Biogeography: BIOL 330
Study guide for Exam 1

Alexey Shipunov

Lectures 1–9

Contents

Outline

1 Syllabus

1.1 Web site

Know your Syllabus!
`http://ashipunov.info/shipunov/school/biol_330/`

Presentations

- From February, every Friday lecture will start from short presentation based on the primary literature representing the most important directions of contemporary biogeography.
- Each student in a class should prepare presentation **individually**.
- Presentation is mandatory as well as participation in the discussion.
- Along with my lecture presentations, your presentations will become materials for exams.
- PDFs of articles for presentations and guidelines will be available for download on the Web site.

For Further Reading

References

[1] A. Shipunov. *Biogeography* [Electronic resource]. 2014—onwards. Mode of access: `http://ashipunov.info/shipunov/school/biol_330`

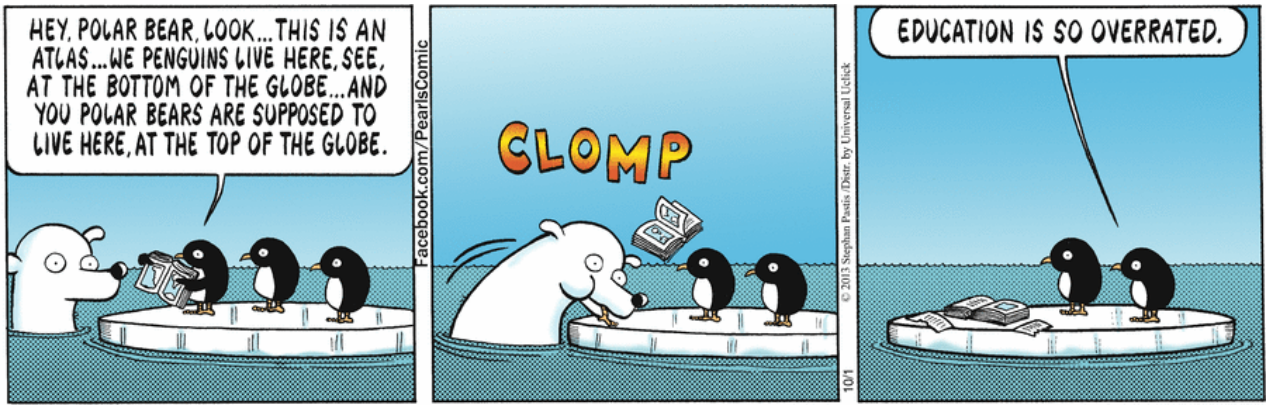
Outline

Presentations, syllabus etc.

- Exam dates are set
- 4 PDF file names
- Availability / time preferences
- Class ID (4 digits, not starting from zero)

2 Biogeography

2.1 Introduction



So why do polar bears not eat penguins?

(Yes, they do not intersect but they are not so far from each other as many think. So why they did not meet?)

http://msubiology.info/shipunov/ph/20151223_chile/20151224_patagonia/mov/

http://msubiology.info/shipunov/ph/20160626_sa/20160711_cape_town/20160713_stone_point/mov/

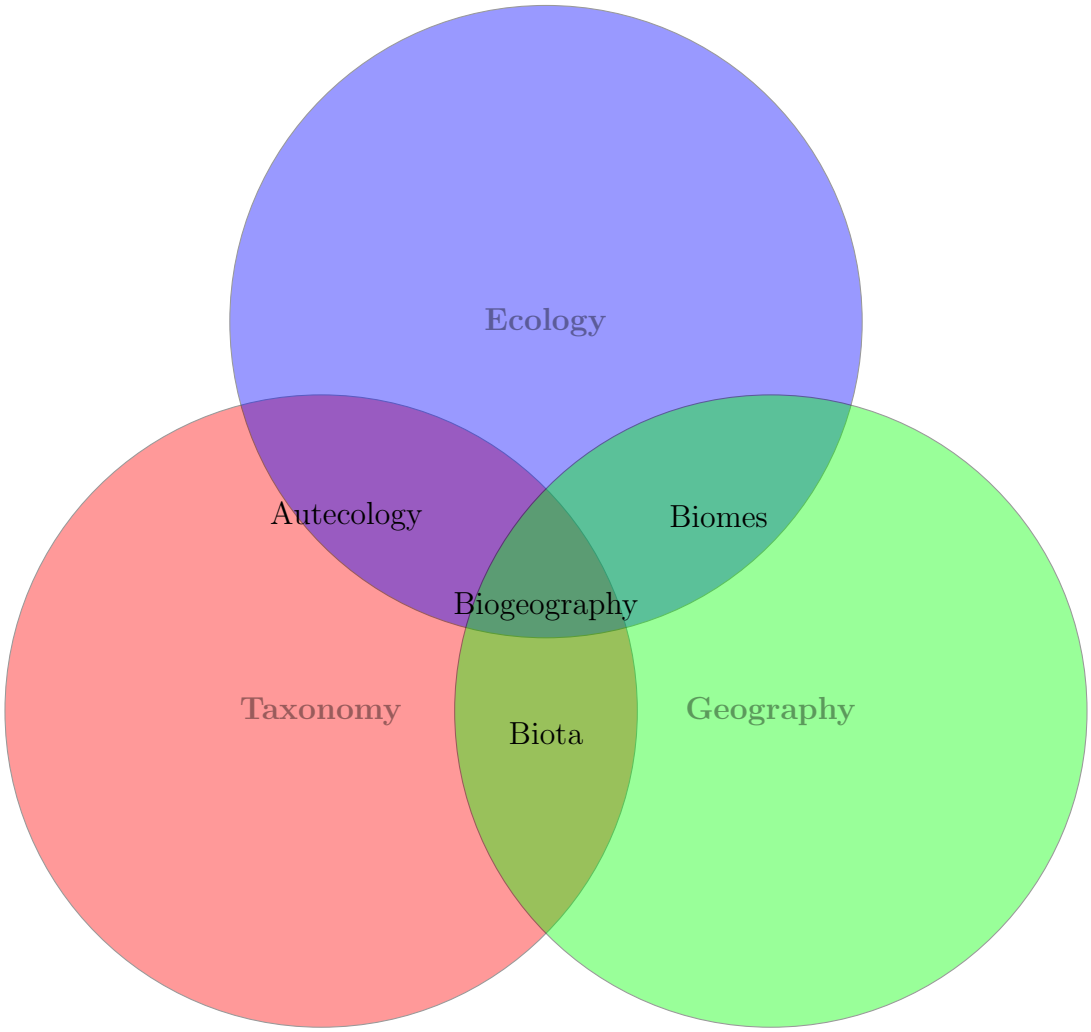
http://www.komar.org/faq/churchill_polar_bear_tours/other-animals-fun-stuff/Polar-Bear-BBQ-Penguin.gif

So what is biogeography?

Intersection between:

- Geography in wide sense (including climatology, landscape science, and even historical geology)
- Ecology (both of organisms and communities)
- Taxonomy (including phylogeny)

Contemporary biogeography always always takes into account the historical aspect.



My contributions to biogeography

- Island biogeography: small uprising islands of White Sea (Russian Arctic)
- Species biogeography: color polymorphism in Caucasian primroses
- Regional biogeography: flora of North Dakota

Around biogeography

- Geography + ecology + taxonomy = biogeography
- Geography + ecology = geographic ecology, Earth biomes
- Geography + taxonomy = floristics and faunistics
- Ecology + taxonomy = autecology, ecology of species

3 Basics of physical geography

3.1 Main categories

Physical geography

- Geodesy, cartography and spatial science
- Climatology
- Palaeogeography
- Geomorphology
- Glaciology
- Hydrology and limnology
- Oceanography

Main parts of Earth: horizontal

- Continents and islands: Greenland criterion, Panama isthmus, isthmus of Suez, Europe-Asia border (Sea of Marmara – Black Sea – North Caucasus – Caspian Sea – River Ural – Ural mountains); Madagascar, Indonesian archipelago
- Oceans and seas: Arctic ocean criterion, different approaches, Tethys traces (Mediterranean, Marmara, Black, Caspian and Aral seas)
- Lakes and rivers: Great Lakes, Great African lakes, Baikal, Lake Eyre, Lake Chad
- Mountains and depressions: Himalayan ridge, Andes and Cordilleras, European ridges, Puerto Rico depression, Mariana trench
- Straits and currents: Gibraltar, Torres and Magellan straits; Gulf stream, Labrador and North Pacific current, equatorial currents, Antarctic circumpolar current

Summary

- Biogeography is an intersection between geography, ecology and taxonomy
- For biogeography, the most important geographical sciences are geodesy, climatology and palaeogeography.

For Further Reading

References

[1] A. Shipunov. *Biogeography* [Electronic resource]. 2014—onwards. Mode of access: `http://ashipunov.info/shipunov/school/biol_330`

Outline

https://goo.gl/HXq3Yz

4 Basics of physical geography

4.1 Main categories

Main parts of Earth: vertical

- Atmosphere: troposphere (lowest 20 km) and stratosphere
- Hydrosphere
- Biosphere
- Lithosphere

Main parts of Earth: horizontal

- Continents and islands: Greenland criterion, Panama isthmus, isthmus of Suez, Europe-Asia border (Sea of Marmara – Black Sea – North Caucasus – Caspian Sea – River Ural – Ural mountains); Madagascar, Indonesian archipelago and Wallace line; microcontinents
- Oceans and seas: Arctic ocean criterion, different approaches, Tethys traces (Mediterranean, Marmara, Black, Caspian and Aral seas)
- Lakes and rivers: Great Lakes, Great African lakes, Baikal, Lake Eyre, Lake Chad
- Mountains and depressions: Himalayan ridge, Andes and Cordilleras, European ridges, Puerto Rico depression, Mariana trench
- Straits: Bering, Gibraltar, Torres and Magellan
- Currents: Gulf stream, Labrador and North Pacific current, equatorial currents, Antarctic circumpolar current, Humboldt and Benguela currents

For Further Reading

References

[1] A. Shipunov. *Biogeography* [Electronic resource]. 2014—onwards. Mode of access: `http://ashipunov.info/shipunov/school/biol_330`

Outline

5 Basics of physical geography

5.1 Basics of geodesy

Basics of geodesy

- Axial tilt
- Equator
- Poles (and magnetic poles)
- Tropics
- Arctic circles
- Longitude and latitude, prime meridian and international date line
- Time zones and UTC
- Hemispheres

For Further Reading

References

[1] A. Shipunov. *Biogeography* [Electronic resource]. 2014—onwards. Mode of access: `http://ashipunov.info/shipunov/school/biol_330`

[2] Major circles of latitude. `http://en.wikipedia.org/wiki/Circle_of_latitude`

Outline

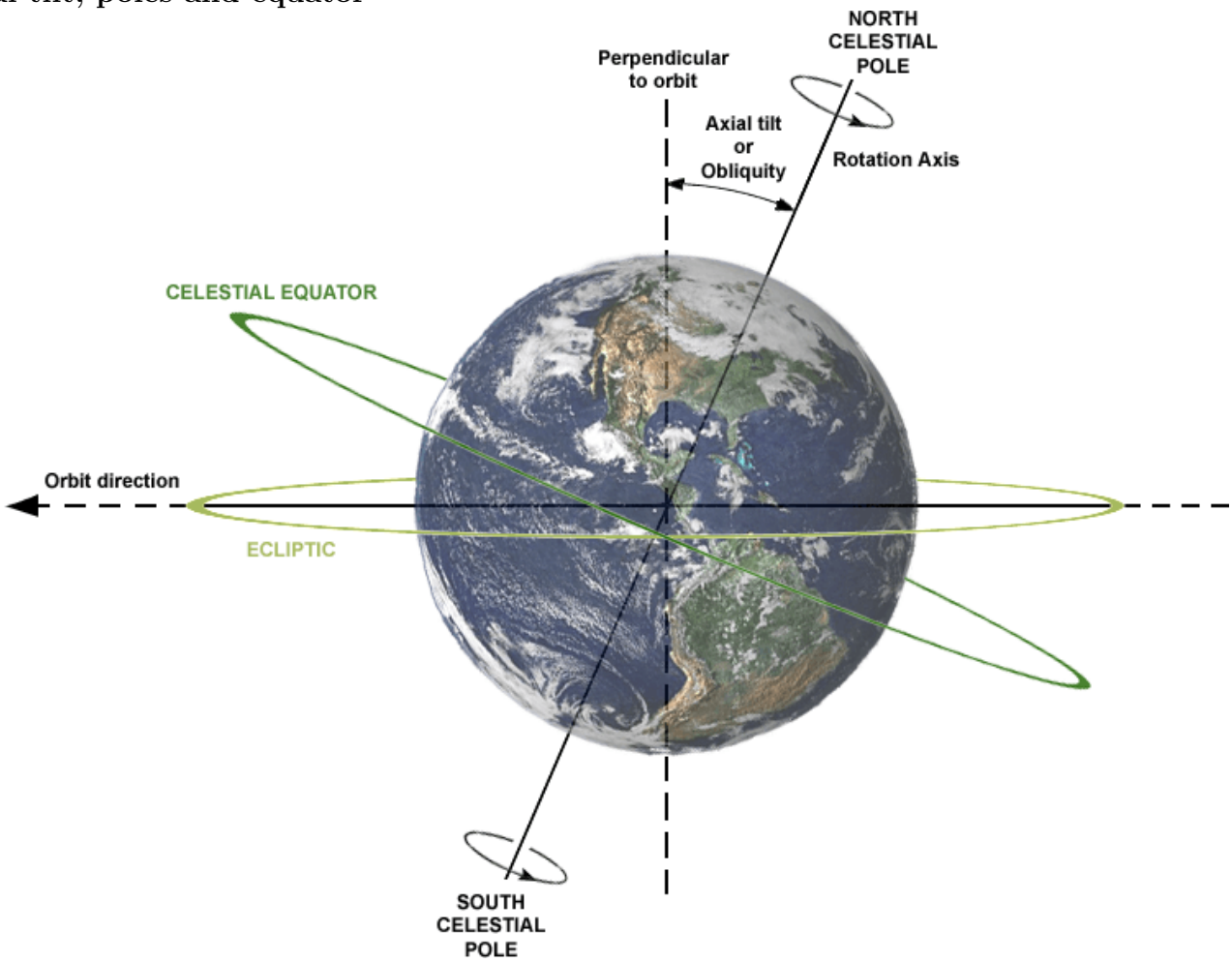
6 Basics of physical geography

6.1 Basics of geodesy

Basics of geodesy

- Axial tilt
- Equator
- Poles (and magnetic poles)
- Tropics
- Arctic circles
- Longitude and latitude, prime meridian and international date line
- Time zones and UTC
- Hemispheres

Axial tilt, poles and equator



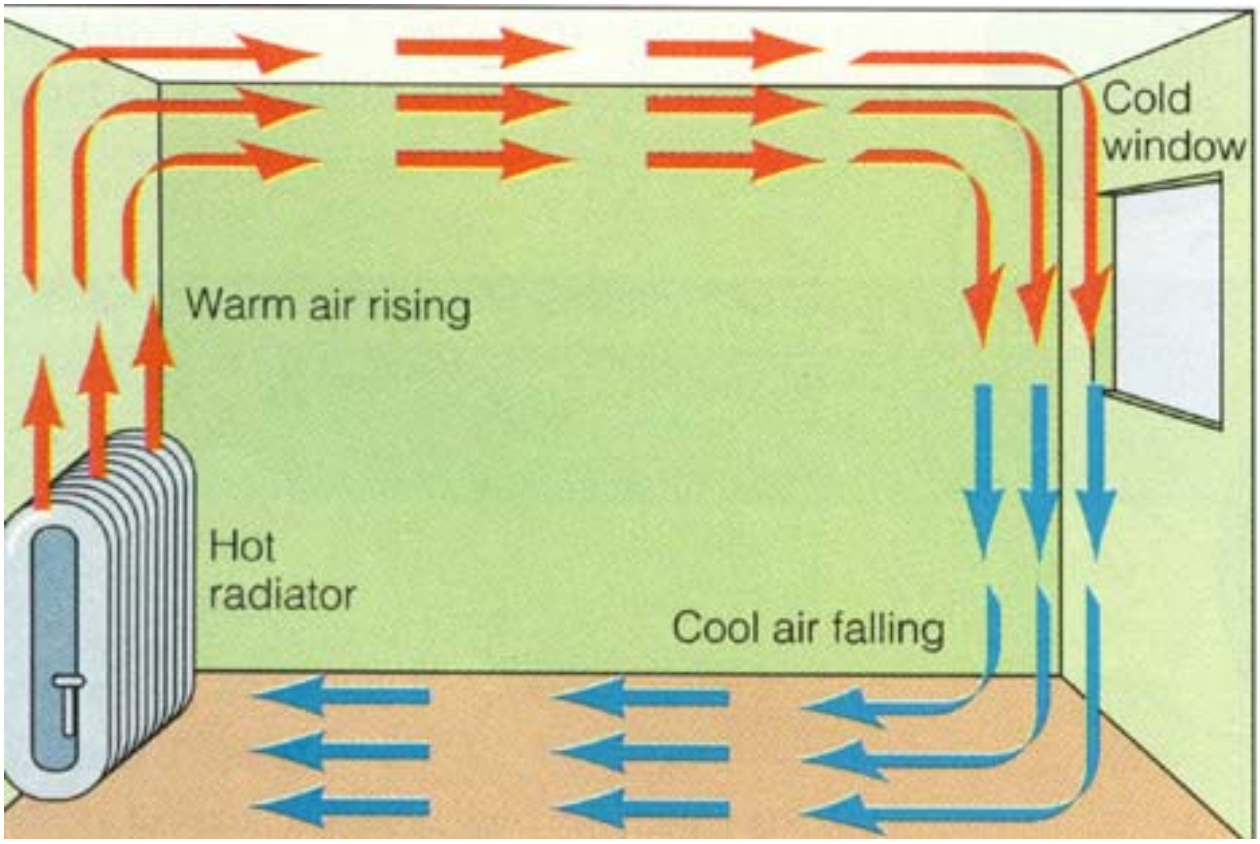
180° **Meridian, Taveuni, Fiji**

6.2 Basics of climatology

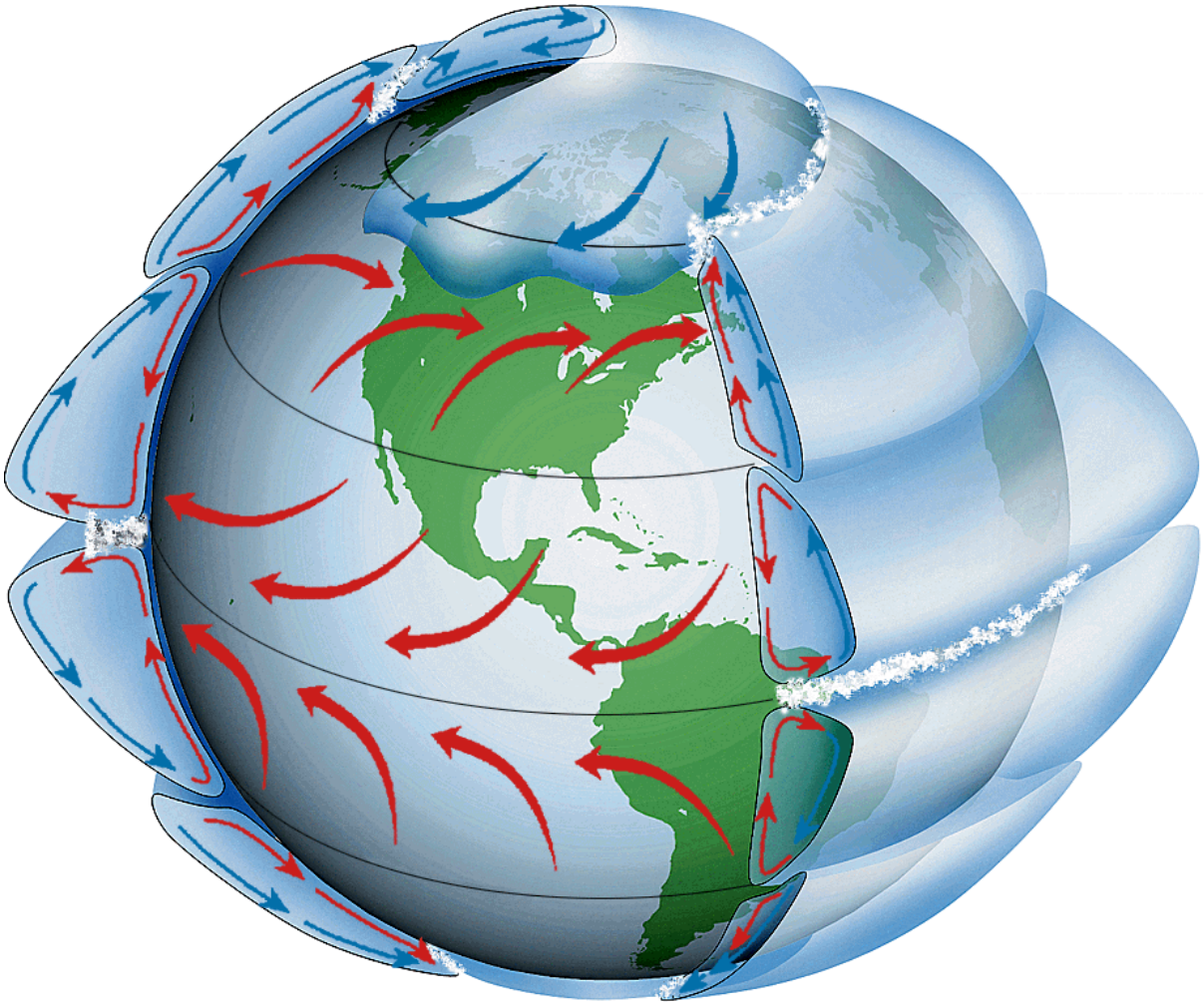
Atmospheric circulation

- High pressure and low pressure zones, cyclones and anticyclones
- Circulation cells
- Trade winds and westerlies
- Horse latitudes and zone of convergence

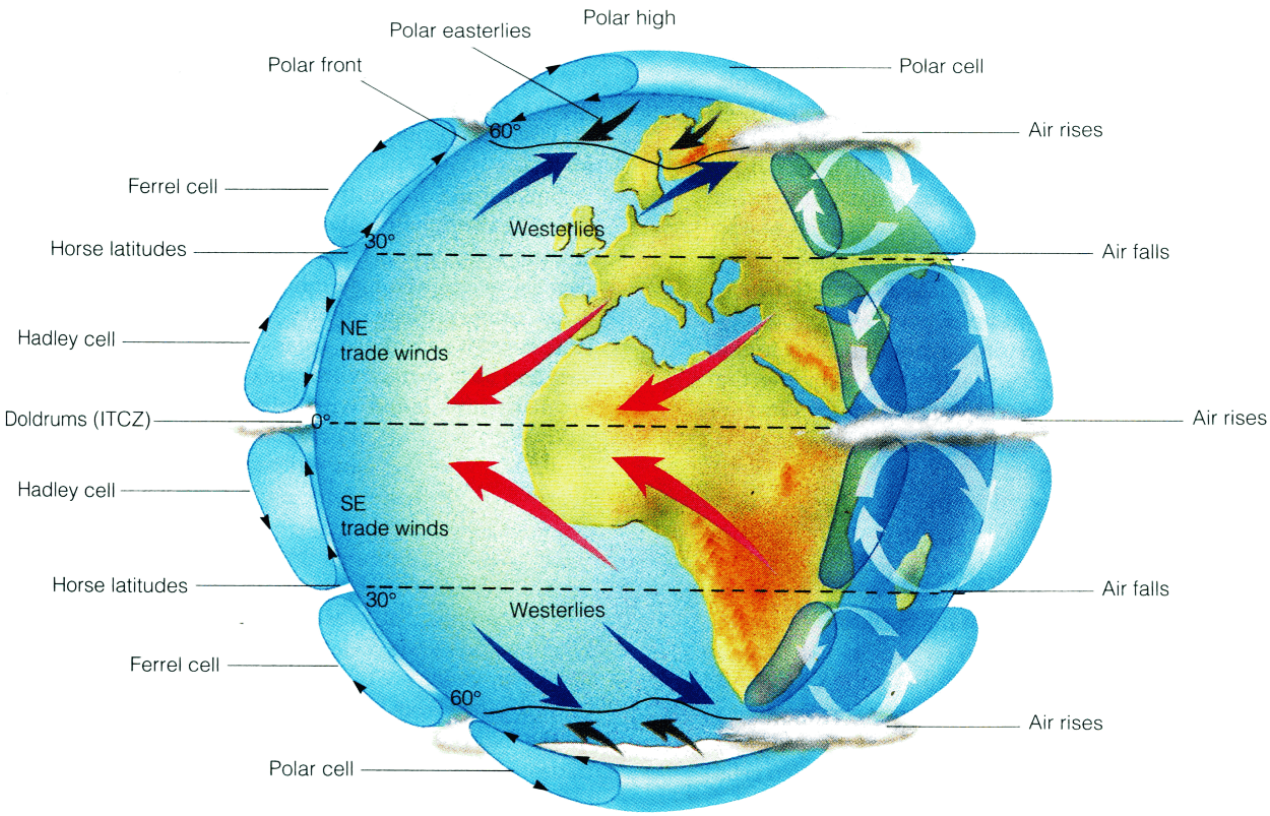
Circulation in a room



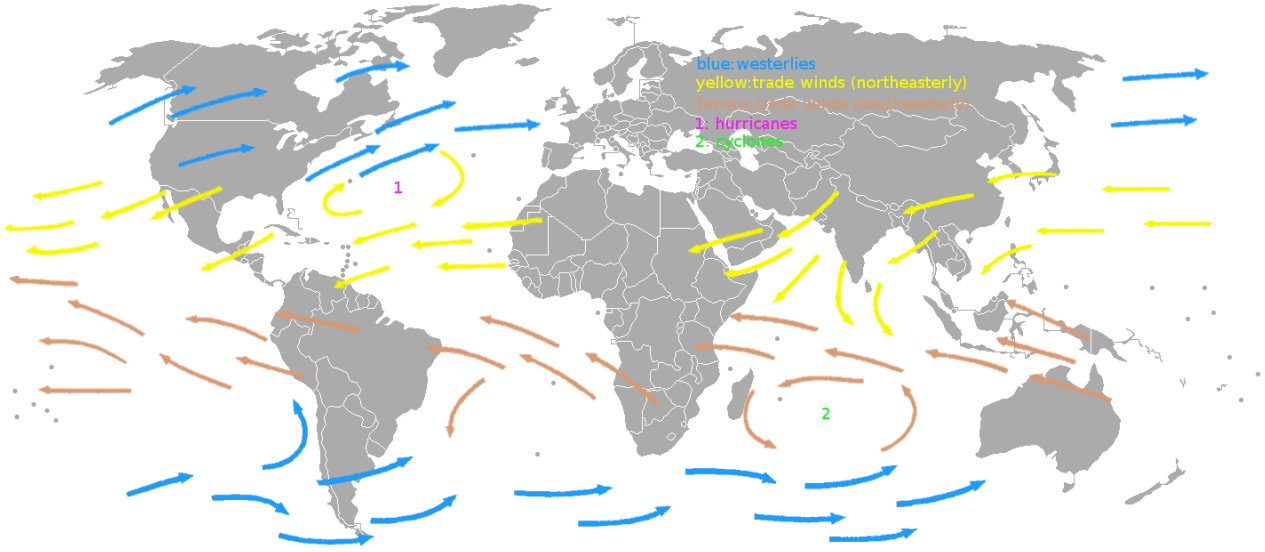
Idealized atmospheric circulation on Earth



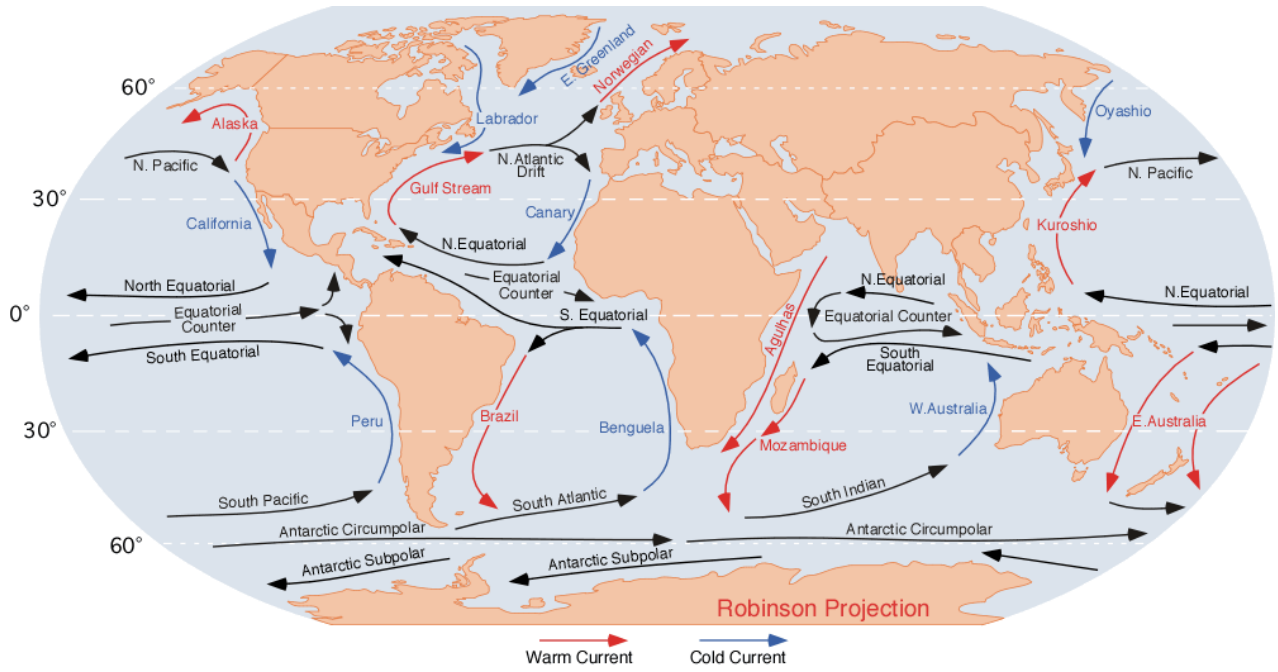
Idealized atmospheric circulation on Earth (with labels)



Prevailing winds



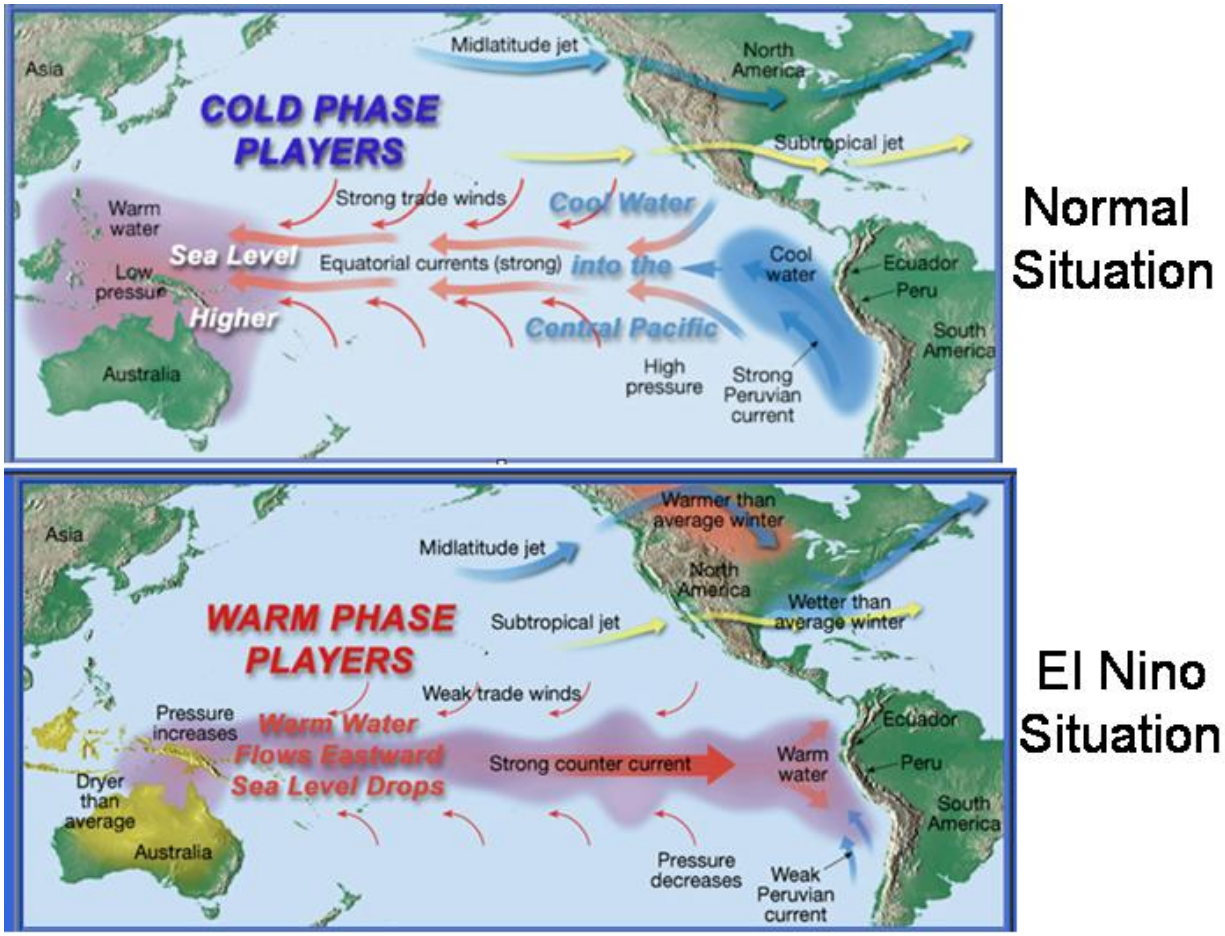
Ocean currents



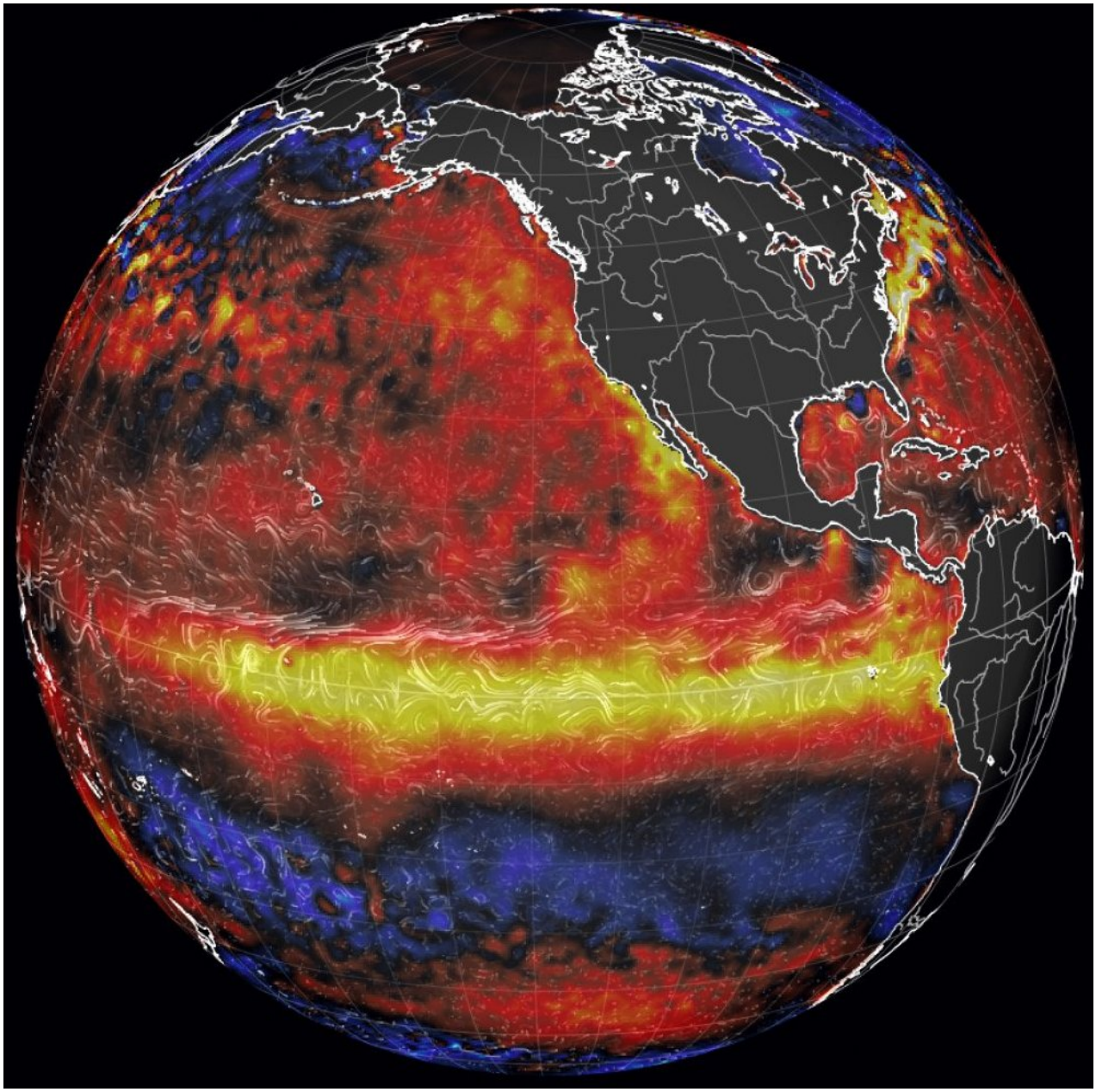
El Niño: climatic oscillation

- Sometimes, western warm currents change atmospheric cicrulation in East Pacific
- They will bring wet and warm weather, mostly damaging to the living organisms from western North and South America (adapted to low precipitation)

La Niña *versus* El Niño



Last El Ninjo (2016)



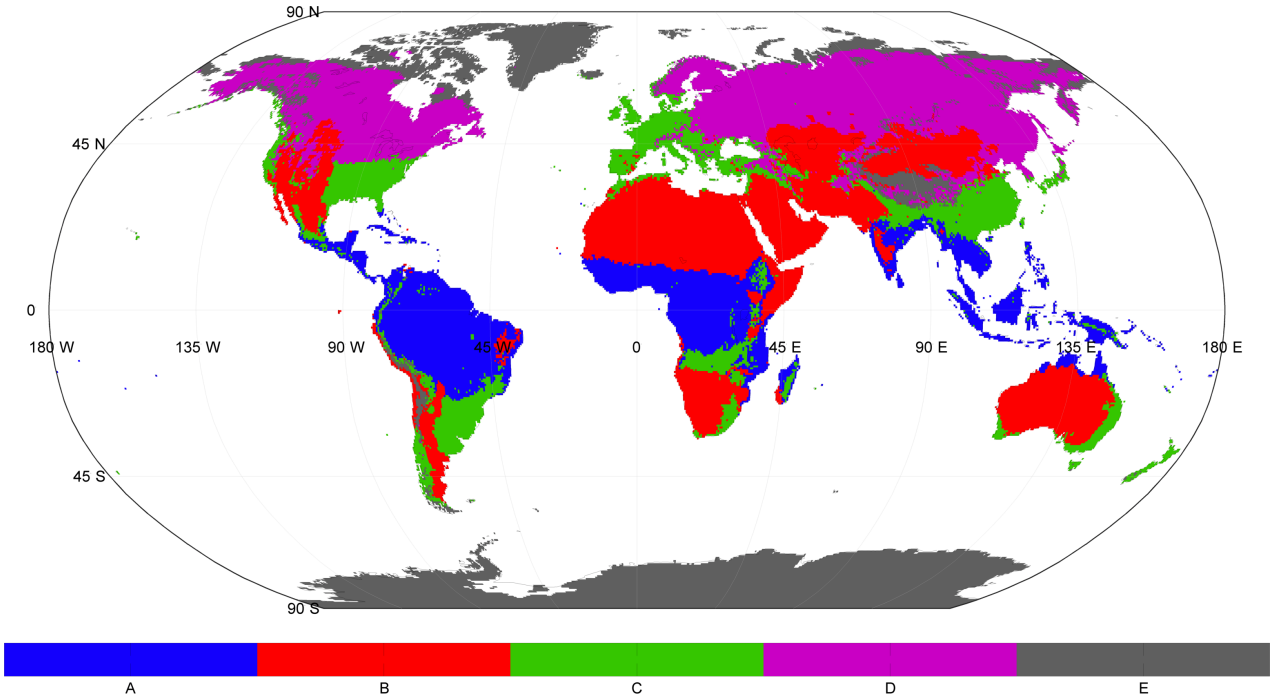
Seasons

- Temperature seasons: axial, not orbital effects
- Tropical wet seasons (monsoons) are related with temperature seasons and circulation

Climates

- Geographical zones: arctic, temperate and tropical
- Koeppen climates: A, tropical; B, dry; C, mild mid-latitude; D, cold mid-latitude; and E, polar

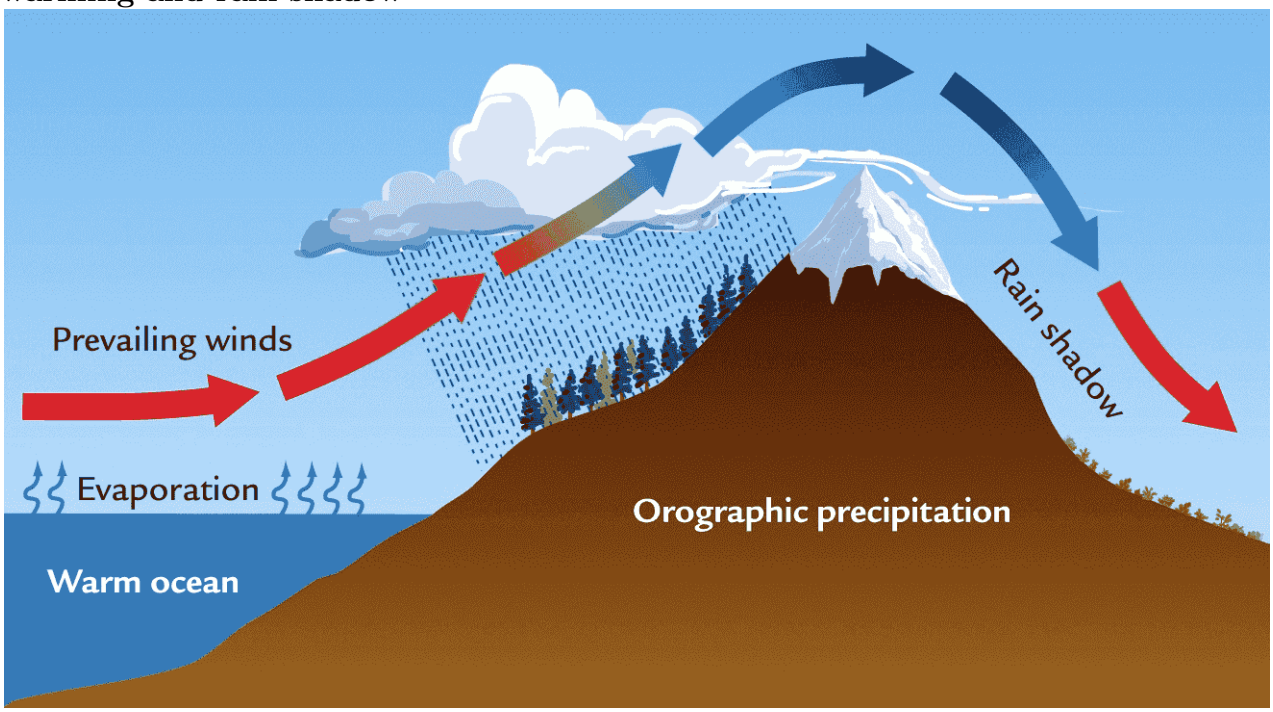
Koeppen climates



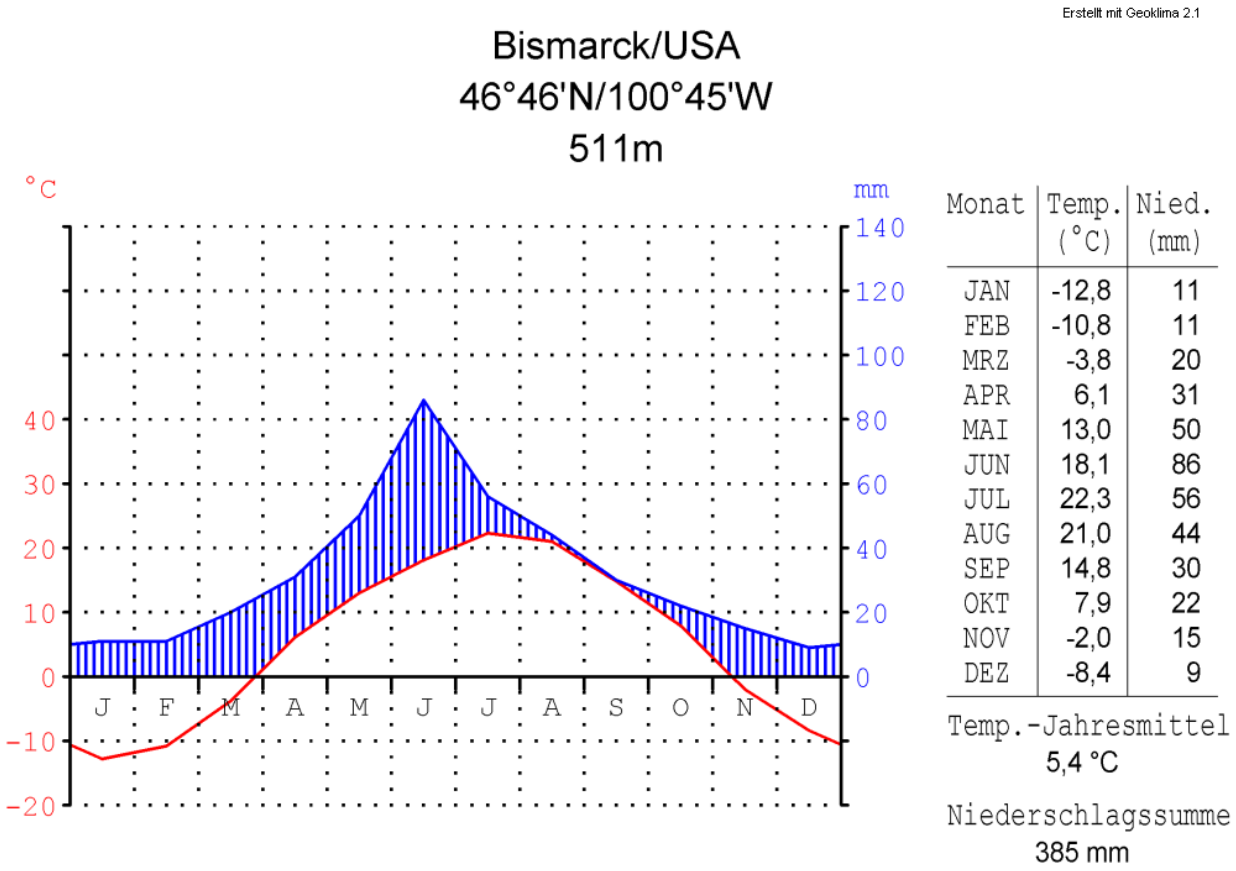
Climate and altitude

- Sea warming and rain shadow
- Altitudinal zones: lowland, montane, subalpine, alpine and snow

Sea warming and rain shadow



Climate diagram I

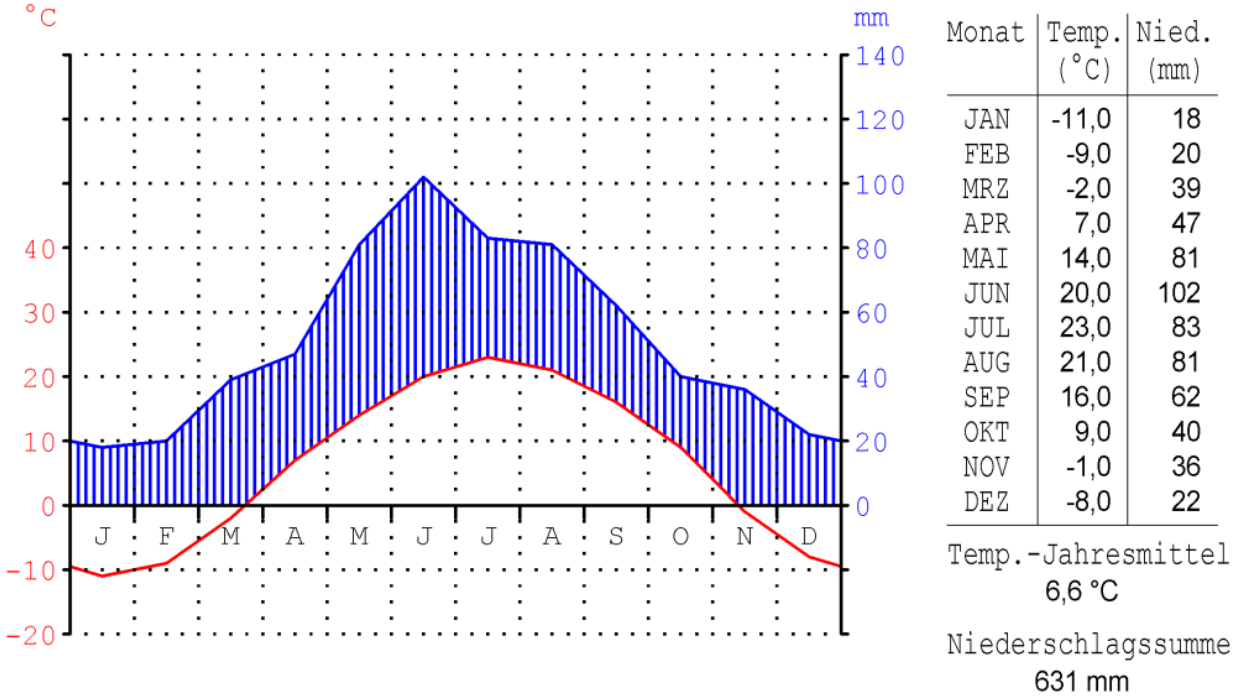


Monat	Temp. (°C)	Nied. (mm)
JAN	-12,8	11
FEB	-10,8	11
MRZ	-3,8	20
APR	6,1	31
MAI	13,0	50
JUN	18,1	86
JUL	22,3	56
AUG	21,0	44
SEP	14,8	30
OKT	7,9	22
NOV	-2,0	15
DEZ	-8,4	9

Temp.-Jahresmittel
5,4 °C

Niederschlagssumme
385 mm

Climate diagram II



Monat	Temp. (°C)	Nied. (mm)
JAN	-11,0	18
FEB	-9,0	20
MRZ	-2,0	39
APR	7,0	47
MAI	14,0	81
JUN	20,0	102
JUL	23,0	83
AUG	21,0	81
SEP	16,0	62
OKT	9,0	40
NOV	-1,0	36
DEZ	-8,0	22

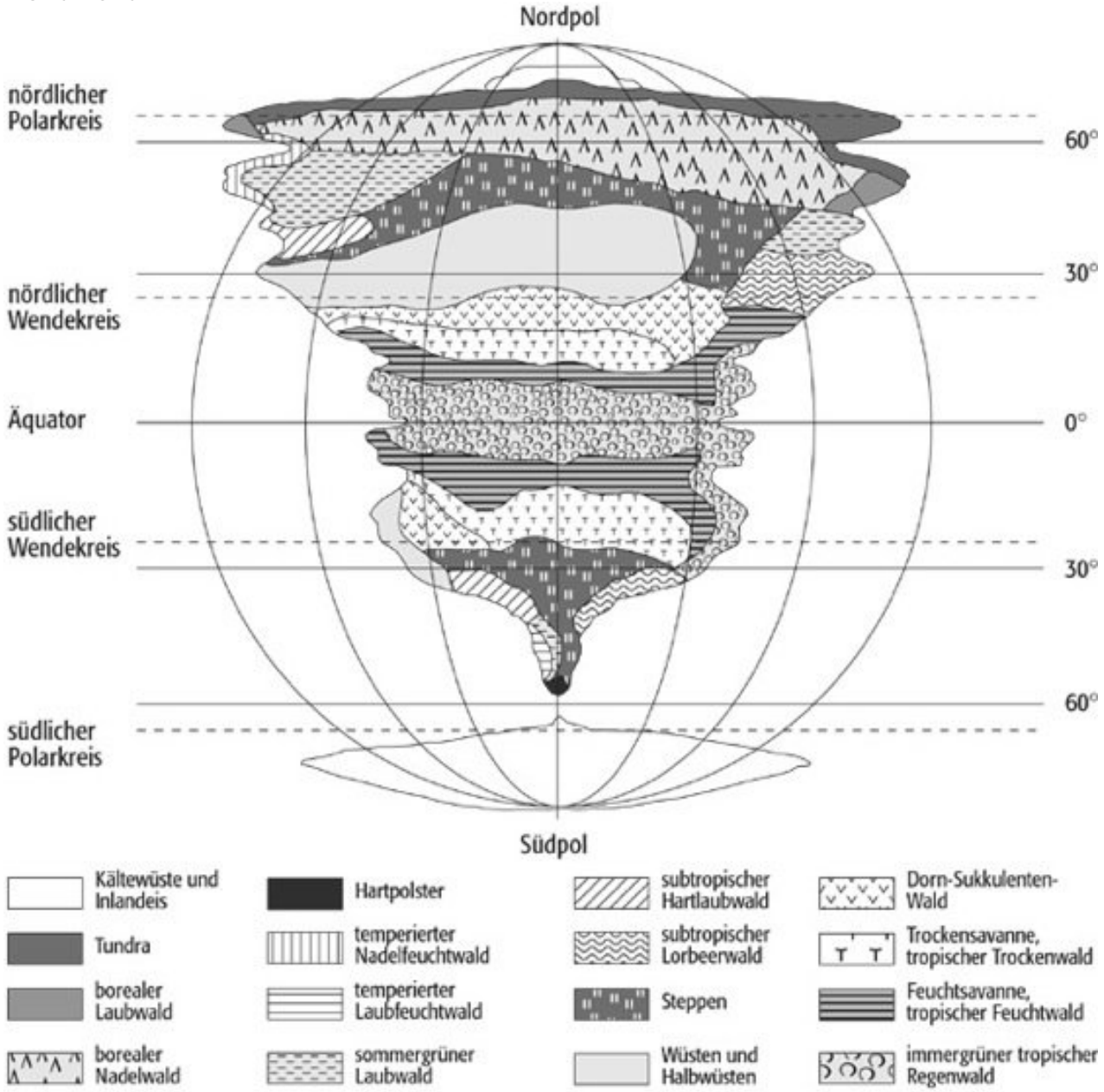
Temp.-Jahresmittel
6,6 °C

Niederschlagssumme
631 mm

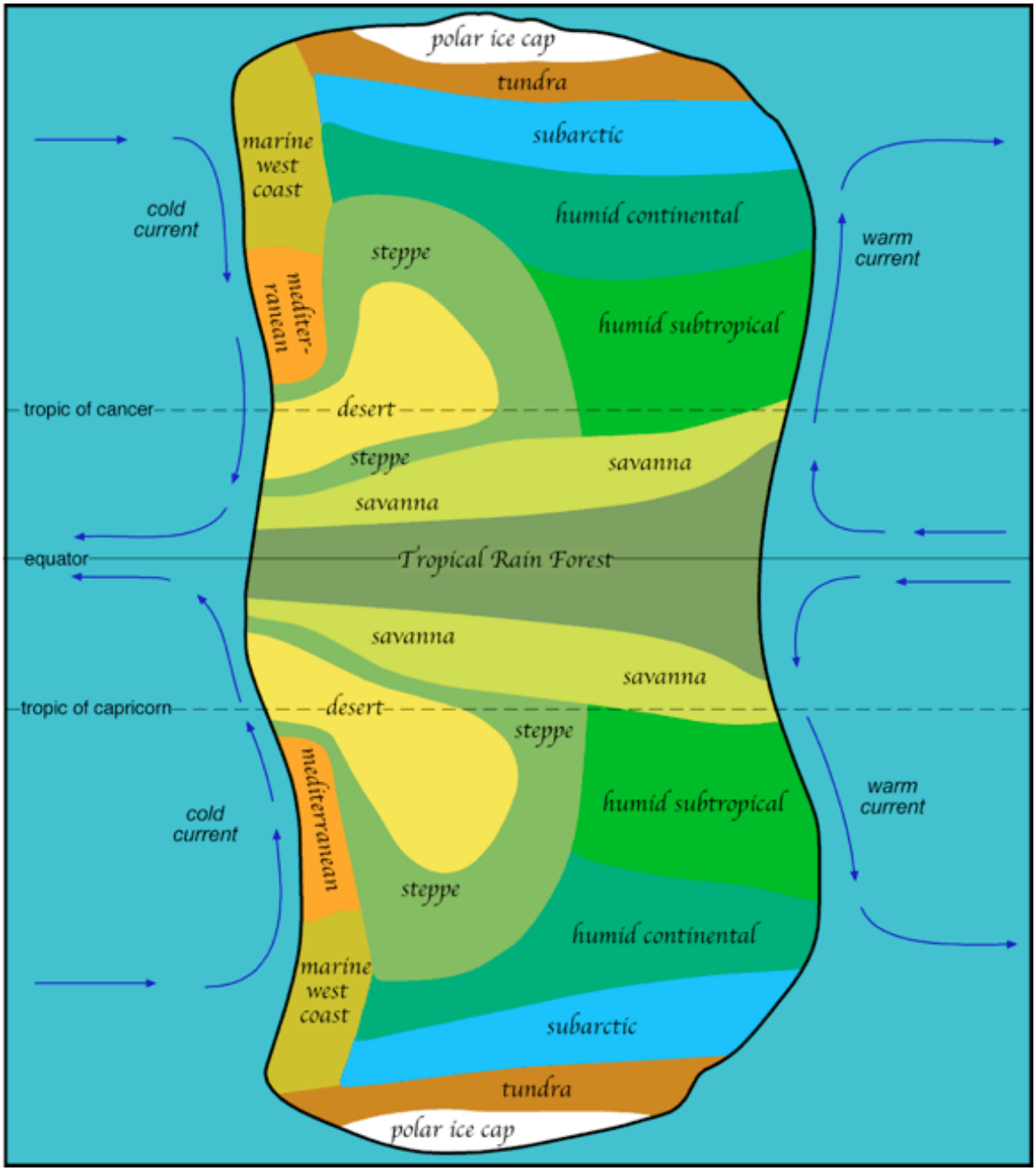
Climate and life

- Life zones are basing on temperature and precipitation
- Ideal continent ("Idealkontinent" in German)

Idealkontinent



Hypothetical continent (another version)



Summary

- Temperature seasons: axial, not orbital effects
- Tropical wet seasons (monsoons) are related with temperature seasons and circulation

For Further Reading

References

[1] A. Shipunov. *Biogeography* [Electronic resource]. 2014—onwards. Mode of access: `http://ashipunov.info/shipunov/school/biol_330`

[2] Major circles of latitude. `http://en.wikipedia.org/wiki/Circle_of_latitude`

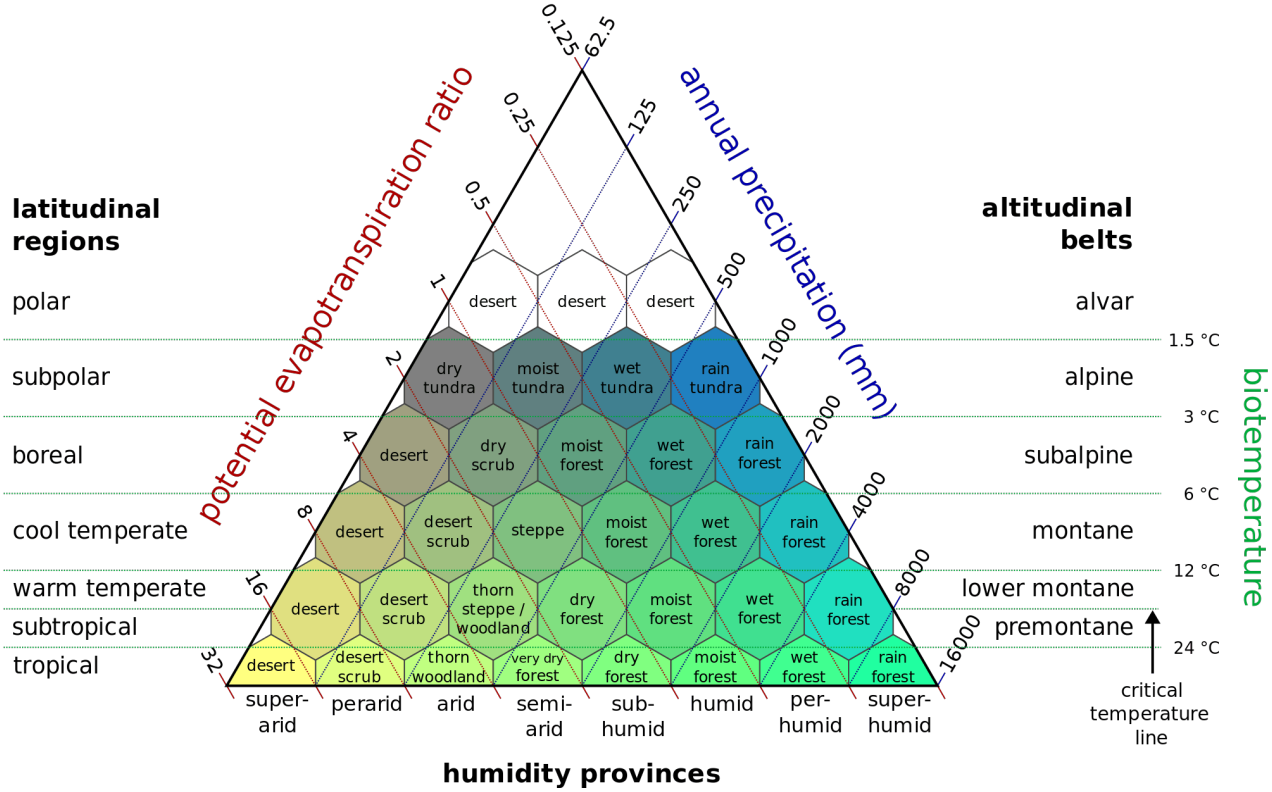
[3] Atmospheric circulation. http://en.wikipedia.org/wiki/Atmospheric_circulation

Outline

7 Basics of physical geography

7.1 Basics of climatology

Holdridge life zones



3 axes: biotemperature, PET (how much water would be evaporated if available) and precipitation. Intersections of all three give life zones.

8 Palaeogeography

8.1 Geological time

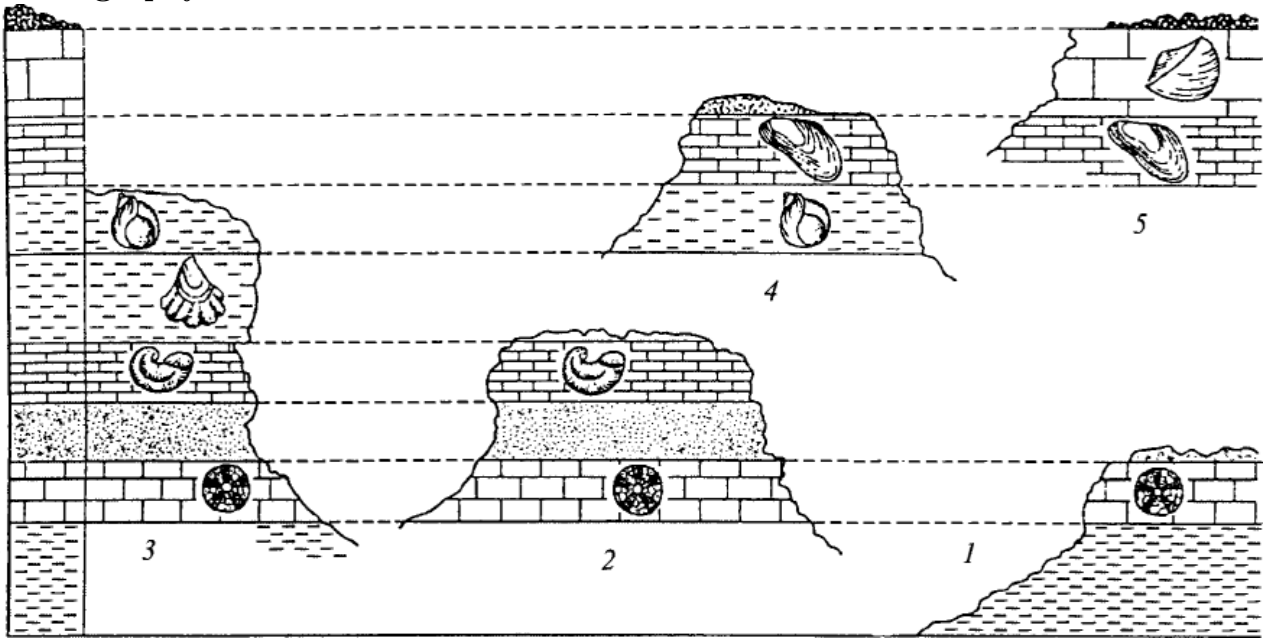
Use of radioactivity

- 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 can calculate the age of mineral from the concentration of radioactive elements

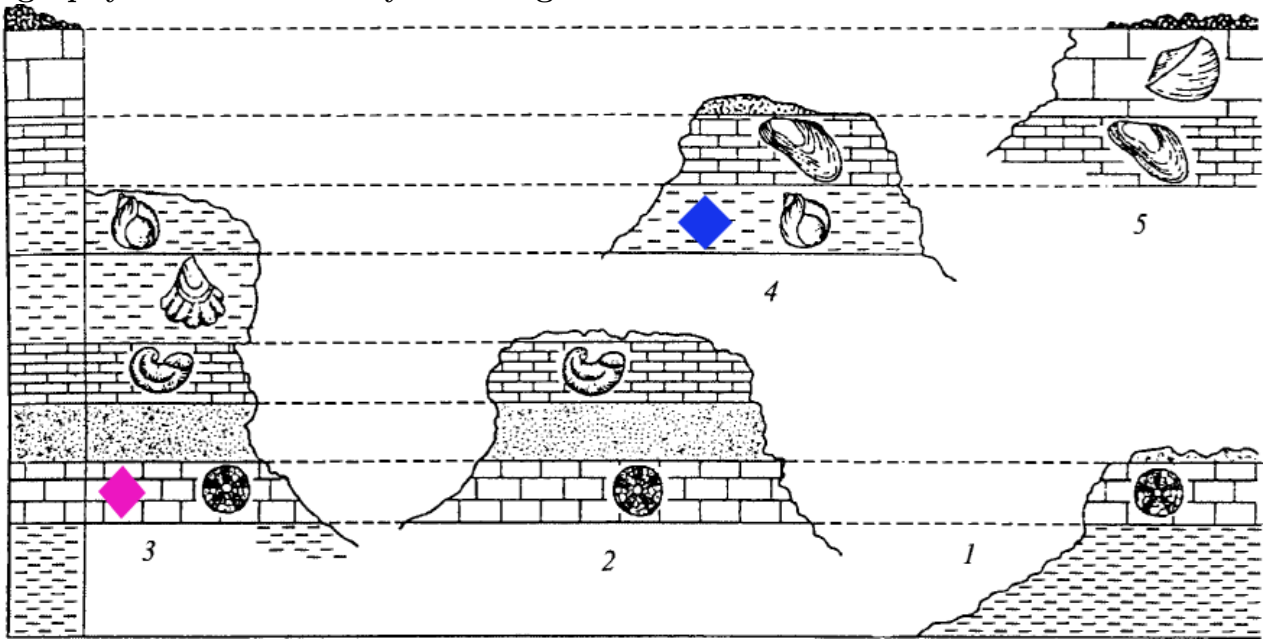
Stratigraphy

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

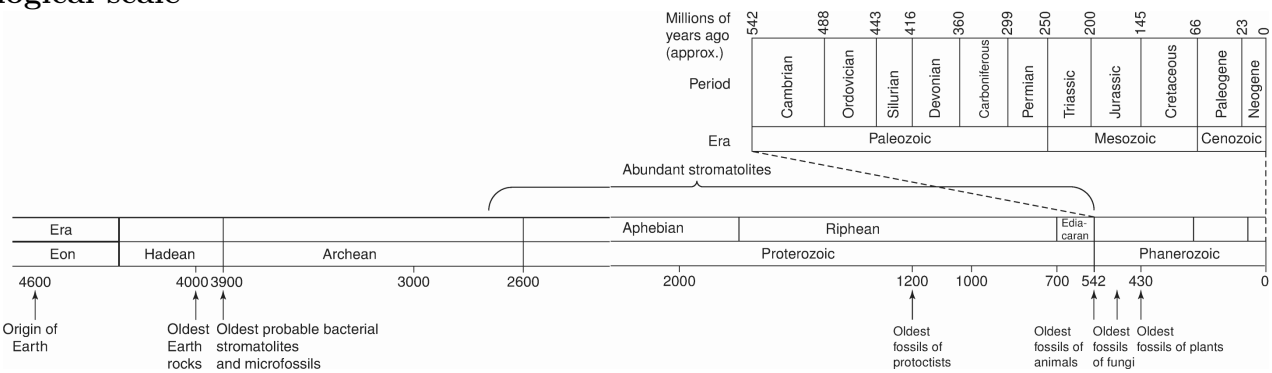
How stratigraphy works



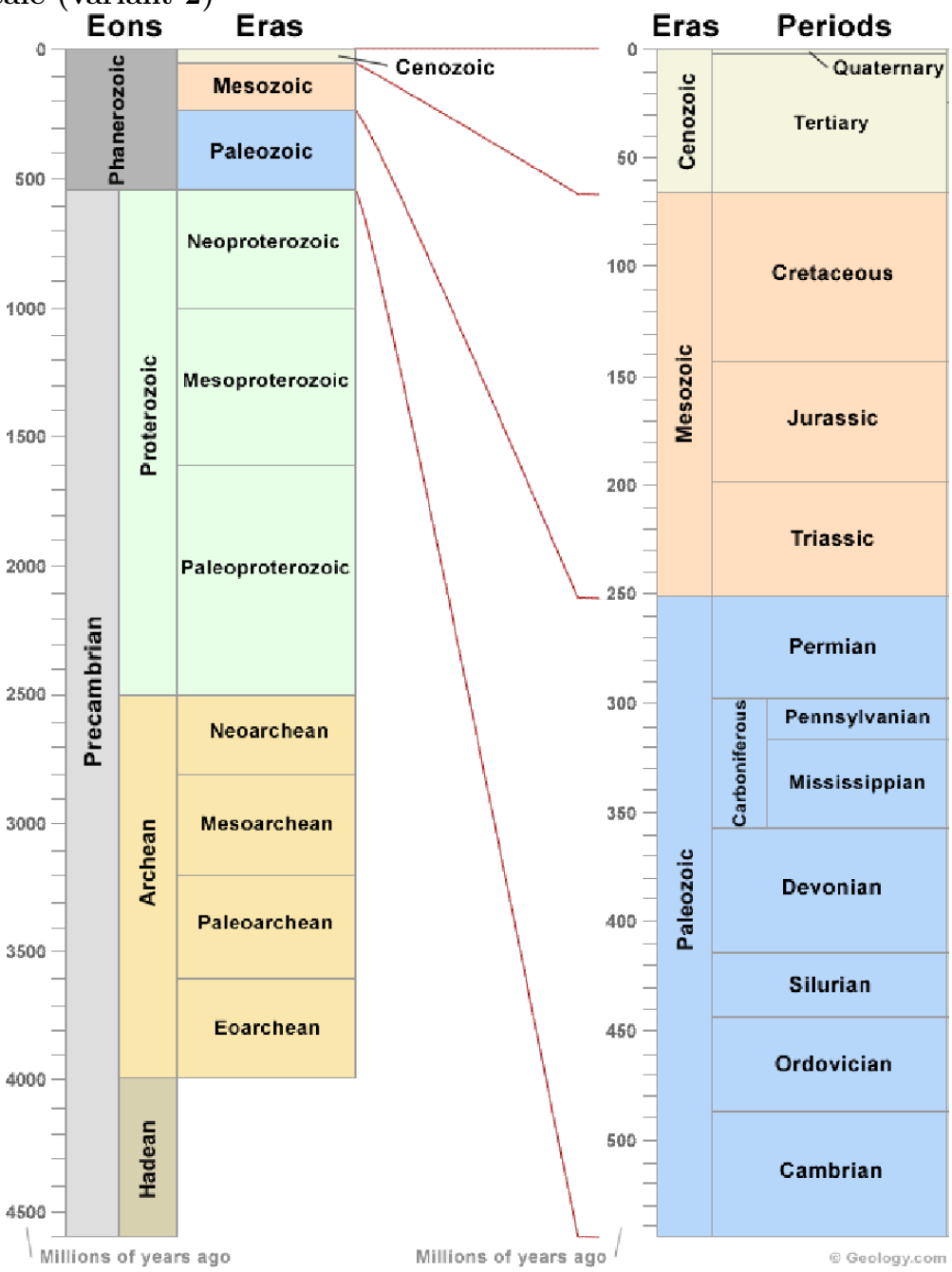
Stratigraphy and radioactivity work together



Geological scale



Geological scale (variant 2)



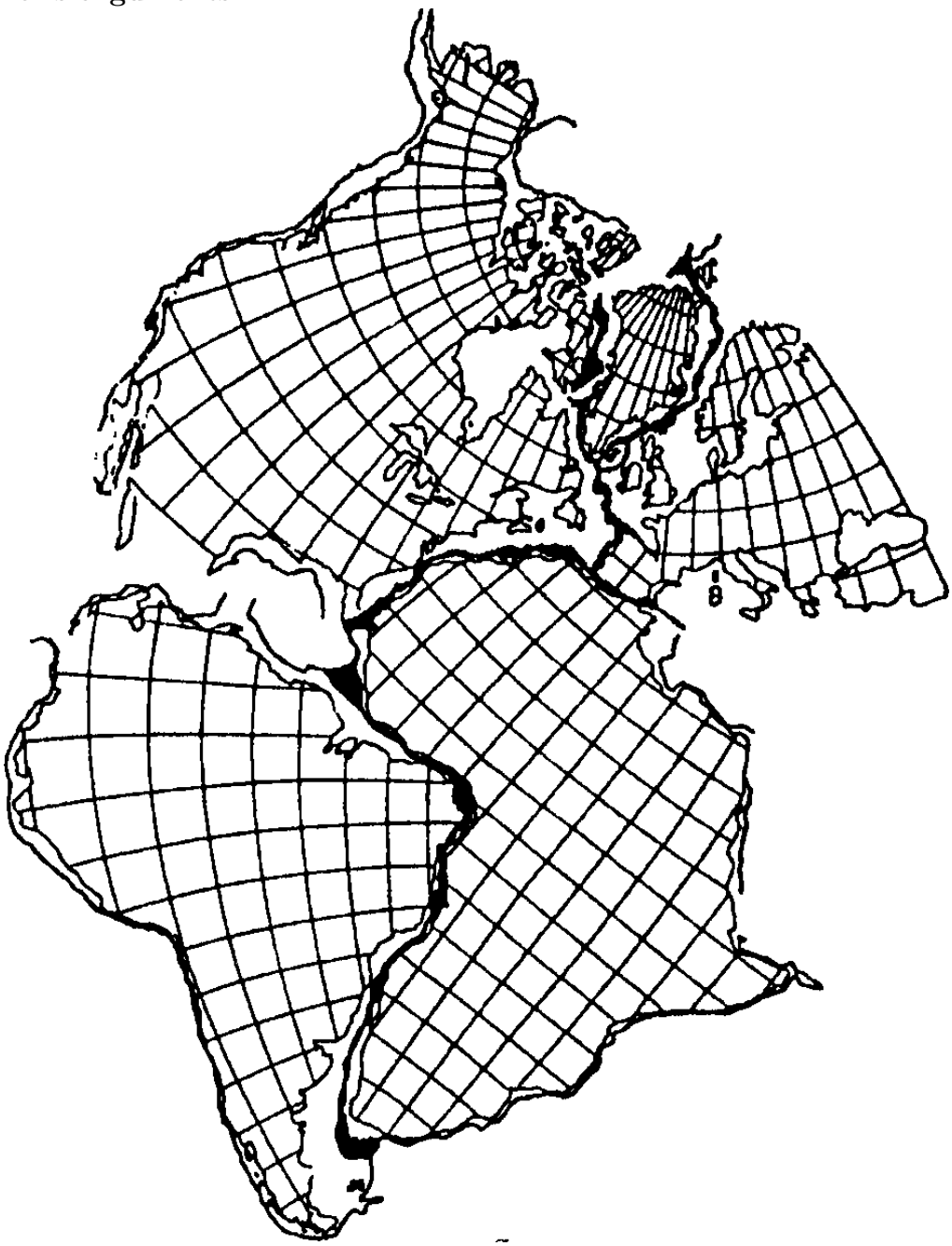
I want you to memorize eras and Mesozoic/Cenozoic periods.

8.2 Plate tectonics

Continental drift

- In 1921, Alfred Vegener invented the idea that South America and Africa were parts of one big continent—Gondwana.
- According to Vegener, 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 Vegener's arguments



Laurasia and Gondwana

Pangaea

Mantle convection

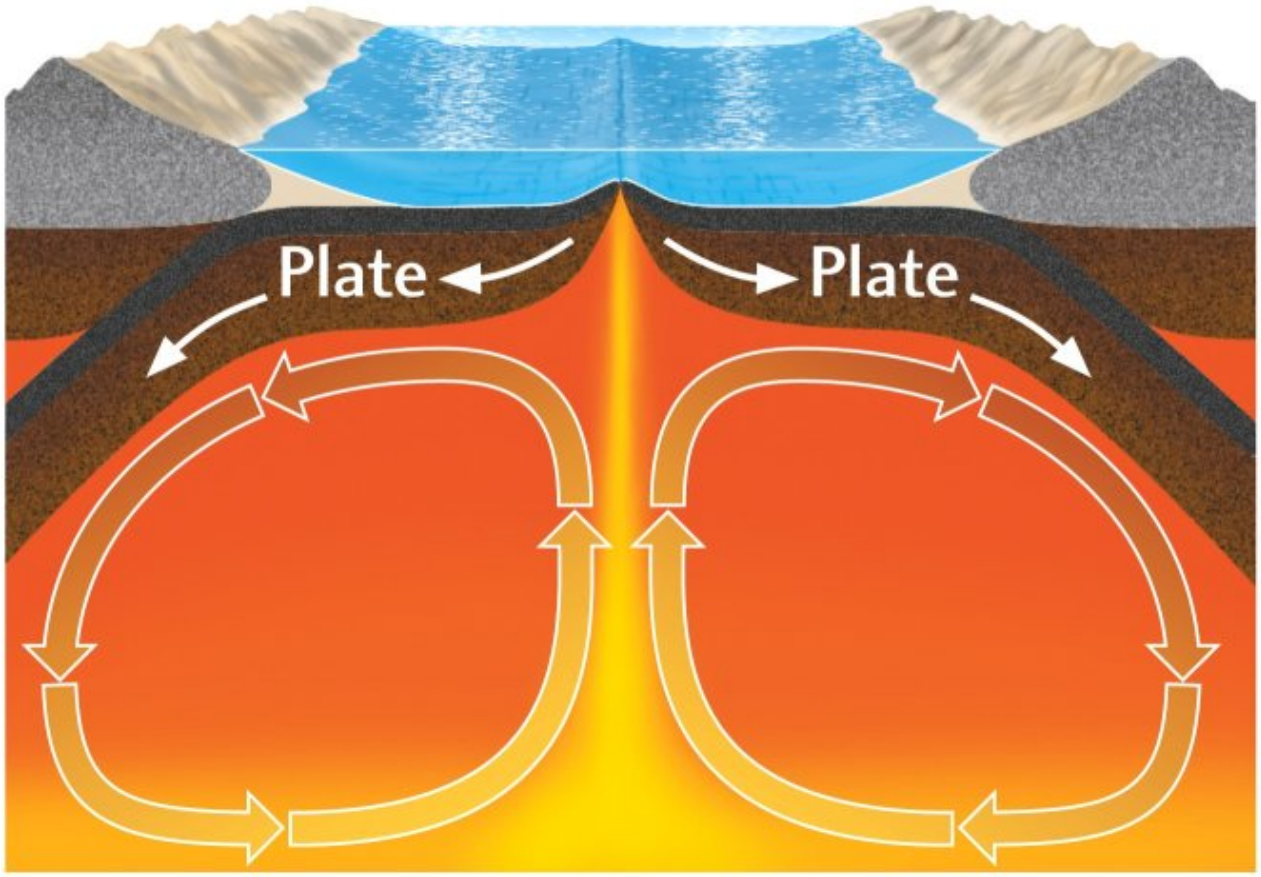
- The driving force of floating continents is a **mantle convection**
- In ocean ridges, new ocean cortex is constantly forming and expanding
- In ocean trenches and continental ridges, different plates are colliding and often forming mountains

Summary

- Geological time is calculated on the basis of both relative (stratigraphy) and absolute (radioactivity) methods
- 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

Mantle convection



For Further Reading

References

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Outline

9 Palaeogeography

9.1 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
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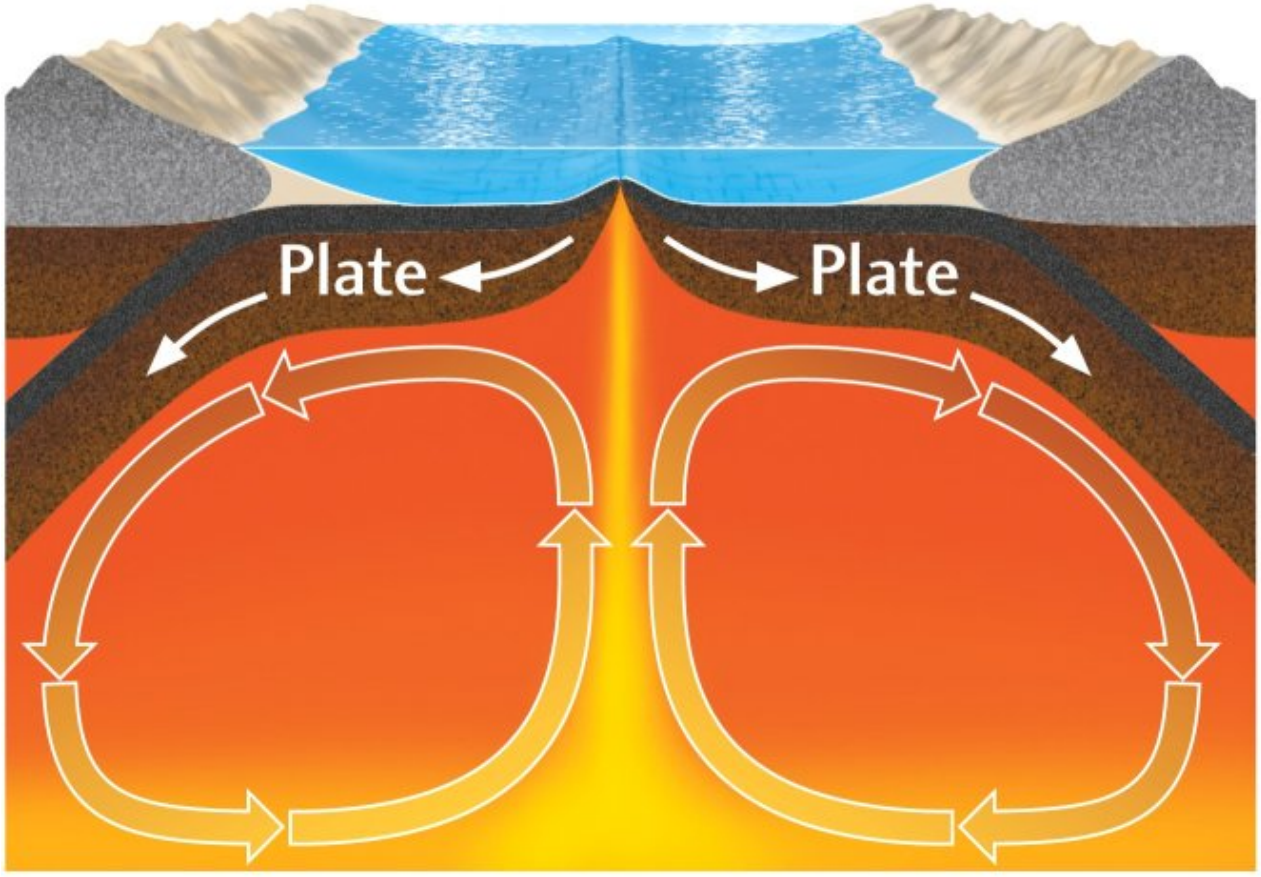
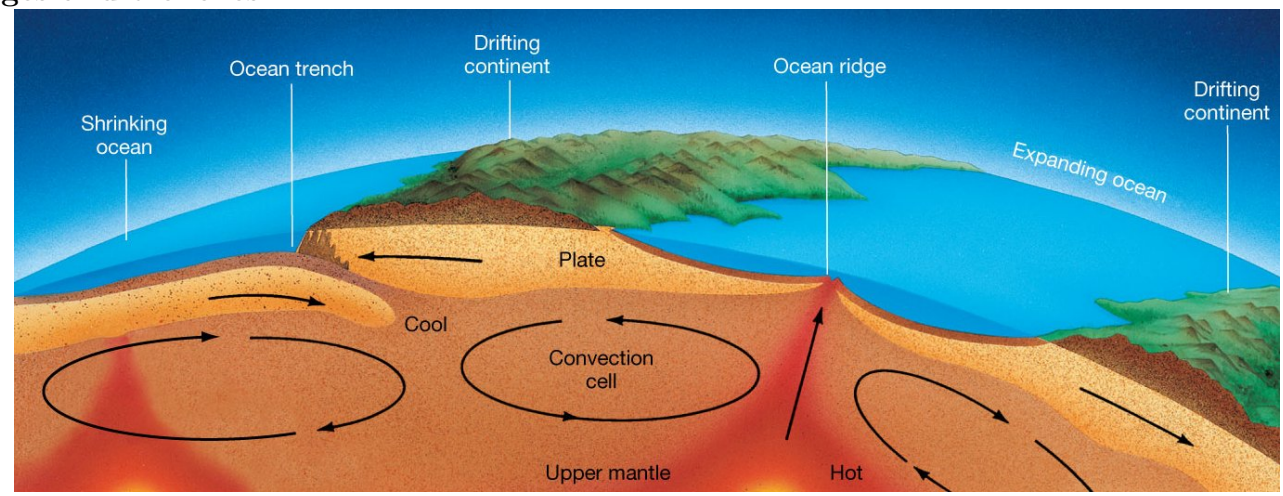
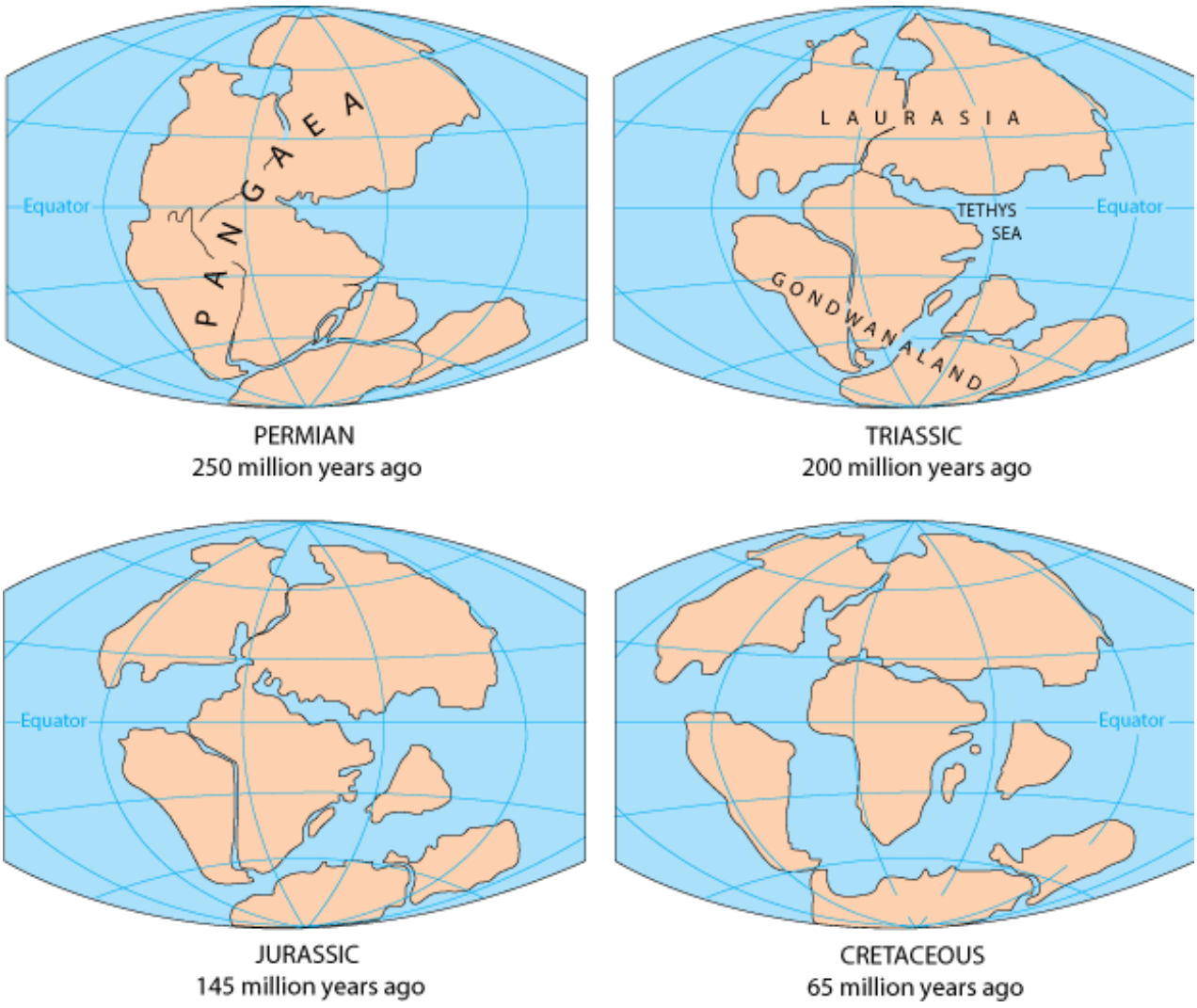
Mantle convection



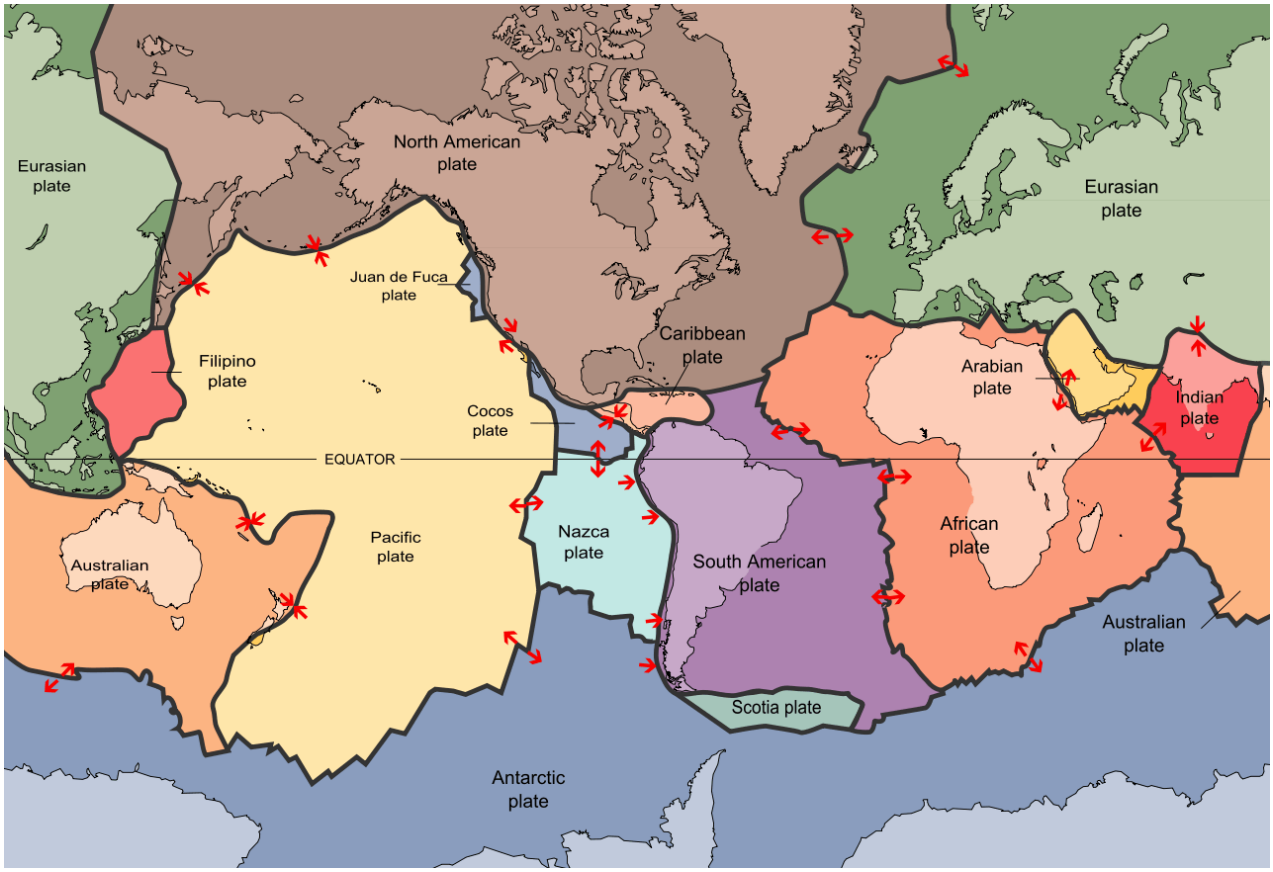
Ridges and trenches



The result of mantle convection



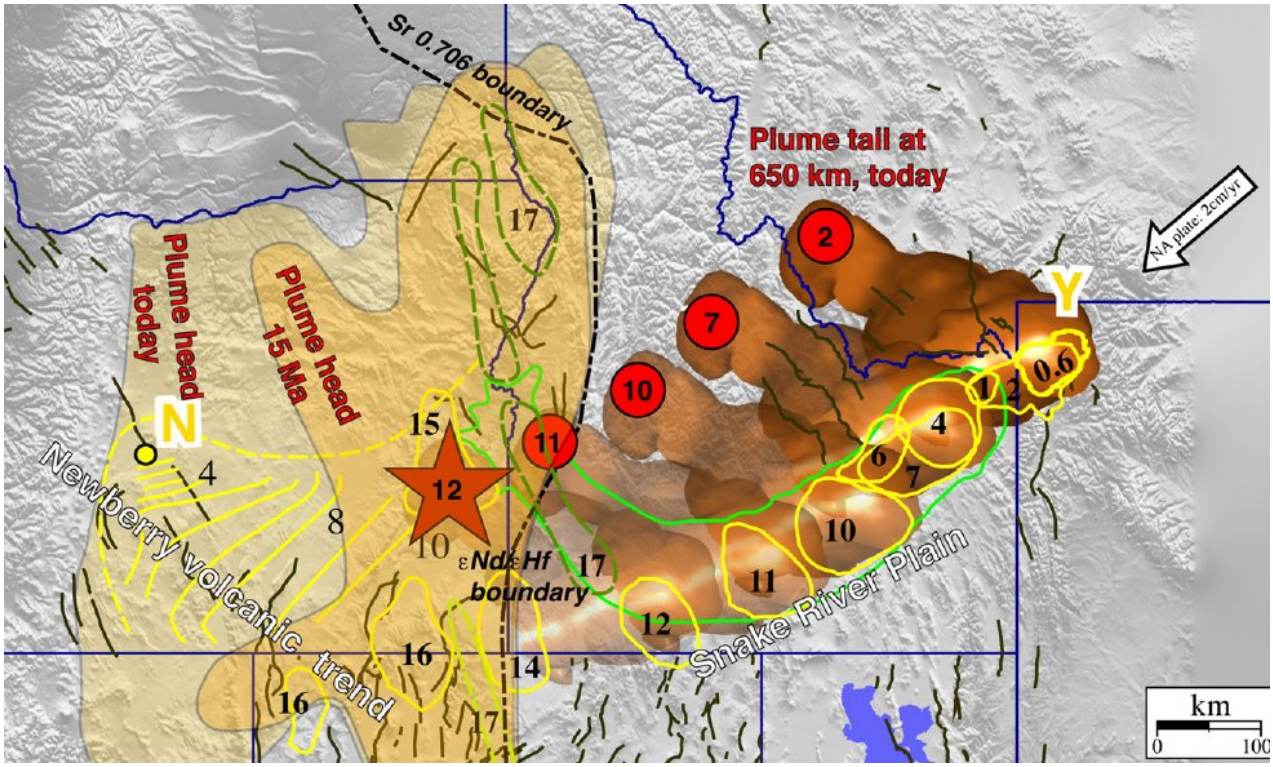
Tectonic plates



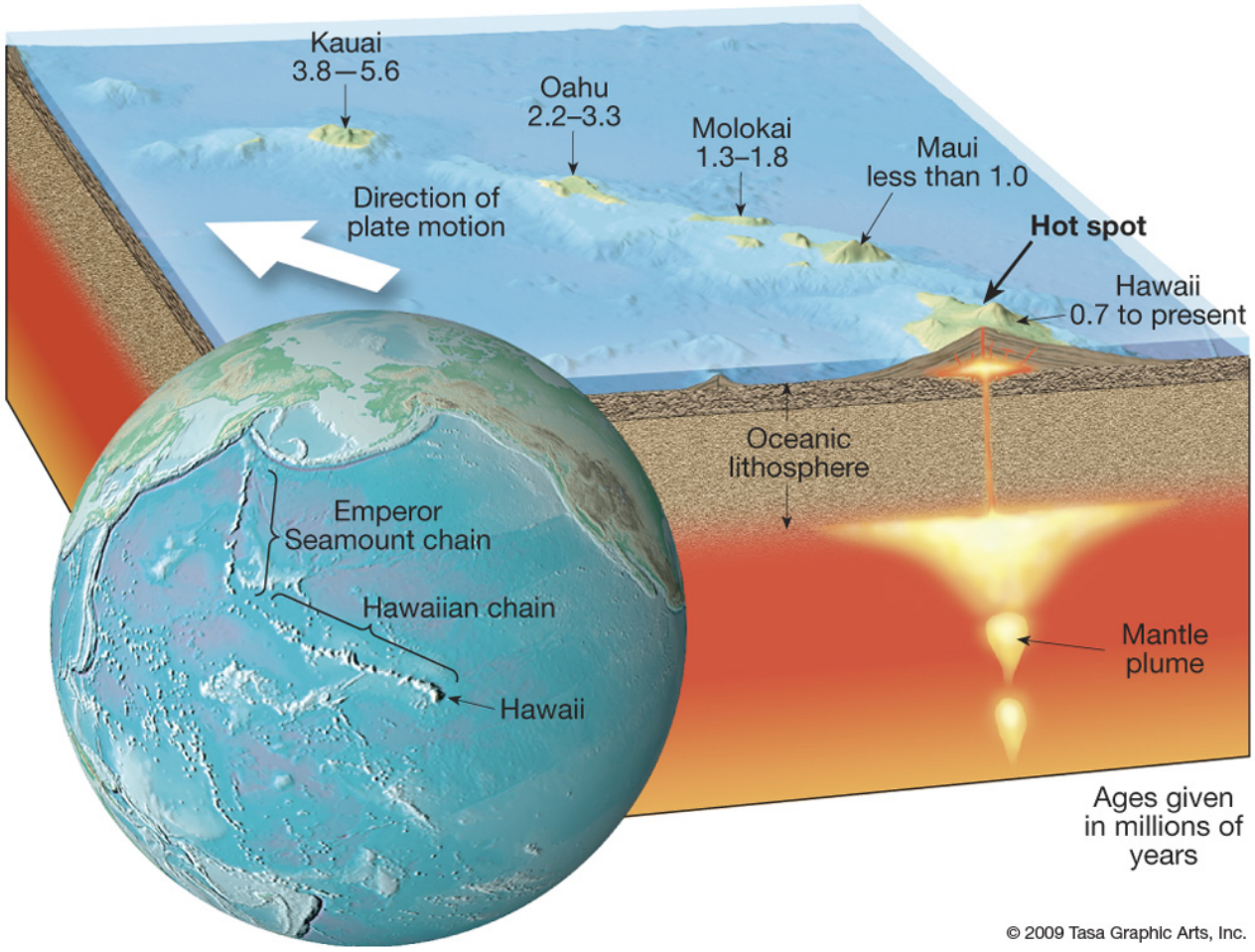
Two living examples of continental drift on U.S. territory

- Yellowstone hotspot
- Hawaiian hotspot

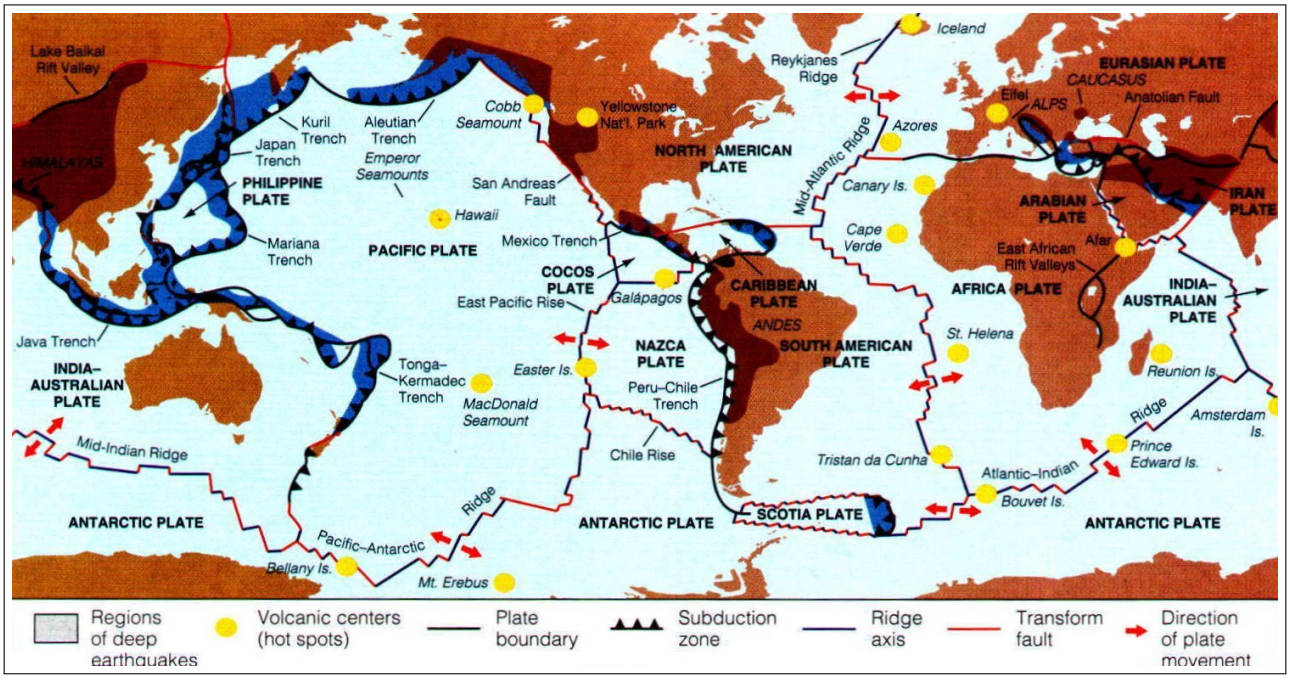
Yellowstone hotspot



Hawaiian hotspot



Hotspots, trenches, ridges and plates



10 History of Life

10.1 The Really Short History of Life

Introduction to Biogegraphy and Tropical Biology

`http://ashipunov.info/shipunov/school/biol_330/intr_biogeogr_trop_biol/intr_biogeogr_trop_biol.pdf`

Summary

- Continents of Earth are constantly changing their position due to the mantle convection ("plate tectonics")
- From Cryogenian to Ordovician, super-continent Rodinia broke and climate on Earth became milder
- Most of water-inhabiting animal groups appeared by Ordovician
- At the end of Permian, all continents formed equatorial super-continent Pangaea
- Jurassic and Cretaceous periods were a peak of dinosaur diversity
- Impact theories are mentally attractive but do not explain slow and "blurred" extinction as well as existence of "untouchable" groups like plants and insects.
- Ecological palaeontology states that most mass extinctions were results of **biological crises**. The nature of these crises is internal.

For Further Reading

References

[1] A. Shipunov. *Biogeography* [Electronic resource]. 2014—onwards. Mode of access: `http://ashipunov.info/shipunov/school/biol_330`

[2] A. Shipunov. *Introduction to Biogegraphy and Tropical Biology* [Electronic resource]. 2017—onwards. Mode of access: `http://ashipunov.info/shipunov/school/biol_330/intr_biogeogr_trop_biol/intr_biogeogr_trop_biol.pdf`

Outline

11 History of Life

11.1 The Really Short History of Life

Introduction to Biogegraphy and Tropical Biology
`http://ashipunov.info/shipunov/school/biol_330/intr_biogeogr_trop_biol/intr_biogeogr_trop_biol.pdf`

Questions?

Continental drift movie
`http://ashipunov.info/shipunov/school/biol_330/mov/earth_byte_phanerozoic_wright_etal_2013.mp4`

12 Very Basics of Ecology

12.1 Ways of life

Ways of life

- How to obtain energy?
    1. From sun light: **phototrophy**
    2. From chemical reactions with inorganic matter ("rocks"): **lithotrophy**
    3. From breaking organic molecules into inorganic (typically, carbon dioxide and water): **organotrophy**
- How to obtain building blocks?
    1. From assimilation of carbon dioxide: **autotrophy**
    2. From other living beings: **heterotrophy**

Six life styles

	Phototrophs	**Lithotrophs**	**Organotrophs**
Autotrophs	Plants	Bacteria	Bacteria
Heterotrophs	Bacteria	Bacteria	Animals

12.2 Ecological factors

Ecological factors

- Everything what surrounds organism
- Types of ecological factors:
  - Abiotic
  - Biotic
  - Anthropogenic

Abiotic: classification A

- Resources
- Conditions

Abiotic: classification B

- General (seasonal)
  - Temperature
  - Solar radiation
  - Content of environment (humidity etc.)
- Particular
  - Environment pressure (atmosphere pressure, gravitation etc.)
  - Environment movement (wind, currents)
  - Relief

12.3 Biotic ecological factors: ecological interactions

Two-species model

- Species I and species II may influence each other differently
- For example, species I may facilitate the increase the number of species II individuals (+ interaction)
- At the same time, species II could be neutral to species I (0 interaction)

Six basic ecological interactions

	+	0	−
+	mutualism	commensalism[1]	exploitation[2]
0	...	neutralism	amensalism
−	...	...	interference[3]

[1] Includes phoresy (transportation), inquilinism (housing) and metabiosis ("sponging" like in sucker fishes)
[2] Includes predation, parasitism and phytophagy
[3] Includes competition, allelopathy and aggression

Summary

- Ecology studies relation between organisms and environment

For Further Reading

References

[1] A. Shipunov. *Biogeography* [Electronic resource]. 2014—onwards. Mode of access: `http://ashipunov.info/shipunov/school/biol_330`

[2] A. Shipunov. *Introduction to Biogegraphy and Tropical Biology* [Electronic resource]. 2017—onwards. Mode of access: `http://ashipunov.info/shipunov/school/biol_330/intr_biogeogr_trop_biol/intr_biogeogr_trop_biol.pdf`

Outline

13 Very Basics of Ecology

13.1 Human-related ecological factors

Anthropogenic factors

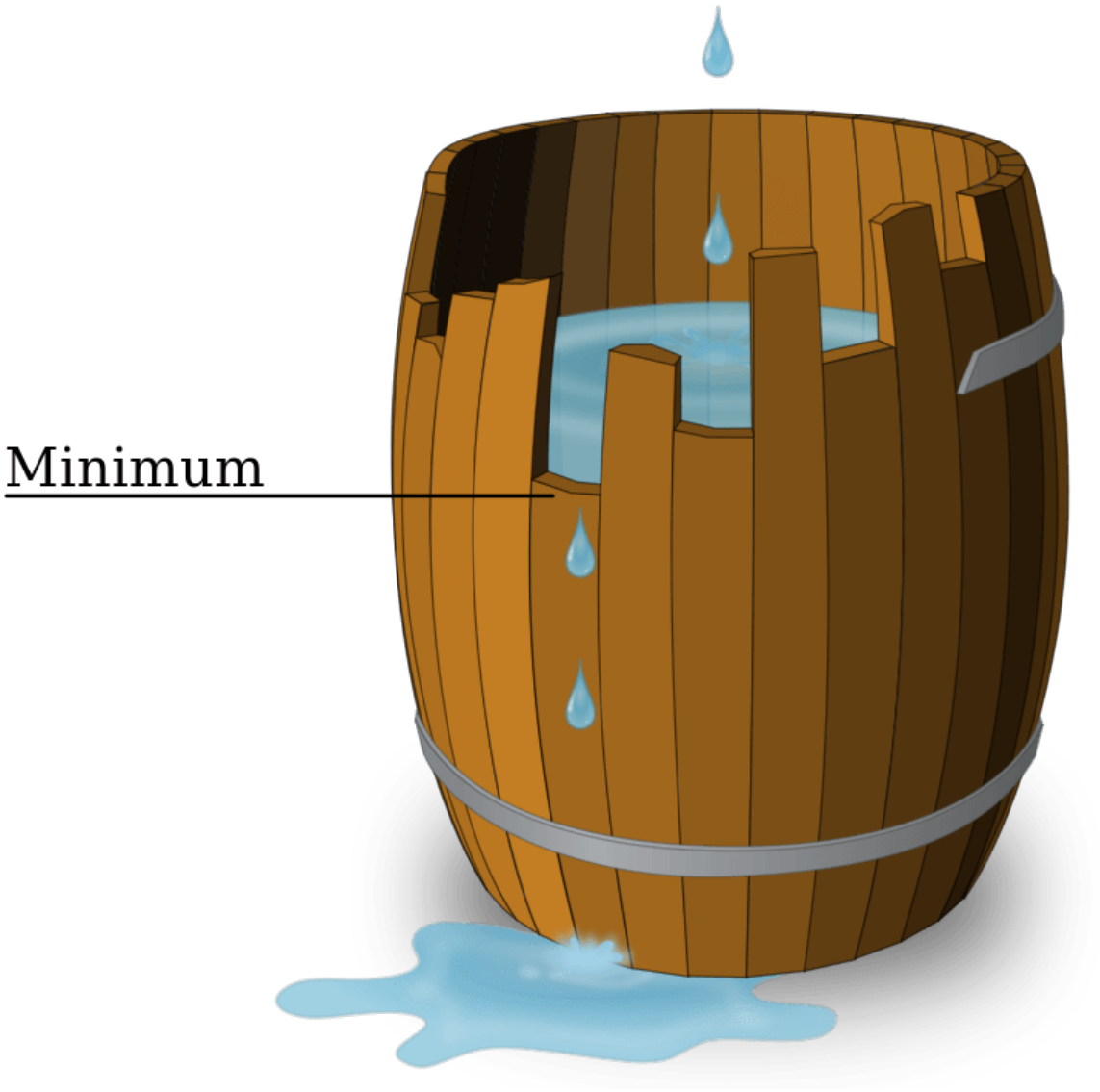
- Direct
  - Collecting
  - Hunting
  - Plowing
  - Tree cutting
- Indirect
  - Grazing
  - Polluting
  - Melioration
  - Recreation

13.2 Ecological niche

The cloud in hyper-space of ecological factors

- Response function: euryoecious and stenoecious species
- Fundamental and realized niche
- Liebig's law of the minimum

Liebig's barrel



13.3 Ecosystems and biosphere

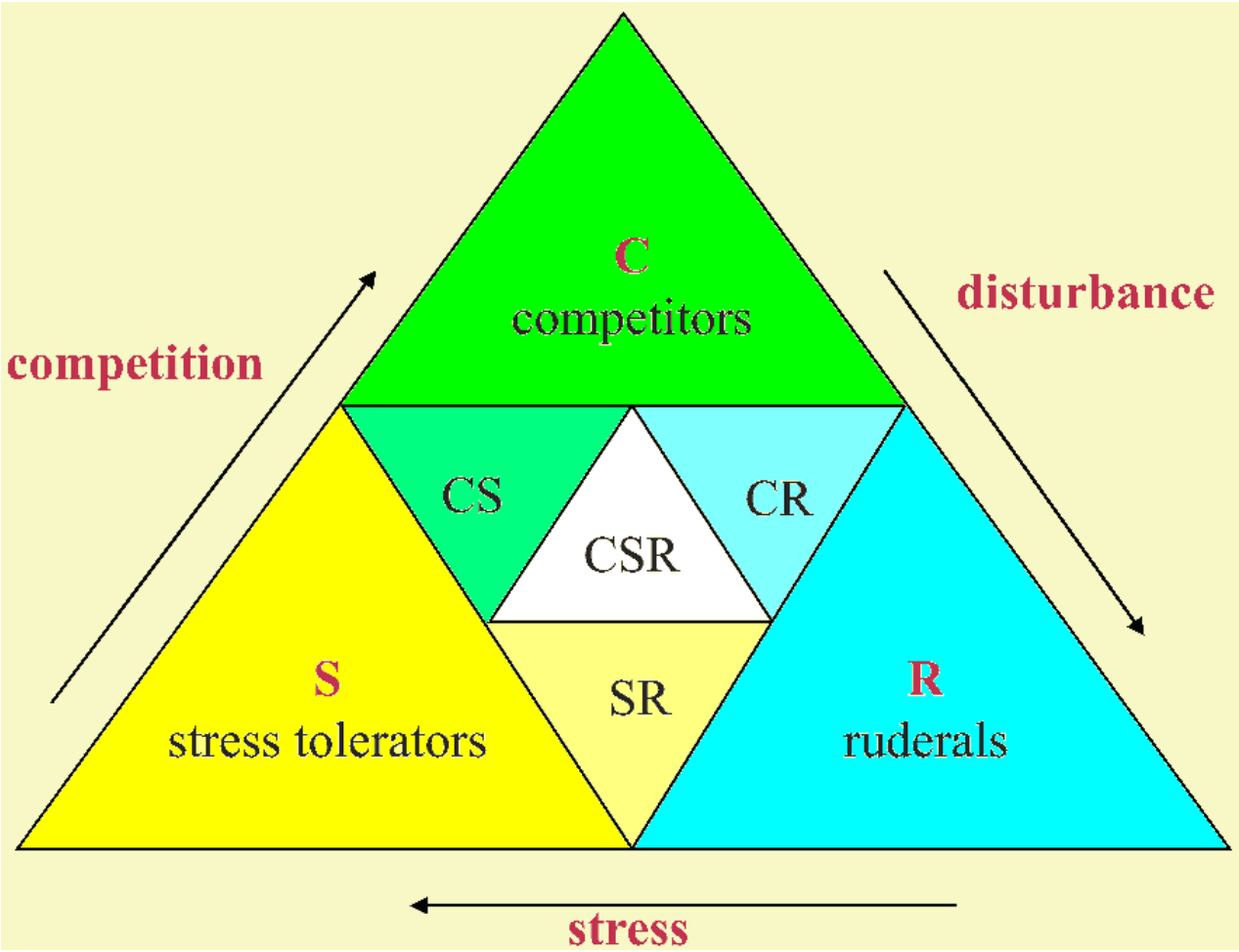
Features of ecosystem

- Biomass, diversity, structure (feeding network, stratification)
- Self-reproduction and self-regulation
- Biosphere is the largest ecosystem possible
- Ecosystem could be split in different ways, for example into life forms and then into populations

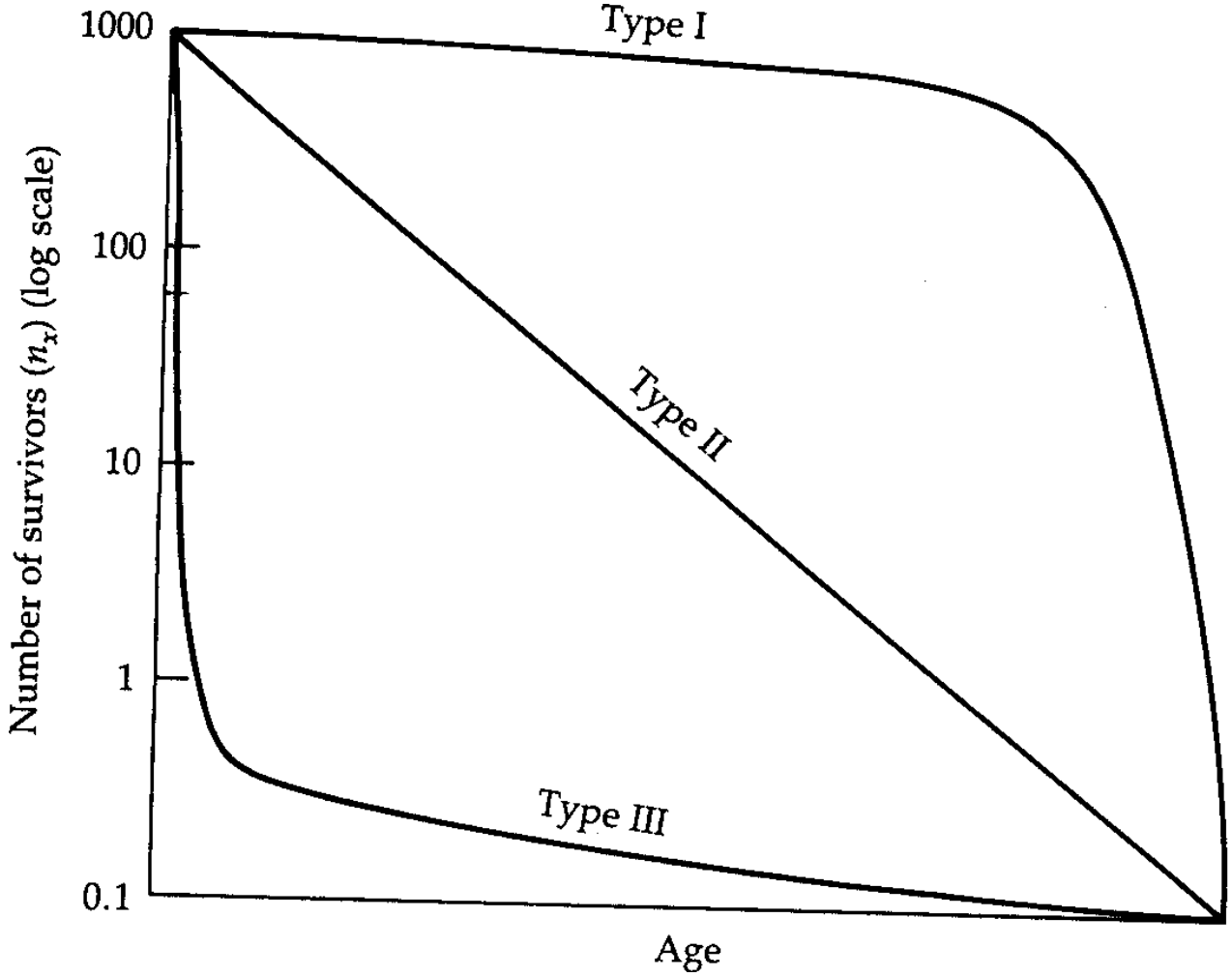
Populations

- Plant strategies: C (competitive), S (stress tolerant) and R (ruderal, or rapid propagation).
- Survivorship curves, population growth curves, r- and K-strategy

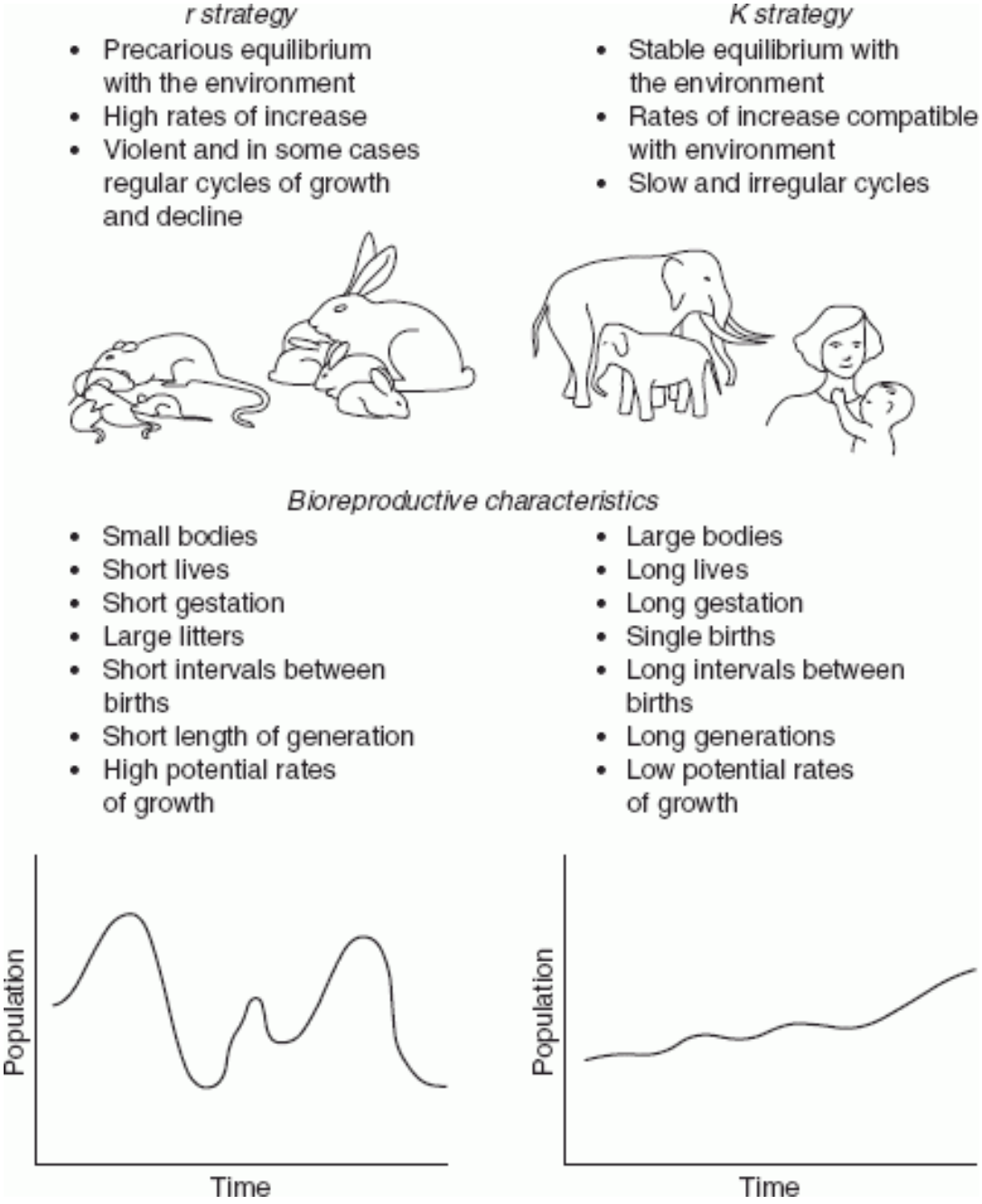
Grime's triangle



Survivorship curves


1000
100
10
1
0.1
Number of survivors (n_x) (log scale)
Type I
Type II
Type III
Age

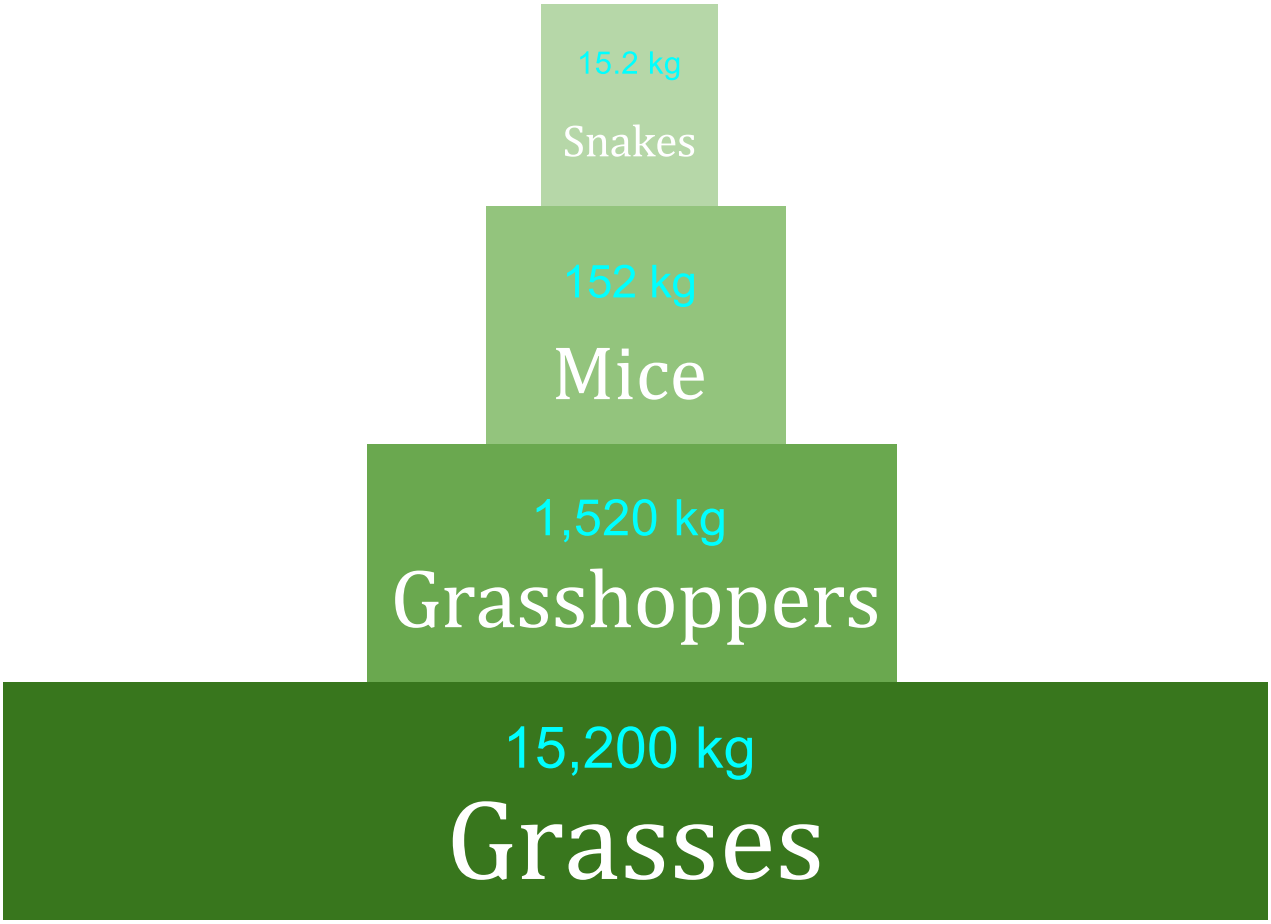
Strategies



Food webs

- Plant-based: producer – herbivore (consumer I) – carnivore (consumer II) etc.
- Detritus-based: decomposer – detritivore – carnivore (consumer II) etc.

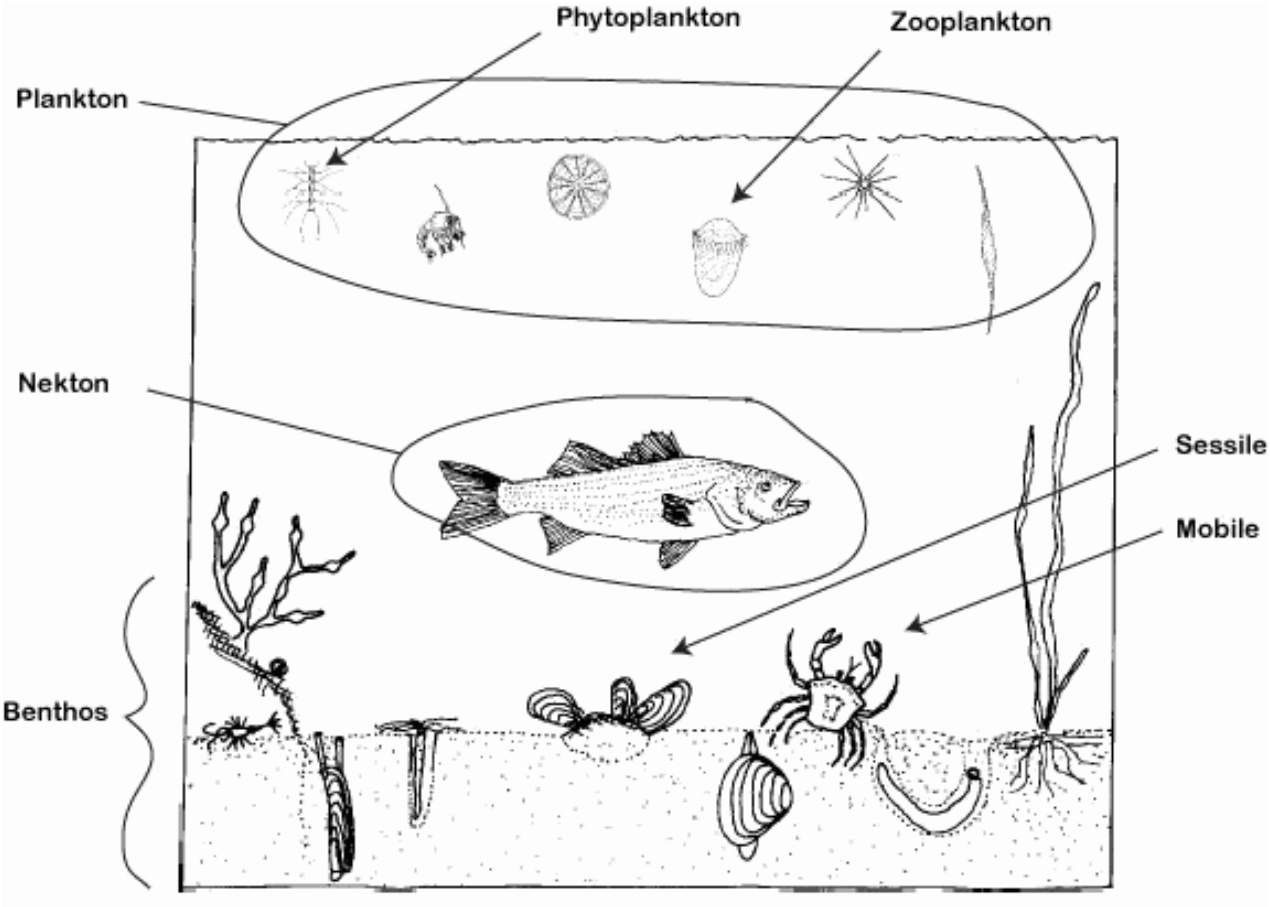
Energy and biomass pyramid (terrestrial)



Examples of ecosystems' structures

- Pond: phytoplankton, zooplankton, nekton, bentos
- Ocean: pelagic and littoral zones and some additional layers like neiston (first mm of surface)
- Forest: layers

Plankton, nekton and bentos



Succession

- Temporal chain of ecosystems
- Primary or secondary
- May start on bare minerals, river deposits, water
- May end with "climax" (F. Clements)

Biosphere, geomerid or Gaia

- All living things together with ecological factors
- Biomass: living matter
- Water, oxygen, carbon dioxide, nitrogen and phosphorous cycles
- Biosphere consists of biomes, geographically "packed" ecosystems

Summary

- Ecology studies relation between organisms and environment
- Ecosystems are self-reproduced and self-regulated units
- Biosphere (living Earth) is a biggest ecosystem
- Phosphorous cycle is the most critical to biosphere

For Further Reading

References

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