

# Chapter 1

## BIOLOGY AND THE TREE OF LIFE:

THEMES IN THE STUDY OF LIFE

&

SCIENTIFIC PROCESS

# Objectives

- Be able to identify, explain and give examples of the six themes central to living organisms that we will emphasize throughout the semester
- Be able to describe how science works as a process
- Be familiar with relevant vocabulary

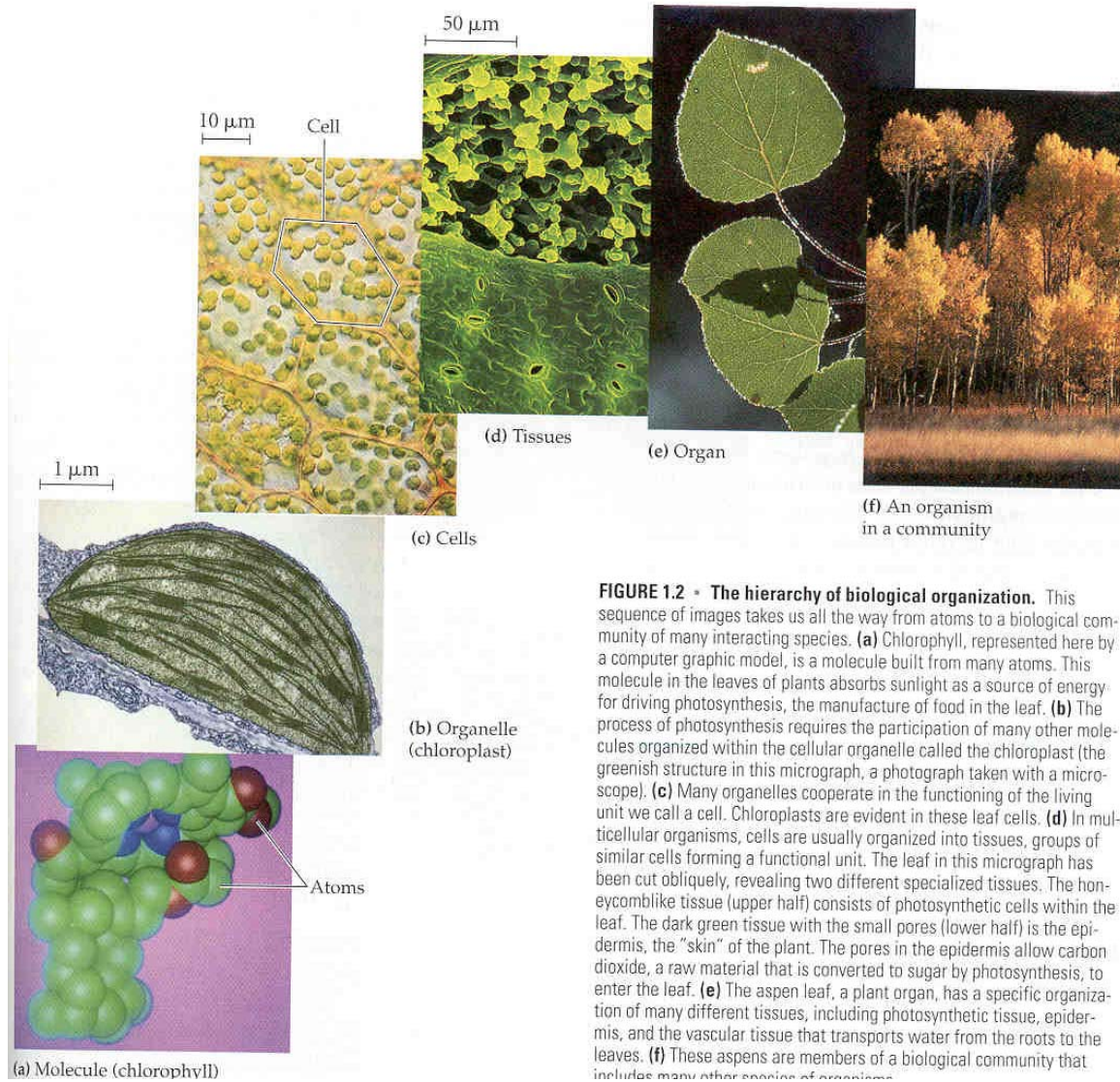
# Six Unifying Themes Of Life

Living things:

- Are **organized**, there are many hierarchical levels of biological structure. Each level exhibits **emergent properties** not seen in the lower level
- Are made of **cell(s)**
- Are self regulating through **regulatory feedback**
- Show correlation between **structure and function**
- **Interact with their environment**, responding to changes
- Contain **heritable information**: encoded on DNA, genes are units of information

# Theme 1: Life is Organized

- Living things demonstrate hierarchical order. A hierarchy demonstrates an interdependence of each level
- Basic levels of order in a multicellular organism are generally considered to reflect the following: Atoms → Complex biological molecules → Subcellular organelles → Cells → Tissues → Organs → Organ systems → Complex organism.



**FIGURE 1.2 • The hierarchy of biological organization.** This sequence of images takes us all the way from atoms to a biological community of many interacting species. **(a)** Chlorophyll, represented here by a computer graphic model, is a molecule built from many atoms. This molecule in the leaves of plants absorbs sunlight as a source of energy for driving photosynthesis, the manufacture of food in the leaf. **(b)** The process of photosynthesis requires the participation of many other molecules organized within the cellular organelle called the chloroplast (the greenish structure in this micrograph, a photograph taken with a microscope). **(c)** Many organelles cooperate in the functioning of the living unit we call a cell. Chloroplasts are evident in these leaf cells. **(d)** In multicellular organisms, cells are usually organized into tissues, groups of similar cells forming a functional unit. The leaf in this micrograph has been cut obliquely, revealing two different specialized tissues. The honeycomblike tissue (upper half) consists of photosynthetic cells within the leaf. The dark green tissue with the small pores (lower half) is the epidermis, the "skin" of the plant. The pores in the epidermis allow carbon dioxide, a raw material that is converted to sugar by photosynthesis, to enter the leaf. **(e)** The aspen leaf, a plant organ, has a specific organization of many different tissues, including photosynthetic tissue, epidermis, and the vascular tissue that transports water from the roots to the leaves. **(f)** These aspens are members of a biological community that includes many other species of organisms.

# Theme 1: Life is Organized

- Levels beyond the individual: Population → Community → Ecosystem → Biomes → Biosphere.
- At each new level of organization, new characteristics become apparent. These new characteristics are referred to as emergent properties.

# Emergent properties

- **Emergent property** = Attribute that is created as a result of interactions between components.
  - New types of **Order**: processes, awareness
  - Different forms of **Reproduction**: asexual vs. sexual
  - **Growth** and **Development**
  - **Energy utilization**
  - **Response** to environment
  - **Homeostasis**: Management of the internal environment
  - Evolutionary **adaptation**: Change in response to natural selection

# Taxonomy

- Biologists utilize the “order” of the system to group organisms by taxonomy
- Taxonomic schemes undergo change as our understanding of life becomes more complete.
- Molecular understanding has brought about revolutionary change

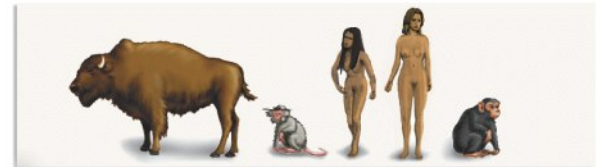
**KINGDOM**  
(Animalia)



**PHYLUM**  
(Chordata)



**CLASS**  
(Mammalia)



**ORDER**  
(Primates)



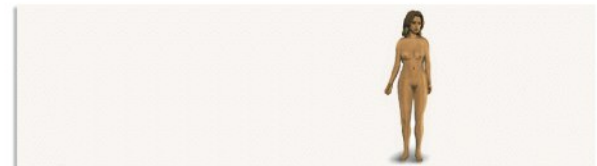
**FAMILY**  
(Hominidae)



**GENUS**  
(*Homo*)

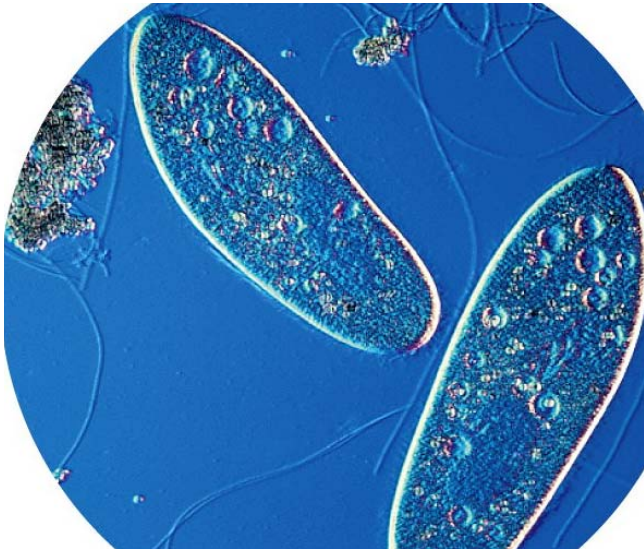


**SPECIES**  
(*sapiens*)

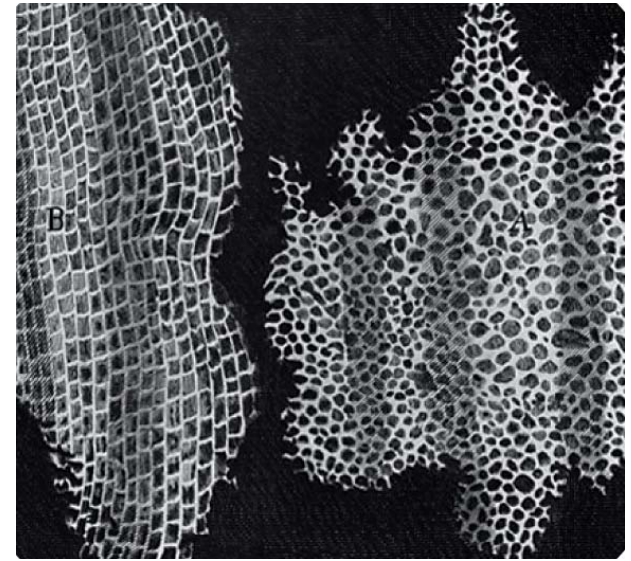


# Theme 2: All Organisms Are Made Of Cells.

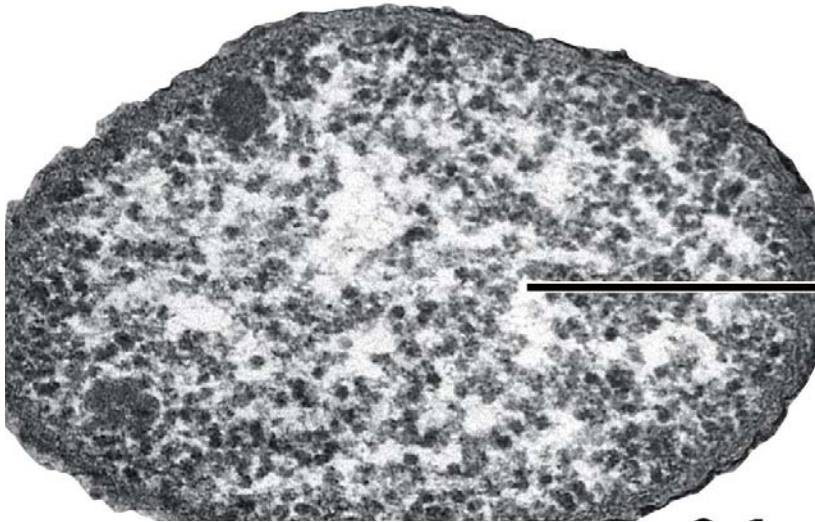
- Cell theory: all living organisms are comprised of cells that come from preexisting cells
- **Antonie van Leeuwenhoek** (1660): inventor of the microscope and 1st person to see living cell
- **Robert Hooke** (1665): coined the term
- **Matthias Schleiden** and **Theodor Schwann** (1839): theorized that all living things are made of cells



Antonie van Leeuwenhoek

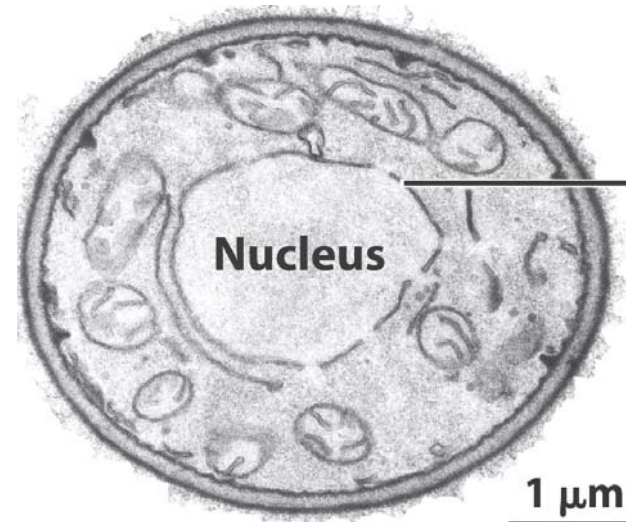


Robert Hooke



Prokaryotic

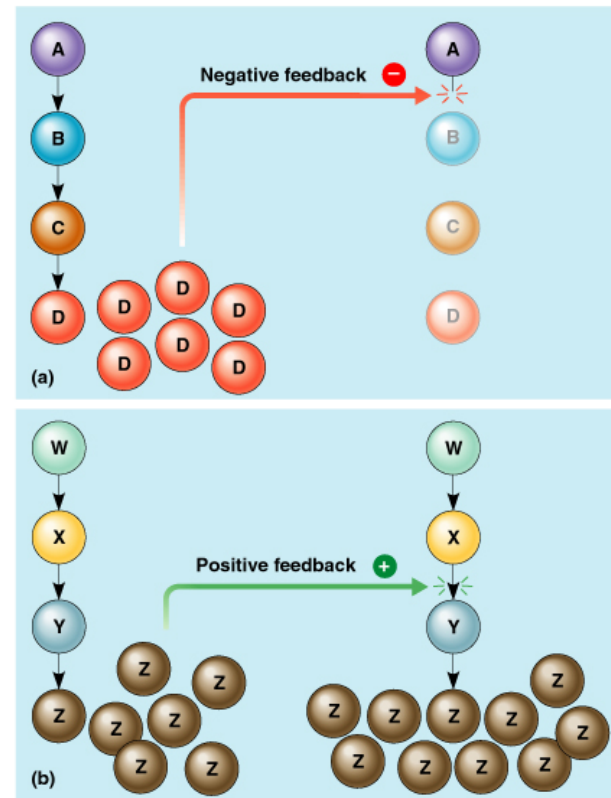
vs.



Eukaryotic Cells

# Theme 3: Regulatory Mechanisms Ensure A Dynamic Balance In Living Systems.

- Negative feedback slows a process down
  - results in a change in activity
- Positive feedback speeds a process up
  - promotes continuation of an activity

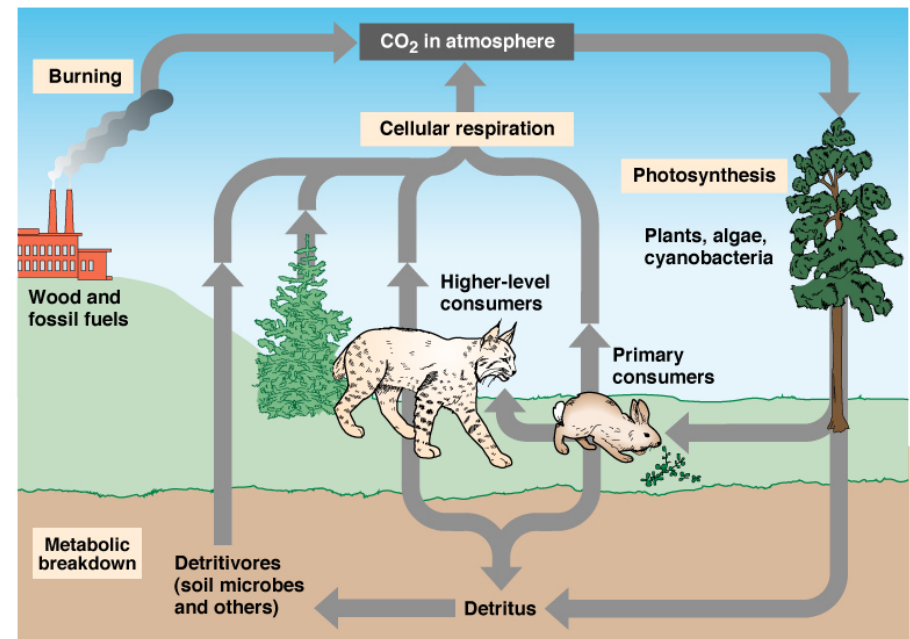


# Theme 4: Form Fits Function.

- Structure and function are correlated at all levels of biological organization
  - Within a structure are clues about what it does and how it works
  - Knowing a structure's function gives insights about its construction
- This correlation is apparent at many levels of biological organization.

# Theme 5: Organisms Are **Open Systems** That Interact Continuously With Their Environments.

- Environmental interactions include both **biotic** and **abiotic** components
- Ecosystem dynamics include two major processes:
  - Nutrient cycling
  - Energy flow



# Theme 6: The Continuity Of Life Is Based On Heritable Information In The Form Of DNA.

- DNA: Made of nucleotides that linearly encode information in a gene
- Inheritance is based on a complex mechanism for copying DNA, passing the information encoded in DNA from parent to offspring
- Similar nucleotide sequences convey the same information to one organism as it does in another
  - Differences between organisms reflect different nucleotide sequences

# Theory of Evolution by Natural Selection

- Evolution means that species are not independent and unchanging entities but are related to each other and can change over time
- Two criteria are needed for Natural Selection to occur:
  - 1) Heritable traits: Adaptation must be genetically based
  - 2) Traits lead to differential survival (some combinations are better than others)

# SCIENCE AS A PROCESS

- Testable hypotheses are the hallmarks of the scientific process.
- The key ingredient of the scientific process is the hypothetico-deductive method.
- Scientific method
- Variable is a condition that is changeable and may influence experimental outcome
- Control group is used to hold the variables constant