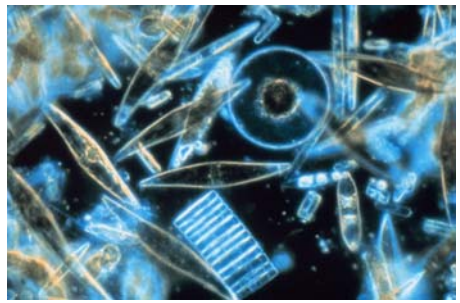
BIOL 200/4
FUNDAMENTALS – HUMAN BIOLOGY
Lecture 12: The Living World Around Us



Lecture plan

1. Taxonomy
2. The origins of life
3. Evolution, ethology, ecosystems

Taxonomy

--is a classification of living organisms into the groups or *taxa (the classification is latin-based)*

-modern taxonomy was initiated by Carl Linnaeus who used a binomial nomenclature that contained the name of genus and a definition that identifies each species (Example: *Homo sapiens*)

-the taxonomy places every organism in *a* classification pyramid that starts from *kingdoms* which are divided into *phyla* (singular: *phylum*) for animals, or *divisions* for plants and fungi, and runs all the way down to species

		Group	**(Subgroup)**
Kingdom	Example:	Animalia	
Phylum	*(Homo*	Chordata	(Vertebrata)
Class	*sapiens*)	Mammalia	(Theria)
Order		Primates	(Haplorrhini)
Family		Hominidae	(Homininae)
Genus		*Homo*	
Species		*H. sapiens*	

Carl Linnaeus (1707-1778)

-the hierarchical system of taxonomy moves from a base containing a large number of organisms (kingdom) towards a relatively small group with very specific characteristics (species)

-a species is a group of closely related organisms that are able to interbreed and produce fertile offspring

-similar species are grouped into a broader taxon called a genus (genera, plural) genera are grouped into families orders classes

-to place a life form into the existing system, biologists analyze:

(i) anatomy and structure of internal organs and systems (for multicellular life forms) or a morphology (shape) and biochemical specifics (for unicellular organisms)

(ii) the early stages of an organism's development, its behavior and habitat

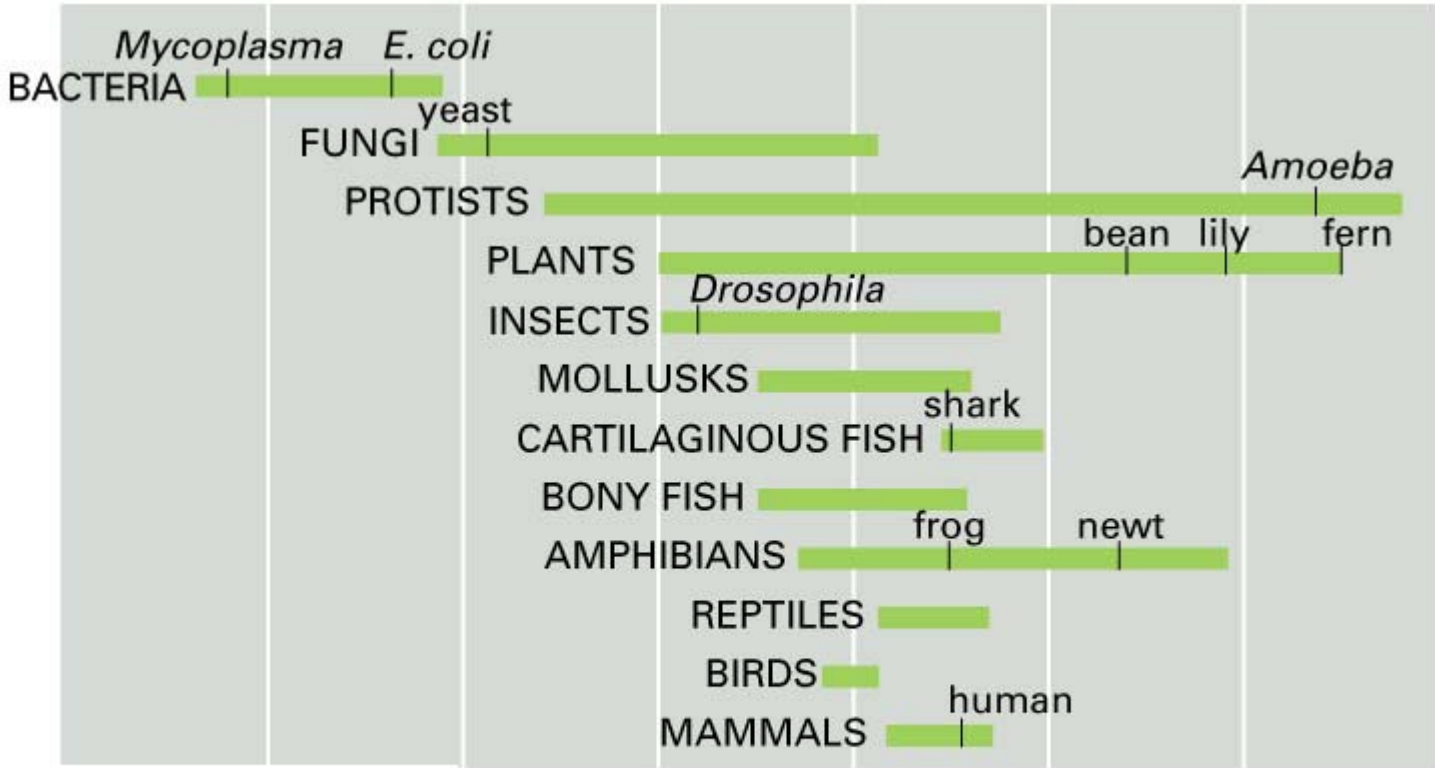
(iii) the fossil record

(iv) genetic and protein similarities (a so-called molecular systematics)

Classification

-grouping, systematics or classification is based on the similarities and traceable evolutionary history of the life forms

-systematics is a main source of the information for the taxonomy in which scientists determine how to place living organisms into an existing classification scheme



Convention on Biological Diversity (CBD)

-calls for "the protection of ecosystems, natural habitats and the maintenance of viable populations of species in natural surroundings“ (ratified by 188 countries, including Canada)

-promotes a biodiversity, i.e. having a greater number of species within one ecosystem

-the biodiversity action plan (BAP) lists the endangered species and their habitats (some countries of European Union, Middle East and Africa are reluctant to support BAP)

-CBD analyzes multiple *abiotic* factors including elevation, humidity, drainage, salinity of water, etc; these data are presented in Land Cover Classification System (LCCS), aquatic classification systems and other documents

-ecosystem services are aimed to preserve natural surroundings, and they could be either direct (Example: hunting and fishing restrictions) or indirect (Example: climate moderation)

Life in uninhabitable conditions

-multiple life forms are able to survive in oxygen-poor, high-salt or waterless conditions

-bacteria are able to survive in high-heat and high-radiation conditions

(i) the highest limit of bacterial viability has been set at 130°C
(ii) the radiation-resistant species of bacteria could withstand the γ-ray doses 1000 fold greater than other organisms

-several species of bacteria that live in the alkaline (high pH) conditions are able to convert mirrored sugars and aminoacids

-“space travel” modifies common bacteria

-experimentally grown *Salmonella* became more virulent after a trip aboard spaceship
-lack of movement, rather than the absence of gravity makes this bacteria more dangerous as it promotes a formation of biofilm, the antibiotic-resistant and therefore extremely dangerous microbial coating of the surface

Ecosystem

-the term was introduced in 1930 by Roy Clapham

-ecosystem is the interactive system established between *biocoenosis* (a group of living creatures) and their *biotope* (the environment in which they live)

-interacting ecosystems make up the biosphere

-the examples of ecosystems are the desert, aquatic and marine ecosystems, urban ecosystem, rainforest, tundra, etc

-introducing a new *biotic* or *abiotic* element into the ecosystem could have a disruptive effect

- the ecological health of the ecosystem depends on
  (i) a disruptive effect of the introduced element
  (ii) the ability of the original ecosystem to recover

-the largest assessment of the earth's ecosystems was published in 2005

Valuable species: bluefin tuna (horse mackerel)

-weight ~300 kg, length ~ 2 meters; lifespan ~30 years, warm-blooded fish (27°C), swimming speed up to 80 km/h (considered to be a marvel of hydrodynamic engineering)

-until 1900s was an object of a sport fishing and not a food source

-to prevent a market-linked depletion, half-grown tuna are fed in marine ranch pens

-by adjusting water temperature and a light the breeding is thought to be possible all year around (naturally, it occurs during summer)

-Japanese scientists were able to hatch bluefin tuna from egg and to raise them to a breeding age in the laboratory

The living world around us (I)
Endangered herbs: Banana

-banana tree is considered a world's biggest herb and its fruit considered a berry

-the most frequently consumed is a yellow Cavendish banana

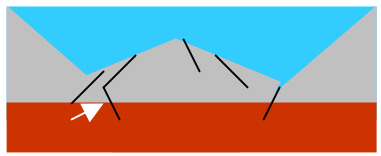
-by 1950s, a fungal infection known as Panama disease has eliminated a popular back then Gros Michel variety that was eventually replaced by a Panama disease resistant Cavendish

-unfortunately, Cavendish is becoming increasingly sensitive to new infections largely because it has a very little genetic variability: this seedless plant is propagated without cross-pollination; in fact, banana is an example of cloned plant

The origins of life: biosignatures

-the biosignatures, i.e. probable evidence of life, include a presence of oxygen (ozone), water, methane (CH_4) or more complex organic compounds, and nitrous oxide

-rarely, the organic matter could be produced when carbon from the Earth mantle interacts with a hydrogen-rich sea water



(this unusual source of hydrocarbons was recently discovered in Lost City, atop a submerged mountain in the Atlantic Ocean; the ocean floor in this area is full of cracks that reach all the way down to the mantle and are filled with hydrocarbon-filled fluid

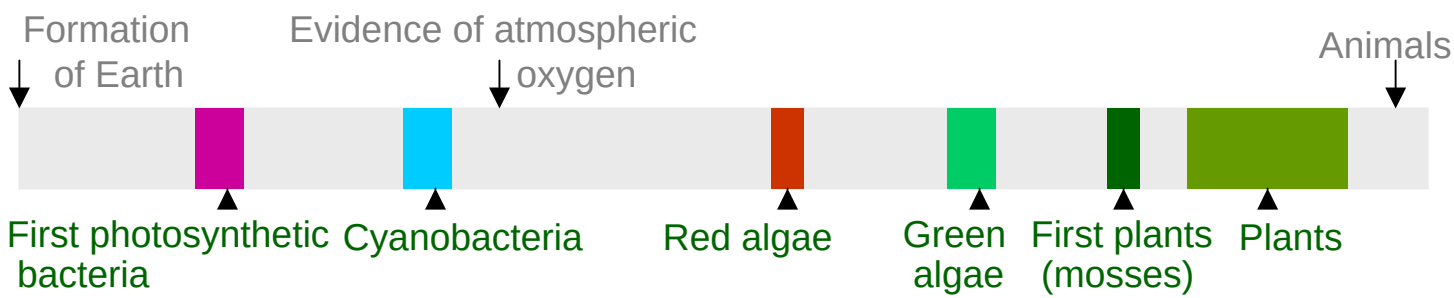
-although carbon and hydrogen isotopes in these hydrocarbons are different from those found in life forms, presence of organic matter is no longer an unquestionable biosignature

Homework: Find the information about "bursts of evolution" which show that active changes were followed by the extended periods during which species remained relatively unchanged

Astrobiology: the colored signs of photosynthesis

-in search for life on extrasolar planets, scientists look at pigmentations of their surface; specifically they search for the color indicators of photosynthesis

-photosynthetic pigments of ancient Earth bacteria are not green but purple and cyan



-the non-biological life probability criteria include:

(i) a type of star (based on its temperature, size, etc): F,G, K, and M stars could emit the energy that is suitable for photosynthesis-suitable energy (Sun is a G-type star)

(ii) a habitable zone around star (in solar system it is the Earth-Mars range)

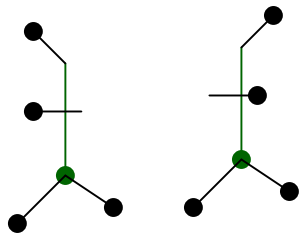
(these materials were published by N. Y. Kiang et al. in Astrobiology, vol.7, Feb, 2007)

Search for alternative life forms

Search for the unusual biomolecules that could belong to non-conventional life forms:

Search for conventional biosignatures
in uninhabitable conditions and astrobiology

-search for a mirror life



simple building blocks for biomolecules, such as monosaccarides and aminoacids come in two types (L and D) of so-called stereo-isomers; all known life forms consume D-glucose but L-aminoacids

-search for unusual aminoacids

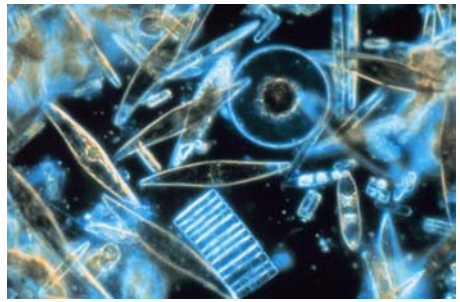
at least two unusual aminoacids isovaline and pdeudoleucine have being found in meteorites

-arsenic as a probable substitute for phosphorus

arsenic mimics phosphorus, suggesting that in some living systems this element could replace phosphorus

-silicon instead of carbon-based molecules

Silicon life: diatoms



-diatoms are the type of algae and the most common type of phytoplankton which represent a major food source for molluscs (oyster) and fishes

-diatoms exist in uni- and multicellular forms (max size 2 mm)

-diatoms are surrounded by cell wall made of silica (a hydrated silicon dioxide) and come in a variety of geometric forms

-diatom’s genome has been sequenced and genes responsible for silica deposition are currently known

-this knowledge could be used in the constructing various nanoscale 'widgets', optical systems, and materials for the semiconductor industry

-the diatom-like shells could be used as vehicles for drug delivery

Ethology

-ethology is a study of animal behavior; the term was introduced in 1902; the science was actively developed after 1920s by N. Tinbergen and K. Lorenz

-ethology is linked to ecology and evolution and it includes studying a communication between life forms, their adaptation, etc based on their genetics, anatomy and phylogenic history

-ethology is not to be confused with a comparative psychology which views the animal behaviour as an instinctive behavior with a node towards human psychology

-traditionally, the first step in studying the behaviour of a new species is to construct an **ethogram** which lists behavioral patterns and frequencies of their occurrence

-Konrad Lorenz was first to systematically record fixed action patterns (FAPs), i.e. the instinctive responses that reccur in the presence of repetitive stimuli

-FAPs are thought to be a rational explanation for “animal communication” including its complex forms (Example: groups of ravens effectively use their “trick-or-treat” behavior to steal from wolves)

Evolution

-is the process of change in the inherited traits from one generation to the next

-inherited traits depend on a genetic information that is passed on to offspring; new traits are introduced by a gene flow between the populations, by a genetic recombination (meiotic gene swapping), and by mutattions

-evolution occurs either non-randomly through a natural selection or randomly, through genetic drift (see Lecture 9)

-*macroevolution* occurs at the level of species, while a *microevolution* that yields much smaller evolutionary changes, such as adaptations, occurs within populations

-most prominent behavioral and physical adaptations are the result of a
(i) a natural selection
(ii) a co-operation between organisms of the same or different species (symbiosis)

-the evolution directs towards a better adaptation, and only sometimes it results in a greater complexity

The ancestry of humans: back to old man

-modern humans (*Homo sapiens*) are thought to descend from a group that left Africa ~100,000 years ago and replaced older european settlements; all modern variations of Y chromosome and mitochondrial DNA are traceable back to this African group

-sequencing of X-chromosome showed that this modern group occasionally mated with *Homo erectus*, an ancient human species that originated 2 million years ago

Australopithecines
Homo erectus
Homo heidelbergensis
Homo neanderthalensis
Homo sapiens

-in contrast, no evidence of gene swapping was found between humans and closely related Neanderthals

-*Homo erectus* ceased to exist about 30,000 years ago, thus overlapping with modern humans by about 15,000 years