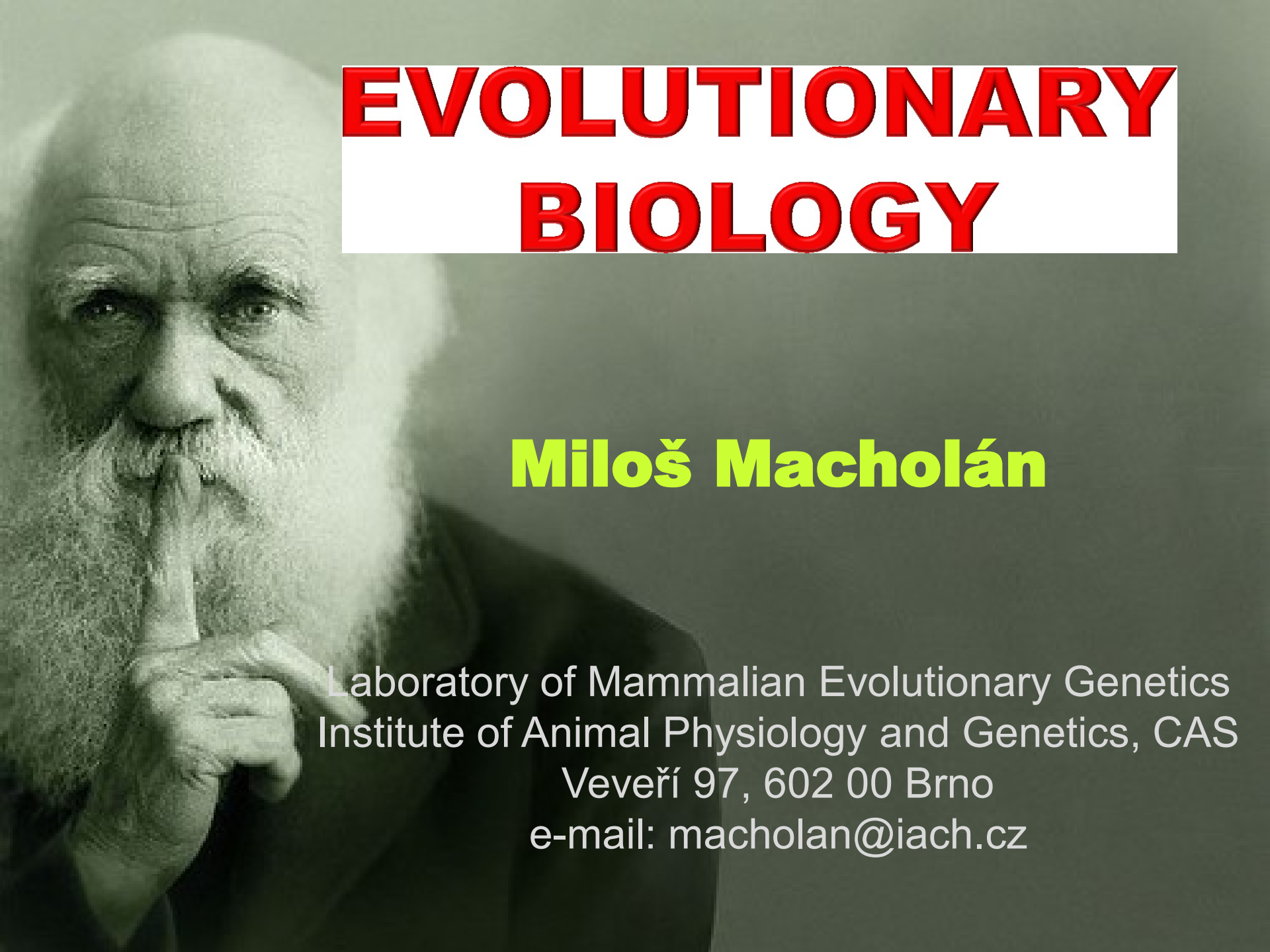

EVOLUTIONARY BIOLOGY

Miloš Macholán

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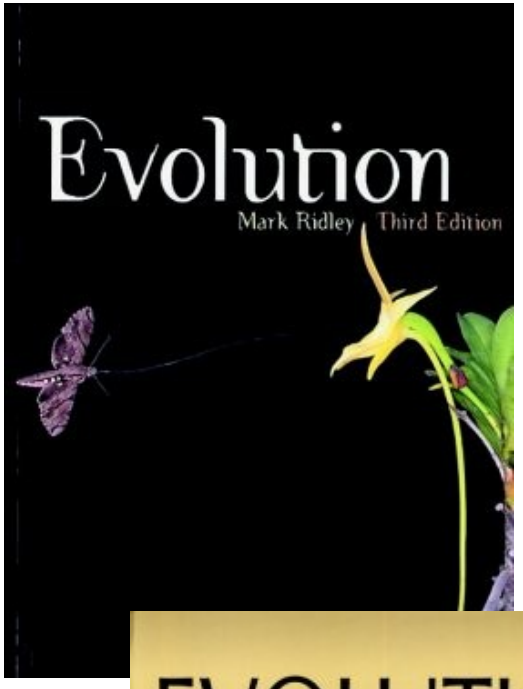
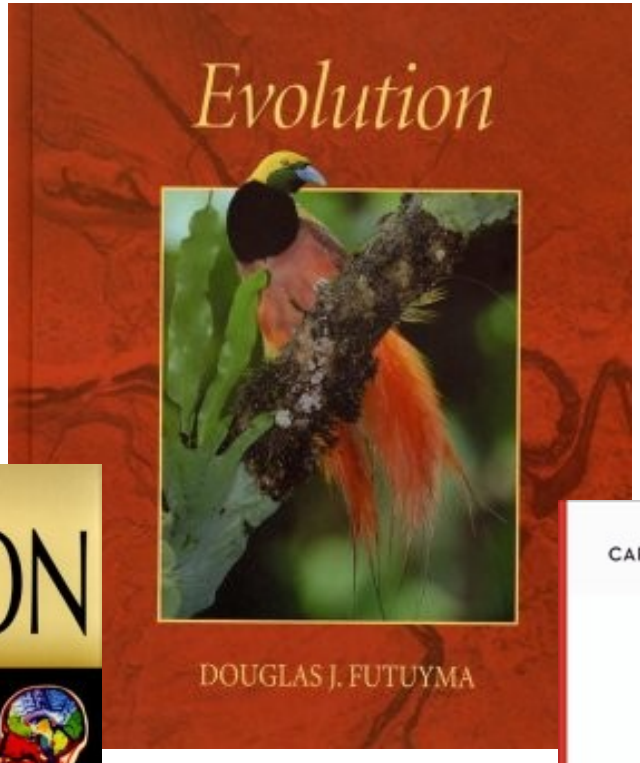
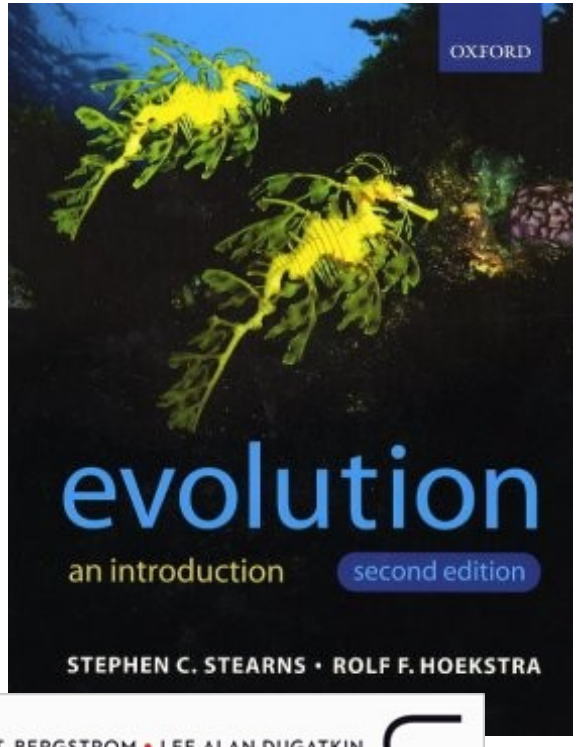
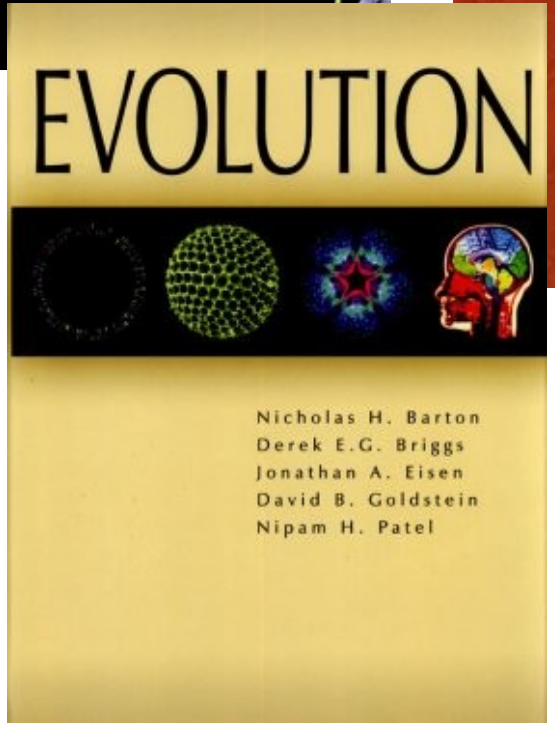
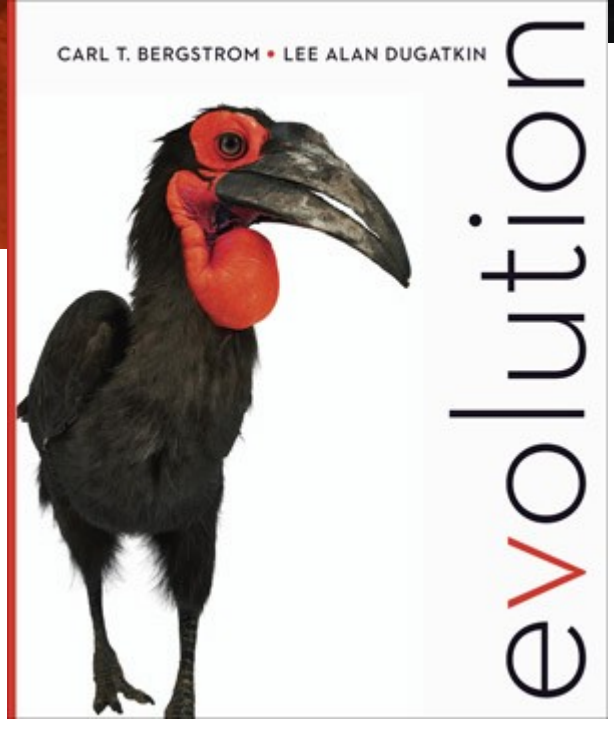
Textbooks


Evolution
Mark Ridley
Third Edition

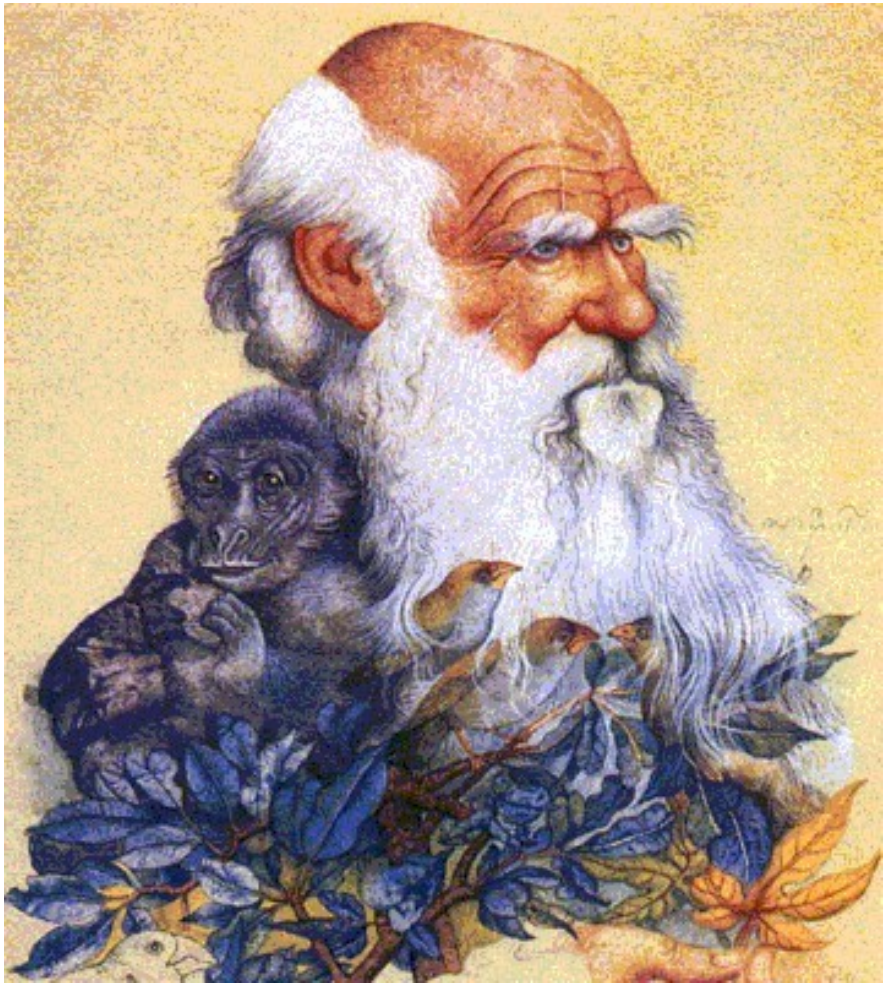

Evolution
DOUGLAS J. FUTUYMA

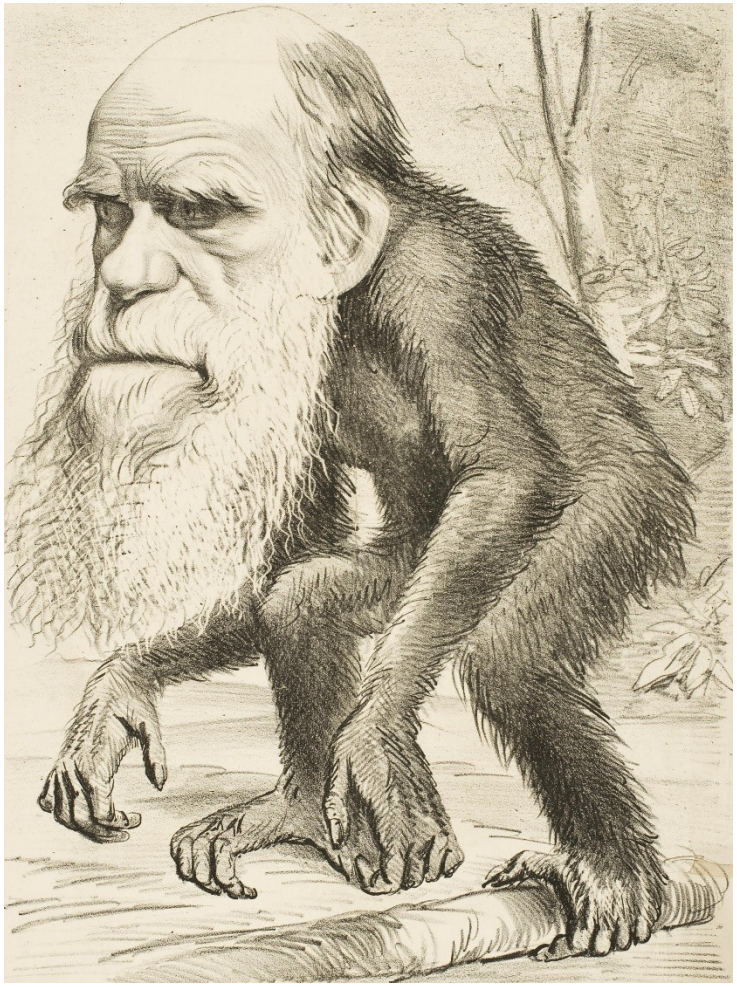

OXFORD
evolution
an introduction
second edition
STEPHEN C. STEARNS • ROLF F. HOEKSTRA


EVOLUTION
Nicholas H. Barton
Derek E.G. Briggs
Jonathan A. Eisen
David B. Goldstein
Nipam H. Patel


CARL T. BERGSTROM • LEE ALAN DUGATKIN
evolution

EVOLUTION AND EVOLUTIONARY BIOLOGY





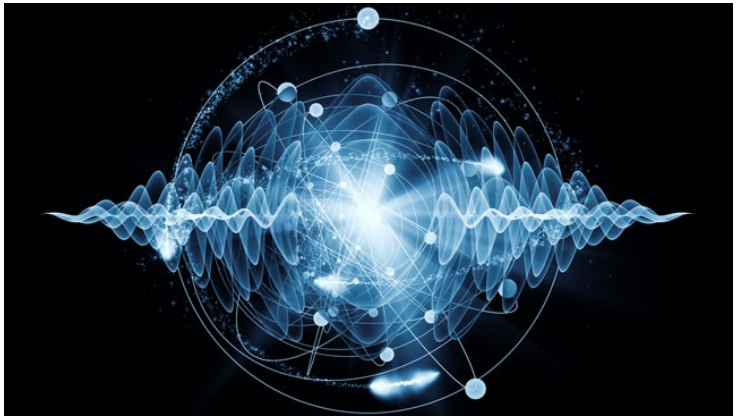
EVOLUTION (*evolvere*, *evolutio*) = unfold, unfolding (of a scroll of papyrus)

Albrecht von Haller (1774):

development of individual embryo

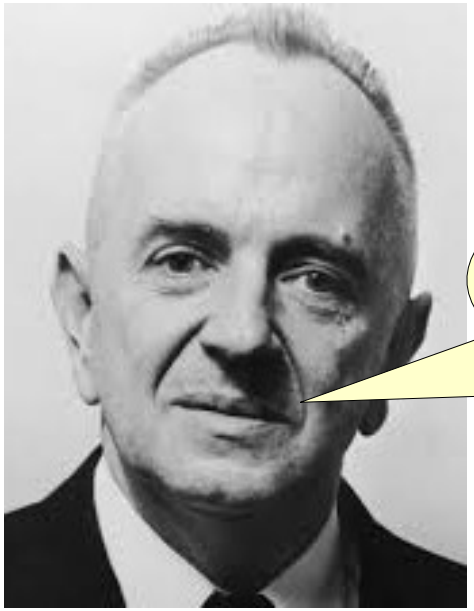
essentially ontogenetic development
according to a preset programme
(~ preformationism)

in a broad sense = change
(politics, economy, technology, scientific theories etc.)



BIOLOGICAL EVOLUTION = heritable change in the properties of populations of organisms over the course of generations
structure, function and organization of organisms or their parts, behaviour and mutual relationships

CULTURAL EVOLUTION



Nothing in biology makes sense except in the light of evolution.

T. Dobzhansky (*American Biology Teacher*, 1973)

EVOLUTIONARY BIOLOGY

= scientific field studying principles of
biological evolution

properties and mechanisms of evolutionary process

PROPERTIES OF BIOLOGICAL EVOLUTION

living systems (reproduction, variability, inheritance)

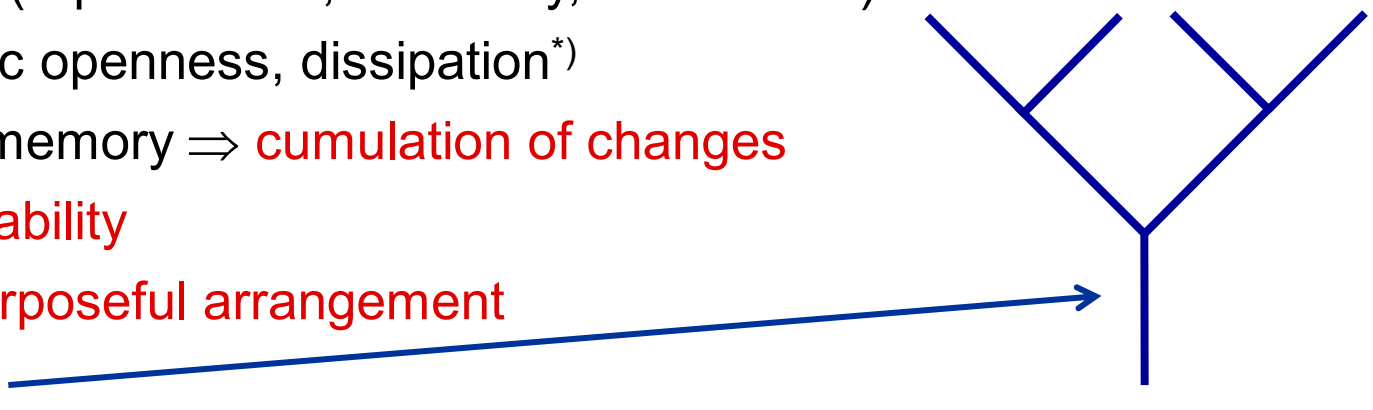
thermodynamic openness, dissipation*)

systems with memory ⇒ cumulation of changes

unlimited heritability

adaptation, purposeful arrangement

cladogenesis



*) = irreversible change of energy

teleology: everything has its purpose

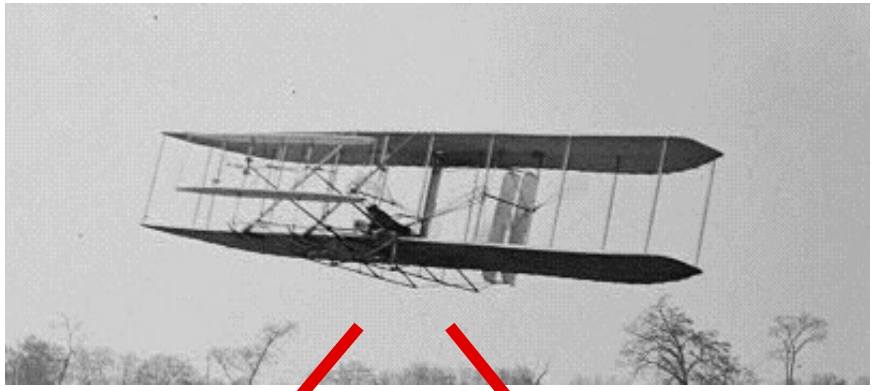
finalism: the doctrine that final causes determine the course of all events -

Teilhard de Chardin: „Omega Point“

PROPERTIES OF BIOLOGICAL EVOLUTION

IS random (both deterministic and stochastic processes and mechanisms)

IS opportunistic, ie. doesn't find global optima



human design
engineer

natural
selection

PROPERTIES OF BIOLOGICAL EVOLUTION

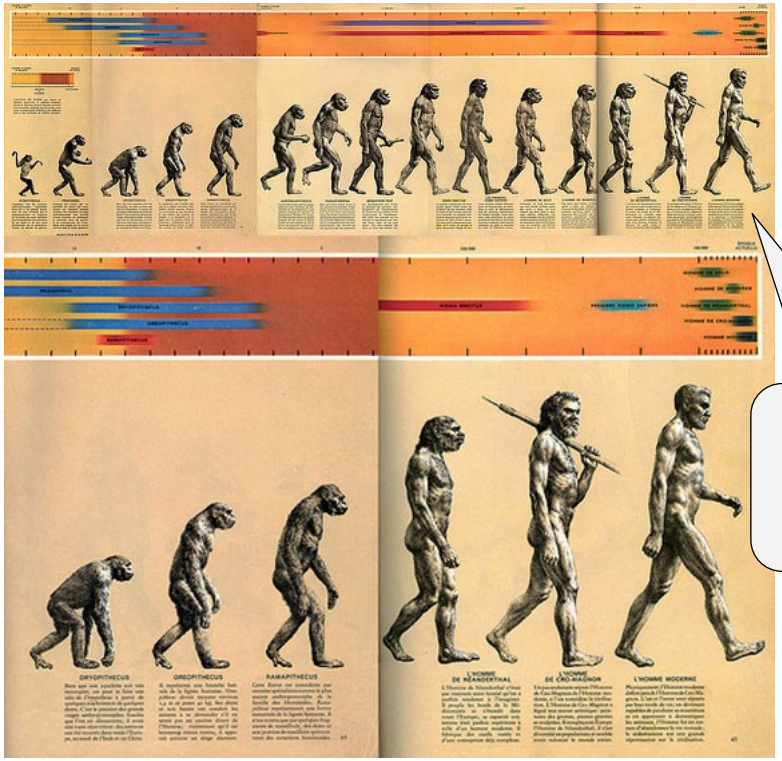
IS random (both deterministic and stochastic processes and mechanisms)

IS opportunistic, ie. doesn't find global optima

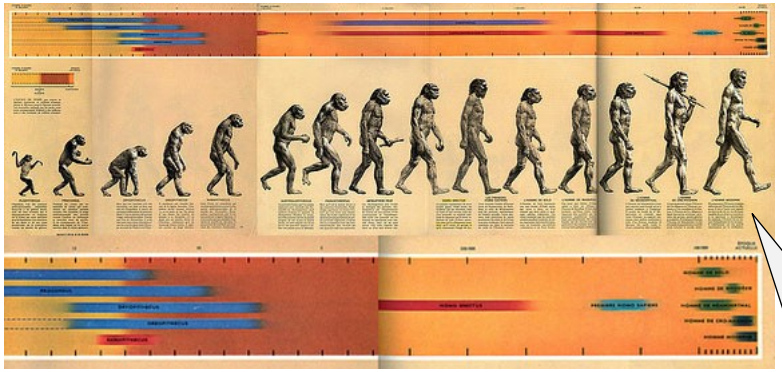
HAS NO purpose or goal (nor survival of species!)

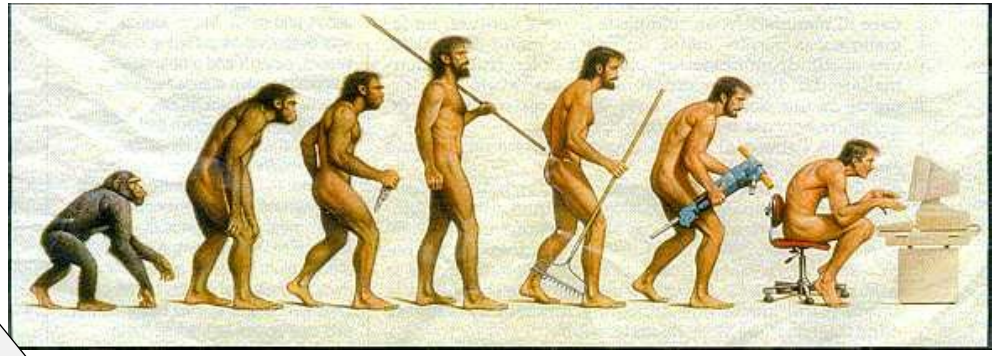
IS neither moral nor amoral

IS NOT progressive

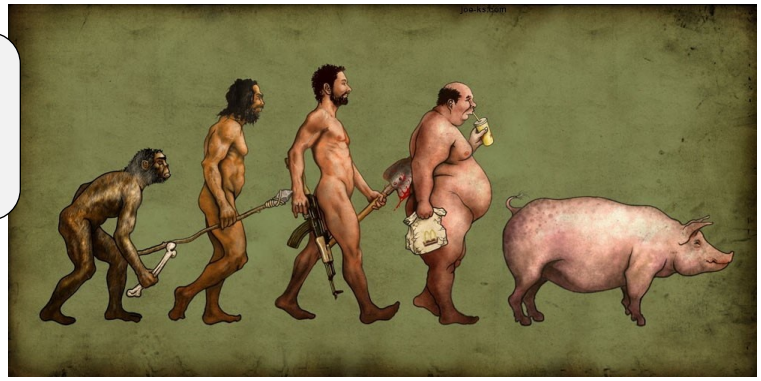


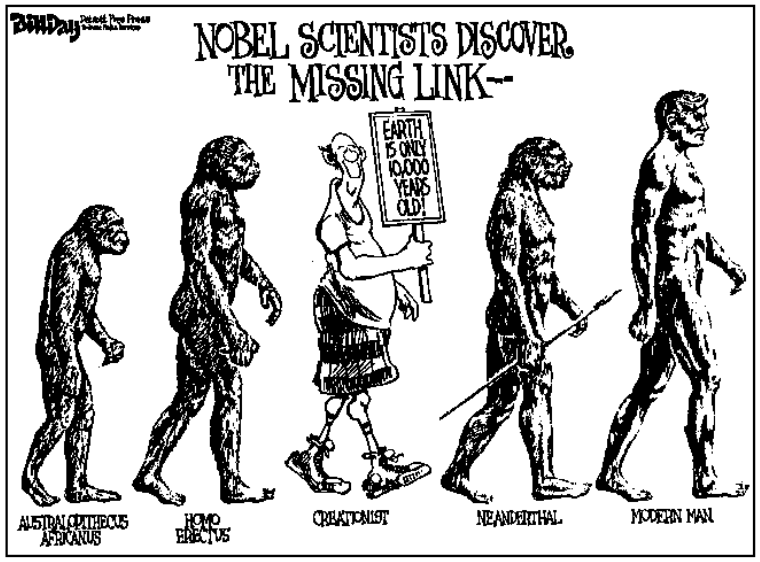
„march of progress“

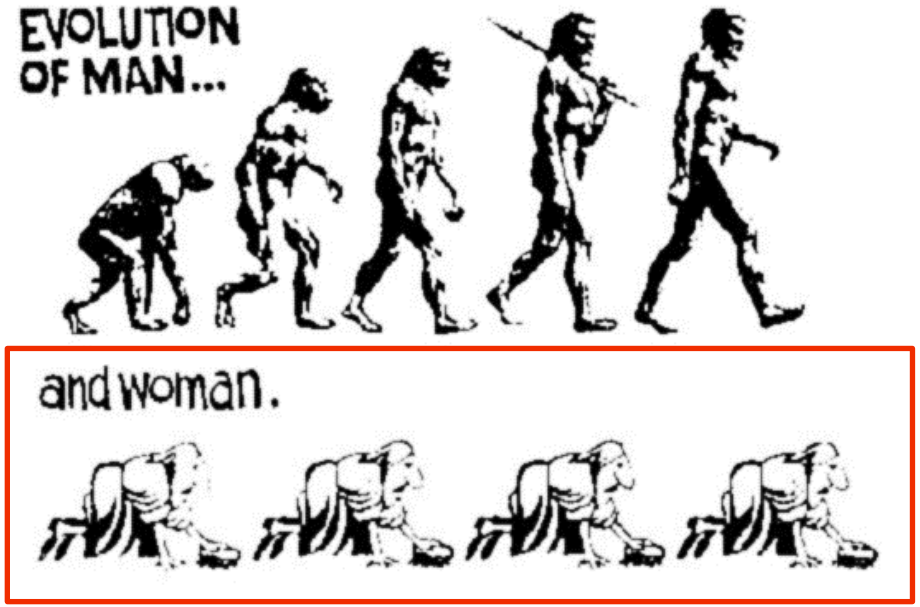




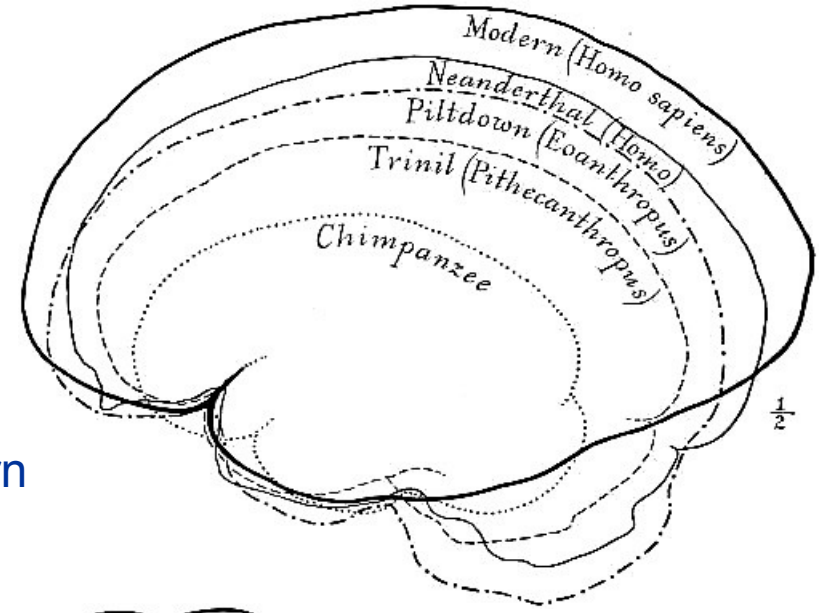
„march of progress“

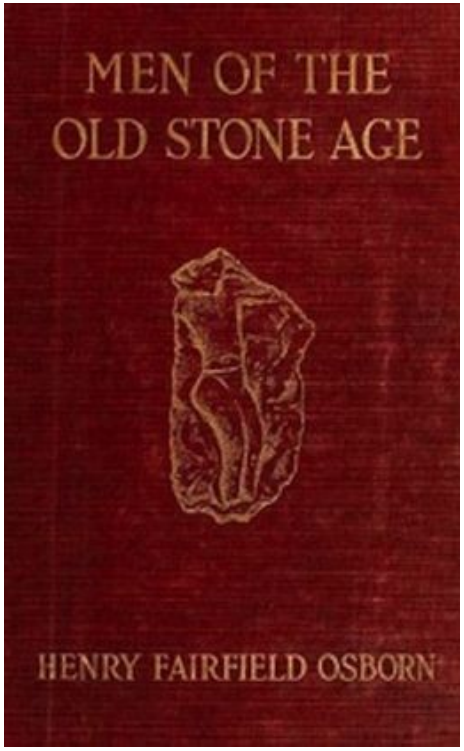


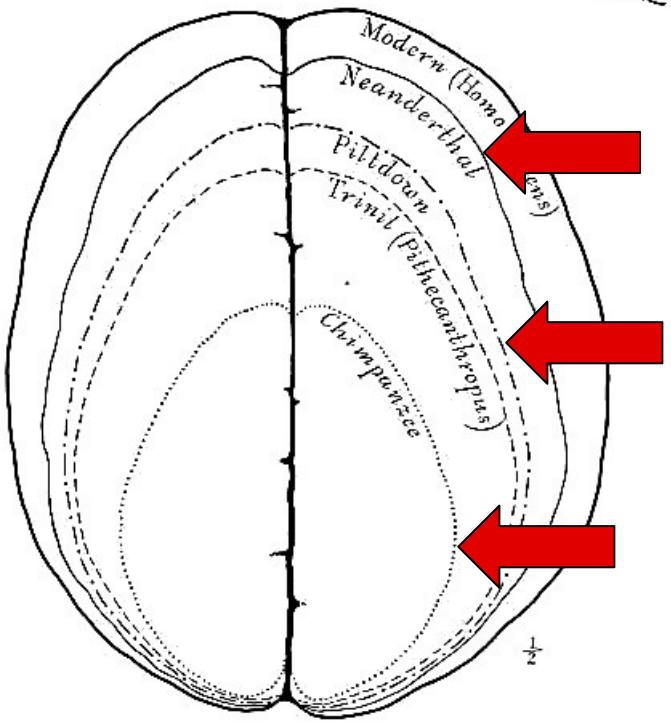




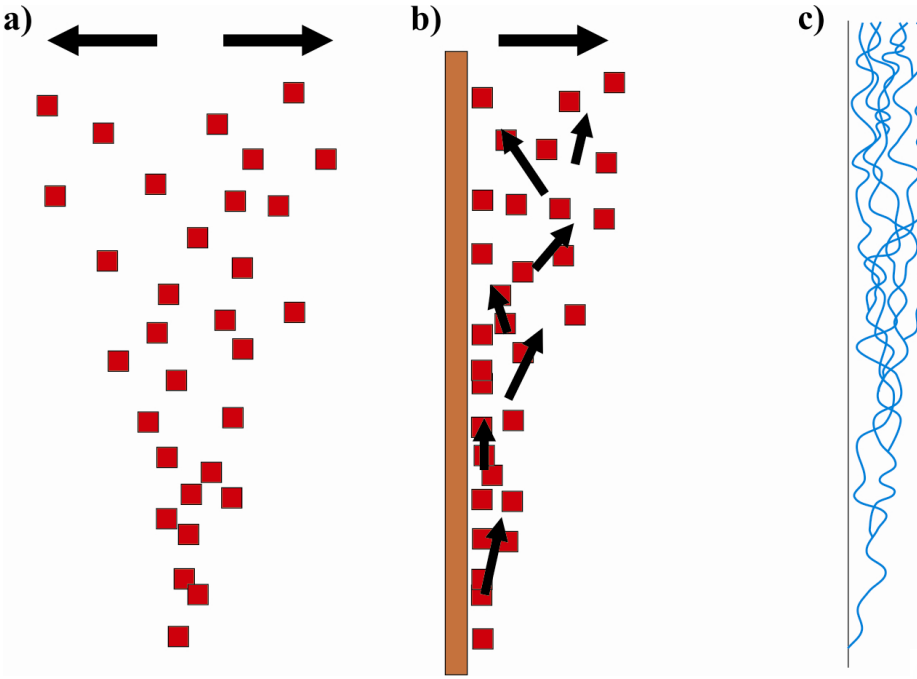
Henry Fairfield Osborn



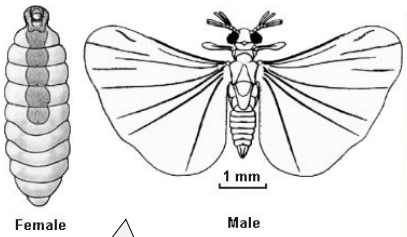




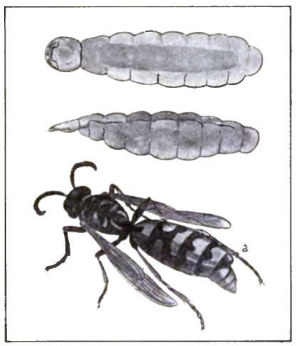
Evolution and progress



„wall effect“

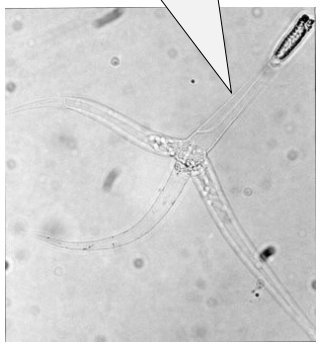


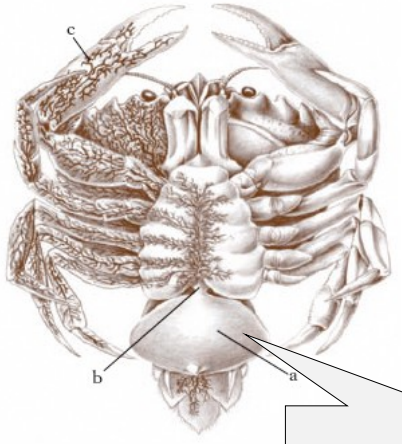
Strepsiptera



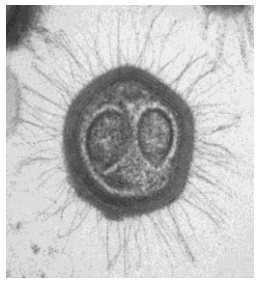
Female Strepsipteron, top and side views and a Stylopized Wasp: *a*, end of the parasite projecting between the abdominal segments of the Wasp. (*After Leuckart's Wandtafeln.*)

Myxozoa





Sacculina carcini



STRUCTURE OF EVOLUTIONARY BIOLOGY

2 principal questions:

History of life?

systematics
paleontology

Mechanisms of changes?

evolutionary genetics
e. ecology
e. developmental biology (evo-devo)
behavioural ecology
sociobiology, e. psychology
e. physiology
e. morphology

HISTORY OF EVOLUTIONARY THOUGHTS

The beginning of evolutionary biology = 1859 (Darwin's *Origin of Species*), BUT:

evolutionary thoughts much older

only after the World War II evolutionary biology considered true science

History of evol. thoughts can be divided into the following stages:

before Darwin

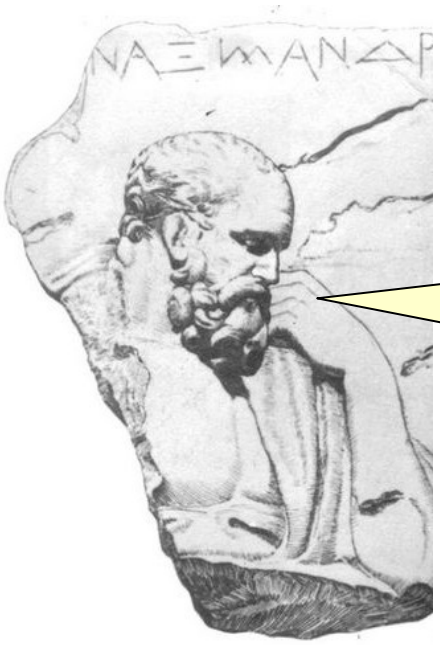
Darwin's/Wallace's theory

evol. theory at the turn of 19th and 20th century

Modern Synthesis and recent history

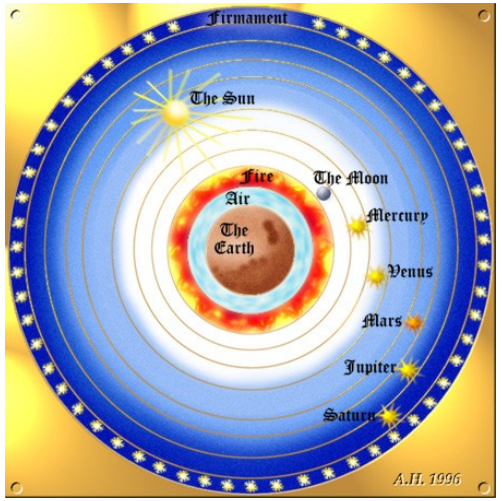
1. Before Darwin

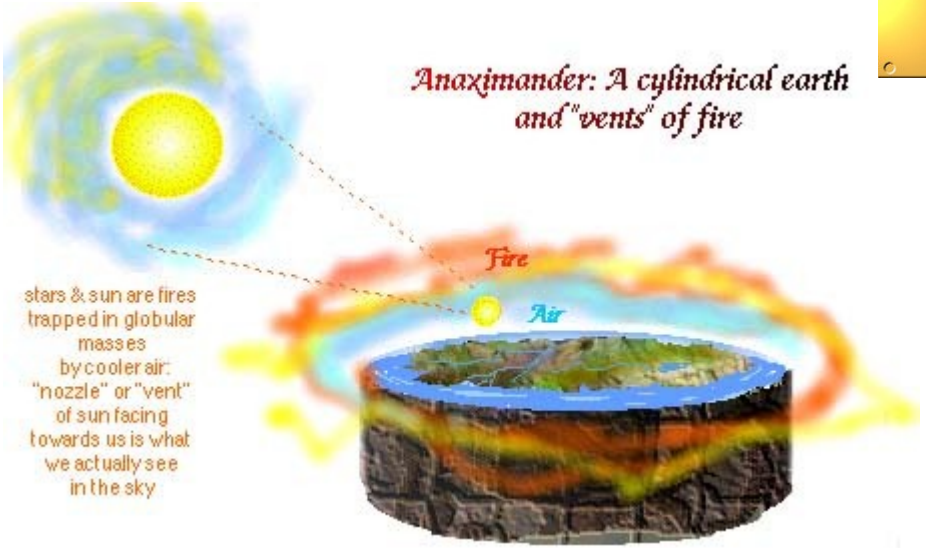
A) Antient history and the Middle Ages:



Anaximander of Miletus (ca. 610–ca. 546 BC)

humans
and animals
have evolved
from fish

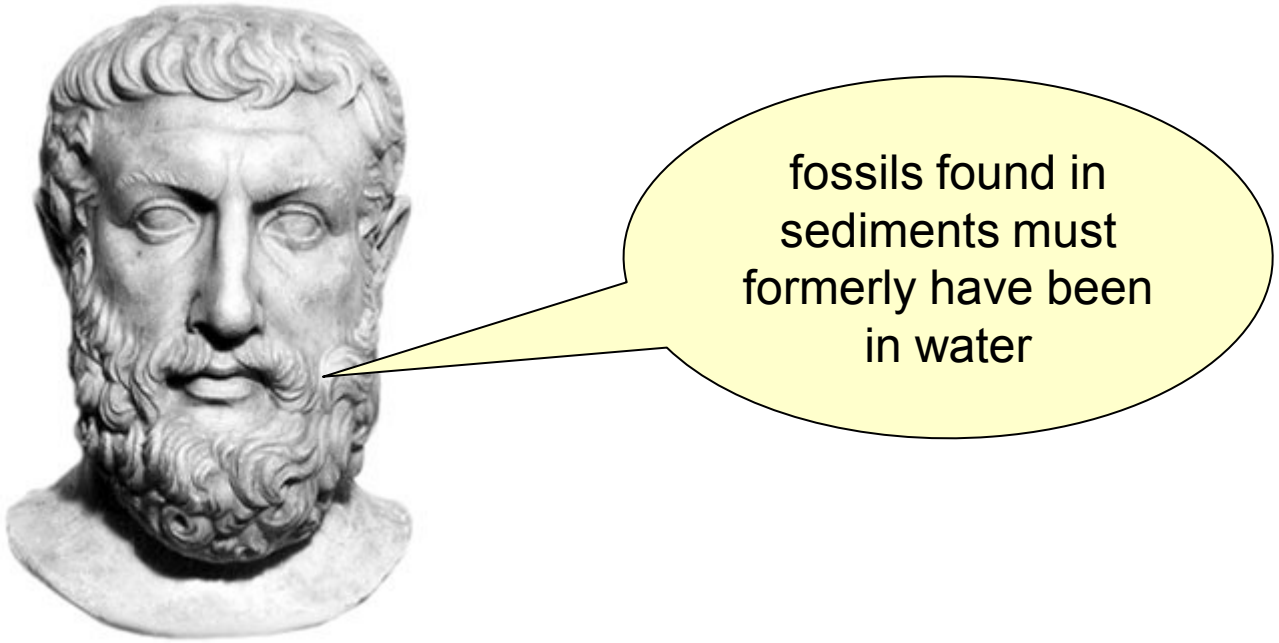




1. Before Darwin

A) Antient history and the Middle Ages:

Xenofanes of Colofon (ca. 570–ca. 475 BC)



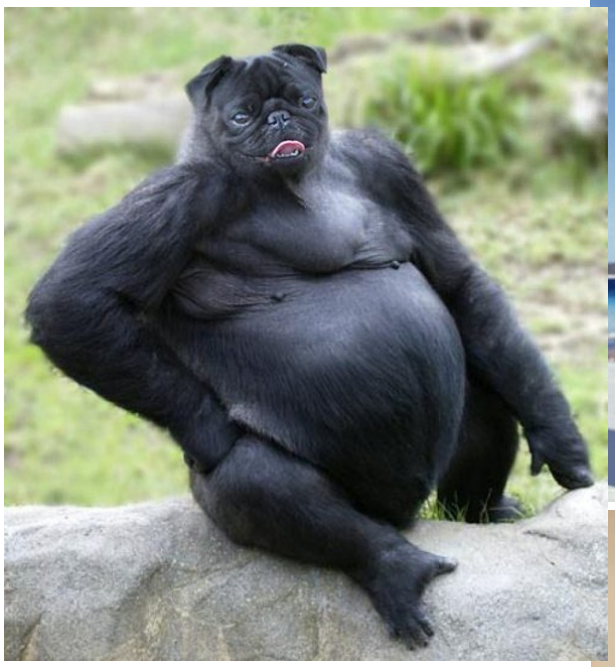
1. Before Darwin

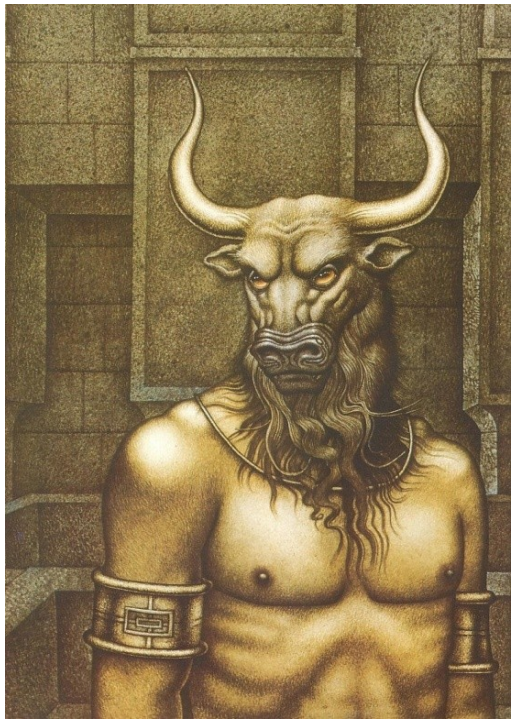
A) Antient history and the Middle Ages:

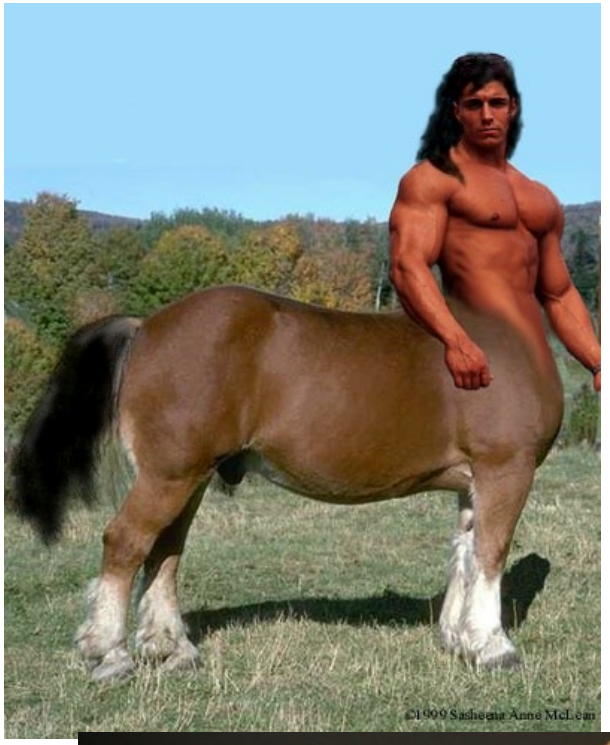
Empedocles z Acragas (ca. 492–432 BC)

plants before animals

random combinations of parts of organisms






©1999 Sasheena Anne McLean

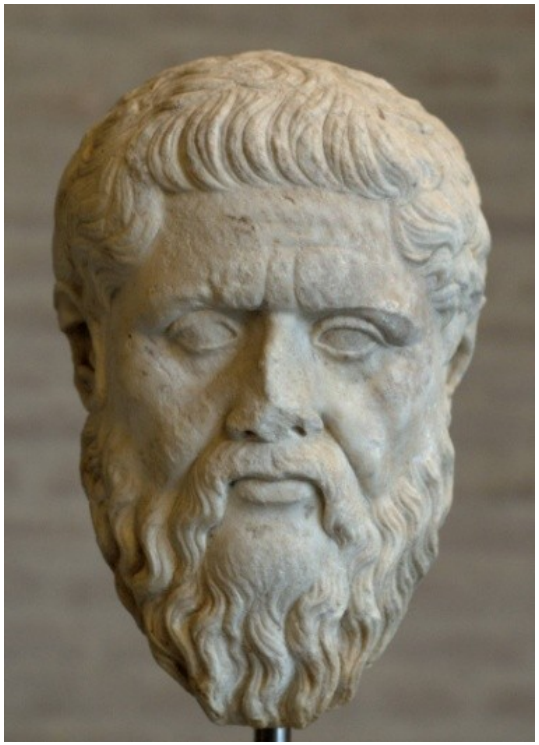
1. Before Darwin

A) Antient history and the Middle Ages:

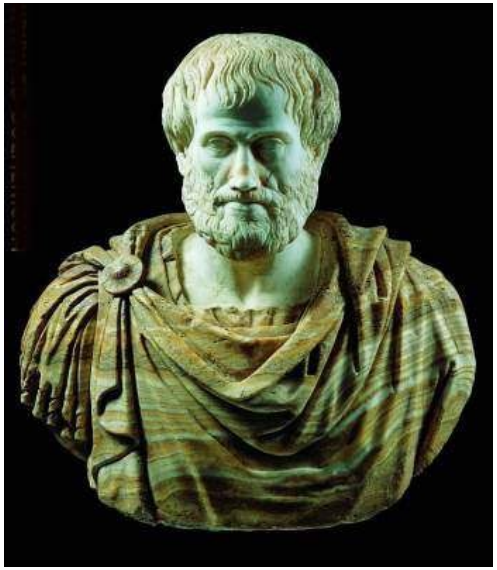
Christian philosophy:

Plato: theory of Ideas ($\rightarrow$ Christian God)

Aristotle: first classification of organisms ($\rightarrow$ *Scala Naturae*)

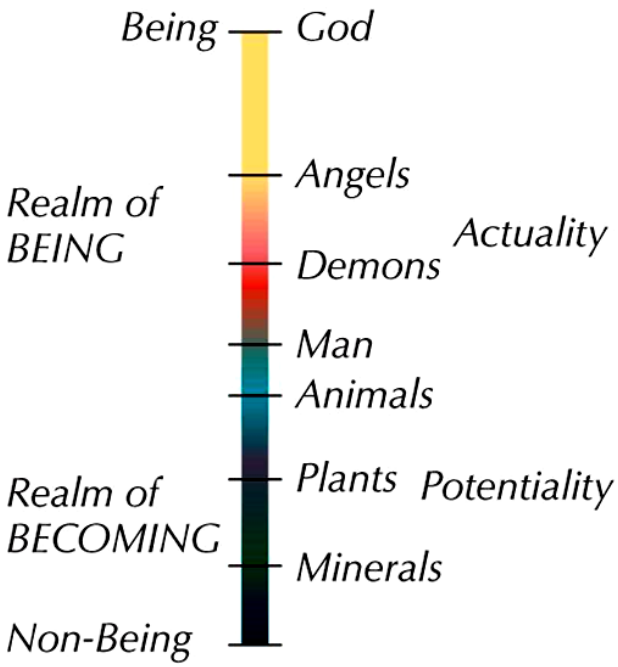


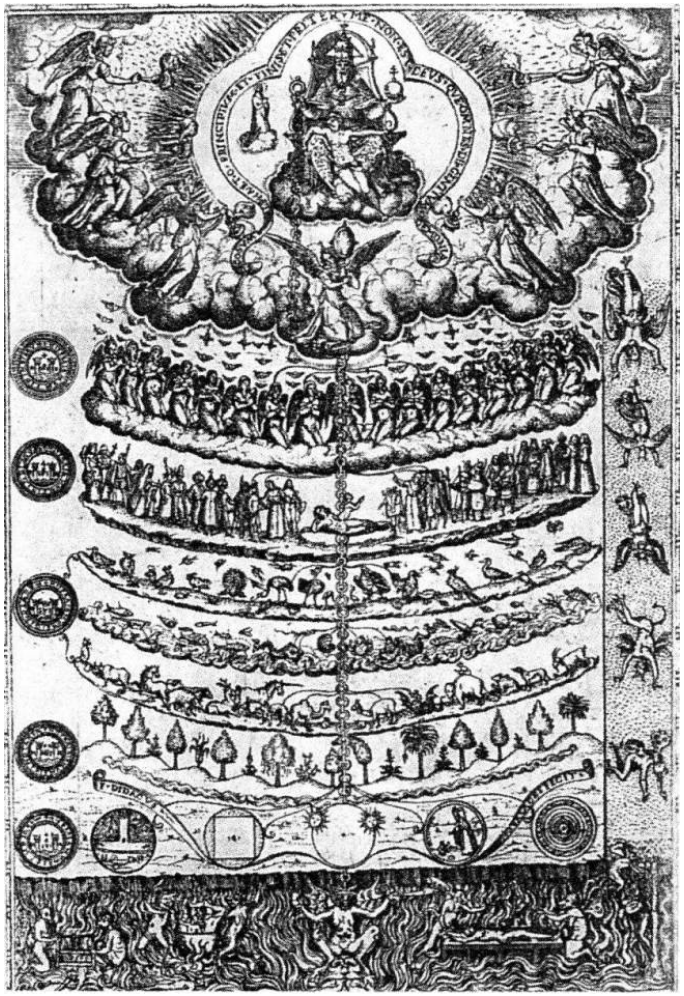
Plato
(427–347 BC)

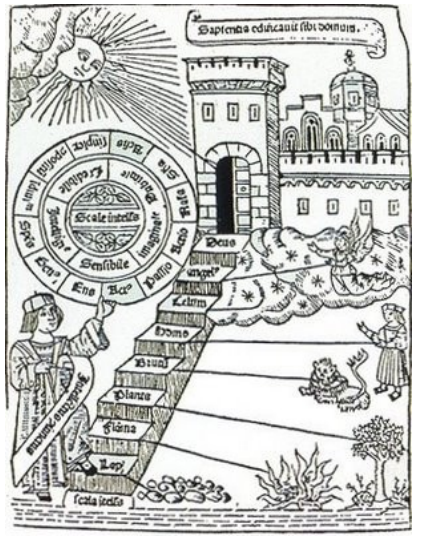


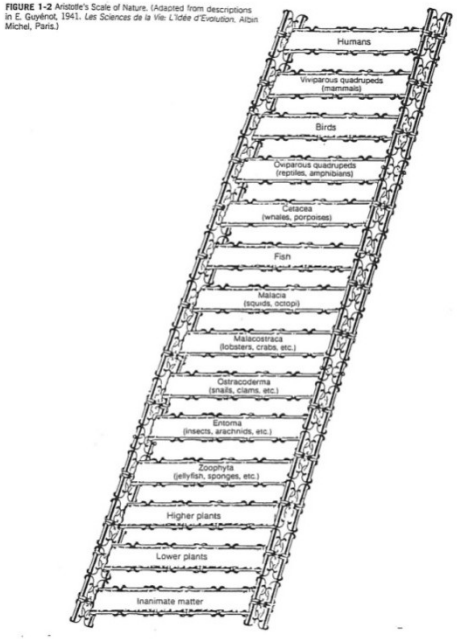
Aristotle
(384–322 BC)

Scala Naturae („Great Chain of Being“)





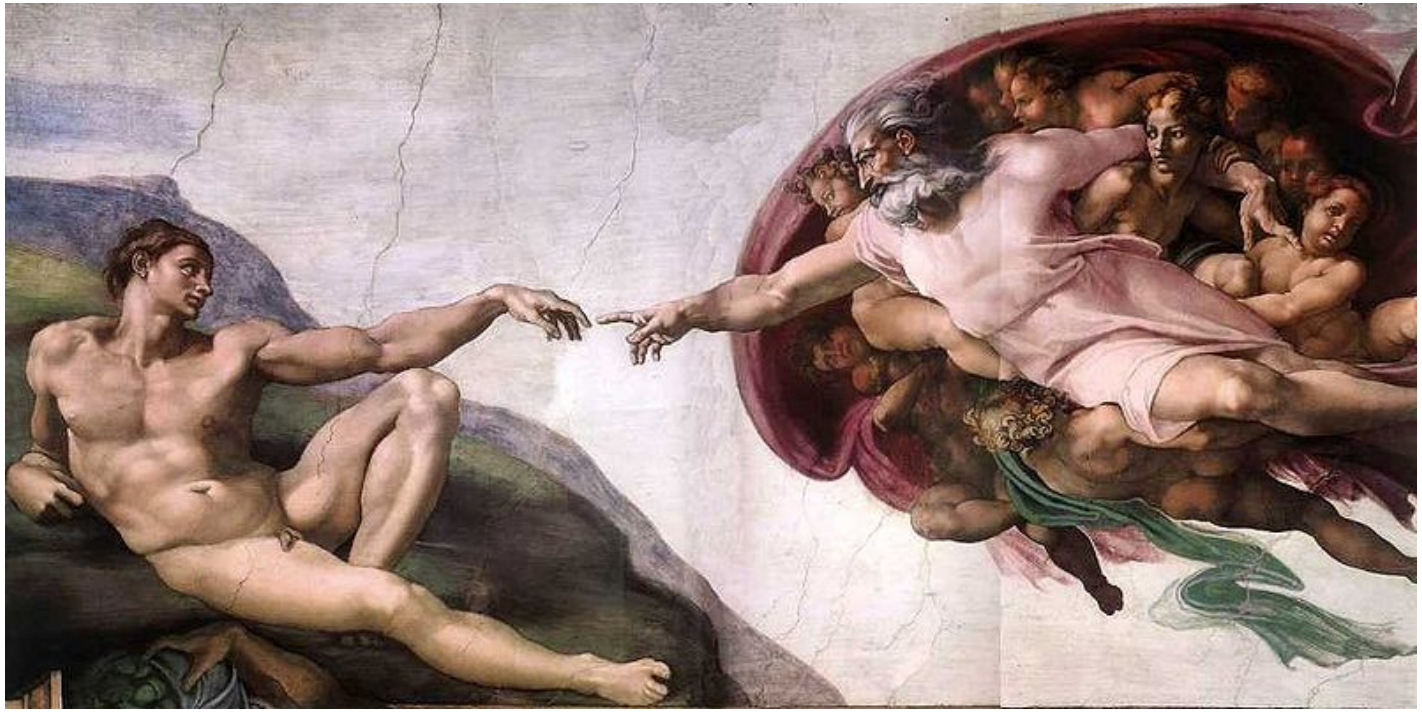




James Ussher – *Annalium pars posterior* (1654):
World created at dusk preceding 23th October 4004 BC
(~ 6000 years old)

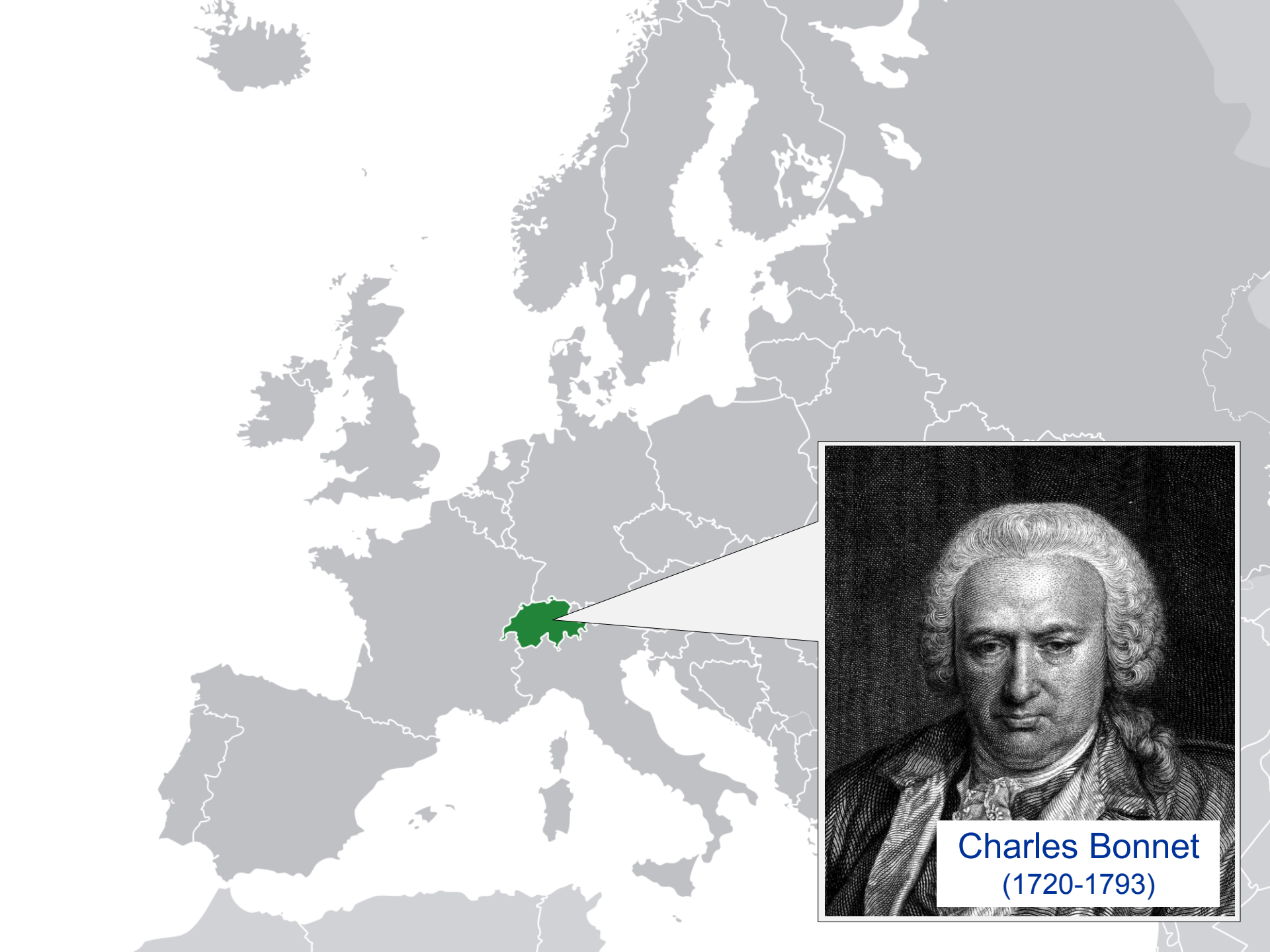
~ Isaac Newton: 3998 BC

literal reading of Bible = creationism



1. Before Darwin

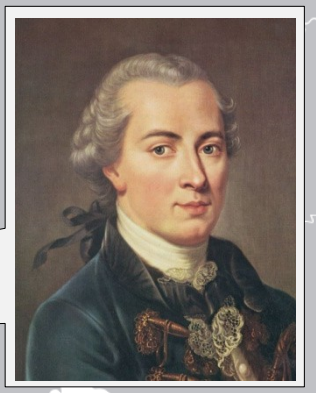
B) since the end of 17th century to the French Revolution:

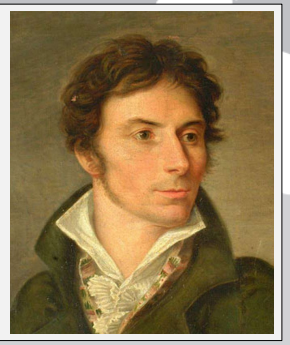

Charles Bonnet
(1720-1793)

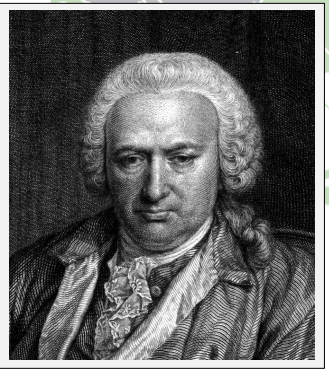

Lorenz Oken
(1779-1851)


Immanuel Kant
(1724-1804)

J. W. Goethe
(1710-1782)

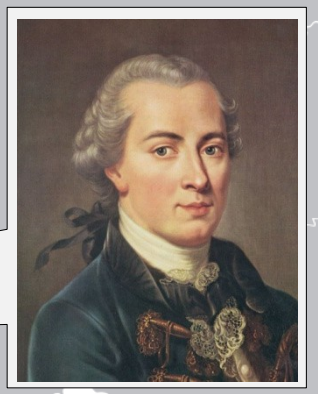


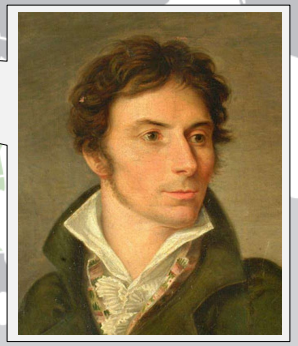


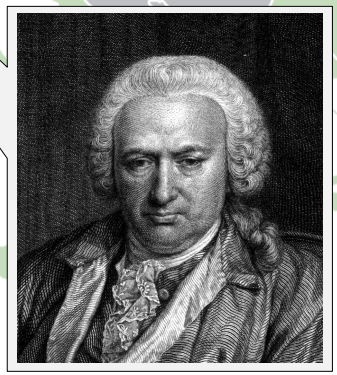


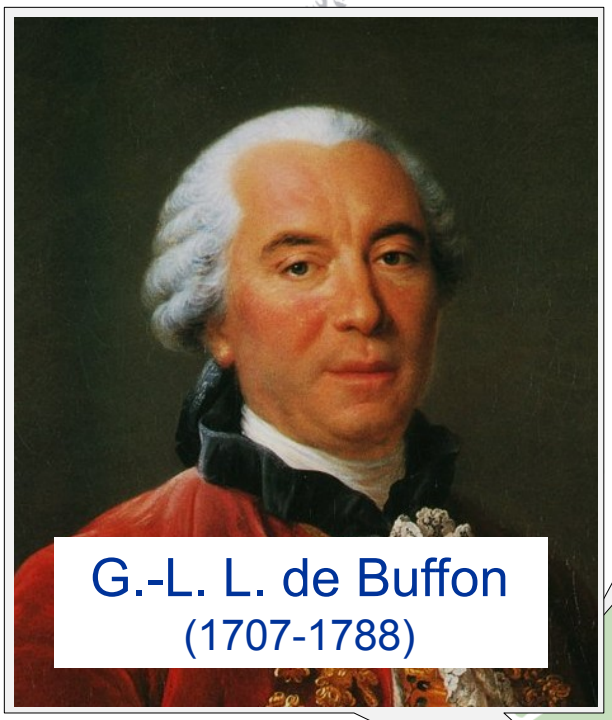
Zoönomia (1794):
„E conchis omnia“
(everything from molluscs)

Erasmus Darwin
(1731-1802)

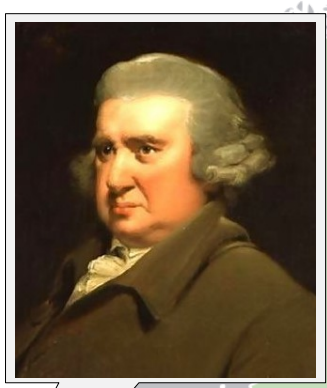


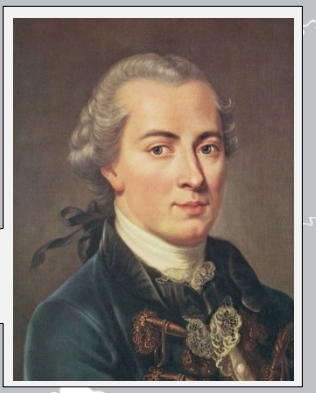


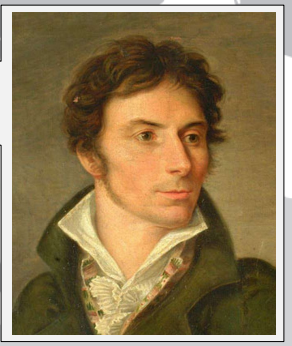


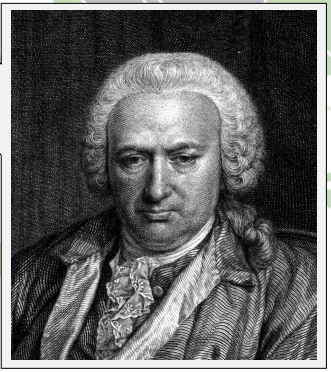


G.-L. L. de Buffon
(1707-1788)









Georges-Louis Leclerc de Buffon (1707–1788):

since 1749–1789: 26 volumes of *Histoire Naturelle*
(1789–1804 another 8 volumes)

age of Earth = 75,000 years

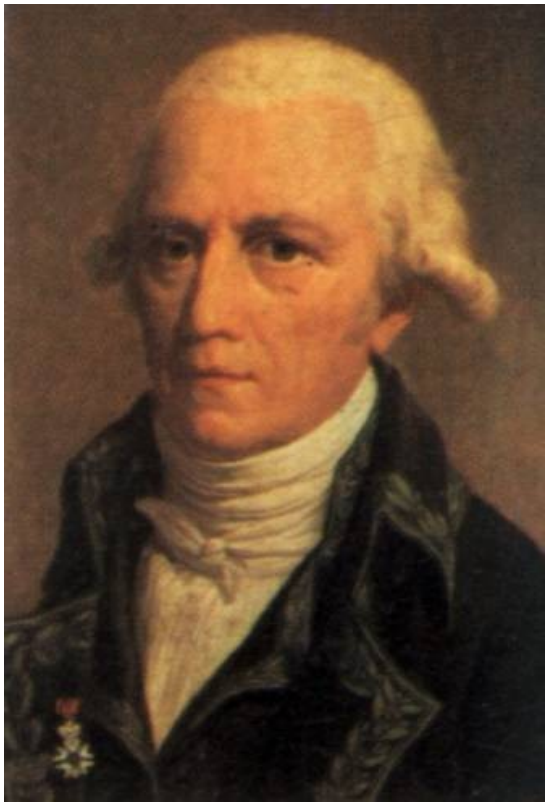
1766: related species from a common ancestor,
modification by climatic factors

1778: age 75 kya – 2-3 Mya

1. Before Darwin

C) 19th century:

Jean Baptiste Pierre Antoine de Monet de LAMARCK (1744–1829)



1809: *Philosophie Zoologique*

1. inherent tendency to change
2. inheritance of acquired characteristics

change of species towards higher organisation (transformism)

continual spontaneous emergence of simple organisms

number of species unchanged

= LAMARCKISM

criticism of Lamarck's theory:

Georges Cuvier (1769–1832)

Étienne Geoffroy Saint-Hillaire
(1772–1844)

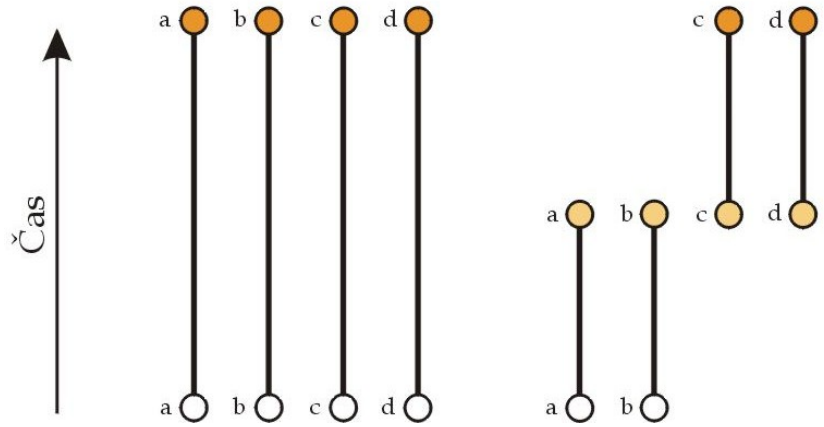
support of Lamarck, against Cuvier

saltations, no common ancestor, direct influence of environment

close to Goethe and Oken (mysticism)

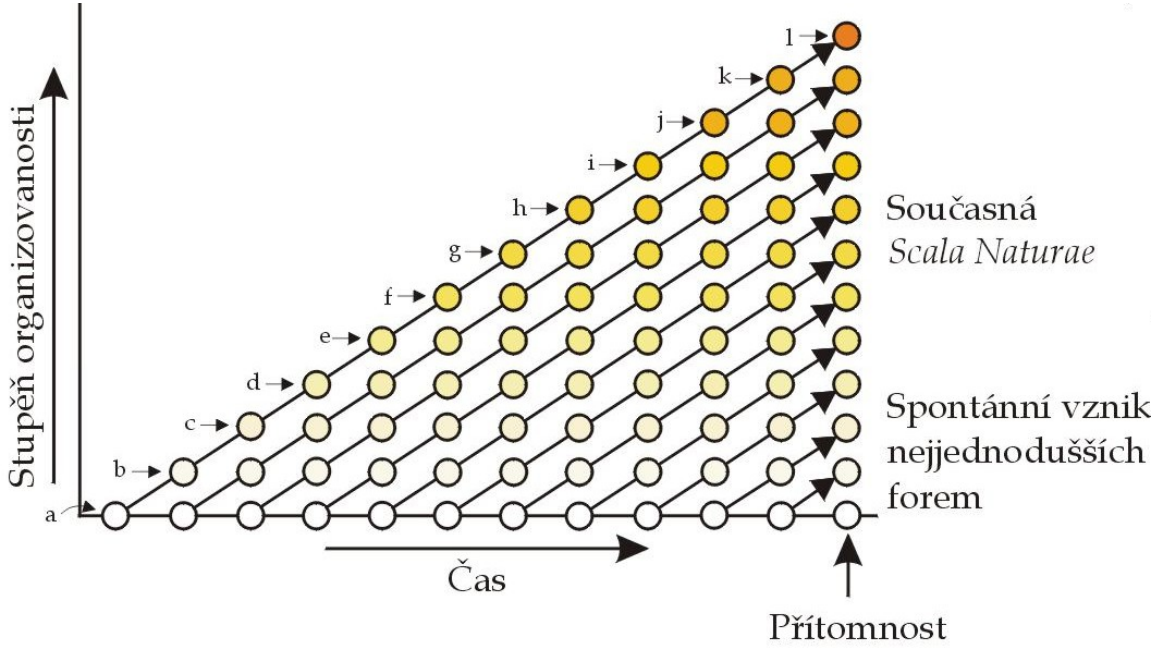
uniformity of structure (vertebrate structure has common features)

„classical“
creationism

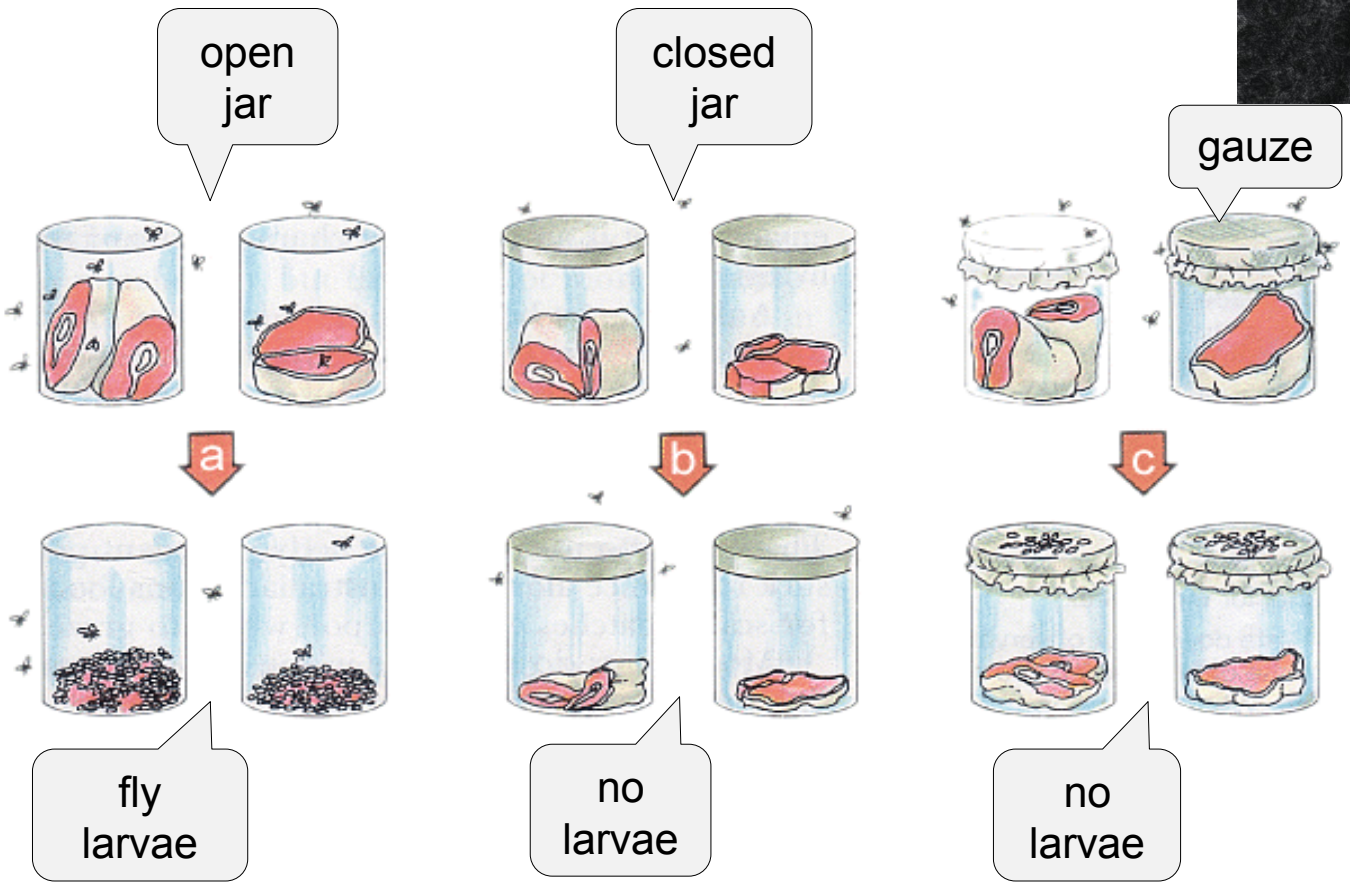


cataclysm and
new creation

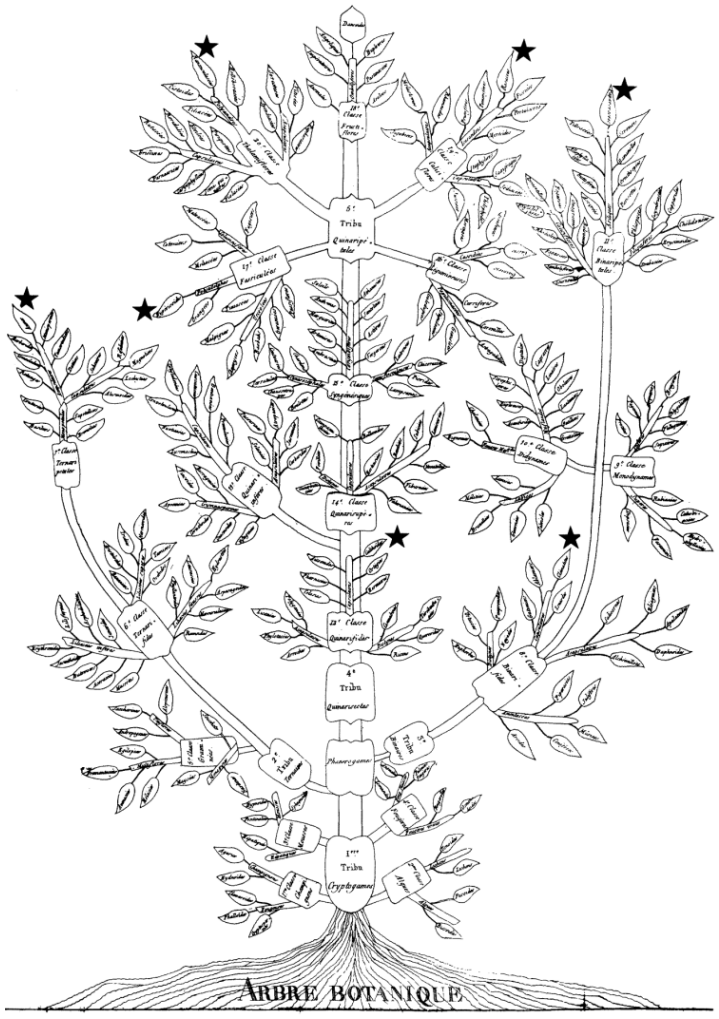
transformism



Francesco Redi (1626–1697)



A. Augier: *Essai d'une nouvelle classification des vegetaux* (1801)



TABLEAU

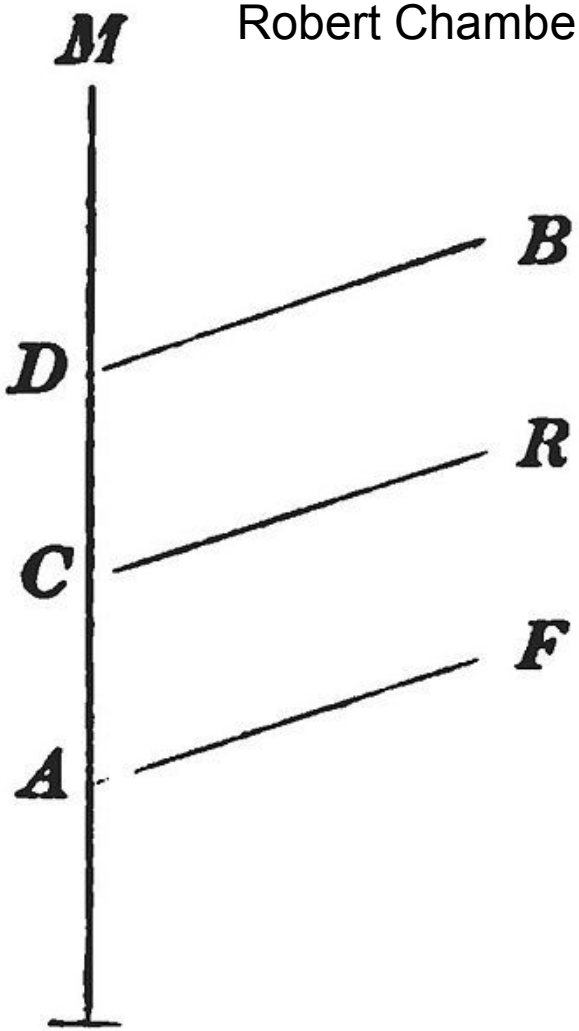
Servant à montrer l'origine des différens animaux.

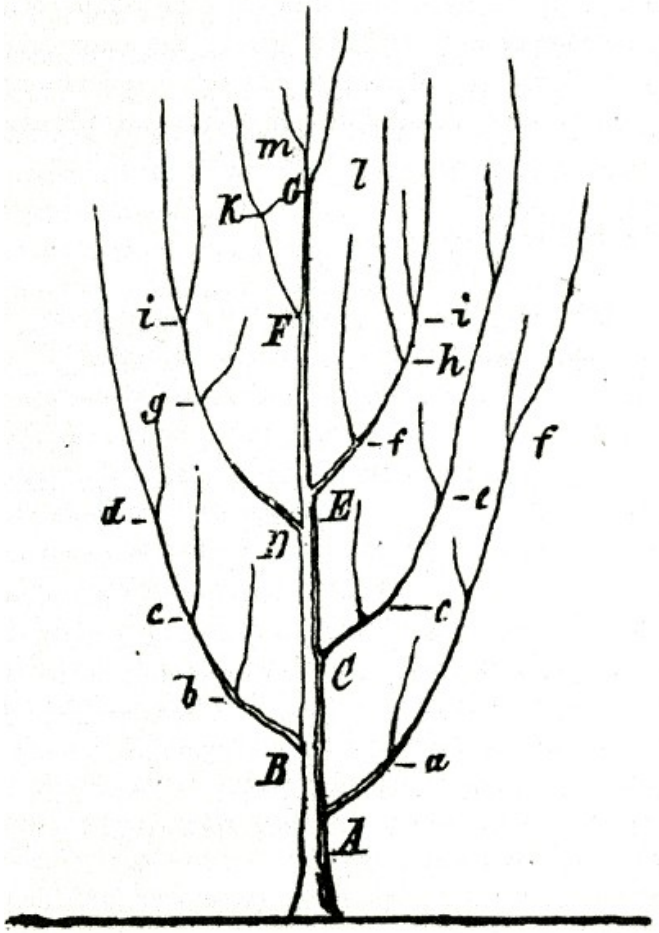
Vers.
Infusoires.
Polypes.
Radiaires.
Insectes.
Arachnides.
Annelides.
Crustacés.
Cirrhipèdes.
Mollusques.
Poissons.
Reptiles.
Oiseaux.
Monotrèmes.
M. Amphibies.
M. Cétacés.
M. Ongulés.
M. Onguiculés.

Cette série d'animaux commençant par deux

J.-B. Lamarck: *Philosophie zoologique* (1809)

Robert Chambers: *Vestiges of the Natural History of Creation* (1844)





Heinrich Georg Bronn: *Untersuchungen über die Entwicklungs – Gesetzte der organischen Welt während der Bildungszeit unserer Erd-Oberfläche* (1858)

Age of Earth

James Hutton (1726–1797): geological evidence suggests that Earth is inconceivably old $\Rightarrow$ How can we use our observation and experiment for explaining changes on such the huge time scale?

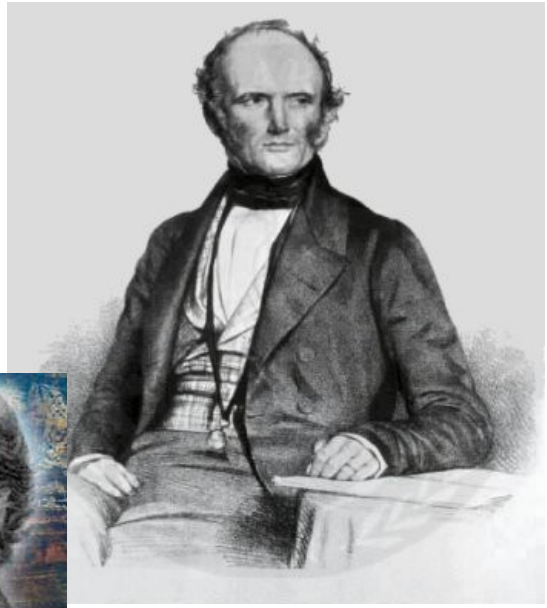
$\rightarrow$ we must rely on processes that we know at present

J. Hutton

Charles Lyell (1797–1875):

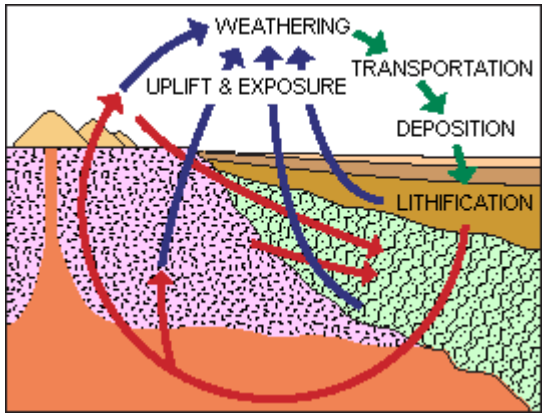
uniformitarianism

Principles of Geology

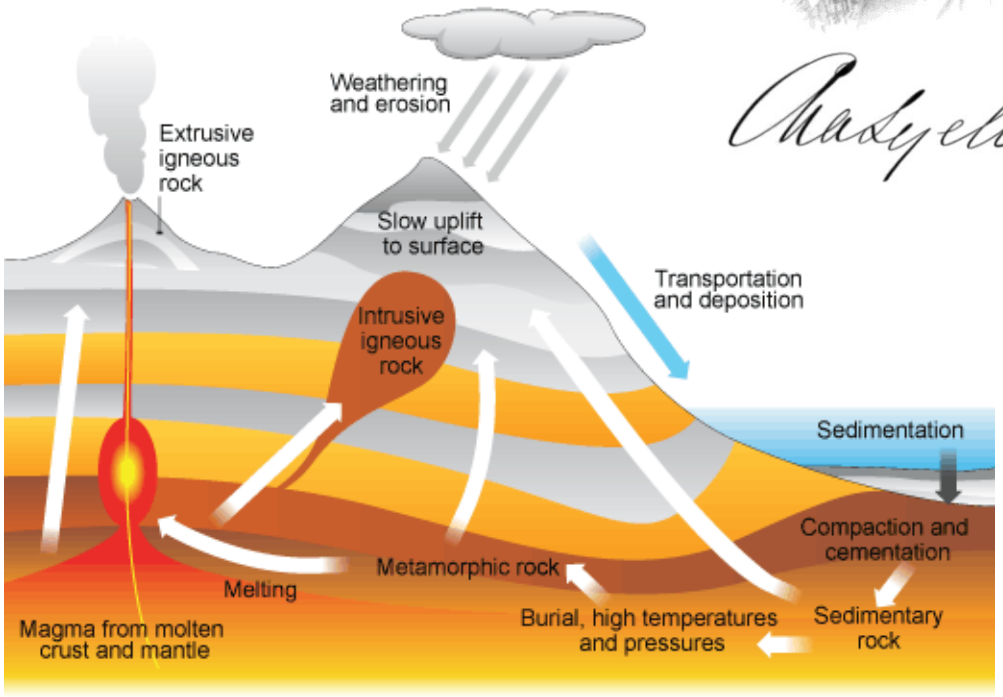


C. Lyell

uniformitarianism



Lyell



× catastrophism

paleontology:

Richard Owen
(1804–1892)

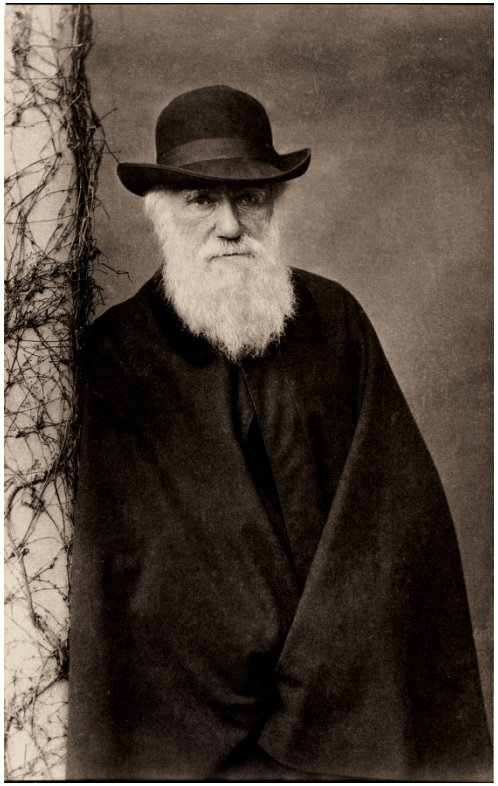
natural theology: William Paley (1743–1805)

metaphor of God as a watchmaker

W. Paley

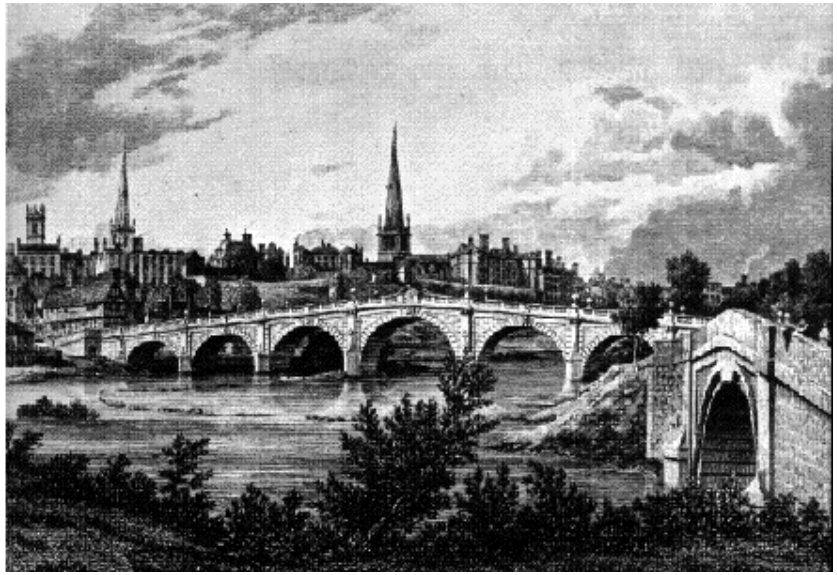
2. Darwin's/Wallace's theory

Charles Robert DARWIN (1809–1882)



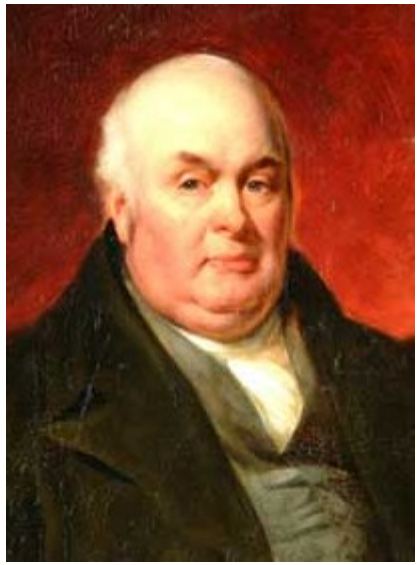
* 12th February 1809 Shrewsbury

The Mount, Shrewsbury



Erasmus Darwin

Josiah Wedgwood I.



Robert Darwin

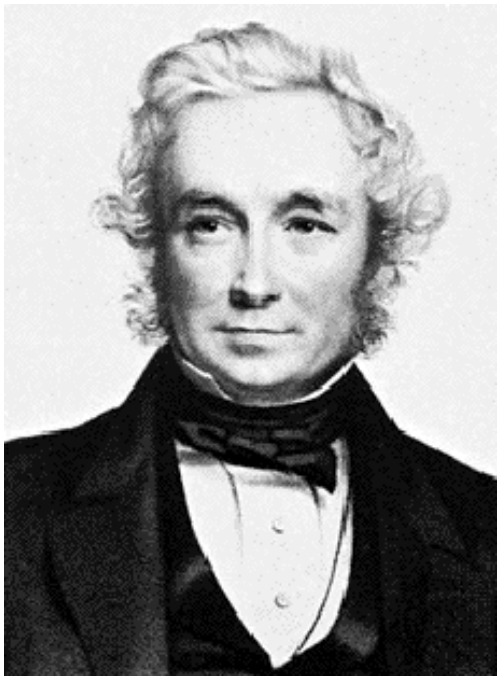
Wedgwood china

Est. 1759

October 1825: University of Edinburgh

January 1828: Christ's College,
University of Cambridge

Adam Sedgwick
(1785–1873), geologist



John Stevens Henslow
(1796–1861), botanist, geologist

Robert FitzRoy
(1805–1865)

HMS Beagle
Plymouth 27.12.1831

HMS Beagle (1831–1836)

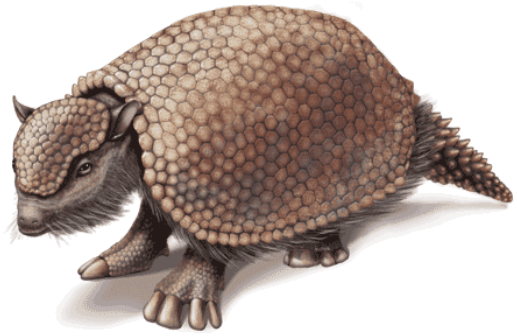
HMS Beagle (1831–1836)

Charles Lyell

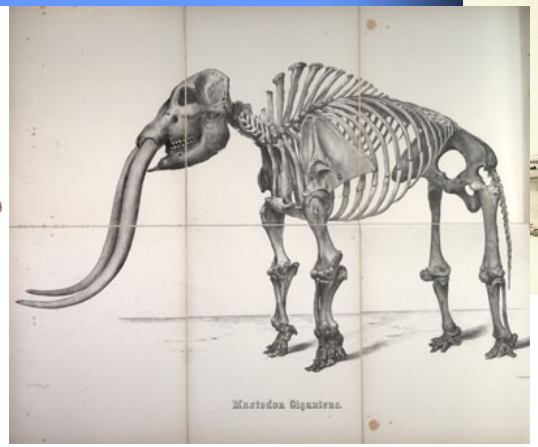
Principles of Geology (1830–1833)

HMS Beagle (1831–1836)

Megatherium



Glyptodon

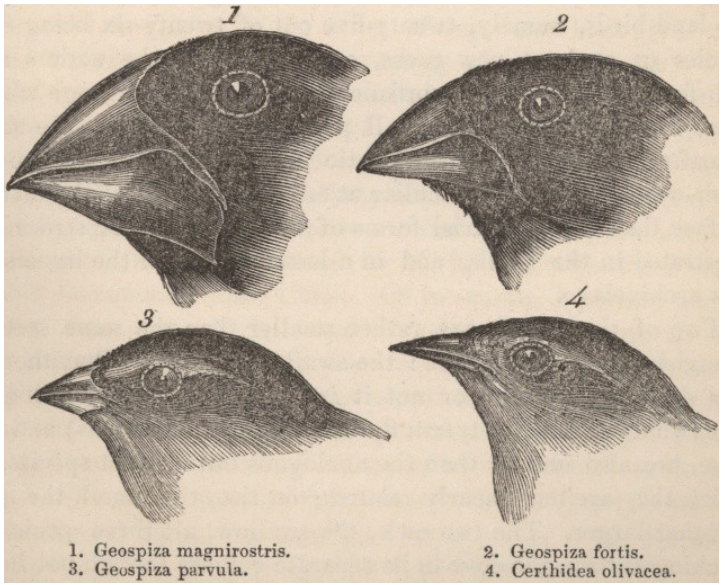


Mastodon

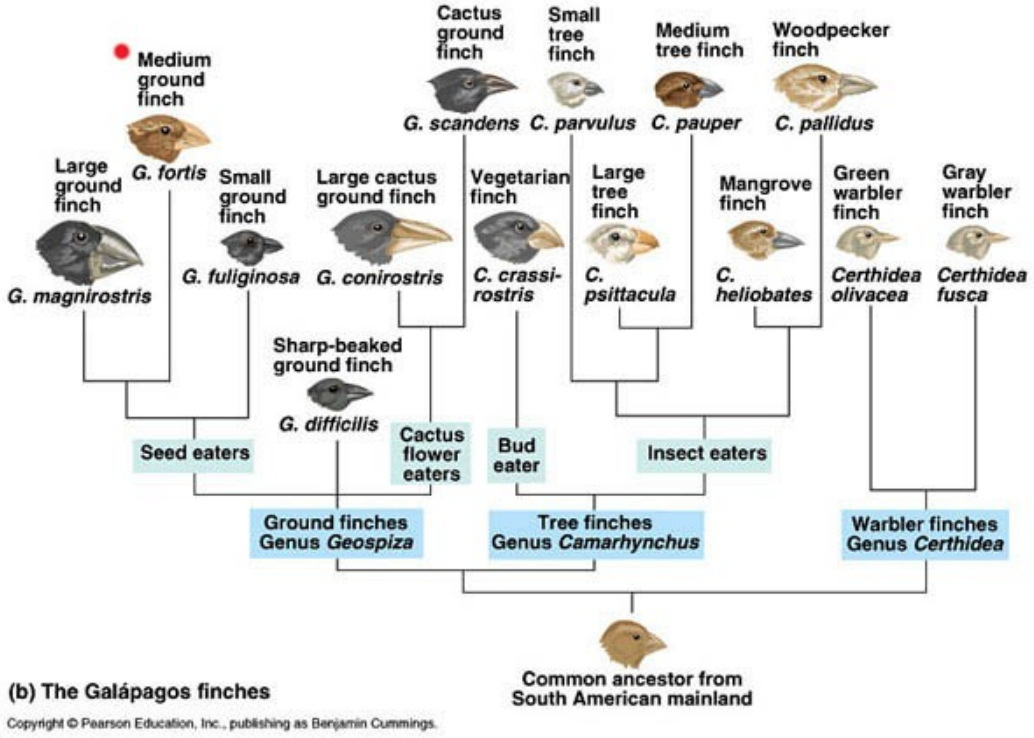
„Rhea Darwinii“

HMS Beagle (1831–1836)

John Gould



„Darwin's finches"
(tanagers)



mockingbirds

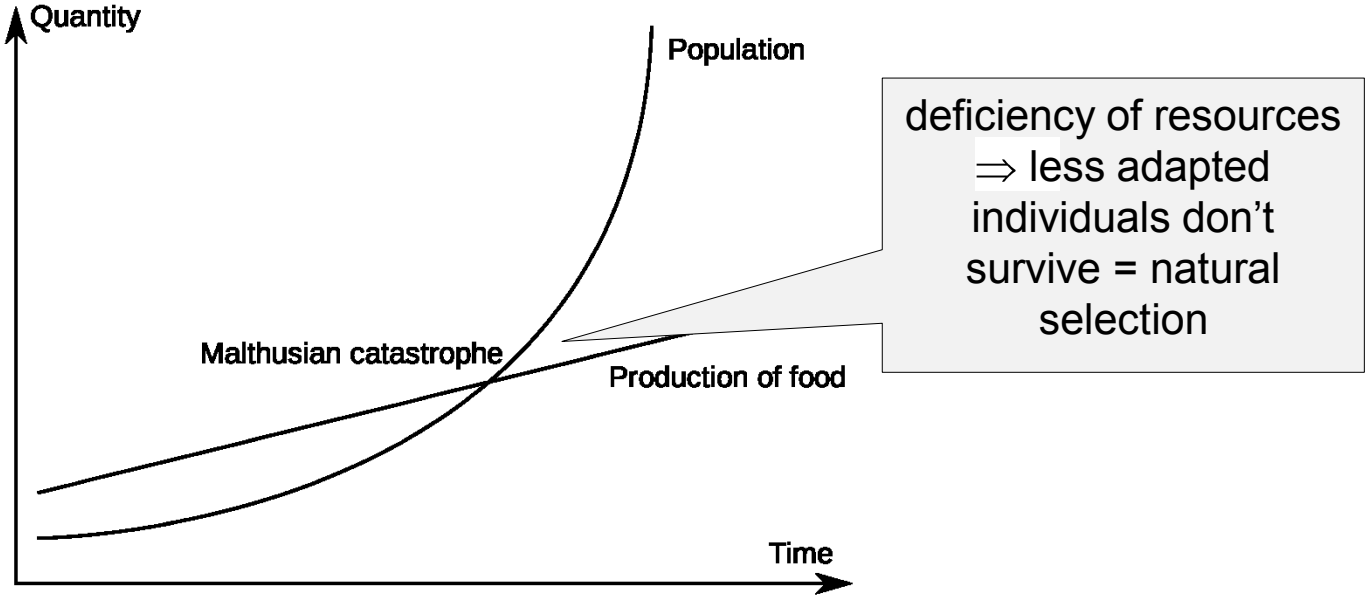
Thomas Robert Malthus (1766–1834)

1798, 1801: *An Essay on the Principle of Population*

decrease of birth and infantile mortality, increase of mean age ⇒ population growth

Great Britain (Glasgow, Liverpool, Birmingham, Manchester, London), Ireland, USA, Naples („city of beggars“)

BUT: agricultural revolution (England, USA), in USA immigrants included to the est.



1842: pencil-written 35-page outline of the theory of natural selection

1844: extension to 230 pages ... asks his wife Emma for publishing after his death

11th January 1844: letter to J. Hooker with the theory outline

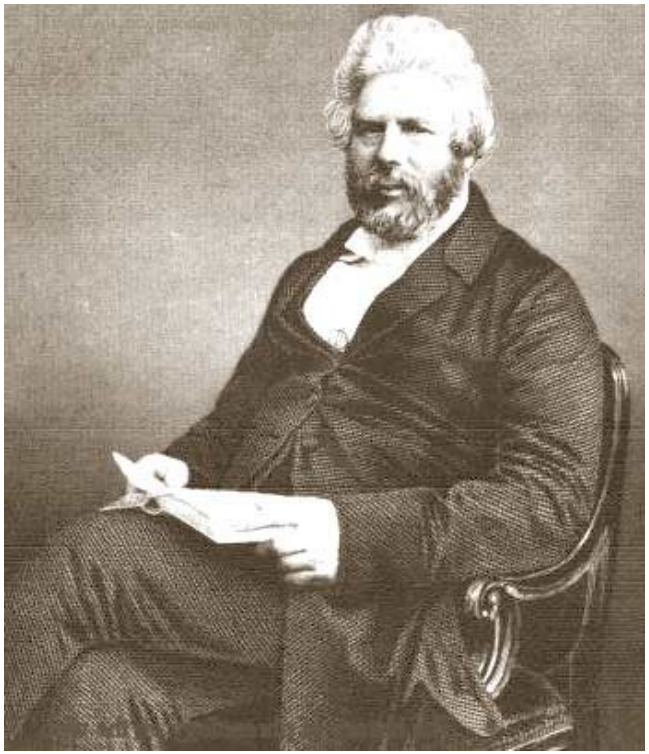
I am almost convinced (quite contrary to opinion I started with) that species are not (it is like confessing a murder) immutable.
[1844, Darwin's letter to Hooker]

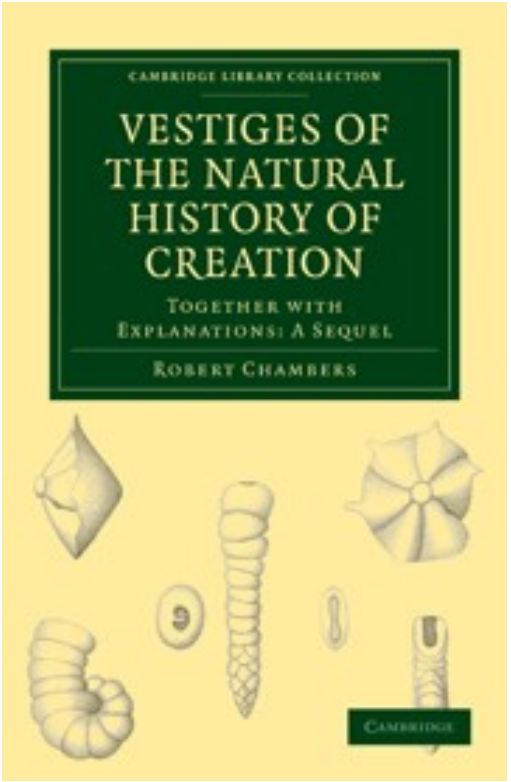
Robert Chambers (1802–1871)

1844: *Vestiges of the Natural History of Creation*)

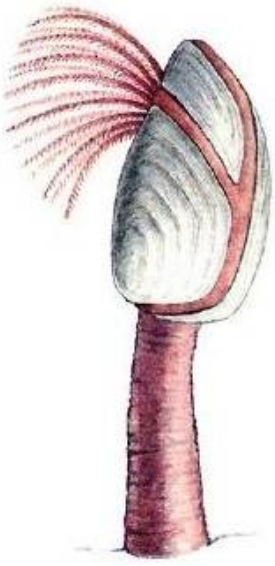
12 editions, in total 100,000 copies

authorship discovered as late as in 1884

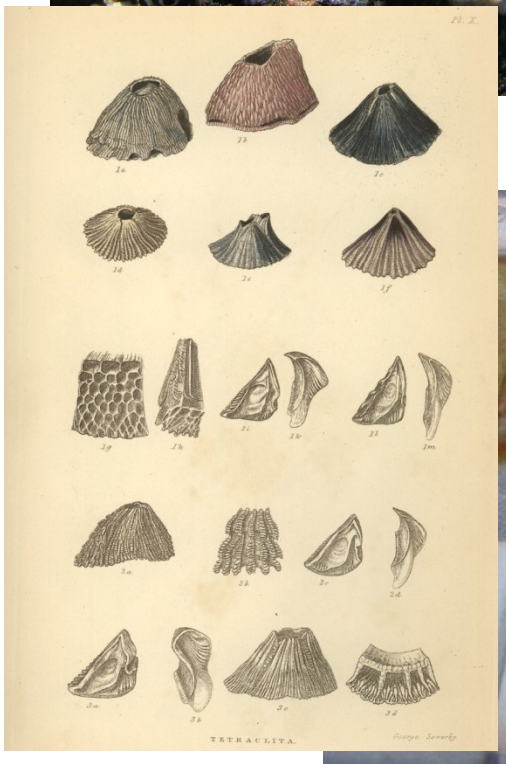




1846 …



barnacles

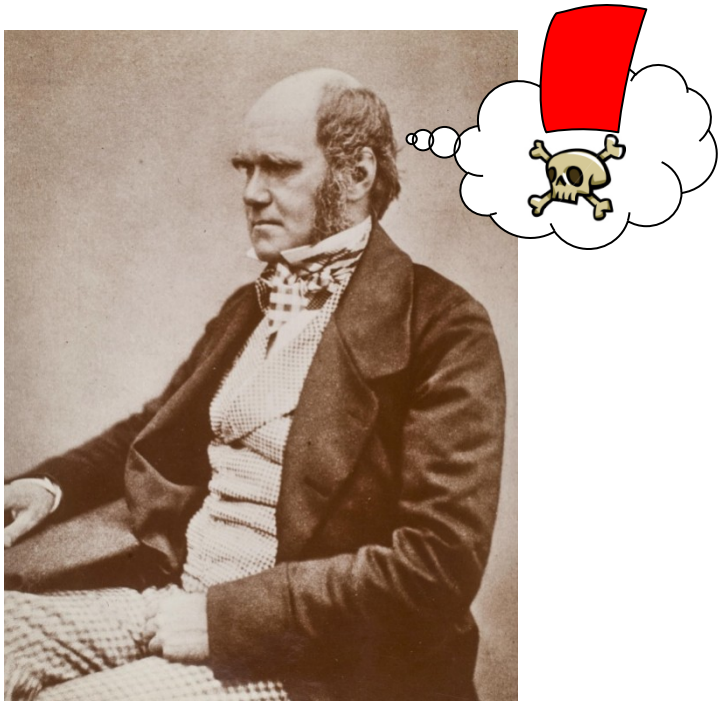


1854: 2 books on extant barnacles and 2 books on extinct barnacles

1856: Darwin starts to work on a book on natural selection,
planned extent 1000 pages ...

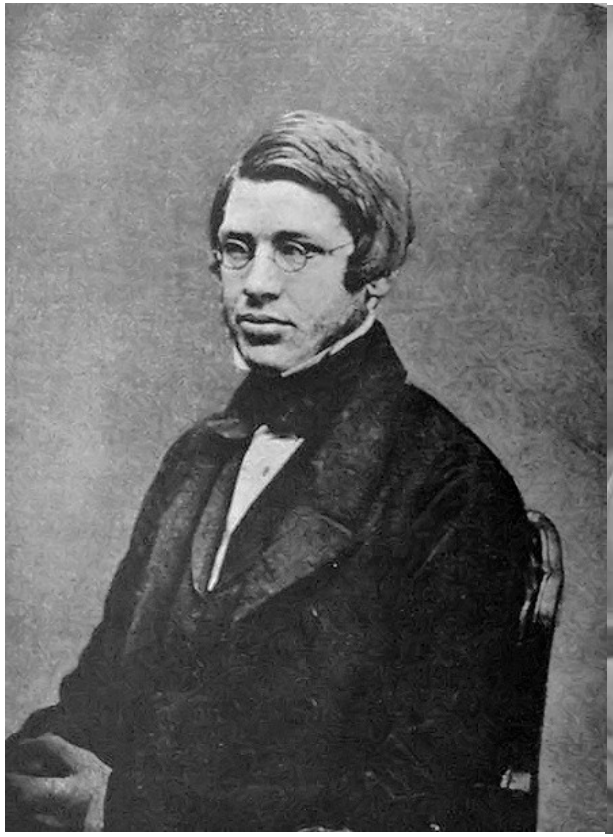
5th August 1857: theory outline to A. Gray

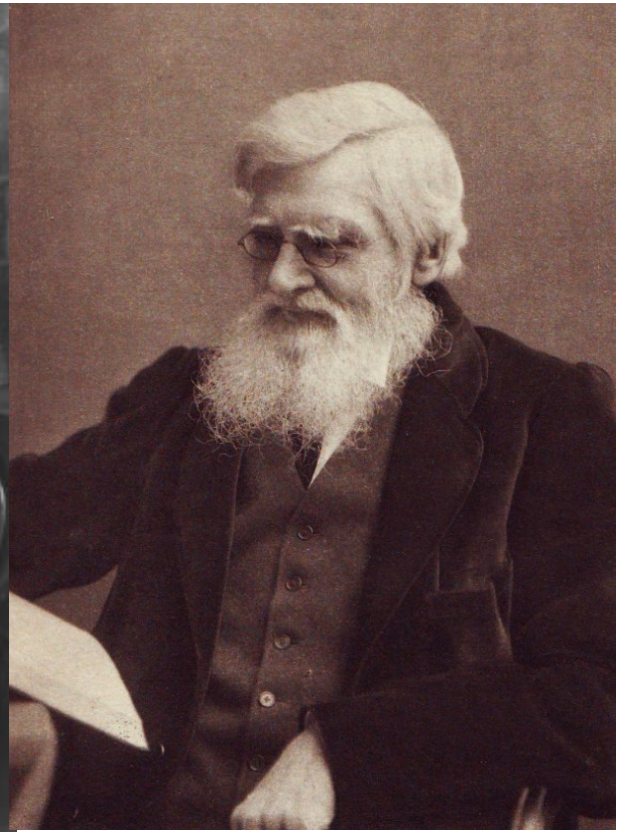
1858: letter from A.R. Wallace *On the Tendency of Varieties to Depart Indefinitely from the Original Type*

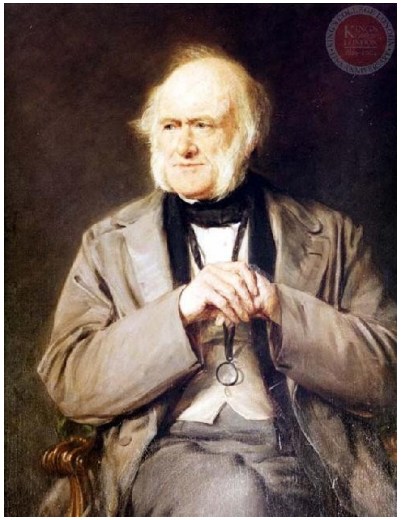


Alfred Russel Wallace

(1823–1913)

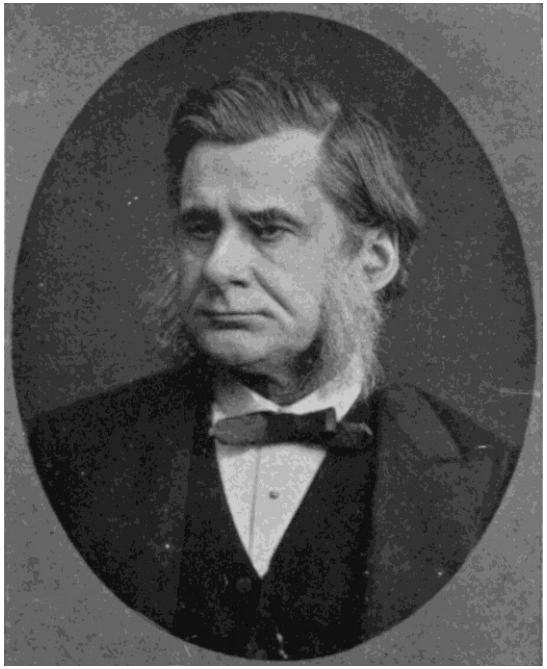






Charles Lyell
(1797–1875)

Joseph Dalton Hooker
(1814–1879)

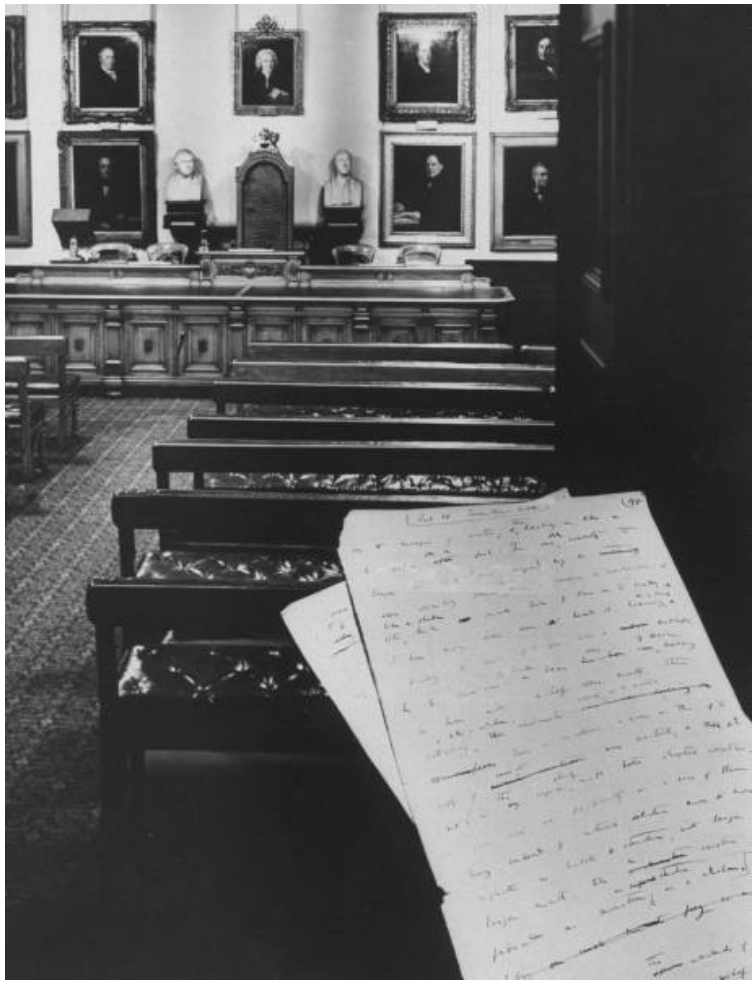


Thomas Henry Huxley
(1825–1895)

Asa Gray (1810–1888)

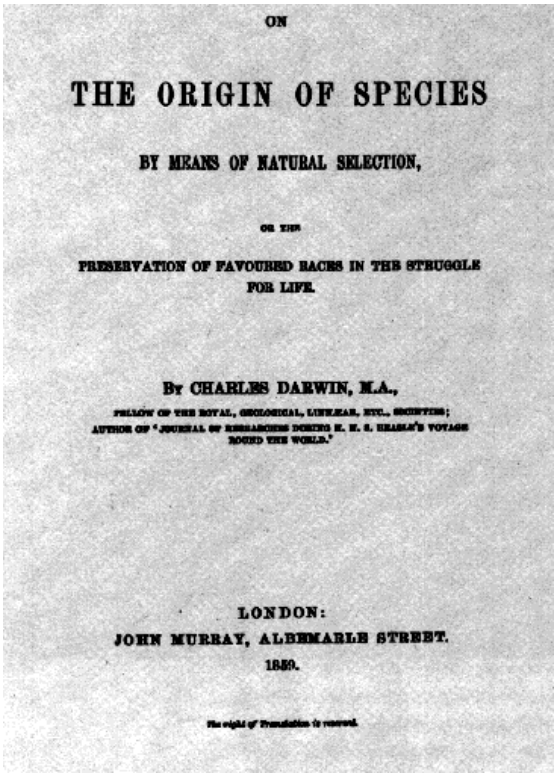
1st July 1858: Linnean Society of London

On the Tendency of Species to Form Varieties; and on the Perpetuation of Varieties and Species by Means of Natural Selection



24. listopadu 1859

On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life


ON

THE ORIGIN OF SPECIES

BY MEANS OF NATURAL SELECTION,

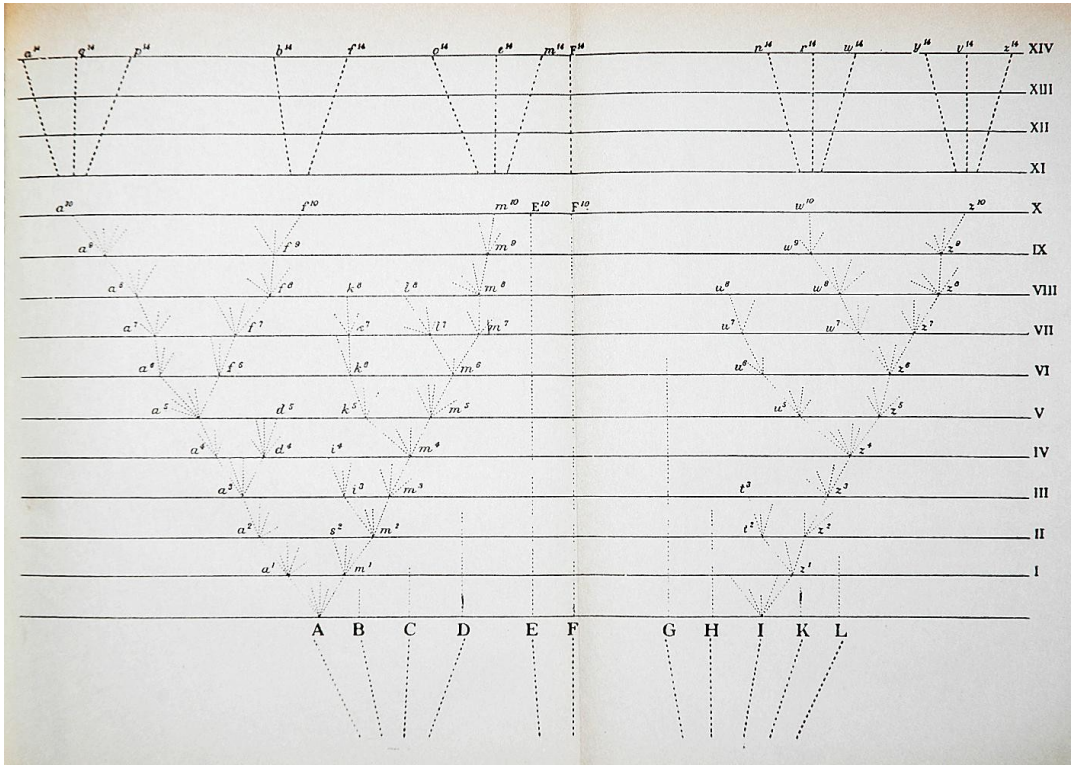
OR THE

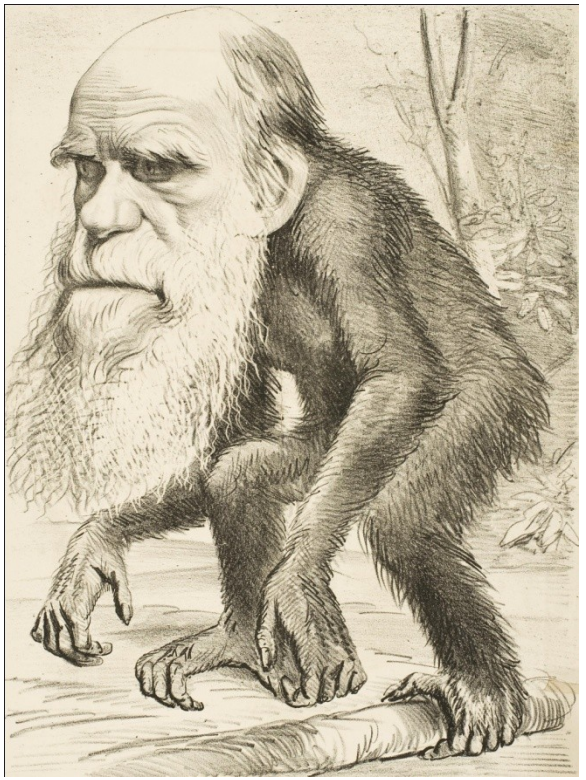
PRESERVATION OF FAVOURED RACES IN THE STRUGGLE FOR LIFE.

By CHARLES DARWIN, M.A.,

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

LONDON:
JOHN MURRAY, ALBEMARLE STREET.
1859.





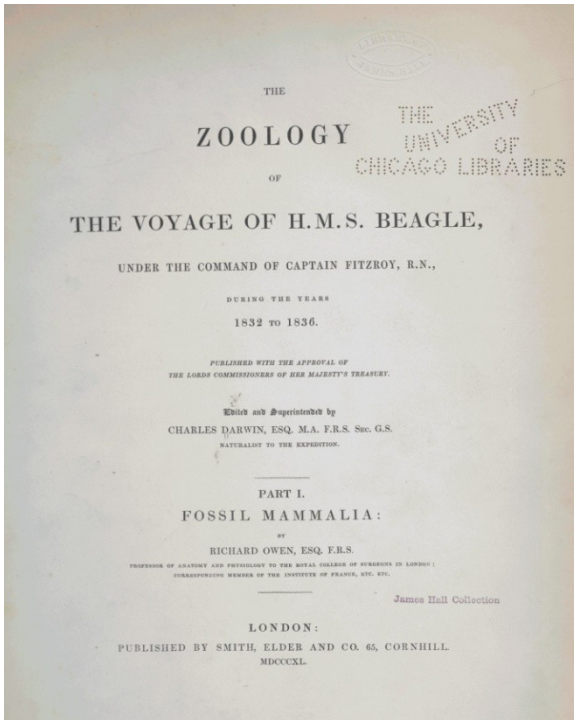
MR. BERGH TO THE RESCUE.

THE DEFRAUDED GORILLA. "That *Man* wants to claim my Pedigree. He says he is one of my Descendants."

MR. BERGH. "NOW, MR. DARWIN, how could you insult him so?"


TRUE BELIEF COMICS
SCIENCE ACTION STORIES
MEANWHILE..
JESUS AND DARWIN
WERE FIGHTING AGAIN.

Richard Owen



THE

ZOOLOGY

OF

THE VOYAGE OF H.M.S. BEAGLE,

UNDER THE COMMAND OF CAPTAIN FITZROY, R.N.,

DURING THE YEARS

1832 TO 1836.

PUBLISHED WITH THE APPROVAL OF
THE LORDS COMMISSIONERS OF HER MAJESTY'S TREASURY.

Edited and Superintended by

CHARLES DARWIN, ESQ. M.A. F.R.S. Sec. G.S.

NATURALIST TO THE EXPEDITION.

PART I.

FOSSIL MAMMALIA:

BY

RICHARD OWEN, ESQ. F.R.S.

PROFESSOR OF ANATOMY AND PHYSIOLOGY TO THE ROYAL COLLEGE OF SURGEONS IN LONDON;
CORRESPONDING MEMBER OF THE INSTITUTE OF FRANCE, ETC. ETC.

LONDON:

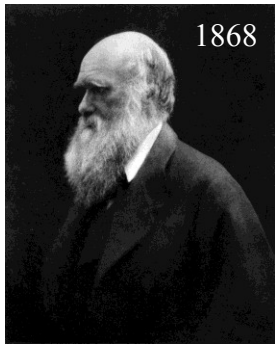
PUBLISHED BY SMITH, ELDER AND CO. 65, CORNHILL.

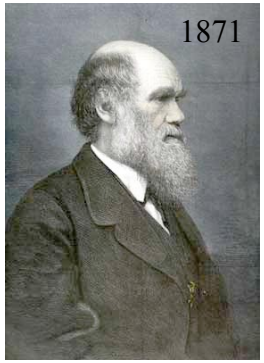
MDCCCXL.

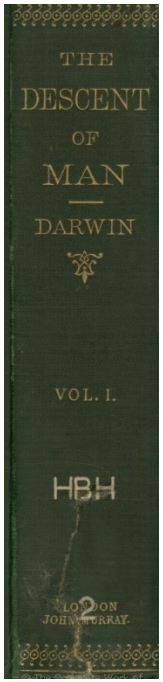
Samuel Wilberforce
(1805–1873)

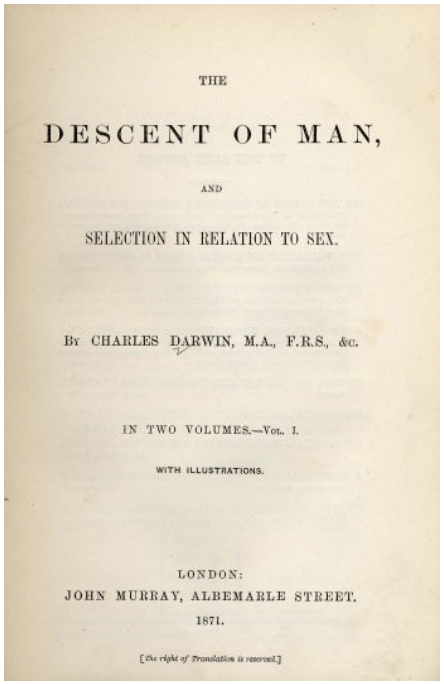
1868: *The Variation of Animals and Plants under Domestication*

1871: *The Descent of Man, and Selection in Relation to Sex*








THE

DESCENT OF MAN,

AND

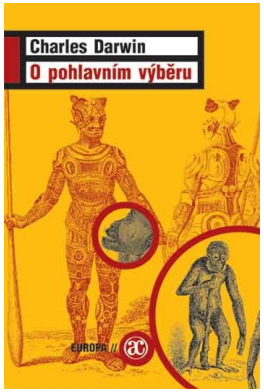
SELECTION IN RELATION TO SEX.

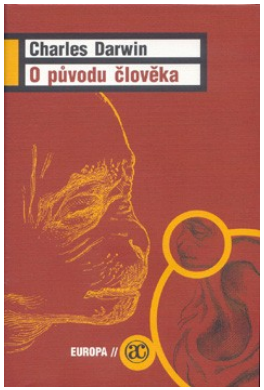
By CHARLES DARWIN, M.A., F.R.S., &c.

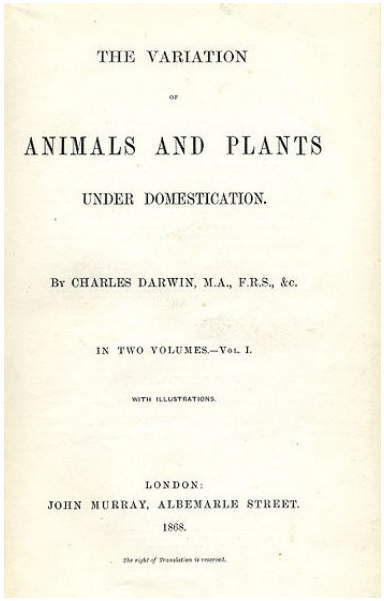
IN TWO VOLUMES.—Vol. I.

WITH ILLUSTRATIONS.

LONDON:
JOHN MURRAY, ALBEMARLE STREET.
1871.






THE VARIATION

OF

ANIMALS AND PLANTS

UNDER DOMESTICATION.

By CHARLES DARWIN, M.A., F.R.S., &c.

IN TWO VOLUMES.—Vol. I.

WITH ILLUSTRATIONS.

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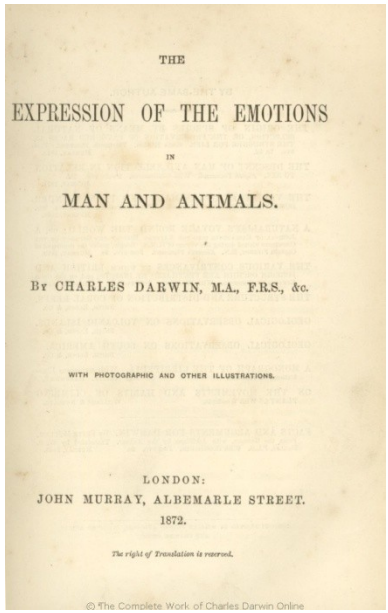
1868.


THE

EXPRESSION OF THE EMOTIONS

IN

MAN AND ANIMALS.

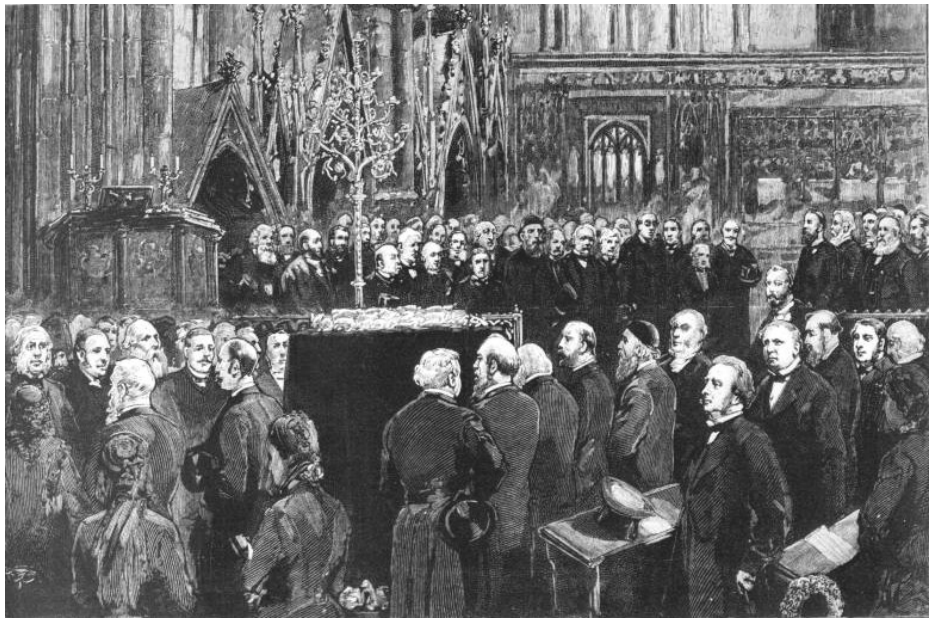
By CHARLES DARWIN, M.A., F.R.S., &c.

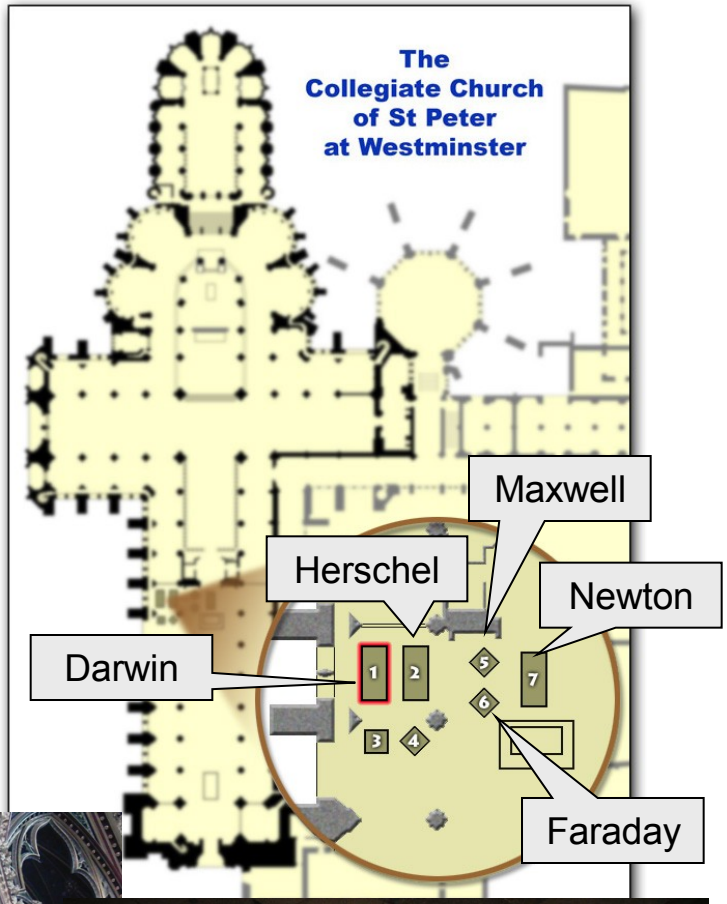
WITH PHOTOGRAPHIC AND OTHER ILLUSTRATIONS.

LONDON:
JOHN MURRAY, ALBEMARLE STREET.
1872.

1872: *The Expression of the Emotions in Man and Animals*

+ 19th April 1882, Down House





FUNERAL OF MR. DARWIN.

WESTMINSTER ABBEY,

Wednesday, April 26th, 1882.

AT 12 O'CLOCK PRECISELY.

Admit the Bearer at Eleven o'clock to the

SOUTH TRANSEPT.

(Entrance by Door at Poet's Corner.)

G. G. BRADLEY, D.D.
Dean.

N.B.—No Person will be admitted except in mourning.

Darwin's theory = DARWINISM:

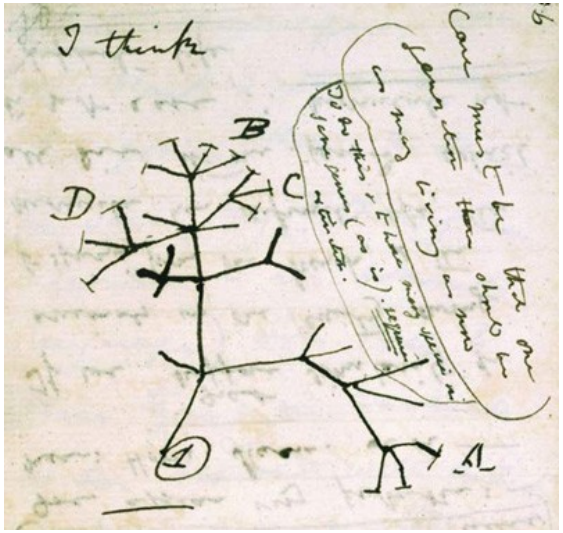
1. Descent of all species from a common ancestor

   no action of a supernatural being
   (materialistic explanation)

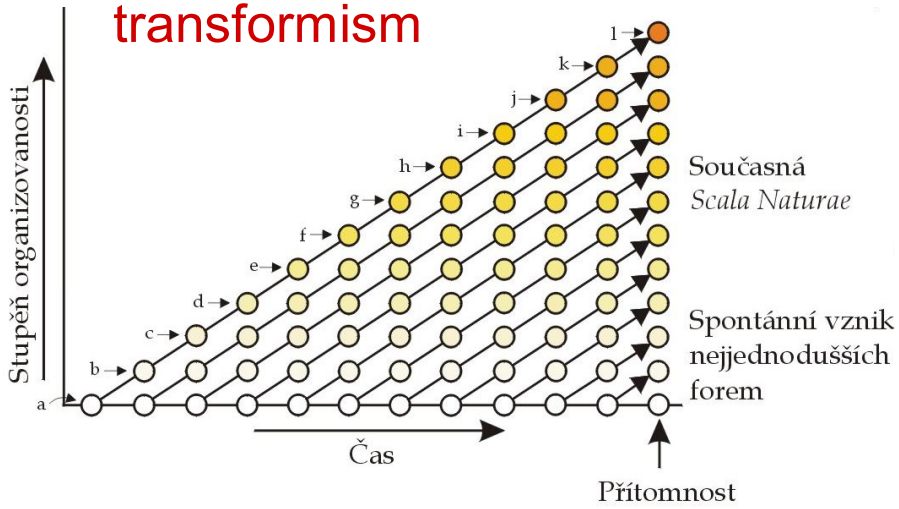
   no abiogenesis, species emerge from other species

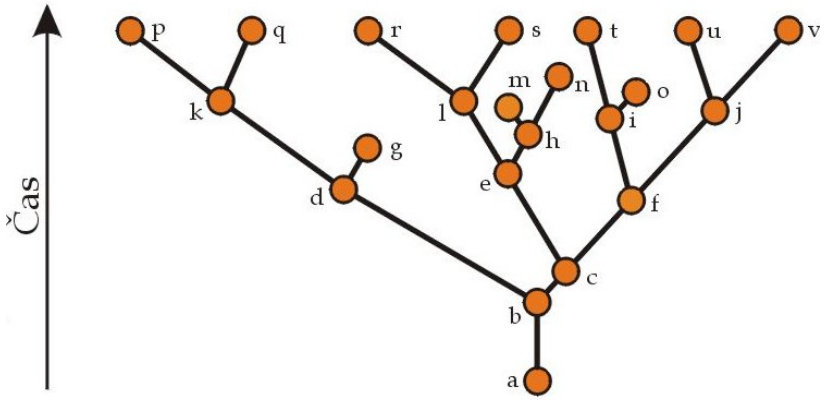
   divergence by accumulating small changes
   (no saltations, no catastrophism)

2. Theory of natural selection

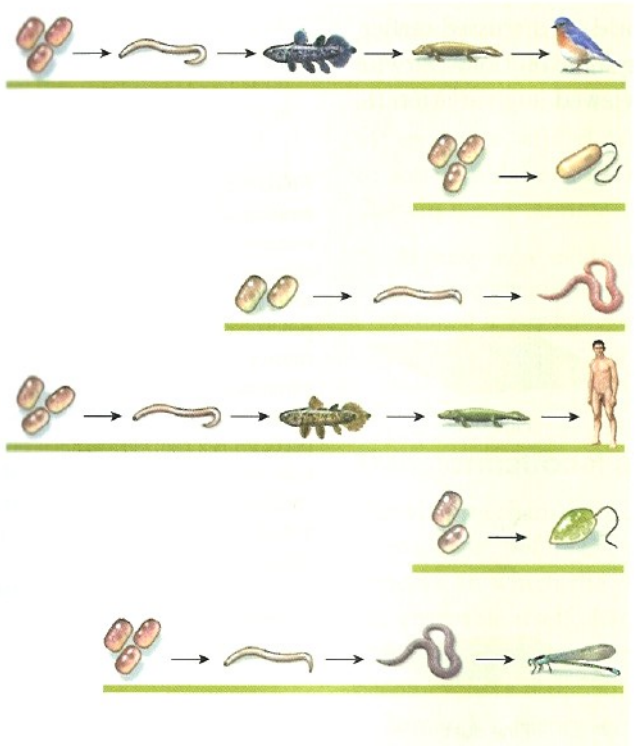


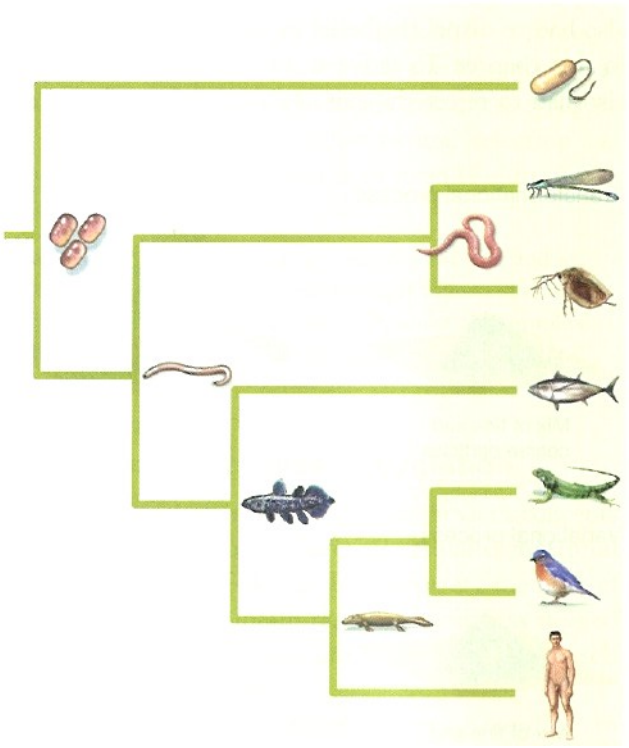
transformism





Darwinism





Lamarck:

„population“ has changed because all individuals have changed (no selection)

„population“ of smaller individuals because big ones have been selected out

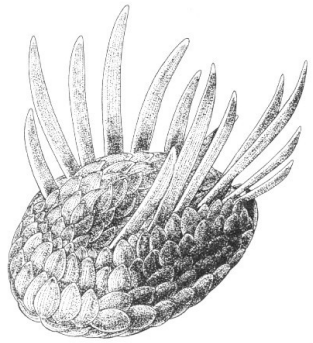
Darwin:

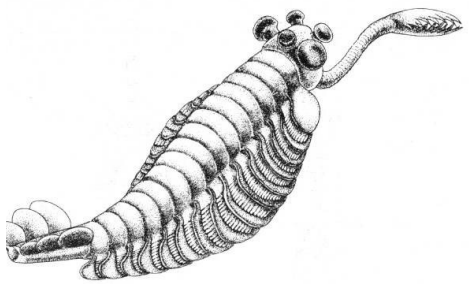
3. Evolutionary theory at the turn of the century

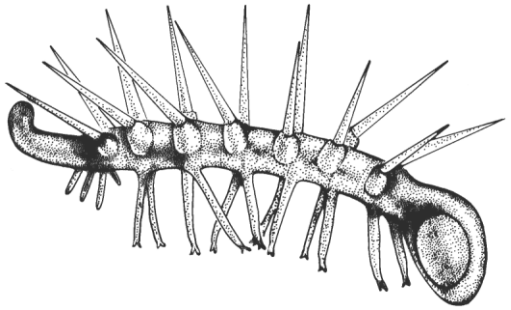
Problems of Darwin's theory:

time: William Thomson, lord Kelvin
age of Earth max. 200 My

Cambrian fossils







stromatolites

Precambrian (Ediacaran fauna)

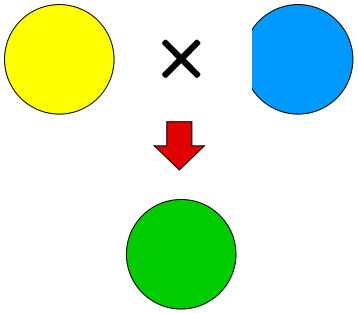
Problems of Darwin's theory:

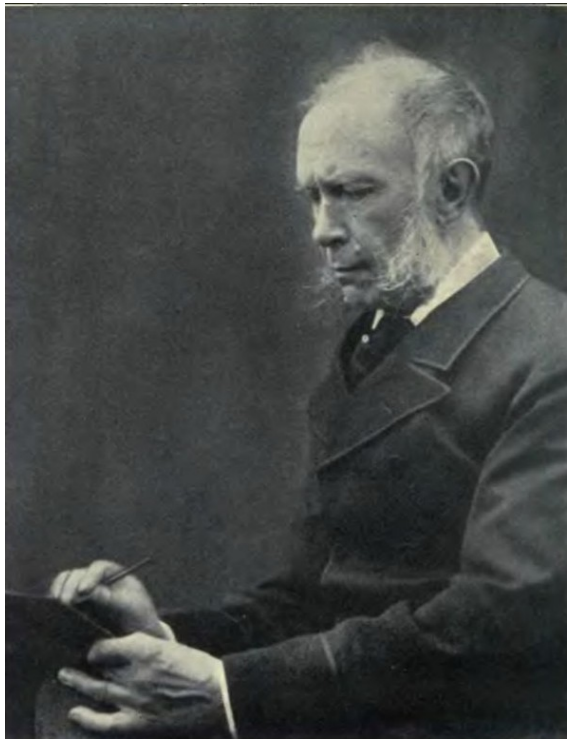
origin of complex organs

ignorance of the theory of heredity:

blending heredity (× 1867 Fleeming Jenkin)

pangenesis (gemmules)

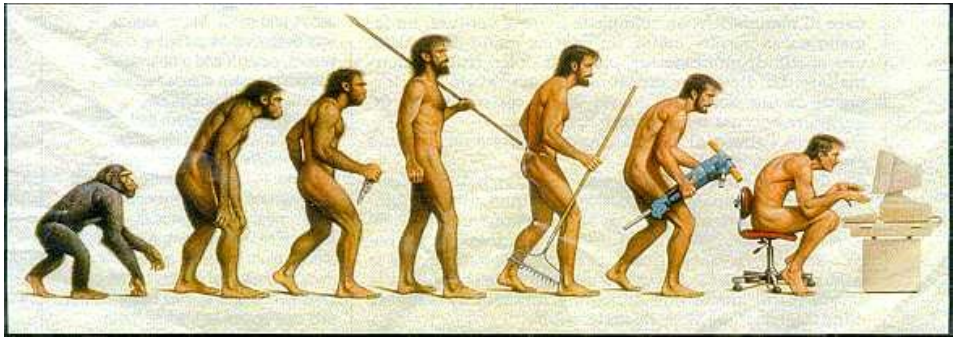


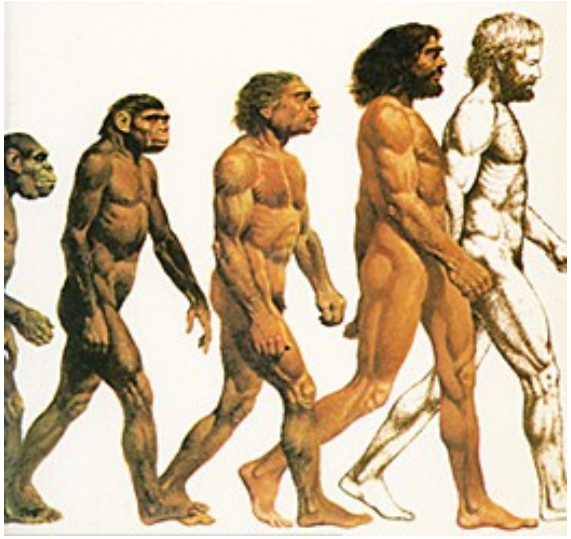


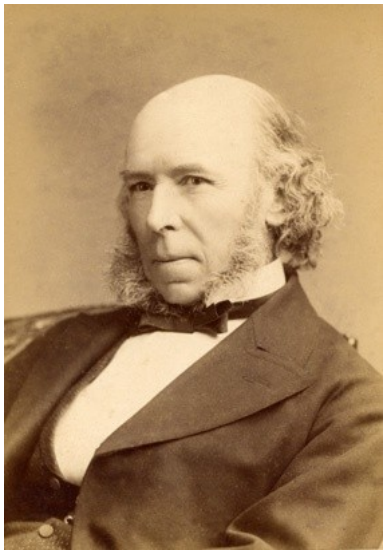
Herbert Spencer (1820–1903): social Darwinism

Marx, Engels: marxism

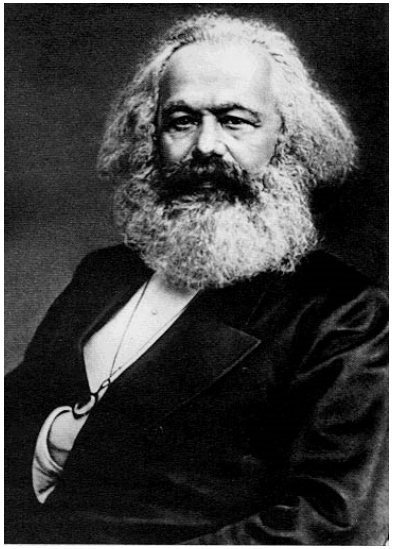
evolution as a progressive process



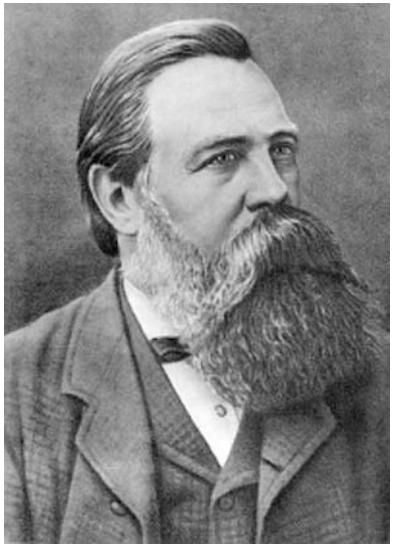




H. Spencer



K. Marx



F. Engels

ALTERNATIVE THEORIES

1. Orthogenesis:

Megaceros giganteus

finalism

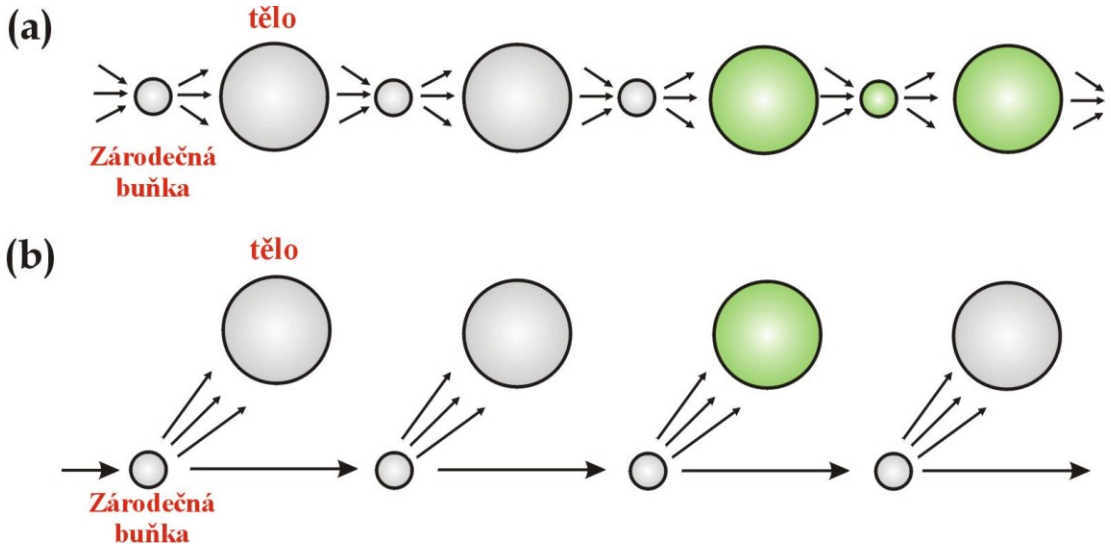
2. Neolamarckism:

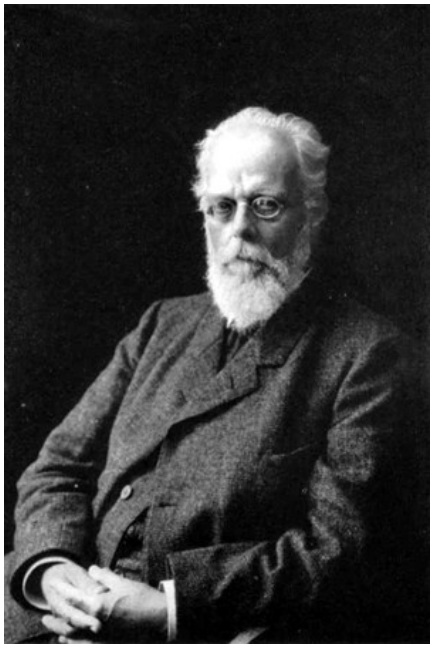
Paul Kammerer, Arthur Koestler

lysenkism: Trofim Děnisovič Lysenko

T. D. Lysenko

August Weismann:
soma + germen





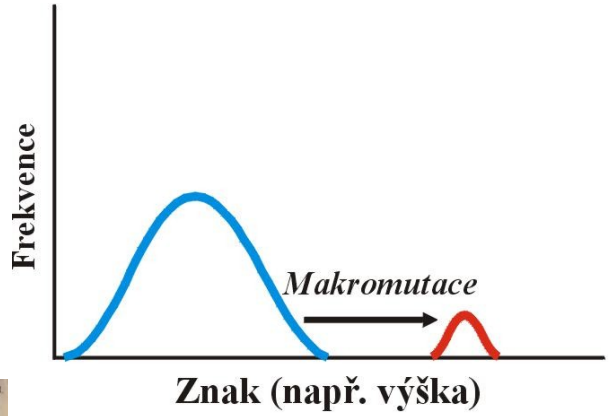
A. Weismann

3. Mutationism:

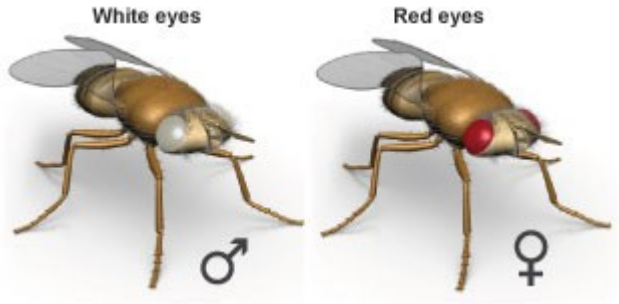
1900: rediscovery of Mendel's laws

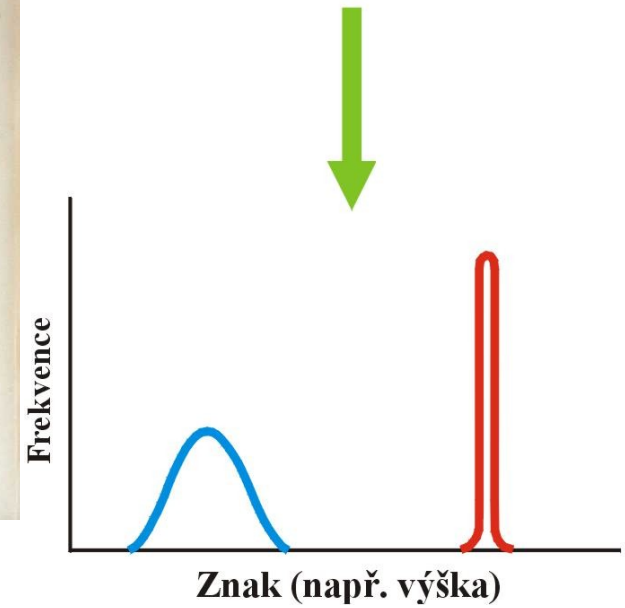
Hugo de Vries: the term mutation
evening primrose (*Oenothera lamarckiana*)

William Bateson, Thomas Hunt Morgan



discrete variation



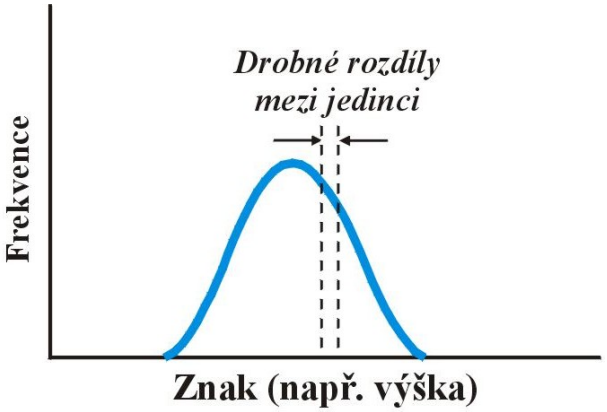


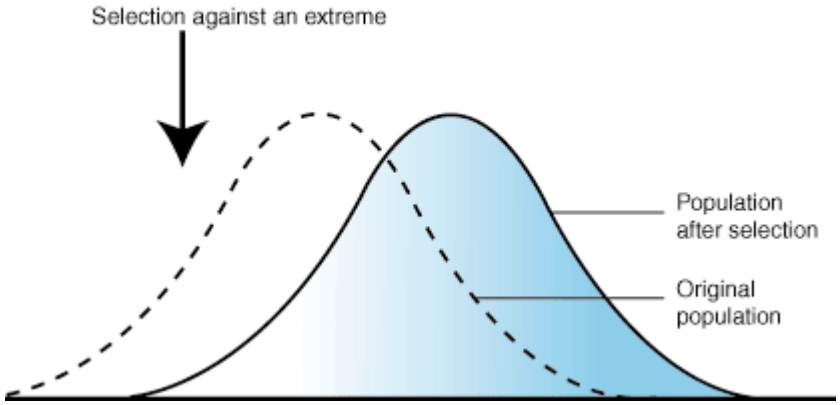
macromutations: Richard Goldschmidt
(1940) - „hopeful monsters"

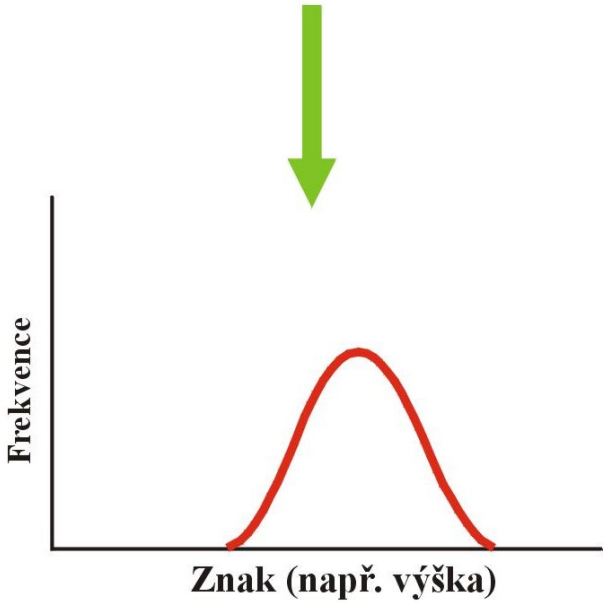
× biometricians:

Francis Galton, Karl Pearson

continual variation







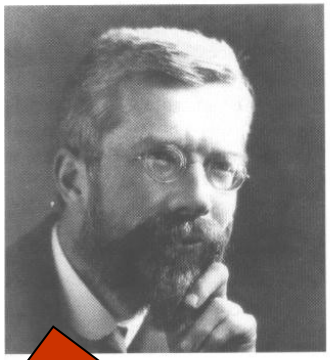
4. Modern Synthesis

RONALD A. FISHER

J. B. S. HALDANE

SEWALL WRIGHT

Ronald Aylmer Fisher (1890-1962)
John B. S. Haldane (1892-1964)
Sewall Wright (1889-1988)
Sergey Chetverikov (1880-1958)

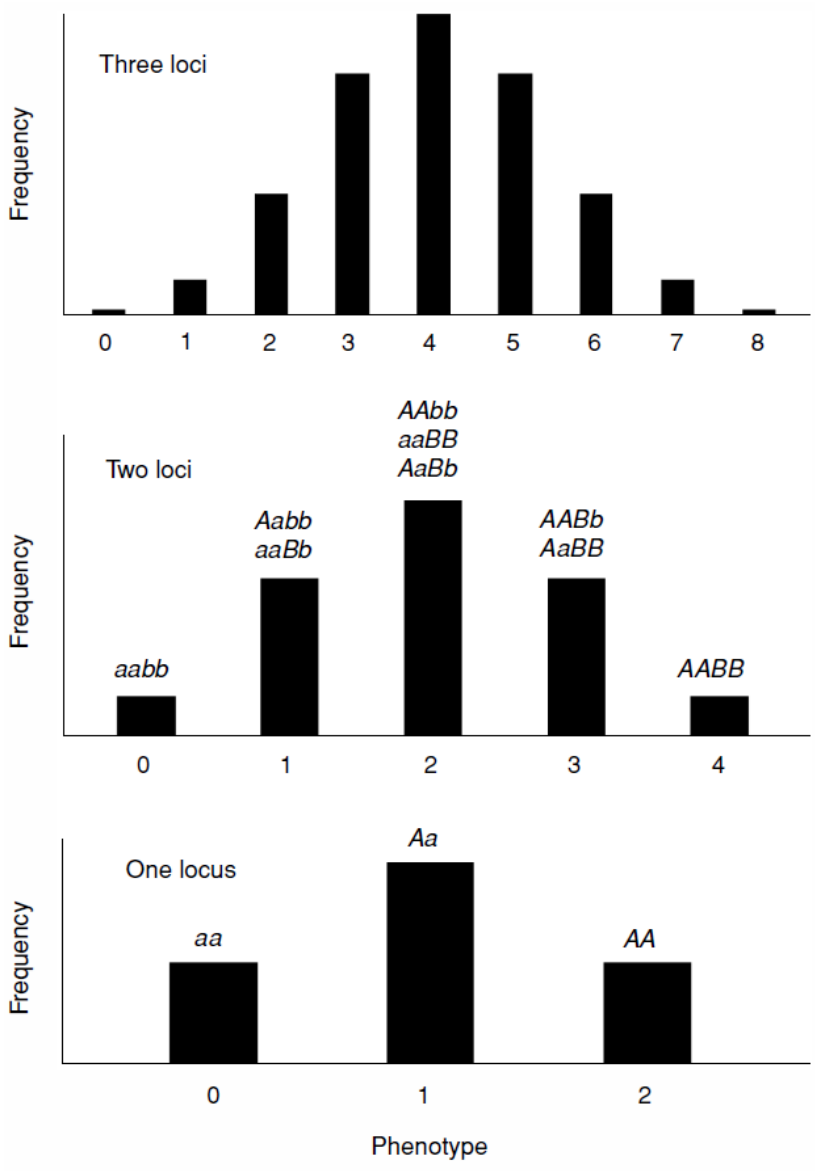


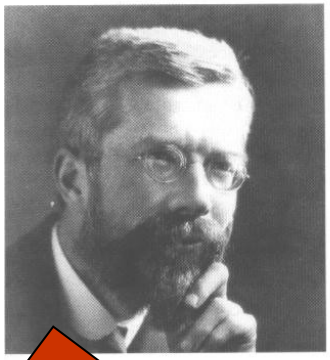
R[illegible] FISHER

J. B. S. HALDANE

SEWALL WRIGHT

1918: results of biometricians
in agreement with Mendelism


Three loci
Frequency
0
1
2
3
4
5
6
7
8
Two loci
AAbb
aaBB
AaBb
Aabb
aaBb
AABb
AaBB
aabb
AABB
Frequency
0
1
2
3
4
One locus
Aa
aa
AA
Frequency
0
1
2
Phenotype



FISHER

J. B. S. HALDANE

SEWALL WRIGHT

1918: results of biometricians in agreement with Mendelism

1930: *The Genetical Theory of Natural Selection*

1931: *Evolution in Mendelian Populations*

1932: *The Causes of Evolution*

principles of population genetics

NEODARWINISM in a narrow sense

Theodosius Dobzhansky (1900-1975)
1937 – *Genetics and the Origin of Species*

Edmund B. Ford (1901-1988)
1964 – *Ecological Genetics*

Julian S. Huxley (1887-1975)
1942 – *Evolution: The Modern Synthesis*

Ernst Mayr (1904-2005)

George Gaylord Simson (1902-1984)

George Ledyard Stebbins (1906-2000)

1947 Princeton
1949 *Genetics, Paleontology, and Evolution*

Synthetic theory of evolution = Modern Synthesis

NEODARWINISM in a broad sense

Some principles of Neodarwinism:

phenotypic differences are caused by differences in genotype and partly by environmental influences

environment can change the mutation rate but not give rise to adaptive mutations

heredity is based on genes which maintain their identity from generation to generation

evolutionary changes take place in populations as changes of gene frequencies

there is no gene flow among species

not even macromutation can cause the origin of a new species

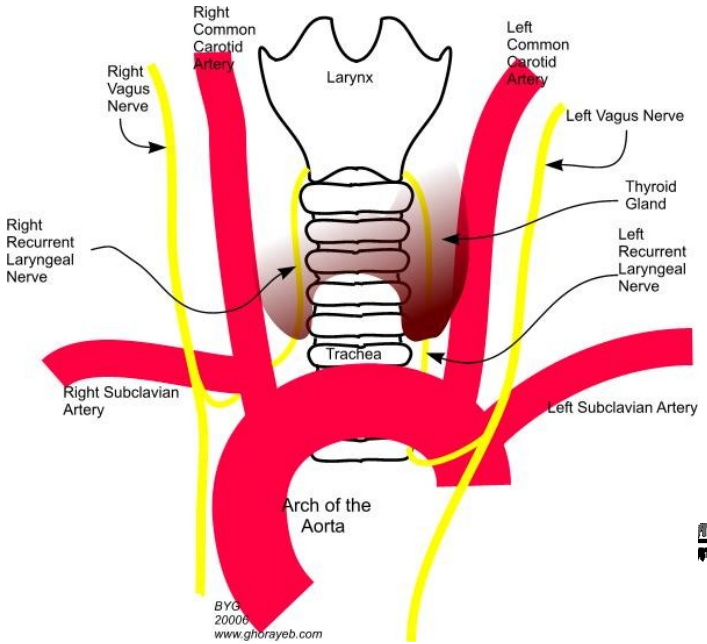
new species generally emerge by genetic divergence of geographically isolated populations

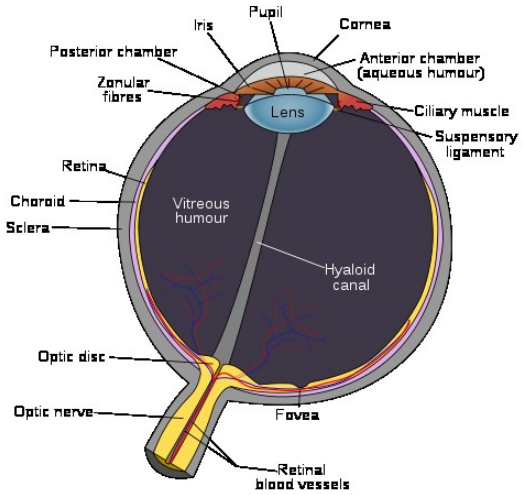
differences, processes and mechanisms on the supraspecific level (macroevolution) can be explained with the same principles as those on the infraspecific level (microevolution)

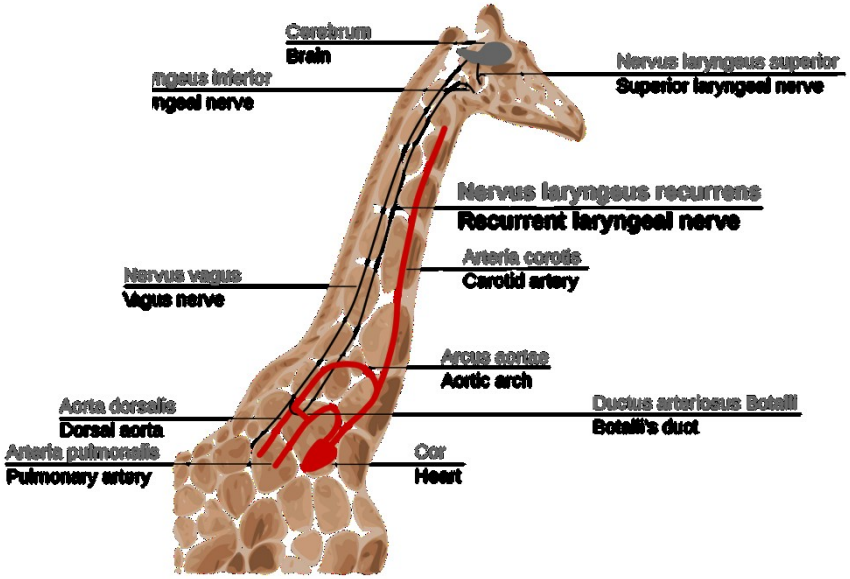
fossil evidence is in agreement with principles of evolutionary changes, no other mechanisms are necessary (lamarckism, orthogenesis, vitalism, mutationism)

CAN EVOLUTION BE PROVEN?

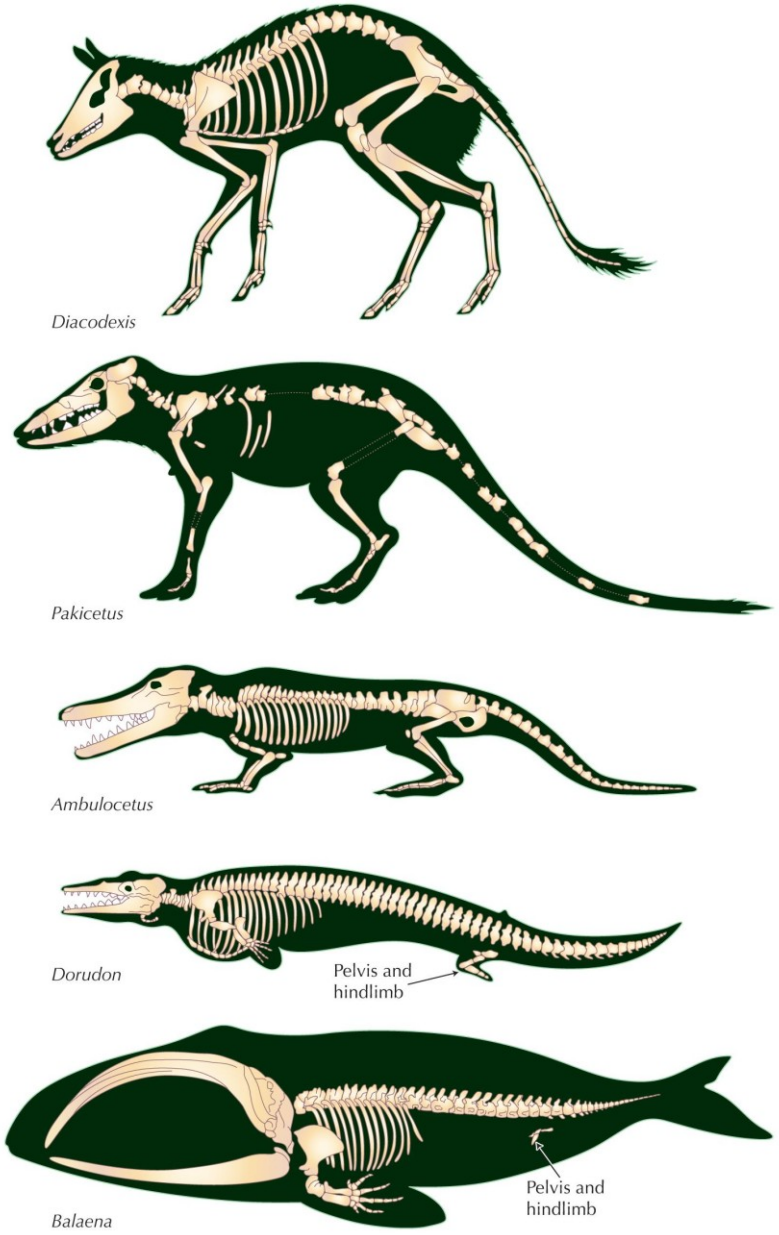
suboptimal traits: inverse eye, pharyngeal nerve



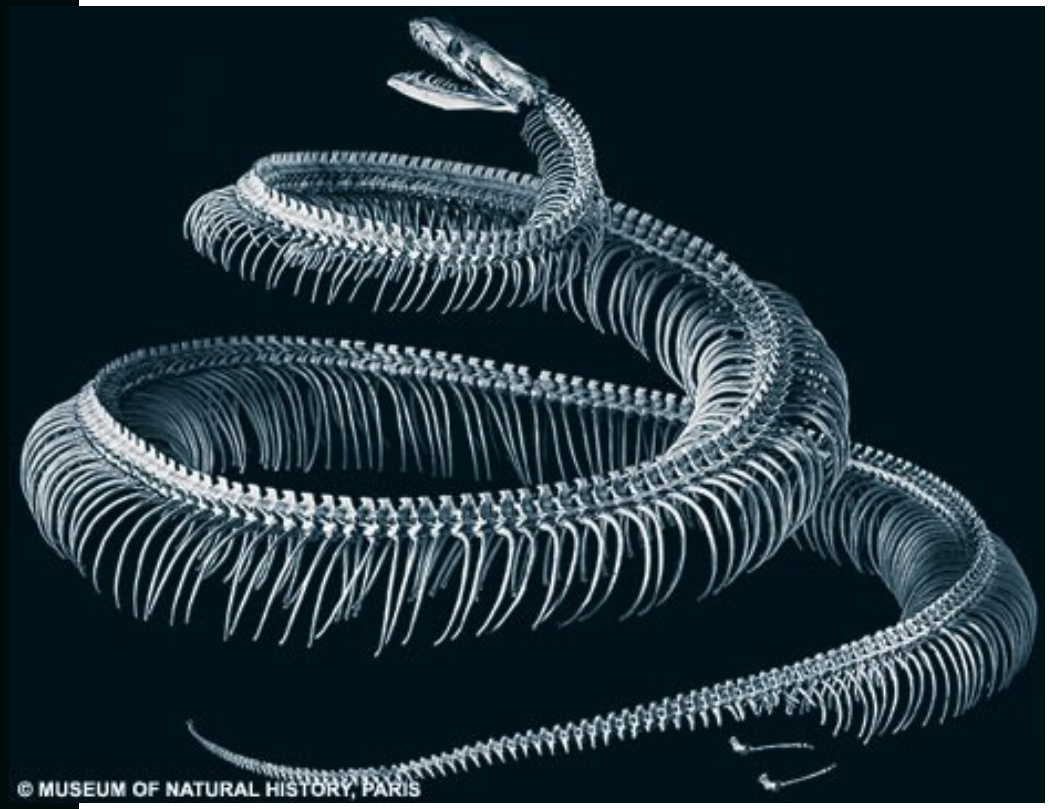




transient forms?



rudimentary structures



rudimentary structures

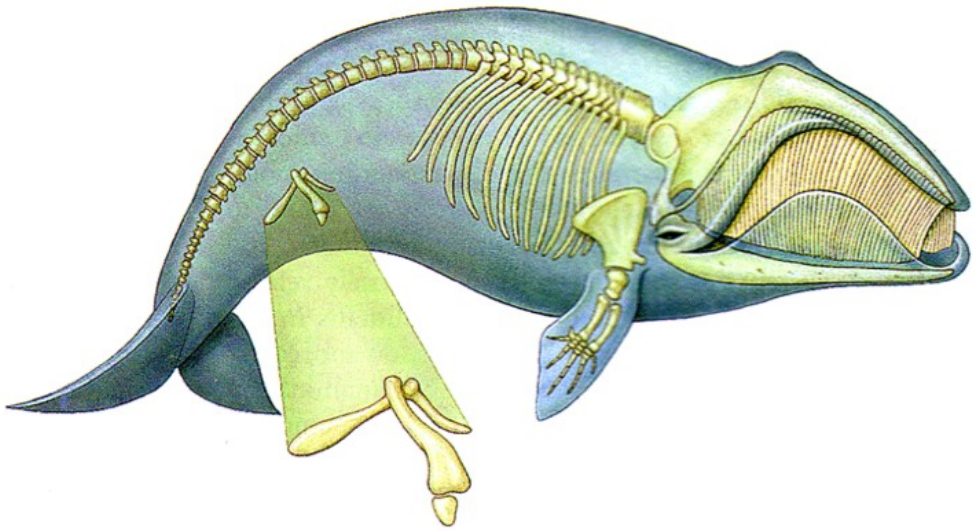
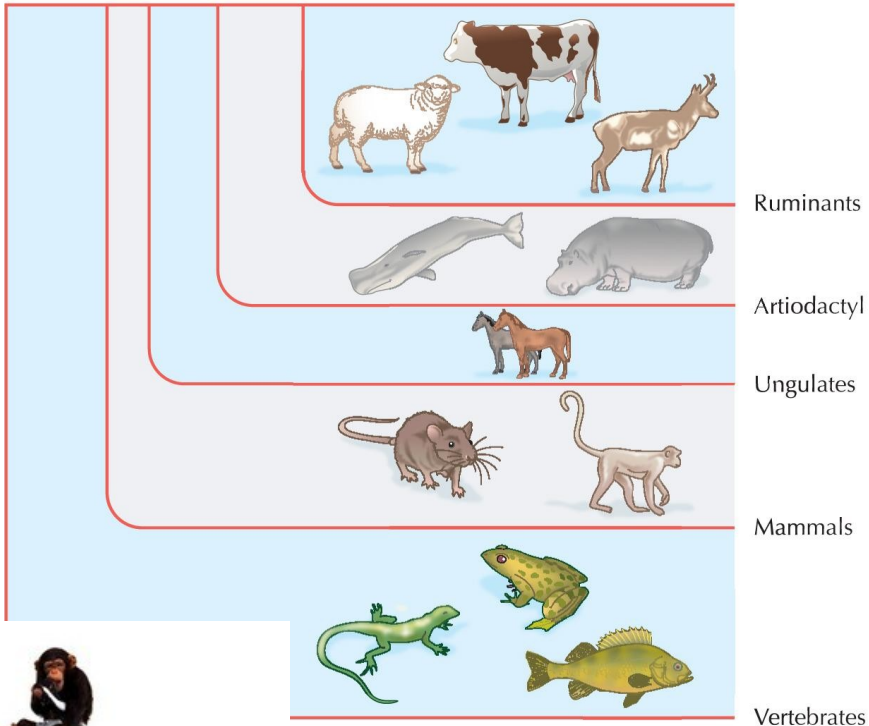
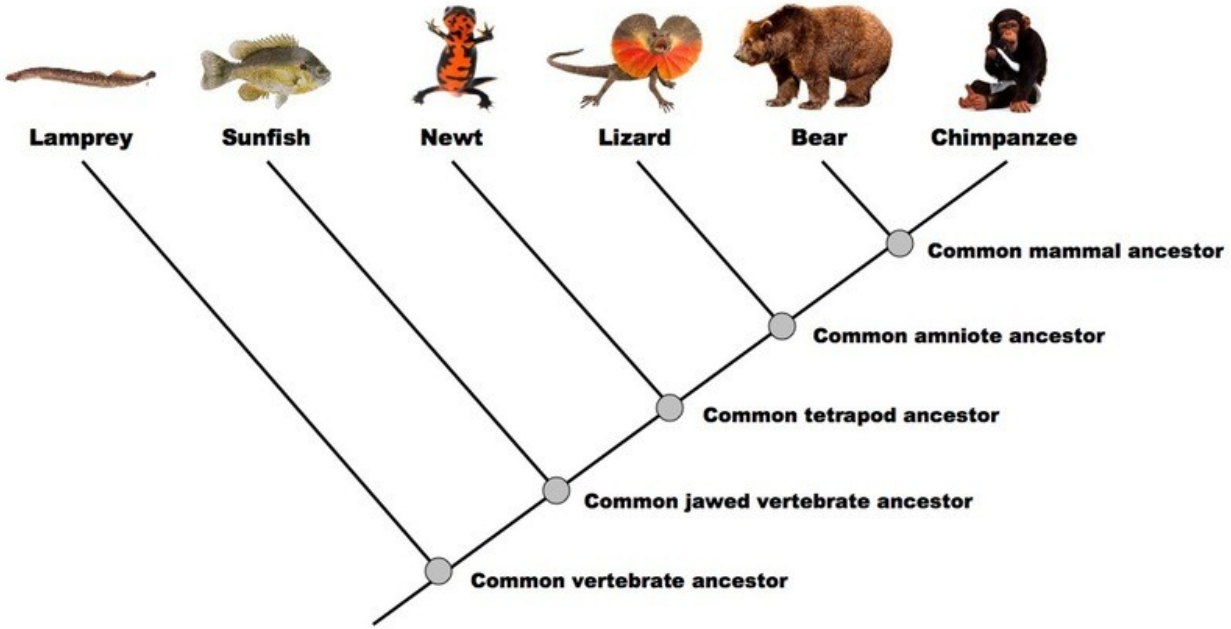


FIGURE 22.19
Vestigial structures. The skeleton of a whale reveals the presence of pelvic bones. These bones resemble those of other mammals, but are only weakly developed in the whale and have no apparent function.

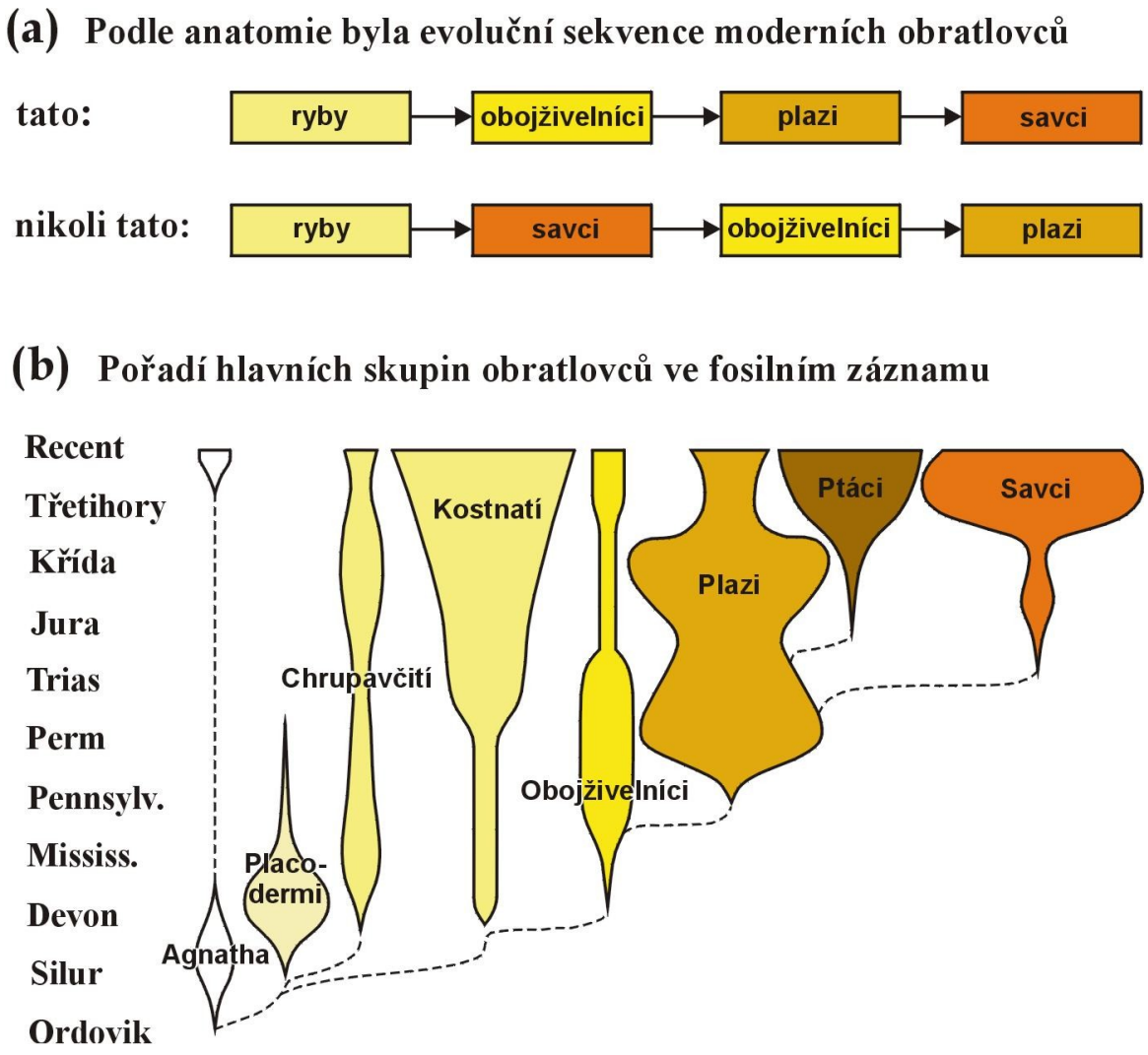
stamens in asexual dandelion

hierarchical arrangement

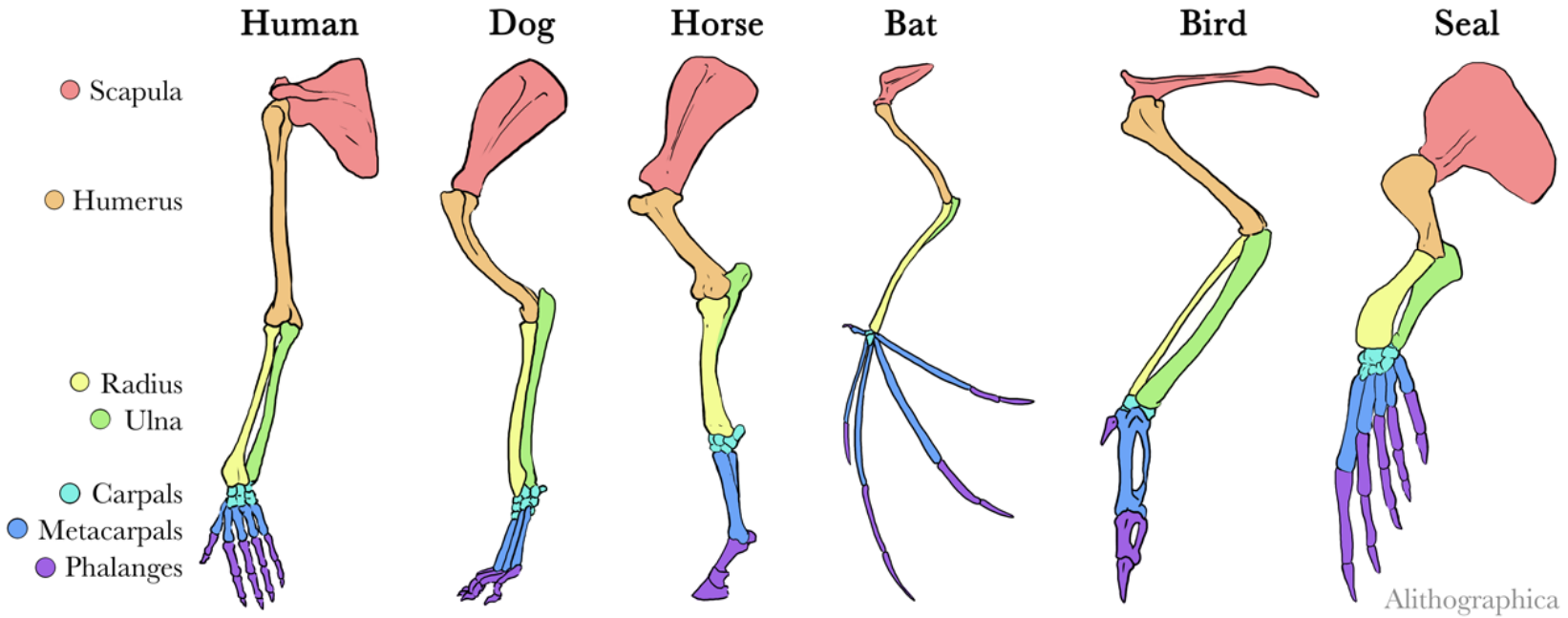




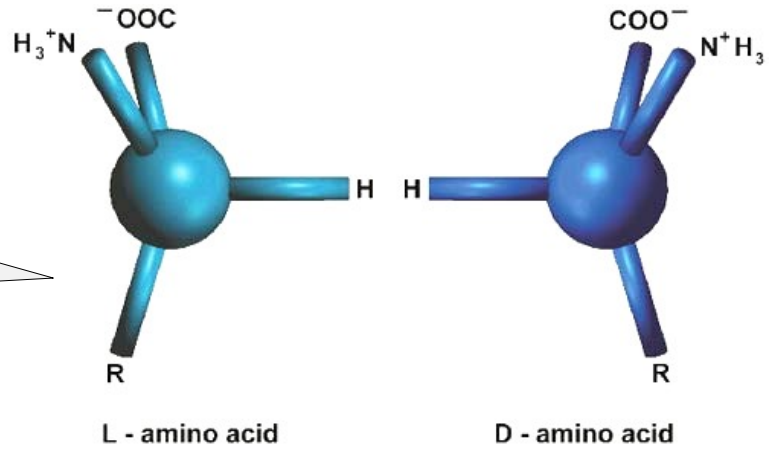
fossil evidence and phylogeny



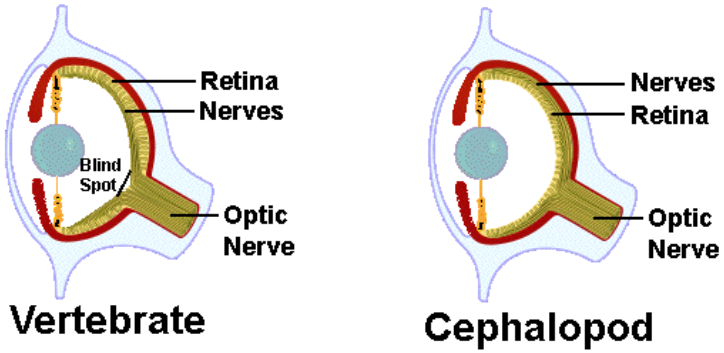
homology: organs, genetic code, amino acids

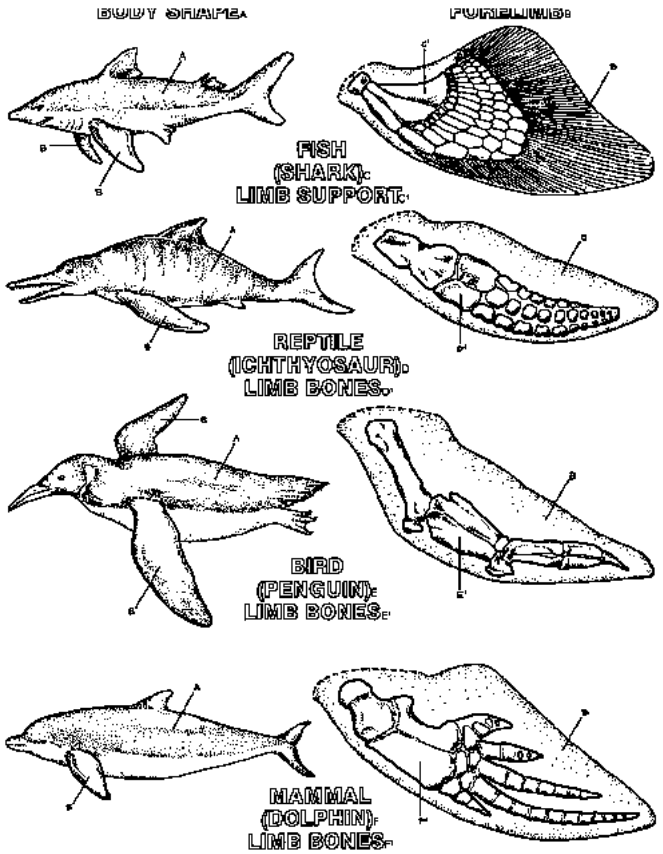


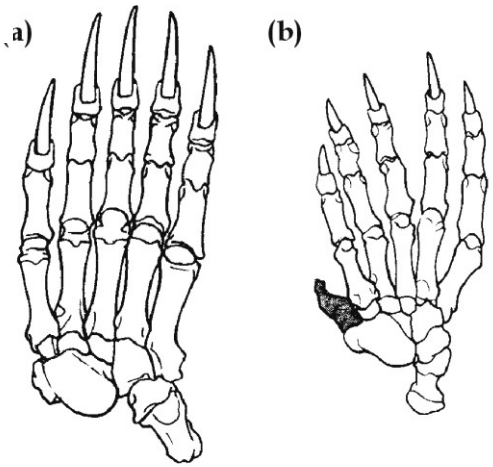
with some exceptions only
L-stereoisomers in nature

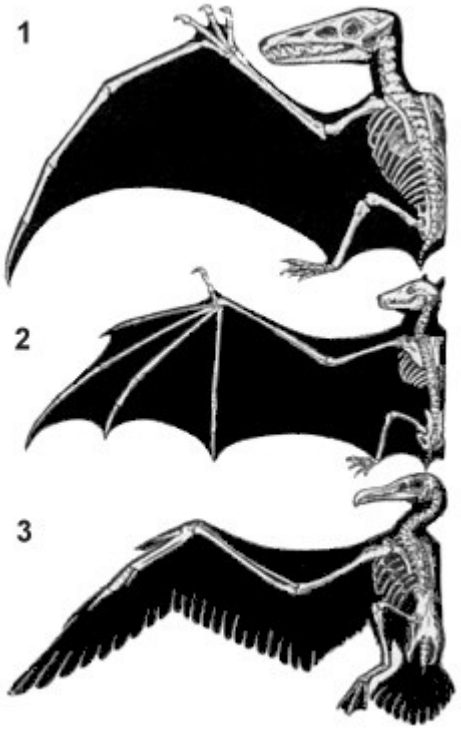


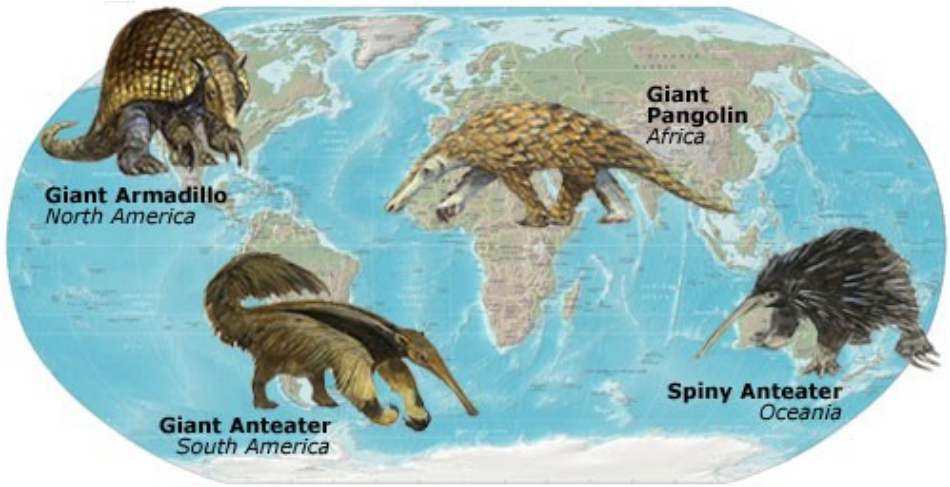
convergence



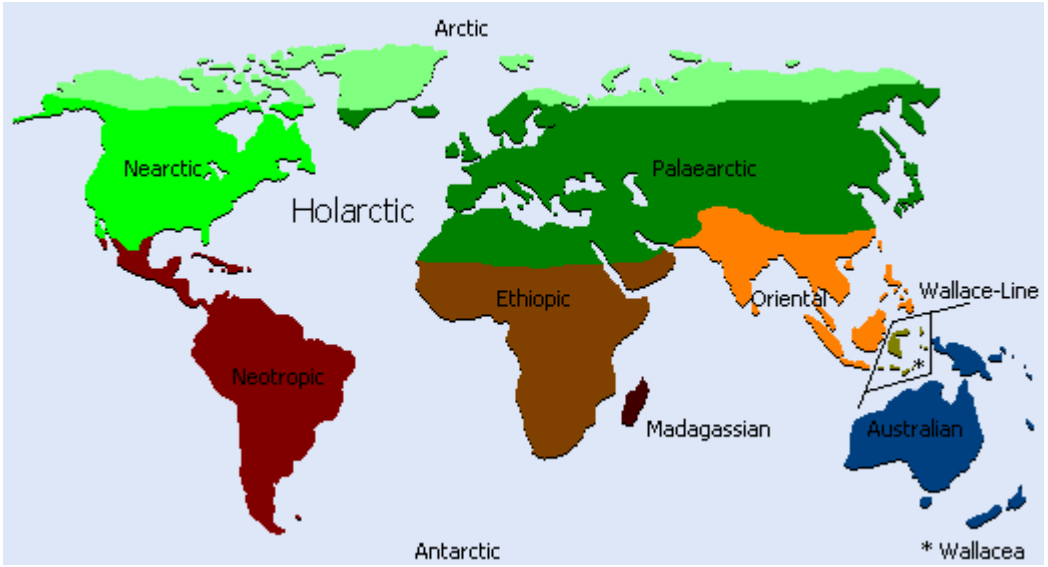








evolution and geography



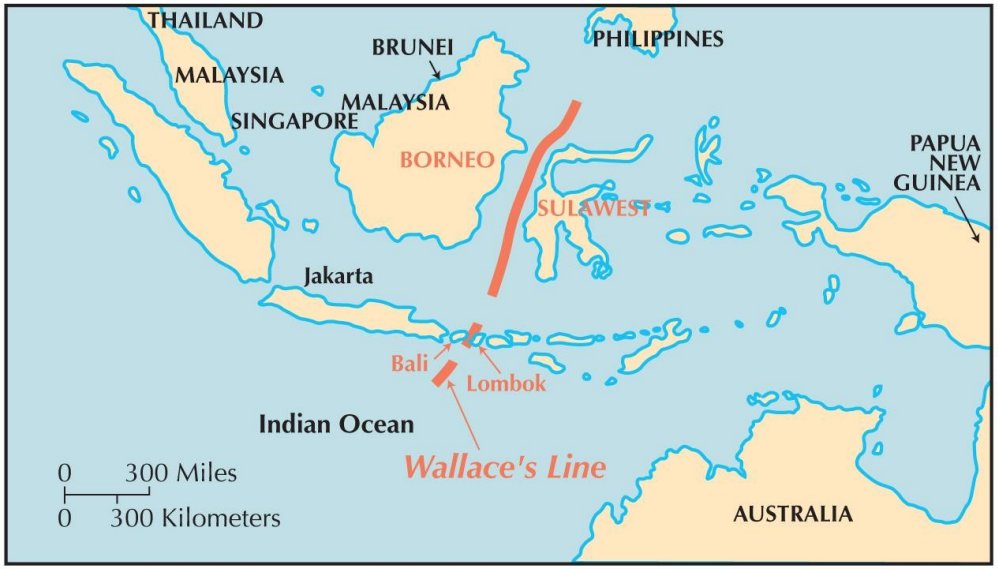


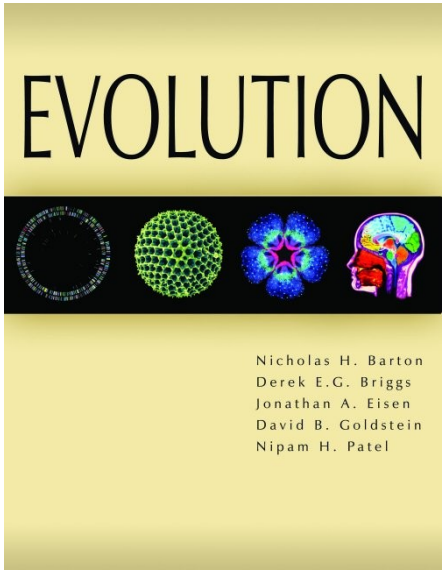
FIGURE 3.6. Wallace's Line (*thick red line*) separates two distinct present-day land faunas.

3.6, adapted from *Spice Island Voyage*, University of Limerick, Ireland Project

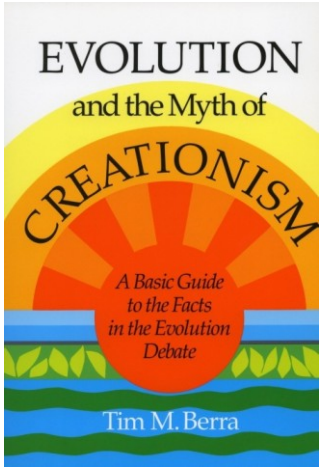
observed evolution: *Primula verticillata* × *P. floribunda* → *P. kewensis*

Galleopsis pubescens × *G. speciosa* → *G. tetralit*

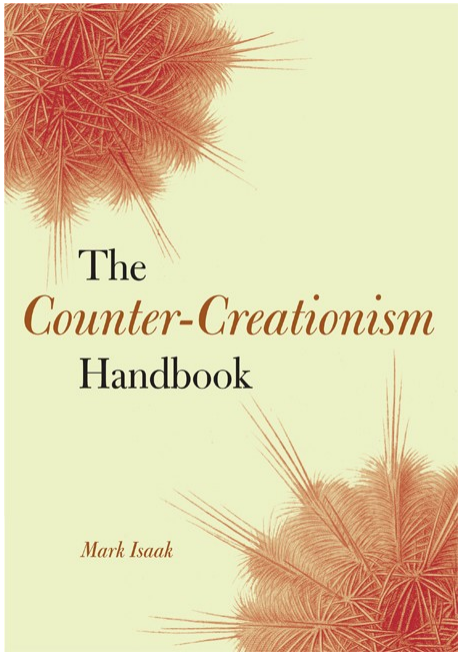
FIGURE 3.10. *Primula kewensis* (*left*) was created artificially by crossing *Primula verticillata* (*middle*) and *Primula floribunda* (*right*). It has twice as many chromosomes as its parent species and so can interbreed with neither.

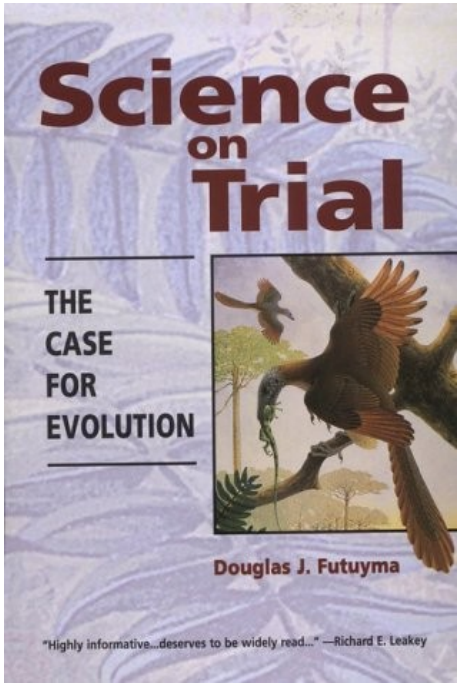


Berra TM (1990): *Evolution and the Myth of Creationism. A Basic Guide to the Facts in the Evolution Debate*



Isaak M (1995): *The Counter-Creationism Handbook*





Futuyma DJ (2007): *Science on Trial: The Case for Evolution*