Chapter 1

An Introduction To Life On Earth
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• 16th year teaching life sciences
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• Development work – Peace Corps Philippines, Fulbright-Indonesia, USAID-Afghanistan
• Introductions
• Syllabus
• How to study for biology
• Assessment of learning
Bio. 102 Knowledge Outcomes

• Can describe various biological levels and how they relate and the properties of life
• Explain basic chemistry and the structure and function of biological molecules
• Describe chemical makeup of organism as well as structure and function
• Eukaryotic vs. prokaryotic cells and how structure relates to function
• Chemical reactions
Bio. 102 Knowledge Outcomes

• Chromosomes and their behavior
• Mendelian patterns of inheritance
• Genetic conditions, diseases
• Describe how a gene determines the structure of a protein
• Recombinant DNA technology
• Theory of Evolution
Bio. 102 Knowledge Outcomes

• Criteria for species classification, reproductive barriers and formation of new species
• Conditions and processes leading to life on Earth
Bio. 102 Knowledge Outcomes

• Identify key parameters of a population
• Understand parameters of an ecological community and how a community might change
• Trophic structures of an ecosystem
• Human dependance on the environment and major human impacts.
Chapter 1 At a Glance

- 1.1 How Do Scientists Study Life?
- 1.2 Evolution: The Unifying Theory of Biology
- 1.3 What Are the Characteristics of Living Things?
- 1.4 How Do Scientists Categorize the Diversity of Life?
How Do Scientists Study Life?

- Life can be studied at different levels
  - Atom, molecule, cell
  - Tissue, organ, organ system
  - Multicellular organism, population, species
  - Community, ecosystem, biosphere
# Levels of Organization of Matter

<table>
<thead>
<tr>
<th>Levels of Organization</th>
<th>Description</th>
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<tbody>
<tr>
<td>Biosphere</td>
<td>That part of Earth inhabited by living organisms; includes both the living and nonliving components</td>
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<tr>
<td>Ecosystem</td>
<td>A community together with its nonliving surroundings</td>
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<tr>
<td>Community</td>
<td>Two or more populations of different species living and interacting in the same area</td>
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<tr>
<td>Species</td>
<td>Very similar, potentially interbreeding organisms</td>
</tr>
<tr>
<td>Population</td>
<td>Members of one species inhabiting the same area</td>
</tr>
<tr>
<td>Multicellular organism</td>
<td>An individual living thing composed of many cells</td>
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<tr>
<td>Organ system</td>
<td>Two or more organs working together in the execution of a specific bodily function</td>
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<tr>
<td>Organ</td>
<td>A structure usually composed of several tissue types that form a functional unit</td>
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<tr>
<td>Tissue</td>
<td>A group of similar cells that perform a specific function</td>
</tr>
<tr>
<td>Cell</td>
<td>The smallest unit of life</td>
</tr>
<tr>
<td>Molecule</td>
<td>A combination of atoms</td>
</tr>
<tr>
<td>Atom</td>
<td>The smallest particle of an element that retains the properties of that element</td>
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Fig. 1-1
1.1 How Do Scientists Study Life?

- Levels of organization
  - All matter is formed of elements
    - An atom is the smallest particle of an element retaining the properties of an element
  - Atoms combine to form molecules
  - Molecules provide the building blocks for cells, the smallest unit of life
The Cell Is the Smallest Unit of Life

Fig. 1-2

- nucleus
- cell wall
- plasma membrane
- organelles
1.1 How Do Scientists Study Life?

- Levels of organization (*continued*)
  - Some forms of life consist of single cells
  - In multicellular forms, cells combine to form **tissues**
  - Tissues combine to form **organs**, which can be united as **organ systems**
  - **Multicellular organisms** are composed of multiple organ systems
1.1 How Do Scientists Study Life?

- Levels of organization *(continued)*
  - Organisms of the same type that are capable of interbreeding are called a **species**
  - A group of organisms of the same species living in a given area is a **population**
  - Interacting populations make up a **community**
1.1 How Do Scientists Study Life?

- Levels of organization *(continued)*
  - A community and its nonliving environment is an **ecosystem**
  - The entire surface of the Earth, including living and nonliving components, is the **biosphere**
1.1 How Do Scientists Study Life?

- The **scientific method** is the basis for scientific inquiry
  - Observation
  - Question
  - Hypothesis
  - Prediction
  - Experiment or Observation
  - Conclusion
The Scientific Method

Observation

Question

Hypothesis

Prediction

Experiment or Observation

Conclusion

The car won't start.

Why won't the car start?

The car won't start because the battery is dead.

Propose a new hypothesis.

IF the hypothesis is correct, THEN the car will start if the battery is replaced.

The battery is replaced. If the car doesn't start: If the car starts:

The dead battery hypothesis is supported.

Fig. 1-4
1.1 How Do Scientists Study Life?

- The scientific method
  - Scientific inquiry is a rigorous method for making observations
  - The scientific method for inquiry follows six steps
1.1 How Do Scientists Study Life?

- The scientific method *(continued)*
  1. **Observation** of a specific phenomenon
  2. The observation, in turn, leads to a **question**
  3. The question leads to formulation of a **hypothesis**, based on previous observations, that is offered as an answer to the question
1.1 How Do Scientists Study Life?

- The scientific method *(continued)*
  4. The hypothesis leads to a **prediction**, typically expressed in “if…then…” language
  5. The prediction is tested by carefully controlled manipulations called **experiments**
  6. The experiments produce results that either support or refute the hypothesis, allowing the development of a **conclusion**
1.1 How Do Scientists Study Life?

- The scientific method (*continued*)
  - Scientific experimentation tests the assertion that a single **variable** causes a particular observation
  - The experiment must rule out the influence of other possible variables on the recorded observations
  - **Controls** are incorporated into experiments
  - Controls keep untested variables constant
The Experiments of Francesco Redi

**Observation:** Flies swarm around meat left in the open; maggots appear on the meat.

**Question:** Where do maggots on the meat come from?

**Hypothesis:** Flies produce the maggots.

**Prediction:** IF the hypothesis is correct, THEN keeping the flies away from the meat will prevent the appearance of maggots.

**Experiment:**

1. Obtain identical pieces of meat and two identical jars
2. Place meat in each jar
3. Leave the jar uncovered
4. Leave exposed for several days
5. Flies swarm around and maggots appear

Control situation:

- Leave the jar uncovered
- Leave exposed for several days
- Flies swarm around and maggots appear

Experimental variable:

- gauze prevents the entry of flies
- time, temperature, place

Experimental situation:

- Cover the jar with gauze
- Leave covered for several days
- Flies are kept from the meat; no maggots appear

**Results:**

**Conclusion:** The experiment supports the hypothesis that flies are the source of maggots and that spontaneous generation of maggots does not occur.
1.1 How Do Scientists Study Life?

- Application of the scientific method to everyday problems
  - Assume you are late for an appointment and hurriedly try to start your car
    - **Observation**: The car won’t start
    - **Question**: Why won’t the car start?
    - **Hypothesis**: The battery is dead
    - **Prediction**: IF the hypothesis is correct, THEN the car will start if the battery is replaced
    - **Experiment**: The battery is replaced and the car starts
1.1 How Do Scientists Study Life?

- Application to everyday problems *(continued)*
  - Premature *conclusion*:
    - The problem was a dead battery because the car starts when replaced with a different one
  - Recognition of inadequate *controls*
    - Did you attempt to start the car more than once?
    - Was the battery cable on the original battery loose?
In Class Now-Applying the Scientific Method

- In a group of 2 or 3 people use the scientific method to analyze the following assertions:
  - 88% of students in this class have student loans
  - 51% of students in this class are women over the age of 35
  - 1 in 5 students in this class rides their bike to school
  - 55% of students eat white bread
1.1 How Do Scientists Study Life?

- Scientific theories have been thoroughly tested
  - A scientific *theory* differs in definition from that of everyday usage
    - Many people use the word *theory* to mean hypothesis, or an “educated guess”
1.1 How Do Scientists Study Life?

- Scientific theories have been thoroughly tested (continued)
  - A **scientific theory** is a general explanation for important natural phenomena
    - It is extensively and reproducibly tested
    - It is more like a principle or natural law (e.g., the atomic, gravitational, and cell theories)
    - If compelling evidence arises, a theory may be modified
1.2 Evolution: The Unifying Theory of Biology

- **Evolution** is the process by which modern organisms descended, with modifications, from preexisting forms of life
Abundant evidence has been found to support evolutionary theory since Charles Darwin and Alfred Wallace proposed it in the mid-1800s. Those who see evolution as “just a theory” don’t understand the *scientific* definition of a theory.
1.2 Evolution: The Unifying Theory of Biology

- Modern organisms descended with modification from preexisting life-forms
- “Nothing in biology makes sense, except in the light of evolution” *Theodosius Dobzhansky*
1.2 Evolution: The Unifying Theory of Biology

- Darwin and Wallace formulated the basis of our modern understanding of evolution
- Evolution arises as a consequence of three natural processes
1.2 Evolution: The Unifying Theory of Biology

- Three natural processes underlie evolution
  1. Genetic variation among members of a population due to differences in their DNA
  2. Inheritance of those variations by offspring of parents carrying the variation
  3. **Natural selection** of individuals whose survival and enhanced reproduction are due to the favorable variations they carry
DNA Model
2. Natural selection
   - Organisms that best meet environmental challenges leave the most offspring
   - Natural selection preserves genes that help organisms flourish
1.3 What Are The Characteristics of Living Things?

1. Living things are complex, organized, and composed of cells
2. Living things maintain relatively constant internal conditions through homeostasis
3. Living things respond to stimuli
4. Living thing acquire and use materials and energy
1.3 What Are The Characteristics of Living Things?

5. Living things reproduce themselves

6. Living things, collectively, have the capacity to evolve
What Are The Characteristics of Living Things?

- Living things are composed of cells
  - Living things are both complex and organized
1.3 What Are The Characteristics of Living Things?

- Living things are composed of cells (continued)
  - The **cell theory** states that the cell is the basic unit of life
  - A single cell has an elaborate internal structure
1.3 What Are The Characteristics of Living Things?

- **Homeostasis**
  - Organisms must maintain relatively constant internal conditions, or **homeostasis**
    - For example, many organisms regulate body temperature
1.3 What Are The Characteristics of Living Things?

- Living things respond to stimuli
  - Organisms sense and respond to internal and external environmental stimuli
    - Sensory organs in animals can detect and respond to external stimuli like light, sound, chemicals, etc.
    - Plants and bacteria respond to stimuli as well (e.g., plants grow toward the light, and bacteria move toward available nutrients in a medium)
1.3 What Are The Characteristics of Living Things?

- Living things acquire materials
  - Materials and energy are required for the organism to maintain organization, to grow, and to reproduce
1.3 What Are The Characteristics of Living Things?

- Living things grow
  - Every organism becomes larger over time
    - Plants, birds, and mammals grow by producing more cells to increase their mass
    - Bacteria grow by enlarging their cells; they also divide to make more individuals
  - Growth involves the conversion of acquired materials to molecules of the organism’s body
1.3 What Are The Characteristics of Living Things?

- Living things reproduce themselves
  - Organisms give rise to offspring of the same type
  - The parent’s genetic material (DNA) is passed on to the offspring, creating continuity of life
1.3 What Are The Characteristics of Living Things?

- Living things have the capacity to evolve
  - The genetic composition of a whole species changes over many generations
  - Mutations and variable offspring allow a species to evolve
The Domains and Kingdoms of Life

Fig. 1-11
1.4 How Do Scientists Categorize the Diversity of Life?

- Categorizing life
  - The domain Eukarya contains four subdivisions, or **kingdoms**
    - Fungi
    - Plantae
    - Animalia
    - The “protists”
1.4 How Do Scientists Categorize the Diversity of Life?

- The domains Bacteria and Archaea consist of prokaryotic cells
- The domain Eukarya is composed of eukaryotic cells
1.4 How Do Scientists Categorize the Diversity of Life?

- Two cell types are seen among all living things: prokaryotic and eukaryotic cells
  - Cell types are named after presence or absence of a nucleus
    - The *nucleus* is a membrane-enclosed sac containing the cell’s genetic material
1.4 How Do Scientists Categorize the Diversity of Life?

- Prokaryotic and eukaryotic cells (*continued*)
  - **Prokaryotic** ("before nucleus" in Greek)
    - They are only 1–2 micrometers in diameter
    - They lack organelles or a nucleus
    - This cell type is found in the domains Bacteria and Archaea
1.4 How Do Scientists Categorize the Diversity of Life?

- Prokaryotic and eukaryotic cells (*continued*)
  - **Eukaryotic** ("true nucleus" in Greek)
    - They are larger than prokaryotic cells
    - They contain a variety of organelles, including a nucleus
    - This cell type is found only among members of the domain Eukarya