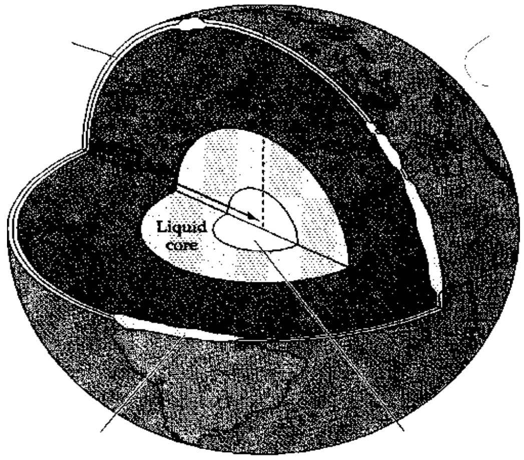
Era	Period	Epoch	mya
Cenozoic	Quarternary	Recent(last5000y)	
		Pleistocene	2.5
	Tertiary	Pliocene	10
		Miocene	25
		Oligocene	40
		Eocene	55
		Paleocene	65
Mezozic	Cretaceous		140
	Jurassic		190
	Triassic		230
Paleozoic	Permian		280
	Carboniferous	Pennsylvanian	330
		Mississippian	350
	Devonian		400
	Silurian		430
	Ordovician		500
	Cambrian		570
Precambrian			4600

4,600 – 3,800	formation of earth
3,800	oldest known rocks
3,500	prokaryotes
1.400	eukaryots
580	Kingdom Animalia
545	Cambrian explosion
550	vertebrates:
500	fish
480	plants
400	amphibians
300	reptiles
170	aves
100	mammals
65	dinosaur extinction
50	primates
5	apes
4 Bipedal hominids	*Austrolepithecus anamensis*
3	*Austrolepithecus africanus*
2	*Homo ergaster*
1	*Homo erectus*
0.25	anatomically modern humans (*Homo sapiens*)

Rock formation	**≈mya**
Kaibab limestone	250
Toroweap limestone	255
Coconino sandstone	260
Hermit shale	265
Supai sandstone	285
Redwall limestone	335
Muav limestone	515
Bright Angel shale	530
Tapeats sandstone	545
Zoroaster granite and Vishnu schist	1,700-2,000

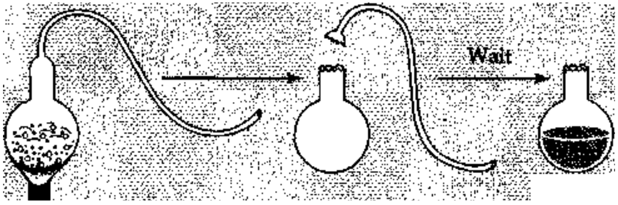
BIODIVERSITY OF LIFE GEOLOGICAL HISTORY OF THE EARTH



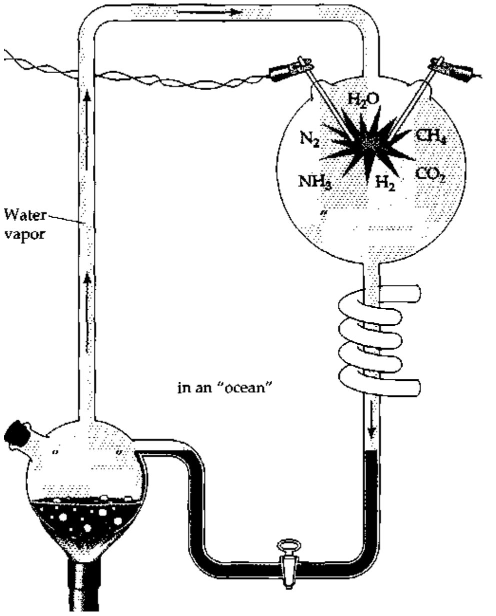
Lecture 1: Origin of the Earth- 1. Where did the earth core from? Until 19century most people shared view that Earth was 10mya. Geologists after time became convinced that Earth was much older, evidence came primarily from the remains of organisms that were found in sedimentary rocks, by: superposition method (younger rocks are deposited over top of older ones); Fossils of organisms ware preserved within the rocks, by differences among similar organisms as they compared the layers, or strata, of older and younger rocks in the same place. They also found remains of familiar organisms at widely separated locations. By assuming that rocks at different locations that contained a particular type of fossil were likely to be of approximately the same age, By making such comparisons among many locations, and always considering the superposition of strata, geologists had determined the general order of events in the history of life long before they knew the actual times that these events occurred, however, gave only relative ages. End of the 19 century scientists discovered radioactivity- Out of this discovery came a way to date rocks and the fossils they contain because as rocks form, radioactive isotopes of uranium, thorium, rubidium, potassium, and other elements— in proportion to their presence in the environment— are incorporated into the rocks. Each type of radio - isotopes begins, to decay at its own constant rate, becoming by this process a stable isotope. These rates of decay can serve as radiometric clocks. The earliest known fossils have been radiometrically dated at 3.8 billion years old. To estimate the age of the genetic code, we can make estimate by comparing the sequences of tRNA among different organisms. The more dissfamiliar alignment Base sequences of different organisms, the longer they probably have been evolving as separate lineages. The patterns of similarities of tRNAs suggest that the genetic code originated before the separation of the bacteria's which is estimated from dated fossils to have happened about *3.7* billion years ago. Putting all of this evidence together we estimate that the gene code is about 3.8bill years old. ;;;**2. The big bang theory;** formation of heavenly bodies; 10-20 billion years ago a mighty explosion occurred. The matter of the universe, which had been highly concentrated, began to spread apart rapidly. The "big bang" sent gases hurtling in all directions. Eventually clouds of gases collapsed upon themselves through gravitational attraction, forming the galaxies, which are great clusters of hundreds of billions of stars. ;;; Somewhat less than 5 billion years ago, toward the outer edge of our galaxy (the Milky Way), our solar system (the sun, Earth, and our sister planets) took form. Most of the planets probably formed by gravity. **3. Structure of the earth;** Earths History **(geology):** Earth slowly grew by this process, the weight of the outer layers compressed the interior of the planet. The resulting pressures, combined with the energy from radioactive decay, heated the interior until it melted. Within this viscous liquid, the settling of the heavier elements produced an iron and nickel core radius 3400km. Around the core lies a mantle of dense silicate materials that is 3,000 km. Over the mantle is crust (40 km) under the continents (5 km), but thinner in some places under the oceans**. 4. Core** (composed of Solid Iron and Nickel base, followed by liquid Iron) about 3400km,**5. Magma**: composed of Lower mantle (next to the core). Then is the Mantle about 3000km. On top of which there is some atmosphere-like CO_2, N_2, etc. heavy stuff=>this interact (resulting in volcano's, which formed the first atmosphere CH_4, N_2, NH_3, H_2,; CO_2; H_2O vapour, which cooled and formed the oceans, separated by Mid-ocean ridge and rift valleys => condensed energy, which form the environment) with the following layer of Lathisphere about 70km **,6. Crust,7. effect of collisions** between the continental plates in subduction zones**; 8. early atmosphere** attraction and the aggregation of cold dust particles**:** Earth's mantle and crust released carbon dioxide, nitrogen€, and other heavier

gases. These gases were held by Earth's gravitational field, and gradually formed a new atmosphere. Earth accumulated an atmosphere consisting mostly of methane (CH_4), carbon dioxide (CO_2), ammonia (NH_3), hydrogen (H_2), nitrogen (N_2), and(H_2O)vapor. As Earth cooled, some of the water vapor escaping from inside the planet condensed into seas. Oceans=> atmosphere surrounding the earth as a security against the meteorites => the earth start cooling temperature down; Continuous supply of energy=. Condensation Energy=>Isolation of environment; **Perpetual** (lasting forever) supply of energy; **Microspers**(artificially compounds + lipids) + cool H/2O→lipid bylayer; **Transduction** =>from the transducer, which passing energy (light, etc.) and make available activities in the side cell, e.g.pigments (chloroplasts, etc, or mitochondria)=> the goal is for copies => RNA=>then DNA ;;; **9. How did life evolve from non-life?** physical conditions that prevailed on Earth before there was life and when life arose. Those conditions determined which types of chemical reactions took place on Earth. If we know what types of reactions took place, we can suggest how those reactions could have led to the appearance of life.

10. **Principles of continuity**: continuous gradual process =>any stage should be derivable from pre-existing states; 11. **Signature principle:** pre-biotic processes should leave traces (signature); 12. **No free lunch principle**: all require some form of energy in order to groll (=>they are NO PRODUCERS of energy). **13. sources of energy**.: **a)** SOLAR; **b)** From reduced compounds of the magma=> the early earth had reducing atmosphere;**14. Solar and chemical; demands of the non-oxygen atmosphere -** No free oxygen was present in this early atmosphere because oxygen is a very reactive element. It reacted with hydrogen to form water and with components of Earth's crust and atmosphere to form iron oxides, silicates, carbon dioxide, and carbon monoxide.**;** **15. The experimental approach to solving the origin of life:** new life is still being assembled from nonliving matter => simple biological molecules accumulate densities that characterize the "primordial soup," in anaerobic environments. In aerobic environments these molecules are quickly oxidized to other forms and would not accumulate even if they were not consumed. Generation of earth life from nonlife (Life generally) on Earth did happen, but it was an event of the remote past. Once it had evolved, life changed, so and forms of it. =>now we have oxidizing atmosphere;



Lecture 2: 16. The difficulty of grasping geological time, like Attenborough model: Origin of Life - All organisms consist of cells and, as far as we know, all cells come from preexisting cells. Nonlife (means life, which forms, shapes, dimensions, approaches, etc we don't know, but we know is always been life everywhere in some kind) evolved into protolife the immediate precursor of life and, even actually into life. Changes in the genetic compositions of organisms through time — also began. Biological evolution over more than 3 billion years has resulted in the millions of species of organisms living today and the many millions more that lived in the past, that became extinct.; **Tests of Spontaneous Generation of life:**before 1668 we don't know any experiments about determine is it life only from life. In 1862 the great French scientist Louis Pasteur-series of meticulous experiments showing that microorganisms from other microorganisms and that a genuinely_sterile solution remains"lifeless indefinitely"_unless contaminated by living_creatures. His most elegant experiment relied on swan-necked flasks that were open to the air (ruling out the "spoiled air". Heated themro kill any microorganisms present,. then cooled them slowly. The shape of the necks prevent any new organisms from falling into" the medium, and new growth appeared in the flasks. *omne vivum e vivo* ("all life from life") ; **Earth's life** that arose on Earth can be no older than Earth itself, but Life generally is infinitive and always been existing (in some kind), which link will lead us to what we looking for (Earth's life) and save us from confusions and not existing contradictions! ; **Experiments by Stanley Miller** in a reducing atmosphere, importance of hydrogen, ammonia, methane and water vapour; Atmospheric" compartment A condenser cools the "atmospheric" gases in a "rain" containing new compounds (a.a.'s, phosphates, sulphates, etc.). The compounds collect Oceanic compartment. In 1950 Stanley Miller conditions simulating those of early Earth. He established reducing atmosphere of hydrogen, ammonia, methane, nitrogen, carbon' dioxide, and water vapor and simulate lightening. Within a few hours the system contained numerous simple organic compounds. In water, these compounds were rapidly converted into amino acids, "simple acids", and other compounds. Because these molecules are relatively stable, they quickly accumulate in solution=> free oxygen is absent there, and the environment is a reducing one. Thus, once Earth cooled enough for water to condense and form oceans, molecules of many kinds formed spontaneously, and they probably accumulated until they reached relatively high concentrations. Earth. ; Life emerged from nonlife(Life generally) **in such an anaerobic "primordial soup."**



The important **large molecules** of which organisms are composed—**polysaccharides, proteins, and nucleic acids—are polymers formed by** the combination of **subunits called monomers => polymerization** generate these large molecules (reactions called condensations or dehydrations). During a condensation reaction, water is formed, one hydrogen atom coming from one molecule and the other hydrogen atom and the oxygen atom coming from another molecule. Large molecules are assembled through repeated condensations of monomers, and each condensation reaction requires energy=>Now molecules of organisms that direct the synthesis of other molecules identical to themselves=>polymers evolve.

The molecules formed on the **prebiotic ("before life")** Earth, most likely capable of **catalyzing their own replication**: **Nucleic acids,** the basis of today's genetic code, are clearly well suited for this purpose, and the two types of **monomers (pu-rines and pyrimidines) that are linked together to form the nucleic acid polymers,** that are formed under conditions similar to those believed to have prevailed on the early Earth=>Formation nucleic acid bases **via polymerisation of hydrogen cyanide (HCN)**, one of the molecules formed in Miller's experiments. This polymerization, by the steps, yields (produce) large amounts of the tetramer diaminomaleonitrile, Dia-minomaleonitrile can rearrange and react again with hydrogen cyanide **to form the purine base adenine.** Under slightly different conditions, diaminomaleonitrile first reacts with formamide generated by the hydrolysis of hydrogen cyanide and then reacts with hydrogen cyanide to give the other important **purine base, guanine**. Other similar reactions yield **and the rest of the pyrimidine bases.** **=>Sugars5,6-C**, another basic component of living cells, are generated by the polymerization of formaldehyde, another molecule formed in Miller's experiments. Solutions of formaldehyde spontaneously polymerize to form several types 5,6-C sugars, but these sugars are **unstable in aqueous solutions and break down to alcohols and carboxylic acids. 3-4C sugars are very stable, and can accumulate for hundreds of years in aqueous solutions.** Over millions of years, these organic molecules would have accumulated in the oceans. They would have reached even higher concentrations in drying bodies of water, where they would have **continued to polymerize**=>The "ocean" is sampled and its composition analysed, by **Synthesis of Molecules in an Experimental Atmosphere.** HCN+HCN->dimer=>+HCN->trimer=>+HCN->tetramer (diaminomaleonitrile), which after rearranges its shape into a ring-shape and then +HCN+ultraviolet light-> adenine. Monomers that form readily under prebiotic conditions can polymerize by phosphorylation (the addition of a phosphate group). Phosphorylated monomers are stable enough to accumulate in solution but reactive enough to polymerize further. The first biologically active polymers of nucleic acid bases may have been compounds formed from three- and four-carbon sugars. Such polymers could have helped polymerize specific amino acids into peptides, as RNA does today. They could also have self-replicated by forming complementary double-stranded molecules, just as pentose-based nucleic acid polymers do today. At some point, by as yet unidentified processes, polymers based on small sugars were replaced by those based on larger sugars, such as ribose, the sugar that is part of RNA.

Start ingredients	Products in the "atmosphere"	Products in the "ocean"
H-gas	HCN- H-cianide	Glycine
N-gas	COH/2- Formaldehyde	Sarcosine
CO/2	C/2N/2 – cynogen	Glycolic acid
H/2O	Acetaldehyde	Alamine
NH/3-amonia	Cyanoacetylene	N-methilalamine
CH/4-methane	Propionaldehyde	Lactic acid
		A-Aminobutyric acid
		α-aminoisobutyric acid
		Formic acid
		Acetic acid
		Propionic acid
		Urea
		Aspatric acid
		Iminoaceticpropionic acid
		Succinic acid
		Glutamic acid

Polysaccharides, proteins and nucleic acids; pre-biotic molecules;need for certain fundamental life characteristics: replicators, mutation, evolution of membranes; Oparin's experiments-protobionts and coacervates: From Ribozymes to Cells: Oparin, studying complex solutions observed that if he shook a mixture of a large protein and a polysaccharide, the drops that formed were divided into two "phases." Their interiors, which were primarily protein and polysaccharide, with some water, were surrounded by an aqueous solution containing low concentrations of proteins and polysaccharides. These drops, known as coacervates, are quite stable and will form in solutions of many different types of polymers; **Coacervates** have other properties relevant to the origin of life. Many substances, when added to a coacervate preparation, are preferentially concentrated within the drops. Lipids coat the boundaries of drops with membranelike structures that strengthen the drops and help contol the rates of passage of materials into and out of the drops. Coacervate drops that contain enzyme molecules exhibit a "metabolism": They can absorb substrates, catalyze reactions, and let the products diffuse back out into the solution; chlorophyll-containing coacervate drops that absorbed an oxidized dye from the solution, used light energy to reduce it, and returned the reduced dye to the medium;**Complex coacervate** drops are possible precursors to cells because they provided the physical framework within which metabolic reactions took place. Because drops in which chemical reactions were better controlled would have survived longer than drops with more poorly controlled reactions, refinements of metabolic processes by the use of enzymes could have evolved. Billions of droplets would have competed with one another for substrate materials from the environment. They would have evolved better abilities to replicate internal reactions and would have engaged in an early form of reproduction by passing on at least rough copies of their molecules to daughter droplets when they divided. At some point, such droplets may have accumulated enough RNA to display the properties we now associate with "earth life".**"Metabolism" of Coacervate Drops**-This hypothetical coacervate drop has a lipid coat that surrounds the drop with a membranelike structure. The drop absorbs glucose 1-phosphate from the surrounding medium. Within the drop the enzyme phosphorylase polymerizes glucose to starch, and the enzyme amylase hydrolyzes starch to maltose. **17.importance of energy transduction**-METABOLISM OF EARLY ORGANISMS- Earth's atmosphere lacked oxygen at the time when life first appeared. Also shows that Earth's atmosphere was a reducing one for about a billion years after life evolved. Therefore, the earliest organisms must have been obligate anaerobes—organisms that obtain their energy without using oxygen. No traces of the metabolic pathways of those early organisms have been preserved, but we can make reasoned guesses about stages in **18.Procaryots: Bacterias: Utilisation of sunlight-Anaerobic Photosynthesis-**oxygen is poisonous to them. 3 types-anaerobic photosynthetic Eubacteria— green(sulfur bacteria), Purple sulfur bacteria, and Purple nonsulfur bacteria—live today in sediments (any particulate matter that can be transported by fluid or wind or any flow and which eventually is deposited as a layer of solid particles on the bed or bottom) that lack oxygen. These eubacteria all contain types of chlorophyll, called bacteriochlorophyll *a, c,* and *d.* Anaerobic photosynthetic bacteria also contain red and yellow carotenoids, which absorb light of wave-lengths that are not absorbed by chlorophyll and pass the energy along to chlorophyll. The photosynthetic system of these bacteria is embedded in membrane complexes called thylakoids. The thy-lakoids possess the electron transport chains by which captured solar energy is passed along and used to generate ATP. Photosynthetic bacteria, which were probably similar in their metabolism to today's forms, were so abundant about 3.4 billion years ago that their partly decomposed (break down) remains formed extensive (vast) deposits of carbon, resembling (looks like) the coal deposits produced by vascular plants 3 billion years later. ; To reduce carbon dioxide (CO_2), a photosynthetic cell needs a source of hydrogen atoms. Many bacteria use light energy to generate ATP and $NADPH + H^+$, but which waste product they liberate depends upon the source of hydrogen atoms they use. The green and purple sulfur bacteria obtain their hydrogen atoms from hydrogen sulfide (H_2S) and generate sulfur as a waste product. The purple nonsulfur bacteria obtain hydrogen atoms from organic compounds such as ethanol, lactic acid, or py-ruvic acid, or directly from hydrogen gas. In some environments today, the hydrogen is provided by other bacteria as the end products of their fermentations. Under the anaerobic conditions of early Earth, hydrogen sulfide and other compounds containing hydrogen would have been more abundant than they are today because atmospheric oxygen quickly oxidizes them into water, carbon dioxide, and sulfur oxides. Organisms that can shift their metabolism between anaerobic and aerobic modes are called **facultative anaerobes**:some can conduct only anaerobic metabolism (fermentation) but are not damaged by oxygen when it is present. Although many types of prokaryotes are facultative anaerobes, alternating between fermentation and cellular respiration as conditions, dictate, others can live only by fermentation because they are poisoned by oxygen gas. These oxygen-sensitive fermenters are called **obligate anaerobes**. At the other extreme, some bacteria are obligate aerobes, unable to survive for extended periods in the *absence* of oxygen. ; Some bacteria carry out respiratory electron transport without using oxygen as an electron acceptor. These forms use oxidized inorganic ions such as nitrate, nitrite, or sulfate as electron acceptors. Among these organisms are the denitrifiers, bacteria that return nitrogen to the atmosphere, completing the cycle of nitrogen in nature.

Nutritional categories (in bacteria): autotrophs=litothrophs

---------photoautotrophs, which are photosynthetic, use light as their source of energy and carbon dioxide as their source of carbon, e.g. group of cyanobacteria, like the photosynthetic eukaryotes, performs photosynthesis with chlorophyll, as the key pigment and produces oxygen as a by-product of noncyclic photophosphorylation.

By contrast the other **photosynthetic bacteria use bacteriochlorophyll** as their key photosynthetic pigment, and they do not release oxygen gas. These photosynthesizers produce particles of pure sulfur instead because hydrogen sulfide (H_2S) rather than H_2O is the electron donor for photophosphorylation. **Bacteriochlorophyll** absorbs light of longer wavelength than the chlorophyll used by all other photosynthesizing organisms. As a result, bacteria using this pigment can grow in water beneath fairly dense layers of algae because light of the wavelengths they can use is not absorbed by the algae

---------photoheterotrophs(also known as the purple nonsulfur bacteria) use light as their source of energy but must obtain their carbon atoms from organic compounds made by other organisms. They use such compounds as carbohydrates, fatty acids, and alcohols as their organic "food."

---------Chemoautotrophs-obtain their energy by oxidizing inorganic substances, and they use some of that energy to fix carbon dioxide in reactions analogous to those of the photosynthetic carbon reduction cycle. Chemoautotrophs include the nitrifiers, which oxidize ammonia or nitrite ions to form nitrate ions that are taken up by plants, as well as other bacteria that oxidize hydrogen gas, hydrogen sulfide, sulfur, and other materials.

---------chemoheterotrophs-obtain both energy and carbon atoms from one or more organic compounds. Most bacteria are chemoheterotrophs—as are all animals, fungi, and many protists.

19.Molecular synthesis-On the early Earth, volcanoes poured large quantities of hydrogen, nitrogen, carbon dioxide, methane, and hydrogen sulfide into the atmosphere. In the waters, compounds such as ammonia, nitrates, carbon dioxide, sulfates, and phosphates also circulated. Under these conditions, a variety of anaerobic bacteria evolved and thrived. The cycles of these elements cannot be completed even today without the involvement of **anaerobic bacteria**. Thus even though anaerobic bacteria survive only in environments lacking oxygen, life as we know it is cycles inter-connected with them.

Need for a hereditary molecule (**The Evolution of DNA**) **-**If the genetic code was first embodied in and transmitted by RNA, then RNA must have provided the template upon which DNA was synthesized. Unlike RNA, DNA is stable only in hydrophobic environments, which in aqueous environments are found only within lipid-based cell membranes. Therefore, DNA probably did not evolve until RNA-based life became enclosed in membrane-bounded cells. Because DNA is a more stable storage location for genetic information than is RNA, however, once the appropriate hydrophobic environments were available, DNA probably evolved rapidly, replacing RNA as the genetic code for most organisms. RNAs would then have assumed their current roles as intermediaries in the translation of genetic information. ;;; **Early RNA in that role;**RNA: The First Biological Catalyst The enzymes that control the types and rates of reactions within organisms are proteins, proteins are synthesized by a process that begins with transcription of information from DNA to an RNA molecule having a base sequence complementary to that of one strand of the DNA. This information is then translated into mRNA and is eventually used to synthesize a specific poly-peptide from an array of amino acids. Amino acids are brought to a ribosome by specific tRNA molecules and are attached sequentially to the growing poly-peptide. Single-stranded RNA folds back on itself to form double-stranded regions. Two stretches of the molecule with sequences of nucleotides that can pair with one another, can join to create double-stranded segments. Long-range interactions lead to more complex three-dimensional shapes. Those shapes enable the RNA to catalyze the excision of some of its own introns. ;;; Studying the excision of introns and the splicing together of exons. To isolate the catalysts required for the reaction, the investigators established two cell-free systems. One contained RNA molecules from which the introns were to be excised and proteins to serve as catalysts; the other, the control system, contained only RNA molecules. As expected, the introns were excised in the RNA-protein system, but contrary to expectations, excision and splicing also took place in the control. The investigators found that the intron itself—a 400-nucleo-tide sequence of RNA—carried out the excision and splicing=> RNA rather than the ribosomal protein is the catalyst of protein synthesis. RNAs that catalyze reactions are called ribozymes. Ribozymes have now been found in many organisms, strongly suggesting that the first biological catalysts were RNAs. upon the "central dogma" (DNA —> RNA —> protein), evolved from gradual changes in much simpler processes. The first information-carrying molecules were short strands of RNA that replicated themselves without the help of enzymes. Evidence that RNAs can replicate themselves came first from experiments conducted by Manfred Eigen in the late 1970s. Eigen added RNA molecules to solutions containing monomers for making more RNA and found that sequences of 5 to 10 nucleotides were formed. If he added a simple inorganic molecule such as zinc, much longer sequences were copied.

These experiments showed that RNA could act on itself, but they did not demonstrate that RNA could act on other molecules as true enzymes do. Within two years, however, studies of ribonuclease P—a tRNA-processing enzyme that contains RNA and a protein in a single package—showed that the RNA alone can cut the pre-tRNA molecule at the correct spot, whereas the protein cannot do so. Thus many scientists now believe that the first genetic code was based on RNA that catalyzed both its own replication and other chemical reactions. Beginning with an RNA molecule that catalyzed its own replication, RNAs would have diversified into a variety of forms that could catalyze other processes, such as the accumulation of lipidlike molecules to form cell membranes and the synthesis of proteins. After proteins evolved, however, they would have taken over most enzymatic functions because they are better catalysts than is RNA. ;;; The shapes of single-stranded RNA molecules depend upon the sequences of nucleotides because their folding is determined by hydrogen bonds between complementary sequences of bases. To replicate, these different RNAs would have competed with one another for monomers. Some RNA molecules would have been better at replicating in certain environments because they had base sequences that produced the most stable configurations under the particular conditions of temperature and salinity. With time these molecules would have come to dominate the populations of RNA in the corresponding environments. "evolution" of ribozymes started with catalytic activity from a random-sequence of RNA. ;;; In the "RNA world," in which RNA was the only genetic information, ribozymes would have needed to fold into an RNA polymerase that used RNA as a template and to unfold and act as templates for other replicase molecules. Investigators have produced RNA molecules with these capabilities by starting with completely random-sequence RNA. These ribozymes ligate (bind together) two RNA molecules that are aligned on a template by catalyzing the attachment of a 3'-end hydroxyl on an adjacent 5'-end triphosphate. This reaction is similar to that employed by the enzymes that synthesize RNA. In addition, "evolution" of these RNA molecules in the test tube improved their ligation activity and led to ribozymes with reaction rates 7 million times faster than the uncatalyzed reaction rate! Therefore, ribozymes may have evolved quite rapidly when conditions on Earth became suitable for the formation of nucleic acids.; **Replicators**- Supply of replicators(molecule, which can replicate it self – could be error, or mutation, or natural selection or genetic drift). Aggregation-can maintain their environment internally, without being affected by outside, called **Protobions**(proto-first, bion-electric); **Bio-Evolution**: change over time in the genetic composition, at the population (=> very slow naturelly); **Micro-Evolution**-life time=> short period;**Macro-Evolution**-long time period; **Evolution of Life**=> prevail the environment; **Earth life** is affected by: volcanic activity or collusions with meteorites (affect the distortions, changes /errors or mutations/or deleting of life species; atmosphere => the climate change); movement of the continents ;;;**MAJOR ORGANIZING CONCEPTS IN BIOLOGY:** *all properties of organisms can be explained in physical and chemical terms. Organisms can be viewed as systems that take in energy from their environments and convert it to biologically useful forms.* **Energy:** The notion of energy is highly abstract. Energy is weightless and occupies no space, yet it exists in many forms. Using experimentally derived formulas, we can calculate the equivalence of these forms. Energy can never be created or destroyed, but it can be converted from one form to another. We measure energy by its *effects upon matter,* which can be weighed and measured *genetic information encodes and transmits information between generations.*

<u>Origin of species (see Evolution definitions):</u> Allopatry-geographical or ecological specifications; **Sympatry** is one of four theoretical models for the phenomenon of speciation. In complete contrast to allopatry, species undergoing sympatric speciation are not geographically isolated by, for example, a mountain or a river. The speciating populations generally share the same territory. **Species-**reproductively isolated groups of interbreeding organisms;e.g. Sympatric speciation events are vastly most common in plants when they double or triple their number of chromosomes, resulting in a condition called polyploidy (=> unfertile because of unpaired possibility for its bivalents), which with time can double its chromosomes=> chromosomes can form bivalents => allopoliploidy (=> new species); **Systematics-** studying of species (animals, plants), based on their evolutionary affinities (connections): -number of cell layers; -symmetry, radial or bilateral; -presents and type of body cavities ;;;

Lecture: General properties of microorganisms: 1) Diseases and resistance; **2)** Natural BioGeoChemical Cycles; **3)** Surve as Food; **4)** Biodegradable; **5)** Used for antibiotics and antiinflamatory; **6)** Utilise raw materials e.g. oils gas, lignocellulose, minerals, etc. **7)** High Surface to Volume ratio (very high metabolic rates per unit weight; **8)** Methabolic diversity (that's how we classify them) and flexibility=> induced enzymes: utilize vary of substrates; e.g. Chemo- auto and heterotrophs, and Photo auto and heterotrophs; **9)** By dissimilation of simple complex organic compounds (chemo-organotrophs). In absence of oxygen this is called Fermentation (usually involves sugars in complex amino acids); **10)** Phototrophs (from light); **11)** Chemolitotrophs (from oxidation of inorganic materials); **12)** Nitrogen can be assimilated in inorganic form NH_3 or directly from the atmosphere=> Nitrogen fixation. Only prokaryots can fix N=> All plants and animals are symbionts with them; **13)** They are easily dispersed. No biogeographical origins=> everywhere all the time in active or inactive form. Parasitism is popular also co-evolution!!!; **14)** Inexpensive techniques: large populations grown rapidly in small containers; many generations per short time; rare events like mutations or transfer of genes can be easily detected in their small genomes. **15)** Often forming symbioses with each other and other species, so we can detect foreign genes are facultative (allowed to happen); **16)** Horizontal gene transfer=> we could use genes to switch them on and/or off, if we can.

Lecture 3 ;;;The three domains of life; Bacteria(Prokaryotes**), Archaea(bacterias**Prokaryotes**) and Eukaraya; BIOLOGY (Greek bio=life) OF THE BACTERIA ;;;**

SUPERKINGDOM **PROKARYA (organelles without nucleus)3.8bya**

KINGDOM **BACTERIA**

Subkingdom **ARCHAEA** (-**aeota**. Membranes from hydrocarbons, linked to glycerol via ether, where in Eubacteria and Eukaryots via esther. Phosphorylation=> ATP by the Sun; Oxidative phosphorylation=> ATP by O_2 or NO_3. Don't sense antibiotics. No tRNA shared. No RNA loop binding protein. Histones. Complex RNA-polymerase. No peptidoglycans)

Phylum I Euryarch**aeota** – produce energy by methane (from CO2), salt

Phylum 2 Crenarch**aeota** – energy from hot-acid, sulfur

Subkingdom **EUBACTERIA** (**-ae, -ia;** Sense antibiotics; Never form tissues; All types of nutrients; Absorb food; Endospores, asexual exospores; Move by flagella; Store complex lipids)

Phylum 3 Proteobacter**ia** (1membrane≠cell wall)– purple bacteria, chemoorganotrophs, chemolithotrophs, photoorganotrophs; G-negative

Phylum 4 Spirochaet**ae** – spirochetes (corkscrew bacteria with internal flagella)

Phylum 5 Cyanobacter**ia** (1membrane≠cell wall)– oxygenic photosynthesizers called blue-green algae→algae ancestor; G-negative

Phylum 6 Saprospir**ae** – fermenting gliders

Phylum 7 **Chloroflexa** – green nonsulphur phototrophs; G-negative

Phylum 8 **Chlorobia** – green sulphur phototrophs; G-negative

Phylum 9 **Aphragmabacteria** – wall-less bacteria

Phylum 10 **Endospora** – bacilli and related formers of internal spores; Anaerobic facultative. Produce toxins. Tolerate high pressure; Low G+C; G-positive

Phylum 11 **Pirellulae** – stalked, protein-walled bacteria

Phylum12 **Actinobacteria** –fungus-like bacteria. Tuberculose, source of natural antibiotics, cheese, acne; High G+C; G-positive

Phylum 13 **Deinococci** – radioresistent, tiny spheroidal bacteria

Phylum 14 **Thermotogae** – thermophilic fermenters

Symbionts theory: Protobacteria eat: bacteria (→microspora→mitochondrion); Or eat cyanobacteria (→algae→chloroplasts)

Shapes: spheres, rods, and curved or spiral forms. A spherical bacterium is a coccus (plural: cocci); a rod-shaped bacterium is a bacillus (plural: bacilli). Cocci may live singly or may associate in two- or three-dimensional arrays as chains, plates, or blocks of cells ;;; Gram-positive **bacteria** thick cell wall (peptidoglycan); flagellum is present, it contains two rings; Teichoic acids and lipoteichoic acids =>type of new lipid as well; retain a crystal violet dye during the Gram stain process(with alcohol) and appear blue or violet under a microscope;;; **Gram-negative** bacteria appear red or pink. The Gram classification system is empirical, and largely based on differences in **cell wall** structure and mycoplasmas (bacteria lacking cell walls). The cell walls of archaebacteria are chemically unrelated to those of the gram-negative and gram-positive bacteria, so these organisms are grouped into phyla according to the habitats in which they thrive (grow well). Many species of Gram-negative bacteria are pathogenic.

SUPERKINGDOM **EUKARYA (organelles with nucleus)1.4bya**

KINGDOM **PROTOCTISTA :** (e.g.ALGAE /Absorb food. Sexual and asexual spores. Wall + cellulose, pectin and silica. Fillaments/differ in number of cell layers and type of chloroplasts=>pigments; or PLANKTONS)**uni- or multicell** organisms. Photo-synthetic or hetero-trophic. Predation of prokaryots. Flagellates, Amebas, Ciliates, Sporozoans; Ingest food; No Cell wall; Form filament tissue; Some spores are resistant to antibiotics; Store glycogen and starch; Protists and Algae doesn't sense antibiotics, because of the cell wall; Chemotrophic or Photoheterotrophs and some are Facultative.

Phylum 1 **Archaeprotista – flagellate (9 pairs=>beating;longer size)**amoebas(with endosymbiont cyanobacteria)-2 membranes(≠cell wall), with primary chloroplasts

Phylum 2 **Microspora –** microsporans→mitochondria

Phylum 3 **Rhizopoda** – amoebas without flagellae (with endosymbiont green algae)-3 membranes;s chloroplast a and c

Phylum 4 **Granuloreticulosa** – foraminifera and relatives

Phylum 5 **Xenophyophora** – large deep-sea benthic protoctists

Phylum 6 **Myxomycota** – plasmodia1 slime molds

Phylum 7 **Dinomastigota** – dinoflagellates (with endosymbiont red algae)- 3 membranes(≠cell wall), but diversity of chloroplast according to sources

Phylum 8 **Ciliophora** – **ciliates (rotate; shorter, but same structure => different control)** – 4 membranes(≠cell wall)

Phylum 9 **Apicomplexa** – symbiotrophs with apical complex

Phylum l0 **Haptomonada** – Coccoliths and other yellow-brown planktonic unicells

Phylum 11 **Cryptomonada** – flattened asymmetric unicells, usually photosynthetic and motile

Phylum 12 **Discomitochondria** –euglenoids

Phylum 13 **Chrysomonada** –golden brown algae

Phylum 14 **Xanthophyta** – yellow green algae

Phylum 15 **Eustigmatophyta** – green eyespot flagellate algae

Phylum 16 **Diatoms** –photosynthetic algae with silica shells. Split the number of cells in 2 after each division=> become sexually active, below critical size cells: **pinnate diatoms** are isogamous- cells settle close to each other and secrete => swells and then cracks open to form conjugation cannal=> protoplasts migrate and fuse, but the haploid nuclei remain distinct => dikaryon (dinucleus), rather then a zygote => then swells and deposite silica cell wall to form an auxospore ; **centric diatoms** are oogamus- all cells can be both, but larger become females most. Meiosis result in a single egg. Male cells undergo mitotic divisions then meiosis => tinsellate flagellum and no chloroplast. Then fertilisation=> zygote => swells and forms silicate auxospore.
Phylum 17 **Phaeophyta** – brown algae
Phylum 18 **Labyrinthulata** – slime nets
Phylum 19 **Plasmodiophora** – symbiotrophs with multinudeate protoplasts
Phylum 20 **Oomycota** – egg moulds; zoosporic conjugators
Phylum 21 **Hyphochytriomycota** –fresh water osmotrophs with single anteriorly directed undulipodium
Phylum 22 **Haplospora** – – unicells in tissues of marine animals
Phylum 23 **Paramyxa** – nesting cells in tissues of marine animals
Phylum 24 **Myxospora** –in tissues of fish, sipuculans, and annelids
Phylum 25 **Rhodophyta** – red algae
Phylum 26 **Gamophyta** –conjugating green algae
Phylum 27 **Actinopoda** – sun animalcules
Phylum 28 **Chlorophyta** – green algae(with endosymbiont cyanobacteria)=>chloroplast with chlorophyll a and b **(plant ancestors)**
Phylum 29 **Chytridiomycota** – chytrid water molds **(fungal ancestors)**
Phylum 30 **Zoomastigota** – zoomastigotes, opalinids, choanomonads **(animal ancestors)**

Kingdom **FUNGI 1000mya (-ota; spore/asexual/ organisms)(multicellular**) –**first on land**; Grow ok in pH3-5; resistant to pressure; better use of water and less Nitrogen compare to bacteria; Can secrete extracellular enzymes; Produce spores sexually and asexually, which fly; Form sybioses with algae, plants, insects. ==>Act as Food; All are multicellular except yeast; Filaments are bind; Sense antibiotics; absorb food substances from their surroundings and digest them within their cells => decomposers of the dead bodies of other organisms. Include within their cellulose the protein chitin.
Phylum 1 Zygomy**cota** – molds
Phylum 2 Basidiomy**cota** – mushrooms, puffballs, rusts, smuts, and jelly fungi
Phylum 3 Ascomy**cota** – molds, yeasts, and lichens

KINGDOM **ANIMALIA 580mya-** (Chemoheterotrophs) digest food outside their cells, and then absorb the products. Animals depend on other forms of life for most of their materials and energy.

Subkingdom **PARAZOA**

Phyluml **Placozoa** 1– trichoplaxes
Phylum 2 **Porifera** – 8000 sponges, early Ordovician a lot.

Subkingdom **EUMETAZOA (metazoa=multicell => not mezozoic)**

Phylum 3 **Cnidaria** 10000– hydroids, medusas and jellyfish; Early Ordovician filter feeders. Ediacaran fossil 600mya in Australia.
Phylum 4 **Ctenophora** – 80 comb jellies
Phylum 5 **Platyhelminthes** 20000– flatworms
Phylum 6 **Gnathostomulida** 80– jaw worms
Phylum 7 **Rhombozoa** 80– dicyemids and heterocyemids
Phylum 8 **Orthonectida** 20– orthonectids
Phylum 9 **Nemertina** 1200– ribbon worms
Phylum10 **Nematoda** 22000–thread worms, round worms
Phylum11 **Nematomorpha** 330–Gordian worms, horsehair worms
Phylum 12 **Acanthocephala** 1200– thorny-headed worms
Phylum 13 **Rotifera** 2000– rotifers
Phylum 14 **Kinorhyncha** 150– kinorhynchs
Phylum 15 **Priapulida** 20– priapulids
Phylum 16 **Gastrotricha** 500– gastrotrichs
Phylum 17 **Loricifera** 10– loriciferans
Phylum 18 **Entoprocta** – entoprocts
Phylum 19 **Chelicerata –** horseshoe crabs, spiders, and sea spiders **arthropods 1115000 species(Dominant late Ordovician)**
Phylum20 **Mandibulata** – insects, centipedes, and millipedes
Phylum 21 **Crustacea** – crustaceans and pentastomes
Phylum 22 **Annelida** 12000– annelid worms
Phylum 23 **Sipuncula** 150– peanut worms
Phylum24 **Echiura** 150– spoon– worms
Phylum 25 **Pogonophora** – beard worms, tube worms
Phylum 26 **Mollusca** 100000– snails, bivalves, slugs, squid and octopuses; Mid Ordovician Ediacaran fossil 600mya in Australia.
Phylum27 **Tardigrada** 800–waterbears
Phylum 28 **Onychophora** 110– velvet worms, peripatuses
Phylum 29 **Bryozoa** 5000– moss animals
Phylum 30 **Brachiopoda** 350–lampshells. Dominant early cambrian
Phylum 31 **Phoronida** 20– phoronids
Phylum 32 **Chaetognatha** 150– arrow worms
Phylum33 **Hemichordata** 90– acorn worms
Phylum34 **Echinodermat 6000–** sea urchins, sea stars, or starfish, and sea cucumbers; Mid Ordovician
Phylum35 **Urochordata** – sea squirts, larvaceans and salps, doliolids, and chain tunicates. Cambrian chordata 52000 species

Phylum 36 **Cephalochordata** – lancelets. Cambrian
Phylum37 **Craniata** – fishes, reptiles, amphibians, mammals, and birds. Cambrian

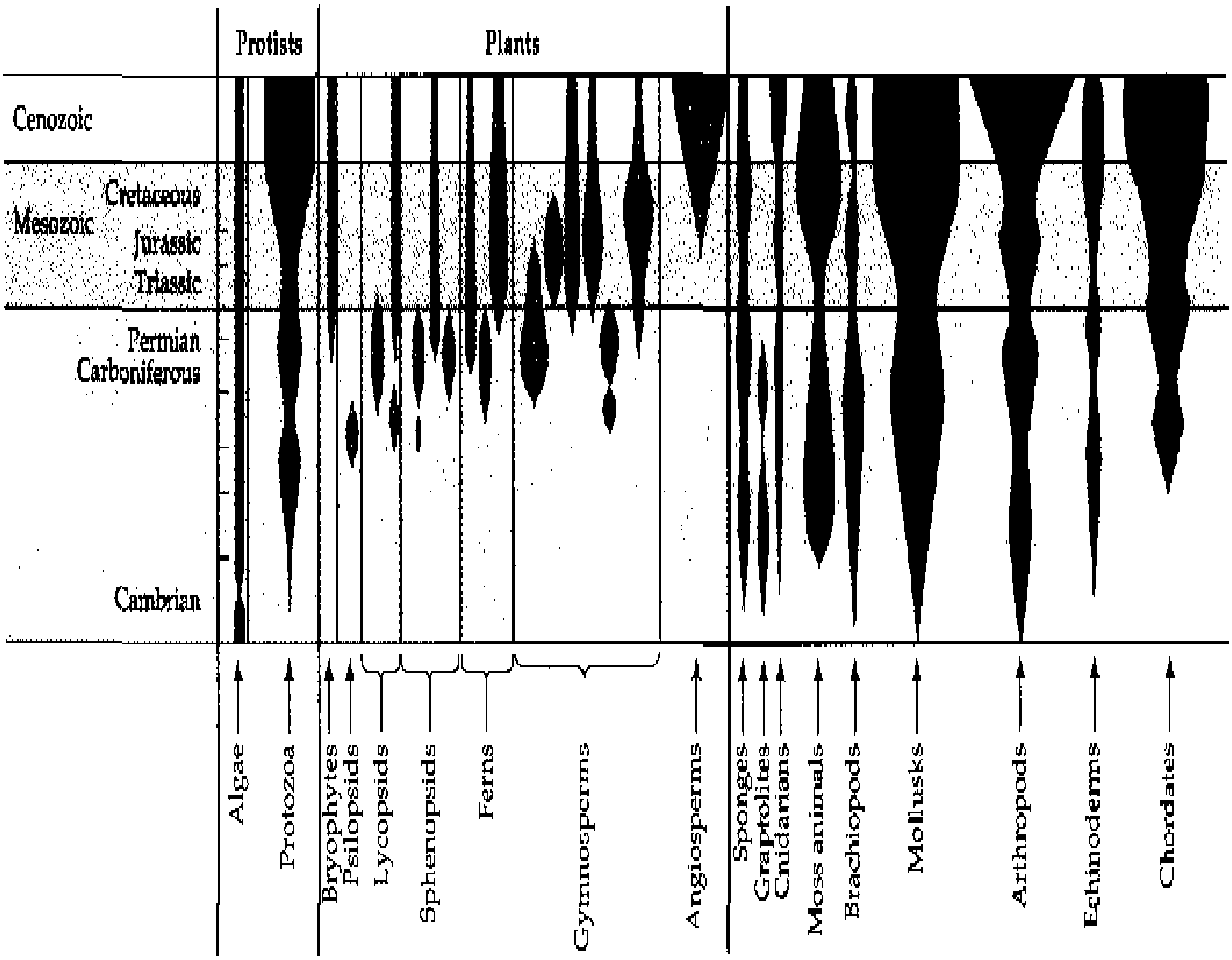
Kingdom **PLANTAE** **480mya**-convert light energy to the energy of chemical bonds by photosynthesis => food and for animals, etc.

Phylum 1 **Bryophyta** – mosses. Ordovician colonize wet land. 450mya small, where 430mya big.
Phylum 2 **Hepatophyta** – liverworts
Phylum 3 **Anthocerophyta** – hornworts thorned liverworts
Phylum 4 **Lycophyta** – club mosses, and spike mosses
Phylum 5 **Psilophyta** – whisk ferns,
Phylum 6 **Sphenophyta** – horsetails. Ordovician colonize wet land. 450mya small, where 430mya big.
Phylum 7 **Filicinophyta** – ferns
Phylum 8 **Cycadophyta** – cycads
Phylum 9 **Ginkgophyta** – maidenhair tree
Phylum 10 **Coniferophyta** – conifers
Phylum11 **Gnetophyta** –(gnetum, ephedra,welwitschia):
Phylum 12 **Anthophyta** – flowering plants

Classification of Microorganisms: 1. Morphology; **2.** Staining reactons; **3.** Reproduction; **4.** Biochemical behavior and products; **5.** Sequencing rRNA=>need of good primers used in PCR

Prokaryots: The most abundant organisms on Earth Prokaryotes:e.g.in one person's mouth, are more then all the humans who have ever lived. Bacteria's play Roles in: cycling of nitrogen, sulfur, and carbon; trap energy from the sun or from inorganic chemical sources; help animals digest their food; biosphere, interacting in one way or another with every other living thing; **Cyanobacteria** (blue + bacterium) also known as **Cyanophyta** is a phylum (or "division") of Bacteria that obtain their energy through photosynthesis. They are often still referred to as blue-green algae, although they are in fact prokaryotes like bacteria. The description is primarily used to reflect their appearance and ecological role rather than their evolutionary lineage. Fossil traces of cyanobacteria have been found from around 3.8 billion years ago (b.y.a.). *See:* Stromatolite. They are a major primary producer in the planetary ocean. Their ability to perform oxygenic (plant-like) photosynthesis is thought to have converted the early reducing atmosphere into an oxidizing one, which dramatically changed the life forms on Earth and provoked an explosion of biodiversity.**Viruses**-even smaller than bacteria. Although small and structurally simple, they are not evolutionarily ancient. Rather, they are believed to have arisen from the plant, animal, and bacterial groups that they infect. ;;;Prokaryots **Reproduction and Resting**: Most bacteria reproduce by fission or by producing spores; both processes are asexual, or vegetative. As you will recall, however, there are also sexual processes—transformation, conjugation, and transduction—that allow the exchange of genetic information between some bacteria**.** Other bacteria produce **endospores.** These spores are resting structures, not reproductive ones. When environmental conditions become extremely hot, cold, dry, or otherwise harsh, the bacterium produces an endospore. It replicates its DNA and encapsulates one copy, along with some of its cytoplasm, in a tough cell wall. The parent cell then breaks down, releasing the endospore. This is not a reproductive process; the endospore merely replaces the parent cell. The endospore can survive the harsh environmental conditions because it is **dormant**—that is, its normal activity is suspended. Later, if it encounters favorable conditions, the endospore germinates—that is, it becomes metabolically active and divides, forming new cells like the parent. Some endospores can germinate (develop) even after more than a thousand years of dormancy.Bacteria differ from one another in many ways— structurally, metabolically, reproductively—and they also play many roles in the environment. Although very few bacteria(as germs)are agents of disease. ;;;**Early prokaryotes and prokaryote fossils**: The bacterial kingdoms (=> all organisms whose cells are **prokaryotic**), have the most ancient origins of any group present today. The **earliest bacterial (=>and prokariotic) fossils** date back at least 3.5 billion years, these ancient traces indicate that there was considerable diversity among the prokaryotes even during the Archean eon. The prokaryotes reigned ([rayn]-control) supreme on an otherwise sterile Earth for more than 2 billion years, adapting to new environments and to changes in existing ones. Bacteria have spread to every conceivable habitat on the planet, including the insides of other organisms. Enormously successful **Algae** (singular *alga*) encompass several groups of relatively simple living aquatic organisms that capture light energy through photosynthesis, using it to convert inorganic substances into organic matter. Algae are photosynthetic organisms that occur in most habitats. Algae varies from small, single-celled forms to complex multicellular forms, such as the giant kelps that grow to 65 meters in length. Thus algae do not represent a single evolutionary direction or line but a level of organization that may have developed several times in the early history of life on Earth into: plants, fungi and animalia. Remarkable diversity of ways in which they obtain their energy;;; Algae range from single-cell organisms to multicellular organisms, some with fairly complex differentiated form and (if marine) called seaweeds. All lack leaves, roots, flowers, seeds and other organ structures that characterize higher plants (vascular plants). Protozoans (evolved over the protozoa period) -they are photoautotrophic; some groups contain members that are mixotrophic, deriving energy both from photosynthesis and uptake of organic carbon either by osmotrophy, myzotrophy, or phagotrophy. Some unicellular species rely entirely on external energy sources and have reduced or lost their photosynthetic apparatus. ;;; All algae have photosynthetic machinery ultimately derived from the cyanobacteria, and so produce oxygen as a byproduct of photosynthesis, unlike non-cyanobacterial photosynthetic bacteria. It is estimated that algae produce about 80% of worlds oxygen. Algae are usually found in damp places or bodies of water => common in terrestrial as well as aquatic environments. However, terrestrial algae are usually rather inconspicuous and far more common in moist, tropical regions than dry ones, because algae lack vascular tissues and other adaptations to live on land. Algae can endure dryness and other conditions in symbiosis with a fungus as lichen (assosiations with protobionts/electron donors/). The various sorts of algae play significant roles in aquatic ecology. Microscopic forms that live suspended in the water column — called **phytoplankton** — provide the food base for most marine food chains. In very high densities (so-called algal blooms) these algae may discolor the water and outcompete or poison other life forms. Seaweeds grow mostly in shallow marine waters. Some are used as human food or harvested for useful substances such as agar or fertilizer. The study of marine and freshwater algae is called phycology or algology.;;; **Cyanobacteria** can be unicellular, colonial, or filamentous. They have a prokaryotic cell structure typical of bacteria and conduct photosynthesis on specialized cytoplasmic membranes called thylakoid membranes, rather than in organelles. Some filamentous blue-green algae have specialized cells, termed heterocysts, in which nitrogen fixation occurs. ;;; **Eukaryotic algae:** All other algae are eukaryotes and conduct photosynthesis within membrane-bound structures (organelles) called chloroplasts. Chloroplasts contain DNA (=>different colours=> eaten by plants in symbiosis; or by animals=> giving them colour. Overall **plastids** are: 1) Chlorophyl; 2) Chloroplasts; 3) Leucoplasts and Proplastids=> immature; 4) Amyloplasts for starch and carbohydrates storage and graviperception; 5) Proteinoplasts; 6) Elacoplasts store lipids)and are similar in structure to cyanobacteria, presumably representing reduced cyanobacterial endosymbionts. The exact nature of the chloroplasts is different among the different lines of algae, reflecting different endosymbiotic events. 3 major groups algae cyanobacteria, green and redalgae;many of these groups contain some members that are no longer photosynthetic. Some retain plastids, but not chloroplasts, while others have lost them entirely. **3DomainsOfLifeOnEarth Look differences between pro and eukaryots in the cell dynamics**

S;K;P;C;O;F;G;S(superkingdom(-ota);kingdom(-ae); phylum(-phyta); class(-opsida); order(-ales); family(-aceae); genus; species)



Ediacaran AnimalsFossils excavated at Ediacara in southern Australia are 600 milllion years old and illustrate the diversity of life that evolved in Precambrian times, *(a) Spriggina floundersi. (b) Mawsoniies.*Among the Ediacaran animals are forms believed by some biologists to represent early annelids, arthropods, echinoderms, and cnidarians, but they are very different from later members of those phyla. They may instead represent a separate radiation of animal groups that have no living descendants. About two-thirds of the species that have been identified in the Ediacaran fauna are thought to be cni-darians. Scientists have discovered fossils of worms and mollusks slightly younger than the Ediacaran fauna that are probably the immediate ancestors of many of the animals found in early Cambrian deposits. These younger worms and **molluscs (snail, slug, octopus, clam)** do not appear to be direct descendants of Ediacaran animals.;;;**Lecture: Geological time scales: eras, periods, epochs; organelles and cell inclusions; the endosymbiosis theory mitochondria and chloroplasts-Living Together: Anemone-Alga Symbiosis-I**n electron micrographs, chloroplasts contain structures that look like stacks of pancakes. These stacks, called **grana (singular; granum)**, consist of a series of flat, closely packed, circular sacs called **thylakoids.** Each thylakoid is a single membrane composed of the usual membrane components (lipids and proteins) to which have been added chlorophyll and other substances needed for trapping photosynthetic energy and producing food. All the cell's chlorophyll is contained in the thylakoid membranes. Thylakoids of one granum may be connected to those of other grana, making the interior of the chloroplast a highly developed network of membranes. The fluid in which the grana are suspended is referred to as stroma. Like the mitochon-drial matrix, the chloroplast stroma contains ribo-somes and DNA. These ribosomes and this DNA provide some—but only some—of the proteins that make up the chloroplast.;;;Chloroplasts are what give plant leaves their green color. Looking at a thin slice of a leaf under the microscope reveals that most of the leaf is quite colorless—the only green to be seen is contained in the numerous chloroplasts within its cells. Not all plant culls contain chloroplasts, however. Most roots, for example, are colorless (or at least not green). This is just as well, because it would be a waste of energy and materials for the plant to provide chloroplasts for cells that reside in the dark, since photosynthesis requires light.;;;Animal culls do not *produce* chloroplasts, but some *contain* functional chloroplasts. Those organelles are taken up either as free chloroplasts derived from plants eaten as food, or as bound chloroplasts contained within unicellular algae living within the animal tissues. The green color of some corals and sea anemones results from chloroplasts in algae that live within the animals. The animals derive some of their nutrition from photosynthesis carried out by their algal "guests.";;;Chloroplasts are not the only plastids found in plants. The red color of a ripe tomato results from the presence of legions of plastids called chromo-plasts. Just as chloroplasts derive their color from chlorophyll, chromoplasts are rod, orange, or yellow because of the pigments (called carotenoids) that they contain. Chromoplasts have no known chemical function in the cell, but the colors they give to some petals and fruits probably help attract animals that assist in pollination or seed dispersal. On the other hand, there is no apparent advantage in a carrot root being orange. Other types of plastids, called leucoplasts, serve as storage depots for starch and fats. All plastid types are related to one another. Chromoplasts, for example, are formed from chloroplasts by a loss of chlorophyll and some change in internal structure. All plastids develop from proplastids, which are very simple in structure.;;;**The Origins of Plastids, Mitochondria, and Eukaryotes:** In the past, biologists tried to grow chloroplasts or mitochondria in culture, outside the cells that they normally inhabit. These organelles are about the size of bacteria, they contain ribosomes and DNA, and they divide within the cell—not been treated like little cells in their own right. Although all such efforts at organelle culture failed because the organelles depend on the cell's nucleus and cytoplasm for some parts. ;;; **Endosymbiotic theory** of the origin of mitochondria and chloroplasts-Picture a time, well over a billion years ago, when only prokaryotes inhabited Earth.

Some of them got their food by absorbing it directly from the environment, others were photosynthetic, and still others fed by eating their prokaryotic neighbors. Suppose that an occasional small, photosynthetic prokaryote was ingested by a larger one but did not get digested, so it sat trapped within the larger cell. Suppose further that the smaller prokaryote survived there and that it divided at about the same rate as the larger one, so successive generations of the larger prokaryote continued to be inhabited (or infected) by the offspring of the smaller one. We would call this **endosymbiosis"living within"** another cell or organism, as, for example, certain algae live within sea anemones. Could the little green prokaryote "eaten" by the larger prokaryote have been the first chloroplast? A present-day chloroplast is surrounded by a double membrane. Such a structure might have arisen when, in the process of engulfing the photosynthetic cell, the membrane of the larger cell stretched around the plasma membrane of the smaller cell. The fact that chloroplasts contain ribosomes and DNA also fits the endosymbiotic theory because the chloroplast is proposed to have arisen from an engulfed prokaryote. In addition, whereas ribosomes in the eukaryotic cytosol are larger than those of prokaryotes, ribosomes in the chloroplast are similar in size to those of prokaryotes, further supporting the theory.;;;Arguments like these can be made for the proposition that mitochondria represent the descendants of respiring prokaryotes engulfed by, and ultimately endosymbiotic with, larger prokaryotes. Also, there are striking similarities between some functions of bacterial plasma membranes and mitochondria! inner membranes, and between the primary structures of certain bacterial and mitochondrial enzymes. Finally, a few modern cells do contain other, smaller cells as endosymbionts, suggesting that the endosymbiotic theory is plausible.

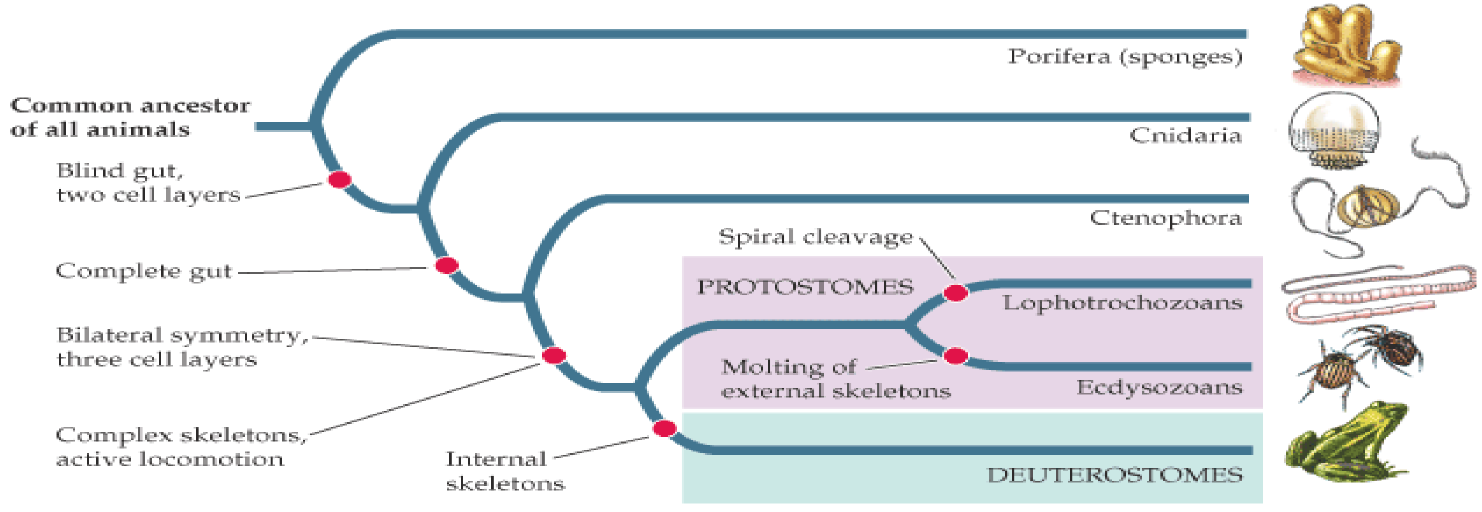
A spectacular example of endosymbiosis is found in the guts of certain Australian termites. We think of a termite as being able to digest wood; yet, strictly speaking, it cannot. Much of the digestive chemistry is accomplished by an endosymbiotic protist, *Mixotricha paradoxa,* that lives in the termite's gut. But that is far from the whole story. *Mixotricha* itself harbors an amazing colony of endosymbionts. *Mixotricha* swims around within the termite gut, apparently propelled (pushed) by multitudes of flagella. Closer examination, however, shows that although there are a few true flagella in a tuft at one end of the organism, the hundreds of other flagellumlike propellers are not fiagella at all—they are long, motile bacteria (spiro-chetes) that are attached at regular intervals to the plasma membrane of the *Mixotricha* cell and that beat just like real flagella. Also covering the surface of the protist, organized in a precise pattern, are other, smaller bacteria. *And* inside the *Mixotricha* are numerous bacteria of a third species, which are thought to help with the digestion of the tiny wood particles ingested by the protist—which, in turn, obtains them from the gut of the termite that is carrying this strange menagerie around inside itself. Perhaps termites are not all that special. If we carried colonies of *Mixotricha* in our digestive tracts, we could eat wood too. We do carry colonies of *Escherichia coll.;;;*We should stress that mitochondria and chloroplasts are not enough to make a prokaryote into a eukaryote. The origin of the nuclear envelope, as well as that of other important structures, including those responsible for nuclear division, still needs to be illuminated. Thus far, the endosymbiotic theory is incomplete, although suggestions have been made for its extension to deal with the origin of other eukaryotic organclles. DNA responsible for the synthesis of most of the enzymes in chloroplasts and mitochondria resides in the nucleus. However the matter ultimately is resolved, the endosymbiotic theory is a good example of creative biological thinking; it gives us a useful perspective on the structures, functions, and origins of mitochondria and chloroplasts.

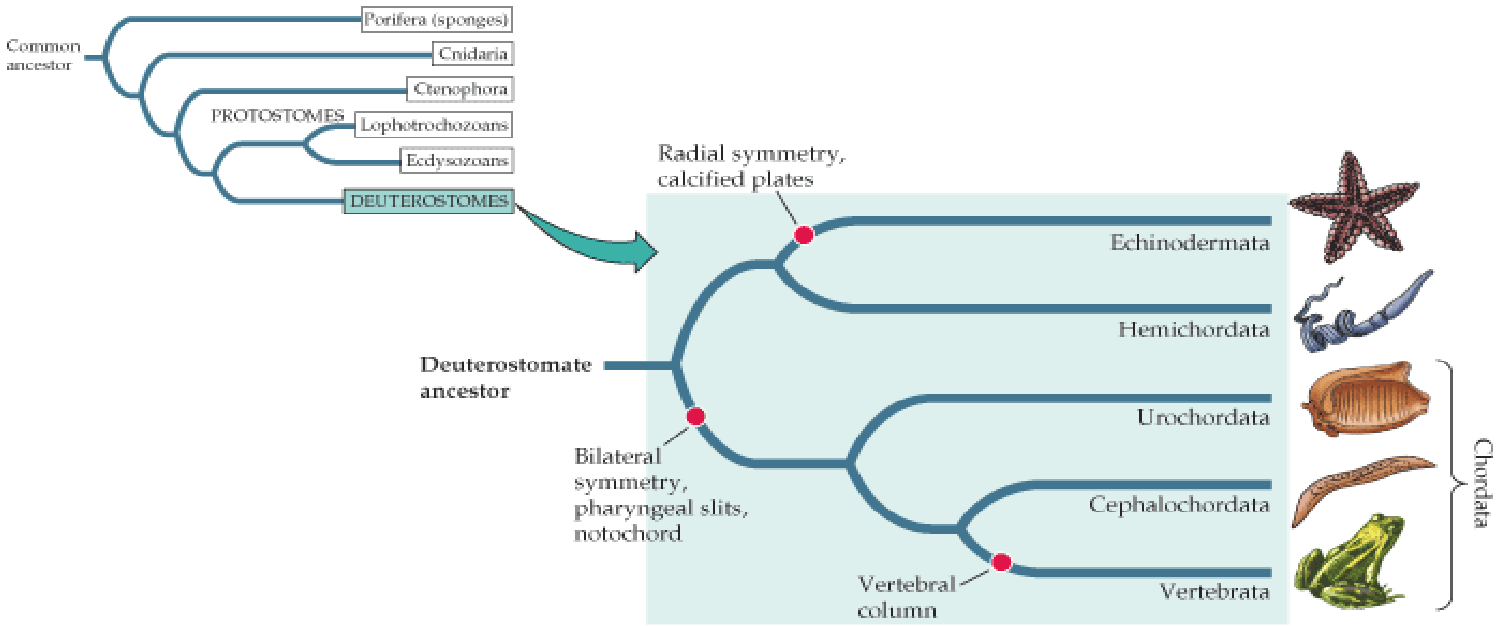
Relationships between oxygen availability and adaptive radiation as a measure of biodiversity- catalysis oxygen and the large cell: S+[O/4]\-2 [Oxidizing Sulfur (thiobacillus sulfolubus)]-> S[O/4]\-2 sulphate ions => +cellular respiration (desulfovibrio)->H/2S (H-sulphate)=> + photosynthesis(ectothiorhodospira chlorobium)->S, which is the end and the start point of this cycle. Several species of eubacteria and archaebacteria that use sulfur-containing compounds as oxidizing and reducing agents may function together to carry out **sulfur cycles**. Representative genera able to conduct the processes are given in parentheses. Many such cycles are found in nature. **Cyanobacteria**, which evolved the ability to split water to obtain hydrogen, created the free oxygen of Earth's atmosphere. **Aerobic Photosynthesis:**Source of the Atmosphere's Free Oxygen

The most recent step in the evolution of photosynthesis, which originated more than one billion years ago, is acquisition of the ability to use water as the source of hydrogen. This ability appeared first in certain sulfur bacteria that evolved into cyanobacteria. The ability to split water was doubtless the cause of the extraordinary success of the cyanobacteria, a success that changed the planet and life on it. The oxygen they liberated opened the way for the evolution of oxidation reactions as the energy source for the synthesis of ATP, and thus for the evolution of the full respiratory chain of reactions now carried out by all aerobic cells. The evolution of life irrevocably changed the nature of our planet. Life created the free oxygen of our atmosphere, and it removed most of the carbon dioxide from the atmosphere by transferring it into sediments.

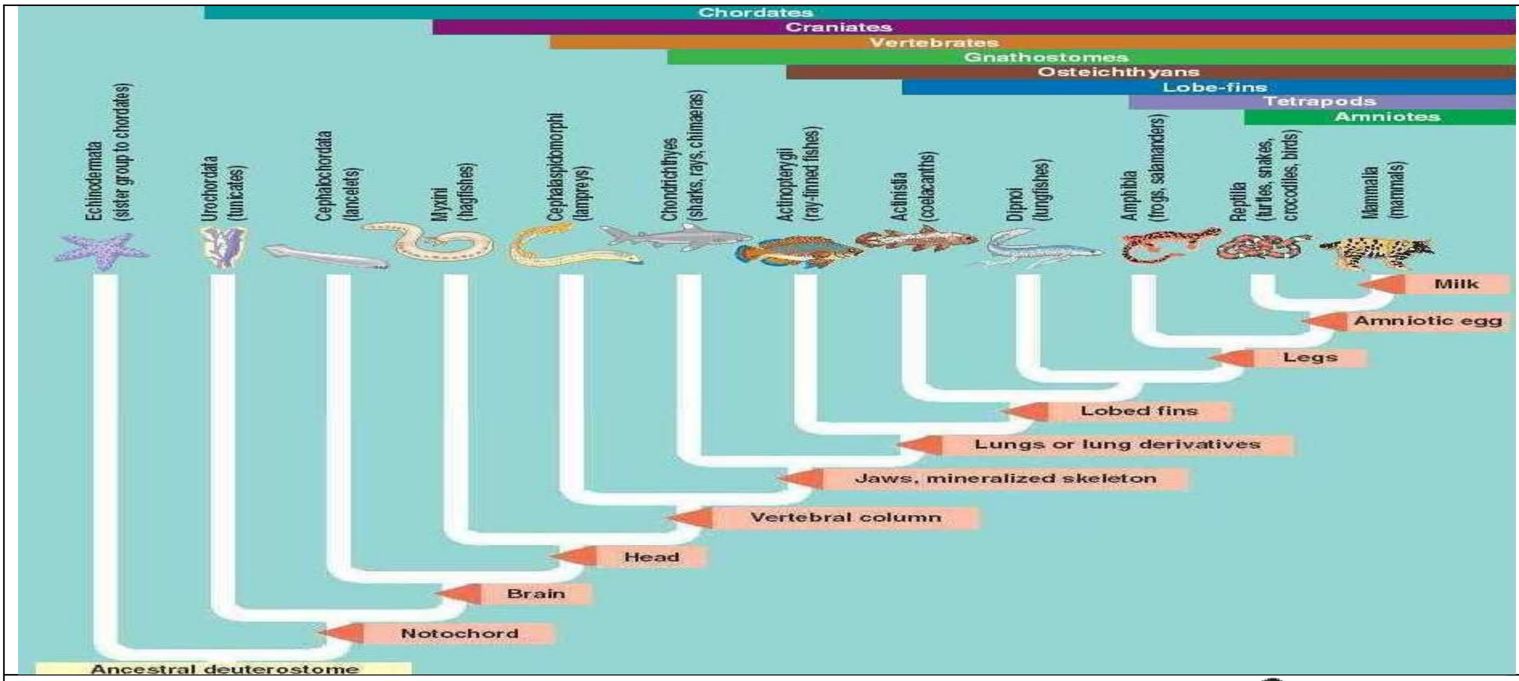
Oxygen and the Evolution of Animals-The generation of atmospheric oxygen by mats of cyanobacteria=>appearance of animals. Most animals must take up oxygen from the environment and distribute it to their cells, and they must get rid of carbon dioxide; this crucial process is called gas exchange. Very small, unicellular, aquatic organisms that are adapted to stagnant water can obtain enough oxygen by simple diffusion even when oxygen concentrations are very low. Larger unicellular organisms, however, have lower surface-to-volume ratios. In order to obtain enough oxygen by simple diffusion, environmental concentrations of oxygen must be higher than those that can support the small prokaryotic cells. Whereas bacteria can thrive on 1 percent of current atmospheric oxygen levels, large eukary-otic cells require oxygen levels that are at least 2 to 3 percent of current atmospheric concentrations. Small multicellular animals with a high surface-to-volume ratio can exchange gases through their body surfaces. Larger animals have evolved specialized structures such as gills and lungs to exchange gases, and circulatory systems to transport oxygen and carbon dioxide to and from their cells. About 1,500 mya (million years ago), oxygen concentrations became high enough for large eukaryotic cells to flourish and diversify. By 700 mya, protist communities were rich in species and ecological types. Photosynthesizing species were pursued by ciliated predatory forms. Different systems of photosynthesis were used in different environments, and a variety of compounds for storing energy not needed for immediate metabolism had evolved.;;;Those early ecological communities were simpler than current ones in that all organisms were small and they did not engage in sexual reproduction. The fact that no part of a small organism is far from its external surface facilitates the transfer of materials from the environment to all parts of its body. However, small size makes it more difficult for an organism to prevent the movement of undesirable materials into its cells. In general, small organisms are more strongly influenced by the physical environment than are large animals. Small organisms are also highly vulnerable to larger predators.;;;Some 700 to 570 mya, it is likely that a combination of changes in the physical environment (especially oxygen concentrations) and interactions between predators and their prey favored increasing sizes of organisms. The steady increase in atmospheric concentrations of oxygen made it possible for larger animals to evolve because they could obtain enough oxygen to maintain the metabolism of all their cells.;;; Diplo=2 layers ;;; Triplo=3layers (acoelomatic) – ectoderm (outside)-> mesoderm (somatic)->endoderm (splanchmic)-> the gut is the most inner one tube. ;;; 4 layers (pseudocoelomate) – the same 3 layers, but + cavity (pseudacoelom, blastocoelom)=>but still no peristalsis, because here is no inner muscle => only feed by pump=>less survive, then the coeol ;;; coeol(5layers)-include layer after the endoderm=>now we have muscle system from the 2 sites of the cavity, so we can control it. ;;; **THE ORIGINS OF ANIMALS:** Animals probably arose evolutionarily from ancestral colonial protists as a result of division of labor among their aggregated cells. Division of labor probably evolved because an undifferentiated mass of cells can exchange materials with its environment only relatively slowly, and because some functions are performed better by specialized cells. Within the ancestral colonies of cells—perhaps similar to those still existing in *Volvox* and other colonial flagellated protists—some cells became specialized for movement, others for nutrition, and still others differentiated into gametes. Once division of labor began, the units continued to differentiate, all the while improving their coordination with other working groups of cells. These coordinated groups of cells evolved into the larger and more-complex organisms that we now call animals. Multicellular animals may have arisen from the protists at least three times. The sponges (phylum Forifera), cnidarians and ctenophores (phyla Cnidaria and Ctenophora), and flatworms (phylum Platyhelminthes) may represent three separate evolutionary lines. The small phylum Placozoa may also have evolved independently from protists. The other animal phyla probably evolved from a flatworm or flatwormlike ancestor. ;;; **Early Animal Evolution**-When the first animals evolved, the mats of cyano-bacteria that until then had been the primary pho-tosynthesizers were being replaced by algae, both floating in the water and on the bottoms of shallow seas. Therefore, the primary food supplies available to the earliest animals were algae floating in the water (phytoplankton; animals floating in the water are called zooplankton), the extensive algal mats covering the shallow sea bottoms, protists, and bacteria.;;;The earliest animals were probably colonies of flagellated cells that fed on bacteria and protists. Some of these animals developed specialized cells with stinging tentacles that allowed the capture of larger prey. Others evolved morphological and behavioral adaptations for grazing in the algal mats. Both of these changes favored the evolution of larger animals that could move about. Not surprisingly, the presence of these larger animals created opportunities for carnivores that fed on them. The predators, in turn, may well have generated in their prey selection for shells and other protection, the ability to burrow, the use of safe refuges such as caves and crevices, and faster movement. These themes in the evolution of animals continue today.;;; **the changing Palaeozoic- by the mid-Cambrian** period, about 530 mya, all animal phyla that have species living today were already present, as revealed by the exceptionally well preserved fossils in the Burgess Shale in British Columbia. Many species belonging to about 10 extinct phyla are known only from this fossil bed. Animals with many different body plans evolved during the Cambrian period, but most of them failed to survive past Cambrian times. The evolution of hard skeletons in representatives of so many phyla between 600 and 530 mya suggests that predation became very intense during this period.;;;During the **Cambrian** period, a small group of wormlike animals evolved fanlike tentacles covered with cilia. Coordinated beating of these cilia created a stream of water through the tentacles. The cilia captured food material in the water and transferred it to the mouth. Another change was the enclosure of the tentacles within a shell, forcing the entire current of water to pass through the tentacles. This adaptation improved filtering efficiency and protected the tentacles from predators. These changes so improved feeding efficiency that organisms possessing them {the early brachiopods) became dominant animals in the early Cambrian seas. ;;; **Ordovician period (500 to 440 mya)** many animal phyla radiated, creating a great profusion of classes and orders. Abundant sponges filtered food from the water much as today's sponges do.;;;Cnidarians, also filter feeders, built large reefs but were different from modern corals, which first appeared in the **mid-Ordovician period.** There was a great increase in other kinds of animals that filter small prey from the water, such as bivalve mollusks and echinoderms. Floating graptolites, members of a now extinct phylum, were abundant . Trilobites were the dominant arthropods, but they also became extinct. Ancestors of club mosses and horsetails colonized wet terrestrial environments, but they were still relatively small. At the end of the Ordovician, when sea levels dropped considerably and much of the continental shelf was exposed=>75% extinct ;;; **Silurian period (440 to 400 mya)**, graptolites declined, corals proliferated, and the colonization of land continued. Nevertheless, late-Silurian marine communities probably looked much the same as those of the Ordovician period. Early vertebrates diversified during this period, and the first terrestrial arthropods—scorpions and millipedes—appeared. ;;; Rates of evolutionary change accelerated in many groups of organisms during the Devonian period (400 to 345 mya). There was great evolutionary radiation of corals, trilobites, and shelled squidlike cephalopods. Fishes diversified as jawed forms replaced jawless ones, and the heavy armor characteristic of most earlier fishes gave way to the less rigid outer coverings of modern fishes. Terrestrial communities also changed markedly during the Devonian period. Land plants became common, and some reached the size of trees. They were mostly club mosses and horsetails, along with some tree ferns. Toward the end of the period the first gym-nosperms appeared. A springtail from this period is the first known fossil of an insect. The first fishlike amphibians began to occupy the land. ;;; Extensive forests grew during the **Carboniferous period (350mya)**compressed remains of trees that grew in swampy forests where they fell into deep, anaerobic mud that preserved them from biological degradation is the coal we now mine for energy. Carboniferous beds are rich in fossils, many of which retain traces of the fine details of their structure. The diversity of terrestrial animals increased greatly in the Carboniferous period. Snails, scorpions, centipedes, and insects were present in great abundance and variety. Amphibians became better adapted to terrestrial existence. Some of them were large animals more than 5 meters long, quite unlike any surviving today. From one amphibian stock, the first reptiles evolved late in the period. ;;; **Permian period (280mya)** deposits contain representatives of most orders of insects, including dragonflies with wingspreads that measured 2 feet, the largest insects that ever lived. By the end of the period reptiles greatly outnumbered amphibians. These reptiles included a variety of terrestrial forms, as well as species that were major predators in marine and freshwater environments. The **mammals appear suddenly** as fossils in rocks that formed about 53 million years ago in Wyoming and Montana- and the atmosphere in the form of carbon dioxide, which is taken up by photosynthetic plants. Animals eating those plants preserve the same isotope ratios in their bones. The oxygen isotope ratios changed suddenly in the teeth and bones of mammals living 53 mya in Montana and Wyoming. The change coincided exactly with the disappearance of a fauna of archaic mammals and its replacement by a new fauna of mammals. Although abrupt warming was clearly the driving environmental change, how it exerted its effects or where the new mammals came from is unknown.;;;

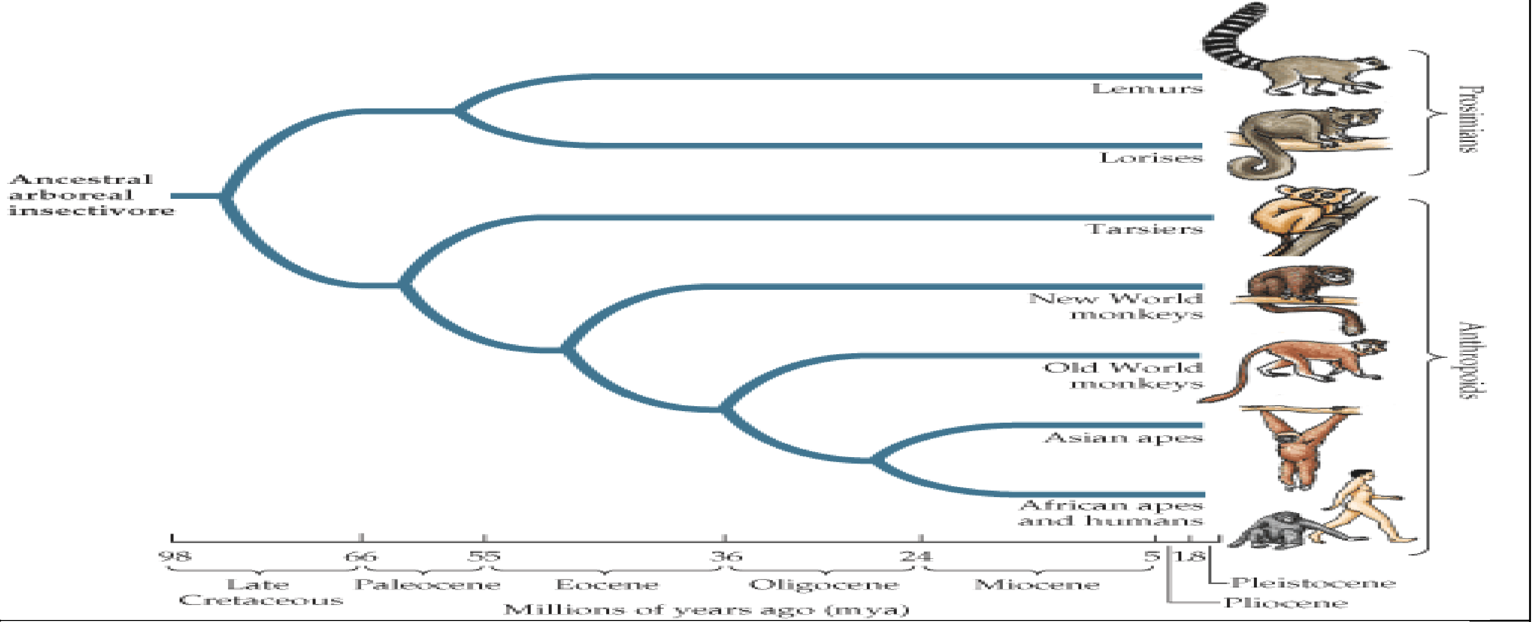
Phylum(pl. Phyla)=Taxonomy-grouping;classification;principles; **The commonAncestorHereIsAnimaliaKingdom**

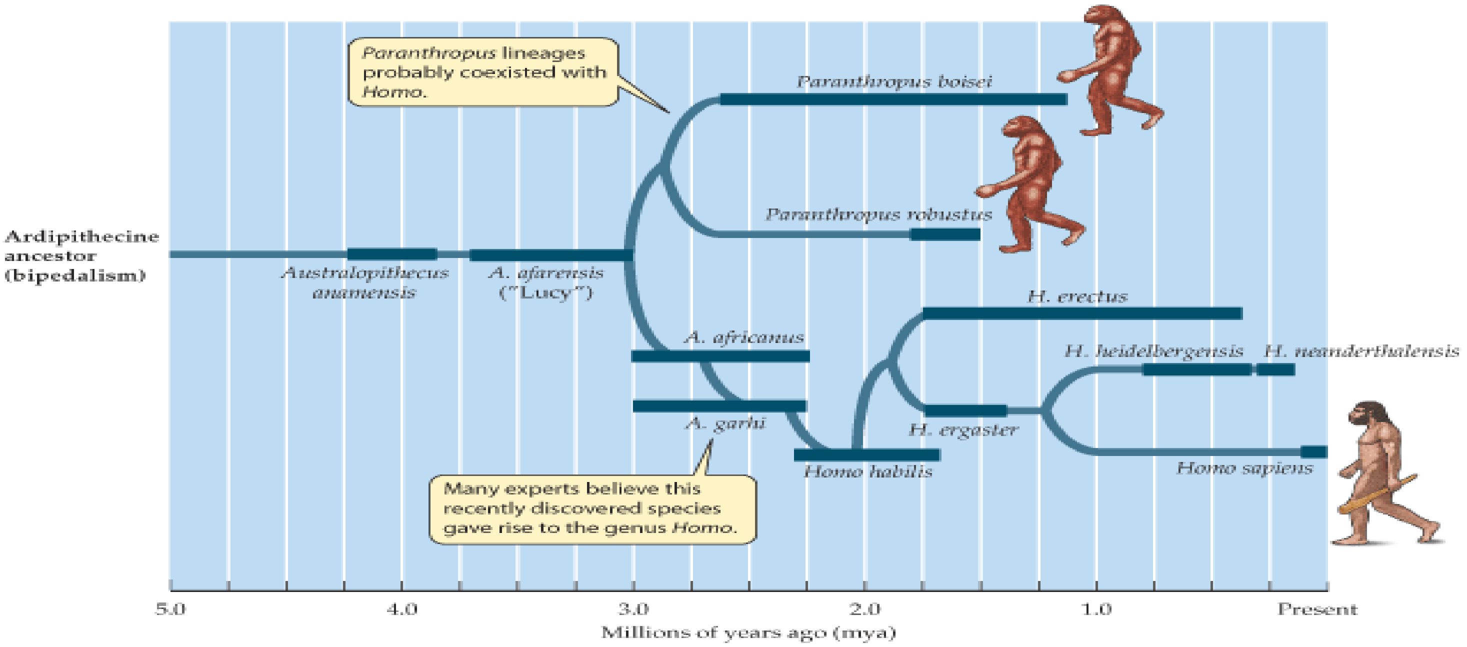




Prolifera (sponges)-LooselyOrganised(=>no tissues): pumpH2O carry food particles trough many pores and feed via cell walls.Don't form true organs; **Cnidaria**(2cellLayersAndBlindGut=>mounth=anus). Radial symmetry and Tissues andFormCollagenActinMyosin and homeobox genes.Carnivores;e.g. medusa;2stagesLifeCycle; **Ctenophora(**completeGut/=>anusAndMounthSeparate/AndTentacles, which it use to feed**) e.g.**jellyfish; Protostomes – FirstMounthFormedInEmbryoSchizocoelomates(solid mass of the embryonic mesoderm split to form a coelom).**Lophophore:** some move by cilia; some have free living larva; adding size of skeletal elements; some are sedimentaryImproveLocomotion (worms; leeches); some colonial(many Linked Live In House); some evolved shells (mollusks;snails;octopus); **Ecdysozoans:**all have cuticle(dead epidermis=>hard skin cover):some evolved as unsegmented roundworms (nematoda); some evolved segmented external skeleton via protein chitin (H2O proofed;strong;flexible pollysaccharide) originally for protection, then and for motion=>muscles appendages evolved(tardigrada)=>latter evolved **arthropods**(jointed foot) =>: Crustacea(crabs)2body regions-thorax,abdomen; Hexapoda(insects)3body regions-head, thorax(some+wings),abdomen; Myriapoda(many legs e.g100) 2body regions; Chelicerata (spiders,scorpions) 2body regions; mostly 8 leggs; **;Deuterostomes**-lateMounthFormedInEmbryo(Enterocoelous, meaning the folds of the archenteron for the coelom) **: Echinodermata(**5radial symmetry**):** evolve Ca internal canal and some muscles=> H2O vascular system(canal tube feet+ gas exchange+motion+feeding); **Hemichordates(INVAGINATED DORSAL NERVE CORD; PHARYNGEAL GILL SLITS)**-3body plan (trunk/body/; collar/small/; proboscis/head/):feed in sediments by trapping small organisms with its coat of sticky mucus (e.g.2m acorn worm), which move to its mouth by cilia's;some live in a tube; some in colonies and have tentacles; **Chordates** (new WaysOfFeeding)- enlarged pharyngeal slits=> more oxygen and more CO2 and H2O out; nerve cord; heart; tail; notochord=> newWays of hunting; Urochordate (DORSAL HOLLOW NERVE CORD;TAIL; tunicates-sea squirts) have larva's with notochords out, as in vertebrates=>link, whereas in adults no notochord on both => bigger link; Cephalochordate(BRAIN; DORSAL AND VENTRAL AORTAE; SOMITES; MUSCULARISED NOTOCHORD):e.g. Branchiostoma/ (Amphioxus); Class: Lancelet **-** Swim slow, because of his ineffective fins. Amphioxus [means both ends (amphi-) are sharp (-oxus)]-marine animal, and the several genera are distributed worldwide, especially in warm, shallow oceans where they burrow tail first into the sand and feed by filtering water. Gas exchange occurs between water and cells at the organism's surface. There are no special respiratory structures; Vertebrate(550mya; KIDNEYS; CALCIUM PHOSPHATE; NEURAL CREST ECTODERM): backbone instead of notochord;2appendages/limbs/;large coelom; better heart and circulatory system: Hagfishes(HEAD,jawless) suck blood and flesh;marine only; Lampreys(VERTEBRAL COLUMN, jawless) suck blood and flesh; all types of H2O; Cartilage-fishes(shark)-JAWS MINERALISED SKELETONS=>better feeding; unjoint fins improve motion; flexible mostly cartilage and no bones;Ray-finned fishes(LUNGS)-swim bladders save energy; bones mostly;Lobe-finned fishes: joint fins=>even better motion;Lung-fishes(both gills and lungs)=>link which evolved into;Tetrapods (first terrestrial-4leggs): Amphibians (LEGS=> invaded land:frogs,toads,salamaders); Reptiles(AMNIOTIC EGG ; turtules;snakes;lizards;crocodiles; dinosaurs=>flying) =>; Aves170mya(more feathers=>better flight)eat almost everything; some can't fly; vary in weight(e.g.2g bee hummingbird), areas and hunting; more warm blooded then mammals; modified bones for flight; lay eggs in nests; mostly give parental care; **Mammals 98mya (MILK)** (vary in weight from 2g bats and shrews/mouse-like/ upto150 tones whales);Some bones from the lower jaw were incorporated into the middle ear, leaving Only 1bone in the lower jaw; the number of bones in the skull also decreased; limbs and pelvic bones were reduced; fewer but more differentiated teeth=>carnivores or herbivores or both diets: Prototheria-milk, but no nipples=>milk just splashing out onto the fur; no placentas=>lay eggs; legs poke out aside; Theria: Marsupialia(kangaroos;koalas;shrews)in kangaroos the mother self-suck and eject milk, until the baby grows enough; however some marsupials have placentas=> link upto; Subclass: Eutherians(placentals): **Clade Atlantogenata Group I: Afrotheria** elephant shrews; elephants; **Group II: Xenarthra**(sloths and anteaters); **Group III: Euarchontoglires (Supraprimates)**; Superorder Euarchonta –treeshrews; flying lemurs; prosimians(lemurs an lorises); antropoids (tarsiers; new world monkeys; old world monkeys; asian apes; african **APES 5mya=>ardipithecine ancestor/bipedalism/=>4myaAustralopitecus anamensis -> A. africanus /Luci/:** Parathropus (boisei and robustus); A. africanus -> A. garhi -> Homo habilis -> : H. erectus; H. ergaster -> : **H. heilderbergensis /➔H. neandertalis/; H. SAPIENS)**; Superorder Glires: rabbits; rodents; **Group IV: Laurasiatheria** (moles, hedgehogs, shrews, solenodons, bats; whales, dolphins; even-toed ungulates(+pigs, hippopotamus, camels, giraffe, deer, antelope, cattle, sheep, goats); odd-toed ungulates(+horses, donkeys, zebras, tapirs, and rhinoceroses)







Lecture Sexual reproduction is a type of reproduction that results in increasing genetic diversity of the offspring. It is characterized by two processes: meiosis, involving the halving of the number of chromosomes(1n)and fertilization, involving the fusion of two gametes and the restoration of the original number of chromosomes(2n). During meiosis, the chromosomes of each pair usually cross over to achieve genetic recombination.=> overall could be: 1)predominantly haploid stage (gametes);2)predominantely diploid stage(zygotte);3)altarnation of generations("alternation of phases of a single generation"=> from 1n stage or phase → 2n stage or phase): **a)isomorhic(**relationship between organisms with independent ancestries, e.g. after **convergent evolution); b)heteromorphic(dominant sporophyte or gametophyte);c)triphasic**. ;;;**Isogamy**: gamets identicle; **Anisogamy**: different size gamets e.g.motiles: big female and smaller male; **Oogamy** – non motile egg. ;;;

PLANTS:

1.Bryophyta(mosses):embryophyte plants ('land plants')(zygotte->multicell in archegonium/embryo sac/) that are non-vascular: they have tissues and

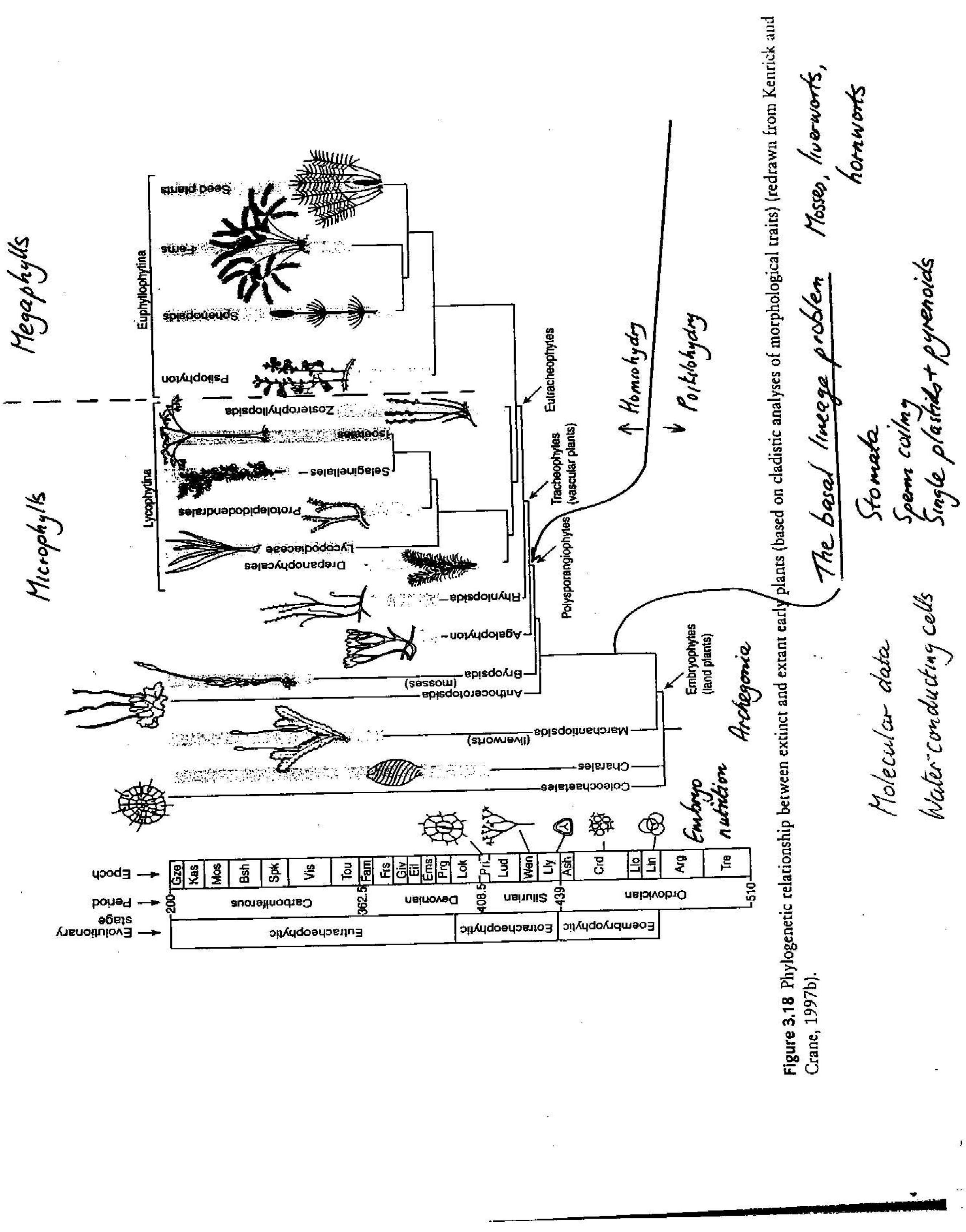


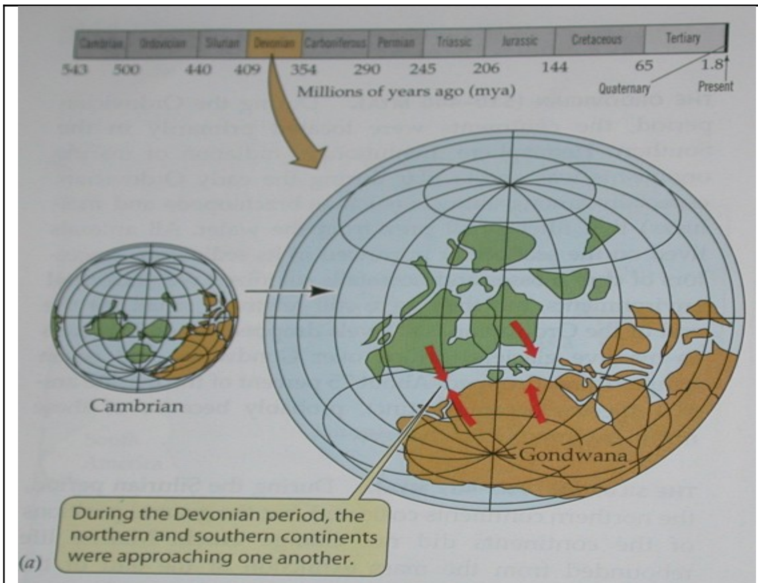
Figure 3.18 Phylogenetic relationship between extinct and extant early plants (based on cladistic analyses of morphological traits) (redrawn from Kenrick and Crane, 1997b).

enclosed reproductive systems, but they lack vascular tissue that circulates liquids. They neither flower nor produce seeds, reproducing via **spores** (reproductive structure that is adapted for dispersion and surviving for extended periods of time in unfavorable conditions. Spores form part of the life cycles of many plants, algae, fungi and some protozoans. Spores are usually haploid and unicellular and are produced by meiosis in the sporophyte. Once conditions are favorable, the spore can develop into a new organism using mitotic division, producing a multicellular gametophyte, which will eventually go on to produce gametes. Two gametes fuse to create a new sporophyte. This cycle is known as alternation of generations however "Biological Life Cycle" is a better term as there may be more than one phase and it cannot therefore be an "alteration" of anything. Haploid spores produced by mitosis (known as mitospores) are used by many fungi for asexual reproduction. It is useful to contrast spores with gametes: spores are the units of *asexual* reproduction as a single spore develops into a new organism; gametes are the units of *sexual* reproduction as two gametes need to fuse to create a new organism)

2.Hepatophyta(liverworts):typically small plants.Appearance of small irregular leaf-like plaques, often covering large areas of the ground but they may also occur on rocks, trees or any other reasonably firm substrate. They can also take on a form very much like flattened mosses. They most often occur in damp locations and are typically found in moderate to deep shade. Some species can be a nuisance in shady green-houses. They do not have flowers or seeds. 3.Anthocerophyta-hornworts[thorned(prickly or problematic)liverworts];group of bryophytes, or non-vascular plants, name refers to the elongated horn-like structure, which is the sporophyte. The flattened, green plant body of a hornwort is the gametophyte plant. Hornworts may be found world-wide, though they tend to grow only in places that are damp or humid. Some species grow in large numbers as tiny weeds in the soil of gardens and cultivated fields. Large tropical and sub-tropical species may be found growing on the bark of trees. **4 Lycophyta(club mosses, and spike mosses)**:tracheophyte subdivision of the Kingdom Plantae. It is the oldest extant (living) vascular plant division at around 420 million years old, and includes some of the most "primitive" extant species. These species reproduce by shedding spores and have macroscopic alternation of generations, although some are homosporous while others are heterosporous. They differ from all other vascular plants in having microphylls, leaves that have only a single vascular trace (vein) rather than the much more complex megaphylls found in ferns and seed plants.; Moss are gametophytes: the sporophyte stage is small. ;;; **5.Psilophyta(whisk ferns)**: lack true roots and leaves, but have a vascular system within a branching cylindrical stem. ;;; **6.Pteridophyta(horsetails) (Sphenopsids)**:tracheids with differentially thickened walls=>vascular plants,that reproduce by spores=>No seeds. the stems were used for scouring cooking pots in the past (due to them being coated with abrasive silica); Perennial plants (herbaceous)= per annial; But some are evergreen; mostly grow 0.2-1.5 m tall,but some go 5-8m.In these plants the leaves are greatly reduced, in whorls(type of spiral pattern) of small, segments fused into nodal sheaths. The stems are green and photosynthetic, also distinctive in being hollow, jointed, and ridged (with (3-) 6-40 ridges). There may or may not be whorls of branches at the nodes; when present, these branches are identical to the main stem except smaller.;;; The spores are borne under sporangiophore in cone-like structures (*strobilus*, pl. *strobili*) at the tips of some of the stems. In many species the cone-bearing stems are unbranched, and in some are non-photosynthetic, produced early in spring separately from photosynthetic sterile stems. In other species are very similar to sterile stems, photosynthetic and with whorls of branches.;;; mostly homosporous; The spores have four **elaters**(like appendages attached to the spores. These appendages develop from an outer spiral layer of the spore wall. At maturity, the four strips peel away from the inner wall, except at a single point on the spore where all four strips are attached.Under moist conditions, the elaters curl tightly around the spore. The wet spores tend to stick to each other and to nearby surfaces because of surface tension. When conditions are dry, the spores no longer stick to each other and are more easily dispersed. At that time, the elaters uncoil to extend out from the spore and will catch air currents. The fact that they are extended only when conditions are dry means that successful spore dispersal is more likely) that act as moisture-sensitive springs, assisting spore dispersal after the sporangia have split open. horsetails were a much larger and more diverse group in the distant past before seed plants became dominant across the Earth. Some species were large trees reaching to 30 m; some are abundant in coal deposits from the Carboniferous period. ;;; **7.Filicinophyta(ferns)**:add a **vascular system**->specialized organs for trasporting fluids throughout the plant. Extra evolution, but the **gametophyte (gametes)** stage of growth is very reduced; Male and female sex organs are located on the underside of the prothallium and, when conditions are right, the sperm swims from the **male *antheridium*** to fertilize the egg in the **female *archegonium* =>sporophyte(zygote)**=>maturity and then produces spores on the undersurface of its leaves or fronds. Fern sporophytes can grow as tall as trees. They can reproduce vegetatively from root cuttings. They never have flowers. Live in environments having low light and relatively high levels of moisture and humidity. Fern allies (related organisms) share the characteristics described here but do not have the ferns' stem and leaf structure.;;; => overall **Progymnosperms added secondary xylem and phloem => woody transport systems, but still no seeds**.;;; **8.Cycadophyta(cycads)**: **seeds (zygotes)**; **large LEAVES** and a stout trunk. They are evergreen, gymnospermous, dioecious plants having large pinnately compound leaves.;;; subtropical and tropical parts of the world.;;; Some are renowned for survival in harsh semi-desert climates, and can grow in sand or even on rock. They are able to grow in full sun or shade, and some are salt tolerant. Though they are a minor component of the plant kingdom today, during the Jurassic period they were extremely common.;;; They have very specialized pollinators and have been reported to fix nitrogen in association with a cyanobacterium living in the roots. This blue-green algae produces a neurotoxin called BMAA that is found in the seeds of cycads. ;;; **9.Ginkgophyta(maidenhair tree=ginkgo)**:best known examples of a living fossil; gymnosperm: its seeds are not protected by an ovary wall. The apricot-like structures produced by female ginkgo trees are technically not fruits, but are the seeds having a shell that consists of a soft and fleshy section (the sarcotesta), and a hard section (the sclerotesta).;;; **10.Coniferophyta(conifers)**: cone-bearing seed plants with vascular tissue; all extant conifers are woody plants, the great majority being trees with just a few being shrubs. growing naturally in almost all parts of the world, and are frequently dominant plants in their habitats, as in the taiga, for example. Conifers are of immense economic value, primarily for timber and paper production; the wood of conifers is known as softwood. ;;; **11 Gnetophyta(gnetum, ephedra,welwitschia)**:differ from other gymnosperms in having vessel elements as in the flowering plants (Angiosperms or Magnoliophytes), and on the basis of morphological data it has been suggested that Gnetophytes may be the group of spermatophytes most closely related to the flowering plants. Molecular data have suggested a closer relationship to other gymnosperms than to angiosperms.;;; ***Gnetum***, which are mostly woody climbers in tropical forests. However, the most well-known member of this group, *Gnetum gnemon*, is a tree. The seeds produced are used to produce a crispy snack. ;;; **welwitschia** grows only in the deserts of Namibia and Angola. The plant is strange in having only two large strap-like leaves for all its life. These grow continuously from the base, and are usually tattered at the ends by flapping in the winds. ;;; ***Ephedra***, and are known as the jointfirs because they have long slender branches which bear tiny scale-like leaves at their nodes. *Ephedra* is reputed to have medicinal properties, but has some legal controls over it in some juristictions due to potentially harmful and deadly side effects that result from consuming large amounts in a single dose. ;;; **12 Anthophyta (Magnoliophyta - Flowering plants;e.g.bananas)-**They occur exactly after the complete morphosis of insect evolution=> co-evolution with insects to atract them with their flowers=> polination efficient=> then after plant interaction first time; double fertilisation; closed carpell; mechanisms ensuring outbreeding. ;;; **Stamens** with 2 pairs of pollen sac, are much lighter than the corresponding microsporophylls of gymnosperms and have contributed to the diversification of angiosperms through time with adaptations to specialized pollination syndromes, such as particular pollinators. Stamens have also been modified through time to prevent self-fertilization, again to increase diversity, allowing angiosperms to eventually fill more niches. ;;; **Reduced male gametophyte** (three cells)-in angiosperms may have evolved to decrease the amount of time from pollination, the pollen grain reaching the female plant, to the fertilization of the ovary. In gymnosperms fertilization can occur up to a year after pollination, while in flowering plants the fertilization process begins very soon after pollination, allowing angiosperms, ultimately, to set seeds sooner and faster than gymnosperms.;;;Closed **carpel (FRUIT => humans can use the fruit, BUT shall leave the seed)** enclosing the ovules (carpel or carpels and accessory parts may become the fruit). The closed carpel of angiosperms also allows adaptations to specialized pollination syndromes and controls to prevent self-fertilization, thereby maintaining increased diversity. Once the ovary is fertilized the carpel and some surrounding tissues develop into a fruit, another opportunity for angiosperms to increase their domination of the terrestrial ecosystem with evolutionary adaptations to dispersal mechanisms.;;;**Reduced female gametophyte** (seven cells with eight nuclei) - like the reduce male gametophyte may be evolutionary adaptations allowing for more rapid seed set, eventually leading to such flowering plant adaptations as annual herbaceous life cycles, allowing the flowering plants to fill even more niches towards their terrestrial domination.;;;**Endosperm** formation generally begins after fertilization and before the first division of the zygote. Endosperm is a highly nutritive tissue that can provide food for the developing embryo, the cotyledons, and sometimes for the seedling when it first appears.;;; **Lecture Evolution of Leaves** do more than photosynthesize. Essentially, they are extravagant expansions of the plant epidermis, increasing its surface area many times. Furthermore, they are typically studded with stomata, thus multiplying the gateways by which the leaves exchange gases with the atmosphere. The gases of most interest are carbon dioxide, oxygen, and water vapor, and. of course, all three are ingredients in the chemical reactions of photosynthesis. But there is another aspect of evapotranspiration, one that may be much more significant for the origin of leaves. **Evaporation (transpiration) from stomata** high on the plant sets up a pressure gradient, a pump, that produces upward **flow in the xylem (woody transport system)** of the plant. Fluid in the xylem flows upward from the roots to the leaves, carrying essential nutrients with it. Without such flow there can be no growth of the tissues high in the plant. The pressure of the pump is the same whether there are 2 stomata or 20,000, but the flow that is generated multiplies with the number of stomata. The origin of leaves would have evolved side by side with increased capacity of xylem and phloem, to accommodate the increased reciprocal flow of nutrient-bearing fluids up and down the plant. There would be no point in evolving leaves if the roots were not gathering and transmitting nutrients from the soil efficiently. And the whole structure of the stem would have been expanded and strengthened to accommodate the transport system, and to bear the weight of the added leaves and their support branches. **Why leaves evolved so late**: Humans sweat profusely if they exercise in hot humid environments, but the sweat doesn't evaporate easily and the human quickly overheats). In plants, slow evapotranspiration means low pressure gradients in the vascular system, low nutrient flow, and overall a small energy budget. Plants cannot grow high, and sophisticated transport systems are not needed, so don't evolve: and that includes size, strength, and complexity of phloem and xylem; size, strength and complexity of roots; and leaves. Nutrition from photosynthesis doesn't do any good if the growth of the plant is handicapped by lack of soil nutrients.

Roots today operate an ion pump to take nutrients from the soil, put them into the root system, and keep them there. This process generates a pressure, called "root pressure", that can move the nutrients round the plant. In addition, many plants today have accessory colonies of fungi called "mycorrhizae" associated with the roots. Mycorrhizae concentrate nutrients from the soil and essentially drag them close to the roots, making the whole process cheaper for the plant: but the mycorrhizae in turn are "fed" by the plant. This is another "high-budget" operation, which costs more but gives a higher return. **Lecture The role of pioneer geologists in dating early life on earth; ;;; In England Lyell and his influence on Darwin;perspectives on the age of the earth-**Measuring of long time spans by using naturally **radioactive materials**. Certain radioactive materials are incorporated into rocks and other materials when they are formed. As time passes, the radioactivity in these materials decreases at a regular rate. Scientists compare the proportions of radioactive and corresponding nonradioactive materials in particular rocks. From the observed ratio, they can estimate how long ago the rocks formed. This method gives us ***absolute*** **ages**. Indirect observations, such as the vertical positions of rock layers in relation to one another, help us assess the ***relative*** **ages of materials**. Young rocks lie on top of older ones (unless the rocks have been subjected to dramatic deformations, which are usually evident). By studying the remains of living things found in different layers of rock and correlating their distributions across many sites, we can determine the relative ages of different deposits even if absolute ages are not known.; **Physiological aging** may require observations extending over the lifetime of organisms, which may range up to centuries for some long-lived plants.;;; In Denmark Steno; methods for dating rocks, radio carbon and palaeomagnetism; details of radio carbon dating, half life explained; ;;; **Crises on earth in time: effects of volcanos and collisions;HOW EARTH HAS CHANGED**-Earth's history has been profoundly influenced by internal processes, such as the activity of volcanoes and the compression and shifting of Earth's crust, and by external events, such as meteorite falls. Before considering these events, we must establish some mileposts in Earth's history to which we can refer when we talk about events in the remote past. **Radioactivity** provides a way to date rocks precisely because in successive, equal periods of time, the same fraction of the remaining radioactive material of any radioiso-tope decays, becoming the corresponding stable isotope. Each radioisotope has a characteristic half-life, e.g. **carbon-14 (^{14}C)** has a half-life of about 5,700 years. We can use ^{14}C to age fossils contained in fairly young rocks; we then infer the ages of sedimentary rocks from the ages of the fossils embedded in them. The half-life of C is long enough to allow us to determine the time of death of anything that has died within the last 15,000 years and has left remains that contain carbon. The ratio of radioactive ^{14}C to nonradioactive ^{12}C in a living creature is always the same as that in the environment because carbon is constantly being exchanged between the environment and organisms. The production of new ^{14}C in the upper atmosphere (by the reaction of neutrons with ^{4}N) just balances the natural radioactive decay of ^{14}C, so a steady state exists. However, as soon as a tree or any other living thing dies, it ceases to equilibrate its carbon compounds with the rest of the world. Its decaying ^{14}C is not replenished from outside, and the ratio of ^{14}C to ^{12}C decreases. By measuring what fraction of the total carbon in a specimen is ^{14}C, we can easily calculate how much time has elapsed since it died.

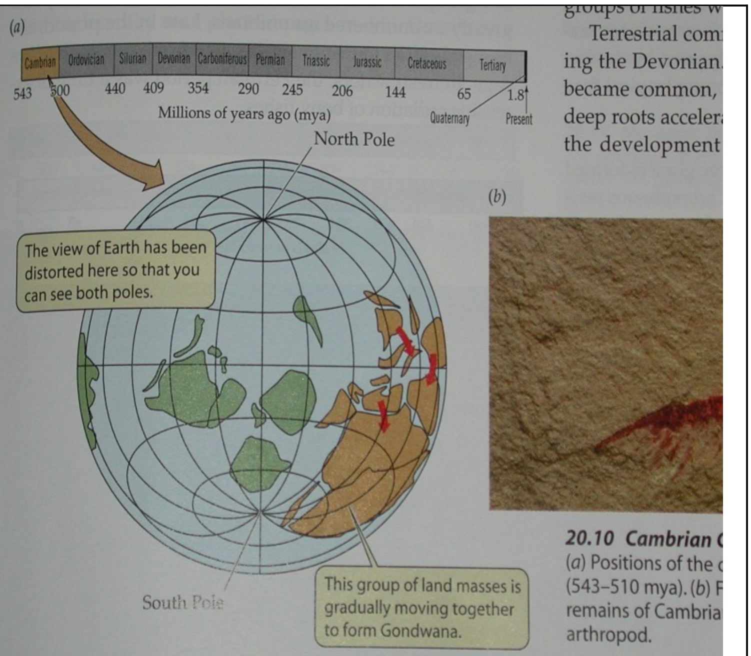
THE FOSSIL RECORD-As the previous discussion shows, much of what we know about the history of life is derived from fossils. Most fossil evidence comes from a rather small number of sedimentary rocks in which organisms are especially well preserved. An organism is most likely to be preserved if it dies or is deposited in an environment lacking oxygen. Most organisms, however, live in oxygenated environments. Thus many fossil assemblages are collections of organisms that were transported by wind or water to sites without oxygen. Occasionally, however, organisms are preserved where they lived. In such cases—especially those of cool, anaerobic swamps, where conditions for preservation were excellent—we obtain a picture of whole organismal communities. ;;; **The Completeness of the Fossil Record**-About 300,000 species of fossil organisms have been described, and the number is growing steadily. However, this number is only a tiny fraction of the species that have ever lived. We do not know how many species lived in the past, but we have ways of making reasonable estimates. Of the present-day biota—the species in all groups (archaebacteria, bacteria, pro-tists, fungi, plants, and animals)—approximately 1.5 million species have already been described. The actual number of living species is probably at least 10 million (and possibly as high as 50 million) because most species of insects, the richest animal group, have not yet been described. Thus the number of known fossil species is less than 2 percent of the probable total of living species. Because life has existed on Earth for 3.5 billion years, and because species last, on average, less than 10 million years, the total number of species that lived in the past must have been many times the number that are alive today. Earth's biota has been replaced many times during geological history. If at any moment in the past the number of species was no greater than at present (or even if it was substantially less), the total number of species over evolutionary time would be much greater than the current number.The sample of fossils, although small in relation to the total number of extinct species, is not uniformly poor. The record is especially good for the phyla of marine animals that have hard skeletons. Among the nine major phyla that have hard-shelled members, approximately 200,000 species have been described from fossils, roughly twice the number of living marine species in these same groups. Paleontologists lean heavily on these groups in their inter- Trapped in the sap of a tree in the Dominican Republic about 25 mya, this ground beetle is exquisitely preserved in the amber that formed from the sap. Details of its external anatomy are clearly visible. pretations of the evolution of life in the past. Insects, although much rarer as fossils, are still well represented in the fossil record. Fossil insects belonging to about 1,265 families and all 30 of the common orders having living species have been identified.The incompleteness of the fossil record can mislead our interpretations of what happened. Most described fossils come from a relatively small number of sites, and an organism that evolved elsewhere may have been fossilized at one of these sites. When such a fossil is found, it gives the impression that the organism evolved very rapidly from one of the species that already lived there when, in fact, it may have evolved slowly elsewhere and moved to the site. ;;; **Stratigraphy-**the oldest layer is the most inside => the newest is the most outside ;;; **Paleontology-** rock fossils ;;; **Paleobotany-** plant fossils ;;; **Paleomagnetism-** magnetism in ancient rock: the polarity and intensity of residual magnetism in ancient rock ;;; bya - billion years ; mya –million years ago



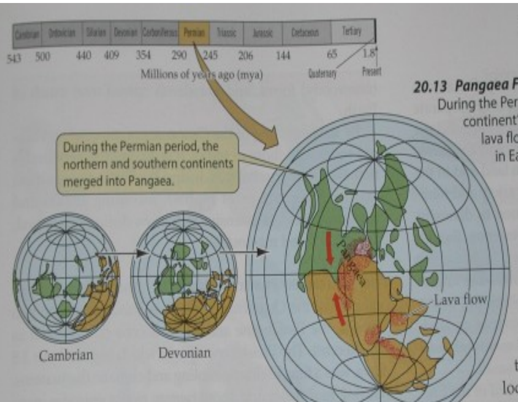
20.11 Devonian Continents and Marine Communities
a) Positions of the continents during the Devonian period 409–354 mya). (b) This artist's reconstruction shows how a Devonian reef may have appeared.

groups of fishes w

Terrestrial com ing the Devonian became common, deep roots acceler the development



20.10 Cambrian C
(a) Positions of the c (543–510 mya). (b) F remains of Cambria arthropod.

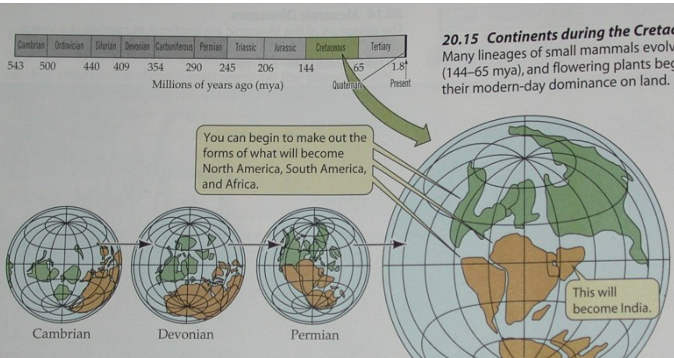


20.13 Pangaea Formed in the Permian Pe
During the Permian (290–245 mya), the in continent" Pangaea experienced hars lava flows spread over Earth, and t in Earth's history formed during

Toward the end of the Permian period, two events may have caused separate mass extinctions. The first event was the massive

During the Mesoz which until that time homogeneous, becam vincialized. Distinct t faunas evolved on each tas of the shallow water tinents also diverged fro localization that began d continues to influence the geo

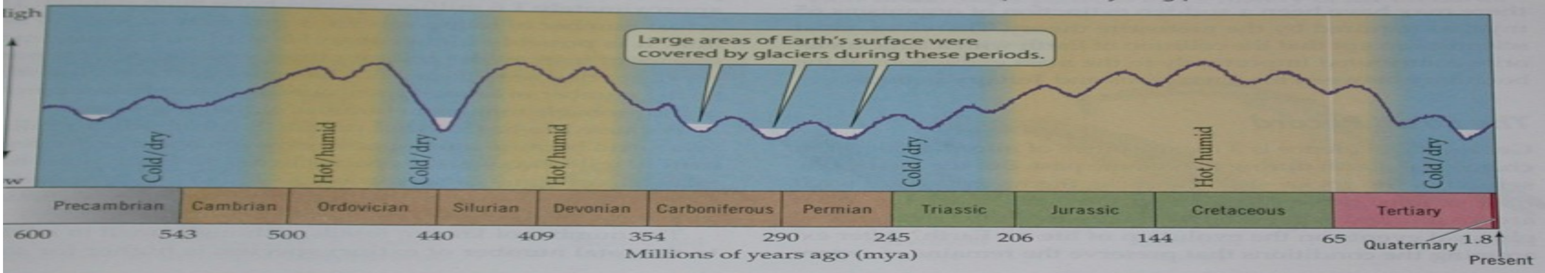
THE TRIASSIC (245–206 MYA). During many invertebrate lineages became mo

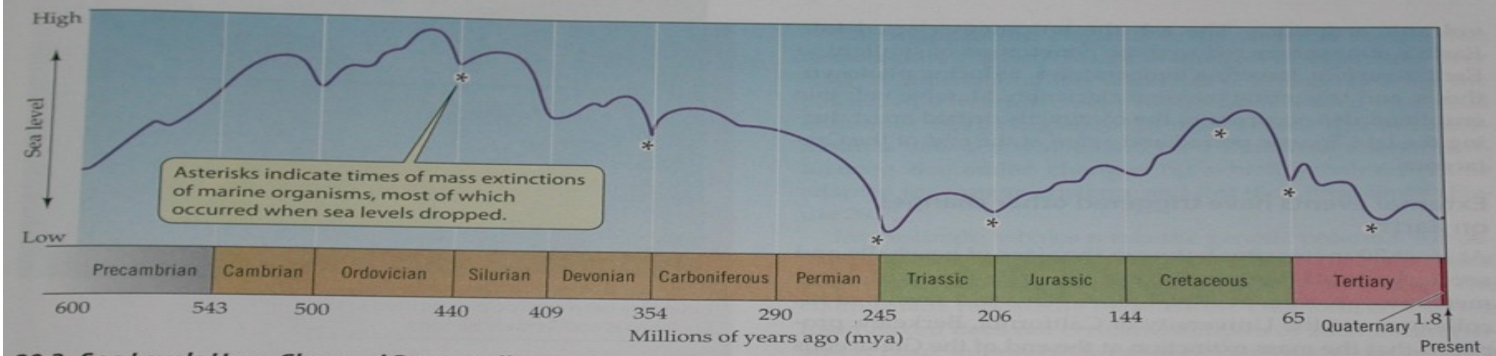


20.15 Continents during the Cretaceous Period
Many lineages of small mammals evolved during the Cretace (144–65 mya), and flowering plants began the radiation leadi their modern-day dominance on land.

ven more rapid. For example, during one Quaternary interglacial period, the Antarctic Ocean changed from being e-covered to being nearly ice-free in less than 100 years.

20.4 Hot/Humid and Cold/Dry Conditions Have Alternated over Earth's History
Throughout Earth's history, periods of cold climates and glaciations have been separated by long periods of milder climates.





20.3 Sea Levels Have Changed Repeatedly
Most mass extinctions of marine organisms have coincided with periods of low sea levels.

Such rapid changes are usually caused by sudden shifts in

ERA (mya)	Some MAJOR EVENTS IN THE HISTORY OF LIFE
3.8 bya	O2 first appear->Origin of life; prokaryotes flourish
1.5 bya	O2 > 1% first aerobic bacteria O2>5%(1bya)Ediacaran.First Multicelluar protists algae. First Eukaryot 1.4mya
CambrianEra 570 [580-Animalia]	O2>10%Exoskeletons;O2>30%FirstChordates.Most animal phyla present; invertebrate animal life, including trilobites, appeared, and marine algae developed.50% mass extinction at end of period.FormGondwana; Hot; First vertebrates550mya
OrdovicianEra500	First plants (480). Diverse of many animal phyla; End period glaciation's; Sea Level Down50m=>75%MassExt.
SilurianEra 430	Diversification of jawless fishes; first ray-finned fishes;SeaLevelUp;2newContinents;Hot end period O2>50% colonization of land by plants(430) and animals
DevonianEra 400	Continents collide at end of this period towards forming Pangea;2asteroids;Diversification of fishes; first insects and amphibians (400), and forests. 75%Mass extinction late in period
CarboniferousEra	350 Glacial; Coal Era. Extensive fern forests; first reptiles(300); insects radiate
PermianEra 280 Visible Strata	O2>80%FirstAngiosperms;PangaeaFull; Meterorite; large glacerias;inside Pangea dry climate;reptilesRadiate;many types of insects OK too,but amphibias decline. Overall at end of this period + a lot volcanos=>Trilobites,and most of bryozoans and brachiopods,+50% of animals,+95% of marines extincted
TriassicEra 230	Pangea slowly start to move apart;hot/humid climate;Massisve eruptions;O2>85%Reptiles flourished and dinosaurs; marine invertebrates diversity; modern corals, and coniferous forests first appeared. 35% of animal families extinct; First Flowering plants;65%MassExtinctEndOfThePeriod
JurassicEra190	Hot; Gondwana+Laurasia;dinosaurs flourished and Birds(170) coevolve; ray-finned fishes ok
Cretaceous Era140	Most continents widely separated; continued dinosaur radiation; flowering plants and mammals(100) diversify. Meteorite strike Peninsula 75%Mass extinction; White Rock; 65-Dinosaurs extinct.
Cenozoic Era 65	flowering plants, and pollinating insects coevolution
Period-Tertiary 65	Mammals become dominant, and plants evolved;
Period-Quaternary EpochPleistocene2.5	Repeated glaciations; people evolve; Pleistocene (extinctions of large mammals and birds); 5Apes; 4Bipedal Hominids (Australopitecus Anamnesis); 3A.Africanus; 2Homo Ergaster; 1Homo Erectus; 0.25Homo Sapiens.

Lecture 4 ;;; Speciation-

Propelling (pushing) into the tops of trees a chemical mist (condensed H2O vapor) that causes the smaller animals to fall to the ground (primarily insects, etc) living high above the ground in tropical forests, etc.- technique discovering so many species and similar techniques. Species on Earth today 30 to 50 million even though only 1.5 million have been described and named. ;;;You already know that all these species, as well as those that lived in the past, are believed to be descendants of a single ancestral species. One species become two, factors stimulate such splitting, time take formation of species ;;; ***Species*** means "kind." Many plants and animals, especially ones of the temperate zone, were classified as species by their appearances, or morphologies (structure of organism). Among organisms in which males and females look very different, the two sexes were sometimes called different species. As soon as such individuals were discovered to be males and females of the same population, they were placed together in the same species. Definition of species by Ernst Mayr in 1940"Species are groups of actually or potentially interbreeding natural populations which are reproductively isolated from other such groups" ;;; Evolution creates two patterns across time and space—vertical evolution and speciation. **Vertical evolution, also called anagenesis**, is change in a single lineage through time. With sufficient time, the changes may be so great that the descendants are given another species name even though no "new" species has formed. Anagenetic changes are a common feature of the fossil record. **Speciation** is the process by which one evolutionary unit splits into two units, which there after evolve as distinct lineages=>allele and gene frequencies may change as a result of the action of evolutionary agents. Charles Darwin *The Origin of Species,* did not discuss how a single species splits into two or more daughter species, but only demonstrating vertical evolution, that species are altered by natural selection over time. ;;; **Gene flow** among populations may be interrupted in several ways, each of which characterizes a mode of speciation:

Allopatric Speciation-results when a population is divided by a barrier (Greek *allo* - "different" and *patris* = "country"), or geographic speciation. Barriers can form when continents drift, sea levels rise, or climates change. **Natural selection** adapts populations to their environments; **Genetic drift** may also bring about genetic changes. The two populations may also start with different mixtures of alleles. A barrier's effectiveness at preventing gene flow depends on the size and mobility of species. What is a firm barrier for a terrestrial snail may be no barrier at all to a butterfly; **Parapatric speciation (Greek *para* = "beside")** is the development of reproductive isolation among adjacent members of a population in the absence of a geographic barrier.

Sympatric Speciation (Greek *sym* = "with"), a gene pool becomes subdivided even though members of the daughter species are not physically separated during the speciation process. One means of sympatric speciation is **polyploidy**, a multiplication of the number of chromosomes. Polyploidy can arise by the duplication of the chromosomes of a single species or by the combination of chromosomes from two different species. Polyploid individuals of either type usually cannot exchange genes successfully with members of the parent populations because the polyploid individuals have different numbers of chromosomes than their parents have=> chromosomes from such matings cannot pair properly during the first meta-phase of meiosis. As a result, the zygotes usually fail to develop properly. Thus, the matings either result in no offspring, or, if offspring are produced, they die before they mature. ;;; **Polyploidy** can create a new species within one generation if the polyploid individuals can mate among themselves or self-fertilize. Plants can accomplish this task much more easily than animals can because plants of many species can reproduce by self-fertilization as well as by outcrossing (crossing with a relatively unrelated individual). If the polyploidy arises in several offspring of a single parent, the siblings (brother or sister) can fertilize one another. Animals that have speciated by polyploidy either are parthenogenetic (produce young from unfertilized eggs), or they survived the initial generations probably by means of matings among siblings. Among animals, sympatric Speciation rarely happens by polyploidy, but it can result from the way species exploit resources.**Polyploids** Can Outperform Their Parents

REPRODUCTIVE ISOLATING MECHANISMS-Any trait of an organism that prevents individuals of two different populations from producing fertile hybrids is called a reproductive isolating mechanism. Any two populations that are not producing fertile hybrids are reproductively isolated from each other, but they do not necessarily have isolating mechanisms. For example, although a geographic barrier may separate two populations, it is not an isolating mechanism because it is not a property of the organisms.

-------Prezygotic mechanisms lower the probability that hybrid zygotes will be formed, either by preventing or reducing mating between individuals of different species or by preventing fertilization of eggs if individuals of two species have mated. **BARIERS:** **GEOGRAPHIC ISOLATION**; **TEMPORAL ISOLATION** (mating periods that are as short as a few hours or days); **BEHAVIORAL ISOLATION; MECHANICAL ISOLATION** (sizes and shapes of reproductive organs may prevent the union of gametes from different species, etc)**; Chemical ISOLATION** (male and female gametes do not attract each other, e.g. Sperm of one species may not be attracted to the eggs of another species because the eggs do not release the appropriate

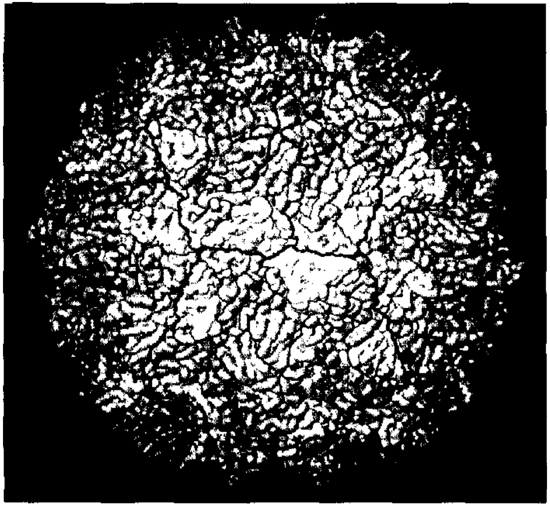
attractive chemicals, or the sperm may be unable to penetrate the egg because it is chemically incompatible).
-------- Postzygotic mechanisms prevent zygotes resulting from hybrid matings from developing into viable, fertile adults. Isolating mechanisms of both types prevent successful interbreeding between two populations. **Bariers: Hybrid inviability** (hybrid zygotes do not develop or fail to reach sexual maturity); Hybrid sterility (hybrids do not produce functional gametes); **Hybrid weakness**(reduced survival rate of these hybrids)**;Hybrid Zones**:when the hybrid is dependent to survival to live in a particular zone, e.g. with different temperature, food, etc.
SPECIES DIFFER GENETICALLY: There is no general rule about how much **time speciation** requires.
allopatry, sympatry;barriers to speciation on land and in the sea; the polar species diversity versus the equatorial species diversity;species groupings-SPECIES AND THEIR FORMATION;Captivity (unable to escape; very attracted) open Barriers to **Interbreeding:** e.g.horses and zebras=>hybrids (zebroids).Mayr viewed species as evolutionary units that are evolving separately from other such units, but he also included within one species, geographically separated populations that are not exchanging genes, if they were judged to be capable of interbreeding. Other evolutionary biologists prefer not to.
Many species that were classified morphologically, when nothing was known about their reproductive behavior, fit Mayr's definition. Members of an evolutionary unit share genes inherited from common ancestors. As a result, these individuals are likely to share many of the same alleles coding for their morphological traits, so their morphologies will be similar.
THE COHESIVENESS (unification) OF SPECIES Species are cohesive units=>can determine the species of an individual simply by examining it superficially. Species within which self-fertilization is the rule, even though some sexual recombination occurs, also show cohesion, widespread or partially self-fertilizing species. Factor promoting cohesion is gene flow, reproduction of some distance from where they were born. Even a very low rate of gene flow among populations can maintain the cohesion of a species because it prevents populations from diverging (separate) as a result of genetic drift or adaptation to local conditions. => natural selection (favors similar organisms) is spread by gene flow=>evolution of them (the species) all.
Diversity hotspots and some examples; Madagascar, Wallacea and Mesoamerica; Major Bridge Geographic Regions
Barriers separating the biogeographic regions are shown as broad bands rather than lines because biotas change gradually rather than abruptly from one region to another. the island the species pool. The first colonists to arrive on the island are all "new" species because there are no species there already. As the number of species on the island increases, a larger fraction of immigrants are members of species already present, so even if the same number of species arrives as before, the rate of arrival of *new* species decreases, until it reaches zero when the island has all the species in the pool. ;;; Now think about extinction rates. First there will be only a few species on the island, and their populations may grow large. As more species arrive and their numbers increase, the resources of the island will have to be divided among more species. We therefore expect the average population size to become smaller as the number of species becomes larger. The smaller a population, the more likely it is to become extinct. In addition, the number of species that can become extinct increases as species accumulate on an island. New arrivals to an island may include pathogens and predators that increase the probability of extinction of other species, further increasing the number of species becoming extinct per unit of time. ;;; Because the rate of arrival of new species decreases and the extinction rate increases as the number of species increases, eventually the number of species should reach an equilibrium. If there are more species than the equilibrium number, extinctions should exceed arrivals. If there are fewer species than the equilibrium number, arrivals should exceed extinctions. Such an equilibrium is dynamic, because even if species richness remains relatively constant, species composition may change as different species replace those that become extinct. The model does not predict which species will arrive and which will become extinct. It predicts only the equilibrium number of species if arrival and extinction rates are known and are constant. If either rate fluctuates very much, there will be no equilibrium number of species. ;;;
Endemism(endemic)-particular place, where unique species (animals,plants) are occurring, and there only.

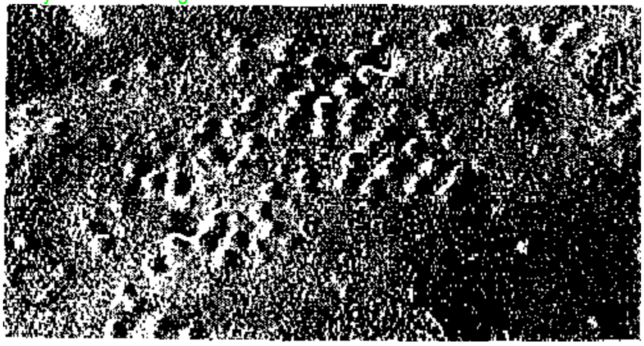
1.Madagascar-A series of islands scattered in the western Indian Ocean off the southeast coast of Africa forms the Madagascar and the Indian Ocean Islands hotspot. chamaeleon from, important biodiversity hotspot. eight plant families, four bird families, and five primate families that live nowhere else on Earth. Madagascar's more than 50 lemur species	Because Madagascar and the continental Seychelles broke off from the Gondwanaland supercontinent more than 160 million years ago, the hotspot is a living example of species evolution in isolation. Despite close proximity to Africa, the islands do not share any of the typical animal groups of nearby Africa. Instead, they have evolved an exquisitely unique assemblage of species, with high levels of genus- and family-level endemism, in only 1.9 percent of the land area of continental Africa.	**Invertebrates** 5,800 species, of which 86%endemic Most of the invertebrate fauna is poorly known: terrestrial snails (651 species, all endemic); scorpions (40 species, all endemic); spiders (460 species, 390 endemics); dragonflies and damselflies (180 species, 130 endemics); lacewings (160 species, 120 endemics); tiger beetles (210 species, 210 endemics); scarab beetles (150 species, all endemic); true butterflies (300 species, 210 endemics); freshwater crayfish (six species, all endemic); and freshwater shrimp of the family Atyidae (30 species, 20 endemics).	**Taxono-mic Group** **Spe-cies** **Ende-mic Spec-ies** Plants **13,000** **12000** Mammals **160** **140** Birds **310** **180** Reptiles **380** **370** Amphi-bians **230** **230** Fresh-water Fishes **160** **100** Vertebrates
2.Wallacea-central islands of Indonesia east of Java, Bali, and Borneo, and west of the province of New Guinea, and the whole of Timor Leste.	it is tropical and made up of many islands and in part because of its complex geological history. The land fragments of Wallacea separated from mainland Asia around 200	**Invertebrates** Most of the invertebrate fauna of Wallacea remains poorly known; 80 species of birdwings butterflies 50%endemic . One species, *Ornithoptera*	Plants **10,000** **1,500** Mammals

world's largest lizard, the Komodo dragon,	million years ago, contributing to their isolation and the evolution of many unique species. The hotspot lies between the Indo-Malayan and Australasian biogeographic realms and includes representatives from each of these regions as well as many endemics in its own right	*croesus* (EN), which is endemic to the northern Moluccas, has a wingspan of nearly 20 centimeters in females. There are also 109 tiger beetles recorded from this hotspot, 79 of which are endemic. The northern Moluccas also contains the world's largest bee (*Chalocodoma pluto*) with females that can grow as large as four centimeters in length.	**220** **130** Birds **650** **260** Reptiles **220** **100** Amphi-bians **50** **30** Fresh-water Fishes **250** **50** Vertebrates
3.Mesoamerica-Spanning most of Central America, the Mesoamerica Hotspot encompasses all subtropical and tropical ecosystems from central Mexico to the Panama Canal. This includes all of Guatemala, Belize, El Salvador, Honduras, Nicaragua, and Costa Rica, as well as a third of Mexico and nearly two-thirds of Panama.	America were once two separate landmasses, with independently evolved plant and animal species. Then, about 3 million years ago, sections of Central America rose above sea level, forming a land bridge between north and south. Species began to flow in both directions between the continents, and their interaction in this transition zone helped produce Mesoamerica's unique and diverse array of life forms.	Additionally, the highlands and mountain chains that run along the hotspot's main north-south axis have facilitated isolation and speciation throughout Mesoamerica. Because the mountains have often posed an impassable barrier, there are considerable differences in species composition between the Pacific and Caribbean coasts. On the other hand, the valleys and lowlands running parallel to the mountains have long served as natural corridors for animal and human migrations.	Plants **17,000** **3000** Mammals **440** **70** Birds **1,110** **210** Reptiles **690** **240** Amphi-bians **560** **360** Fresh-water Fishes **510** **340** Vertebrates

Koch's postulate: 1. Isolate pathogen from the organism; 2. Grow the pathogen in pure culture, identify and classify; 3. Inject/apply the pathogen to uninfected host; 4. Observe symptoms; 5. Isolate pathogen again and re-identify.
Viruses (50-100nm): Most viruses are much smaller than most bacteria. Viruses have become well understood only within the last half century, but the first step1892 (Ivanovski can't see it with Light Microscope and can't apply the Koch's postulate) alcohol, which kills cultures of bacteria, does not destroy the tiny agents' ability to cause disease;In 1935 (Stanley) first crystallizing viruses. The crystalline viral preparation became infectious again when it was dissolved. It was soon shown that crystallized viral preparations consist of protein and nucleic acid. Finally, direct observation of viruses with electron microscopes confirmed how much they differ from bacteria and other organisms.
Viral Structure: Unlike the organisms that make up the six taxonomic kingdoms of the living world, viruses are acellular; that is, they are not cells and do not consist of cells. Unlike cellular creatures, viruses do not metabolize energy—they neither produce ATP nor conduct fermentation, cellular respiration, or photosynthesis.
Common Sizes of Microorganisms: TYPICAL SIZE RANGE; Whole viruses never arise directly from preexisting viruses. They are *obligate ititracellular parasites;* that is, they develop and reproduce only within the cells of specific hosts. The cells of animals, plants, fungi, protists, and bacteria serve as hosts to viruses. Viruses outside host cells exist as individual particles called **virions.** The virion, the basic unit of a virus, consists of a central core of either DNA or RNA (but not both) surrounded by a **capsid,** or coat, which is composed of one or more proteins. These proteins are assembled so as to give the virion a characteristic shape. Many animal viruses also acquire a membrane consisting of lipids and proteins as they bud through host cell membranes in the course of viral reproduction, and many bacterial viruses have specialized "tails" made of protein. The complex architecture of HIV-I, the AIDS virus, is shown. **Reproduction in Bacteriophage: Steps: 1)** Penetration: phage release lysosomes from the tail, which dissolve part of the host cell. Tail then contracts trough and inject DNA. Reminder of the virus stays outside. Viral DNA circularises in the host, where may be some viral proteins assisting penetration, but all else is from the host; **2)** Biosynthesis: new viral DNA use viral coded enzymes and host nucleotides to make proteins using viral coded mRNA and host ribosomes; **3)** Maturation: capsids are assembled into complete virions; **4)** Release: viral coded lysosome is produced, which ruptures the host membrane, releasing 50-200 new virions. Completion, after which step-wise the number of particles increase again; **5)** Detect concentrations by: grow host and virus=> produce "bacterial lawn". So after time some will lyse. So, clear places ("plaques") can be count and compared with library.

Reproduction of Viruses (differ from bacteriophage): Viruses reproduce by taking over their host cell's metabolism; the viral nucleic acid directs the production of new viruses from host materials. Animal viruses begin the process by: **1)** attaching to the plasma membrane(no cell wall) of the host cell. They are then taken up by endocytosis or fission (where the receptor sides are proteins and glycoproteins. Once first attachment occur, additional receptors migrate to that site. **2)** Receptors can also mutate via allelic variation), which traps them within a membranous vesicle inside the cell; **3)** The virus has to be uncoated => vesicle breaks down (sometimes by endocytosis or by specific coded viral enzymes), and the host cell digests the protein capsid. At this point, the viral nucleic acid self insert takes charge. The host cell replicates the viral nucleic acid and synthesizes new capsid protein as directed by the viral nucleic acid. **4)** New capsids and new viral nucleic acid combine spontaneously, and in due course, the host cell releases the new virions by budding=>many at once=> may lyse the cell=> kill it through virus-modified areas of the plasma membrane. During this process the completed virions acquire a membrane similar to that of the host cell; **5)** Detection of concentrations by: inject virus in the host, e.g. in embryo eggs or tissue. So after time some cells will die of mutate, etc.=> count and compare with library. **;;;** Plant viruses must pass through a cell wall as well as through the host plasma membrane. They accomplish this penetration through their association with **vectors,** which are intermediate carriers of disease from one organism to another. Infection of a plant usually results from attack by a virion-laden insect vector. The insect uses its proboscis (snout) to penetrate the cell wall, allowing the virions to move via the proboscis from the insect into the plant. ;;; Overall many viruses can be slowed down in their reproductive success (so the immune system can dettect and destroy them, before they go overcoming, which is easiest reached by immunisations) via antiviral's, which act on the virus protein or on the cell protein to which the virus should have bond. However still the cure is mostly active if the virus is in an very early stage of infecting the host. ;;; **A Virion:**The capsid of a poliovirus virion, as drawn by computer. There are three major proteins in the capsid. The proteins are organized into building blocks, outlined by the wavy black lines. ;;; plant or bacterial cells by lysing (breaking apart) the host cell, rather than by budding. Some bacterio-phages have lytic life cycles (cycles that result in rapid lysis of host cells); others have lysogenic life cycles, in which the viral and host nucleic acids replicate at the same time, and the virus may be present as a "silent" provirus for many bacterial cell generations.





Buds of an Animal Virus: The numerous small bumps on the curved surface of this cell are buds in the plasma membrane. At this stage the capsids are acquiring membranous envelopes that completely surround each virion when the process is complete. These membrane envelopes make the first contact when these virions infect new host cells. ;;; **Bacteriophage life cycles.;;; How does a virion recognize a suitable host**? Some bacteriophages use a specific interaction between the proteins of the bacteriophage tail and of the host cell wall. Membrane-surrounded animal viruses probably depend on the membrane to recognize suitable cells: Because the membrane was obtained from the previous host, it can readily fuse with the plasma membrane of a new host cell. It is not known how other virions recognize their host cells. ;;; **Classification of Viruses: 1)** whether they have DNA (replication in the nucleus) or RNA (replication in the cytoplasm=> direct transcription and production of capsid proteins. Host mRNA and proteins are inhibited by specific enzyme called RNA dependant RNA polymerase; e.g Lysogenic Retrovirus like HIV have RNA genome, but carry reverse-transcriptase RNA-dependant DNA polymerase, which transcribe DNA from RNA, incorporating it into the host cell chromosome, and eventually transcribing it. Viral DNA never leaves the genome=> heritable and is called provirus or prophage) and then by whether their nucleic acid is single- or double-stranded, and whether is circular or linear. Also is it one or more molecules of RNA and/or DNA. **2)** Differ in protein coats (around the nucleic acid) called capsids, which mutate often; Some of the RNA viruses have more than one molecule of RNA, and the DNA of one virus family is circular. Further levels of classification depend upon factors such as the overall shape of the virus and the symmetry of the capsid. Most capsids may be categorized by their glycoproteins spikes as: **Enveloped Helical** (coiled like a spring), **Enveloped Polyhedral** or **Icosahedral** (a regular solid with 20 faces), or **binal** (having a polyhedral, or many-faced, head with a helical tail); **Complex viruses (**bacteriophages with additional structures attached to the capsid, such as sheath, tail, fibres, plate and pin. Also with simpler structure. Ussually no envelope. Reproduce lytic (=>host die); or lysogenic (=> host survive)=> virus is called **prophage**, which however can become lythic, But meanwhile is immune via its reminder proteins left outside the cell, or via making the host cell to produce toxins=>phage conversion. Also there can be transduction=> the phage add genes from the host and transfer them to other cells => new expression possible, e.g. cancer, mutations, etc.**);** **.3)** Surfacemolecules; **4)** Small genome**; 5)** Strategy of replication; **10)** Morphology; **11)** Size of the capsid. ;;; Another level of classification is based on the presence or absence of a membranous envelope around ;;; **Viruses Come in Different Shapes;;;**e.g. : (a) inner helix of RNA covered with helical array of protein molecules;*(b)* Adenoviruses have an icosa-hedral capsid as an outer shell. Inside this 20-faced structure is a spherical mass of other proteins and DMA. *(c)* These T2 bacteriophages illustrate the binal form of capsid. *(d)* Not all virions are regular in shape. Wormlike virions of Ebola virus infect humans, causing hemorrhages. the virion; still further subdivision relies on capsid size.;;; **Viroids: RNA without a Capsid:** The distribution of viruses in terms of host organisms is puzzling. Viral diseases of flowering plants are very common, but such diseases are rare in the cone-bearing seed plants, ferns, algae, and fungi. Almost all vertebrates are susceptible to viral infections, but among invertebrates, such infections are common only in arthropods. A group of viruses called arboviruses (short for arthropod-borne viruses) causes serious diseases, such as encephalitis, in humans and other mammals. Arboviruses are transmitted to the mammalian host through a bite (certain arboviruses are carried by mosquitoes, for example). Although carried within the arthropod vector's cells, arboviruses apparently do not affect the insect host severely; they affect only the bitten and infected mammal,;;; Pure viral nucleic acids can produce viral infections under laboratory conditions, although only inefficiently. Might there be infectious agents in nature that consist of nucleic acid without a protein capsid-> isolation of agents of this type, called viroids. Viroids are single-stranded RNA molecules consisting of 270 to 380 nucleotides. They are one-thousandth the size of the smallest viruses. All the viroids studied thus far have substantial regions of internal complementarity, so they fold into double-stranded rods. These rods are most abundant in the nuclei of infected cells. Viroids have been found only in plant cells. There they produce a variety of diseases. Two mechanisms are known by which viroids may be transmitted from plant to plant. If two plants (one infected and one uninfected) are injured and their wounded surfaces come into contact, viroids may be transmitted from the infected plant to the uninfected one. The other mechanism of transfer operates from generation to generation. If a pollen grain or an ovule produced by an infected plant contains viroids, these will infect the plant produced after this gamete unites with another in fertilization. ;;; There is no evidence that viroids are translated to synthesize proteins, and it is not known how they cause disease. Viroids are replicated by the enzymes of their plant hosts. Similarities in base sequences between viroids and transposable genetic elements strongly suggest that viroids evolved from transposable elements; ;;; Scrapie-Associated Fibrils; Infectious Proteins?A class of protein fibrils, called scrapie-associated fibrils, or prions, has been associated with certain degenerative diseases of mammalian central nervous systems. These fibrils consist entirely of protein, with no evident nucleic acid component. The fibrils are associated with scrapie, a disease of sheep and goats, and may be the infective agent of the disease. Such fibrils have also been identified in connection with two similar diseases of the human central nervous

;;; TEST Example

Features of leaves

Microphylls arose from lateral appendages that initially lacked vascular tissue**.** T

Lygodium and *Gleichenia* have leaves with indeterminate growth. T

Leaves are always the principal photosynthetic organs in flowering plants. F

Megaphylls arose from dichotomously branching axes. T

Can regenerate new leaves directly. F

Spore-producing vascular plants

These are known as bryophytes and pteridophytes. T

Heterosporous plants have exosporic gametophytes. F

The sexual dispersal unit in homosporous pteridophytes is the microspore. F

All have placentas. T

Homosporous members have bisexual gametophytes. T

Bacterial metabolism

Chemolithotrophs obtain their energy from light. F

Chemolithotrophs obtain their carbon from CO_2. T

Chemoorganotrophs obtain both energy and carbon from pre-existing organic compounds. T

Bacterial photosynthesis is always anoxygenic. F

Reduction of CO_2 to CH_4 is widespread in bacteria. F

The Archaea

show high resistance to heat, cold, salinity and pressure. T

include *Halobacterium halobium*. T

include actinobacteria. F

lack peptidoglycan in the cell wall. T

can be aerobic, anaerobic, phototrophic or chemotrophic. T

5. Fossil plants
   a) Stomata are absolutely diagnostic of land plants. T
   b) The earliest land plants were herbaceous. T
   c) Many lacked roots and leaves. T
   d) Algal fossils predate those of land plants. T
   e) Fossil trees make up the Carboniferous coal measures. T

References: my notes in Queen Mary University of London; Wikipedia; other Internet sources; "Life. The science of Biology" 7th edition, Purves, Sadava, Orians, Heller; etc. However, if you have any questions, etc. don't hesitate to contact, call or e-mail us