UNIT 1	Lesson A: Experimental Design	4 Days
BENCHMARK(S): **SC.7.N.1.1 (SC.8.N.1.1) Define a problem from the seventh grade curriculum: use appropriate reference materials to support scientific understanding; plan and carry out scientific investigations of various types, such as systematic observations or experiments; identify variables; collect and organize data; interpret data in charts, tables, and graphics; analyze information; make predictions; and defend conclusions.** **SC.7.N.1.3 (SC.8.N.1.1) Distinguish between an experiment (which must involve the identification and control of variables) and other forms of scientific investigation and explain that not all scientific knowledge is derived from experimentation.** SC.6.N.1.3 (SC.8.N.1.1) Explain the difference between an experiment and other types of scientific investigation, and explain the relative benefits and limitations of each. **SC.7.N.1.4 (SC.8.N.1.1) Identify test variables (independent variables) and outcome variables (dependent variables) in an experiment.** SC.6.N.1.4 (SC.7.N.1.2) Discuss, compare, and negotiate methods used, results obtained, and explanations among groups of students conducting the same investigation. **SC.7.N.1.2 (SC.7.N.1.2)Differentiate replication (by others) from repetition (multiple trials).** SC.6.N.1.2 (SC.7.N.1.2) Explain why scientific investigations should be replicable. **SC.7.N.1.5 Describe the methods used in the pursuit of a scientific explanation as seen in different fields of science such as biology, geology, and physics.**	**CONTENT FOCUS/ ITEM SPECS:** • SC.8.N.1.1 • SC.7.N.1.2
ESSENTIAL CONTENT		

LEARNING TARGETS:

- I can design and carry out a scientific investigation including repeated trials in order to solve a problem or answer a question.
- I can use empirical data (charts, graphs) to form conclusions, make predictions, and defend results of scientific investigations?
- I can identify tested (Independent) variables, outcome (dependent) variables, control variables, control groups, and experimental groups in investigations.
- I can differentiate between replication (by others) and repetition (multiple trials from one person).

ESSENTIAL QUESTIONS:

- Why is it important to have only one tested (independent) variable in an experiment?
- How can a hypothesis still be valuable, even when the data fails to support it?
- Why are replication and repetition essential parts of scientific investigations?

HIGHER ORDER QUESTIONS:

1. If two groups performing the same experiment obtain different results and conclusions, what should take place next?
2. If a scientist wants to test two different independent variables, what must they do?

ALIGNED VOCABULARY:

- Empirical Evidence
- Experiment
- Investigation
- Tested (Independent) Variable
- Outcome (Dependent) Variable
- Controlled Variable
- Tested Group
- Control Group
- Hypothesis
- Quantitative Data
- Qualitative Data
- Observation
- Analysis
- Conclusion
- Replication
- Repetition

KEY IDEAS:

<u>EXPERIMENTS VS INVESTIGATIONS</u>

- Scientific experiments are tightly controlled and utilize variables to ensure the accuracy of the conclusion. Ex.) A chemist wants to find how fast a chemical change takes place at different temperatures.
- Scientific investigations do not involve controlling variables. They involve many different scientific methods and include quantitative and/or qualitative observations. Ex.) Jane Goodall observed primate behavior to understand how they interact.
- Although experiments use different methods, the conclusions are valid if based upon evidence.

<u>EXPERIMENTAL DESIGN</u>

Students learn how to design experiments by participating in the inquiry process and collecting evidence so that they can make a claim. In order for them to understand, they should have opportunities to be the experimenter. Embed experimental design into all concepts that can be investigated using a controlled experiment.

- Procedures must be meticulously documented and the data carefully collected in order to ensure that the experiment is replicable (peer review).
- Data must be organized and collected in data tables. The data should be graphed in order to look for patterns, relationships, and to make sense of the data.
- All claims require data-based evidence to support it and are subject to peer review.
- **Experiments:** A type of scientific investigation (test or procedure) that is carried out under controlled conditions to answer a scientific question.
    - Control group—A group in a scientific experiment that serves as a reference for comparison to the experimental group; a group that is untreated by the factor being tested.
    - Variable—An event, condition, or factor that can be changed or controlled in order to study or test a hypothesis in a scientific experiment.
    - Controlled variable—A factor or condition in a scientific experiment that is purposefully kept the same.
    - Test variable (independent variable)—The variable manipulated by the experimenter in order to study changes in the outcome variable.
    - Outcome variable (dependent variable)—A factor, usually being measured or observed, that responds to, or depends on, another factor (test variable).

HYPOTHESES

- Hypotheses are not “educated guesses” because initial observations, research and prior knowledge influence the formation of the hypothesis.
- A hypothesis is a predicted outcome to an investigation based on initial observations, research and prior knowledge.
- Hypotheses are never proven, correct, or incorrect. They are supported by data or not supported by data.
- Hypotheses are valuable- even if yours was not supported by data because it provides you with an alternative explanation for a concept. The information gathered from an experiment that was not supported by data leads the experimenter to future investigations and research questions.

EXPERIMENTAL VALIDITY

- In order for conclusions to their experiments to be valid, there needs to be repetition and replication.
  - Repeated trials ensure that there is enough data to support your conclusions. The greater the number of trials, the more valid the conclusions will be. (ex. Would you want a drug that was tested on 10 people or one that was tested on 1,000,000 people?)
  - The experimental results must be able to be replicated, meaning that another experimenter follows the same instructional design as the original experiment and the results from both experimenters are compared to determine if more testing is needed. Peer review is an essential part of the scientific process and ensures that the conclusions are reliable.

POSSIBLE STUDENT MISCONCEPTIONS:

- Hypotheses are “educated guesses” that an experimenter makes.
  - Experimenters based their hypotheses on prior observations, background knowledge, and preliminary research. Scientists never “guess”.
  - Hypotheses can be right or wrong.
- There is one linear scientific method process that all scientists use to get scientific results.

NOT ASSESSED FOR THIS BENCHMARK:

- Items addressing hypotheses **will not assess whether the hypothesis is supported by data.**
- **Items will not address or assess replication, repetition, or the difference between replication and repetition.**
- **Items will not assess the reason for differences in data across groups that are investigating the same problem.**
- Scenarios in items will be limited to those familiar to a middle-school student rather than global situations.
- The term *test variable* should be followed by *(independent variable)*, and the term *outcome variable* should be followed by *(dependent variable)*.

NOT ASSESSED UNDER THIS/THESE BENCHMARK(S):

- **Items will not address or assess replication, repetition, or the difference between replication and repetition. (Will be assessed through SC.7.N.1.2)**

LEARNING PROGRESSION

PRIMARY: (k-2ND)

SC.1.N.1.1 Raise questions about the natural world, investigate them in teams through free exploration, and generate appropriate explanations based on those explorations.
SC.2.N.1.1 Raise questions about the natural world, investigate them in teams through free exploration and systematic observations, and generate appropriate explanations based on those explorations.
SC.1.N.1.2 Using the five senses as tools, make careful observations, describe objects in terms of number, shape, texture, size, weight, color, and motion, and compare their observations with others.
SC.2.N.1.2 Compare the observations made by different groups using the same tools
SC.1.N.1.4 Ask “how do you know?” in appropriate situations.
SC.2.N.1.4 Explain how particular scientific investigations should yield similar conclusions when repeated.
SC.2.N.1.5 Distinguish between empirical observation (what you see, hear, feel, smell, or taste) and ideas or inferences (what you think).

UPPER GRADES: (3RD-5TH)

SC.3.N.1.1 Raise questions about the natural world, investigate them individually and in teams through free exploration and systematic investigations, and generate appropriate explanations based on those explorations.
SC.4.N.1.1 Raise questions about the natural world, use appropriate reference materials that support understanding to obtain information (identifying the source), conduct both individual and team investigations through free exploration and systematic investigations, and generate appropriate explanations based on those explorations.
SC.5.N.1.1 Define a problem, use appropriate reference materials to support scientific understanding, plan and carry out scientific investigations of various types such as: systematic observations; experiments requiring the identification of

variables; collecting and organizing data; interpreting data in charts, tables, and graphics; analyze information; make predictions; and defend conclusions
SC.3.N.1.2 Compare the observations made by different groups using the same tools and seek reasons to explain the differences across groups.
SC.4.N.1.2 Compare the observations made by different groups using multiple tools and seek reasons to explain the differences across groups.
SC.5.N.1.2 Explain the difference between an experiment and other types of scientific investigation.
SC.3.N.1.3 Keep records as appropriate, such as pictorial, written, or simple charts and graphs, of investigations conducted.
SC.4.N.1.3 Explain that science does not always follow a rigidly defined method ("the scientific method") but that science does involve the use of observations and empirical evidence.
SC.5.N.1.3 Recognize and explain the need for repeated experimental trials.
SC.3.N.1.4 Recognize the importance of communication among scientists.
SC.4.N.1.4 Attempt reasonable answers to scientific questions and cite evidence in support.
SC.5.N.1.4 Identify a control group and explain its importance in an experiment.
SC.3.N.1.5 Recognize that scientists question, discuss, and check each others' evidence and explanations.
SC.4.N.1.5 Compare the methods and results of investigations done by other classmates. SC.5.N.1.5 Recognize and explain that authentic scientific investigation frequently does not parallel the steps of "the scientific method."
SC.3.N.1.6 Infer based on observation.
SC.4.N.1.6 Keep records that describe observations made, carefully distinguishing actual observations from ideas and inferences about the observations.
SC.5.N.1.6 Recognize and explain the difference between personal opinion/interpretation and verified observation.
SC.3.N.1.7 Explain that empirical evidence is information, such as observations or measurements, that is used to help validate explanations of natural phenomena.
SC.4.N.1.7 Recognize and explain that scientists base their explanations on evidence.
SC.4.N.1.8 Recognize that science involves creativity in designing experiments.
SC.4.N.2.1 Explain that science focuses solely on the natural world.
SC.5.N.2.1 Recognize and explain that science is grounded in empirical observations that are testable; explanation must always be linked with evidence.
SC.5.N.2.2 Recognize and explain that when scientific investigations are carried out, the evidence produced by those investigations should be replicable by others.

MIDDLE SCHOOL:
SC.7.N.1.1 Define a problem from the seventh grade curriculum: use appropriate reference materials to support scientific understanding; plan and carry out scientific investigations of various types, such as systematic observations or

experiments; identify variables; collect and organize data; interpret data in charts, tables, and graphics; analyze information; make predictions; and defend conclusions.
SC.7.N.1.3 Distinguish between an experiment (which must involve the identification and control of variables) and other forms of scientific investigation, and explain that not all scientific knowledge is derived from experimentation.
SC.7.N.1.4 Identify test variables (independent variables) and outcome variables (dependent variables) in an experiment.
SC.8.N.1.3 Use phrases such as “results support” or “fail to support” in science, understanding that science does not offer conclusive “proof” of a knowledge claim.
SC.8.N.1.4 Explain how hypotheses are valuable if they lead to further investigations, even if they turn out not to be supported by the data. CC: High
SC.7.N.1.2 Differentiate replication (by others) from repetition (multiple trials).
SC.6.N.1.2 Explain why scientific investigations should be replicable.
SC.6.N.1.4 Discuss, compare, and negotiate methods used, results obtained, and explanations among groups of students conducting the same investigation.
SC.8.N.1.2 Design and conduct a study using repeated trials and replication.
SC.7.N.1.5 Describe the methods used in the pursuit of a scientific explanation as seen in different fields of science such as biology, geology, and physics.
SC.7.N.3.2 Identify the benefits and limitations of the use of scientific models.
SC.8.N.1.5 Analyze the methods used to develop a scientific explanation as seen in different fields of science.
SC.8.E.5.10 Assess how technology is essential to science for such purposes as access to outer space and other remote locations, sample collection, measurement, data collection and storage, computation, and communication of information.

HIGH SCHOOL:
SC.912.N.1.1 Define a problem based on a specific body of knowledge, for example: biology, chemistry, physics, and Earth/ space science, and do the following: 1. pose questions about the natural world; 2. conduct systematic observations; 3. examine books and other sources of information to see what is already known; 4. review what is known in light of empirical evidence; 5. plan investigations; 6. use tools to gather, analyze, and interpret data (this includes the use of measurement in metric and other systems, and also the generation and interpretation of graphical representations of data, including data tables and graphs); 7. pose answers, explanations, or descriptions of events; 8. generate explanations that explicate or describe natural phenomena (inferences); 9. use appropriate evidence and reasoning to justify these explanations to others; 10. communicate results of scientific investigations; and 11. evaluate the merits of the explanations produced by others.

LESSON RESOURCES

HMH (ADOPTED TEXTBOOK):

- Unit 1 Lesson 2 “Scientific Investigations” pp. 18-31
- Unit 1 Lesson 3 “Representing Data” pp. 32-41
- HMH Digital Lesson “Scientific Investigations”
- HMH Digital Lesson “Representing Data”

CPALMS

- How Science Works: Flowchart
- Microscope Investigations Lab
- Science Research Part 1: Setting up an Experiment
- Science Research Part 2: Conducting an Experiment and Analyzing Results

GIZMOS:

- Time Estimation
- Sight vs. Sound Reactions

PENDA LESSONS:

- Conducting 7th Grade Investigations
- Types of Scientific Investigations
- Variables
- Experiment, Repeat, Replicate

NATURE OF SCIENCE CONNECTIONS:

Cell Theory will be reviewed in the next unit. Use/modify the information in these Google slides to practice identifying variables and bridge into the next unti..

Identifying Experimental Variables: The Cell Theory

ADDITIONAL RESOURCES:

Articles

- What is a Hypothesis (newsela)
  - 840L
  - 710L
  - 550L

Other

- Identification of Variables
- Repetition and Replication Tutorial

WRITING PROMPT/ CER:

An experimenter is investigating how long different balls take to drop to the floor. They use a baseball, basketball, and bouncy ball and drop them from 3 ft, 4 ft, and 5 ft in height. What error did they make in their experimental design and how would you change their experiment to make it valid?

TARGETED REMEDIATION/ EXTENSION IDEAS

CHECK FOR UNDERSTANDING:	DEVELOPING:	ACHIEVING:	EXCEEDING: