

The Science of Biology Chapter 1

Sec. 1-1 What Is Science?

What Science Is and Is Not

- Science – a way of using evidence to learn about the natural world.
- Goals of Science:
 - Investigate and understand the natural world
 - Explain events in the natural world
 - Use those explanations to make useful predictions

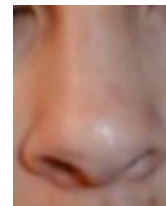
Thinking Like a Scientist



- Science starts with an observation
- Observation – the process of gathering information in a careful, orderly way

□ Use your senses:

- Sight
- Hearing
- Touch
- Smell
- Taste



- Data – information gathered from observation
- Two Types:
 - Quantitative = numbers
 - Ex) There are 7 birds at the feeder
 - Qualitative = descriptive using characteristics that can't be counted
 - Ex) The bird has a red head.
- Inference - a logical interpretation based on prior knowledge and experience



Observation and Inference

Statement	Observation	Inference
Object A is round and orange.	X	
Object A is a basketball.		X
Object C is round and black and white.	X	
Object C is larger than Object B.	X	
Object B is smooth.	X	
Object B is a table-tennis ball.		X
Each object is used in a different sport.	X	X

- Object A is a basketball.
- Object B is a table-tennis ball.
- Object C is a soccer ball.

Explaining and Interpreting Evidence

- Hypothesis - proposed scientific explanation for a set of observations
"educated guess"
- Useful only if it can be tested through a controlled experiment
- Prediction - expected outcome of a test, assuming the hypothesis is correct

Science as a Way of Knowing

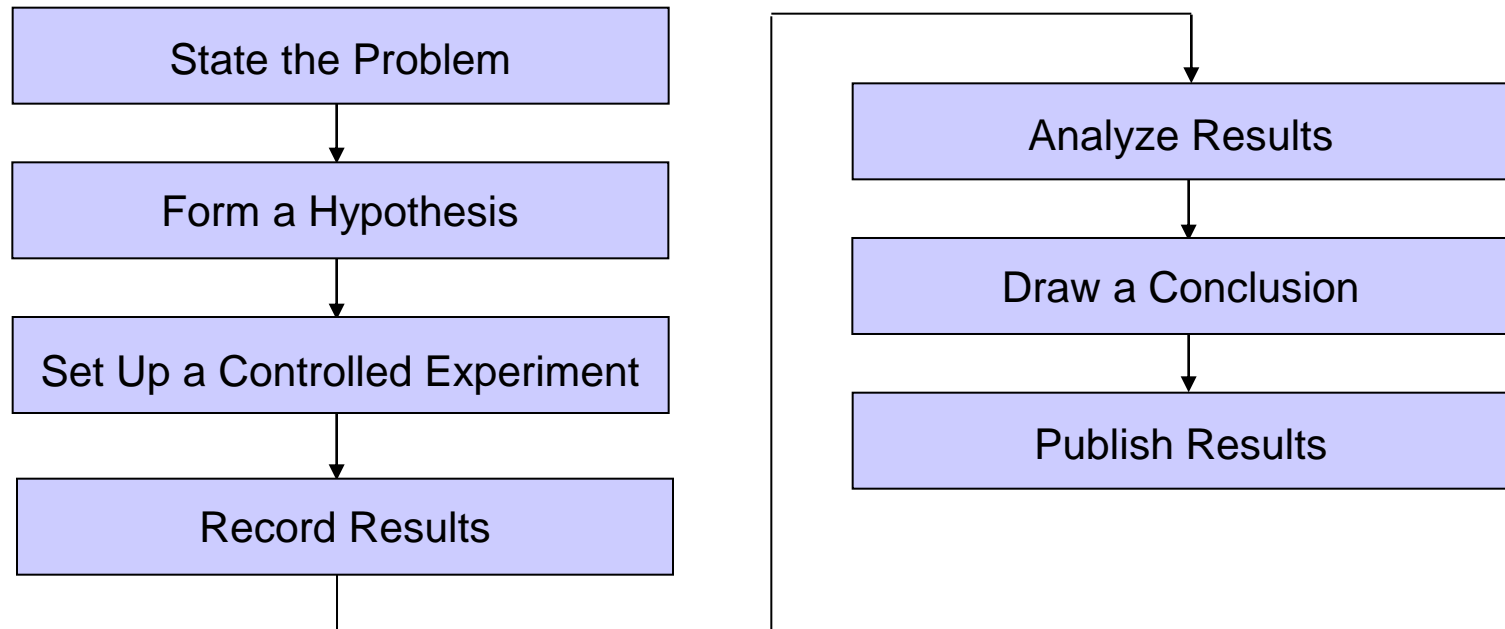
- Science is ongoing and involves:
 - asking questions
 - observing
 - making inferences
 - testing hypotheses
- Science is always changing!



Science and Human Values

- Science involves society and the economy that provides jobs, food and shelter.
- Laws and morals need to be considered when making final decisions.

Designing an Experiment



Sec. 1-2: How Scientists Work

Designing an Experiment

- Collect Observations
- State the Problem
 - identify the problem to be solved
- Forming a Hypothesis
 - a statement that can be tested
 - Ex) Maple leaves change color due to a change in temperature



■ Setting up a Controlled Experiment

- a planned procedure to test a hypothesis
- variables are factors in an experiment that can change
 - equipment used, types of material, amount of material, temperature, light, time
- Controlled experiment - a test of the effect of a one variable by changing it while keeping all other variables the same
- Manipulated variable - deliberately changes (independent variable)
- Responding variable - what changes in response to the manipulated variable (dependent variable)



■ Recording and Analyzing Results

- data is recorded on computers today

■ Drawing a Conclusion

- data is used to evaluate the hypothesis and draw a conclusion

■ Publishing and Repeating Investigations

- scientists test each other's investigations
- an experiment is published in a scientific journal
- experiments are repeated by others to make sure data is not flawed

When Experiments Are Not Possible

- Ethical considerations prevent certain experiments
 - Ex) determine the effects on people of a chemical suspected of causing cancer
- In field studies, such as animals in the wild, researchers try not to disturb natural systems when observing
- Scientists choose volunteers who may already be exposed and compare them to a group who has not

How a Theory Develops

- Theory - a well-tested explanation that unifies a broad range of observations
- **No theory is considered absolute truth!**
- A theory may be revised or even replaced
- Science is characterized by both continuity and change!

Sec. 1-3 Studying Life



- The word *biology* means the study of life.
 - (bios means "life" and -logy means "study of")
- Biology - the science that seeks to understand the living world.
- A biologist is someone who uses a scientific method to study living things.

Characteristics of Living Things

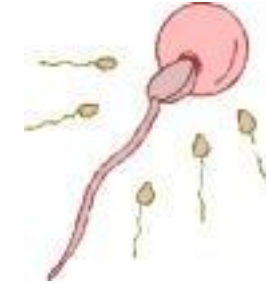
Characteristic	Examples
Living things are made up of units called cells.	Many microorganisms consist of only a single cell. Animals and trees are multicellular.
Living things reproduce.	Maple trees reproduce sexually. A hydra can reproduce asexually by budding.
Living things are based on a universal genetic code.	Flies produce flies. Dogs produce dogs. Seeds from maple trees produce maple trees.
Living things grow and develop.	Flies begin life as eggs, then become maggots, and then become adult flies.
Living things obtain and use materials and energy.	Plants obtain their energy from sunlight. Animals obtain their energy from the food they eat.
Living things respond to their environment.	Leaves and stems of plants grow toward light.
Living things maintain a stable internal environment.	Despite changes in the temperature of the environment, a robin maintains a constant body temperature.
Taken as a group, living things change over time.	Plants that live in the desert survive because they have become adapted to the conditions of the desert.


Need for Materials and Energy

- Use energy and materials to grow, develop and reproduce.
- Metabolism - the sum of all of the chemical reactions carried out by an organism.
 - Sunlight is the main source of energy
 - plants/algae - photosynthesis
 - Organisms eat plants or other organisms
 - Organisms eat remains of organisms that have died.



Reproduction



- All organisms produce new organisms through reproduction.
- Two Types: 
 - Sexual - two cells from different parents unite to produce the first cell of the new organism
 - Asexual - the new organism has a single parent

Evolution

- Organisms may experience changes but traits they have inherited usually do not change.
- As a group, any given organism can evolve or change over time.
- Over a short period of time, changes may not seem significant.
- Over thousands or millions of years, the changes can be dramatic.

Growth and Development

- Growth for single-celled organisms is a simple increase in size.
- Multicellular organisms go through development.
- Development - cells dividing again and again to produce many cells.
- Differentiation is when cells change shape and structure to form cells such as liver cells, brain cells, and muscle cells.

Characteristics of Life

- Nine (9) Characteristics all living things have in common

FRED H GARC

Characteristics of Life

■ FRED

- **F** – **F**ood for **M**etabolism
- **R** – Must be capable of **R**eproduction
- **E** – **E**volve is to change over time
- **D** – **D**evelop
 - Undergo a series of stages to reach maturity
 - Infant – Toddler – Young Adult - Adult

Maintaining Internal Balance



- Homeostasis - the maintenance of stable internal conditions in spite of changes in external conditions
 - Ex) body temperature and water content
- Your body works similar to a thermostat in your home.
 - If you are too hot, your biological thermostat turns on "air conditioning" by causing you to sweat.

Characteristics of Life

■ H

H – Homeostasis

- Steady internal state
 - Blood Pressure
 - Respiration
 - Body Temperature

Based on a Genetic Code



- Offspring usually resemble their parents.
- DNA carries the directions for inheritance.
- The DNA code determines the inherited traits of every organism on Earth.

Adaptation

- Adaptations are traits that give an organism an advantage in an environment.
- It gives an advantage on some members of a species in a changing environment.



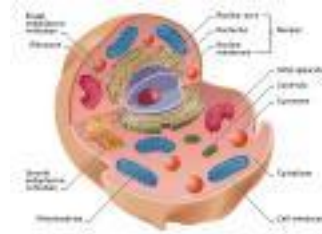
Which animal is better adapted for their environment?



Response to the Environment

- Organisms detect and respond to stimuli from their environment.
- Stimulus - a signal to which an organism responds.
 - External changes - temperature or amount of light
 - Internal stimuli - level of glucose in your blood

Made up of Cells



- **Cell** - a highly organized, tiny structure with a thin covering called a membrane.
- Smallest unit capable of all life functions.
- Cells, grow, respond to their surroundings and reproduce.
- *Unicellular* - only a single cell
 - bacteria, algae
- *Multicellular* - composed of many cells
 - animals and plants

Characteristics of Life

■ **GARC**

G – **G**enetic Code

- All organisms are made of DNA

A – **A**dapt to change

- Structural – wings, arms, ect.
- Physiological – internal body processes
- Behavioral – innate, learned

R – **R**espond to stimuli

C – Made of at least one (1) **C**ell

Branches of Biology

- Biology is divided into different fields.

- Zoologists study animals 🦁.







- Botanists study plants.



- Paleontologists study ancient life.



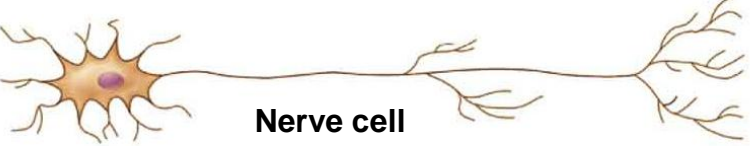



Levels of Organization

Biosphere	The part of Earth that contains all ecosystems	 <p>Biosphere</p>
Ecosystem	Community and its nonliving surroundings	 <p>Hawk, snake, bison, prairie dog, grass, stream, rocks, air</p>
Community	Populations that live together in a defined area	 <p>Hawk, snake, bison, prairie dog, grass</p>
Population	Group of organisms of one type that live in the same area	 <p>Bison herd</p>

The largest is the biosphere.

Levels of Organization

Organism	Individual living thing	 Bison
Groups of Cells	Tissues, organs, and organ systems	 Nervous tissue Brain Nervous system
Cells	Smallest functional unit of life	 Nerve cell
Molecules	Groups of atoms; smallest unit of most chemical compounds	 Water DNA

The smallest are molecules.

- Smaller living systems are found within larger systems.

- Molecular and cell biologists study the smallest systems.



- Population biologists and ecologists study the largest systems.



Biology in Everyday Life

- Biology helps you understand what affects the quality of your life.
- Biology involves:
 - Your pets
 - Information about food
 - Conditions of good health
 - Diagnose and treat medical problems
 - Identifies environmental factors
- Biologists do not make decisions about most matters affecting human society; citizens and governments do!



Sec. 1-4 Tools and Procedures

- Scientists use a variety of equipment and technology to conduct scientific experiments.

- Computers



- Electronic balances



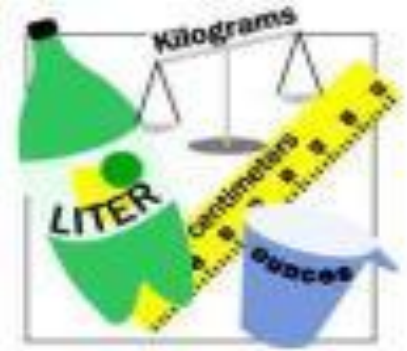
- Microscopes



- Telescope



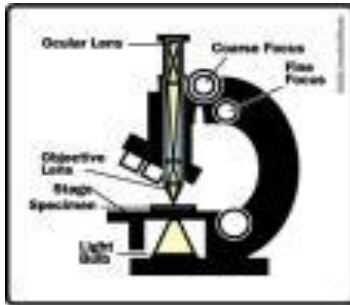
A Common Measurement System



- Most scientists use the metric system.
- The metric system is a decimal system of measurement whose units are based on multiples of 10.
- A revised version of the original metric system is called the International System of Units or SI.

Analyzing Biological Data

- Scientists record collected data in a table and then make a graph.
 - Easy to detect a pattern of change with this method
- Scientists use computers to help analyze large amounts of data.
 - Structure of molecules
- Computers gather data from satellites to make predictions about complex phenomena.
 - global climate patterns



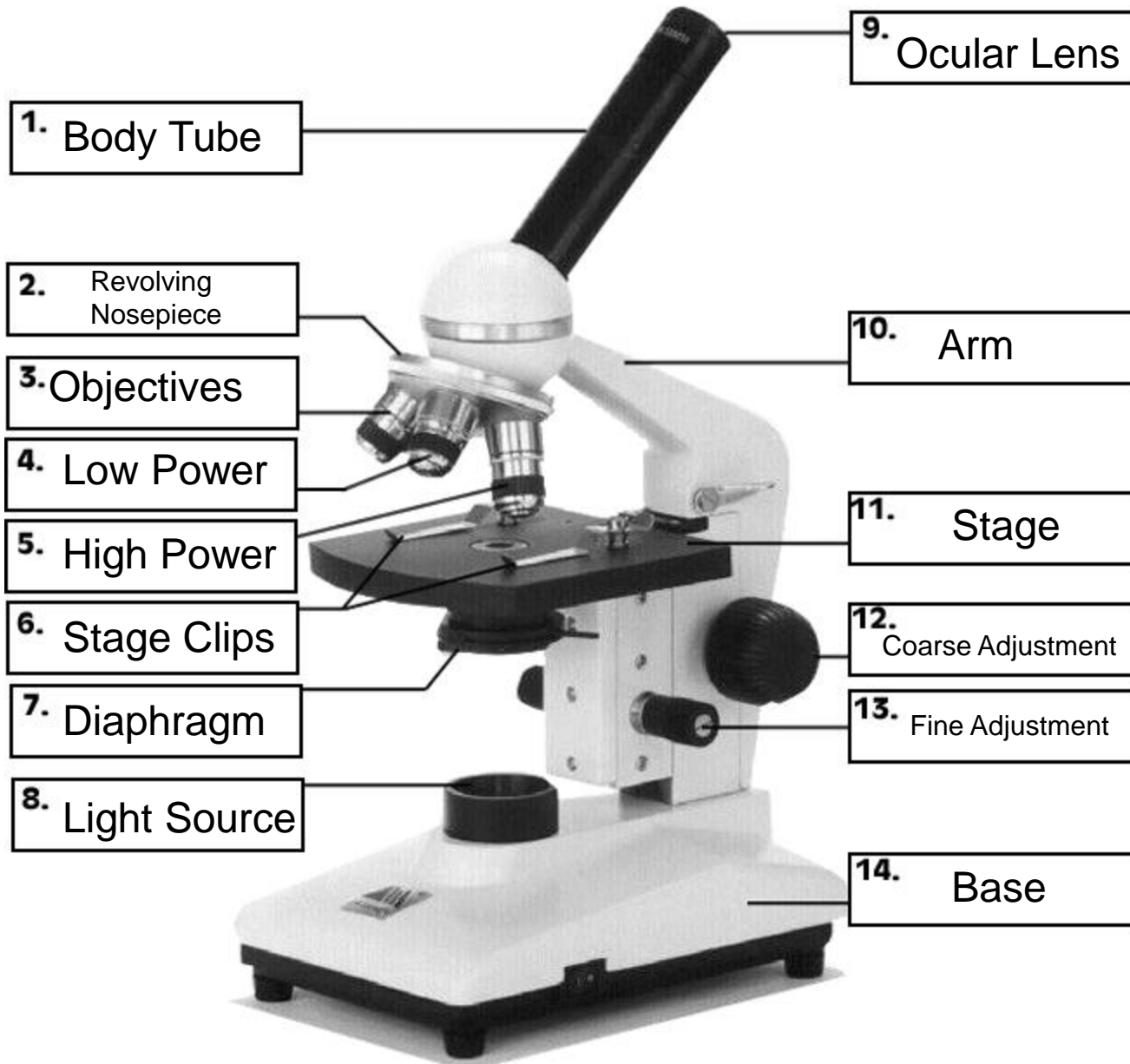
Microscopes



- Microscopes are devices that magnify images that are too small to see with an unaided eye.
- Light microscopes magnify using visible light.
- Electron microscopes focus using beams of electrons.

Light Microscope

- Light microscopes can produce clear images of objects at a magnification of about 1000 times,
- Compound light microscope allows light to pass through the specimen and uses two lenses to form an image.
- Characteristics:
 - observe dead organisms and their parts
 - observe tiny organisms and their cells while they are still alive
 - chemical stains or dyes are used to show specific structures
 - video camera can be used to produce moving 3D images



Electron Microscope

- Electron microscopes use beams of electrons to produce images almost 1000 times more detailed than light microscopes.
- Two main types:
 - Transmission electron microscope (TEM) shines a beam of electrons through a thin specimen.
 - Scanning electron microscope (SEM) scans a narrow beam of electrons back and forth across the surface of a specimen.
- Both require a vacuum to operate so samples must be preserved and dehydrated.
- Living cells cannot be observed with an electron microscope.

Laboratory Techniques



Cell Culture

- A cell culture is a group of cells grown in a nutrient solution (agar) from a single original cell.
- Cell cultures can be used for:
 - test cell responses under controlled conditions
 - study interactions between cells
 - select specific cells for further study

Cell Fractionation

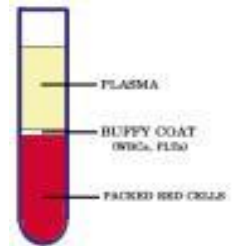
- Cell fractionation is a technique that separates the cell into different parts.

- This process involves:

- A special bender breaks cells into pieces.
- Broken cell bits are added to a liquid and placed in a tube.
- The tube is inserted in a centrifuge and spun 20,000 times per minute to separate the cell parts.
- The densest parts settle to the bottom and least dense parts rise to the top.



- Biologists can now study individual layers.



Working Safely in Biology

- Before starting any activity, **read all the steps and make sure you understand the entire procedure** including any safety procedures.
- **Always follow your teacher's instructions.**
- **Ask for an explanation when you are in doubt** about any part of an activity.
- **Wash your hands thoroughly** after every scientific activity!

