

# Introduction to Biology. Lecture 6

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# Outline

- 1 Where we are?
  - Continental drift and plate tectonics
- 2 Origin of life
  - Proofs of evolution



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# Where we are?

## Continental drift and plate tectonics

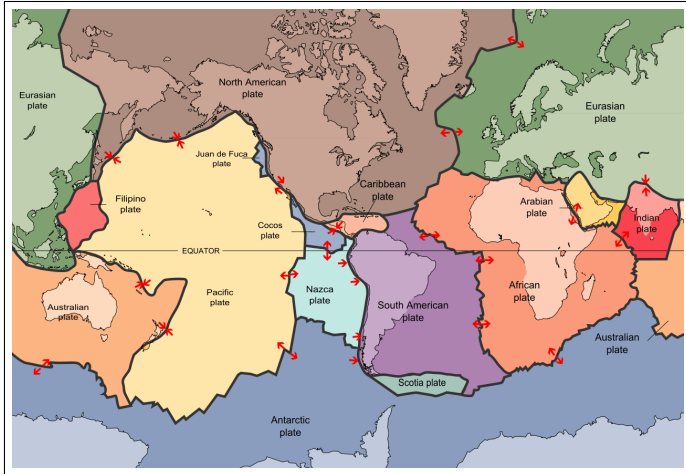


# Continental drift and plate tectonics

- 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

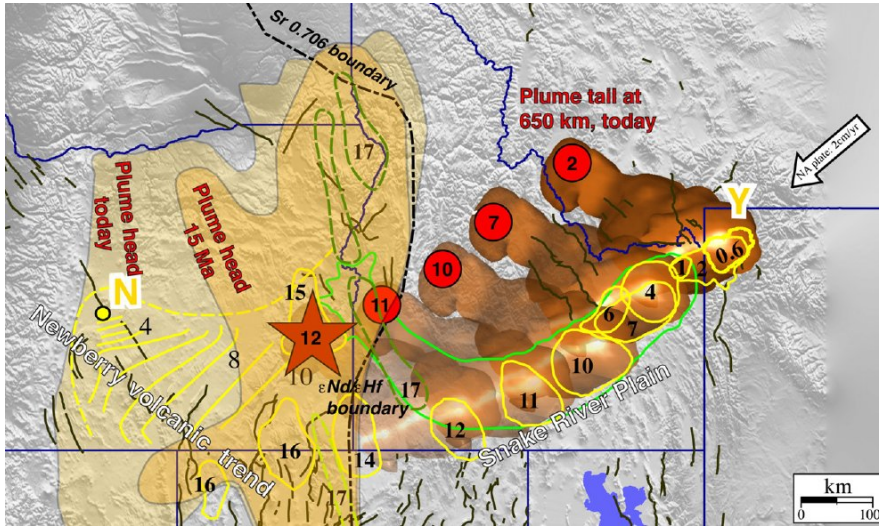


# Two living examples of continental drift on U.S. territory

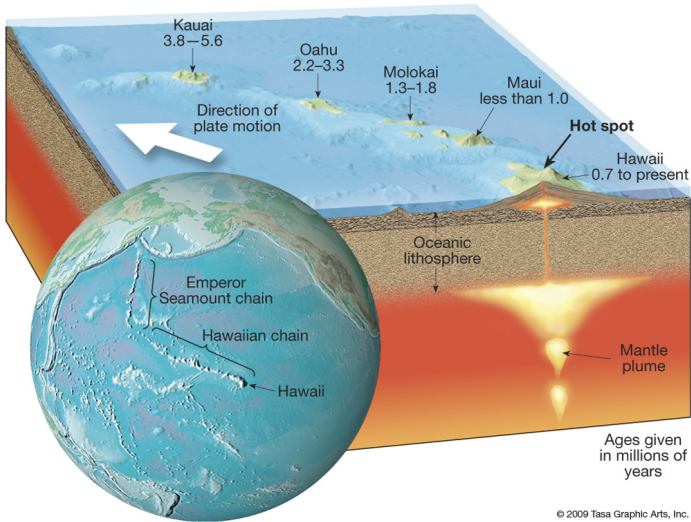
- Yellowstone hotspot
- Hawaiian hotspot



# Yellowstone hotspot



# Hawaiian hotspot (more scientific)



# 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)

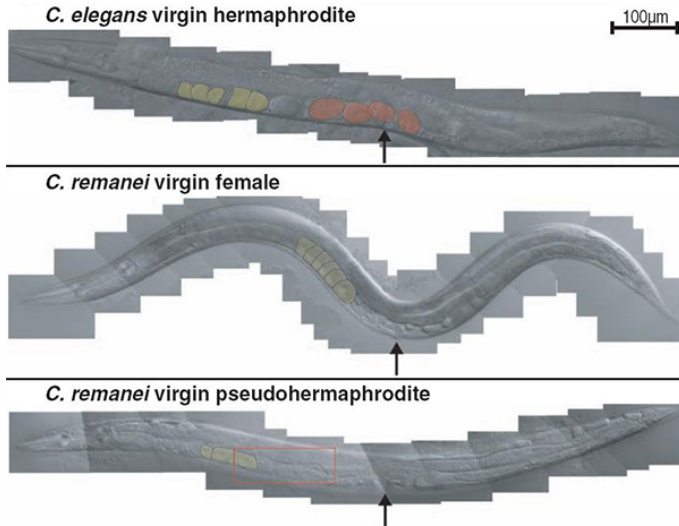


# New useful characters appear as a result of mutations

- 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)

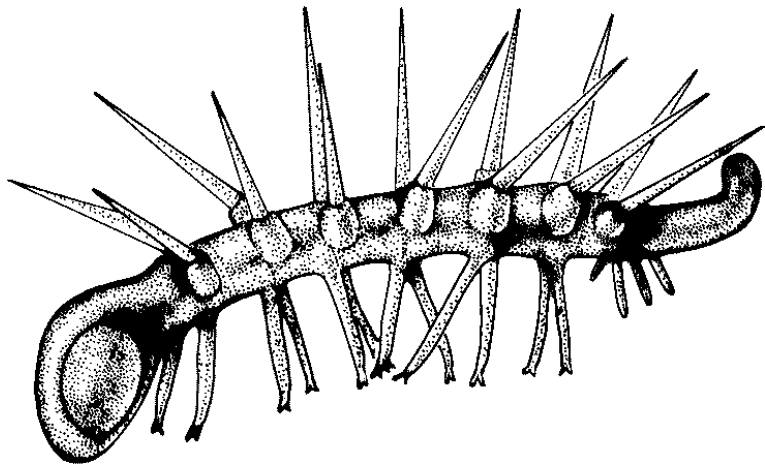


# Fossils are direct evidence of evolution

- 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”



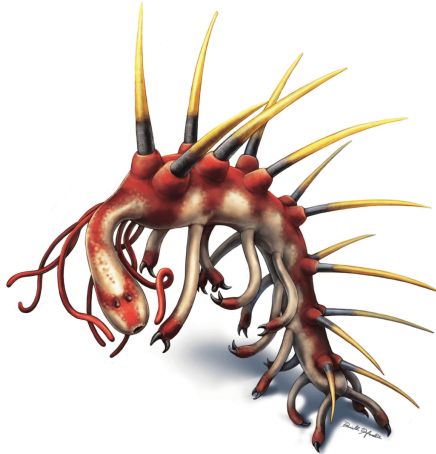
# *Hallucigenia*—mysterious Cambrian fossil



# *Hallucigenia* in stone



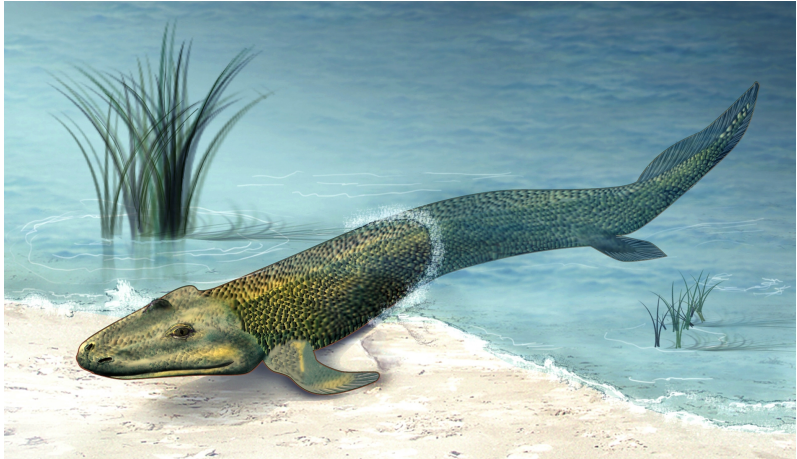
# *Hallucigenia*—new reconstruction, with head!



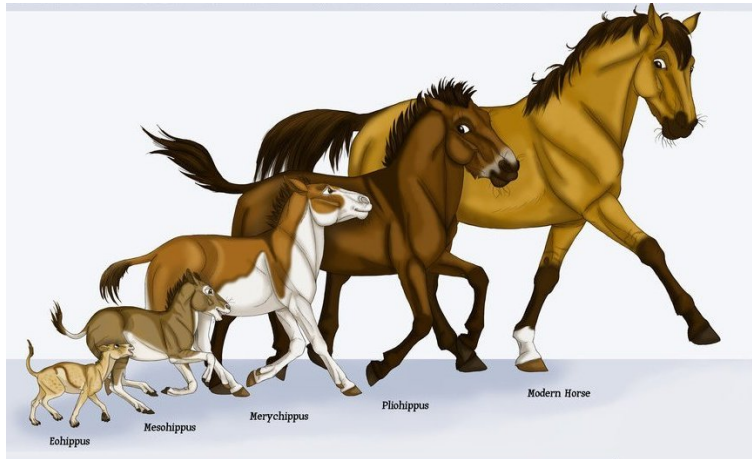
Now clear that it is half-worm, half-arthropod



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



# Evolution of horses

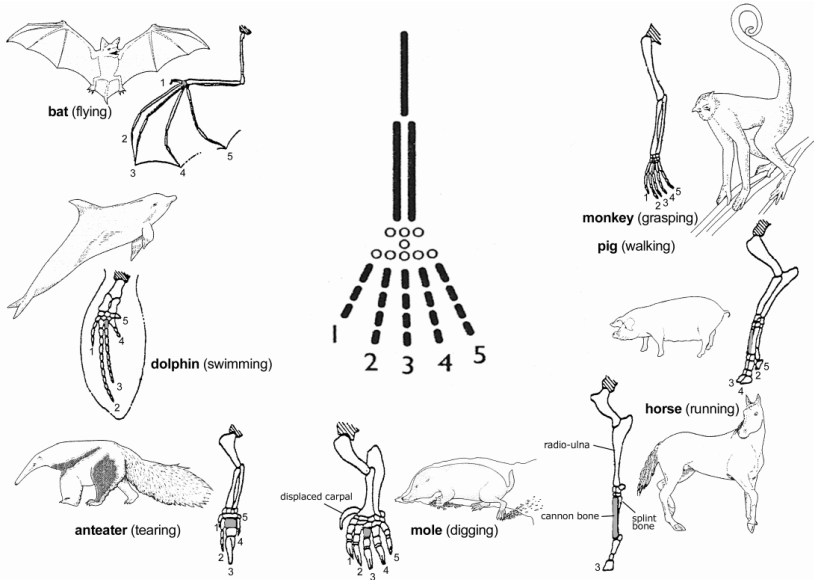


# Similarities in structure (morphology) prove evolution

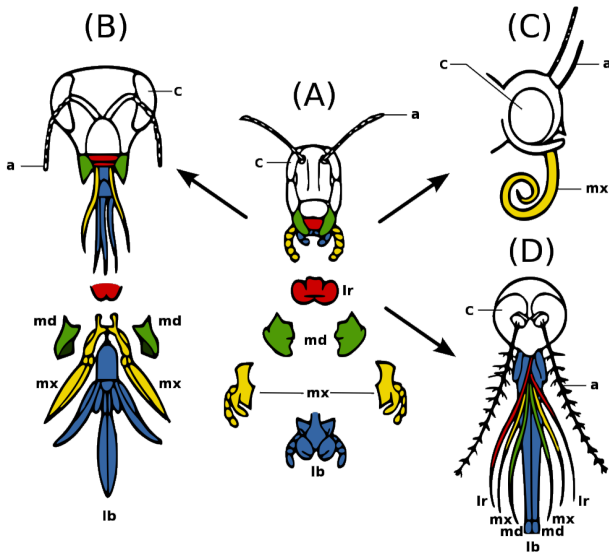
- So-called *homological structures* are descendants of one ancestral structure
- *Vestigial organs* remind us of the past
- *Reversion organs* demonstrate ancestral states
- *Analogous structures* demonstrate how evolution led to the same outcome



# Pentadactyl limb of terrestrial vertebrates



# Insect mouth



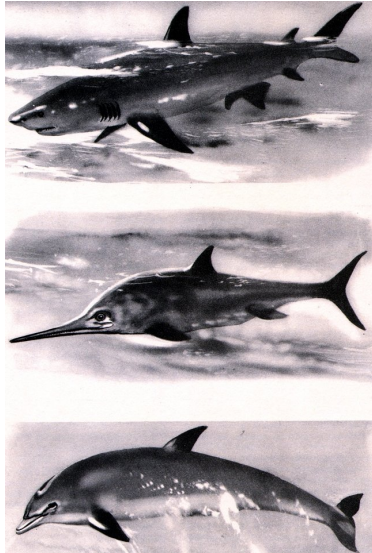
# Vestigial hind legs of python



# 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
ATGACCCCGACACGCAAAATTAACCCACTAATAAAATTAATTAATCACTCATTATCGAC 60
||||||| | ||||||| ||||| ||||||| ||||||| ||||||| |||||||
ATGACCCCAATACGCAAAACTAACCCCTAATAAAATTAATTAACTCACTCATTCATCGAC 60
M T P M R K T N P L M K L I N H S F I D

L P T P S N I S A W W N F G S L L G A C
CTCCCCACCCCATCCAACATTTCCGCATGATGGAATTTCGGCTCACTTCTCGGCGCCTGC 120
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CTCCCCACCCCATCCAACATCTCCGCATGATGAACTTCGGCTCACTCTTGGGCGCCTGC 120
L P T P S N I S A W W N F G S L L G A C

L I L Q I T T G L F L A M H Y S P D A S
CTAATCCTTCAAATTACCACAGGATTATTCCTAGCTATACACTACTCACCAGACGCCTCA 180
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CTGATCCTCAAATCACACAGGACTATTCCTAGCCATGCACTACTCACCAGACGCCTCA 180
L I L Q I T T G L F L A M H Y S P D A S

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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* is growing only in South America, New Zealand and Australia



# Evolution evolved from the hypothesis to the fact and then to research program

- Ⓐ Hypothesis
- Ⓑ Theory
- Ⓒ Fact
- Ⓓ Research program



# 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)

