A Theory does NOT become a Law!

Focus on Inquiry

Students will participate in making predictions, collecting data and defending their position on theories, laws, hypothesis, and facts.

Lesson Content Overview

Students will explore the relationships and differences between hypothesis, theories, and laws.

Duration	Setting	Grouping	PTI Inquiry Subskills
minutes	Classroom	Groups of 2-3 students	

Lesson Components	Estimated Time	Inquiry Subskills Used	Technology Used	Level of Student Engagement	Brief Description
Engage	15 minutes		Roloc Excel Spreadshee t	3	Students will discover that laws come before theories by playing a simulation game with cards. (Timed)
Explore	40 minutes		Card Sort	3	Students will read the informational text on Theory and Law and will use it to sort data for an argument driven activity.
Explain	30 minutes		Powerpoint –Anchor Chart	3	Students will use an anchor chart to categorize theories, laws, and hypothesis.
Elaborate	12 minutes			3	Students will share out and defend their claims to classmates in student guided gallery walk. (Timed 2 minutes per group)
Evaluate	10 minutes			3	In addition to their completed anchor charts students will take a short multiple choice exit quiz.

Level of Student Engagement

1	Low	Listen to lecture, observe the teacher, individual reading, teacher demonstration, teacher-centered instruction
2	Moderate	Raise questions, lecture with discussion, record data, make predictions, technology interaction with assistance
3	High	Hands-on activity or inquiry; critique others, draw conclusions, make connections, problem-solve, student-centered

Next Generation Science Standards – Inquiry

NGSS Practice 1: Identify Inquiry Questions
NGSS Practice 2: Developing and Using Models
NGSS Practice 3: Planning and Carrying Out Investigations
NGSS Practice 4: Analyzing and Interpreting Data
NGSS Practice 6: Constructing explanations
NGSS Practice 7: Engaging in arguments from evidence
NGSS Practice 8: Obtaining, Evaluating and Communicating Information

Next Generation Science Standards – Nature of Science

Florida Science Standards – Nature Of Science

SC.6.N.3.1 Recognize and explain that a scientific theory is a well-supported and widely accepted explanation of nature and is not simply a claim posed by an individual. Thus, the use of the term theory in science is very different than how it is used in

everyday life.

SC.7.N.3.1 Recognize and explain the difference between theories and laws and give several examples of scientific theories and the evidence that supports them.
SC.8.N.3.2 Explain why theories may be modified but are rarely discarded.

Materials and Advance Preparation

Materials List

Consumables:

- Chart Paper
- Markers
- Science Notebooks or Lined Paper for lab work
- Scissors/Glue

Non-Consumables:

- Computers

Blackline Masters

1. Excel Spreadsheet with Engage Game (can also be done with playing cards)
2. Blackline Master #1- Law vs Hypothesis vs Theory, one per group or one per student
3. Blackline Master #2- 2017 Theory and Law
4. Blackline Master #3- Laws, Hypothesis, Theories (Category List)
5. Blackline Master #4- Evaluation
6. Blackline Master #5- Major Misconceptions about Theories and Laws- A reading for teachers

Advance Preparation

1. Read Article on Major Misconceptions about Theories and Laws
2. Print all of the attachments, Blackline Masters.
3. Students will need individual or group access to a computer for the excel file. Obtain laptops or technology to use with the program. (Excel Spreadsheet- Engage Game)
4. Review Powerpoint on Argument Chart

Lesson Information

Learning Objectives
Students will...

- explore how a hypothesis and a theory are connected
- differentiate between a law and a theory
- understand that theories can be modified but are rarely discarded
- understand that theories NEVER become laws
- explore differences between theories, laws, facts, and hypothesis
- construct an argument based on evidence
- collaborate with peers to categorize theories, laws and hypothesis

Prior Knowledge Needed by the Students

- None

Background Information

- No background info needed for this concept- this is an ABC Lab (Activity *Before* Content)

Lesson Procedure

Engage

1. **Prepare for lesson by reading… Major Student Misconception about Theories and Laws for Teachers.**
2. **Pose this question to your students: "***How does a scientist test a Scientific Law?" Provide Think time and have a very brief share out.*
3. **Model/Demonstrate** how to utilize the excel file with students.
    a. Using an overhead projector, demonstrate how to open the "Planet Roloc" Excel Workbook.
    b. Inform students they are going to conduct an investigation. The goal for the students is use observation to determine why the animals in the simulations are becoming a certain color. (Remember this is just the hook… this should be very surface level) DO NOT use the words hypothesis or theory yet, just focus on the law. *The "Law" in this case has to do with animals on this planet appear a certain color for an unknown reason on this planet.*
    c. Type in the name of an animal and observe the color change.
    d. Ask a student for another name of animal and type it into the file; have the students observe the color.
    e. Ask students if they can determine a pattern.
4. **Distribute computers** to groups or individual students (have the Excel file pre-loaded onto each computer in an easy to find location). Set a timer. Give students approximately 3 minutes to explore the simulation and do as many tests as possible. Encourage them to explore as many animals as possible and look for patterns or trends in the observations. Conversation amongst students is a good thing!
5. **Have a Brief Class Discussion** on the patterns your students have discovered.
6. Pose the question to students, "How do scientists investigate a scientific law." Students should discuss the following:
    a. Making careful observations
    b. Conducting repeated trials
    c. Looking for patterns and similarities
    d. Discussing findings with other scientists

Explore

1. Distribute the article, "Laws vs Hypothesis vs Theory" to all students in your class.
2. Use Text Based Strategies **(Blackline Master – 1)** while reading the article (students may read the article in small groups, individually or as an entire class). Be sure to use one of the following strategies with the students, as they will need to draw evidence from the text when completing the following sorting activity. Examples of text based strategies include (but are not limited to):
    - Highlighting the Text
    - Individual or Group Readings
    - Marking the Text
3. *Distribute and Review* **Blackline Master #2** – PowerPoint "2017 Theory and Law" This PowerPoint will provide students with examples of theories and laws which they are allowed to reference during the remainder of the lesson.
4. Pass out the Blackline Master #3- Laws, Hypothesis, Theories (Category List)
5. Explain to students that they are to group these statements into 3 piles/categories (Law, Hypothesis, Theory) students should be able to justify their groupings based on the evidence from the article and PowerPoint from steps 2 and 3. (above)

6. Provide approximately 10 to 15 minutes think time to complete step 4.

Explain

7. Pass out one big piece of chart paper to each group.
8. When students seem to have completed their groupings, introduce the Powerpoint Argument Chart. This will guide you through having students create a graphic organizer in order to organize their information on the chart paper. Have the students draw the chart from the PowerPoint onto their poster.
9. Provide students markers, scissors, and glue OR have them neatly write their responses into the anchor chart. Using the PowerPoint from step 8, explain to the students the expectations of poster project. Below are a few brief examples. A more detailed description is available on powerpoint argument chart.
    - Students should glue/tape/write their categorized theories, laws and hypotheses onto the evidence side.
    - Students should pull key evidence from the PowerPoint and article that helped them identify the categories and place the highlighted content under evidence.
    - Students will place their marked text under evidence.
    - Students will write a summary of their groupings under justification.

Expand/Elaborate

10. Students will participate in a modified gallery walk. We recommend having one student (teacher selected) stay with the chart that the students have created. The student who stays behind will be expected to explain their group's findings and answer any questions the visiting groups may have. Each group should spend 1 to 2 minutes visiting *each* group. The other students will rotate to each chart as a team to collaborate.
11. Upon completion of the gallery walk, the students that were walking around should report their findings back to the student who "stayed behind." Give the students 3-4 minutes for them to explain what they discovered to the student who was left behind.

Evaluate

WRAP UP.

Provide the 3 question quiz (blackline master 4) as an exit ticket.

CITATION OF SOURCES.

Works Cited

Shmoop Editorial Team. "Law vs. Hypothesis vs. Theory in Nature of Science." *Shmoop*. Shmoop University, Inc., 11 Nov. 2008. Web. 9 Sep. 2016.

Wiki How. "How to Explain the difference between a theory, law and fact." WikiHow, http://www.wikihow.com/Explain-the-Difference-Between-Theory,-Law,-and-a-Fact. Web. 9 Sep. 2016.

__✓__ Yes, I cited all materials and resources used in this lesson.

Kellie McClarty

Lesson author signature

Blackline Master #1

Law vs. Hypothesis vs. Theory

Law. Hypothesis. Theory. If you're taking a science class, you are going to hear these three words *a lot.* We were thinking it would be nice if we were all on the same page about what they mean, so we can discuss them at parties and stuff. What? You don't like to talk about science vocabulary at parties? Weird…

Run-In With The Law

Let's start with a scientific **law**. Scientific laws describe some sort of phenomenon we have observed. Sometimes we'll see them in the form of a mathematical equation, other times not, but we'll always see a boatload of evidence tagging along. The only limitation to a scientific law is that it doesn't explain *how* the phenomenon works. Bummer.

The equation for the force of gravity is a great example of a law. It describes the phenomenon of our cell phone crashing into the ground when we let go of it, or the fact that the computer we're staring at isn't floating off into space. Look at it: $F = \frac{Gm_1m_2}{r^2}$. Just beautiful. What the law of gravity doesn't tell us, though, is why this happens, or what gravity actually is.

The Hypothesis: It's More Than An Educated Guess

Up next is the humble **hypothesis**. A hypothesis is like a testable explanation of stuff we've observed. The fact that it's testable means we can do an experiment to see if our hypothesis was correct. For example, maybe we observed that putting a little salt in our pasta water makes it boil faster. We could totally do an experiment to determine if this is actually true, or if we were just more patient in waiting for our mac n' cheese that day. The evidence we collect from our experiment will support or refute our hypothesis.

A hypothesis is usually focused on explaining something specific. Notice that our salty water hypothesis is just trying to explain one specific phenomenon. We're not trying to explain how atoms move when they're heated or how chemical reactions form new compounds with different boiling points. We save the complex explanations for theories.

Here's A Theory

Theories allow us to explain a broad range of observations and even make predictions. Fancy. Theories aren't born overnight, though. Just like laws, theories come from tons of empirical evidence and experiments whose results have been reproduced over and over and over again. Theories can even take a bunch of hypotheses that have already been supported by scientific evidence and give us a nice, overarching explanation for the lot of them.

Take the atomic theory, for example. It states that everything is made up of these little particles called atoms, which come in different forms called elements. We can use this theory to explain how ice becomes water or how gasoline becomes exhaust. Of course, atomic theory is backed up by countless experiments that have produced mountains of evidence to support the fact that we are made of carbon and the atoms in your ice cream

are starting to move faster with each second that passes. Better catch that drip.

There's also the theory of evolution. This one explains, using boatloads of evidence from a bunch of different scientific fields, how species have changed over the course of billions of years. If you can turn that explanation into an equation, we'd love to see it, because it is one wildly complex process. Definitely a job for a theory.

Common Mistakes

Understanding theories, laws, and hypotheses can get confusing. One of the biggest uh-oh's people make when it comes to understanding theories, laws, and hypotheses is thinking that they are hierarchical.

What we mean by that is that lots of people think that if we add more evidence, a hypothesis can become a theory, and a theory can graduate into a law. This isn't really the case, though. First of all, laws aren't the boss when it comes to scientific explanations. Scientists actually consider theories to be top dog when it comes to explaining stuff.

Secondly, we use laws, hypotheses, and theories to explain different things. For example, a law explains something specific, usually using a mathematical equation, and is supported by a lot of experiments and evidence. A hypothesis is an explanation for a specific phenomenon that can be tested by an experiment. A theory is an explanation, also supported by lots of experiments and evidence, for a broader concept or set of supported hypotheses.

Comparing these three is sort of like comparing a hippo, a huckleberry, and a housefly. The hippo isn't going to turn into a huckleberry, which certainly isn't going to turn into a housefly. At least not without us having to make some major changes to some pretty important theories.

Blackline Master #2

Law

Tells only that *something* happens*;* consistently and across the universe; frequently it can be stated mathematically.

Example:

Consider Newton's Law of Gravity. Newton could use this law to predict the behavior of a dropped object, but he COULDN'T EXPLAIN *WHY* it happened.

Scientific Law tells
WHAT WILL

Hypothesis

An educated guess. Usually, a hypothesis can be supported or refuted through experimentation or more observation.

Example:

You observe that, upon waking up each morning, your trashcan is overturned with trash spread around the yard. You form a hypothesis that raccoons are responsible. Through testing, the results will either support or refute your hypothesis.

Theory

Notes ***why something happens;*** explains why laws and facts are true.

Theories can, and do, change. They might be confirmed by overwhelming data or altered by new evidence.

Examples:

Cell Theory	Big Bang Theory
Climate Change Theory	Atomic Theory

Scientific Theory tells
WHY OR HOW IT

Blackline Master #3

For every action, there will be an equal and opposite reaction.

If a basketball is dropped from 5 meters then it always bounces back up to the same height.

Light from some stars appears to bend as it travels through space. This is caused by black holes.

If one solar panel is used then it can replace two AA size batteries.

It is thought that the dinosaurs were killed off by a meteor strike.

Force equals mass times acceleration (F=ma).

Newton's Laws of motion explain why orbits are ellipses.

Thermal energy always moves from a greater energy level to a lesser level.

Electrons are negative in order to balance out the positive charge of the nucleus.

The universe was created at the Big Bang, this is why the galaxies are moving away from each other.

If it is the night of a full moon, then more crimes will occur.

Momentum is an object's mass times its velocity.

An object in motion stays in motion unless acted upon by an outside force.

If we use Bounty paper towels then more water will be absorbed than Brawny.

If other people are watching you then you will be better behaved.

Blackline Master #4

1) Based on your knowledge of scientific laws and theories, which of the following is true?

A) They are hierarchical.

B) They are a hypothesis.

C) They are based on evidence and observations. (Correct student response)

D) They both represent definite facts that are not subject to change.

2) Thinking back to our sorting activity, we now know that:

A) Laws and theories both explain a phenomenon.

B) Laws and theories both describe a phenomenon.

C) Laws and theories can change into one or the other.

D) Laws and theories serve different purposes in science. (Correct student response)

3) Which of the following allows scientists to explain a broad range of observations and even make predictions?

A) Laws (Correct student response)

B) Facts

C) Theories

D) Hypothesis

4) What do laws allow scientists to do when they observe something in the natural world?

A) Explain

B) Predict

C) Describe (Correct student response)

D) Hypothesize

5) Which of the following is a common misconception about scientific theories and laws?

A) Theories and laws work together to help scientists better understand the world around us.

B) Theories explain and laws describe phenomenon.

C) Theories eventually become laws. (Correct student response)

D) None of the above are examples of misconceptions about scientific theories and laws.

Blackline Master #5

How to explain the difference between a theory and a law.

Within scientific communities, “theory,” “law,” and “fact” are technical terms which have distinct and complex meanings. Many people who do not have a scientific background—including students in introductory science classes in high school and colleges—do not have a firm understanding of the differences between these three terms. Many adults are also unaware of the distinctions between these three terms, and can benefit from a polite, conversational explanation. This article will help you understand and explain the differences between proper scientific uses for each of the three terms.

Method 1

Explaining the Difference between Scientific Theory and Law

1

Define a scientific law. Understanding law is fundamental to understanding scientific terminology: a scientific law is a statement, based on repeated long-term observation, which describes any phenomena of nature.[1]

- Laws have never been refuted (hence their relatively small number) and are not explanations; they are descriptions and are often stated through relatively simple mathematical equations.
- Scientific laws, despite their formality, can change or have exceptions as scientific understandings of phenomena evolve.[2]

2

Provide examples of laws. Helping someone understand scientific law—an admittedly abstract concept—will allow them to differentiate between theory and fact. In many ways, laws are a starting place; they are often observed and have never been refuted, but do not explain why something occurs.[3]

- A common example is Newton’s 2nd Law of Motion: this law describes a phenomenon that has been observed throughout nature, but the law does not explain why motion occurs.

- As another example, the Law of Gravity has been known in the scientific community since the late 17th century. The law describes the natural phenomenon of gravity, but does not provide an explanation as to how and why gravity functions.

3

Define a scientific theory. Scientifically speaking, a theory is a rational explanation of why an aspect of our world functions in a certain way. The definition of a theory will incorporate facts and laws, although the three are fundamentally separate.[4]

- A theory builds from initial hypotheses (educated guesses) and can be revised in accordance with the development of a scientific understanding of a phenomena's cause.
- A theory is confirmed by all available evidence such that it can be used to predict new, as yet unobserved phenomena.

4

Provide an example of scientific theory. This will help clarify your point and make a clearer explanation. The theory is used to explain an occurrence, while the law describes a phenomenon under specific circumstances in nature.

- For example, the scientific Theory of Relativity corresponds with the Law of Gravity.[5] While the law states an observed natural phenomena, the theory describes how and why this happens.

Method 3

Explaining Scientific Theories, Laws, and Facts in the Classroom

1

Ask your students to define some scientific theories. You can build from their own understandings to develop a more sophisticated definition of "theory." A good definition

should clarify that a scientific theory is a statement intending to explain natural phenomena. Clarify to your students:

- A theory is worth very little if it doesn't correctly predict all known evidence.
- Theories are subject to changes as new evidence becomes available.

(Most theories that you will discuss in a high school science class are well-confirmed and are unlikely to be revised in any significant sense.)

2

Ask the students to name some scientific theories. You will get some common answers like:

- The theory of relativity: that the laws of physics are the same for all observers
- Big Bang theory: that the universe began as an infinitely small point that underwent expansion to form the universe as we know it today.

3

Define a scientific fact for your students. A fact is an objective, verifiable observation, which is the same everywhere. It can be, and has been, verified many times.

- For example, we know that the germ theory of illness is a fact because we can take bacteria from someone suffering from an illness, look at that bacteria under a microscope, and then inject that bacteria into another individual, who will then get that same illness.
- We know that the Earth is round because we can travel due west and eventually end up where we started from.

4

Clarify that theories can never be transformed into a fact; the two are fundamentally different. Remember, a theory is a general statement intended to

explain facts. As a useful example, present your students with the development of the theory of the heliocentric theory and the facts that inform the theory.

- Ancient peoples noticed peculiar points of light that “wandered” among their background. (We now know these to be the planets.)
- The planets moved through the sky because they, like the Earth, were orbiting around the sun, each at different speeds, different distances from the Sun.
- Nicolaus Copernicus is generally considered to be the first to propose this theory, and supported his theory with hard evidence, but ancient cultures stumbled upon this through speculation.
- We now consider this a fact because we have sent many craft to these planets and can predict their motions to a very high precision. Of course, our predictions come from the theory (and the laws underlying that theory).

5

Define a scientific law. This is a complicated concept and tends to confuse students. Laws tend to be more mathematical in nature and are usually derived from simple statements about mathematical systems and their behaviors. Explain that, like a theory, a law can also be used to make predictions, but the primary purpose of a law is to describe natural phenomena. Some scientific laws include:

- Newton's Law of heating and cooling: the change in temperature of two bodies in thermal contact is proportional to their difference in temperature.
- Newton's Laws of motion: statements about how large objects made of atoms behave when moving at low speeds relative to each other.
- The Laws of Thermodynamics: statements about entropy, temperature, and thermal equilibrium.
- Ohm's Law: the voltage across a purely resistive element is equal to the current through the element times its resistance.

6

Discuss how theories are made and evolve. First, a theory is constructed from facts; fact precede and inform a theory. Secondly, theories contain laws, but laws mean very little without supportive facts. Theories also contain logical inferences.

- For example, one must infer that the derived laws actually predict the facts. Accumulating all of the previous forms of knowledge, a scientist makes a general statement to explain all the evidence.
- Other scientists reaffirm the facts and use the theory to make predictions and obtain new facts.