Everglades K-12 Publishing's Florida Science Standards Biology End-of-Course
Table of Contents by Benchmark

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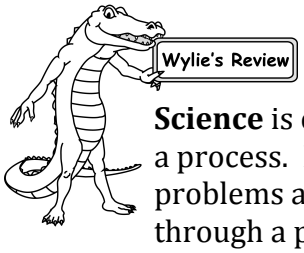
Biology End-of-Course Benchmarks

The Scientific Method

SC.912.N.1.1	**Define a problem based on a specific body of knowledge, for example: biology, chemistry, physics, and earth/space science, and do the following:** **1. pose a question about the natural world;** **2. conduct systematic observations;** **3. examine books and other sources of information to see what is already known;** **4. review what is known in light of empirical evidence;** **5. plan investigations;** **6. use tools to gather, analyze, and interpret data (this includes the use of measurement in metric and other systems, and also the generation and interpretation of graphical representations of data, including data tables and graphs);** **7. pose answers, explanations, or descriptions of events;** **8. generate explanations that explicate or describe natural phenomena (inference);** **9. use appropriate evidence and reasoning to justify these explanations to others;** **10. communicate results of scientific investigations; and** **11. evaluate the merits of the explanations produced by others.**
Also assesses:	
SC.912.N.1.4	**Identify sources of information and assess their reliability according to the strict standards of scientific investigation.**
SC.912.N.1.6	**Describe how scientific inferences are drawn from scientific observations and provide examples from the content being studied.**
SC.912.L.14.4	**Compare and contrast structure and function of various types of microscopes.**



Science is often thought of as the study of something, but in reality, science is a process. It is a way of looking at the world and a method for solving problems and seeking answers. It can be thought of as knowledge gained through a process of inquiry. Science depends upon critical thinking, as well as curiosity and creativity.

Scientists use a modified version of the **scientific method** – a procedure for systematic discovery that, when followed, allows scientists to replicate and validate each other's work.

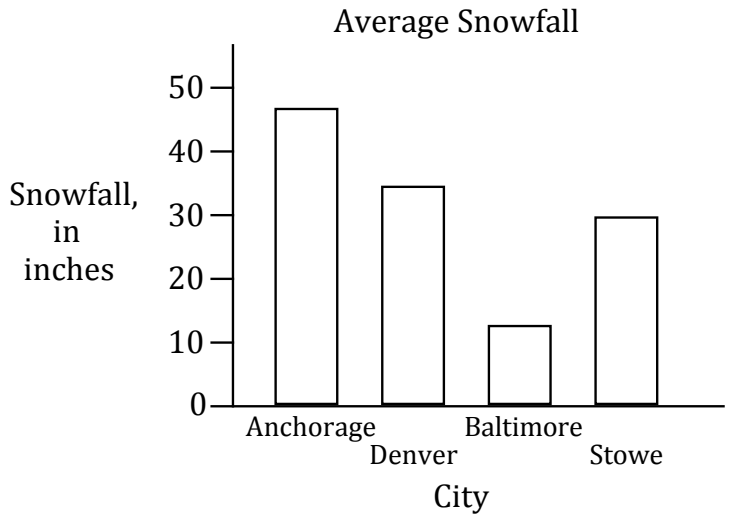
- Traditionally the scientific method begins with a problem. Research into that problem leads to a **hypothesis** – an educated guess. A hypothesis is often written as an If _____, then _____ statement: If something is done to an independent variable, then it results in some measurable change to a dependent variable. The **independent variable** is the variable that is changed or manipulated. The **dependent variable** is the one that is measured. For example, if different fertilizers (the independent variable) are applied to a plant, differences in growth (dependent variable) will be measured.
- Once a hypothesis has been established, the next step would be to either conduct further research and/or design or execute an experiment. An **experiment** is a planned process designed to test a hypothesis. Many scientific experiments are controlled experiments. In a controlled experiment there is a group (the **control**) that remains unchanged (no experimental treatment) – the control is there for comparison.
- Results of an experiment create **data** – pieces of information, be it facts or statistics that can be analyzed (examined). Data is often displayed in a table or a graphic format.

Diversity of Selected Species on Caribbean Islands

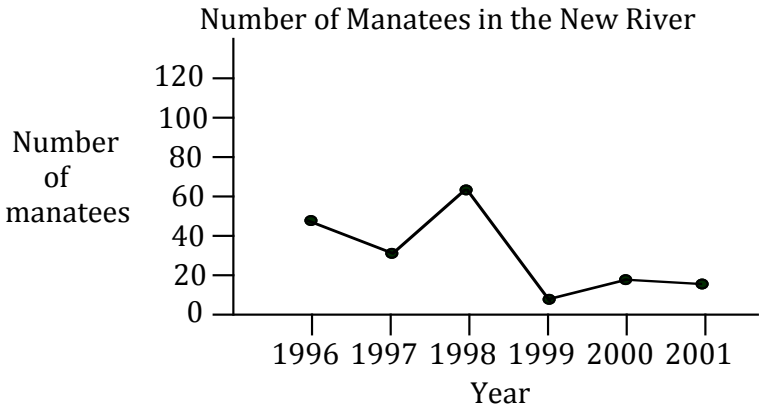
Island	Area of Island (square miles)	Number of Selected Species
A	8	8
B	80	12
C	1400	70
D	15,000	110
E	17,000	110

The two most common graphs for scientific data are bar graphs and line graphs.

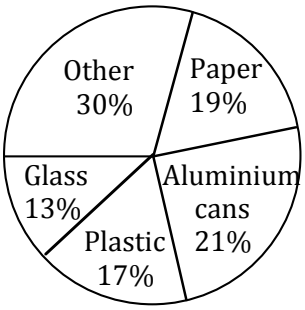
- Bar Graphs – bar graphs are useful when comparing discrete data. The independent variable goes on the X-axis; the Y-axis is the dependent variable. Bar graphs represent the frequency of distinct, separate pieces of information. The bars of a bar graph do not touch as the data is discrete.



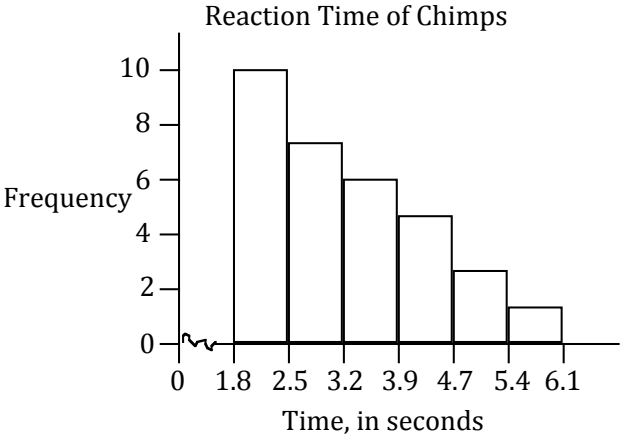
- Line graphs – line graphs are used to show changes over time. They are especially useful when there are many data points for one variable. Line graphs graph continuous data.



Occasionally scientific data is presented as a circle graph (pie chart). Circle graphs show the relationship of parts to a whole.



Histograms are similar to bar graphs, but the bars MUST touch, because the data represents continuous data, which forms a continuous range from left to right, usually time.



Once the data has been collected and analyzed, a conclusion – based on the hypothesis – can be determined. A **conclusion** is an explanation of what happened. In order to be scientifically useful, a conclusion must be related to the original hypothesis.

- The final check on any scientific experiment is for it to be repeatable. Results must be **verifiable** – other scientists must be able to get the same or similar results from the same experiment.
- Conclusions can either support a hypothesis or refute it. Hypotheses that have been refuted have been disproved. The hypothesis must be re-worked or an entirely different approach to the problem may be necessary. Conclusions that support a hypothesis do just that – provide support. A hypothesis is never proven correct because there may be other information that would impact the hypothesis. A hypothesis that has withstood the test of time becomes a theory – as close to a fact as scientists can be.

Scientists work in the metric (S.I.) system.

Conversions Between Metric Units

1 centimeter (cm) = 10 millimeters (mm)
1 meter (m) = 100 centimeters = 1000 millimeters
1 kilometer (km) = 1000 meters

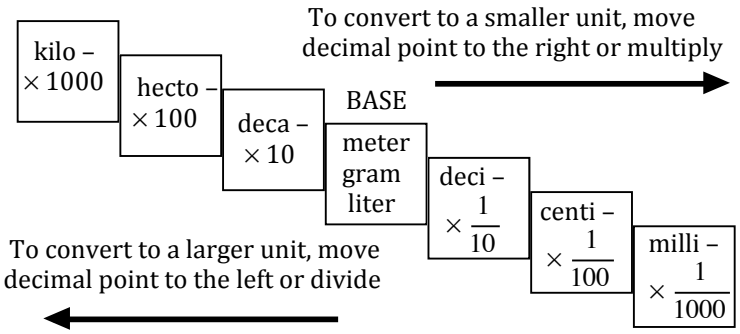
1 liter (l) = 1000 millimeters (ml) = 100 centiliters (cl)
1 kiloliter (kl) = 1000 liters = 1,000,000 milliliters

1 gram (g) = 1000 milligrams (mg)
1 kilogram (kg) = 1000 grams

Length (distance) is measured using the meter; mass is expressed in grams; volume is expressed in liters. Temperature can be measured in either K (Kelvin) or C (Celsius). Celsius is usually used for measuring temperature between the freezing (0˚C) and boiling (100˚C) points of pure water. Kelvin is used to measure temperatures down to absolute zero.

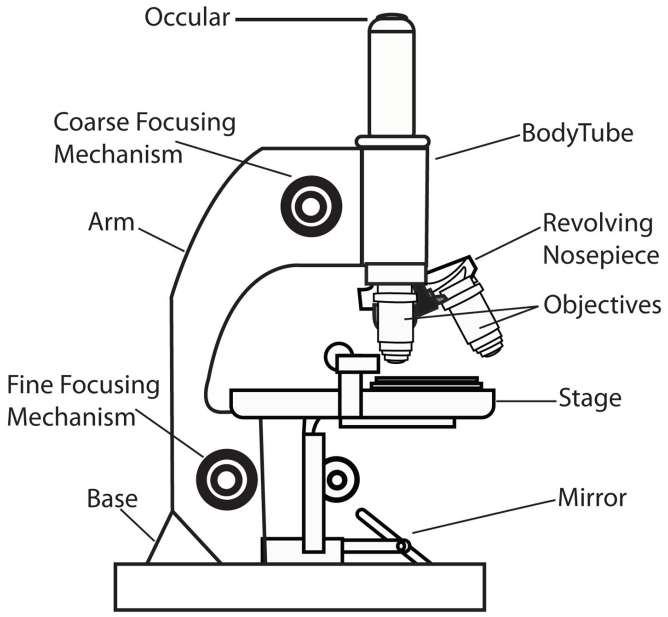
Temperature	Kelvin, K	Celsius, ˚C	Fahrenheit, ˚F
Boiling point of water	373.14	100	212
Melting point of ice	273.15	0	32
Absolute zero	0	-273.15	-459.67
Average room temperature		20 to 25	68 – 77
Average human body temperature		37	98.6

Because the metric system is based on the powers of 10, conversion is as simple as moving the decimal point.



Over the years there have been many technological advances that have directly impacted scientific discovery. Chief among these, particularly for the science of biology, was the invention of the microscope. The first "microscope" was invented in 1590 by a Dutch glasses maker. **Anton van Leeuwenhoek** improved on the microscope, in the late 1600s, to the point where he could see (and describe) bacteria, protists, yeast cells, etc. He called his discoveries "animacules" – little animals. **Robert Hooke** improved upon this microscope and invented the term "cell."

- In the mid-1800s, Charles Spencer invented the first light microscope and present-day light microscopes are just a bit better. But there have been major advances in other microscopes.
- The microscope you use in your biology class is a compound light microscope, like the one below.



- This **compound light microscope** has four different lenses. The eyepiece itself usually has a magnification of 10x. One objective will be a scanning power (generally 4x magnification) for a total of 40x (10×4) magnification. The second objective is often 10x and the third 40x. Therefore the highest magnification for that particular microscope would be 10×40 or 400x magnification. The bulb in the base of the microscope provides the light source.

- **Electron microscopes** are much more powerful than light microscopes. In these microscopes a beam of electrons is bounced off the specimen. Both the beam and the specimen must be in a vacuum otherwise the beams will bounce off the molecules in the air. Because living things cannot survive in a vacuum, electron microscopes can only be used to view things that are not alive.
- In a **transmission electron microscope** (TEM), an electron beam is directed at a very thinly sliced specimen that has been stained with metal ions. Some parts of the structure will become more heavily stained than others. The parts that are lightly stained will not absorb as many electrons as the heavily stained areas. Electrons that are not absorbed pass through onto a screen projecting an image of the object being scanned. TEMs are the most powerful microscopic tool available, able to produce detailed images of objects 1 nanometer in size.
- A **scanning electron microscope** (SEM) is similar – but here the image produced is three-dimensional. The specimen is coated with a thin layer of metal. Electrons that bounce off the metal form the image. The SEM can magnify objects up to 300,000 times.

Now Try These:

For 1 – 10, use the following information.

Daphnia are small, transparent crustaceans. Using a compound microscope, it is possible to see their heart beat. Students placed the *Daphnia* in a nicotine solution and recorded the rates at which their hearts were beating. The students generated the following data chart.

Solution	Trial 1	Trial 2	Trial 3	Average
Spring water	182	175	180	
Nicotine	210	190	200	

1. What question might the students be investigating?

2. For that question, create a hypothesis. (Remember, use the format ("If ____, then_____.")

3. What is the independent variable?

4. What is the dependent variable?

5. Why were the *Daphnia* tested in spring water?

6. Give a brief analysis of the data.

7. Why were there three trials?

8. If you were to graph this data, what type of graph would you use?

9. Why did you choose that type of graph?

10. Discuss the conclusion you could infer from the data given.

For 11 – 20, use the following information.

In an effort to get the school's gardeners to practice composting, members of Ms. P's "Save What's Left" club decided to investigate the effect of different-aged grass compost on plant growth. Because decomposition is necessary for release of nutrients, the group hypothesized that older grass compost would produce taller plants. Four flats of bean plants, each containing 20 plants, were grown for 5 days. The plants were then fertilized as follows: (a) Flat A: 500g of 3-month-old compost, (b) Flat B: 500 g of 6 month-old compost, (c) Flat C: 500 g of new compost (5 days old), and (d) Flat D – no compost added. The plants received the same amount of sunlight and water each day. At the end of every 10 days, the group recorded the height of the plants for a total of 30 days.

11. Write the hypothesis (in the correct format) for this experiment.

12. What is the independent variable?

13. What is the dependent variable?

14. What units should be used to measure plant growth over a 30-day period?

15. What is the control?

16. What type of graph would be best for this data?

17. What would it look like?

18. What would be on the Y-axis?

19. What would be on the X-axis?

20. Explain why you made that choice.

Unit 1 – The Nature of Science

Chapter 1 – The Scientific Method

Formative Assessment 1

Select the best answer for each question.

For 1 – 5, in an effort to get the town to practice composting, members of the gardening club decided to investigate the effect of different-aged grass compost on plant growth. Four flats of coleus, each containing 20 plants, were grown for 7 days. The plants were then fertilized as follows: Flat A: 500 g of 3-month-old compost, Flat B: 500 g of 6-month-old compost, Flat C: 500 g of new compost (5 days old), and Flat D: no compost added. The plants received the same amount of sunlight and water each day. At the end of every 10 days, the group recorded the height of the plants for a total of 60 days.

1. In the above scenario what is the dependent variable? SC.912.N.1.1

A. water

B. days

C. fertilizer

D. the height of the plants

2. Based on the information, which of the following would be the BEST hypothesis for this experiment. SC.912.N.1.1

A. If a little bit of compost is good for plants, then more compost would be better.

B. If plants are fertilized with fresh compost, then they will grow better than those not fertilized.

C. If plants are fertilized with 6-month-old compost, then they will grow taller than those fertilized with 3-month-old compost or no compost.

D. Plants that are not fertilized will die.

3. What is the independent variable in the garden club's experiment? SC.912.N.1.1

A. the health of the plants

B. the age of the compost

C. the height of the plants

D. rate of plant growth

4. Which of the following graphs would give the best picture of the results? SC.912.N.1.1

A. bar graph

B. line graph

C. histogram

D. pie (circle) chart

5. What, if any, is the control in this experiment? SC.912.N.1.1

A. no control

B. Flat B

C. Flat C

D. Flat D

For 6 – 9, the school district wanted to determine whether the more expensive floor wax (Brand A) was better than the cheaper (Brand X) floor wax at protecting its floor tiles against scratches. One liter of each brand of floor wax was applied to each of 10 test sections of the cafeteria floor. The test sections were all the same size. Ten (10) other test sections received no wax. After 4 weeks, the number of scratches in each of the test sections was counted.

6. What is the dependent variable in this scenario? SC.912.N.1.1

A. numbers of tiles

B. types of wax

C. number of scratches

D. number of weeks

7. What is the independent variable? SC.912.N.1.1

A. numbers of tile

B. types of wax

C. number of scratches

D. number of weeks

8. What, if any, is the control in this experiment? SC.912.N.1.1

A. floor tiles with no wax

B. Brand A

C. Brand X

D. no control

9. Based on the scenario, which of the following would be the best hypothesis for this experiment? SC.912.N.1.1

A. Because Brand A is more expensive, it will protect the tile floors better than Brand X.

B. If Brand A protects floor tiles better than Brand X, then there will be fewer scratches on the tiles coated with Brand A.

C. If Brand A protects floor tiles better than Brand X, then it will last longer.

D. If the tiles coated with Brand X have twice the number of scratches, it is still better because it is cheaper.

10. All of the following are correct statements about compound microscopes EXCEPT which one? SC.912.N.1.1

A. They can be used to observe living specimens.

B. They can be used to observe preserved specimens.

C. They use light as their illuminating source.

D. They use electrons as their illuminating source.

11. In a compound microscope, the magnification of the eyepiece is 10x, and a student is using the objective with a 40x magnification to view a preserved specimen on a slide. The object being viewed will be magnified ___?___ times. SC.912.N.1.1

A. 30x

B. 40x

C. 50x

D. 400x

12. Which of the following microscopes would allow you to view the largest objects? SC.912.N.1.1

A. a compound light microscope

B. a scanning electron microscope (SEM)

C. a transmission electron microscope (TEM)

D. a stereomicroscope

13. A major disadvantage to using a SEM or TEM microscope is that SC.912.N.1.1

A. they can only view living objects.

B. they can only view whole objects.

C. they can only view objects which are not alive.

D. they cannot view preserved objects.

14. Which of the following is an appropriate unit to use when measuring liquids? SC.912.N.1.1

A. meter

B. gram

C. liter

D. kelvin

15. Jose and Maria are doing background research before setting up an experiment on Daphnia (a small transparent crustacean). They are using the Internet. Which of the following would be the most appropriate site for them to explore? SC.912.N.1.1

A. a student report on Daphnia

B. a site that ends in "edu" or "org"

C. Wikipedia

D. Google Daphnia and use the first site on the list.