Chapter 01

Lecture Outline

See separate PowerPoint slides for all figures and tables pre-inserted into PowerPoint without notes.

1.1 The Characteristics of Life

• Life exists almost everywhere on Earth.

• Earth possesses a great variety of diverse life forms.

• All living things have certain characteristics in common.
The Characteristics of Living Organisms

- Are organized
- Acquire materials and energy
- Reproduce
- Respond to stimuli
- Are homeostatic
- Grow and develop
- Have the capacity to adapt

Organisms organized in a hierarchy of levels

- A **cell** is the smallest unit of life.
- A **tissue** is a group of similar cells that perform a particular function.
- Several tissues join together to form an **organ**.
- Organs work together to form an **organ system**.

- Organisms need external material and energy sources to maintain their organization and carry on life’s activities.
- Energy is the capacity to do work.
### Organisms Reproduce

- Life arises from life.
- **Genes** are units of information within an individual's DNA.
- **Reproduction** is the process by which an organism makes more of itself.
- DNA which directs cellular functions is duplicated prior to an organism reproducing.

### Organisms Respond to Stimuli

- Organisms respond to external stimuli by moving toward or away from the stimuli.
- Organisms use a variety of mechanisms for movement in response to stimuli.
- Movement of an organism constitutes a large part of its behavior.
- Behavior is directed toward avoiding injury, acquiring food or mating.

### Organisms are Homeostatic

- **Homeostasis** ("staying the same") refers to the requirement that organisms maintain a relatively constant internal environment.

- For example, human body temperature fluctuates slightly throughout the day.
Organisms Have the Capacity to Adapt

- During the nearly 4 billion years that life has been on Earth, the environment has constantly changed.
- Some individuals of a species may be better fit in a new environment.
- Adaptations are features that make individual organisms better suited to the new environment.

Organisms Have the Capacity to Adapt

- Individuals better adapted to their environment tend to produce more offspring.
- **Natural Selection** is the differential reproductive success of adapted individual.
  - Results in changes of characteristics of a population over time
- **Evolution** the change in frequency of traits in populations and species.
1.2 The Classification of Organisms

- Living organisms are assigned to groups based upon their similarities.

- **Systematics** is the discipline of identifying and classifying organisms.

- Each organism is classified in a domain, kingdom, phylum, class, order, family, genus and species.

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**Domains**

- **Domains** are the largest classification category.

- Organisms are assigned to 1 of 3 domains based on biochemical and genetic evidence: domain Archea, domain Bacteria, or domain Eukarya.

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**Domains**

- Domains Archea and Bacteria include unicellular prokaryotic cells.
  - Cells that lack a true nucleus

- Domain Eukarya include eukaryotic cells.
  - Cells with a true nucleus
  - Genes found in the DNA within the nucleus
Domain Archaea

• Archaea live in extreme environments.
  – Too little O₂, too salty, too hot, or too acidic for most other organisms

Figure 1.5a

1.6 µm

Domain Bacteria

• Bacteria are found almost everywhere on the planet Earth.
• Some are present within humans.
• Some bacteria cause disease but many are beneficial.

Figure 1.5b

Kingdoms

• Eukaryotes (Domain Eukarya) are further categorized into one of four Kingdoms
  – Kingdom Protista – may be several kingdoms
  – Kingdom Fungi
  – Kingdom Plantae
  – Kingdom Animalia
Categories of Classification

Domain
Kingdom
Phylum
Class
Order
Family
Genus
Species

Most inclusive

Least inclusive
Categories of Classification

• Systematics helps biologists better understand the variety of life on Earth.
• Organisms are classified according to their presumed evolutionary relationships.
• Systematists now perform experiments that may result in changes in the current classification system.

Scientific Names

• **Taxonomy** is the assignment of a binomial to each species.
• **Binomial (two name)**
  – Genus name, species name
  – Genus capitalized, both words in italics
  – Examples:
    » *Homo sapiens*
    » *Pisum sativum*
    » *Felis domesticus*
1.3 The Organization of the Biosphere

• **Biosphere**
  – The zone of air, land, and water at the surface of the Earth where living organisms are found

• **Population**
  – All the members of a species within a particular area

• **Community**
  – All the different populations in the same area

The Organization of the Biosphere

• **Ecosystem**
  – Community interact among themselves & with the physical environment (soil, atmosphere, etc.)
  – Characteristics
    • Chemical cycling – chemicals move from one species to another
    • Energy flow – energy flows from the sun, through plants, through the food chain
Ecosystems

- Climate largely determines where different ecosystems are found around the globe.

- The two most biologically diverse ecosystems—tropical rain forests and coral reefs—occur where solar energy is most abundant.

The Human Species

- The human species tends to modify existing ecosystems for its own purposes.

- Tropical rain forests and coral reefs are severely threatened as global human population increases.

- Humans depend on healthy ecosystems for food, medicine, and raw materials.
Biodiversity

- Encompasses
  - Total number of species
  - The variability in their genes
  - The ecosystems in which they live
- As many as 5-30 million species exist on Earth.
- Human activities cause the extinction of about 400 species per day.

1.4 The Process of Science

- **Biology** is the scientific study of life.
- Biologists—and all scientists—generally test hypotheses using the scientific method.
Observation

- Scientists tend to be curious about nature and how the world works.
- Natural phenomena may be better understood by observing and studying them.
- Scientists use their senses to make observations.
- They can extend their abilities by using instruments.

Hypothesis

- Inductive reasoning occurs when one uses creative thinking to combine isolated facts into a cohesive whole.
  - A scientist states a hypothesis, a tentative explanation for the natural event.
  - It is presented as a falsifiable statement.
  - Personal experiences may influence their hypothesis.
  - Hypotheses should be testable.

Experiment/Further Observations

- To determine how to test a hypothesis, scientists use deductive reasoning
  - Involves “if, then” logic
- For example, a scientist might reason, if organisms are composed of cells, then examination of an organism should reveal cells.
- One can also imply that the scientist has made a prediction.
Experiment/Further Observations

- To test their hypothesis, scientists conduct experiments.
- **Experimental design** is the manner in which a scientist intends to conduct an experiment.
- Experimenter should ensure that testing is specific and the results will be meaningful.
- A **control** should be included in the experiment.

Experiment/Further Observations

- Scientists often use a **model**, a representation of an actual subject.
- For example:
  - Computer modeling to study climate changes
  - Mice to perform cancer research

Data

- **Data** represent the results of an experiment.
  - Should be observable and objective
  - Should not be subjective or opinion-based
- Mathematical data is displayed as table and/or graph.
- Statistical data is used to rule out that results were due to chance.
### Conclusion

- **A conclusion** is the analysis of the data to determine if the hypothesis can be supported or not.
- The conclusion from one experiment may be used to form a hypothesis for another experiment.
- If the results do not support the hypothesis, then it may be used to formulate an alternate hypothesis.

### Scientific Theory

- Scientific theories are concepts that join together well-supported and related hypotheses.
- In science, a theory is supported by a broad range of observations, experiments, and data.
  - Examples: cell, homeostasis, gene, ecosystem, and evolution
- The theory of evolution is the unifying concept of biology.

### A Controlled Study

- Experiments in controlled studies have two types of groups:
  - Control Group – receives no treatment
  - Experimental Group – receives treatment

<table>
<thead>
<tr>
<th>Experimental Variable (Independent Variable)</th>
<th>Response Variable (Dependent Variable)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor of the experiment being tested</td>
<td>Result or change that occurs due to the experimental variable</td>
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A Controlled Study

• Experimental background:
  – nitrogen fertilizers increase crop yields in the short term;
  – continued use can cause pollution, as well as alter soil properties;
  – altered soil properties lead to reduced crop yields;
  – one solution is to leave the land unplanted for several years.

A Controlled Study

• Experimental background:
  – An alternate to nitrogen fertilizers is to use legumes, such as peas or beans.
  – These plants allow the growth of bacteria on their root nodules.
  – These bacteria convert atmospheric nitrogen to a form usable to plants.
  – These legume crops can be rotated with cereal crops to increase yield.

The Experiment

• HYPOTHESIS: A pigeon pea/winter wheat rotation will cause winter wheat production to increase, as well as, or better than, nitrogen fertilizer.

• PREDICTION: Wheat production (biomass) following the growth of pigeon peas will surpass wheat biomass following nitrogen fertilizer treatment.
The Experiment

- **Control Pots**
  - Winter wheat with no nitrogen fertilizer or legume preplanting

- **Test Pots**
  - Winter wheat in soil treated with nitrogen fertilizer (45kg/ha)
  - Winter wheat in soil treated with nitrogen fertilizer (90kg/ha)
  - Pigeon pea plants tilled into soil and then winter wheat planted

All other conditions were kept the same in all pots.
- Exposed to same environmental conditions
- Watered equally

The following spring, wheat plants were dried and weighed.
- Biomass was determined.
The Experiment

- The results after one year:
  - Wheat biomass was higher in test pots than control pots.
  - Pots with 45kg/ha of fertilizer had only slighter higher biomass.
  - Pots with 90kg/ha of fertilizer had nearly twice the biomass as control.
  - Pots with pigeon pea plants tilled into soil and then winter wheat planted did not have a biomass greater than control pots.
Continuing The Experiment

• The Results after Two Years:
  – Conclusion: The hypothesis was supported.
  – At the end of two years, the yield of winter wheat following a pigeon pea/winter wheat rotation was better than for the other type pots.

Continuing The Experiment

• The Results after Three Years:
  – Winter wheat biomass decreased in both the control pots and pots treated with nitrogen fertilizer.
  – Pots with fertilizer still had more wheat biomass than control pots.
  – Wheat biomass increased almost fourfold in pots pea/wheat rotation.

Ecological Importance of Study

• The use of legumes long-term was more effective in wheat biomass production than the use of nitrogen fertilizer.
• This study represents a form of organic gardening which not only increased yield, but also reduced pollution.
• Organic farming may benefit farmers and the environment.
1.5 Science and Social Responsibility

- **Technology** is the application of knowledge for a practical purpose.

- Technology has both benefits and drawbacks

- Ethical and moral issues surrounding the use of technology must be decided by everyone.
  - Responsibility for how to use scientific technology must reside with people from all walks of life, not with scientists alone.