Defining Life

What is life:

can't define life very well in one sentence

eg. a highly organized interaction of matter and energy

must consider several **characteristics** (or properties) of life

these characteristics are inextricably interwoven in complex ways to produce the quality we call "life"

each property taken individually is NOT unique to living things

many nonliving things do one or more of them

eg. viruses don't quite fit

General properties of all living things:

1. **Unique & complex chemical structure**
2. **Compartmentalization/Boundaries**
3. **A genetic program of DNA**
4. **Metabolism**
5. **Reproduction**
6. **Development and Growth**
7. **Environmental Interactions**
8. **Adaptation & Evolution**

General Properties of Life

1. Unique & complex chemical structure

biology at the simplest level is **chemistry**

all life shares a communal pool of atoms and molecules

the atoms of life were generated long ago in giant red stars and supernovae explosions

life is made of a relatively few different kinds of **atoms** (=**elements**)

there are only 92 naturally occurring **elements** in the universe

and only a couple of dozen of these are regularly found in living organisms

→ 99% of all living organisms consist of just 6 elements: **C,H,O,N,P,Ca**

groups of **atoms** combine to form **molecules**

eg. water is made of 2 atoms of hydrogen and 1 atom of oxygen

it is the way these 6 atoms combine into 1000's of different kinds of **molecules** that create the complexity of life

even the simplest life forms are much more complex, chemically, than any nonliving object

eg. smallest living organism: PPLO (pleuropneumonial like organism)

→ contains ~12,000,000 atoms = ~1200 molecules

there are 2 main kinds of molecules found in living organisms

inorganic: small, little or no carbon atoms

organic: large to very large, lots of carbon, usually form large **polymers**:

sugars	→ starches
amino acids	→ proteins
fatty acids	→ lipids
nucleotides	→ nucleic acids

organic molecules can consist of 1000's to 100,000's of atoms

each organism is continually making and breaking down these organic molecules as part of its life processes (=**metabolism**)

2. Compartmentalization/Boundaries

all living organisms are confined to a limited volume surrounded by a boundary

there is a clear "**inside**" and "**outside**"

→ the organized processes of life must be contained and separated from its surroundings

the most basic "compartment" of living organisms

is the "**cell**"

all organism consist of **at least** one cell

→self contained "life unit"

the CELL is the basic unit of life

an organism can consist of one or many cells:

unicellular = solitary cell

→ eg. bacteria, some protists

colonial = loose association of single celled species

→ eg. some bacteria, many protists (algae, protozoa)

multicellular = always consist of many cells, cells are interdependent, cells **never** found alone

→ most fungi, all plants, all animals

in all life there are two main kinds of cells:

prokaryote cells & **eukaryote** cells

Prokaryotes

very small, simple, no nucleus, few identifiable "parts" inside or on the surface;

always **unicellular** or **colonial**

eg. bacteria & archaea

Eukaryotes

much larger, much more complex, most genetic material contained in prominent **nucleus**, lots of internal and surface structures including **organelles**; can be **unicellular**, **colonial**, or **multicellular**

eg. protists, fungi, plants, animals

organelles provide a division of labor and make the cells work much more efficiently

eg. **mitochondria** → energy factories

eg. **chloroplasts** → photosynthesis

eg. **vacuoles** → storage containers

there are two main kinds of **eucaryotic cells** depending on how they get their energy:

autotrophs & heterotrophs

autotrophic cells (eg algae, plant cells):

→ surrounded by a rigid **cell wall**
→ have green organelles called **chloroplasts** that capture solar energy in a process called **photosynthesis**

heterotrophic cells (eg. protozoa, animal cells):

→ lack a cell wall (have cell membrane only)
→ lack chloroplasts, but lots of mitochondria

in multicellular organisms (eg. plants & animals) groups of cells are specialized into **tissues**

3. A Genetic Program Made of DNA

all living organisms today use DNA as the genetic material

→ codes for all the organism is and does

= blueprint for structure and function

all cells today also use a similar molecule, RNA, to help DNA do its work

most of a cell's DNA is contained in structures called **chromosomes**

on each chromosome are thousands of **genes**

each **gene** codes for one 'job' in the cell

the simplest living organism has ~200 genes

most bacteria have several 3-4000 genes

animals and plants have 10-30,000 of genes

4. Metabolism

life, at simplest level, can be visualized as a bag of 1000's of chemical reactions all occurring at the same time = **metabolism**

metabolism = all the chemical reactions occurring in a cell or organism

metabolism includes two basic kinds of reactions:

synthesis reactions → combine small atoms and molecules to make larger molecules

decomposition reactions → break larger molecules into smaller molecules and atoms

metabolism = synthesis + decomposition

these chemical reactions have two main uses in living organisms:

a. construction projects

b. release of energy

a. construction projects

nutrients are used as **building blocks** to make new molecules and cells

synthesis is required to prevent parts from wearing out

decomposition
removes unwanted materials, dead cells, etc

eg. skin and bone completely replaced every 7 years

eg. RBC's are replaced every 4 months

eg. entire lining of digestive tract is replaced every 3 days

b. release of energy

organisms also need an **energy source** to "power" everything that an organism does

the **direct** source of life's energy is the break down of **organic** molecules (mainly sugar)

→ ie. they use **chemical energy**

energy is stored in "chemical bonds"

when you break bonds you release energy

organic molecules have lots of bonds and store lots of energy

5. Reproduction

all life arise from preexisting life

there are two main kinds of reproduction

→ sexual & asexual reproduction

sexual: unique combination of traits produces variation which allows adaptation and evolution

involves specialized cells: sex cells (meiosis)

asexual: exact copies, clones
easier, quicker, don't need a mate (mitosis)

6. Development and Growth

all organisms (even bacteria) pass through a **life cycle**

changes in size and shape; from immature to sexually mature organisms

eg. Frog: embryo→ larva→adult

eg. Human: embryo→fetus→juvenile→adult

in some the embryonic or immature stage is a dormant or resistant stage

eg. seeds, cysts, gemmules, some insects

some involve two distinct generations, one that

reproduces asexually, one sexually

eg: fungi, ferns, mosses, jellyfish

7. Environmental Interactions

all organisms monitor and respond to their environment (including each other)

=**ecology**, **natural history**

=**ethology** - behavior simple to very complex

all life uses chemicals to communicate

eg. pheromones, hormones, chemical trails, etc

in larger organisms these activities require some kind of more complex coordination and control:

nervous system
endocrine system/ hormones
immune system

8. Adaptation & Evolution

all living organisms constantly **adapt** to their environment

some adaptations involve behavioral changes and learning

eg. tool use among animals

eg. cultures

other adaptations can be in the form of changes in growth and physiology

eg. same species of plant has air leaves and water leaves

eg. euglena with and without light

adaptations also occur across generations as the most useful traits are selected for and passed on while harmful traits are eliminated

=evolution by natural selection