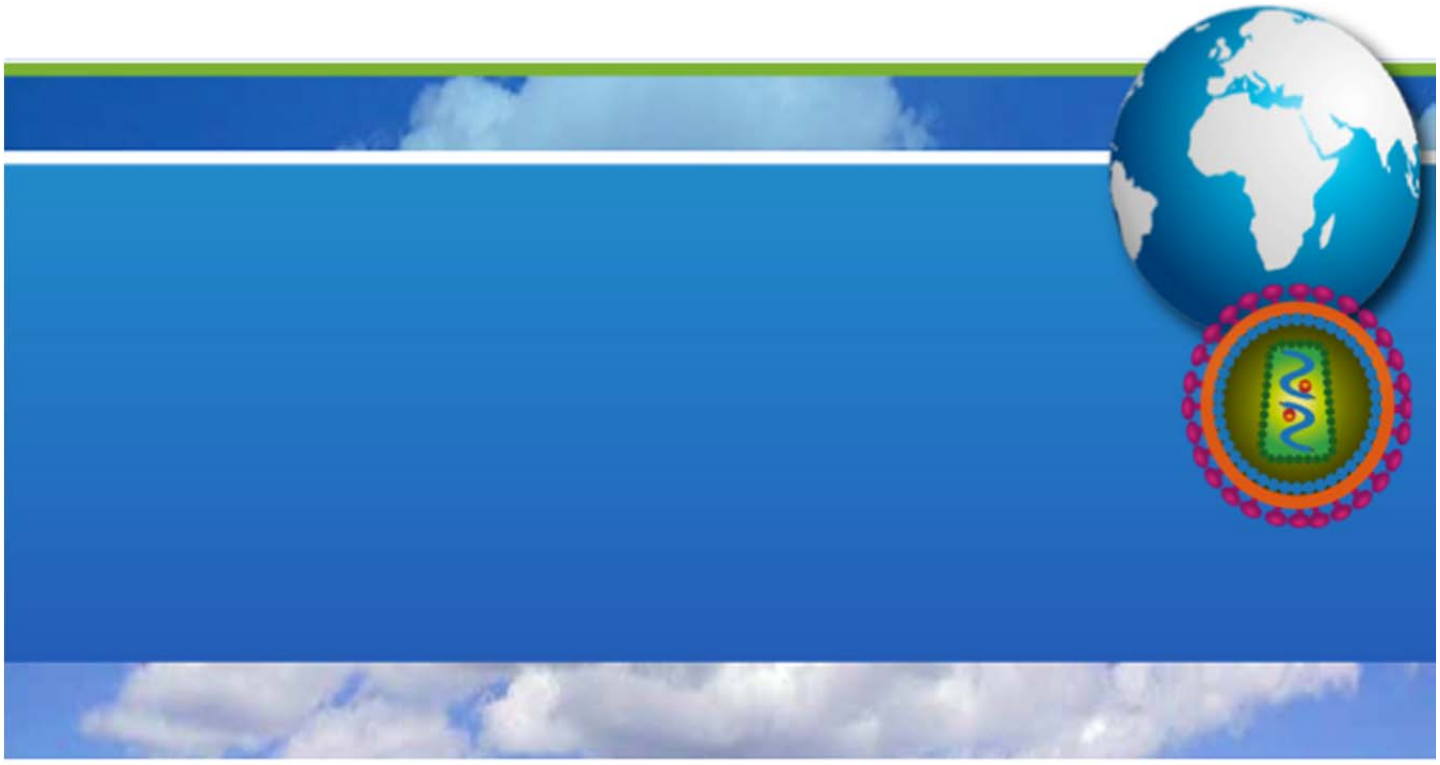


Basic Scientific Literacy

Participant Guide

_____

Name

INTRODUCTION

What Will We Do in This Workshop?

In this workshop, we will look at many important and interesting areas of science. We will present important information and you will be able to ask questions. We will also do activities together to help you remember what you learn. The objectives of this workshop are to:

- Demonstrate how science helps people.
- Learn about the scientific method.
- Describe scientific research.
- Explore the human side of science.

This workshop is designed to give you an opportunity to:

- Apply the information you learn in activities and discussions.
- Ask questions about information you do not understand.
- Practice what you learn.

This Participant Guide includes information, facts, space to write your own notes, and a glossary. The glossary has many words, abbreviations, and definitions that may not be familiar to you.

Basic Scientific Literacy

Welcome to this workshop about basic scientific literacy that will provide a general foundation in science. Science provides knowledge about how and why things work the way they do. This knowledge can help you understand the world around you—and your place in it.

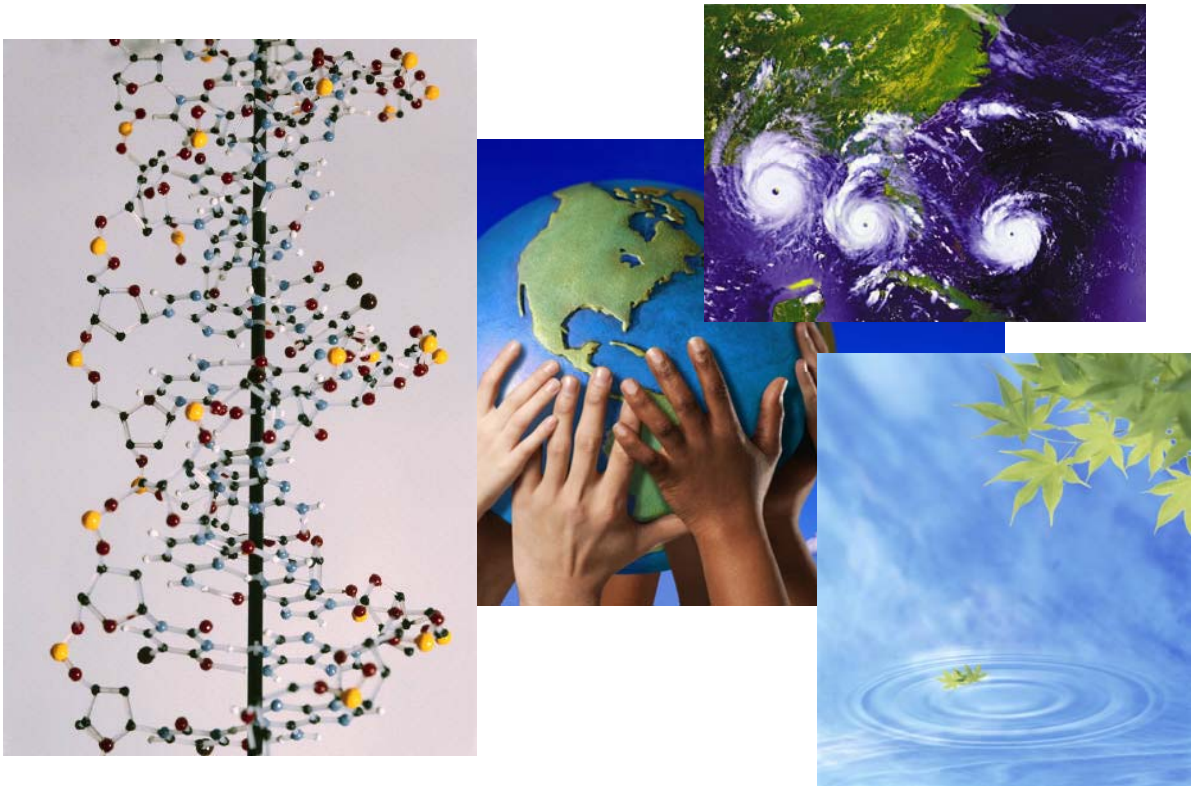
The Basics of Science

This workshop focuses on the following basics of science:

- Biology:
  - How living things work so we have a better understanding of our bodies and health.
  - How to maintain health and treat diseases.
  - How living things are connected to understand our place in the world.
- Social science:
  - How people interact.
  - What people have done in the past that impact the future.
  - Looking at things in new ways.
  - How people from different backgrounds live so we can better understand them.

The Importance of Science

Everything we know and all new discoveries are based on science. Everything we rely on is related to science. Without science, the human race would be far from where it is today, and there would be many unanswered questions about the world around us.



Science Studies the Natural World

WHAT IS SCIENCE?

Objectives

In this session, you will learn about:

- The definition of science
- Natural science and social science
- Why research is important in science
- Scientific research and some of the problems scientists face when conducting research

Introduction

Science has given us the knowledge to develop tools and conveniences we take for granted:

- Use cell phones and Skype™ to call friends and family around the world.
- Develop vaccines to prevent diseases like polio.

Science Also Helps Us…

- Increase Americans' average lifespan because of improved:
  - Food and water safety
  - Hygiene and sanitation
  - Vaccines, antibiotics, and other medications
  - Better nutrition
  - Improved access to health care[1, 2]
- Build skyscrapers.
- Drive cars, motorcycles, trucks, and airplanes to move us to more places faster and more comfortably.

Science Helps Us Answer Important Questions

Science also helps us answer important questions like[3]:

- Where and when will the next tornado occur?
- Where and when will a volcano erupt?
- How can crops be protected from pests?
- How can risk of disease be predicted?
- How can the study of genetics help us?

Science Is a Detailed Study of a Subject

Science is a detailed study of a subject to:

- Discover new information
- Reach a new understanding

Science is Also…

- An organized inquiry to help solve a problem
- A careful and systematic investigation to establish facts or principles
- An examination of patterns or rules to explain how something works
- A sharing of observations, discoveries, and what is learned (the findings)[4]

Science Provides…

- A rigorous and relevant contribution to knowledge
- An understanding of causes and effects of a given situation or phenomenon
- Development of:
  - Laws and processes that can be observed over and over again
  - An explanation of why the laws and processes happen
  - Predictions about what ***will*** happen

Science Answers…

For example, the law of gravity explains how people and things stay on earth instead of floating away into outer space.[5]

Science is important to help us understand our world and our place in it.

Natural Science and Social Science

Science is usually divided into two major groups:

- The natural sciences, which study natural phenomena (including biological life)
- Social sciences, which study human behavior and societies

"Empirical" Sciences

The natural and social sciences are "empirical" sciences. This means they are:

- Based on observation
- Capable of being tested

Scientific research needs to be tested and reproducible by other researchers working under the same conditions.

Why Research Is Important in Science

Research is an important part of science because it helps us understand how things work, how things are made, and why things happen the way they do. Research asks and answers the questions that solve problems and produce knowledge that can be used in new ways.

Research leads to the science that helps us understand our world and our place in it.

The Importance of Research

On April 2, 2013, President Obama spoke about the importance of research:[6]

> *Ideas are what power our economy. It's what sets us apart. It's what America has been all about. We have been a nation of dreamers and risk-takers; people who see what nobody else sees sooner than anybody else sees it…*
>
> *…We support labs and universities to help them learn and explore. And we fund grants to help them turn a dream into a reality…*
>
> *And the investments don't always pay off. But when they do, they change our lives in ways that we could never have imagined…And sometimes, in fact, some of the best products and services spin off completely from unintended research that nobody expected to have certain applications.*

Scientific Research Shares the Same Ingredients

All scientific research shares the same ingredients.[7]

Ingredient	Description
Logical and systematic	It should be reasonable and understood by others.
Creative	It leads to new solutions, theories, or technologies.
Generalizable	It investigates a small sample which can be generalized to a larger population.
Replicable	Others can test the findings by repeating it.
Presentable	It is presentable to others (oral or writing).

Example: The Human Genome Project (HGP)

The Human Genome Project (HGP) is a good example of significant research. The project's goal is to provide researchers with powerful tools to understand how inheritance impacts human disease. Each human cell contains a molecule that carries the instructions that make each of us unique individuals. Researchers call this complete set of instructions a genome.

Each of Us Has…

- 1 genome
- 75-100 trillion cells
- 46 chromosomes in each cell (chromosomes transmit our hereditary information):
  - 23 chromosomes come from your biological father
  - 23 chromosomes come from your biological mother
- 20,500 sets of instructions carried in our genome

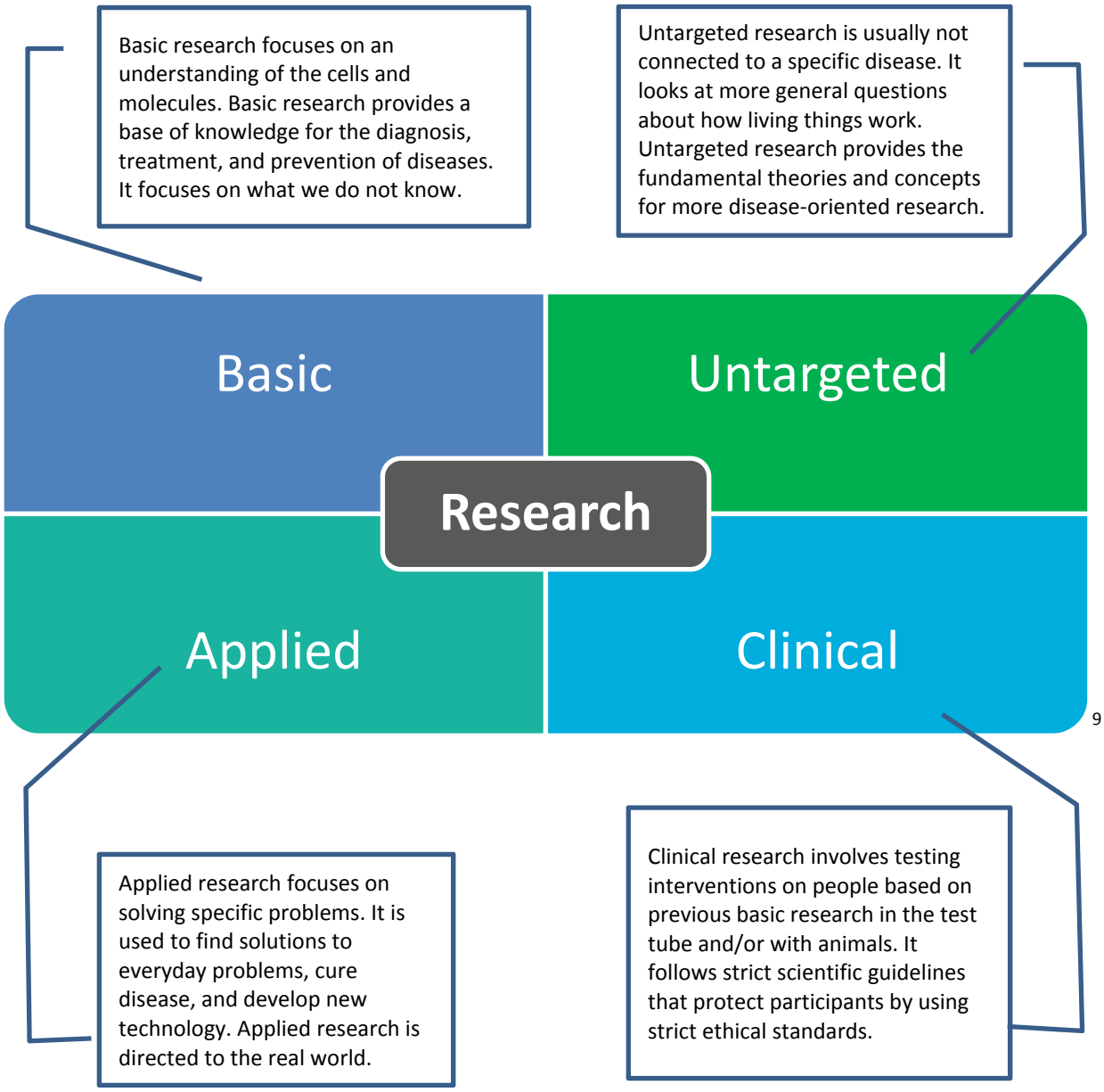
Variations in Our Cells Make Us Unique

The variations in our cells are what make each of us unique, including:

- Hair, eyes, and skin color
- Risk of disease and response to drugs

HGP research has produced important new strategies for disease diagnosis, treatment, and prevention.[8]

Types of Research



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Research Dilemmas

The difference between basic and applied research is not always clear. A good question to ask is:[10]

"How long will it be before some practical application results from the research?"

- If a practical use is only a few years away, it is applied research.
- If a practical use is still 20-50 years away, it is a little of both, or a combination of applied and basic research.
- If a practical use is not envisioned in the foreseeable future, it is basic or untargeted.

Questions Facing Research Activities

Some important questions facing research activities today are difficult to answer and include:

- Who will pay for what?
- How do we set priorities for research projects?
- How can the result be applied on a population-wide level?

Example: Edward Jenner

Sometimes research priorities change over time. And sometimes what is not currently acceptable may become acceptable and valuable.

Hand of a person infected with cowpox[11].

In 1796, Edward Jenner tested his theory, drawn from the folklore of the countryside, that milkmaids who suffered the mild disease of cowpox never contracted smallpox, one of the greatest killers of the period, particularly among children.

What Did Edward Jenner Find?

He found that an inoculation using cowpox made people immune to smallpox. Jenner was told that his ideas were too revolutionary and that he needed more proof.

So he conducted more research. In 1798, the results were finally published and Jenner coined the word vaccine from the Latin “vacca” for cow. Jenner was widely ridiculed. Critics said it was repulsive and ungodly to inoculate someone with material from a diseased animal. But the obvious advantages of vaccination and the protection it provided soon became widespread.[12]

What Does it Mean? Activity

In this activity, you will work with a partner to see how your body and brain work together. You will conduct research and then share your results about what you discovered.

- First, one person will direct the experiment, ask the questions below, and write down the results; the other person will perform the experiment
- Then reverse roles
- When you are both done, answer the questions at the end of the activity together

Questions to Ask Your Partner

1.	Are you left handed or right handed?	Right	Left
2.	Wink your eye. Which eye did you wink?	Right	Left
3.	Take one of the pieces of paper and roll it up into a tube so it is long instead of short. Look through the tube. Which eye did you use?	Right	Left
4.	Extend your arms in front of your body. Make a triangle shape using your fore fingers and thumbs. Bring your hands together, making the triangle smaller (about the size of a coin is good). Find a small object in the room and focus on it through the hole in your hands (using both eyes). Try closing just your left eye and then just your right. If your view of the object changed when you closed your left eye, circle "left." If it changed when you closed your right eye, circle "right."	Right	Left
5.	Write your name on a piece of paper. Which hand did you use?	Right	Left
6.	Pick up something near you. Which hand did you use?	Right	Left
7.	Take one of the pieces of paper and crumple it into a ball. Throw the paper ball. Which hand did you use?	Right	Left
8.	Take a few steps and then jump onto one foot. Which foot did you use to jump **off** from?	Right	Left
9.	Drop your crumpled ball on the floor. Kick it. Which foot did you use to kick it?	Right	Left

Continued on the next page

10.	Are your parents left handed, right handed, or one of each? If you do not know, leave blank.	Right Left One of each
11.	Are any of your siblings left handed, right handed, or a combination of left and right handed. If you do not know, leave blank.	Right Left Some of each

Add up your scores:

Right: _____

Left: _____

Questions to Answer WITH Your Partner:

1. Are you more likely to be left handed if one of your parents is left handed?

2. What are some disadvantages if you are left handed?

3. Do left-handed people have an advantage in sports?

4. Is it better to be left handed in some sports than others?

5. How might you apply what you learned from this research project?

What Did You Learn?

In this activity, you will brainstorm how you can apply what you learned about science by answering a question. With your group:

- Brainstorm the question you are assigned (you only need to brainstorm one of the questions).
- Share your answers with the whole group so they can hear your ideas.

1. How can you use what you have learned about science in your life?

2. What have you heard in the news recently about any area of science that you would like to know more about (for example, health, space, technology, weather, etc.)?

3. Imagine that someone in your family has asked you to help develop a family health history so everyone related to you will have information to share with their doctors. What kinds of information would be important to collect about your family members' health without intruding on their privacy?

4. Imagine that you are a scientist and you can investigate or invent something, what would it be and why?

Summary

Research is designed to help answer questions, make decisions, and solve problems. Anyone can do research because we answer questions, make decisions, and solve problems every day. Research is conducted by ordinary and extraordinary people who have a passion to understand the world around them.

In this session, you learned about:

- The definition of science
- The difference between natural science and social science
- Why research is important in science
- Scientific research and some of the problems scientists face when conducting research

Glossary

The following terms and abbreviations were used in this section that you may not be familiar with:

applied research	Research focused on solving specific problems, especially if a practical use is only a few years away; it is used to find solutions to everyday problems, cure disease, and develop new technology; applied research is directed to the real world
basic research	Research focused on an understanding of cells and molecules; it provides a base of knowledge for the diagnosis, treatment, and prevention of diseases; it focuses on what we do not know
biology	The science of life and of living organisms, including their structure, function, growth, origin, evolution, and distribution; it includes botany and zoology and all their subdivisions[13]
chromosomes	Chromosomes are contained in cells and they transmit our hereditary information
clinical research	Clinical research includes using carefully developed investigations first in the test tube or with animals and then with people; it follows strict scientific guidelines that protect participants by using strict ethical standards
creativity	Creativity includes viewing things in new ways or from a different perspective and generating new possibilities or new alternatives
disease	A condition of the living animal or plant or of one of its parts that impairs normal functioning and results in distinguishing signs and symptoms
ethics	Ethics is respect for persons; beneficence (which means to do good, to do no harm, and maximize possible benefits and minimize possible harm), and justice (or fairness)
experiment	A test or investigation, especially one planned to provide evidence for or against a hypothesis (a proposed explanation for a phenomenon or the question the research is asking)
generalizable	In research, an investigation of a small sample that can be generalized for a larger population

genetics	The branch of biology that studies heredity and variation in plants and animals[14]
genome	A complete set of instructions in a molecule in each human cell that makes each of us unique individuals
heredity	The passing of traits to offspring from a biological parent or ancestors
HGP	Human Genome Project
inheritance	The reception of genetic qualities by transmission from parent to offspring; the acquisition of a condition or trait from past generations
knowledge	The collection of interpreted information and understanding from data, information, experience, and individual interpretation
logic	The ability to reason or use reasoning in an orderly way
prediction	A statement about the way things will happen in the future, usually based on experience or knowledge
processes	A systematic series of actions directed to some end
replicable	The ability of others to test research findings by repeating them
science	Science is the process of the discovery of how and why things work the way they do
scientist	A person who studies or practices any of the sciences or who uses scientific methods
untargeted research	Untargeted research is usually not connected to a specific disease; it looks at more general questions about how living things work; untargeted research provides the fundamental theories and concepts for more disease-oriented research

Frequently Asked Questions (FAQs)

See below for commonly asked questions about research:

Who can participate in clinical research?	All clinical research studies have pre-defined rules called inclusion/exclusion criteria that determine who can be eligible to participate. These criteria are based on such factors as age, type and extent of disease, medical history, current medical condition and past treatment history. These criteria are used to identify appropriate participants and keep them safe as well.
What are the potential benefits of human genome research?	Genome research can potentially reap fantastic benefits for humankind, some that we can anticipate and others that will surprise us. Generations of biologists and researchers have been provided with detailed information that will help them understand the structure, organization, and function of chromosomes. Genome maps of other organisms will provide the basis for comparative studies that are often critical to understanding more complex biological systems. Information generated and technologies developed are revolutionizing future biological explorations. It may lead to prevention and treatment personalized to each individual to maximize benefits and minimize risks.
How does heredity influence a person's health?	Your heredity can greatly influence your health because your heredity determines what types of diseases you are prone to. For example, if many people in your family had a specific disease or condition, then you, being related to them, would possibly also be more at risk for that specific condition/disease.

Additional Resources

For more information about science, researchers, and research, go to:

http://www.nih.gov/about/FAQ.htm

http://www.ornl.gov/sci/techresources/Human_Genome/home.shtml

http://www.genome.gov/Education/

http://www.cancer.org/cancer/cancercauses/geneticsandcancer/heredity-and-cancer

http://www.icsu.org/about-icsu/about-us

http://www.nsf.gov/

http://undsci.berkeley.edu/article/whatisscience_03

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

http://www.mind360.com/blog/in-the-classroom/12/concept-formation-or-how-we-learn-things/

http://wiki.answers.com/Q/How_do_you_learn

http://www.ehow.com/facts_5207146_introduction-scientific-research.html#ixzz2JIaVUswp

http://weirdsciencekids.com/WhatDoScientistsDo.html

http://www.pearsonhighered.com/assets/hip/us/hip_us_pearsonhighered/samplechapter/0205701655.pdf

WHAT IS THE SCIENTIFIC METHOD?

Objectives

In this session, you will:

- Learn about the four steps of the scientific method
- Practice using the scientific method
- Explore common mistakes using the scientific method

Introduction

The scientific method starts with a *hypothesis*, which is a question the research is designed to answer. It is often a proposed explanation for something that is happening. After stating a hypothesis, scientists and researchers conduct research that either proves or disproves the hypothesis by:

- Observing
- Measuring
- Experimenting
- Testing

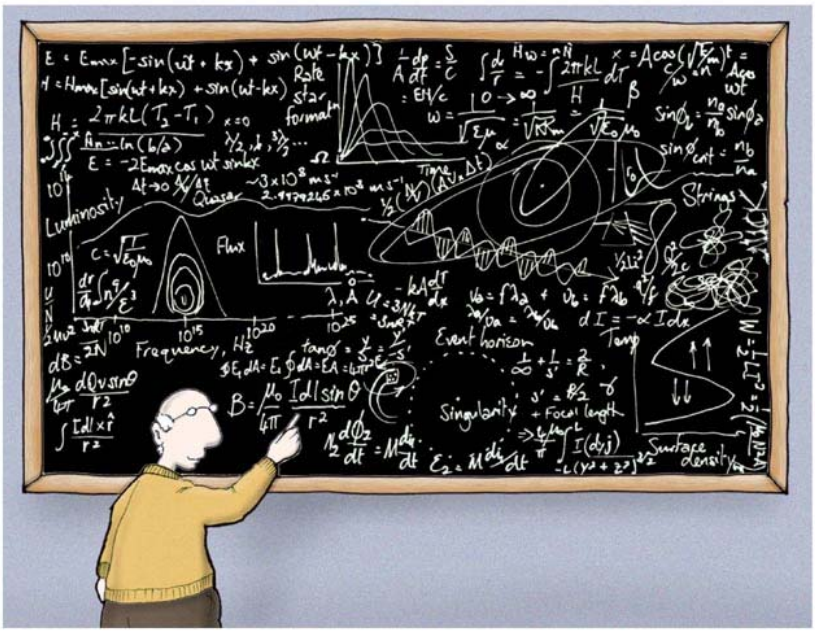
What the Scientific Method Allows Scientists and Research to Do

The scientific method allows scientists and research to:

- Acquire knowledge
- Confirm a theory when a hypothesis is proven
- Challenge a theory when predictions or a hypothesis are shown to be false[15]

What Scientists and Researchers Do

Scientists and researchers propose a hypothesis and design experiments or studies to test the hypothesis. The exciting thing about science is that it builds on and advances previous knowledge, which improves our understanding.



Astrophysics made simple

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Scientific Method Cycle

A simplified view of the scientific method shows the scientific method cycle.

Step 1: Ask a Question (the Hypothesis)

Deciding on which question to ask is important because it focuses:

- Data collection
- Testing

The question can be:

- An explanation of a specific observation (for example, “Why is water blue?”)
- An open-ended question (for example, “Does sound travel faster in air or water?”)

Researchers often decide on which question to ask because they are curious or passionate about something.

Experiment Activity: Step 1

In this activity, we are going to start using the scientific method by creating a question (hypothesis) about graphology.

What Is Graphology?

Graphology is the study of handwriting. Handwriting is believed to be unique to each person. Some scholars believe that personality is reflected in a person's writing. Scientists began to compile evidence and theories to prove this belief in the 17th century. Early scientific work in France, Italy, and Germany happened in the 19th and early 20th centuries. This makes graphology a relatively new science, which may explain why many people remain skeptical. Graphology is now widely used in fields ranging from education, recruitment and human resources, to criminal psychology and illness diagnosis.[17]

Our question (hypothesis): Is it possible to use graphology to determine the sex of a writer?

Write your opinion below:

Step 2: Collect Data

Focusing on the question, a researcher then reviews what research already exists and begins thinking about which experiments to use. Researchers should ask the following questions:

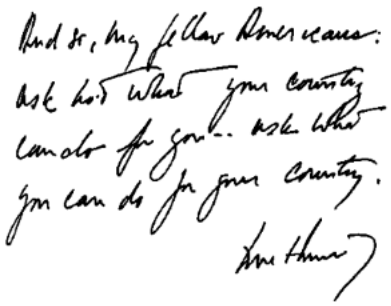
- Has the question already been tested?
- If so, what were the results?
- Were there areas that were suggested for further explanation?

The question to be explored ***must*** be considered based on research and data that already exists. Researchers do not decide if the research is true or not at this point.

If the question still seems interesting, the researcher goes to the next step.

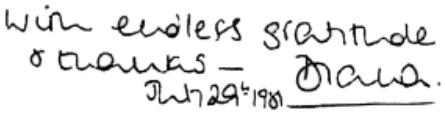
Experiment Activity: Step 2

The basic research below might be helpful at this step.[18]



In President Kennedy's handwriting we see a very fast movement and decisiveness. There are strong angles, especially in the upper zone, which pertains to ideas, principles, and ambitions. His signature is a little smaller than the writing, which indicates humbleness. The last letter "y" looks like a shield. This shield shows that the person is more sensitive than what is presented on his outside appearance. In order to protect himself, he puts this shield between himself and the world.

Walt Disney animates his letters. His signature shows vitality, lightness, humor, and movement, just like his many cartoons.



Princess Diana's signature is closely attached to the text. There is no space between the writing and the signatures. This way of spacing the signature indicates that the person feels like a part of society. People who write this way have a strong sense of belonging to the society. When a signature is underlined it shows that the person who signs likes to have recognition from the public and to be on center stage.

Now answer the questions below for this step in the scientific method:

Is there already some research about your question/hypothesis?

If so, what were the results?

Are there areas for further explanation?

Should we go on to the next step?

Step 3: Experiment

Experiments give researchers a chance to see if what they predict will happen really does happen. During experiments, researchers:

- Make observations
- Compare test results against the original hypothesis
- Make rational conclusions based on the observed results (or data) about the reality of what happened

Another way to look at the experimenting step is to think of problem solving. Problem solving is a process to work through details of a problem to reach a solution.

The 5 Whys Problem-Solving Technique

The 5 Whys problem-solving technique is very useful to help reach a conclusion and/or solution. To find out a reason for something, ask Why? at least five times. For example, you have a problem: Your car will not start.

Why? The battery is dead

Why? The alternator is not working

Why? The alternator belt broke

Why? The alternator belt is old

Why? Replacement parts are no longer available

Solution Buy a new car

Experiment Activity: Step 3

You will now conduct your own experiment. In the box below, write (use handwriting, not printing) the following and then sign your name. Do not worry if you stay on the lines or if you spell correctly.

I am conducting research. This is an experiment to see if we can use graphology to determine a writer's sex. If this works, we can use it to figure out who wrote the ransom note in kidnappings.

Continued on the next page

Now look at the Graphology Analysis Checklist.[19] Follow the instructions on the checklist.

For each item you checked "yes," write down what it says in the last column below (for example, if you checked "yes" for "small writing," write "detailed, technical" below).

Does the graphology analysis describe you? Why or why not?

Step 4: Conclusion?

At this point, researchers have evaluated their findings from their experiments. And they have probably refined the original question (hypothesis).

After assembling all the research and results from the experiments, it is time to draw a conclusion. A conclusion is what you get when you put together:

- What you know
- What research shows

A conclusion is what you decide is true after thinking about it carefully and looking at all the evidence.[20]

Review and Publish

After a conclusion has been reached, researchers likely publish their results to share their findings so others can repeat and validate the results. However, before results are published, they will be peer reviewed by other experts in the field. These experts provide validity to the research and conclusions, which supports the value of the work. [21]

Experiment Activity: Step 4

Now answer the questions for this step in the scientific method:

Do you have enough information to come to a conclusion that you feel confident about?

Do you believe your results from your graphology checklist?

What might you do next?

Review the original question: Is it possible to use graphology to determine the sex of a writer?

The Peer Review Process and Funding Research

The peer review process is the evaluation of research by other reputable people in the same field in order to ensure the quality of the work. Peer review is also used when reviewing research funding requests.

The Importance of Peer Reviews

On April 29, 2013, President Obama on the occasion of the 150th anniversary of the National Academy of Sciences said:[22]

> *To maintain our edge . . . we've got to protect our rigorous peer review system and ensure that we only fund proposals that promise the biggest bang for taxpayer dollars . . . that's what's going to maintain our standards of scientific excellence for years to come.*

Funding Research

Most scientific research is funded by government grants, private companies, and non-profit organizations. For example, in the U.S., the National Institutes of Health (NIH) funds and supports research about the nature and behavior of living systems and the application of that knowledge to enhance health, lengthen life, and reduce the burdens of illness and disability. The NIH uses the peer review process to identify the most promising biomedical research. The research funding requests are evaluated for their scientific and technical merit.[23]

NIH Applications and Reviewers

Currently, the NIH handles approximately 80,000 applications for funding requests each year and uses approximately 20,000 reviewers each year.[24]

Common Mistakes Using the Scientific Method

The graphology activity showed some common mistakes when using the scientific method. These are the most common mistakes:

The original question/ hypothesis is faulty	Graphology does not result in information that can be proven. It is subjective.
The prior research cannot be proven	Just because research has been published or is available on the internet does not mean it is true.
Researchers know what they want the outcome to be	As in the graphology hypothesis, when you were asked your opinion, you already made a decision about what would probably happen.
Researchers ignore data that does not support the hypothesis	Researchers who want to get a certain result may only look for proof that supports that result and discount or ignore evidence to the contrary.
Data is handled differently by different researchers	Many members of a scientific community may work on a project. The experiments, tests, and conclusions may vary because of differences in experience, methods, and priorities.

Example

For example, in 2010, a prominent English medical journal retracted a 1998 research paper that stated the measles, mumps, and rubella (MMR) vaccine caused autism. After the 1998 research paper was published, MMR vaccination rates dropped in England and the number of measles cases soared. After 12 years of investigation, the researcher was found to have financial and scientific conflicts that were not revealed as part of his publication.[25]

What Did You Learn?

In this activity, you will brainstorm how you can apply what you learned about the scientific method by answering a question. With your group:

- Brainstorm the question you are assigned (you only need to brainstorm one of the questions).
- Share your answers with the whole group so they can hear your ideas.

1. How can you use what you have learned about the scientific method in your life?

2. In what ways can you use problem solving in your daily life?

3. If you could be a scientist and make a difference to the world, what research would you work on and why (list 2-3 options)?

4. In what ways has this information about the scientific method impacted YOU?

Summary

One of the outstanding things about science is the objectivity of its findings. Researchers and scientists are trained to observe, to experiment, and to analyze the data objectively. Wishful thinking has no place in their work. Their findings will not become a permanent part of science until they have been challenged and confirmed by other scientists and researchers. In other words, science is a very democratic process. Anyone can question a "law" of science.

The strength of science and its power rests on:

- The thorough testing of its structure
- An interesting combination of collaboration and competition
- Scientists' independence[26]

In this session, you:

- Learned about the four steps of the scientific method
- Practiced using the scientific method
- Explored common mistakes using the scientific method

Glossary

The following terms and abbreviations were used in this section that you may not be familiar with:

5 Whys	A problem-solving technique to help reach a conclusion and/or solution by asking Why? at least five times
conclusion	What you get when you put together what you know and what research shows
data collection	Systematic gathering of data for a particular purpose from various sources
experiment	Make observations, compare test results against the original hypothesis, and make rational decisions about the reality of what happened
graphology	The study of handwriting
hypothesis	A proposed explanation for something that is happening
peer review	The evaluation of research by other reputable people in the same field in order to maintain or enhance the quality of the work; peer review is also used when reviewing research funding requests
problem solving	A process to work through details of a problem to reach a solution
scientific method	Acquiring knowledge to let reality speak for itself, supporting a theory when a theory's predictions are confirmed and challenging a theory when its predictions prove false
scientific method cycle	A four-step cycle that includes questioning, collecting data, experimenting, and reaching a conclusion

Frequently Asked Questions (FAQs)

See below for commonly asked questions about the scientific method:

If scientific theories keep changing, does truth change, too?	Truth does not change. The universe is the same as it always was. However, scientific theories may change over time as new instruments are used and new facts become available.
Why are scientists sometimes careful about their explanations?	Scientists know their explanations and theories may change if new evidence is found.
What is Ockhams's razor?	The idea, that, all else being equal, a straightforward explanation is preferred over an explanation requiring more assumptions and sub-hypotheses.

Additional Resources

For more information about the scientific method, go to:

http://www.pearsonhighered.com/assets/hip/us/hip_us_pearsonhighered/samplechapter/0205701655.pdf

http://teacher.nsrl.rochester.edu:8080/phy_labs/AppendixE/AppendixE.html

http://myathleticlife.com/the-scientific-process/

http://www.pearsonhighered.com/assets/hip/us/hip_us_pearsonhighered/samplechapter/0205701655.pdf

http://teacher.nsrl.rochester.edu:8080/phy_labs/AppendixE/AppendixE.html

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THE HUMAN SIDE OF SCIENCE

Objectives

In this session, you will learn about:

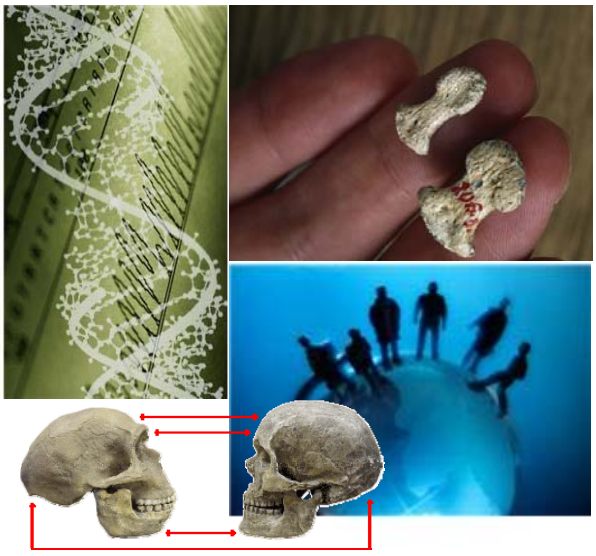
- The characteristics of life
- The role of inheritance and experience in who we are
- The importance of research participants
- Ways to protect research participants

Introduction

The study and science of life helps us to understand how life changes, how life reproduces, and how it adapts over time. Understanding how we fit into the world around us impacts who we are, where we came from, and where we might go in the future. Humans have inhabited the earth for approximately 200,000 years. During that time, we have adapted and changed in order to survive and grow.

New Research Helps Us Explain More of the World

As science develops, new research is conducted that helps us explain more of the world around us.



Fingertip photo courtesy of IRA BLOCK/National Geographic Creative; skull photo from http://anthro.palomar.edu/homo2/mod_homo_4.htm

Who Am I? Activity

In this activity, you will answer some questions (below) that make you who you are: special!

1. Circle all of the things below that apply to you (these are confidential):

Dimples	Can roll tongue	26-40 years old
Blond hair	Can see red and green	41-65 years old
Black hair	Naturally wavy hair	66 or over
Dark brown hair	Naturally curly hair	Employed
Light brown hair	Naturally straight hair	Unemployed
Red hair	African-American	Employed part time
Grey hair	Caucasian	Retired
Black eyes	Hispanic/Latino	Attached earlobes
Brown eyes	Asian/ Pacific Islander	Detached earlobes
Hazel eyes	Middle Eastern	Have children
Blue eyes	Native Indian	Do not have children
Green eyes	Asian Indian	Touch tongue to tip of the nose
Pierced ears	European	Cleft chin
Allergies	African	Male
Right handed	Renter	Female
Left handed	Homeowner	High school graduate
Freckles	Under 18 years old	College graduate
I like adventure	18-25 years old	I like to do sports
I do not like to do sports	I do not like to travel	I do not like to watch TV
I cross my left thumb over my right thumb when clasping my hands together	Widow's peak	I like to watch TV

2. What other things make you special (for example, I love cooking)?

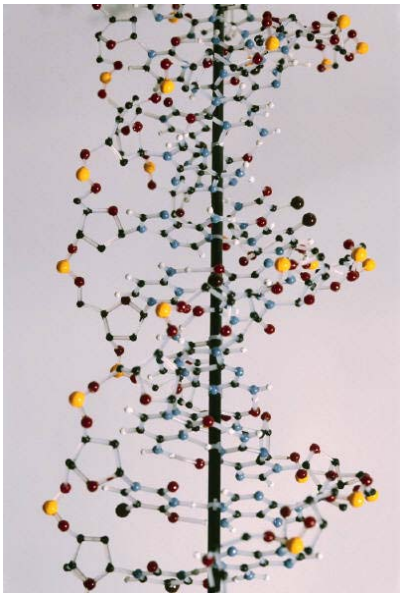
Characteristics of Life

Life is diverse. Plants, animals, people, the universe—all contain life. There is a basic connection between all life forms:

- All life is made of cells, proteins, and the DNA molecule that determines its structure and function.
- All life needs energy:
  - Plants get energy directly using sunlight (a process called photosynthesis).
  - Animals (including people) get energy by metabolizing the food they eat.
- By definition, a common characteristic of all life forms is a process of reproduction that ensures that life goes on even if individuals die.
- All life changes or evolves over time because changes in the DNA molecule create changes of the life form.[27]

DNA is Important in Science

As we said earlier:



DNA is important in science because it helps explain life.

Think of DNA as the internal building blocks of a person or organism:

- Our ancestors
- Us as individuals today
- Future generations

DNA is an important part of genome research and understanding the basics of life.

Inheritance

DNA makes each of us unique individuals. In other words, each of us inherits certain characteristics from our parents:

- Traits (contained in DNA) are observable characteristics passed from parent to child.
- People have many traits in common with others and more so with siblings and parents.
- People's overall combination of traits makes them unique.
- Some traits are more common in a population than others.
- An equal number of traits are passed from each parent.
- Variations in DNA lead to the inheritance of different traits.[28]

Experience

The rest of what makes us different are our experiences, including:

- Where we live
- How we were raised
- The things we learned
- How we react to things

Simply said, people are the sum of both their inheritance (DNA) and their experiences.

WHY Am I Who I Am? Activity

In this activity, you will go back to the Who Am I? activity you just completed. Answer the questions below.

1. Which of the things you circled are traits (things you probably inherited from your parents)? Write them below.

2. What are the things you said make you special (the things you wrote down for question 2)? Write them below.

People and Research

Scientists and researchers today are focusing on understanding:

- DNA (the molecule that carries the instructions that make us who we are)
- Genomes (the complete set of instructions for each person: each person has one genome)

This focus is important for understanding how different people respond to:

- Diseases
- Vaccines and drugs
- Their environment

Results of Understanding How Different People Respond

Results of this understanding help:

- Develop personalized medical treatment to treat a disease or other health condition
- Develop a personalized plan to prevent a disease or other health conditions

Benefits of DNA Research

The importance of this DNA research for participants is:

Help themselves and their families

Help future generations

Give back to society

Other Benefits May Include

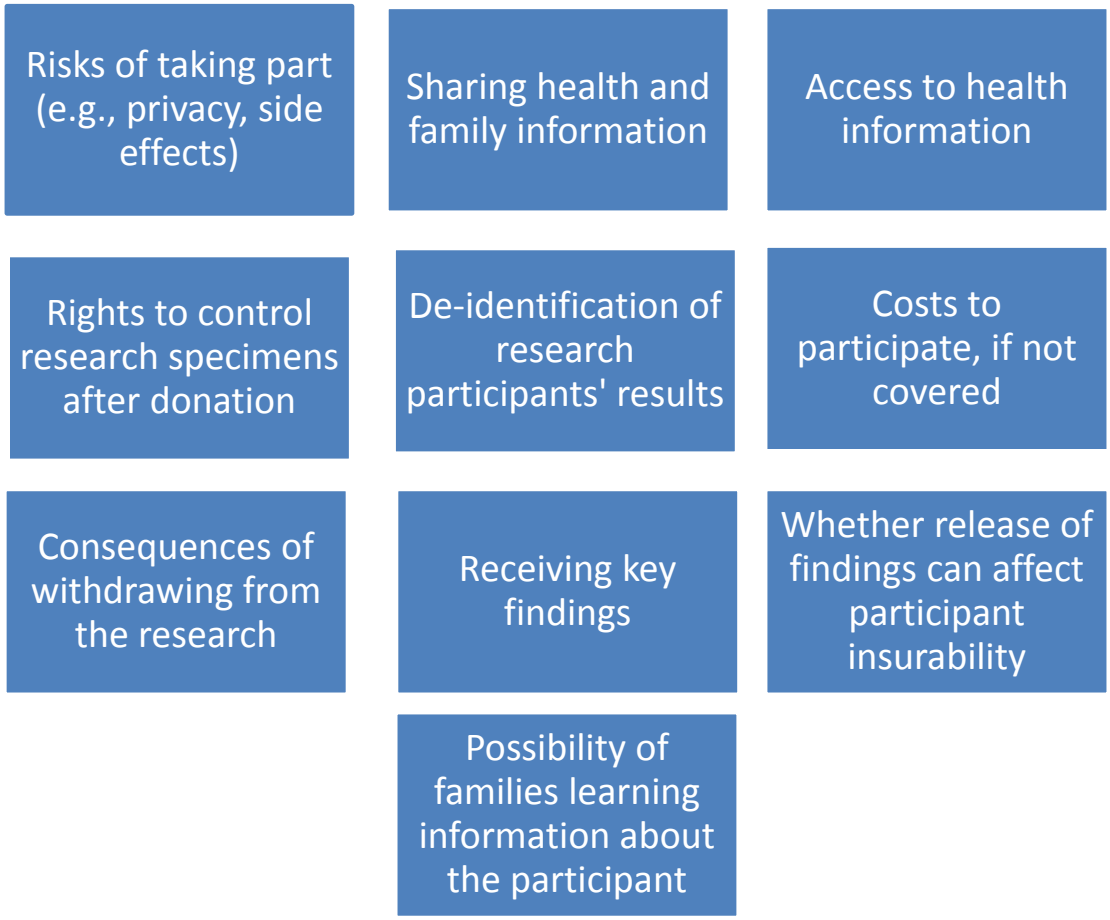
- Ability to predict risks of disease
- Improve lab tests for early detection of disease or other health conditions
- Develop new medications and treatments for serious health issues like HIV, cancer, diabetes, and heart disease

Informed Consent to Protect People Participating in Research

Informed consent is the process of providing potential participants with important facts about the research before they decide to participate.

What Does Informed Consent Include?

Informed consent includes:



Ethical, Legal, and Social Issues (ELSI) to Protect Research Participants

Ethics means:

- Respect for persons
- Beneficence
- Justice, or fairness

Ethical Principles Must Guide All Research Activities

Ethical principles must guide all research activities including:

- Formation of research questions
- Design of the research (sometimes called a “study” and “clinical trial”)
- Conduct of research
- Analysis of data
- Interpretation of findings

Example: Henrietta Lacks

In 1951, researchers took cells from a cancer patient named Henrietta Lacks, known by scientists as HeLa.[29]

Henrietta Lacks was never informed that researchers took the cells.

Henrietta Lacks' cells were commercialized and have generated millions of dollars in profit for the medical researchers who patented her tissue. Those cells are still in use today.

Lacks' family, however, did not know the cell cultures existed until more than 20 years after her death.

Henrietta Lacks History

In 1951, an African-American woman named Henrietta Lacks was diagnosed with terminal cervical cancer. She was treated at Johns Hopkins University, where tumor cells were snipped from her cervix without her knowledge.

Since then, Lacks' cells have been used in research into the genes that cause cancer and those that suppress it; they helped develop drugs for treating herpes, leukemia, influenza, hemophilia, and Parkinson's disease; and they've been used to study lactose digestion, sexually transmitted diseases, appendicitis, human longevity.

There are calculations that if you could lay all HeLa cells ever grown end-to-end, they would wrap around the Earth at least three times, spanning more than 350 million feet despite the fact that neither Lacks nor her family ever gave permission for her cells to be used for scientific research.

Safe Practices to Reduce Research Participant Risks

Examples of measures that researchers use to help protect and ensure the safety of research participants include:

Institutional Review Board (IRB)	An IRB committee is an independent committee that ensures that research (studies and clinical trials) are ethical and that the rights of all participants are protected before the study begins. The IRB carefully reviews the research before it is conducted to ensure that the risks are minimal and offset by the potential benefits. The IRB also ensures that potential research participants are well-informed about the research prior to their enrollment through the informed consent process. An IRB includes physicians, statisticians, and other members of the community.
Data and Safety Monitoring Board (DSMB)	The DSMB is an independent group of experts who monitor patient safety and the conduct of the study at regular intervals while the study is being conducted. These experts have access to confidential data from the study to make sure that no one is being harmed and to monitor the effects of the treatment or prevention method being tested. If these experts see a positive effect early on, they can recommend a study be stopped so that the beneficial treatment or prevention can be made more broadly available. If the experts see that it is not working or that the study will never be able to determine effectiveness, the can recommend that a study be stopped.
Ethics Committee (EC)	The EC is made up of people from different backgrounds not directly involved in the research. They must have no conflict of interest, include community representatives, and be trained. The EC ensures the research is ethical, just like the DSMB does.

The Future of Science

As people continue to move into new areas of research, the future of science can only be imagined. These are some of the questions that science will likely try to answer:[30]

- What are the limits of intelligence?
- Can a machine think?
- How big is the universe?
- Is there life and intelligence beyond earth?
- How and why do men and women behave differently?
- How can we find cures for AIDS, cancer, diabetes, and heart disease?
- Will people time travel?
- Will people travel to the Milky Way?
- Can aging be slowed or reversed?

What Will We Be When We Grow Up? Activity

In this activity, you will use your creativity to develop a "picture" of what you think people will be like in the next century (100 years from now):

- You can tell a story or draw pictures or act out a day in the life of future people.
- Your "picture" can be negative, positive, or anything in between.
- Think about all the things you have learned about science and research.
- You have 20 minutes to create your "picture" and then you will share it with everyone.

Bring the future alive for us!

Notes:

What Did You Learn?

In this activity, you will brainstorm how you can apply what you learned about the human side of science by answering a question. With your group:

- Brainstorm the question you are assigned (you only need to brainstorm one of the questions).
- Share your answers with the whole group so they can hear your ideas.

1. How can you use what you have learned about the human side of science in your life?

2. What have you heard in the news recently about research that you would like to know more about?

3. In what ways has the information about people and research impacted YOU?

4. In what ways has the information about DNA and inheritance impacted YOU?

Summary

The mysteries of who we are and how we evolve give us a fascinating look at the wonder of our world and our place in it. 100 years ago, we could not imagine what we know today. 100 years from now, our place in the world and our understanding of the world will be just as amazing.

Scientists and researchers today conduct health research and human clinical trials to prevent, treat, and cure disease. Health research in the past has positively affected our lives today. Health research today will positively affect our lives in the future.

In this session, you learned about:

- The characteristics of life
- The role of inheritance and experience in who we are
- The importance of research participants
- Ways to protect research participants
- Created a picture of people in the next century

Glossary

The following terms and abbreviations were used in this section that you may not be familiar with:

DSMB	Data and Safety Monitoring Board
diverse	Being different
DNA	The molecule that carries the instructions that make each of us who we are; DNA is the hereditary material in humans and almost all other organisms; DNA is important in science because it helps explain life; think of DNA as the internal building blocks of a person or organism: our ancestors, us as individuals today, and future generations
empirical science	Science that is based on observation and capable of being tested
ethics	Ethics is respect for persons; beneficence (which means to do good, to do no harm, and maximize possible benefits and minimize possible harm), and justice (or fairness)
EC	Ethics Committee
genome	A complete set of instructions in a molecule in each human cell that makes each of us unique individuals
informed consent	The *process* of providing potential participants with all the important facts about the research before they decide to participate
inheritance	The acquisition of a condition, or a trait from past generations
IRB	Institutional Review Board
metabolize	The process that occurs in humans from eating food; the body uses the calories from this food to for energy
natural science	Science that studies natural phenomena, including biological life
photosynthesis	The process where plants get energy directly using sunlight

reproduction	The process by which an animal or plant produces one or more individuals similar to itself
social sciences	Science that studies human behavior and societies
trait	Characteristics of a person determined by inheritance/genetics

Frequently Asked Questions (FAQs)

See below for commonly asked questions about the human side of science:

What is functional genomics?	Understanding the function and regulation of the expression of genes and other parts of the genome is known as functional genomics. The Human Genome Project was just the first step in understanding humans at the molecular level. Though the project is complete, many questions still remain unanswered, including the function and regulation of most of the estimated 30,000 human genes.[31]
What is comparative genomics?	Comparative genomics is the analysis and comparison of genomes from different species. The purpose is to gain a better understanding of how species have evolved and to determine the function of genes and noncoding regions of the genome. Researchers have learned a great deal about the function of human genes by examining their counterparts in simpler model organisms such as the mouse.[32]
Has animal research contributed to science?	Almost every major medical advance has depended on the use of animals at some stage in its research, development, or testing. Examples include antibiotics, anesthetics, insulin for diabetes, organ transplants, hip replacements, etc.[33]
Are there alternatives to using animals in research and testing?	It has proved very difficult to develop non-animal methods to replace the use of animals in research and testing. A great deal of progress has been made in replacing animals in safety testing. Once non-animal methods have been developed, validated, and accepted by regulatory authorities, they must be used in preference to the animal tests. Animal experiments are just one method of biological and medical research. Research can also be done using cells, tissues, people, and high-tech equipment. Some people regard these methods as alternatives, but they are really complementary methods that are used alongside animal research to answer different kinds of questions. Animal research and testing accounts for a small proportion of all research and testing.[34]

Additional Resources

For more information about the human side of science, go to:

http://www.ornl.gov/sci/techresources/Human_Genome/elsi/elsi.shtml

http://ethics.iit.edu/library/scientific-research-ethics

http://www3.imperial.ac.uk/secretariat/collegegovernance/provisions/policies/scientificconduct

http://www.iaea.org/Publications/Magazines/Bulletin/Bull252/25205383740.pdf

http://www.essortment.com/six-characteristics-life-47733.html

http://www.ornl.gov/sci/techresources/Human_Genome/home.shtml

http://www.genome.gov/12011238

http://www.genome.gov/

CONCLUSION

Laws of Flight Activity

In this activity, you will work with a group to make a paper airplane. This paper airplane experiment follows the same laws of flight as a jet.

Follow the scientific process below:

1. Construct 2 ***different*** paper airplanes in any way you think will fly. Do ***NOT*** fly them yet.

2. Fly the first plane, observe it to see what happens, and then write your observations below. Airplane 1 Observations (How far did it fly? Did it fly at all?, etc.):

3. Fly the second plane, observe it to see what happens, and then write your observations below. Airplane 2 Observations (How far did it fly? Did it fly at all?, etc.):

4. What was different between airplane 1 and airplane 2? Which one flew farther?

5. Why do you think one flew farther than the other?

6. What might you change in your designs to increase the distance your planes can fly?

7. Change the design on your airplane that flew the furthest. Then fly the plane again. What happened?

What Is Science?

Research is designed to help answer questions, make decisions, and solve problems.

Anyone can do research because we answer questions, make decisions, and solve problems every day.

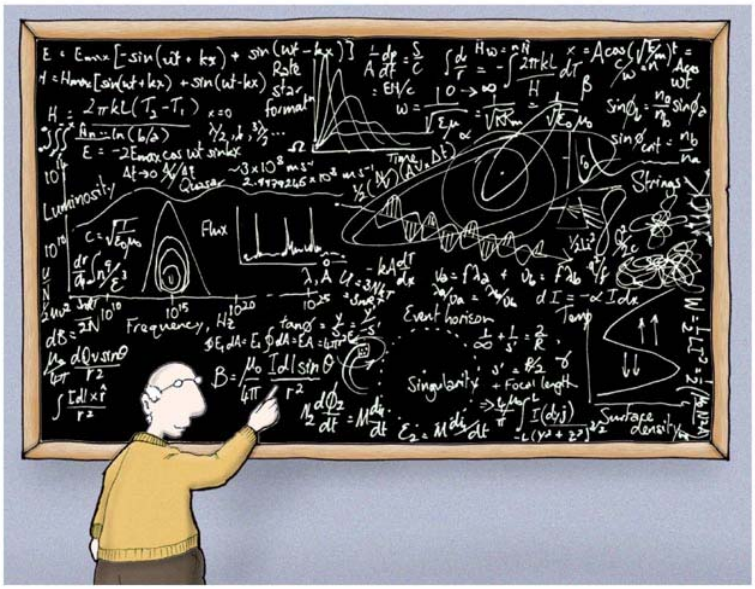
Research is conducted by ordinary and extraordinary people who have a passion to understand the world around them.

What Is the Scientific Method?

One of the outstanding things about science is the objectivity of its findings. Researchers and scientists are trained to observe, to experiment, and to analyze objectively. Wishful thinking has no place in their work. Their findings will not become a permanent part of science until they have been challenged and confirmed by other scientists and researchers. In other words, science is a very democratic process. Anyone can question a "law" of science.

The strength of science and its power rests on:

- The thorough testing of its structure
- An interesting combination of collaboration and competition
- Scientists' independence



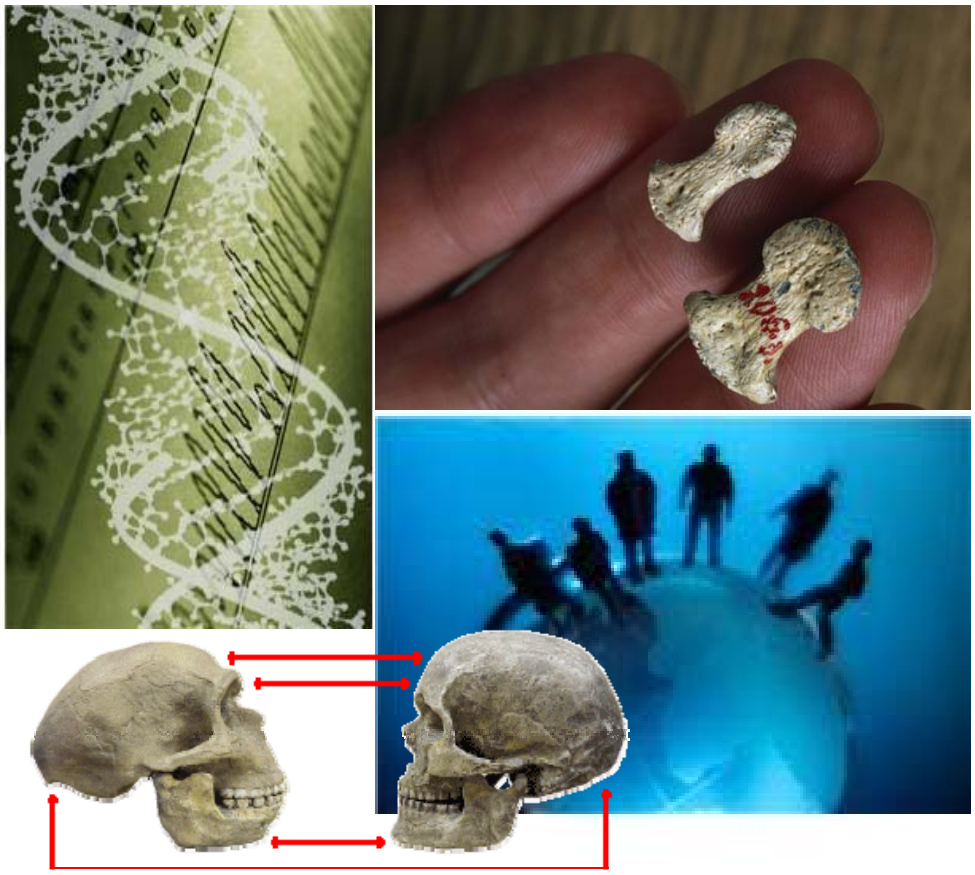
Astrophysics made simple

The Human Side of Science

The mysteries of who we are and how we evolve give us a fascinating look at the wonder of our world and our place in it.

100 years ago, we could not imagine what we know today.

100 years from now, our place in the world and our understanding of the world will be just as amazing.



-Fingertip photo courtesy of IRA BLOCK/National Geographic Creative; skull photo from http://anthro.palomar.edu/homo2/mod_homo_4.htm

This project was supported through Federal funds from the Division of AIDS (DAIDS), National Institute of Allergy and Infectious Diseases, National Institutes of Health, Department of Health and Human Services Grant # UM01 AI068614: "Leadership Group for a Global HIV Vaccine Clinical Trials (Office of HIV/AIDS Network Coordination)."

Endnotes

[1] http://www.cdc.gov/nchs/fastats/lifexpec.htm

[2] http://www.huffingtonpost.com/susan-blumenthal/public-health-how-science_b_784726.html

[3] http://undsci.berkeley.edu/article/0_0_0/whatisscience_12

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[5] http://weirdsciencekids.com/WhatDoScientistsDo.html

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[10] http://www.lbl.gov/Education/ELSI/research-main.html

[11] http://www.zephyrus.co.uk/edwardjenner.html

[12] http://www.bbc.co.uk/history/historic_figures/jenner_edward.shtml

[13] http://www.thefreedictionary.com/Biology

[14] http://www.thefreedictionary.com/genetics

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[23] http://grants.nih.gov/grants/PeerReview22713webv2.pdf

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[25] http://www.nytimes.com/2010/02/03/health/research/03lancet.html?_r=0

[26] http://www.nsf.gov/pubs/1953/annualreports/ar_1953_sec6.pdf

[27] http://www.exploratorium.edu/traits/exhibits.html

[28] http://teach.genetics.utah.edu/content/heredity/

[29] http://rebeccaskloot.com/the-immortal-life/

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[31] http://www.ornl.gov/sci/techresources/Human_Genome/faq/compgen.shtml#function

[32] http://www.ornl.gov/sci/techresources/Human_Genome/faq/compgen.shtml#function

[33] http://www.understandinganimalresearch.org.uk/resources/faqs

[34] http://www.understandinganimalresearch.org.uk/resources/faqs