A Brief History of Life

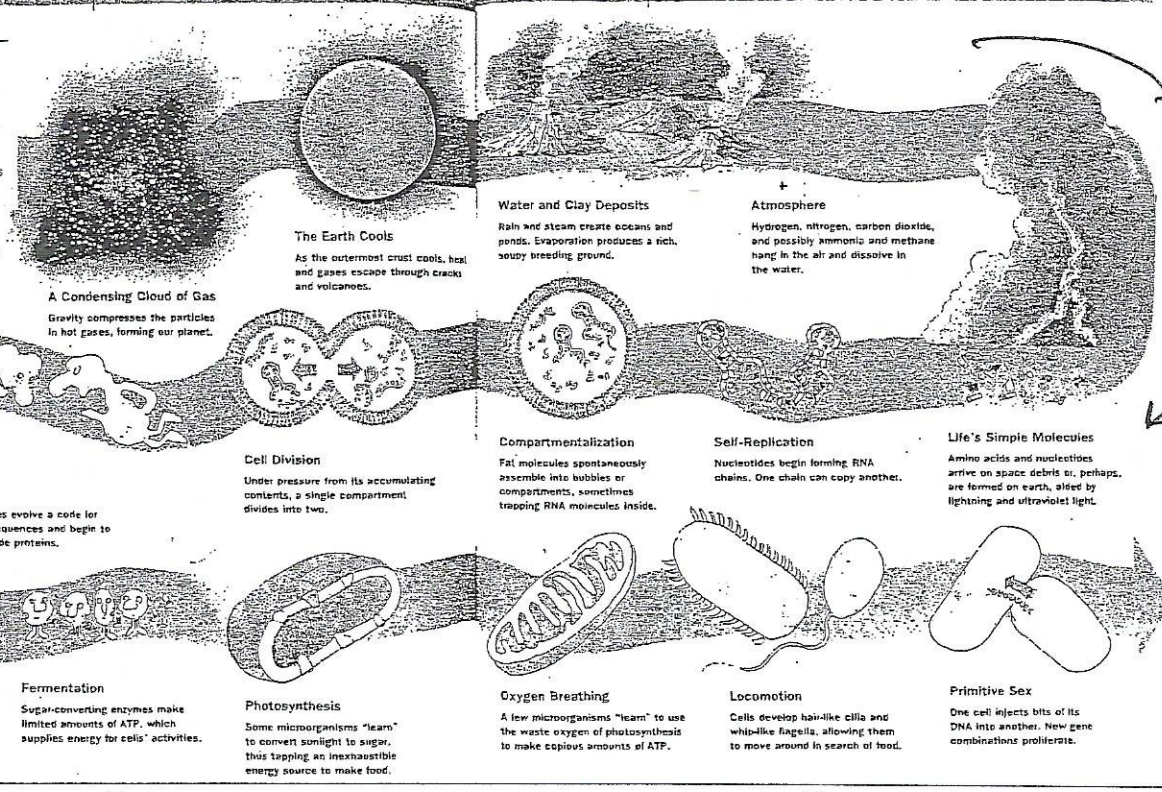
Evolutionary Time Line

(Colors on this time line correspond to the colors on the path of evolution below.)

4.5 Billion Years Ago — 4 Billion Years Ago — 3 Billion Years Ago

Accumulating Information — From Soup to Brains

During most of life's nearly four billion years on earth, tiny unicellular and multicellular creatures living in water were hard at work setting the stage for the big, showy creatures that appeared only in the last half billion years of the drama. Frogs, dinosaurs, trees, birds, mammals, and all the rest arose as elaborations of developmental scenarios worked out by players too small to be seen.



A Condensing Cloud of Gas
Gravity compresses the particles in hot gases, forming our planet.

The Earth Cools
As the outermost crust cools, heat and gases escape through cracks and volcanoes.

Water and Clay Deposits
Rain and steam create oceans and ponds. Evaporation produces a rich, soupy breeding ground.

Atmosphere
Hydrogen, nitrogen, carbon dioxide, and possibly ammonia and methane hang in the air and dissolve in the water.

Life's Simple Molecules
Amino acids and nucleotides arrive on space debris or, perhaps, are formed on earth, aided by lightning and ultraviolet light.

Self-Replication
Nucleotides begin forming RNA chains. One chain can copy another.

Compartmentalization
Fat molecules spontaneously assemble into bubbles or compartments, sometimes trapping RNA molecules inside.

Cell Division
Under pressure from its accumulating contents, a single compartment divides into two.

Proteins
RNA molecules evolve a code for amino acid sequences and begin to assemble crude proteins.

DNA
DNA takes over as the information carrier. RNA becomes the functional link between DNA and amino acids.

Fermentation
Sugar-converting enzymes make limited amounts of ATP, which supplies energy for cells' activities.

Photosynthesis
Some microorganisms "learn" to convert sunlight to sugar, thus tapping an inexhaustible energy source to make food.

Oxygen Breathing
A few microorganisms "learn" to use the waste oxygen of photosynthesis to make copious amounts of ATP.

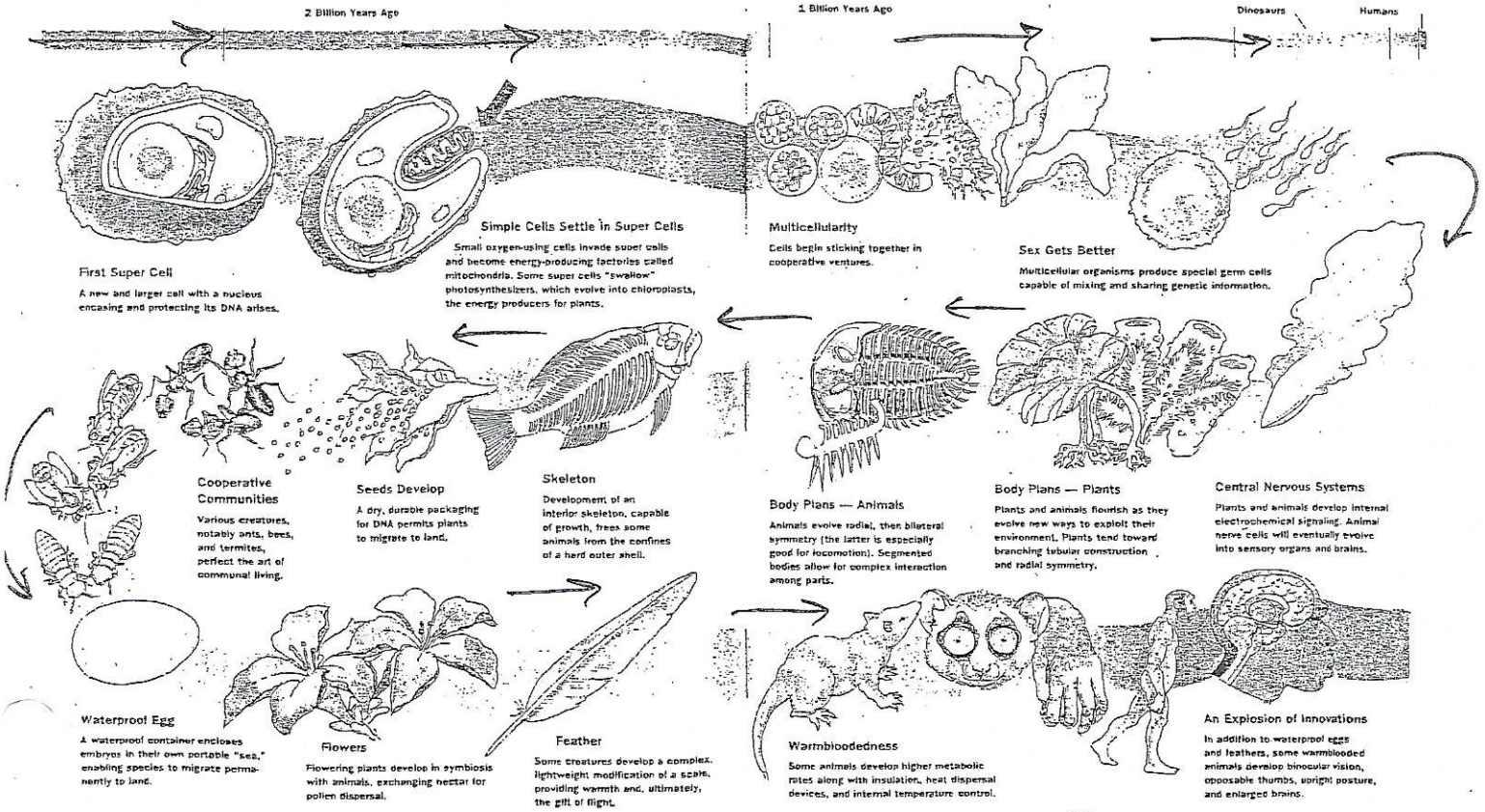
Locomotion
Cells develop hair-like cilia and whip-like flagella, allowing them to move around in search of food.

Primitive Sex
One cell injects bits of its DNA into another. New gene combinations proliferate.

A Brief History of Life (continued)

Evolutionary Time Line

2 Billion Years Ago — 1 Billion Years Ago — Dinosaurs — Humans



First Super Cell
A new and larger cell with a nucleus encasing and protecting its DNA arises.

Simple Cells Settle in Super Cells
Small oxygen-using cells invade super cells and become energy-producing factories called mitochondria. Some super cells "swallow" photosynthesizers, which evolve into chloroplasts, the energy producers for plants.

Multicellularity
Cells begin sticking together in cooperative ventures.

Sex Gets Better
Multicellular organisms produce special germ cells capable of mixing and sharing genetic information.

Cooperative Communities
Various creatures, notably ants, bees, and termites, perfect the art of communal living.

Seeds Develop
A dry, durable packaging for DNA permits plants to migrate to land.

Skeleton
Development of an interior skeleton, capable of growth, frees some animals from the confines of a hard outer shell.

Body Plans — Animals
Animals evolve radial, then bilateral symmetry (the latter is especially good for locomotion). Segmented bodies allow for complex interaction among parts.

Body Plans — Plants
Plants and animals flourish as they evolve new ways to exploit their environment. Plants tend toward branching tubular construction and radial symmetry.

Central Nervous Systems
Plants and animals develop internal electrochemical signaling. Animal nerve cells will eventually evolve into sensory organs and brains.

Waterproof Egg
A waterproof container encloses embryos in their own portable "sea," enabling species to migrate permanently to land.

Flowers
Flowering plants develop in symbiosis with animals, exchanging nectar for pollen dispersal.

Feather
Some creatures develop a complex, lightweight modification of a scale, providing warmth and, ultimately, the gift of flight.

Warmbloodedness
Some animals develop higher metabolic rates along with insulation, heat dispersal devices, and internal temperature control.

An Explosion of Innovations
In addition to waterproof eggs and feathers, some warmblooded animals develop binocular vision, opposable thumbs, upright posture, and enlarged brains.