CONCEPTS OF BIOLOGY

Chapter 1 INTRODUCTION TO BIOLOGY

PowerPoint Image Slideshow

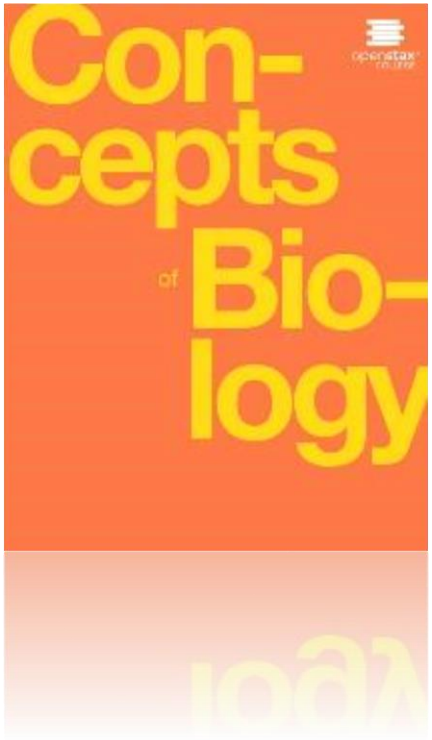

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FIGURE 1.1

This NASA image is a composite of several satellite-based views of Earth. To make the whole-Earth image, NASA scientists combine observations of different parts of the planet. (credit: modification of work by NASA)

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1.1 THEMES AND CONCEPTS OF BIOLOGY

- **Biology** – the science that studies life
- What exactly is life?
- Biologists created a list of characteristics that living things have
- Biologist consider an object to be alive if, and only if, it displays **ALL** of these properties

Viruses

Viruses can be transmitted from one organism to another and cause diseases. But are they considered living? Here are some interesting facts about viruses:

- A virus can attack a living organism
- A virus can reproduce inside that organism and cause disease
- A virus is not composed of cells.
- A virus cannot reproduce on its own.

Would you consider a virus a living organism? Why or why not?

Properties of Life

Living things must have **all** these characteristics:

1. **Order**- living things are complex and ordered
2. **Sensitivity or Response to Stimuli**- respond to their environment
3. **Reproduction**- reproduce to keep the species alive
4. **Adaptation**- environment influences survival
5. **Growth & Development**- can grow and develop (change) throughout life
6. **Regulation**- coordination of internal functions
7. **Homeostasis**- maintain internal balance
8. **Energy Processing**- perform metabolism

FIGURE 1.2 -ORDER

A toad represents a highly organized structure consisting of cells, tissues, organs, and organ systems. (credit: “Ivengo(RUS)”/Wikimedia Commons)

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FIGURE 1.3- SENSITIVITY OR RESPONSE TO STIMULI

The leaves of this sensitive plant (*Mimosa pudica*) will instantly droop and fold when touched. After a few minutes, the plant returns to its normal state. (credit: Alex Lomas)

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Watch this video:

http://openstaxcollege.org/l/thigmonasty

FIGURE 1.4- REPRODUCTION

Although no two look alike, these kittens have inherited genes from both parents and share many of the same characteristics. (credit: Pieter & Renée Lanser)

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FIGURE 1.5- HOMEOSTASIS

Polar bears and other mammals living in ice-covered regions maintain their body temperature by generating heat and reducing heat loss through thick fur and a dense layer of fat under their skin. (credit: “longhorndave”/Flickr)

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FIGURE 1.6- ENERGY PROCESSING

A lot of energy is required for a California condor to fly. Chemical energy derived from food is used to power flight. California condors are an endangered species; scientists have strived to place a wing tag on each bird to help them identify and locate each individual bird. (credit: Pacific Southwest Region U.S. Fish and Wildlife)

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Levels of Organization of Living Things (1 of 4)

As already mentioned, living things are highly organized and structured

- The **atom** is the smallest and most fundamental unit of matter
- It consists of a nucleus surrounded by electrons
- A **molecule** is two or more atoms held together by a chemical bond
- **Macromolecules** is large molecule formed by combining smaller units called monomers

Levels of Organization of Living Things (2 of 4)

- Molecules come together with other molecules to form **organelles**, small structures the exist within cells and perform specialized functions
- **Cells** are the smallest fundamental unit of a living organism
- All living things are made up of cells

Classifying Organisms

Organisms can be classified by the types of cells they are made up of:

- **Prokaryotes** - single-celled organisms that do not have a membrane-bound nucleus nor organelles surrounded by a membrane
- **Eukaryotes** - organisms with cells that do have a membrane-bound nucleus and other membrane-bound organelles

Levels of Organization of Living Things (3 of 4)

- Cells combine to make **tissues**, a group of similar cells that carry out the same function
- **Organs** are collections of tissues grouped together based on a common function
- **Organ System** consists of functionally related organs
- **Organisms** are individual living entities

Levels of Organization of Living Things (4 of 4)

- A **population** is all the individuals of a species living within a specific area
- A **community** is the set of populations inhabiting a particular area
- A **ecosystem** consists of all the living things and abiotic (non-living) things in a particular area
- The **biosphere** is the collection of all ecosystems and it represents the zones of life on Earth, includes land, water, and portions of the atmosphere

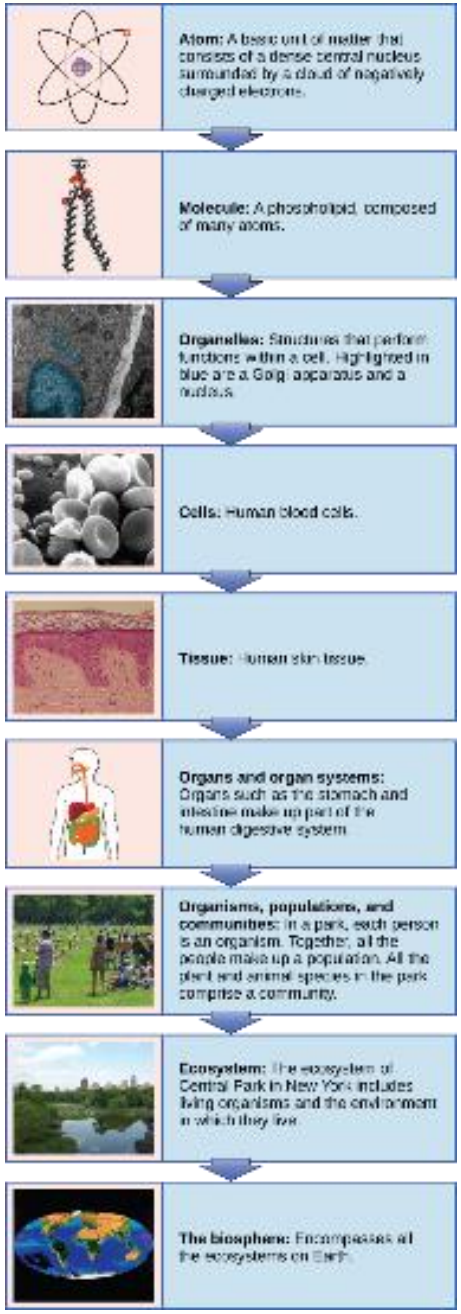

FIGURE 1.8

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From an atom to the entire Earth, biology examines all aspects of life. (credit “molecule”: modification of work by Jane Whitney; credit “organelles”: modification of work by Louisa Howard; credit “cells”: modification of work by Bruce Wetzel, Harry Schaefer, National Cancer Institute; credit “tissue”: modification of work by “Kilbad”/Wikimedia Commons; credit “organs”: modification of work by Mariana Ruiz Villareal, Joaquim Alves Gaspar; credit “organisms”: modification of work by Peter Dutton; credit “ecosystem”: modification of work by “gigi4791”/Flickr; credit “biosphere”: modification of work by NASA)

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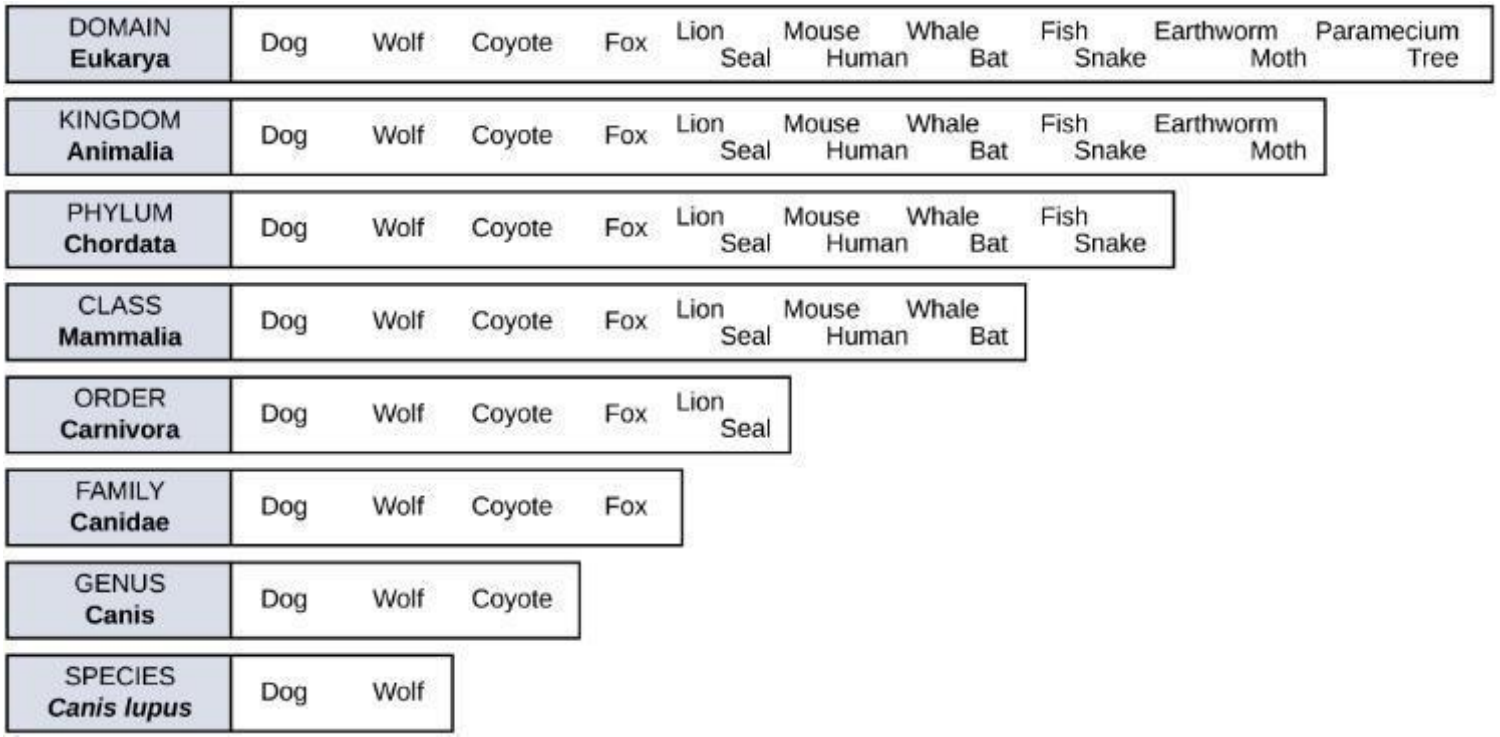
The Diversity of Life

- **Evolution** - the process of gradual change during which new species arise from older species
- Evolution has led to great diversity of life on Earth

Hierarchical Taxonomy

- Approximately 8.7 millions living things have been studied on the Earth
- Such a large number of living things are organized by grouping organisms by their similarities
- Each large group gets broken down into smaller groups that are even more similar
- This organizational system (known as **hierarchical taxonomy**) was proposed by a scientist named Carl Linnaeus in the 18th century

FIGURE 1.9



This diagram shows the levels of taxonomic hierarchy for a dog, from the broadest category—domain—to the most specific—species.

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FIGURE 1.10- DOMAINS

domain Bacteria

domain Archaea

domain Eukarya

These images represent different domains. The scanning electron micrograph shows (a) bacterial cells belong to the domain Bacteria, while the (b) extremophiles, seen all together as colored mats in this hot spring, belong to domain Archaea. Both the (c) sunflower and (d) lion are part of domain Eukarya. (credit a: modification of work by Rocky Mountain Laboratories, NIAID, NIH; credit b: modification of work by Steve Jurvetson; credit c: modification of work by Michael Arrighi; credit d: modification of work by Frank Vassen)

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Binomial Naming System

- Linnaeus was also the first to name organisms using two unique names, now called the **binomial naming system**
- Binomial names consist of the genus name (always capitalized) and the species name (lower-case)
- In print, the genus and species are set in italics
- Examples: the North American blue jay is known as *Cyanocitta cristata* and we are known as *Homo sapiens*

Hierarchical Taxonomy of a Human

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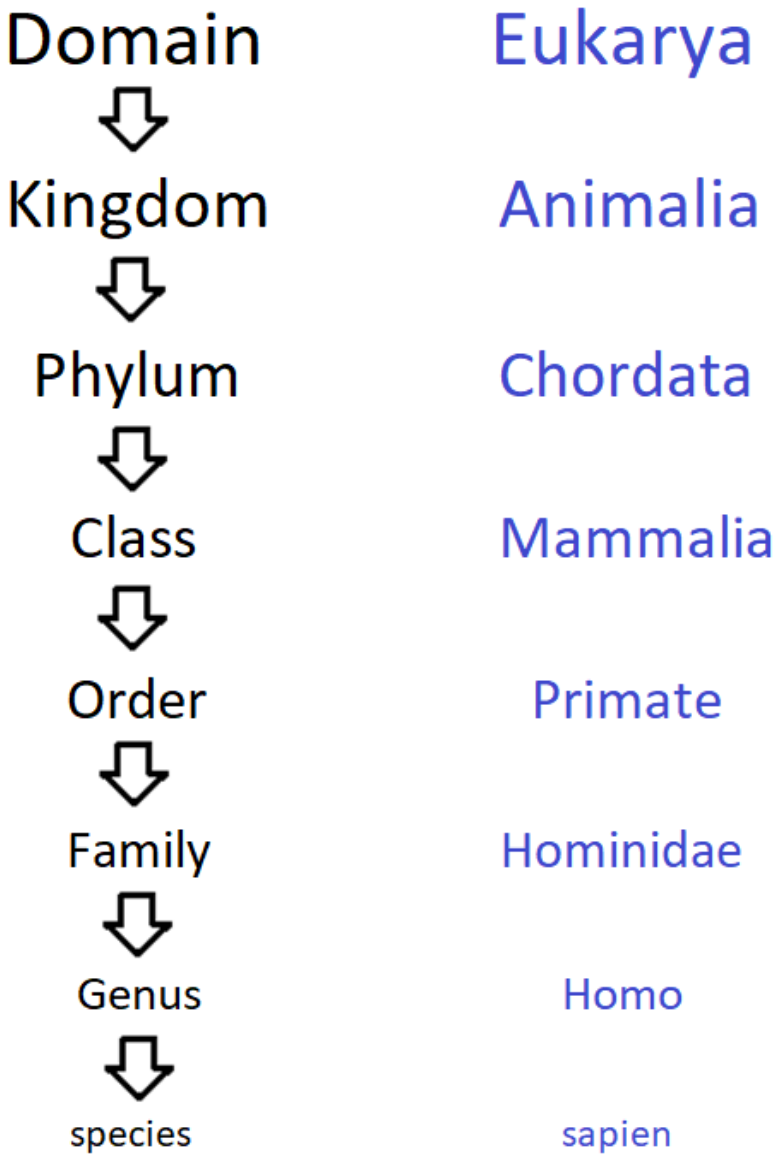

Phylogenetic Tree

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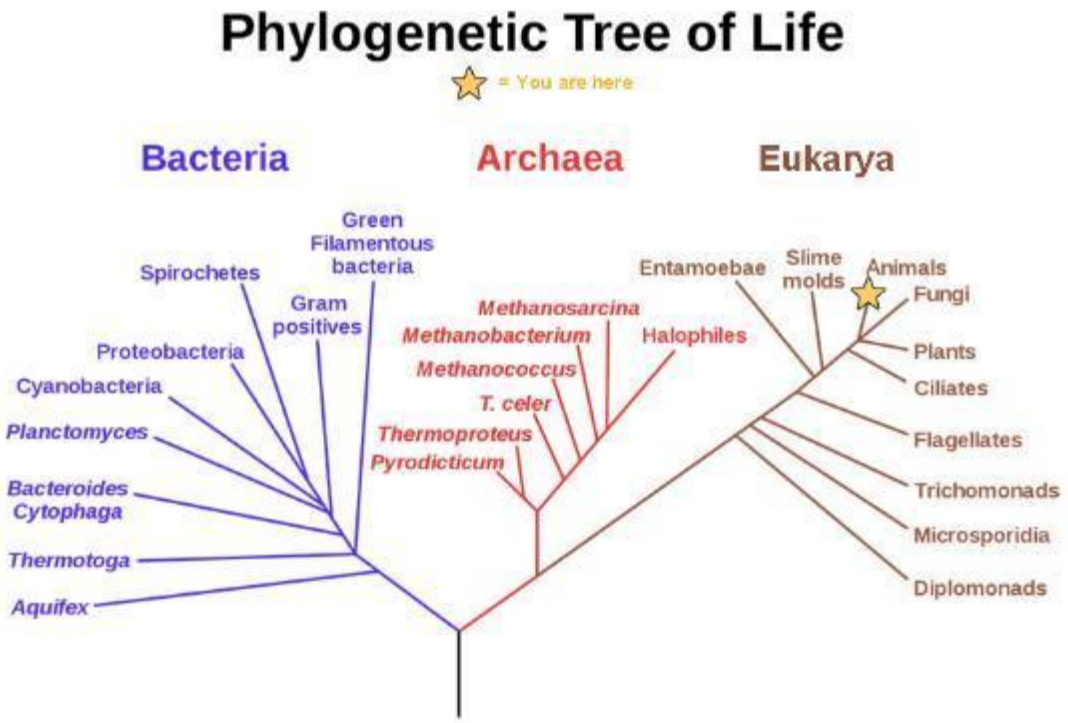
- **Phylogenetic tree** - a diagram showing the evolutionary relationship among biological species based on similarities and differences in genetic or physical traits or both

FIGURE 1.11



This phylogenetic tree was constructed by microbiologist Carl Woese using genetic relationships. The tree shows the separation of living organisms into three domains: Bacteria, Archaea, and Eukarya. Bacteria and Archaea are organisms without a nucleus or other organelles surrounded by a membrane and, therefore, are prokaryotes. (credit: modification of work by Eric Gaba)

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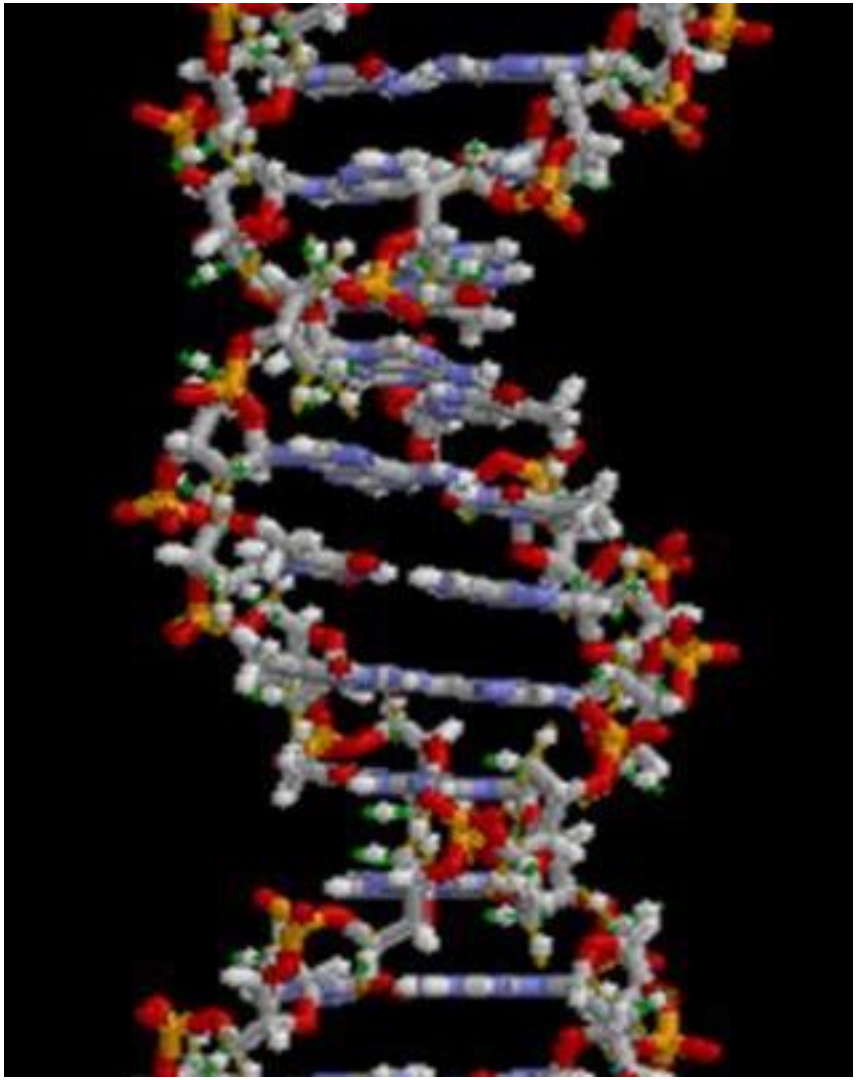
FIGURE 1.7- DNA ANALYSIS CAN SHOW US THE RELATIONSHIP BETWEEN ORGANISMS



A molecule, like this large DNA molecule, is composed of atoms. (credit: “Brian0918”/Wikimedia Commons)

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Branches of Biological Study

There are many branches and sub disciplines in the scope of biology

- Molecular biology – studies biological processes at the molecular level
- Microbiology – studies the structure and function of microorganisms, includes microbial physiologist, ecologists and geneticists, among others
- Neurobiology – studies the biology of the nervous system, including molecular, cellular, developmental, medical, and computational
- Paleontology – studies life history
- Zoology – studies animals and plants
- Biologists can specialize as biotechnologists, ecologists, or physiologists, to name just a few areas

FIGURE 1.12- FOSSILS GIVE US A LOOK INTO THE PAST

Researchers work on excavating dinosaur fossils at a site in Castellón, Spain. (credit: Mario Modesto)

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FIGURE 1.13

Forensic science is the application of science to answer questions related to law. Forensic scientists include biologist, chemist and biochemist.

This forensic scientist works in a DNA extraction room at the U.S. Army Criminal Investigation Laboratory. (credit: U.S. Army CID Command Public Affairs)

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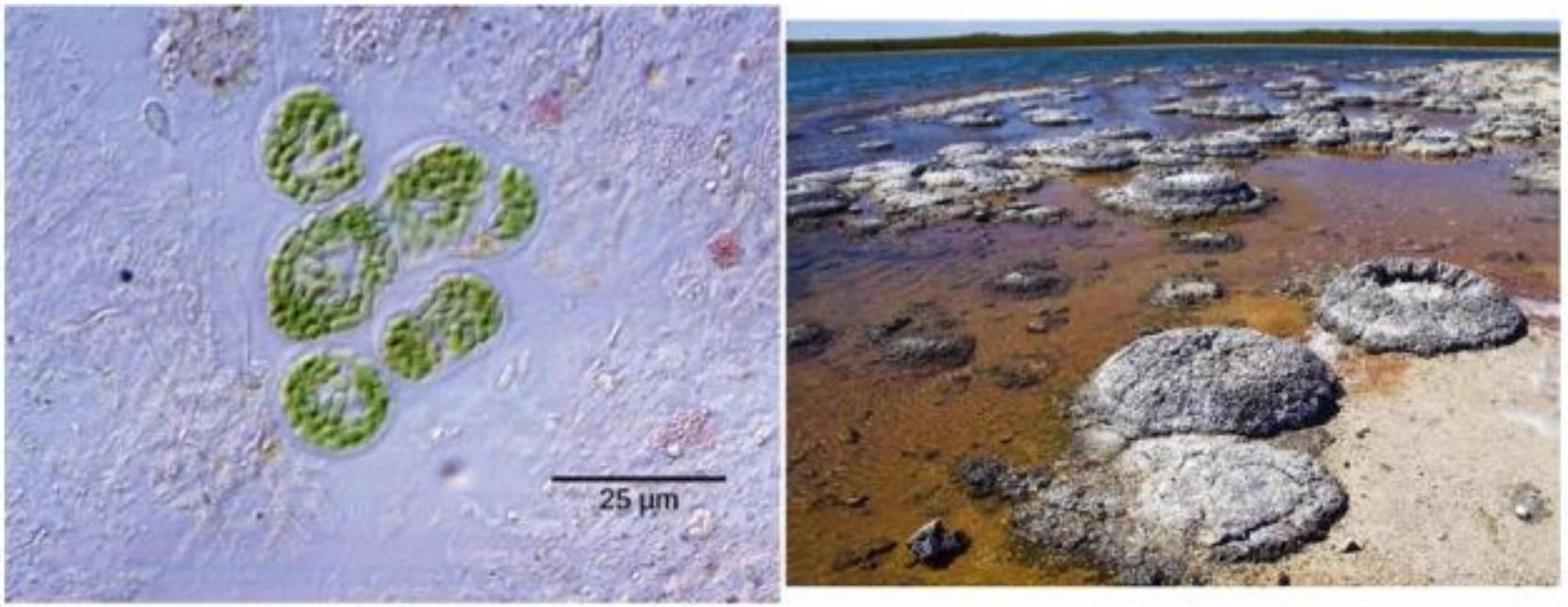
FIGURE 1.14



Formerly called blue-green algae, the (a) cyanobacteria seen through a light microscope are some of Earth's oldest life forms. These (b) stromatolites along the shores of Lake Thetis in Western Australia are ancient structures formed by the layering of cyanobacteria in shallow waters. (credit a: modification of work by NASA; scale-bar data from Matt Russell; credit b: modification of work by Ruth Ellison)

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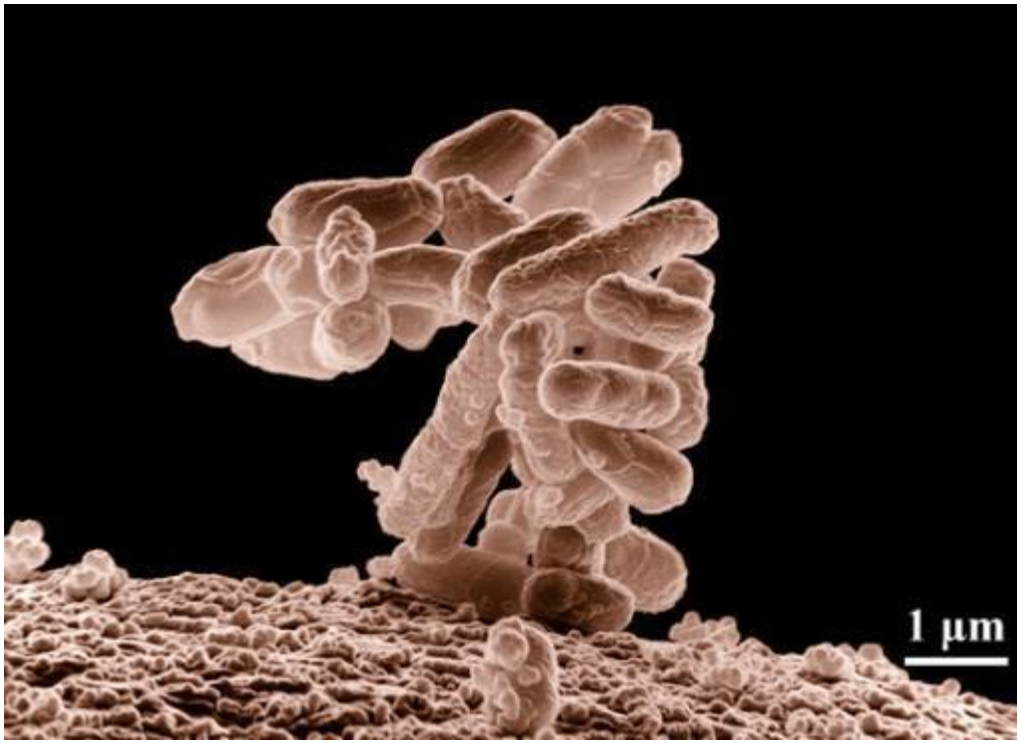
FIGURE 1.15



Biologists may choose to study *Escherichia coli* (*E. coli*), a bacterium that is a normal resident of our digestive tracts but which is also sometimes responsible for disease outbreaks. In this micrograph, the bacterium is visualized using a scanning electron microscope and digital colorization. (credit: Eric Erbe; digital colorization by Christopher Pooley, USDA-ARS)

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1.2- THE PROCESS OF SCIENCE

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- The discoveries of biology are made by a community of researchers who work individually and together using agreed-on methods

The Nature of Science

- **Science** can be defined as knowledge about the natural world
- Science can not answer purely moral questions, aesthetic questions or spiritual questions

The Scientific Method (1 of 2)

- Scientists tend to use the same general steps to find answers to important questions, this is called the scientific method
- The **scientific method** - a method of research with defined steps that include experiments and careful observations; it is a guideline, and can be altered to fit many different research projects

The Scientific Method (2 of 2)

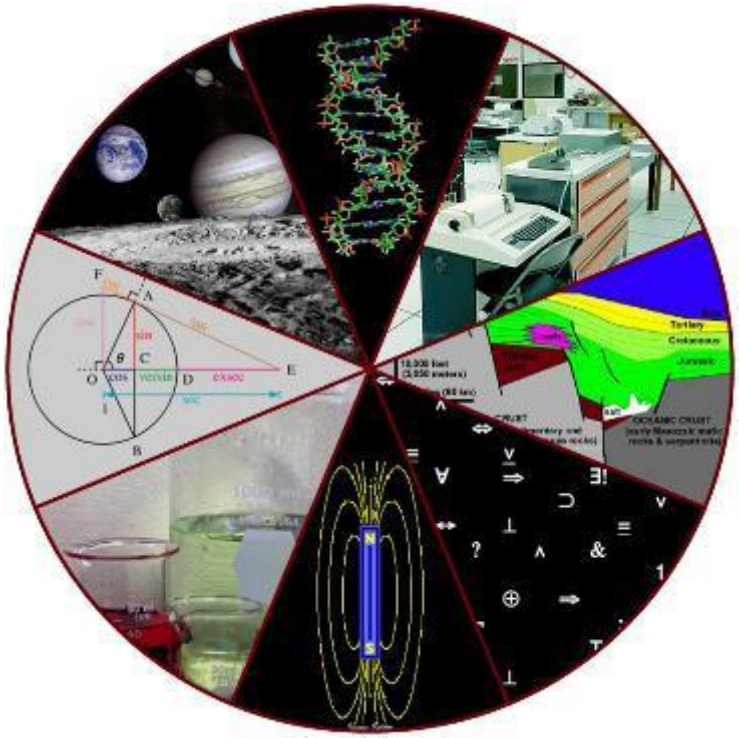
- **Hypothesis** - a suggested explanation for an event, which can be tested
- **Scientific theory** - a generally accepted, thoroughly tested, and confirmed explanation for a set of observation or phenomena
- **Scientific laws** describe how elements of nature will behave under certain specific conditions, often expressed in mathematical formula

Natural Sciences

Natural sciences are fields of science related to the physical world and its phenomena and processes

- Includes biology, astronomy, geology, physics, chemistry, etc
- Some scholars choose to divide natural sciences into life sciences (study of living things, including biology) and physical sciences (study of nonliving matter, including astronomy, physics and chemistry)
- Some disciplines , like biophysics and biochemistry, build on both sciences

FIGURE 1.16



Some fields of science include astronomy, biology, computer science, geology, logic, physics, chemistry, and mathematics. (credit: “Image Editor”/Flickr)

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Scientific Inquiry (1 of 2)

Scientist use two methods of logical thinking to try to understand and explain the world

- **Inductive reasoning** - a form of logical thinking the uses related observation to arrive at a general conclusion

- **Deductive reasoning** - a form of logical thinking that uses a general principle or law to forecast specific results

Scientific Inquiry (2 of 2)

Both types of logical thinking are related to the two main pathways of scientific study: descriptive science and hypothesis-based science

- **Descriptive (or discovery) science** aims to observe, explore and discover
- **Hypothesis-based science** aims to test a potential answer to a specific problem
- Most scientific endeavors combine both approaches

FIGURE 1.17

Sir Francis Bacon is credited with being the first to document the scientific method

The scientific method is not exclusively used by biologists, it can be applied to almost anything as a logical problem-solving method

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Hypothesis Testing

Step 1: **Make an observation** – observe something of interest.

Step 2: **Question** something about what you observed.

Step 3: **Formulate a hypothesis**, a possible answer to the question.

A hypothesis must be testable. It should also be **falsifiable**, meaning that it can be disproven by experimental results. A hypothesis can be disproven, or eliminated, but it can never be proven.

Step 4: **Make a prediction** based on your hypothesis.

Typically has the format "If..., then…"

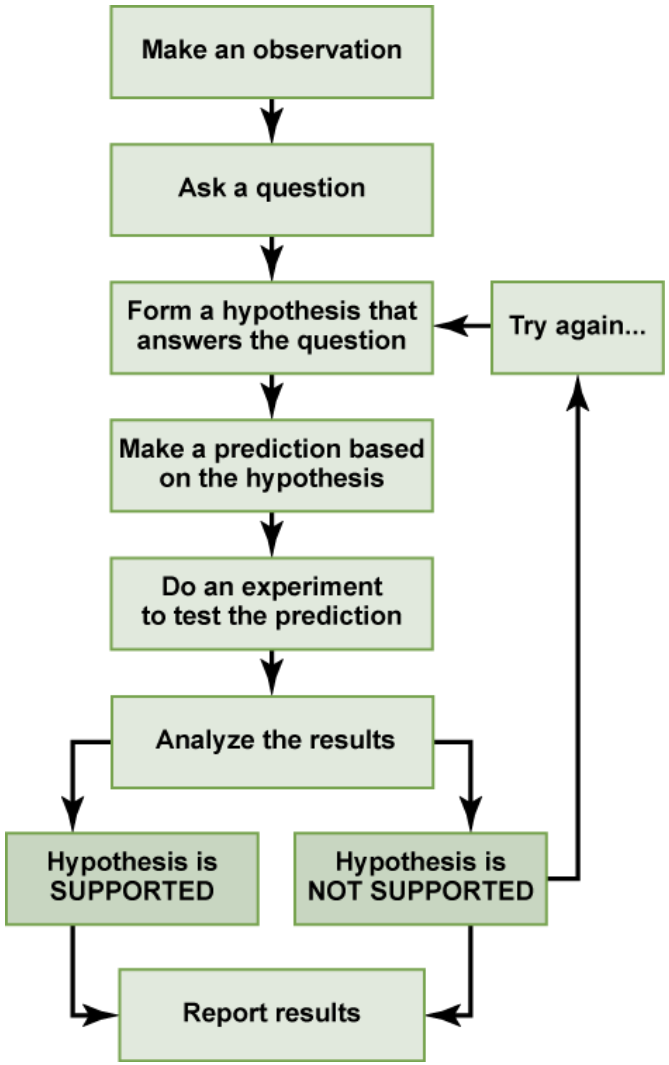
Step 5: **Create an experiment** to test your hypothesis.

An experiment will have **variables** (the part of the experiment that varies or changes) and **controls** (the part of the experiment that does not change).

Step 6: **Collect data/results** from the experiment.

Step 7: **Form a conclusion** after analyzing the results.

FIGURE 1.18



The scientific method is a series of defined steps that include experiments and careful observation. If a hypothesis is not supported by data, a new hypothesis can be proposed.

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Basic and Applied Science

- **Basic (or pure) science** seeks to expand knowledge regardless of the short-term application of that knowledge.
  - It does not focus on developing a product or a service of immediate public or commercial value
- **Applied (technology) science** aims to use science to solve real-world problems
  - Focuses on things such as improving farm, curing diseases or saving animals

Most applied sciences wouldn't be possible without basic science

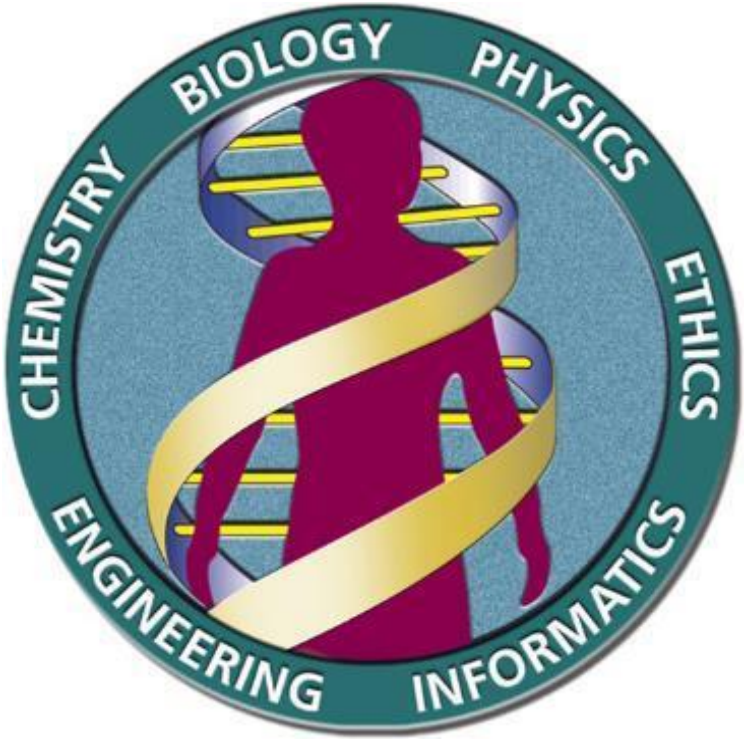
Reporting Scientific Work

Peer-reviewed articles - scientific papers that are reviewed, usually anonymously by a scientists colleagues or peers

**There are many journals and popular press that do not use a peer-review system. Results of any study published without peer review are not reliable and should not form the basis for other scientific work.

FIGURE 1.19

The human genome project started with basic science to map out all the genes of humans. It lead to applied science using that knowledge to discover genetic diseases.



The Human Genome Project was a 13-year collaborative effort among researchers working in several different fields of science. The project was completed in 2003. (credit: the U.S. Department of Energy Genome Programs)

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