

Introduction to Botany: BIOL 111

Study guide for Exam 1

Alexey Shipunov

Lectures 1–6

Contents

1 Course in general	1
1.1 Description	1
1.2 Grading	3
1.3 Course schedule	5
2 Intro test	5
2.1 Multiple choice questions	5
3 Questions and answers	10
3.1 Comments to introductory test	10
4 Age and time. Basic principles	24
4.1 Geological time	24
4.2 Some basic principles	25
5 Where we are?	26
5.1 Basic principles of science	27
6 Origin of Earth. Basic Chemistry	29
6.1 Origin of Earth	29
6.2 Very basics of chemistry	31
7 Where we are?	32
8 Origin of Earth. Basics of chemistry	33
8.1 Basics of chemistry	33
9 Where we are?	34
10 Floating continents	35
10.1 Continental drift	35
10.2 Plate tectonics	38
11 Where we are?	43

12 Origin of life	44
12.1 Proofs of evolution	44

Outline

1 Course in general

1.1 Description

Course description from catalog

- This course is designed to accommodate one semester of the General Education requirement for non-science majors at Minot State University.
- The course focuses on a comprehensive survey of modern biology with an emphasis on enhancing the science literacy of the college educated student.
- Topics include: cell biology, genetics, evolution by natural selection, systematics, and the impact of human activity on the biosphere.

My description

- Biology is the largest of all sciences, and develops most rapidly. It is simply impossible to cover **BIOLOGY** in one-semester course.
- I choose a strategy to elucidate the most important biological concepts from the standpoint of the **History of Life**.
- We will go through the major events in this history and learn basic chemistry of life, cell construction, genes and DNA, organization of animal body and other fundamental biological ideas.
- In general, this course is not recommended for science majors

Instructor

- Dr. Alexey Shipunov
- Office: Moore 229
- Office Hours: Mondays, Wednesdays and Fridays, 11 am to 12 am
- Phone: 858-3116
- E-mail: alexey.shipunov@minotstateu.edu

Lectures Mondays, Wednesdays and Fridays, 12:00 am to 12:50 am, Moore 16

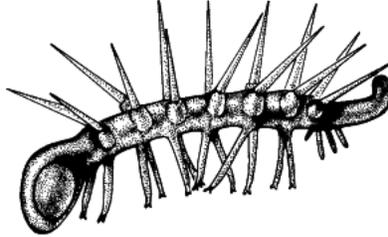
Laboratories Mondays and Wednesdays, **Swain 304**

Laboratories will start from September 8!

Web site

© Shipunov, A. Introduction to Biology [Electronic resource]. 2012—onwards.
Mode of access: http://ashipunov.info/shipunov/school/biol_111

BIOL 111: Introduction to Biology



Course materials:

- [Syllabus](#) (PDF, 0.2 Mb)
- [Lecture 1](#) (PDF, 0.5 Mb)
- [Lab manual](#) (PDF, 1.6 Mb)

[Back](#)

http://ashipunov.info/shipunov/school/biol_111

Please check it regularly. There will be much more material due course. As a rule, slides of every lecture will be available after this lecture.

Textbook

None. Instead, for every lecture I will give a list of readings, mostly from



WIKIPEDIA

The Free Encyclopedia

1.2 Grading

Exams

- **Five** exams are given during the semester.
- Only **four** best exams contribute to the final grade.
- Missed exams count zero points. There are **no make-up** exams.

Absence

Absence from exams or laboratories needs to be announced to the instructor in advance. There are five legitimate reasons for absence:

- A. emergency situations,

- B. attested medical conditions
- C. military duty,
- D. participation in MSU sports events,
- E. dependent sick leave.

If you have a legitimate reason (above) it is possible to come for the lab with different section. Please, however, *do not forget to inform **both** instructors in advance.*

I strongly recommend attending lectures regularly. Lecture contents will be the main source of information required for the exams.

Points

A total of ≈ 420 points can be earned and are distributed as follows (grading points may vary):

Four best exams : ≈ 240 points

Laboratories : 180 points (15 points per lab)

Grade calculation

- $A \geq 90\%$
- $B \geq 80\%$
- $C \geq 70\%$
- $D \geq 60\%$
- $F < 60\%$

A minimum of one letter grade will be deducted from the grade for academic dishonesty / plagiarism.

Preparation to exams

- Download go through all lecture slides / study guide
- Read everything what is listed in “For Further Reading” section
- Try not only memorize this stuff, but also understand how described things work

Exam grades

- I will grade the curve by “trimmed maximum”
- For example, if the maximum results are (in descending order): 67, 63, 61, 61, 61, 60, 60, 60, 60, ... — I will take out “outliers” and set the trimmed maximum (or 100%, or “A”) as **61**.
- Then “B” will start from 54, “C” will start from 48 and so on.

1.3 Course schedule

Tentative course sequence: from past to present

- Origin of Earth, basic chemistry
- Origin of life, DNA, RNA and proteins
- First cells, structure of cell
- Animals
- Plants
- Reproduction
- Adaptation, rise and fall of dinosaurs
- Current life, humans, and the future evolution

2 Intro test

2.1 Multiple choice questions

Question 1

- 1 Why deciduous plants take off their leaves?
 - A. To prevent freezing
 - B. To prevent drying
 - C. To get rid of poisonous chemicals

Question 2

- 2 Where does human digestion process start?
 - A. In the mouth
 - B. In the intestines
 - C. In the stomach

Question 3

- 3 Which birds do NOT live in Minot on winter?
 - A. Crows
 - B. Hummingbirds
 - C. Sparrows

Question 4

4 Home country of watermelon:

- A. Central America
- B. Canada
- C. South Africa

Question 5

5 Why do insectivorous plants eat insects?

- A. To obtain the lacking mineral resources
- B. To get an addition to their common “menu”
- C. To get rid of herbivores

Question 6

6 Which insects have no queen?

- A. Bumblebees
- B. Ants
- C. Cockroaches

Question 7

7 Oak tree is pollinated by:

- A. Wind
- B. Bees
- C. Flies

Question 8

8 Spider has:

- A. 6 legs
- B. 8 legs
- C. 4 legs

Question 9

9 Apple flower has:

- A. 5 petals
- B. 4 petals
- C. 3 petals

Question 10

10 Frightened man has:

- A. Bigger pupils
- B. Smaller pupils
- C. Normal pupils

Question 11

11 Polar bears are not eating penguins because:

- A. Penguins run very fast
- B. They cannot meet
- C. Penguins are poisonous for bears

Question 12

12 How many toes are on each of cat's hind legs?

- A. 5
- B. 4
- C. 3

Question 13

13 Pineapple is a:

- A. Tree
- B. Shrub
- C. Herb

Question 14

14 If somebody has an artery cut on the arm or leg, it is recommended:

- A. Put a tight bandage below the cut
- B. Put a tight bandage above the cut
- C. Do nothing

Question 15

15 Which of the following is the most precise statement?

- A. We are breathing to support our life
- B. We are breathing to obtain the energy from food
- C. We are breathing to have enough strength for food consuming

Question 16

16 Which tree is better to plant in Minot house backyard:

- A. Sycamore
- B. Ash
- C. Yew

Question 17



17 Moles eat:

- A. Worms
- B. Roots
- C. Frogs

Question 18

18 Which fish gives birth to the fully developed offspring?

- A. Sturgeon
- B. Shark
- C. Flounder

Question 19

19 Which human organ lives longer?

- A. Heart
- B. Lungs
- C. Brains

Question 20

20 Which plant normally has a longer root?

- A. Spruce
- B. Chokecherry
- C. Blueberry

The key

1B; 2A; 3B; 4C; 5A; 6C; 7A; 8B; 9A; 10A; 11B; 12B;
13C; 14B; 15B; 16B; 17A; 18B; 19A; 20B

Please calculate a sum (every right answer = 1 virtual point)

Summary

- Please download syllabus from the Web site (http://ashipunov.info/shipunov/school/biol_111)
- **Five** exams, best **four** will be counted, **no make-ups**
- Again, no make-ups!
- The course sequence is the history of life on Earth

References

[1] Biology. Wikipedia. <http://en.wikipedia.org/wiki/Biology>

[2] History of Life. Wikipedia. http://en.wikipedia.org/wiki/History_of_life

Outline

3 Questions and answers

Interesting in being a note taker?

- Disability Services is looking for a note taker in this class. The individual will be paid for taking notes.
- Interested students who will have **consistent attendance** and take complete and legible notes should contact:
- **Melanie Moore**, Student Health and Development Center: Lower level Lura Manor (must enter through South Door facing University Ave) or call 858-**4233**

3.1 Comments to introductory test

Question 1

- 1 Why deciduous plants take off their leaves?
 - A. To prevent freezing
 - B. **To prevent drying**
 - C. To get rid of poisonous chemicals

Question 2

- 2 Where does human digestion process start?
 - A. **In the mouth**
 - B. In the intestines
 - C. In the stomach

Amylase and lipase

Question 3

- 3 Which birds do NOT live in Minot on winter?
 - A. Crows
 - B. **Hummingbirds**
 - C. Sparrows



Question 4

4 Home country of watermelon:

- A. Central America
- B. Canada
- C. **South Africa**



Question 5

- 5 Why do insectivorous plants eat insects?
- A. **To obtain the lacking mineral resources**
 - B. To get an addition to their common “menu”
 - C. To get rid of herbivores



Question 6

6 Which insects have no queen?

- A. Bumblebees
- B. Ants
- C. **Cockroaches**



Bumblebees

Question 7

7 Oak tree is pollinated by:

- A. **Wind**
- B. Bees
- C. Flies



Oak flowers

Question 8

8 Spider has:

- A. 6 legs
- B. **8 legs**
- C. 4 legs

Question 9

9 Apple flower has:

- A. **5 petals**

B. 4 petals

C. 3 petals

Question 10

10 Frightened man has:

A. **Bigger pupils**

B. Smaller pupils

C. Normal pupils



Question 11

11 Polar bears are not eating penguins because:

A. Penguins run very fast

B. **They cannot meet**

C. Penguins are poisonous for bears



■ POLAR BEAR DISTRIBUTION (approx.)

Question 12

12 How many toes are on each of cat's hind legs?

- A. 5
- B. 4
- C. 3



Question 13

13 Pineapple is a:

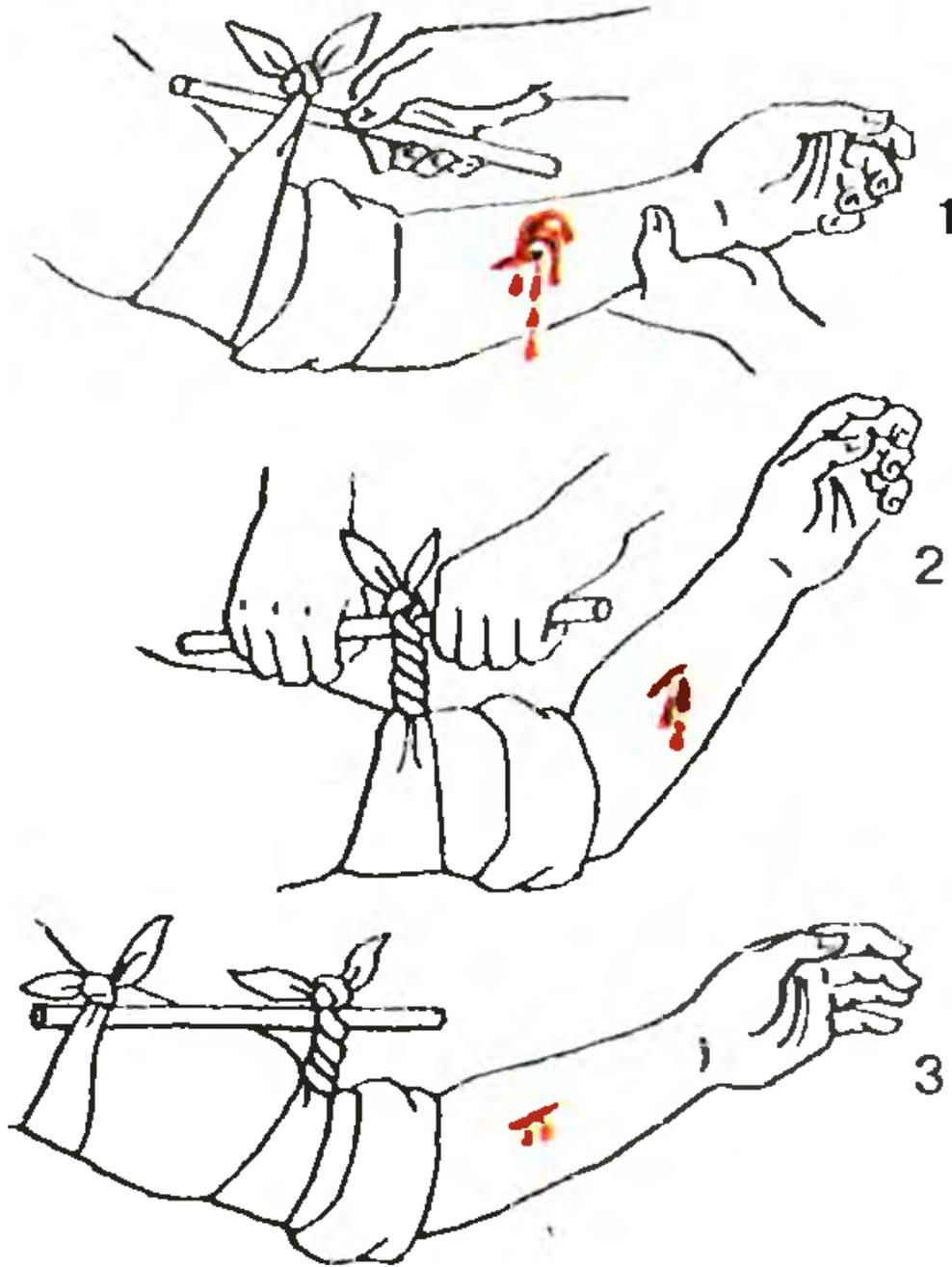
- A. Tree
- B. Shrub
- C. **Herb**



Question 14

14 If somebody has an artery cut on the arm or leg, it is recommended:

- A. Put a tight bandage below the cut
- B. **Put a tight bandage above the cut**
- C. Do nothing



Question 15

15 Which of the following is the most precise statement?

- A. We are breathing to support our life
- B. **We are breathing to obtain the energy from food**
- C. We are breathing to have enough strength for food consuming

Question 16

16 Which tree is better to plant in Minot house backyard:

- A. Sycamore

B. Ash

C. Yew

Question 17

17 Moles eat:

A. **Worms**

B. Roots

C. Frogs



Question 18

18 Which fish gives birth to the fully developed offspring?

A. Sturgeon

B. **Shark**

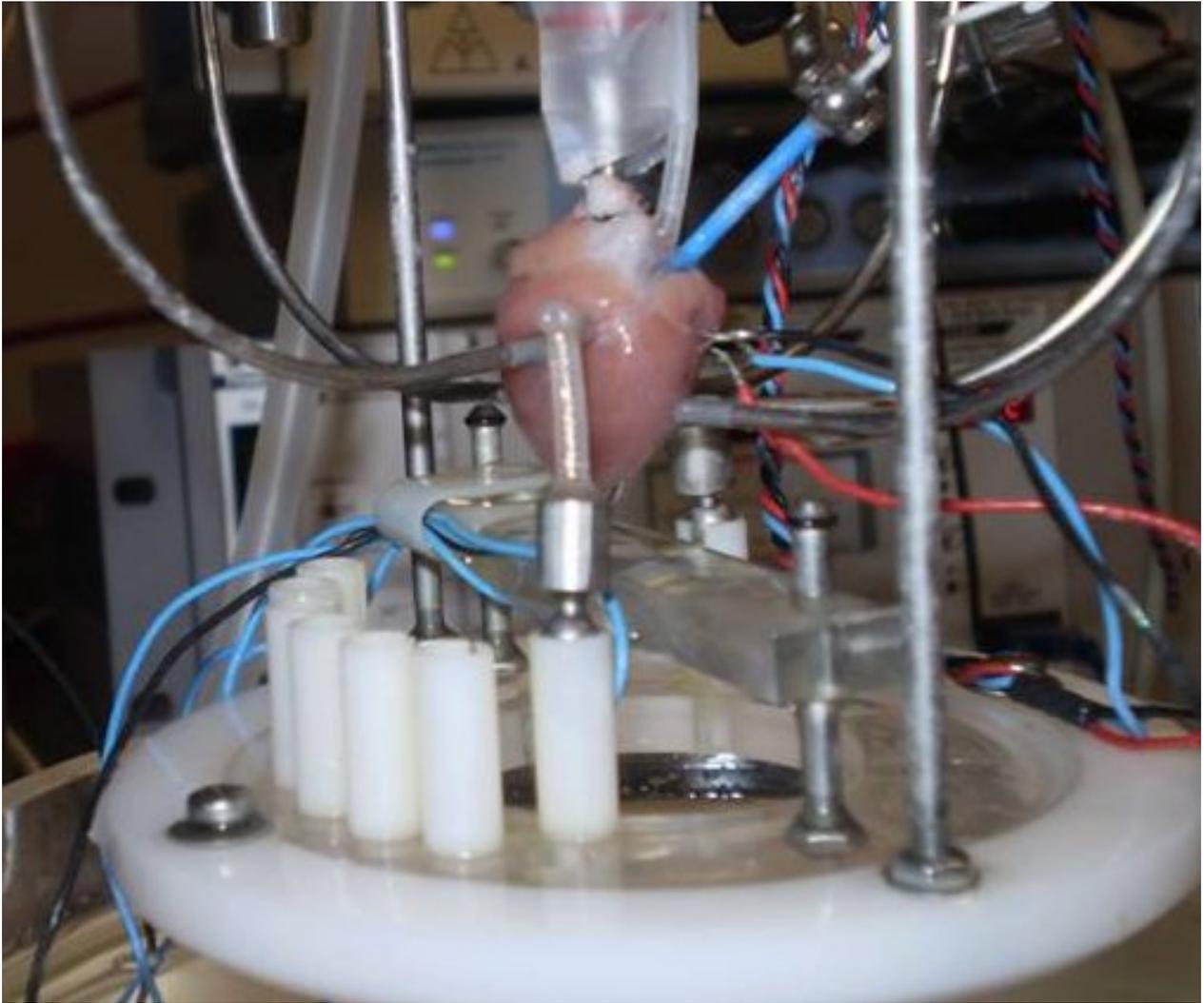
C. Flounder



Question 19

19 Which human organ lives longer?

- A. **Heart**
- B. Lungs
- C. Brains



Question 20

20 Which plant normally has a longer root?

- A. Spruce
- B. **Chokecherry**
- C. Blueberry



Fallen

spruce tree

4 Age and time. Basic principles

4.1 Geological time

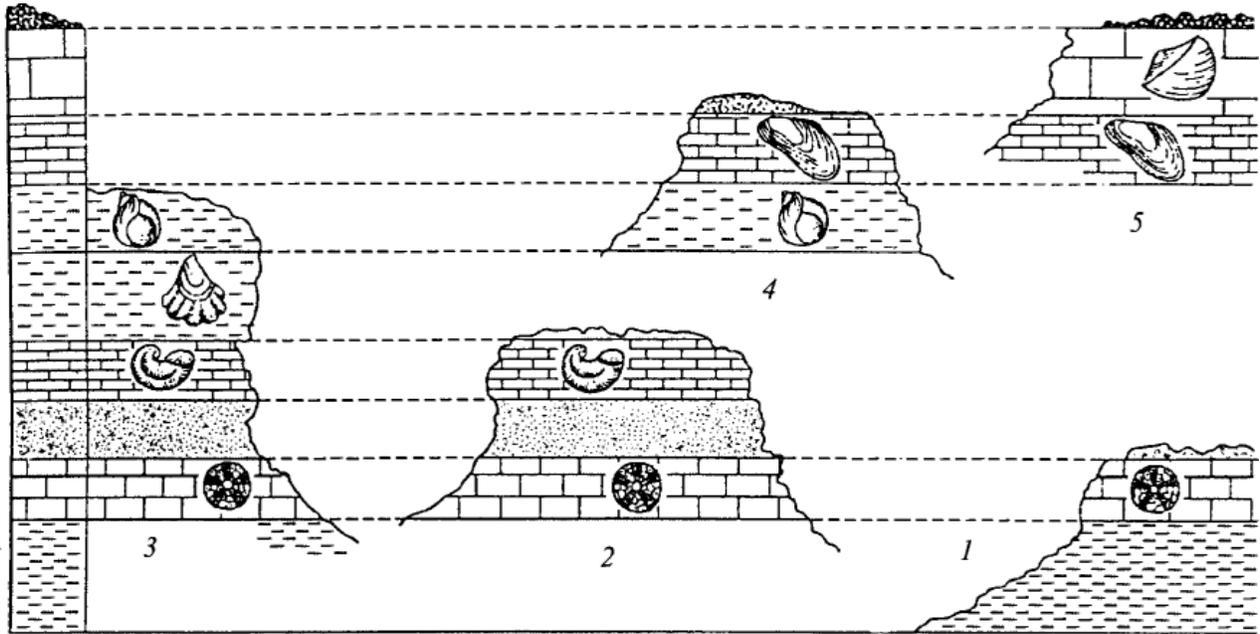
First attempts to calculate age of Earth (1830–1850)

- Helmholtz calculated that if Sun is shrinking to obtain the energy, then the age of Earth should not exceed 18 My (millions of years, 18,000,000 years)
- Lyell calculated that if the **speed of sedimentation was the same in the past**, then age of Earth should be approximately 200 My

Stratigraphy

- Upper layers are younger than lower
- Two layers contained similar species of fossils have the same time of origin

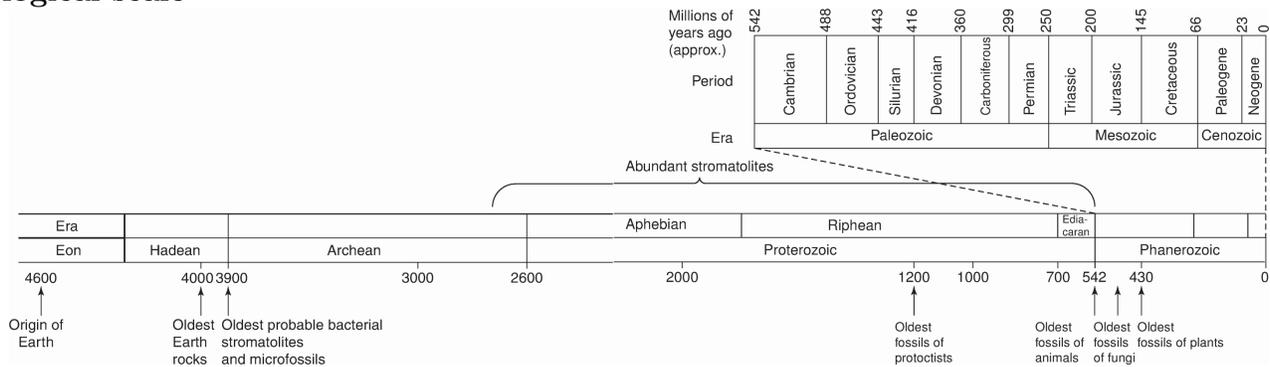
How stratigraphy works



Use of radioactivity

- In 1896, Becquerel discovered **radioactivity**. It was found that some atoms are constantly breaking into smaller ones, sometimes with very slow speed
- Consequently, it is possible to calculate the age of mineral from the concentration of radioactive elements

Geological scale



4.2 Some basic principles

Principle of actuality

- Charles Lyell (1830)
- “The present is the key to the past”

Occam’s razor

- Father William of Ockham (ca. 1300)
- “Plurality must never be posited without necessity”

Science as falsification

- Karl Popper (1963)
- “If something cannot be proved wrong, then it is meaningless”

Summary

- Geological time is calculated on the basis of both relative (stratigraphy) and absolute (radioactivity) methods
- Science is based on the principles of actuality, falsification, Occam’s razor, and hypothesis testing

References

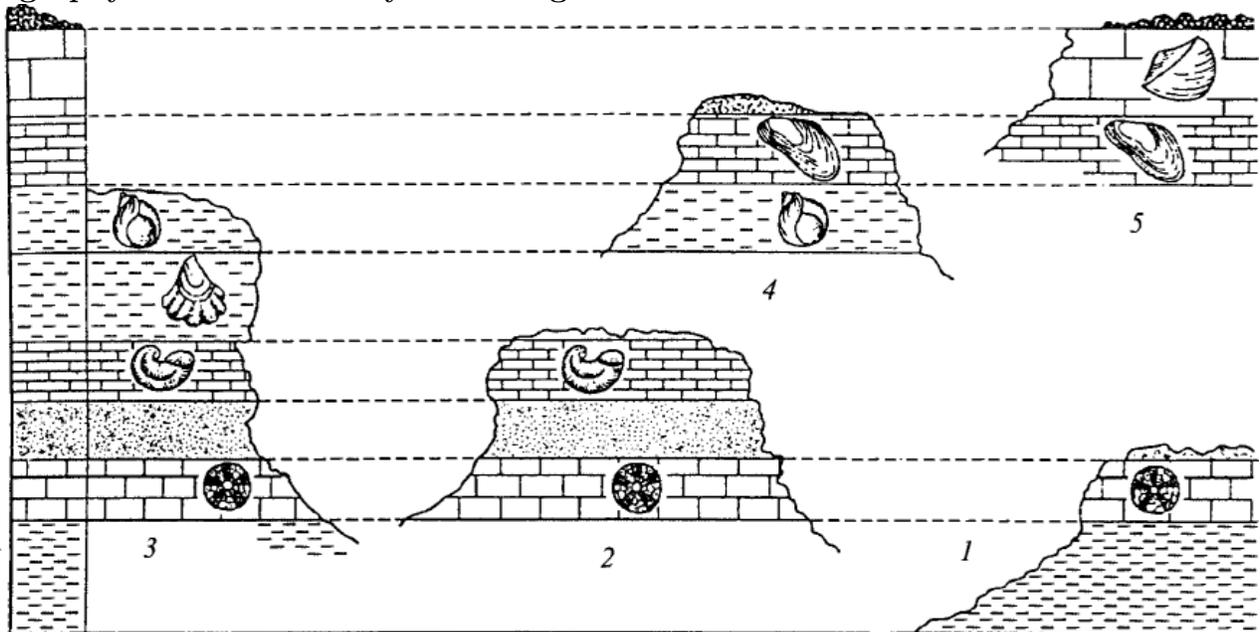
[1] Biology. Wikipedia. <http://en.wikipedia.org/wiki/Biology>

[2] History of Life. Wikipedia. http://en.wikipedia.org/wiki/History_of_life

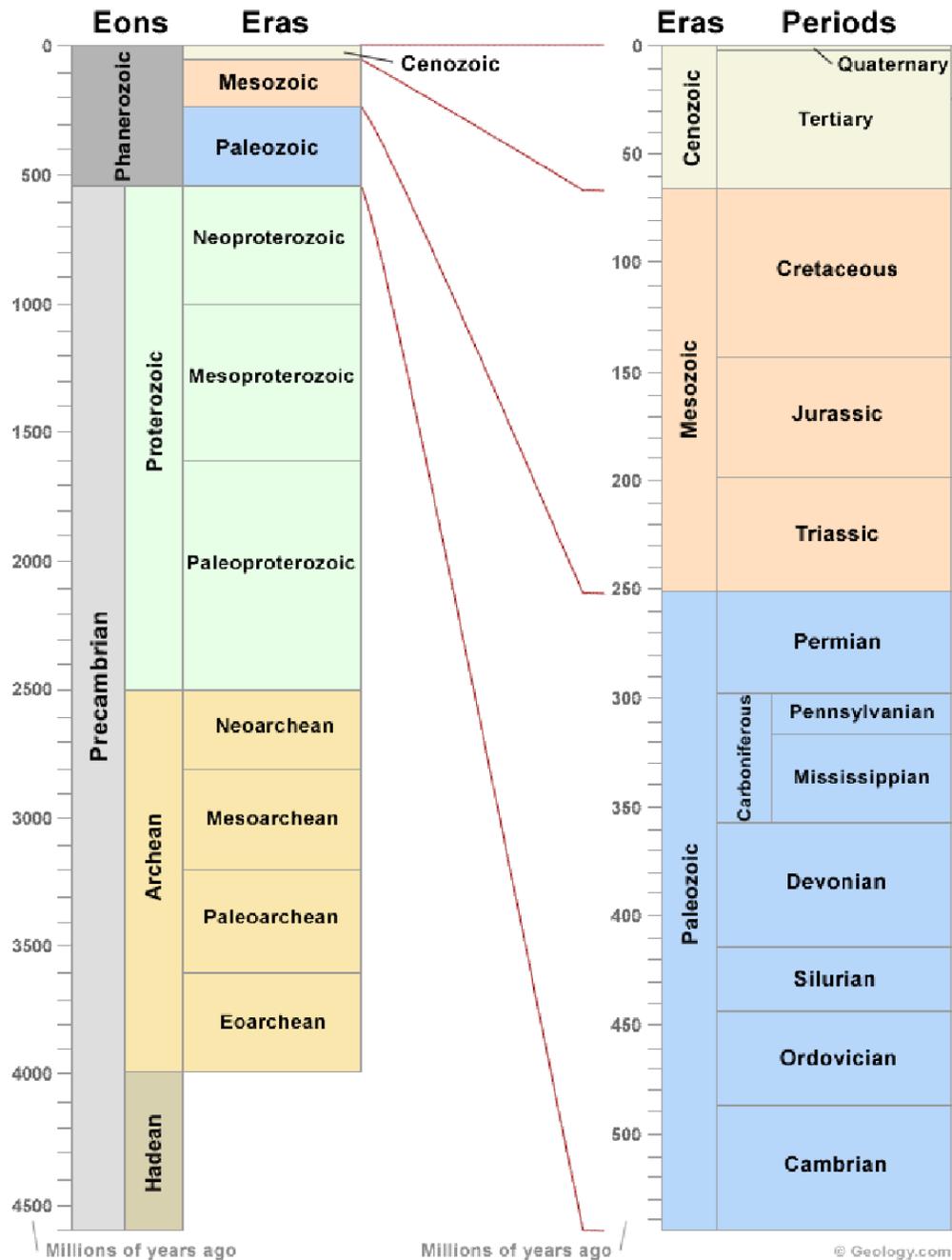
Outline

5 Where we are?

Stratigraphy and radioactivity works together



Geological scale (variant 2)



5.1 Basic principles of science

Principle of actuality

- Charles Lyell (1830)
- “The present is the key to the past”

Occam’s razor

- Father William of Ockham (ca. 1300)
- “Plurality must never be posited without necessity”

Science as falsification

- Karl Popper (1963)
- “If something cannot be proved wrong, then it is meaningless”

Example of non-falsifiable hypothesis: Russel’s teapot

... If I were to suggest that between the Earth and Mars there is a china teapot revolving about the sun in an elliptical orbit, nobody would be able to disprove my assertion provided I were careful to add that the teapot is too small to be revealed even by our most powerful telescopes.

(Bertrand Russel, 1952)



Null and alternative hypotheses

- Ronald Fisher (1935)
- Null: nothing happened; alternative: something happened
- Normally, we are able only to reject one of them and therefore **fail-to-reject** (not “support”!) the other

Basic science principles

- Actuality
- Occam’s razor
- Falsification
- Hypothesis testing

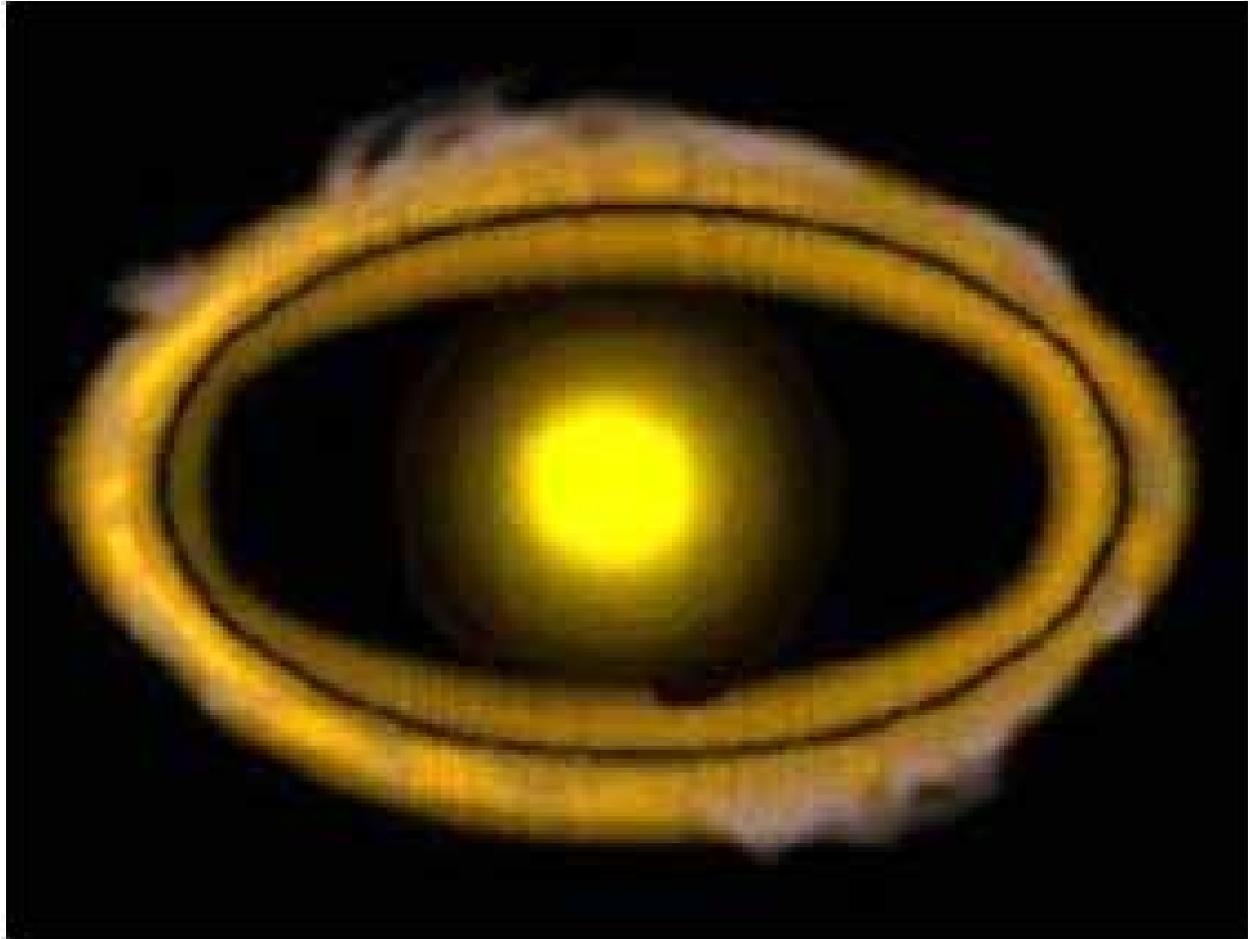
6 Origin of Earth. Basic Chemistry

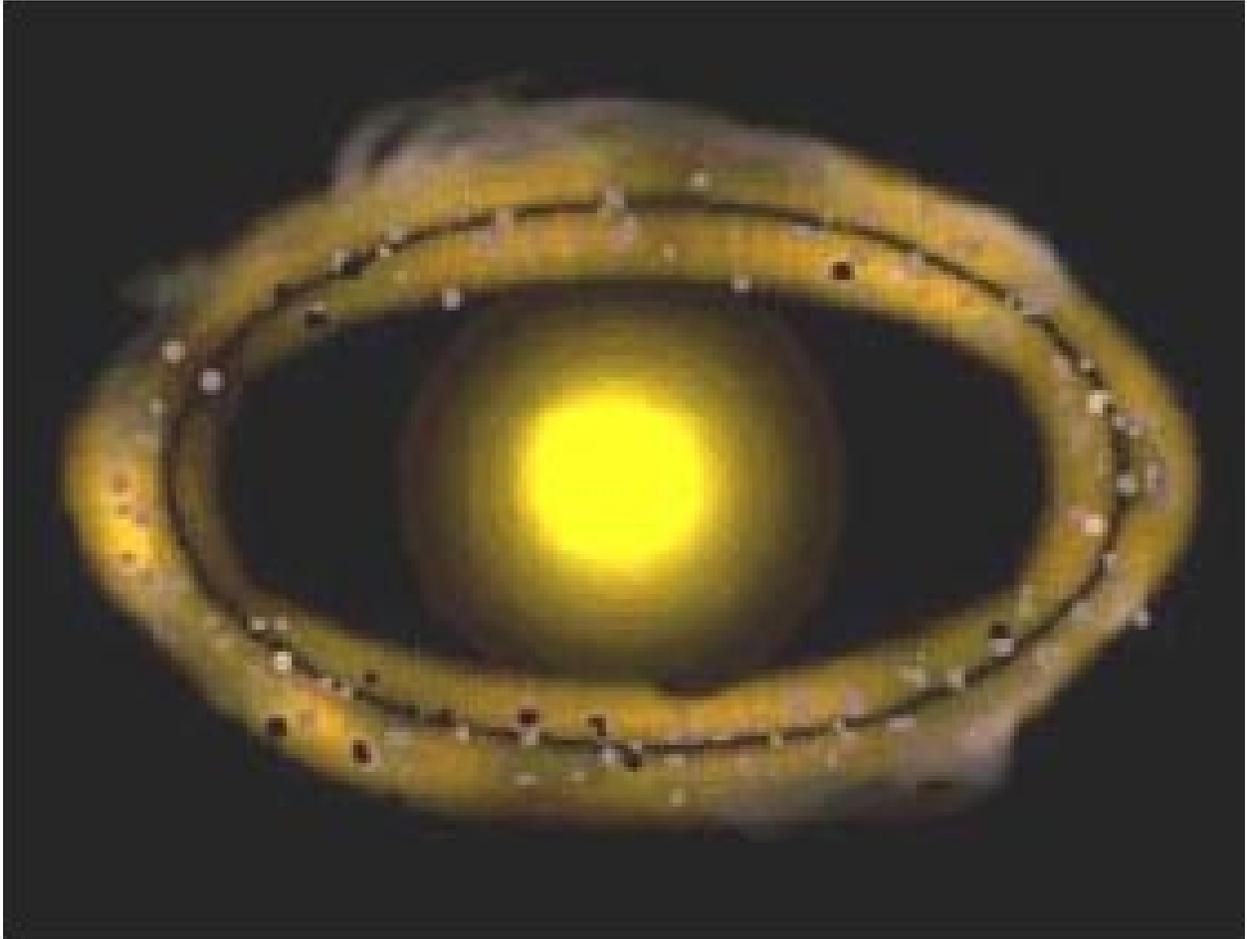
6.1 Origin of Earth

Nebula theory: cold Earth

- Pierre-Simon Laplace (1796): Earth originated from a “dust cloud”
- When cloud started to rotate around the Sun, the differentiation into planets started

Nebula: first and second steps





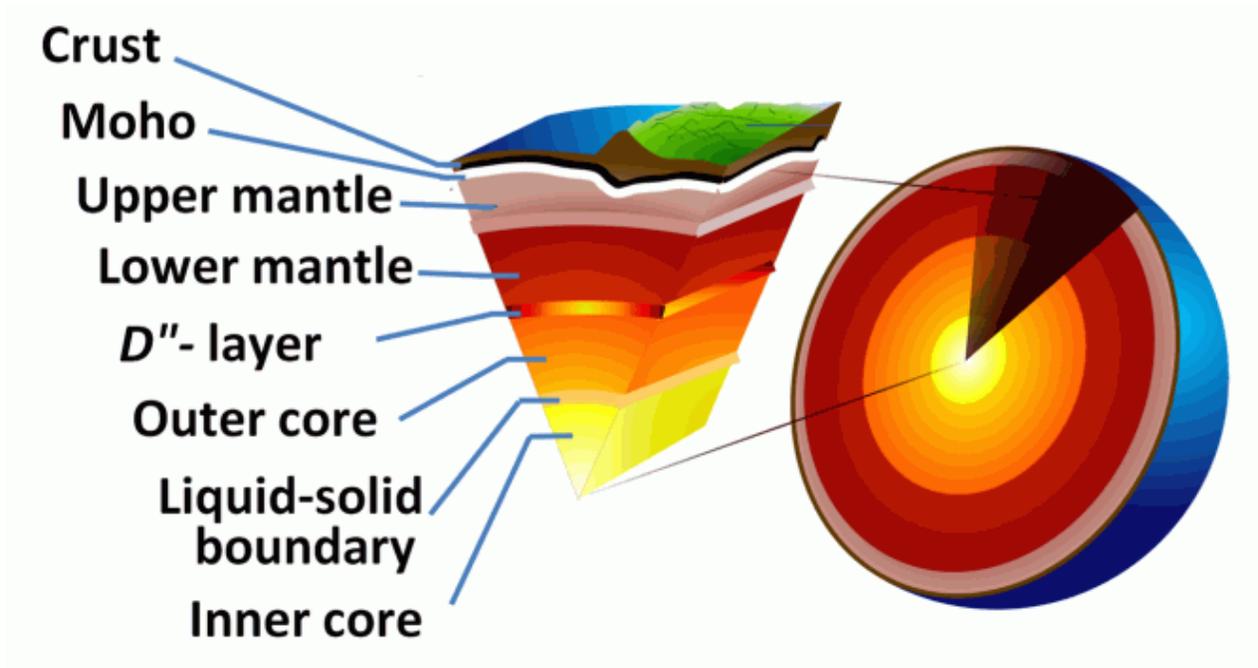
Heating: differentiation of depths

- “Heavy” elements went to the Earth center, light elements—to the surface
- The energy of this movings came out as warmth, and Earth melted (partly)

Structure of Earth

- Now, Earth is spheric drop of extremely viscous and heavy “liquid”
- This drop is structured into several layers. Most important are: crust, mantle and core.

The section of Earth



Atmosphere and hydrosphere

- The differentiation of Earth body finally resulted in developing of lighter gas layer on the surface (primary atmosphere), initially very thin and relatively cold ($\approx 15^\circ\text{C}$)
- Therefore, water vapor were condensed into primary ocean (primary hydrosphere)

Chemistry of atmosphere and hydrosphere

- According to the principle of actuality, it should be close to today's volcanic gases
- 15% of CO_2 , plus CH_4 (methane), NH_3 (ammonia), H_2S , SO_2 and different "acidic smokes" like HCl

6.2 Very basics of chemistry

Very basics of chemistry

- Atoms
 - Protons
 - Neutrons
 - Electrons
- Atomic weight
- Isotopes
- Elements and periodic table
- Chemical bonds

- Valence
- Molecules
- Molecular weight

Summary

- Geological time is calculated on the basis of both relative (stratigraphy) and absolute (radioactivity) methods
- Science is based on the principles of actuality, falsification, Occam's razor, and hypothesis testing

References

- [1] Structure of the Earth. Wikipedia. http://en.wikipedia.org/wiki/Structure_of_the_Earth
- [2] Atom. Wikipedia. <http://en.wikipedia.org/wiki/Atom> (until "Identification").

Outline

7 Where we are?

Very basics of chemistry

- Atoms
 - Protons
 - Neutrons
 - Electrons
- Atomic weight
- **Isotopes**
- Elements and periodic table
- Chemical bonds
- Valence and group
- Molecules
- Molecular weight

1 IA										18 VIIIA																																																	
1	H Hydrogen										2 He Helium																																																
2	3 6.941 Li Lithium		4 9.0122 Be Beryllium												5 10.811 B Boron		6 12.011 C Carbon		7 14.007 N Nitrogen		8 15.999 O Oxygen		9 18.998 F Fluorine		10 20.180 Ne Neon																																		
3	11 22.990 Na Sodium		12 24.305 Mg Magnesium												13 26.982 Al Aluminium		14 28.086 Si Silicon		15 30.974 P Phosphorus		16 32.065 S Sulphur		17 35.453 Cl Chlorine		18 39.948 Ar Argon																																		
4	19 39.098 K Potassium		20 40.078 Ca Calcium												31 69.723 Ga Gallium		32 72.64 Ge Germanium		33 74.922 As Arsenic		34 78.96 Se Selenium		35 79.904 Br Bromine		36 83.8 Kr Krypton																																		
5	37 85.468 Rb Rubidium		38 87.62 Sr Strontium												49 114.82 In Indium		50 118.71 Sn Tin		51 121.76 Sb Antimony		52 127.6 Te Tellurium		53 126.9 I Iodine		54 131.29 Xe Xenon																																		
6	55 132.91 Cs Caesium		56 137.33 Ba Barium												81 204.38 Tl Thallium		82 207.2 Pb Lead		83 208.98 Bi Bismuth		84 209 Po Polonium		85 210 At Astatine		86 222 Rn Radon																																		
7	87 223 Fr Francium		88 226 Ra Radium												113 284 Nh Nihonium		114 289 Fl Flerovium		115 288 Uup Ununpentium		116 293 Lv Livermorium		117 292 Uus Ununseptium		118 294 Uuo Ununoctium																																		
										<table border="1"> <tr> <td>57 138.91 La Lanthanum</td><td>58 140.12 Ce Cerium</td><td>59 140.91 Pr Praseodymium</td><td>60 144.24 Nd Neodymium</td><td>61 145 Pm Promethium</td><td>62 150.36 Sm Samarium</td><td>63 151.96 Eu Europium</td><td>64 157.25 Gd Gadolinium</td><td>65 158.93 Tb Terbium</td><td>66 162.50 Dy Dysprosium</td><td>67 164.93 Ho Holmium</td><td>68 167.26 Er Erbium</td><td>69 168.93 Tm Thulium</td><td>70 173.04 Yb Ytterbium</td><td>71 174.97 Lu Lutetium</td> </tr> </table>										57 138.91 La Lanthanum	58 140.12 Ce Cerium	59 140.91 Pr Praseodymium	60 144.24 Nd Neodymium	61 145 Pm Promethium	62 150.36 Sm Samarium	63 151.96 Eu Europium	64 157.25 Gd Gadolinium	65 158.93 Tb Terbium	66 162.50 Dy Dysprosium	67 164.93 Ho Holmium	68 167.26 Er Erbium	69 168.93 Tm Thulium	70 173.04 Yb Ytterbium	71 174.97 Lu Lutetium	<table border="1"> <tr> <td>89 227 Ac Actinium</td><td>90 232.04 Th Thorium</td><td>91 231.04 Pa Protactinium</td><td>92 238.03 U Uranium</td><td>93 237 Np Neptunium</td><td>94 244 Pu Plutonium</td><td>95 243 Am Americium</td><td>96 247 Cm Curium</td><td>97 247 Bk Berkelium</td><td>98 251 Cf Californium</td><td>99 252 Es Einsteinium</td><td>100 257 Fm Fermium</td><td>101 258 Md Mendelevium</td><td>102 259 No Nobelium</td><td>103 262 Lr Lawrencium</td> </tr> </table>										89 227 Ac Actinium	90 232.04 Th Thorium	91 231.04 Pa Protactinium	92 238.03 U Uranium	93 237 Np Neptunium	94 244 Pu Plutonium	95 243 Am Americium	96 247 Cm Curium	97 247 Bk Berkelium	98 251 Cf Californium	99 252 Es Einsteinium	100 257 Fm Fermium	101 258 Md Mendelevium	102 259 No Nobelium	103 262 Lr Lawrencium
57 138.91 La Lanthanum	58 140.12 Ce Cerium	59 140.91 Pr Praseodymium	60 144.24 Nd Neodymium	61 145 Pm Promethium	62 150.36 Sm Samarium	63 151.96 Eu Europium	64 157.25 Gd Gadolinium	65 158.93 Tb Terbium	66 162.50 Dy Dysprosium	67 164.93 Ho Holmium	68 167.26 Er Erbium	69 168.93 Tm Thulium	70 173.04 Yb Ytterbium	71 174.97 Lu Lutetium																																													
89 227 Ac Actinium	90 232.04 Th Thorium	91 231.04 Pa Protactinium	92 238.03 U Uranium	93 237 Np Neptunium	94 244 Pu Plutonium	95 243 Am Americium	96 247 Cm Curium	97 247 Bk Berkelium	98 251 Cf Californium	99 252 Es Einsteinium	100 257 Fm Fermium	101 258 Md Mendelevium	102 259 No Nobelium	103 262 Lr Lawrencium																																													
<ul style="list-style-type: none"> Alkali Metal Alkaline Earth Metal Metal Metalloid Non-metal Halogen Noble Gas Lanthanide/Actinide 										<table border="1"> <tr> <td>Z</td><td>mass</td><td colspan="2">man-made</td></tr> <tr> <td>Smb</td><td></td><td colspan="2">Name</td></tr> </table>										Z	mass	man-made		Smb		Name																																	
Z	mass	man-made																																																									
Smb		Name																																																									

8 Origin of Earth. Basics of chemistry

8.1 Basics of chemistry

Acids and bases

- Acids: take out H^+ (proton), like
 $HCl \rightarrow H^+ + Cl^-$
- Bases: take out OH^- (hydroxyl)
 $NaOH \rightarrow Na^+ + OH^-$

Molar mass and molar concentration

- Molar mass is a gram equivalent of molecular mass
- For example, molecular mass of salt ($NaCl$) is $23 + 35^1 = 58$ Da. We take “Da” out and replace it with “g” (grams). Therefore, 1 mole of salt is 58 g.
- Every mole contains $6.02214078 \times 10^{23}$ molecules (Avogadro’s number)
- Concentration is the density of dissolved substance
- In water solution, 1 M (1 molar) concentration of salt means that in 1 liter of distilled water 58 g of salt was diluted
- If we take half of this water, concentration will still be 1 M whereas amount of diluted salt will decrease twice

¹If we accept that atomic mass of chlorine is 35.

Concentration of protons, and pH and acidity

- If concentration of protons is 0.1 M (1×10^{-1} , 0.1 g of protons in 1 l of water), this is an extremely acidic solution
- In distilled water, concentration of protons is equal to 1×10^{-7} (0.0000001) M
- This is because water molecules can (rarely) dissociate: $\text{H}_2\text{O} \rightarrow \text{H}^+ + \text{OH}^-$
- pH of distilled water is equal to $-\log(10^{-7}) = -(-7) = 7$
- pH of the extremely acidic solution (first example) is 1

Summary

- In chemistry, moles are using to make chemical reactions go without problems
- Concentration will not change if we throw away half of liquid

References

[1] Mole. Wikipedia. [http://en.wikipedia.org/wiki/Mole_\(unit\)](http://en.wikipedia.org/wiki/Mole_(unit))

Outline

9 Where we are?

Chemical terms

- Atoms
 - Protons
 - Neutrons
 - Electrons
- Atomic weight
- Isotopes
- Elements and periodic table
- Molecules and molecular weight
- Chemical bonds, valence and group
- Mole
- Molar concentration
- Acids and bases, pH

Chemistry basics (2)

- 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

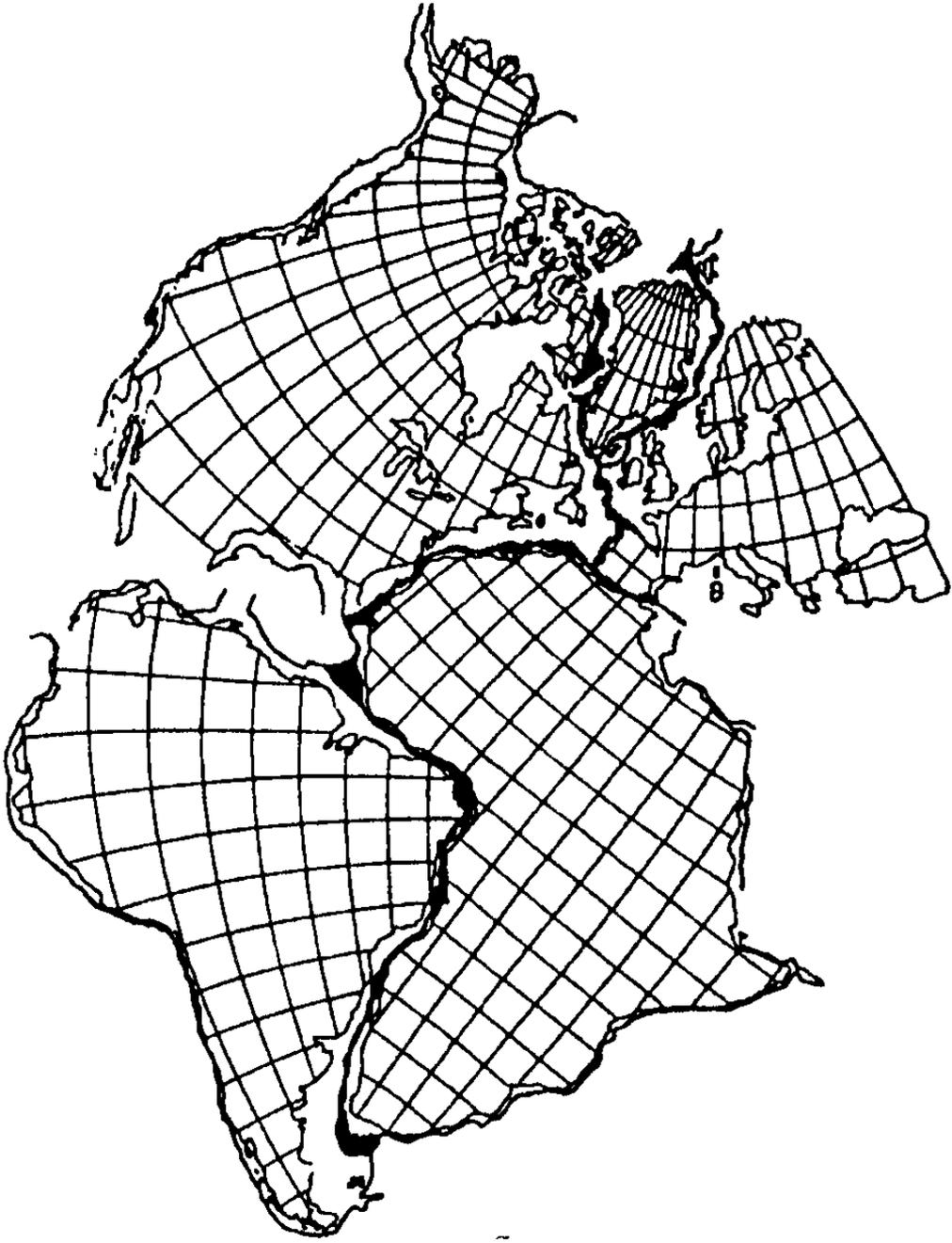
10 Floating continents

10.1 Continental drift

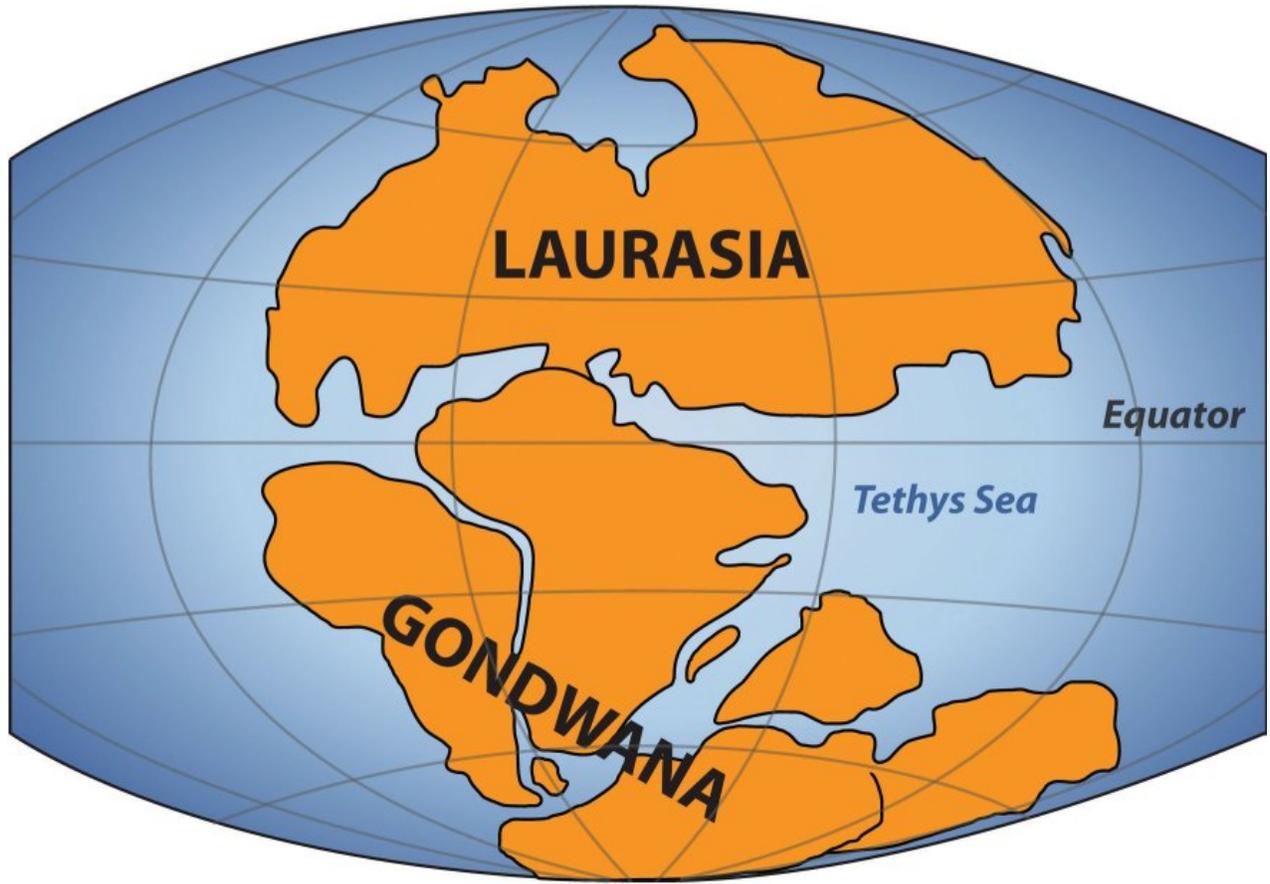
Continental drift

- In 1921, Alfred Wegener invented the idea that South America and Africa were parts of one big continent—Gondwana.
- According to Wegener, in the end of Paleozoic era, there were two big continents—Gondwana and Laurasia separated by Tethys ocean
- Before that, all continents were united in one—Pangaea surrounded by one big ocean.

One of Wegener's arguments



Laurasia and Gondwana



Pangaea

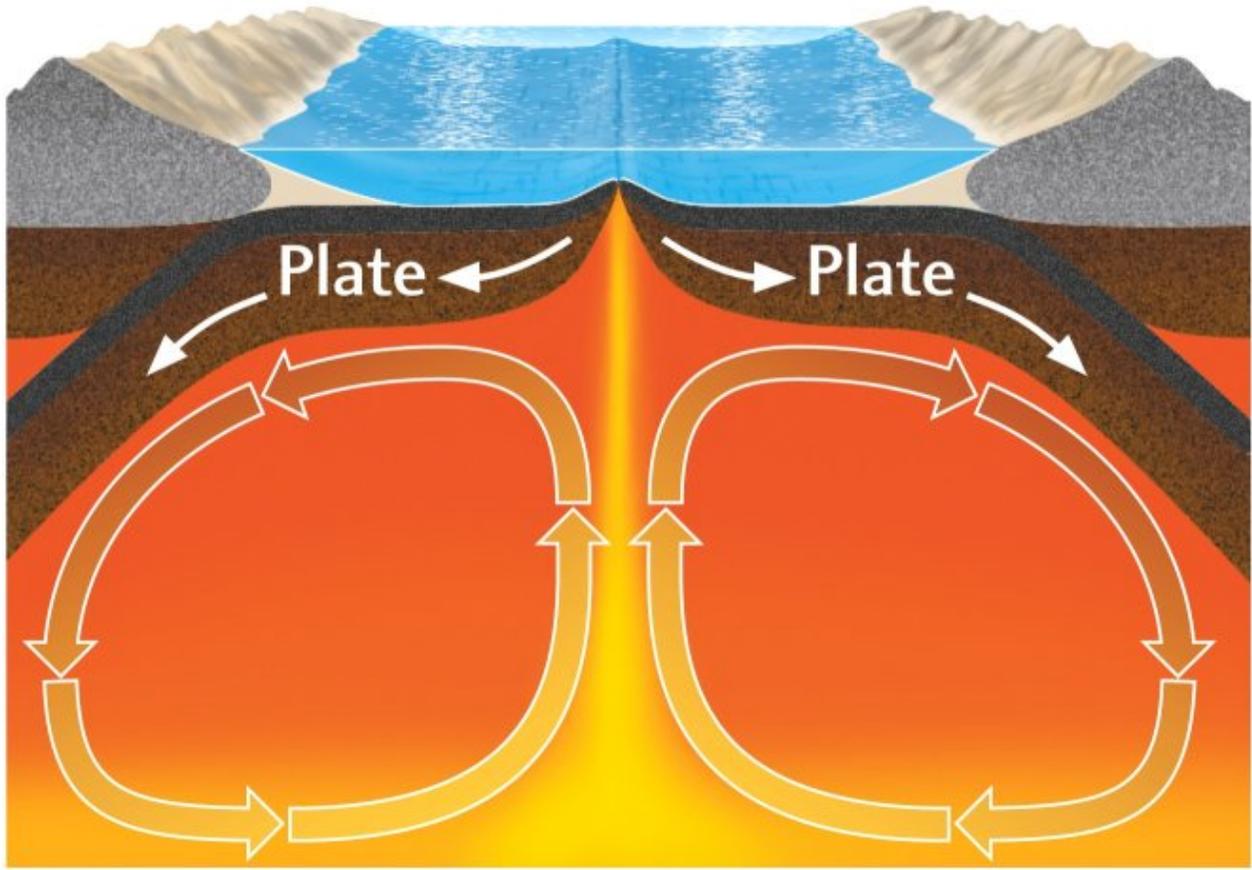


10.2 Plate tectonics

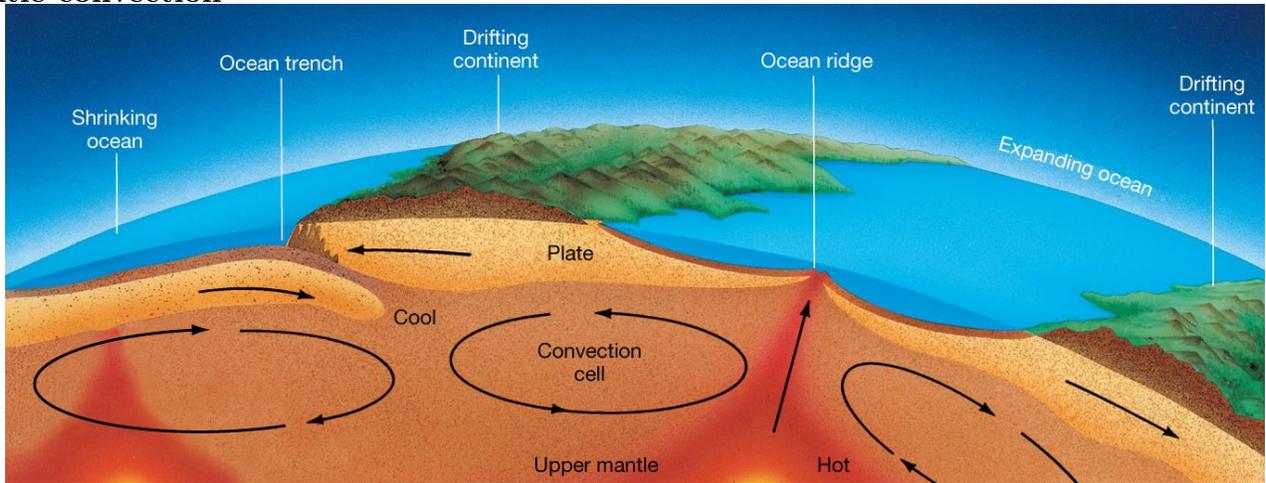
Mantle convection

- The driving force of floating continents is a **mantle convection**
- In ocean ridges, new ocean cortex is constantly forming and expanding
- In ocean trenches and continental ridges, different plates are colliding and often forming mountains

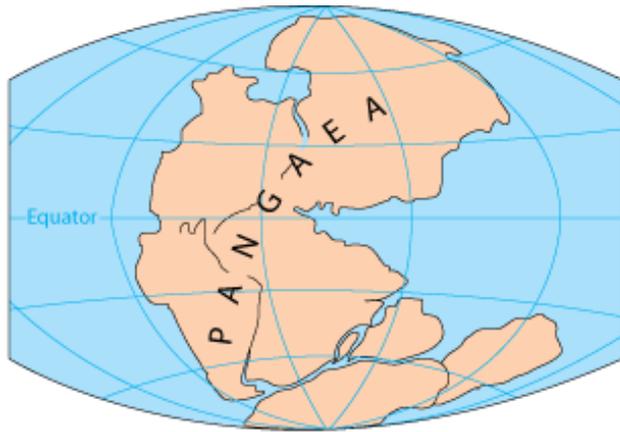
Mantle convection



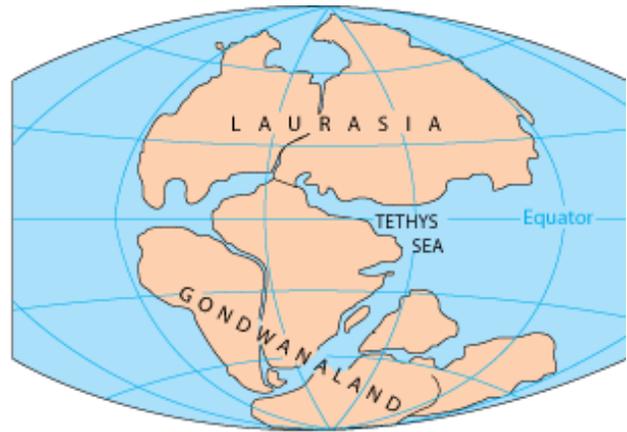
Mantle convection



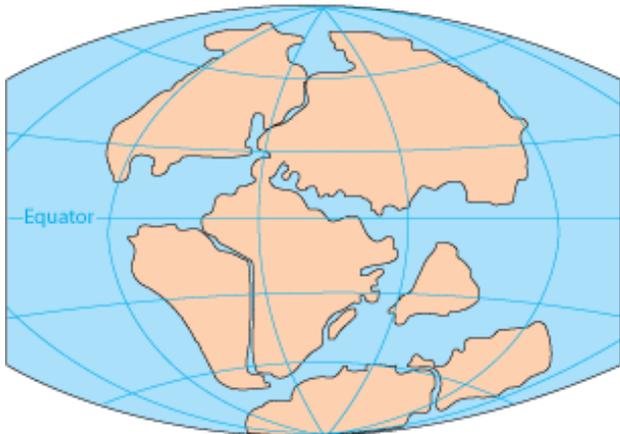
The result of mantle convection



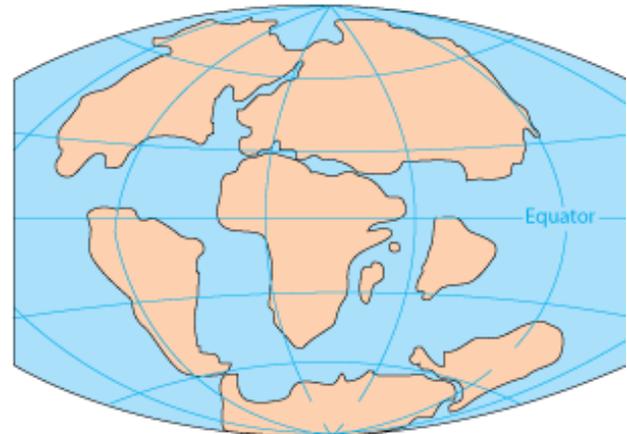
PERMIAN
250 million years ago



TRIASSIC
200 million years ago

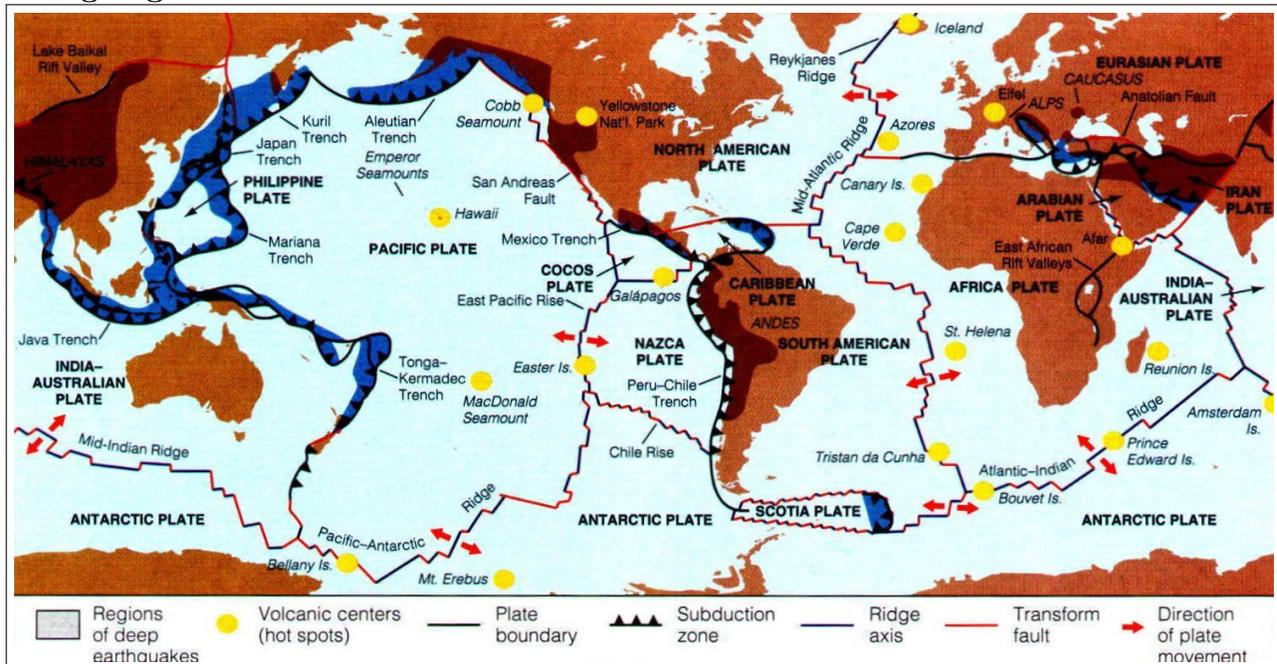


JURASSIC
145 million years ago

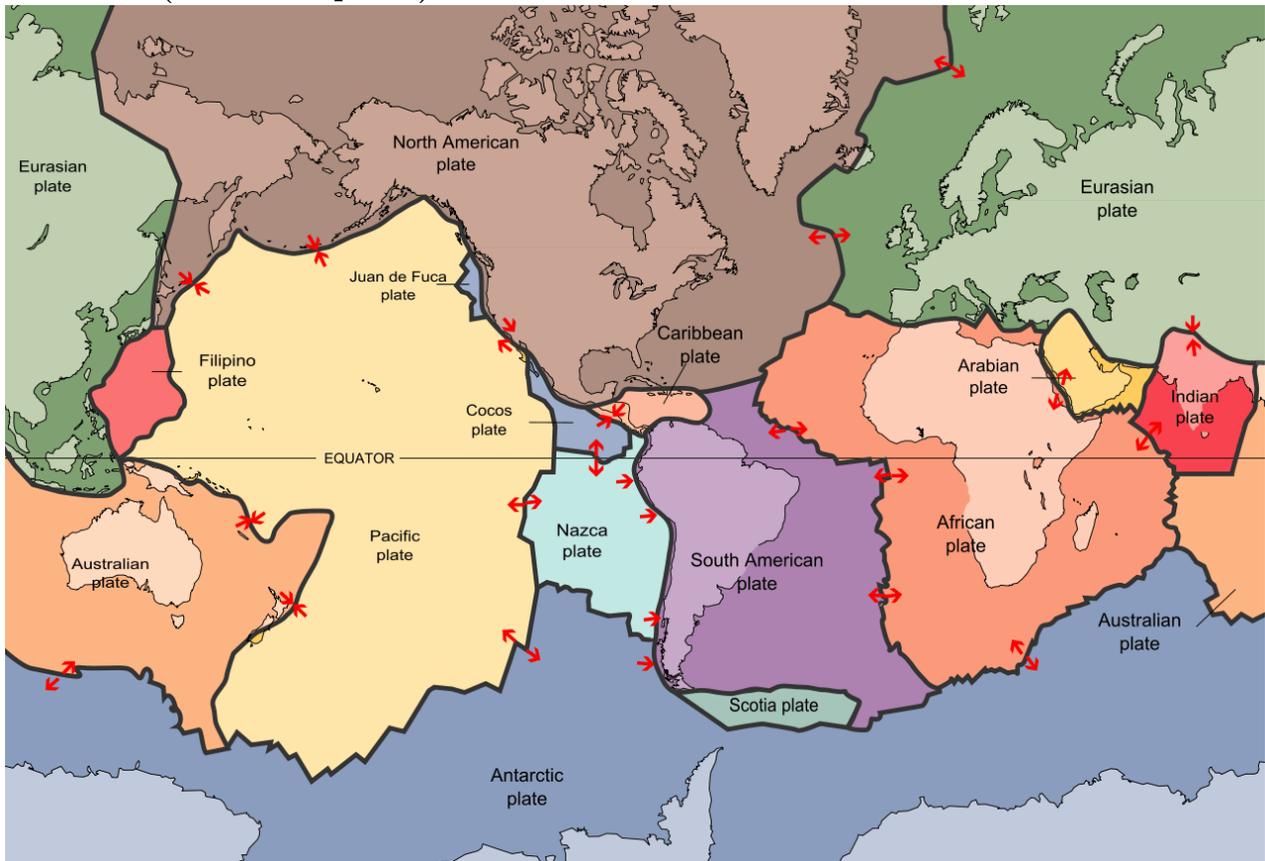


CRETACEOUS
65 million years ago

What is going on now



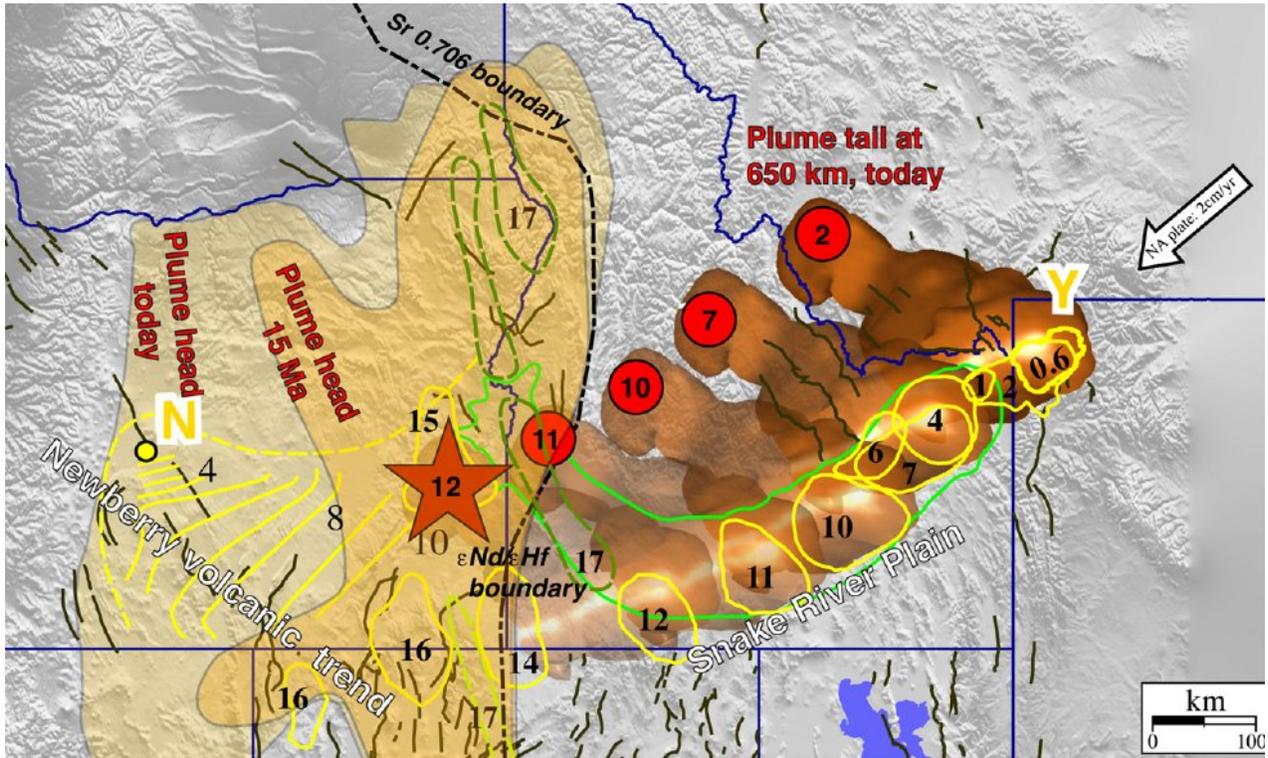
Another view (from Wikipedia)



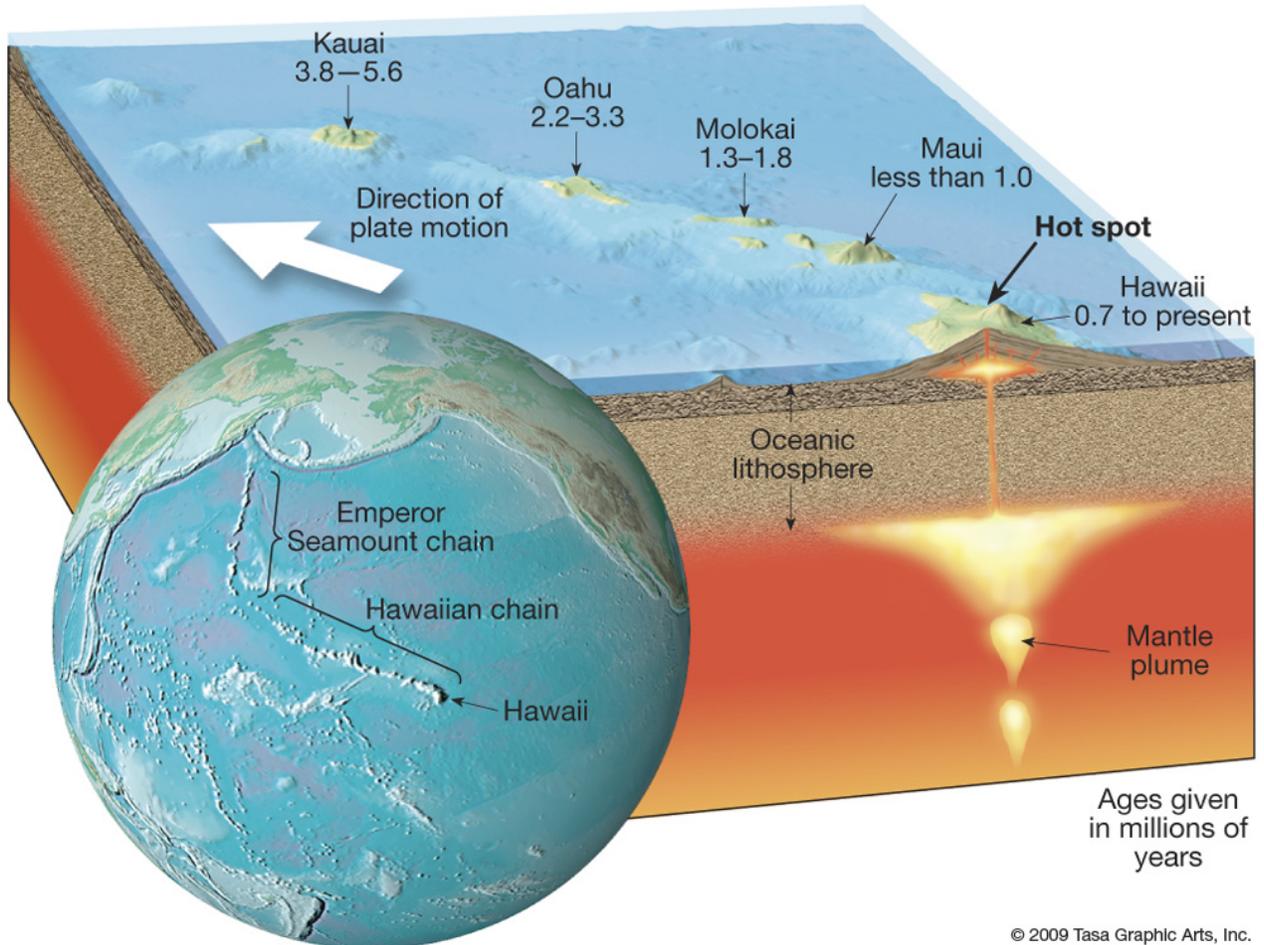
Two living examples of continental drift on U.S. territory

- Yellowstone hotspot
- Hawaiian hotspot

Yellowstone hotspot



Hawaiian hotspot



Summary

- 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

References

[1] Plate tectonics. http://en.wikipedia.org/wiki/Plate_tectonics

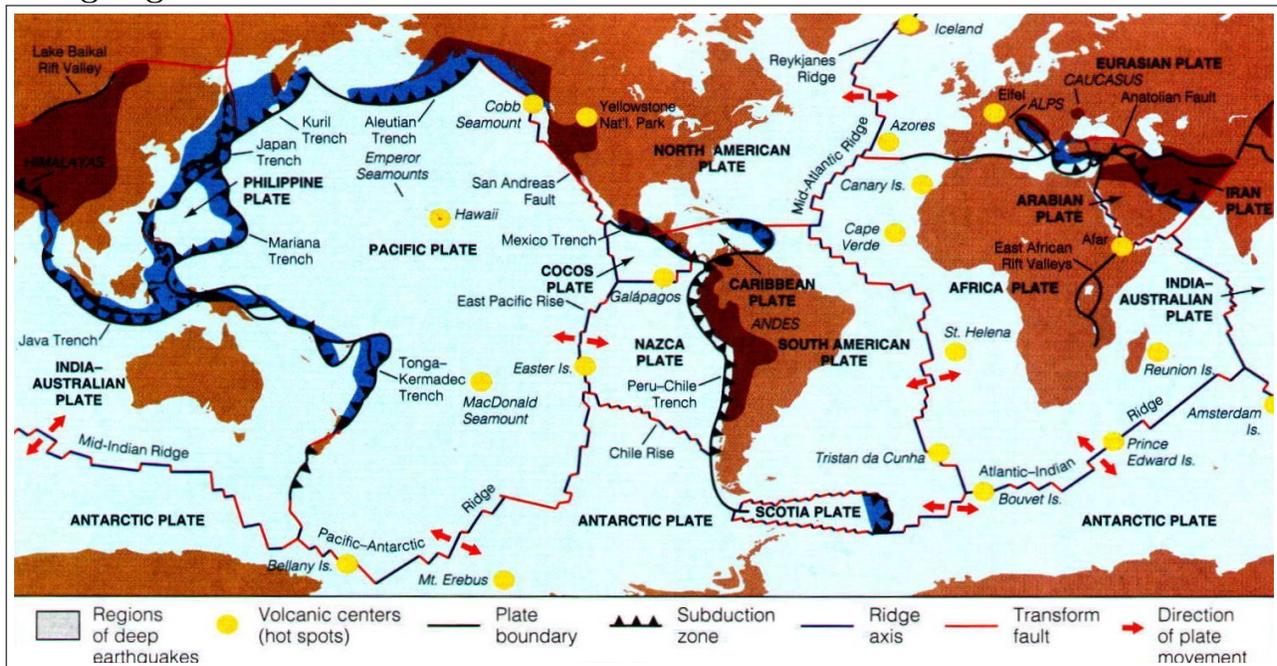
Outline

11 Where we are?

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



12 Origin of life

12.1 Proofs of evolution

Evolution is a working research program

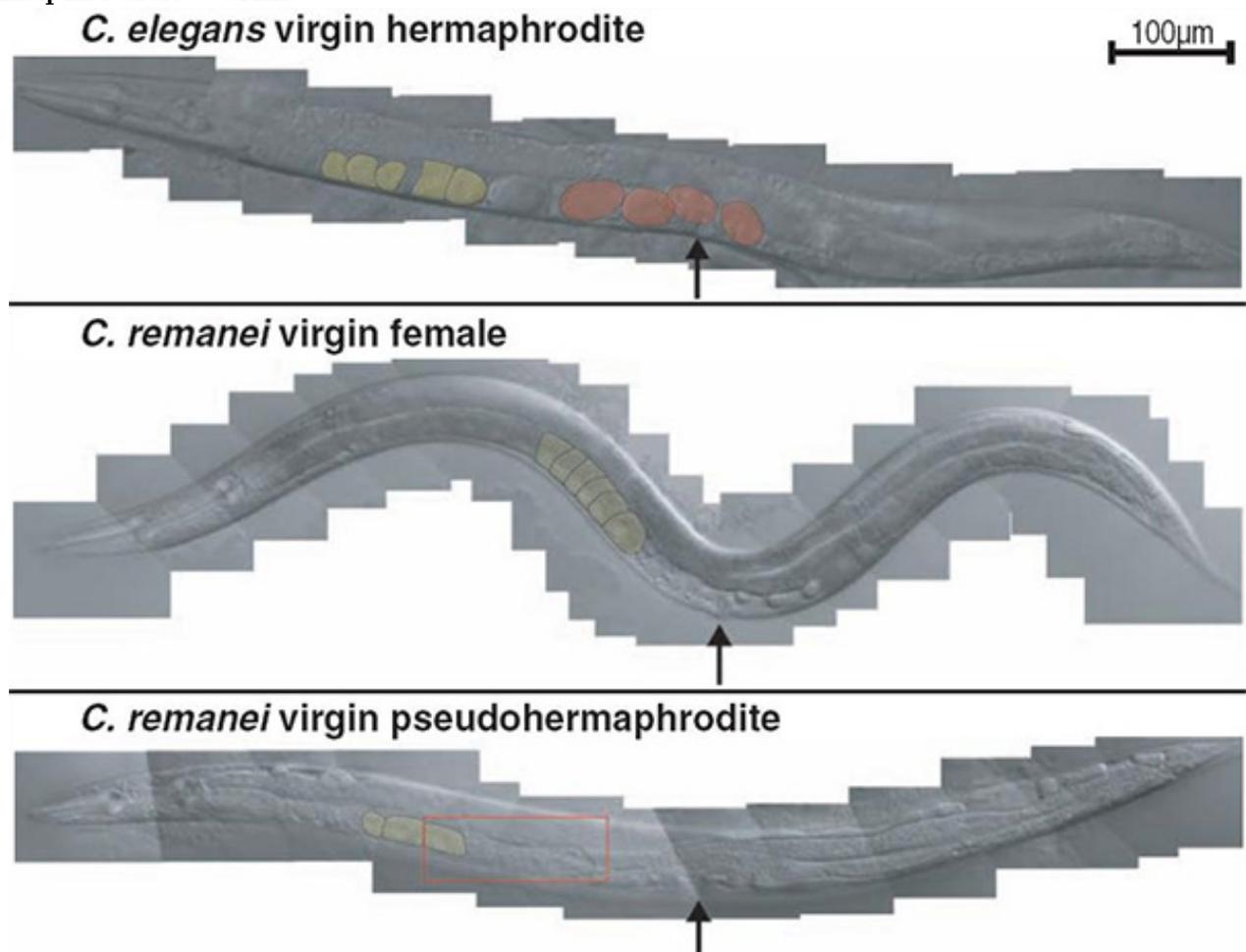
“Nothing in Biology Makes Sense Except in the Light of Evolution”

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

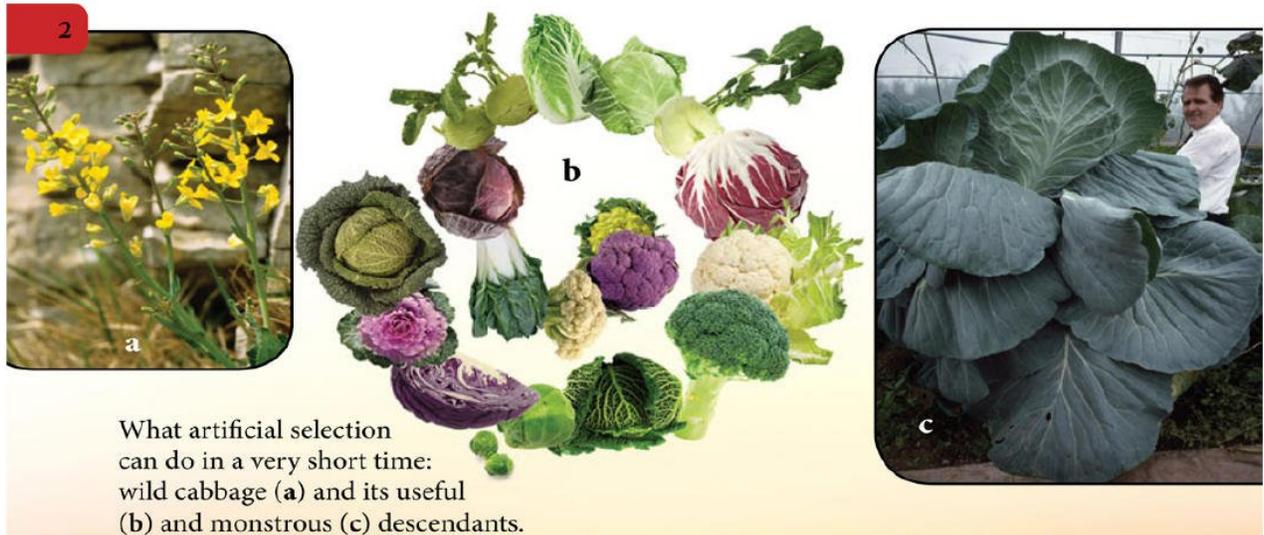
Hermaphroditic worms



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



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)

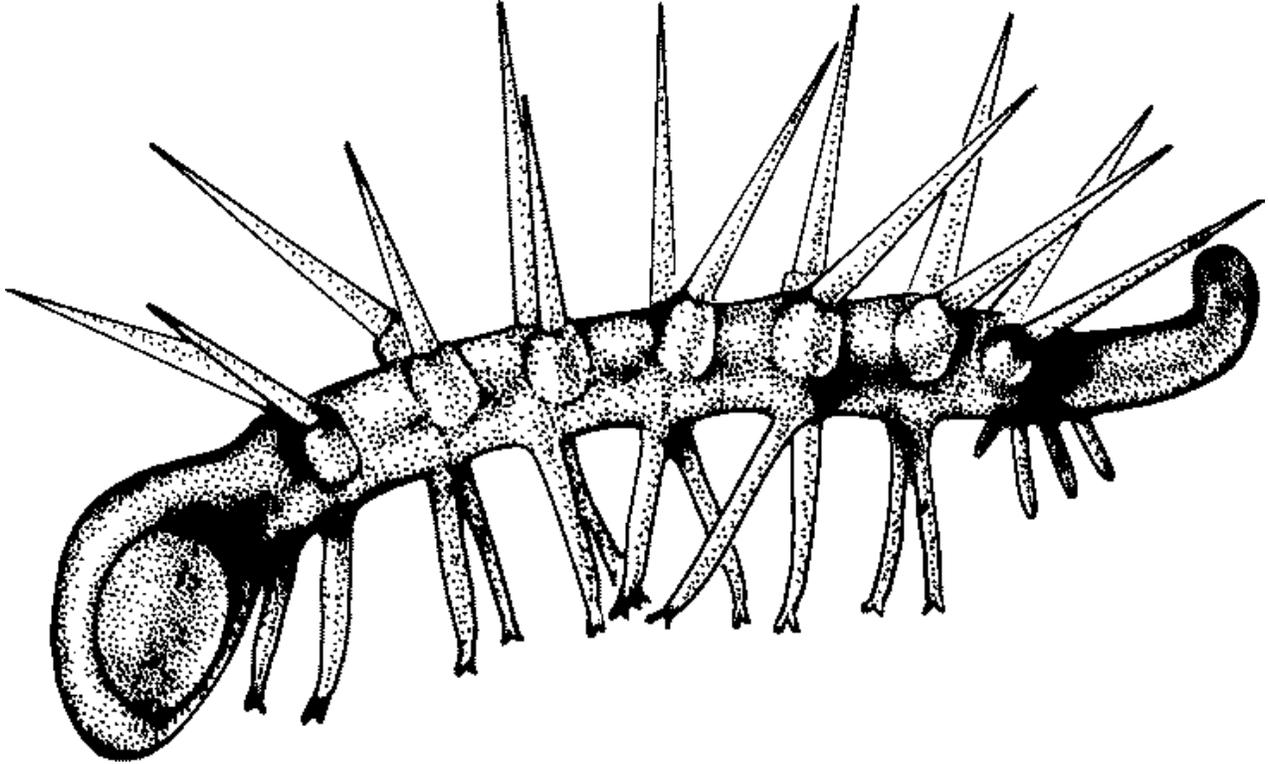


Fossils are direct evidence of evolution

- The older fossils are, the more unusual are they

- Many fossils are transitional forms (see http://en.wikipedia.org/wiki/List_of_transitional_fossils)
- Many fossils could be arranged in well-documented “evolutionary chains”

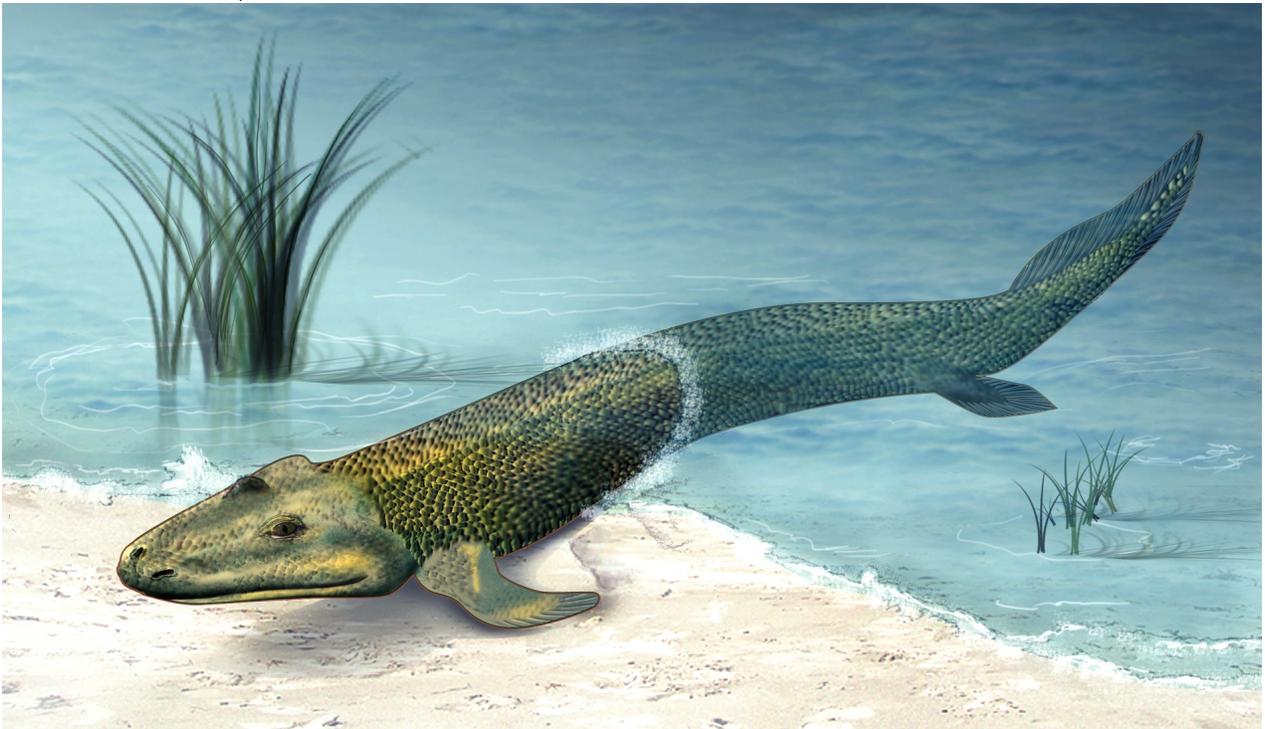
Hallucigenia—mysterious Cambrian fossil



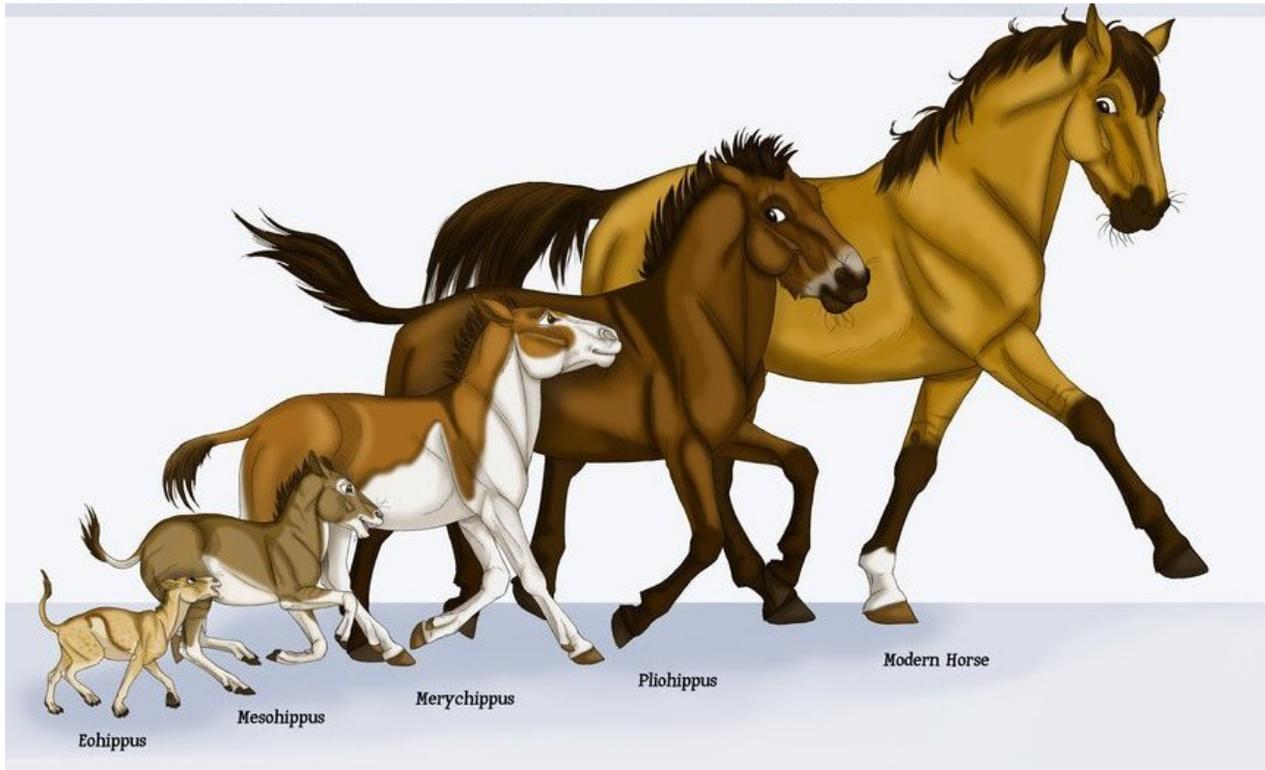
Hallucigenia in stone



Tiktaalik—half-fish, half-salamander



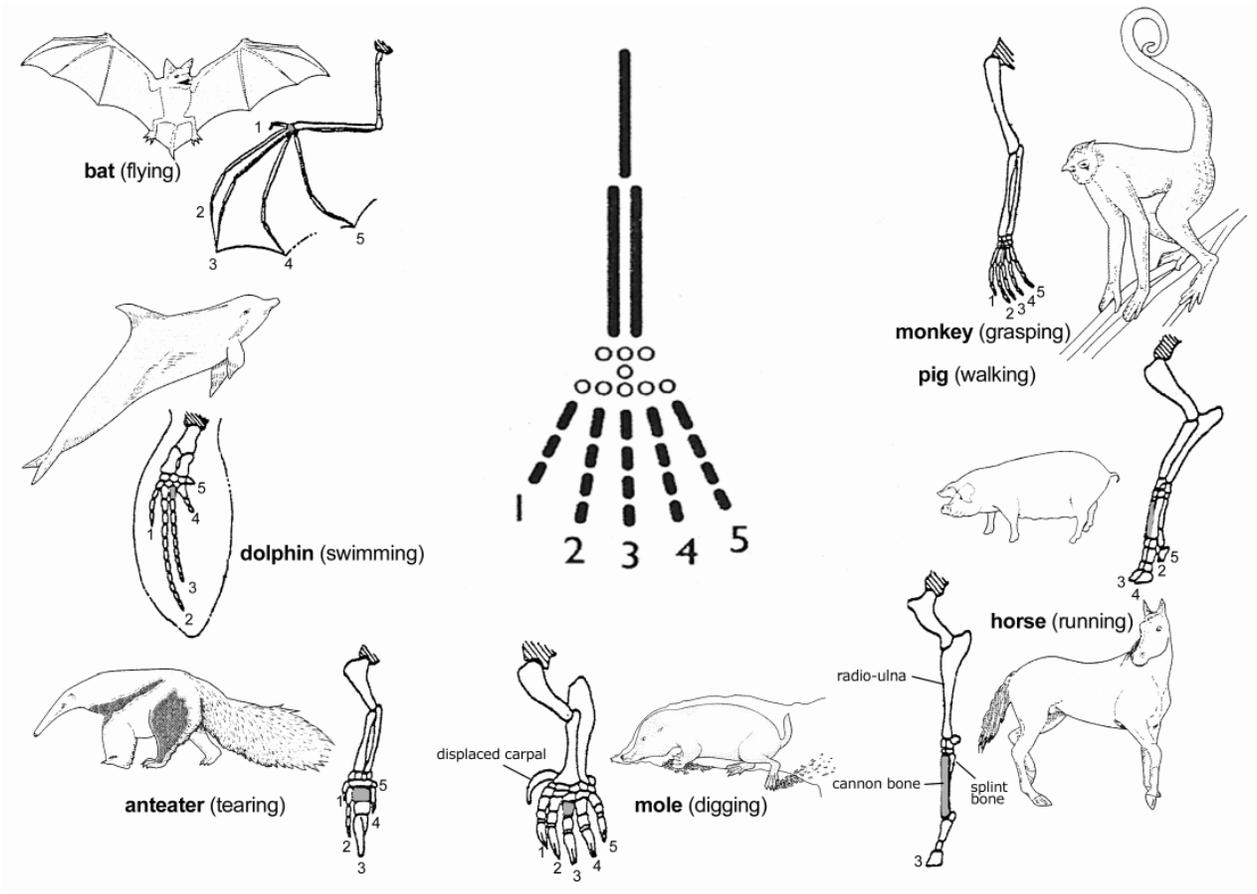
Evolution of horses



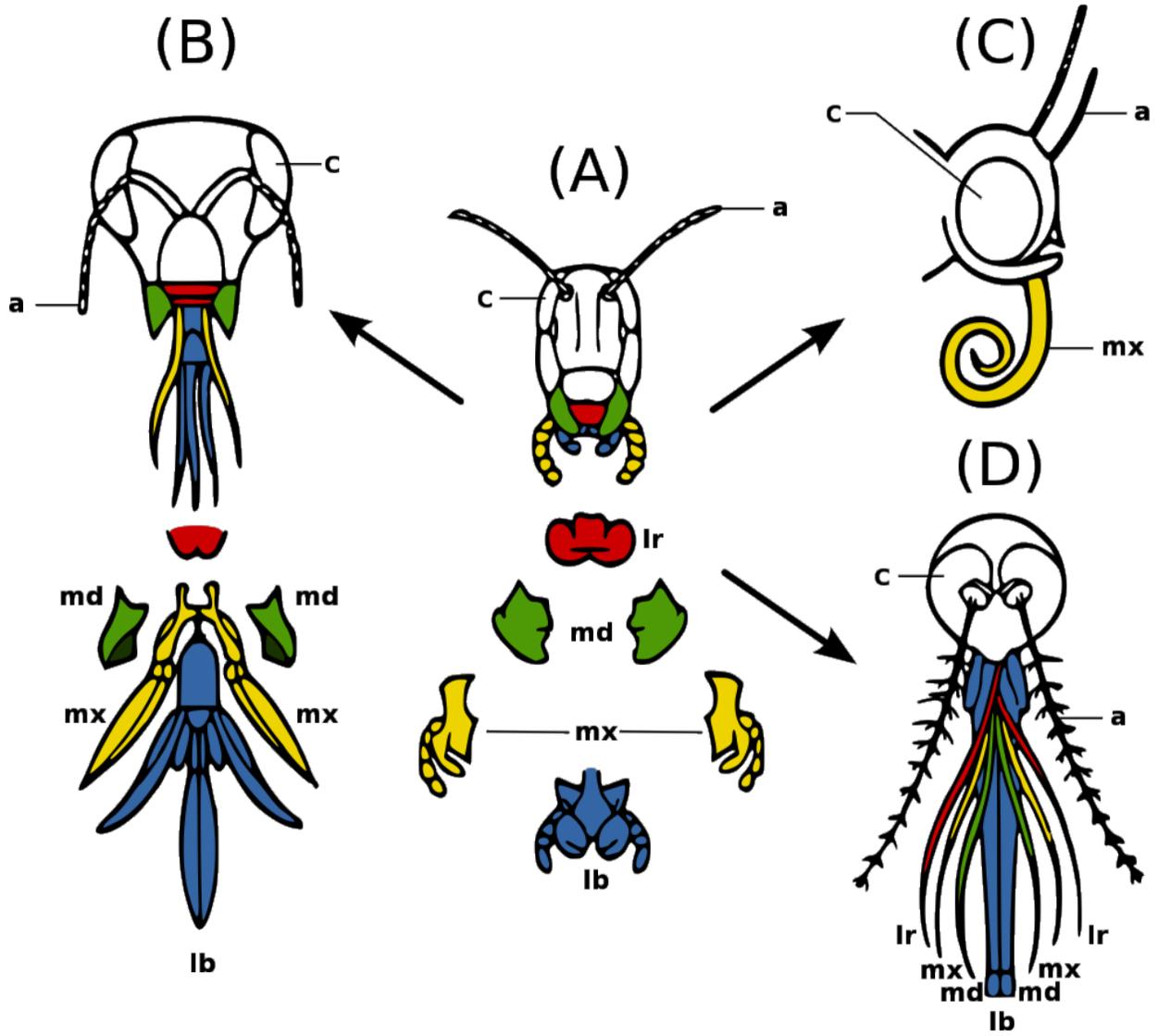
Similarities in structure (morphology) prove evolution

- 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



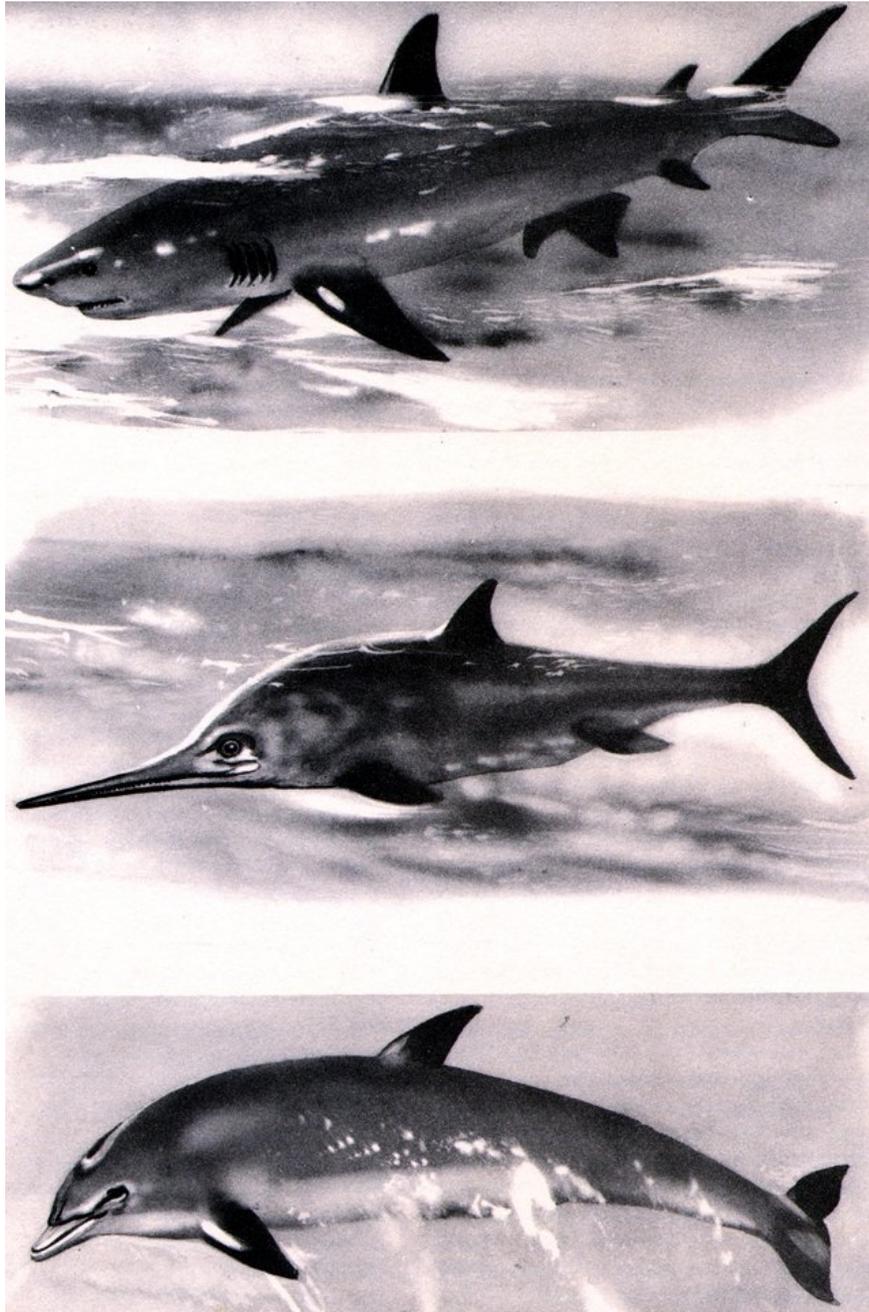
Vestigial hind legs of python



Reversal hind legs in dolphin



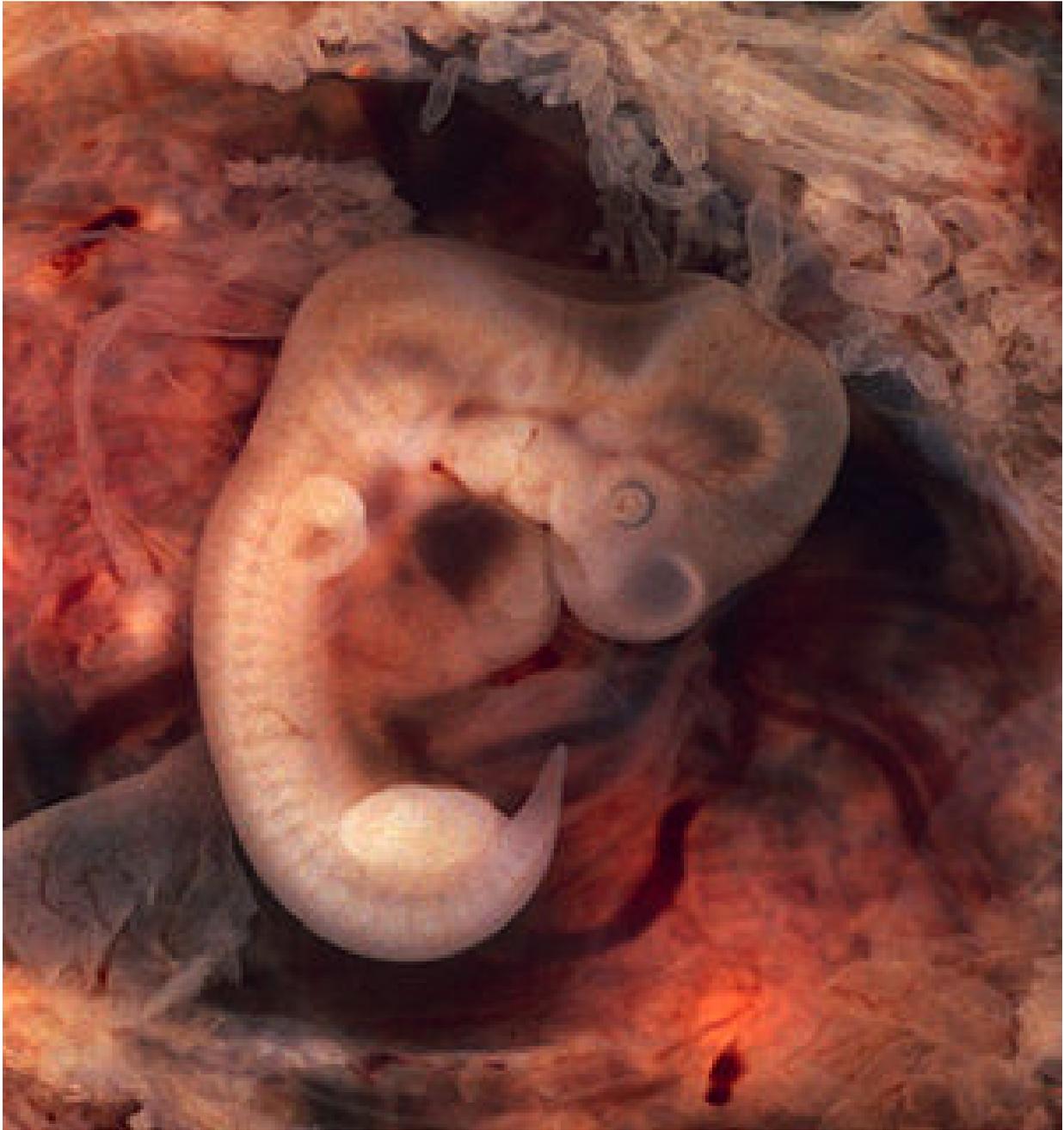
Analogous structures help shark, ichthyosaur and dolphin to swim



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

```
M T P T R K I N P L M K L I N H S F I D
ATGACCCCGACACGCAAAATTAACCCACTAATAAAATTAATTAATCACTCATTATCGAC 60
||||||| | ||||||| ||||| ||||||| ||||||| ||||||| |||||||
ATGACCCCGATACGCAAAACTAACCCCCTAATAAAATTAATTAACCACTCATTCATCGAC 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
CTCCCCACCCCATCCAACATTTCCGCATGATGGAACTTCGGCTCACTTCTCGGCGCCTGC 120
||||||| ||||||| ||||||| ||||||| || |||||||
CTCCCCACCCCATCCAACATCTCCGCATGATGAAACTTCGGCTCACTCTGGGCGCCTGC 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
|| ||||| ||||| ||||||| ||||||| || ||||||| ||||||| |||||||
CTGATCCTCCAAATCACCACAGGACTATTCCTAGCCATGCACTACTCACCAGACGCCTCA 180
L I L Q I T T G L F L A M H Y S P D A S
```

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 and then to research program

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

Questions before exam 1?

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

References

- [1] Evolution. <http://en.wikipedia.org/wiki/Evolution>
- [2] Evidence of common descent. http://en.wikipedia.org/wiki/Evidence_of_common_descent

Example questions for the exam

Start time _____

End time _____

Multiple choice

Every question in this section costs either 1 or 0. Please **mark** the appropriate answer on the **scantron**.

A. If tap water has pH equal to 6.8, it is:

- (a) Slightly acidic
- (b) Neutral
- (c) Slightly basic

B. Laurasia:

- (a) Was a super-continent which included all contemporary continents
- (b) Was a continent which broke into South America, Australia, Antarctic, Africa and India
- (c) Was a continent which broke into North America and Europe

C. Who did speculate about extra-terrestrial teapot as an example of non-falsified hypothesis?

- (a) Bertrand Russel
- (b) Charles Darwin
- (c) Theodosius Dobzhansky

D. What is the molecular weight of sulfuric acid, H_2SO_4 ? Atomic weights: H=1, O=16, S=32.

- (a) 7
- (b) 49
- (c) 98

Answers

1A, 2C, 3A, 4C