Chapter One: The Science of Life

Section Objectives:
1-The World of Biology
2-Themes in Biology
3-The Study of Biology
4-Tools and Techniques
Vocabulary
- Biology
- Organization
- Cell
- Unicellular
- Multicellular
- Organ
- Tissue
- Organelle
- Biological Molecule
- Homeostasis
- Metabolism
- Cell Division
- Development
- Reproduction
- Gene

Objectives
- Relate the relevance of biology to a person’s daily life.
- Describe the importance of biology in human society.
- List the characteristics of living things.
- Summarize the hierarchy of organization within complex multicellular organisms.
- Distinguish between homeostasis and metabolism and between growth, development, and reproduction.
Biology and You

- **Biology** – the study of life that questions:
  - How living things work
  - How they interact with the environment
  - How they change over time

- Biologists study:
  - Living organisms ranging from bacteria to large animals
  - What foods are healthy to eat
  - How much exercise one needs
  - How to avoid sickness
  - How air, land, and food supply will be affected in the near future
Biology and Society

- Having knowledge about biological issues allows people to make informed decisions on issues that impact their way of life.
  - Ex: Polluted water system
    - Question or Problem relating Biology and Society?
    - Answer?
    - Action?
Characteristics of Life

What classifies something as living or nonliving?

Biologists found 7 characteristics that all living things share:

- Organization and the Presence of Cells
- Response to Stimuli
- Homeostasis
- Metabolism
- Growth & Development
- Reproduction
- Change Over Time
Organization and the Presence of Cells

- **Organization** – the high degree of order within an organism’s internal and external parts and in the interactions with the living world
  - **Ex – Owl vs. Rock**
    - Shape? Size? How do they compare

- **Levels of Organization:**
  - Atoms, Biological Molecule, Organelle, Cell, Tissue, Organ, Organ System, Organism
  - Example:
    - Oxygen, Phospholipid, Mitochondrion, Nerve Cell, Nervous Tissue, Ear, Nervous System, Owl
Organization and the Presence of Cells

- **Cell** – the smallest unit that can perform all life’s processes
  - **Unicellular** – made of one cell (bacteria)
  - **Multicellular** – made of more than one cell (human)

- When highly organized, organisms have **organ systems** – groups of specialized parts that perform specific functions for the organism

- Organ systems are made up of **organs** – structures that carry out special jobs within the system

- Organs are made up of **tissue** – groups of cells that have similar functions that allow the organ to work
Organization and the Presence of Cells

- Tissues are made up of **cells** that are covered in a membrane that contains all the genetic information that lets them replicate and perform cell functions.

- Cells are made up of **organelles** – tiny structures that carry out functions to keep the cell alive.

- Organelles contain **biological molecules** – chemical compounds that allow movement, energy use, cell functions and physical structure.

- Biological molecules are made up of **atoms** – simplest particle in an element that holds all the elements properties.
Response to Stimuli

- Stimulus – physical or chemical change in the internal or external environment
  - Ex: An owl’s pupil dilates to keep the level of light entering their eyes constant

- An organism must be able to react to changes in the environment to stay alive

- Physical & Chemical - ? Give some examples
Homeostasis

- **Homeostasis** – the maintenance of a stable level of internal conditions even though environmental conditions are constantly changing

(Keeping internal conditions stable, despite change in the immediate environment)

- Organisms have systems to regulate temperature, water content, and uptake of nutrients by cells
  - Ex: If our cells take in too much water they burst, if they do not get enough water they shrivel – both situations equal cell death
  - Our body has a mechanism to control this function
Metabolism

- Living things use energy for all life processes: growth, repair, movement, etc.

  **Metabolism** – sum of all the chemical reactions that take in and transform energy and materials from the environment

  - **Ex:** Plants take in the sun’s energy during photosynthesis and generate sugar molecules
Growth and Development

- Growth in living things happens from the division and enlargement of cells
  - **Cell Division** – the formation of two new cells from an existing cell
    - In unicellular – after cell division the primary change is cell enlargement
    - In multicellular – organism matures through cell division, enlargement, and development
  - **Development** – process where the organism becomes a mature adult
    - Involves cell division, and differentiation (specialization)
    - Development allows for cells to have specialized functions – carry blood, hear, etc.
- The human body has trillions of cells that all have special functions and all those cells came from one cell – the fertilized egg
Reproduction

- **Reproduction** – the process organisms use to produce a new organism like themselves
  - Not essential for survival, but for species continuation

- Hereditary information is passed down to offspring during reproduction, encoded in DNA – *deoxyribonucleic acid*
  - **Gene** – short segment of DNA that contains the instructions for a single trait of an organism

**Two Types:**

- **Sexual Reproduction** – hereditary information recombines from two organisms of the same species
  - Results = offspring are SIMILAR but not IDENTICAL to the parents

- **Asexual Reproduction** – hereditary information from different organisms is not combined
  - Results = original organism and new organism are genetically the same
Change Over Time

- Organisms go through many changes in their lifetime, but their basic genetic characteristics do not change
  - Populations evolve – change through time
    - This gives the population the ability to survive the changing world
    - This also allows us to see and explain diversity of life-forms on Earth
# Themes in Biology (1-2)

<table>
<thead>
<tr>
<th>Vocabulary</th>
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<tbody>
<tr>
<td>Domain</td>
</tr>
<tr>
<td>Kingdom</td>
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<tr>
<td>Ecology</td>
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<td>Ecosystem</td>
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<td>Evolution</td>
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<tr>
<td>Natural Selection</td>
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<tr>
<td>Adaptation</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Objectives</th>
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<tbody>
<tr>
<td>Identify three important themes that help explain the living world.</td>
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<td>Explain how life can be diverse, yet unified.</td>
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<td>Describe how living organisms are interdependent.</td>
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<td>Summarize why evolution is an important theme in biology.</td>
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Themes in Biology

- Three themes covered in this section are:
  - Diversity and Unity of Life
  - Interdependence of Organisms
  - Evolution of Life
Diversity & Unity

- Diversity refers to variety
  - 1.5 million species (2006) identified

- Unity means all the features that living things have in common
  - Genetic Code – Rules for cells on how to use hereditary information
  - Presence of organelles

- All living things share certain genes (common ancestry), but no two types of organisms have the same full set of genes
Diversity & Unity

- Tree of Life – shows relation between organisms that share common ancestry
  - Organisms with similar sets of genes are placed on “branches” close together
  - Organisms with fewer similar genes are placed farther apart.
  - Branches = lineage
- Reason for Tree: to relate and unite life’s diversity
  - Scientists believe all living organisms came from a common ancestor, with different lineages for different species
  - This relates all life

Themes in Biology (1-2)
Diversity & Unity (3 Domains)

- **Domain** – major subdivision of all organisms
  - Bacteria
  - Archaea
  - Eukarya

- **Kingdoms** – major categories (6 in total)
  - Domain Eukarya
    - Plantae
    - Animalia
    - Fungi
    - Protista
  - Domain Archaea
    - Archaea
  - Domain Bacteria
    - Bacteria
Interdependence of Organisms

- **Ecology** is the branch of biology that studies organisms interacting with each other and with the environment.
- **Ecosystems** are communities of living species and their physical environments.

Interdependence Example:
- Panther → Birds → Nuts → Trees → CO$_2$
  - CO$_2$ is a byproduct of all animals.

Problem: Deforestation by humans is impacting all forms of life.
- Rainforests are vital for the global environment and clearing them out causes huge problems for everyone.
Evolution of Life

- **Evolution** – the process where inherited characteristics in a population change over generations
  - This allows distinct populations and new species to develop
- Evolution clears up 3 things:
  - How the “Tree of Life” branches work
  - How organisms alive today are related to ones in the past
  - Helps us understand the mechanisms that underlie the way an organism looks and behaves
Natural Selection

- The Theory of Evolution by **Natural Selection** states – organisms with favorable traits are better able to survive and reproduce successfully, than those that lack these traits

- **Adaptations** – Traits that improve an individual’s ability to survive and reproduce

- The survival and reproductive success of organisms with favorable traits causes a change in populations over generations and this modification is an important factor for explaining the diversity we see today
The Study of Biology

Vocabulary
- Scientific method
- Observation
- Hypothesis
- Prediction
- Experiment
- Control group
- Experimental group
- Independent variable
- Dependent variable
- Theory
- Peer review

Objectives
- Outline the main steps in the scientific method
- Summarize how observations are used to form hypotheses
- List the elements of a controlled experiment
- Describe how scientists use data to draw conclusions
- Compare a scientific hypothesis and a scientific theory
- State how communication in science helps prevent dishonesty and bias
Science as a Process

- **Scientific Method** – organized approach to learn how the natural world works

- **Two Principles:**
  - Events in the natural world have natural causes
  - Uniformity – idea that fundamental laws of nature operate the same way at all places and times

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The Study of Biology (1-3)

- **Steps:**
  - Observation – act of perceiving a natural occurrence that causes someone to pose a question
  - Hypothesis – proposed explanation for the way a particular aspect of the natural world functions
  - Prediction – state that forecasts what would happen in a test situation if the hypothesis is correct
  - Experiment – used to test the hypothesis and its prediction
  - Gather data
  - Analyze data gathered
  - Draw conclusion from analyzed data
  - Publish finding through journals, blogs, internet, to scientific peers
  - Allow them to verify, reject, or modify conclusions
Scientific Method Example

1: Observation – Owl catches prey in complete darkness

1a. Question: How does an owl detect its prey in the dark?

2: Hypothesis – (answers the question)
A: Owls hunt in the dark by vision
B: Owls hunt in the dark by hearing
C: Owls hunt in the dark by sensing body heat
Scientific Method Example

3: Prediction – (what you expect to happen based on hypothesis) (if / then statement)

A: If an owl hunts by vision, then it will only pounce on the mouse in either a light or dark room.

B: If an owl hunts by hearing, then when in a light room the owl will pounce near the head of the mouse, but in a dark room the owl will pounce near a rustling leaf attached to the mouse.

C: If the owl hunts by sensing body heat, then it will attack only the prey in any room condition because it is detecting the body heat.
Scientific Method Example

4: Experiment – controlled experiments compare an experimental group and a control group and only have one variable

- **Control Group** – provides normal standard against which the biologist can compare results of the experimental group
- **Experimental Group** – identical to experimental group except for the one factor that is being tested – **independent variable** (manipulated variable)
  - Measure the **dependent variable** (responding variable) also.

**Owl Experiment** –
- Control = In the light
- Experimental = In the dark
  - Independent variable = presence of absence of light
  - Dependent variable = distance from mouse head that striking occurred

Tests can be “blind” – you do not know which group is experimental or controlled
- Eliminates bias in results
- Makes results more meaningful
Scientific Method Example

5: Gather Data – Measure the dependent variable – will be quantitative data (numbers)
   - Do this by using your senses

6: Analyze Data – Goal is to determine if data was reliable, and whether or supports or fails the predictions
   - Compare to other studies if it has been tested before
   - Display the data in tables or graphs so that it is easy to see patterns and connections

Owl Experiment – Measure and compare the distance from the owl’s strike to the mouse and to the leaf in light and dark.
Scientific Method Example

7: Draw Conclusions – Take the analyzed data and figure out if your hypothesis is right or wrong

“Data” – The owl struck at greater accuracy to the mouse than the leaf in the lighted room, but the owl struck at greater accuracy to leaf than mouse in the dark room.

Conclusion: Data supports the hearing hypothesis: owls hunt in the dark by hearing.

BIG DEAL: Experiments can only DISPROVE, not prove hypotheses

Ex: smell could have been the key factor and we didn’t test it.
Inferences & Models

- Inferences – conclusion made on the basis of facts and prior knowledge rather than on direct observation

- Models – represents or describes things in a measurable way.

Tools scientists use to work with data collected from a study or experiment
Theory

- Hypothesis confirmed many times → Theory constructed
- Theories are highly tested, and generally act as a principle that is accepted to explain a vast number of observations and experimental data
Communicating Ideas

- With the growing importance of Science in solving societal issues, communication between scientists and the public at large is very important
  - Publish Papers
  - Journals
  - Research Data

- Four main parts to a published work
  - Introduction – problem & hypothesis
  - Materials and Methods – stuff needed, steps for experiment
  - Results – what was found, actual data
  - Discussion – significance of experiment & future direction

- Peer Review: scientists who are experts in the experimented field ANONYMOUSLY read and critique the paper
  - Give feedback
  - Test the results
  - Keep the researcher honest in the findings
Honesty and Bias

Science depends on honesty
- A scientist’s job is to disprove his/her favorite idea
  - Verify that results are still correct
- Bias can taint an entire experimental process and conclusion

Scientists avoid “conflicts of interest”
- Ex: Scientist owns a biotech company and manufactures a drug
  - He shouldn’t test drug safety and effectiveness because if the data is tampered with and misleading his career is over.
  - He would use a research group to keep his research honest and fair.
Tools and Techniques (1-4)

- Vocabulary
  - Compound light microscope
  - Eyepiece (ocular lens)
  - Objective lens
  - Stage
  - Light source
  - Magnification
  - Nosepiece
  - Resolution
  - Scanning Electron Microscope (SEM)
  - Transmission Electron Microscope (TEM)
  - Metric System
  - Base Unit

- Objective
  - List the function of the major parts of a compound light microscope
  - Compare two kinds of electron microscopes
  - Describe the importance of having the SI system of measurement
Microscopes as Tools

- Compound Light Microscope – shines light through a specimen and has two lenses to magnify an image

- 4 Major Parts
  - Eyepiece – magnifies the image (usually 10x)
  - Objective lens – enlarges image of specimen
    - Sometimes stains are used for clarity
  - Stage – platform that supports the slide holding the specimen
  - Light Source – light bulb that provides light to see image

- How to Use it:
  - Mount specimen on glass slide
    - Make sure the specimen is thin enough
  - Light passes through the specimen and then through the objective lens
  - Look through the eyepiece and focus the image by adjusting the magnification and resolution
    - Magnification – increase of an objects apparent size
    - Resolution – power to show details clearly in an image
Electron Microscopes

- In an electron microscope a beam of electrons produces an enlarged image on the specimen
  - More powerful in magnification and resolution compared with light microscopes
  - Always black and white (computers add colors)
  - Needs a vacuum chamber
    - Cannot be used to view living specimens
Electron Microscopes

**SEM**
- Scans beam over specimen that is coated with thin layer of metal
  - A shower of electrons are emitted by the beam and produce an image on the screen or photographic plate
- 100,000x magnification

**TEM**
- Transmits beam of electrons through a very thin sliced specimen
- Magnification = 200,000x
- Magnetic lenses enlarge and focus image on a screen or photographic plate
Units of Measurements

- Metric System – decimal system based on powers of 10
  - Official name is SI Units – international system of units

- Base and Other Units – SI has 7 fundamental base units
  - Length – m
  - Mass – kg
  - Time – s
  - Electric current – ampere
  - Thermodynamic temp – K
  - Amount of Substance – mole
  - Luminous Intensity - Candela
Units of Measurement

- SI Pre-fix (pg. 23)
  - Copy Table of base units (1-1)
  - Copy Table in notes (1-2)
  - Copy derived units table (1-3)

- Derived unit – produced by mathematical relationship between two base units