

# Biogeography: BIOL 330

## Study guide for Exam 1

Alexey Shipunov

Lectures 1–10

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## Outline

# 1 Syllabus

## 1.1 Web site

### Know your Syllabus!

[http://ashipunov.info/shipunov/school/biol\\_330/](http://ashipunov.info/shipunov/school/biol_330/)

### Presentations

- From February, every Wednesday lecture will start from short presentation based on the primary literature representing the most important directions of contemporary biogeography.
- Every 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.

# 2 Biogeography

## 2.1 Introduction

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?)

### For Further Reading

## References

- [1] A. Shipunov. *Biogeography* [Electronic resource]. 2014—onwards. Mode of access: [http://ashipunov.info/shipunov/school/biol\\_330](http://ashipunov.info/shipunov/school/biol_330)

## Outline

Ecuador-2018

<http://goo.gl/GkBseN>

## 3 Biogeography

### 3.1 Introduction

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/20151223_chile/20151224_patagonia/mov/)

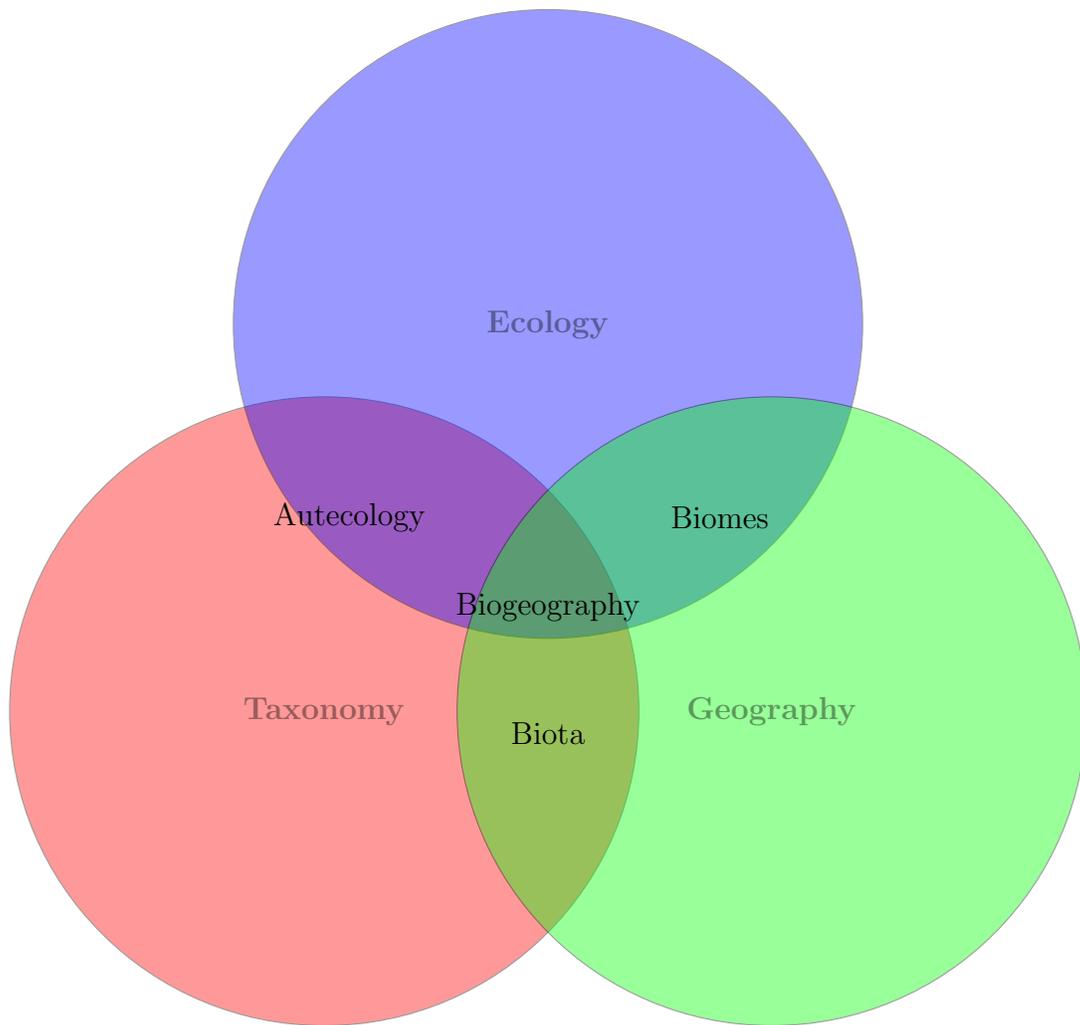
[http://msubiology.info/shipunov/ph/20160626\\_sa/20160711\\_cape\\_town/20160713\\_stone\\_point/mov/](http://msubiology.info/shipunov/ph/20160626_sa/20160711_cape_town/20160713_stone_point/mov/)

### 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

## 4 Basics of physical geography

### 4.1 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](http://ashipunov.info/shipunov/school/biol_330)

#### Outline

# 5 Basics of physical geography

## 5.1 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; 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
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### For Further Reading

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### Outline

# 6 Basics of physical geography

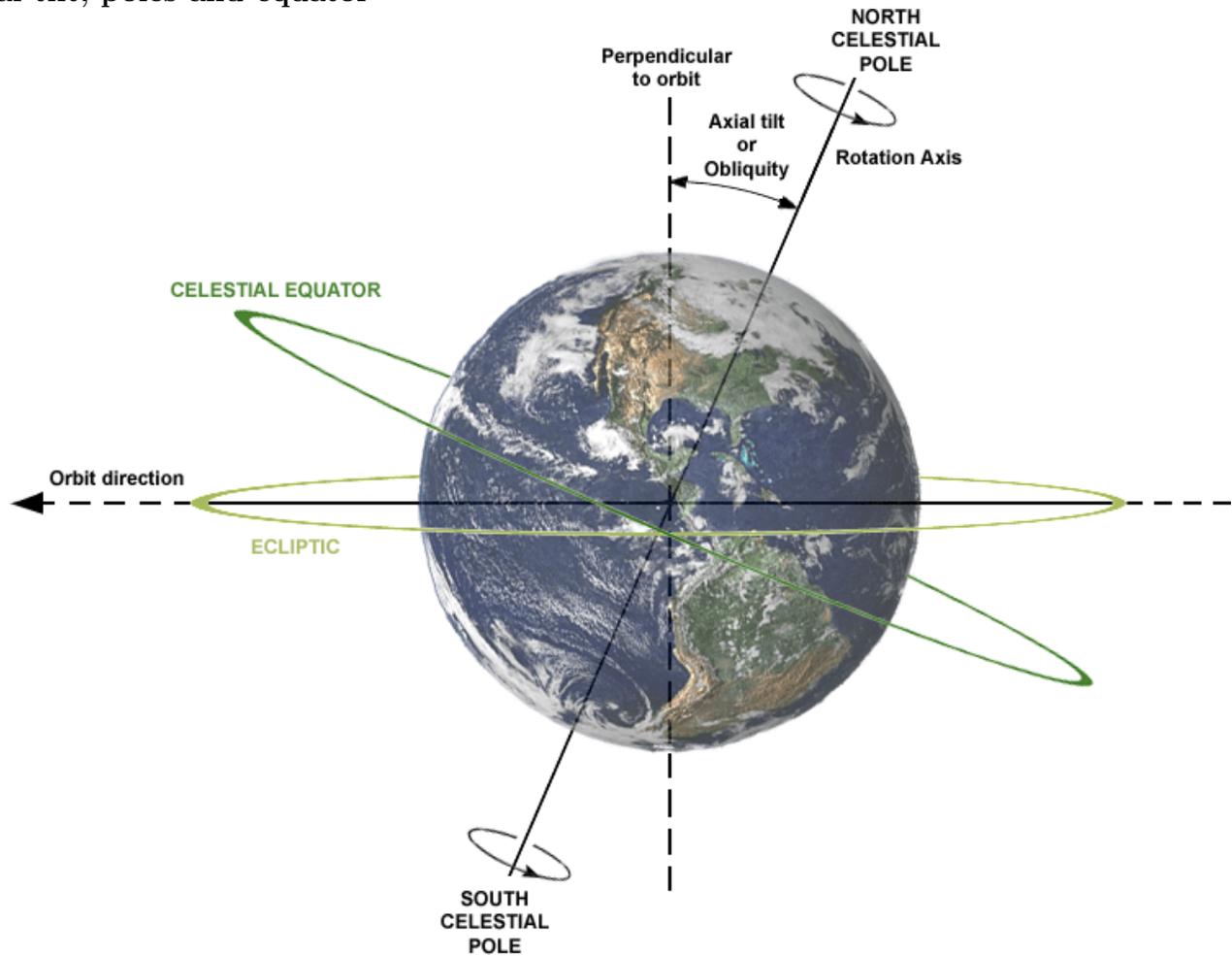
## 6.1 Basics of geodesy

### 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

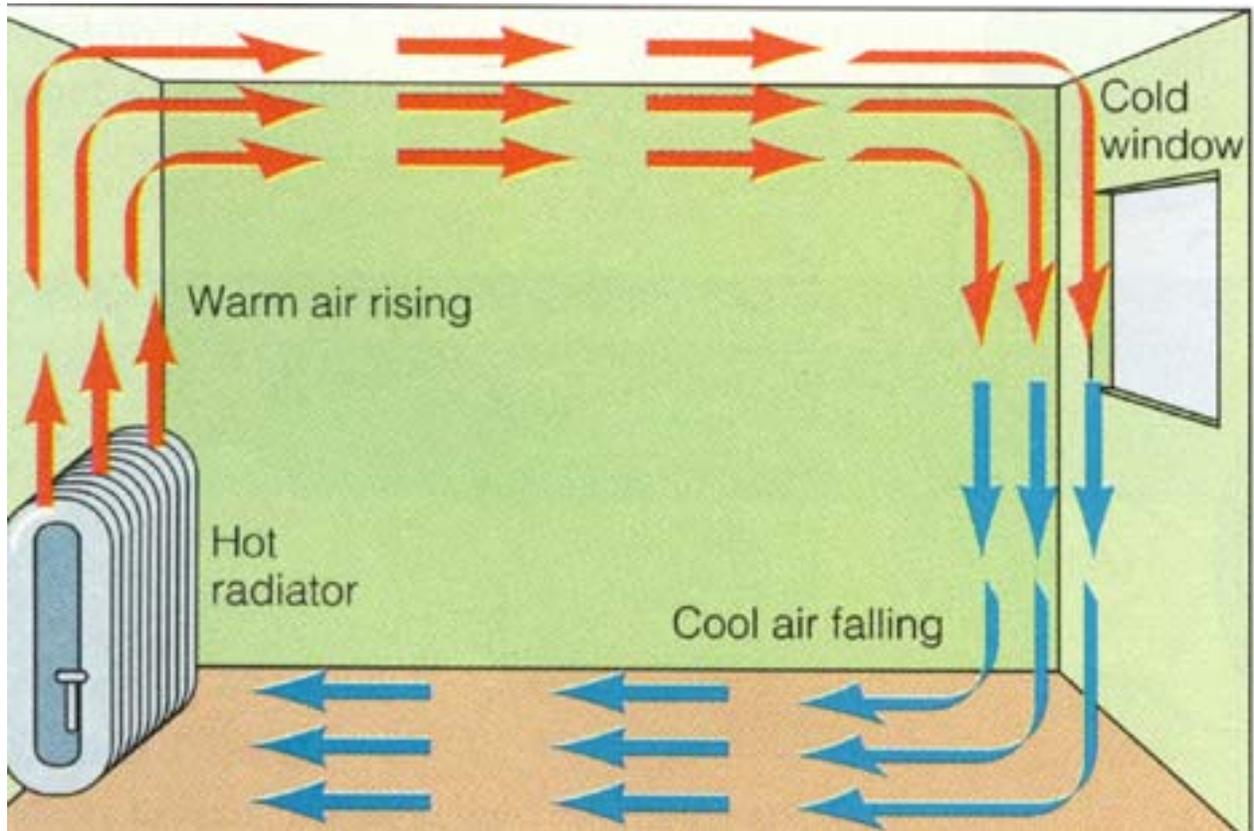


## 6.2 Basics of climatology

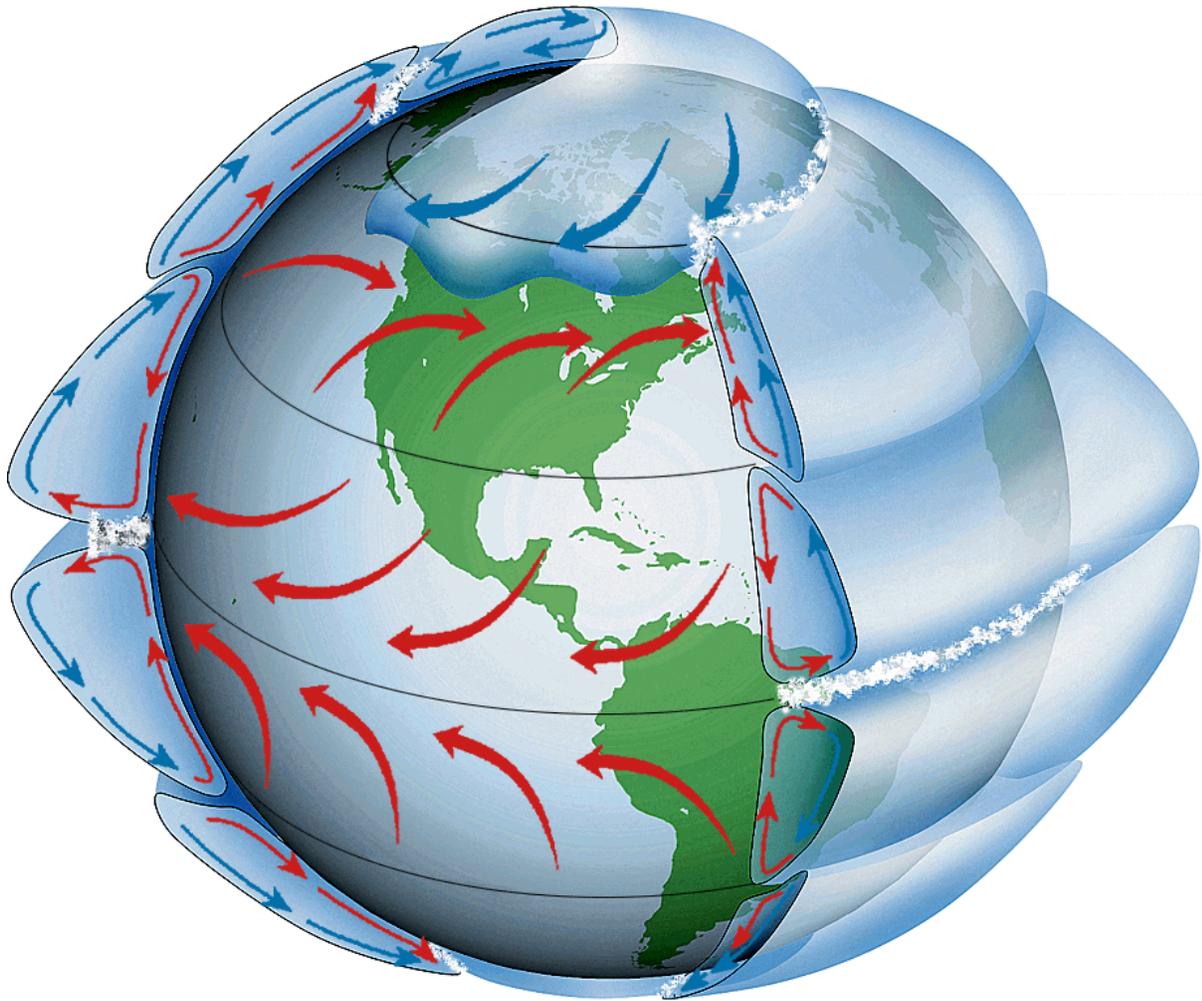
### Atmospheric circulation

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

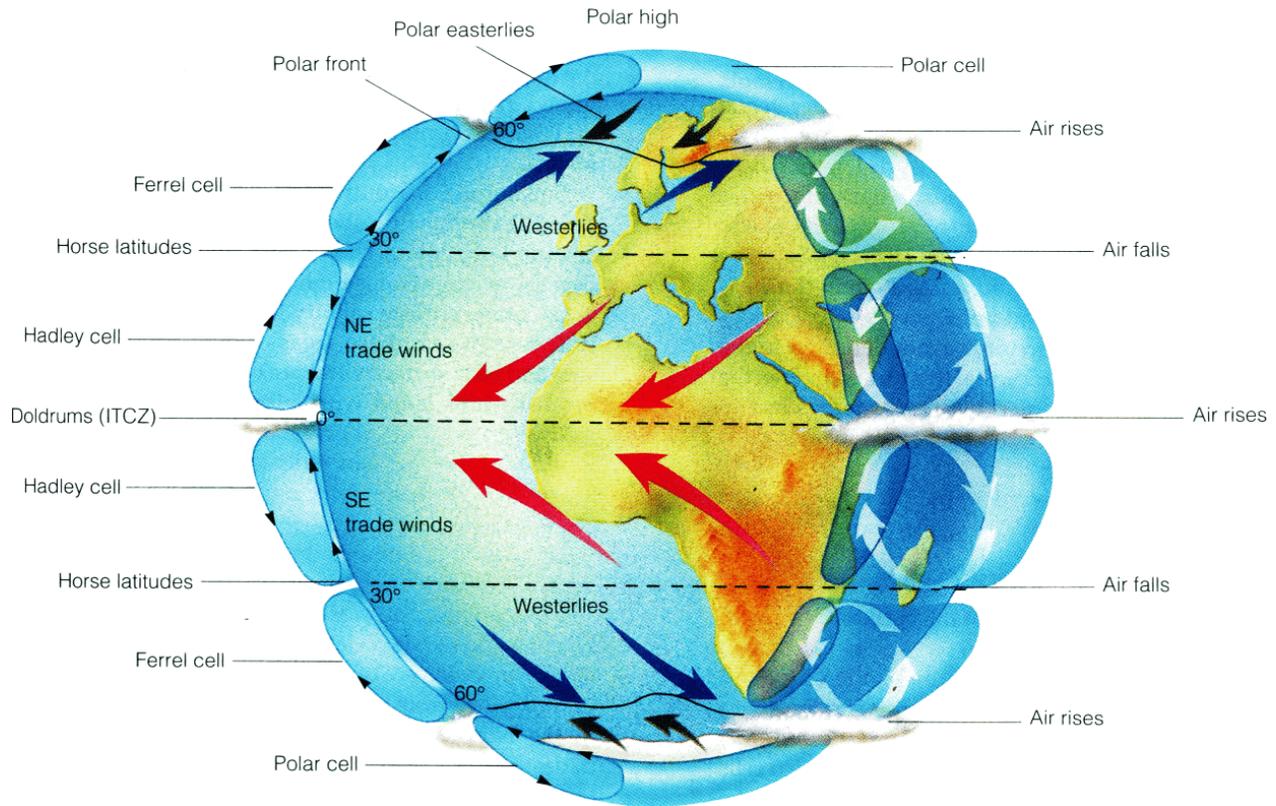
### Circulation in a room



Idealized atmospheric circulation on Earth



Idealized atmospheric circulation on Earth (with labels)



## Summary

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

## For Further Reading

## References

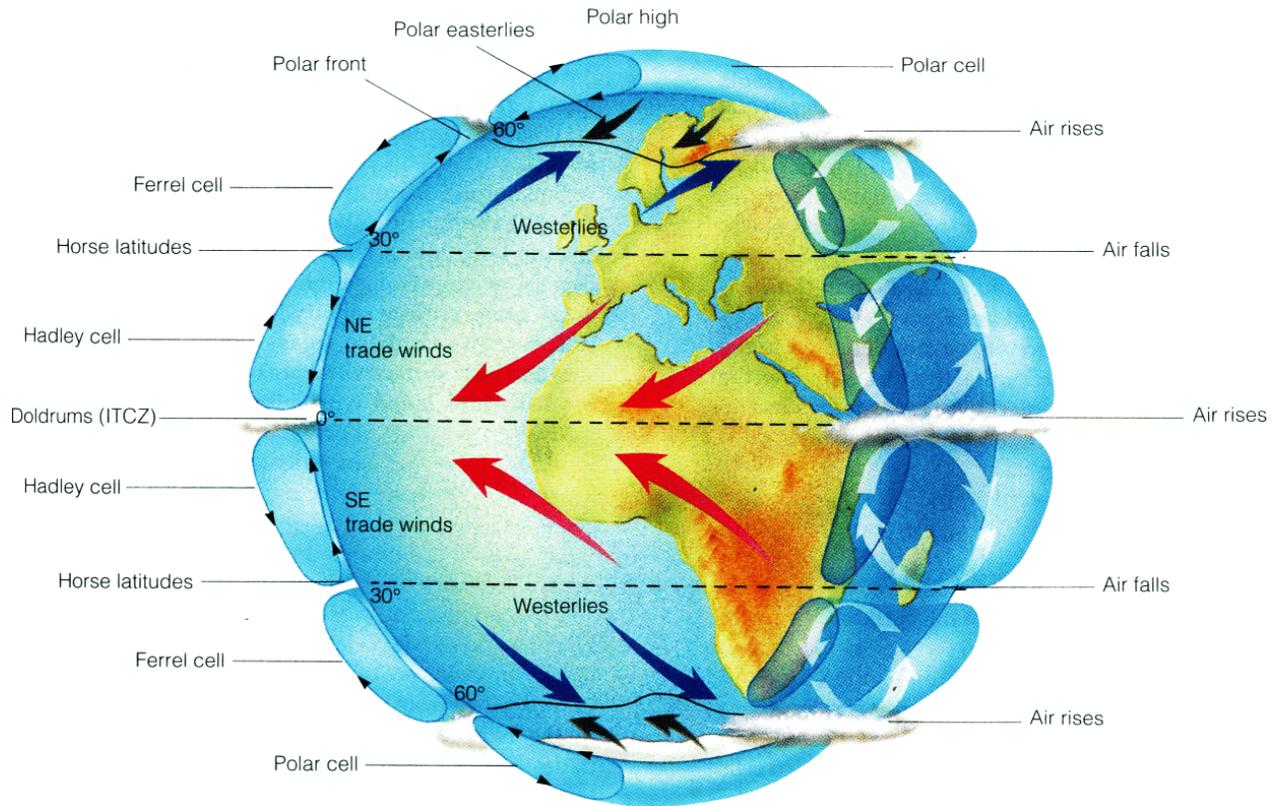
- [1] A. Shipunov. *Biogeography* [Electronic resource]. 2014—onwards. Mode of access: [http://ashipunov.info/shipunov/school/biol\\_330](http://ashipunov.info/shipunov/school/biol_330)
- [2] Major circles of latitude. [http://en.wikipedia.org/wiki/Circle\\_of\\_latitude](http://en.wikipedia.org/wiki/Circle_of_latitude)
- [3] Atmospheric circulation. [http://en.wikipedia.org/wiki/Atmospheric\\_circulation](http://en.wikipedia.org/wiki/Atmospheric_circulation)

## Outline

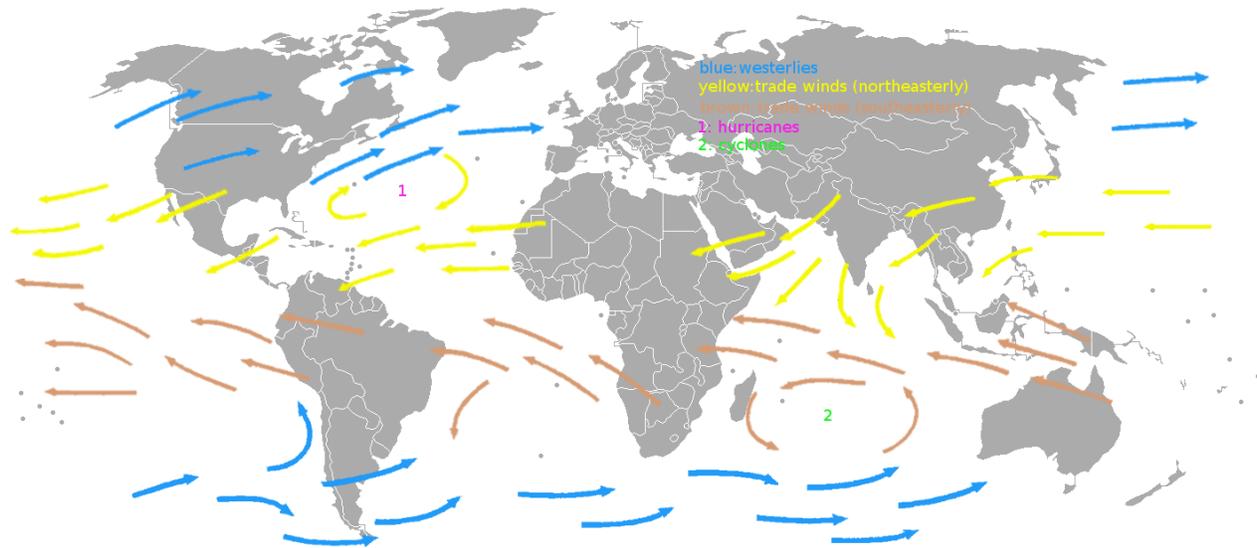
# 7 Basics of physical geography

## 7.1 Basics of climatology

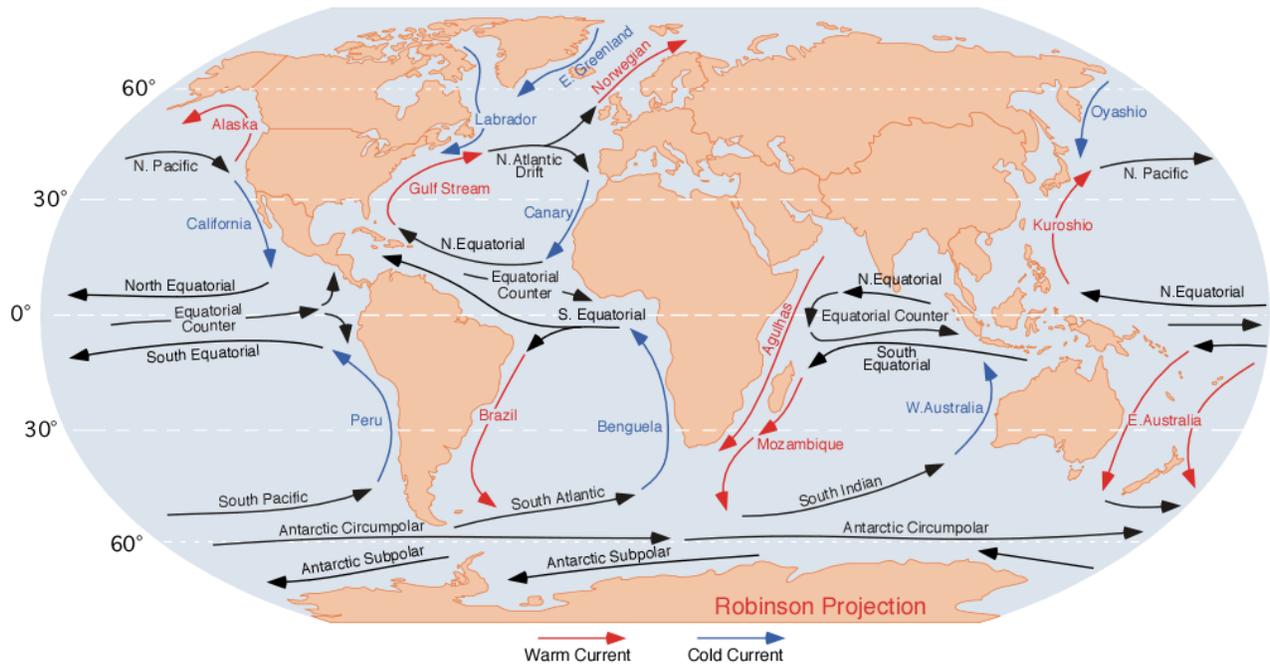
### Idealized atmospheric circulation on Earth (with labels)



## Prevailing winds



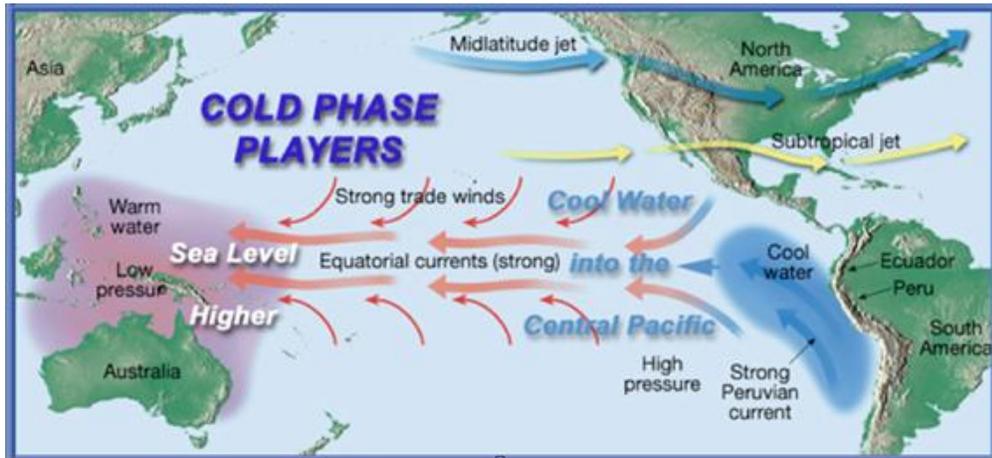
## Ocean currents



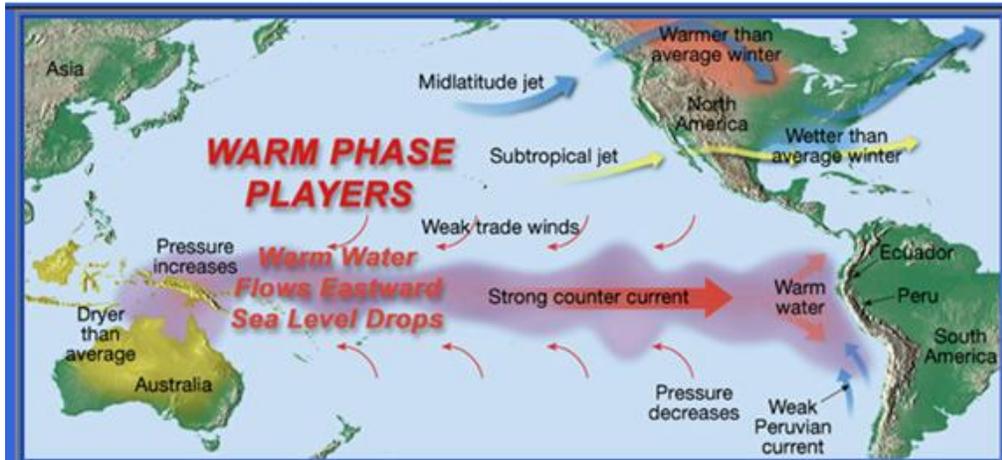
## El Niño: climatic oscillation

- Sometimes, western warm currents change atmospheric circulation 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

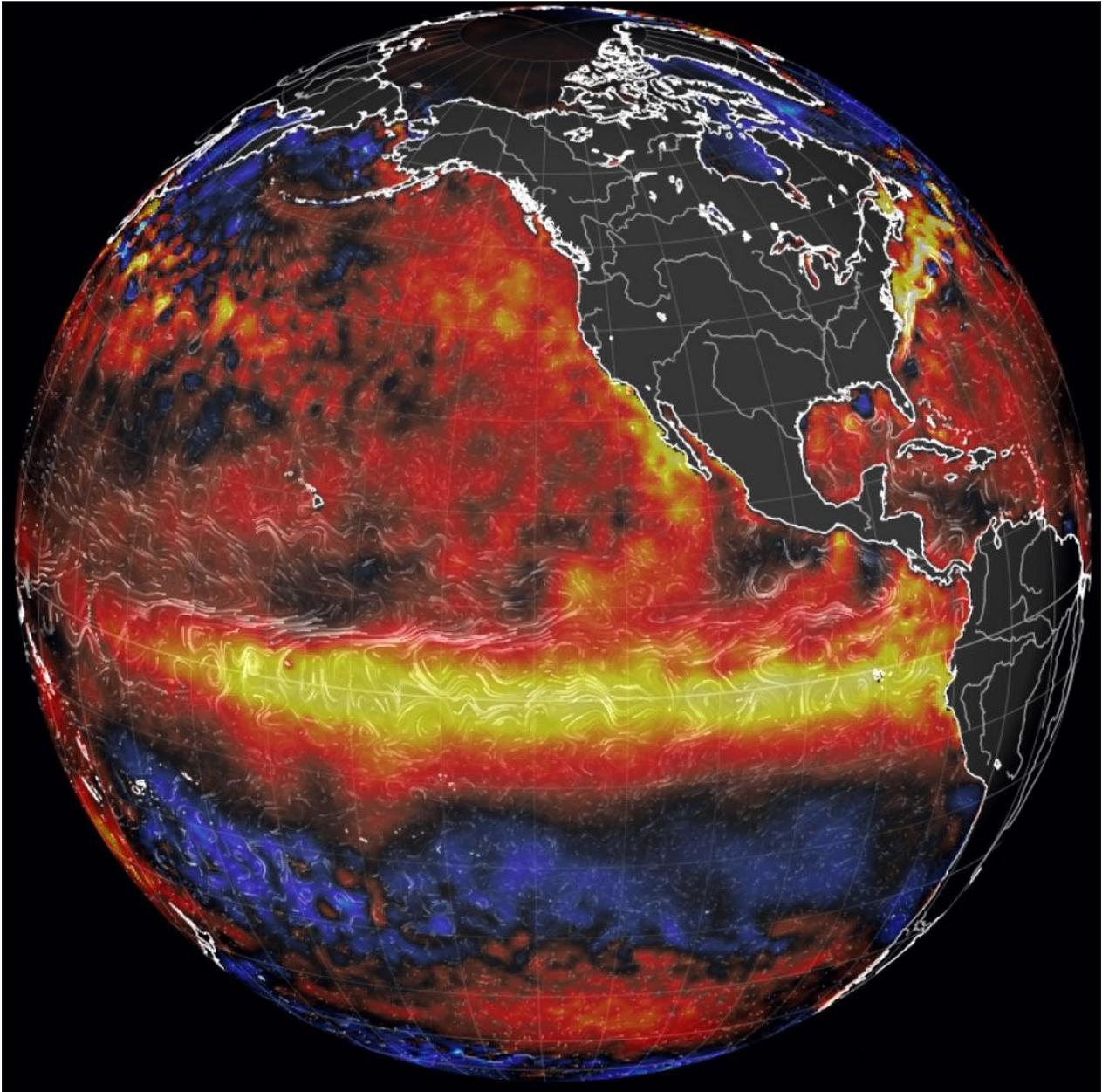


Normal Situation



El Niño Situation

Last El Niño (2016)



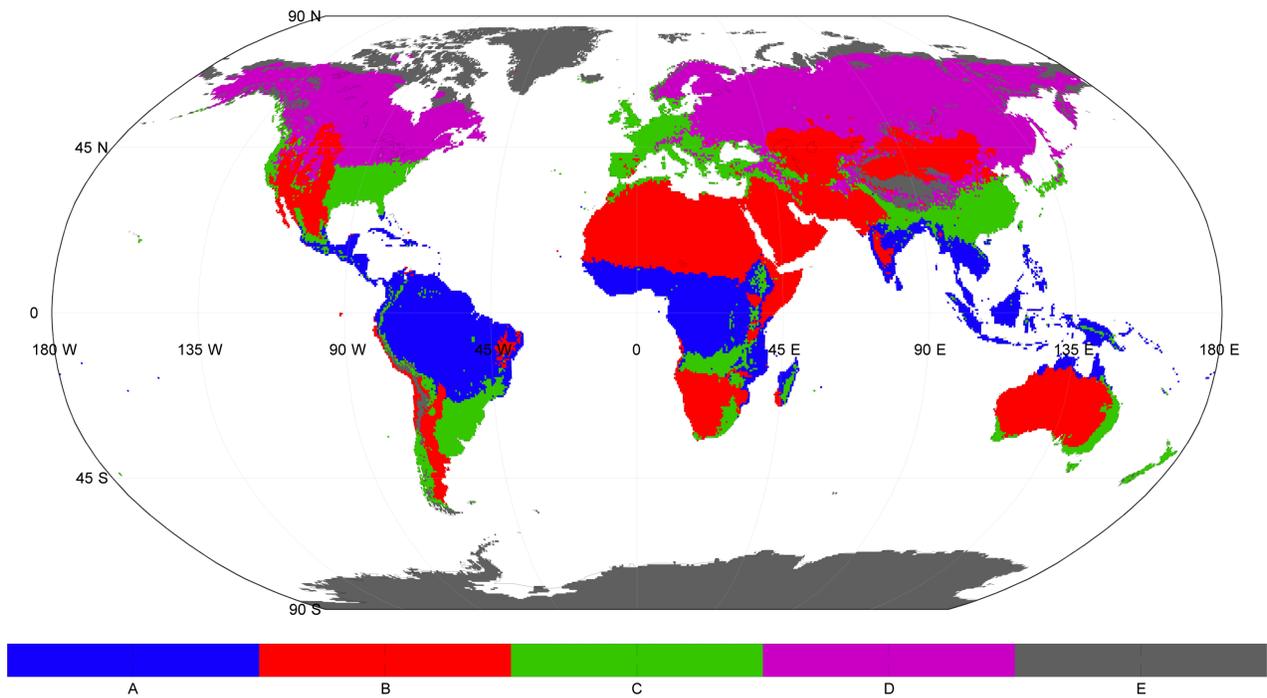
## Seasons

- 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

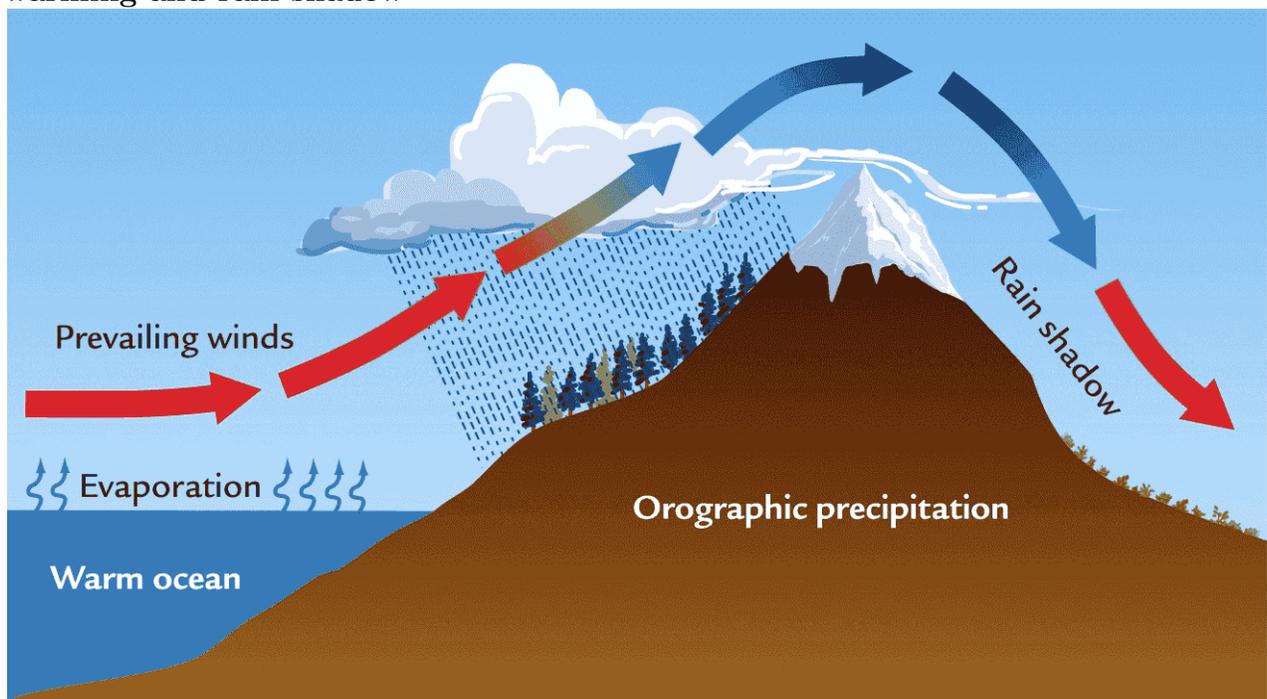
## Koeppen climates



### Climate and altitude

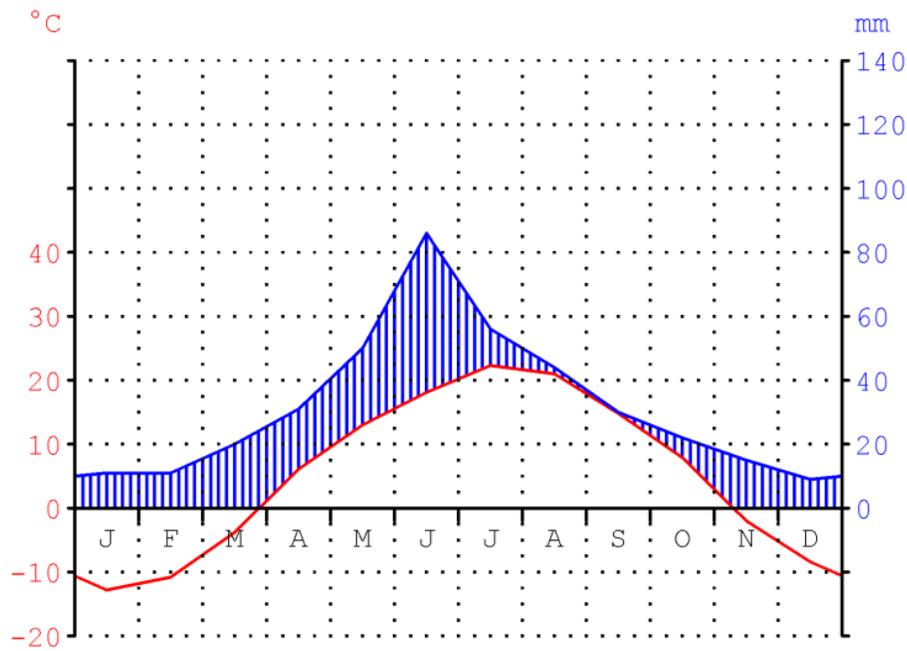
- Sea warming and rain shadow
- Altitudinal zones: lowland, montane, subalpine, alpine and snow

### Sea warming and rain shadow



### Climate diagram I

Bismarck/USA  
46°46'N/100°45'W  
511m



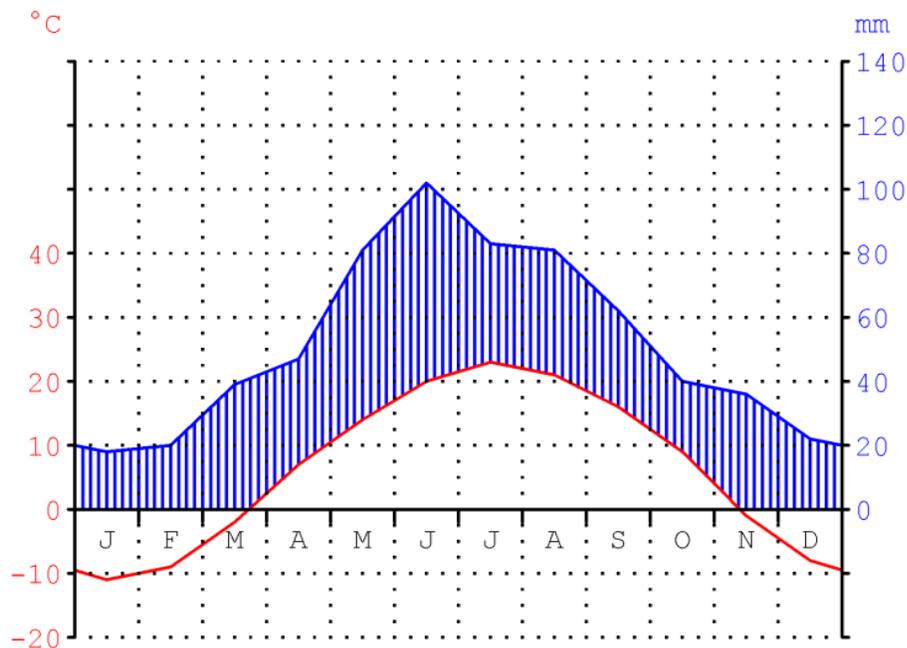
Monat	Temp. (°C)	Nied. (mm)
JAN	-12,8	11
FEB	-10,8	11
MRZ	-3,8	20
APR	6,1	31
MAI	13,0	50
JUN	18,1	86
JUL	22,3	56
AUG	21,0	44
SEP	14,8	30
OKT	7,9	22
NOV	-2,0	15
DEZ	-8,4	9

Temp.-Jahresmittel  
5,4 °C

Niederschlagssumme  
385 mm

## Climate diagram II

Minneapolis/USA  
44°53'N/93°13'W  
254m



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

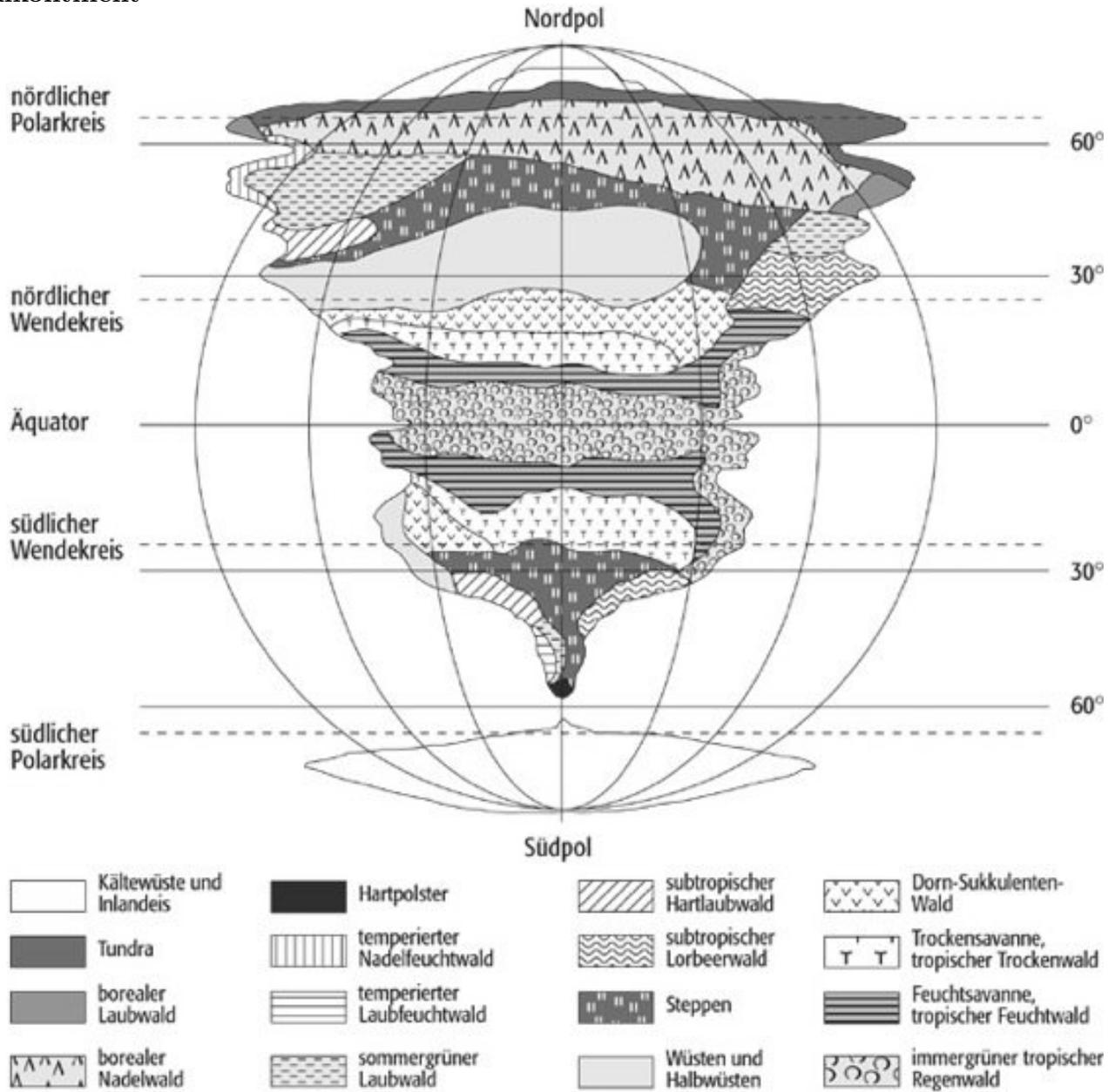
Temp.-Jahresmittel  
6,6 °C

Niederschlagssumme  
631 mm

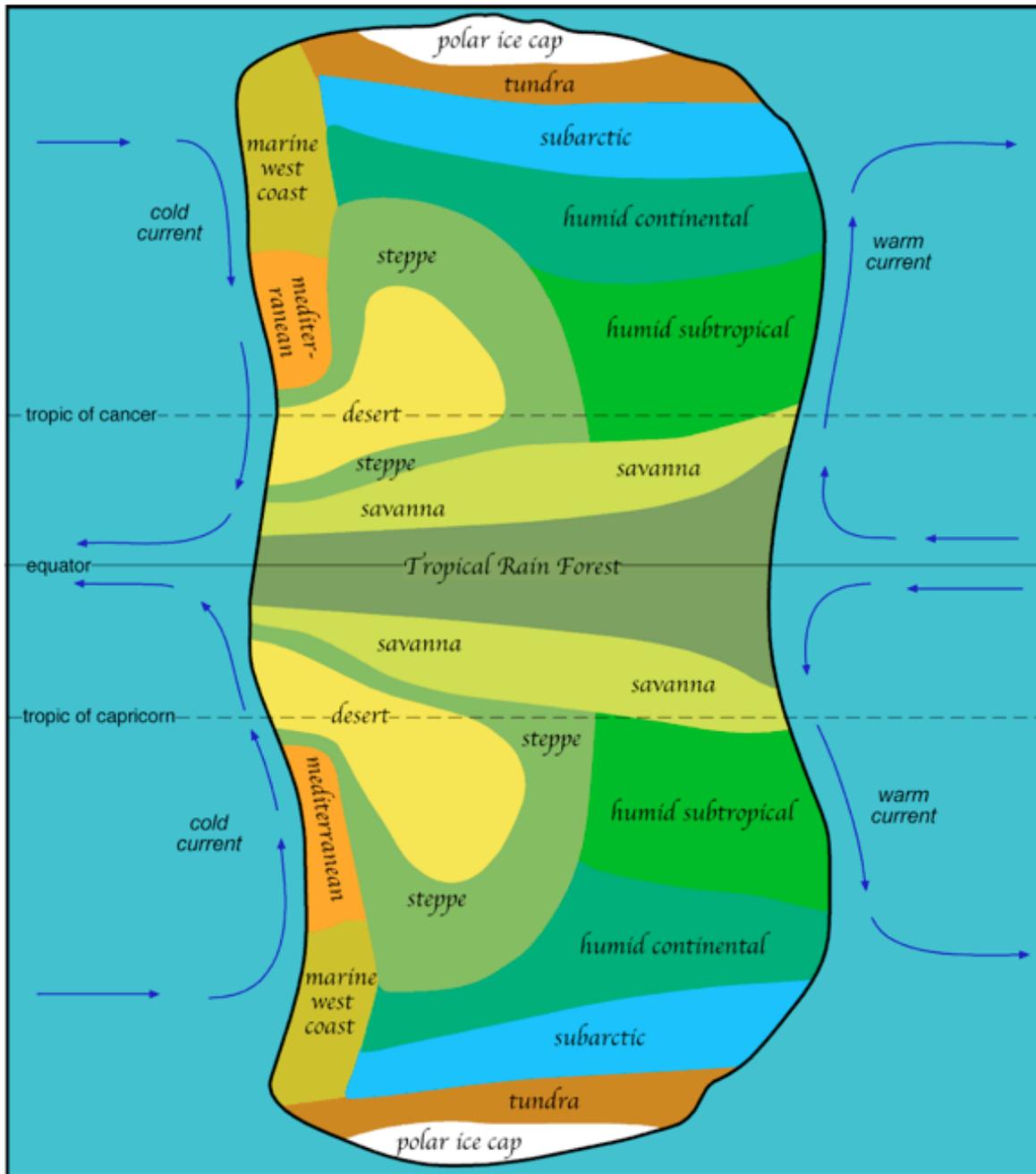
## Climate and life

- 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

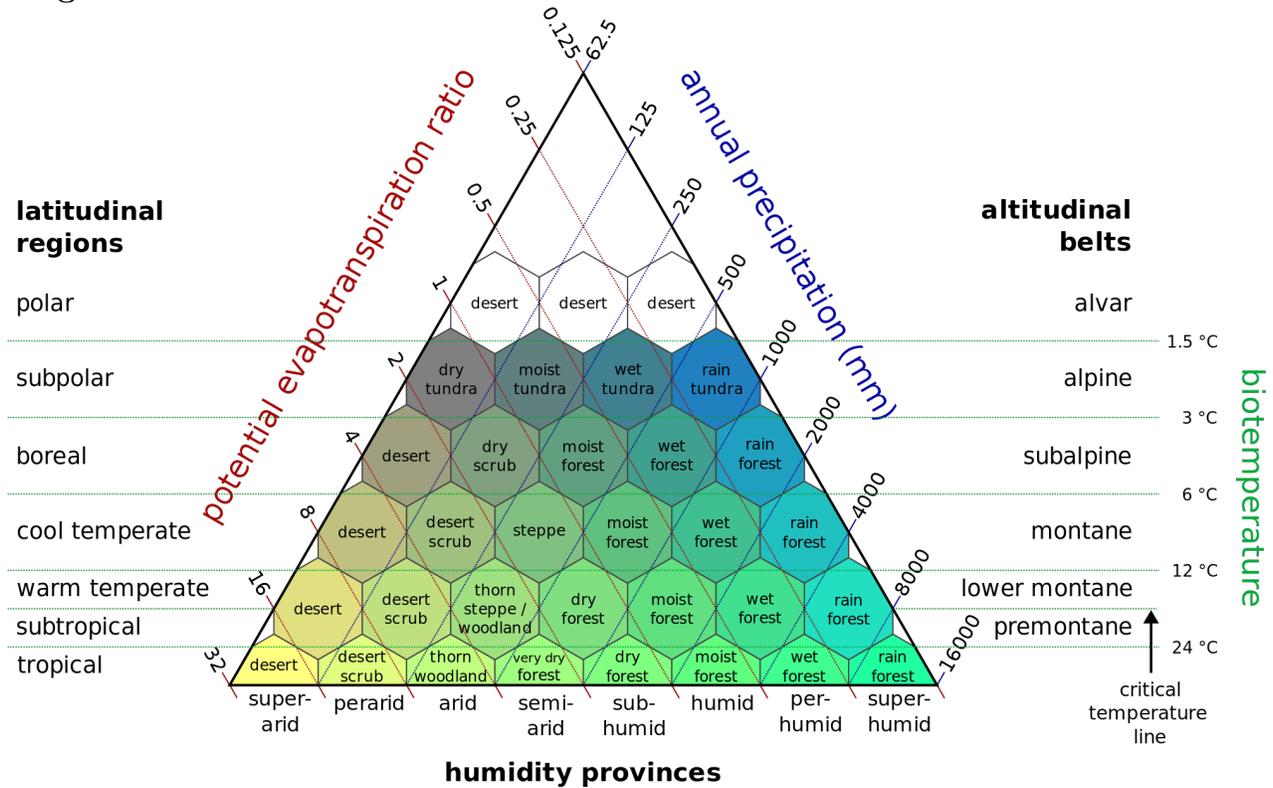
- [1] A. Shipunov. *Biogeography* [Electronic resource]. 2014—onwards. Mode of access: [http://ashipunov.info/shipunov/school/biol\\_330](http://ashipunov.info/shipunov/school/biol_330)
- [2] Major circles of latitude. [http://en.wikipedia.org/wiki/Circle\\_of\\_latitude](http://en.wikipedia.org/wiki/Circle_of_latitude)

## Outline

# 8 Basics of physical geography

## 8.1 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.

# 9 Palaeogeography

## 9.1 Geological time

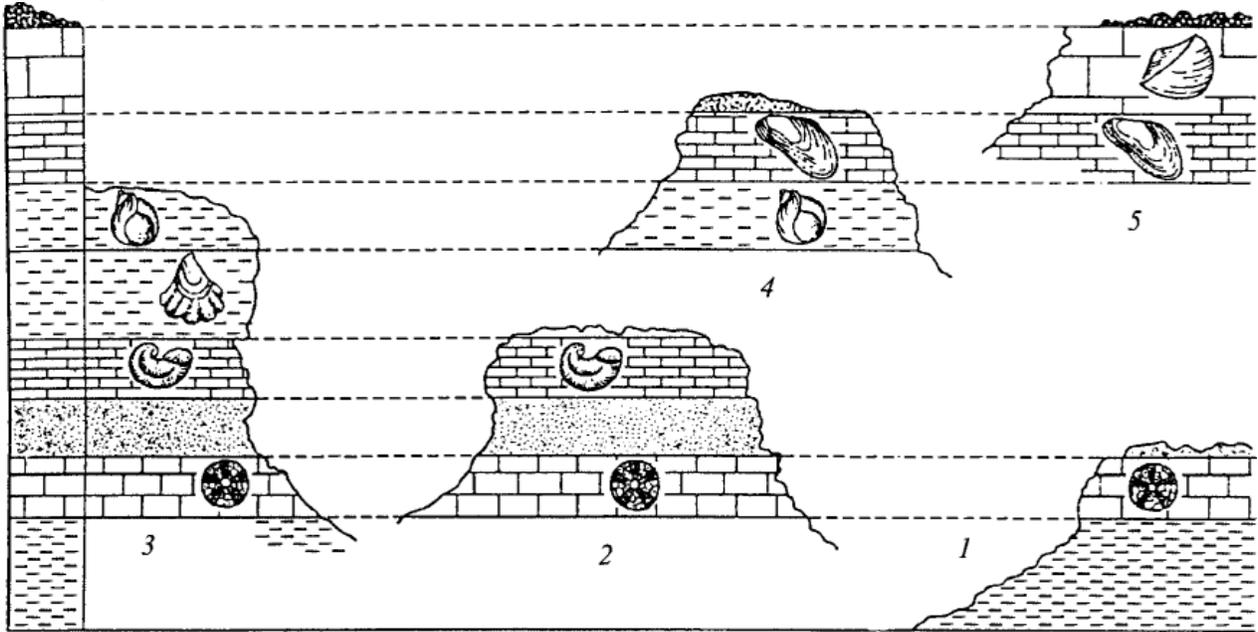
### Use of radioactivity

- 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

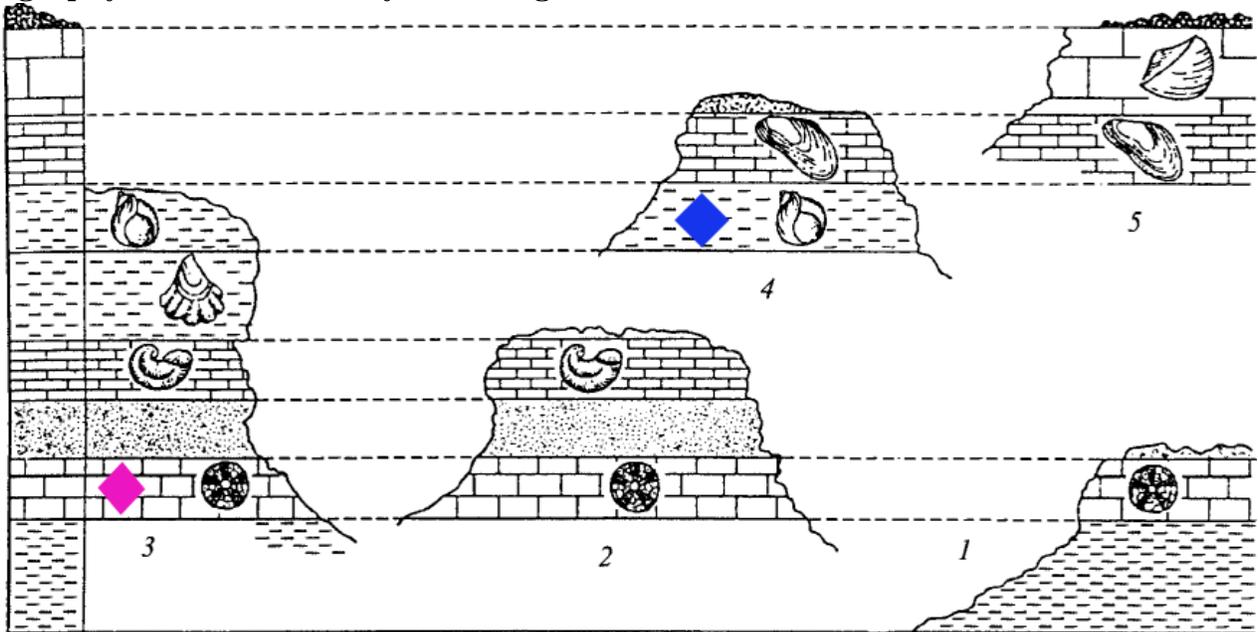
### Stratigraphy

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

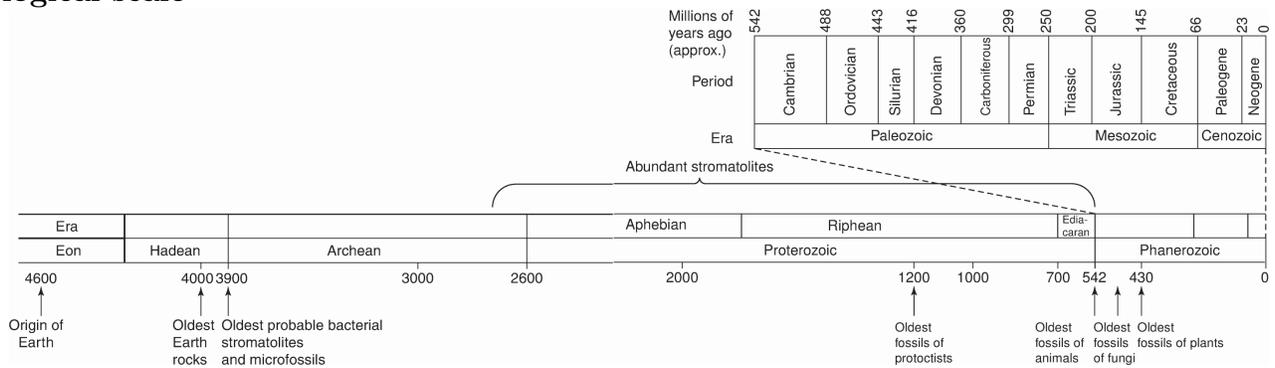
## How stratigraphy works



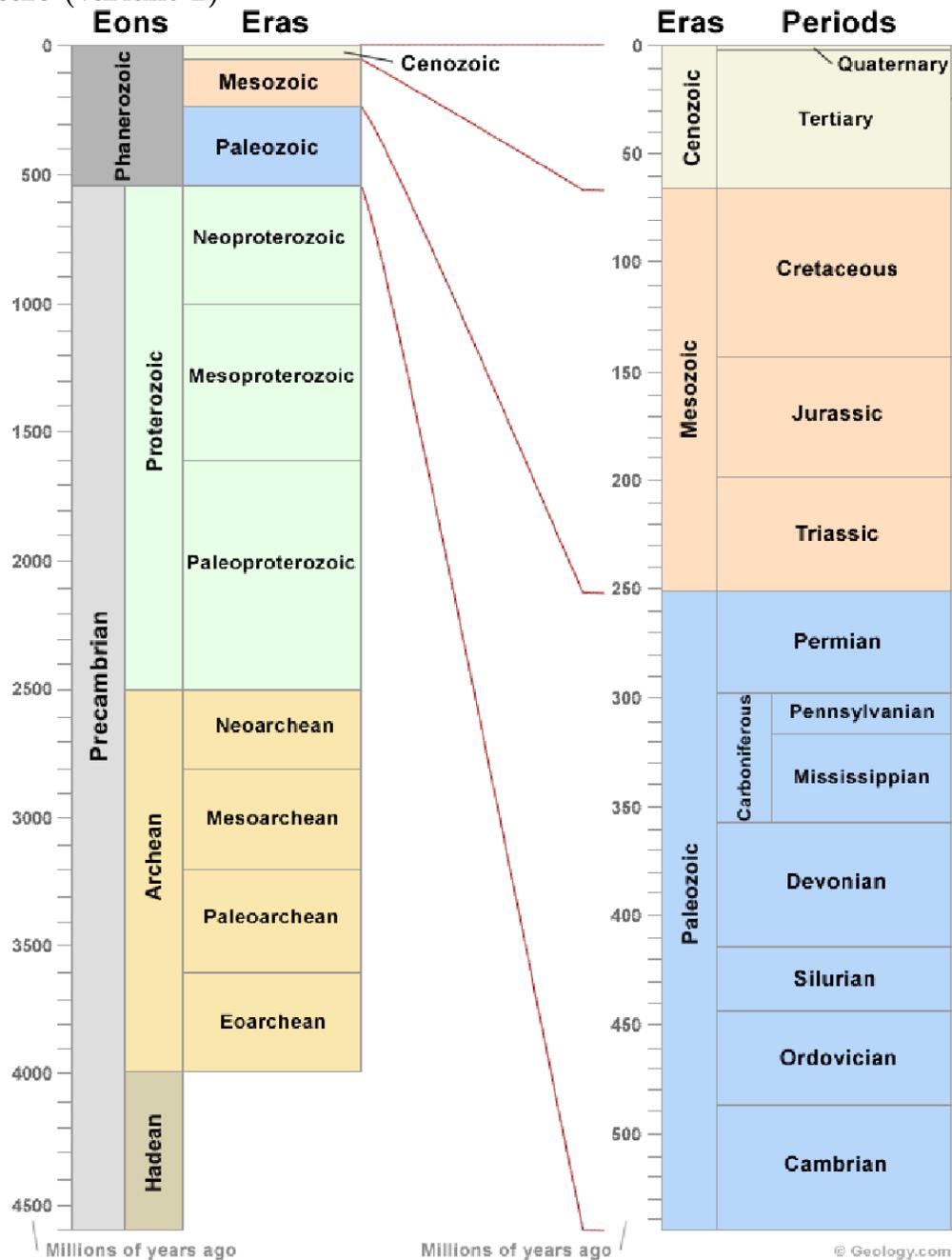
## Stratigraphy and radioactivity work together



## Geological scale



## Geological scale (variant 2)



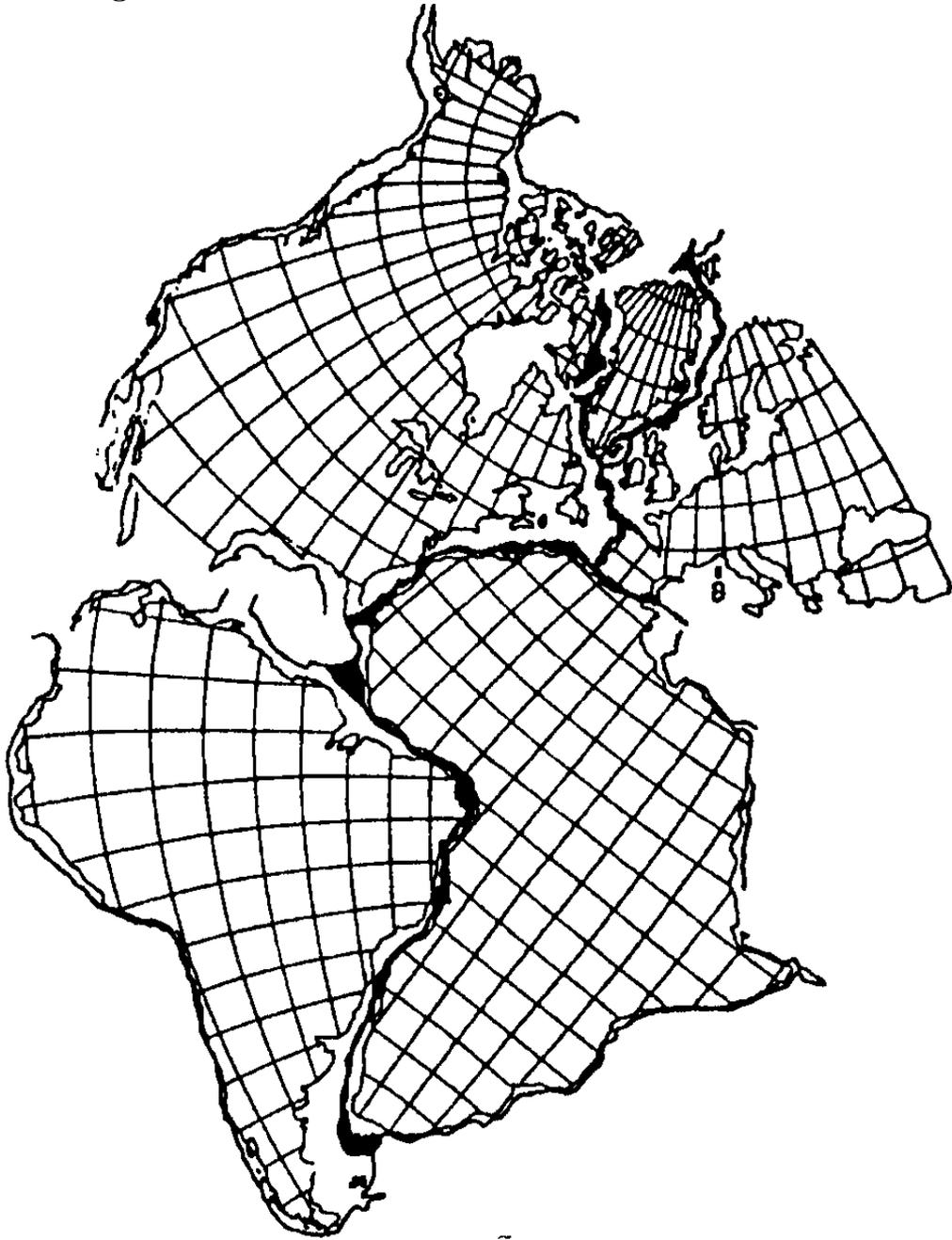
I want you to memorize eras and Mesozoic/Cenozoic periods.

## 9.2 Plate tectonics

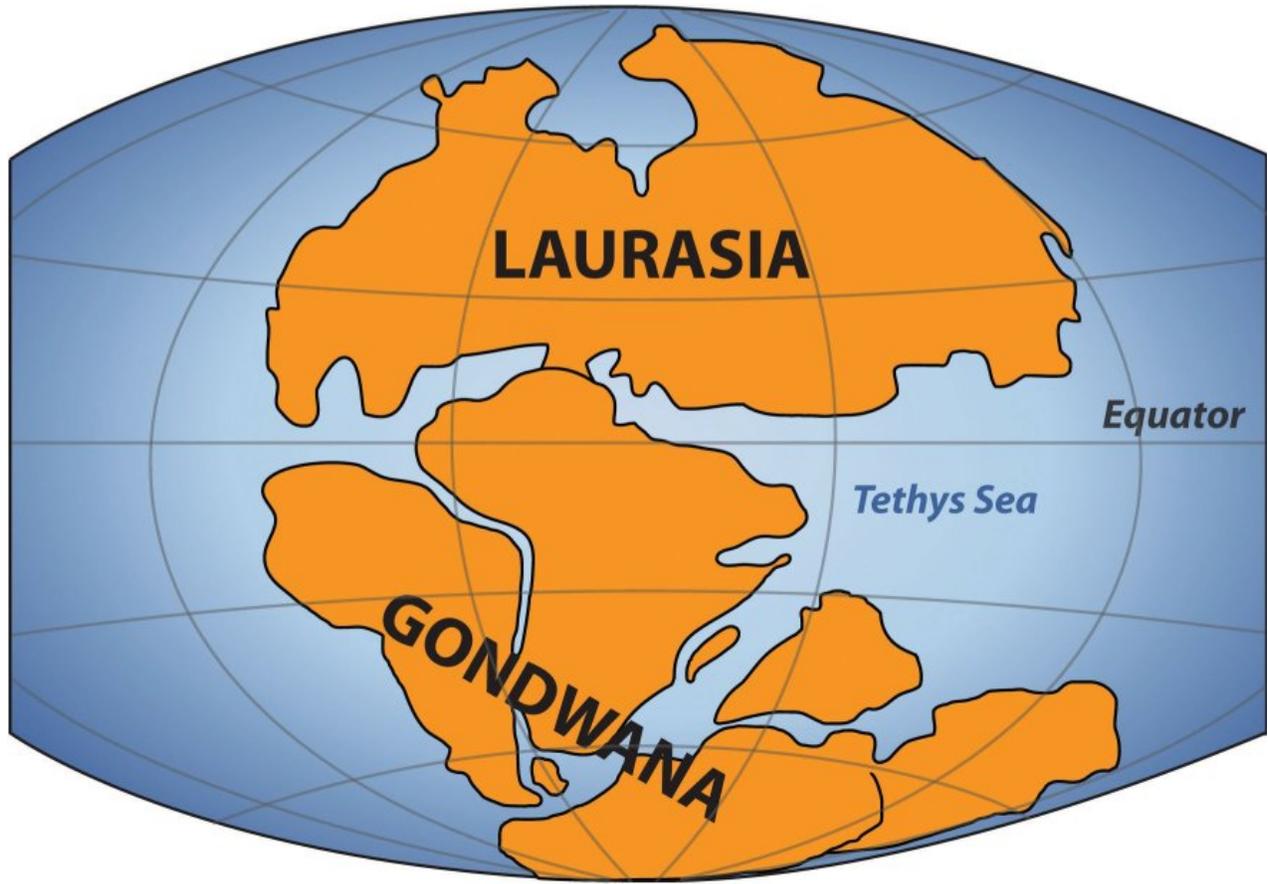
### Continental drift

- 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 Vegener's arguments



Laurasia and Gondwana



Pangaea



### Mantle convection

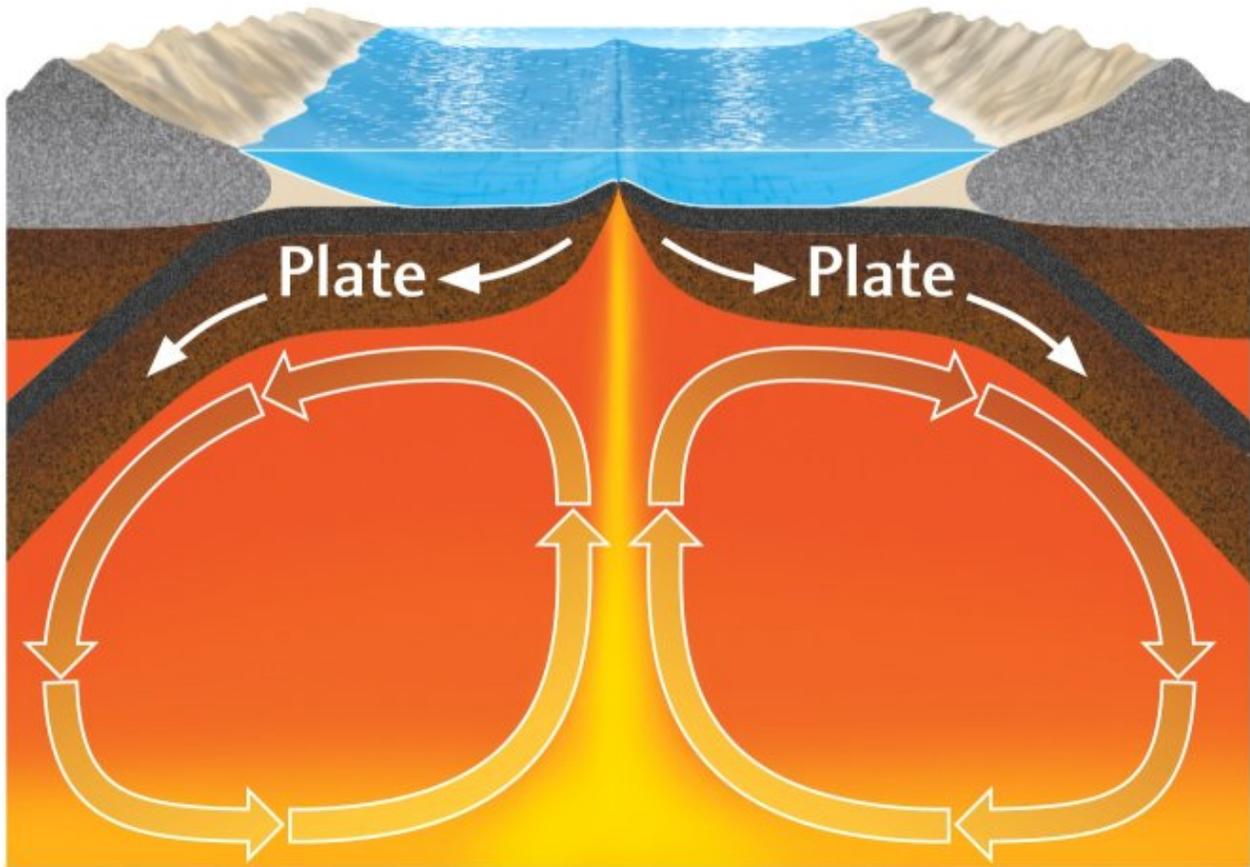
- The driving force of floating continents is a **mantle convection**
- In ocean ridges, new ocean cortex is constantly forming and expanding
- In ocean trenches and continental ridges, different plates are colliding and often forming mountains

### 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

- [1] A. Shipunov. *Biogeography* [Electronic resource]. 2014—onwards. Mode of access: [http://ashipunov.info/shipunov/school/biol\\_330](http://ashipunov.info/shipunov/school/biol_330)

### Outline

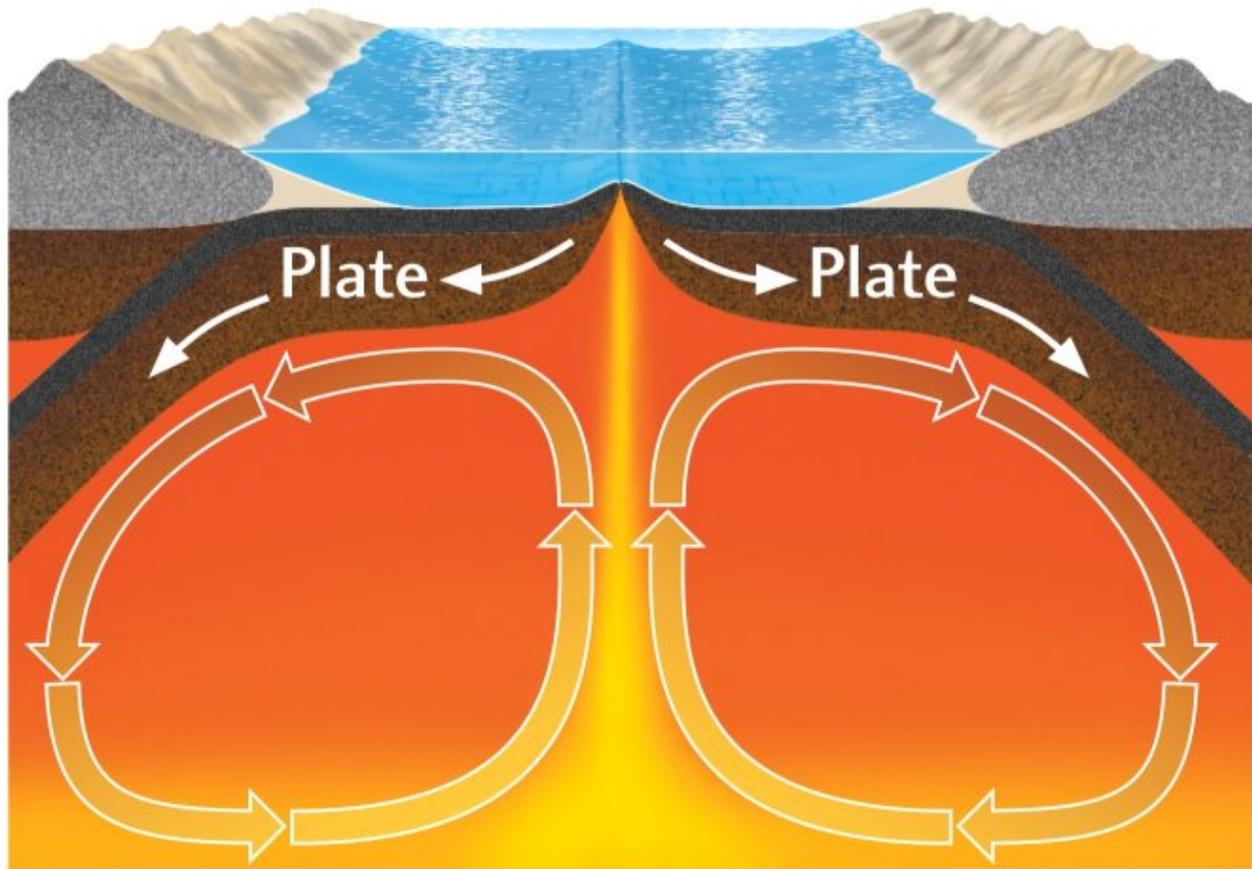
## 10 Palaeogeography

### 10.1 Plate tectonics

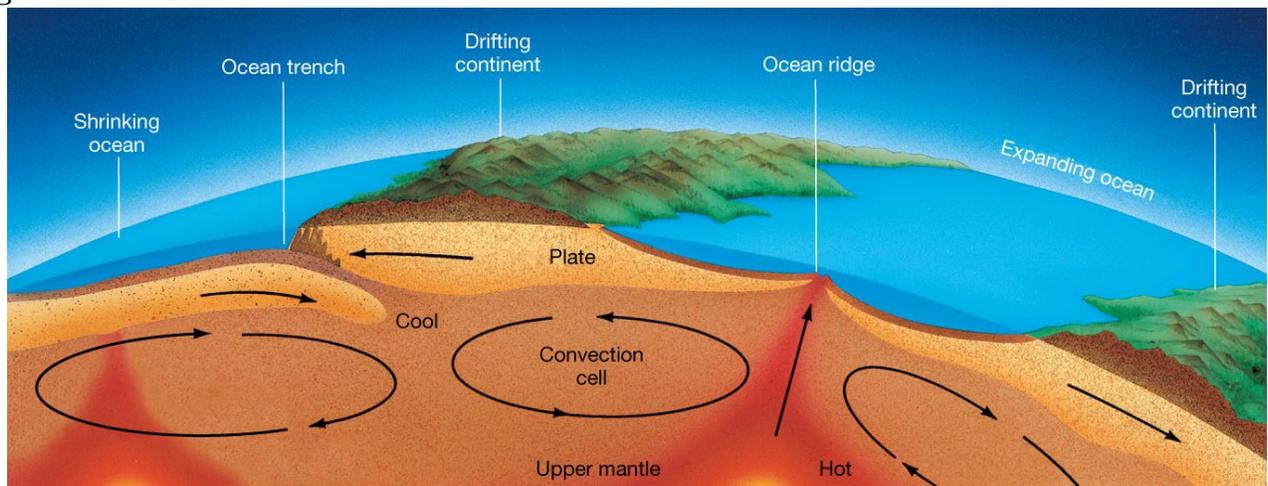
#### Mantle convection

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

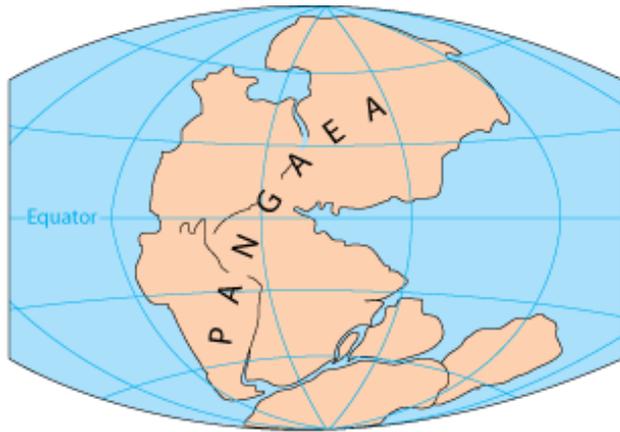
## Mantle convection



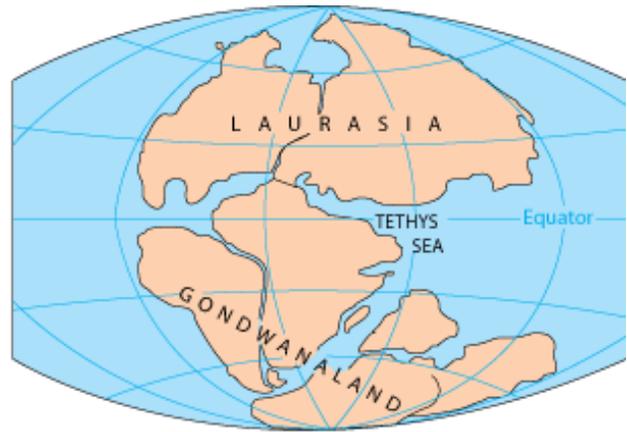
## Ridges and trenches



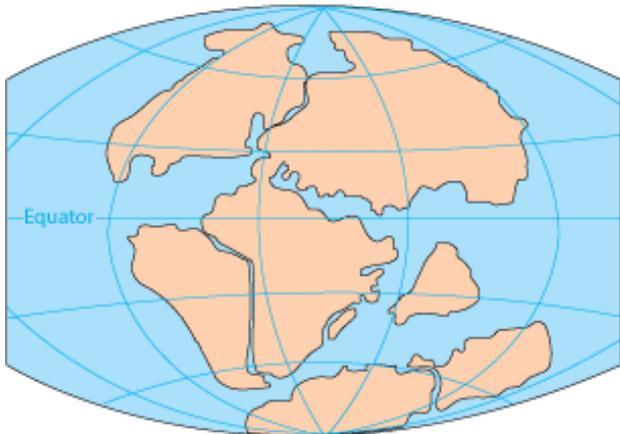
## The result of mantle convection



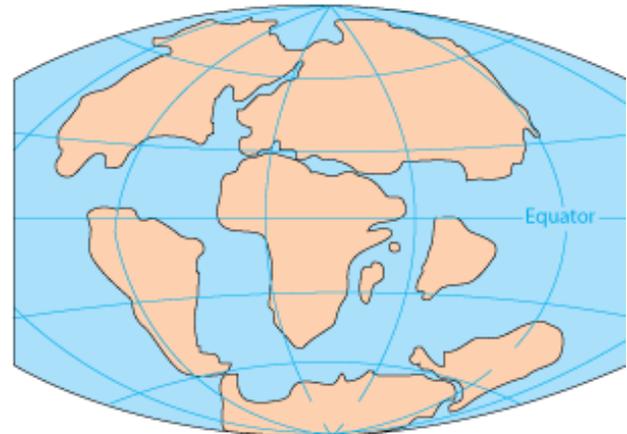
**PERMIAN**  
250 million years ago



**TRIASSIC**  
200 million years ago

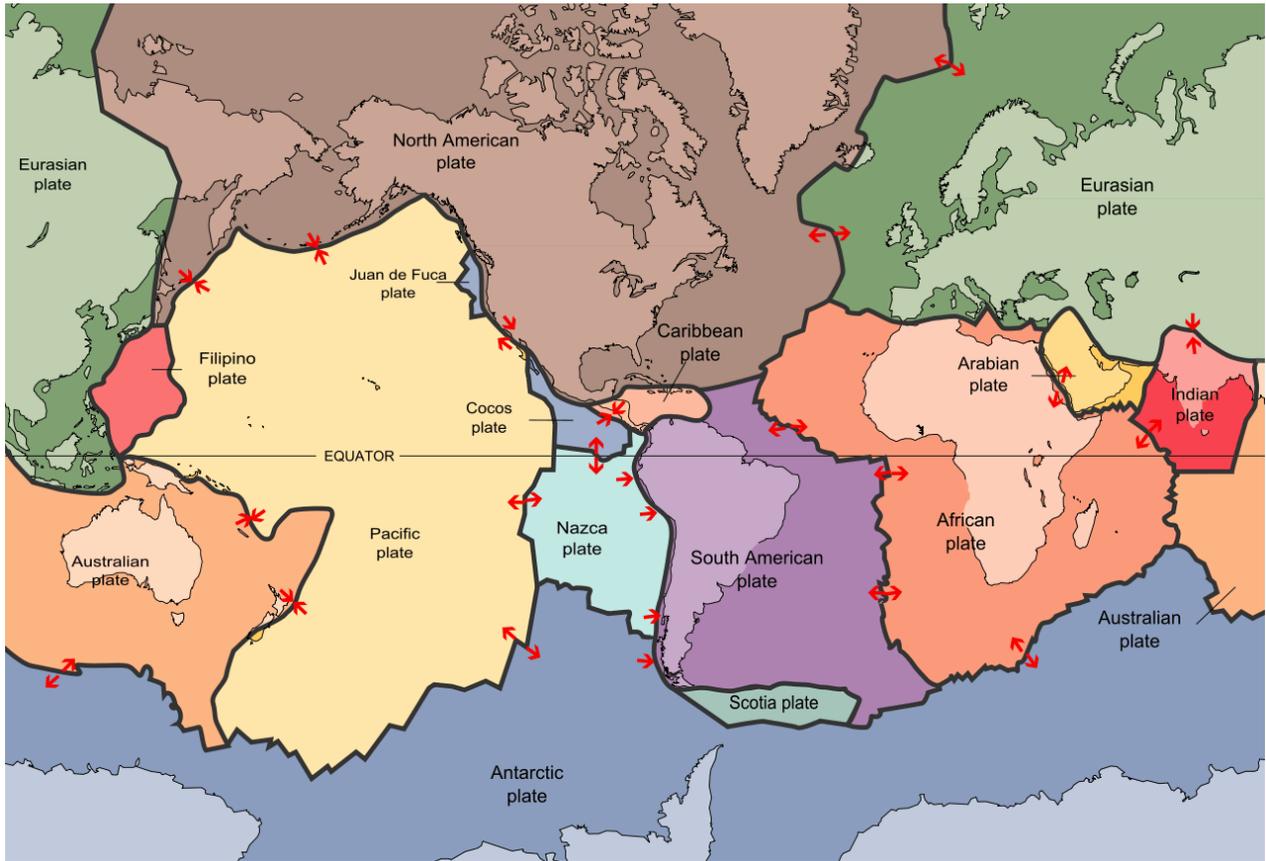


**JURASSIC**  
145 million years ago



**CRETACEOUS**  
65 million years ago

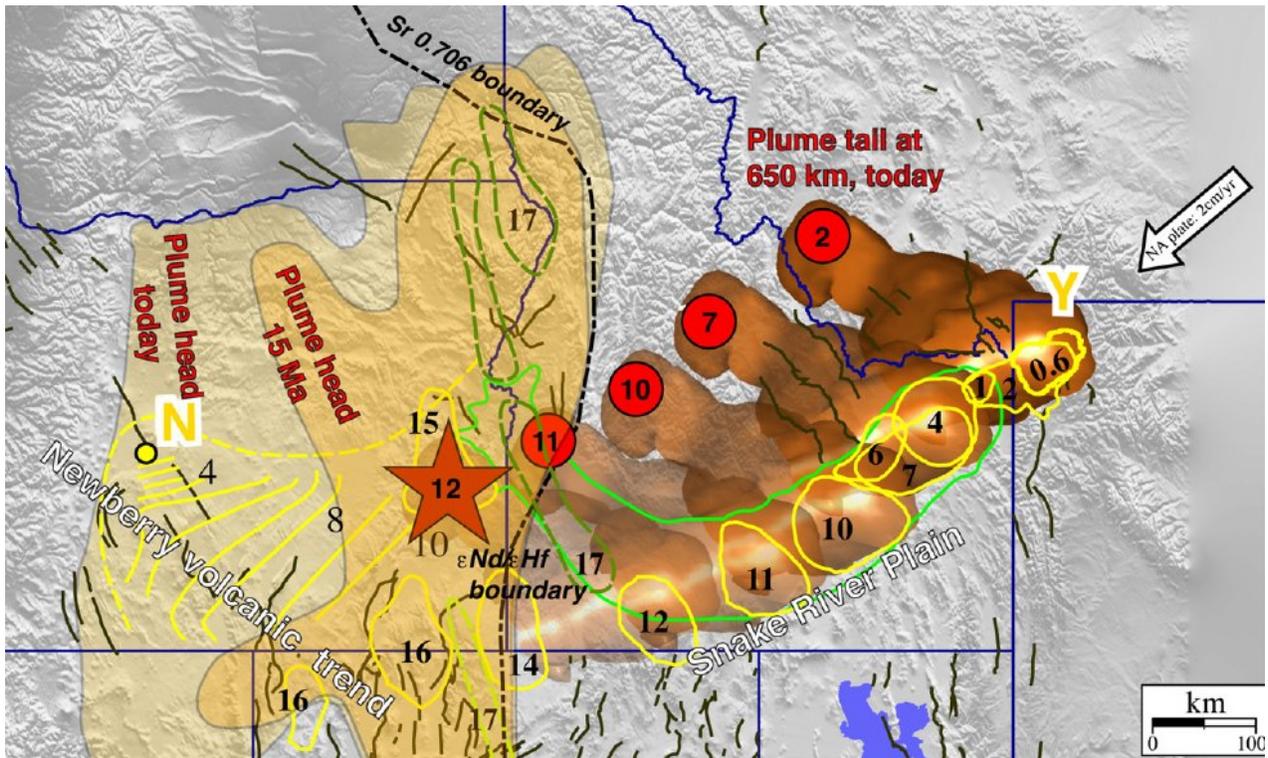
## Tectonic plates



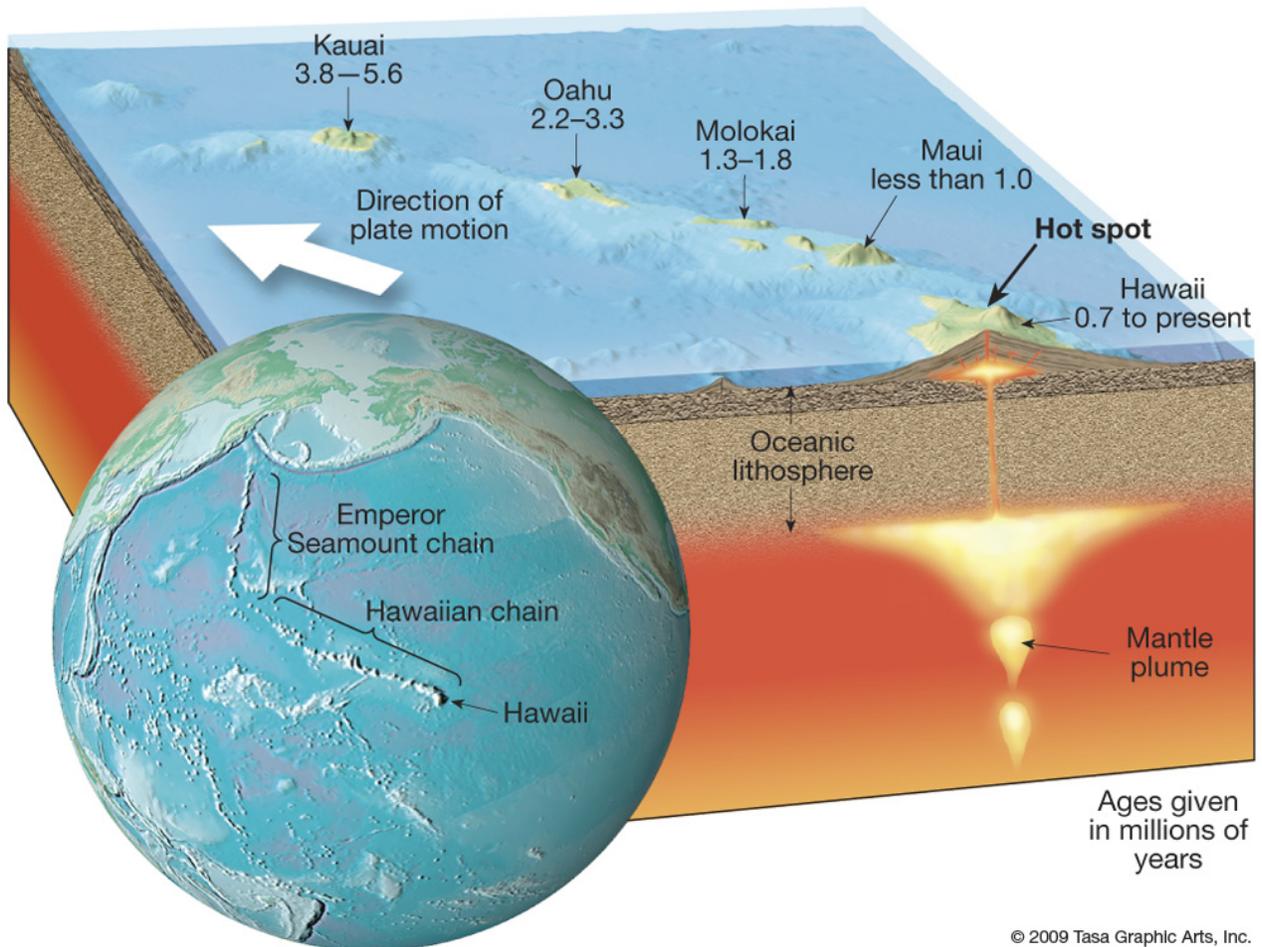
## Two living examples of continental drift on U.S. territory

- Yellowstone hotspot
- Hawaiian hotspot

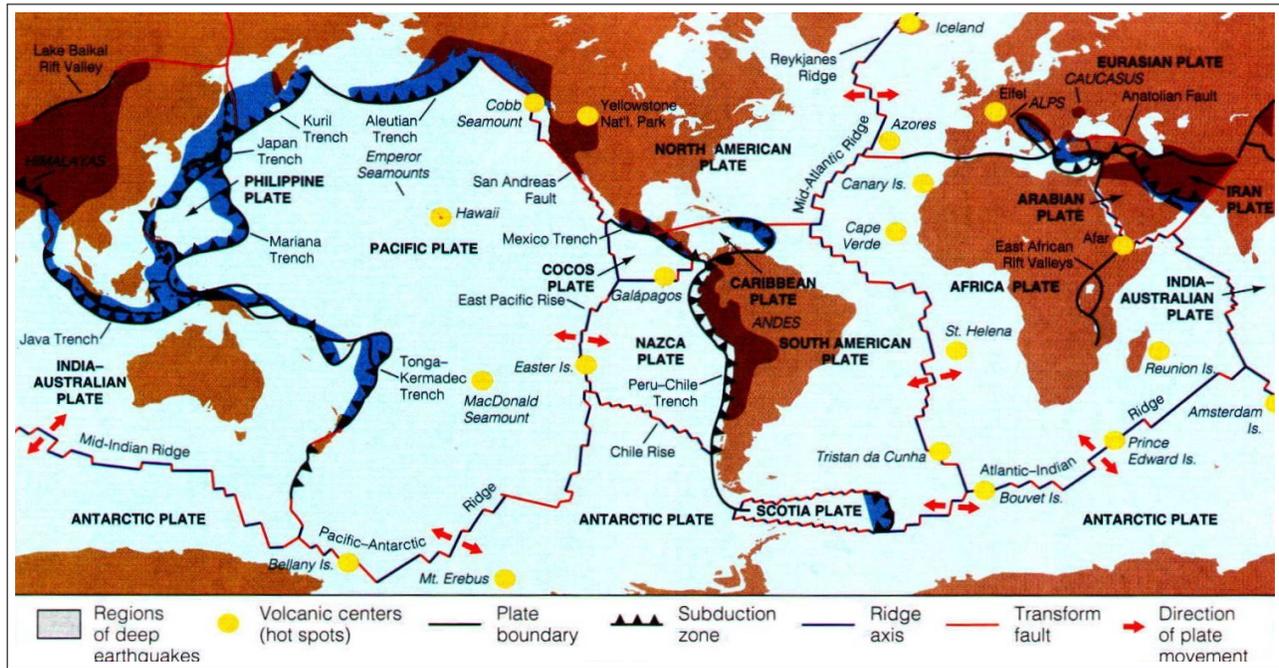
## Yellowstone hotspot



Hawaiian hotspot



Hotspots, trenches, ridges and plates



## 11 History of Life

### 11.1 The Really Short History of Life

#### Introduction to Biogeography and Tropical Biology

[http://ashipunov.info/shipunov/school/biol\\_330/intr\\_biogeogr\\_trop\\_biol/intr\\_biogeogr\\_trop\\_biol.pdf](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 period was 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](http://ashipunov.info/shipunov/school/biol_330)
- [2] A. Shipunov. *Introduction to Biogeography 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](http://ashipunov.info/shipunov/school/biol_330/intr_biogeogr_trop_biol/intr_biogeogr_trop_biol.pdf)

## Outline

Darwin Day and extra credit

## 12 History of Life

### 12.1 The Really Short History of Life

Introduction to Biogeography and Tropical Biology

[http://ashipunov.info/shipunov/school/biol\\_330/intr\\_biogeogr\\_trop\\_biol/intr\\_biogeogr\\_trop\\_biol.pdf](http://ashipunov.info/shipunov/school/biol_330/intr_biogeogr_trop_biol/intr_biogeogr_trop_biol.pdf)

Questions?

## 13 Very Basics of Ecology

### 13.1 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

	<b>Phototrophs</b>	<b>Lithotrophs</b>	<b>Organotrophs</b>
<b>Autotrophs</b>	Plants	Bacteria	Bacteria
<b>Heterotrophs</b>	Bacteria	Bacteria	Animals

## 13.2 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

## 13.3 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 <sup>1</sup>	exploitation <sup>2</sup>
0	...	neutralism	amensalism
–	...	...	interference <sup>3</sup>

<sup>1</sup> Includes phoresy (transportation), inquilinism (housing) and metabiosis (“sponging” like in sucker fishes)

<sup>2</sup> Includes predation, parasitism and phytophagy

<sup>3</sup> 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](http://ashipunov.info/shipunov/school/biol_330)
- [2] A. Shipunov. *Introduction to Biogeography 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](http://ashipunov.info/shipunov/school/biol_330/intr_biogeogr_trop_biol/intr_biogeogr_trop_biol.pdf)

## Outline

Darwin Day and extra credit

## 14 Very Basics of Ecology

### 14.1 Human-related ecological factors

#### Anthropogenic factors

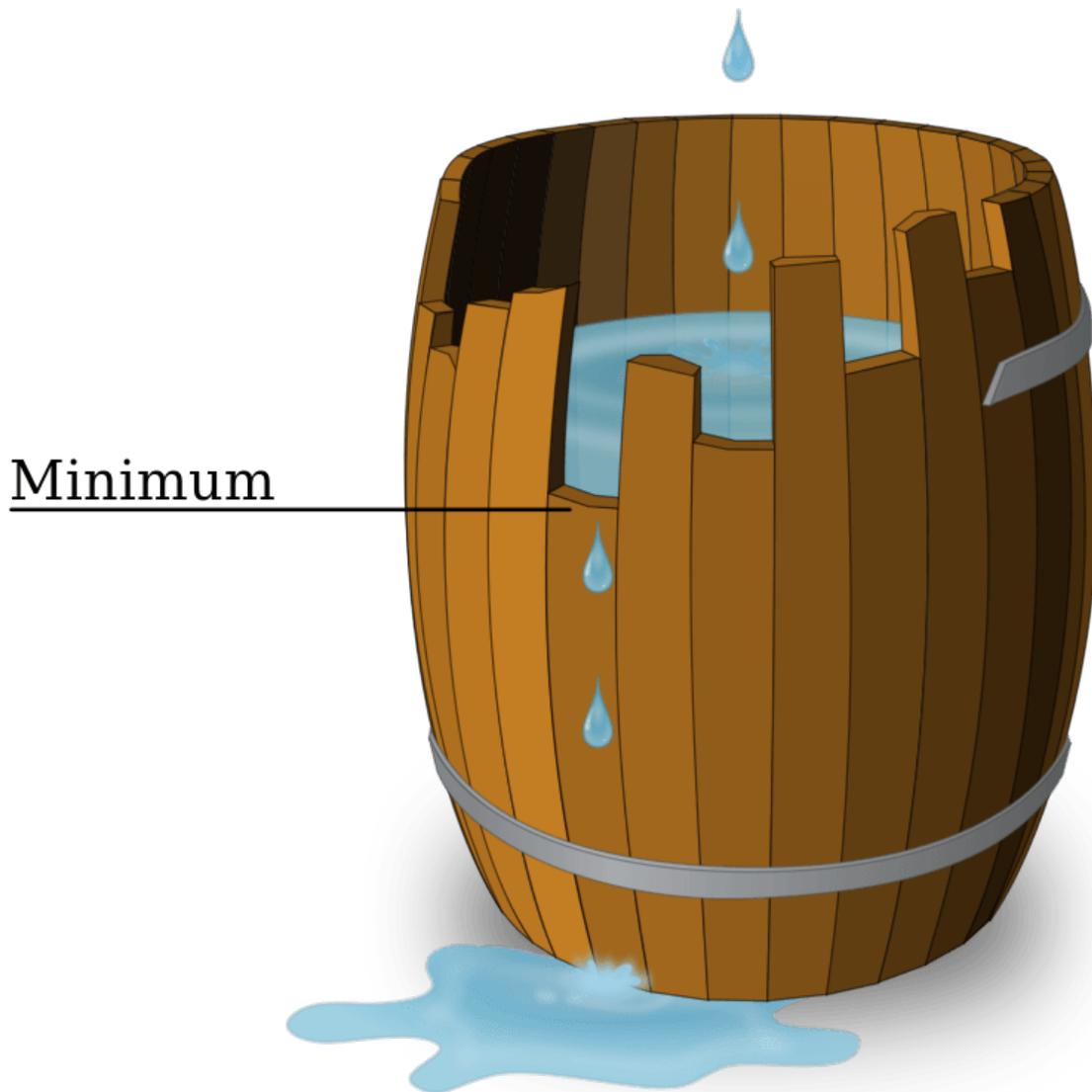
- Direct
  - Collecting
  - Hunting
  - Plowing
  - Tree cutting
- Indirect
  - Grazing
  - Polluting
  - Melioration
  - Recreation

## 14.2 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



## 14.3 Ecosystems and biosphere

### Features of ecosystem

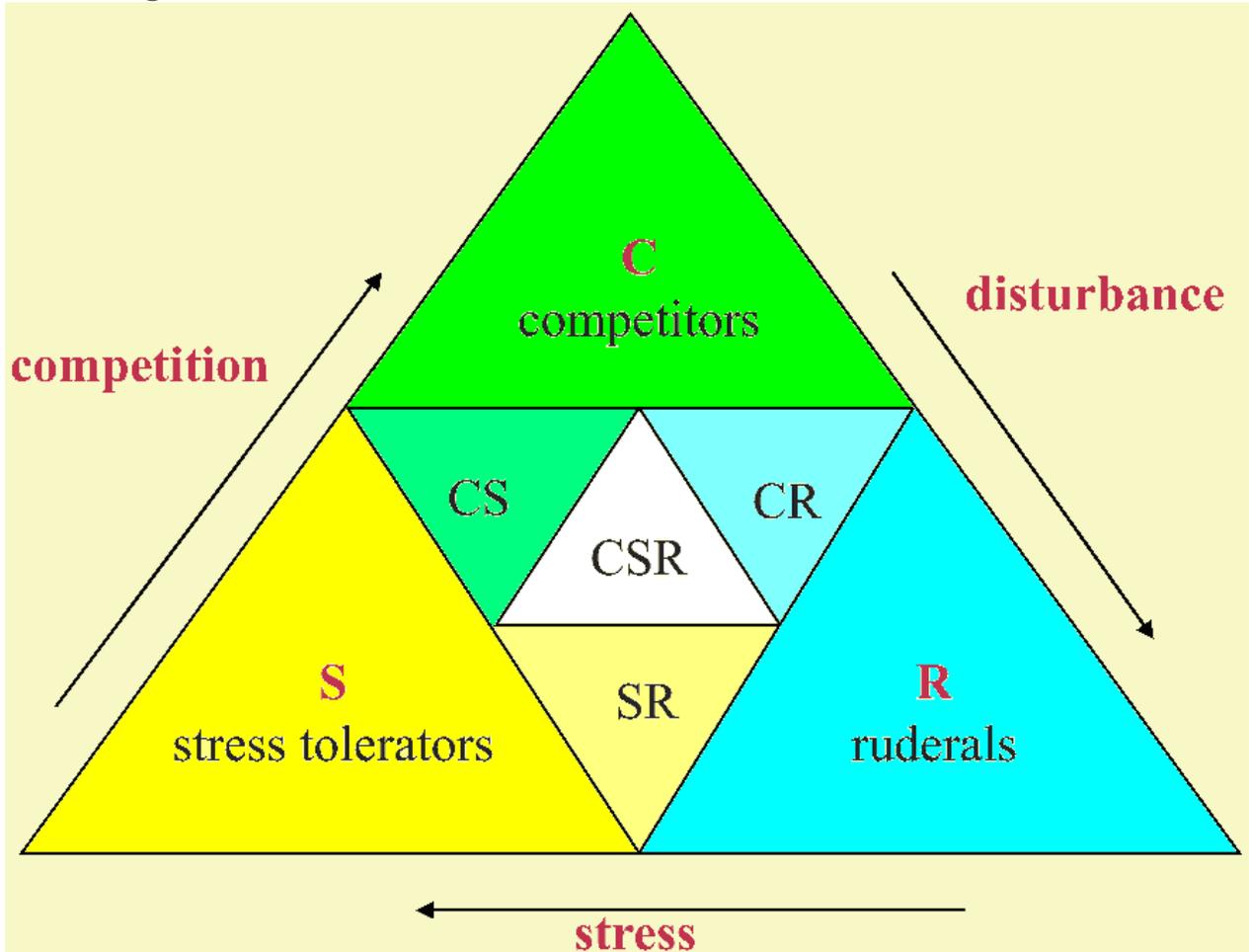
- Biomass, diversity, structure (feeding network, stratification)
- Self-reproduction and self-regulation
- Biosphere is the largest ecosystem possible

- Ecosystem could be split in different ways, for example into life forms and then into populations

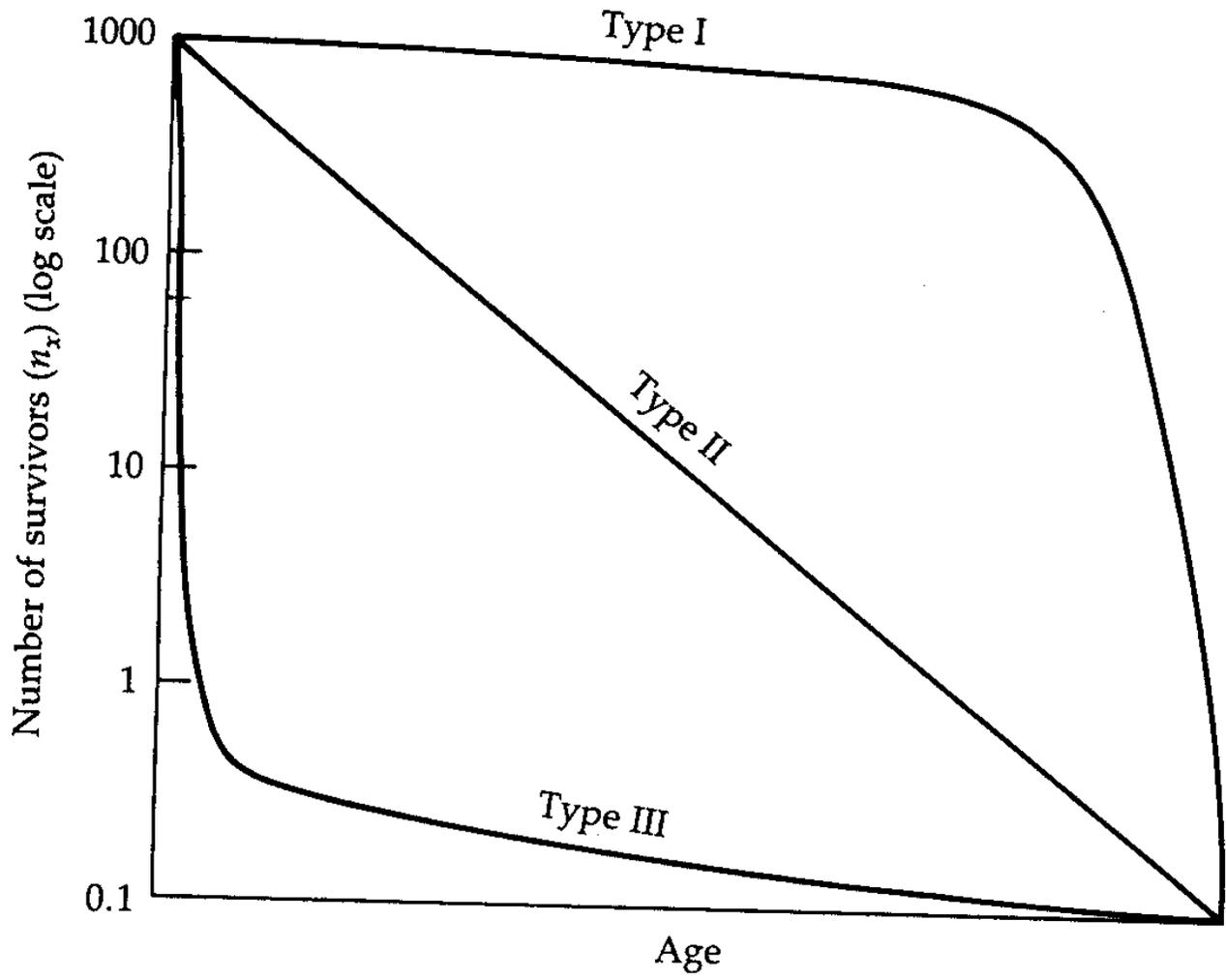
### Populations

- 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



Strategies

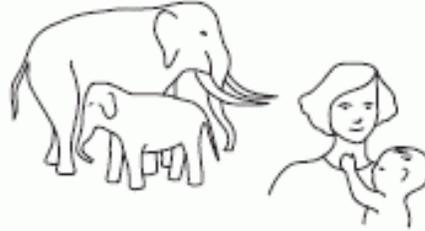
### *r strategy*

- Precarious equilibrium with the environment
- High rates of increase
- Violent and in some cases regular cycles of growth and decline



### *K strategy*

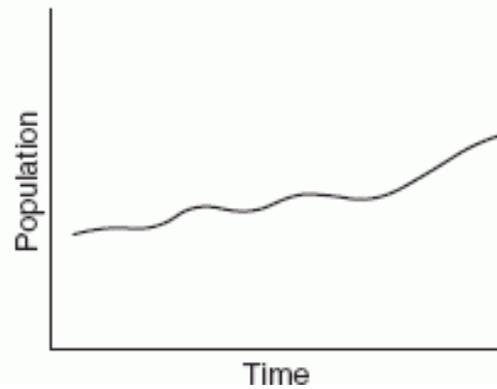
- Stable equilibrium with the environment
- Rates of increase compatible with environment
- Slow and irregular cycles



### *Bioreproductive characteristics*

- Small bodies
- Short lives
- Short gestation
- Large litters
- Short intervals between births
- Short length of generation
- High potential rates of growth

- Large bodies
- Long lives
- Long gestation
- Single births
- Long intervals between births
- Long generations
- Low potential rates of growth



## Food webs

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

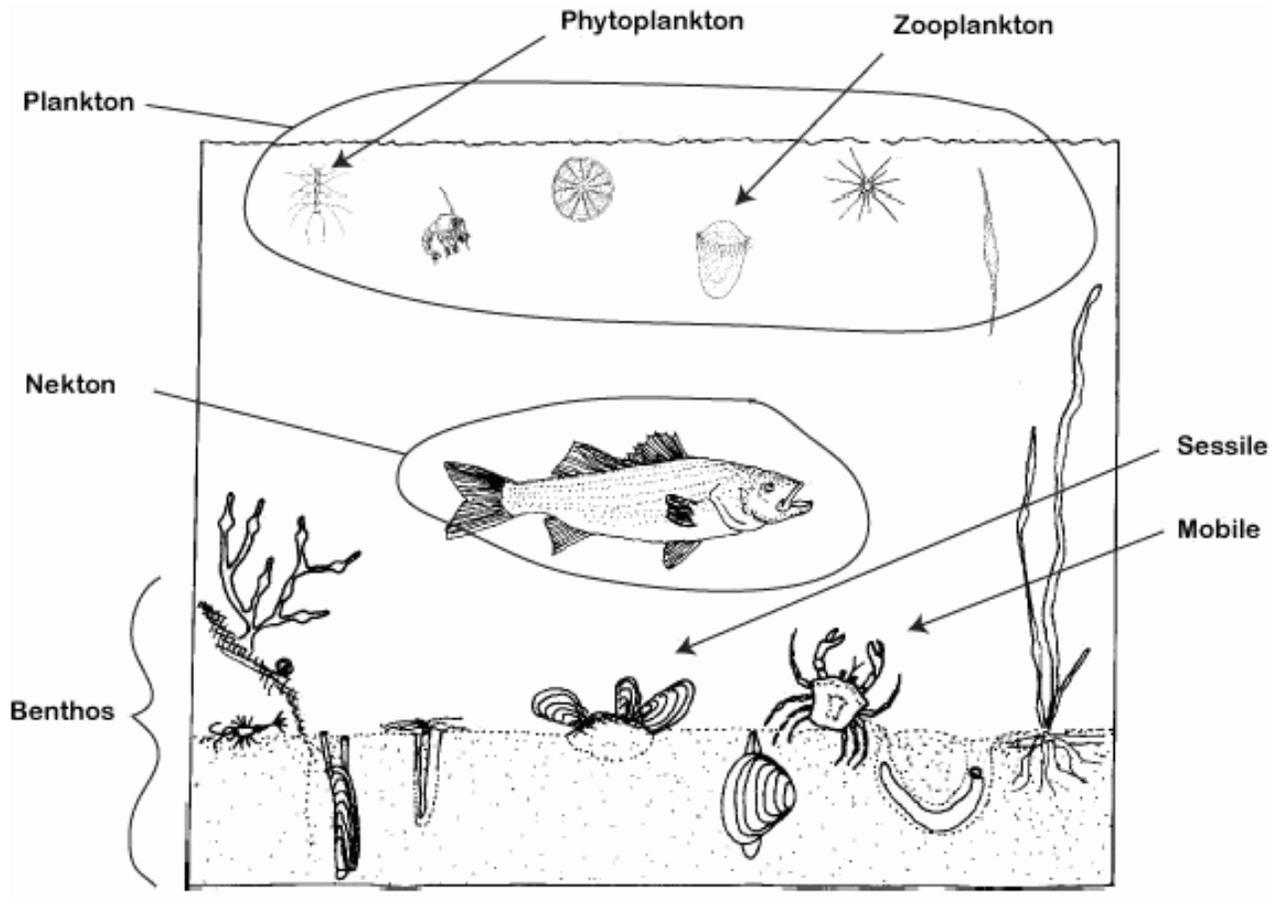
## Energy and biomass pyramid (terrestrial)



### Examples of ecosystems' structures

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

### Plankton, nekton and benthos



## 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

- [1] A. Shipunov. *Biogeography* [Electronic resource]. 2014—onwards. Mode of access: [http://ashipunov.info/shipunov/school/biol\\_330](http://ashipunov.info/shipunov/school/biol_330)
- [2] A. Shipunov. *Introduction to Biogeography 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](http://ashipunov.info/shipunov/school/biol_330/intr_biogeogr_trop_biol/intr_biogeogr_trop_biol.pdf)