Nature of Science Organizer

Key Ideas about the Nature of Science	Related Practices	Reflection Questions to Develop Understanding of the Nature of Science
1. Tentativeness		
• There is often no single "right" answer in science. • All scientific knowledge is subject to change in light of new evidence and new ways of thinking. • Many ideas in science have survived repeated challenges, and have remained largely unchanged for hundreds of years. Thus, it is reasonable to have confidence in scientific knowledge, even while realizing that such knowledge may change in the future.	• Engaging in investigations that can lead to multiple possible explanations. • Revising explanations based on new evidence. • Comparing new explanations to what was already known. • Investigating how current well established laws and theories have changed over time.	• How do we decide which explanation is the best? • How did the evidence change your thinking? • How is this explanation similar or different from the currently accepted scientific explanation? • What was the scientifically accepted explanation 200 years ago? Why did it change?
2. Empirical Evidence		
• Scientific knowledge relies heavily upon empirical evidence. Empirical refers to both quantitative and qualitative data.	• Collecting and recording both qualitative (describing, drawing) and quantitative data (measuring). • Determining the uncertainty in the data	• Why do we need to record our data? • What could be some reasons that our results are different? How do we deal with these differences? • What could be some reasons for the uncertainty in our data?
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3. Observation and Inference		

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• Scientific knowledge involves observation and inference (not just observation alone). • Observation refers to using the five senses to gather information, often augmented with technology. • Inference involves developing explanations from observations and often involves entities that are not directly observable.	• Making observations. • Making Inferences based on observations. • Using senses and technology to collect data • Using evidence in combination with prior knowledge, logical reasoning, and creativity to develop explanations. • Deciding which data counts as evidence in support of explanations. • Deciding if there is enough evidence to develop an explanation. • Using models to make sense of the data and as a tool to develop explanations.	• Did you observe this or did you infer this? What is the difference? • Which senses did you use to collect the data? • How did the technology help you collect data and how did it add to your senses? • Why is it important to cite your evidence? • How do you decide which explanation is the best? • How confident are you about this explanation? • What are the strengths and weaknesses of this model?
Key Ideas about the Nature of Science	**Related Practices**	**Reflection Questions to Develop Understanding of the Nature of Science**
4. Scientific Laws, Theories, and Hypotheses		

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• In science, a law is a succinct description of relationships or patterns that are consistently observed in nature. Scientific laws are often expressed in mathematical terms.	• Using mathematical models to describe a observed relationship between two or more variables.	• How are scientific laws different from everyday use of the word law?
• A scientific theory is a well-supported explanation of natural phenomena.	• Analyzing multiple pieces of evidence for currently well established theories.	• How are scientific theories different from everyday use of the word theory?
• A scientific hypothesis is a proposed explanation for a fairly narrow set of phenomena, usually based on prior experience, scientific background knowledge, preliminary observations, and logic.	• Developing a hypothesis: "I expect to observe A because B." (A is the prediction and B is the hypothesis).	• What is the difference between your hypothesis and your prediction?
• Hypotheses and theories can be used to make predictions that can be tested through observation.	• Making predictions based on a hypothesis: "I expect to observe A because B." (A is the prediction and B is the hypothesis).	• How can you use your hypothesis to make a prediction? • What is your prediction based on?
5. Scientific Methods		
• There are many ways to do science. There is no single scientific method that all scientists follow. • Scientists employ a wide variety of approaches to generate scientific knowledge, including observation, inference, experimentation, and even chance discovery.	• Designing and conducting investigations that employ a wide variety of approaches: observing, describing, sorting, ordering, classifying, inferring, experimenting	• What approach did you follow in your investigation? • How was that similar or different from the previous investigation? • Why do you think we followed a different approach?
	• Keep an eye out for chance discoveries.	• Did you expect to find this? Why or why not?
Key Ideas about the Nature of Science	**Related Practices**	**Reflection Questions to Develop Understanding of the Nature of Science**
6. Creativity		
• Creativity is a source of innovation and inspiration in science. Scientists use creativity and imagination throughout their investigations.	• Using evidence in combination with prior knowledge, logical reasoning, and creativity to develop explanations.	• How did your creativity play a role during the investigation? • How did individual creativity affect the outcome of the investigations done by different groups?

Nature of Science Organizer

7. Objectivity and Subjectivity		
• Scientists tend to be skeptical and apply self-checking mechanisms such as peer review in order to improve objectivity. • Intuition, personal beliefs, and societal values all play significant roles in the development of scientific knowledge. • Subjectivity can never be (nor should it be) completely eliminated from the scientific enterprise.	• Using models to test and critique your own explanation or an explanation provided by others. • Sharing how the investigation was conducted together with the data and explanation in sufficient detail so that other can review it. • Critiquing investigations or explanations of others.	• Is the evidence cited appropriate? • Is the evidence cited sufficient? • Does the evidence support the explanation? • Was the explanation convincing? What is it that convinced you?
• Scientific conclusions can be influenced by scientists' background knowledge. • Theories provide frameworks for data interpretation.	• Using prior knowledge or exiting theories or laws to analyze data or develop an explanation.	• How did your previous knowledge influence your data analysis or explanation?

Reference: Teaching the Nature of Science – Three Critical Questions, by Dr. Randy Bell, National Geographic Science