could identify students who were prepared and capable of coming to college without finishing high school. And I know Harvard was one, and Morehouse. It was a full scholarship the Ford Foundation funded. And they gave tests, examinations around the country, around the South at least, and it was like an SAT or something, I don't remember. But they gave the test in Jackson and I went up with three or four other students, on Royal Street, to take the test. And my mother, in fact I drove the car we took, our car, and my mother was going up to take classes at Jackson State. She continued to take classes 'cause she didn't finish school, when she had me, but she kept taking these education classes, try to get her bachelor's degree. And we went to Jackson and I took the exam. I didn't expect anything to come of it, and a few months later, we received this letter that said I'd been admitted to Morehouse College with this full scholarship. I mean we were all flabbergasted and I don't think people, if they had to bet on who would've gotten the scholarship, I don't think they would have bet that I would be the one. But I did and then we had to discuss whether or not I should take it. My father was not too certain, he thought I was probably too young to go off to Atlanta and we only knew one person who'd gone to Morehouse…I was ready to go as I told you, early on, this was my chance to leave Hattiesburg early and wherever they were going to send me, I was going. And my mother was very supportive of it, so we all decided that I should accept it.

Clip 3 - Challenges at Morehouse:
I didn't become interested in science until I came to Morehouse…So after the freshman week, when I called my mother and told her I wanted to come home, I said this is not going to work, these, everybody's too smart, everybody's much smarter than me. You know, just speaking with them about courses they've had, they've taken calculus and physics and chemistry. I had taken nothing. I hadn't taken biology. I hadn't taken trigonometry, let alone calculus. I said, I just won't survive. And when I decided, she said, stay, just stay, go through the week, stay there. We had to take placement exams then and during freshman week, and they would post them by rank of all the freshmen students. Number one person's score, number two, number three, all the way down to the person who scored number ninety. In those days, they put it on the dorm door and I had a score of I think five, and I was just, I mean I was blown away, I was so flabbergasted. It was the first time in my life that I realized that I might be smart. I mean, I realized that well, maybe I am, maybe I'm smart. I mean, I couldn't believe I came before all of these guys from all over the country, you know, who were so smart that, I was five or six or something. Field Thompson was one, Bo Plessy was second, the Green brothers Frank and Al were there, and I was a five or six. And that changed my whole view of who I was and how I thought of myself…I realized that I was ignorant but I wasn't dumb, you know, there's a big difference, I didn't know things, but I wasn't a person who was incapable of learning. And that's what really, that story, that's how I really got into science. Because everyone said, I liked math and you know I was going to do that. I said well, nobody takes McBay's course, Henry McBay, as a freshman. Chemistry. Very few, shouldn't do that. I said, well, I'm going to take it, so Hops and I, we said we're going to take this course. So we just took the hardest courses in the sciences and they said well, nobody majors in physics and they taught physics at Clark College across the street, we didn't even have a

physics department, it was one for the Center, and I said, well, I'm going to go take physics. So I went over, I took physics and I fell in love with physics. Because what I liked about it, it was a way you could use mathematics to help you understand just common everyday, phenomena. You know, how light works, why things shine in a certain way, what sound is like, why it travels this way, electricity, and the mathematics was a basis for understanding the physics to me. So I came into the sciences from a mathematical [background]: I was a double major in math and physics. But then once I got into physics, it was a way of learning more about the world and physical and natural phenomena and yet using the mathematics as an aid to do that.

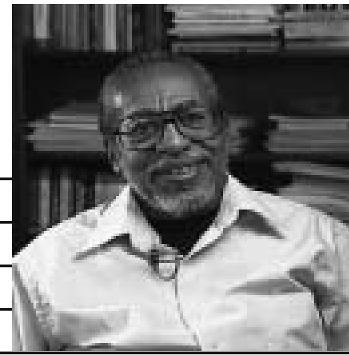
Clip 4 - Inspiring Teachers: S.H., Sabinas Hobart Christansen. He was Danish and he was white. We had many white teachers. He taught physics and he became really my mentor throughout life, until he died…There were a coterie of the professors who I thought of as anchors in the department. And the classes were small, and so you really got to know the professors and many of them lived right in the community so you would see them after school, they would invite you over to their homes on weekend or Sundays, Chris did in particular. And Chris really sort of opened my eyes to another world because he and his wife Marion, they both played string instruments and he would invite Hops and I over sometimes on Sunday and we'd have dinner and then she would play the piano and he would play the violin. I mean I'd never been in a setting like that in my life, these sophisticated, European, educated people. And they had a pet skunk that had been denatured is the word, and Chris would let us have a sherry, you know, it was very sophisticated. We could have a small glass of sherry with dinner, after dinner. And he became very close to me. He was the one who really convinced me that I was smart enough to be a physicist, that I could do physics.

Clip 5 - Why Physics is Cool: It's really trying to understand how some phenomena works and seeing how the mathematics allows you to explain it. And that's just marvelous. There's no reason that it should be true. There's no reason that the universe should be created so that it has a mathematical basis to understand physical phenomena, but it does. And so you could actually figure out why the sky is blue by working through a mathematical equation that relates different frequencies of light to the way it scatters from particles in the air and all of those things. And low and behold, you come out with some wavelength which is how you measure color and yes, that's, that's, these things have a logic to them, some rational basis and it can be understood.

Clip 6 - Sound Through Liquid Helium: When I first went to Argonne [National Laboratory] I said they were--had these experiments, the results of which you couldn't explain on the basis of the existing theories about how sound travels through liquid helium. And there was an issue with the sound dispersing (falling, being attenuated), and it shouldn't have been. It shouldn't have happened given the way we--you understood how these interactions took place between the atoms and sound waves. And so we developed a theory to explain that. And it's quite well known…The phenomena was: if you sent sound--and you just pulse helium create a sound wave and the sound travels through, and the sound waves are called phonons. And it travels through helium. Of course it dies down after a while. It's like sound dies off. But there was at one point at a certain level of phonon energy, the sound just sort of dropped off. It's called anomalous dispersion. Why should that hap--what happened at that point? And we--and there was a process in the liquid he--the only way--It shouldn't have. There was just no way you could conserve energy and momentum, which you have to in anything, and have that happen. Because there was a process that this phonon could--How could it lose energy? It could split into two phonons, three phonons. Each one [would] have less energy or be dispersed in another direction. And so we show--And this turned out it was based on what I brought to it was work I had done in my thesis. We showed that, in fact, there was a way this three phonon process could take place and conserve energy and momentum. Because of some anomaly in something called the liquid structure function, which I had calculated. And we knew there was this anomaly in the liquid structure function. But we didn't [see how to] relate it. And so we explained that. And it was a big deal. It was a big deal.

ScienceMakers

Spotlight: Ronald E. Mickens



Full Name:	Ronald Elbert Mickens
Born:	February 7, 1943
Place:	Petersburg, VA
Parents:	Daisy Mickens
	Joseph Mickens
Spouse:	Maria Kelker
Education:	Peabody High School - Petersburg, VA (1960)
	Fisk University - Nashville, TN (B.A. Physics, 1964)
	Vanderbilt University - Nashville, TN (Ph.D. Physics, 1968)
Type of Science:	Particle Physics, Mathematics
Achievements:	Worked on nonlinear, ordinary differential equations
	Authored textbooks for advanced mathematics students

Favorites:

Color:	Black
Quote:	"It wasn't me."
Time of Year:	Anytime I can get up in the morning.

Biography

Ronald Elbert Mickens was born in Petersburg, Virginia, on February 7, 1943, to Daisy and Joseph Mickens. Mickens spent much of his youth with his maternal grandparents; his grandfather was responsible for introducing him to science. By the time Mickens was eight years old, he knew he wanted to become a scientist. He graduated from the Peabody High School in Petersburg, Virginia, a few months after his seventeenth birthday.

Mickens entered Fisk University with a full scholarship, where he studied chemistry, mathematics, and physics. Graduating in 1964 with his B.A. degree in physics, Mickens entered the Ph.D. program at Vanderbilt University; in 1968, he received his Ph.D. in theoretical physics. Elected to Sigma Chi and Phi Beta Kappa, Mickens also won a Woodrow Wilson Fellowship, a Dansworth Fellowship, and a National Science Foundation Postdoctoral Fellowship, which allowed him to study at the Massachusetts Institute of Technology. At MIT, Mickens spent two years conducting research in chemistry particle physics at the Center of Theoretical Physics.

In 1970, Mickens accepted a teaching position in the physics department at Fisk University while continuing to conduct research at other universities, including his work on nonlinear, ordinary differential equations. In 1982, Mickens became a professor at Clark Atlanta University and was named a Calloway Professor of Physics in 1985. Mickens was honored with a fellowship in the American Physical Society.

Mickens authored textbooks for advanced mathematics students, wrote over 250 research papers, authored biographies on several African American women scientists and published six books on assorted topics including, "The African American Presence in Physics" and "Edward Bouchet: The First African American Doctorate."

Discussion Questions

Personal:

1. What did you like best about listening to Dr. Mickens?

2. What do you think Dr. Mickens' favorite quote means? What does this tell you about him?

3. Where was Dr. Mickens 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. Mickens attend high school? What do you suppose high school was like for him?

4. How old are you? In what year was Dr. Mickens your age? What was happening in the country that year? What was happening in the world that year? What do you suppose his life was like when he was your age?

5. How did Dr. Mickens first become interested in science? Who was his primary influence? Who has a similar place in your life? **(See Clip #1)**

6. What was Dr. Mickens' best Christmas ever? Why? How does he relate this to his love of science? **(See Clip #2)**

7. Dr. Mickens has unusual ideas about how to get young people excited about science, based on how he first got excited about science. What are they? What do you think about his ideas? Do you think his ideas work with you and your friends? What suggestions would you have for Dr. Mickens? **(See Clip #2)**

8. Dr. Mickens discusses his process of choosing a college. How do you relate to what he says? Are you planning to go to college? Where? Why? Are your friends planning on going to college? Where? Why? If not, why not? **(See Clip #3)**

9. What do you think is the benefit of summer programs like the one Dr. Mickens describes? Why? How do you spend your summers? What has been your best summer yet and why? **(See Clip #3)**

10. Dr. Mickens talks about how he decided what to study in college. What did you think about what he said? What could you do by studying these things? **(See Clip #4)**

11. Dr. Mickens has a definition of a great teacher. What is it? What do think of his definition? How does he measure his success as a teacher? Have you ever had a great teacher? What made that teacher great? **(See Clip #10)**

Science:

12. What do you think a physicist does? Would you like to be a physicist? Why?

13. If you were a physicist, what kinds of questions would you study?

14. How does Dr. Mickens describe science? **(See Clip #5)**

15. Physics is about understanding how the universe works. Can anything be known for sure? Why or why not? **(See Clip #5)**

16. What kinds of questions can science help us answer? What kinds of questions can science never answer? **(See Clip #5)**

17. Dr. Mickens states that mathematics is a language. What does he mean by this? Can you think of examples? **(See Clip #6)**

18. Dr. Mickens explains particle physics. What example does he use? How would you describe particle physics after listening to him? **(See Clip #7)**

19. Dr. Mickens talks about using mathematics to describe the relationship between two things, such as something to observe and the energy needed to observe it. Describe the relationship between two things using mathematical expressions. **(See Clip #8)**

20. Describe mathematical modeling. How would you use it? **(See Clip #9)**

21. Dr. Mickens talks about mathematical models. Create your own mathematical model to describe the behavior of your class over a period of time. **(See Clip #9)**

Physics

Experiment - Singing Rod

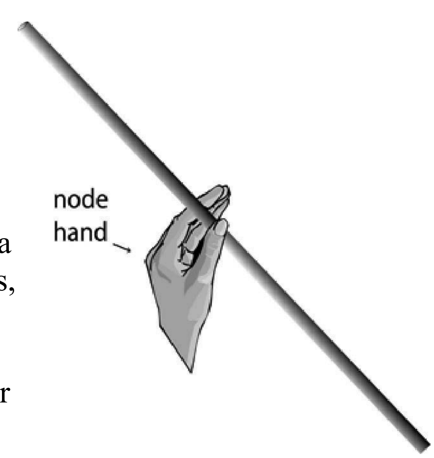
This activity was developed by Physics Central.

Concerto #1 for the Singing Rod in AI# Major
While everyone knows that the world needs more cowbell, it is a little known fact that an aluminum rod can sing to your heart's content.

What you Need

- ¼" Aluminum Rod from the hardware store that is about 2 feet or longer
- Violin or cello rosin

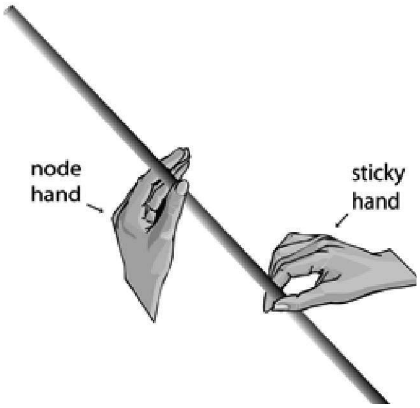
What to Do



Legend has it that the song of the singing rod summons the Physics Fairy. She has been known to guide kids like you through physics problems and experiments. It is thought that the physics fairy inspired a young patent clerk in 1905 to imagine what it would be like to ride on a beam of light. He then developed a very special theory that changed the world of physics. If you aspire to greatness, then keep reading and learn to play the singing rod.

To begin, you will need to find the middle of the rod by balancing it across your finger. Pinch the rod at that middle point and hold it up into the air like a fairy wand. Let's call this your node hand. As you will see later, your fingers will be pinching the nose; I mean the node of the rod. You may use either hand depending on whether you are left handed or right handed. Much like playing the violin, the manner in which you hold the rod is very important.

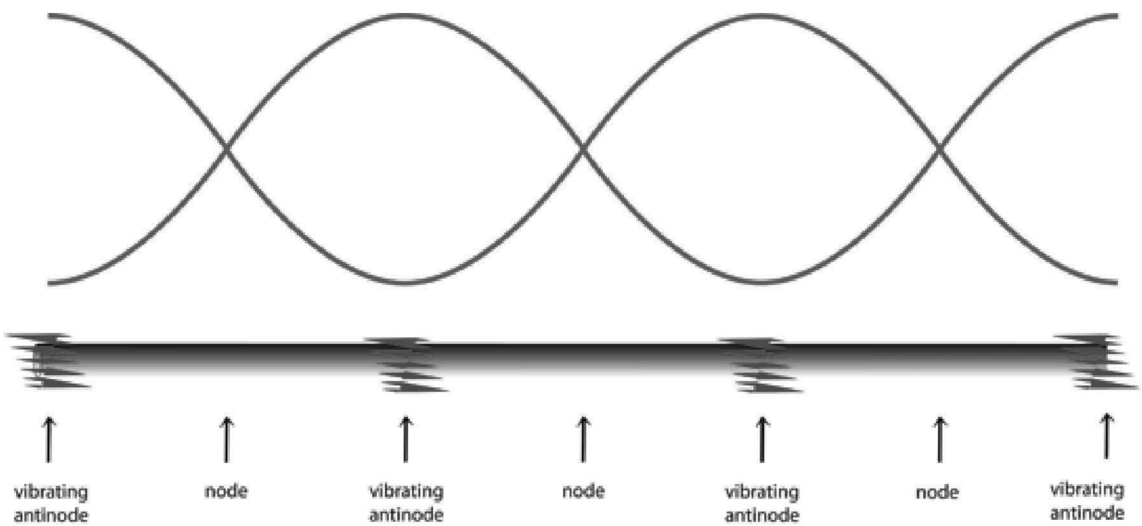
Now rest the end of the rod on your foot for stability and rub the rosin up and down along half of the rod. *Caution: Do not eat the rosin* You may also want to rub rosin directly on the pointer finger and thumb of your other hand. We will appropriately call this your sticky hand.



Once the rod is sufficiently sticky, you are ready to play. While pinching the node of the rod with your node hand, firmly rub along the sticky end of the rod with your sticky hand. Continue to rub repeatedly in one direction. Vary the speed and pressure of each stroke until you hear the rod sing. As with any musical instrument, this will take some practice. Someday you could be the first to play Bach's Concerto No. 1 for the Singing Rod in C# BWV 1065.5 at Carnegie Hall!

What's Going On?

Stroking the rod with sticky fingers creates longitudinal vibrations in the rod. Longitudinal vibrations are waves that travel along the length of the rod. The waves travel to the end of the rod in which they transmit vibrations to the surrounding air molecules. Longitudinal vibrations of air molecules are then interpreted by your ears as sound. However, that is only part of the story. Some of the vibrations traveling toward the end of the aluminum rod are reflected. The reflected waves return and head back in the opposite direction toward your fingers. On their way back, they collide in a head on collision with similar waves created by your sticky fingers!



Now don't worry, a wave collision is not quite a massacre. Waves can either interfere constructively or destructively depending on how they meet. The points on the rod where the waves interfere destructively are called nodes. Waves at the nodes cancel each other out. Hence, there are no vibrations at the nodes. Then where is the rod vibrating? Naturally, the points where the rod is vibrating are called the antinodes. Waves at the antinodes meet constructively and add up to create bigger waves.

When you pinch the rod in the center, you restrain it from vibrating. This creates a node at that point. If you rub the rod slowly, you will produce waves of a relatively low pitch. These waves will create an antinode at the end of the rod. This pitch is called the natural frequency of your rod. Long rods will have a lower natural frequency than short rods. You should try both sizes.

Now to go beyond the natural frequency, you will rub the rod more aggressively. This will create a higher pitch sound that your parents might describe as shrieking or just plain unpleasant. These vibrations are called harmonics.

Try This!
Another clever way of finding the center of the rod is to place it over the ends of your pointer fingers. Now slowly bring your arms together while allowing your fingers to slide beneath the rod. The pressure of the rod on each finger will adjust the amount of sliding friction so that your fingers will automatically come together at the center of mass of the rod. Since the rod is uniform in shape, the center of mass is also the geometric center.

The shower in your bathroom and the stairwell of a building have the perfect acoustics for many physics experiments. When you sing in the shower, the waves reflect off of the walls. At certain pitches, the waves will constructively interfere and produce a phenomenon called resonance. Try singing high and low until you find the resonant frequency of your shower. You will know it when you hear it, because resonance will make you think that you are an opera star.

See this experiment online at: http://www.physicscentral.org/experiment/physicsathome/rod.cfm

Ronald E. Mickens - Video Clip Transcription

Clip 1 - Early Interest: My grandfather mainly talked to me about science. About what it means to be a scientist, and how does one distinguish scientific knowledge from other kinds of knowledge…So we had, you know, lots of interesting discussions. But also, I think, formed the basis of my wanting to be around people who were much older than I. I mean, you know, why be around somebody my age, I didn't know anything, and they probably knew less than I did. So, you go with the people who have the knowledge.

Clip 2 - First Chemistry Set: My best ever, goodest of all Christmases, and that's when my parents bought me a chemistry set. I must have been about eight years old. That was something that I really wanted. You know, you ever think back, what was the best Christmas. I mean it wasn't, it was one of these little small things, but the thing I liked about that Christmas gift, the chemistry set, was that you could actually kill yourself with this stuff. See nowadays, you know, they give you these chemicals that you can swallow it, nothing happens. It's basically Kool-Aid. But in those days, they gave you things where you could actually blow off a face. Or you could set the house on fire. Or you could, you know, maim yourself or whatever. And that was good, I mean fortunately most of the destructive power ended up being directed toward the house, but there were some close [calls], you know. But that was fun, I mean, it was, I mean you could mix stuff up and it would actually blow up. I remember one time, and I'm not sure what happened, I mixed up some powdered metal with some sulfur, it was basically gunpowder and it went off in my face. But fortunately it was in a test tube and I was sitting like this, and it went down and blew a hole in the floor and it missed my face because it was directed almost like a gun, it went up to the ceiling. But that was, I mean, that's how you get, people talk about how do you interest kids in science? Give them some dynamite, I mean really, you know, some nitroglycerin, some acid, I mean, then, well at least the ones that survive, they will be in science. But now you can't get that excitement out of a video game, I mean, no. There has to be some real danger there.

Clip 3 - Starting at Fisk: I had these full fellowships, scholarships to three or four colored schools and I decided I wasn't going. I mean, it's not that I had anything against them as being colored schools, I wanted to get out of Virginia. That was my whole thing. I had never heard of Fisk before. So I went down and this is a science program, and we had calculus, we had chemistry, we had physics and all kinds of stuff. But at the beginning of the summer institute, they gave us a standardized exam. And I made 99 percentile on the standardized exam. I blew them out, as they say. The thing that's interesting is that at the end of the summer, they gave us exactly the same exam [as] before, and I made 92 percentile, so I told [them], this has been a negative learning experience.

I came here intelligent. But I was interested. But no, it was a very good institute. And in fact…at least half of the kids returned to Fisk as freshmen, that's when school started in September. But out of that experience, one of my instructors, Dr. Samuel Massie, who was at Fisk. He actually left that August and became president of two or three colleges and ended up at the Naval Academy as Professor of Chemistry. He offered me a small scholarship. My mother paid the rest for the first year, but after that it was very clear that this was a major strain on her, so fortunately, I was able to get jobs at Fisk that involved work in the laboratorial science-based things.

Clip 4 - Major at Fisk: Well I went there [to Fisk University] to major in mathematics. The mathematics department was very weak. At least I thought it was weak. So I decided to try chemistry, and I didn't like the laboratories. I mean, I think that during my previous days of blowing things up and setting the house on fire, that my spark for chemistry went out, and so I decided on physics, so I ended up majoring in physics.

Clip 5 - What is Science: Science is a way of looking at the world in which you provide answers that can become part of the public domain and by public domain, what I mean is that if you understand what the rules are, and if you follow those rules, that you will get the same answer as I. A very simple example is called the Betty Crocker example: you get the stuff in a box, you know, it tells you pour it in a bowl, put some water, milk over it, stir it and put it in the oven. And you expect to get the same thing every time. Science is like that. Science is public knowledge. It's knowledge that does not depend upon one's particular view of how the world is. What that means, therefore, is that not everything is scientific. Not all knowledge is scientific. But scientific is a special kind of knowledge. And the various fields that science is broken down into deal with particular aspects of this physical world. For example, in physics, you can make predictions relative to where the planets are going to be tomorrow or a thousand years from now. Actually, you can do even better, you can make what are called retrodictions. And a retrodiction, that means you can tell where the moon was a month ago and so forth, and people have done this for example, to try to verify specific kinds of historical events that have also taken place at the same time certain astronomical events have taken place. So science is a particular way of looking at the world, and interpreting it such that it doesn't really depend upon one's individual views. That doesn't mean that in order to get that individual views and prejudice and things don't come into it, but once it gets established, you know, then, you know, it's something that stays there.

Clip 6 - Essence of Mathematics: One way of thinking about mathematics is that mathematics is a language. It's just that it's a very sophisticated language. You can define mathematics as the, and some people have, the science of patterns. You see various things and from that, you try to figure out if there is some meta-rule, some rule that will tell you what these things are. For example, let's take a simple example. Suppose you pick any two numbers. If one number is even, and one number is odd, then on a little reflection, if you add them together, and it doesn't matter what the numbers are, when you add an even number and an odd number, you have to get an odd number. That's a statement that's true independent of what numbers you put in there. Because an even number is anything that's divisible by two, so an odd number's not, so if you add two together, you get an odd number. So that the essence of mathematics is to…well, there are two aspects, one is where you're just trying to look at patterns themselves and not relate them to anything. Fortunately for us, almost all of mathematics that we know about turns out we can relate them to things…Another aspect of the use of mathematics, particular in its role as a language, is to help us to understand various aspects of the world. For example, suppose you want to predict what happens if you throw an apple into the sky. Well there are rules, Newton's Laws, that will tell that. What mathematics in this sense does is instead of having a table that one second later, distance, two seconds later it's this distance, what mathematics does is give you a single formula such that you specify what the time is in the future and I'll tell you where the apple is. And so, it's a very concise, note that this is very concise. You just have this one little single formula as opposed to this very large table that gives these things to you.

Clip 7 - Particle Physics: Suppose you have a piece of iron, you have an iron bar and you cut it in half. Well you just have a short iron bar and you cut that in half. The question is, can you always continue cutting and what do you get? Do you reach a stage in which you have something that's not iron? In other words, is there a smallest unit of iron? The answer is yes, that's an atom. Now the question is, suppose in some sense you could split that atom. You chop it. Do you reach something that's different from an atom? The answer is yes. You can get nuclei, electrons. Then you can ask that about the nuclei…So what elementary particles deal with is trying to understand these various levels. See, nature is actually separated into various levels. That's why we can do science. You have, let's say, the level that we deal with, the so-called macroscopic level, then you have a level below that, the atomic level where you have atoms and molecules, where they are important, and then you have a level below that where you have the nucleus. It turns out that you can actually chop open in some sense, using that metaphor, the nucleus, there's another level. We call those things quarks. You know, and so nature is separated into various levels and what elementary particle physics tries to do is to deal with this bottom layer and ask fundamental questions. Is that the end, or is there something else? Now so far, you know, I mean, it appears that that's the end. But it may not be. Because we thought it was the end when it was up here, and then we got here and thought it was the end. So we don't know, but that's one of the fundamental things. What is the structure of the material universe? That's what elementary particles deals with.

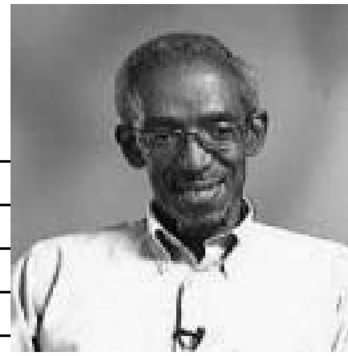
Clip 8 - Explanation of Accelerators: An accelerator is just a microscope. It turns out that there's an inverse relationship between the energy. Think of microscopes now as objects that produce, objects that have some energy, or detecting energy. It turns out that the smaller an object is, then the larger energy is required in order to see it. And so for example, if I want to see what's in the want ads, I have a little hand magnifying glass. If I want to see a cell, then I have an optical microscope that's about this large. If I want to see things that are parts of cells, more than likely I may have to go to an electron microscope, which will be as tall as this room, and if I want to see really down deep into the nucleus, I need an accelerator. And usually the larger the energy of the accelerator, the larger the accelerator is. And so there's this correlation between the size in some sense of the accelerator and the objects that you're trying to see. The bigger the accelerator, on average, then the smaller the object that you can see. Because the larger accelerator will, in principle, allow you to have a larger energy. And you can actually write down a mathematical relationship that gives that to you.

Clip 9 - Mathematical Models: Currently, I'm working on a variety of topics. One of the most interesting deals with the mathematical spread of diseases, particularly so-called periodic diseases. An example is measles. And they are periodic because if you plot their incident versus time, they give you something like a sine wave. One of the issues that we're dealing with is mathematically modeling these things. And there are reasons why you want mathematical models. One is that if you have a good mathematical model, you can do things to the model that you can't do to a human being. So, what a model will do is to allow you to play with things. If it's a good model, you can see, well if I carry out this policy, this strategy for vaccination, I'll get a certain result. And you can also compare it with the economics.

Clip 10 - Great Teacher: What is a great teacher? A great teacher is someone who motivates you, and as I always tell my students, I am not a teacher. You know, I'm not here to present you with facts, even though that may come out. What I'm here to do is to give you the benefit of my experience and to see at least at this time what are things that I consider to be important. And to put you in a position where you can acquire some of these abilities. But as a teacher, my success depends on you being better than I. 'Cause if you can't do any better than me, nothing has changed.

ScienceMakers

Spotlight: Carl Spight



Full Name:	Carl Spight
Born:	September 8, 1944
Place:	Indianapolis, IN
Parents:	Erma Mae White Spight
	William Herman Spight
Spouse:	Martha Spight
Education:	Arsenal High School - Indianapolis, IN (1962)
	Purdue University - West Lafayette, IN (B.S. Electrical Engineering, 1966)
	Princeton University - Princeton, NJ (M.A. Plasma Physics, 1971)
	Princeton University - Princeton, NJ (Ph.D. Plasma Physics, 1971)
Type of Science:	Physics
Achievements:	Recipient of the William F. Thornton Award for Professional Achievement
	Chief scientist for Jackson, Tull, and Graham, Inc.

Favorites:

Color:	Purple
Food:	Lentils
Quote:	"The future of the future is in the critical recovery of the past."
Time of Year:	Late Summer & Early Fall
Vacation Spot:	Cuba

Biography

Physicist, educator, statistical analyst, and community activist, Carl Spight grew up asking questions in Indianapolis, Indiana, where he was born on September 8, 1944. Living across the street from Francis W. Parker School, Spight arrived early each day to pour over encyclopedias that his family could not afford at home. With NBC's "Watch Mr. Wizard" as his favorite television show, Spight fixed his neighbors' appliances and despite prevalent racism won the statewide science fair.

Graduating from Arsenal High School in 1962, at Spight's mother's suggestion he enrolled at Purdue University and graduated with a B.S.E.E. degree (with highest honors) in 1966. Spight earned his M.A. degree and Ph.D. in plasma physics from Princeton University in 1971.

Spight taught at Southern University in 1970, and he served as a tenured professor of physics at Morehouse College from 1972 to 1980, where he eventually became chairman of the Department of Physics. In 1977, Spight was a Visiting Professor of Physics at the Massachusetts Institute of Technology's Center for Theoretical Physics. From 1980 to 1983, he worked for AMAF Industries, where he became director of research. Spight served as the chief of advanced technology programs, the director of engineering, and the chief scientist for Chicago-based Sonicraft, Inc. from 1986 to 1989. As dean of the School of Arts and Sciences and executive assistant to the president, Spight advised on all aspects of the consolidation of Clark Atlanta University from 1989 to 1990. He then served as chief scientist and regional manager of information systems for Jackson, Tull, and Graham, Inc. from 1990 to 2000. Concurrently, he served as manager of academic services for the Office of Information Technology, City Colleges of Chicago from 1994 through 2000. Spight taught at and guided academic programs for Chicago State University, Olive Harvey College, Providence St. Mel High School, North Lawndale College Preparatory Center and the Betty Shabazz Charter School; all of these institutions and businesses serve or originate from the African American community.

Later in his career, primarily as a statistical consultant, Spight served as the Vice President of Forte Development Corporation in Columbia, Maryland. As statistical analyst for Oak Park River Forest High School's Goals 2000 Project, Spight was a co-author of "The Learning Community Performance Gap: An Analysis of African American Achievement at Oak Park River Forest High School, May 2003." Author of numerous scientific articles, Spight was also a featured presenter at the Olive Harvey Black Studies Conference for seventeen years. Spight was the recipient of the William F. Thornton Award for Professional Achievement from the National Technical Association in 1989 and the Distinguished Alumni Award from Princeton University, among many other honors. Spight, an avid percussionist, often performed with his brother, Roy, a carver of African tongue drums.

Together, Spight and his wife Marsha raised three children.

Discussion Questions

Personal:

1. What did you like best about listening to Dr. Spight?

2. What do you think Dr. Spight's favorite quote means? What does this tell you about him?

3. Where was Dr. Spight 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. Spight attend high school? What do you suppose high school was like for him?

4. How old are you? In what year was Dr. Spight your age? What was happening in the country that year? What was happening in the world that year? What do you suppose his life was like when he was your age?

5. Dr. Spight had to be at school early every day. Why? What did he do with this time? What kinds of things do you like to learn about outside of school? How could these interests help you decide on a career? **(See Clip #2)**

6. Dr. Spight talks about his relationships with his friends. What does he say is most important if you are interested in science and math? What were his relationships like with his friends? What are your relationships like with your friends? Are you or any of your friends interested in science or math? What is the attitude towards this among your friends? How can your friends help you to be a better person? How can they bring you down? Why is it important to know the difference? **(See Clip #3)**

7. Dr. Spight talks about his experiences at Purdue. What was the experience of African American students there? What was his experience as an African American physics major? How did he handle it? **(Clip #4)**

8. What was Dr. Spight's experience of Princeton? How did it differ from that of Purdue? Have you thought about where you might go to college? Have you thought about how one college differs from another? Do you have a process for picking colleges? **(See Clip #5)**

9. When Dr. Spight was preparing to leave Princeton, he changed his life direction. What was his thought process? What did he ultimately decide to do? **(See Clip #6)**

Science

10. What do you think a physicist does? Would you like to be a physicist? Why?

11. If you were a physicist, what kinds of questions would you study?

12. Dr. Spight talks about taking apart televisions and radios. What led him to do this? He mentions things like cathdodes, transistors and capacitors. Find out what each of these components does and how it relates to the operation of a television or a radio. How are televisions and radios different today? Explain how integrated circuits work. How did microcircuitry come to be? What was science's role in this? **(See Clip #1)**

13. Dr. Spight discusses wanting to study nuclear fusion at Princeton. What is nuclear fusion? What is the difference between nuclear fusion and nuclear fission? Give some examples of each and explain the difference on an atomic level. What area of nuclear fusion was Dr. Spight interested in researching? Why? **(See Clip #5)**

Experiment - Pop Can Hero

This experiment was developed by the Center of Science and Industry, Columbus, OH.

Description:
Demonstrate Newton's Third Law of Motion by using the force of falling water to cause a soda pop can to spin.

Concept: Newton's Third Law of Motion states that for every action there is an equal and opposite reaction.

Materials:
- For Demonstration:
  - Skateboard
  - Hero Engine (Flask w/ Rubber Stopper and 90 degree glass elbows)
  - Heat Source
- Per Participant:
  - Soda Pop Can
  - Screwdriver
  - Fishing Line
  - Access to Water

Instructions:
Rockets can liftoff from a launch pad only when it expels gas out of its engine. The rocket pushes on the gas, and the gas in turn pushes on the rocket. The whole process is very similar to riding a skateboard.

Imagine that a skateboard and rider are in a state of rest (not moving). (Reveal a skateboard and climb on board.) What would happen if I were to jump off the skateboard? (Take a few hypotheses and then forcibly leap from the skateboard.) In Newton's Third Law of Motion, the jumping is called an action. The skateboard responds to that action by traveling some distance in the opposite direction. The skateboard's opposite motion is called a reaction.

To further demonstrate Newton's Third Law of Motion, let's examine the Hero Engine. The Hero Engine is similar to a water kettle…heat it up…steam comes out.

Demonstration of Hero Engine:
1. Place a small amount of water (about 10 to 20 ml) into the float. The precise amount is not important. The float can be filled through the top if you drilled an access hole or through the tubes by partially immersing the engine in a bowl of water with one tube submerged and the other out of the water.

2. Suspend the engine and heat its bottom with the torch according to the diagram. In a minute or two, the engine should begin spinning. Be careful not to operate the engine too long because it may not be balanced well and could wobble violently. If it begins to wobble, remove the heat.

Making a Soda Pop Can Hero Engine:
1. Distribute one soda pop can and one screwdriver to each group. Tell the participants that you will demonstrate the procedure for making the Hero engine.
2. Lay the can on its side and use the screwdriver to punch a single hole near its bottom. Before removing the screwdriver, push the handle to one side to bend the metal, making the hole slant in that direction.
3. Remove the screwdriver and rotate the can approximately 90 degrees. Make a second hole like the first one. Repeat this procedure two more times to produce four equally spaced holes around the bottom of the can. All four holes should slant in the same direction going around the can.
4. Bend the can's opener lever straight up and tie a 40-50 centimeter length of fishing line to it. The Soda Pop Can Hero Engine is now complete.

Physics

Running the Engine:
1. Dip the can in the water tub until it fills with water. Ask the participants to predict what will happen when you pull the can out by the fishing line.
2. Have each group try out their Hero Engine.

Possible Interactive Questions:
- What were your observations? Why did the cans begin spinning when water poured out of the holes?
- What was the action? What was the reaction?
- Did all cans spin equally well? Why or why not?

What's Going On?
Hero of Alexandria invented the Hero engine in the first century B.C. His engine operated because of the propulsive force generated by escaping steam. A boiler produced steam that escaped to the outside through L-shaped tubes bent pinwheel fashion. The steam's escape produced an action-reaction force that caused the sphere to spin in the opposite direction. Hero's engine is an excellent demonstration of Newton's Third Law of Motion.

During the group activity, the action is the force produced by falling water, while the reaction is the spinning of the pop can.

Newton's Law states that every action has an equal and opposite reaction. If you have ever stepped off a small boat that has not been properly tied to a pier, you will know exactly what this law means.

With rockets, the action is the expelling of gas out of the engine. The reaction is the movement of the rocket in the opposite direction. To enable a rocket to lift off from the launch pad, the action, or thrust, from the engine must be greater than the weight of the rocket. While on the pad the weight of the rocket is balanced by the force of the ground pushing against it. Small amounts of thrust result in less force required by the ground to keep the rocket balanced. Only when the thrust is greater than the weight of the rocket does the force become unbalanced and the rocket lifts off. In space where unbalanced force is used to maintain the orbit, even tiny thrusts will cause a change in the unbalanced force and result in the rocket changing speed or direction.

One of the most commonly asked questions about rockets is how they can work in space where there is no air for them to push against. The answer to this question comes from the Third Law. Imagine the skateboard again. On the ground, the only part air plays in the motions of the rider and the skateboard is to slow them down. Moving through the air causes friction, or as scientists call it, drag. The surrounding air impedes the action-reaction.

As a result, rockets actually work better in space than they do in air. As the exhaust gas leaves the rocket engine, it must push away the surrounding air; this uses up some of the energy of the rocket. In space, the exhaust gases can escape freely.

Further Exploration:

Experiment with different ways of increasing the spin of the can. Does increasing the size of the holes increase spin?

1. Provide each group with the materials listed above; however, this time screwdrivers should have different diameter shafts from the one used to make the first engine. Identify these screwdrivers as small (S) and large (L).
2. Have the groups make two additional engines exactly like the first, except that the holes will be different sizes.
3. Discuss how to count the times the engines rotate. To aid in counting the number of rotations, stick a brightly colored round gum label or some other marker on the can. Tell them to practice counting the rotations of the cans several times to become consistent in their measurements before running the actual experiment.
4. Discuss the results of each group's experiment. Did the results confirm the experiment hypothesis?
5. Ask the students to propose other ways of changing the can's rotation. (Make holes at different distances above the bottom of the can, slant holes in different directions or not at all, etc.) Be sure they compare the fourth Hero Engine they make with the engine previously made that has the same size holes.

COSI
Center of Science and Industry

Carl Spight - Video Clip Transcription

Clip 1 - Tearing up Old Radios: I came up in a ghetto, essentially, a poor, very poor community, where people had TVs and radios but when they get broken, they couldn't afford to get them repaired, at least not quickly. And most of the time, what was wrong, because this was the era of the vacuum tube, where you had these filament heated devices which now have been totally replaced by integrated circuitry and so on, you don't even see what is the active part. There, you could at least look into the box and see the glass-encased devices, some of them glowy and some not. So on first pass you could say to yourself, well, this radio or TV doesn't work because this tube is defective in some form or fashion, at least the cathode, this heated element, was not displaying in the way that it normally would. So you take it out and you literally as you say, as we were sharing, carry it down to the corner or whatever, drugstore, neighborhood grocery story, and they would have a device in there and you plug the thing in and it would give you a reading as to whether the filament, the thing that heats up the cathode that would glow and you would be able to observe that it was functioning, if it was functioning. It would test the filament but it would also test other electronic aspects which was that next layer, I mean, there's one thing to establish as to whether it was blown out, as a vacuum tube element 'cause you could all but determine that visually. It was another thing to say, whereas it may not be blown up, but it has some absence of functionality and wasn't performing in a way that allowed the radio or TV to function in terms of either the video display or the audio and so on. So, it turns out there are a couple of layers of expertise. A lot of my buddies got the kind of hang of it, especially when I got a little fifty cent here and a dollar there for being Mr. Radio, got the kind of hang of carrying the tube down to the corner store. But it was another thing to figure out that there might be other things that might be wrong, that there are other things inside the radio, like capacitors and you know, and other little boxes and cylindrical devices and so on, resistors that might be burnt out and to know what to do when that was true essentially came from tearing it apart, just literally tearing apart discarded radios and TVs and messing around and probably getting shocked electrically and just destroying a few things here and there. But that was my laboratory.

Clip 2 - Living Close to School: So I would literally read encyclopedias, there's no mistaking that I actually did read encyclopedias, I mean if there was nothing else to do, I'd get to school early because I lived right across the street, and my mother was the school crossing guard. So she had to be out there before school starts, right. She had to be out of the house, my father was at work, as I told you, he worked several days a week going very early in the morning, seven days a week, literally, never took a vacation, and I have no idea what the mentality of that all was but it was something that he did religiously. So anyway, so she would go to school so we had to go to school, too. So I got to school early, you know, we had to be out of the house because she was out of the house and so what am I to do? I got to school early, I'm the Mr. Wizard and the encyclopedia is there, so I literally would kind of open them up and spend a half an hour or so just looking at them and found it vastly fascinating, you know, just another world.

Clip 3 – Friends: You can be interested in things, ideas, in science for example, and literature, in knowing and learning. You can be interested in that. The thing that you can't do while being so interested is to think of yourself as therefore better than, of higher than, of having something over, of being raised up, you know, lifted up above those who are not interested in that. You can't carry yourself in certain kinds of ways and be accepted. But I never had the sense of being, like I said, I was Mr. Radio, Mr. Wizard, Whiz Kid, clearly the guy who was in the courses that no blacks even thought about taking. But I had friends, and they never talked to me about why are you doing that, I mean that's uncool, that's not black, or any other such thing. If anything, they took some pride, I think.

Clip 4 – Purdue: My father didn't have any money to send me to Purdue, that's for sure. I ended up getting a General Motors Scholarship that paid a lot of the freight…it was about $1,000 a year, then that was a lot of money, a whole lot of money then. Far more money than my family could provide, that's for sure. So I ended up going to Purdue in engineering out of Arsenal Technical High School, not because they were giving any encouragement to apply to a white engineering or science college or university, but because my father had been influenced to think about that for me by having him work at RCA. So I put my dream of being a nuclear physicist on hold; it wasn't on the radar screen. He had no calculus, no place for such a dream, my father.

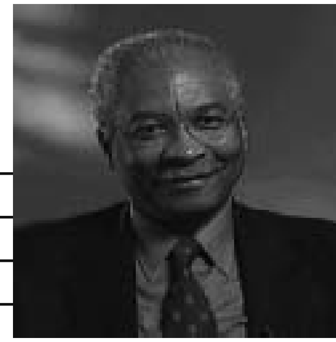
Purdue University is about 58 miles, about 60 miles from Indianapolis. So, you know, it was a hop, skip and jump in one sense but a giant leap depending on how you think about those things. It was reachable, but West Lafayette boy, Lafayette, Indiana was another kind of place then. You know, when I was an undergraduate student at Purdue University, the notion of a black student being in engineering…Now, they have a Black Student Union…They have the National Society of Black Engineering, which is one of the strongest chapters up there. In fact, they may have started at Purdue. But back then, you know, black students who were at Purdue were football players or they were majoring in speech therapy in terms of the co-eds or other miscellaneous stuff. So, anyway, I went up the road, primarily because my father said that that was a good place for me to start the process. And that literally was the reason. I had no other sense of Purdue and had no sense of engineering as such. I did very well there, graduated with highest honors and so on. I was the president of the Electrical Engineering Honorary Society, which you've probably seen on the resume and so on. I say that only to say that in the context where black folks just didn't do those kind of things, I was able to find some way to get in there even find some support. I couldn't have been elected to be president of the Electrical Engineering Honor Society without some white engineering students somehow at least recognizing me as a person, as a co-student and so on. Lafayette, Indiana and West Lafayette, Indiana was a racist piece of the world, just like most of Indiana was back then. I got called nigger there, too, to be sure. But it wasn't only that, it was a vast engineering school, of course.

Clip 5 – Princeton: I had this dream, right, remember my dream. I wanted to be a nuclear physicist. Princeton at the time was the place in the world, not in the country, in the world, in the forefront of controlled thermal nuclear fusion research. Controlled thermal nuclear fusion research, and that's the whole notion of course of capturing the nuclear combining processes that regularly go on in suns in a controlled environment to extract energy and so on. Right, so notice the magic for me already, right. This was a facility, best in the world, major federal investment and university draped around it, invested in looking at nuclear processes, right. I said, "Wow, this is my dream." I discovered and ended up doing something important, right? That is, they were concerned about harnessing the energy of nuclear fusion to use for human application. Not bombs, for example. Not bombs. So anyway, I applied to Princeton because that was, as far as I was concerned, the best of all possible realizations, nuclear stuff, doing stuff [that was] important and [positive] human implication for humankind, that they can succeed, and an excellent university…I got a fellowship, a research fellowship to Princeton based primarily on the fact that I had excellent grades and excellent, ultimately excellent recommendations, I hope. I never saw the letters, but I assume I did, since I had all of these other credentials from Purdue. Princeton was a whole different universe, I mean, as Purdue was an engineering school, Princeton was a university, right, it was an intellectual environment. It was a wholly different kind of place, I mean, Nobel Laureates all over the place, brilliant speakers of all kinds, black, white, green, yellow, regularly in music repertory theater, a library that's fabulous, and a technical library that was also fabulous, not to mention just a general library of humane letters, just one of the best in the world. So, now it was an explosion for me, intellectually, and that's what it was. It was - I made the break finally that I'd been kind of dreaming about all this time.

Clip 6 - Decision to Teach: Princeton for me was this opening up, this flowering out intellectually into an arena that was big enough for what I had as a dream, on the one hand, but also it was a time in which my seventies consciousness, you know, the notion of myself as a progressive, as an activist, was developed and ultimately matured, I guess is the only way to say that. By the time I left there, it was clear, it was clear in my mind what I wanted to do, even though I had gone there with the aspiration of being on the forefront, innovators of controlled nuclear fusion research, and I was going to do all these great things scientifically, by the time I got to the end of that journey, I said to myself, I have mastered a fair amount of technology skills and technique and understanding, and I want to find a way to invest this in the black community. So I had a ninety-degree turn in the road. So the first job out of Princeton was not to work at some controlled thermal nuclear fusion laboratory, but to work at Southern University Baton Rouge campus, so that's the other trajectory of my life.

ScienceMakers

Spotlight: Herman White



Full Name:	Herman Brenner White, Jr.
Born:	September 28, 1948
Place:	Tuskegee, AL
Parents:	Susie M. White
	Herman Brenner White, Sr.
Education:	Tuskegee Institute High School - Tuskegee, AL (1966)
	Earlham College - Richmond, IN (B.A. Physics, 1970)
	Michigan State University - East Lansing, MI (M.S. Physics, 1974)
	Florida State - Tallahassee, FL (Ph.D. Physics, 1991)
Type of Science:	Particle Physics, Mathematics
Achievements:	Helped design high-energy particle beams and detector systems
	Researcher at Fermilab National Accelerator Laboratory

Favorites:

Color:	Blue
Food:	Apple Pie with Ice Cream
Quote:	“Outstanding!”

Biography

Distinguished physicist Herman Brenner White, Jr., was born in Tuskegee, Alabama, on September 28, 1948. Growing up attending public schools in Macon County, Alabama, White developed a great interest in science at an early age. After graduation from Tuskegee Institute High School in 1966, White attended Earlham College in Richmond, Indiana, where he earned his A.B. degree in physics. White completed his graduate education in nuclear and accelerator physics at Michigan State University and high energy and particle physics at Yale University and Florida State University, earning his M.S. and Ph.D. degrees in physics.

White went on to serve as a member of the Fermi National Accelerator Laboratory (Fermilab) scientific staff for over thirty-three years. During his tenure at Fermilab and other laboratories, White collaborated on numerous high-energy particle physics experiments in addition to the design of high-energy particle beam and detector systems. White worked as both Kaon researcher and diplomat in collaborating with Universidad Autonoma de San Luis Potosi in Central Mexico to build components of the detector for Fermilab's proposed charged Kaons at the main injector experiment. White worked as a senior scientist at the highest energy particle accelerator in the world, where atoms are smashed to reveal more about nature's fundamental building blocks.

Among his honors, White received an Alfred P. Sloan Foundation travel fellowship to CERN, Geneva, Switzerland, in 1972, and he was awarded a university fellowship in physics at Yale University from 1976 to 1978. White was selected as the third Illinois Industrial Research Corridor Fellow for North Central College in 1994. In addition, he served as Adjunct Professor of Physics at North Central College in Naperville, Illinois. White held a membership in the American Physical Society's Public Face of Physics Team, and he served on various physics communication and advisory panels for the American Physical Society and governmental agencies.

Discussion Questions

Personal:

1. What did you like best about listening to Dr. White?

2. What do you think Dr. White's favorite quote means? What does this tell you about him?

3. Where was Dr. White 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. White attend high school? What do you suppose high school was like for him?

4. How old are you? In what year was Dr. White your age? What was happening in the country that year? What was happening in the world that year? What do you suppose his life was like when he was your age?

5. Dr. White talks about an early interest in science, but he calls it something else. What does he call it? What are you curious about? Do you wonder how things work, like Dr. White did? How can you find the answers? **(See Clip #1)**

6. Dr. White talks about using a lens to focus the sun's light and trying to figure out how light in the sky behaves. What kinds of things do you wonder about light? Do you ever wonder how shadows work? What about reflections? How about rainbows? How could you find the answers to these questions? **(See Clip #1)**

7. Dr. White talks about growing up in Tuskegee, Alabama, home of Tuskegee University. What does he say was one of the advantages of living in a college town? Do you have any colleges in your community? Are there scientists working there? What kinds of science do they study? What discoveries are they making about the world? Find out and report back to the class. **(See Clip #1)**

8. Dr. White talks about his college experience in terms of the Civil Rights Movement. How did the Civil Rights Movement impact the academic community, according to Dr. White? What was the specific choice that he made in leaving his hometown for college? What did it mean to be a pioneer in college at that time? Do you know any other pioneers like this? Who? Have you thought about whether you will go to college? If so, where? Would you want to stay close to home or travel far away? Why? **(See Clip #2)**

9. Dr. White would like people to think of him as a pioneer. When you think of a pioneer, what comes to mind? Who are some of the pioneers you can think of? What does it mean to be first at something? What does it mean to build on the achievement of others and chart a new direction for yourself? What new directions in the world interest you? What types of knowledge would you need in order to pursue those new directions? Would you like to "smash atoms for a living?" **(See Clip #7)**

Science:

10. What do you think a physicist does? Would you like to be a physicist? Why?

11. If you were a physicist, what kinds of questions would you study?

12. Dr. White discusses the various fields within physics. What are some of the ones he talks about? Find out what each one of these fields explores. Which of these fields sounds the most interesting to you? What about the rest of the class? **(See Clip #3 and Clip #5)**

13. Dr. White talks about thinking ahead to how the science could be applied to industry. What are some ways in which scientific advances have led to technological innovations? Find at least five things you use that have been made possible through science. **(See Clip #3)**

14. What was the subject of Dr. White's first published paper? What kinds of things did he study in his research? What happened as a result of this paper? Have you ever started a project and then discovered that it changed part way through? What was the project? What happened? Explain how this relates to the overall story of science. **(See Clip #4)**

15. What is the difference between nuclear and particle physics? Can you think of any examples of nuclear or particle physics that you have seen? Why do labs like Fermilab and CERN require so much energy to "see" such small particle? What happens in a particle accelerator? Find out and report back to the class. **(See Clip #5)**

16. Dr. White talks about increasing the number of minority scientists. He lays out a very specific plan. What do you think of this plan? Are you interested in any of the topics he discusses? Why? What sparks your interest about that topic? Dr. White also mentions that his career has been possible because of the support he received along the way. Who are the individuals in your life now who can support you in achieving your academic and career goals? **(See Clip #6)**

Experiment - Floating and Sinking

These experiments were designed by Dr. Bassam Shakhashiri.

Soda Cans

Imagine a hot summer day. You're at a picnic and go to the ice chest where the sodas are staying nice and cool. Which cans are floating in the ice water and which have sunk to the bottom?

For this experiment you will need:

- Several unopened cans of regular soda of different varieties
- Several unopened cans of diet soda of different varieties
- A large aquarium or sink

Fill the aquarium or sink almost to the top with water. Place a can of regular soda into the water. Make sure that no air bubbles are trapped under the can when you place it in the water. Does it sink or float? Repeat the experiment with a can of diet soda. Does it sink or float?

Why does one can sink and the other can float?

The cans of soda have exactly the same volume, or size. But their densities differ due to what is dissolved in the soda. Regular soda contains sugar as a sweetener. If you look at the nutrition facts on a can of regular soda, you will notice that it contains sugar...a lot of sugar. In some cases, a 12-ounce can of regular soda will contain over 40 grams of sugar. Diet sodas, on the other hand, use artificial sweeteners such as aspartame. These artificial sweeteners may be hundreds of times sweeter than sugar, which means that less than a few grams of artificial sweetener is used in a can of diet soda. The difference in the amount of dissolved sweeteners leads to a difference in density. Cans of regular soda tend to be more dense than water, so they sink. Cans of diet soda are usually less dense than water, so they float.

Are there any varieties of regular soda that will float? Are there any varieties of diet soda that sink? Can you think of other factors that might influence which sodas float or sink?

Find this experiment online at: http://scifun.org/HomeExpts/cans.htm

Bowling Balls

We all know that heavy objects, such as a bowling ball will sink in water – right? Are you sure? Try this experiment to find out for yourself.

Physics

For this experiment you will need:

- An 11 pound or lighter bowling ball
- A 13 pound or heavier bowling ball
- A large aquarium, a bathtub, or a trash can
- A piece of string 30 inches or longer
- A ruler
- A bathroom scale

Fill the aquarium, bathtub, or trash can ¾ of the way with water. Place the 13 pound or heavier bowling ball (CAREFULLY - DO NOT DROP) into the water. Does it sink or float? Is this what you expected? Now CAREFULLY place the 11 pound or lighter bowling ball into the water. Does it sink or float? Is this what you expected?

We can figure out if a bowling ball (or any object) will sink or float in water if we know its density. Density is a measure of how much mass is present in a given volume. Once we know the density of an object, we can compare it to the density of water, which is about 1 g/cm^3. If the density of the object is greater than the density of water, it will sink. If the density of the object is less than the density of water, it will float.

Let’s figure out the density of the bowling balls. To do this, we need to know their volume and their weight.

Measure the circumference of each of your bowling balls by wrapping a piece of string around the ball at its widest part, marking the circumference of the ball on the string. Next, lay the string out flat and straight to measure the length with a ruler. What is the circumference of your ball? It should be pretty close to 27 inches. The rules of bowling state that “the circumference of a ball (the distance around it) shall not be more than 27.002 inches nor less than 26.704 inches”.

In science, we usually measure using the metric system. You can convert inches to centimeters using the ratio 1 in. = 2.54 cm. What are the circumferences of the bowling balls in centimeters?

Now you can determine the volumes of your bowling balls using the equations for circumference and volume of a sphere. Remember that π is 3.14. The equation for circumference is:

circumference = 2 * π * radius

Once you have solved for the radius of each ball, you can find the volumes using the equation:

volume = $\frac{4}{3}$ * π * radius^3

You may notice that bowling balls are not perfect spheres. There are usually 3 or 4 holes in each ball. We must subtract the volume of these finger holes to determine the true volume of each ball. We can determine the volume of these holes by assuming they are roughly cylindrical in shape and measuring the depth and radius of the holes. An easy way to measure the depth of each of the finger holes is to put a pencil into the ball so that it touches the bottom of the finger hole. Mark the pencil at the point where it is even with the ball's surface by pinching the pencil between your fingers and lifting it out of the hole). Then measure the distance from your fingers to the end of the pencil. This is the depth of the finger hole. To find the volume you will need to also measure the radius of each hole (the radius is half the diameter or maximum width of the hole). Remember to convert your measurements to centimeters if you measured in inches. Now use the equation for the volume of a cylinder:

volume = π * radius^2 * height

Determine the volume of each finger hole (are they different?). For each bowling ball, subtract the total volume of the finger holes from the volume of the sphere that you calculated earlier. This will give you more accurate values for the volumes of your bowling balls.

Now let's find the weight of the balls using the bathroom scale. Some scales don't measure small weights accurately, so you might try this technique: weigh yourself, then weigh yourself holding a bowling ball, and subtract the two weights to find the weight of the ball. Most scales in the U.S. give the weight in pounds. The conversion between pounds and grams is 1 lb = 453.6 g. Finally, for each ball divide the weight of your ball (in grams) by the volume of your ball in cubic centimeters to get their densities.

Compare the densities of the bowling balls to the density of water, which is around 1 g/cm^3. If the density of a ball is less than 1 g/cm^3, it will float. If it is greater than 1 g/cm^3, it will sink. Do these results agree with what you saw when you put the balls in the water?

Did subtracting the volume of the finger holes affect your final volume calculation greatly? By what percentage did the volume of your ball change?

The density of steel is around 7.8 g/cm^3, much greater than that of water. So how are large ships, which are made mostly of steel, able to stay afloat in water? It's important to keep in mind that the ability of an object to float is not entirely based on the density of the material that it is made out of. Ships are constructed in such a way that they contain a lot of open space inside them. The overall density of the ship includes all of the air inside it, so its average density is less than that of water.

Find this experiment online at: http://scifun.org/HomeExpts/bowling.htm

<u>Herman White - Video Clip Transcription</u>

Clip 1 - Childhood Interest in Science: My interest in science was: I cannot remember when I wasn't interested in science. And of course, now I call it science, but I think certainly when I was growing up, it was just curiosity. My concern was really answering some very basic questions. I go back and give my parents a great deal of credit for tolerating some of my eccentricities. I would always try to mix things up in my mother's kitchen, and I learned how to clean the kitchen very well as a result of that mixing up experiments. But I was given a great deal of latitude to try to explore and understand in fact how nature worked around me. I recall actually being in the woods next to my house, [and] finding the bottom part of one of these old Coca-Cola bottles. And this effectively turns out to be a lens because these were thick pieces of glass, and it was fascinating to me that I could actually use this thick piece of glass to essentially focus down the rays of the sun and start, I'm not a pyrotechnic person, but focus down the sun's rays and cause a little heat combustion with some leaves. And that was very fascinating to me. I could not understand how it would be possible to do that, and I could put my hand, not at the focus, but put my hand underneath this lens and nothing would happen to it. But there would be enough heat concentrated at the focal point to actually cause combustion. And I think this sort of thing was sort of the basis by which I actually started to study and to think about how things really work, why the sky is the color it is, why the stars look the way they do. And of course in Alabama in the early 1950's, you could actually see the sky rather clearly, you didn't have as much pollution and that sort of thing, light pollution or any other type of pollution. So it was very, very fascinating for me to be able to put these things together to see in fact the environment that I lived in, and also to understand something about the science that would probably answer some of these questions. And I had a great deal of, how do I put it, I had a great deal of support with regard to the community as well. Tuskegee, Alabama is a real significant place with regard to education activities, certainly as a young person growing up there and having a university town, essentially where you could go and talk to chemists or you could talk to physicists, or you could talk to people who were aviation pioneers. This was a very easy thing to do so it was, it seemed normal to me to be able to actually exercise some of the resources that I had to be able to do things. And I really enjoyed that a great deal, I think once I started down this path of asking these questions and being able to do little small experiments and so forth, I think that sort of provided the, at least the direction, at some level the motivation as well, to continue to do scientific work.

Clip 2 - Legacy of Civil Rights Movement: The Civil Rights Movement was something I think that did provide an opportunity for us. I mean, I thought certainly when I was high school student, or prior to high school student, that various people would come to our house and my mother's friends from the institutes and say they couldn't wait to have your son in their class. And the reason being, of course, was that I knew all about the university and they knew all about the students who were coming out of the high school. So it was sort of a *fait accompli* that I would be expected to finish high school and go to the hometown college. When I chose to go somewhere else, that was, I think, probably a significant part of just doing the work but also a significant part of the times, the Civil Rights Movement and so forth. And you couldn't quite say no. Those who wanted to leave college, leave and go away to college as opposed to going to a hometown school, understood in fact what they were doing. But also understood that not all the students who went away were successful. Some actually did not do what they thought they would do, some did not quite, they weren't quite successful in terms of dealing, not only with their academic development, but with the fact that you did have a burden to carry with regard to civil rights and the fact that you were really going to be the pioneer. It wasn't the nice cocoon, highly trained African American community that you grew up in. You were now the identified one in a much larger community.

Clip 3 - Getting into Nuclear Physics: I had studied basically elementary physics. I'd studied electricity and magnetism, mechanics, nuclear physics, modern physics, quantum mechanics, and we had various seminars also within our physics curriculum. There were only seven physics students, seven physics majors in my class. So there was a small group of people that pretty much did everything together. We had individuals who would come as colloquium speakers. And they would talk about cosmic ray physics. They would talk about nuclear physics. They would talk particularly about solid state physics. And this has to do with the atomic physics and the structure that you might find that would be applied to electronics, for example. Traditionally, we call it condensed matter physics, but solid state physics is the sort of subject matter that's associated with basically the electronics industry. So we were thinking at some level about the application of our science to industrial development, to building things and so forth. And I still have sort of a thought process about building things… But there came a time when I started to really ask some very fundamental questions about, particularly about nuclear structure. I didn't quite understand it, and I began to read and to think more about it and decided that this might be a reasonable thing for me to start to study. The instruments associated with nuclear structure and the subject itself. So instead of graduating or leaving in three years to study engineering, I decided to stay an additional year and finish my undergraduate thesis work as well as a bachelors, A.B. degree, Bachelor of Arts degree in physics.

Clip 4 - Transition to Particle Physics: My first research paper that I published had to do with the study of looking for heavy elements in an environment of bulk light elements. This came out of a study that was motivated by the concern that people had about mercury in tuna fish. So we were looking for trace amounts of heavy elements in biological materials. So I had already done radioactive materials in soil samples, so this was not significantly different to some extent. I got to use a cyclotron to do the work, and that was very significantly different, rather than just counting the activated materials that were coming off soil. So, during this particular year, I began to study the heavy elements, or trace elements, in various types of biological materials…I had a lot of fun doing that, and it's very interesting, cause I learned a great deal about the new techniques of making thin targets, about using alpha particles scattering from cyclotrons and also about building and performing an experiment as well as the analysis of it. After that work, I also received an Alfred P. Sloan travel fellowship basically. It was suggested by what's now the Fermi National Accelerator Laboratory. But I received funds to be able to do work outside of Michigan State University and my mentor, Dr. Henry Blauser, suggested that I take these funds to the Central European Laboratory for Particle Physics Research in Geneva, Switzerland. And so this would be the first time that I'd actually gone to Europe and while at CERN, I made the transition, perhaps to the disappointment of my mentor, from nuclear and accelerator physics into particle physics.

Clip 5 - Difference Between Physics Types: At some level the difference between nuclear physics and particle physics is designed to be associated with the energy. So in fact, if I'm dealing with particles that are in the range of millions of electron volts, and I look at the structure of the nucleus of the atom, which means the protons and neutrons that make up the structure of the atom, I'm doing nuclear physics. If in fact I want to do particle physics, I have to go to much, much higher energies because you have to have a high-energy beam to be able to probe not just into the nucleus of the atom, but into the particles that make up the particles of the nucleus of the atom. And those particles are known as quarks, or partons. So what we do essentially as an "atom smasher," so to speak, is that we break apart the structures that hold the nuclear forces that hold the nuclear components together within an atom, and that is essentially nuclear interactions. And then, we also take some of the individual particles with high-energy particle beams, and we break up the components that are inside of the protons and neutrons that are the massive parts of the atomic structure, and we look at the particles that come out. This is true conversion between the energy that's in particle beams and the mass that's equivalent to that energy. The E equals MC squared really means something when you're actually dealing with the production of elementary particles, because the higher the energy that you're going to have, the more energy conversion that you can produce, and in fact the more precision you can have in terms of studying the particles inside of the nuclear structure.

Clip 6 - Getting more Minority Scientists: If you want to make a scientist that's even close to being, say, a high-energy particle physicist, you have to start in the eighth grade. You have to get someone, not necessarily whether that person is a member of an underrepresented group, but you have to look at the members of underrepresented groups and say, who's interested in understanding gravitational lensing, black holes, why the sun shines, how nuclear structure works, how particles work, CP violation. Anyone who's interested in doing those sort of things is the person that you want to support because once you get that particular interest, that you get that, I guess you would call it that spark in the eye, that asks questions that are fundamental to our entire existence, you don't need to actually do any of the work, but just support that person because they will do all the work for you. And it turns out, I believe that we're just not identifying those individuals and we're not making the kind of effort that we need to do that. We believe, I certainly believe, that children are inherently interested, and inherently curious. And that's all it takes. If we don't beat that interest out of them, if we don't say, you shouldn't do this, you shouldn't study physics, you should maybe study basketball or something, we could have as many scientists as we want. We could probably have more scientists than we could ever want. But we tend to make heroes and we tend to put things in a way that people believe that the best definition of success are the definitions that we see on TV and in the entertainment industry. And that's not to denigrate the entertainment industry. I think it's great for people to actually use and expose their talent and develop that talent. My history, as you've just heard in fact, comes from basically a significant number of people over a very long number of decades that have said, "Oh, you want to study nuclear physics? You want to study nuclear engineering? You want to study accelerators? You want to study particle physics? You're interested in a lot of things? Well, fine. We'll help you." And that's, in my personal opinion, all it takes.

Clip 7 - Reflections on Legacy: I think I would like people to know, or to think that perhaps I was an innovator. That I didn't do things the way everyone else did. That I was a trailblazer, basically. And I think when I look back, I really did pioneer a lot of things. I did some things that, from conducting orchestras to learning neutrino physics in a way that was special on some level, teaching students, creating lecture series, writing, being in movies, that the things that I did were somewhat pioneering and I would like that to be thought of as not only important, but also as being a reasonable way to pursue things, to make your contribution. Good citizen's contribution sort of thing. My nieces, you know, always thought I was a fairly unusual person because I was different than most of the people that they interacted with as they grew up. And the whole concept of smashing atoms for a living makes you a little bit different than perhaps the people around you, but if you didn't know I smashed atoms for a living, you might just think I was the regular guy who just sat down and watched the Bears game.

The HistoryMakers® ScienceMakers YouTube Oral History Contest Guidelines, Rules and 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 worldwide scientific community, whether as engineers, college biology professors, seismologists, research chemists, 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 DVD**, a two-part disc series included with the **ScienceMakers DVD Toolkit**.

There are many possibilities for your video—maybe you're a scientist recording this from Mars. How did you get there? Why did you go there? Maybe you are in the Amazon observing a rare bird species near extinction. Or maybe you are in a nuclear physics lab smashing atoms like **ScienceMaker Herman White**. Will you observe the sky and the climate like **ScienceMaker Warren Washington**? Or tell people around the world that an earthquake has occurred like **ScienceMaker Waverly Person**? You could even study cows, pigs, and other farm animals to sniff out diseases and stop epidemics such as swine flu like **ScienceMaker Sheila Grimes**. How will you make your contribution to science? We welcome any type of future scientist—a physicist, a chemist, a biologist, an animal behaviorist, a surgeon…watch the **ScienceMakers DVD** for inspiration from real life African American scientists who have made critical discoveries in their fields, from singing birds to particles so small, you can't even see them with a microscope.

If you ever thought George Washington Carver was the only famous black scientist, our DVD will inspire and motivate you by showing you REAL LIFE stories about African Americans who weren't afraid to work hard, take chances, and rise to the top of their careers while changing the world at the same time.

Here's how it works:

Before you even think about making your video, check with your science teacher, after-school 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**. They will also have an aspect of oral history, describing the lives of the entrants or the scientists and the times in which the entrants or the scientists live.

Identify a personally inspiring **ScienceMaker** from the collection. If you decide to **impersonate a ScienceMaker,** you will need to:

- Watch all the ScienceMaker's clips on the ScienceMakers DVD.
- What makes this ScienceMaker special?
- What was his or her most important discovery?
- Where is he or she from?
- Who inspired the ScienceMaker to become a scientist?
- What struggles did he or she face? How did the ScienceMaker survive those challenges?
- What field is the ScienceMaker in? What does he or she do every day at work?

If you decide to make a video of **your future scientist self**, here are some questions for you to think about:

- Where did you go to school?
- What science field did you choose and why?
- Who inspired you? (This is where you talk about the ScienceMaker!)
- What do you research? Animals? Organisms? Nature? Atoms?
- What new discoveries have you made?
- Have you won any awards for your research, like **ScienceMaker Erich Jarvis**?
- How did you get interested in science? How old were you?

Visit www.thehistorymakers.com to review more information about our featured scientists.

No matter what approach you decide to take, here are the rules that everyone must follow:

1. **No inappropriate videos will be accepted**, and we will not upload to YouTube any videos containing inapropriate material. Would you let your teacher, parents, or grandparents watch the video? If the answer is no, do not send us your video.
2. **Teamwork is allowed and even encouraged**, but each contest entry must feature only one (1) student and, if needed, an interviewer to ask questions. First, second, and third place prizes will each be awarded to one (1) student.
3. Videos must be submitted in **English**.
4. Videos must contain **only original material** and must be in accordance with the YouTube Terms of Service.
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 must be between 13 and 18 years of age to submit a video, and students under 18 must get parental permission** before entering the contest.
8. **Students must work with help** from their science teachers, after-school club organizers, or other educational leaders to ensure safety.
9. **You must have fun** making your video!

When you make your video, it must be only your work. No professional help is allowed. While we encourage creativity and imagination, science should be at the focus of your video. Don't spend more time creating a costume than thinking about what you're going to say!

To submit your video, attach it to an e-mail. Address the e-mail to **sciencemakers2010@thehistorymakers.com**. Please include your name and the title of your video in the subject line. Write your full name, mailing address, e-mail address, phone number, and date of birth in the body of the message. All of this information is confidential; we will only use it to verify your age and to contact you in case you are one of the winners. Just make sure that if you are under 18 you have your parents' or guardians' permission!

When you've submitted your video, don't forget to **check out all the other entries** and **vote for your favorite**!

Be as creative as you can in the presentation of your future self. We encourage you to use props, costumes, scenery, or anything else you can find. Just make sure to get your parents' permission first! Then send your video to **sciencemakers2010@thehistorymakers.com**. Each entry will be required to be no less than **1 minutes** but no longer than **3 minutes**. 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, the Science Producer, representatives from each of the featured science centers (3-4 individuals), and a professional science association member and scientist (from the **ScienceMakers** Advisory Board). **In order for your video to be judged, you must do each of the following:**

1. Choose a ScienceMaker from the collection (either to impersonate or use as inspiration).
2. Tell what about the ScienceMaker inspired you.
3. Tell what scientific field you have chosen.
4. Describe how you became a successful scientist.
5. Mention what accomplishments you have made.
6. Use your creativity and imagination!
7. Include a clear visual demonstration of anything in the scientific field you have chosen.

Okay, what do I win?

The winning video from each year of the contest will be featured on the **ScienceMakers** website, YouTube, and Teacher Tube. It will be shown at a public event at each of the **ScienceMakers** featured science centers. The winner will be showcased at this event, and depending on the winner's hometown, he or she will either attend the public event or participate in a **ScienceMakers** videoconference to talk about the story of the winning video! The top three videos will also be featured on a **ScienceMakers Video Oral History Contest DVD**, and **cash prizes** of **$300** (first place), **$200** (second place), and **$100** will be awarded. Travel is not necessary in order to win.

How long do I have?

The video oral history contest will be held in **2009**, **2010**, and **2011**. Each year, entries must be sent to us in the fall from October 1 through December 19. Judging will occur from December 19 through January 15. All valid entries will be judged by the Judging Panel (described above). Winners will be notified and winning videos posted on the website by January 31 of each year.

How do I make a quality video?

- **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 inter view you?
- When shooting your video, **make sure the camera isn't too far away**. Look at the **ScienceMakers DVD** for good examples of a close-up face shot.
- **Test out your equipment** before shooting.
- **Try out different shooting angles** and see what looks best.
- **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.

- **Tripods work best for filming people**, but if you don't have one, don't worry about it!
- **Take your time!** Remember, this video will be on YouTube for the entire world to see.

Okay, so here's the fine print:

- By participating, contestants agree to the ScienceMakers YouTube Oral History Contest Guidelines described in this document.
- 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.
- Void outside of the United States and where prohibited, taxed, or restricted by law. All federal, state, and local laws and regulations apply.
- Videos must not contain identifying information about any person, including the entrant. Identifying information includes last name, phone number, address, or email.
- Each contestant may only submit one (1) video.
- Winners who fail to respond in a timely manner to notification of winning or 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.
- Contestants must only submit their own original work; videos must not violate copyright or intellectual property rights. Videos must also not be inappropriate, defamatory, or libelous.
- 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.
- 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.

The HistoryMakers® ScienceMakers DVD Toolkit
Media and Advocacy Guide

About Us and Goals of the ScienceMakers Project
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. To date, our oldest **HistoryMaker** is 105 years old and the youngest is 29 years old. We have done interviews in over 80 cities and towns as well as in the Caribbean, Mexico and Norway. Our collection presently 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 next methodic and wide-scale collection effort since the WPA Slave Narratives Project.

The Birth of the ScienceMakers
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 (science, technology, engineering and math) professions. It will also disseminate these stories broadly to youth, public and professional audiences using the Internet, a unique digital video oral history archive, public programs, exhibits, radio, TV, print and other new technologies. Over a three year period, **ScienceMakers** will become the largest collection of interviews of African American scientists, resulting in an educational, career and media resource for teachers, parents, students and the national community at large.

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 are 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 their formal and informal learning environments, the perceptions of science as "not cool" and the "lack of appropriate role models".

Catching the Science Bug
Although advocacy and education organizations such as the National Science Foundation have noted a lessening of the achievement gap between African Americans and other students in math and science, the low visibility of African American scientists and mathematicians in many African American communities will continue to contribute to this gap. Many successful STEM professionals in our collection cite an inspirational teacher, television show or even a chemistry set as the factor that encouraged them to pursue a career in the

sciences. The HistoryMakers strives to add the ScienceMakers DVD Toolkit to the list of inspirational tools for today's school-age youth. Exposing the remarkable achievements of thirty-four African American scientists, professors, researchers and administrators, the 2009 incarnation of the Toolkit is intended to be a flexible and useful resource for teachers, science center educators and afterschool program leaders to help their students catch the "science bug."

Getting Familiar with the ScienceMakers DVD Toolkit
Although this Toolkit contains many different resources, they can be used independent of each other for different age groups and skill levels. Below, you will find descriptions of each component of the Toolkit, which consists of a two-disc DVD set and a binder of written materials.

ScienceMaker Interview Clips DVD
The DVD set features **ScienceMakers** who have been interviewed for **The HistoryMakers** collection since its inception in 1999. Each ScienceMaker has his or her own menu page with a selection of clips taken directly from the ScienceMaker's interview, which usually spans anywhere from three to seven hours. The clips included in this kit do not exceed seven minutes to facilitate viewing during short class/activity periods. Clips need not be viewed in succession; they may be viewed separately or as a collection of clips, giving a more thorough perspective on the ScienceMaker and his or her achievements and experiences.

ScienceMaker Spotlight
The ScienceMaker Spotlight provides basic biographical information on each featured scientist, with details that young students will find relevant—not only simple facts such as birthdate, hometown and college attended, but more entertaining facts such as the ScienceMaker's favorite food, favorite vacation destination and favorite phrase or saying. The Spotlight provides an easy and non-threatening entry into learning about the ScienceMaker.

Biographies
Each featured ScienceMaker has a complete biography written especially for the ScienceMakers DVD Toolkit, giving the ScienceMaker's family background, education, career progression, awards and honors. The biographies may be reproduced and distributed when students show interest in a particular ScienceMaker. The teacher may choose to focus on a particular ScienceMaker and distribute his or her biography to an entire group.

Discussion Questions
An original curriculum guide accompanies each ScienceMaker Spotlight, with suggested questions and inquiries to get students thinking about the content of the ScienceMaker DVD interview. Questions are written specifically for each scientist, and they probe the technicalities of the ScienceMaker's field, whether it be pathology, veterinary medicine or engineering.

Experiment
Each ScienceMaker profile is accompanied by an intermediate-level scientific experiment focused on the ScienceMaker's particular field. From creating an "atom smasher" to playing with magnets to learn about chirality, students will be immersed in a hands-on learning experience by participating in the ScienceMaker experiments, which have been created with attention to the differing resources of schools and science centers across the country. Materials needed for the experiments are of an everyday, accessible nature.

Promotional Video
The ScienceMakers DVD contains a short promotional video featuring interviews with several notable scientists, educators and students about the importance and significance of the ScienceMakers project. This video will be useful to show at science nights, parent gatherings or any other educational event with a gathered audience. The video expresses the mission of the ScienceMakers poignantly and with an eye both to history and to the future.

These components are not intended to be used all at once; any combination is possible depending on the user's time frame and curriculum goals.

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. The more people who are aware of ScienceMakers and its advocacy for African American math and science education, the more young minds we have a chance of reaching. Included with this guide is a sample press release/informational letter detailing the project, its goals and its components, to help you answer any questions that may arise as you introduce ScienceMakers to students, parents and community members.

FOR IMMEDIATE RELEASE
CONTACT
(your name)
(your phone number)

SCIENCEMAKERS DVD TOOLKIT PROGRAM ENCOURAGES AFRICAN AMERICAN STUDENTS TO CATCH THE SCIENCE BUG

A groundbreaking National Science Foundation-funded effort by The HistoryMakers, a Chicago-based African American video oral history archive, is intended for students of all ages. Its innovative DVD Toolkit features interview footage from some of the foremost African American scientists and mathematicians in the country, conceived and executed with the guidance of a prestigious board of advisors from organizations such as the American Association for the Advancement of Science (AAAS) and the National Academy of Science. The multimedia interviews are just one component of the Toolkit, however. Also included is an extensive booklet of original written curriculum material for use by educators, program coordinators, parents or anyone else who has interest in learning more about African Americans and their accomplishments in the STEM professions.

The achievement gap in math and science between African American students and those of other ethnic groups is well-documented nationally. This gap extends well into adult life and careers, as African Americans comprise only 6.9% of our nation's STEM workforce according to the 2006 National Science Foundation Science Indicators Report. In order to increase the number of African Americans, women and other minorities in the STEM (science, technology, engineering and math) professions, it is important to highlight the contributions of African American scientists as inspiring examples, and the ScienceMakers DVD Toolkit does just that.

Many of the scientists featured in the ScienceMakers collection cite a favorite teacher who gave them a book or a chemistry set that set them down the path to becoming a successful scientist. The ScienceMakers DVD Toolkit includes media clips, experiments, complete biographies and thought-provoking discussion questions. The kits are available to science educators inside and outside of school communities and will also be featured at several of the most notable science centers in the country: The Museum of Science and Industry in Chicago, the Columbus Center of Science and Industry, and the Saint Louis Science Center.

Scientists, researchers and educators featured in the ScienceMakers DVD Toolkit are:

Albert Antoine, chemist
Clayton Bates, Jr., physicist
Joanne Berger-Sweeney, neurobiologist
James Bowman, geneticist and pathologist
Wayne Bowen, neurobiologist
Alfred Brothers, Jr., aeronautical engineer
George Campbell, Jr., physicist
Edwin Cooper, immunobiologist
S. Allen Counter, neurophysiologist
Darnell Diggs, physicist
Julian Earls, NASA administrator

Ralph Gardner-Chavis, chemist
Larry Gladney, particle physicst
Sheila Grimes, veterinary pathologist
Shirley Ann Jackson, particle physicist
Erich Jarvis, neurobiologist
George Jones, biochemist
William Lester, Jr., computational chemist
Walter Massey, physicist
Samuel Massie, organic chemist
Ronald E. Mickens, physicist and mathematician
Shawna Nesbitt, cardiologist
Waverly Person, geophysicist and seismologist
Roderic Pettigrew, radiologist
Cecil Pickett, biologist
Carl Spight, physicist
Welton Taylor, bacteriologist
John D. Terry, electrical engineer
Isiah M. Warner, chemist
Warren M. Washington, atmospheric scientist
John Watson, cardiology researcher
Herman White, physicist
Luther S. Williams, biologist
Bobby L. Wilson, chemist

For more information, please contact The HistoryMakers at (312) 674-1900, info@thehistorymakers.com, or (your contact information here).

About The HistoryMakers:

The HistoryMakers is a national 501 (c)(3) nonprofit 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. Designed to promote and celebrate the successes and to document movements, events and organizations that are important to African American society, **The HistoryMakers** is sharing its collection through **The HistoryMakers Education Institute** and through **The HistoryMakers Speakers Bureau**, live public programs and its interactive website, www.thehistorymakers.com. Plans are underway for the establishment of a unique digital archive that will provide access to more than 30,000 hours of content in a format that is searchable by image and text. The purpose of this archive is to educate; to show the breadth and depth of this important American history as told in the first person; to highlight the accomplishments of individual African Americans across a variety of disciplines; to showcase those who have played a role in African American-led movements and/or organizations; and to preserve these video oral histories for years and generations to come, creating a priceless collection and helping to refashion a more inclusive record of American history.

East Midlands Oral History Archive

Information Sheet #9

Oral History in Schools

How can I use oral history in school?

Oral history is an exciting resource that can be used with different age groups to support learning across the curriculum. Taking part in an oral history project enables children and older students to develop a wide range of knowledge, skills and understanding and offers schools the opportunity to develop links with the wider community.

This sheet will explain:

- What oral history is.
- How to use oral history in a variety of curriculum areas.
- How to develop your own oral history project.

What is oral history?

Oral history is spoken history. It gives children an opportunity to learn about the past through the first hand accounts of the people who actually experienced it. Oral accounts of the past can take different forms, from stories, songs and edited recordings, to interviewing people directly about their experiences of a particular time or event.

Things to consider

Find an appropriate starting point: this could arise from your History Scheme of Work, or relate to an anniversary or festival connected with your school.

Discuss the value of oral history with the children/students: setting oral history in the context of other sources of historical evidence, such as photographs, books and artefacts will enable children to discover its unique characteristics.

Identify who you will interview: a starting point may be to contact people who already have connections with the school, such as friends or relatives. If you are seeking to establish links with the wider community, you could start with your local newspaper, radio station or library. It is also worth contacting local organizations that represent particular cultural, ethnic or religious groups.

Prepare questions with the children/students carefully: encourage questions that are open-ended. Remind the children that their questions are a *framework* to guide their interviews and need not be stuck to too rigidly.

Using the tape recorder and carrying out the interview: check that the equipment works. It is useful if the children/students can practise interviewing in pairs or small groups beforehand to ensure that they are confident about asking questions and taping interviews. Find somewhere as quiet as possible in your school for the interviews to take place. It is useful if the children/students tick off replies to their questions, as it will help keep their interviews on track.

After the interview: recordings could be used alongside other sources of historical evidence to support a range of activities. For younger children these might include group or whole class discussions, sequencing activities, role-play or drawing. For older children and students, extracts of the recordings could be transcribed and analysed, used to support presentations and displays, or used as a stimulus for work in drama, art or literacy. Depending on the amount of time you have available, the recordings could also be used to develop a school archive or booklet. You could even consider depositing copies of any interviews you make with the East Midlands Oral History Archive for future generations to enjoy!

East Midlands Oral History Archive

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Oral history extracts

'We used to save the cigarette cards and have games with them – you'd set one card up against a wall & the others you'd use to skim & hit it down.'

'I used to go two days a week to the woodwork school...I drew my first wages before I was thirteen.'

' I was born in 1905... there was ten cottages. They were small, run right up. No taps inside, no toilet out the back you'd just got a kind of a sink and a bowl.

Oral history and learning

There are many benefits of using oral accounts to support classroom learning:

History: speaking about their own past and listening to others' memories actively involves younger children in developing their understanding of the passing of time and its associated language. Sometimes it is the *way* that something is said, rather than *what* is said, that is important. Oral accounts can be used with older children and students to compare different points of view, to evaluate different sources of evidence, and to investigate events from different times in the past.

Literacy: oral history provides opportunities for children to develop their speaking and listening skills. Oral accounts can be used to investigate the differences between written and spoken language and are a valuable resource for exploring different accents and dialects. Carrying out their own interviews provides opportunities for children to devise and ask questions, and to listen and respond to what they have heard. Oral history can also be used as a stimulus for work in drama.

Geography: oral evidence can be used in conjunction with maps and other documents to support the study of settlements, the local area and the impact of changes in the environment on 'ordinary' people.

Religious Education: oral recordings of people from the different faith communities provide many opportunities for children and young people to develop an understanding of the customs, practices and stories associated with them.

PSHE and Citizenship: oral accounts can be used to enhance children's and older students' understanding of a wide range of issues, from the importance of respecting the differences between people, to understanding what a democracy is and the role of the government. Oral history can also be used to enhance a sense of identity and belonging, and to promote communication skills.

ICT: children and young people can develop a range of skills in ICT through oral history projects, from research using CD ROMs or the Internet, to taping and editing their own recordings. Organising and presenting their work can also involve children and older students in developing other skills in ICT, for example, learning how to combine sound, images and text using a multimedia software package. There are further opportunities to extend learning in ICT through developing oral history projects with family and other community groups to produce a booklet, newsletter, or even a school website.

National Science Content Standards Alignment

The National Science Standards serve as a guide for the science standards of each state. In order to make this guide as applicable as possible, we have included the National Science Standards that we feel are appropriate for the content contained in the ScienceMakers DVD 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. If you are seeking to align this curriculum with the standards in your area, this should serve as an appropriate guide.

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.