

Chapter 1

1.1 How to Define Life

A. Living Things Are Organized

1. Organization of living systems begins with **atoms**, which make up basic building blocks called **elements**.
2. The **cell** is the basic structural and functional unit of all living things.
3. Different cells combine to make up **tissues** (e.g., myocardial tissue).
4. Tissues combine to make up an **organ** (e.g., the heart).
5. Specific organs work together as a **system** (e.g., the heart, arteries, veins, etc.).
6. Multicellular organisms (each an “individual” within a particular species) contain **organ systems** (e.g., cardiovascular, digestive, respiratory, etc.).
7. A species in a particular area (e.g., gray squirrels in a forest) constitutes a **population**.
8. Interacting populations in a particular area comprise a **community**.
9. A community plus its physical environment is an **ecosystem**.
10. The **biosphere** is comprised of regions of the Earth’s crust, waters, and atmosphere inhabited by organisms.
11. Each level of organization is more complex than the level preceding it.
12. Each level of organization has *emergent properties* due to interactions between the parts making up the whole; all emergent properties follow the laws of physics and chemistry.

B. Living Things Acquire Materials and Energy

1. Maintaining organization and conducting life-sustaining processes require an outside source of **energy**, defined as the capacity to do “work.”
2. **Metabolism** is all the chemical reactions that occur in a cell.
3. The ultimate source of energy for nearly all life on earth is the sun; plants and certain other organisms convert solar energy into chemical energy by the process of **photosynthesis**.
4. All organisms must maintain a state of biological balance, or **homeostasis**. Temperature, moisture level, pH, etc. must be maintained within the tolerance range of the organism. Organisms have intricate feedback and control mechanisms to maintain homeostatic balance.

C. Living Things Respond

1. Living things interact with the environment and with other living things.
2. Response often results in movement of the organism (e.g., a plant bending toward the sun to capture solar energy, a turtle withdrawing into its shell for safety, etc.).
3. Responses help ensure survival of the organism and allow the organism to carry out its biological activities.
4. The collective responses of an organism constitute the **behavior** of the organism.

D. Living Things Reproduce and Develop

1. **Reproduction** is the ability of every type of organism to give rise to another organism like itself.
2. Bacteria, protozoans, and other unicellular organisms simply split in two (*binary fission*).
3. Multicellular organisms often unite sperm and egg, each from a different individual, resulting in an immature individual which develops into the adult.
4. The instructions for an organism's organization and development are encoded in **genes**.
5. Genes are comprised of long molecules of *DNA* (deoxyribonucleic acid); DNA is the genetic code in all living things.

E. Living Things Have Adaptations

1. Adaptations are modifications that make organisms suited to their way of life.

1.2 Evolution, the Unifying Concept of Biology

A. Organizing Diversity

1. Taxonomy is the discipline of identifying and grouping organisms according to certain rules.
2. Taxonomic classification changes as more is learned about living things, including the evolutionary relationships between species.
3. From smaller (least inclusive) categories to larger (more inclusive), the sequence of classification categories is: species, genus, family, order, class, phylum, kingdom, and domain.
4. The species within one genus share many specific characteristics and are the most closely related.
5. Species in the same kingdom share only general characteristics with one another.

B. Domains and Kingdoms

1. Biochemical evidence suggests that there are three domains: **Bacteria**, **Archaea**, and **Eukarya**.
2. The domains Bacteria and Archaea contain unicellular prokaryotes; organisms in the domain Eukarya have a membrane-bound nucleus.
3. The prokaryotes are structurally simple but are metabolically complex.
4. Archaea can live in water devoid of oxygen, and are able to survive harsh environmental conditions (temperatures, salinity, pH).
5. Bacteria are variously adapted to living almost anywhere (water, soil, atmosphere, in/on the human body, etc.).
7. The domains Archaea and Bacteria are not yet categorized into kingdoms.
8. Eukarya contains four kingdoms: **Protista**, **Fungi**, **Plantae**, and **Animalia**.
9. **Protists** (kingdom Protista) range from unicellular forms to multicellular ones.
10. **Plants** (kingdom Plantae) are multicellular photosynthetic organisms
11. **Fungi** (kingdom Fungi) are the molds and mushrooms.
12. **Animals** (kingdom Animalia) are multicellular organisms that ingest and process their food.

C. Scientific Name

1. A **binomial name** is a two-part scientific name: the genus (first word, capitalized) and the specific epithet of a species (second word, not capitalized).
2. Binomial names are based on Latin and are used universally by biologists.
3. Either the genus name or the specific epithet name may be abbreviated.

D. Evolution is Common Decent with Modification

1. **Natural selection** is the process by which species become modified over time.
2. In natural selection, members of a species may inherit a genetic change that makes them better suited to a particular environment.
3. These members would be more likely to produce higher numbers of surviving offspring.

1.3 How the Biosphere is Organized

A. Levels of Complexity

1. The **biosphere** is the zone of air, land, and water where organisms exist.
2. A **population** consists of all members of one species in a particular area.
3. A **community** consists of all of the local interacting populations.
4. An **ecosystem** includes all aspects of a living community and the physical environment (soil, atmosphere, etc.).
5. Interactions between various food chains make up a **food web**.
6. Ecosystems are characterized by chemical cycling and energy flow.
7. Ecosystems stay in existence because of a constant input of solar energy and the ability of photosynthetic organisms to absorb it.

B. The Human Population

1. The human population modifies existing ecosystems which can upset their natural nutrient cycles, causing harm to human populations and disrupting the ecosystem's natural energy flow.

C. Biodiversity

1. Two biologically diverse ecosystems, **rain forests** and **coral reefs**, are severely threatened by the human population.
2. Destruction of healthy ecosystems has unintended effects including: loss of food, medicine, raw materials, extinction of organisms.
3. **Biodiversity** is the total number of species, their variable genes, and their ecosystems.
4. **Extinction** is the death of a species or larger group; perhaps 400 species become extinct every day.
5. The continued existence of the human species is dependant on the preservation of ecosystems and the biosphere.

1.4 The Process of Science

A. Scientific Method

1. **Biology** is the scientific study of life, and it consists of many disciplines.

2. The scientific process differs from other ways of learning in that science follows the **scientific method**, which is characterized by **observation**, development of a **hypothesis**, **experimentation and data collection**, and forming a **conclusion**.
- B. Observation
1. Scientists believe nature is orderly and measurable, and that natural laws (e.g., gravity) do not change with time.
 2. Natural events, called, **phenomena** can therefore be understood from observations.
 3. Scientists also use the knowledge and experiences of other scientists to expand their understanding of phenomena.
 4. Chance alone can sometimes help a scientist get an idea (e.g., Alexander Fleming's discovery of penicillin).
- C. Hypothesis
1. **Inductive reasoning** allows a person to combine isolated facts into a cohesive whole.
 2. A scientist uses inductive reasoning to develop a possible explanation (a **hypothesis**) for a natural event; the scientist presents the hypothesis as an actual statement.
 3. Scientists only consider hypotheses that can be tested (i.e., moral and religious beliefs may not be testable by the scientific method).
- D. Experiments/Further Observations
1. Testing a hypothesis involves either conducting an experiment or making further observations.
 2. **Deductive reasoning** involves "if, then" logic to make a **prediction** that the hypothesis can be supported by experimentation.
 3. An **experimental design** is proposed to test the hypothesis in a meaningful way.
 4. An experiment should include a **control group** which goes through all the steps of an experiment but lacks (or is not exposed to) the factor being tested.
 5. Scientists may use a **model** (a representation of an actual object) in their experiments.
 6. Results obtained from use of a model will remain a hypothesis in need of testing if it is impossible to test the actual phenomenon.
- E. Data
1. **Data** are the results of an experiment, and are observable and objective rather than subjective.
 2. Data are often displayed in a graph or table.
 3. Many studies rely on statistical data which, among other things, determines the probability of error in the experiment.
- F. Conclusion

1. Whether the data support or reject the hypothesis is the basis for the **conclusion**.
2. The conclusion of one experiment can lead to the hypothesis for another experiment.
3. Scientists report their findings in scientific journals so that their methodology and data are available to other scientists.
4. The experiments and observations must be repeatable or the research is suspect.

G. Scientific Theory

1. The ultimate goal is to understand the natural world in **scientific theories**, which are speculative ideas that join supported, related hypotheses, and are supported by a broad range of observations, experiments, and data.
2. Some basic theories of biology are:
 - a. Cell: all organisms are made of cells.
 - b. Homeostasis: the internal environment of an organism stays relatively constant.
 - c. Gene: organisms contain coded information that dictates their form, function, and behavior.
 - d. Ecosystem: organisms are members of populations which interact with each other and the physical environment.
 - e. Evolution: all living things have a common ancestor.
3. A **principle** or a **law** is a theory that is generally accepted by most scientists.

H. Using the Scientific Method

1. A controlled study ensures that the outcome is due to the **experimental (independent) variable**, the factor being tested.
2. The result is called the **responding (dependent) variable** because it is due to the dependent variable.
3. The Experiment
 - a. Observation: Nitrogen fertilizer in the short run exchanges yield and increases food supplies.
 - b. Hypothesis: pigeon pea/winter wheat rotation will increase winter wheat production as well as or better than the use of nitrogen fertilizer.
 - c. Prediction: wheat biomass following the growth of pigeon peas in the soil will surpass wheat biomass following nitrogen fertilizer treatment.
 - d. Control group: winter wheat that receives no fertilizer.
 - e. Test groups: winter wheat treated with different levels of fertilizer; winter wheat grown in soil into which pigeon pea plants had been tilled.
 - f. Environmental conditions and watering were identical in control and test groups.
 - g. Results: all test groups produced more biomass than control group, but high level of nitrogen fertilizer produced more biomass than pigeon pea test group. Thus, hypothesis is **not supported**.

4. Continuing the Experiment
 - a. To test the hypothesis that pigeon pea residues will build up over time and will increase winter wheat production compared to nitrogen fertilizer, the study is continued for another year.
 - b. The fertilizer-only treatment no longer exceeded biomass production with the use of pigeon peas; biomass in the pigeon pea-treated test group was highest.
 - c. Conclusion: at the end of two years, the yield of winter wheat is better in the pigeon pea-treated test group. Hypothesis **supported**.
 - d. Continuation of the study for another year showed that the soil was continuously improved by the pigeon peas compared to the nitrogen fertilizer test groups.
 - e. Results were reported in a scientific journal.
- I. A Field Study
 1. Hypothesis: aggression of the male mountain bluebird varies during the reproductive cycle.
 2. Prediction: aggression will change after the nest is built, after the first egg is laid, and after hatching.
 3. To test the hypothesis, a male bluebird model was placed near the nest while the male was gone and observations were made upon his return.
 4. Control: a model of a male robin placed near certain nests.
 5. Results: resident male bluebirds did not bother the control model but were aggressive toward the male bluebird model depending on the stage in the reproductive cycle.
 6. Conclusion: hypothesis is **supported**.
 7. Study was reported in scientific journal with evolutionary interpretation.
- J. The Benefits and Limitations of Statistical Studies (*Science Focus* box)
 1. Benefits of Statistical Studies
 - a. Benefits of statistical studies include: Basis for supporting null or alternative hypotheses, gaining information and insights into problems scientists are trying to solve.
 2. Limitations of Statistical Studies
 - a. One of the main limitations to statistical studies is that data collected supports correlations, not causations.
 - b. There are always additional details that could be identified and quantified. There is no scientific study that has collected the perfect quantity and quality of data.