Arizona's Instrument to Measure Standards

AIMS Science

Sample Test
High School

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Arizona Department of Education
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Instruction

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THEORIES, LAWS, AND HYPOTHESES

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One aspect of the nature of science is that scientific laws and scientific theories are different kinds of scientific knowledge and have different roles in science (Bell 2002; Chiappetta and Koballa 2004; Osborne et al. 2003). Perhaps the simplest way to think about a scientific law is as a "generalization derived from facts" (Bell 2008, p. 113). In science, a "fact" is a behavior or phenomenon that has been repeatedly observed and therefore enjoys a high degree of consent among the scientific community.

A law describes a generalization or pattern observed in the natural world, is based on many observations, and is often expressed as a relationship or in mathematical terms. Laws provide no explanation for why a phenomenon occurs. For example, Boyle's law describes the relationship between the pressure and volume of a gas under relatively normal conditions (close to room temperature and pressure). Boyle's law states that, when holding temperature constant, the pressure of a gas is inversely proportional to its volume. This law describes what happens under specific conditions but does not provide an explanation for why it happens.

A scientific theory offers an explanation for why a phenomenon occurs or a relationship exists. Theories are wellsupported explanations, based on abundant data, which typically develop over time (Bell 2008; Lederman and Lederman 2004). They provide the explanation for scientific laws, but they can also explain phenomena for which no law has been identified. For example, chromosomal theory helps explain Mendel's laws of heredity, while Darwin's theory of evolution through natural selection explains the phenomenon of genetic change in biological populations over time. Either way, theories are powerful ideas in that they offer evidence-based explanations for natural phenomena, including scientific laws. Sometimes, theories explain multiple laws. Kinetic molecular theory, for example, explains the relationship expressed by Boyle's law in terms of gas particle motion. It also explains Charles's law (the direct relationship between the temperature and volume of a gas). In other cases, we have scientific laws for which there is no widely accepted theory. Newton's first law (the law of inertia) and the law of gravity have no single accepted theories to explain them.

Scientific laws and theories both require substantial evidence before they are generally accepted by scientists, and either can change with new evidence. However, theories and laws are different types of scientific knowledge; neither can change into the other.

Scientific hypotheses can be tentative explanations for an observation or phenomena that can be tested through investigation (explanatory) or proposed answers to research questions (e.g., generalizing, descriptive, simple if-then predictions). Depending on which type of hypothesis one starts with, a hypothesis that is well-supported by data could eventually become a scientific theory or law; thus hypotheses can be thought of as either "trial theories," "trial laws," or simple predictions. Explanatory hypotheses may become theories, and hypotheses that provide descriptive generalizations may become laws. However, it's important to note that most hypotheses do not propose new theories or laws; rather, they work within existing theories and laws.

Read the information about a photosynthesis experiment then answer questions 1-3.

Mrs. Ryland placed a water plant in a test tube, filled the test tube with water, and then inverted the tube in a beaker half filled with water. She placed a lamp next to the beaker and turned on the light (see Figure 1). The next day the class saw that the level of water in the test tube had gone down (see Figure 2).
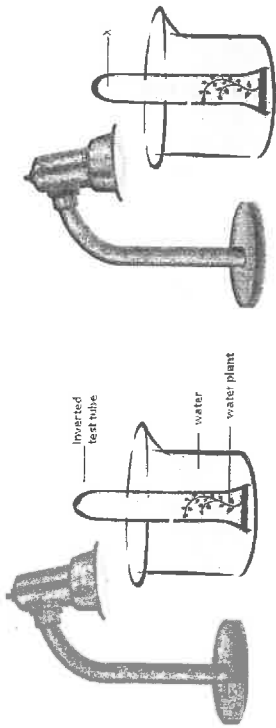
inverted test tube
water
water plant

Figure 1

Figure 2

After seeing these results, Ella wrote four questions in her lab notebook.

Question 1: Why did the water level in the test tube go down?
Question 2: Is light needed to change the water level in the test tube?
Question 3: Did light cause the water level in the test tube to go down?
Question 4: Would a different type of plant change the water level in the test tube?

Ella set up an experiment to investigate one of her questions. She set up one test tube to look like Figure 1. She set up another test tube similar to Figure 1 but without a lamp, and placed it in a dark closet. A day later, Ella checked the water level in each test tube.

1 Which question could best be answered with her experiment?

A Question 1

B Question 2

C Question 3

D Question 4

2 What was the dependent variable in the student's experiment?

A the amount of light

B the amount of time

C the water level in the test tube

D the type of plant in the test tube

3 What is the main substance found in the top part of the test tube labeled X in Figure 2?

A oxygen

B nothing

C water vapor

D carbon dioxide

4 In fruit flies, the allele for red eyes (R) is dominant and the allele for sepia eyes (r) is recessive. A female fly has red eyes. How can you determine the female fly's genotype?
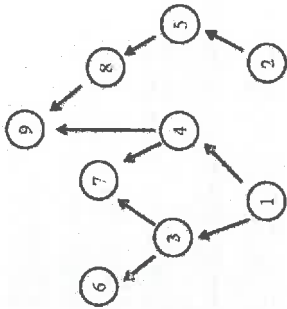
A Mate the female with a male with red eyes. If any of the offspring have sepia eyes, she must be RR.

B Mate the female with a male with red eyes. If any of the offspring have red eyes, she must be Rr.

C Mate the female with a male with sepia eyes. If any of the offspring have sepia eyes, she must be Rr.

D Mate the female with a male with sepia eyes. If any of the offspring have red eyes, she must be RR.

Read pages 224-225 in the textbook

Directions

Read the information about the food web below then answer questions 5 – 7.

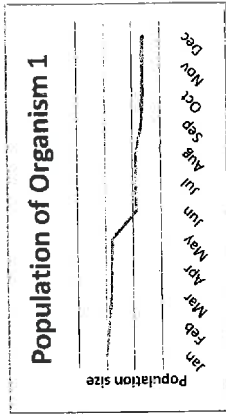Each number represents an organism in the food web.

Textbook pages 244 - 245

5 Which of the following organisms can transform light energy into chemical energy?
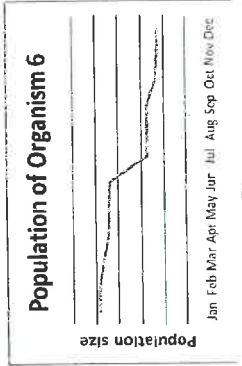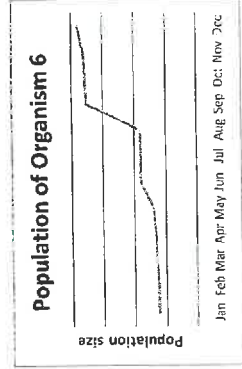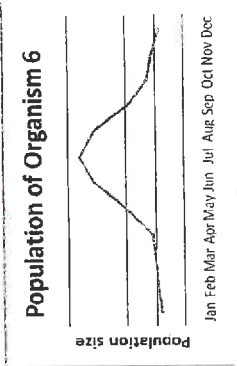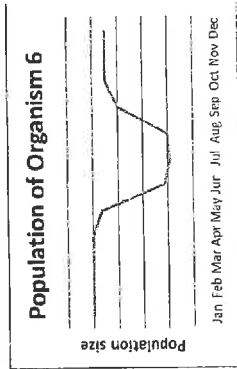
A organism 1

B organism 4

C organism 7

D organism 9

6 If a disease killed off all of organism 2, which of the following organisms would be most affected?

A organism 3

B organism 7

C organism 8

D organism 9

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7 A scientist monitored the population sizes of organisms 1 and 6 over a one year period. Below is a graph showing how the population of organism 1 changed.

Population of Organism 1

Which of the following graphs would best represent the population size of organism 6 over the same time period?

A — Population of Organism 6

B — Population of Organism 6

C — Population of Organism 6

D — Population of Organism 6

Directions

Read the information about fish hatcheries then answer questions
8 – 10.

Fish hatcheries are an enclosed environment used to farm a large number of fish. A fish biologist wondered if fish raised in hatcheries would be able to survive in a wild environment. The biologist thought that fish raised in hatcheries lost their fear of predators.
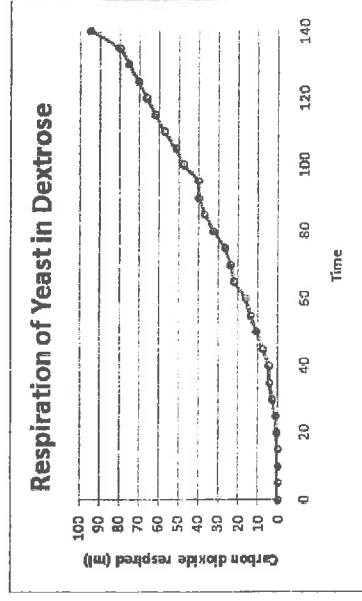
To test the idea, he placed 15 young hatchery trout and 15 wild trout of the same age and species into two separate but identical tanks. He divided each tank in half by inserting a clear divider made out of plexiglass. The biologist placed the trout on one side of the plexiglass divider and a large predatory fish – the northern pike – on the other side of the plexiglass. He then recorded the amount of time it took the young trout to move to the back of the tank away from the northern pike. The biologist found that the hatchery fish moved away much slower than the wild fish.

8 What information is **least** relevant to understanding this experiment?

   A the number of fish in each tank

   B the location where the trout were raised

   C the type of clear divider used to separate the fish

   D the time it took the trout to move to the back of the tank

9 Which of the following statements is the basis for the hypothesis that was tested?

   A "A fish biologist wondered if fish raised in hatcheries would be able to survive in a wild environment."

   B "The biologist thought that fish raised in hatcheries lost their fear of predators."

   C "To test the idea, he placed 15 young hatchery trout and 15 wild trout of the same age and species into two separate but identical tanks."

   D "The biologist found that the hatchery fish moved away much slower than the wild fish."

10 Prior to starting the experiment, the biologist needed to fill out paperwork explaining procedures for using and caring for the fish in his experiment. What is the purpose for this paperwork?

   A to ensure that his research animals will be treated humanely

   B to determine whether all of the fish were of the same species and age

   C to verify that his sample size will be sufficient for meaningful results

   D to document procedures so his experiment can be reviewed or repeated

11 Teresa placed 1.0 g of dry yeast in a 10% solution of dextrose and measured the amount of carbon dioxide released at 5 minute intervals. Teresa collected the data and graphed the results. All data points are accurately plotted.

Respiration of Yeast in Dextrose

Which of the following changes should Teresa make to better communicate the results?

   A Add units to the label of the independent variable.

   B Include a legend that shows the type of solution used.

   C Label the x-axis to display the time in increments of five.

   D Scale the y-axis to end at the greatest respiration rate (94 ml).
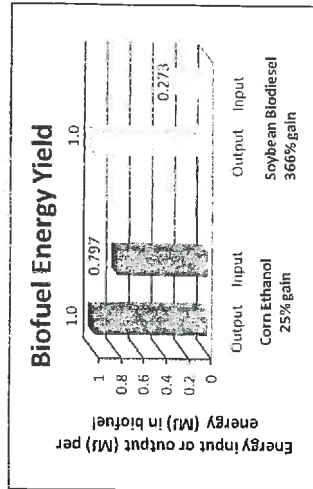
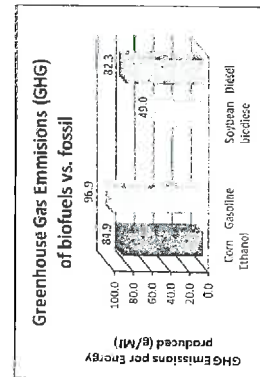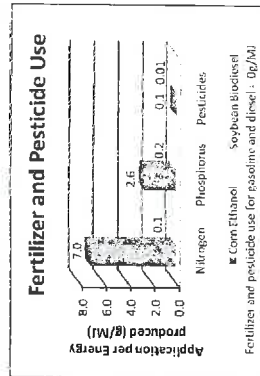Read the information about biofuels then answer questions 12 – 14.

Negative environmental consequences of fossil fuels and concerns about petroleum supplies have led to the search for renewable biofuels. To be a viable alternative, a biofuel should provide a net energy gain, have environmental benefits, be economically competitive, and be producible in large quantities without reducing food supplies.

An energy consultant wanted to determine whether two biofuels, corn ethanol and soybean biodiesel, met the criteria for a viable alternative fuel. Corn ethanol is a biofuel that could be used to replace gasoline. Soybean biodiesel is a biofuel that could be used to replace diesel fuel.

The consultant collected data for these two fuels and summarized them in the following graphs.

Biofuel Energy Yield

Energy input is the amount of energy needed to grow and harvest the crop and convert it to biofuels. Energy output is the amount of energy yielded from the biofuel.

Fertilizer and Pesticide Use

Greenhouse Gas Emmisions (GHG) of biofuels vs. fossil

(data from http://www.pnas.org/content/103/30/11206.full.pdf+html)

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12 Why is it important to know the energy input and output when comparing possible biofuels?

A Low energy input leads to low energy output of the biofuel.

B High energy input leads to high energy output of the biofuel.

C Biofuels should have a high energy input and a lower energy output.

D Biofuels should have a low energy input and a higher energy output.

13 The consultant concluded that soybean biodiesel was a viable alternative to diesel fuel. Which of the following statements has data to support this conclusion?

A Soybean biodiesel requires more energy to make than it produces.

B Soybean biodiesel releases less greenhouse gas pollution than diesel fuel.

C Growing soybeans for biodiesel adds needed nitrogen into the environment.

D Growing soybeans for biodiesel increases the amount of pesticides in the environment.

14 During heavy rains, water runoff from crop fields can contaminate nearby lakes or rivers with fertilizers, leading to eutrophication. Which fuel source has the greatest potential to cause eutrophication?

A diesel

B gasoline

C corn ethanol

D soybean biodiesel

Read pages 274 - 277 in the textbook.
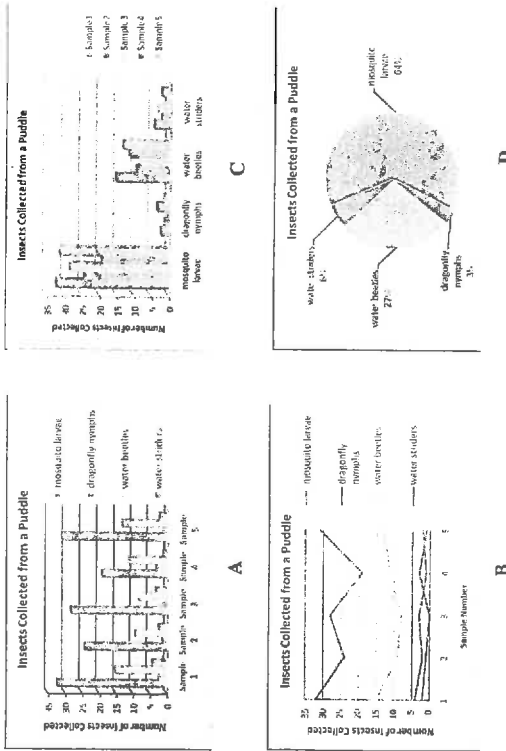
15 What molecules do both DNA and RNA contain?

A uracil

B thymine

C nucleotides

D deoxyribose

Read pages 214 - 217 in the textbook.

16 An entomologist collected 5 samples of insects from a large puddle. The table below shows the collected data.

Insect Collected	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
mosquito larvae	32	24	28	19	31
dragonfly nymphs	2	1	0	3	1
water beetles	15	9	8	11	13
water striders	4	2	3	1	2

Which of the following data displays **best** represents the distribution of insects collected from the puddle?

A

B

C

D

17 Which list shows different levels or organization within a population ordered from **least** to **most complex**?

A   organ systems, organs, organelles, organisms

B   organelles, organs, organ systems, organisms

C   organisms, organ systems, organs, organelles

D   organs, organelles, organisms, organ systems

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18 Jim collected owl pellets in a field near his home and then dissected them. The following table shows the frequency of mice found in the collected owl pellets.

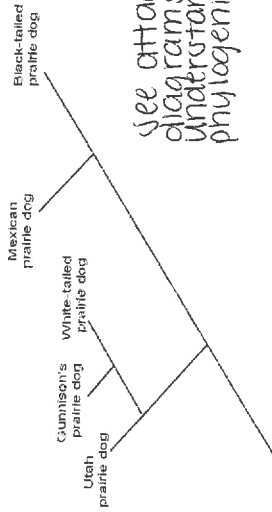| Number of Mice per Pellet	Number of Pellets
0	2
1	4
2	3
3	7
4	3
5	1

What is the mean number of mice per owl pellet?

A   2.0

B   2.4

C   3.0

D   3.3

19 A professor of molecular biology has completed an experiment on mutations. The results indicate that the current understanding of how mutations occur is incomplete. Which is the most appropriate way to share the results of this experiment?

A   hold a press conference

B   publish the results in a scientific journal

C   send the results to newspapers and magazines

D   share the results with classes of university students

Hint: what group of people should hear about this new info first?

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20 The figure below shows the classification of several types of prairie dogs.

see attached reading: diagrams about understanding phylogenics.

Which of the following statements is **best** supported by the classification in this figure?

A The Utah prairie dog was the ancestor of the Gunnison's prairie dog.

B The White-tailed prairie dog evolved from the Black-tailed prairie dog.

C The Mexican prairie dog and the Utah prairie dog share a common ancestor.

D The Mexican prairie dog is the closest relative of the White-tailed prairie dog.

21 Fruit flies have 3 chromosomes plus sex chromosomes (X and Y). Mutations occurred within four different cells of an individual female fruit fly as shown in the table below.
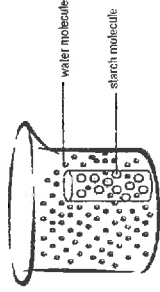
Cell Type	Chromosome	Trait	Normal Phenotype	Mutated Phenotype
exoskeleton	2	head features	eyes present	eyes are absent
gamete	2	wing shape	straight wings	curly wings
muscle	X	body color	tan body	yellow body
nerve	3	antenna shape	normal antennae	leg-shaped antennae

Which of these mutations could be passed on to this fruit fly's offspring?
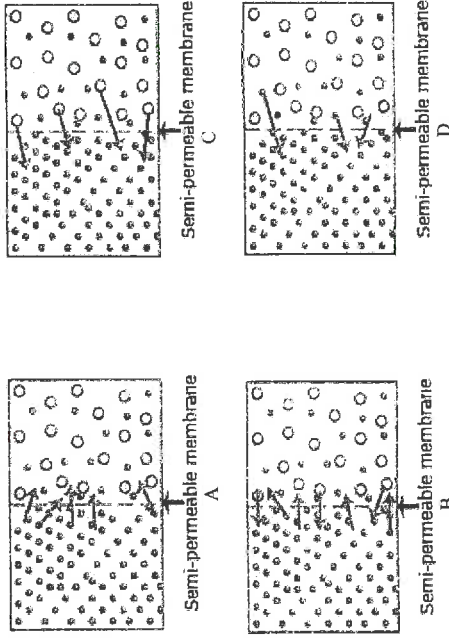
A absent eyes

B curly wings

C yellow body

D leg-shaped antennae

Reference pages in textbook: 224-225; 228-229

22 A potato core was placed in a beaker of water as shown in the figure below.

Which diagram **best** represents the net movement of molecules?

23 A tree frog population lives in the canopy of a tropical rain forest. In this tree frog population, a mutation occurs that results in a new allele for skin coloration causing stripes on their legs.

Which of the following factors has the **greatest** effect on whether leg stripes will become more common in the tree frog population?

A if the reproduction rate of the tree frog population remains constant over time

B if the new allele for stripes is dominant or recessive in the tree frog population

C if the new allele for stripes increases the survival of the tree frogs in their environment

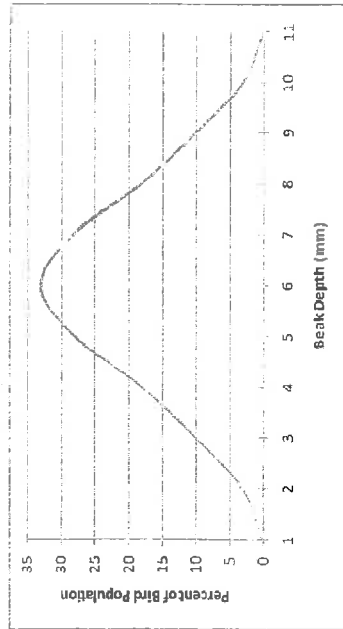D if enough food and water is available in the rain forest canopy for the tree frog population

Allele definition → textbook p. 222

24 How do nitrogen-fixing bacteria help cycle nitrogen through ecosystems?

A They release nitrogen into the atmosphere when they replicate their DNA.

B They convert nitrogen into the atmosphere which is then stored in the nitrogen.

C They convert ammonia from animal feces and urine into forms that plants can use.

D They capture nitrogen from the atmosphere and convert it into forms that plants can use.

textbook pages: 252-253

25 On a small isolated island, there is a single species of seed-eating birds. Individual birds are able to eat seeds that are within 2 mm (larger or smaller) of their beak depth. The distribution of individuals is shown in the figure below.
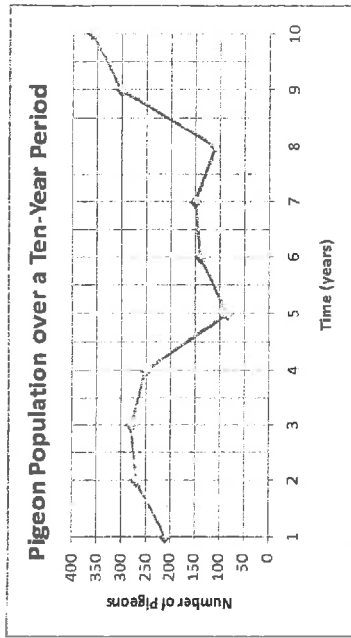

textbook pages: 238-239

A long drought caused the plant species that produce seeds between 3-9 mm in size to go extinct. What does the Theory of Natural Selection predict will happen to the population of seed-eating birds over time?

A It will permanently shrink to approximately 25% of its current size.

B It will go extinct because there aren't enough seeds to support all of the individuals.

C It will diverge into two species: one that eats small seeds and one that eats large seeds.

D It will adapt and the birds that ate the medium sized seeds will learn to eat fish, insects, or other animals.

26 The graph below shows a population of pigeons living in a neighborhood over a ten-year period.

Which of the following statements could account for the change in population seen between years 7 and 8?
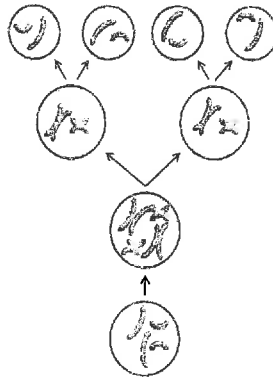
A The birth rate of the pigeons increased.

B The emigration rate of the pigeons decreased.

C The death rate of the pigeons exceeded the birth rate.

D The neighborhood reached its carrying capacity for the pigeon population.

textbook page 255

27 A fertilizer company claims that their fertilizer causes rose bushes to produce more flowers. To support this claim, they set up an investigation. They added the recommended amount of fertilizer to 100 rose bushes in a greenhouse, and then they counted the number of flowers that developed on each plant. The number of flowers on each rose bush ranged from 28 to 36. The mean number of flowers on each plant was 33.

A gardener was skeptical of the company's claim. Which statement provides the **best** reason to be skeptical?

A The sample size was too small to be valid.

B The investigation tested only one variable.

C The research was conducted without a control.

D The investigation was conducted only on rose plants.

28 The distribution of chromosomes in one type of cell division is shown in the diagram below.

textbook pages 218 - 221

Which process and type of resulting cells are represented in the diagram?

A mitosis, which produces gametes

B mitosis, which produces body cells

C meiosis, which produces gametes

D meiosis, which produces body cells

29 The city of Surprise, Arizona converts raw sewage into reclaimed water through filtering and disinfection. Most of Surprise's reclaimed water is used for agricultural irrigation, landscape irrigation, dust control, and recharging the aquifer. Approximately 3.2 million gallons per day are reused.

What is one environmental benefit of reclaiming waste water?

A It reduces the demand for ground water.

B It is less expensive than purified ground water.

C It keeps golf courses and landscape grasses green.

D It can be used during water restrictions in a drought.

textbook pages 284 - 285

30 Which of the following organisms has cells with chloroplasts?

A cauliflower

B mushrooms

C green tree frogs

D photosynthetic bacteria

31 Which of the following statements about scientific theories is **not** correct?
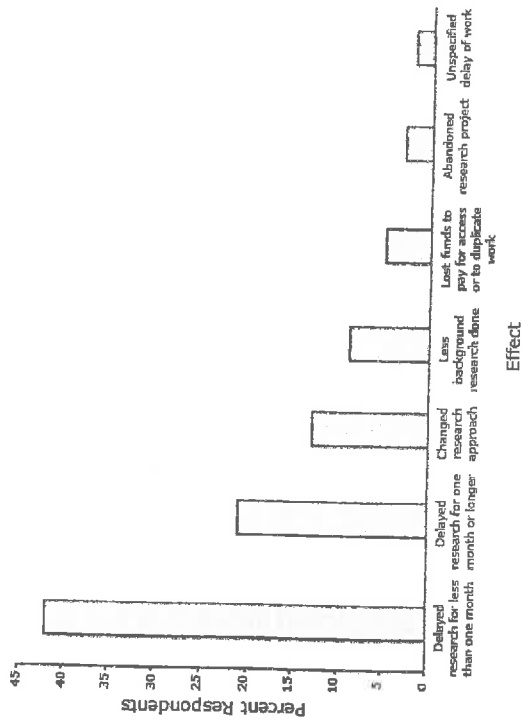
A Theories have been tested many times.

B Theories are incomplete, temporary ideas.

C Theories are inferred explanations, strongly supported by evidence.

D Theories explain a range of observations and are used to make predictions.

Read attached info about hypotheses, laws and theories.

32 Scientific research has traditionally been conducted on the principle of open science, but now patents are granted to things like experimental methods and genes. Scientists now copyright their work to protect the rights to their ideas. If patents and copyrights hinder scientific research, they could become a serious problem. The figure below shows areas of difficulties that scientists face when trying to access copyrighted literature.

Difficulties in Accessing Copyrighted Literature

Source: *AAAS-SIPPI 2006 Effects of Intellectual Property Protections Survey Database*

What is one way that copyrights on scientific literature hinder scientific advancement?

A Background research for experiments is more complete.

B Experiments or research projects are not able to start on schedule.

C Scientists are protected so other labs or companies can't steal their ideas.

D Paying for copyright use increases the amount of funds available to do research.