

# Life on Earth

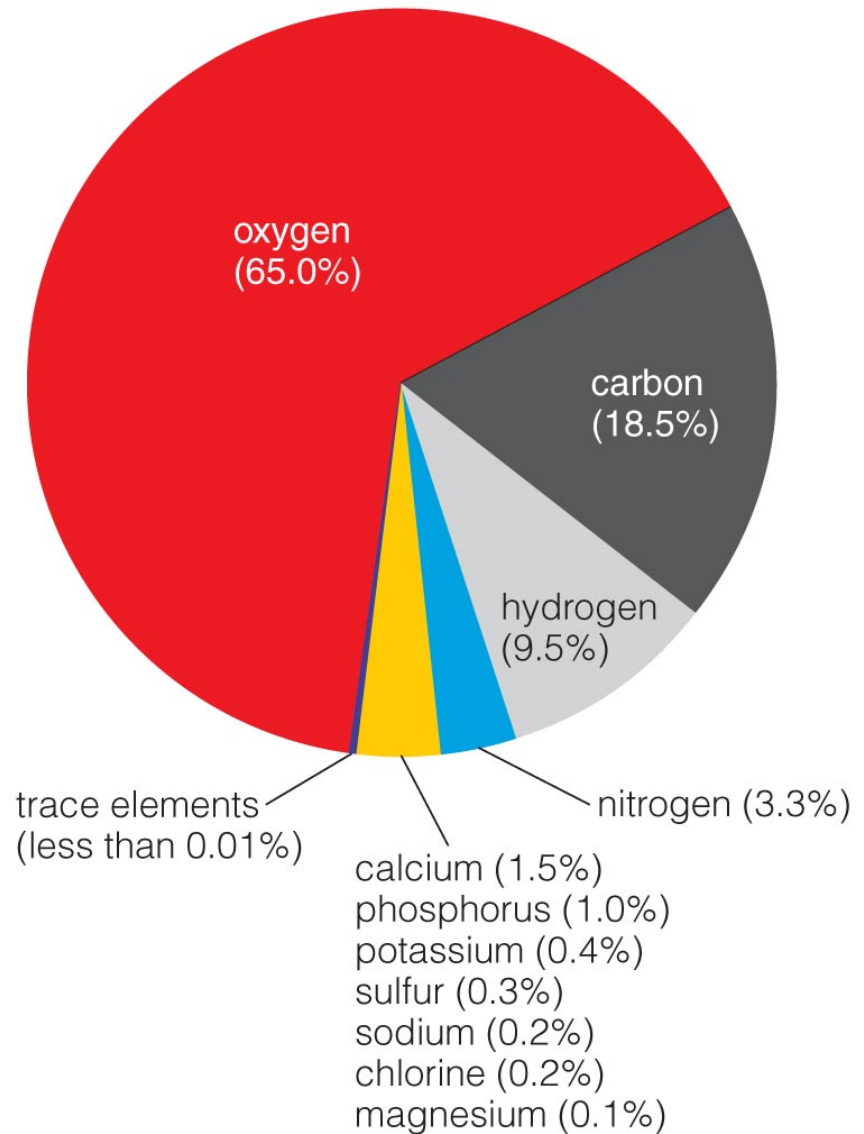


# FROM CHEMISTRY TO BIOLOGY

You're all atoms, in Earthly proportions.

By number of atoms:

**H**    **55%**  
**O**    **28%**  
**C**    **10%**  
**N**    **5%**



# Water is Special

- Three-quarters of the Earth's surface is submerged in water
- The abundance of water is the main reason the Earth is habitable



Figure 3.1

# Carbon is Special

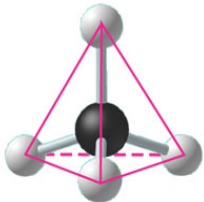

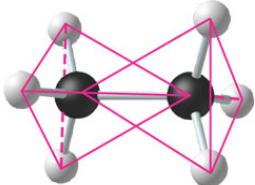

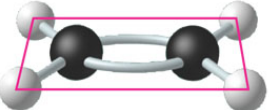
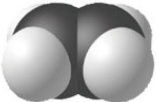
- Overview: Carbon—The Backbone of Biological Molecules
- All living organisms
  - Are made up of chemicals based mostly on the element carbon: organic chemistry



Figure 4.1

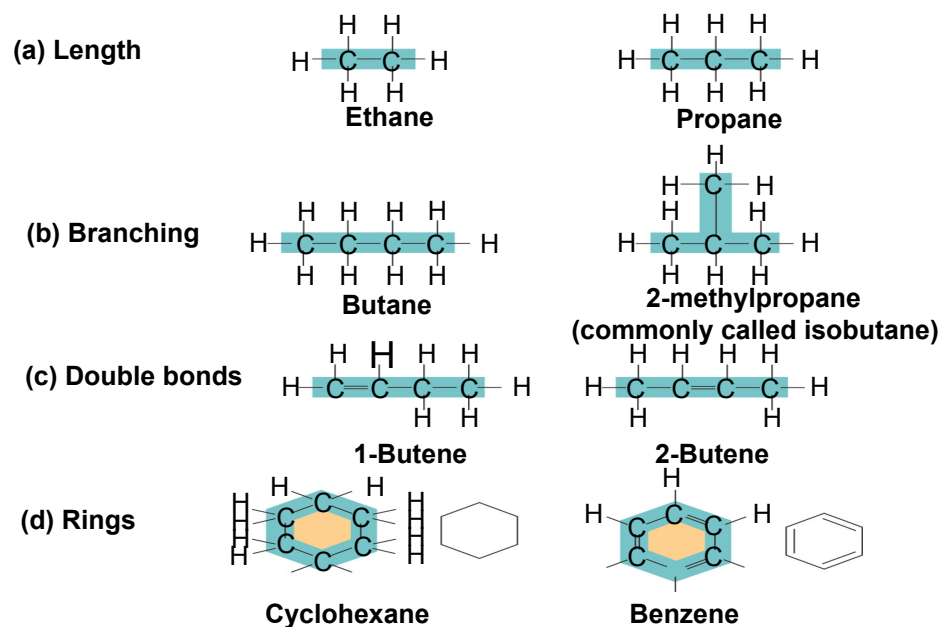
# The Formation of Bonds with Carbon

- The bonding versatility of carbon
  - Allows it to form many diverse molecules, including carbon skeletons

Name and Comments	Molecular Formula	Structural Formula	Ball-and-Stick Model	Space-Filling Model
(a) Methane	CH <sub>4</sub>	$\begin{array}{c} \text{H} \\   \\ \text{H}-\text{C}-\text{H} \\   \\ \text{H} \end{array}$		
(b) Ethane	C <sub>2</sub> H <sub>6</sub>	$\begin{array}{c} \text{H} \quad \text{H} \\   \quad   \\ \text{H}-\text{C}-\text{C}-\text{H} \\   \quad   \\ \text{H} \quad \text{H} \end{array}$		
(c) Ethene (ethylene)	C <sub>2</sub> H <sub>4</sub>	$\begin{array}{c} \text{H} \quad \quad \text{H} \\ \diagdown \quad / \\ \text{C}=\text{C} \\ / \quad \quad \diagdown \\ \text{H} \quad \quad \quad \text{H} \end{array}$		

# Molecular Diversity Arising from Carbon

- Carbon chains
  - Form the skeletons of most organic molecules
  - Vary in length and shape

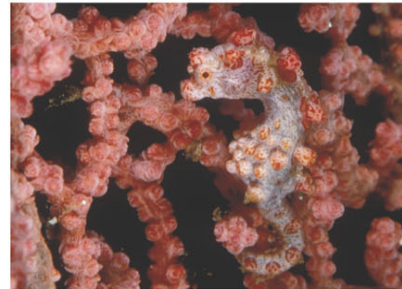


# Properties of Life

Life is something that can reproduce and evolve through natural selection



(a) Order



(b) Evolutionary adaptation



(c) Response to the environment



(d) Regulation



(e) Energy processing



(g) Reproduction



(f) Growth and development

Figure 1.2

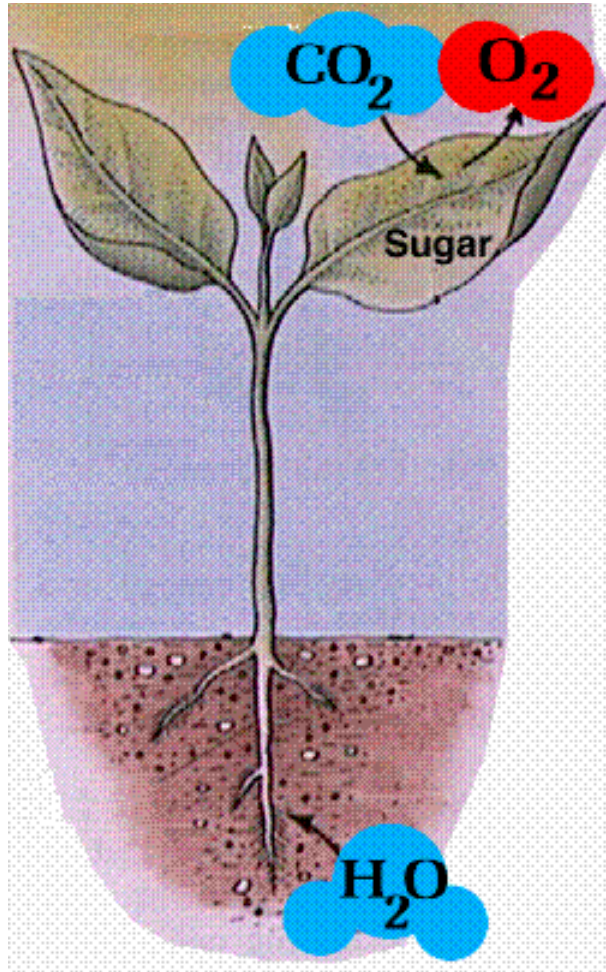
Take something as familiar as a tree...



Photo by Peter Lik



# Photosynthesis



# Photosynthesis



light + water + carbon dioxide → glucose + oxygen

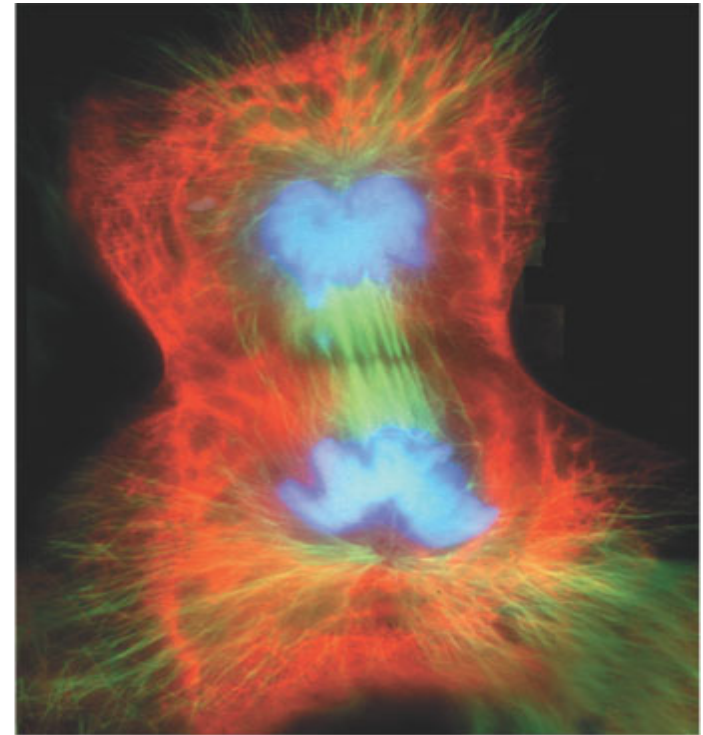
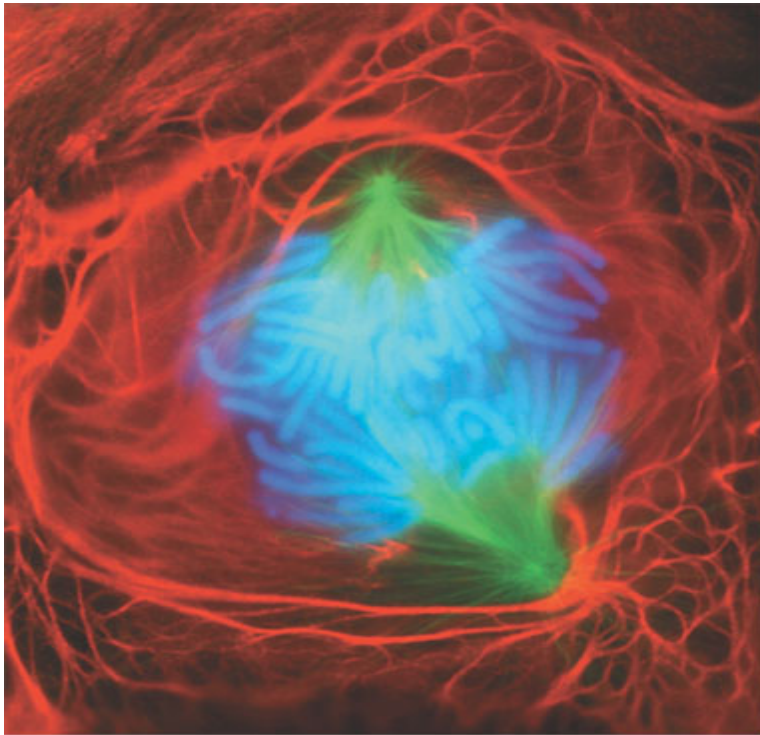
Plants take in water and carbon dioxide and rearrange the molecules into organic material like cellulose, respiring oxygen.

In mass units: 10 + 22 → 16 + 16  
(water) (air) (plant) (air)

Plants are 2/3 water but 90% of water is transpired so only 1 unit from water and 6 from air—*carbon is snatched from the air!*

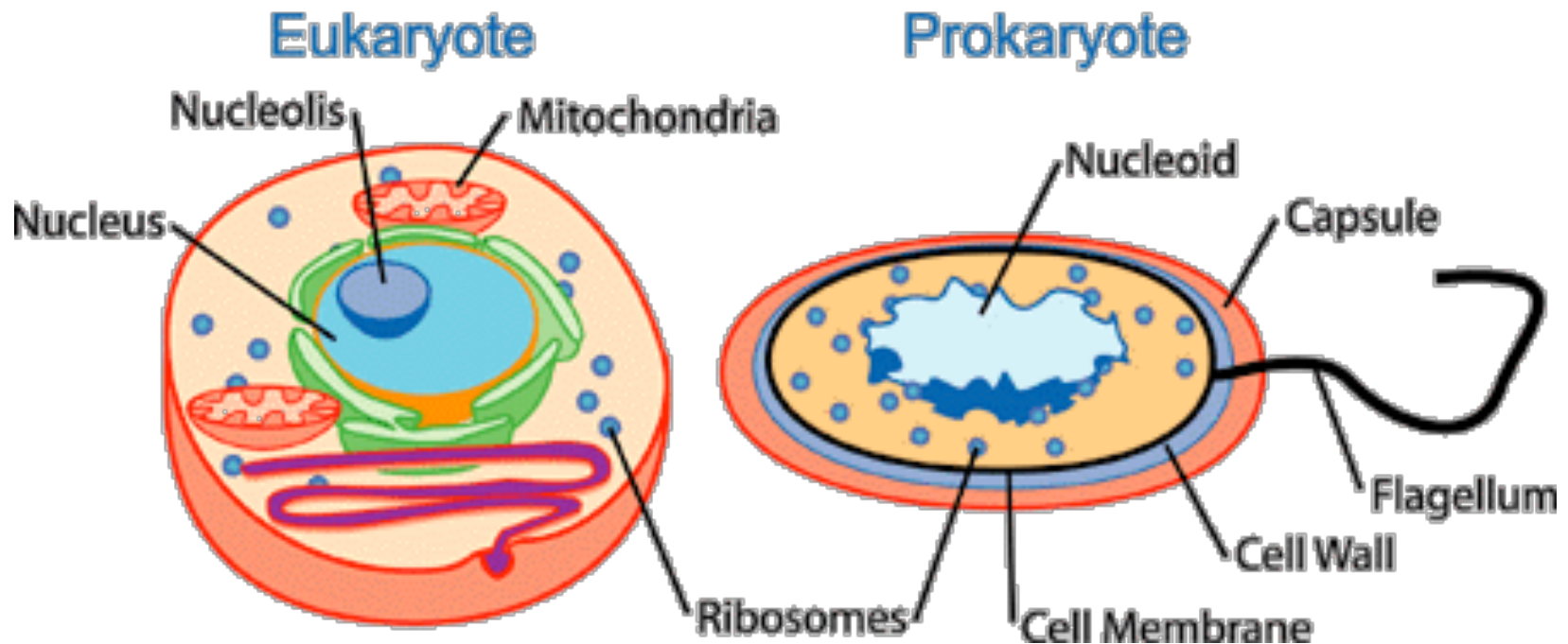
# A Closer Look at Cells

- The cell
  - Is the lowest level of organization that can perform *all* activities required for life



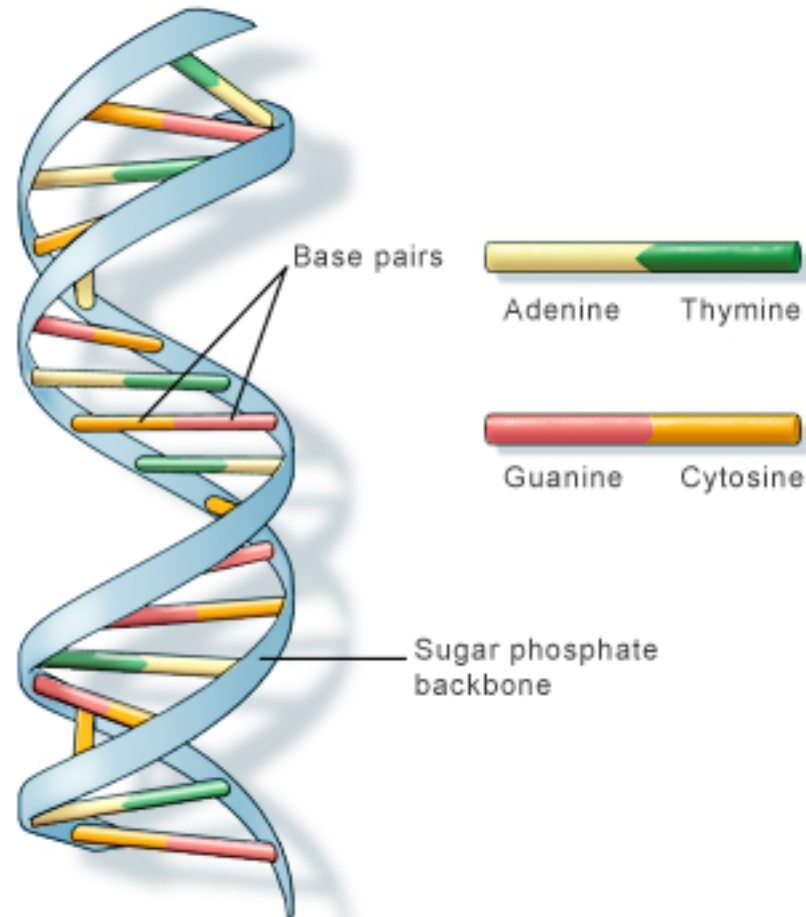
25  $\mu\text{m}$

- **All cells share certain characteristics**
  - They are all enclosed by a membrane
  - They all use DNA as genetic information
- **There are two main forms of cells**
  - Prokaryotic (lacks nucleus)
  - Eukaryotic

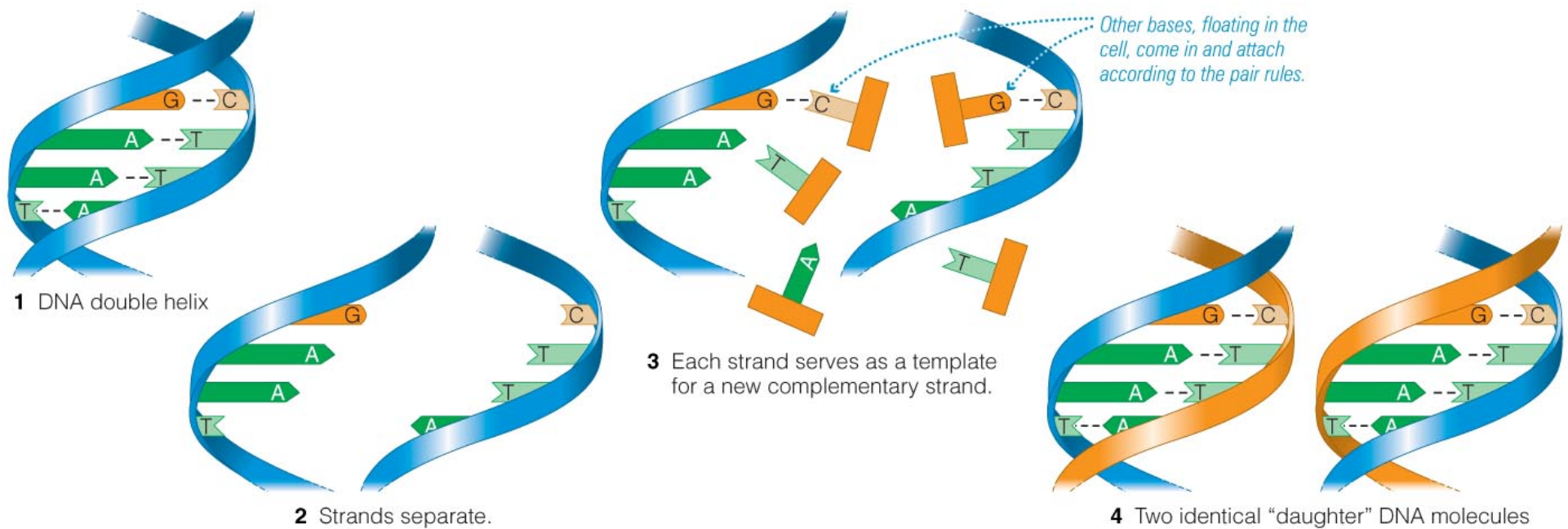


# DeoxyriboNucleicAcid

- The molecular structure of DNA
  - Human DNA has **3 billion base pairs** which accounts for its information-rich nature

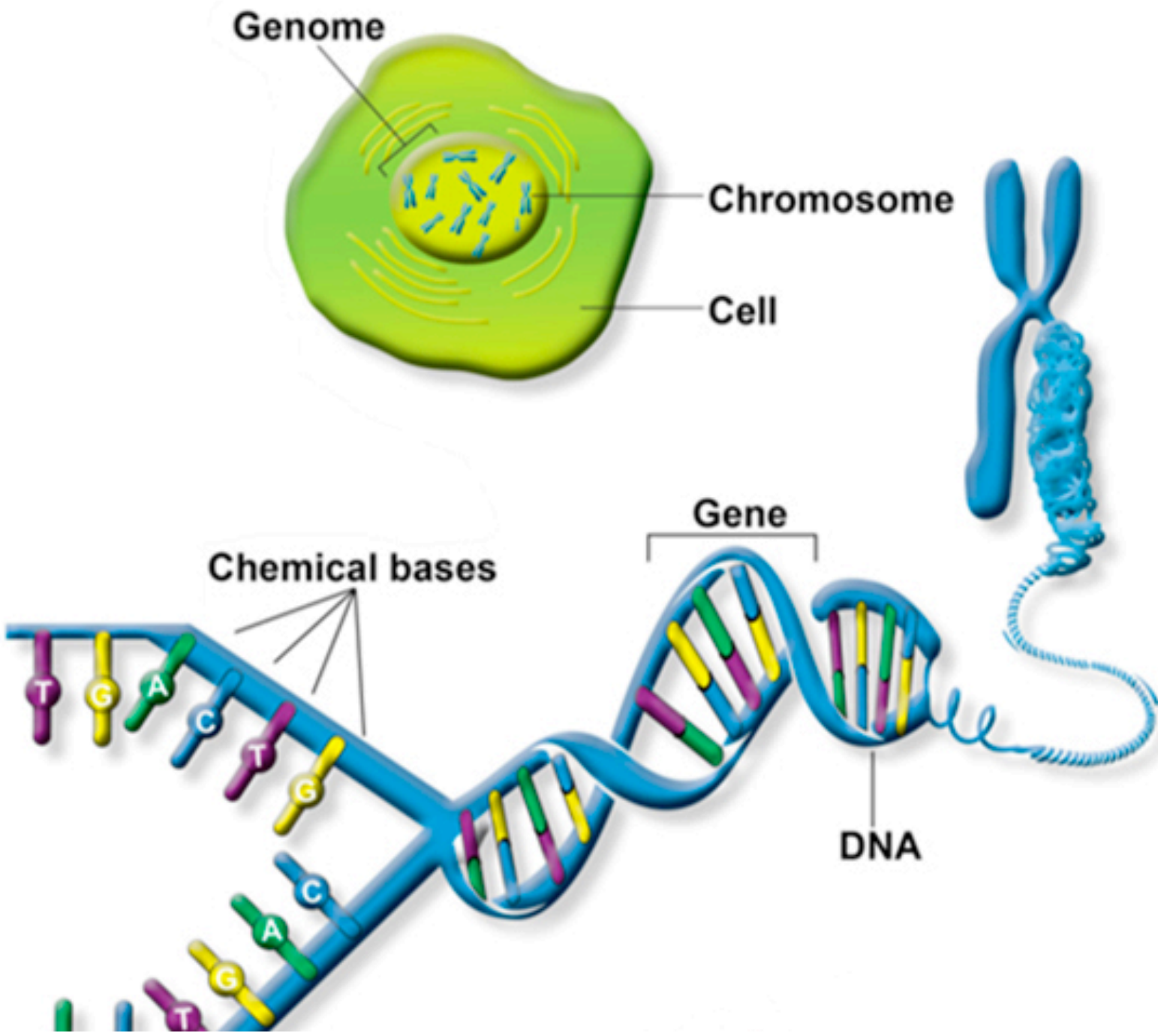


- The DNA double helix
  - Consists of two anti-parallel nucleotide strands



# Nucleic Acids

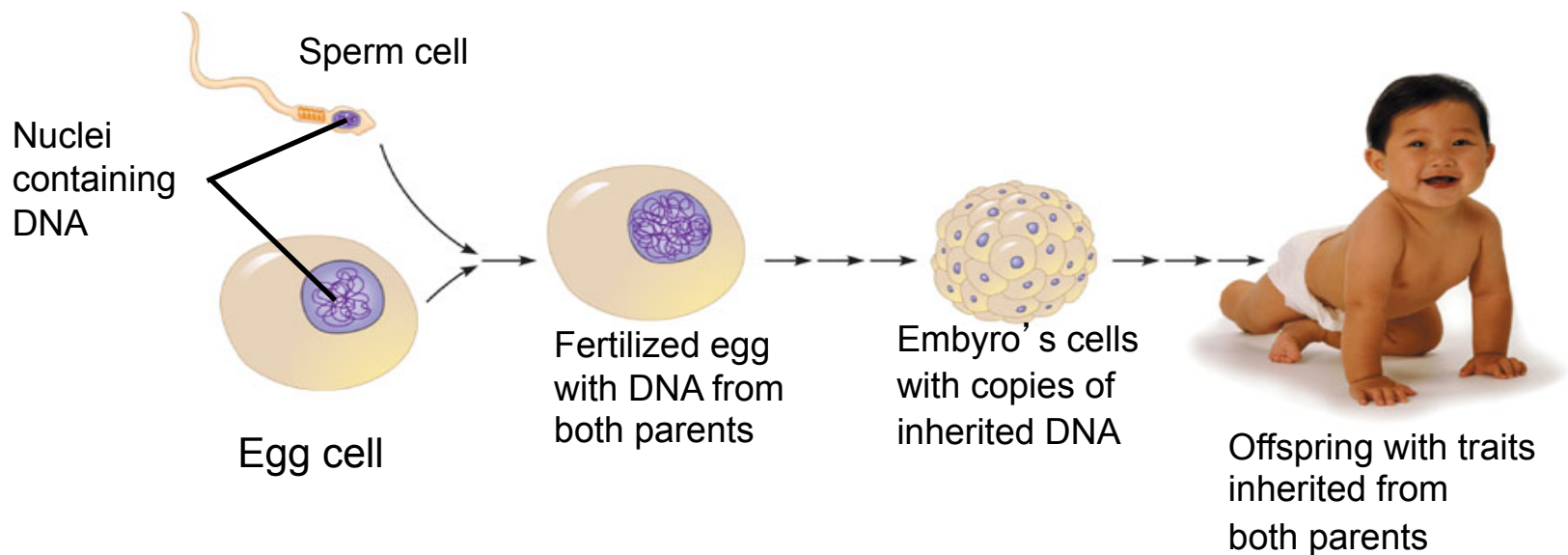
- Nucleic acids store and transmit hereditary information
- Genes
  - Are the units of inheritance
  - Program amino acid sequences
  - Are made of nucleic acids
- There are two types of nucleic acids
  - Deoxyribonucleic acid (DNA)
  - Ribonucleic acid (RNA)





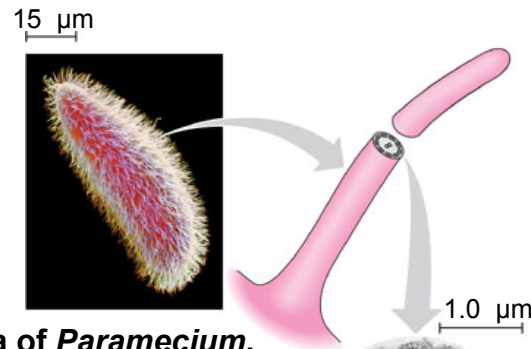
# *The Cell's Heritable Information*

- Cells contain chromosomes made partly of DNA, the substance of genes
  - Which program the cells' production of proteins and transmit information from parents to offspring

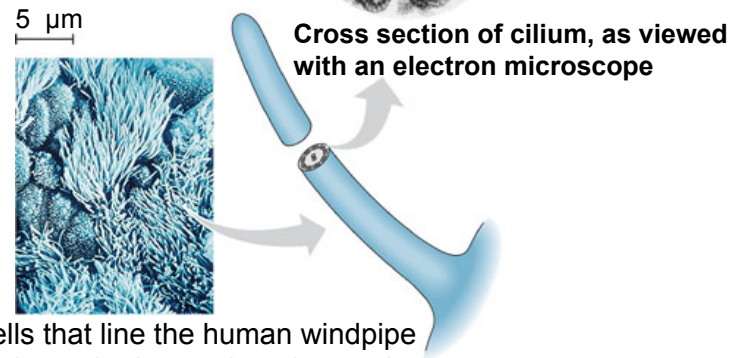


# Unity in the Diversity of Life

- As diverse as life is
  - There is evidence of remarkable unity



**Cilia of *Paramecium*.**  
The cilia of *Paramecium* propel the cell through pond water.



**Cilia of windpipe cells.** The cells that line the human windpipe are equipped with cilia that help keep the lungs clean by moving a film of debris-trapping mucus upward.

- *The Origin of Species* by Charles Darwin (1859) articulated two main points
  - Descent with modification
  - Natural selection



# Natural Selection

- Darwin proposed natural selection
  - As the mechanism for evolutionary adaptation of populations to their environments

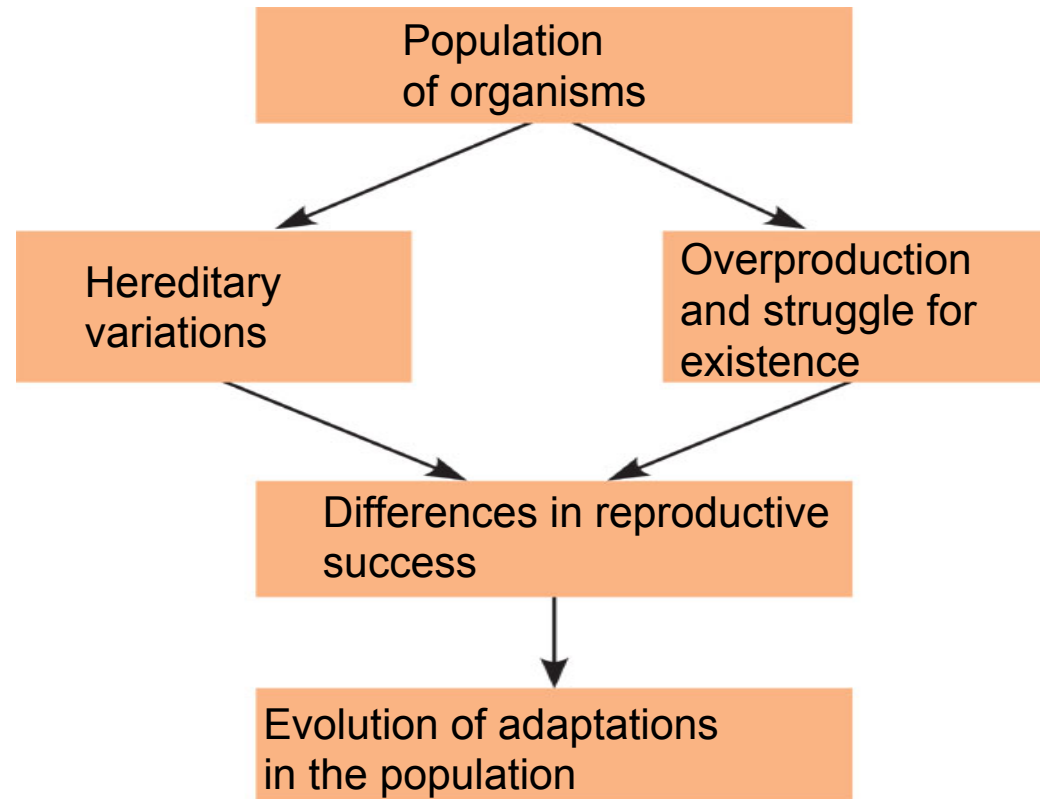


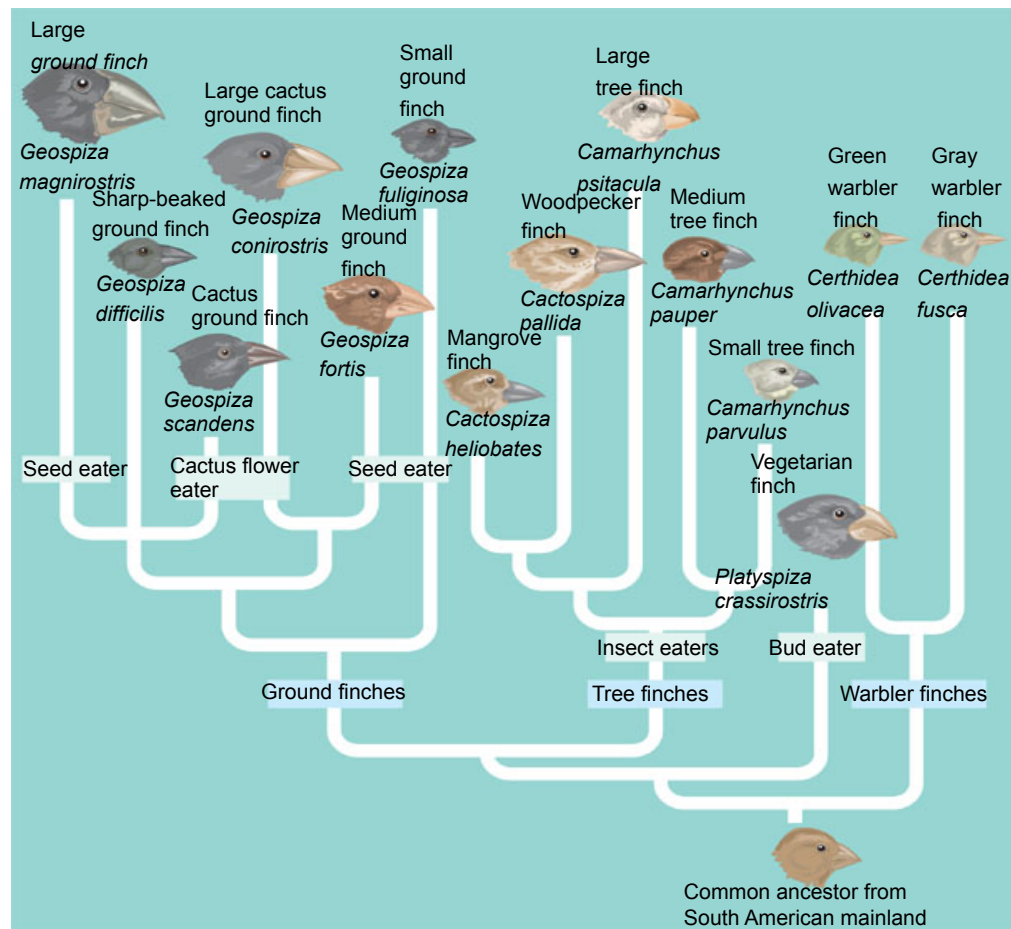
Figure 1.20

- The products of natural selection
  - Are often exquisite adaptations of organisms to special circumstances and the environment

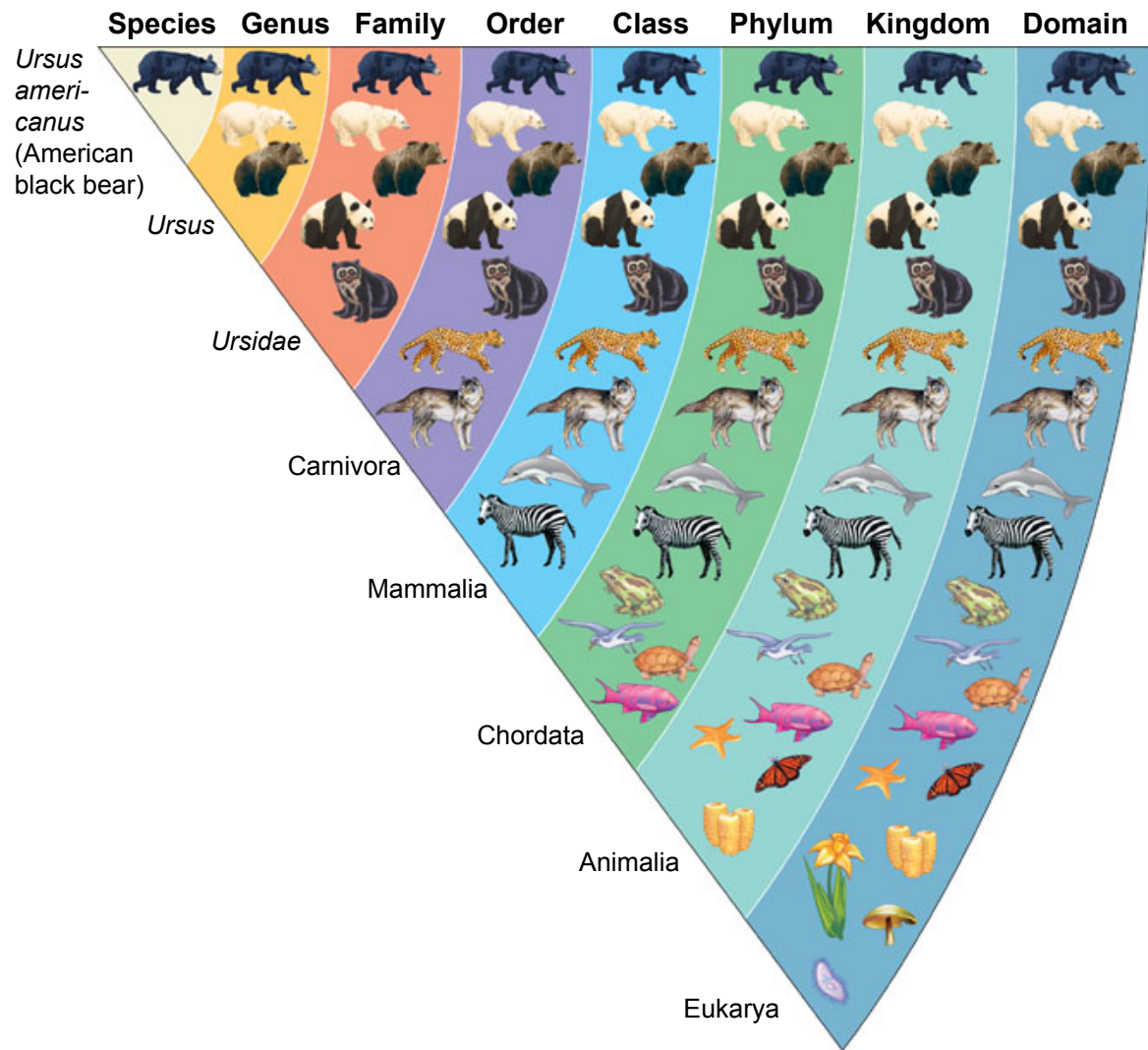


# The Tree of Life

- Darwin proposed that natural selection
  - Could enable an ancestral species to “split” into two or more descendant species, resulting in a “tree of life”



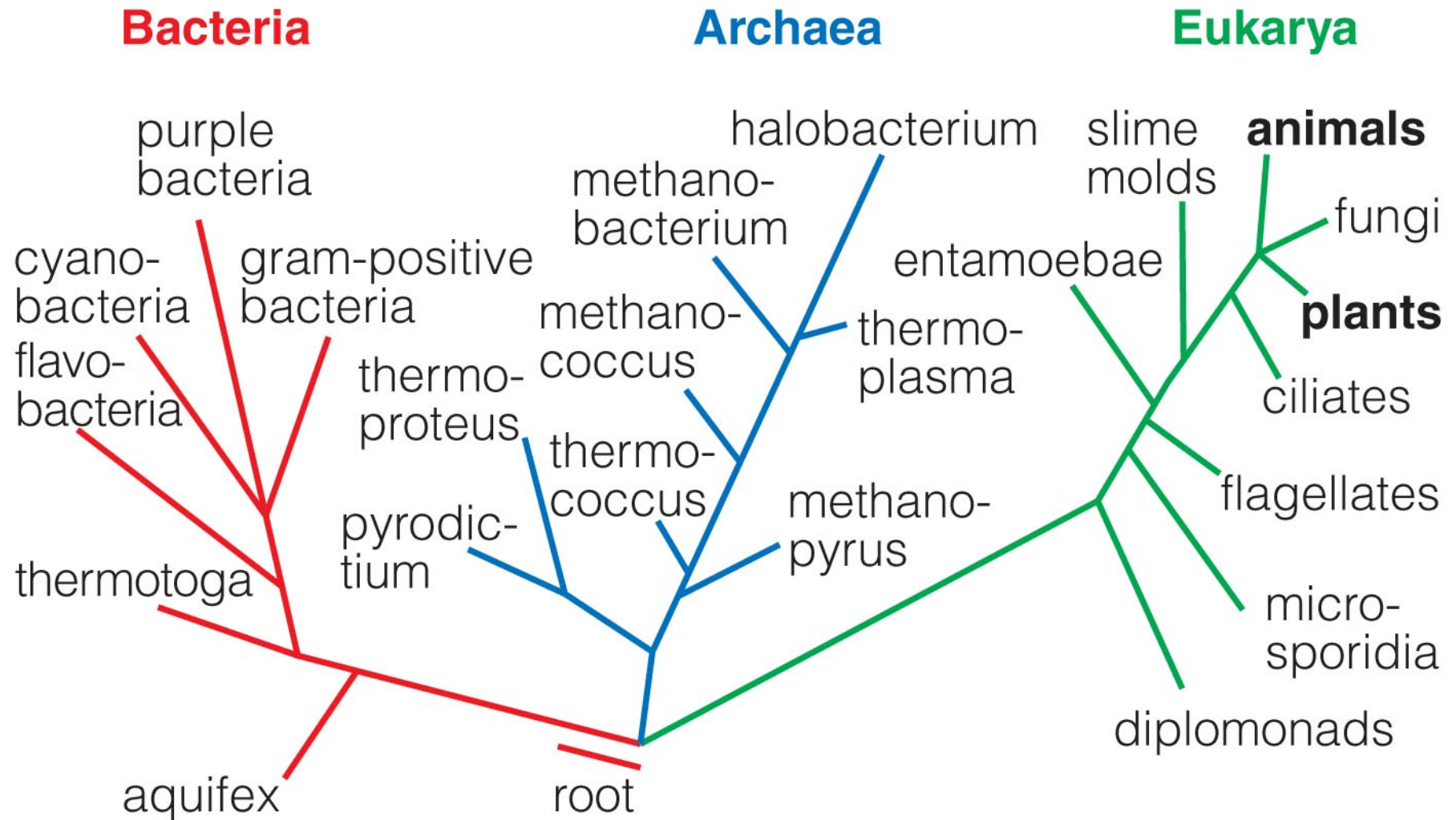
- Classifying life



- The Modern Tree of Life
  - Maps evolution via the gradual deviation of the base pair sequences in DNA or RNA
  - Does not depend on identifying or recognizing distinct species
  - Can track evolution back to the dawn of life but not with good time precision
  - Places us as a minute twig on the tree of life

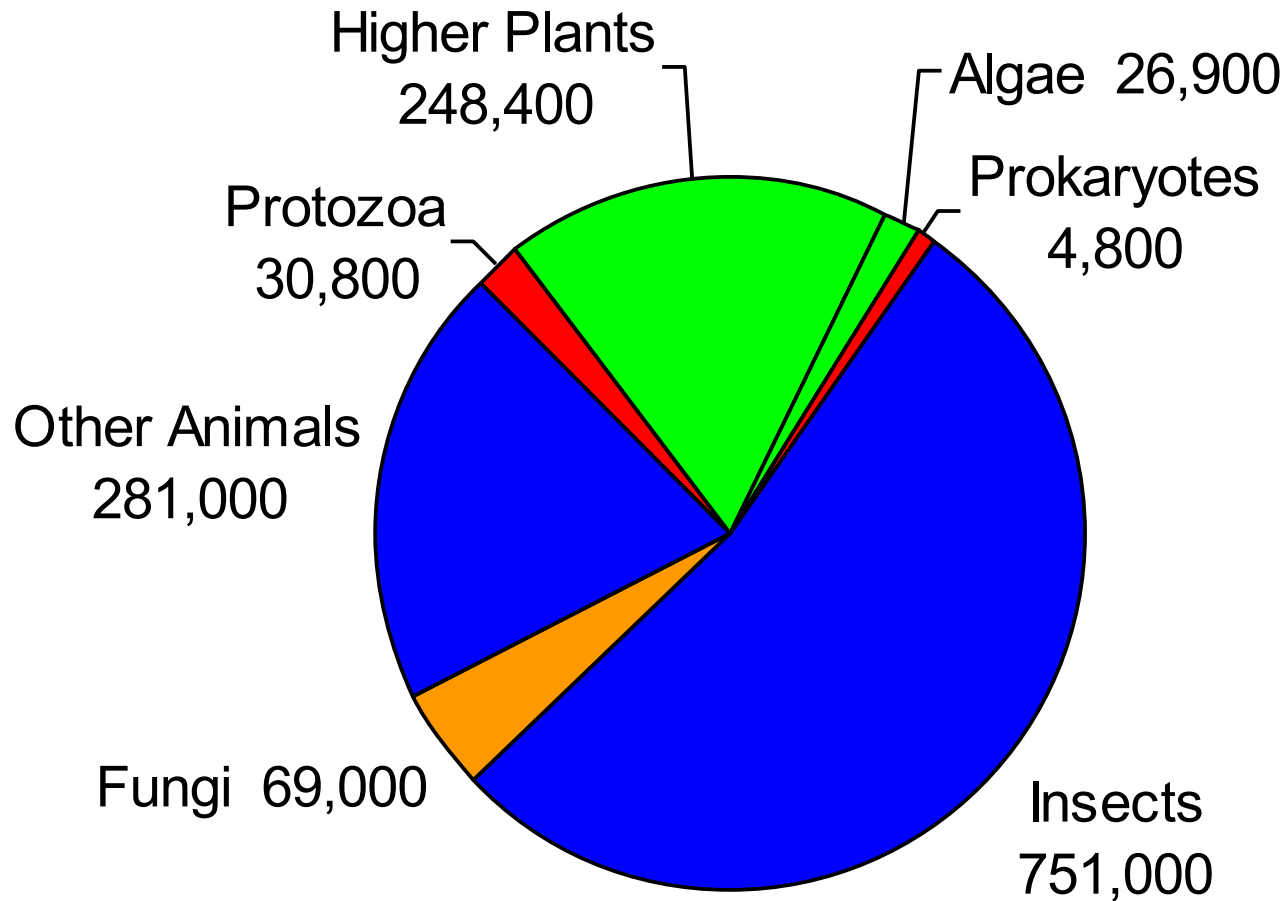


# The Modern Tree of Life



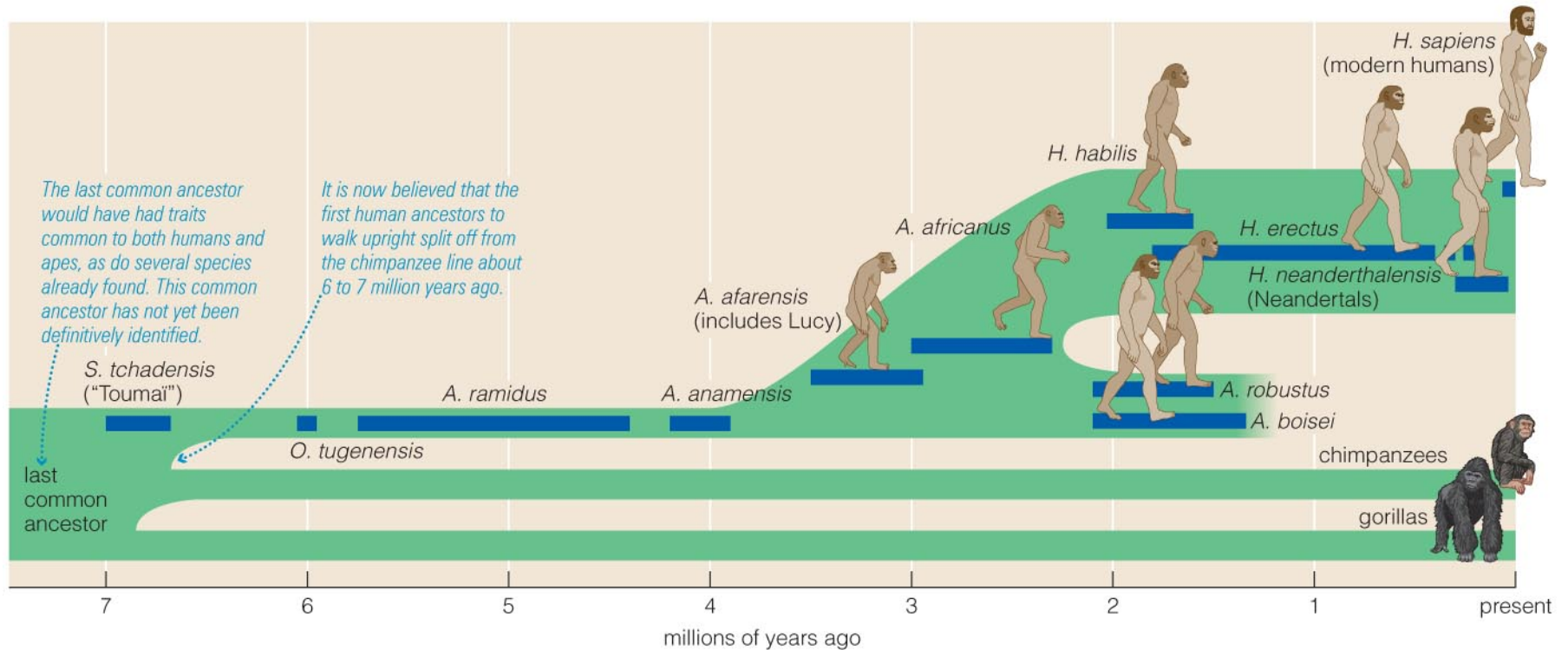
# *Recognized Diversity of Life*

**> 1,413,000 Species**

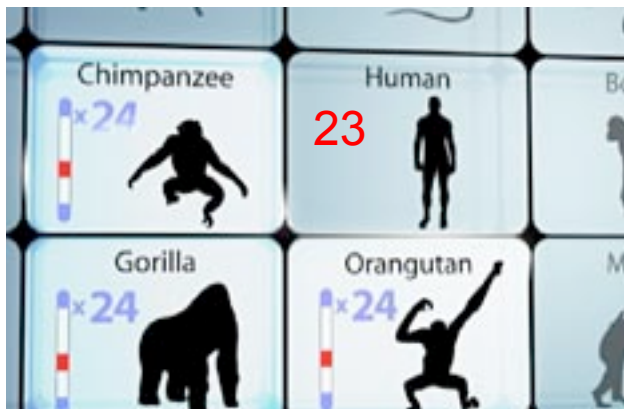




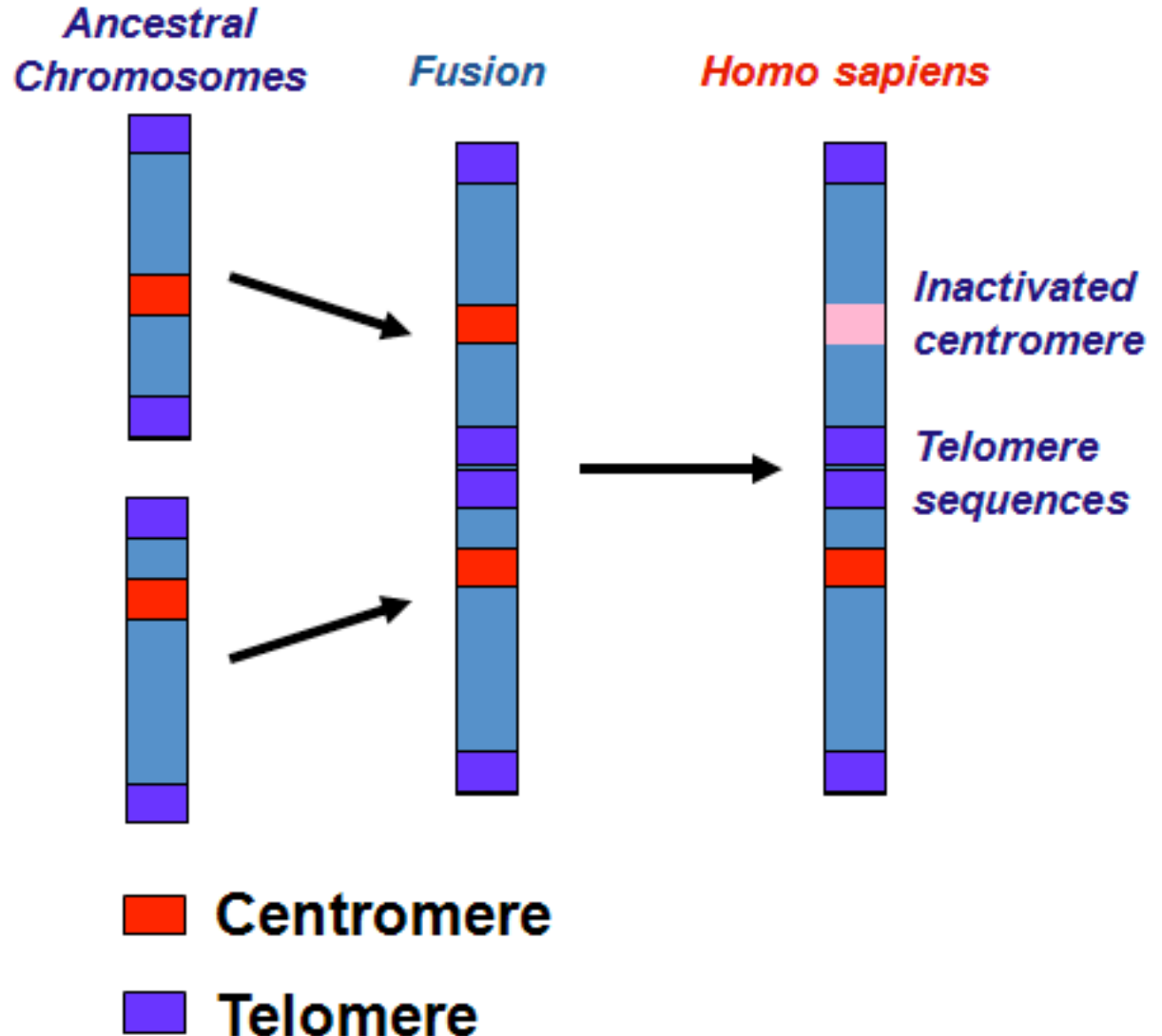
After four billion years of life on Earth, homo sapiens emerged to dominate the planet and venture into space. Was this just a fluke or did something like this happen anywhere else on distant planets?



# Genetic Evidence for Human Evolution: Human Chromosome 2



Other primates have 24 pairs of chromosomes but Humans only have 23. How can we be genetically related? The answer: Human chromosome 2 is a fusion of 2 chromosomes from a common ancestor



# Evolution is Convergent

Eyes and brains and wings arose in different parts of the tree of life. Are bilateral body plans and central nervous systems inevitable?

