Nature of Science (NOS): A Checklist

Use this collection of NOS prompts throughout the school year to stress the NOS concepts embedded within a variety of biology topics. These prompts can easily be adapted to specific biology content. For example, take the general question about explanations relying on evidence and apply it specifically to a topic such as photosynthesis. You could ask, "What evidence do we have that supports the explanation that plants need sunlight for photosynthesis? Or, "What evidence do we have that supports the explanation that hybrids are typically sterile?" Followed by, "Could this evidence be used to support any other explanation?"

NOS CONCEPT: Scientists construct explanations based on well-reasoned, logical arguments built upon multiple lines of valid scientific evidence using what they already know as a foundation.

- **Scientific explanation relies on evidence – Why?** Scientific explanations need to be reliable and accurate descriptions of the universe – for this reason they must rely on evidence and not just guesses or popular opinion.

- **What is valid scientific evidence?** Valid scientific evidence must meet a variety of rigorous tests, such as being repeatable, having proper controls, being carefully recorded and reported.

  - **In the design of an experiment, what is the purpose of controls?** Controls provide a way to ensure any changes seen as a result of an experiment were due to the factor being studied, and not due to other unknown conditions
    What controls were used in {fill in the experiment being studied}?

  - **Why should the variable features of an experiment be limited?** In order to understand what you observe in an experiment, you need to know what factors have brought about the results. If you change several things at one time, you cannot know which factor or factors are responsible for the effects you observe. In other words, change one thing at a time so that you know what you are testing.
    What variables are used in {fill in the experiment being studied}?

  - **Why are experiments repeated?** Experiments are repeated to test their reliability.

- **What is the role of existing scientific knowledge in building new ideas?** Scientific investigations, and so scientific knowledge, are based upon an understanding of existing ideas. Because of this, what we know determines what we find out in an investigation. We can take advantage of existing knowledge to help us ask a good scientific question, and to understand what we see in an investigation.

  - **Does existing knowledge always benefit current investigations?** We should also recognize that what we know can limit what we see in an experiment. For instance, because early scientists expected to see dominant male behavior in a group of

baboons or chimpanzees, that is what they observed when studying these groups. When a scientist with a different expectation made the same observation, she documented a much greater role for females in these groups, observations that have since been recorded by many others. So it is important to document your expectations before beginning an investigation.

- **Effective scientific exploration requires asking the right question. What makes a good scientific question?** A good scientific question is one that can be answered. Often this means that a large question needs to be broken up into smaller, answerable questions.

- **Scientific evidence comes from many sources. Why are scientific explanations built on multiple lines of evidence?** More lines of evidence that support a scientific explanation make that explanation more credible.

- **Identify more than one line of evidence that shows ---[adapt to your topic]**

  - **Is all scientific evidence derived from experiments? Explain.** Observation of naturally occurring phenomena is a powerful way of collecting data. It requires careful, objective observation and careful, accurate note taking.

- **Objectivity in scientific observation is taught, not automatic. What rules do scientists follow to help maintain objectivity?** There are many checks and balances to guard against non-objective reports. Scientists take careful notes, they provide controls in experiments, they repeat experiments, and most important of all, they report their findings to other scientists who must be convinced before the findings become part of the accepted body of scientific knowledge. Peer-reviewed literature is one of the checks and balances that maintain objectivity in all scientific investigations.

<u>NOS CONCEPT</u>: A change in scientific knowledge is a strength and allows for the overall durability of scientific knowledge.

- **What makes scientific ideas change over time?** New data from new discoveries or new reasoning using existing data can result in a modification, expansion or revision of scientific ideas. This process is how scientific knowledge grows and remains strong.

- **New evidence is compared with existing scientific explanations – What happens if the new evidence is in conflict with the existing explanation?** First you must determine if both the new and existing evidence were collected carefully and are scientifically valid. If so, it cannot be ignored. The existing explanation must be modified or expanded to be in accord with the new evidence. Sometimes an old explanation must be completely discarded, but because scientific explanations rely on valid scientific evidence, this is much less common.

- **Change in scientific explanations over time is a strength – Explain that.** If scientists clung to ideas even when new observations showed them to be incorrect, scientific knowledge would be a weak description of the universe. Change reflects the constant

testing and expansion or modification of scientific explanations in response to new data and new reasoning.

- **What is meant by the term "peer-reviewed literature?" Why is it important to scientific study?** Peer-reviewed literature refers to scientific reports that have been reviewed and found acceptable by other scientists with specific knowledge in the area being reported. It is important because it is one of the checks and balances that makes scientific knowledge reliable and accurate.