EVOLUTION, SPECIES, ZOOLOGICAL NOMENCLATURE, ZOOGEOGRAPHY

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FAPPZ 37

ORIGIN OF LIFE

- Where?
- Whenn?
- How?

- Question „where“ has only two possible answers: on the Earth or somewhere in the Universe (under quite different conditions)
- Whenn? (if on Earth), we know relatively precisely (isotopes C of biogennic origin) – 3.9 billions years ago (3 900 000 000)
- How? We do not have enough knowledge

THE ORIGIN OF THE FIRST CELL

- A large number of different organic substances floated in the ocean which, if met, united. This was repeated with another compounds, to form a bunch entitled **coacervate**
- After coacervate acquired certain dimension, it disbanded in two or more parts, which continue to join with another organic compounds, again reached certain dimensions and crumbled again
- Certain chemical reactions apparently occurred inside coacervates which would normally do not occur in the surrounding ocean. In such a way, the first protein was built whose structure was then somehow built into nucleic acids. Such, certain order (rule) was created, this structure was encapsulated by a membrane, began to copy DNA accurately, etc.

ARE ALL ORGANISMS ON THE EARTH MONOPHYLETIC?

- Monophyletic = common ancestor
- Most scientists think yes (strong evidence: uniform system of passing genetic information)
- First cells on the Earth differentiated into three types: archaebacteria, eubacteria and eucaryonta
- Archebacteria together with eubacteria form procaryonta: procaryontic cells are much smaller, have only a single membrane, lacking organoids (no nucleus, a single chromozome in cytoplazm), all other parts (ribosoms, special biochemic cycles) are free, no cytoskeleton
- Eukaryontic cells are larger, nearly all parts are firmly attached inside membranous compartments and the shape of cells is strengthened by cytoskeleton

WE HAVE PRACTICALLY NO INFORMATION ABOUT BIOLOGY OF THE FIRST ORGANISMS

- We cannot use knowledge on extant organisms (surely very different), cannot use evolutionary theory, so several conflicting hypotheses appeared
- Often cited: fusion hypothesis (by fusion of eubacterial with archebacterial cell originated „urcaryontic“ cell and fusion of urbacterial cell with another bacterial cell (which later on changed into mitochondria) resulted in eucaryontic cell
- ?? Cytoskeleton
- ??Much larger size of eucaryontic cell
- This theory is not universally accepted

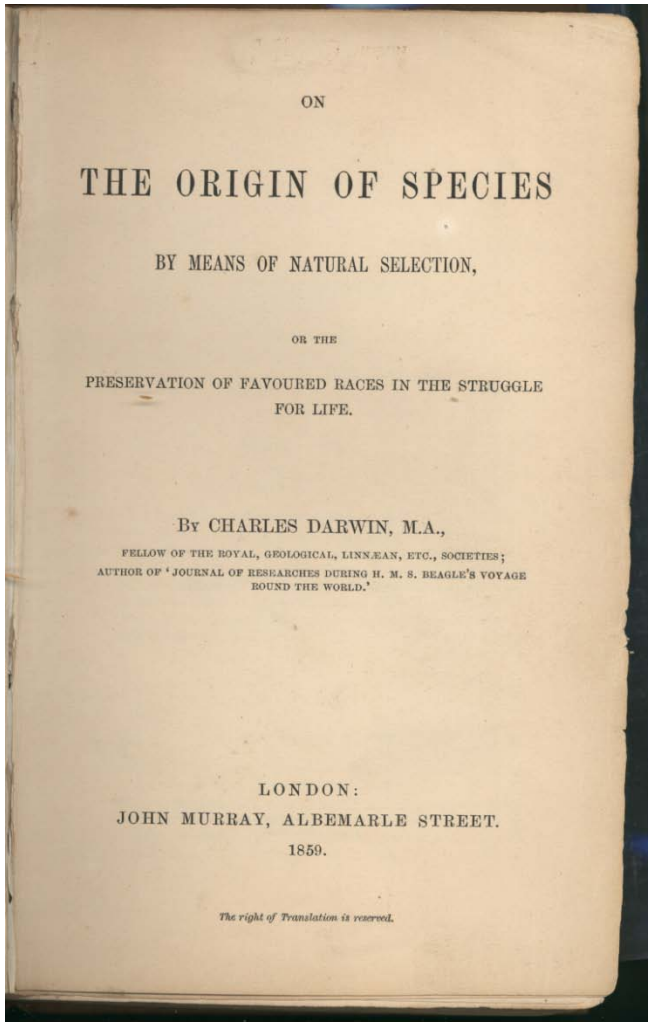
THE ORIGIN OF MULTICELLULAR ORGANISMS

- All multicellular organisms on our Earth are eucaryontic, procaryontic ones form at most colonies
- Teories about origin of m.o. often rely on Haeckel´s biogenetic law
- In early morula, cells start to produce special chemical, morphogen, captured by nearby cells. Concentration gradient of this compound differentiates cells into groups, and according to these differences cells develop in different specialised tissues, which process, later in ontogenesis, creates certain organ
- Maybe, similarly, by chemical communication between cells, orientation of cells in space, specialization and differentiation lead to the origin of m.o.

THE ORIGIN OF NUMEROUS FORMS OF LIVING THINGS

- Two basic groups of theories:creationistic and eolutionary
- Creationism (certain „higher form“ – God – created Universe with all living beings in their final and unchangeable form) is deeply rooted in most religions
- Evolutionism (organisms change from time to time) evolved slowly in the end of 18th century, his older versions represents e.g. J.B. Lamarck or Erasmus Darwin: organisms are changing in time based on „internal feeling“, by means of „living force“, etc.

EVOLUTIONARY THEORY WAS ERECTED BY CHARLES DARWIN (1809-1882)



ON

THE ORIGIN OF SPECIES

BY MEANS OF NATURAL SELECTION,

OR THE

PRESERVATION OF FAVOURED RACES IN THE STRUGGLE FOR LIFE.

By CHARLES DARWIN, M.A.,

FELLOW OF THE ROYAL, GEOLOGICAL, LINNÆAN, ETC., SOCIETIES;
AUTHOR OF 'JOURNAL OF RESEARCHES DURING H. M. S. BEAGLE'S VOYAGE ROUND THE WORLD.'

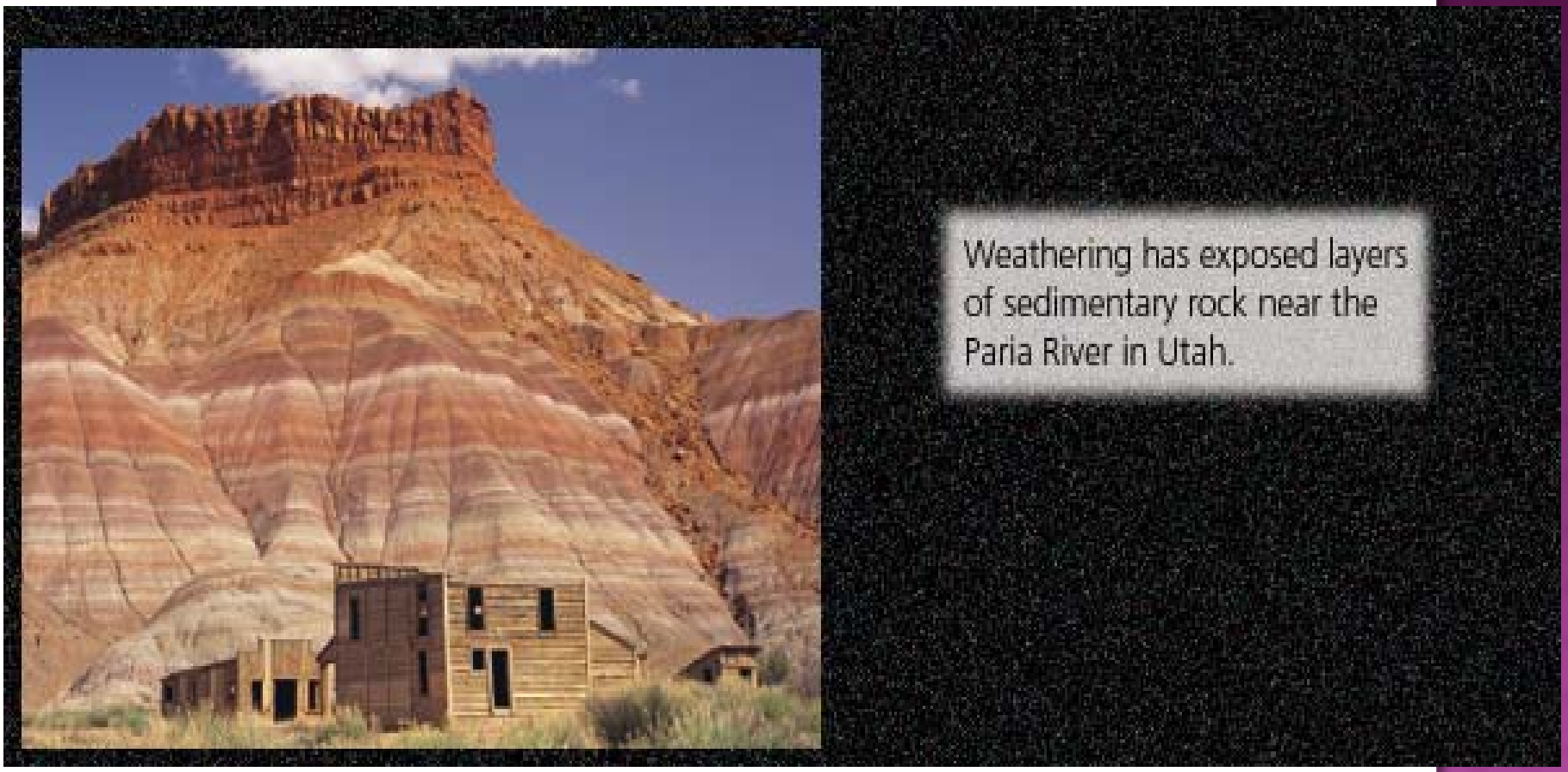
LONDON:
JOHN MURRAY, ALBEMARLE STREET.
1859.

EVIDENCE FOR EVOLUTION

- Evidence Available to Darwin
  - Fossils
  - Taxonomy
  - Comparative Anatomy
  - Comparative Embryology
  - Biogeography

FOSSILS

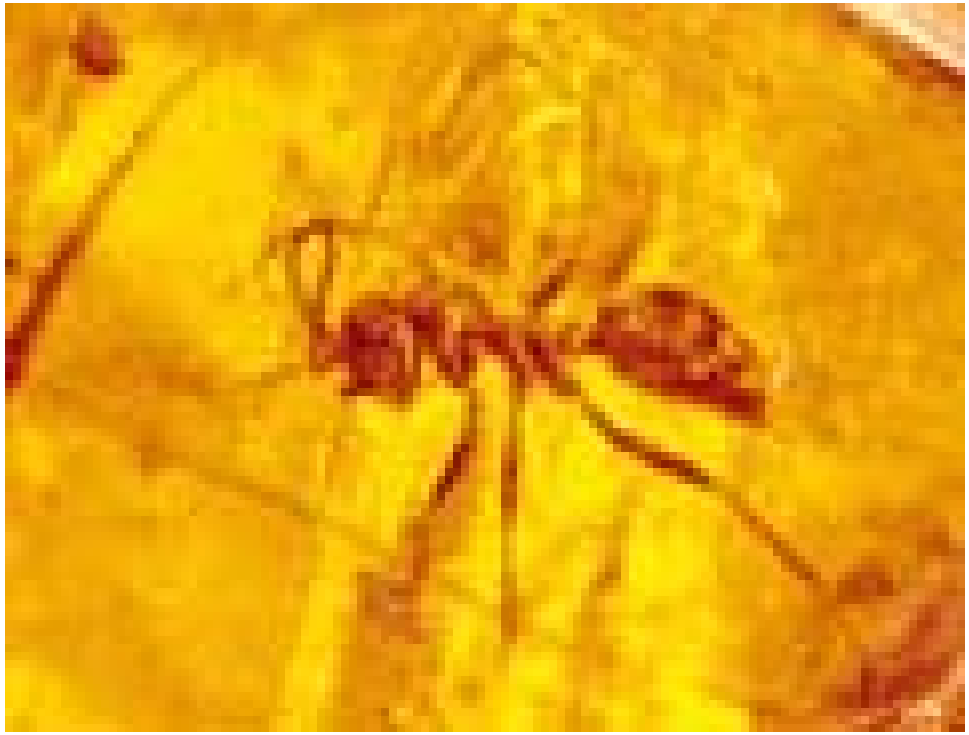
- Fossils are
  - remains or imprints of past life
  - preserved in sediments
  - occur in layers (strata)
  - many no longer occur
  - others resemble modern species



Weathering has exposed layers of sedimentary rock near the Paria River in Utah.

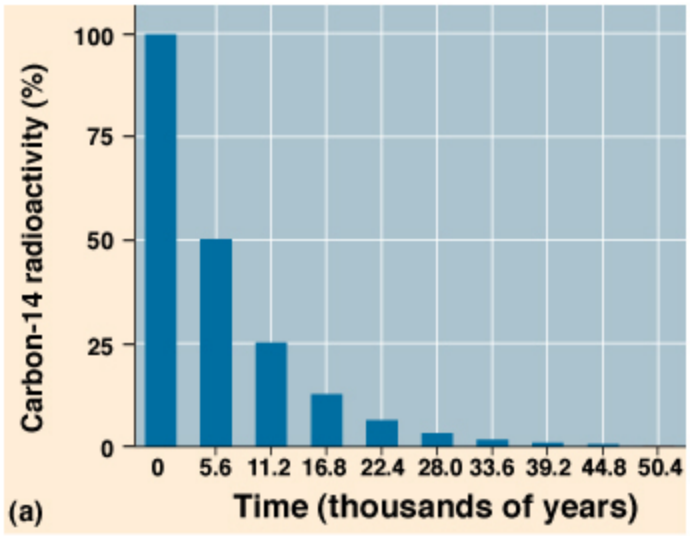
Fossilized remains of a bird like dinosaur *Archeopteryx*

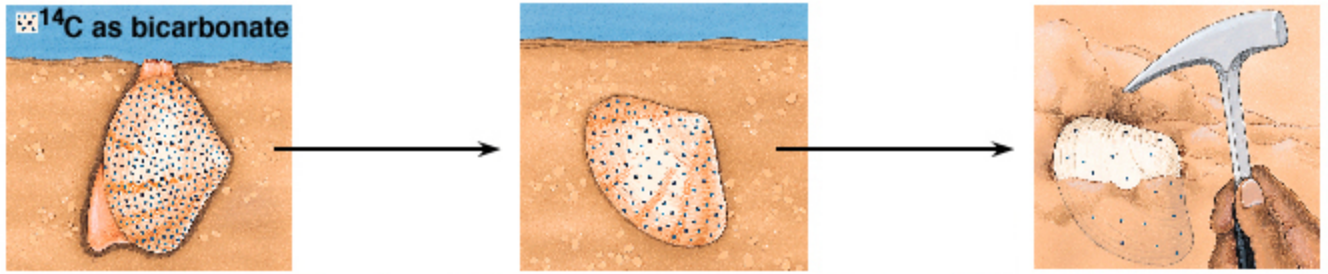
FOSSILS IN AMBER



FOSSIL EVIDENCE FOR EVOLUTION

- Fossils distributed consistently throughout strata of same age
- Order of fossil appearance shows more complex forms appearing after simpler forms
- Recent fossils (new strata) most closely resemble modern organisms





(b)

1. While an organism, in this case a clam, is alive, it assimilates the different isotopes of each element in proportions determined by their relative abundances in the environment. Carbon-14 is taken up in trace quantities, along with much larger quantities of the more common carbon-12.

2. After the clam dies, it is covered with sediment, and its shell eventually becomes consolidated into a layer of rock as the sediment is compressed. From the time the clam dies and ceases to assimilate carbon, the amount of carbon-14 relative to carbon-12 in the fossil declines due to radioactive decay.

3. After the clam fossil is found, its age can be determined by measuring the ratio of the two isotopes to learn how many half-life reductions have occurred since it died. For example, if the ratio of carbon-14 to carbon-12 in this fossil clam was found to be one-fourth that of a living organism, this fossil would be about 11,200 years old.

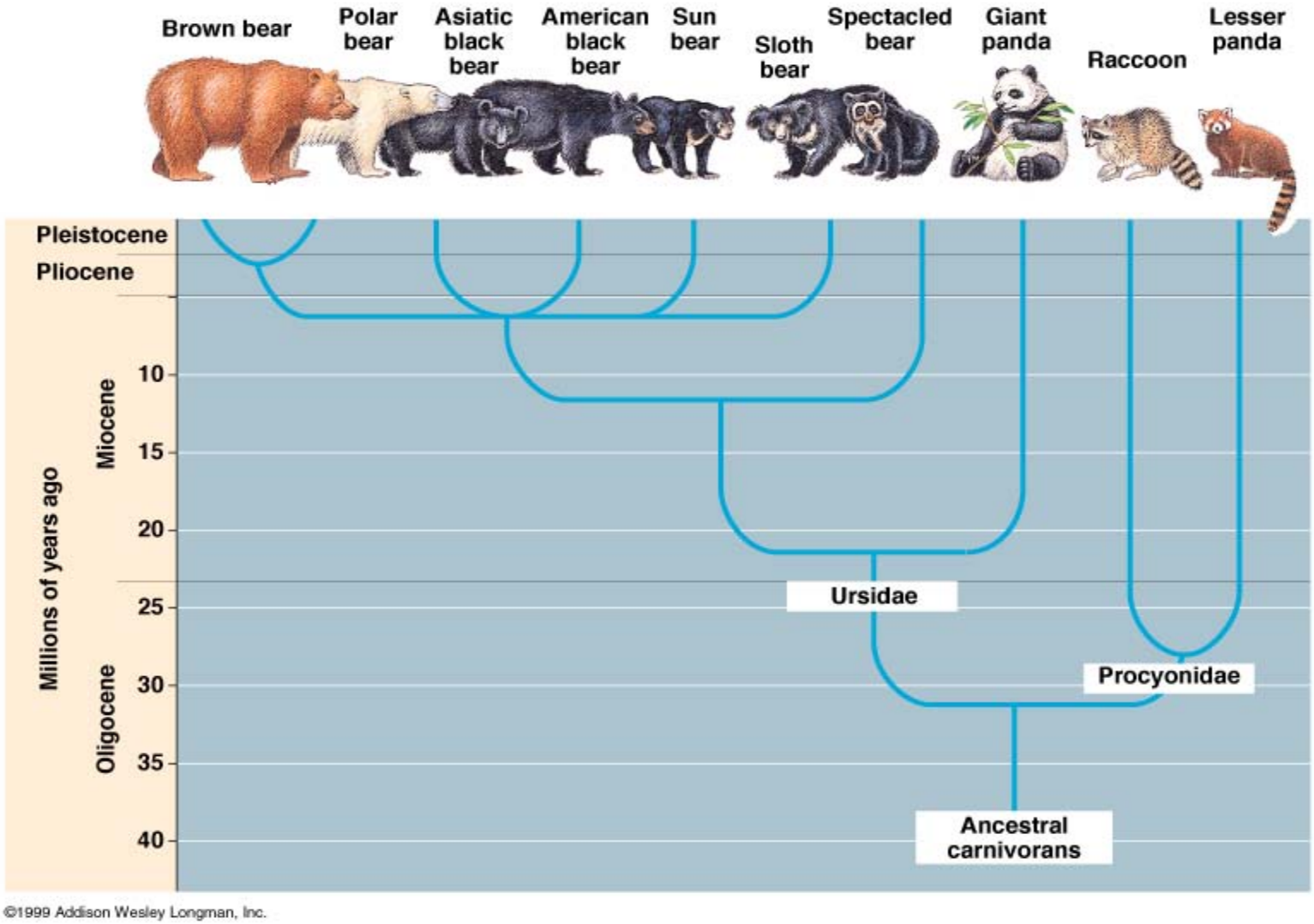
EVIDENCE FOR EVOLUTION

- Evidence Available to Darwin
  - Fossils
  - Taxonomy
  - Comparative Anatomy
  - Comparative Embryology
  - Biogeography

TAXONOMY

- Hierarchical classification structure developed by Linnaeus
- Implies that species can be grouped together based on their relatedness
- Bears with bears, bees with other bees
- A family tree can be made implying descent

FAMILY TREE OF BEARS



EVIDENCE FOR EVOLUTION

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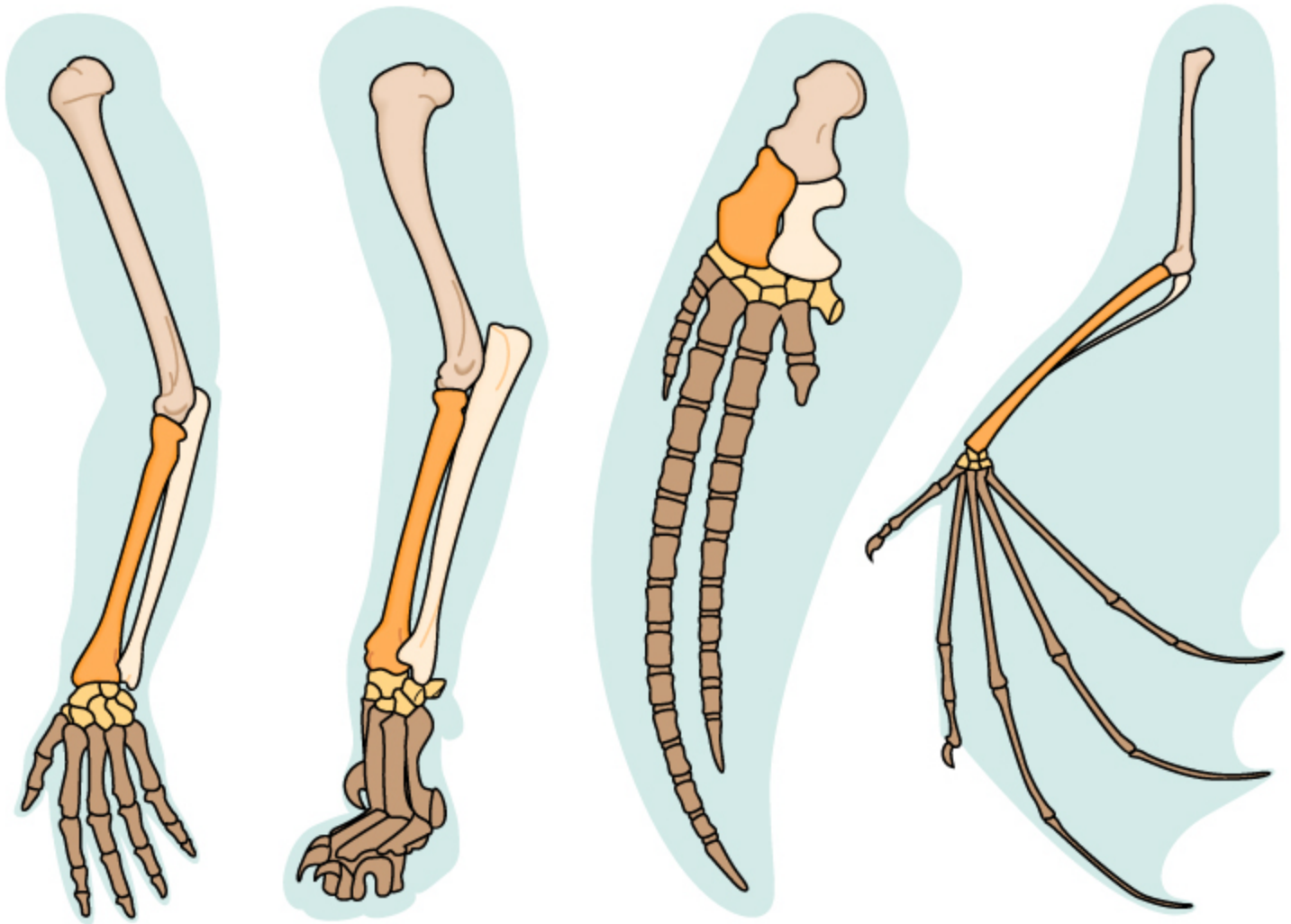
  - Biogeography

COMPARATIVE ANATOMY

- Compares anatomical structures from different organisms
- Similar structures in two or more species are called homologous structures
- Homologous structures may perform different tasks in different organisms

HOMOLOGOUS FORELIMBS



EVIDENCE FOR EVOLUTION

- Evidence Available to Darwin
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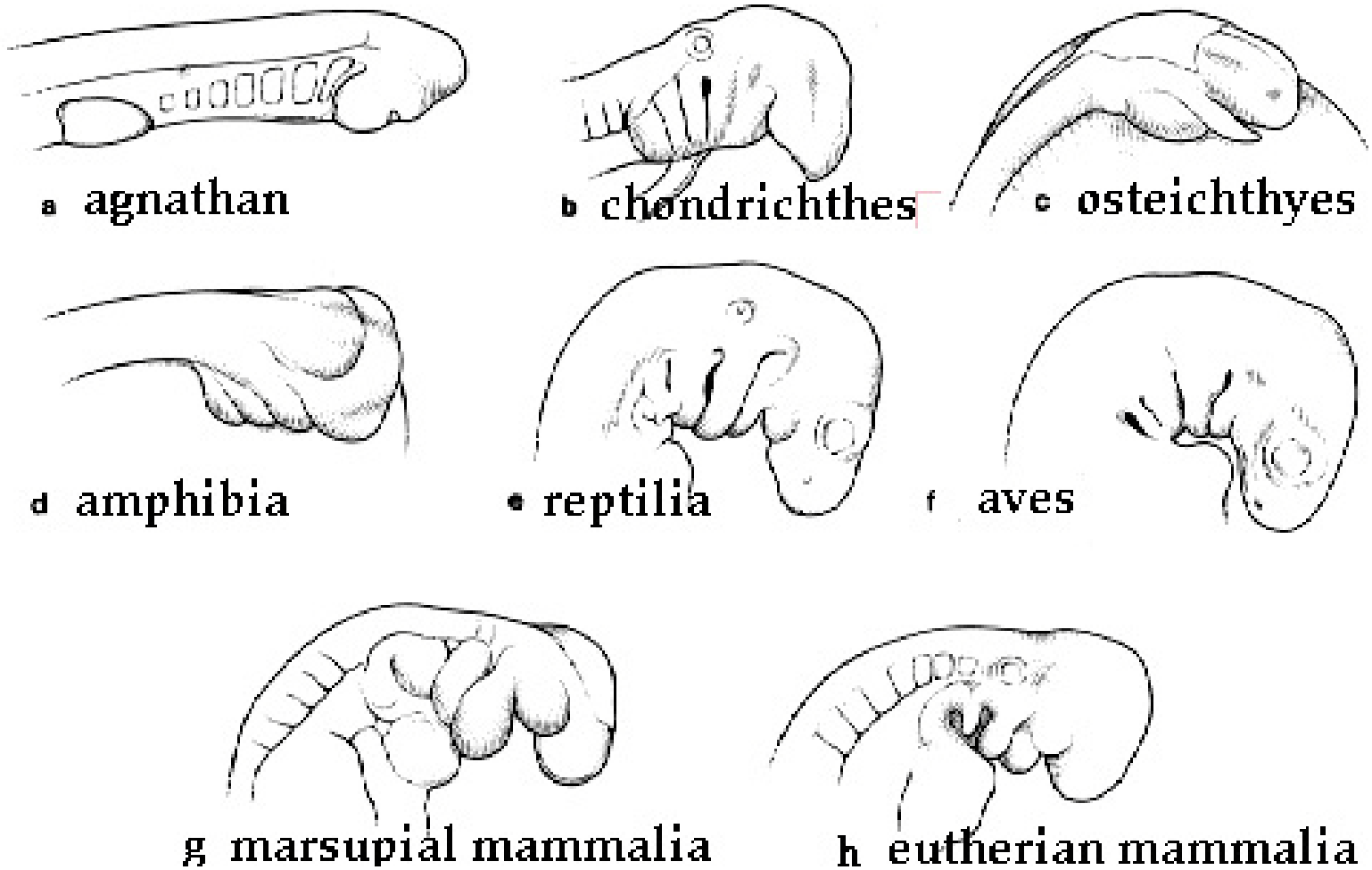
  - Comparative Embryology
  - Biogeography

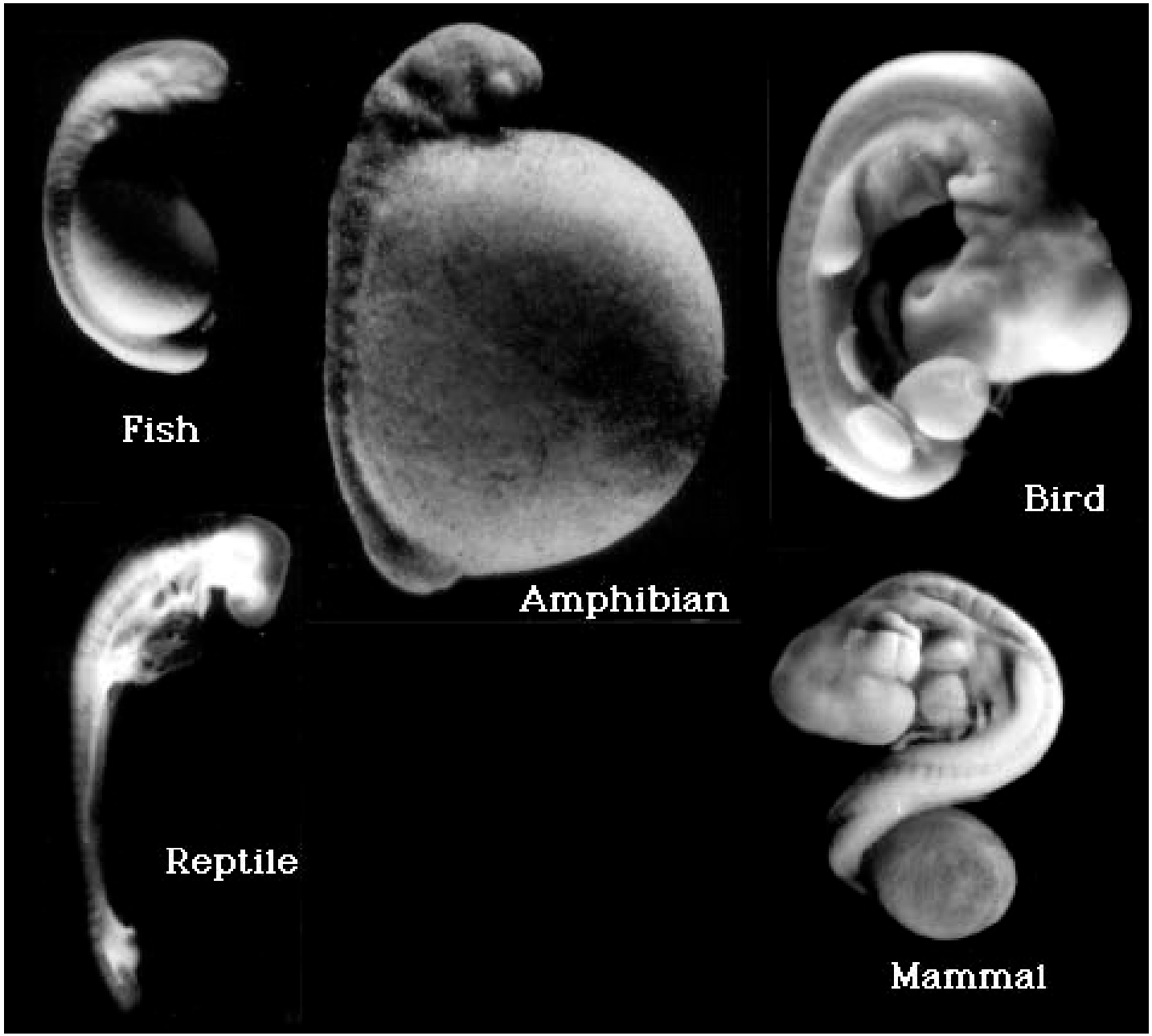
EVOLUTION VIEWPOINT

- Ontogeny is a replay of Phylogeny. (Development reflects descent)

COMPARATIVE EMBRYOLOGY

- Embryos (young stage of organisms are compared)
- Show similar features due to shared ancestry
- All vertebrates have
  - tails
  - gill-like branchial arches


a agnathan
b chondrichthes
c osteichthyes
d amphibia
e reptilia
f aves
g marsupial mammalia
h eutherian mammalia


Fish
Amphibian
Bird
Reptile
Mammal

EVIDENCE FOR EVOLUTION

- Evidence Available to Darwin
  - Fossils
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  - Comparative Embryology
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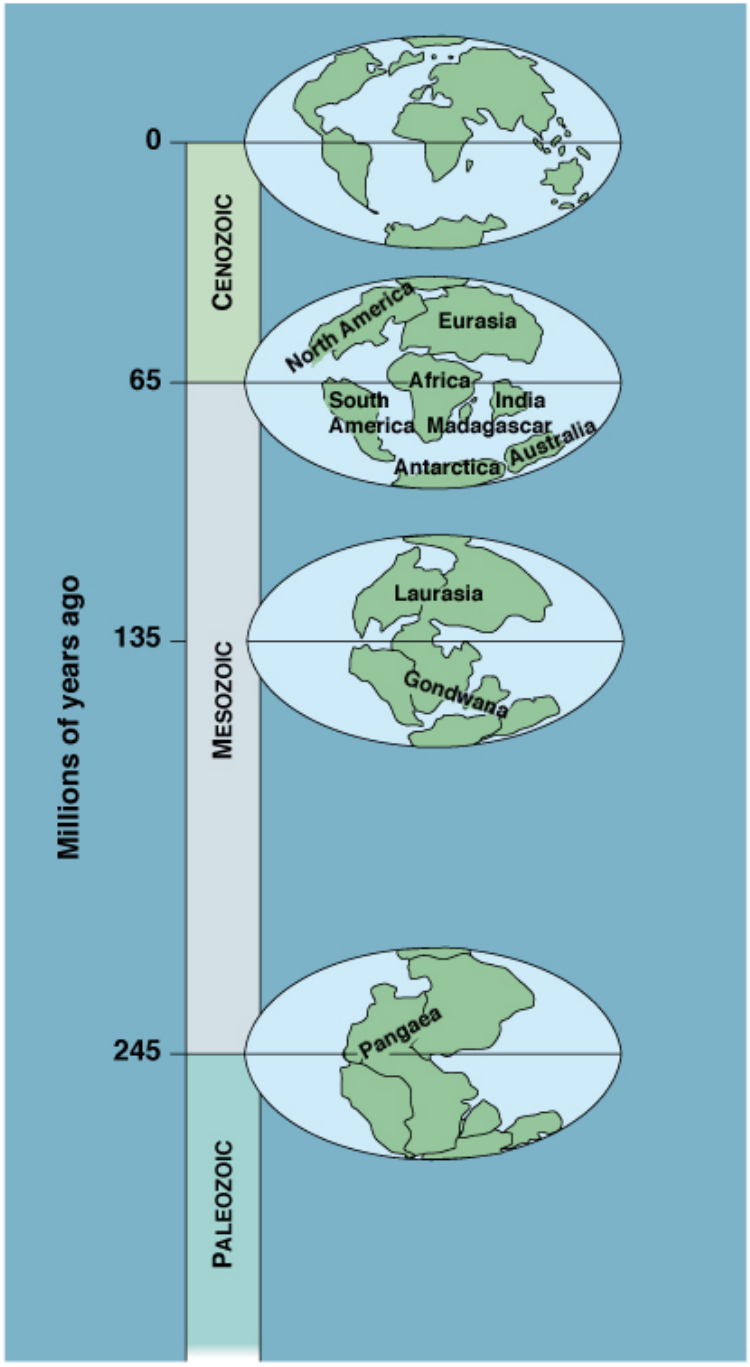
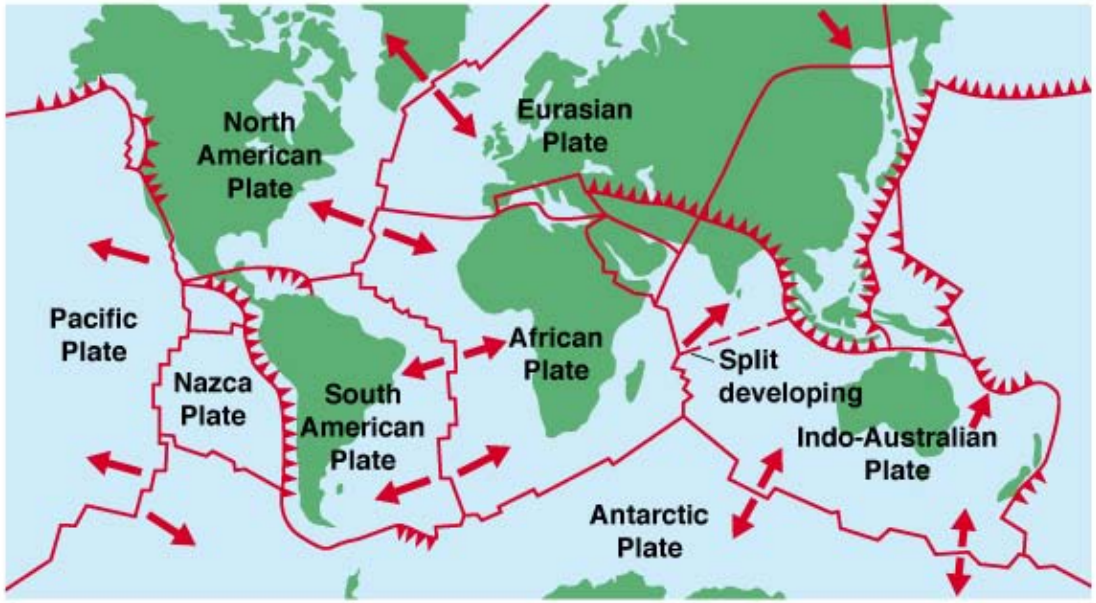
BIOGEOGRAPHY

- Distribution of species
- Many related species occur across the earth
- Isolated areas (islands, Australia) often have unique species
- Biogeography explained by continental drift of plates and speciation





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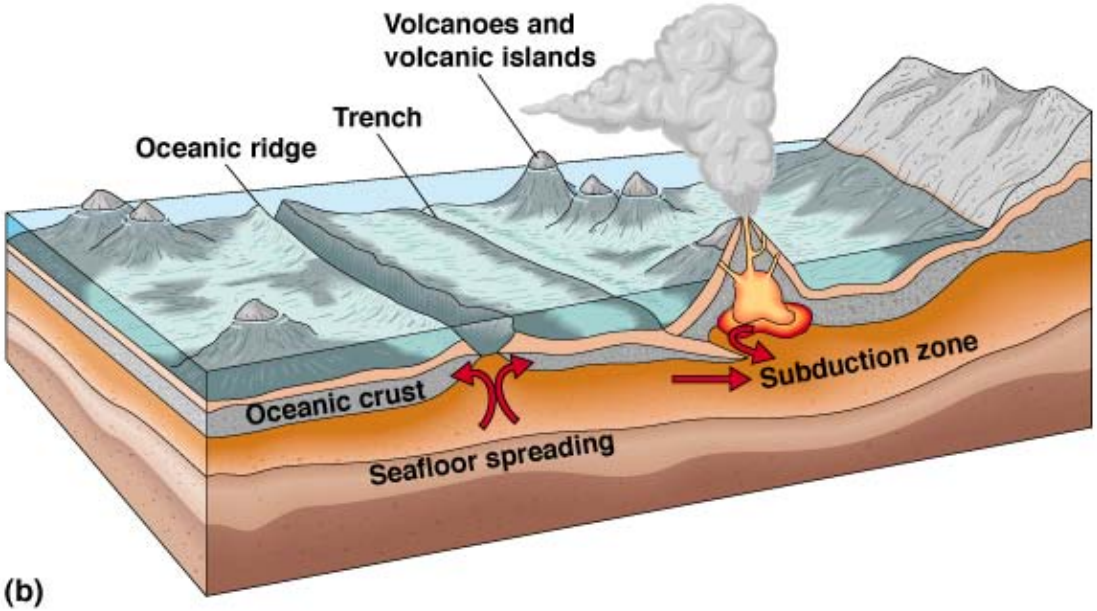

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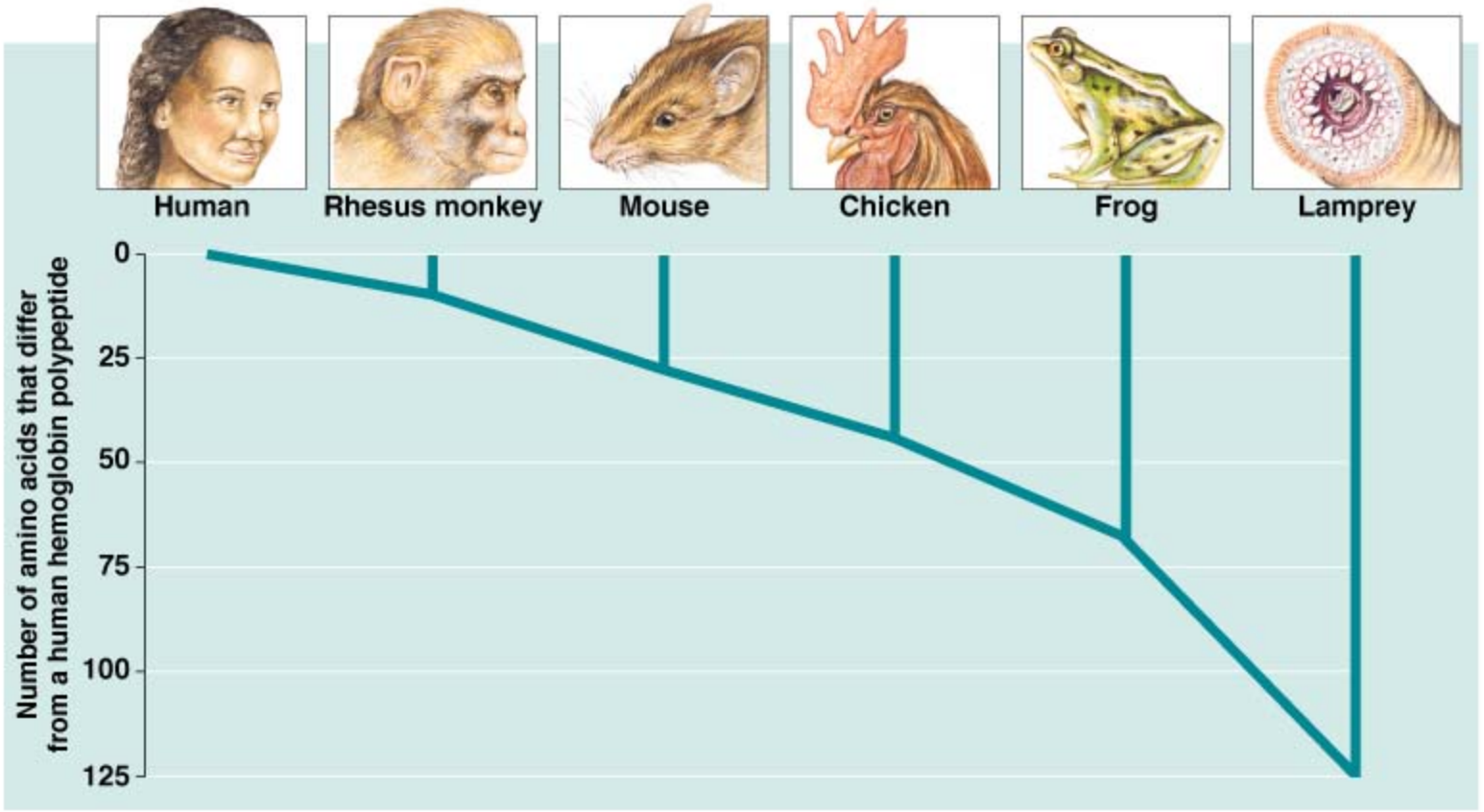
MOLECULAR BIOLOGY

- Not available to Darwin in 1800's
- Includes comparisons of
  - protein sequences
  - DNA sequences
  - cytochrome c
  - chloroplast genomes (plants only)
- Used to developed phylogenetic trees (hypothesized relationships)



EVOLUTION VIEWPOINT

- Related species share a common ancestrial DNA. The closer the relationship, the more similar the DNA sequences should be.

DARWIN QUITE CHANGED SCIENCE AND OUR VIEW OF SURROUNDING WORD

- Darwin did not need any „internal feeling“ or „living force“ to explain that species are changing in time
- Natural selection results from two facts: 1) individuals differ in characers which they pass on progeny and 2) this variation results from different abilities to survive and reproduce
- Variation: Individuals in a population show variations.
- Heritability: Variations can be inherited.
- Reproductive Advantage: Variations that increase reproductive success will have a greater chance of being passed on.
- Darwin called his theory Natural Selection.
- He reasoned that, given enough time, natural selection could modify a population enough to produce a new species.

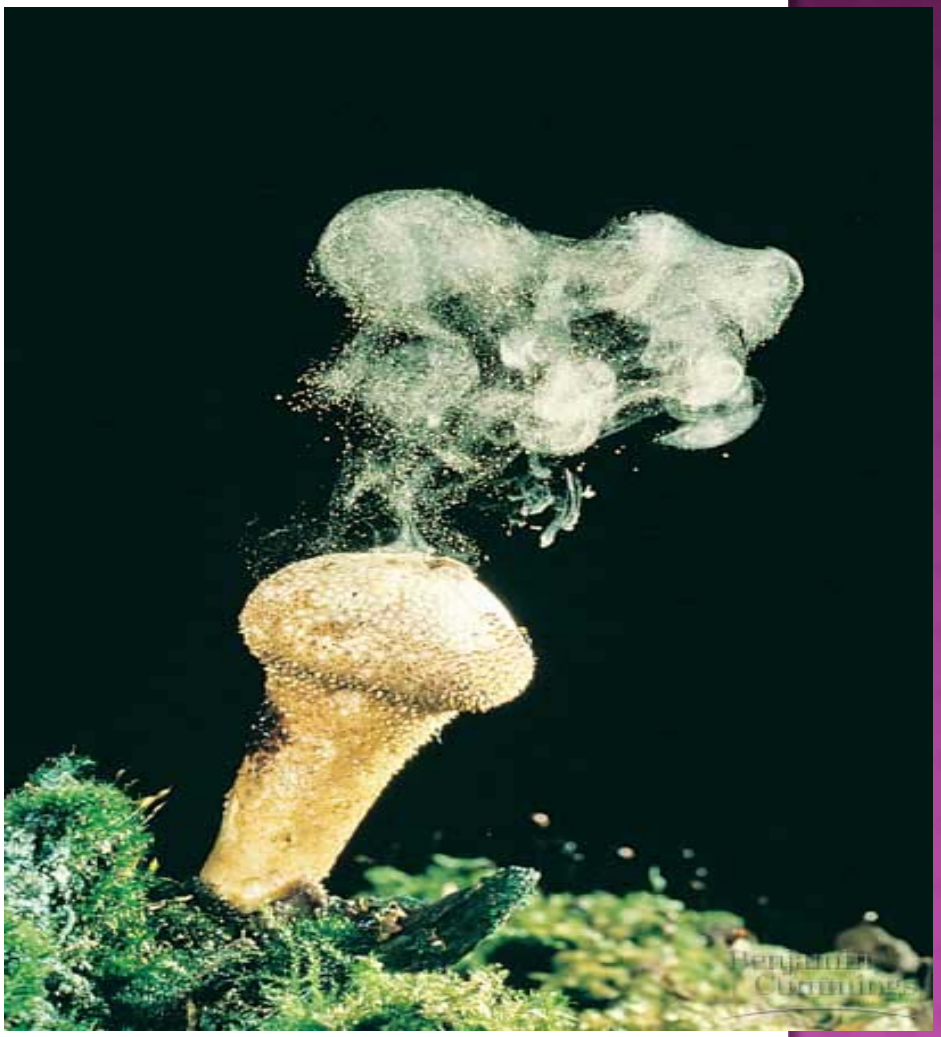
"THE ORIGIN OF SPECIES"

- Documented the occurrence of evolution.
- Suggested that the mechanism for evolution was Natural Selection.

THE FACTS:

Fact 1 -

All species reproduce themselves exponentially.



Fact 2 - Most populations are normally stable in size.

Fact 3 - Natural Resources are limited (finite).

INFERENCE 1

- The large number of offspring must compete for the finite resources.
- Result - Most offspring die.

MORE FACTS

Fact 4 - No two individuals in a population are exactly alike.

INFERENCE 2

- Those individuals whose inherited characteristics fit them best to their environment survive and reproduce.

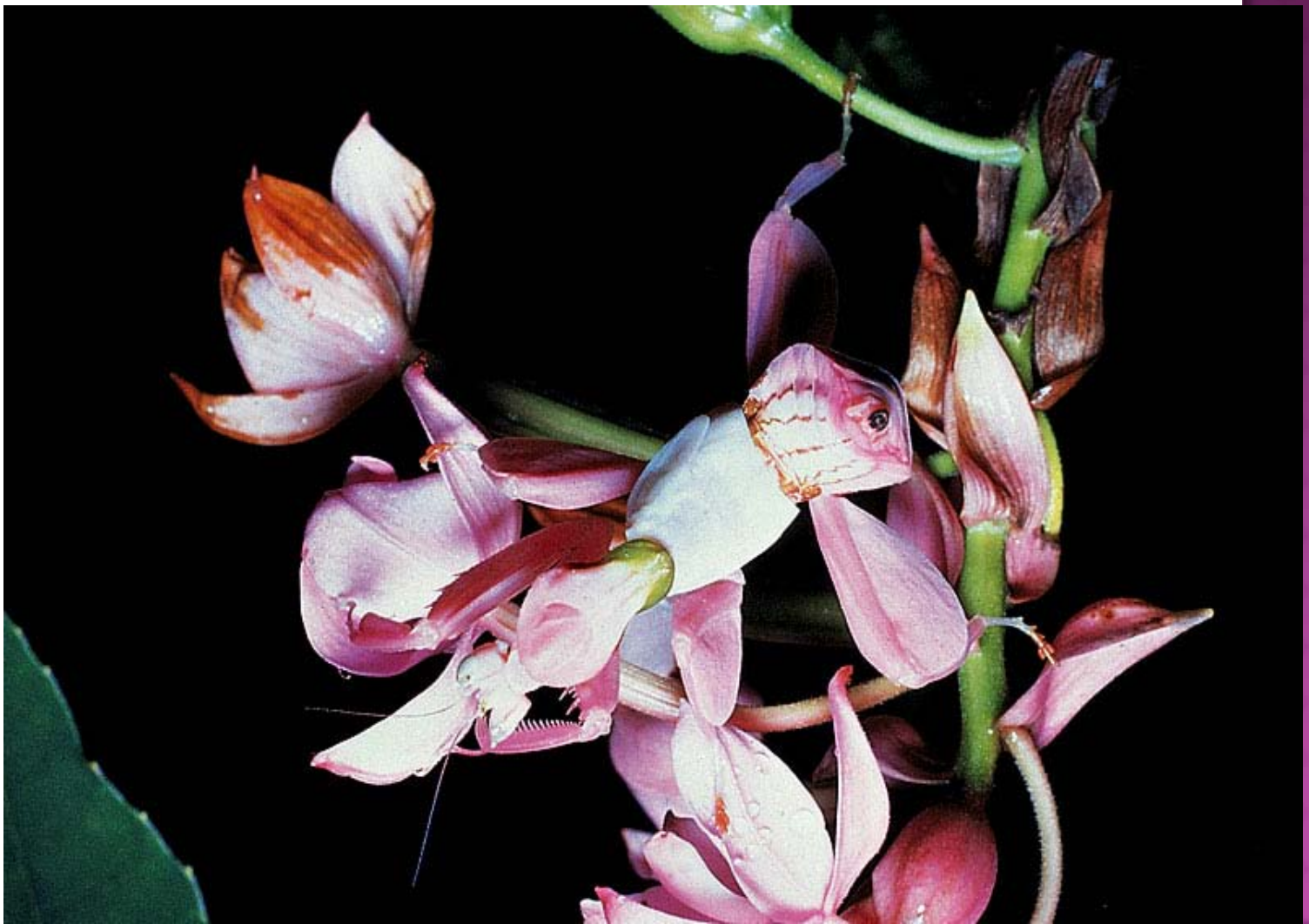
INFERENCE 3

- Offspring inherit the favorable characteristics. Populations shift over time as the favorable characteristics accumulate.

NATURE

- Determines which characteristics are favorable.
- Determines who survives.
- Result - “Natural Selection”

NATURAL SELECTION IN ACTION



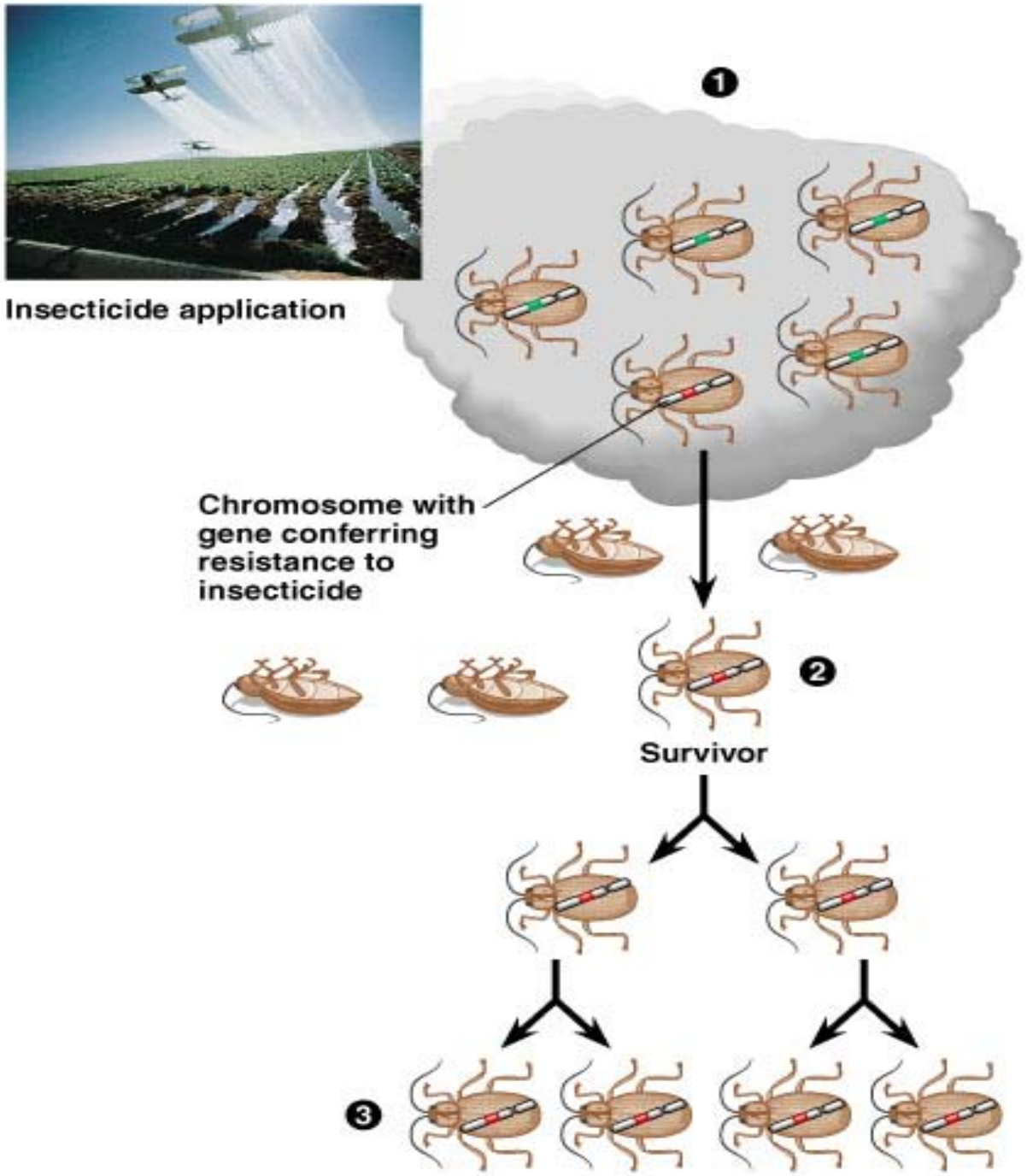
ARTIFICIAL SELECTION

- When man determines the characteristics that survive and reproduce.
- Result - the various breeds of animals and plants we've developed.

EX - MUSTARD PLANT

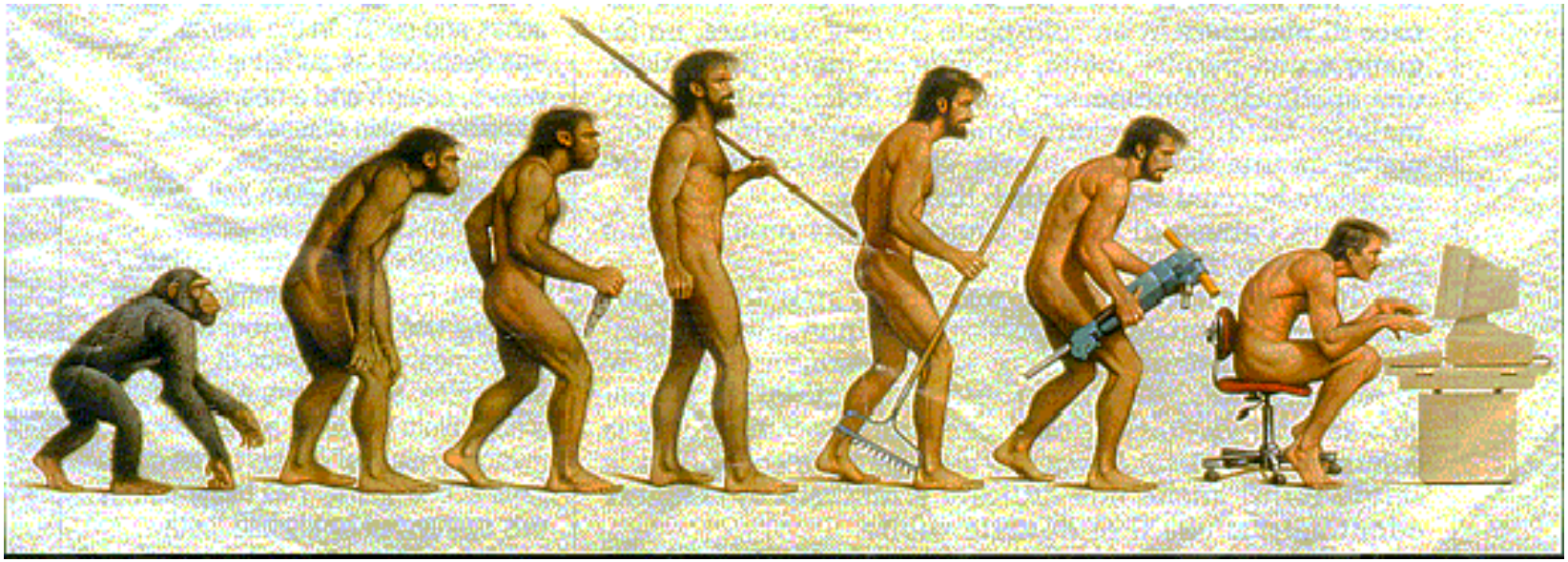
Original

Cultivars



DARWIN´S THEORIES LEAD TO THEORY OF THE ORIGIN OF UNIVERSE

- Big bang theory of the beginning of Universe
- Astrophysical evolution followed („evolution“ of galactic and planetal systems
- Biochemical evolution on our Earth (origin and develompent of life)



CONTEMPORARY WITH DARWIN – ANOTHER EPOCHAL INVENTION FRUITED IN BRNO

Gregor Mendel
(1822-1884)

MENDEL - FOUNDER OF GENETICS

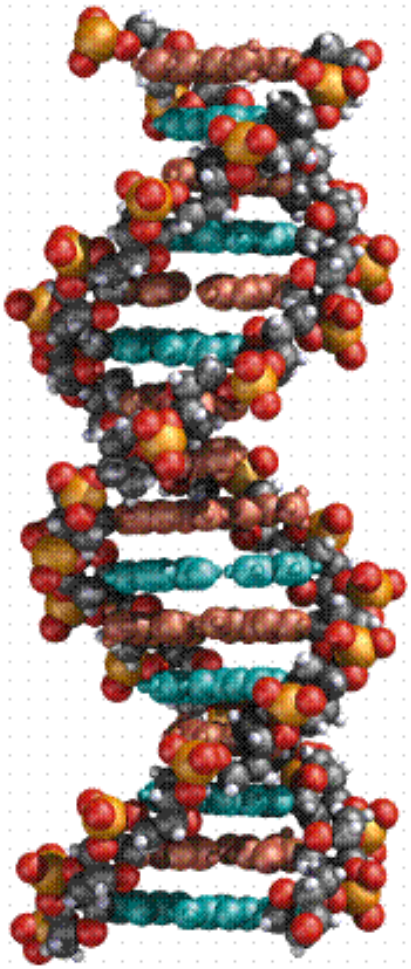
- **Gregor Mendel**, Darwin´s contemporary, monch from Brno, studied in monastery garden transfer of characters between generations of peas (beside other experiments)
- He created „pure lines“ of plants by means of self-crossing (all specimens in *F1* generation are identical)
- Then he crossed indivuduals with red flowers with those having white flowers and noticed that all descendants have red flowers
- What occurred with character responsible for white colour of flowers?

NEXT (F2) GENERATION GAVE THE ANSWER

- In F2 generation Mendel received 929 specimens, 705 (approximately 75 %) with red flowers and 224 (approx. 25 %) white
- Mendel reasoned from this result that „inheritable factor“ responsible for white colour was not lost in F1 generation but this factor responsible for red flowers is controlling and he also reasoned that there should be two such factors
- As a result, Mendel formulated three important postulates: 1) inheritable factors are driven by two different units, 2) each of these units originates from one parent and an individual may have these units different or identical, a 3) if they are different, resulting character is driven by one of them (dominant) whereas the second (recessive) does not influence this character
- Of course, Mendel did not know anything about the nature of these „inheritable units“ or „inheritable factors“

MENDEL SHOWED THE WAY - ON ITS END WAS DNA STRUCTURE

- Discovery of DNA structure, and how the genetic information is „stored“ in it (genetic code), belong to the most important inventions of natural sciences in 20th century: within about 12 years, 20 Nobel´s prices were awarded in this area
- The most important result: **genetic code is universal**, all living beings have similar genetic background
- The difference between species lies only in differnet number and sequence of nucleotides
- Great number of nucleotides: bacteria having about 4 millions, humans about 3 billions



NEODARWINISM = CONNECTION OF DARWIN´S EVOLUTIONARY THEORY WITH GENETICS

- Darwin revealed the cause of evolutionary changes, however, he could not know mechanisms
- Changes in DNA are caused by mutations
- Mutations and new gene combinations have selective influence on survival and reproduction rate of individuals
- If mutations increase fitness, their proportion in successive generations increases, and, if they decrease fitness, disappear
- According to neodarwinism, mechanism of evolution is the change in gene frequencies

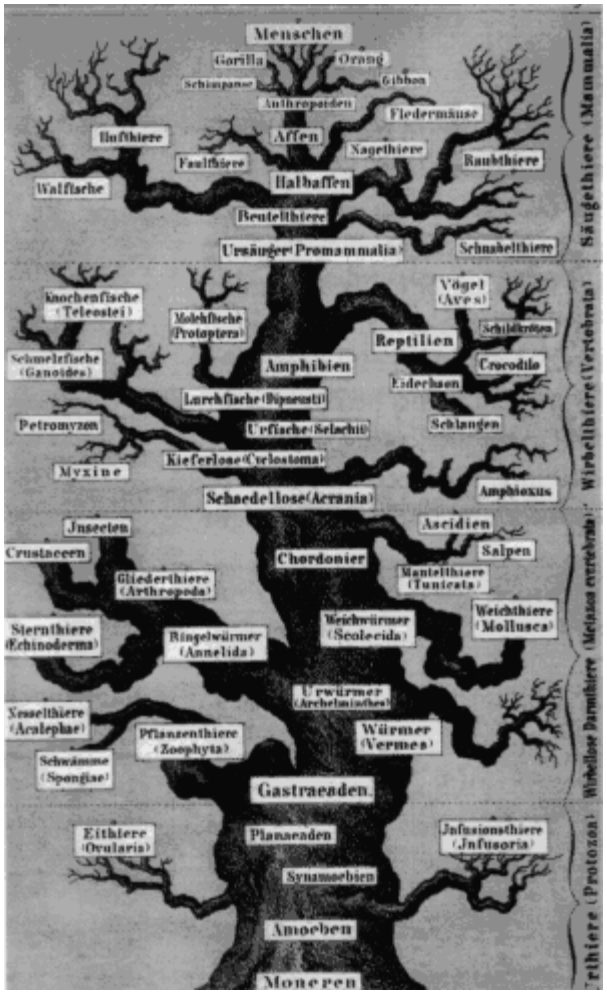
EVEN NEODARWINISM CANNOT EXPLAIN EVERYTHING

- First of all: it supposes only one-way flow of genetic information (from DNA to proteins and other structures)
- One-way mechanism of information flow cannot explain contemporary appearance of DNA and proteins at the beginning of life
- Enormous number of mutations is necessary for evolving new structures; the probability of „change to better status“ is very small (many scientists hesitate to admit mutations as source of evolution)

„Adaptive mutations“ theory

- Recent theory: e.g. When removing a gene for enzyme splitting lactose, bacterium „develops“ another, different enzyme to survive in a medium. How? We do not know
- Or: genetics cannot explain how to transfer positive mutation from a somatic cell of an animal to a sperm cell (observed in some immune properties)

HORIZONTAL AND VERTICAL GENE TRANSFER



„Tree of life“ constructed by E. Haeckela, Darwin´s follower. We see supposed monophyly of all life forms as well as vertical one way-flow of genetic information (from bottom to tip) ↑

However, we know that genes may be transferred also horizontally

→

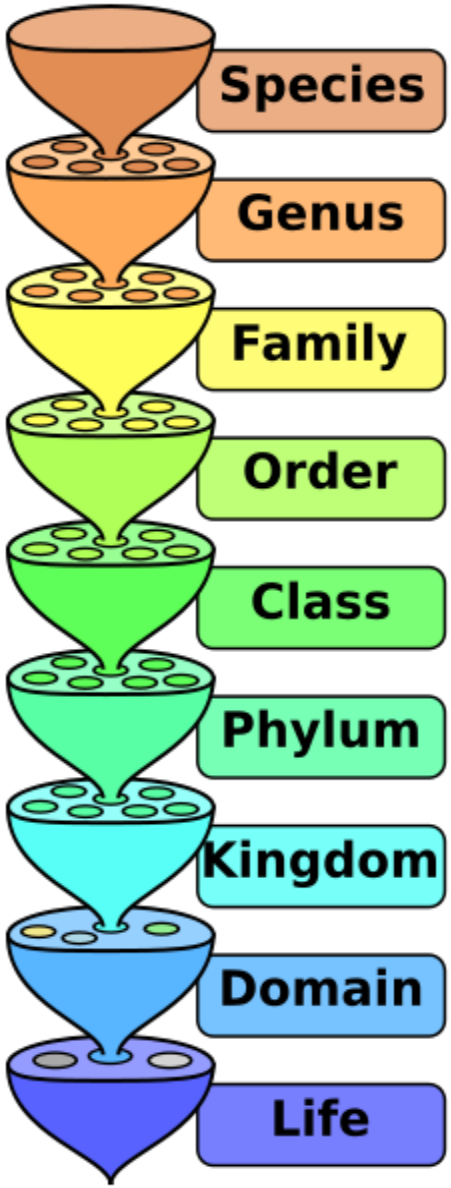
And we know that genom is highly flexible (much more we expected before)

DIFFERENTIATION OF LIFE FORMS BY CHANGING ENVIRONMENTS

- Environmental factors changed even in the beginning of life (- 4 000 000 000 years)
- Irrespective of specific mechanisms of differentiation of life forms (mutations and subsequent natural selection of advantageous forms, adaptive mutations, horizontal gene transfer, etc.), life forms differentiated into numerous species and higher taxonomic units
- What is biological species?

SPECIES

- Basic unit used in biology (classification of life forms), result – **scientific name** of species
- Useful definition of species and ability to recognise different species = necessary for testing hypotheses about biodiversity
- Biological species represents a group of similar individuals which may produce viable and reproducing progeny



PROBLEMS OF TRADITIONAL DEFINITIONS

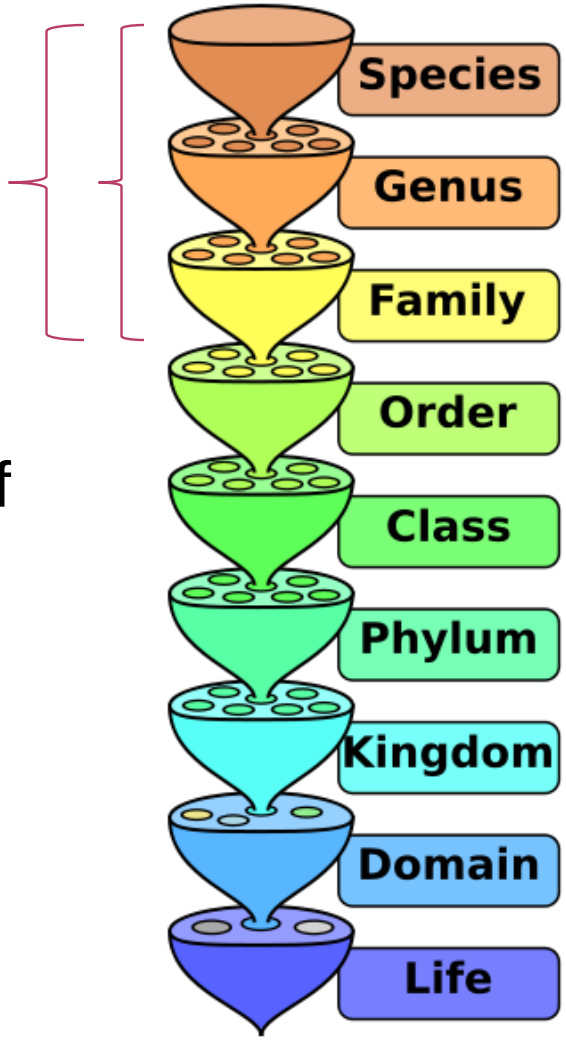
- Asexually reproducing forms
- Horizontal gene transfer
- Hybrids between species (animals – rare, however, sometimes partially fertile), in plants more common
- „Ring species“ – closely occurring populations fully compatible, distant – reproduction barriers
- Pseudoextinct species: where are the boundaries between two successive species (chronospecies)?
- Morphospecies concept

TAXONOMY

- Science of Classification.

ZOOLOGICAL NOMENCLATURE

- ICZN
- They cover only taxa from subspecies to superfamily
- Ensure only a single name as valid for each taxon
- Year „0“ chosen as 10 th issue of Linné´s „Systema naturae“ (1758)
- Basic principles: (1) binominal nomenclature, (2) principle of priority, (3) principle of continuity, (4) principle of types



BIODIVERSITY

- Concept of „***biodiversity“*** concerns different (hierarchical) levels of variation between living things
- From genetic diversity (variation of genes and gene combinations within population, species) to species diversity of communities (including variations in higher taxa), up to regional diversity of ecosystems
- Ecosystem diversity concerns variations in habitat types and bioms in a given area
- Conservation of biodiversity, biodiversity represents the most important natural resource

WE OBSERVE MANY PATTERNS OF BIODIVERSITY

- Species diversity changed in the past, mostly increased (however, partly extinct – even high taxa, mass extinctions)
- Number of species of most taxa decreases from equator towards poles (area theory, glaciation) and with altitude
- Diversity is often determined by characters (suitability) of habitats (low species diversity in hot and dry deserts)
- Physiographic diversity alongside character of a habitat often determine vegetation diversity and this, in turn, determine other components of biodiversity
- Controversial influence of fertility (on broad scale it determines productivity – energy level of ecosystem, however, on local scales often decreases biodiversity)

REGIONAL/HISTORICAL VIEW ON BIODIVERSITY

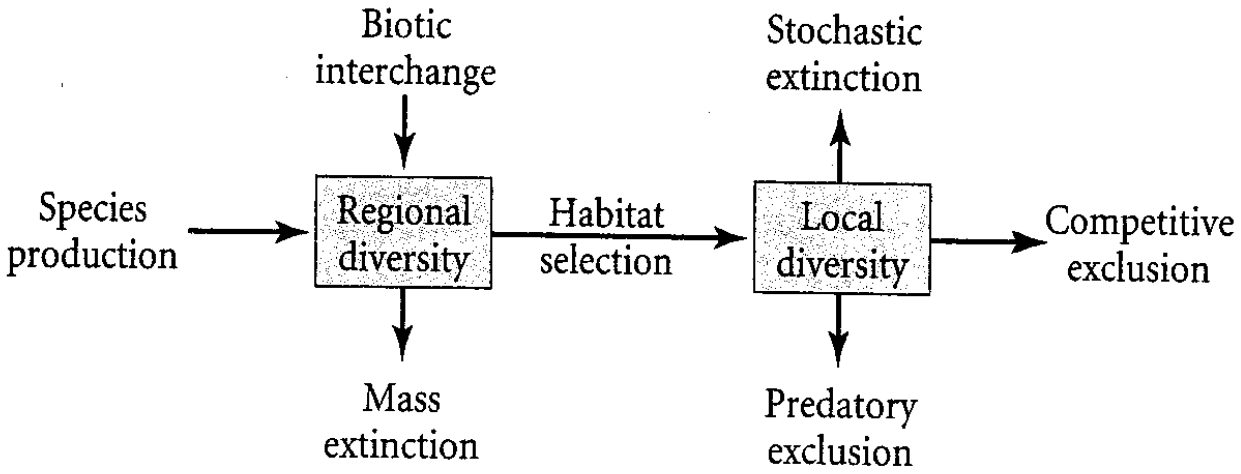
- Long time in ecology prevailed the opinion, that biodiversity is largely determined by sequence of historical events the region was exposed in the past
- It concerns the following factors: speciation, migration, evolutionary development of communities, geological forces (continental drift), changes in macroclimate, etc.
- These factors basically influence regional „pool“ of species and this pool is modified by local influences (next slide)

LOCAL VIEW ON BIODIVERSITY

- Basic idea: biodiversity is largely determined by local conditions, mostly by appropriateness of habitats (fertility, temperature, vegetation, water, soil), interspecific interactions (predation, competition, herbivory, local extinctions, etc.)
- These factors determine the community of species coexisting on particular habitat
- Modern view on this problem: regional and local processes interact in different time and spatial scales and both together co-determine biodiversity

GENERAL BIODIVERSITY MODEL

The interactions depicted below occur in broader and broader spatial and time scales, beginning with local population, across larger units, regions, continents etc., and all events on broader spatial scales or farther time scales are influenced by processes on lower sptial or closer time scales (the degree of influence decreases along this spatial and time gradient)



BIOGEOGRAPHY

- Science dealing with distribution of plants (phytogeography) and animals (zoogeography) on the Earth (both terrestrial and marine environments) and also about factors influencing distributional paterns
- Biogeography is boundary science between biology and geography, exploits findings of ecology, geology, paleontology, climatilogy incl. palaeoclimatology
- Distributional patterns are results of regional processes inflencing biodiversity

AREA OF DISTRIBUTION = BASIC UNIT OF ZOOGEOGRAPHICAL STUDIES

- Areals differ in area/space (endemit x cosmopolitan), origin (autochtonne x allochtonne), connectivity (continuous x disjunct), in migratory birds: breeding part (euareal) or non-breeding (epiareal)
- All species are unequaly distributed (clumped distribution on large scales)
- Species have the tendency to disperse, and dispersal sometimes leads to enlargement of areals (special case: anthropogenical dispersal)

MAIN ZOOGEOGRAPHICAL UNITS