

# Chapter 1

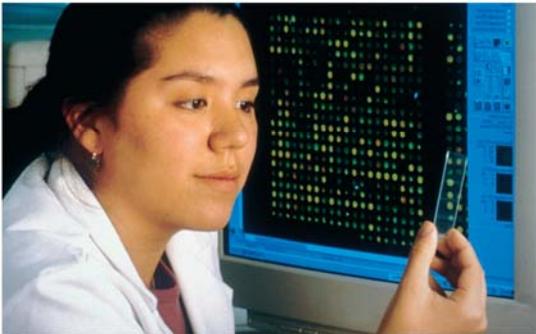
## The Scientific Study of Life



### Learning Outcomes

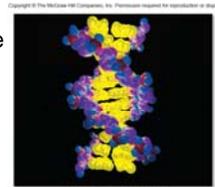
- Describe the characteristics shared by all living organisms
- Compare and contrast the three main taxonomic branches of life
- Identify standardized, dependent and independent variables in an experiment
- Apply the scientific method to analyze data
- Discuss the limitations of the scientific method

### Biology is everywhere.



### What is Biology?

- If we define biology as the scientific study of life, then we need to define life.
- We can define life by listing its basic components
  - The cell is the basic unit of life
  - Every organism consists of one or more cells
  - In those cells, DNA is used to produce proteins



DNA: The Informational Molecule of Life.

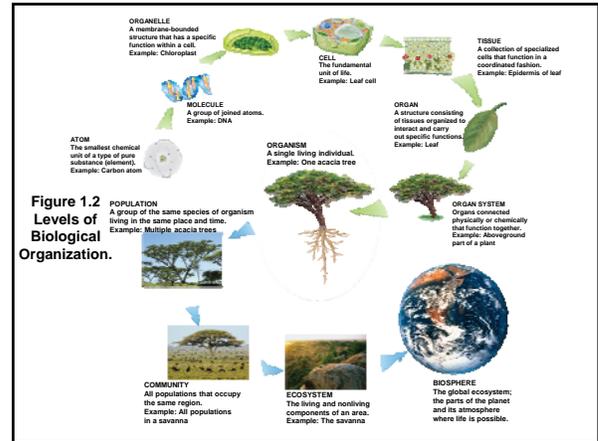
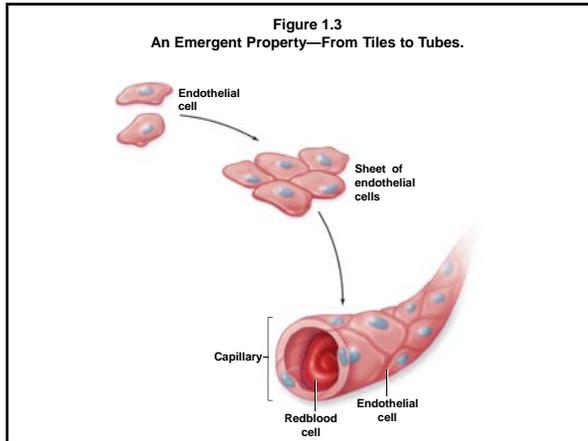
### We can define life by discussing its characteristics

- What are the characteristics of life?
  - Organization
  - Energy Use
  - Homeostasis (maintains internal constancy)
  - Reproduction, Growth and Development
  - Evolution

## 1.1 What is Life?

### Life is Organized

- In a hierarchical pattern
- Biological organization is apparent in all life and all aspects of life and biology
- In addition to this hierarchical organization are the emergent properties of life
  - In other words life is more than the parts, the way those parts interact gives rise to organs, organisms, species, communities and etc.



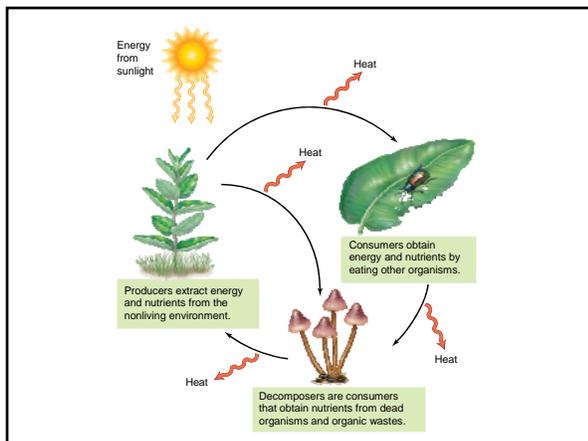
## Characteristics of Life

### Life Requires Energy

- Metabolism is defined as the sum of all chemical reactions in a cell
  - Metabolism allows organisms to acquire and use energy to grow, build new structures, repair old ones, and reproduce

## Classification based on energy sources

- Producers or autotrophs, make their own food by extracting energy from non-living sources and nutrients.
- Consumers or heterotrophs, obtain energy by consuming other organisms, whether living or dead.
  - Decomposers are a special group of heterotrophs that obtain energy from wastes or dead organisms



## Characteristics of Life

### Life Maintains Homeostasis

- Homeostasis is the maintenance of relatively constant internal conditions.
- All physiological systems respond to changes in homeostasis and act to return the body to homeostasis.

## Characteristics of Life

### Life Reproduces Itself, Grows, and Develops

- Living organisms generally reproduce in one of two ways
- Asexual reproduction occurs when an organism clones itself and produces a genetically identical offspring
  - This can occur by cell division, fragmentation, vegetative growth, or parthenogenesis
- Sexual reproduction, involves sex

## Characteristics of Life

### Life Reproduces Itself, Grows, and Develops

- Sex is particularly useful because it involves the fusion of gametes that are genetically different from the parents, giving rise to offspring that are essentially genetically unique
- Growth and development are the processes by which an organism develops from a fertilized egg into a reproductively mature adult.

## Characteristics of Life

### Life Evolves

- Evolution is defined as genetic change in a population over time.
- “Nothing in Biology makes sense except in the light of evolution”
  - Theodosius Dobzhansky
- Populations of organisms evolve through the process of natural selection.

- How does natural selection occur?
  - Resources are in limited supply
  - Organisms produce more offspring than can survive on those limited resources
  - Some individuals are better able to gain resources, survive, and reproduce than others
  - Those individuals that survive and reproduce pass on the genetic traits that allowed them to survive and reproduce to their offspring

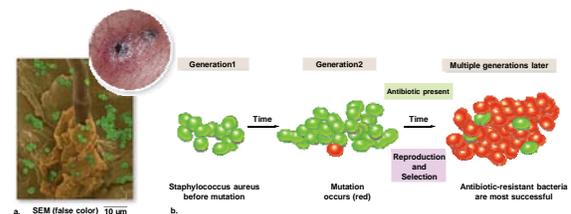
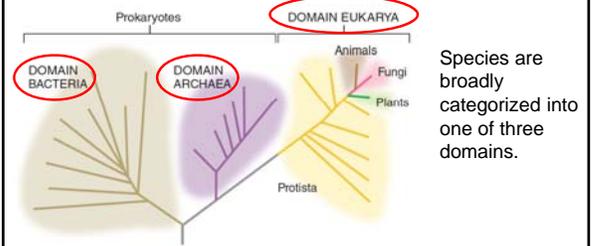


Figure 1.8 Natural Selection.

## Taxonomy

- Taxonomy is the science of classifying and naming organisms
- Classification is based on evolutionary relationships between organisms
- Species are a distinct evolutionary and biological unit that is at the 'lowest' end of the classification spectrum.
- The most useful species definition is the biological species definition of Ernst Mayr
- Species: Any group of actually or potentially interbreeding organisms that are reproductively isolated from other such groups

## The Tree of Life Includes Three Main Branches

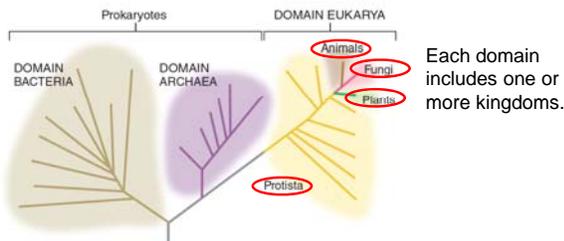


Species are broadly categorized into one of three domains.

Section 1.2

Figure 1.9

## The Tree of Life Includes Three Main Branches



Each domain includes one or more kingdoms.

Section 1.2

Figure 1.9

## The Tree of Life Includes Three Main Branches

Domain Bacteria and Domain Archaea are prokaryotic and unicellular.

Section 1.2

Figure 1.9

## The Tree of Life Includes Three Main Branches

Organisms in Domain Eukarya have cells with nuclei.

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Section 1.2

Amoeba: © Misha Photo Agency/PunchStock RF

Figure 1.9

## The Tree of Life Includes Three Main Branches

Organisms in Domain Eukarya have cells with nuclei.

Section 1.2

Bee: Courtesy of The National Human Genome Research Institute

Figure 1.9

### The Tree of Life Includes Three Main Branches

**Kingdom Fungi**

- Most are multicellular
- Heterotrophs (by external digestion)

Organisms in Domain Eukarya have cells with nuclei.

Section 1.2 Mushroom: © Cortis (RF) Figure 1.9

### The Tree of Life Includes Three Main Branches

**Kingdom Plantae**

- Multicellular
- Autotrophs

Organisms in Domain Eukarya have cells with nuclei.

Section 1.2 Leaf: © Photo by Keith Walker/USDA Figure 1.9

### The Scientific Method

In general, all scientific inquiry follows a standard process.

Section 1.3 Field biologist © Patrick Landmann/Science Source Figure 1.10

### Types of Science

Scientists test their hypotheses with discovery science or controlled experiments.

Section 1.3 Birdwatcher: U.S. Fish & Wildlife Service/JMK Hoffingsworth; Coffee tasters: © Cortis (RF) Figure 1.11

### Components of Experiments

Often experiments include independent, dependent, and standardized variables.

- Independent variable: what is manipulated (e.g., type of coffee bean)
- Dependent variable: what is measured (e.g., amount of caffeine)
- Standardized variable: held constant for all subjects in an experiment (e.g., mass of beans)

Section 1.3 Coffee tasters: © Cortis (RF) Figure 1.11

### Clicker Question #5

What is the dependent variable in the experiment outlined in this graph?

Dose of vaccine	Any rotavirus illness (# cases/100 child-years)	Severe rotavirus illness (# cases/100 child-years)
Placebo (control)	25.86	0
Low	2.15	2.15
Medium	6.19	0
High	6.86	0

Section 1.3 Figure 1.11

### Clicker Question #5

What is the dependent variable in the experiment outlined in this graph?

Dose of vaccine	Any rotavirus illness (# cases/100 child-years)	Severe rotavirus illness (# cases/100 child-years)
Placebo (control)	25.86	14.46
Low	2.15	2.15
Medium	6.19	0
High	6.86	0

Figure 1.11

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**Table 1.2** Types of Variables in an Experiment: A Summary

Type of Variable	Definition	Example
Independent variable	What the investigator manipulates to determine whether it influences the phenomenon of interest	Dose of experimental vaccine
Dependent variable	What the investigator measures to determine whether the independent variable influenced the phenomenon of interest	Number of children with illness caused by rotavirus
Standardized variable	Any variable intentionally held constant for all subjects in an experiment, including the control group	Age of children in study

### Scientific Theories Help Explain Observations

in 1862 when Charles Darwin saw the nectar tubes on these orchids he *predicted* that a moth pollinator would be discovered that had an equally long tongue.

Sections 1.3 & 1.4

Figure 1.13

### Scientific Theories Help Explain Observations

He based this prediction on his theory of evolution. Since these orchids shared characteristics with other orchids known to be moth pollinated

Sections 1.3 & 1.4

Figure 1.14

### Scientific Theories Help Explain Observations

In 1895, the moth was discovered by Alfred Russel Wallace

Sections 1.3 & 1.4

Figure 1.15

### 1.4 Mastering Concepts

What observations led Darwin and to predict the existence of a long-tongued moth in Madagascar?

Cowise rays CPete Ostro@Midori Pictures

## 1.3 Scientists Study the Natural World

### Theories Are Comprehensive Explanations

- Theory vs. hypothesis
  - Scope
  - Acceptance
  - Predictive power



## Scientists Study the Natural World

### Scientific Inquiry Has Limitations

- Scientific inquiry is neither foolproof nor always easy to implement
- Misinterpretation ([and see this](#))
- Slow acceptance
- Some questions cannot be answered by science