FCPS MS Science "The Nature of Science" Field Test Lesson PPT Script

Please read the following "script" as you show students the Nature of Science PPT. Please treat the field test as you would any experiment and present the lesson "as is" rather than changing it and thus, inserting variables.

No Slide	General Comments	• The accompanying Powerpoint presentation has been created by Linda Peterson to be used with the lesson "The Nature of Science: Investigating Key Ideas Related to NOS", to help students learn about and apply the ideas related to NOS to their classroom investigations and the greater body of scientific research. • This "script" is designed to be used in conjunction with the NOS Student Powerpoint. The Powerpoint is intended to be "experienced" by the students as they view the slides and listen to the accompanying stories read by their teacher. The teacher's stories, rather than the PPT are the main mode of learning for the students. • Teachers should practice reading the stories until they are fluid. It's not essential that students get every point of the stories. Rather, that they connect each concept of the Nature of Science to something tangible. ◦ Teachers are welcome to use other examples if they wish as long as they match with the particular concept of NOS being discussed. • The slides need to remain "clean" and "clear." Teachers are asked not to copy the PPT and insert additional graphics or bullet points. The stories are merely to be used to paint a mental picture in the minds of the students. • Some slides are "hidden" from students and merely contain the text of the script/examples. • The lesson is designed to be done in small increments over time. An estimated six 20-minute sessions are needed to complete the lesson. Additional time will be required for students to use the NOS Focus Questions with their hands-on investigations during the year.
 	Title Slide #1	• Prior to viewing the PPT, students should have already read the opening paragraph of the Nature of Science lab investigation, discussed the questions for investigation, and completed the "Before You Begin" Anticipation-Reaction Guide. • Start the Powerpoint and tell students that you will tell them some stories to help them understand the nature of science. Instruct them to take a few notes if they wish in the space provided on the lesson.

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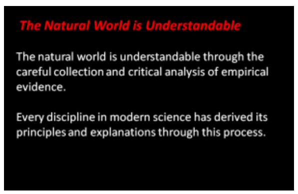
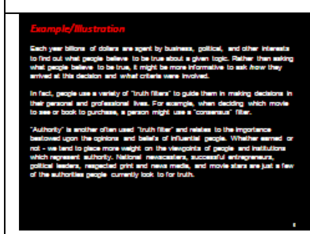
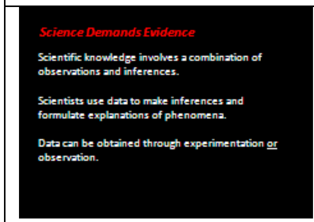
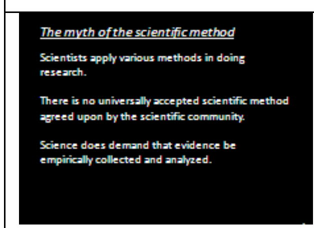
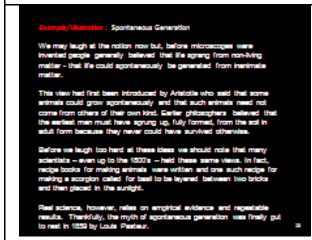
	Intro Slide #2	<u>Teacher Reads</u>: *Science is organized around several concepts which make up what is called “the nature of science” (NOS). These concepts serve to standardize and guide the work of scientists around the globe. Understanding the nature of science will help you understand how science applies to your everyday life and scientific research.* <u>Teacher Info</u>: Learning about NOS helps students become scientifically literate. A scientifically literate person has the knowledge and habits of mind needed to make informed personal decisions and contribute to society. If we are to produce scientifically literate citizens who are fully able to “take part in our country's political discourse” and compete in a competitive global economy we must understand the nature of science.
	Slide #3	Teacher: Pause here for about 10 seconds to let the words and graphic on the slide sink in. Proceed to the next slide where you will read the explanation of this component of NOS.
	Slide #4	<u>Teacher Reads</u>: *Perhaps the most central concept of the nature of science is the universal belief that the natural world is understandable. The natural world is understandable through the careful collection and critical analysis of evidence. Every branch of modern science has developed its principles and explanations in this manner.* *Knowing that scientific conclusions are formed in this manner allows the public “to react thoughtfully to scientific claims. Most importantly, this way of thinking makes sure that science limits its investigtions to “testable” questions.* <u>Teacher Info</u>: This way of thinking precludes the actions of supernatural forces as causative agents of natural phenomena and helps to focus research on <u>testable</u> questions. -- [this means that the motion of a ball rolling down a ramp is governed by natural laws rather than the actions of ghosts, fairies, or sprites].
	Slide # 5 HIDDEN SLIDE Story/ example	***Example/Illustration :*** Truth Filters <u>Teacher Reads</u>: *Each year billions of dollars are spent by business, political, and other interests to find out what people believe to be true about a given topic. Rather than asking what people believe to be true, it might be better to ask* ***how*** *they arrived at their decision..* *People use a variety of “truth filters” to guide them in making decisions in their personal and*

	illustrating the key ideas –	*professional lives. For example, when deciding which movie to see, car to buy, or book to purchase, a person might use a "consensus" filter. [Teacher: insert an example from your own life to illustrate this point if possible].* *"Authority" is another often used "truth filter" and relates to the importance we give to the opinions and beliefs of influential people. Whether earned or not - we tend to place more weight on the viewpoints of people and institutions which represent authority. National newscasters, successful business and political leaders, respected print and news media, and movie stars are just a few of the authorities people look to for truth.*
	Slide # 6 HIDDEN SLIDE	***Example/Illustration :*** Truth Filters (cont'd) Teacher Reads: *Truth can also be inherited. If a fact, story, or opinion has been around for a long time then it is more likely to be believed because it has withstood the test of time. [optional: "For most of us today it is hard to appreciate just how important inherited truth was before the Enlightenment and the industrial revolution."]* *This brings us to science as a "truth filter. "Of all the truth filters, science is probably the one we rely on least in our daily lives yet … none has had a greater impact on our success as a nation.* *"The invention of scientific thinking [has been] … a powerful tool for spurring technological change and economic progress."* *By its very nature, science is a unique truth filter. It operates around the idea that the natural world is understandable and that the universe is "knowable." It is governed by natural factors that can be seen through observation or experimentation.* *The major difference between science and other "truth filters" is that science relies on <u>internal</u> processes of validation through data collection, objective analysis, and evaluation.* ***Pause after this slide and provide time for students to add to their notes in their lab investigation.***

	Slide # 7	Teacher: Pause here for about 10 seconds to let the words and graphic sink in. Proceed to the next slide where you will read the explanation of this component of NOS.
	Slide # 8	Teacher Reads: *Scientists use the data they collect to make inferences and formulate key ideas around which scientific fields are organized. These data can be obtained through* ***observation*** *or* ***experimentation****. Both types of data are equally useful and valuable in the scientific endeavor.* *For example, data about the usefulness of a new cancer treatment drug would require a formal* ***experiment*** *with controls, and variables but a modern astronomer would use* ***observations*** *collected from space telescopes to look for patterns from which to formulate inferences and conclusions.* *Unfortunately, there is a mistaken belief that all scientific knowledge has been the result of experiments. While experiments can offer strong evidence to support a hypothesis or theory, it is incorrect to believe that the most scientific ideas are supported by controlled experiments.* *For example, concepts such as biological classification, plate tectonics, and even our model of the atom were not experimentally derived. These represent theoretical ideas.* Additional Teacher Info: One can assume that students hold similar misconceptions [that all scientific paradigms are experimentally derived] that should be addressed if they are to accurately understand the nature of science. Thus, it's important to call to students' attention the fact that the data they collect through **observation** or **experimentation** are equally useful in helping them formulate scientific conclusions.
	Slide # 9	Teacher Reads: *It often comes as a surprise when people learn that there is no universally accepted scientific method agreed upon by scientists.* *In reality, scientists apply various methods in doing research and no clear definition of a scientific investigation exists. We should focus less attention on remembering the sequential "steps" of the so-called scientific method and spend more time understanding the value each part of the process provides.*

<table>
<tr><td></td><td></td><td>Although no set "scientific method" exists, science does demand that evidence (observational or experimental) be collected and analyzed.</td></tr>
<tr><td>
</td><td>Slide # 10

HIDDEN SLIDE</td><td>Example/Illustration : Spontaneous Generation

Teacher Reads: We may laugh at the notion now but, before microscopes were invented people generally believed that life sprang from non-living matter.

This view had first been introduced by Aristotle and, before we laugh too hard at these ideas we should note that many scientists – even up to the 1800’s, – held these same views. In fact, recipe books for making animals were written and one such recipe for making a scorpion called for basil to be layered between two bricks and then placed in the sunlight.

Real science, however, relies on empirical evidence and repeatable results. Thankfully, the myth of spontaneous generation was finally put to rest in 1859 by Louis Pasteur.

Pause after this slide and provide time for students to add to their notes in their lab investigation.</td></tr>
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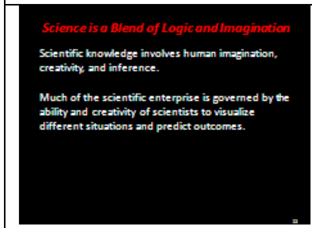
</td><td>Slide # 11</td><td>Teacher: Pause here for about 10 seconds to let the words and graphic sink in.

Proceed to the next slide where you will read the explanation of this component of NOS.</td></tr>
<tr><td>
</td><td>Slide # 12</td><td>Teacher Reads: Albert Einstein once said “logic will get you from A to B. Imagination will take you everywhere.”Scientific knowledge involves human imagination, creativity, and inference.

Scientists and students both use science skills to gather data about the natural world. To determine which data constitutes evidence, and what that evidence means, are not entirely based upon logic, however.

Much of the work of scientists is governed by the ability and creativity of scientists to visualize different situations and predict outcomes. Einstein’s “thought experiments” about Special Relativity and Schrodinger’s “cat” are two examples of how visualization and creativity can be used to help in formulating and conveying science concepts.</td></tr>
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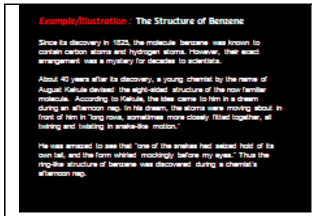
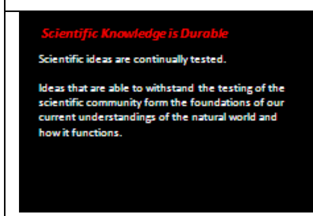
	Slide # 13 HIDDEN SLIDE	***Example/Illustration :*** The Structure of Benzene Teacher Reads: *Since its discovery in 1825, the molecule benzene was known to contain carbon atoms and hydrogen atoms. However, their exact arrangement was a mystery for decades to scientists.* *About 40 years after its discovery, a young chemist by the name of August Kekule devised the six-sided structure of the now familiar molecule. According to Kekule, the idea came to him in a dream during an afternoon nap. In his dream, the atoms were moving about in front of him in "long rows, sometimes more closely fitted together, all twining and twisting in snake-like motion."* *He was amazed to see that "one of the snakes had seized hold of its own tail, and the form whirled mockingly before my eyes." Thus the ring-like structure of benzene was discovered during a chemist's afternoon nap.* ***Pause after this slide and provide time for students to add to their notes in their lab investigation.***
	Slide # 14	Teacher: Pause here for about 10 seconds to let the words and graphic sink in. Proceed to the next slide where you will read the explanation of this component of NOS.
	Slide # 15	Teacher Reads: *Those scientific ideas and explanations that are able to withstand the scrutiny of the scientific community form the backbone of our current understandings of the natural world and how it functions.* *For example, our understanding of planetary motion is derived from the work of Ptolemy, Copernicus, Galileo, and Newton - each contributing a bit of information to the planetary puzzle.* *Sharing scientific ideas and explanations is a critical part of the scientific enterprise. This practice not only helps to spread new information, it also ensures that explanations will be exposed to testing by others. Continually tested in this way, scientific ideas are revised when new, credible data become available.*

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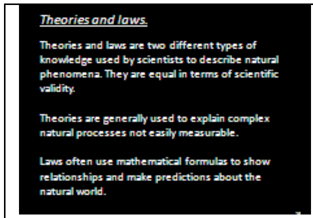
<td>
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<td>Slide # 16</td>
<td>Teacher Reads: A major misconception exists with respect to scientific theories and laws. Theories and laws are two different types of knowledge used by scientists to describe natural phenomena. Scientists value them equally.

Both theories and laws have much supporting evidence and it is false to believe that “hypotheses become theories and theories become laws”.

Theories combine many facts, concepts, and laws to form scientific understandings around which fields of science are organized. A good example of this is atomic theory which includes the law of conversation of mass, Avogadro’s Law, Boyle’s Law, Periodic Law, etc..” From this example it is clear that the <u>theory provides the framework</u> for more detailed explanations of phenomena which are represented by laws.

Therefore, “we should not think of scientific theories as ideas built on shaky facts and flimsy evidence because many of the major theories of science have held up to considerable scrutiny and have shown to be durable” over time.

Pause after this slide and provide time for students to add to their notes in their lab investigation.</td>
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<td>Slide # 17</td>
<td>Teacher: Pause here for about 10 seconds to let the words and graphic sink in.

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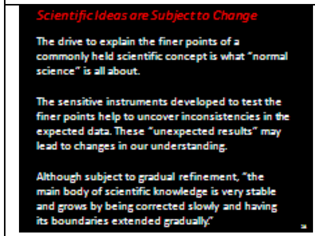
<td>
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<td>Slide # 18</td>
<td>Teacher Reads: Normal science is built upon a system of jointly held concepts about the natural world and how it works. The drive to examine and explain the finer points of a concept is what drives “normal science”.

To this end, new instruments are developed for the purpose of collecting extremely precise measurements in order to “match fact with theory” related to a concept.

Ironically, the sensitive instruments developed to explain these finer points help to uncover unexpected findings in the data.</td>
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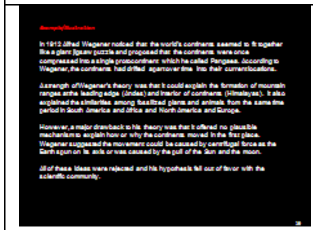
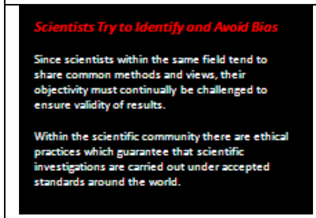
		Only by having an idea of what to expect are scientists able to recognize when it does not occur. New explanations often arise from researchers who are able to view unusual data with fresh eyes. *Science strives to continually test and refine our understanding of the natural world.* *Although subject to refinement, "the main body of scientific knowledge is very stable and grows by being gradually being corrected" over time.*
	Slide # 19	***Example/Illustration:*** Plate Tectonics Teacher Reads: *In 1912 Alfred Wegener noticed that the world's continents seemed to fit together like a giant jigsaw puzzle and suggested that the continents were once squeezed into a single proto-continent which he called Pangaea. According to Wegener, the continents had drifted apart over time into their current locations.* *One strength of Wegener's theory was that it could explain the formation of mountain ranges at the leading edge (Andes) and interior of continents (Himalayas). It also explained the similarities among fossilized plants and animals from the same time period in South America and Africa and North America and Europe.* *However, a major problem with his theory was that it offered no reasonable mechanism to explain how or why the continents moved in the first place. Wegener suggested the movement could be caused by centrifugal force as the Earth spun on its axis or was caused by the pull of the Sun and the moon.* *All of these ideas were rejected and his hypothesis fell out of favor with the scientific community.*
	Slide # 20	***Example/Illustration :*** Plate Tectonics (cont'd) Teacher Reads: *However, in 1929, Arthur Holmes proposed that continental drift was caused by thermal convection currents in the Earth's mantle. He explained that these convection currents acted as giant conveyor belt moving continents from one place on the Earth to another.* *Holmes' idea was largely ignored until the 1960's when marine geologists reported the existence of deep sea trenches and mid-ocean ridges on the ocean floor – all perfectly explained by Wegener and Holmes' ideas.*

		Today, the theory of plate tectonics is derived from Wegener's "continental drift" and is universally accepted to explain the motion of the Earth’s crust. [optional: Strangely enough, some data do support the effects of gravitational pull of the Sun and moon as well as Earth’s rotation as secondary forces at work in continental movement.] *Thus, the example provided by the work of Alfred Wegener demonstrates that scientific knowledge is durable yet subject to change as new instrumentation and data become available.* ***Pause after this slide and provide time for students to add to their notes in their lab investigation.***
	Slide # 21	Teacher: Pause here for about 10 seconds to let the words and graphic sink in. Proceed to the next slide where you will read the explanation of this component of NOS.
	Slide # 22	Teacher Reads: *Within the scientific community there are ethical practices, such as the accurate and truthful reporting of data and peer and public review, which ensure that scientific investigations are carried out under common standards around the world.* *The world’s public trusts and believes in the results of scientific research only because of the professional rigor imposed by the community in an effort to identify and avoid personal bias.* *Because scientists within the same field tend to share common methods and views, their neutrality must constantly be tested to ensure validity of results. Although scientists strive for objectivity in their data analysis they nonetheless rely on a healthy skepticism within the scientific community to replicate and verify their results.* *The scientific community self-regulates and will not allow those who falsify or misrepresent their data. In addition to ensuring professional integrity, such scrutiny helps to protect the public from the impact of poor science.*

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<td>Slide # 23</td>
<td> Example/Illustration : The Cost of Falsifying Data
Teacher Reads: One recent case of scientific misconduct occurred in 2009 when a researcher at UCLA the UCLA falsified data in two scientific journal articles and lied about experimental procedures and findings.
As a result the researcher was asked to leave the university and is not allowed to conduct research at the university (or others for that matter)
The details of individual cases of scientific misconduct are less important than the swift and sure condemnation and ostracism of the perpetrator(s) by the scientific community.
Pause after this slide and provide time for students to add to their notes in their lab investigation. </td>
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<td>Slide # 24</td>
<td> Teacher: Pause here for about 10 seconds to let the words and graphic sink in.
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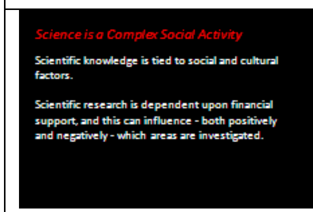
<td>
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<td>Slide # 25</td>
<td> Teacher Reads: Science is a social activity. Scientific research can take place in a laboratory or out in the “real” world in deep sea submersibles, space shuttles, in caves, etc. The one critical factor linking all science investigations is that the data gathered will ultimately be shared with others for their review and critique. Scientists share their findings with their peers through a wide variety of media such as print, electronic, and even video.
While these communications serve to inform others’ of the work being done in a particular field, they also help to expose ideas to the scrutiny and criticism of the general science community. In this way, results are “peer reviewed” and challenged for their authenticity.
It is important to recognize that scientific knowledge is tied to social and cultural factors. Scientific research is dependent upon financial support and this can sometimes make it difficult for scientists to carry out the research that most interests them because funding can be influenced by religious, commercial, or political agendas. </td>
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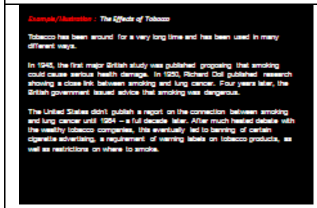
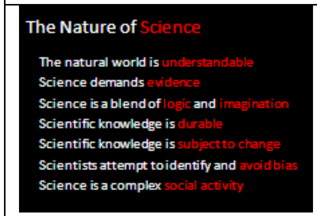
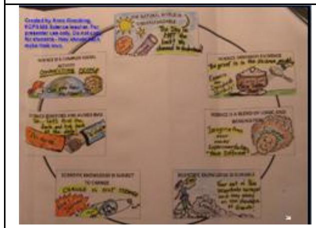
<tr><td>
</td><td>Slide # 26</td><td>Example/Illustration : Research on Smoking

Teacher Reads: Tobacco has been around for a very long time and has been used in many different ways – including as a medicine.

In 1948, the first major British study was published suggesting that smoking could cause serious health damage. Soon after, research was published showing a close link between smoking and lung cancer. In 1n 1954, the British government issued advice that smoking was dangerous.

Conversely, the United States didn’t publish a report on the connection between smoking and lung cancer until 1964 – a full decade later. It is widely held that the pressure of the large and powerful American tobacco companies had a hand in slowing the message that smoking was harmful to health. Finally, after much heated debate, a ban on advertising on television and magazines was begun, laws against selling cigarettes to minors were passed, and today we see smoking gas a hazard to even those who do not smoke and have put in place restrictions on where to smoke.

Pause after this slide and provide time for students to add to their notes in their lab investigation.</td></tr>
<tr><td>
</td><td>Slide # 27</td><td>Have this slide up on the screen while students are completing their graphic organizer</td></tr>
<tr><td></td><td>Slide # 28</td><td>Here is the sample graphic that can be shown to students.

It was created by Anne Woodring as part of a virtual in-service in 2009. It provides an excellent example of the use of a “catchy” phrase and illustration to synthesize the concepts of the nature of science. Use this sample with students if you feel it will help get their creative juices flowing!</td></tr>
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	Slide # 29	FOR TEACHERS ONLY