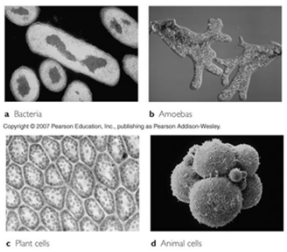
Lecture 14

Cells: The Building Blocks of Life



Astronomy 141 – Winter 2012

This lecture describes Cells, the basic structural units of all life on Earth.

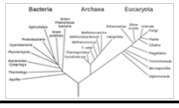
Basic components of cells: carbohydrates, lipids, proteins, left-handed amino acids, and nucleic acids.

Prokaryotes: single-celled organisms that lack cell nuclei.

Eukaryotes: single- or multi-celled organisms that have cell nuclei.

The *Phylogenetic Tree of Life* is a way of ordering life by biochemical and genetic relationships.

Bacteria, Archaea, and Eukaryea



The basic structural unit of all living organisms on Earth is the Cell.

Cells provide a *boundary* called the *membrane*

Keeps the biochemical functions inside…

Keeps the environment outside…

Membrane is permeable to let nutrients in and wastes out.

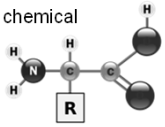
All cells on Earth share great similarities of structure despite considerable diversity of forms.

All use DNA to encode hereditary information.

All use RNA to make proteins and enzymes.

All cells have broadly similar chemical functions.

All use a similar mix of a few specific chemical compounds (especially amino acids)

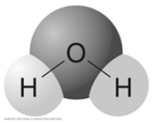


Evidence of a common ancestor for all life on Earth.

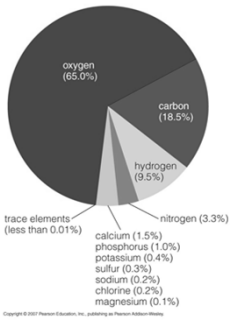
The basis of life on Earth is Carbon Chemistry.

Oxygen is the most abundant element in life, but...

Most O is tied up in Water.



Molecules responsible for cell structure and function are all based on Carbon.



Chemical Content of Humans

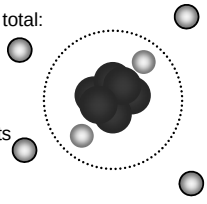
Carbon has unique chemical properties that make it extremely versatile.

Carbon nucleus has 6 protons (and 6 neutrons)

Surrounded by 2 shells of 6 electrons total:

2 inner shell electrons

4 valence electrons available for chemical bonds with other elements *including other Carbon atoms*.



Can form single, double and triple bonds.

Carbon chemistry is very rich, able to form a vast variety of organic compounds.

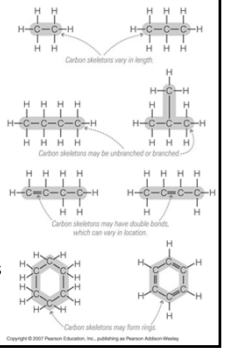
Long chains (polymers)

Chains with complex branching

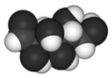
Close rings or networks of rings

Carbon compounds dissolve readily in liquids, especially water

Millions of possible organic compounds that can be formed.

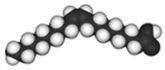


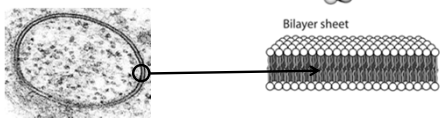
The major molecular components of cells are complex organic molecules.



Carbohydrates:
- Store and transport energy (sugars)
- Provide structural components (e.g., cellulose).

Lipids:
- Store and transport energy
- Main components of cell membranes
- Cell signaling (control cell function)



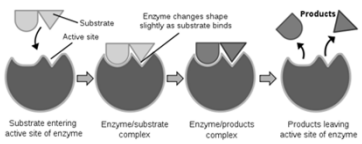


Proteins are the main chemicals of cell function.

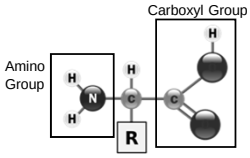
Proteins are composed of long chains of *amino acids*.

Some perform structural roles (provide stiffness)

Enzymes are important proteins that act as catalysts for chemical reactions inside cells.



Amino acids are the building blocks of proteins.

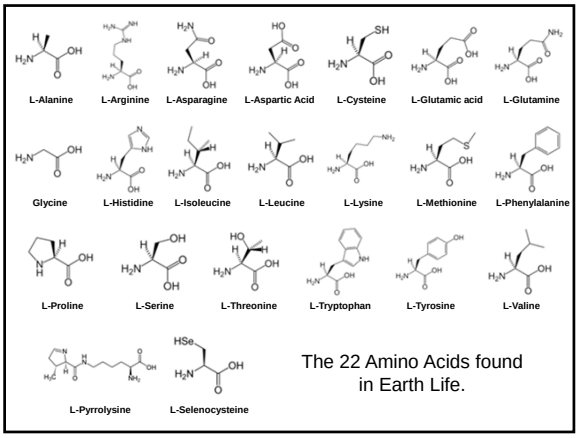


More than 70 amino acids known.

All life on Earth uses *only 22* of the 70+ known amino acids.

Of those, 2 are only found in very rare micro-organisms.

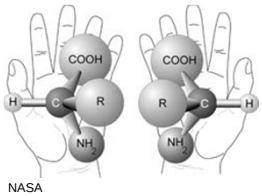
All are only used in their left-handed molecular form.



The 22 Amino Acids found in Earth Life.

Naturally occurring amino acids come in left- and right-handed forms.

This property is called “chirality”



NASA

Amino acids in non-living systems are a mix of left- and right-handed forms.

Biological system only use the left-handed forms.

A protein’s handedness is essential for its proper functioning.

Additional evidence of a common ancestor for all Earth life.

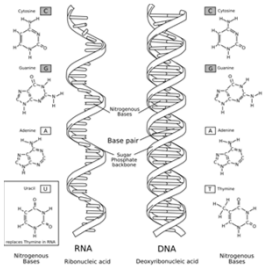
Nucleic Acids are the basis for the storage and transmission of hereditary information in all cells.

DNA
Deoxyribonucleic Acid

Encodes instructions for making proteins and RNA.

RNA
Ribonucleic Acid

Determines a cell's function and manufactures proteins & enzymes.



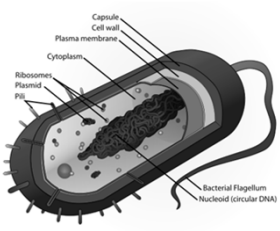
DNA stores the "operating instructions" for a cell.
RNA carries out the instructions and determines cell function.

Prokaryotes are single-celled organisms that lack cell nuclei.

Very small: 1-10μm

Simplest and most common forms of life on Earth.
- Bacteria
- Archaea

Can form large colonies of organisms.



The first forms of life on Earth were prokaryotes.

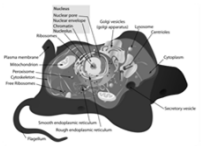
Eukaryotes are single- or multi-celled organisms that have cell nuclei.

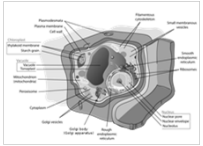
Sizes of 10-100μm

Cell nucleus that encapsulates the DNA

Organelles that compartmentalize various cell functions.

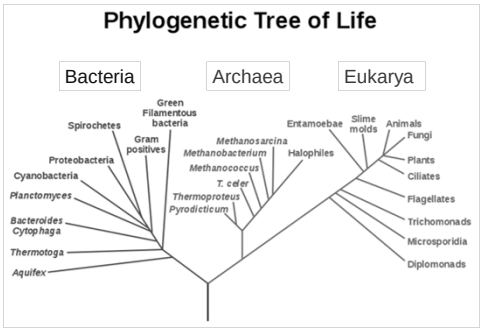
Multi-celled organisms are made of cells that perform different functions that together constitute the organism.





Plants and Animals are Eukaryotes.

The Phylogenetic Tree of Life organizes all forms of life by biochemical and genetic relationships.



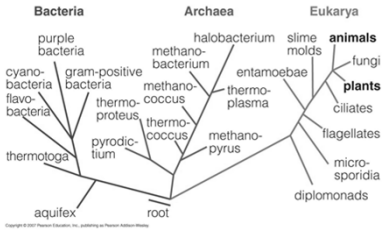
Three main branches show the genetic relations among different types of organisms

Three groupings:

Bacteria

Archaea

Eukarya



Branches represent the amount of genetic difference.

Life on Earth shows tremendous diversity, but also similarly tremendous commonality.

All life uses only 20-22 left-handed amino acids

All life uses DNA to encode and store hereditary information

All life employs broadly similar cellular chemistry

Detailed study of the genetic makeup of life shows deep relationships illustrated by the Phylogenetic Tree.

All evidence points to an as-yet unidentified universal common ancestor that arose in the distant past.