

# Introduction to Biology. Lecture 5

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# Outline

- 1 Where we are?
- 2 Origin of life
  - Proofs of evolution

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# Very basics of chemistry

- pH of distilled water is equal to  $-\log(10^{-7}) = -(-7) = 7$
- Molar mass is a gram equivalent of molecular mass
- For example, molecular mass of salt (NaCl) is  $23 + 35 = 58$ . Therefore, 1 mole of salt is 58 g
- Every mole contains  $6.02214078 \times 10^{23}$  molecules (Avogadro's number)
- In water solution, 1 M (1 molar) concentration of salt means in 1 liter of distilled water 58 g of salt was diluted

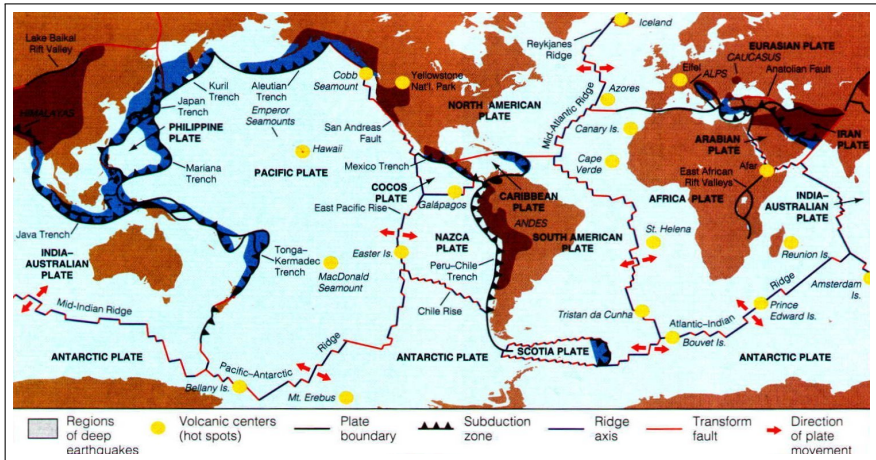


# Continental drift and plate tectonics

- Continents of Earth are constantly changing their position due to the mantle convection (“plate tectonics”)
- In the past (Permian period) all continents formed super-continent Pangaea, which then broke into Laurasia and Gondwana
- Two living examples of continental drift on U.S. territory: Yellowstone hotspot and Hawaiian hotspot



# What is going on now



# Origin of life

## Proofs of evolution

# Evolution is a working research program

“Nothing in Biology Makes Sense Except in the  
Light of Evolution”

Theodosius Dobzhansky  
1973



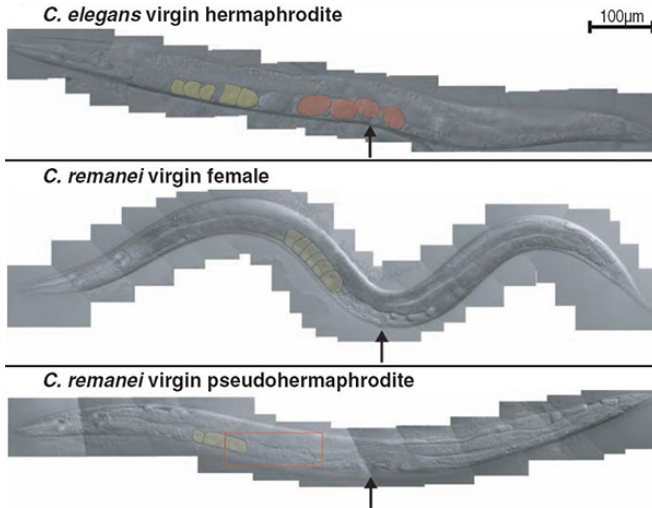


# New useful characters appear as a result of mutations

- Wild rice evolved into domesticable by one mutation:  
<http://www.sciencemag.org/content/311/5769/1936.short>
- Malaria parasite became resistant to drugs due to one mutation: <http://www.sciencemag.org/content/325/5948/1680.abstract>
- Two mutations may turn worms into hermaphrodites:  
<http://www.sciencemag.org/content/326/5955/1002.abstract>  
and so on



# Hermaphroditic worms



# Artificial selection is a bridge to natural selection

- Artificial selection is a full analog of natural selection
- Animals are also doing “artificial” selection
- Results of artificial selection may be called “new species”

# Cabbages

2



What artificial selection  
can do in a very short time:  
wild cabbage (a) and its useful  
(b) and monstrous (c) descendants.



# There are dozens of observed and documented cases of evolution

- Bacteria make major evolutionary shift in the lab (40,000 generations experiment):  
<http://www.newscientist.com/article/dn14094-bacteria-make-major-evolutionary-shift-in-the-lab.html>
- Harmful insects escaped from viral biological weapons:  
<http://www.sciencemag.org/content/317/5846/1916.abstract>
- Maggot flies and their parasitic wasps formed several new species for 150 years: <http://www.sciencemag.org/content/323/5915/776.abstract>
- Accidental hybridization turned black chokecherry into delightful fruit (*Aronia melanocarpa* to *Aronia mitchurinii*)
- American evening primrose gave birth to new species, red-stem evening primrose in Europe (*Oenothera biennis* to *Oenothera rubricaulis*) in 100 years

# Apple maggot fly: new species



# Black choke cherry and Russian *Aronia mitchurinii* (new species)



# Evening primroses: American and European (new species)



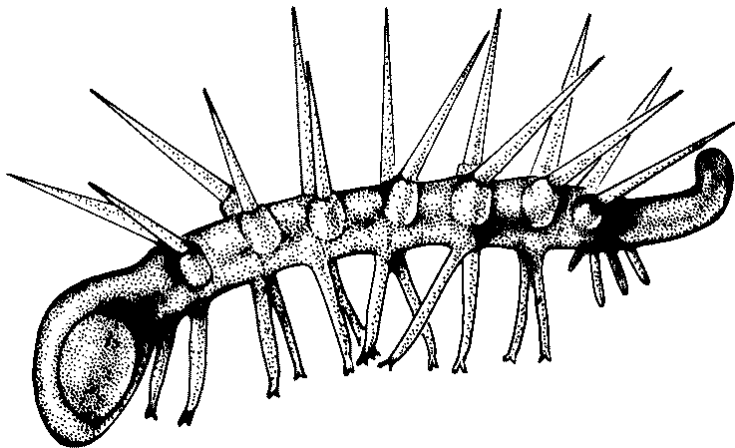


# Fossils are direct evidence of evolution

- The older fossils are, the more unusual are they
- Many fossils are transitional forms (see [http://en.wikipedia.org/wiki/List\\_of\\_transitional\\_fossils](http://en.wikipedia.org/wiki/List_of_transitional_fossils))
- Many fossils could be arranged in well-documented “evolutionary chains”



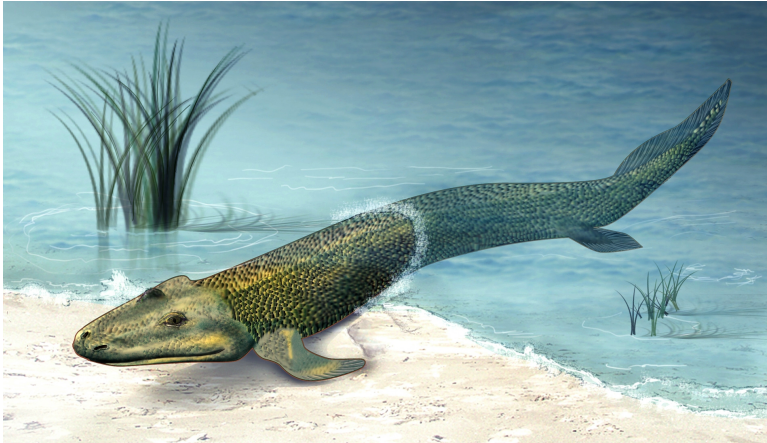
# *Hallucigenia*—mysterious Cambrian fossil



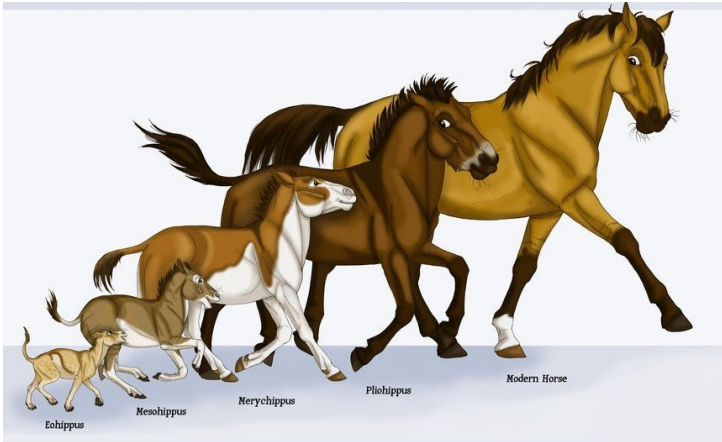
# *Hallucigenia* in stone



# *Tiktaalik*—half-fish, half-salamander



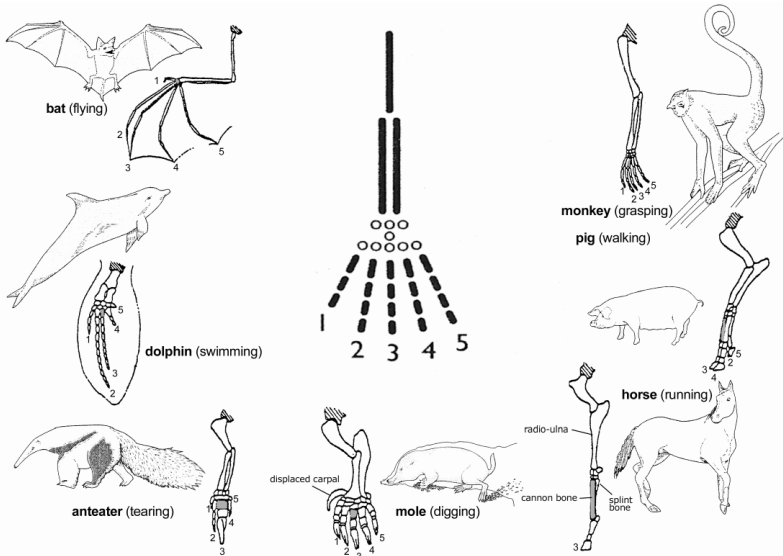
# Evolution of horses



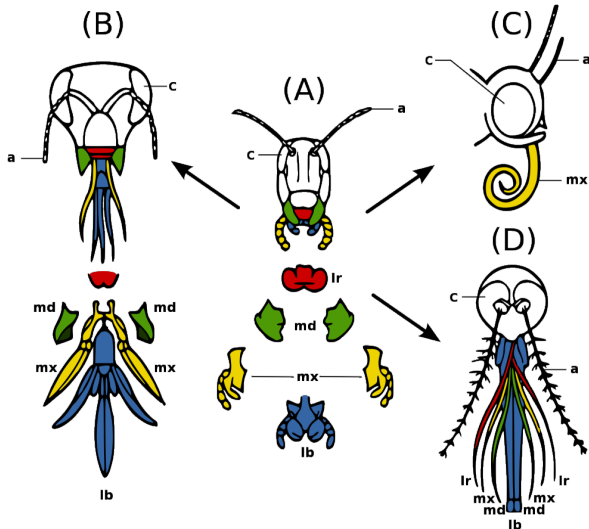
# Similarities in structure (morphology) prove evolution

- So-called homological structures are descendants of one ancestral structure
- Vestigial organs remind us of the past
- Reversion organs demonstrate ancestral states
- Analogous structures demonstrate how evolution led to the same outcome

# Pentadactyl limb of terrestrial vertebrates



# Insect mouth





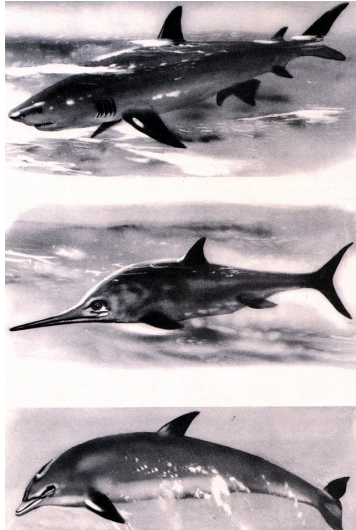
# Vestigial hind legs of python



# Reversal hind legs in dolphin



# Analogous structures help shark, ichthyosaur and dolphin to swim



# Embryonic development is another proof

- Embryos retain ancestral characters
- We may now switch development programs and uncover hidden structures

# Mammal embryo with gills



# Switching fly back to four wings



# Molecular biology tells about common roots

- All living things have same molecular base
- Genetic distance between close species is small
- Human DNA contains “fossil” viruses: <http://www.biomedcentral.com/1471-2148/8/266> and silenced genes (pseudogenes, e.g., olfactory receptor genes in humans)



# Chimpanzee and human: only 1% difference

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M T P T R K I N P L M K L I N H S F I D
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CTCCCCACCCCATCCAACATCTCCGCATGATGAAACTTCGGCTCACTCCTTGGGCGCCTGC 120
L P T P S N I S A W W N F G S L L G A C

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# Biogeography shows why species evolve

- Isolated islands and small continents facilitate analogous forms (parallel evolution and radiation)
- Many groups of animals and plants now reflect Gondwanan distribution

# Can you distinguish Australian sugar glider from American flying squirrel?



# *Araucaria* in growing only in South America, New Zealand and Australia



# Evolution evolved from hypothesis to the fact

- Hypothesis
- Theory
- Fact

# Summary

- Given the amount of evidence presented, evolution is a fact
- Evolution is also an extremely useful, working research program, both in biology and medicine



# For Further Reading



## Evolution.

<http://en.wikipedia.org/wiki/Evolution>



## Evidence of common descent.

[http://en.wikipedia.org/wiki/Evidence\\_of\\_common\\_descent](http://en.wikipedia.org/wiki/Evidence_of_common_descent)

