Ch 1

Introduction to Biology

BIOL 160

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What is Science?

- Science is a body of knowledge (and more)
  - but only looks to find "what is there?"
- Based upon:
  - observation
    - objectivity
  - repeatability

- 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)

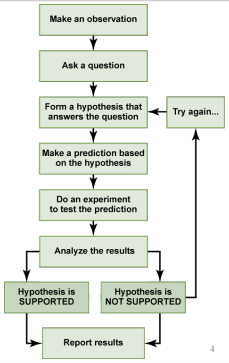
What is Science?

- Repeated objective observations may eventually lead to a theory
- **Theory -**
  - A general set of principles, supported by evidence (observations), that explains some aspect of nature.
  - Very different from a "theory" outside of science.
    - conjecture

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

Two Approaches to Science

- **Scientific method**
  - a series of defined steps including experiments and careful observation
    - If a hypothesis is not supported by data, a new hypothesis can be proposed
  - Discovery Science
  - Hypothesis Driven Science
    - most scientists use a combination of both types



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Hypothesis and Prediction

- Hypothesis
  - a scientific "prediction"
    - based on prior knowledge
  - a type of "if …. then" statement
    - that is testable and only has ONE factor or variable

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Design the Experiment

- hardest part of the experiment
- many factors will affect your experiment
  - called variables
- independent variable
  - what you change
- dependent variable
  - what you measure
- in a controlled experiment
  - it is "assumed" that you have accounted for as many of the variables as possible

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Collect the Data

- defining your dependent variable is the most important step
  - Again, is it testable?
- you may have to refine your technique
  - Organized trial and error

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

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)

Evaluate

- Correlation versus causation
- Very rarely will a "good" scientist say that results are causation.
  - Correlation
  - Statistically supported

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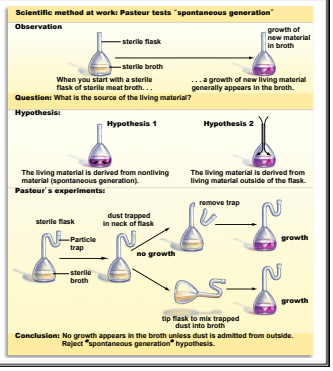
Example

- An example of hypothesis testing is Louis Pasteur's experiment regarding the spontaneous generation of life
  - Prior to this experiment, many believed life could arise from nothing…
    - Maggots appear to "spontaneously generate" on meat left exposed



When is a Theory Proven?

- Never! (officially anyway)
  - Only falsifiable
- Every assertion regarding the natural world is subject to challenge and revision.
  - Hence, repeatability
- As hypotheses are independently repeated, they are either "supported" or "unsupported"
  - Only after many repetitions with the same result will a hypothesis become a theory
    - Always and forever subject to further testing or knowledge

The Nature of Biology

- Biology is the study of life
  - Bio = life
  - ology = study of
- So, What defines life?

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

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)

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)

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

The Nature of Biology

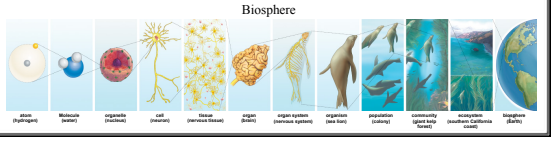
Life is defined by a group of eight characteristics possessed by living things.

- 1. Assimilate energy.
- 2. Respond to their environment.
- 3. Maintain a relatively constant internal environment.
- 4. Reproduce.
- 5. Possess an inherited information base, encoded in DNA, that allows them to function.
- 6. Are composed of one or more cells.
- 7. Evolve
- (8. Are highly organized compared to inanimate objects.)

Organization of Life

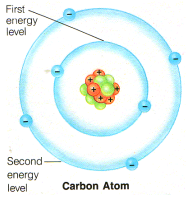
- Life is organized in a hierarchical manner, in increasing complexity:

Atoms
Molecules
Organelles
Cells
Tissues
Organs
Organ systems
Organisms
Populations
Communities
Ecosystems
Biosphere



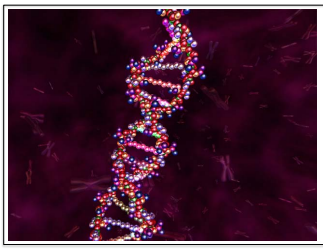
Levels of Organization

- Atoms
  - Made in stars
  - Most consist of protons, neutrons and electrons



Levels of Organization

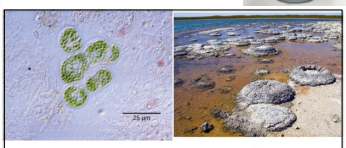
- Molecules
  - Made up of atoms



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

Levels of Organization

- Cells
  - Smallest unit of life
  - A membrane bound unit of living matter



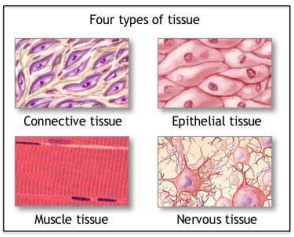
(a) (b)

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)

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)

Levels of Organization

- Tissues
  - Groups of similar cells that work together
  - 4 Main Types (CMEN)
    - Connective, Muscle, Epithelial, Nervous



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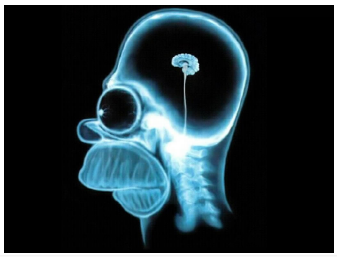
Levels of Organization

- Organs
  - Different tissues working together in a coordinated manner.



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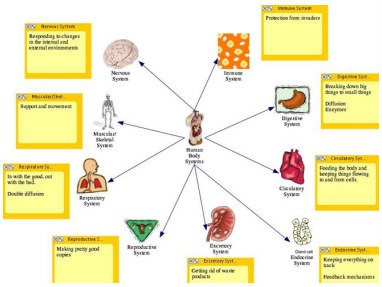
Levels of Organization

- Organ Systems
  - Individual organs working together
  - Digestive, excretory, nervous, etc.



Levels of Organization

- Organism
  - All organ systems working together
  - The individual

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Levels of Organization

- Population
  - Individuals of a species that interact

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Levels of Organization

- Community
  - All the organisms of different species (biotic)

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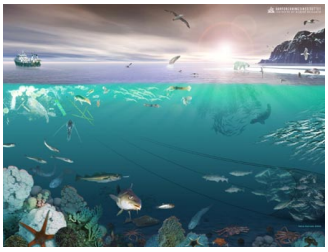
Levels of Organization

- Ecosystem
  - Includes biotic and abiotic factors



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Levels of Organization

- Biosphere
  - Sum of all ecosystems

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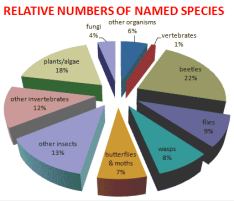
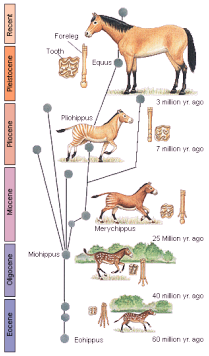
Special Qualities of Biology

- Biology's subject matter—the living world—is notable for its complexity and diversity compared to other aspects of the natural world
  - Estimated as many as 5-30 million species
    - Some say 100 million
  - 1.5 million described (~5%)



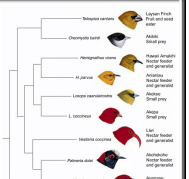
Special Qualities of Biology

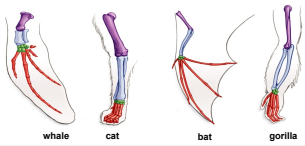
- Evolution
  - Biology's chief unifying principle
  - The gradual modification of populations of living things over time.
  - This modification sometimes results in the development of new species.

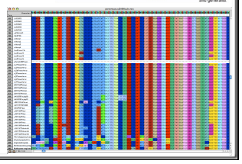


Classification of Organisms

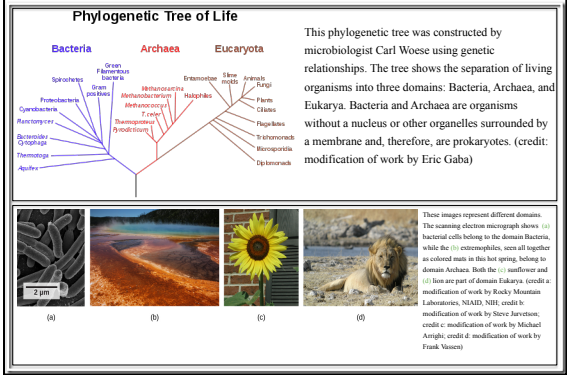
- Taxonomy
  - Methods of arranging specific living organisms into a hierarchy
    - Based upon degree of relatedness
      - Measured by similarity of characteristics
        - Genetic
        - Morphological
        - Physiological







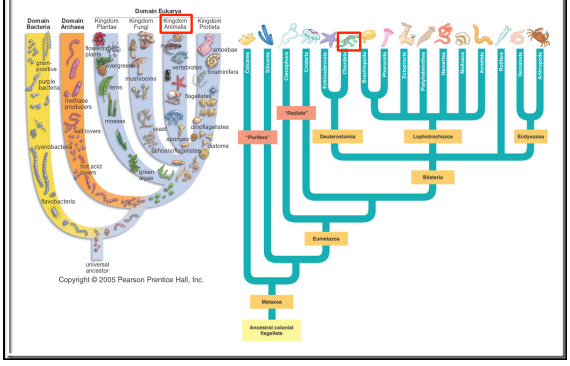
Three domains



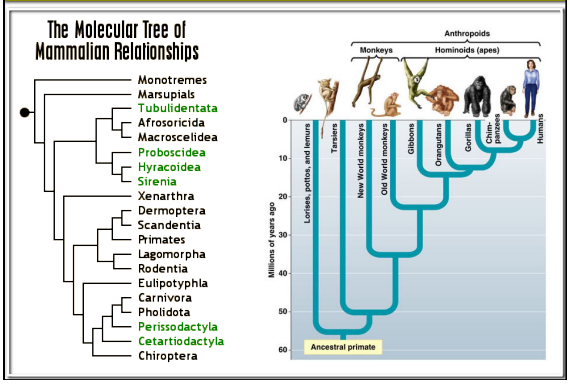
This phylogenetic tree was constructed by microbiologist Carl Woese using genetic relationships. The tree shows the separation of living organisms into three domains: Bacteria, Archaea, and Eukarya. Bacteria and Archaea are organisms without a nucleus or other organelles surrounded by a membrane and,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

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)

Kingdom Animalia / Phylum Chordata

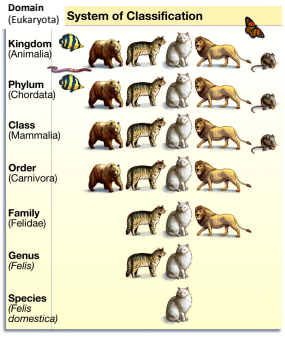


Class Mammalia / Order Primates



Linnaean Classification System

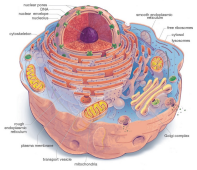
Dear
King
Philip
Came
Over
For
Good
Soup

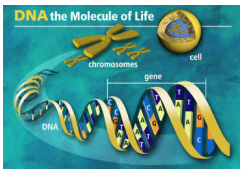


Carolus Linnaeus
Systema Naturae
1735

Similarity is a Function of DNA

- Every cell (~60 trillion!)
  - contains a complete copy of our DNA
    - = genome
  - DNA codes for everything we are (via proteins)
    - Relatedness ultimately derived from that DNA





Relatedness Means Genetic Similarity

- Genetic Divergence
  - % difference in genetic sequence