LOOKING FOR CRITICAL THINKING DURING THE RESEARCH QUEST

OBSERVATION

Observations serve as a major form of evidence in the *Research Quest* investigations. Students make scientific observations of authentic materials using technology-supported tools and reference material. Observations should be sense-based and detailed.

- *Advanced:* Look for student use of detailed observations that are derived from the senses. Good observations are detailed enough so they are descriptive only of the object being observed; in this way, they could be used to distinguish between different objects or several similar objects of the same type. Good observations may be quantitative ("There are 35 teeth.") or qualitative ("Teeth are sharp with slightly jagged edges.").

- *Intermediate:* Students may make sense-based observations that lack detail or are broadly descriptive. For example, "It is white" or "It is cracked." Encourage students at this level to go beyond broad descriptions and add detail to their observations.

- *Beginning:* Beginning students may have trouble distinguishing an observation from identification ("It's a claw.") or opinion ("It's ugly."). Encourage students to use their senses to write down facts about the object that led them to these ideas or conclusions. Note that scientists' first impressions are often not the strongest explanation, so they must learn to hold off on forming an idea or an opinion until they gather as much evidence (data) as they can.

INTERPRETATIONS

Students can use observations to make reasonable interpretations and inferences about objects. This may include the use of an object ("It's sharp, so it could be used to rip and tear flesh."), cause/effect ("The bone is cracked, so it probably was attacked and died."), or an inference about an observation ("If it were a tooth and not a claw, it would have a longer root."). You do not need to discourage interpretations, right or wrong, as students should be evaluating them during the course of inquiry.

- *Advanced:* Students should be making inferences that are warranted by (or reasonable in light of) the data that is at hand. Good interpretations are consistent with the data/observations they have and with what is known about the world.

- *Intermediate:* Students may start to make inferences but have trouble explaining the reasoning behind their ideas. For example, they may say, "It's a carnivore because of its teeth." This may be a great inference if the student is looking at a jaw with very sharp, pointed teeth. However, their reasoning may not be apparent to others. Encourage these students to make it clear what data/observations/evidence are leading them to their interpretations.

- *Beginning:* Students may not explain their interpretations, staying at the level of observations. Or, students may make "wild" inferences that go far beyond the available evidence and/or require supernatural explanations. For example, students may say the animal was "Definitely a raptor, because they had sharp claws like that." Encourage these students to make more reasoned interpretations. For example, remind them many dinosaurs may have sharp claws and ask what they can infer based on a sharp claw.

EVALUATIONS

Evaluations occur when students think about the accuracy or probability of a claim, idea, or hypothesis. They may justify their own idea or that of another student. They also may evaluate the strength of particular hypotheses or ideas, either their own or those posed by others. Ideally, students will use multiple forms of evidence when making evaluations. However, beginning students may struggle to articulate a rationale for their acceptance or rejection of ideas.

- *Advanced:* Students use multiple forms of evidence and/or evaluate the strength of their evidence when

evaluating an idea or hypothesis. In doing so, they may note some of the evidence is weak and some is strong. For example, "The bone is 21 inches which is in the range of an adult femur, but what if it was a juvenile? So, the size could be wrong, but the knobs at the top and the bottom of the bone look just like the femur, not any other leg or arm bone."

- *Intermediate:* At this stage, students will articulate a single source of evidence to evaluate a claim or idea, typically without regard to whether the evidence is strong or weak (e.g., "It's a femur because it's 21 inches."). Spontaneous use of evidence-based evaluations are not common, so even this level of evaluation should be encouraged and reinforced. However, encourage students to bring in more evidence and to think about the strength of evidence for different ideas.

- *Beginning:* Students in this category tend to believe personal opinions or beliefs are sufficient reason to accept or reject an idea or hypothesis. They may summarily dismiss ideas ("It's just not a tooth, okay.") or reassert their own thinking without offering evidence of their evaluation of the idea. ("Whatever. You're wrong. It's a claw.") Note students may be right, but this practice still should be discouraged. Remind students that scientists' initial ideas are often not the strongest explanation, so they must learn to use evidence to carefully evaluate their own ideas as well as those of others.

CONNECTIONS

Students make connections between multiple pieces of available evidence, including their own observations drawn from authentic objects and available information from published materials and guides. Students also may make connections to known objects from the natural world (e.g., "Have you ever had a tooth pulled at the dentist? It has a long root under the gum!").

- *Advanced:* Students seek out multiple sources of evidence, including objects and reference materials. Evidence found in one source/object may be used to guide data gathering from other sources. For example, a student may see many broken teeth on a jaw and then search for signs of damage in the other fossils.

- *Intermediate:* Students gather information from several sources and use them in conjunction. However, their use of multiple sources may be less strategic than their more advanced peers.

- *Beginning:* Students may remain focused on one source of information or summarily ignore specific sources. Their data gathering is focused on one source at a time and appears to be more haphazard rather than strategic.

PROBLEM FINDING

Students pose a clear question that needs to be answered, identify evidence that needs to be gathered, and/or propose a hypothesis to be evaluated.

- *Advanced:* Students propose relevant ideas and/or hypotheses and note relevant evidence that could be used to evaluate or inform the idea. For example, "It's probably a carnivore claw since it seems sharp, but I'd have to compare it to a herbivore claws to know for sure." Or, "If we had another example of the jaw, we could figure out if it was missing any teeth."

- *Intermediate:* Students pose relevant ideas and/or hypotheses, but do not make connections to relevant evidence. They may throw out a question for the group "We need to know whether it was a meat eater!" or may summarily propose an idea "It's a claw!"

- *Beginning:* Students in this category propose ideas that will be difficult (or impossible) to evaluate (e.g., "Maybe there was a volcano and an earthquake and a flood all at the same time!") or are unrelated to the problem at hand (e.g., "What made the dinosaurs go extinct?"). Encourage these students to focus on the current goals and think about questions they need to answer to come up with a well-reasoned hypothesis.

COMPARISON

Students make clear comparisons between observations drawn from multiple objects. Students also may notice and articulate patterns among materials or objects (e.g., "They all have broken teeth on the lower jaw.").

- *Advanced:* Students note similarities and differences across objects and multiple sources. They articulate consistencies and inconsistencies in data and/or observations. In many cases, this may look like comparison and contrasting focused on specific features of objects and/or aspects of known information.
- *Intermediate:* In this category, students notice similarities among objects and/or data, but often fail to notice or articulate differences. Encourage these students to compare and contrast with available evidence.
- *Beginning:* Students limit thinking to one object or source at a time. Although they may move between resources and/or materials, they do not clearly articulate comparisons or contrasts among related features/data.

FLEXIBLE THINKING

Students remain open to multiple ideas and hypotheses until sufficient evidence is gathered and analyzed. Students likely will begin with their own idea but may generate multiple ideas and/or incorporate the thinking of others into their own thinking. Students should consider questions and evidence from multiple perspectives.

- *Advanced:* Students generate their own ideas and may incorporate the thinking of others into the possibilities they are considering. As a result, students have multiple ideas (which may be generated by themselves, others, or a combination) they consider as they gather and evaluate evidence. As new evidence is identified, students consider how it may support or go against their ideas/hypotheses. Students wait to settle on a "leading" or "best" hypothesis until all available data is evaluated.
- *Intermediate:* Students initially consider multiple ideas and listen carefully to the ideas of others, but they may find it hard to maintain these ideas for long (particularly if early evidence seems to support a single idea/hypothesis). In this case, students may settle into a single idea or hypothesis before all evidence is gathered. Encourage these students to continue evaluating all ideas as new evidence is gathered.
- *Beginning:* These students settle into a single idea or hypothesis early in the process and are focused on evaluating evidence based upon this single idea. Students may have been taught that a hypothesis is a "guess" and that you gather evidence for your hypothesis. Encourage these students to think of the hypothesis as the "most likely idea" or the "strongest idea" that can only be determined by looking at all evidence in conjunction.

CRITICAL THINKING RUBRIC

	BEGINNING	INTERMEDIATE	ADVANCED
OBSERVATION	Examines objects and identifies it (e.g., "It's a claw.") or offers an opinion ("It's ugly.").	Makes broad, sense-based observations that are supported by evidence but not detailed (e.g., "It's sharp.").	Makes detailed, sense-based observations that discriminate among objects (e.g., "It's flat and tapers into a sharp, curved point.").
INTERPRETATIONS	Fails to make inferences or makes inferences/ interpretations that are not warranted by the available evidence (e.g., "It's so weird, it must be from an alien.").	Makes inferences and interpretations that do not clearly articulate the link between the evidence and the interpretation (e.g., "Its teeth mean it probably was a carnivore.").	Makes inferences and interpretations that clearly articulate a link between the evidence and the interpretation (e.g., "It has very sharp teeth to bite other animals, so it probably was a carnivore.").
EVALUATIONS	Evaluates ideas or hypotheses using opinions, beliefs, or personal preference without data or evidence (e.g., "I just don't think it's a tooth.").	Evaluates ideas or hypotheses based upon a single piece of evidence that may not be strong (e.g., "I think it's a femur because it's 21 inches.").	Evaluates ideas or hypotheses using multiple pieces of evidence and/or considers the strength of evidence when evaluating an idea/hypothesis.
CONNECTIONS	Considers one object or material at a time. Does not move across multiple materials.	Uses materials and objects in conjunction. Gathers similar/ related evidence from multiple sources.	Uses multiple materials and objects; uses evidence from one source to examine related data in another source.
PROBLEM FINDING	Proposes an idea that is not related to data or will be difficult to evaluate.	Proposes an idea related to the data and evidence being evaluated.	Proposes a relevant idea and articulates the need for information and/or evidence to evaluate the idea.
COMPARISONS	Limits thinking to one source of data at a time. Fails to make clear comparisons across multiple sources/ objects.	Notes similarities across objects and compares common findings across data sources.	Notes similarities and differences across objects and articulates consistent and inconsistent data.
FLEXIBLE THINKING	Students settle on a single idea or hypothesis early in the process and remain focused on "proving" this idea.	Students initially consider multiple ideas and listen carefully to the ideas proposed by other students. However, they have trouble keeping their mind open to multiple ideas throughout the process.	Students keep their minds open to multiple ideas as they gather evidence and evaluate each piece of evidence across multiple ideas/hypotheses. Students do not settle on a single idea/hypothesis until all data is evaluated.

OBSERVATION TOOL TO MONITOR CRITICAL THINKING IN THE CLASSROOM

This tool can be used to monitor critical thinking skills in students during *Research Quest* investigations. Place a check mark next to each student's name and the associated skill and level observed. Prompt students to engage in higher-order thinking using the tips provided in the *Critical Thinking Rubric*.

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