Grade 10 NTI Day #2 Biology

Assignment: Please read the following excerpt, then answer the questions below.

Start Here:

Science, Change, and Uncertainty Scientists have gathered lots of important information that helps cure and prevent disease, grow food, and link the world electronically. Yet much of nature remains a mystery. Almost every scientific discovery raises more questions than it answers. Often, research yields surprises that point future studies in new and unexpected directions. This constant change doesn't mean science has failed. On the contrary, it shows that science continues to advance.

That's why studying science means more than just memorizing what we know. It also means understanding what we don't know. You may be surprised to hear this, but science rarely "proves" anything. Scientists aim for the best understanding of the natural world that current methods can reveal. Uncertainty is always part of the scientific process, and is part of what makes science exciting!

We hope to show you that understanding science isn't just about learning "facts." We hope you'll gain some understanding of the spirit of scientific inquiry, of the way scientists think, and of both the process and excitement of discovery. Don't just memorize today's scientific facts and ideas. And please don't believe them, just because they are in a textbook! Instead, try to understand how scientists developed those ideas. Pose the kinds of questions scientists ask. Try to see the thinking behind the experiments we describe.

READING CHECK **Construct an Explanation** How is scientific knowledge different from other types of knowledge?

INTERACTIVITY

Discover the power of scientific methodology.

Scientific Methodology

Is science a mysterious process that only scientists do under special circumstances? Nope! You use scientific thinking all the time! Suppose your family's car won't start. What do you do? You use what you know about cars to ask questions. Is the battery dead? You test that idea by turning the key in the ignition. If the starter motor works but the engine doesn't start, you reject the dead battery idea. Is the car out of gas? A glance at the fuel gauge tests that idea. Again and again, you apply scientific thinking until the problem is solved—or until you run out of ideas and call a mechanic!

Scientists work in pretty much the same way. There isn't a single, cut-and-dried "scientific method." But there is a general style of investigation we call scientific methodology, which is a fancy way of saying "the way science works." ***Scientific methodology involves observing and asking questions, forming hypotheses, conducting controlled experiments, collecting and analyzing data, and drawing conclusions.*** **Figure 1-2** shows how one research team used scientific methodology in its study of one particular species of marsh grass in a New England salt marsh.

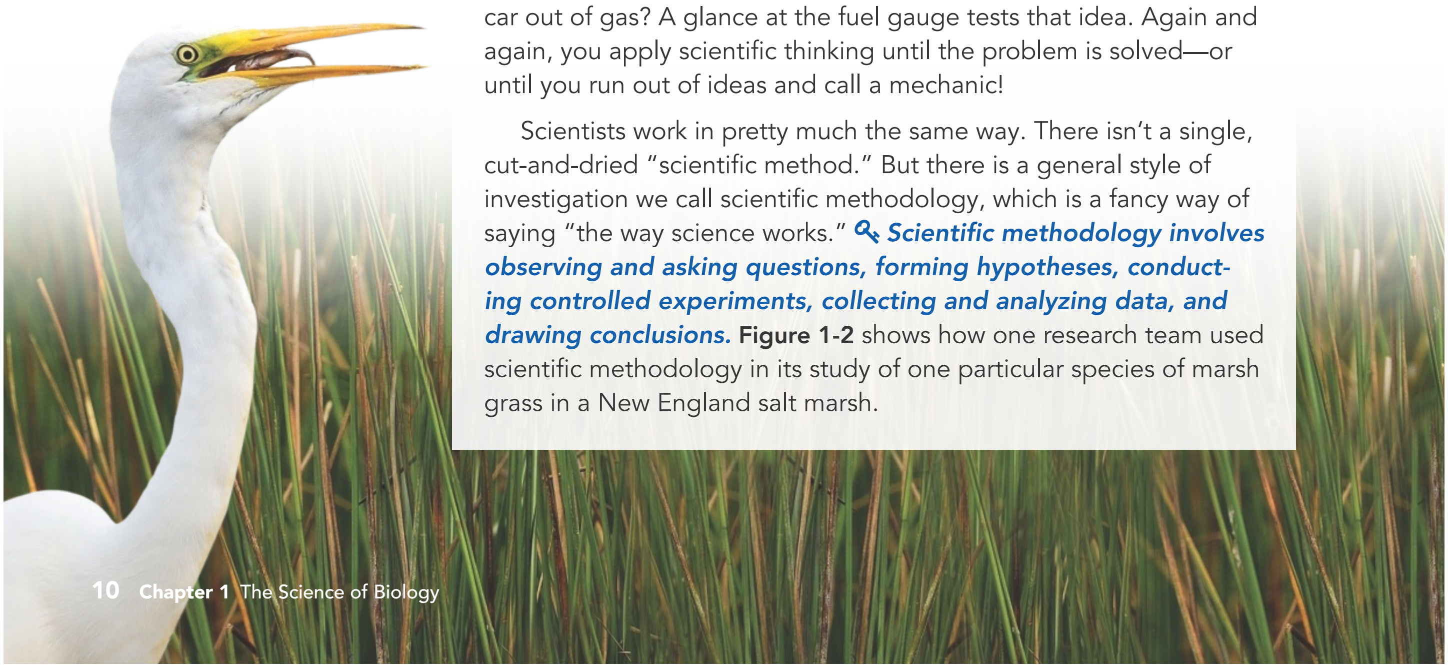
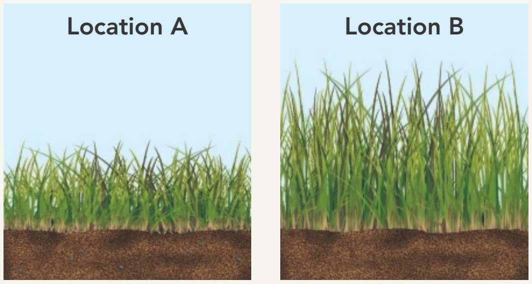


Figure 1-2

Salt Marsh Experiment

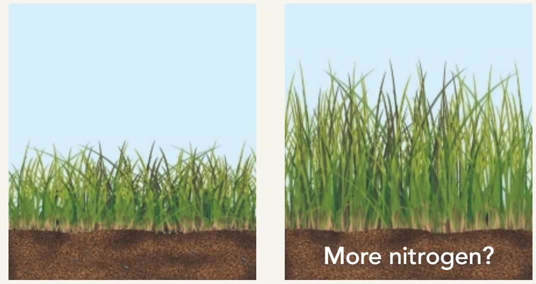
Salt marshes are coastal environments often found where rivers meet the sea. Researchers made an interesting observation about the way a particular species of marsh grass grows. They then applied scientific methodology to answer questions that arose from their observation.

1. OBSERVING AND ASKING QUESTIONS



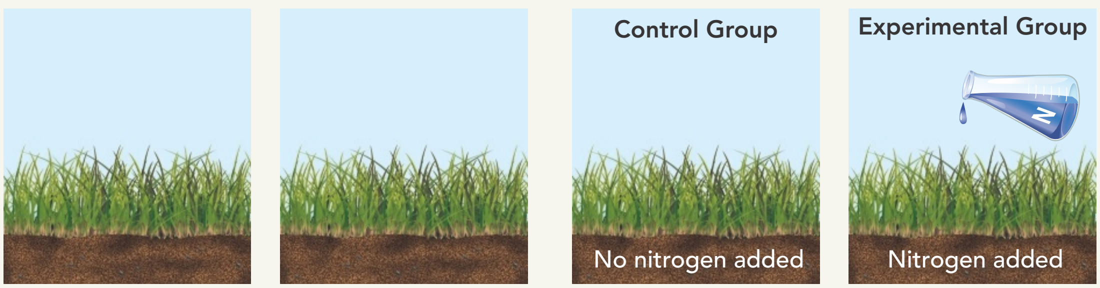
Researchers observed that marsh grass grows taller in some places than others. This observation led to a question: *Why do marsh grasses grow to different heights in different places?*

2. INFERRING AND HYPOTHESIZING



The researchers inferred that something limits grass growth in some places. It could be any environmental factor—temperature, sunlight, water, or nutrients. Based on their knowledge of salt marshes, they proposed a hypothesis: *Marsh grass growth is limited by available nitrogen.*

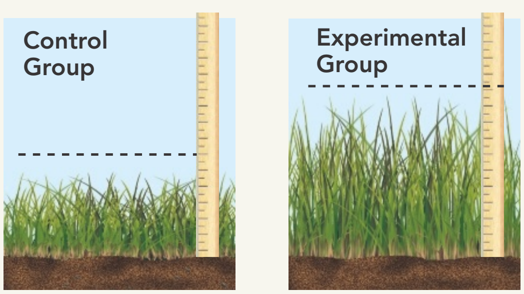
3. DESIGNING CONTROLLED EXPERIMENTS



The researchers selected similar plots of marsh grass. All plots had similar plant density, soil type, input of freshwater, and height above average tide level. The plots were divided into control and experimental groups.

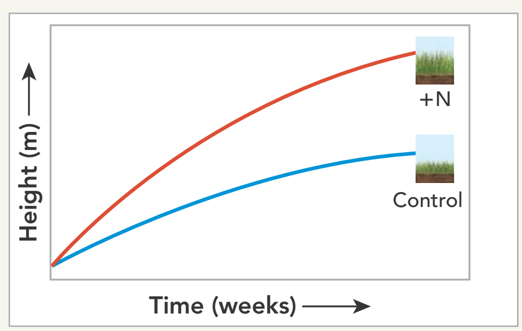
The researchers added nitrogen fertilizer (the independent variable) to the experimental plots. They then observed the growth of marsh grass (the dependent variable) in both experimental and control plots.

4. COLLECTING DATA



The researchers sampled all the plots throughout the growing season. They measured growth rates and plant sizes, and analyzed the chemical composition of living leaves.

5. ANALYZING CONCLUSIONS



Data from all plots were compared and evaluated by statistical tests. Data analysis confirmed that marsh grasses in experimental plots with additional nitrogen did, in fact, grow taller and larger than controls. The hypothesis and its predictions were supported.

READING TOOL

Make a chart that lists and describes the different steps of scientific methodology.

INTERACTIVITY

Try your hand at a simulation of a scientific investigation.

Observing and Asking Questions Scientific investigations begin with **observation**, the act of noticing and describing events or processes in a careful, orderly way. Of course, scientific observation involves more than just "looking." The right kind of observation leads to asking questions that no one has asked (or answered) before.

Inferring and Forming a Hypothesis After posing questions, scientists use further observations to make inferences. An **inference** is a logical interpretation based on what scientists already know. Inference, combined with a creative imagination, can lead to a hypothesis. A **hypothesis** is a tentative scientific explanation that can be tested by further observation or by experimentation. Scientific hypotheses must then be tested by gathering data that can either support or reject them.

Designing Controlled Experiments Testing hypotheses often involves designing experiments that measure factors that can change. These changeable factors are called variables. Some possible variables include temperature, light, time, and availability of nutrients. Ideally, a hypothesis should be tested by an experiment in which only one variable is changed. All other variables should be kept unchanged, or controlled. This is called a **controlled experiment**.

Controlling Variables It is important to control variables because if several variables are changed, researchers can't easily tell which variable is responsible for any results they observe. The variable deliberately changed is called the **independent variable**. The variable that is observed and that changes in response to the independent variable is called the **dependent variable**.

Control and Experimental Groups Typically, experiments are divided into control and experimental groups. A **control group** is exposed to the same conditions as the experimental group except for changes in the independent variable. Scientists always try to reproduce or replicate their observations by setting up several control and experimental groups, rather than just a single pair.

Collecting and Analyzing Data Scientists observe their experiments, gathering two main types of **data**. *Quantitative data* are numbers obtained by counting or measuring. In the marsh grass experiment, quantitative data could include the number of plants per plot; the length, width, and weight of each blade of grass; and so on. *Qualitative data* are descriptive and involve characteristics that cannot usually be measured. Qualitative data in the marsh grass experiment might include notes about whether the grass was growing upright or sideways, or whether one or another plot was disturbed by clam diggers.

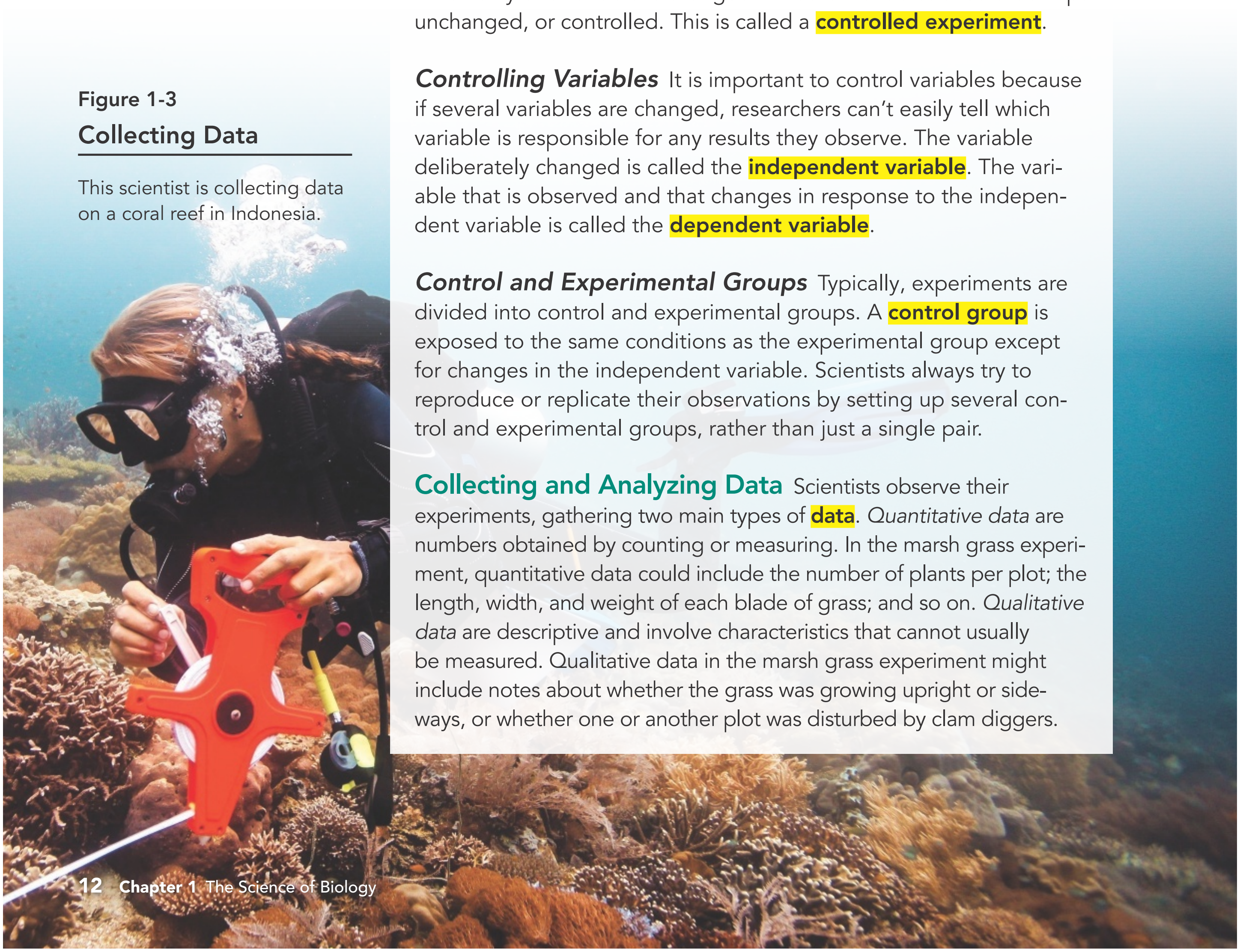


Figure 1-3

Collecting Data

This scientist is collecting data on a coral reef in Indonesia.

Selecting Equipment and Technology Scientists collect and analyze data using tools that range from simple meter sticks to complex hardware that measures leaf nitrogen content. Data are often gathered directly by hardware controlled by computers running software that organizes and analyzes results. Statistical analysis helps determine if an experimental treatment is significantly different from controls.

Sources of Error Researchers must avoid errors in data collection and analysis. Tools used to measure the size and mass of marsh grasses, for example, have limited accuracy. Data analysis and sample size must be chosen carefully. The larger the sample size, the more reliably researchers can analyze variation within each group, and evaluate differences between experimentals and controls.

Interpreting Data and Drawing Conclusions Data analysis may lead to conclusions that support or refute the hypothesis being tested. Often, new data indicate that a hypothesis is on the right track, but is off-base about a few details. New questions lead to new and revised hypotheses, which are tested with new experiments that involve better control of variables or other changes in experimental design.

When Experiments Aren't Possible Not all hypotheses can be tested by experiments. Animal behavior researchers, for example, might propose hypotheses about how groups of animals interact in nature. These hypotheses are tested by field observations designed to disturb natural behavior as little as possible. Analysis of data from these observations may lead to new hypotheses that can be tested in different ways. If investigations suggest, for example, that members of a group are related to one another, genetic tests can gather data that support or reject that hypothesis.

Sometimes ethics prevent certain types of experiments. For example, in medical research, when a chemical is suspected as a cause of cancer, researchers do not purposely expose volunteers to the chemical. They study people who have already been exposed, using those who have not as the control group.

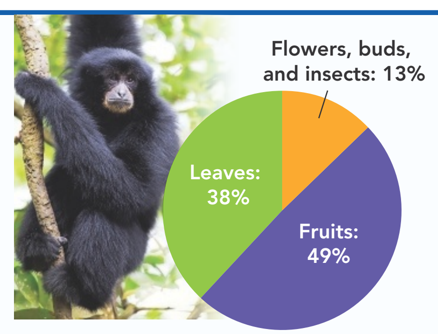
READING CHECK **Describe** What is the difference between quantitative data and qualitative data?

Analyzing Data

What's in a Diet?

The circle graph shows the diet of the siamang gibbon, a type of ape found in the rain forests of Southeast Asia.

1. **Analyze Graphs** According to the circle graph, which plant parts do siamangs rely on most as a food source?
2. **Form a Hypothesis** How would siamangs be affected if the rain forests they live in produced less fruit? Explain your reasoning.



Scientific Theories

Researchers hope that data from many individual experiments add up to something bigger—a larger and more useful understanding of how the world works. That's where we encounter an important scientific term: **theory**. Many other terms you'll learn this year will be new to you, because they are used only in science. But the word *theory* is also often used in everyday life. That causes problems, because nonscientists use the word *theory* in a very different way than scientists do. When most people say, "I have a theory," they mean, "I have a hunch" or "I have a guess." When a friend says, "That's just a theory," she may mean, "People aren't too certain about that idea." Scientists would never use the word *theory* in that way. In those situations, a scientist would use the common words "guess" or "hunch" or a scientific term we've already discussed: *hypothesis*.

When scientists refer to gravitational theory or evolutionary theory, they do not mean "a hunch about gravity" or "a guess about evolution." ***In science, the word theory applies to a tested, highly-reliable scientific explanation of events in the natural world that unifies many repeated observations and incorporates durable, well-supported hypotheses that enable scientists to make accurate predictions.*** Charles Darwin developed lots of hypotheses over many years. It took a long time for him to assemble his thoughts and hypotheses into his theory of evolution by natural selection. Since then, evolutionary theory has predicted things Darwin couldn't have imagined, such as the evolution of bacteria that resist antibiotics and insects that are immune to pesticides. Today, evolutionary theory is the central organizing principle of all biological science.

Once a theory has been thoroughly tested and supported by many lines of evidence, it may become the dominant scientific view. But remember that no theory is absolute truth. Science is always changing; as new evidence is uncovered, a theory may be revised or replaced by a more useful explanation.

BUILD VOCABULARY

ACADEMIC WORDS A scientific **theory** describes a well-tested explanation for a range of phenomena. Scientific theories are different from scientific laws, and it is important to understand that theories do not become laws. Laws, such as ideal gas laws in chemistry or Newton's laws of motion, are concise, specific descriptions of how some aspects of the natural world are expected to behave in a certain situation. In contrast, scientific theories, such as cell theory or the theory of evolution, are more dynamic and complex. Scientific theories encompass a greater number of ideas and hypotheses than laws, and are constantly fined-tuned through the process of science.

LESSON 1.1 Review

KEY IDEAS

1. In your own words, define the term *science*.
2. Why are hypotheses so important to controlled experiments?
3. How does a theory differ from a hypothesis?

CRITICAL THINKING

4. **Form a Hypothesis** You observe mold growing on one side of a slice of bread, but not on the other side. Form a hypothesis to explain this difference in mold growth.
5. **Plan an Investigation** Design a controlled experiment to test the effect of water temperature on goldfish. Be sure to include your hypothesis, independent variable, and dependent variable, as well as the experimental and control groups in your experiment.

Assignment: Scientific Methodology

Multiple Choice (Choose the correct answer for each question)

1. **What is the first step in scientific methodology?**
   a) Designing a controlled experiment
   b) Observing and asking questions
   c) Drawing conclusions
   d) Collecting data
2. **In a controlled experiment, which variable is deliberately changed?**
   a) Independent variable
   b) Dependent variable
   c) Control variable
   d) Experimental variable
3. **Which of the following statements best describes a hypothesis?**
   a) A well-tested explanation for a wide range of observations
   b) A logical interpretation based on prior knowledge
   c) A tentative explanation that can be tested
   d) A statistical result from data analysis
4. **Why is it important to control variables in an experiment?**
   a) To observe all factors that could influence the outcome
   b) To ensure that results are not biased by multiple changing factors
   c) To allow the researcher to change as many conditions as possible
   d) To prove that the hypothesis is correct
5. **What is the role of quantitative data in scientific research?**
   a) It describes characteristics that cannot be measured
   b) It involves numbers and measurements obtained from experiments
   c) It helps form hypotheses
   d) It is used to control variables
6. **Which of the following is true about scientific theories?**
   a) Theories are the same as hypotheses
   b) Theories can become scientific laws if tested enough
   c) Theories are highly reliable explanations supported by evidence
   d) Theories are guesses scientists make before testing

Short Answer

7. **In one to two sentences, explain why scientific theories are not considered absolute truth, even if they are well supported by evidence.**