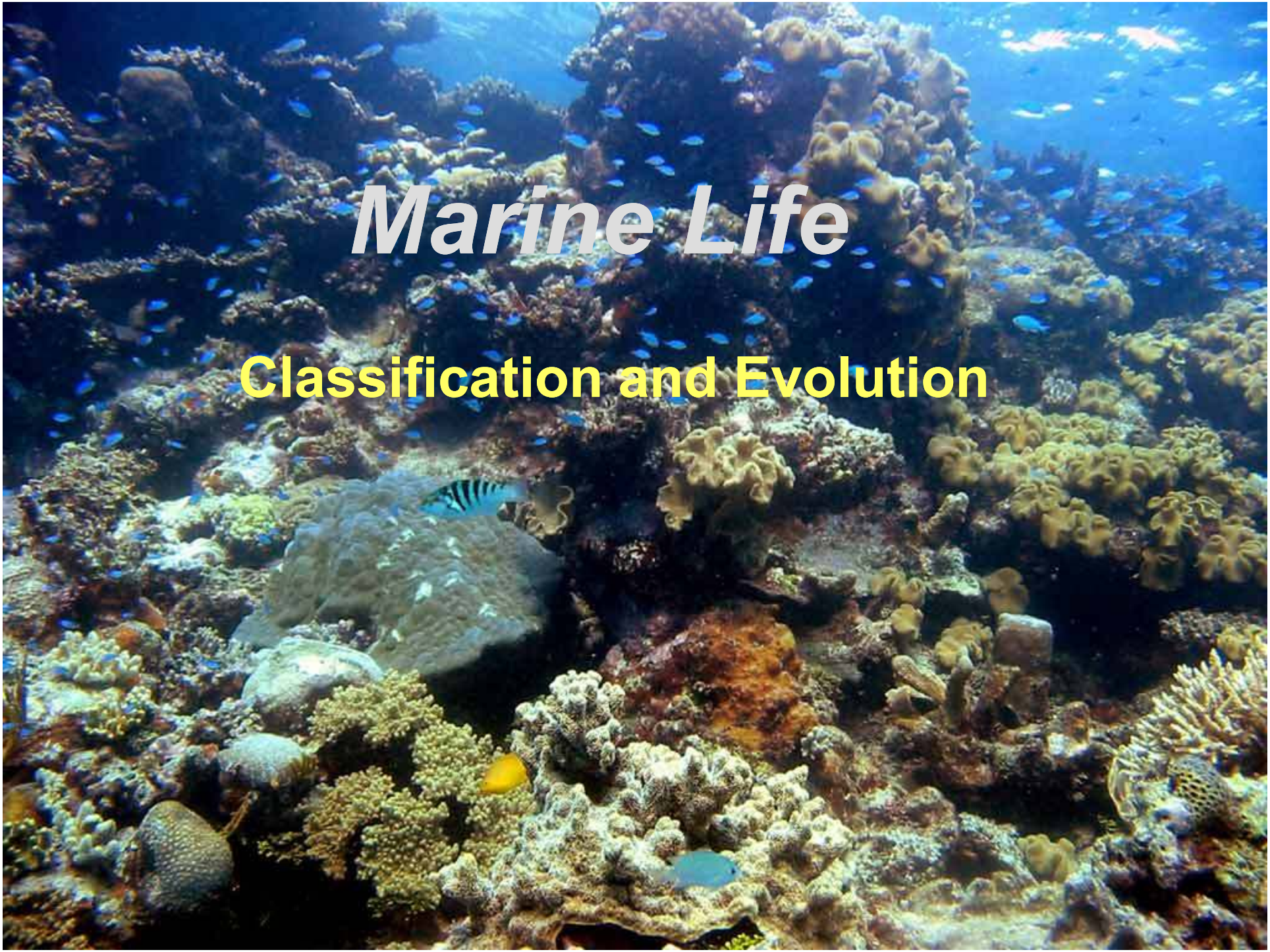

Marine Life
Classification and Evolution

Big Concepts - Classification and Evolution

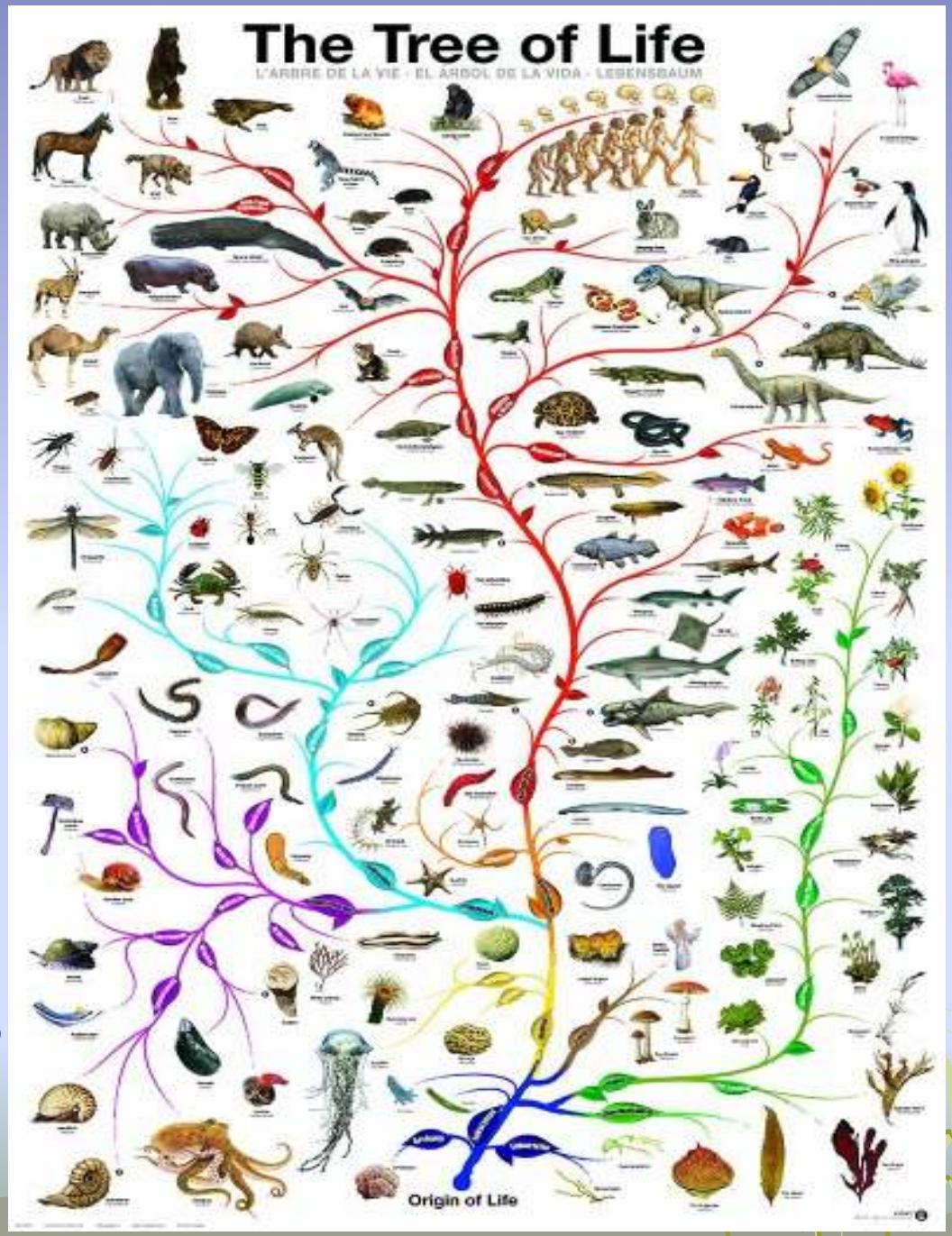
- **Life on Earth has both great diversity and unity**
  - ✓ Diversity = Millions of different species of living organisms
  - ✓ Unity = All species share similar underlying materials, structures, and processes
- **Scientists use a natural classification system for living organisms**
  - ✓ Relies on evolutionary history and development characteristics
  - ✓ Based on common underlying natural origin that makes structural and evolutionary sense
  - ✓ Groups of organisms arranged systematically in a hierarchal set of categories = phylogeny
  - ✓ Each type of organism has a scientific name and is uniquely placed in the phylogeny
- **Classification of Organisms into a Phylogeny**
  - ✓ Hierarchy includes Kingdom, Phylum, Class, Order, Family, Genus, Species
  - ✓ Each nested level of category indicates a certain degree of complexity, grade or class
  - ✓ Each category becomes more specific with every drop in level
  - ✓ This is the optimum type of classification system for the scientific study of marine life
- **Life on Earth has systematically changed over a great span of time**
  - ✓ Life made its first humble appearance over 3 ½ billion years ago
  - ✓ Great explosion of most phyla occurred during the Cambrian Period over 500 MYA
  - ✓ A unique assemblage of species are found in the rock record for each time period
  - ✓ The order in which different major groups of organisms appear is unique
  - ✓ Every species appears on Earth at some point in time; most eventually go extinct
- **The Theory of Evolution is the best scientific explanation for changing Life**
  - ✓ Darwin's Natural Selection = environment-controlled selection of fittest individuals
  - ✓ Genetic mutation = random development on new traits in offspring
  - ✓ Evolution in the marine environment highlighted by convergent evolution

The Scientific Classification of Life

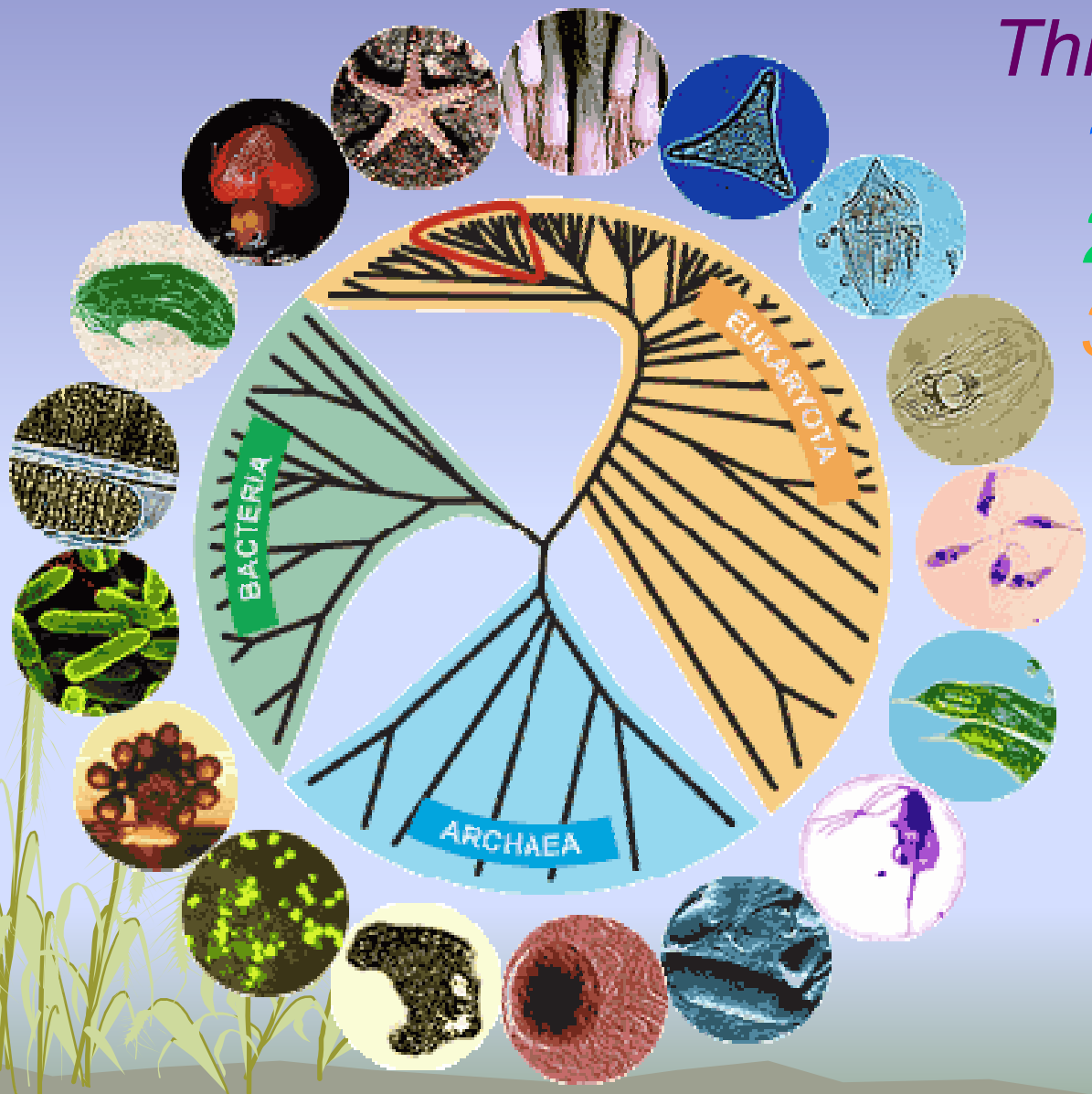
- *Biologists classify organisms into various groupings in order to better understand them.*
- ***Taxonomy** is the art or study of classification – placing organisms into groups or taxa (taxon = singular)*
- *Modern organism taxonomy uses a tree (branching)-like system of grouping, called a **phylogeny.***
- *A **phylogeny** is the branching, hierarchal grouping or arrangement of organisms that reflects organisms' evolutionary histories and ancestral relationships; closely related species share a common ancestor (possibly now extinct)*
- *Various criteria used in classification include, genetics (DNA), anatomy, behavior, life stage development, and cellular structure*

Tree of Life Phylogeny

- *The **phylogeny** is a branching, hierarchal grouping or arrangement of organisms that reflects organisms' evolutionary histories and ancestral relationships; closely related species share a common ancestor (possibly now extinct)*
- *Various criteria used in classification include, genetics (DNA), anatomy, behavior, life stage development, and cellular structure*
- *The base of the phyogeny is the origin of life itself.*



Life Domains – Base of the Tree of Life



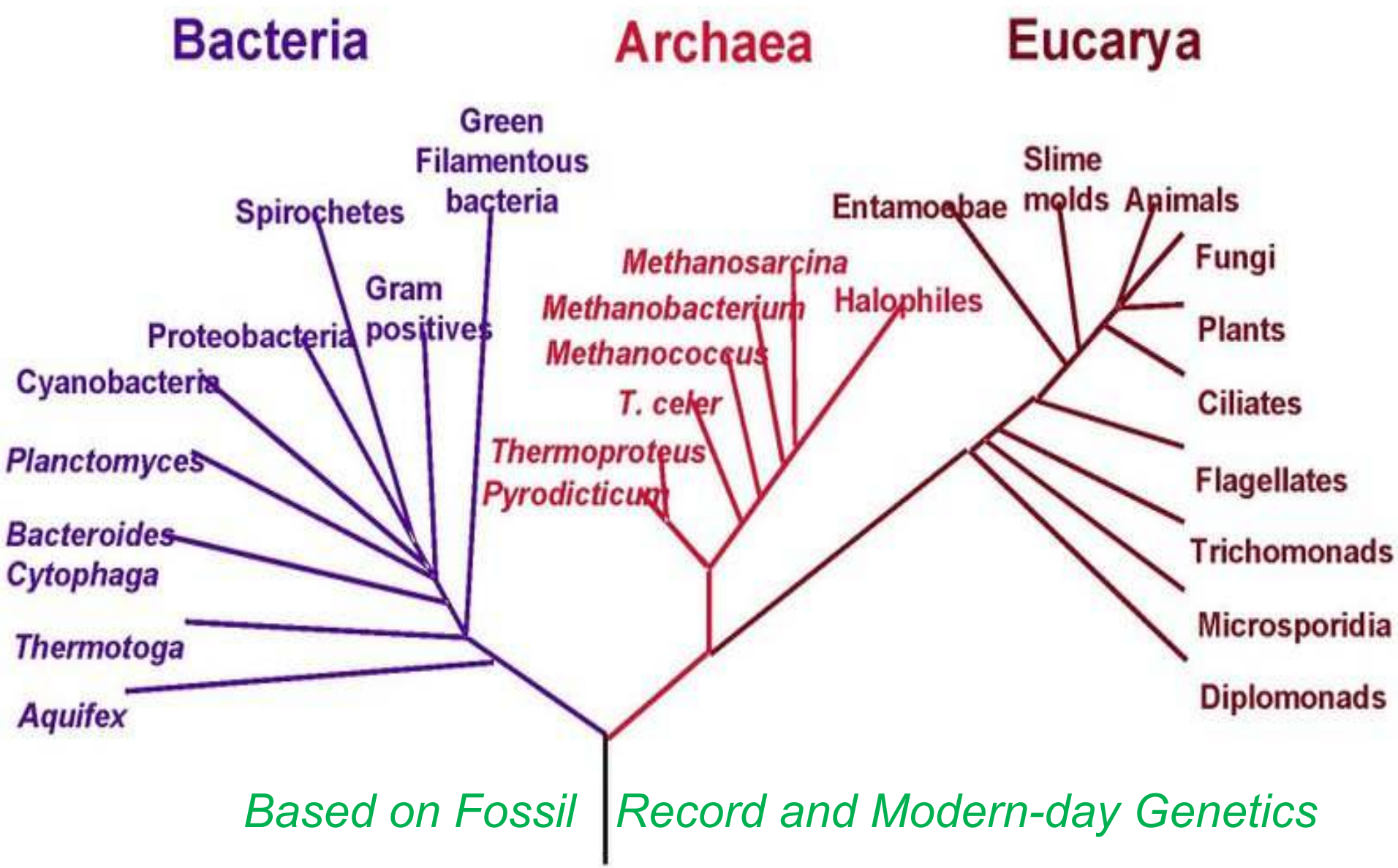
Three Life Domains

1) Archaea

2) Bacteria

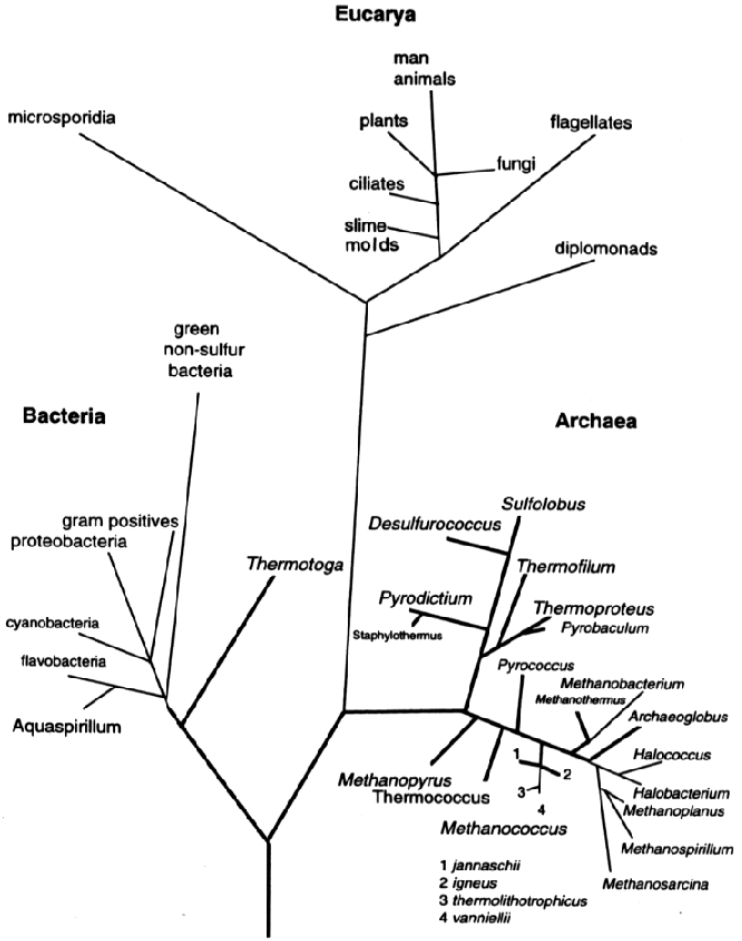
3) Eukaryota

Phylogenetic Tree of Life

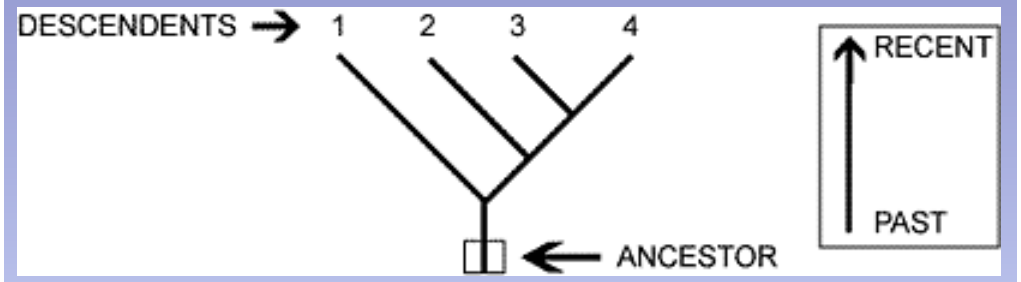


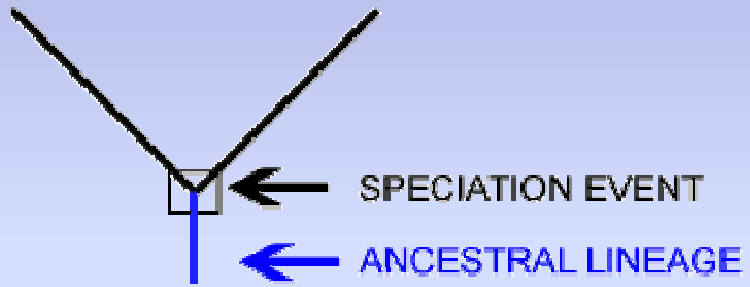
Based on Fossil Record and Modern-day Genetics

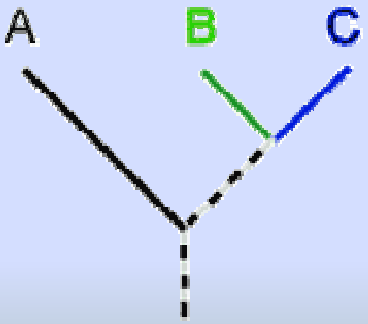
Understanding Phylogenies



Universal phylogenetic tree based on 16 S rRNA sequences showing the three domains of Bacteria, Archaea, and Eucarya (Woese *et al.*, 1990). Distances were derived from numbers of mutations. The root was derived from sequences of the two subunits of the F_1 - ATPases and the two translation elongation factors EF-1α (Tu) and EF-2 (G) (Iwabe *et al.*, 1989). Bold lines lead to hyperthermophiles. Modified from Woese *et al.* (1990).





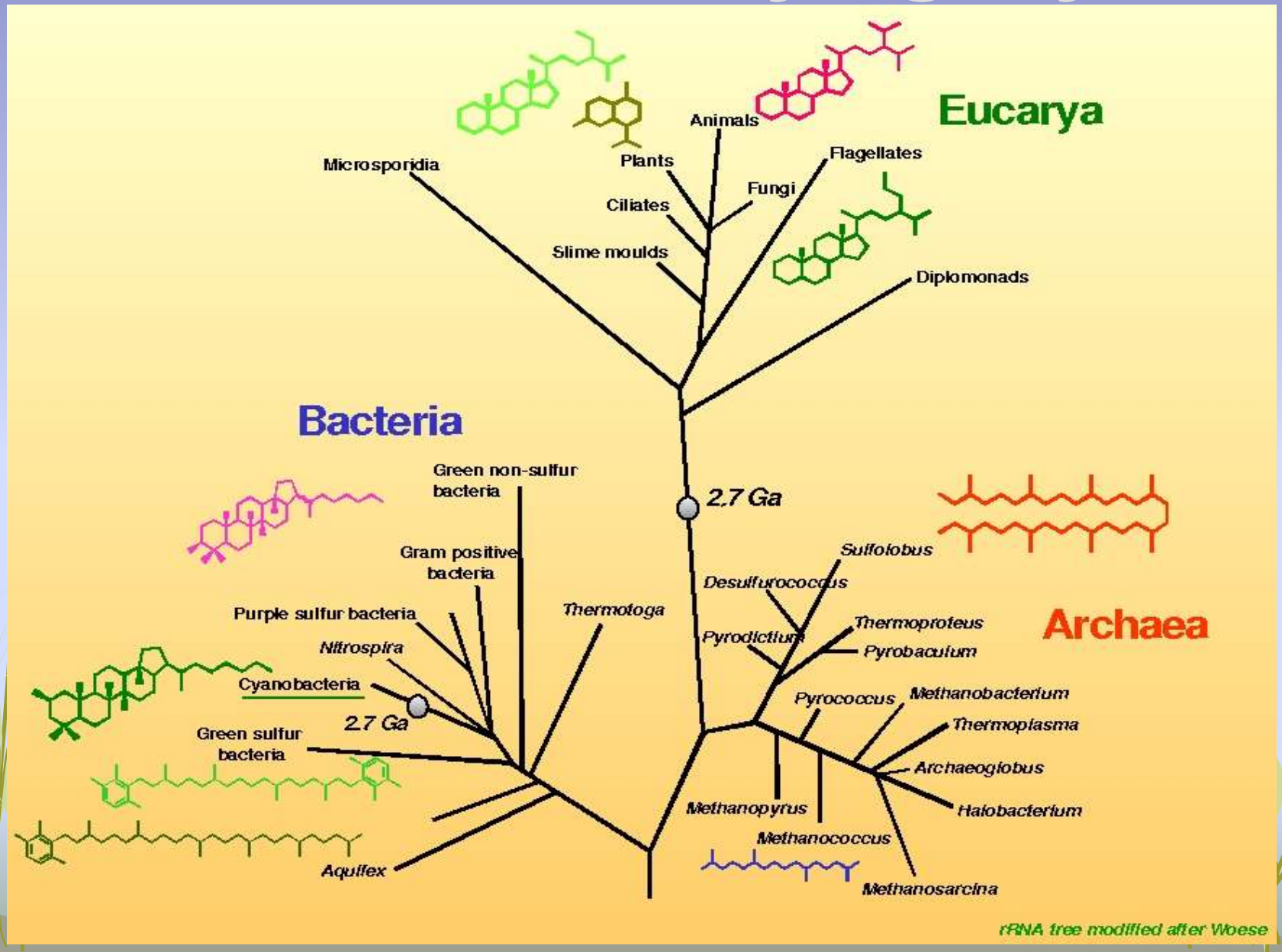


Unique history of B

Unique history of C

Shared history of B and C

Tree of Life Phylogeny

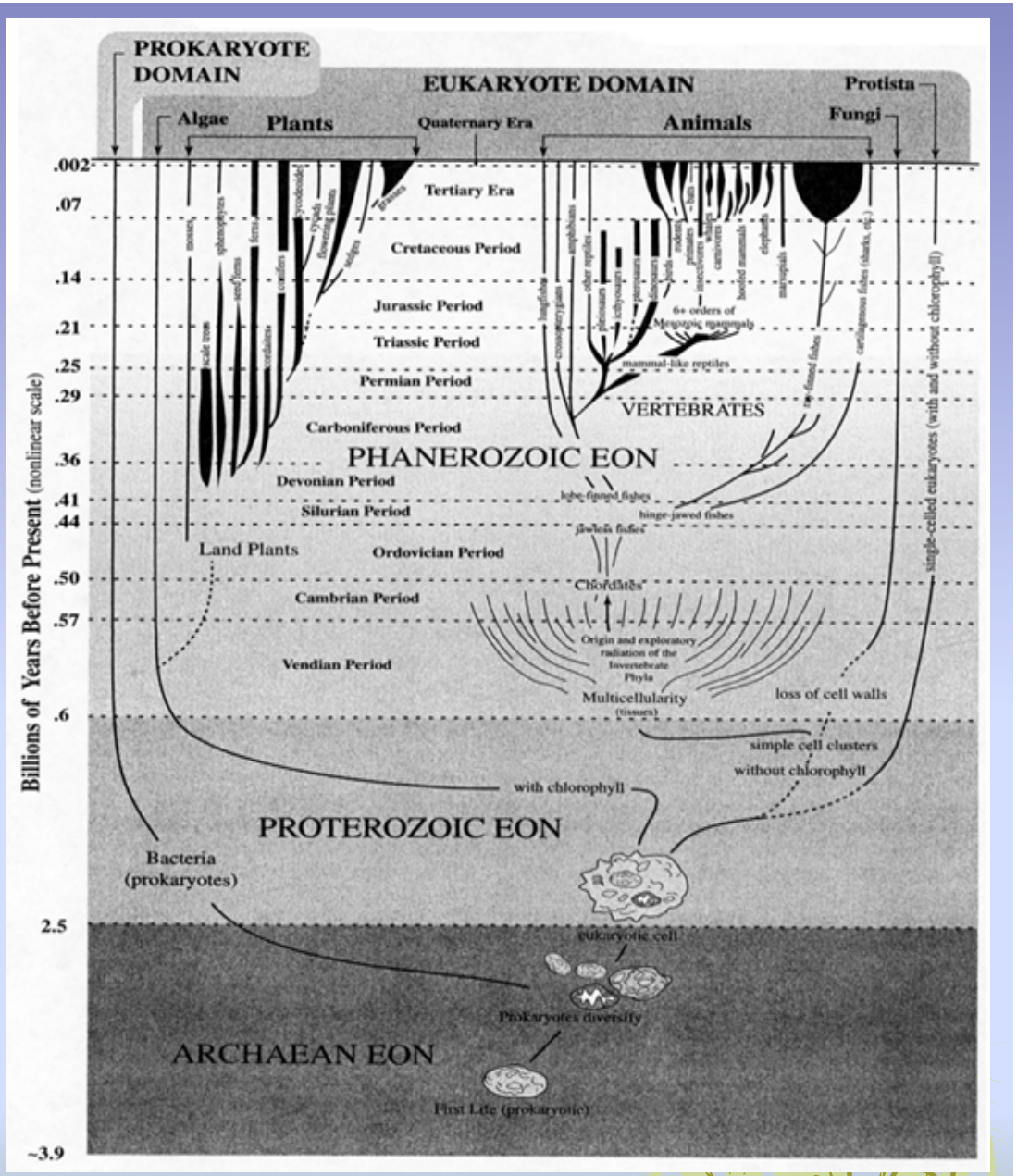


Life Domains and Underlying Kingdoms

Classification of Living Things						
DOMAIN	**Bacteria**	**Archaea**	**Eukarya**			
KINGDOM	**Eubacteria**	**Archaebacteria**	**Protista**	**Fungi**	**Plantae**	**Animalia**
CELL TYPE	Prokaryote	Prokaryote	Eukaryote	Eukaryote	Eukaryote	Eukaryote
CELL STRUCTURES	Cell walls with peptidoglycan	Cell walls without peptidoglycan	Cell walls of cellulose in some; some have chloroplasts	Cell walls of chitin	Cell walls of cellulose; chloroplasts	No cell walls or chloroplasts
NUMBER OF CELLS	Unicellular	Unicellular	Most unicellular; some colonial; some multicellular	Most multicellular; some unicellular	Multicellular	Multicellular
MODE OF NUTRITION	Autotroph or heterotroph	Autotroph or heterotroph	Autotroph or heterotroph	Heterotroph	Autotroph	Heterotroph
EXAMPLES	*Streptococcus*, *Escherichia coli*	Methanogens, halophiles	*Amoeba*, *Paramecium*, slime molds, giant kelp	Mushrooms, yeasts	Mosses, ferns, flowering plants	Sponges, worms, insects, fishes, mammals

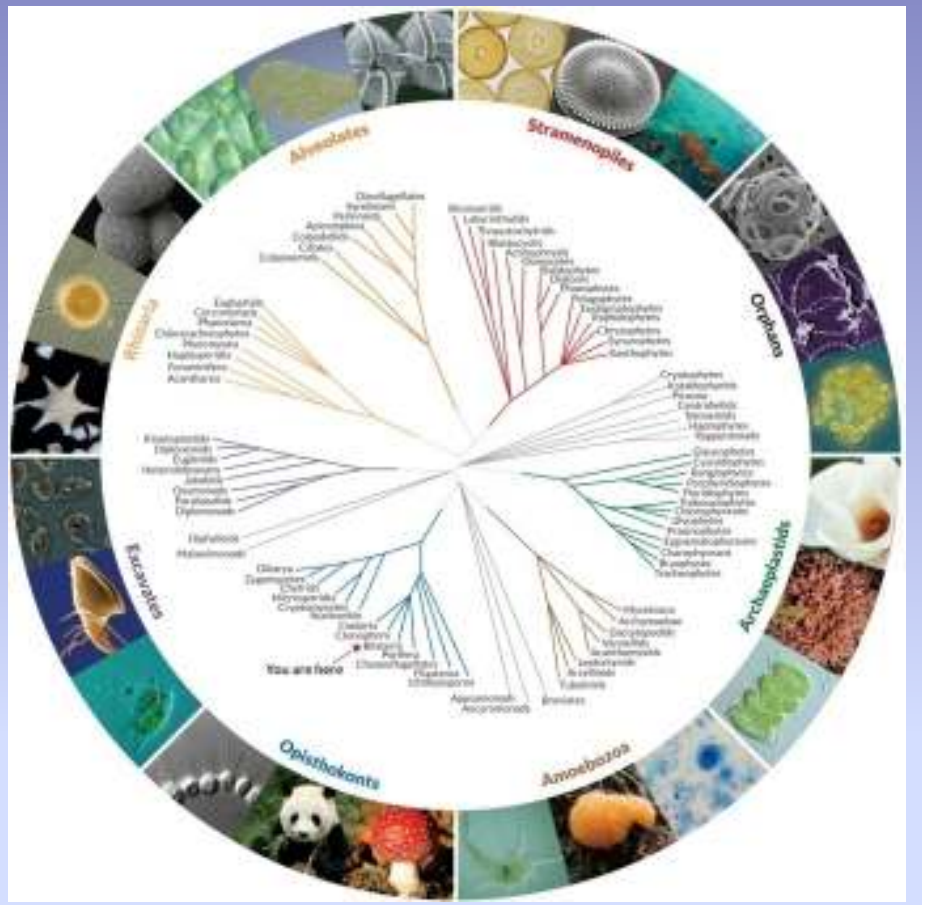
Life's Evolution & Diversification on Earth

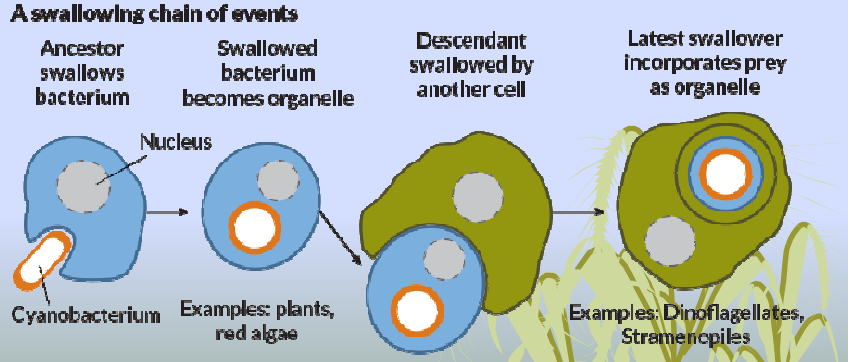
1) *Evolution of Prokaryote and Eukaryote domains*
2) *Eukaryotes divided into 5 kingdoms*
3) *Range of diversity indicated by line thickness*
4) *Branches that don't extend to top are extinct dead ends*
5) *Uncertainties indicated by dashed lines*



"Newer" Eukaryote Treetop of Life

1) *A newer, more genetically-accurate phylogeny of the eukaryotes that does not use "kingdoms" was proposed*
2) *Eukaryotes divided into 7 genetically-tied "Supergroups"*
3) *Tree shows both convergence and divergence*
4) *Big part of evolution of single-celled Eukaryotes involved organisms assimilating other organisms into their cells*





Major Marine Life Phyla

Kingdom Monera

Phylum **Bacterium**

- ✓ Archeabacteria
- ✓ Eubacteria

Kingdom Protista

Micro-Protista Phyla

Phylum **Bacillariophyta**

- ✓ Diatoms

Phylum **Sarcomastigophora**

- ✓ *Dynaflagellates*
- ✓ *Foraminifera*
- ✓ *Radiolarians*

Macro-Protista Phyla

Phylum **Chlorophyta**

Phylum **Pheaophyta**

Phylum **Rhodophyta**

Kingdom Animalia

Invertebrates

Phylum **Porifera**

Phylum **Cnidaria**

*Phylum **Ctenophora***

*Phylum **Bryozoa***

*Phylum **Brachiopoda***

Phylum **Mollusca**

Phylum **Arthropoda**

Phylum **Echinodermata**

Several **Worm Phyla**

Vertebrates

*Class **Agnatha***

*Class **Chondricthyes***

*Class **Osteichthyes***

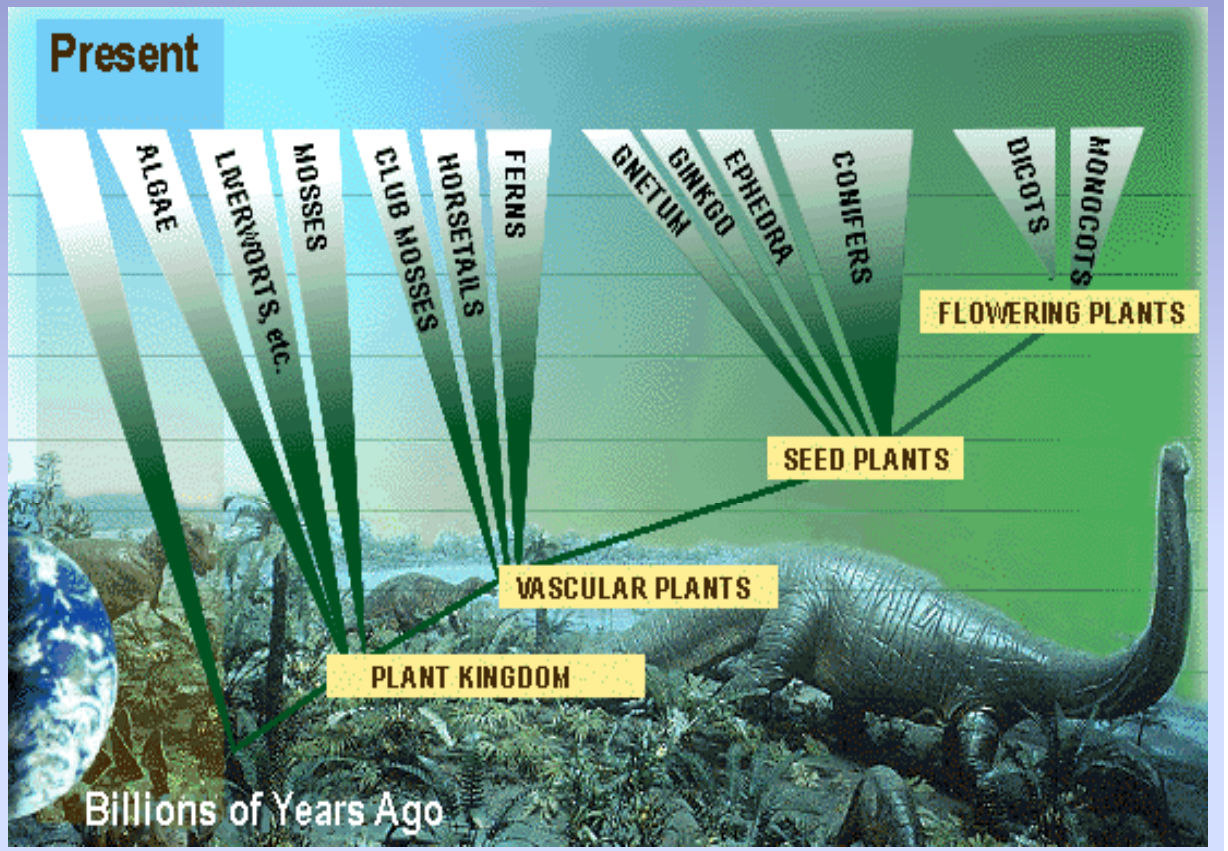
*Class **Reptilia***

*Class **Ave***

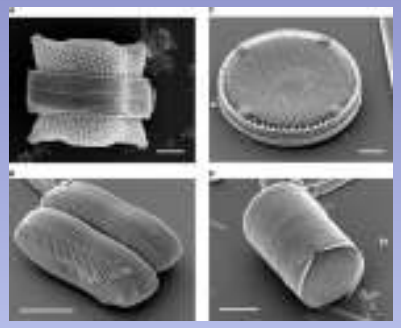
*Class **Mammalia***

Marine Plant Phyla

- ✓ **Micro-Algae**
  - ➢ *Diatoms*
  - ➢ *Cocolithophores*
  - ➢ *Dinoflagelletes*
- ✓ **Macro-Algae**
  - ➢ *Kelp*
  - ➢ *Seaweed*
- ✓ **Vascular Plants**
  - ➢ *Sea Grasses*
  - ➢ *Mangrove*



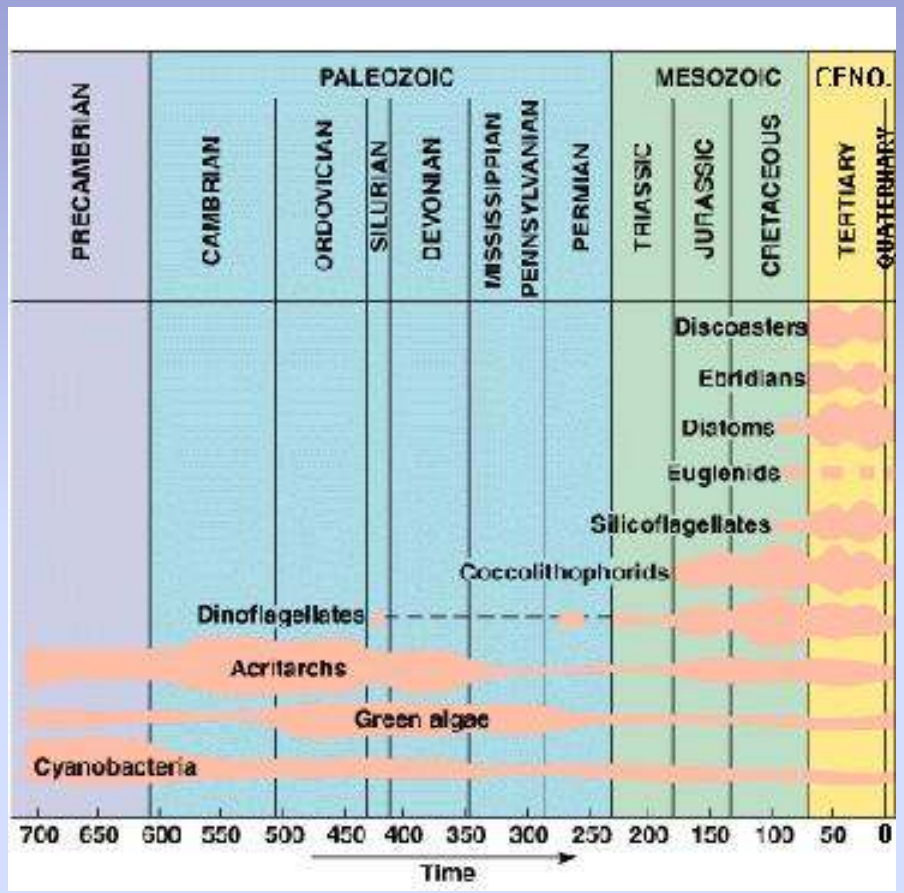
Evolution of Phytoplankton



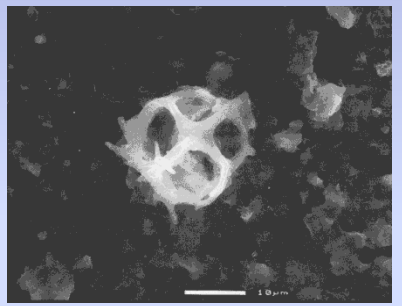
Diatoms

Dinoflagelletes

Cocolithophores



Cyanobacteria



Silicoflagelletes

Green Algae

Marine Invertebrate Animals

The Major Marine Invertebrate Phyla

1) Phylum **Porifera** = Sponges

2) Phylum **Cnidaria** = Jellyfish, Sea Anemone, and Coral

3) Phylum **Ctenophora** = Comb Jellies

4) Phylum **Mollusca** = Bivalves, Gastropods, and Cephalopods

- Class **Bivalves** (clams, mussels, oysters, scallops.), Class **Gastropods** (snails, slugs, and nudibrachs), and Class **Cephalopods** (squids, cuttlefish, octopusm, nautilus)

5) Phylum **Arthropoda** = Class **Crustacea** = Shrimp, Crabs, Lobsters, Krill, Copepods, and Barnacles

6) Phylum **Echinodermata** = Sea Urchins, Sea Stars, Brittle Star, and Sea Cucumber

7) Phylum **Bryozoa** = Moss-like animals

8) Phylum **Brachiopoda**= Lamp-shelled animals

9) Phylum **Annelida** = Segmented worms (polychaetes)

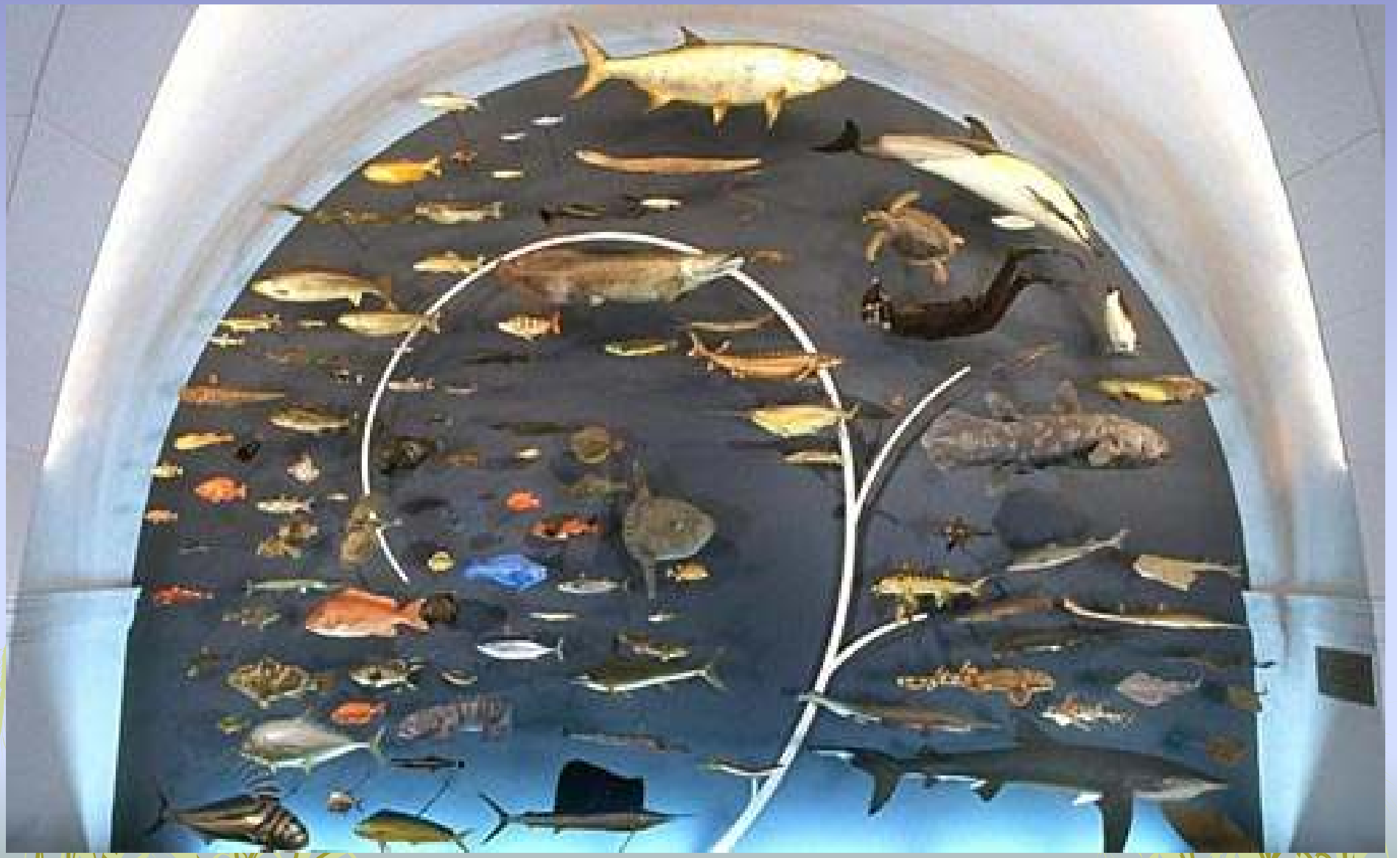
10) Phylum **Nematoda** = Roundworms

11) Phylum **Phoronida** = Tube worms

12) Phylum **Platyhelminthes** = Flatworms

13) Subphylum **Tunicata** – Sac-like, nano-corded animal

Marine Vertebrate Animals



Major Classes of Marine Vertebrates

*Under Sub-Phylum **Vertebrata***

*1) Class **Agnatha** = Jawless Fish*

*2) Class **Chondrichthyes** = Cartilaginous Fish (sharks, rays)*

*3) Class **Osteichthyes** = Bony or Ray-Fin Fish*

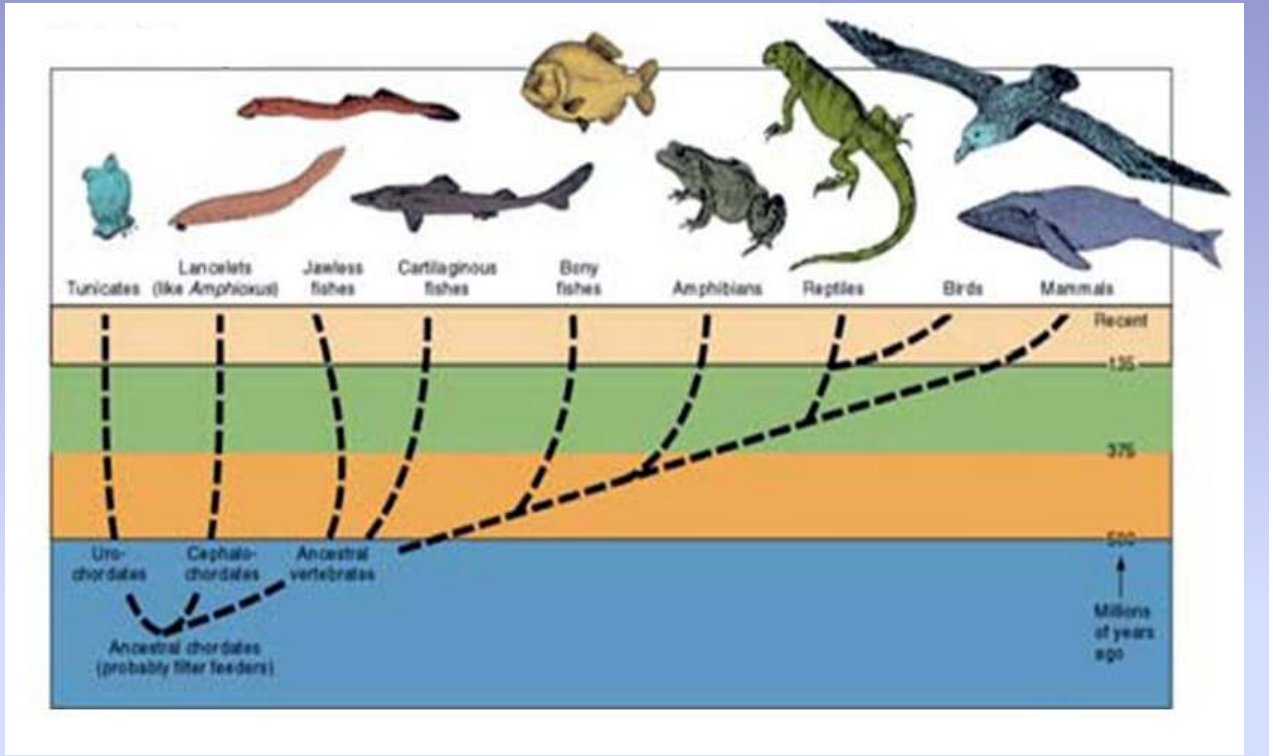
*4) Class **Reptilia** = Marine Reptiles (turtles, lizards, snakes)*

*5) Class **Aves** = Marine Birds*

*6) Class **Mammalia** = Marine Mammals (whales, pinepeds)*

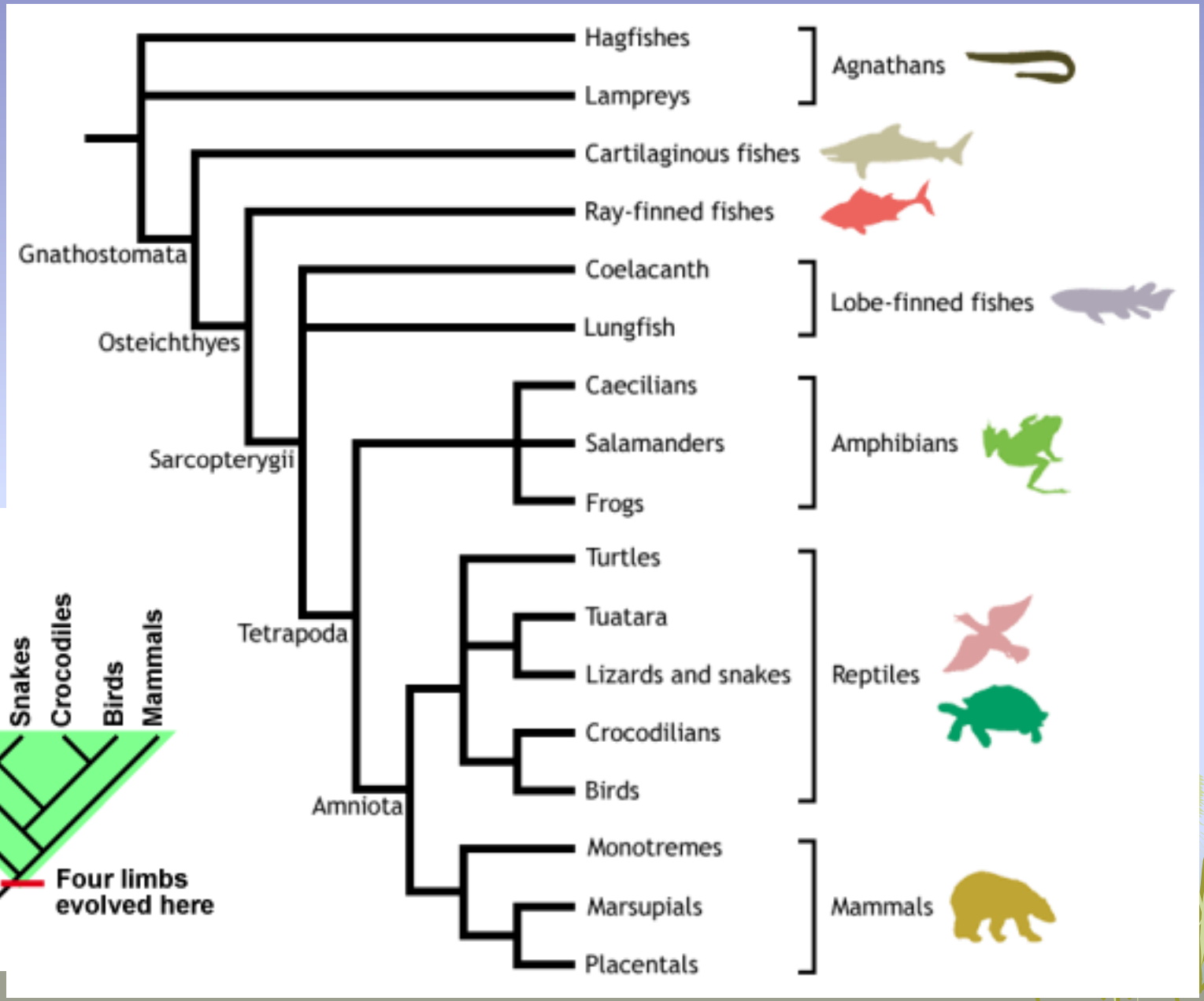
Marine Vertebrate Phylogeny

1) *Vertebrates came from an ancestral chordate invertebrate*
2) *First vertebrates were jawless fish*
3) *Jawed fish came later – like sharks and rays*



4) *Bony-skeleton fish came even later*
5) *The tetrapod vertebrates (originally only the class of amphibians) evolved from an ancestral lobe-finned fish*
6) *All marine tetrapods evolved from ancestral land-dwelling forms, including the marine reptiles, birds, and mammals*

Vertebrate Phylogeny



The Fish Vertebrates

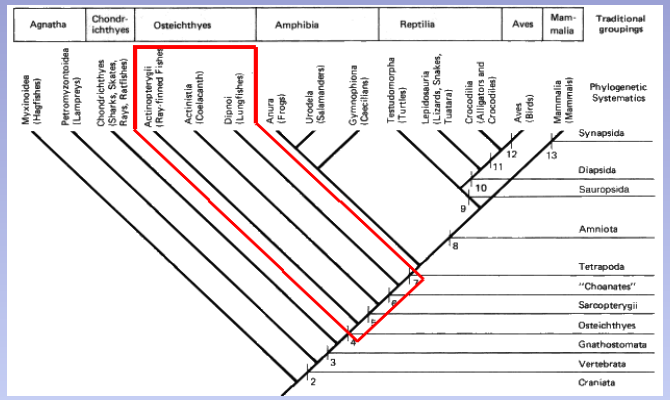
- Class Agnatha (jawless fish)
- Class Chondrichthyes (cartilaginous fish)
- Class Osteichthyes (bony fish)

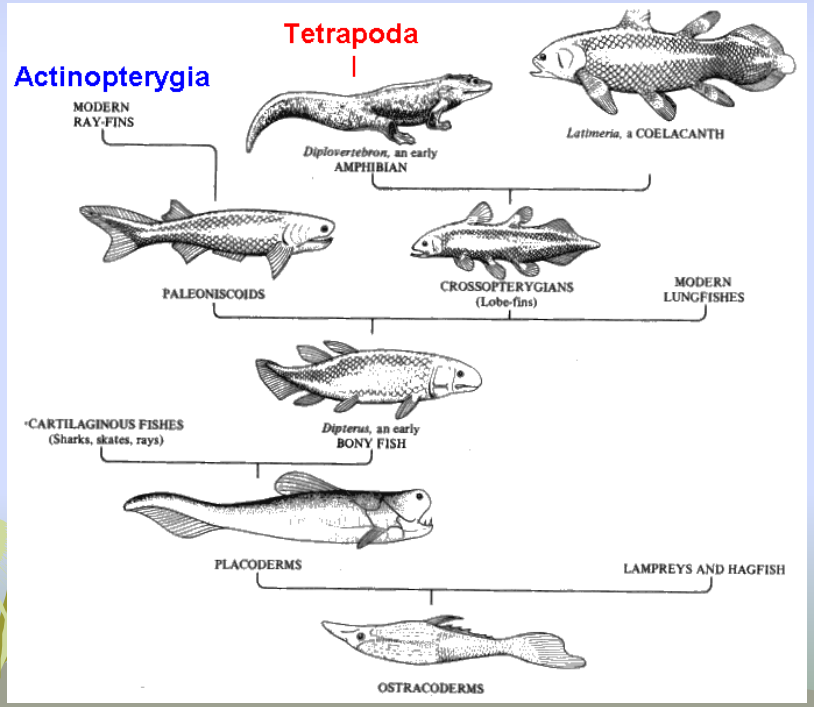
These classes of Fish have several things in common:

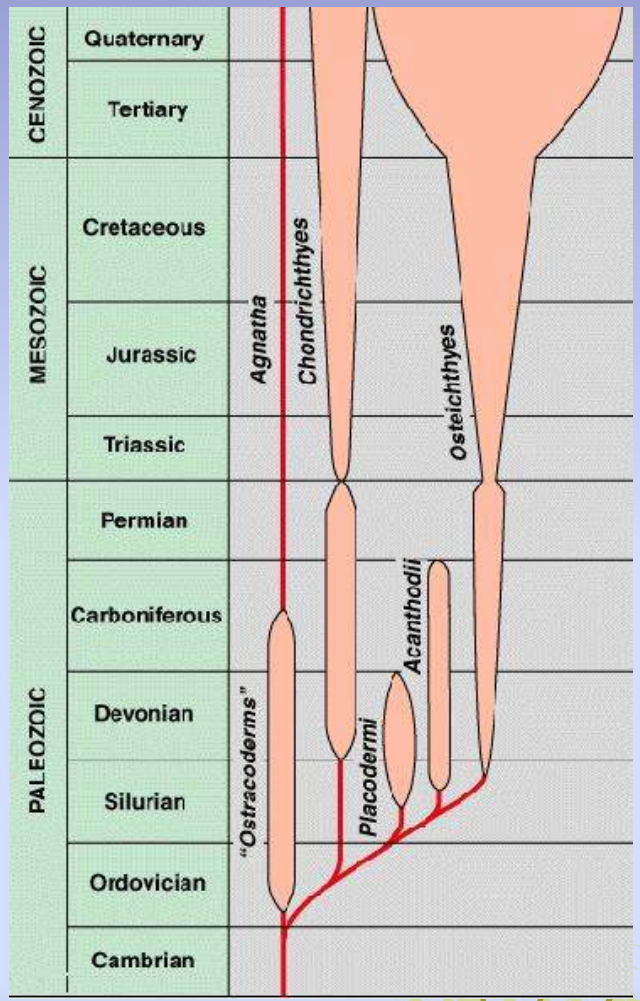
1) *Their earliest common ancestor lived in the early Paleozoic*
2) *They are all well-adapted to live in salt water*
3) *They all are interconnected in marine food webs*
4) *Most successful and longest-lived marine vertebrate*
5) *One or more of these classes found in every marine ecosystem*
6) *Over 30,000 species of marine fishes*

Fish Phylogeny

- ✓ *Ostracoderms*
- ✓ *Placoderms*
- ✓ *Lampereys*
- ✓ *Cartilaginous Fish*
- ✓ *Bony Fish*







Marine Mammals

1) Marine vertebrate animals that possess lungs for breathing, mammary glands for nursing and body hair; give birth to live young; many have flippers for swimming; all are "warm-blooded."

2) All marine mammals' ancestors were originally land mammals that, over a long period of time, adapted to living in the ocean

3) There are about 110 species of marine mammals

4) Three taxonomic Orders of marine mammals:

***Order Cetacea** -- toothed and baleen whales*

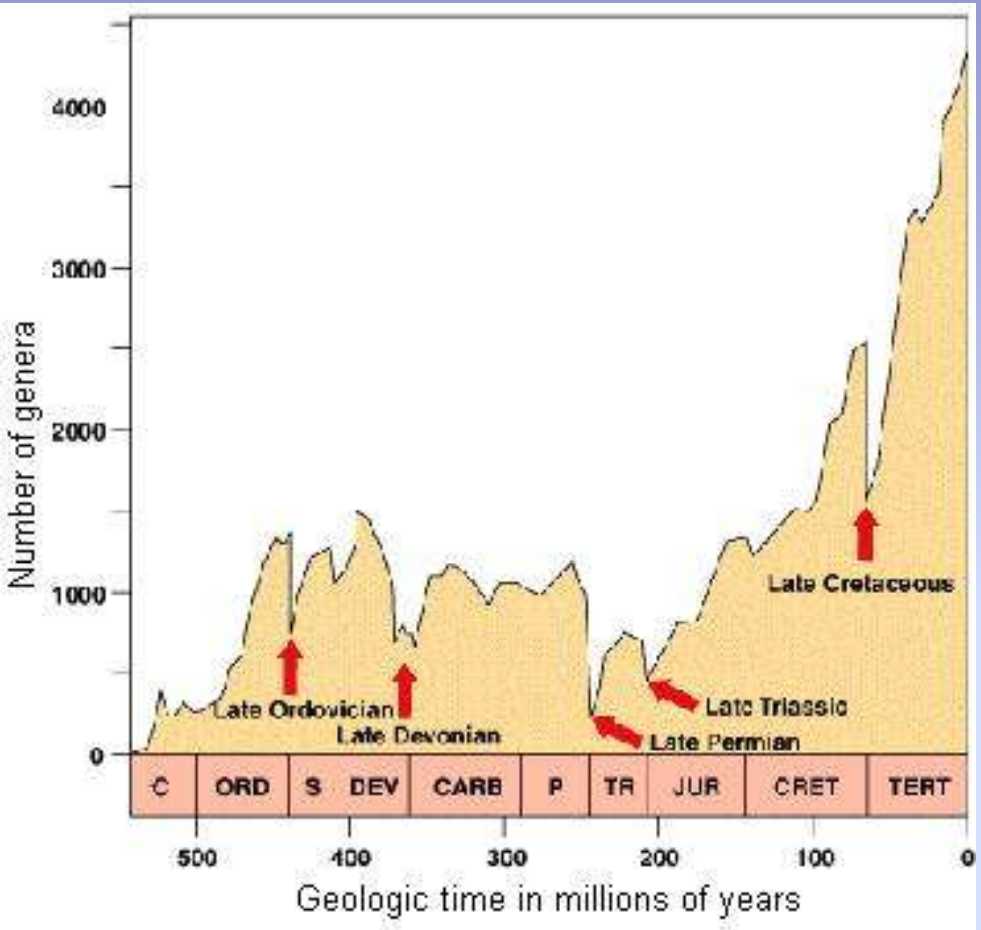
***Order** Carnivora **- Suborder Pinnipedia** = (seals, sea lions, and walruses); also the sea otters and polar bear*

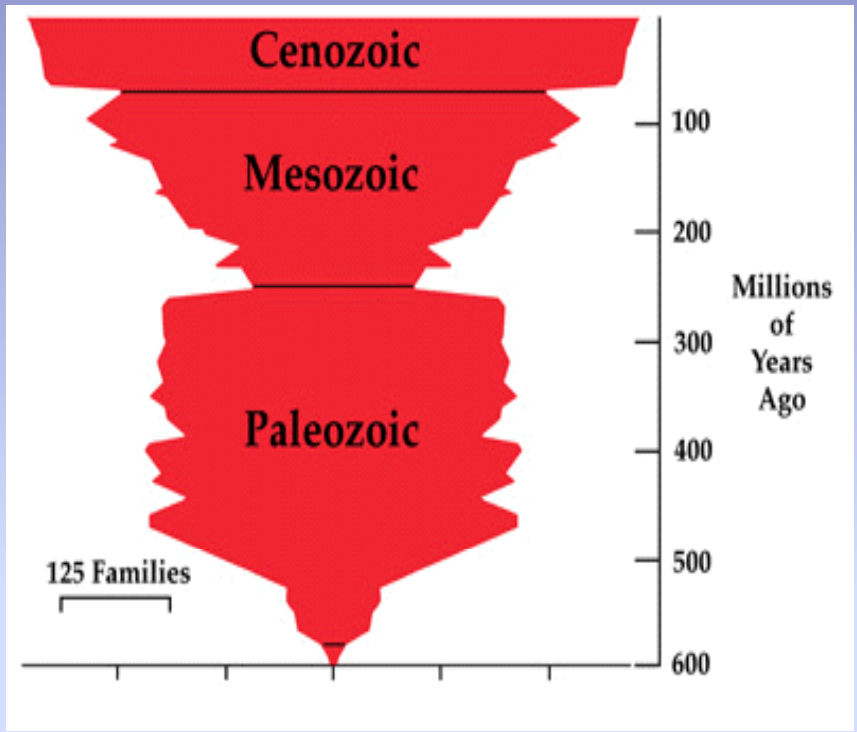
***Order Sirenia** (manatees and dugongs)*

5) Most marine mammals sit near the top of the food chain except for the baleen whales and the sea cows.

6) Most marine mammals face difficult environmental challenges

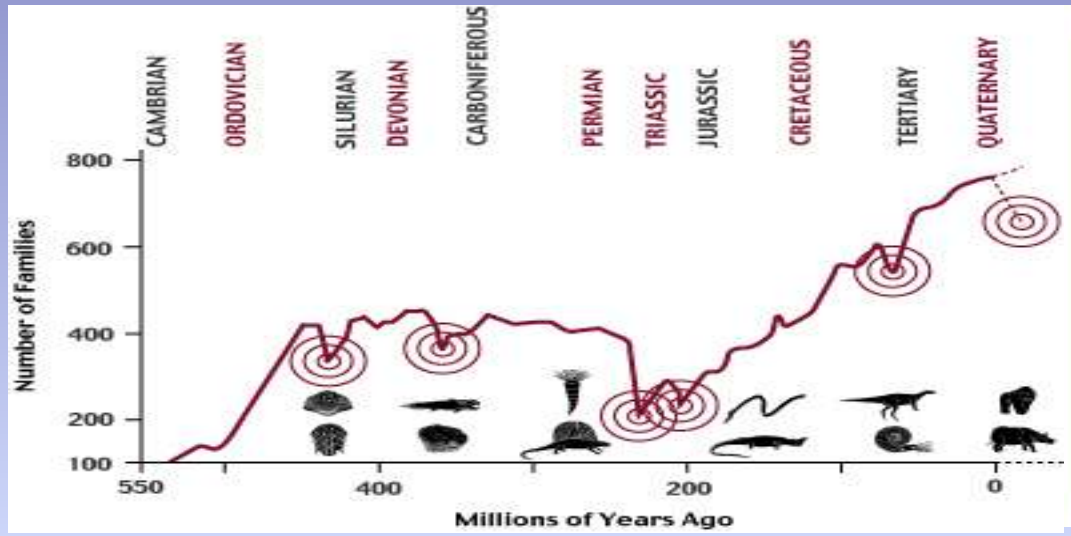
Diversity of Marine Life Through Time





Increasing Diversity Punctuated by Mass Extinction Events

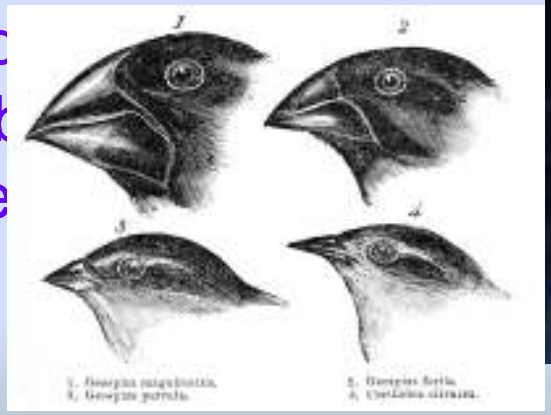
GLOBAL MASS EXTINCTION EVENTS



Date of the Extinction Event	Percent Species Lost	Species Affected
65 mya (million years ago)	85	Dinosaurs, plants (except ferns and seed bearing plants), marine vertebrates and invertebrates. Most mammals, birds, turtles, crocodiles, lizards, snakes, and amphibians were unaffected.
213 mya	44	Marine vertebrates and invertebrates
248 mya	75-95	Marine vertebrates and invertebrates
380 mya	70	Marine invertebrates
450 mya	50	Marine invertebrates

Scientific Study of the History of Life

- Science attempts to explain nature using natural laws, forces, and processes
- The Theory of Evolution is. by far, the best scientific explanation
- The Theory of Evolution is extremely well-tested, and, broadly supported by a wide variety of robust physical evidence



Definition of Biological Evolution

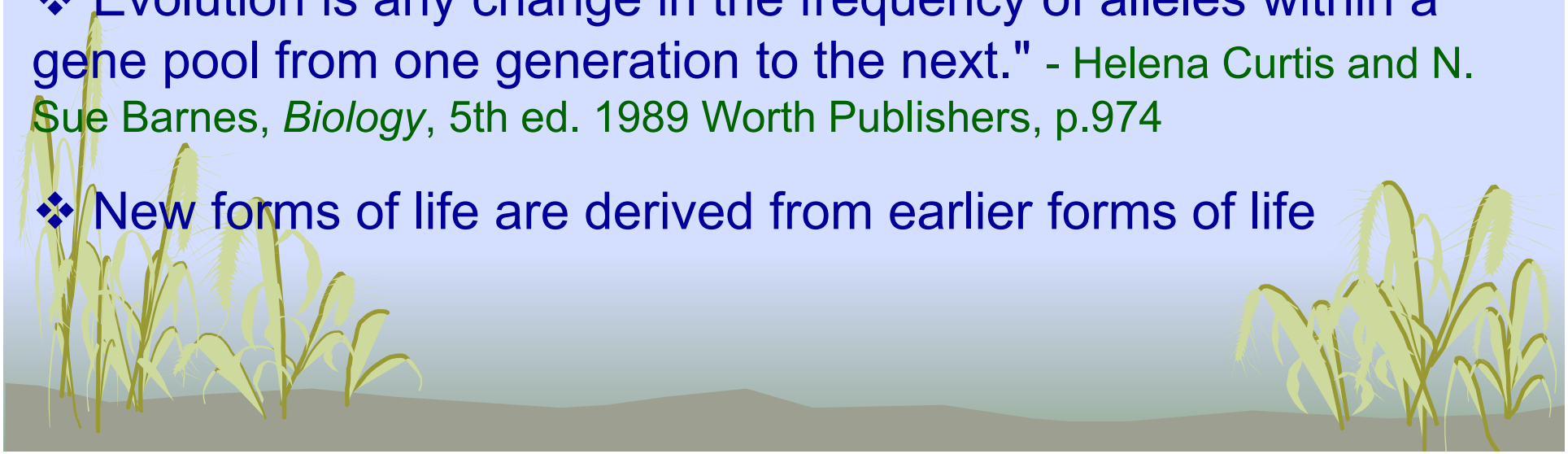
❖ Evolution is the maintenance of life under changing conditions by the continuous adaptation of successive generations of a species to its environment

❖ Biological evolution refers to populations and not to individuals and that the changes must be passed on to the next generation.

❖ Evolution is a process that results in heritable changes in a population spread over many generations.

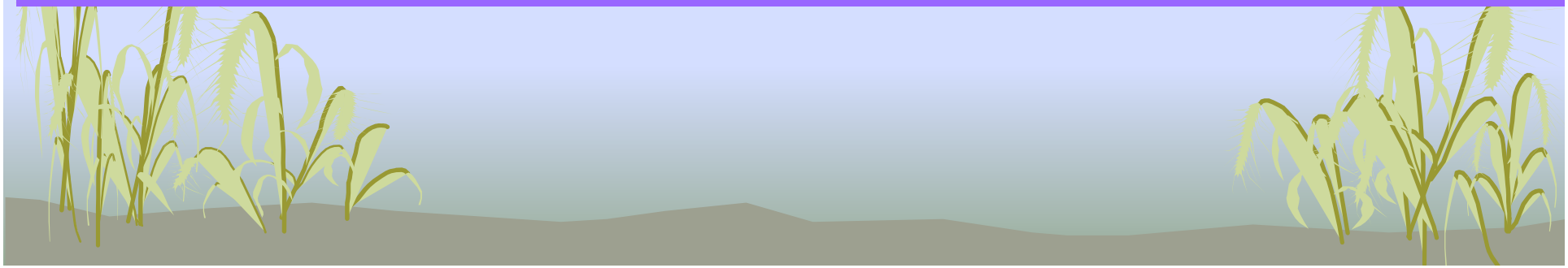
❖ Evolution is any change in the frequency of alleles within a gene pool from one generation to the next." - Helena Curtis and N. Sue Barnes, *Biology*, 5th ed. 1989 Worth Publishers, p.974

❖ New forms of life are derived from earlier forms of life



Incorrect Definitions of Biological Evolution

- "Evolution: The gradual process by which the present diversity of plant and animal life arose from the earliest and most primitive organisms, which is believed to have been continuing for the past 3000 million years." - Oxford Concise Science Dictionary
- "Evolution: ...the doctrine according to which higher forms of life have gradually arisen out of lower.." – Chambers
- "Evolution: ...the development of a species, organism, or organ from its original or primitive state to its present or specialized state; phylogeny or ontogeny" - Webster's
- Advanced forms of life are derived from primitive forms of life



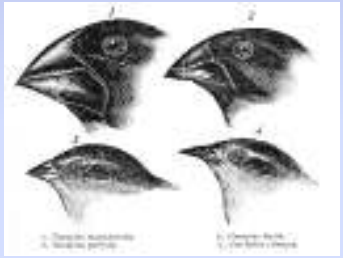
Theory of Evolution and Natural Selection

➢ Darwin's and Wallace's Ideas on *How* life may have changed through long spans of time

✓ More offspring are produced than can survive to reproduce

✓ Random variations occur in all organisms – some passable to offspring

- ❖ Meiosis
- ❖ Mutations



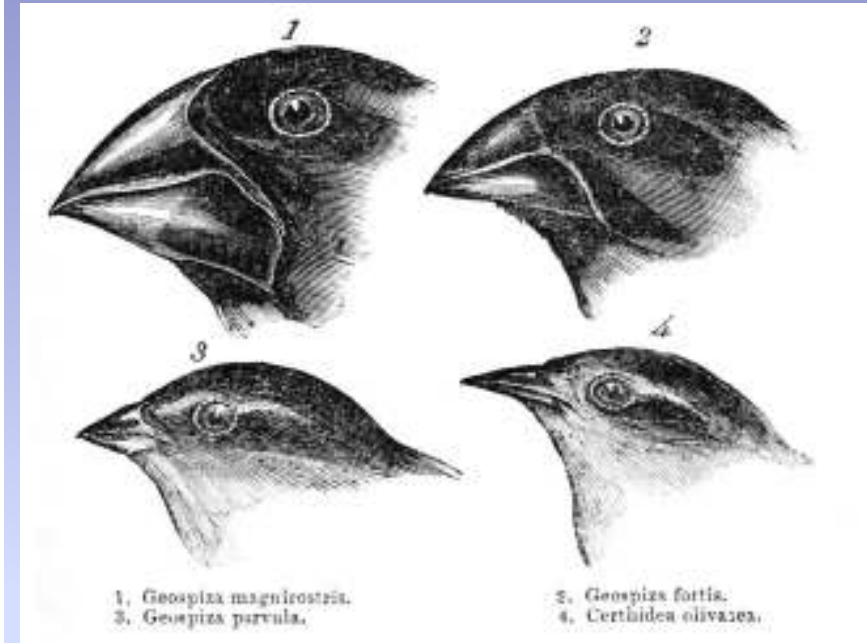
Darwin's Finches

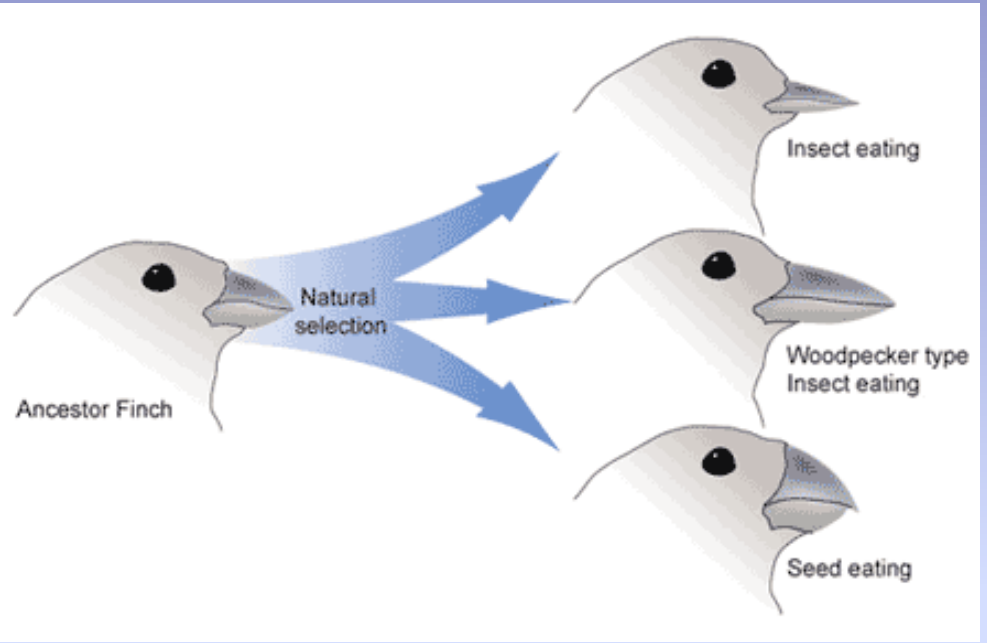
✓ Favorable inheritable traits increase the likelihood that the organism will survive to reproduction age

✓ Unfavorable traits decrease the likelihood that the organism will survive to reproductive age

✓ The organism's natural environment itself does the selection

Theory of Evolution and Natural Selection





Darwin's Finches as Explained by Natural Selection

Evolution = SURVIVAL OF THE FIT ENOUGH

- No biological predetermination = Purely a response to environmental pressures
- Accumulation of beneficial inherited structural or behavioral traits = favorable adaptations
- Organisms evolve to adequately fit their environment
- Rates of change are variable, depending primarily on environmental stress, population size, and degree of geographic isolation
- Mass extinction events create extreme environmental pressures on species

Big Concepts - Classification and Evolution

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  - ✓ Diversity = Over 100 million different species of living organisms
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- **Scientists use a natural classification system for living organisms**
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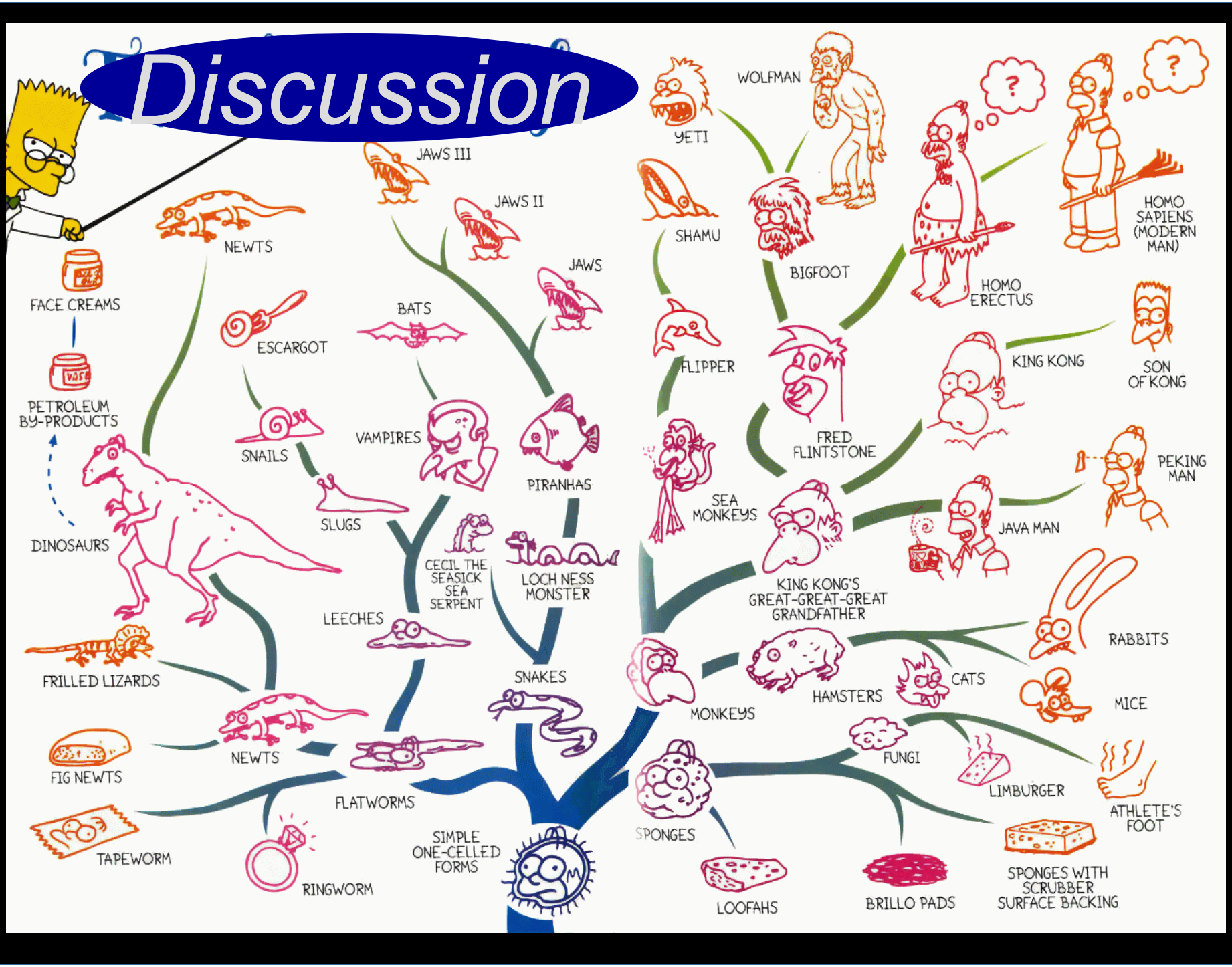
  - ✓ Genetic mutation = random development on new traits in offspring
  - ✓ Evolution in the marine environment highlighted by convergent evolution


Discussion
JAWS III
JAWS II
JAWS
NEWTS
FACE CREAMS
ESCARGOT
BATS
PETROLEUM BY-PRODUCTS
SNAILS
VAMPIRES
PIRANHAS
DINOSAURS
SLUGS
CECIL THE SEASICK SEA SERPENT
LOCH NESS MONSTER
LEECHES
FRILLED LIZARDS
SNAKES
NEWTS
FIG NEWTS
FLATWORMS
TAPEWORM
RINGWORM
SIMPLE ONE-CELLED FORMS
YETI
WOLFMAN
SHAMU
BIGFOOT
HOMO SAPIENS (MODERN MAN)
HOMO ERECTUS
FLIPPER
KING KONG
SON OF KONG
FRED FLINTSTONE
SEA MONKEYS
PEKING MAN
JAVA MAN
KING KONG'S GREAT-GREAT-GREAT GRANDFATHER
RABBITS
MONKEYS
HAMSTERS
CATS
MICE
FUNGI
LIMBURGER
ATHLETE'S FOOT
SPONGES
LOOFAHS
BRILLO PADS
SPONGES WITH SCRUBBER SURFACE BACKING

Conclusion: Life Changes Through Time