Section A1: Exploring Life on its Many Levels

1. Each level of biological organization has emergent properties
Introduction

• Biology, the study of life, is rooted in the human spirit.

• Biology is the scientific extension of the human tendency to connect to and be curious about life.

• The adventure of biology takes us:
  • Into a variety of environments to investigate ecosystems
  • To the laboratory to examine how organisms work
  • Into the microscopic world to explore cells and the submicroscopic to explore molecules in cells
  • Back in time to investigate the history of life.

• This is the most exciting era for biology.
  • The largest and best-equipped community of scientists in history is beginning to solve problems that once seemed insolvable.
  • Genetics and cell biology are revolutionizing medicine and agriculture.
  • Molecular biology provides new tools to trace the origins and dispersal of early humans.
  • Ecology is helping evaluate environmental issues.
  • Neuroscience and evolutionary biology are reshaping psychology and sociology.
  • Unifying themes pervade all of biology.
1. Each level of biological organization has emergent properties

- Life’s basic characteristic is a high degree of order.
- Biological organization is based on a hierarchy of structural levels, each building on the levels below.
  - At the lowest level are **atoms** that are ordered into complex biological molecules.
  - Many **molecules** are arranged into minute structure called organelles, which are the components of cells.
- **Cells** are the subunits of organisms, the units of life.
  - Some organisms consist of a single cells, others are multicellular aggregates of specialized cells. **Tissues**
  - Whether multicellular or unicellular, all organisms must accomplish the same functions: uptake and processing of nutrients, excretion of wastes, response to environmental stimuli, and reproduction among others.
Multicellular organisms exhibit three major structural levels above the cell: similar cells are grouped into tissues, several tissues coordinate to form **organs**, and several organs form an **organ system**.

For example, to coordinate locomotory movements, sensory information travels from sense organs to the brain, where nervous tissues composed of billions of interconnected neurons, supported by connective tissue, coordinate signals that travel via other neurons to the individual muscle cells.
• **Organisms** belong to populations, localized group of organisms belonging to the same species.

• **Populations** of several species in the same area comprise a biological community.

• These populations interact with their physical environment to form an **ecosystem**.

• Investigating biology at its many levels is fundamental to the study of life.

• Biological processes often involve several levels of biological organization.
  
  • The coordinated strike of a rattlesnake at a mouse requires complex interactions at the molecular, cell, tissue, and organ levels within its body.

  • The outcome impacts not only the well-being of the snake and the mouse but also the populations of both with implications for their biological community.

• Many biologists study life at one level but gain a broader perspective when they integrate their discoveries with processes at other levels.
• Novel properties emerge at each step upward in the biological hierarchy.
• These emergent properties result from interactions between components.
  • A cell is certainly much more than a bag of molecules.
• This theme of emergent properties accents the importance of structural arrangement.
• The emergent properties of life are not supernatural, but simply reflect a hierarchy of structural organization.
• Life resists a simple, one-sentence definition, yet we can recognize life by what living things do.
The complex organization of life presents a dilemma to scientists seeking to understand biological processes.

- We cannot fully explain a higher level of organization by breaking down to its parts.
- At the same time, it is futile to try to analyze something as complex as an organism or cell without taking it apart.

- **Reductionism**, reducing complex systems to simpler components, is a powerful strategy in biology.
- Reductionism is balanced by the longer-range objective of understanding emergent properties.