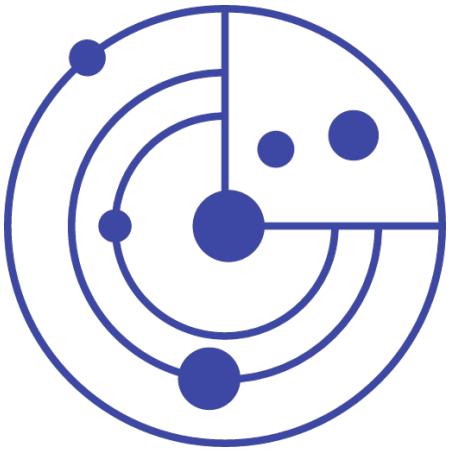
Asking
Questions



Developing
and Using
Models

Planning and
Carrying Out
Investigations

Analyzing and
Interpreting
Data

Developing and Using Models

Using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural world.

Performance

- Identify components of the model
- Identify relationships between components
- Use connections to describe, explain and predict

Asking Questions

Formulating, refining, and evaluating empirically testable questions using models and simulations.

Performance

- Addressing phenomena or theories
- Identifying the nature of the question
- Evaluating empirical testability

Analyzing and Interpreting Data

Organize and interpret data through tabulating, graphing, or statistical analysis. Such analysis can bring out the meaning of data—and their relevance—so that they may be used as evidence.

Student Performance

- Organizing data
- Identifying relationships within datasets
- Identifying relationships between datasets
- Interpreting data

Planning and Carrying Out Investigations

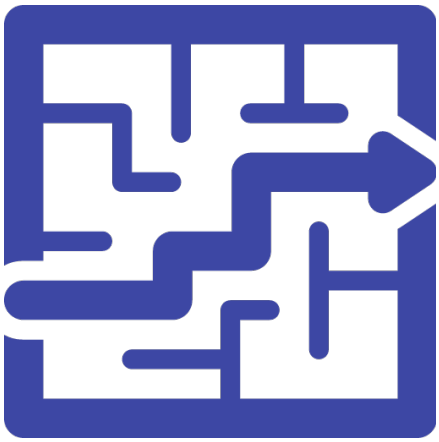
Planning and carrying out investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

Performance

- Identifying the phenomenon
- Identifying the evidence and purpose
- Planning the investigation
- Collecting the data
- Refining the design

Mathematics

Computational Thinking



Constructing Explanations

Engaging in Argument from Evidence

Obtaining, Evaluating, and Communicating Information

Constructing Explanations

Constructing explanations that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

Student Performance

- Developing a claim
- Identifying scientific evidence
- Evaluating and critiquing evidence
- Reasoning and synthesis

Using Mathematics and Computational Thinking

Using algebraic thinking and analysis for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

Student Performance

- Identify representations in a system
- Use mathematics and mathematical modeling
- Use computational thinking
- Analyze results

Obtaining, Evaluating, and Communicating Information

Evaluating the validity and reliability of the claims and methods. Communicating information, evidence, and ideas in multiple ways: using tables, diagrams, graphs, models, interactive displays, and equations as well as orally, in writing, and through extended discussions.

Student Performance

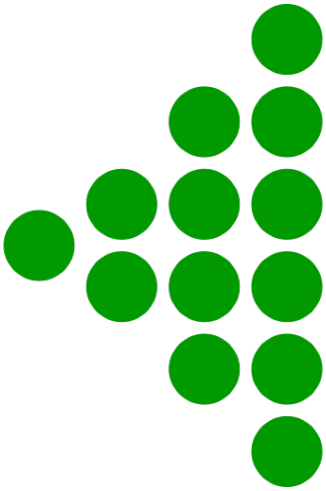
- Obtaining information
- Evaluating information
- Communicating information
- Selecting appropriate style and format

Engaging in Argument From Evidence

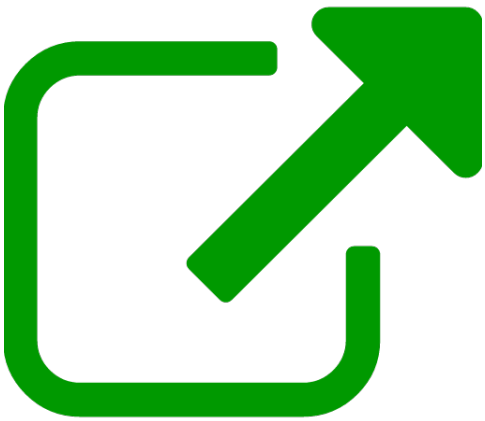
Using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural world. Arguments may also come from current scientific or historical episodes in science.

Performance

- Identifying a given claim
- Identifying provided evidence
- Identifying any relevant additional evidence
- Evaluating and critiquing evidence
- Reasoning and synthesis



Patterns



Cause
Effect

Scale
Proportion
Quantity

Systems
System Models

Cause and Effect

Events have causes, sometimes simple, sometimes multifaceted. Correlation doesn't imply causation.

What relationships between events or patterns do I observe in this phenomenon or system?
What can I explain about these relationships?
Are any of these relationships cause and effect?
What evidence supports a cause and effect relationship?
Can my model provide a mechanism for this cause and effect relationship?
What further investigations would help determine if these relationships are cause and effect?

Patterns

Repeating cycles, shapes, or spatial features

What do I notice in this phenomenon or system after careful observation?
What patterns do I observe?
What questions do I have about these patterns?
What additional observations could I make?
How do these patterns compare to other patterns?
How can I model these patterns?
What might cause these patterns?
What further investigations would help clarify these patterns and their cause?

Systems and System Models

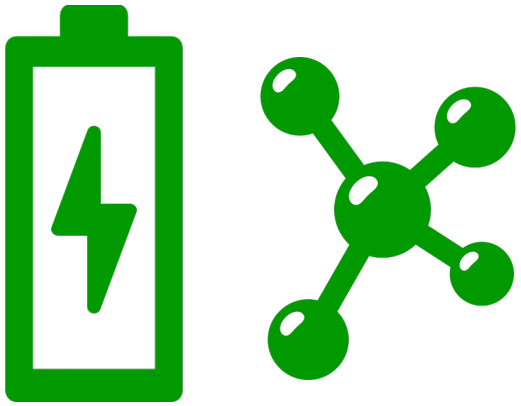
A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

What system or systems do we need to model to explain this phenomenon?
What are the inputs and outputs of the system?
What scale(s) within the system do we need these models to describe and represent?
How can we delineate the boundary of the system?
What are the components or sub-systems of this system?
What are the relationships between the components in this system?
What predictions can be make from our model?
What are the limits of the system model?

Scale, Proportion, and Quantity

It is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.

How can we investigate nature at this scale?
What aspects of this system do we need to measure to describe it more precisely?
On what scale must we make these measurements?
What do we need to control as we make these measurements?
What relationships between quantities do we observe?



Energy
Matter

Structure
Function

Stability
Change

Structure and Function

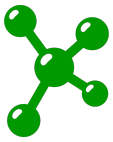
The way an object is shaped or structured determines many of its properties and functions.

What shapes or structures are observed in this system at this scale?
What roles do these structures play in the functioning of the system?
How do the structures support the functions?
How do different conditions relate to patterns of differences in structures or appearance?

Energy and Matter

Tracking energy and matter flows, into, out of, and within systems.

What matter flows into, out of, and within the system?
What physical and chemical changes occur in this system?
What energy transfer occurs into, out of, or within this system?
What transformations of energy are important in this system?
What are the needed inputs in this system?
What are the desired outputs in this system?
How are energy and matter related in this system?



Stability and Change

Conditions that affect stability and factors that control rates of change are critical elements to consider and understand in natural systems.

Under what range of conditions does this system operate effectively?
What changes in conditions causes changes in its stable operation?
What characteristics of the system change?
What changes in conditions could cause it to become unstable or to fail?
What feedback loops in the operation of this system enhance its range of stable operations?
What feedback loops in the operation of the system tend to destabilize it?