Howard County Public School System
Essential Curriculum for Middle School Science

(Adapted from the Maryland Voluntary State Curriculum for Science 6-8)

Skills and Processes

Introduction: At this level, students need to become more systematic and sophisticated in conducting their investigations, some of which may last for weeks or more. This means closing in on an understanding of what constitutes a good investigation and explicitly discussing how explanation relates to experimental design. Even though the main purpose of student investigations is to help students learn how science works, it is important to back up such experience with selected readings. Scientific explanation of the material world is built on theories and this is a good time to introduce a) an understanding of how theories are constructed and find both historical and modern examples of the theory development process; and b) an appreciation for the explanatory and predictive power of theories. By the end of Grade 8, children will have had multiple experiences applying and practicing all of the listed science skills and processes across the concept areas.

Science Safety

Goal 1. Demonstrate the ability to use proper safety procedures when conducting an investigation.

a. Identify safety concerns in specific laboratory situations.
b. Explain what must be done to change an unsafe situation into a safe one.
c. Identify and describe the proper use of science laboratory equipment.
d. Use proper lab safety procedures when using science laboratory equipment.

Constructing Knowledge

Goal 15. Design, analyze, or carry out simple investigations and formulate appropriate conclusions based on data obtained or provided.

a. Develop the ability to clarify questions and direct them toward objects and phenomena that can be described, explained, or predicted by scientific investigations.
   - Formulate questions related to everyday experiences and experimental observations.
   - Distinguish among questions that are and are not appropriate for scientific investigation.
   - Write specific and well-defined questions for scientific investigations to disprove ideas such as spontaneous generation.
   - State a research question in terms of a cause and a measurable effect.
   - Assess the testability of the hypothesis.
   - Use a variety of resources to select a question for the research project. **[G/T]**

b. Explain and provide examples that all hypotheses are valuable, even if they turn out not to be true, if they lead to fruitful investigations.
   - Describe patterns in observations and information.

- Distinguish among questions that are and are not appropriate for scientific investigation.
- Formulate questions based on observations and information appropriate for scientific investigation.
- Write a scientific hypothesis as an "if-then" statement.

c. Locate information in reference books, back issues of newspapers, magazines and compact discs, and computer databases.
- Describe the scientific content that supports a hypothesis.
- Explain the importance of a review of literature before generating a testable hypothesis. **[G/T]**
- Describe the essential information that should be included in a review of literature. **[G/T]**
- Use an appropriate bibliographic style to document resources. **[G/T]**
- Prepare a list of works cited in an appropriate bibliographic style. **[G/T]**
- Evaluate the accuracy and usefulness of online sources. **[G/T]**
- Conduct a review of literature related to the research problem. **[G/T]**
- Use a variety of sources to identify a problem for a research project. **[G/T]**
- Generate a research hypothesis, based on a review of literature. **[G/T]**
- Write an introduction, based on a formal review of literature. **[G/T]**
- Defend the introduction and testable hypothesis to an audience that includes peers, teachers, and a scientist. **[G/T]**

d. Explain that if more than one variable changes at the same time in an investigation, the outcome of the investigation may not be clearly attributable to any one of the variables.
- Identify the data that should be collected to test a hypothesis.
- Identify the independent (manipulated) and dependent (responding) variables.
- Identify the experimental control as the trial or group in which the independent variable is omitted or set at a typical level and is used as a standard for comparison and a test of the validity of the experimental design.
- Identify the constants, the conditions, and procedures that remained the same, in the experiment and explain their importance.
- Review the major components of experimental design. **[G/T]**
- Use an appropriate format to write an experimental design. **[G/T]**
- Use a graphic organizer to write an experimental design. **[G/T]**
- Change one variable, repeat the experiment, and compare results to original results. **[G/T]**

e. Give examples of when further studies of the question being investigated may be necessary.

f. Give reasons for the importance of waiting until an investigation has been repeated many times before accepting the results as correct.
- Explain the purpose of multiple trials and adequate sample size.

g. Use mathematics to interpret and communicate data.
- Use appropriate metric measurements.
- Compare measurements in different units (i. e., milliliters and liters) and choose the appropriate metric measurement.
- Use tools such as calculators, spreadsheets, databases, and graphing programs to record and manipulate data in tables, charts, and graphs.
- Describe raw data in terms of statistics such as central tendency (i. e., mean, median, mode) and variation (i. e., frequency, distribution, range). **[G/T]**
- Construct an appropriate data table to represent descriptive statistics. **[G/T]**

- Evaluate the experimental data using appropriate descriptive statistics. **[G/T]**
- Convert from metric to English units and English to metric units. **[G/T]**
- Compare the accuracy of electronic instrumentation (satellite imagery, battery probe, to manual and mechanical instruments. **[G/T]**

h. Explain why accurate record keeping, openness, and replication are essential for maintaining an investigator's credibility with other scientists and society.
  - Identify the importance of multiple trials.
  - Identify the importance of clear, logical, and repeatable directions for data collection and experimentation.

i. Explain that scientists differ greatly in what phenomena they study and how they go about their work.
  - Read a selection related to a career in science and describe, in writing, the required skills and training.
  - Explore various scientific career options.
  - Explain how scientists report their findings to the world.

Applying Evidence and Reasoning

Goal 16. Review data from a simple experiment, summarize the data, and construct a logical argument about the cause-and-effect relationships in the experiment.

a. Verify the idea that there is no fixed set of steps all scientists follow, scientific investigations usually involve the collection of relevant evidence, the use of logical reasoning, and the application of imagination in devising hypotheses and explanations to make sense of the collected evidence.
  - Develop a set of clear and concise procedures for completing a task.
  - Design and implement a controlled, repeatable experiment, with step-by-step instructions.
  - Evaluate the design of an experiment.
  - Read a laboratory investigation, develop an appropriate hypothesis for the investigation, and give reasons to support the hypothesis using references to relevant details in the experimental design.
  - Identify in writing a sequence of steps in a process from a reading selection.
  - Read two similar laboratory investigations and explain, in writing, which procedure best controls the variables that would affect the outcomes of the investigation.
  - Read two similar laboratory investigations and explain, in writing, which procedure best controls the accuracy of the data.
  - Read a laboratory investigation and paraphrase the directions.
  - Critically analyze a laboratory procedure in writing.
  - Critically analyze a laboratory procedure in writing and revise it for accuracy. **[G/T]**

b. Explain that what people expect to observe often affects what they actually do observe and that scientists know about this danger to objectivity and take steps to try to avoid it when designing investigations and examining data.
  - Form predictions and hypotheses based on observations.
  - Write the procedures and construct the raw and descriptive data table that will be used to test the hypothesis for the individual project. **[G/T]**
  - Defend the procedures and data table to an audience that includes peers, teachers, and a scientist. **[GT]**

- Determine the sources of error that limit the accuracy or precision of experimental results. **[G/T]**

c. Explain that even though different explanations are given for the same evidence, it is not always possible to tell which one is correct.
- Locate several sources of information on a scientific concept. Critique the information and identify possible sources of bias.
- Research a current topic of scientific debate, identify controversial issues or ethical concerns, select a specific topic, and use science to defend a position. (e. g., debate, paper, power point, artwork, print media).

d. Describe the reasoning that lead to the interpretation of data and conclusions drawn.
- Distinguish between an explanation and a description.
- Describe the observations that support an explanation.
- Summarize in writing the data collected in an experiment.
- Construct valid conclusions based on scientific collection and analysis of data.
- Write a conclusion that includes a restatement of the hypothesis and an explanation of how the results support or fail to support the hypothesis, with specific references to the data.
- Write the results and conclusion section of the research paper. **[G/T]**
- Organize the scientific research paper using an appropriate format. **[G/T]**
- Present the scientific research project to an authentic audience. **[G/T]**

e. Question claims based on vague statements or on statements made by people outside their area of expertise.

Communicating Scientific Information

Goal 17. Develop explanations that explicitly link data from investigations conducted, selected readings and, when appropriate, contributions from historical discoveries.

a. Organize and present data in tables and graphs and identify relationships they reveal.
- Relate patterns in data to the actual objects or events.
- Interpret and analyze data to discover patterns and make predictions.
- Describe the thinking involved in collecting, organizing, and presenting data.
- Use a database program to record data collected.
- Use a graphic organizer to compare data.
- Present data in appropriately labeled tables, charts, and graphs.
- Summarize in writing the data collected in an experiment.
- Construct an appropriate data table using correct labels and units.
- Select and construct the appropriate type of graph for collected data.
- Interpret graphs to identify trends and draw conclusions.
- Read a selection about the impact of a scientific development and write an explanation of how the information in the accompanying graphs, figures, or illustrations supports the information in the text.
- Read a selection describing a scientific experiment and identify the strategy the author used to clarify information. Explain in writing whether the strategy did or did not contribute to personal learning.
- Read an article that describes a scientific idea. Explain in writing the evidence the authors use to support their arguments.
- Create an appropriate data table for collecting raw data. **[G/T]**

- Identify the type of graph that best fits a set of data. **[G/T]**
- Construct an appropriate graph when provided with a brief description of an investigation and a set of data. **[G/T]**

b. Interpret tables and graphs produced by others and describe in words the relationships they show.

c. Give examples of how scientific knowledge is subject to modification as new information challenges prevailing theories and as a new theory leads to looking at old observations in a new way.
- Distinguish among observations, inferences, and predictions related to historical research such as Redi and Pasteur's work.
- Define and give examples of classification systems and how they changed historically (i. e., states of matter or properties).
- Analyze classification systems to determine which one is most accurate. **[G/T]**

d. Criticize the reasoning in arguments in which:
- Fact and opinion are intermingled.
- Conclusions do not follow logically from the evidence given.
- Existence of control groups and the relationship to experimental groups is not made obvious.
- Samples are too small, biased, or not representative.
- Analyze the adequacy of supporting evidence used to form conclusions. **[G/T]**
- Determine the sources of error that limit the accuracy or precision of experimental results. **[G/T]**

e. Explain how different models can be used to represent the same thing. What kind of a model to use and how complex it should be depend on its purpose. Choosing a useful model is one of the instances in which intuition and creativity come into play in science, mathematics, and engineering.
- Develop a model.
- Correlate elements of a model to an actual event, object, or system.
- Identify limitations of a model.
- Evaluate the usefulness and clarity of models from a variety of sources. **[G/T]**

f. Participate in group discussions on scientific topics by restating or summarizing accurately what others have said, asking for clarification or elaboration, and expressing alternative positions.

g. Recognize that important contributions to the advancement of science, mathematics, and technology have been made by different kinds of people, in different cultures, at different times.

Technology - Design and Systems

Design Constraints: An idea to be developed in the middle grades is that complex systems require control mechanisms. The common thermostat for controlling room temperature is known to most students and can serve as a model for all control mechanisms. However, students should explore how controls work in various kinds of systems-machines, athletic contests, politics, the human body, learning, etc. At some point, students should try to invent control mechanisms, which need not be mechanical or electrical, that they can actually put into operation.

Goal 18. Explain that complex systems require control mechanisms.

a. Explain that the choice of materials for a job depends on their properties and on how they interact with other materials.
b. Demonstrate that all control systems have inputs, outputs, and feedback.
c. Realize that design usually requires taking constraints into account. (Some constraints, such as gravity or the properties of the materials to be used, are unavoidable. Other constraints, including economic, political, social, ethical, and aesthetic ones also limit choices.)
d. Identify reasons that systems fail—they have faulty or poorly matched parts, are used in ways that exceed what was intended by the design, or were poorly designed to begin with.

Designed Systems: Systems thinking can now be made explicit -- suggesting analysis of parts, subsystems, interactions, and matching. Student projects should now entail analyzing, designing, assembling, and troubleshooting systems -- mechanical, electrical, and biological -- with easily discernable components. The idea of system should be expanded to include connections among systems. For example, a can opener and a can may each be thought of as a system, but they both -- together with the person using them -- form a larger system without which neither can be put to its intended use.

Goal 19. Analyze, design, assemble, and troubleshoot complex systems.

a. Provide evidence that a system can include processes as well as things.
b. Explain that thinking about things as systems means looking for how every part relates to others. (The output from one part of a system (which can include material, energy, or information) can become the input to other parts. Such feedback can serve to control what goes on in the system as a whole.)
c. Analyze any system to determine its connection, both internally and externally to other systems and explain that a system may be thought of as containing subsystems and as being a subsystem of a larger system.

Making Models: Models and their use can now be dealt with much more explicitly than before because students have a greater general knowledge of mathematics, literature, art, and the objects and processes around them. Students should have many opportunities to learn how conceptual models can be used to suggest interesting questions, such as "What would the atmosphere be like if its molecules were to act like tiny, high-speed marshmallows instead of tiny, high-speed steel balls?" The use of physical models also can increase in sophistication. Students should discover that physical models on a reduced scale may be inadequate because of scaling effects.

Goal 20. Analyze the value and the limitations of different types of models in explaining real things and processes.

a. Explain that the kind of model to use and how complex it should be depends on its purpose and that it is possible to have different models used to represent the same thing.
b. Explain, using examples that models are often used to think about processes that happen too slowly, too quickly, or on too small a scale to observe directly, or that are too vast to be changed deliberately, or that are potentially dangerous.
c. Explain that models may sometimes mislead by suggesting characteristics that are not really shared with what is being modeled.