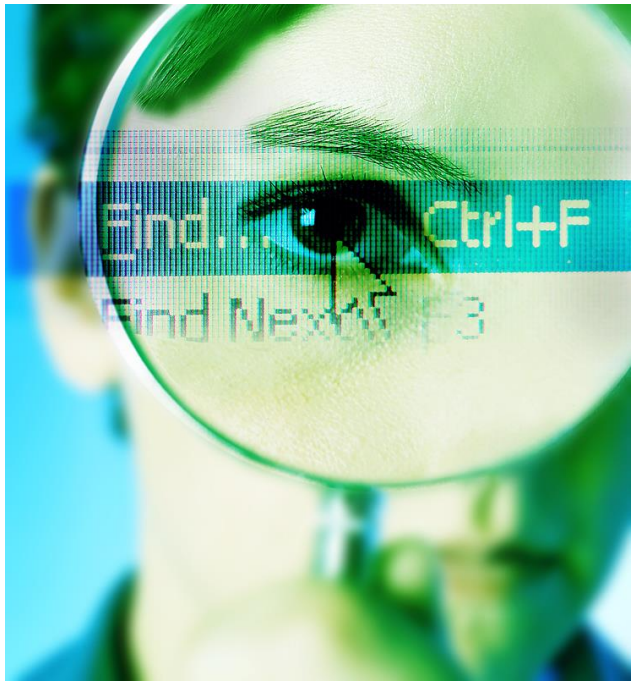
Scientific Inquiry and the GED® Science Test

Becki Lemke

Session Objectives



- Identify strategies and activities to build scientific inquiry skills
- Explore the scientific method
- Integrate graphic literacy into science content
- Share resources

What has science done for you lately?

Scientific knowledge helps us make decisions that affect our lives every day.

Workbook – p. 4

Ever think about . . .

- What causes gravity?
- How tectonic plates move around on Earth's surface?
- How do our brains store memories?
- How do water molecules interact with each other?

“Inquiry is something that students do, not something that is done to them.”

— Inquiry and the National Science Education Standards

The Puzzle of Scientific Inquiry

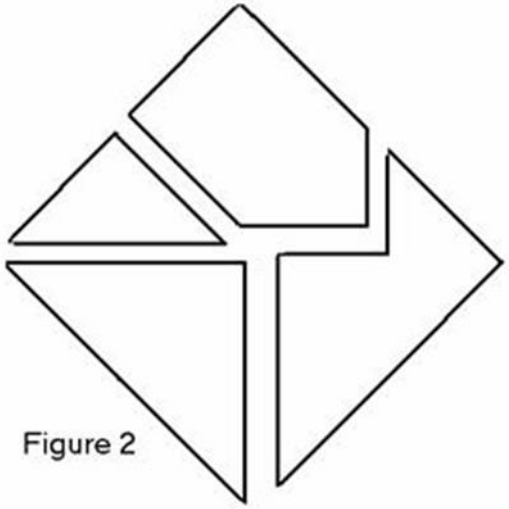


Figure 2

Can you take these four puzzle pieces and put them together to form a square?

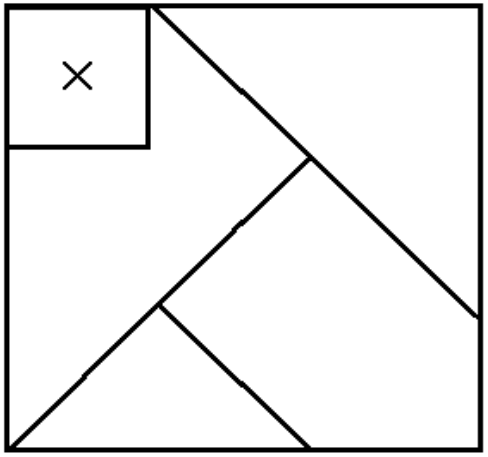
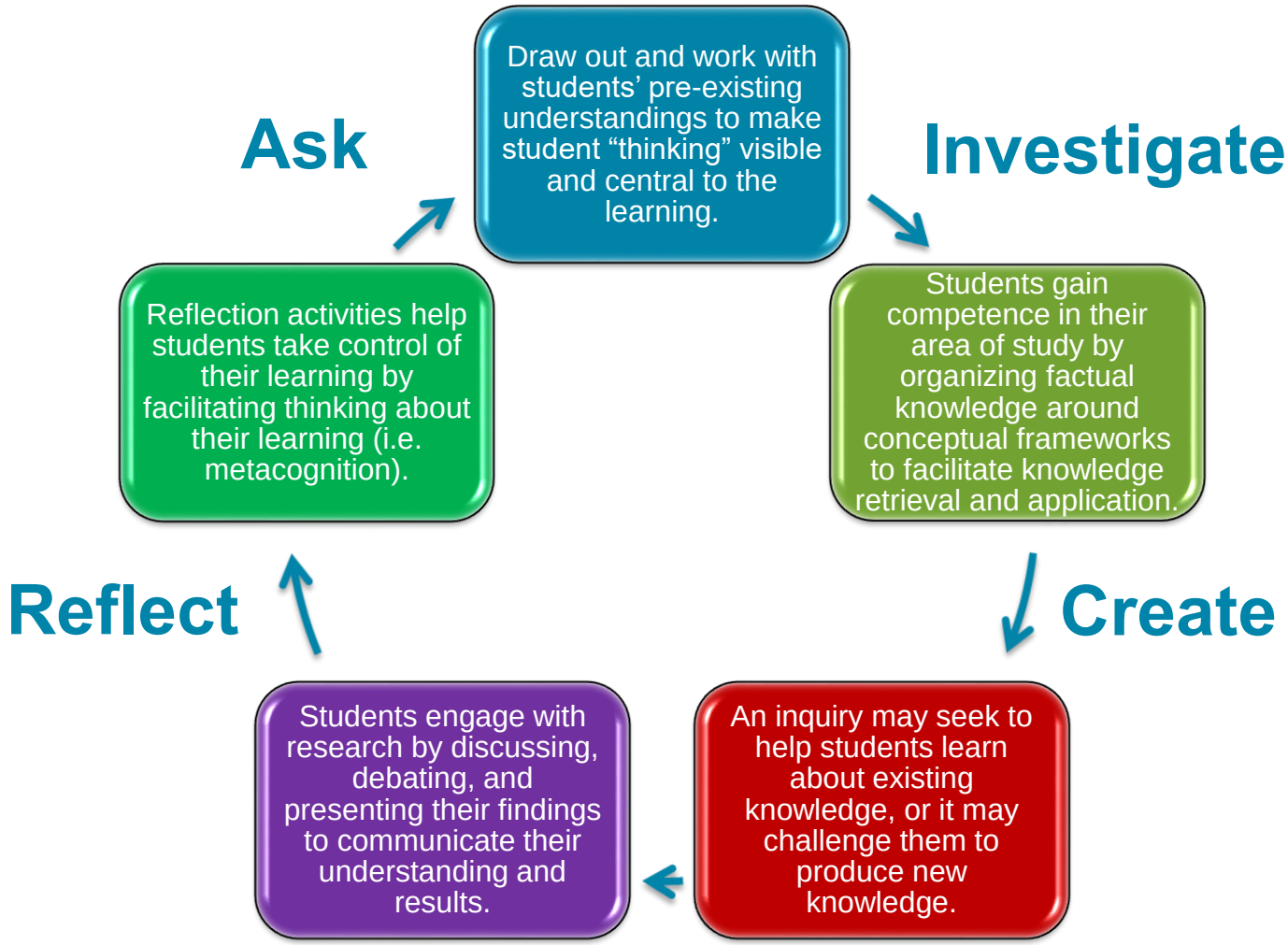


Figure 1

What would you happen, if you received a fifth piece? Do you think you could add something new and still construct a square?

Circle of Inquiry

Workbook – p. 5



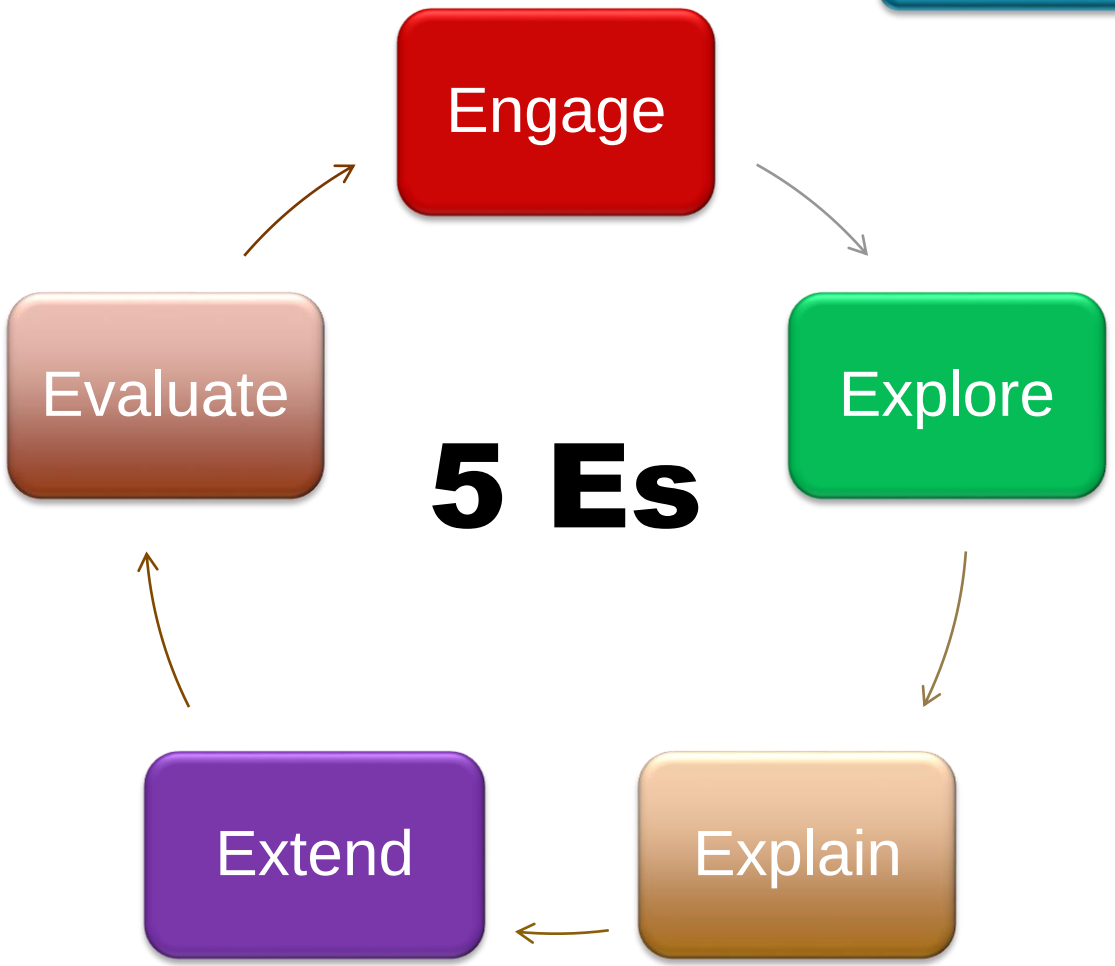
Five Features of Science Inquiry

The learner

- Engages in scientifically oriented **Questions**
- Gives priority to **Evidence** in responding to questions
- Formulates **Explanations** from **Evidence**
- Connects **Explanations** to **Scientific Knowledge**
- Communicates and justifies **Explanations**

Teaching Through Inquiry – 5Es

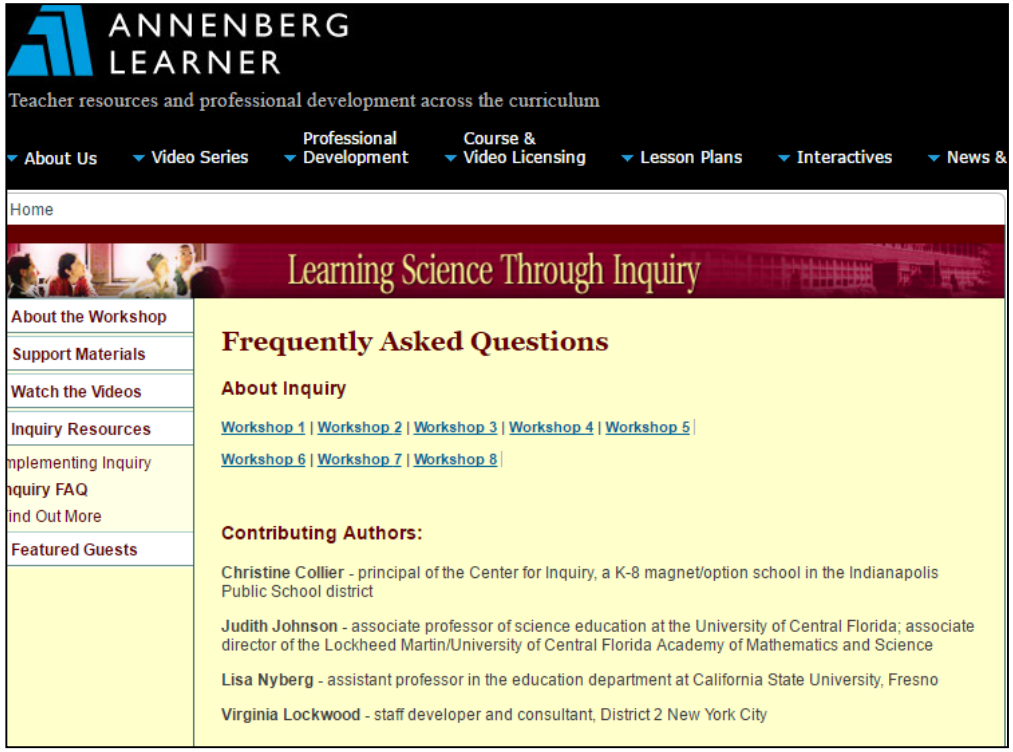
Workbook – p. 6



Resources

Learning Science through Inquiry

https://www.learner.org/workshops/inquiry/about/overview.html



Thematic Lessons

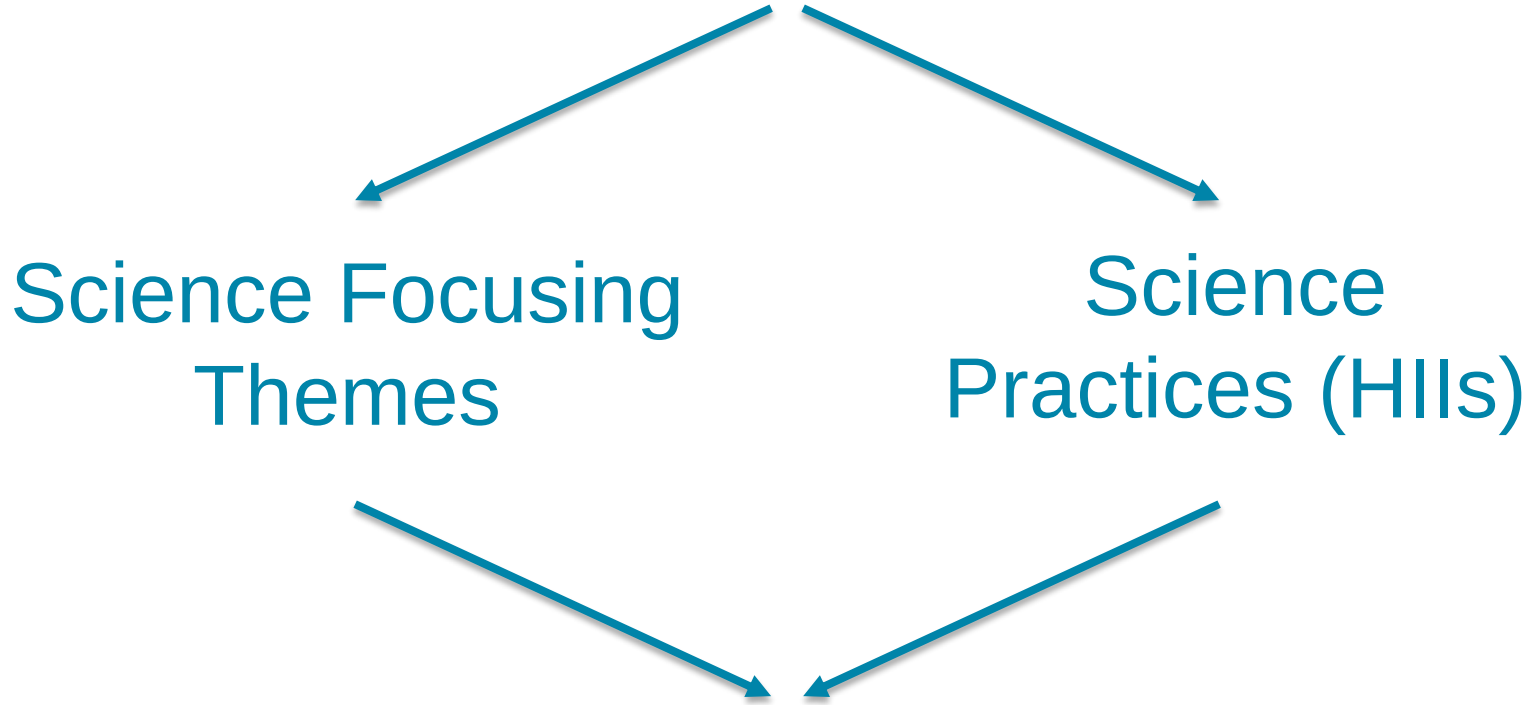
Integrating Concepts

What Should I Teach?

Workbook – pp. 7-9

Science Content

(Life Science, Physical Science, Earth and Space Science)



Focusing Themes

Workbook – p. 7

		Science Content Topics		
		Life Science (40%)	Physical Science (40%)	Earth & Space Science (20%)
Focusing Themes	Human Health and Living Systems	• Human body and health • Organization of life • Molecular basis for heredity • Evolution	• Chemical properties and reactions related to human systems	• Interactions between Earth's systems and living things
	Energy and Related Systems	• Relationships between life functions and energy intake • Energy flows in ecologic networks (ecosystems)	• Conservation, transformation, and flow of energy • Work, motion, and forces	• Earth and its system components • Structure and organization of the cosmos

Science Practices

Workbook – p. 8

- Key skills for scientific reasoning in both textual and quantitative contexts
- Derived from important skills identified in CCRS
- Aligned with National Research Council's Framework for Science Education

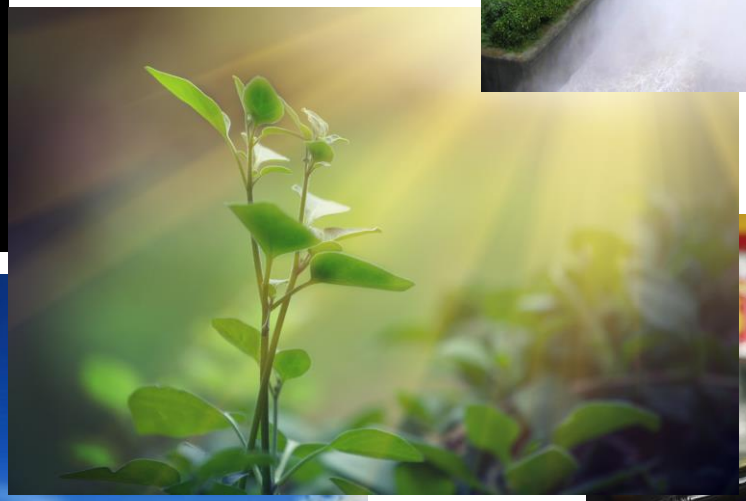
High Impact Indicators

Workbook – p. 9

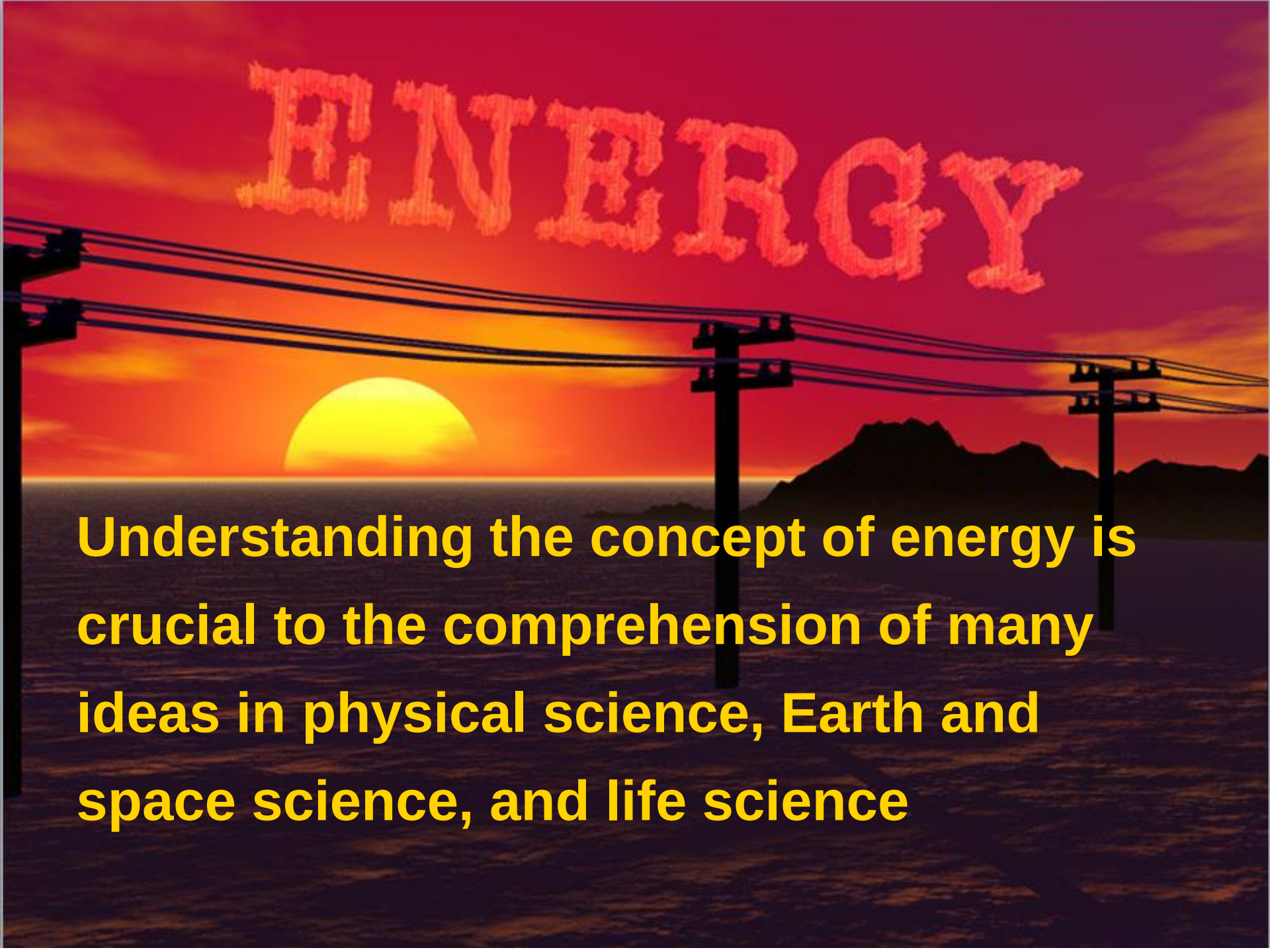
- Describe the critical thinking skills essential to test-taker success in college, career training, and the workforce
- Represent foundational skills that are the basis for development of other skills
- Have broad usefulness that can be applied in multiple contexts

Integrating a Thematic Approach

Noticing/Wondering



Workbook – p. 10



Understanding the concept of energy is crucial to the comprehension of many ideas in physical science, Earth and space science, and life science

Building on a Theme

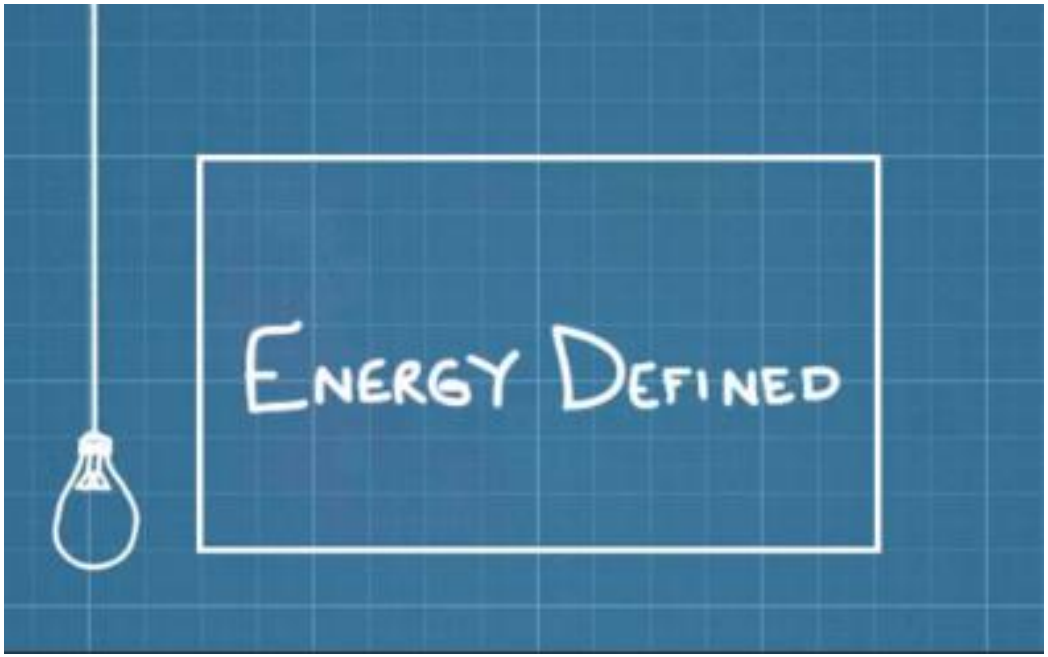
Energy

- **Life Science**
  - Energy for life functions (photosynthesis & respiration)
  - Flow of energy in an ecosystem (energy lost as heat)
- **Physical Science**
  - Types of energy (kinetic, chemical, mechanical)
  - Sources of energy, e.g., sun, fossil fuels
- **Earth and Space Science**
  - Ecosystems - Interaction of matter between living and non-living things
  - Renewable vs. non-renewable resources and sustainability

Workbook – p. 11-13

GED TESTING SERVICE

Engage with a Video



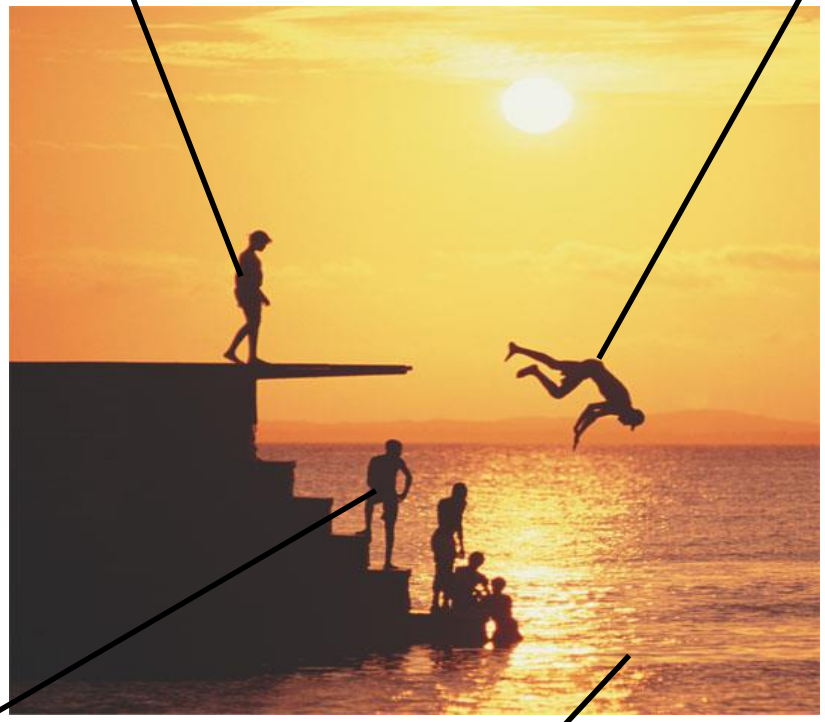
http://www.pbs.org/wgbh/nova/labs/videos/#energy

Engage with Real-World Experiences

- Try to think of something that doesn't involve energy
- What uses the most energy in your home?

http://www.visualcapitalist.com/what-uses-the-most-energy-home/

Types of Energy – Connect It!



Explore Real World Energy

Which involves more work, carrying a 100 lb child for a mile, or picking up a 10 lb bag of flour? Why?

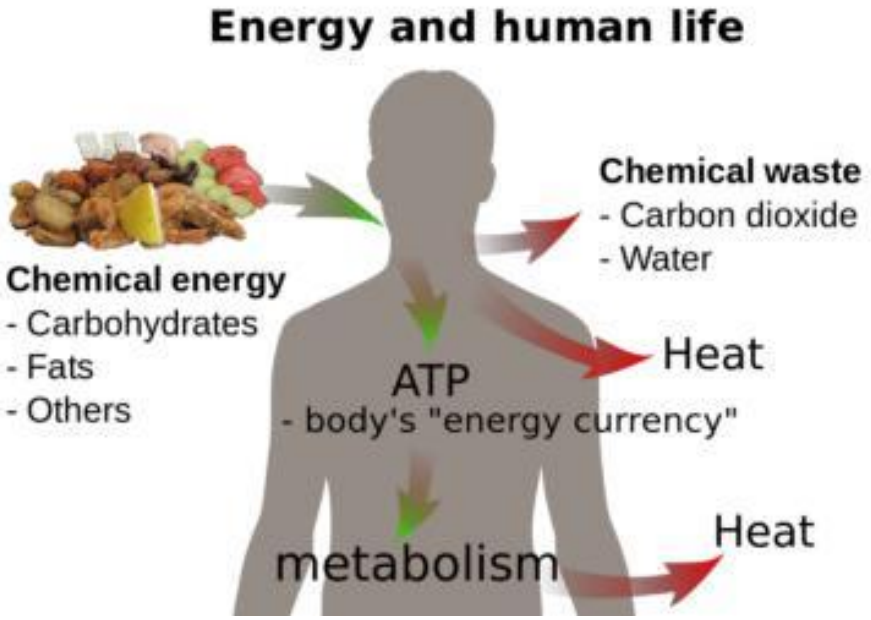
The Physics Classroom
http://www.physicsclassroom.com/class/energy

Explore Energy through Task Cards or Matching Activities

https://www.educaplay.com/en/learningresources/3675179/energy_match.htm

Workbook – p. 65

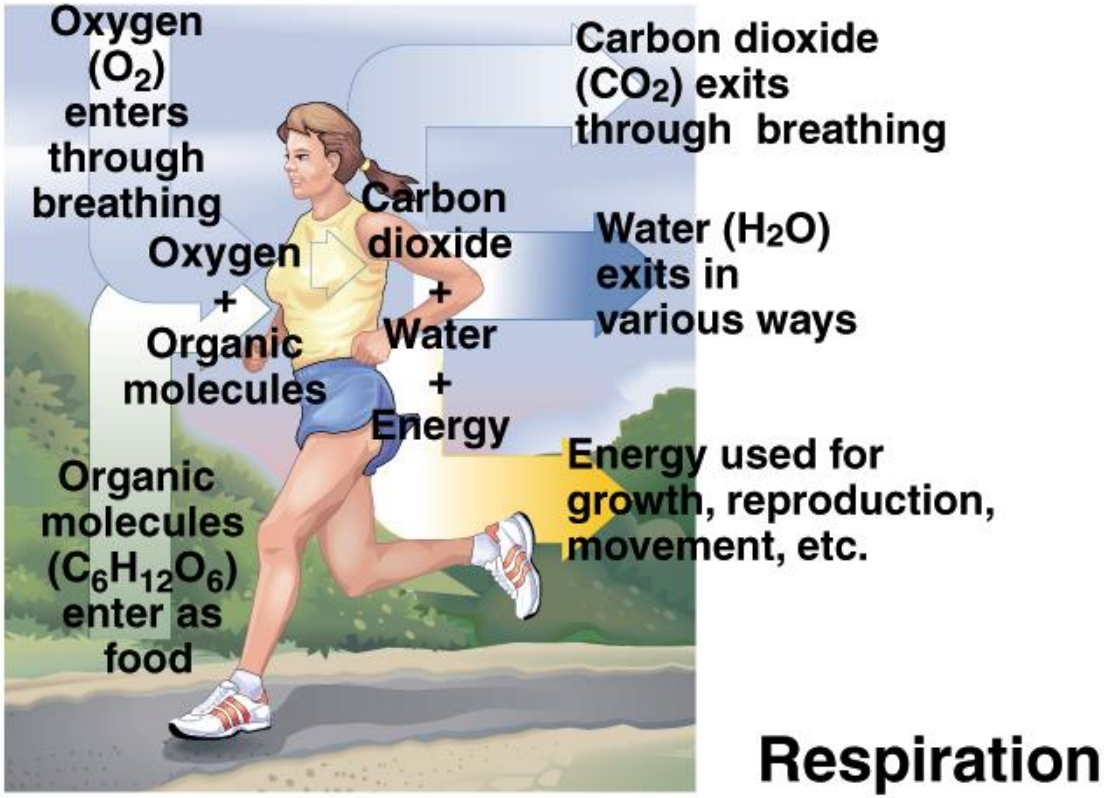
Life Science and Energy



Life forms must acquire energy from the environment to maintain their structure and function.

Respiration

Respiration is the process of releasing chemical energy stored in food to be used by living things.

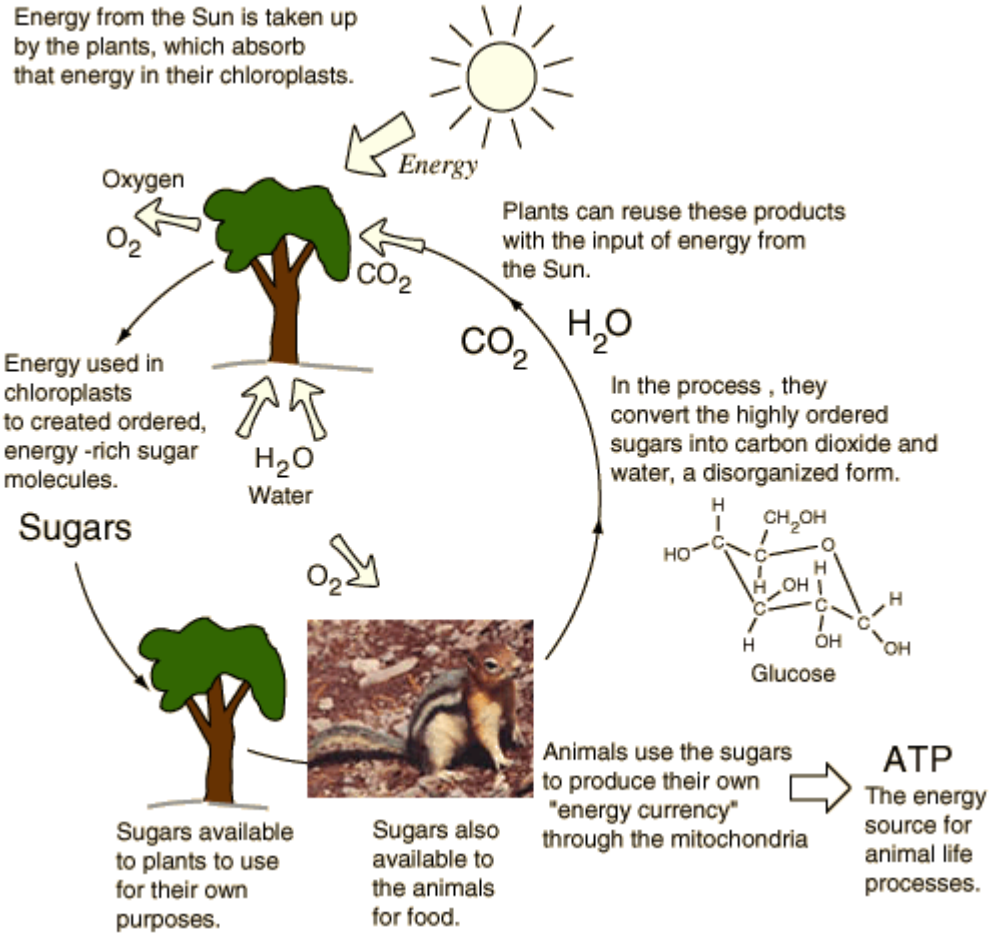


$C_6H_{12}O_6 + O_2 \text{---> } CO_2 + H_20$

Energy Cycle in Living Things

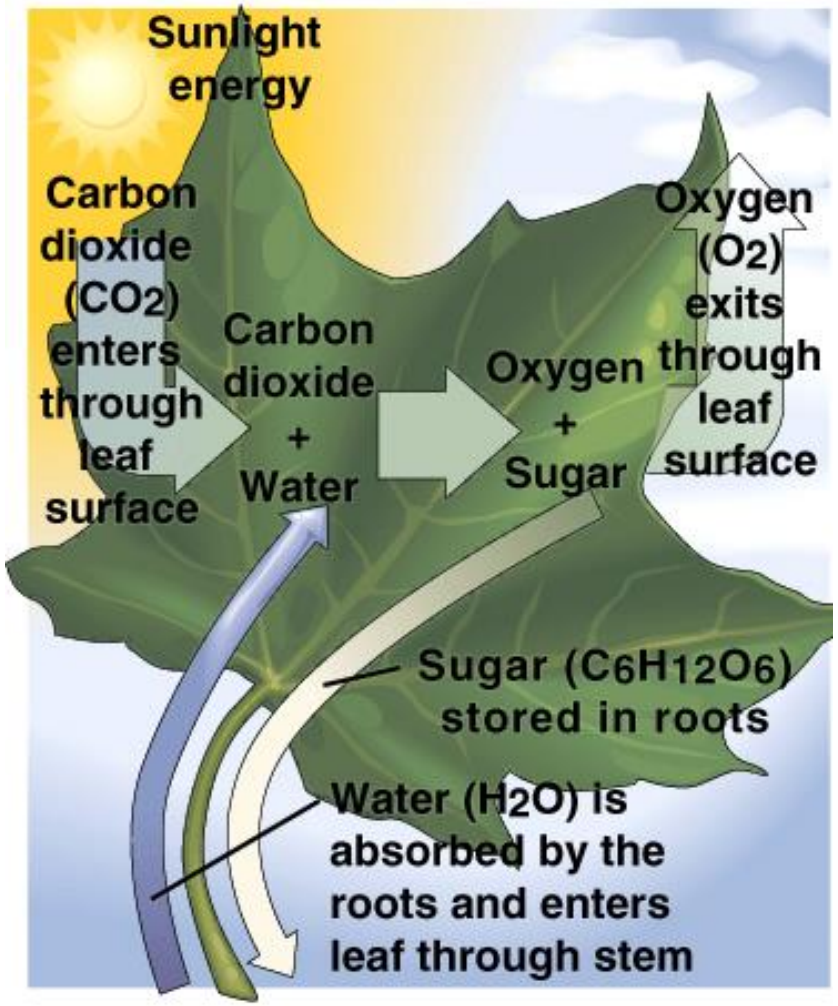
Energy Cycle in Living Things

http://hyperphysics.phy-astr.gsu.edu/hbase/Biology/enercyc.html



How About Photosynthesis?

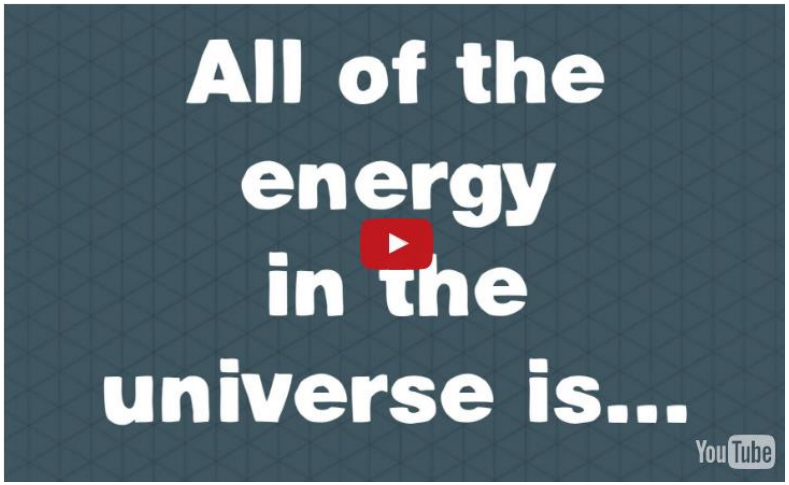
Photosynthesis is the process of converting solar energy into chemical energy stored in food



$CO_2 + H_20 \text{ ---> } C_6H_{12}O_6 + O_2$

Earth and Space Science

- Interaction of matter between living and non-living things
- Renewable vs. non-renewable resources and sustainability

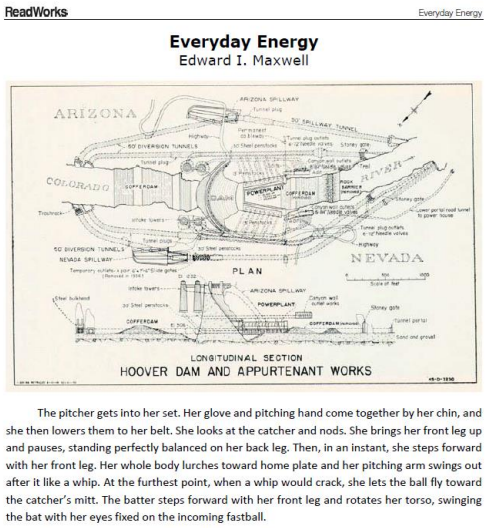


How about Ted-Ed for a lesson?

https://ed.ted.com/lessons/all-of-the-energy-in-the-universe-is-george-zaidan-and-charles-morton

Explain - Use Non-fiction Texts to Build Knowledge

https://www.readworks.org



ReadWorks Everyday Energy

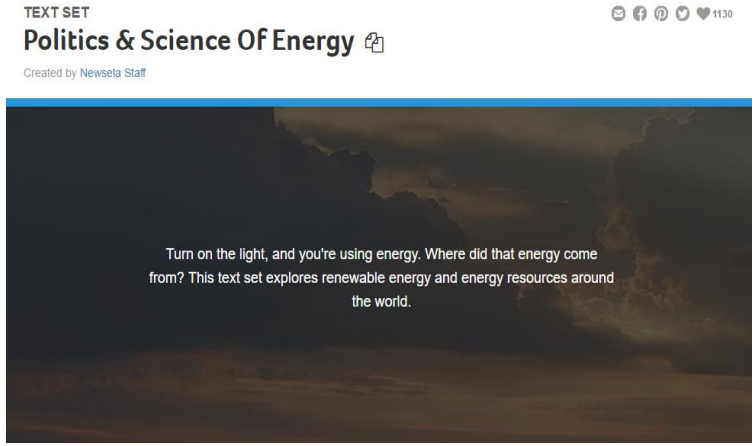
Everyday Energy

Edward I. Maxwell

The pitcher gets into her set. Her glove and pitching hand come together by her chin, and she then lowers them to her belt. She looks at the catcher and nods. She brings her front leg up and pauses, standing perfectly balanced on her back leg. Then, in an instant, she steps forward with her front leg. Her whole body lurches toward home plate and her pitching arm swings out after it like a whip. At the furthest point, when a whip would crack, she lets the ball fly toward the catcher's mitt. The batter steps forward with her front leg and rotates her torso, swinging the bat with her eyes fixed on the incoming fastball.

http://www.readworks.org/passages/everyday-energy

https://newsela.com/



https://newsela.com/text-sets/58/science--politics-science-energy

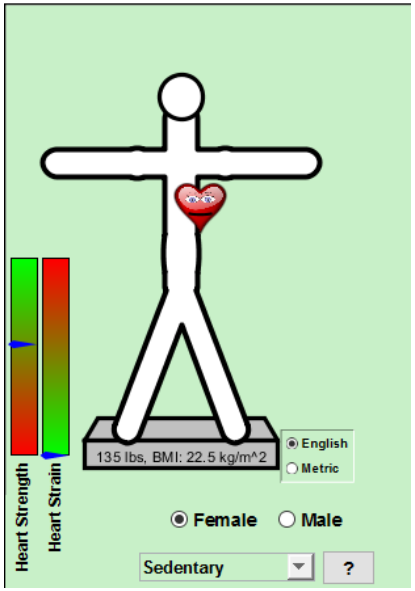
Extend through Hands-On Activities

Nova Energy Lab

http://www.pbs.org/wgbh/nova/labs/lab/energy/

Extend through SIMS

- How many calories are in your favorite foods?
- How much exercise would you have to do to burn off these calories?
- What is the relationship between calories and weight?



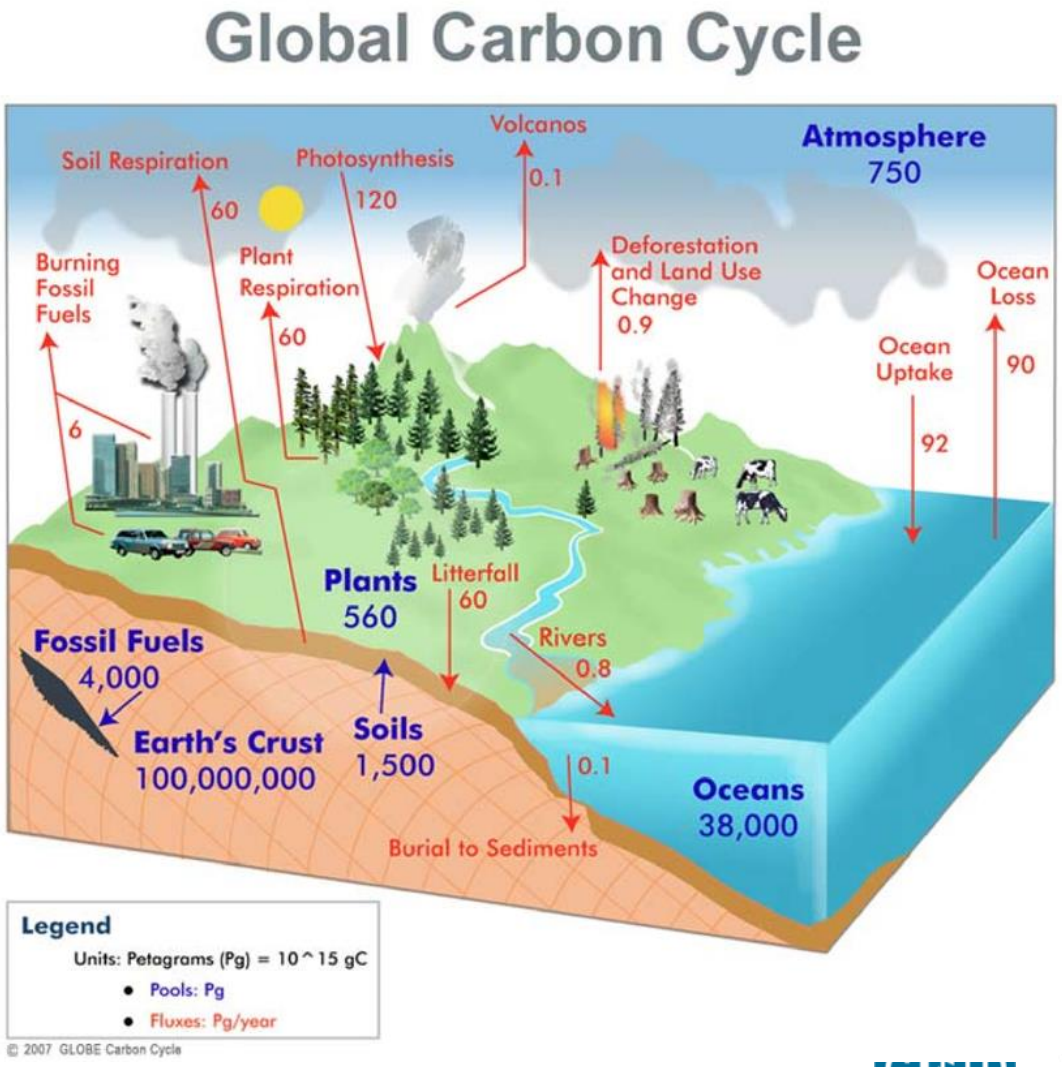
https://phet.colorado.edu/en/simulations/category/new

What do forests have to do with global warming?

A Case Study

http://serc.carleton.edu/eet/globecarbon/index.html

Graphic
https://d32ogoqmya1dw8.cloudfront.net/images/eet/globecarbon/global_carbon_cycle.v2.jpg



Evaluate - What do you think?

- What are society's energy needs and how have we traditionally met them?
- What are the advantages and disadvantages of different ways of meeting our energy needs? (For example, how do energy-capturing systems differ in their impact on the land and in their efficiency or inefficiency?)

Evaluate – Use Research

Energy: The U. S. in Crisis?

- http://sciencenetlinks.com/lessons/energy-the-us-in-crisis/
- Research and assess past, present, and future decisions related to energy shortages.
- http://www.cpalms.org/Public/PreviewResourceLesson/Preview/46550

Evaluate – Constructed Responses

Cite multiple pieces of data from the table that support why wind energy would be a preferable energy source over coal. Explain how a significant increase in the use of wind energy would affect the energy supply of coal.

Type your response in the box. This task may require approximately 10 minutes to complete.

Underline the verb. Determine action to be done. Complete the chart.

Do	What
Cite	Multiple pieces of data
Explain	How increase in use of wind energy would affect coal supply
Type	Response
Take	10 minutes

Workbook – pp. 14-16

Claim

My claim is . . .

Wind energy is far more resourceful compared to coal.

This is the relationship!

What's the Evidence?

Table	Article
Wind • no ongoing fuel costs • zero CO^2 emissions • visible, noise factor (may harm birds) Coal • high CO^2 emissions • ongoing fuel costs, • Impacts our environment – strip mining, mercury contamination • non-renewable fuel source	Coal will last ~ 100 more years Fossil fuel burned to create energy negative environmental impacts Renewable energy (like wind) expected to increase in use

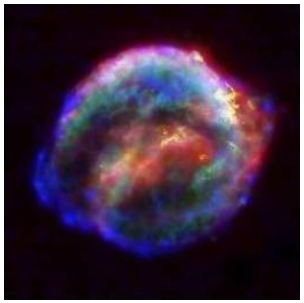
Sample Short Answer

Wind energy is far more resourceful compared to coal. Coal has ongoing fuel costs, and has many more impacts to the environment as wind energy does not. Wind does not produce any CO2 emissions, as where coal produces 200 pounds of CO2 emissions per kWh. Coal has many impacts that will affect the environment in the long run, as to wind energy. Simple inconveniences are the main issue. The effects of wind energy would help with the coal consumption. Projections show that coal resources will only last 100 years if we don't find alternate energy sources.

Need More Direction?

https://www.learner.org/workshops/energy/workshop1/

http://highschoolenergy.acs.org/content/hsef/en.html



http://www.explainthatstuff.com/energy.html

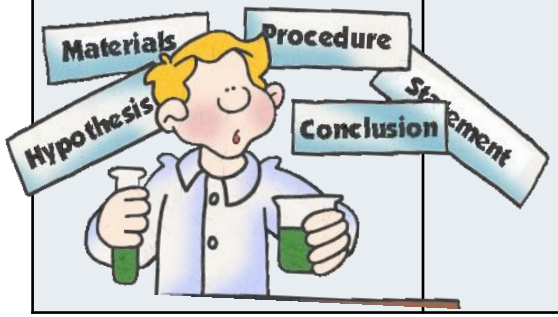
Workbook – pp. 12-13

Build Students' Scientific Reasoning Skills

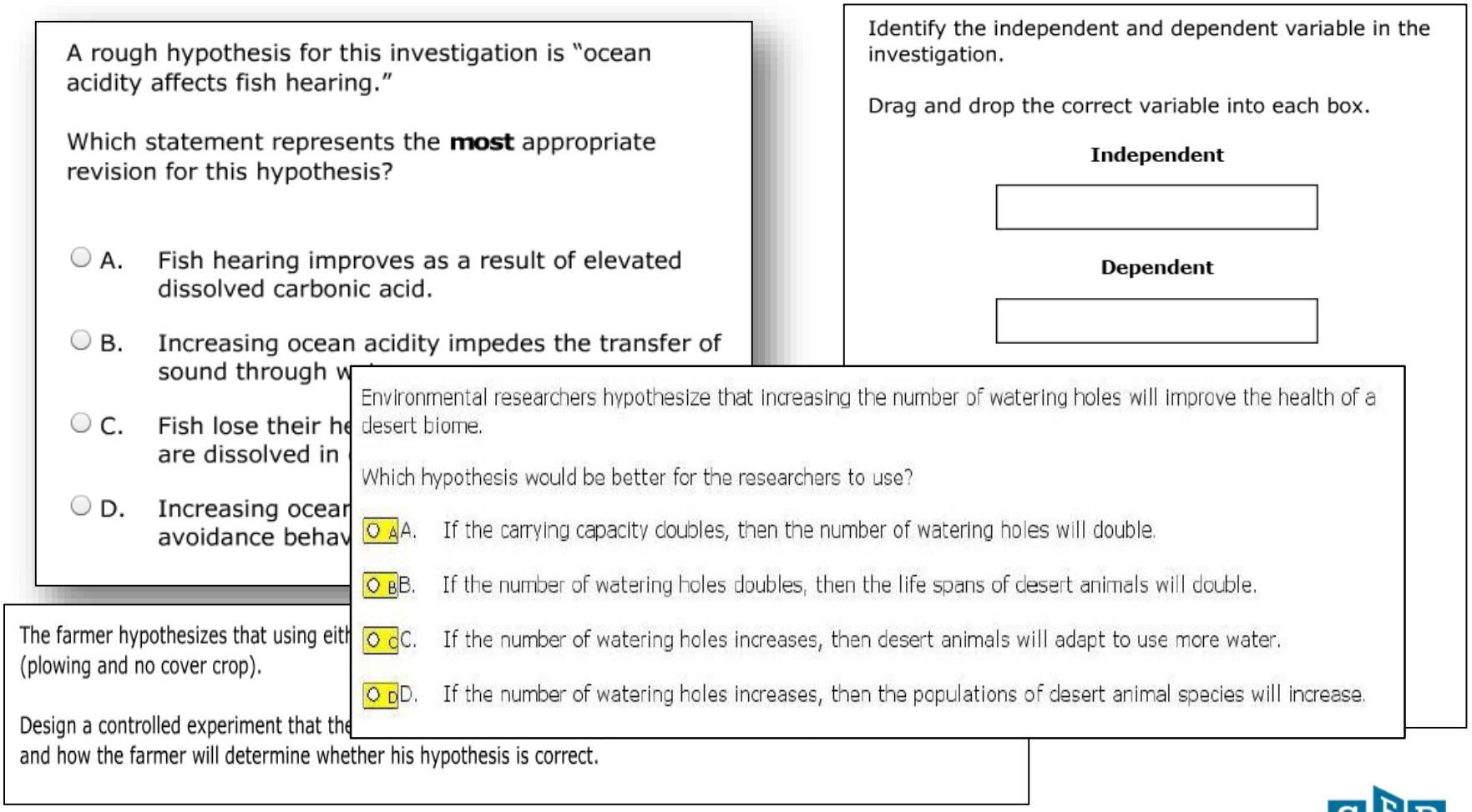
One Experiment at a Time

Assessment Target—SP.2

Assessment Target	Indicators	What to look for in student work: The student has . . .
SP.2 Investigation Design (Experimental and Observational)	SP.2.b Identify and refine hypotheses for scientific investigations SP.2.e Identify and interpret independent and dependent variables in scientific investigations.	• identified a hypothesis for a given scientific investigation. • differentiated between an appropriate hypothesis and a poorly conceived hypothesis. • used a hypothesis to support or challenge a given conclusion. • identified a hypothesis for a given data set. • refined a hypothesis to more appropriately suit a scientific experiment. • identified the independent variable in a given investigation. • identified the dependent variable in a given investigation. • fully explained the relationship between the independent and dependent variables in a given experiment.



GED® Sample Science Questions – Look Familiar?



Can your students . . .

Evaluate whether data supports a hypothesis?

Identify variables in an experimental process?

Determine a method for collecting data?

Determine the correct process for an experiment?

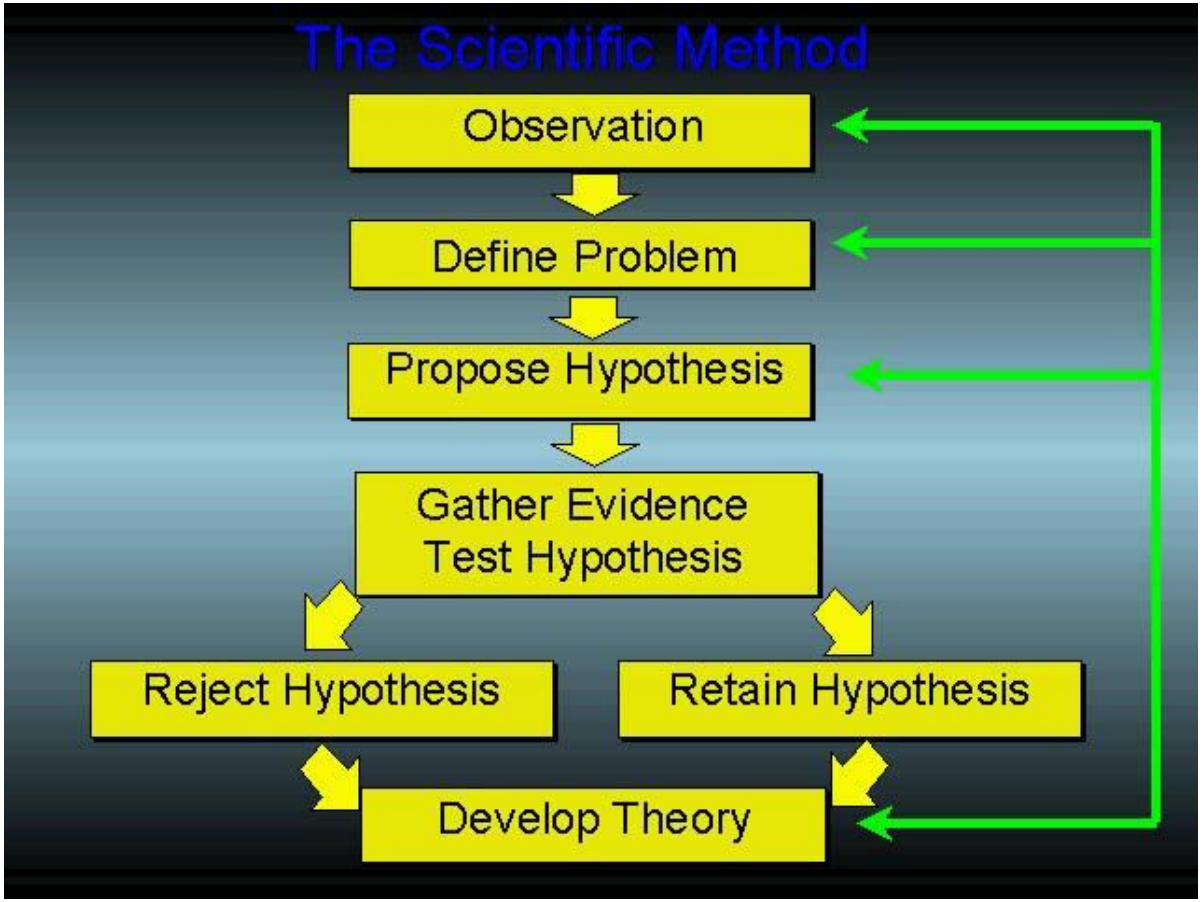
Draw a conclusion based on scientific data?

Create a hypothesis?

Design a scientific investigation based on a given hypothesis?

The Scientific Method

Teach experimental design through real-world application and reporting.



Workbook – p. 17

Scientific Method in Action

Observation and Problem	It takes me too long to get to work. I need to find a better route. Looking at the map, I know that there are many different routes.
Hypothesis	If I use Route X, I will arrive at work more quickly.
Gather Evidence and Test the Hypothesis	I drive to work the same time each day at the same speed taking a variety of routes, including Route X.
Analyze Results	I look at the different route times. I find that Route X is faster than the original route that I took or any of the alternates.
Draw Conclusion	Route X is the best route. However, I may want to test my hypothesis when driving home as traffic patterns may change.

Observation/Define the Problem

Does exercise make your heart beat faster?

Why is the health of the desert biome deteriorating?

Observation is getting information through the senses.

All investigations start with a question.

Formulate a Hypothesis

- Prediction/Educated Guess
- Use If, then statements
  - If _____ [*I do this*], then _____ [*this will happen*]
- Focus on one variable only

Variables in Experimental Design

Independent Variable	Dependent Variable	Control Variable
• What is tested by the scientist • What is changed (varied) by the scientist (What I change…)	• What is observed • What is measured • The effect (response) caused by the independent variable (What do I measure?)	• Things that could change but don't • Kept constant (the same) by scientists • These allow for a fair test (What stays the same?)

It's Your Turn!

Which battery will last the longest: Energizer or Duracell?

Independent Variable: **Brand of battery**

Dependent Variable: **Life of battery**

Constant Variable (Control): **Size of battery, use of battery, temperature**

Gather Evidence and Experiment

- Develop a procedure, list the needed materials and then, determine the control group.
- Conduct the experiment.
- Record the data in a data table.

Conclusion

- Look back at the hypothesis.
- Analyze the data to see if the hypothesis was accepted or rejected.
- If hypothesis is rejected, give possible reasons for the difference between the hypothesis and the experimental results.

It's Chemistry, M&M's® and the Scientific Method!

Problem: Will M&M's® color dissolve faster in water or in another clear liquid?

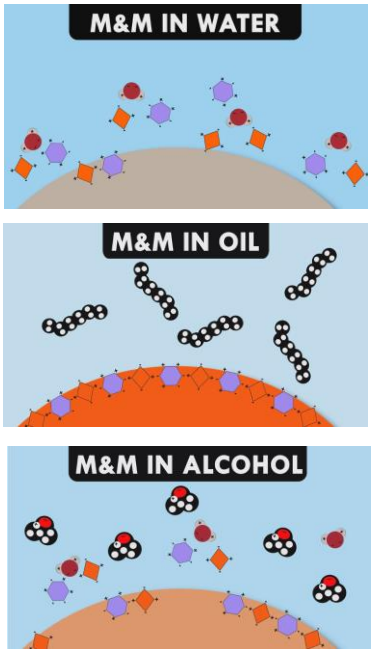
Workbook – pp. 18-19

Apply Learning - Set up an experiment

- State your hypothesis
- Set up a controlled experiment
  - Identify the control group
  - Identify the experimental group
  - Determine the constant (independent) variable
  - Determine the experimental (independent) variables
- Set up your data collection system
- Conduct the experiment
- Analyze your results

Why does the color come off differently in each liquid?

The candy coating is made up of coloring and sugar. The coloring and the sugar molecules both have positive and negative charges on them.



- The water molecule has positive and negative charges so it can attract and dissolve the color and sugar pretty well.
- The oil molecules have no positive and negative areas. They don't attract the coloring or sugar molecules so the candy coating doesn't dissolve at all in oil.
- The alcohol molecules don't have as many positive and negative areas as the water. The alcohol molecules can't attract the coloring and sugar molecules as well as the water, so the candy coating doesn't dissolve well in alcohol.

Remember, for a liquid to dissolve a solid, the molecules of the liquid and solid must attract one another. (American Chemistry Society - Chemistry for Life® https://www.acs.org/)

Experimental Design

Experimental Design

Questions on experimental design require:

- A description of the experimental design (what you would do to prove hypothesis)
- A method for collecting data
- An explanation of criteria for evaluating the hypothesis – justify a line of reasoning

Analyze the Prompt

Workbook – p. 20

The farmer hypothesizes that using either method will reduce erosion compared to using traditional farming methods (plowing and no cover crop).

Design a controlled experiment that the farmer can use to test this hypothesis. **Include** description of data collection and how the farmer will **determine** whether his hypothesis is correct.

Type your response in the box. This task may require approximately 10 minutes to complete.

Underline the verb. Determine action to be done.

Analyze the Source Text

Workbook – p. 20

Steps in Scientific Method	What text tells you
Observe	Topsoil is about 20 centimeters in thickness. Farmer knows two methods to reduce soil erosion 1) No till 2) Winter cover crop
Hypothesis	Believes either method 1 or 2 will be better than traditional method (plowing and no cover)
Experiment	
Collect Data	
Evaluate Results	

Set up the Experiment

Workbook – p. 20

Steps in Scientific Method	What text tells you
Observe	Topsoil is about 20 centimeters in thickness. Farmer knows two method to reduce soil erosion 1) No till 2) Winter cover crop
Hypothesis	Believes either method 1 or 2 will be better than traditional method (plowing and no cover)
Experiment	Has 30 acres of farmland so could use all 3 methods (10 acres per method). Use traditional method as control group. Conduct experiment for 1 year.
Collect Data	Measure topsoil in each group monthly and record data in a log to show comparison
Evaluate Results	Analyze data to see how the 2 variable methods compared to the control group

Craft the Response

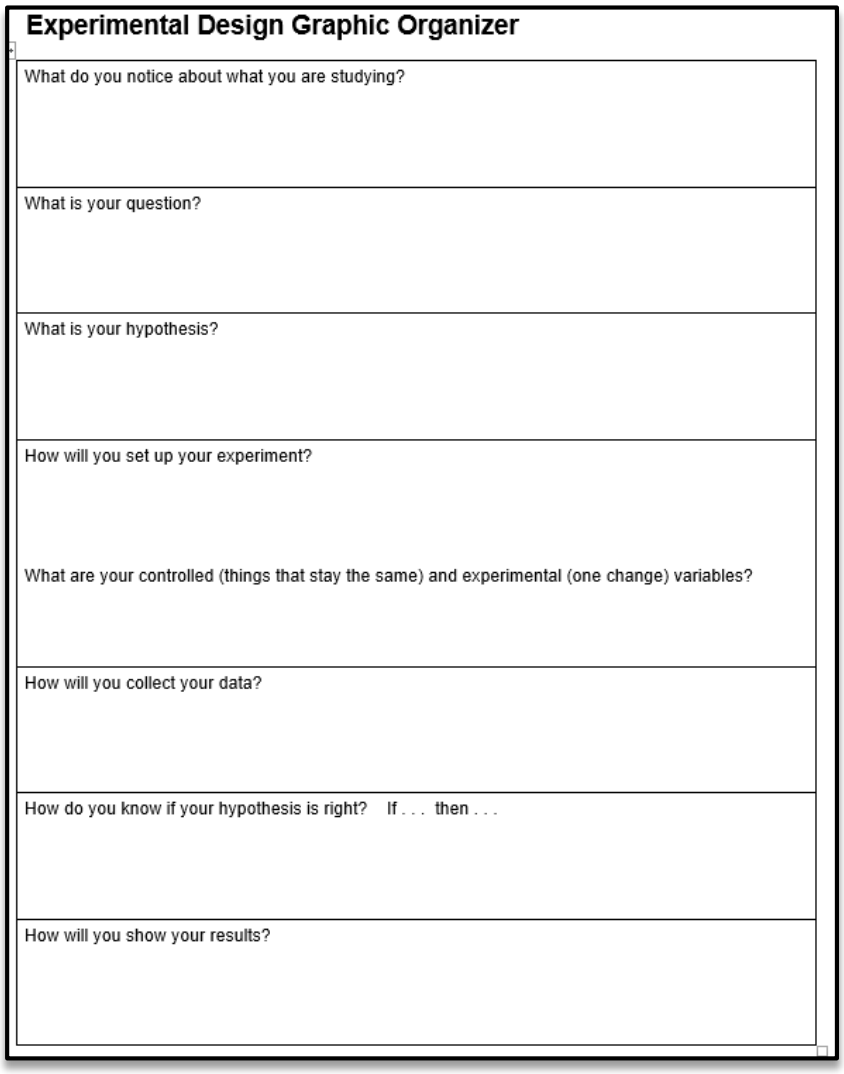
The farmer could set up the experiment to last one year and include all three methods. 10 acres would be set aside for each of the three methods.

- Control group – traditional methods (plow and no cover)
- No till
- Cover crop

The farmer would identify three areas within each group where he would measure the topsoil on a monthly basis for the entire year. This way he could get an average for each group each month. He would record the data in a log to review at the end of the year.

Based on the data collected, the farmer would be able to determine which of the three groups saw the least erosion and determine if his hypothesis was correct.

Experimental Design Graphic Organizers



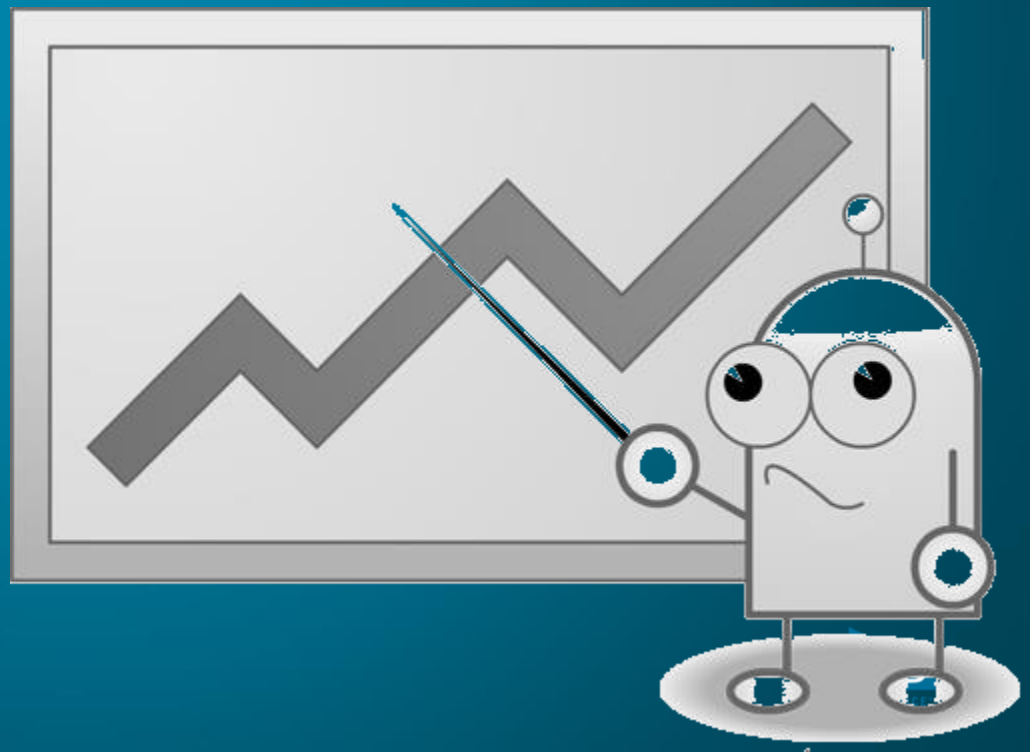
Experimental Design Graphic Organizer

What do you notice about what you are studying?
What is your question?
What is your hypothesis?
How will you set up your experiment? What are your controlled (things that stay the same) and experimental (one change) variables?
How will you collect your data?
How do you know if your hypothesis is right? If . . . then . . .
How will you show your results?

Developed by S.J. Schmidt. Appalachian State University. http://abspd.appstate.edu/teaching-resources

Workbook – pp. 28-29

Statistics in Science

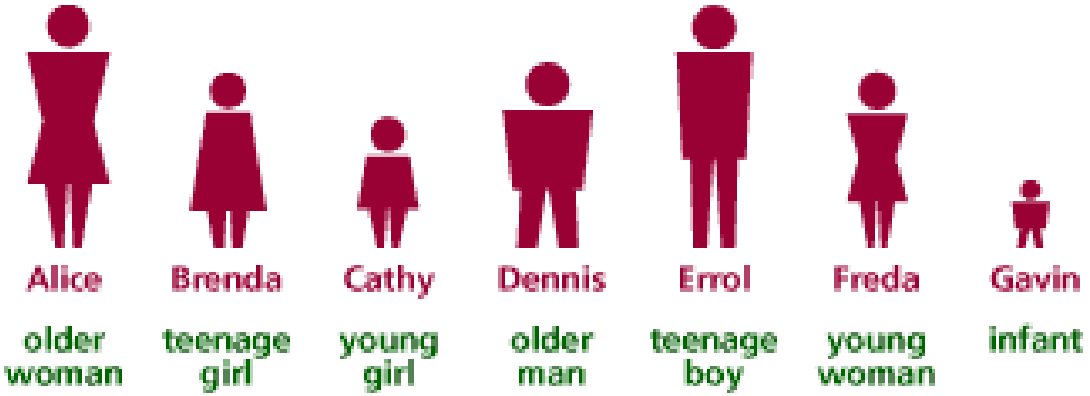


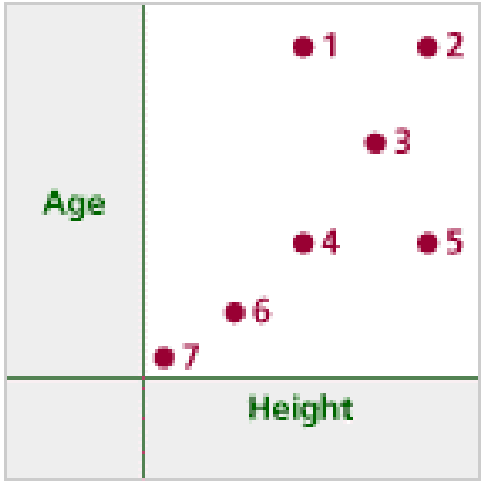
Where do we see statistics, data, and math on the test?

- Questions assessing statistics and data indicators on social studies and science
- Use of calculator and formulas in different content areas
- Charts, tables, and graphs

Time Out for a Graph Starter!

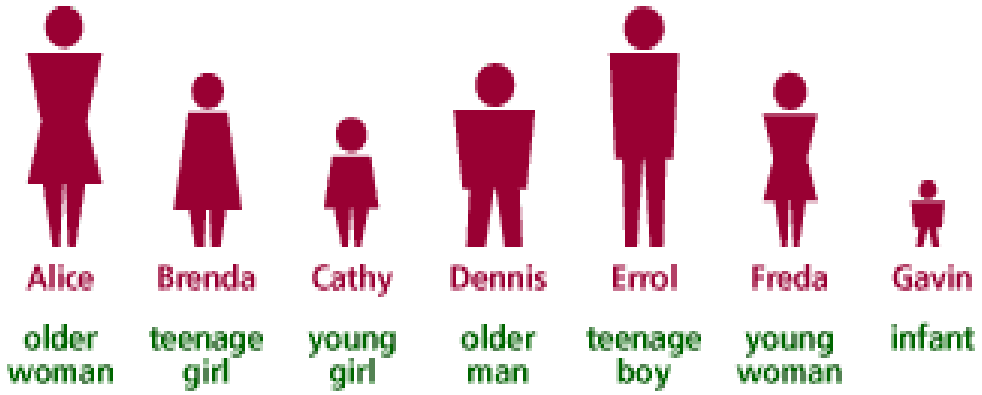
Let's get started problem solving with graphics by looking at the following graph. Who is represented by each point?

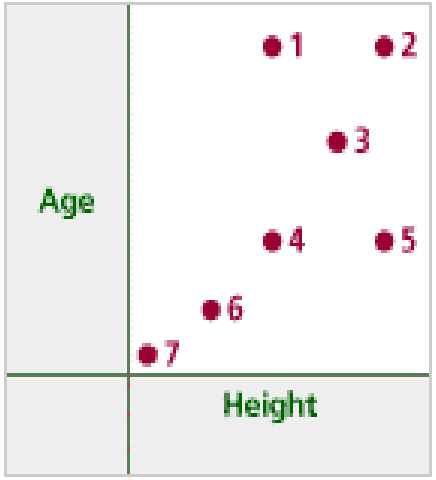




Workbook – p. 21

The Answers!





1 = Dennis
2 = Alice
3 = Freda
4 = Brenda
5 = Errol
6 = Cathy
7 = Gavin

Do your students know…

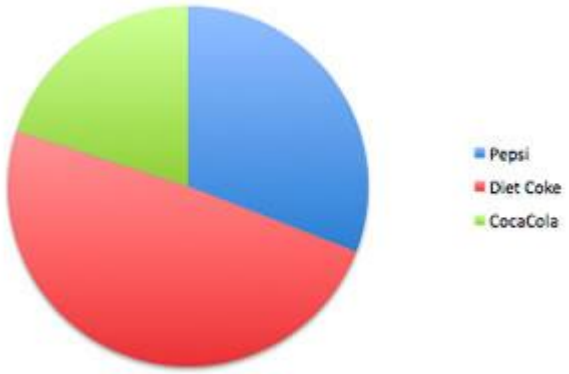
Data tables

- Present data in a series of rows or columns
- Give easy access to information
- Compare and contrast information
- Set information for transfer to a graphic

Plant Group	pH of Soil	Average Plant Growth (cm)
1	6.0	25.4
2	6.2	33.0
3	6.4	50.8
4	6.6	53.3
5	6.8	53.3
6	7.0	30.5
7	7.2	22.9

Circle graphs (pie charts)

- Represent categorical data or values of variables
- Are divided into segments which reflect proportion of variable to the whole
- Work best if segments are ordered clockwise from largest to smallest (easier to read)



Do your students know…

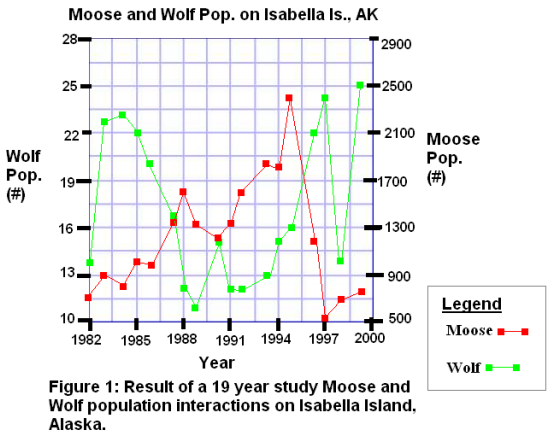
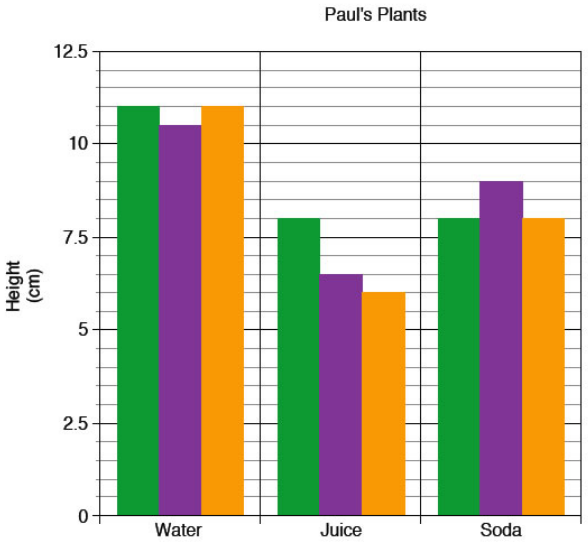


Figure 1: Result of a 19 year study Moose and Wolf population interactions on Isabella Island, Alaska.



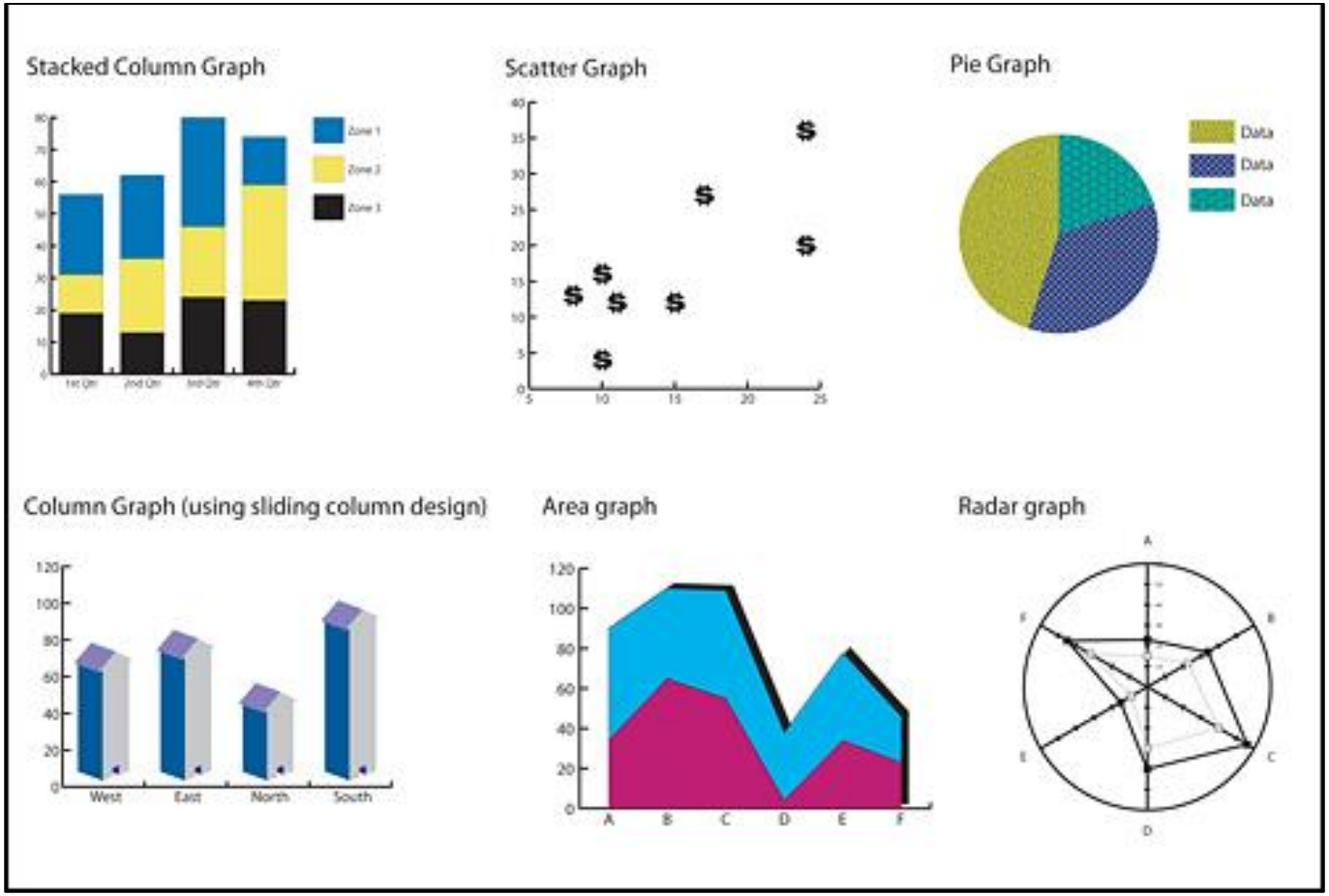
Line graphs

- Show changes in direction – trends
- Compare two variables
  - *x*-axis usually represents time
  - *y*-axis represents percentage or measures of quantity

Bar graphs

- Present and compare data
- Can include single, double, or multiple bars
- Include scales on the axes
- Present a numerical or categorical variable for each bar

Teach Multiple Ways to Display Data



Representing Data in Different Formats

Think of the simplest way you can organize the data below, showing the length of nails found in a packet of assorted nails.

Length of Nails (mm)															
11	22	29	15	17	27	21	23	27	26	19	16	11	10	16	15	21
21	17	15	23	20	16	17	25	16	21							

One way is to arrange it in increasing order.

Nails arranged in order of increasing length (mm)																
10	11	11	15	15	15	16	16	16	16	17	17	17	19	20	21	21
21	21	22	23	23	25	26	27	27	29							

Workbook – p. 22

Use a Tally Table

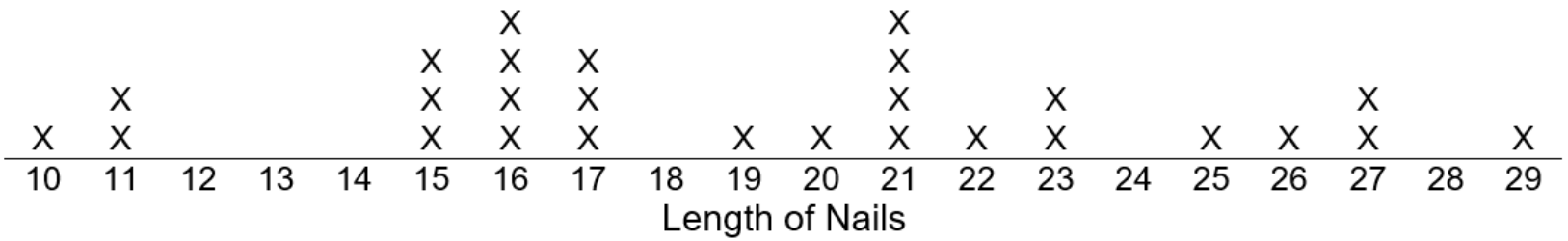
Nails arranged in order of increasing length (mm)

10 11 11 15 15 15 16 16 16 16 17 17 17 19 20 21 21
21 21 22 23 23 25 26 27 27 29

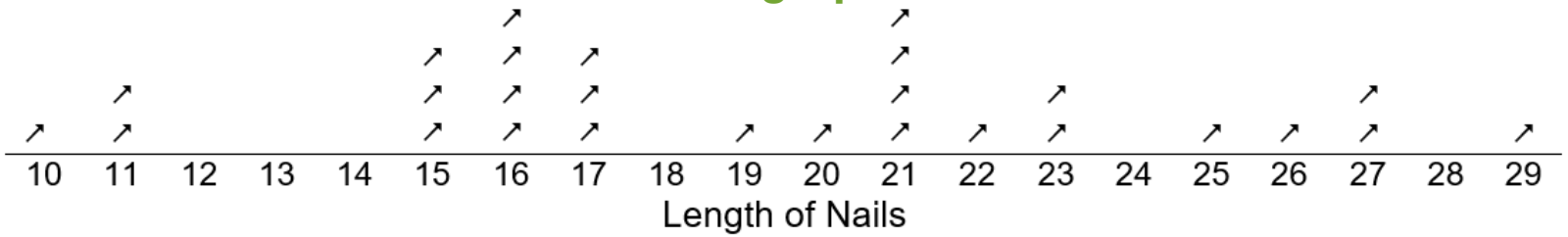
Length	Tally	Length	Tally
10	I	20	I
11	II	21	IIII
12		22	I
13		23	II
14		24	
15	III	25	I
16	IIII	26	I
17	III	27	II
18		28	
19	I	29	I

Line Plot or Pictographs

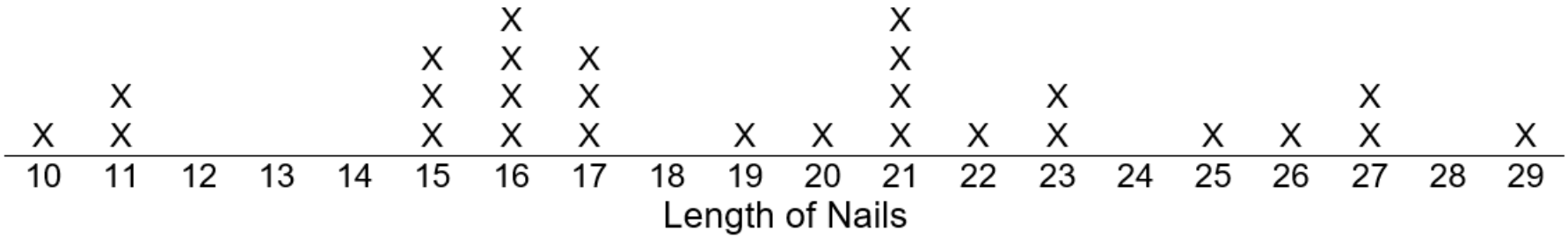
Line Plot



Pictograph



Frequency Table



Frequency Table

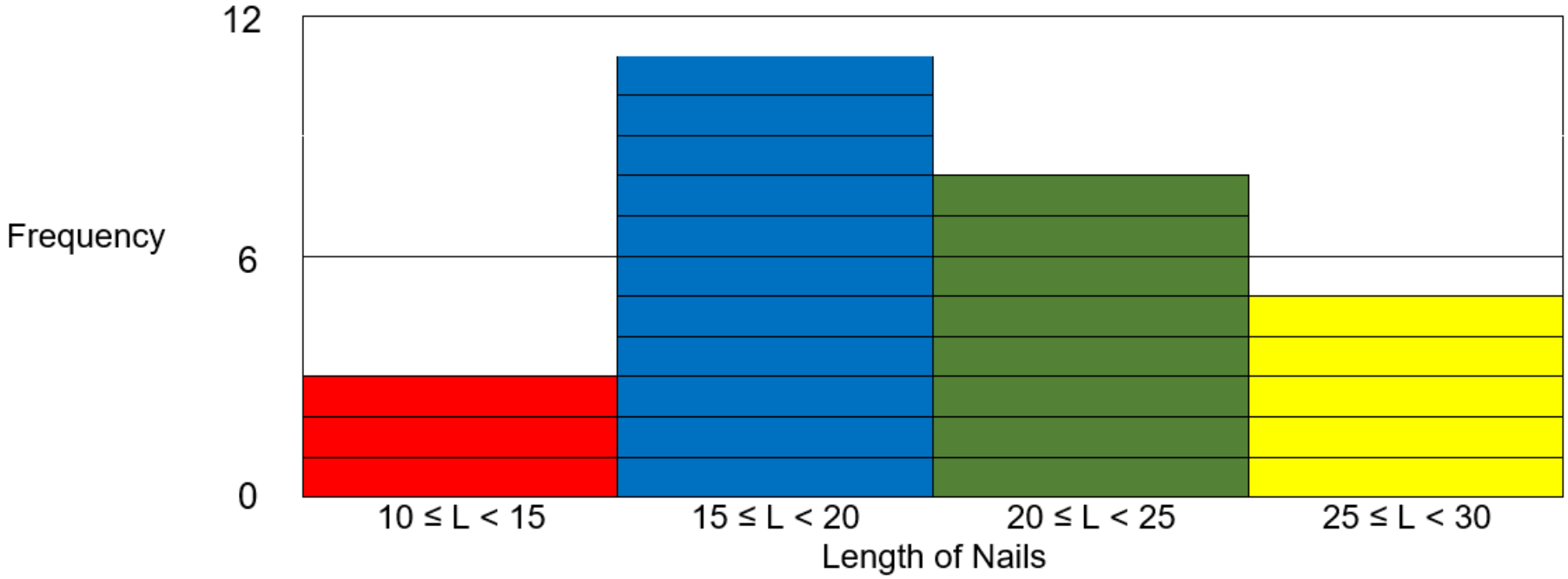
Length of Nails

Length	Frequency
$10 \le L < 15$	3
$15 \le L < 20$	11
$20 \le L < 25$	8
$25 \le L < 30$	5

Length of Nails

Frequency	3	11	8	5
Length	$10 \le L < 15$	$15 \le L < 20$	$20 \le L < 25$	$25 \le L < 30$

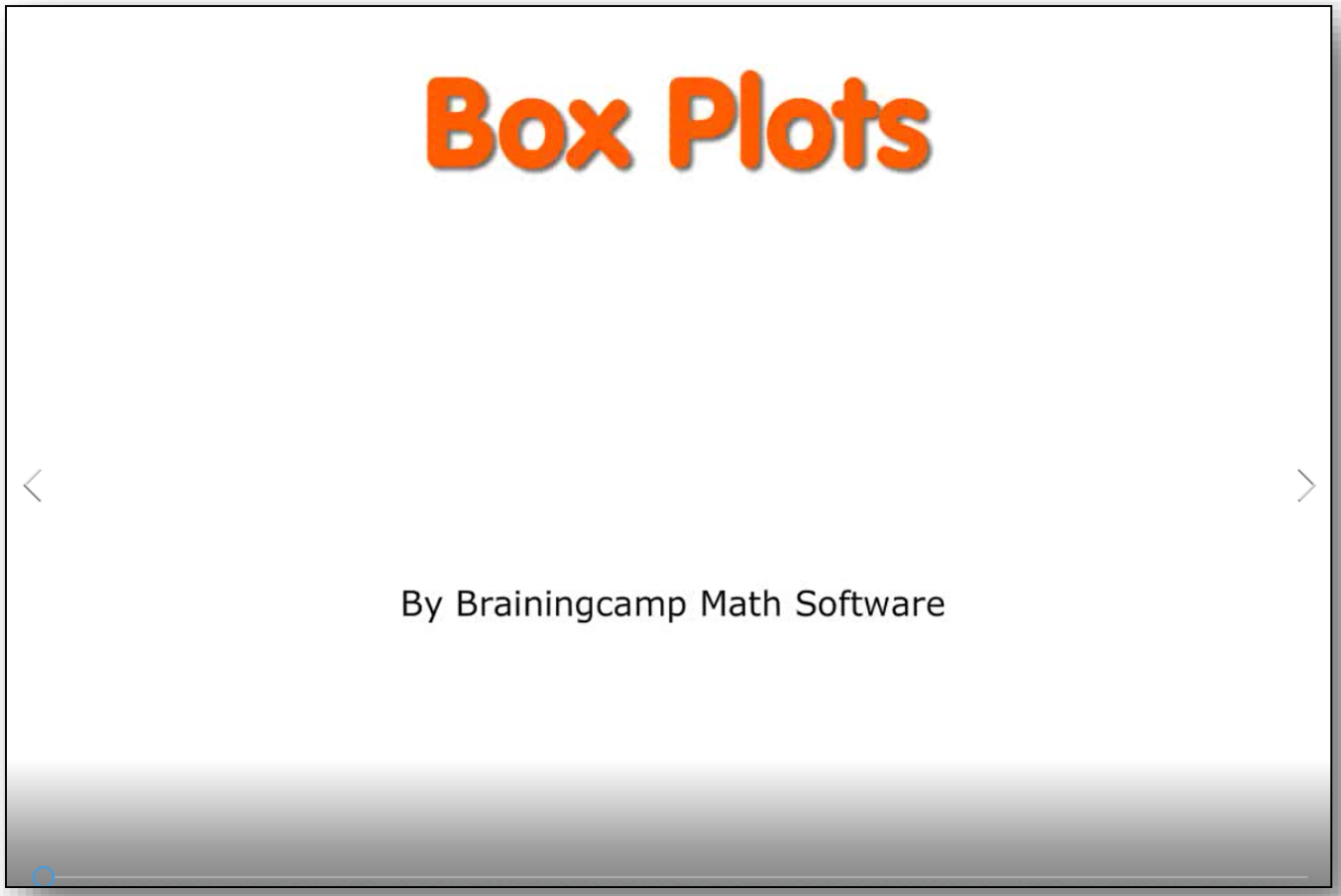
Histogram



Length of Nails

Frequency	3	11	8	5
Length	10 ≤ L < 15	15 ≤ L < 20	20 ≤ L < 25	25 ≤ L < 30

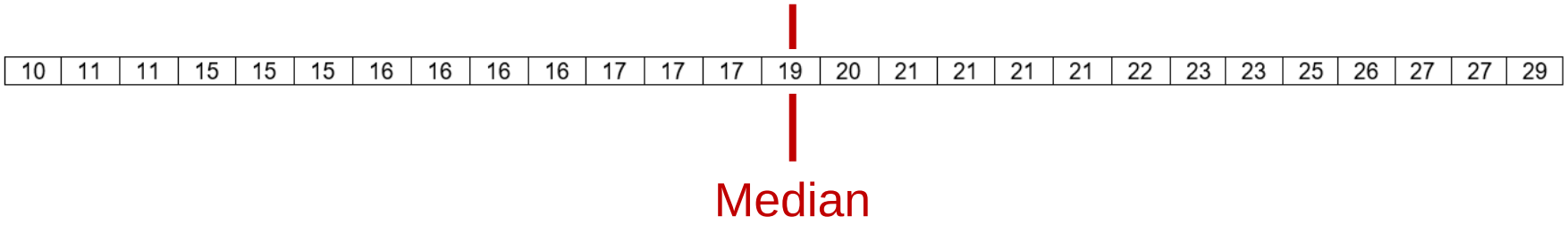
How About a Box Plot?



https://www.youtube.com/watch?v=CoVf1jLxgj4

Let's Create a Box Plot

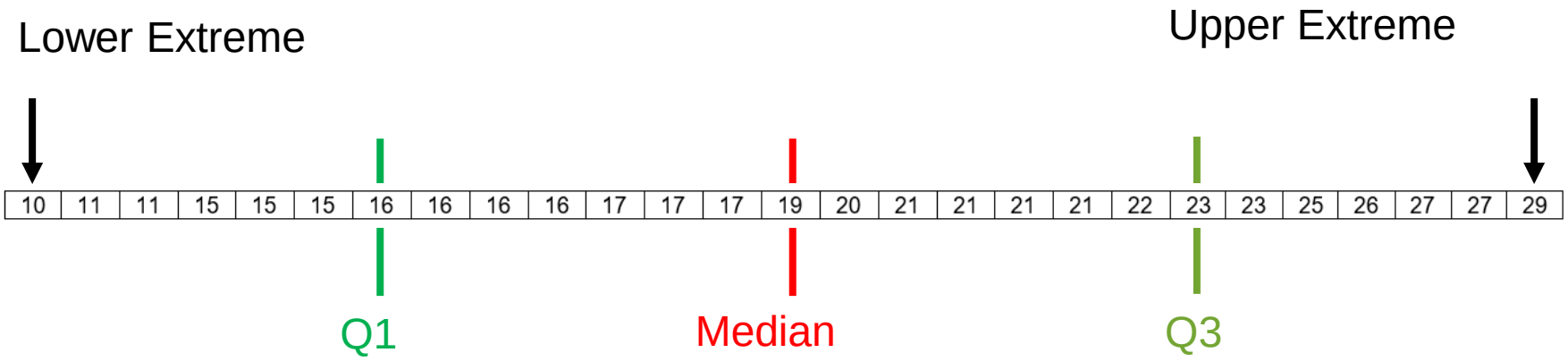
- Arrange data in order and divide into quarters
- Find the median of the data set



Let's Create a Box Plot

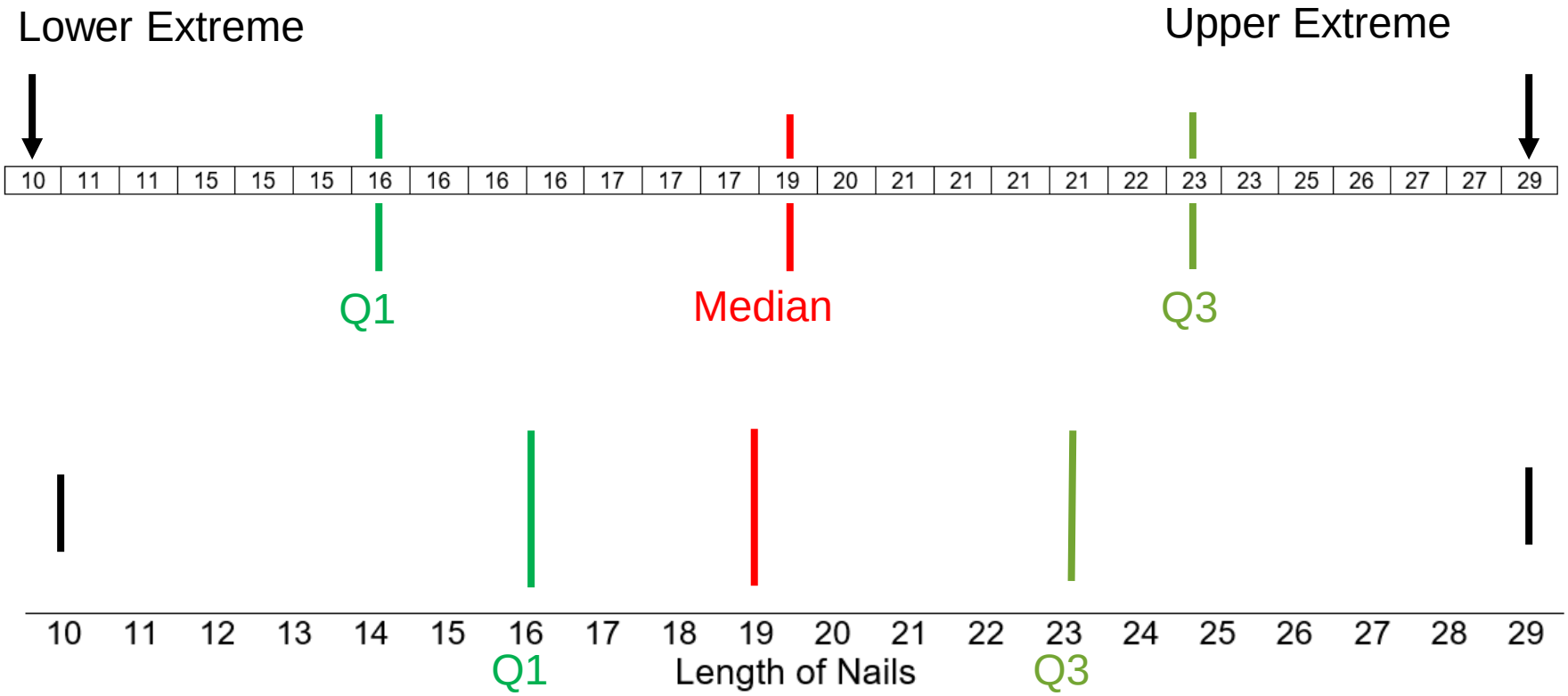
Find the middle value (Q3) of the lower quartile and the upper quartile

Find the extreme values of the data set



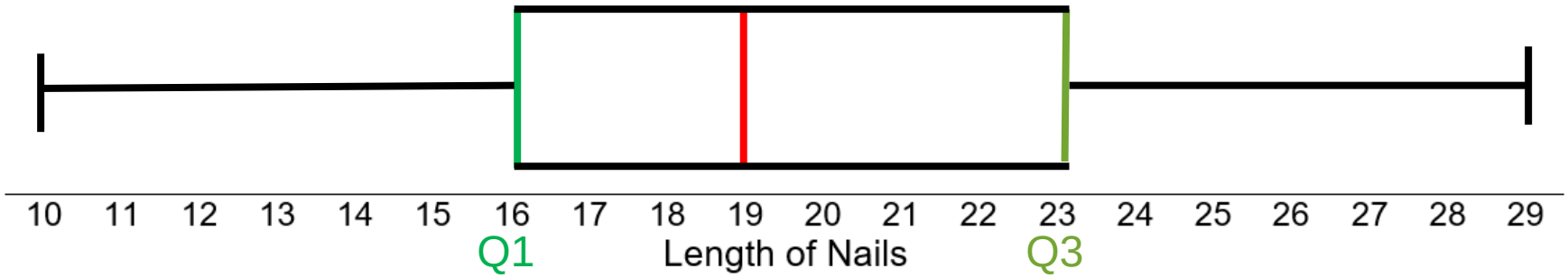
Let's Create a Box Plot

We now draw a number line to plot all the numbers we identified.



Let's Create a Box Plot

The last step is to draw a box from Q1 to Q3 and lines connecting the extreme values to our box.



Now, we have successfully created a box plot to represent our data.

Measures of Central and Spread

Another way to describe data is to describe its center and/or spread.

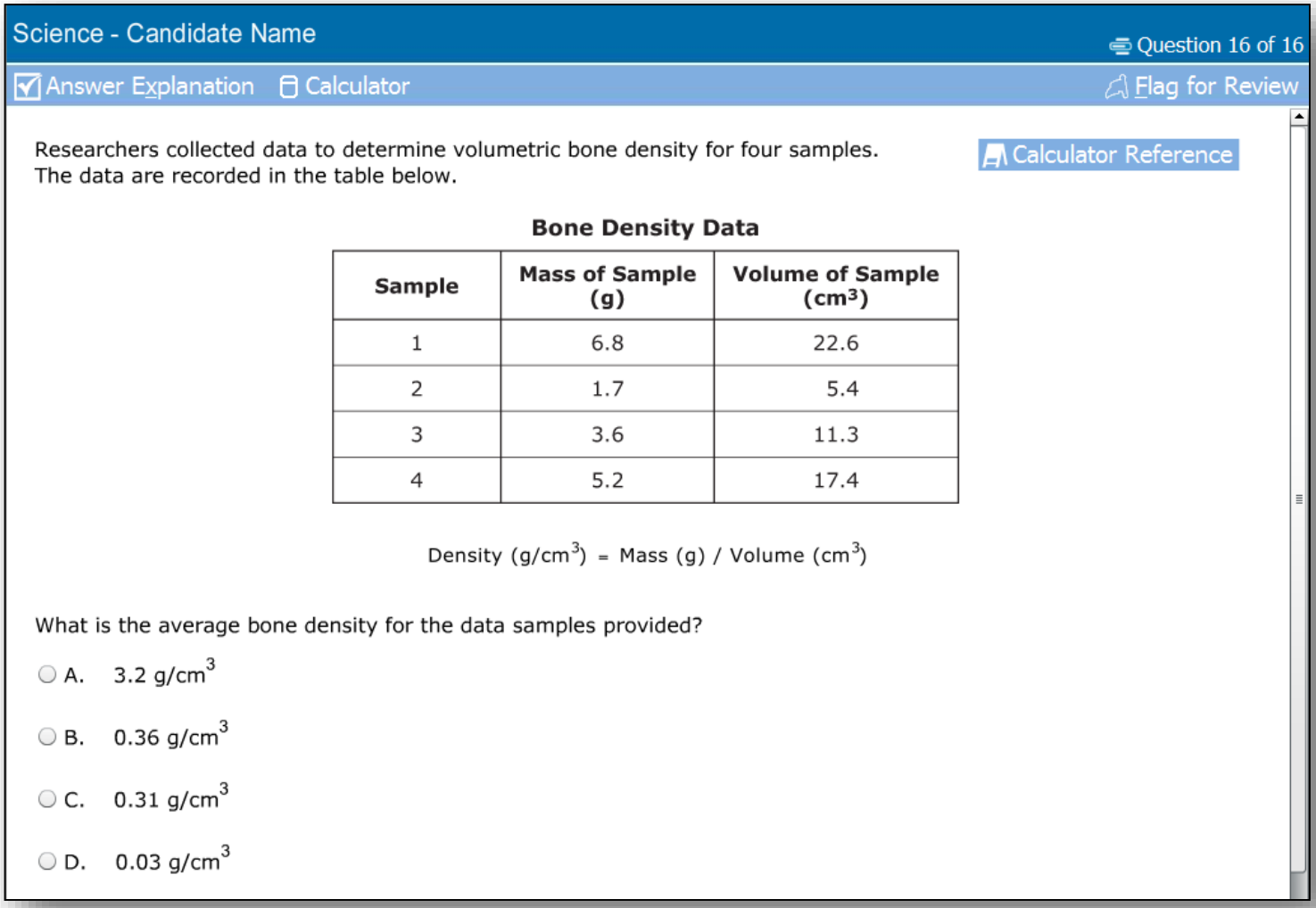
Measures of Central Tendency

- Mean (Average)
- Median
- Mode

Measures of Variability

- Range
- Mean Absolute Deviation
- Standard Deviation

Mean, median, and mode . . .



Science - Candidate Name

Question 16 of 16

Answer Explanation Calculator Flag for Review

Researchers collected data to determine volumetric bone density for four samples. The data are recorded in the table below.

Calculator Reference

Bone Density Data

Sample	Mass of Sample (g)	Volume of Sample (cm^3)
1	6.8	22.6
2	1.7	5.4
3	3.6	11.3
4	5.2	17.4

Density (g/cm^3) = Mass (g) / Volume (cm^3)

What is the average bone density for the data samples provided?

A. 3.2 g/cm^3

B. 0.36 g/cm^3

C. 0.31 g/cm^3

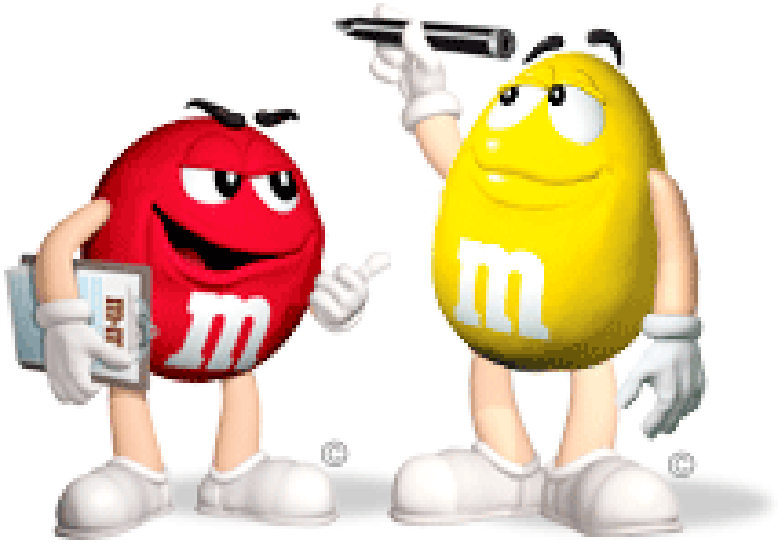
D. 0.03 g/cm^3

It Doesn’t Get Much Better

https://www.youtube.com/watch?v=oNdVynH6hcY

The Scientific Method, Statistics, and M&M's®

- ✓ Observations and Questions
- ✓ Hypothesis
- ✓ Gather Evidence and Test the Hypothesis
- ✓ Analyze Results
- ✓ Draw Conclusions



Workbook – pp. 23-25

The Official Color Estimates for Plain M&M's®

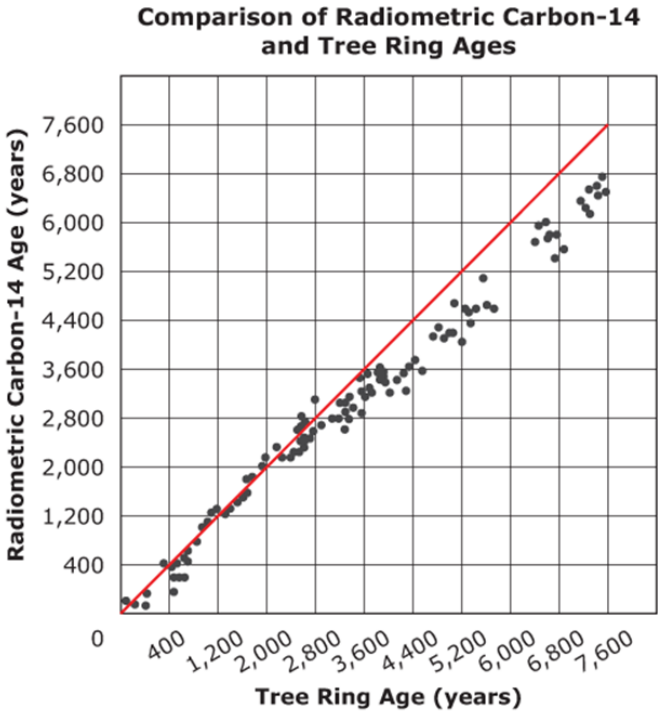
Let's conduct a scientific experiment!

- Question: How does your sample compare to the population?
- Problem: Are the Mars sorters working properly?

	CLV	HKP
	12.4%	12.5%
	13.5%	12.5%
	13.1%	12.5%
	20.7%	25%
	20.5%	25%
	19.8%	12.5%

The Basics of Scatter Plots

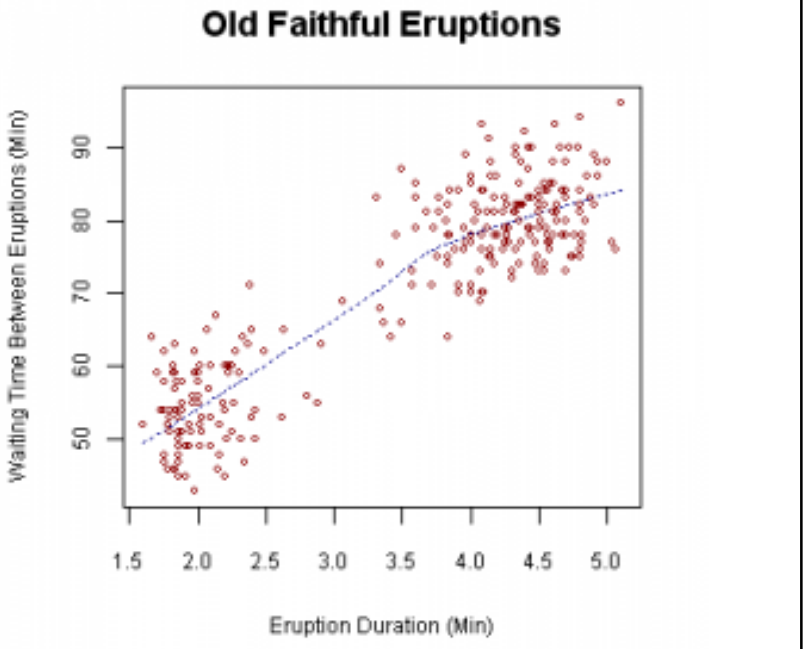
- Are similar to line graphs
- Have horizontal and vertical axes
- Have two sets of data that are plotted as ordered pairs on a coordinate to show the relationship
- Show how much one variable is affected by another – the correlation



Source: National Institute of Standards and Technology

The Vocabulary of Scatter Plots

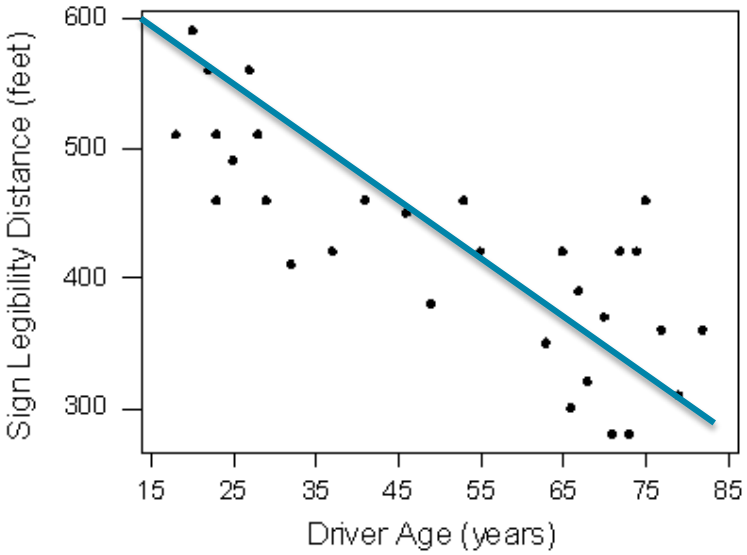
- Bivariate data
- Independent variable
- Dependent variable
- Line of best fit
- Correlation
  - Positive
  - Negative
  - No
- Causation



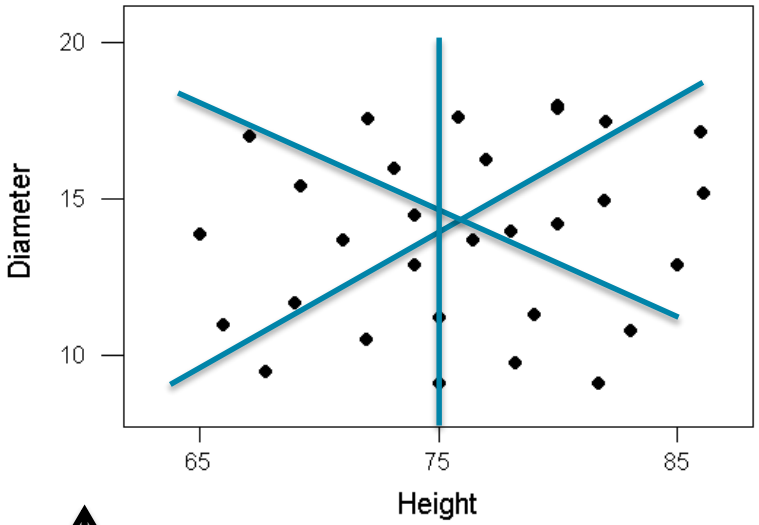
Waiting time between eruptions and the duration of the eruption for the Old Faithful Geyser in Yellowstone National Park, Wyoming, USA. This scatterplot suggests there are generally two "types" of eruptions: short-wait-short-duration, and long-wait-long-duration.

Scatter Plots

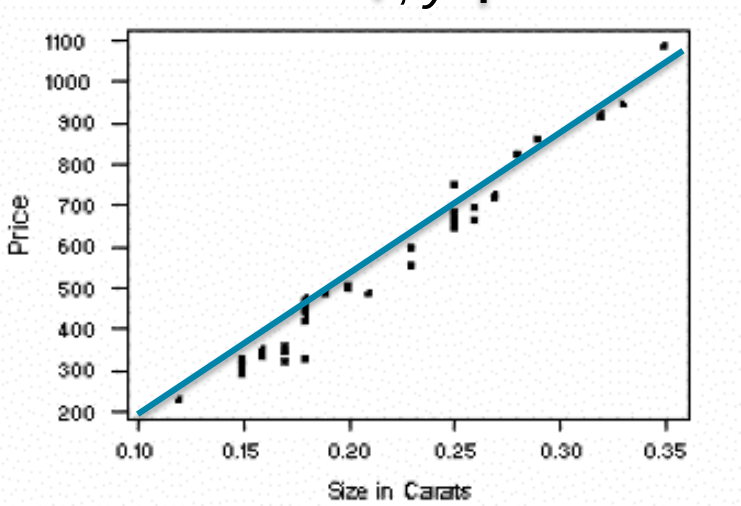
As x ↑, y ↓



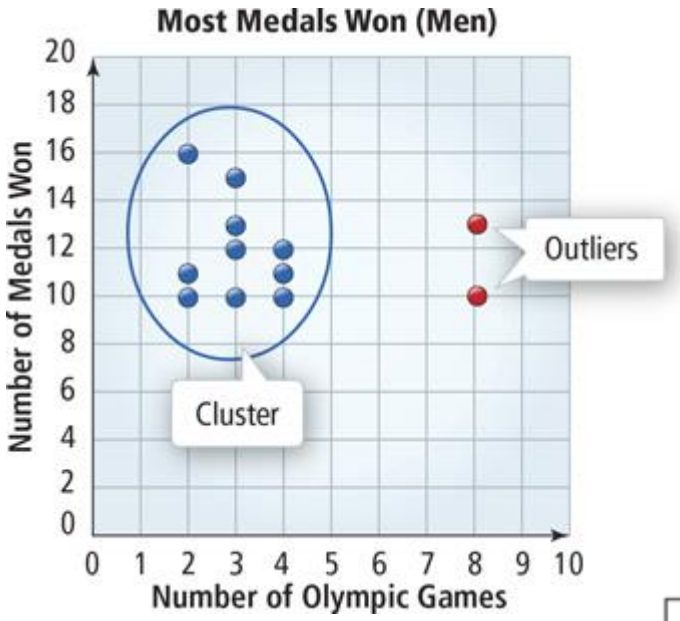
No correlation



As x ↑, y ↑

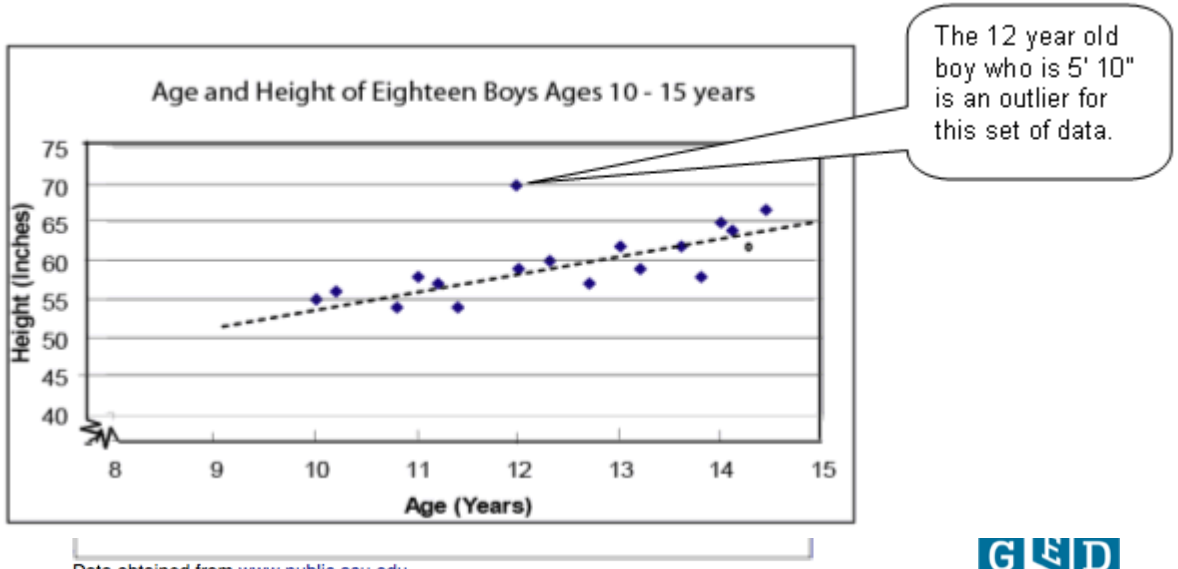


Clusters and Outliers



A **cluster** is formed when several data points lie in a small interval.

An **outlier** has a value that is much greater or much less than other data in the set.

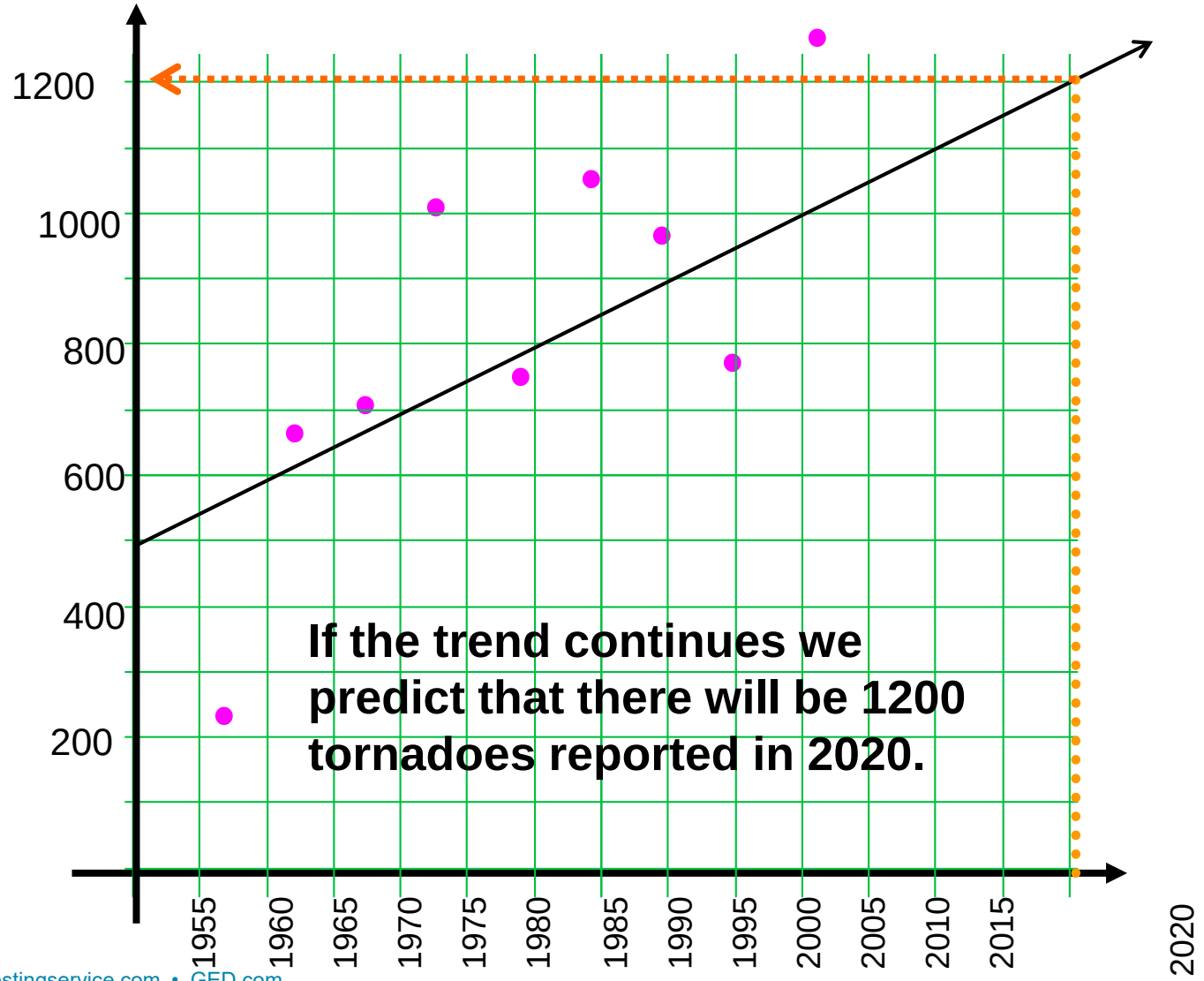


Data obtained from www.public.asu.edu

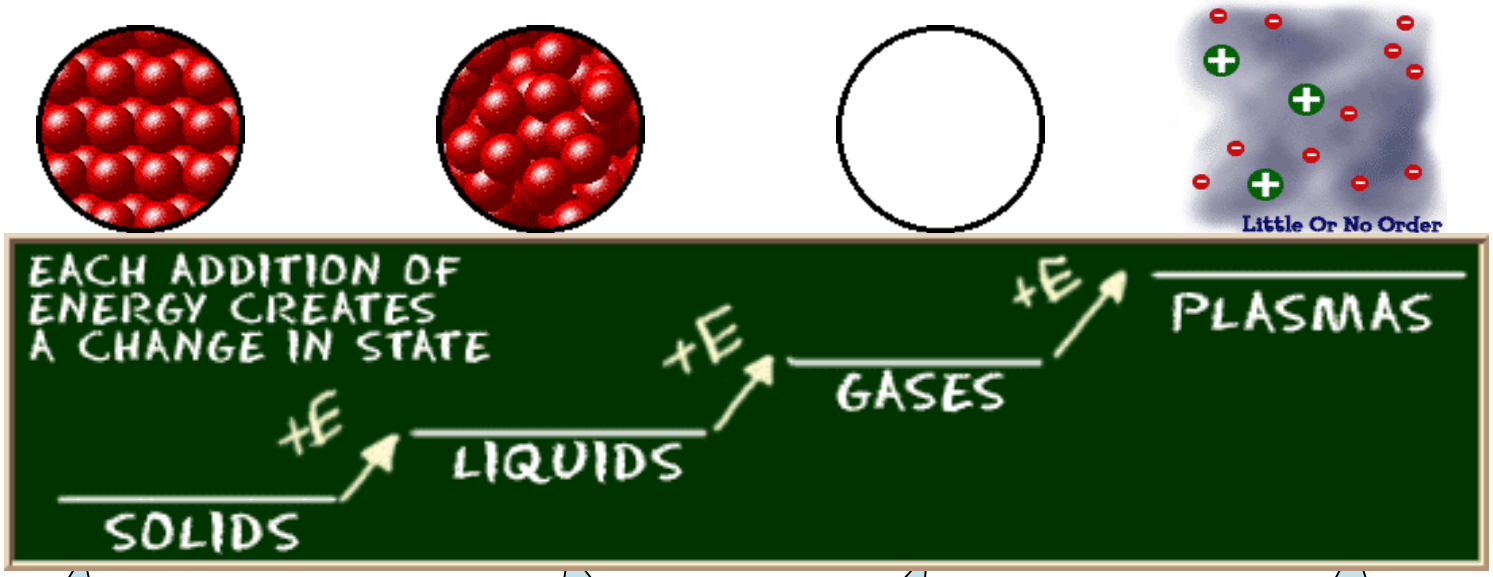
Correlation vs. Causation

Correlation	Causation
• Measures the relationship between two things • Tells us that two variables are related, but we cannot say anything about whether one caused the other	• Any cause that produces an effect • Tells us when something happens (cause), something else will also always happen(effect).

Use the line of best fit to predict how many tornadoes may be reported in the United States in 2020 if the trend continues.

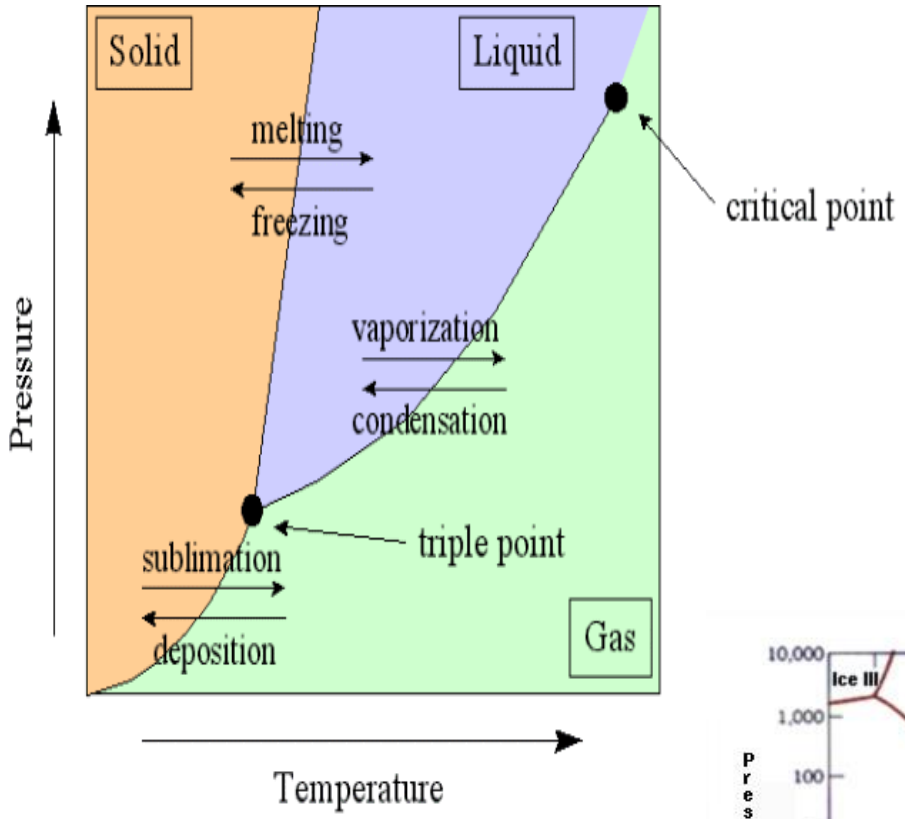


Teach Big Ideas through Graphics

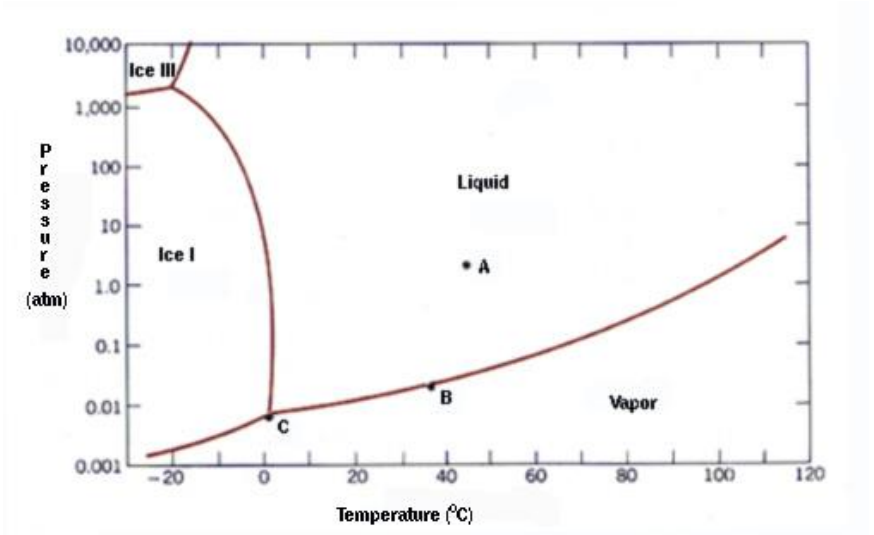


SOLID	LIQUID	GAS	PLASMA
Tightly packed, in a regular pattern Vibrate, but do not move from place to place	Close together with no regular arrangement. Vibrate, move about, and slide past each other	Well separated with no regular arrangement. Vibrate and move freely at high speeds	Has no definite volume or shape and is composed of electrical charged particles

Phase Diagram – It's a Roadmap!



A phase diagram is a graphical way to depict the effects of pressure and temperature on the phase of a substance.

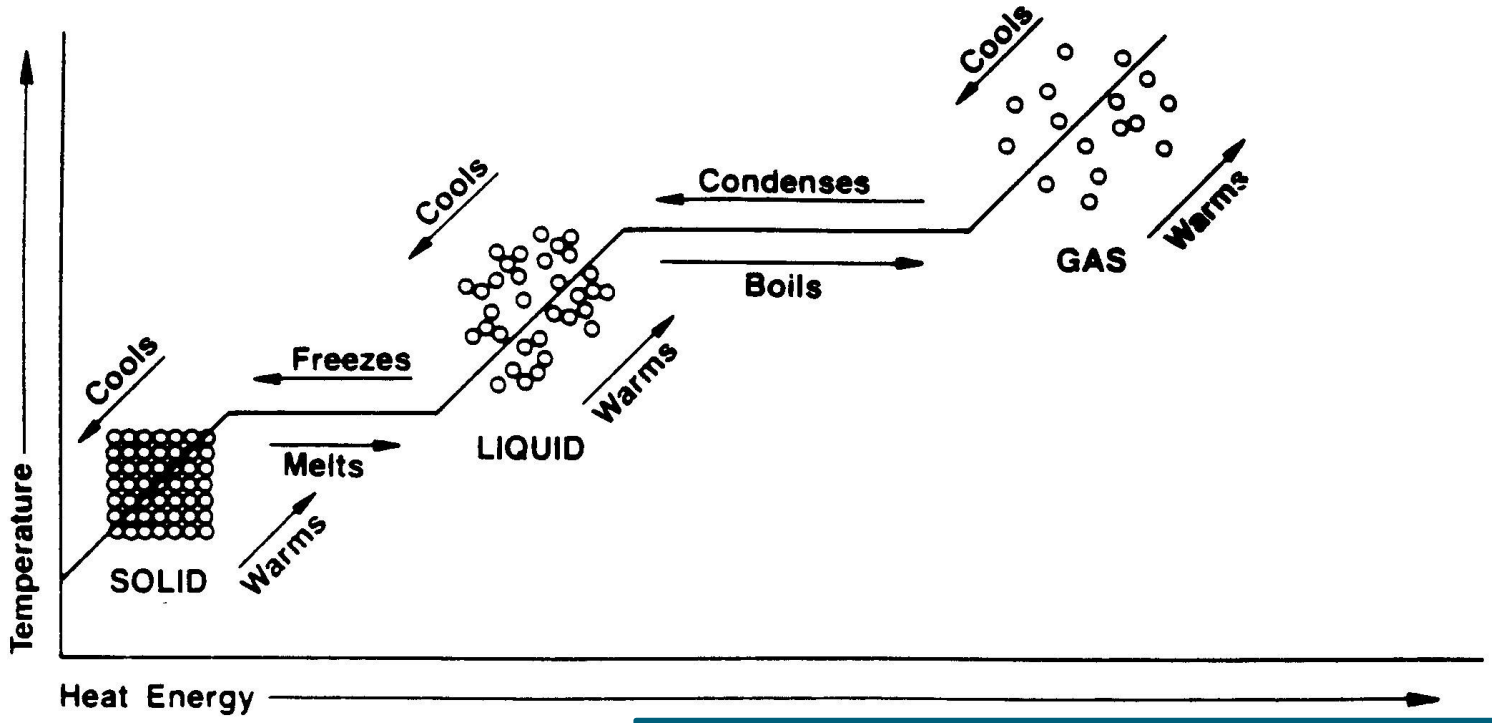


Workbook – p. 26

Interpreting a Graph

The slanted portions = temp is changing

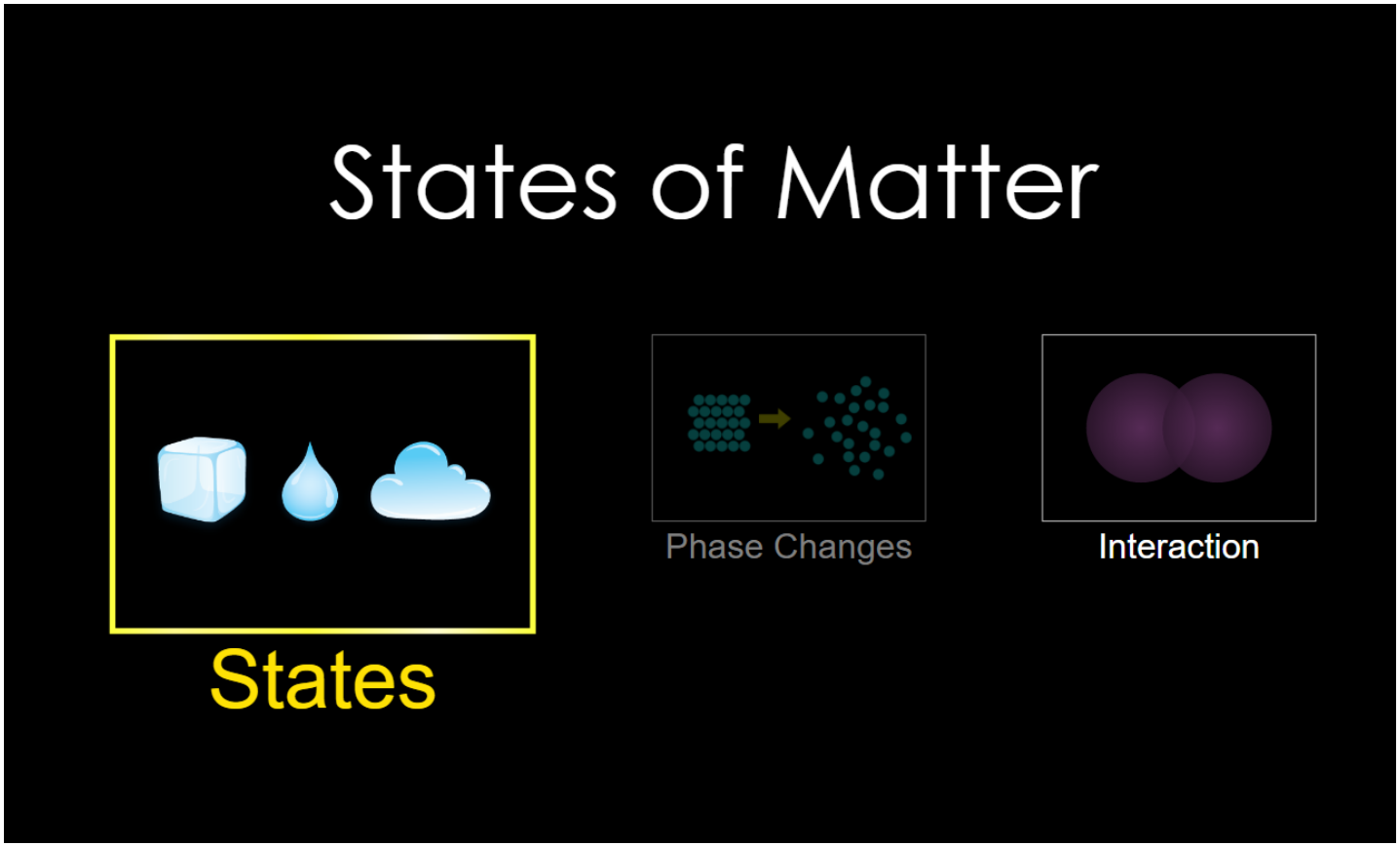
- Single phase is heating up or cooling down



The flat portions = temp not changing

- Substance undergoing a phase change

States of Matter – Application

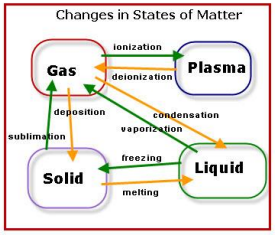


https://phet.colorado.edu/sims/html/states-of-matter/latest/states-of-matter_en.html

Getting Started with Data Analysis

- Data Analysis, Statistics, Probability

  http://www.learner.org/courses/learningmath/data/index.html



- How Structure Can Affect Properties Through Phase Changes (a classroom lesson)

  https://florida.pbslearningmedia.org/resource/psu06-nano.sci.phasechanges/how-structure-can-affect-properties-through-phase-changes/

- Phase Change Diagrams

  https://www.youtube.com/watch?v=JJSZbfXnBq4

- Using Data in the Classroom – National Science Digital Library

  http://serc.carleton.edu/usingdata/index.html

Resources for Science

Getting Started

Resources

National Science Teachers Association – Freebies for Science Teachers

http://www.nsta.org/publications/freebies.aspx

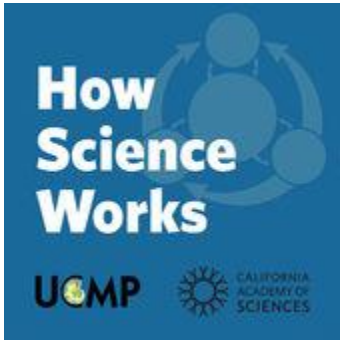
Mythbusters

http://www.discovery.com/tv-shows/mythbusters/

Study Jams

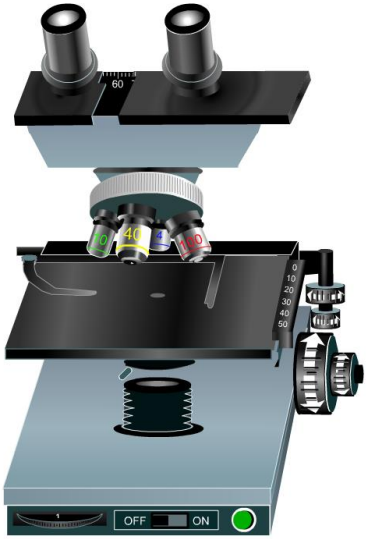
http://studyjams.scholastic.com/studyjams/jams/science/index.htm

More Resources



How Science Works

https://itunes.apple.com/us/course/how-science-works/id689052881



Virtual Microscope

http://www1.udel.edu/biology/ketcham/microscope/scope.html

Videos

Newton's Apple

http://www.newtonsapple.tv/

Steve Spangler

http://www.stevespanglerscience.com/

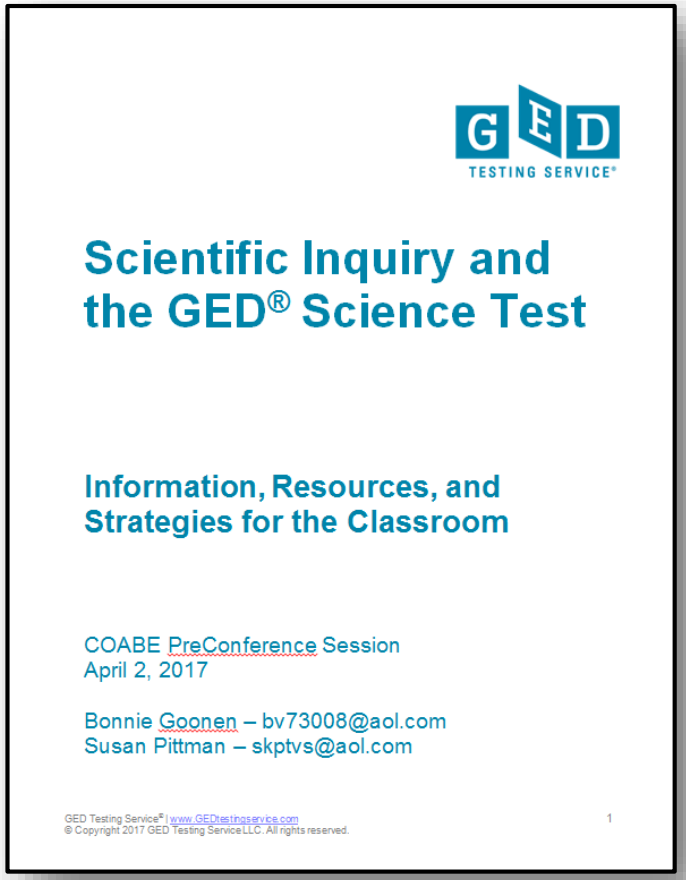
Ted-Ed

http://ed.ted.com/lessons?category=science-technology

Khan Academy

https://youtu.be/N6IAzlugWw0

Resources for the Classroom



https://ged.com/educators_admins/teaching/

Summing It Up

What takeaways from this workshop will be important to know now? Three years from now?

Why?

Questions

Thank you!

Becki Lemke

becki.lemke@cornerstonescareer.com