Biogeography: BIOL 330
Study guide

Alexey Shipunov

Lectures

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`

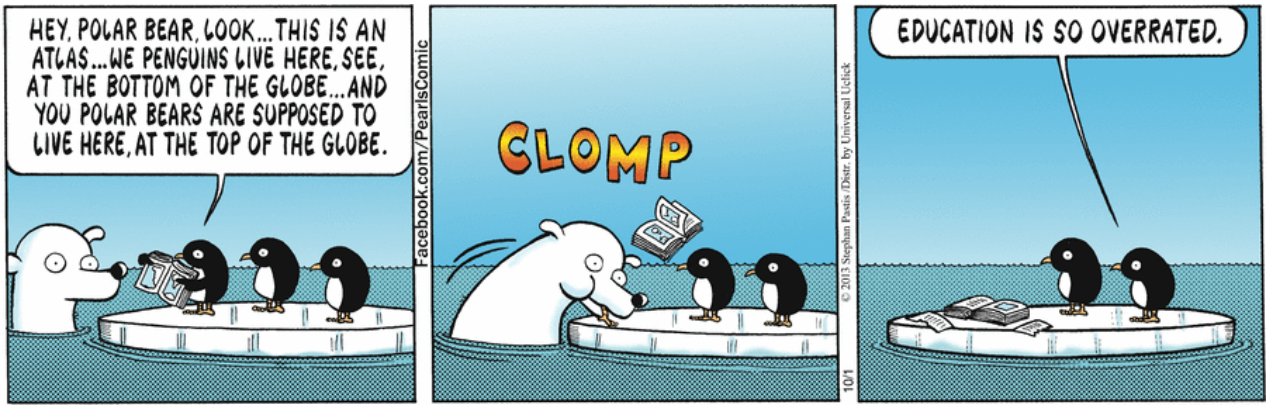
Outline

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/

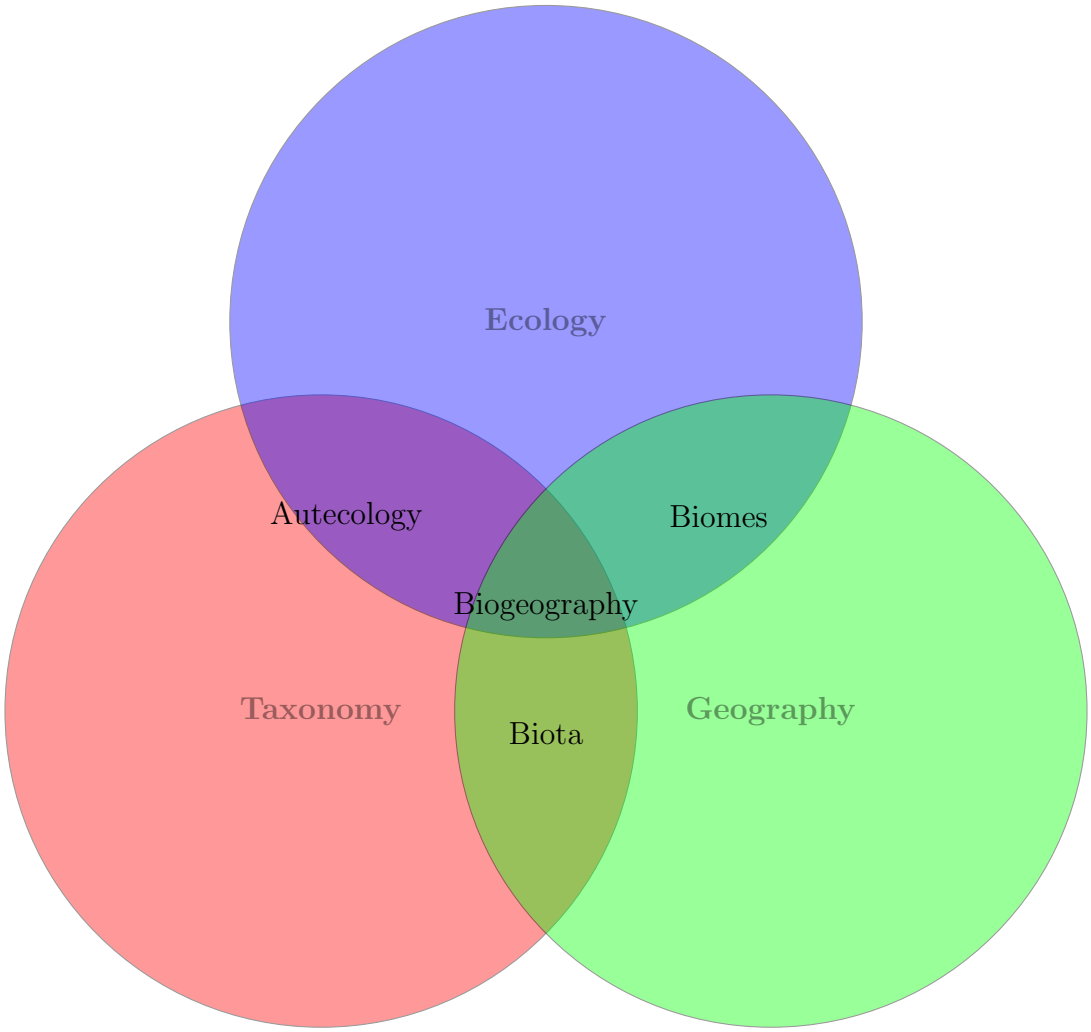
http://www.komar.org/faq/churchill_polar_bear_tours/other-animals-fun-stuff/Polar-Bear-BBQ-Penguin.gif

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

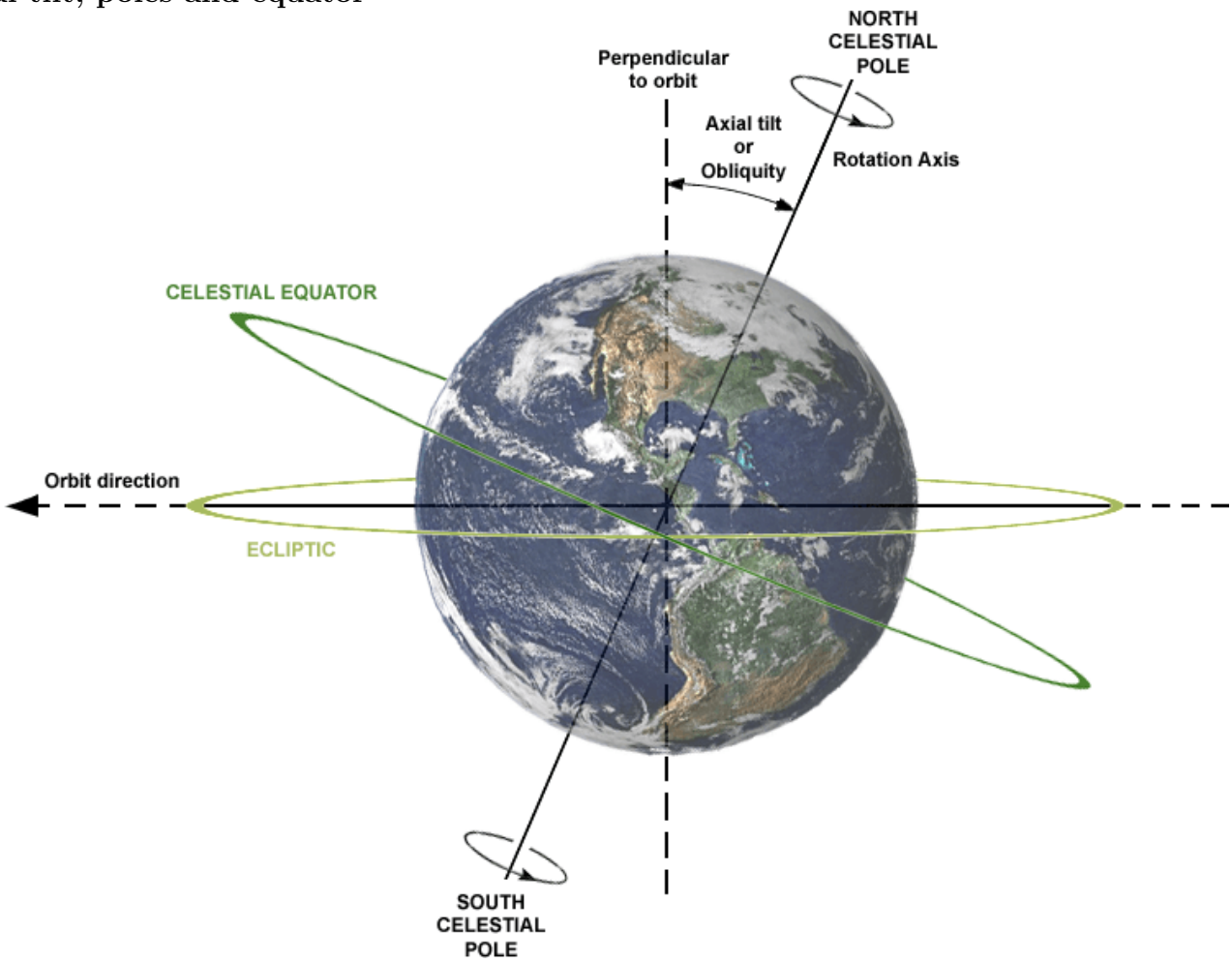
6 Basics of physical geography

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



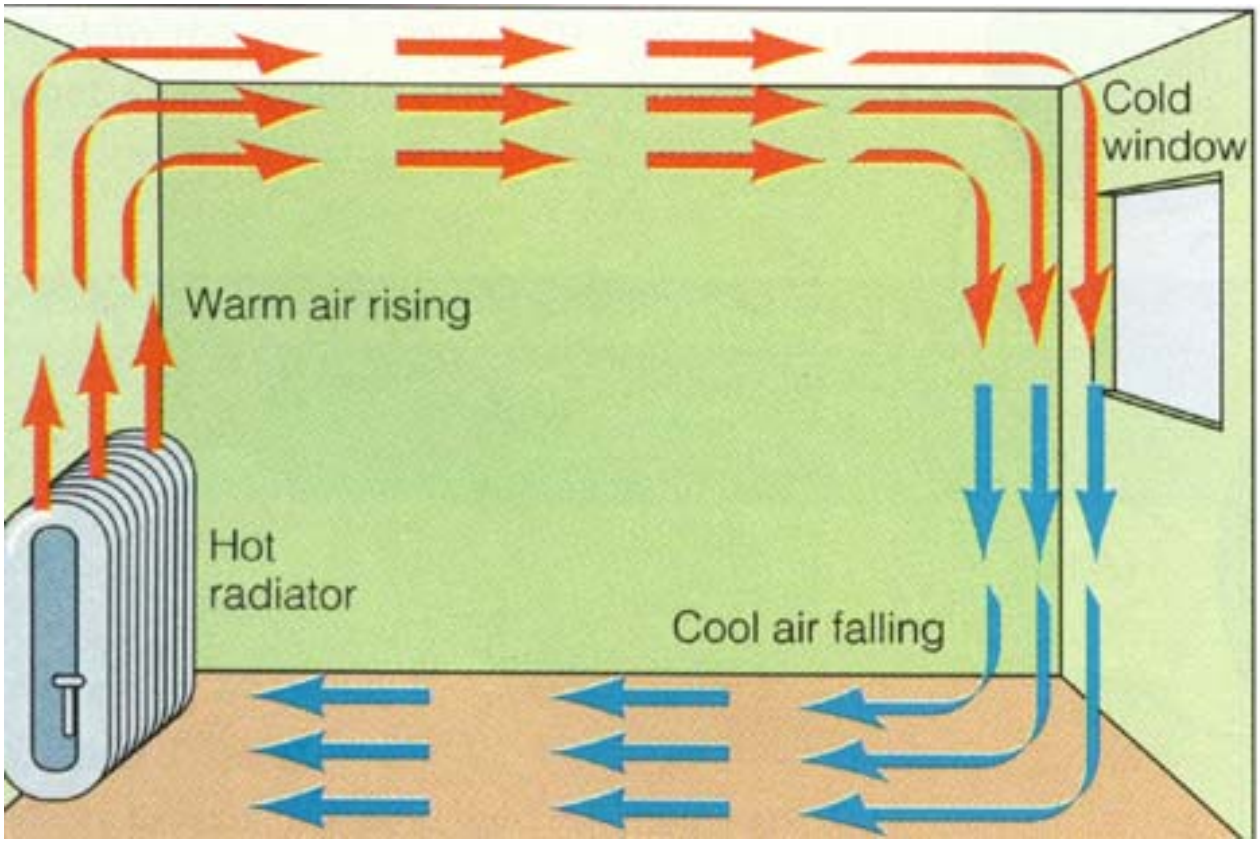
180° **Meridian, Taveuni, Fiji**

6.2 Basics of climatology

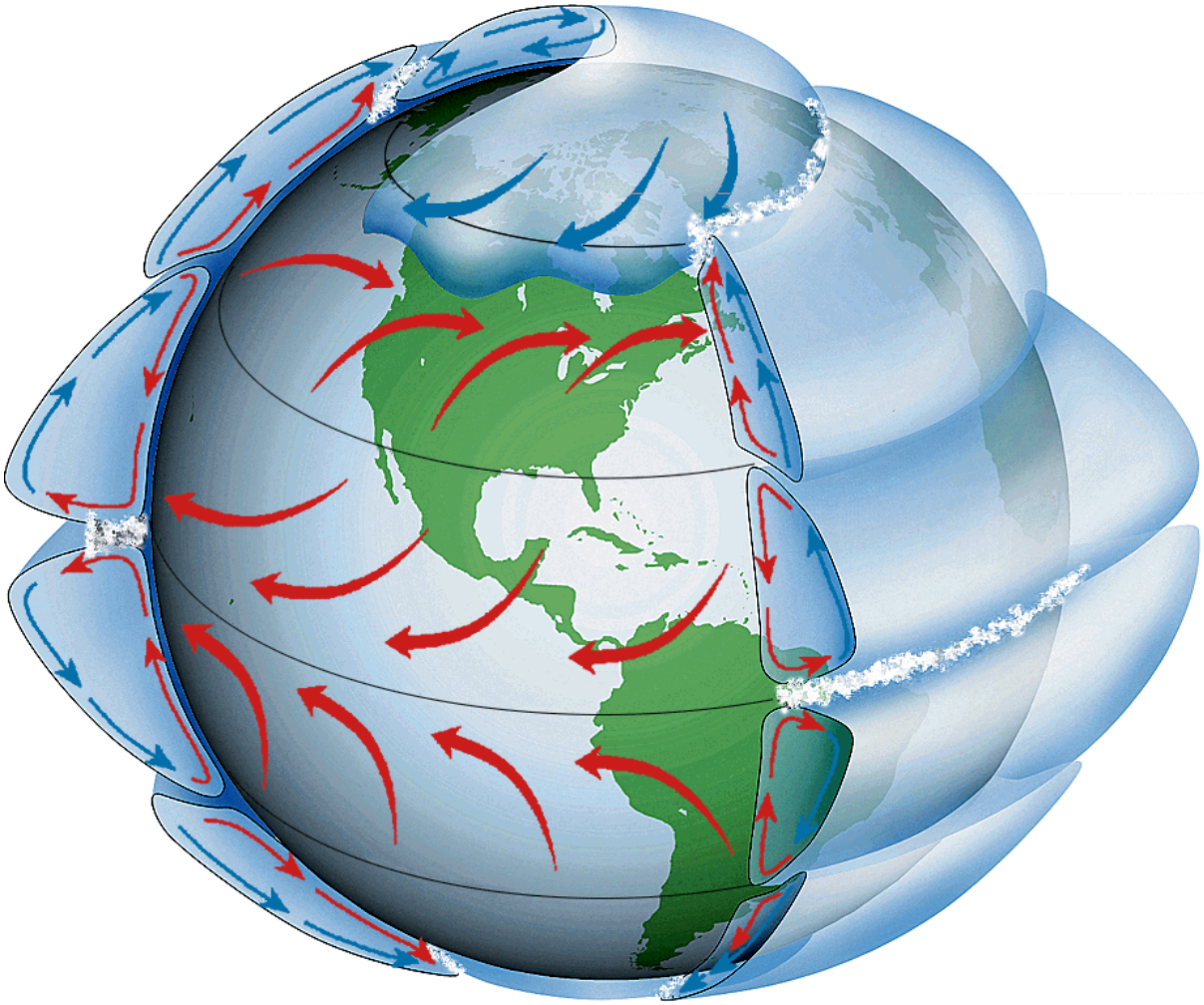
Atmospheric circulation

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

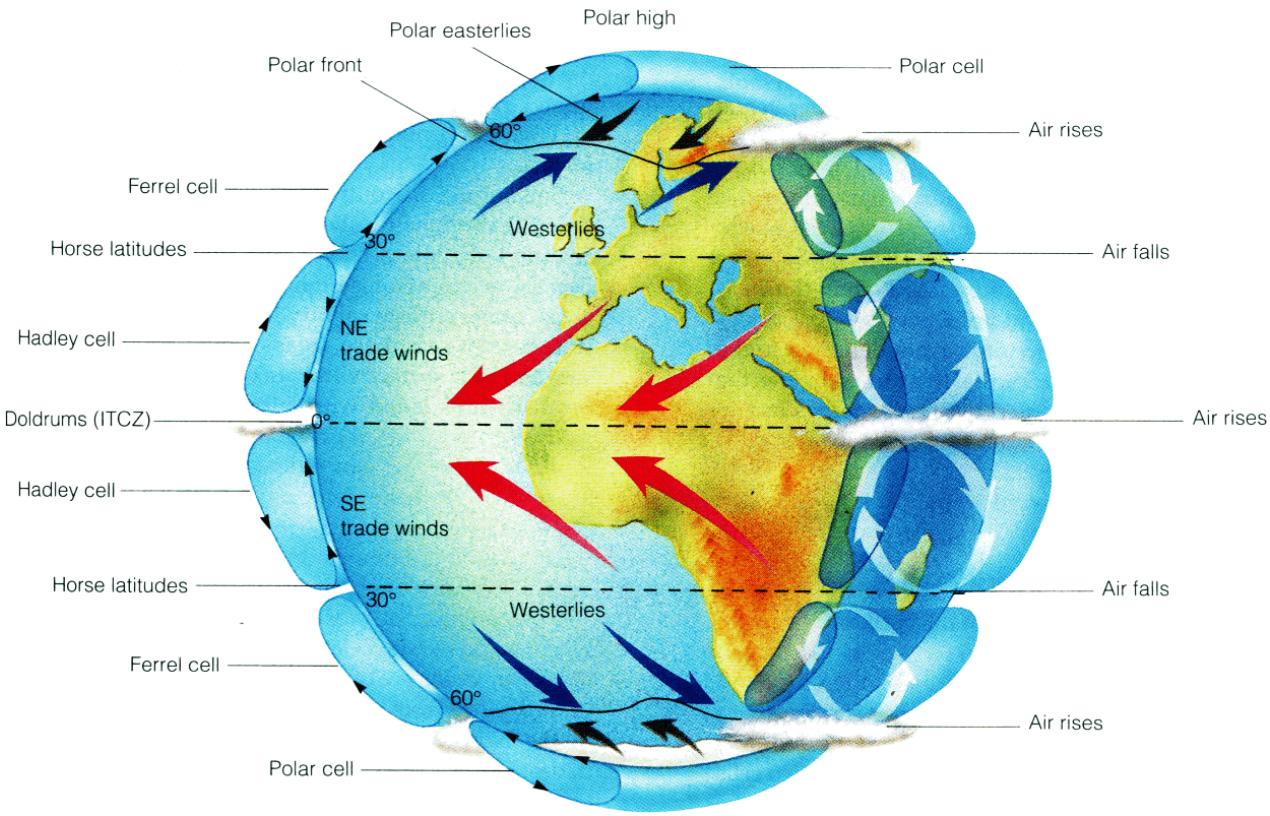
Circulation in a room



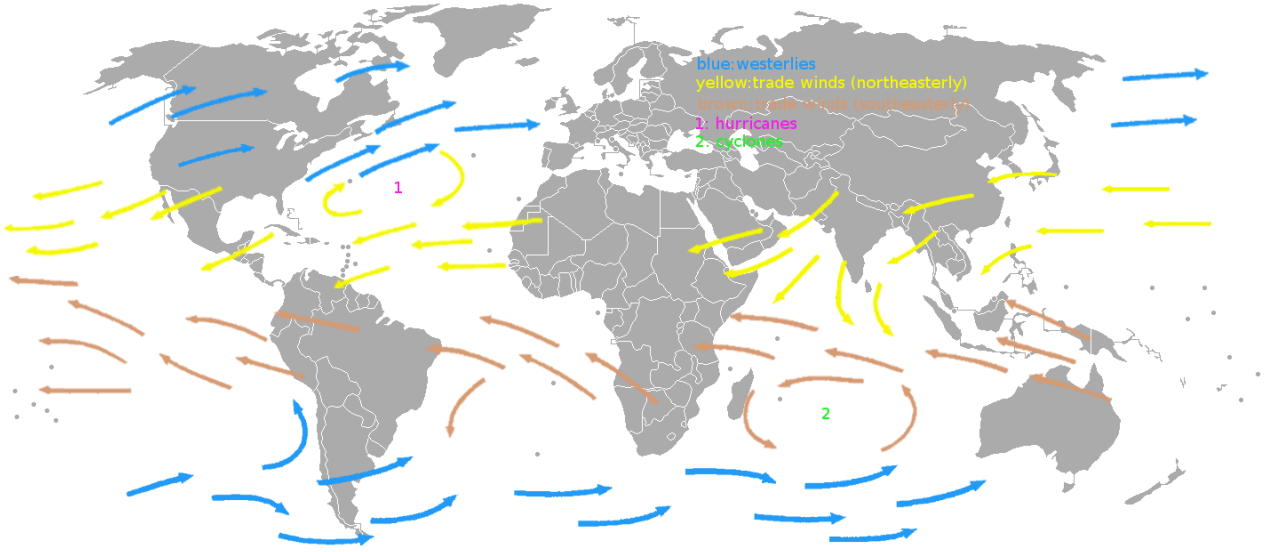
Idealized atmospheric circulation on Earth



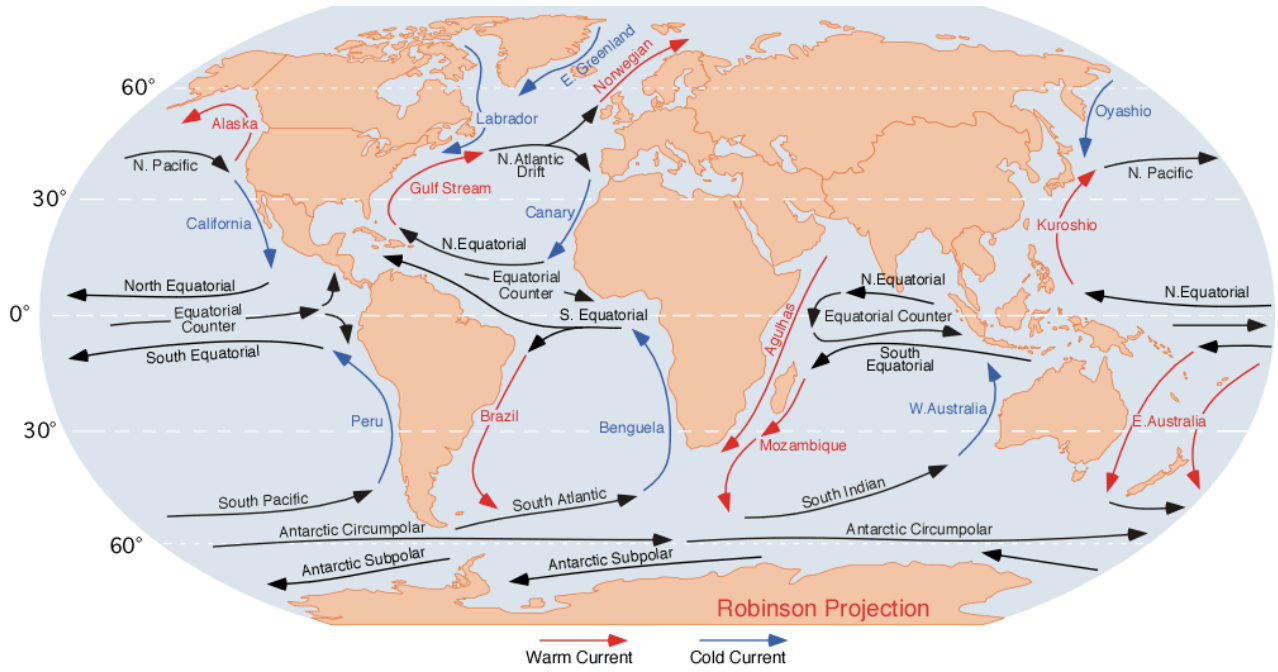
Idealized atmospheric circulation on Earth (with labels)



Prevailing winds



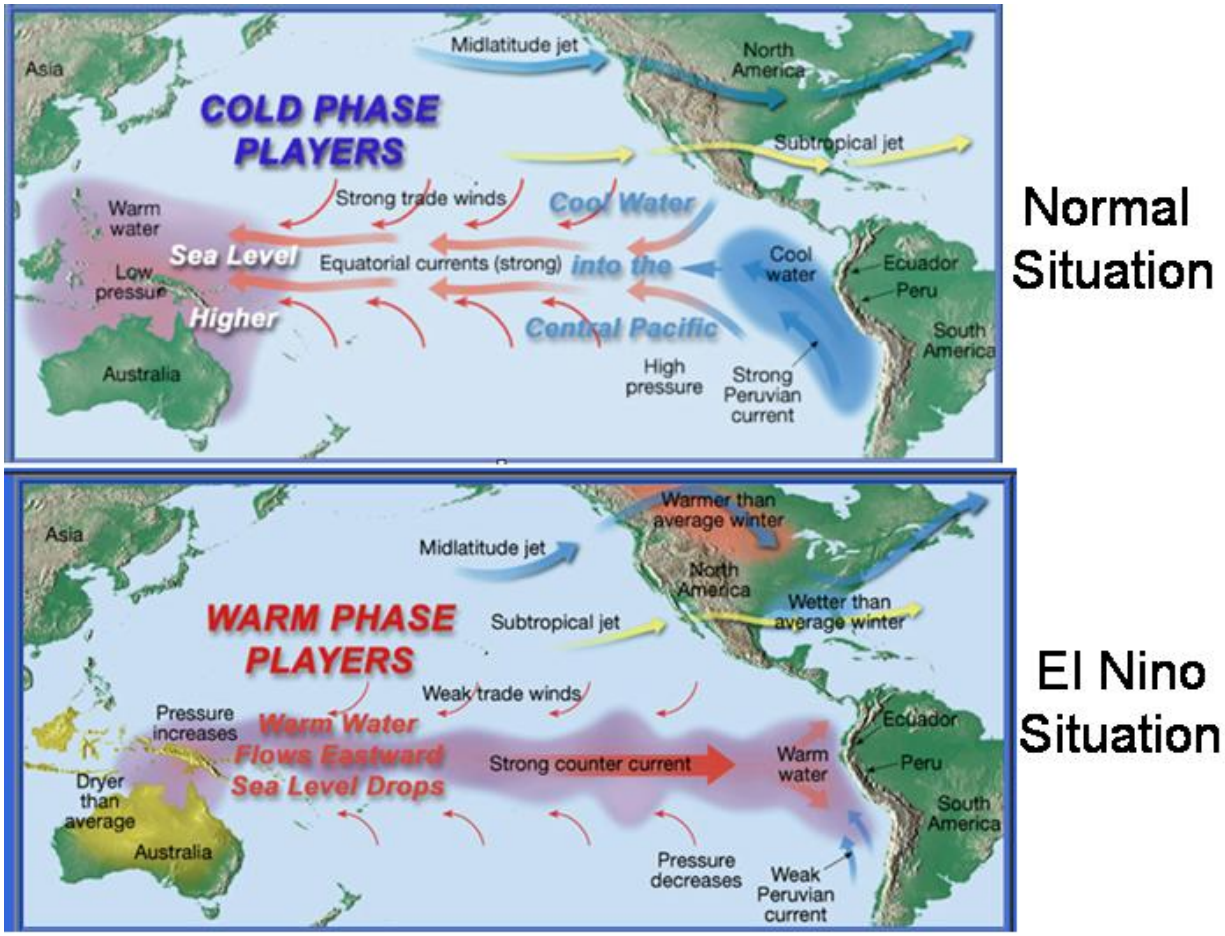
Ocean currents



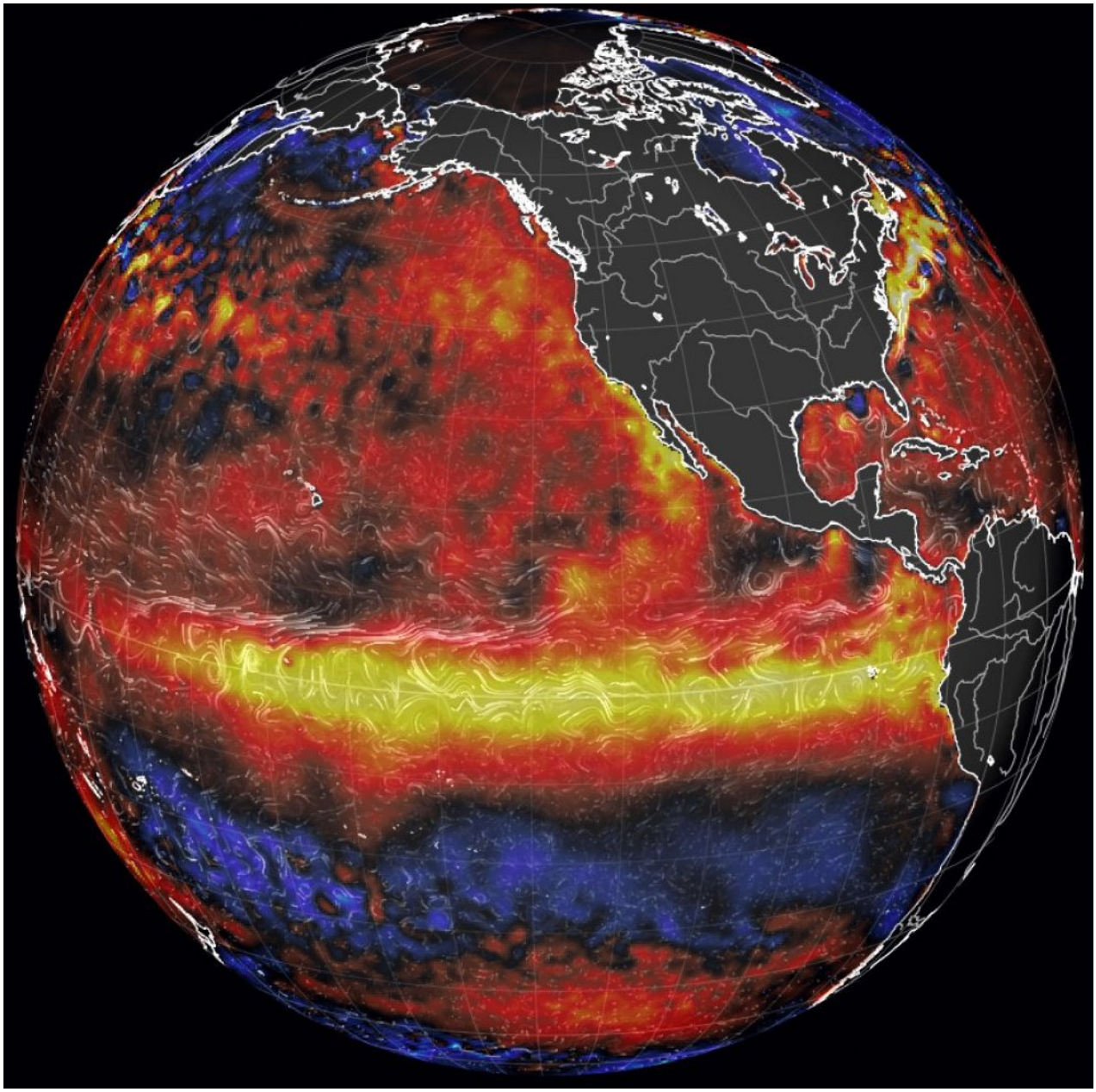
El Niño: climatic oscillation

- 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)



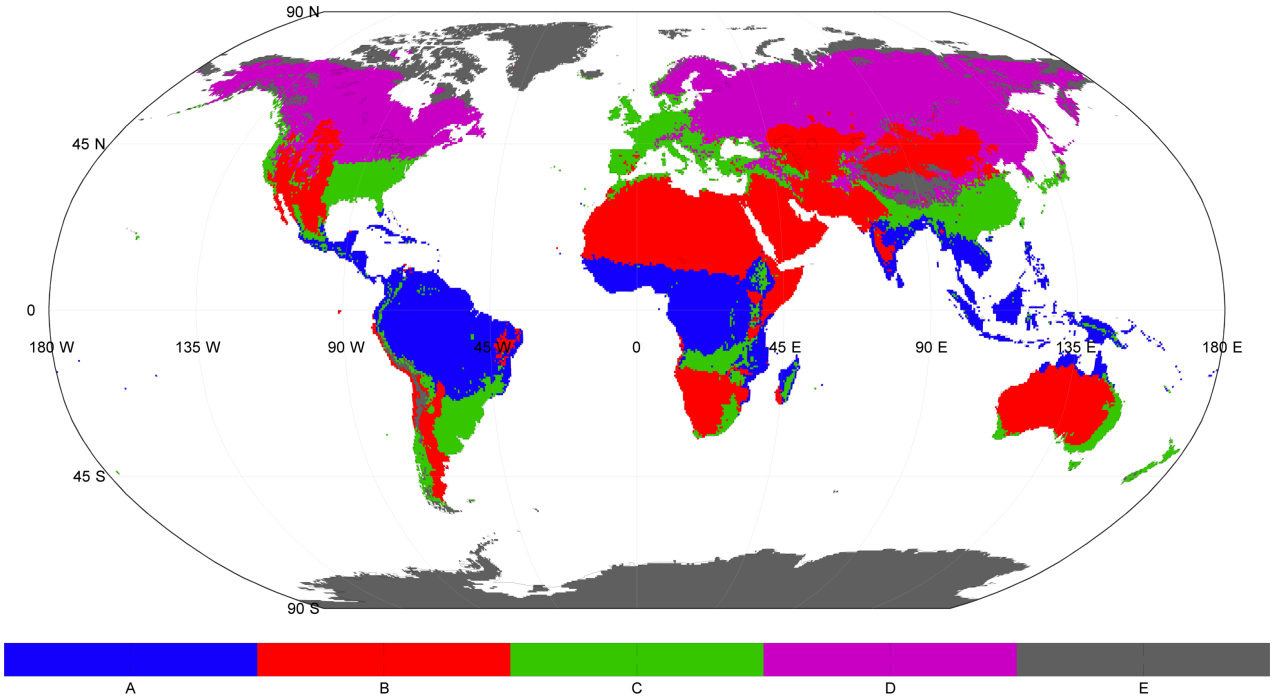
Seasons

- 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

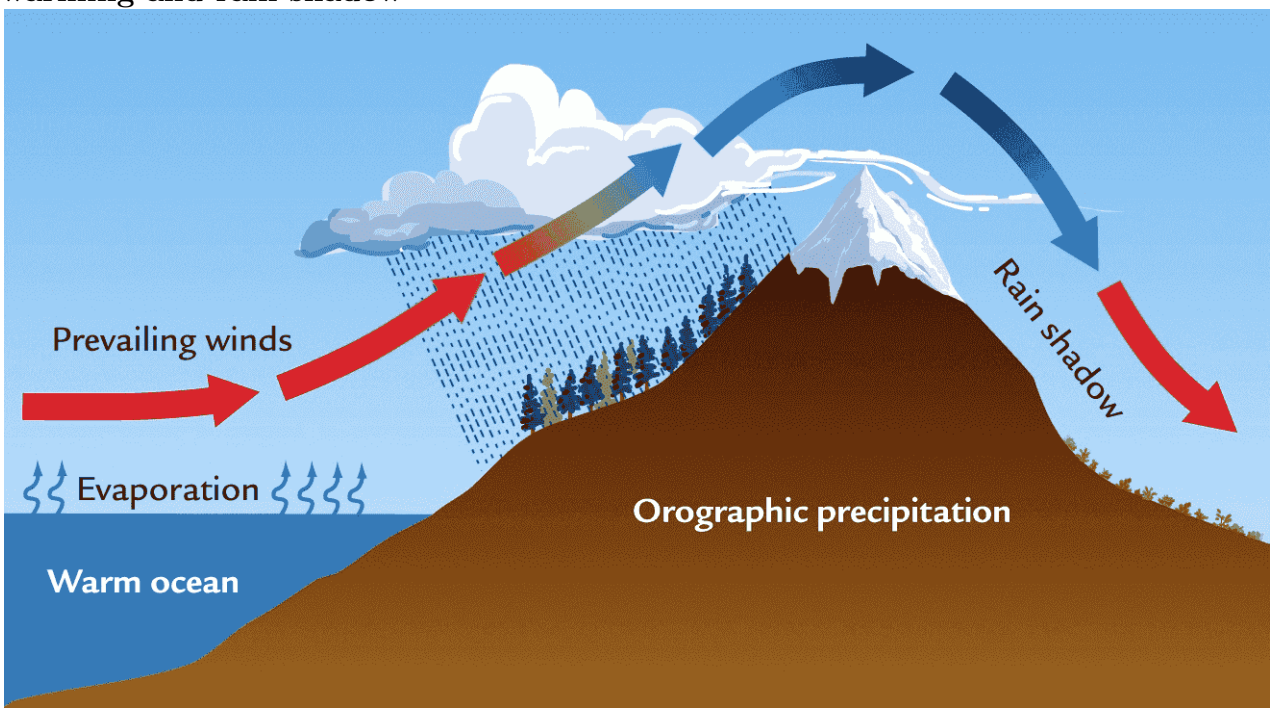
Koeppen climates



Climate and altitude

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

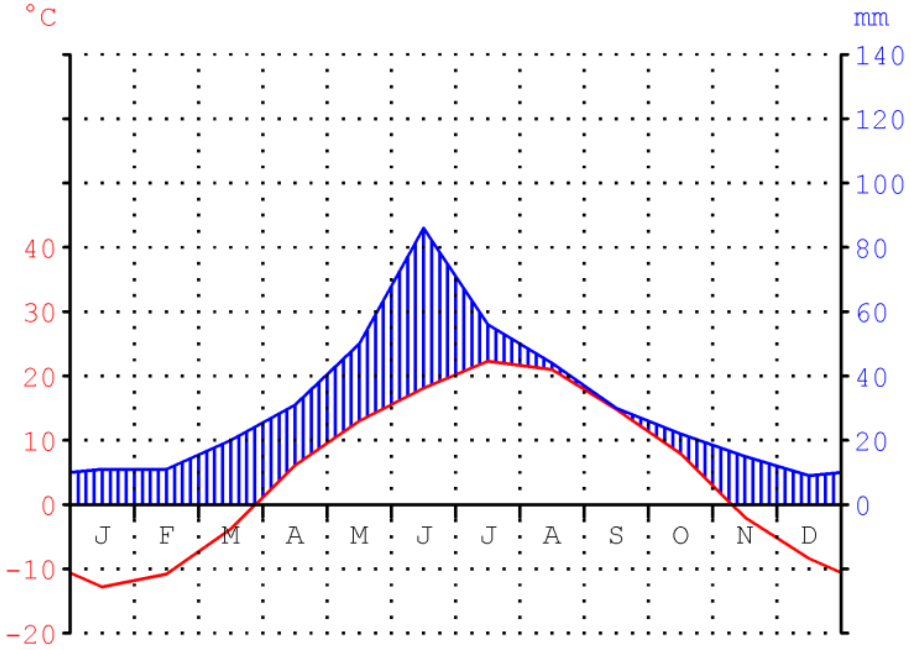
Sea warming and rain shadow



Climate diagram I

Erstellt mit Geoklima 2.1

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

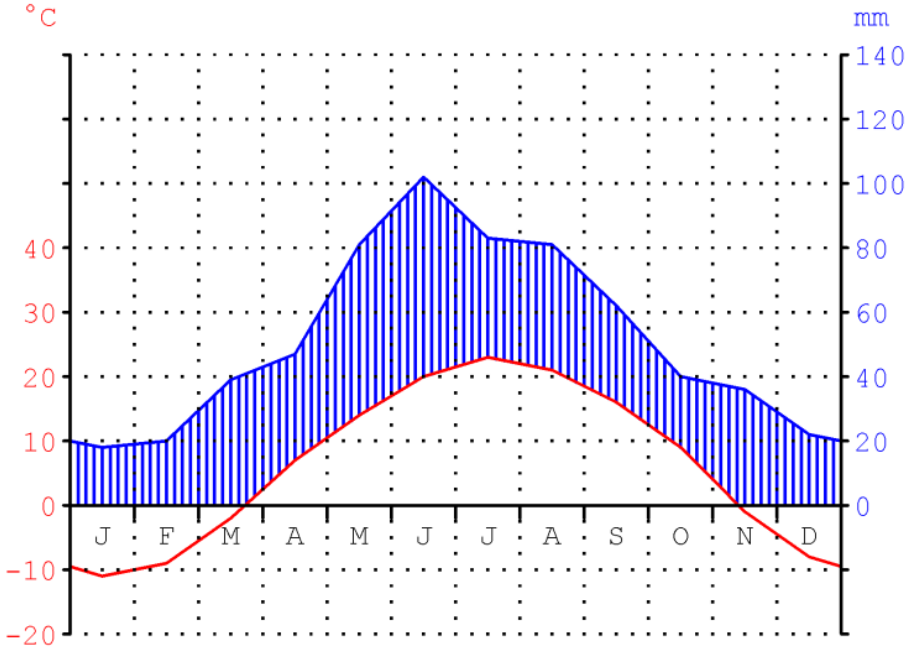
Temp.-Jahresmittel
5,4 °C

Niederschlagssumme
385 mm

Climate diagram II

Erstellt mit Geoklima 2.1

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

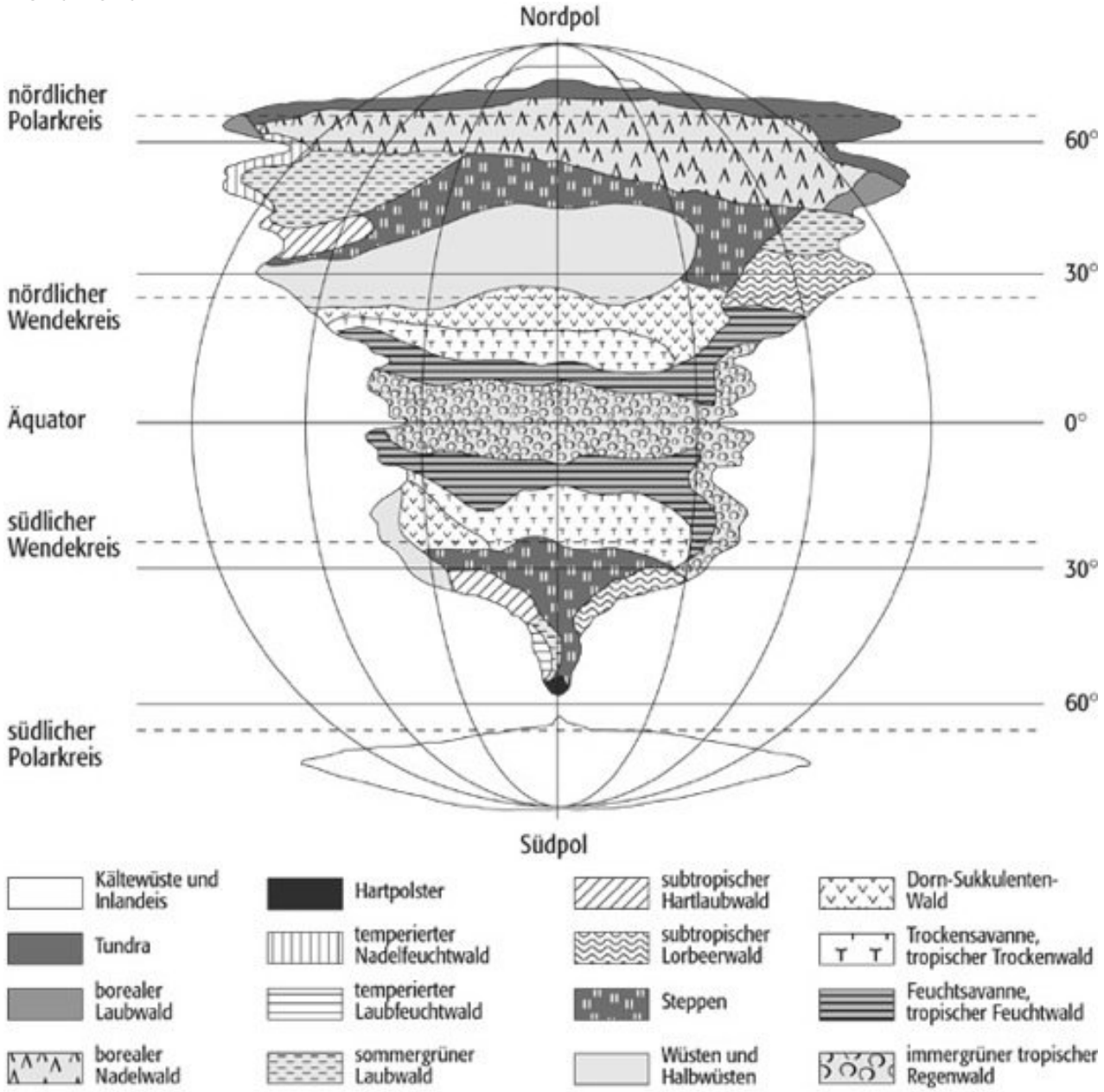
Temp.-Jahresmittel
6,6 °C

Niederschlagssumme
631 mm

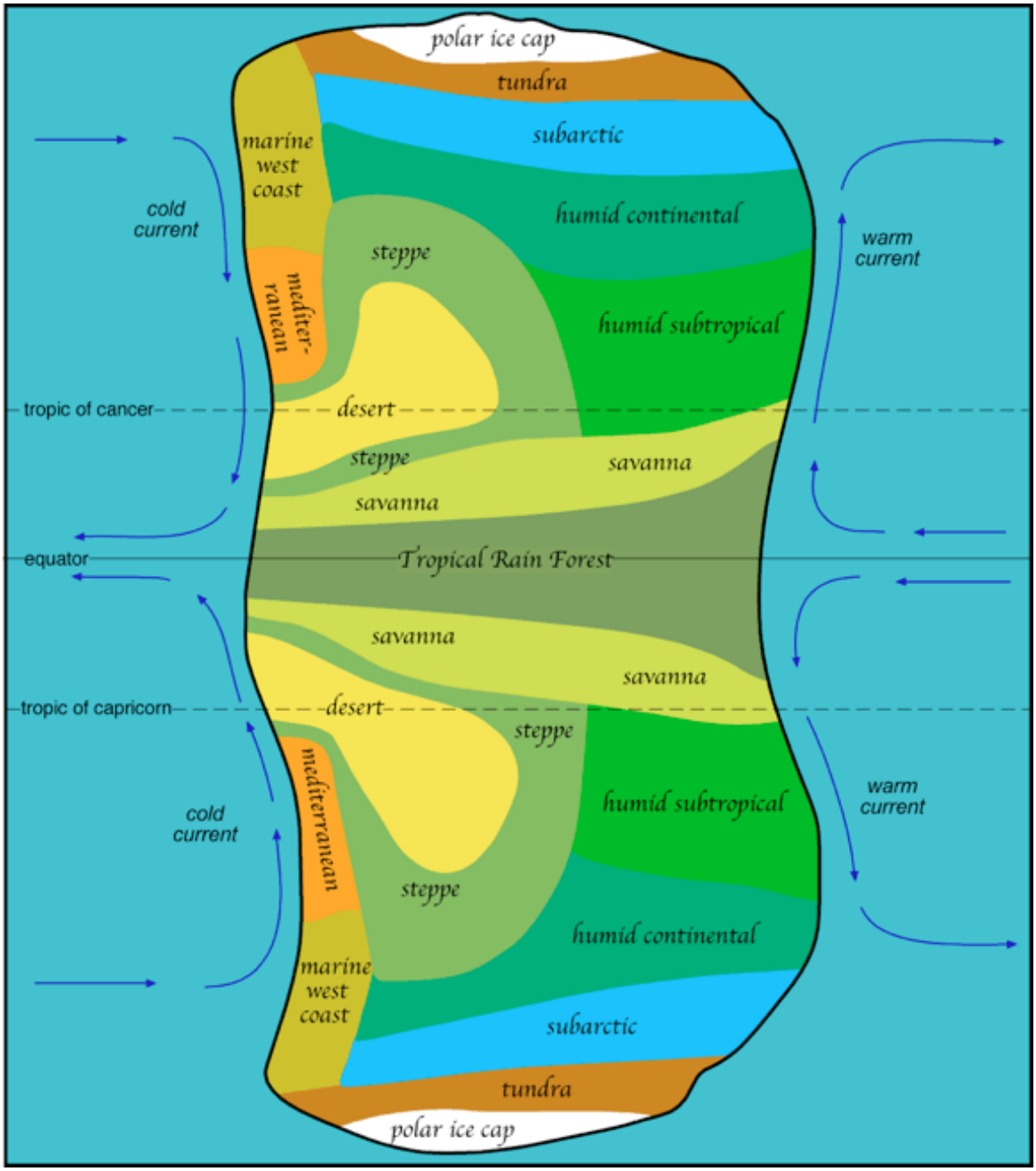
Climate and life

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

Idealkontinent



Hypothetical continent (another version)



Summary

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For Further Reading

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

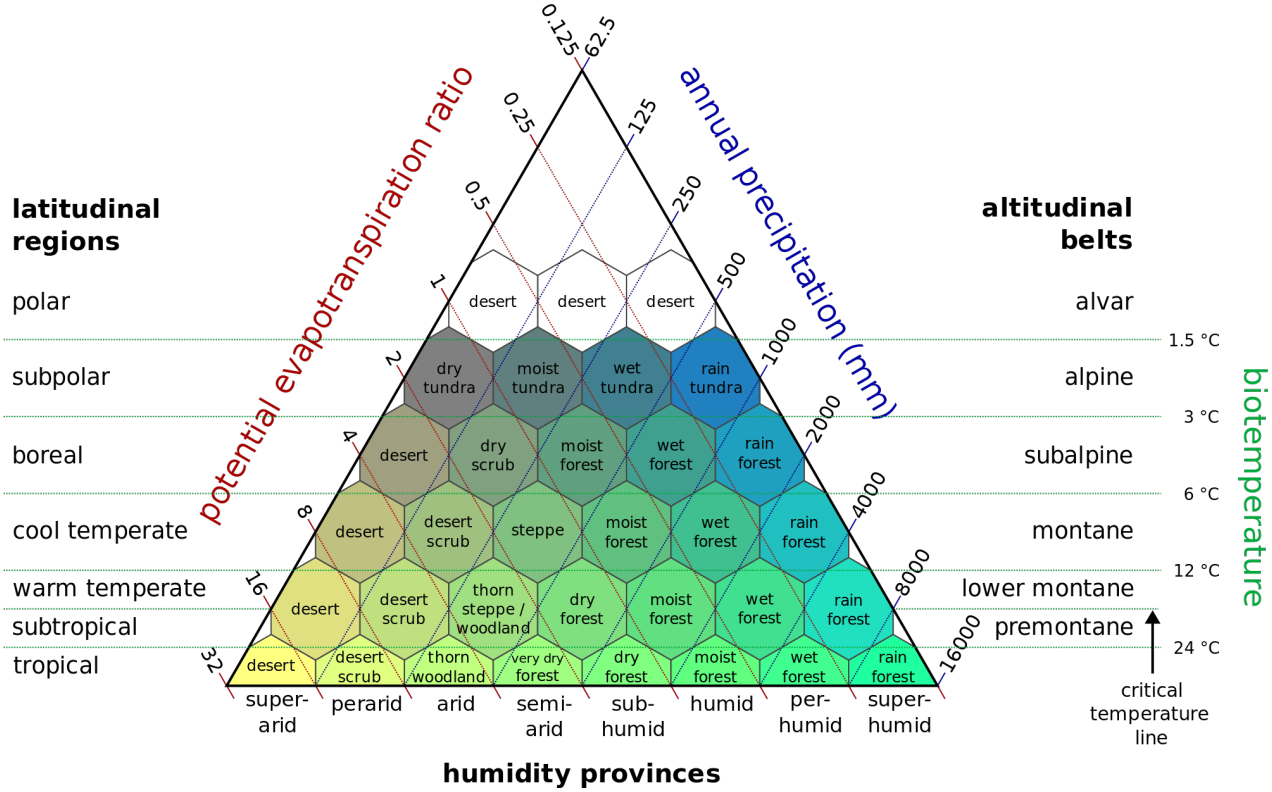
[3] Atmospheric circulation. http://en.wikipedia.org/wiki/Atmospheric_circulation

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

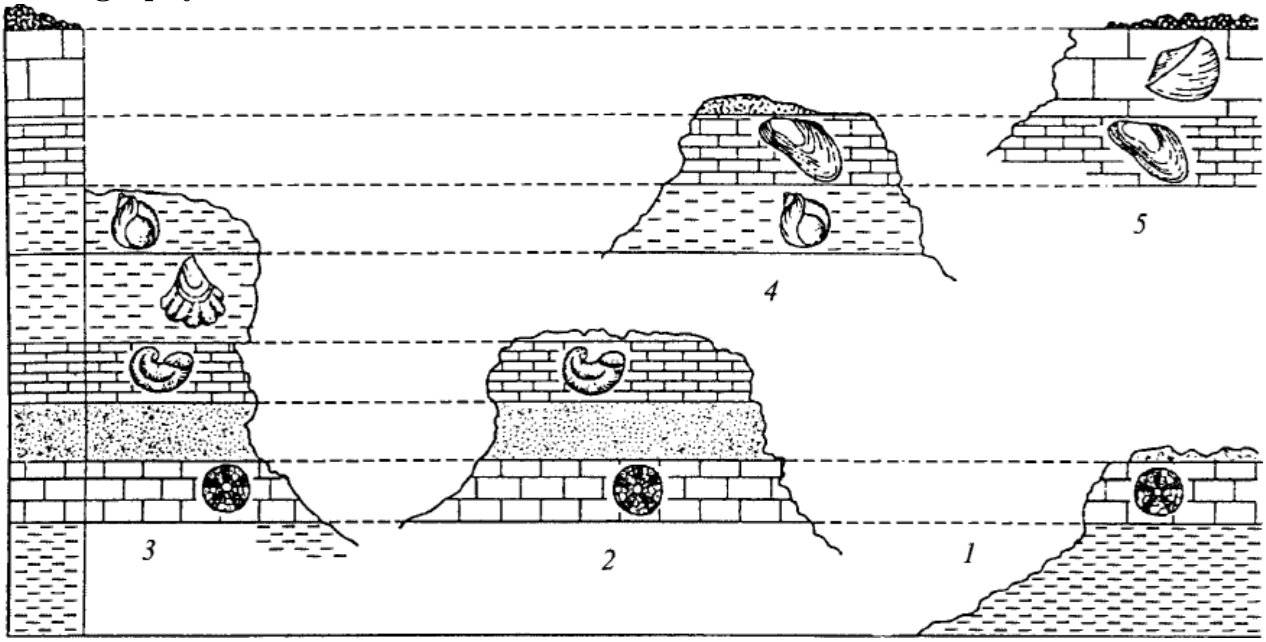
Use of radioactivity

- 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

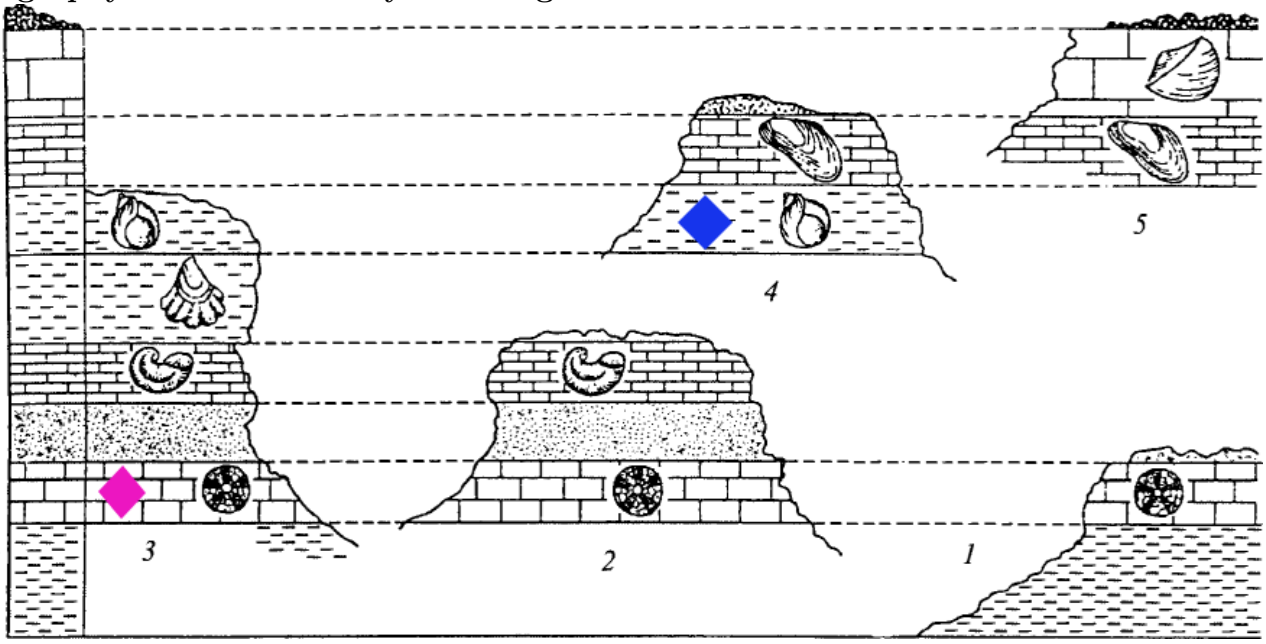
Stratigraphy

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

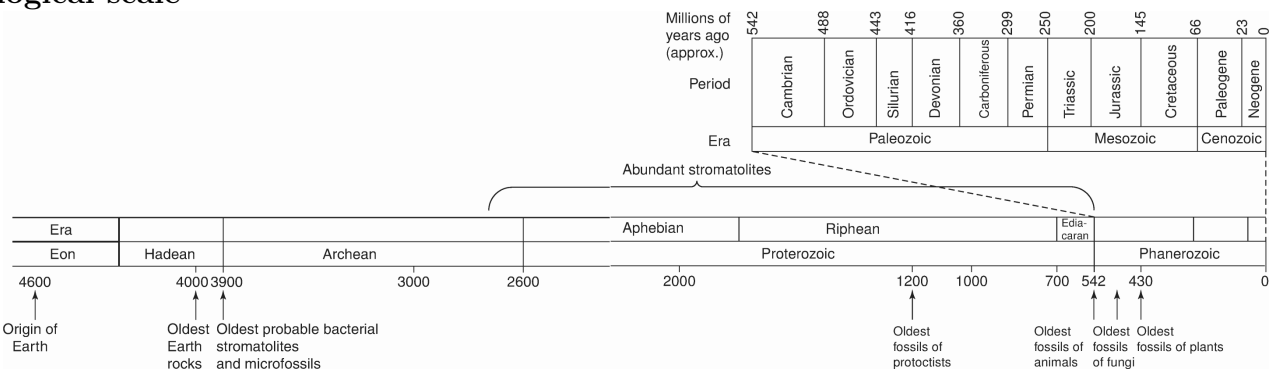
How stratigraphy works



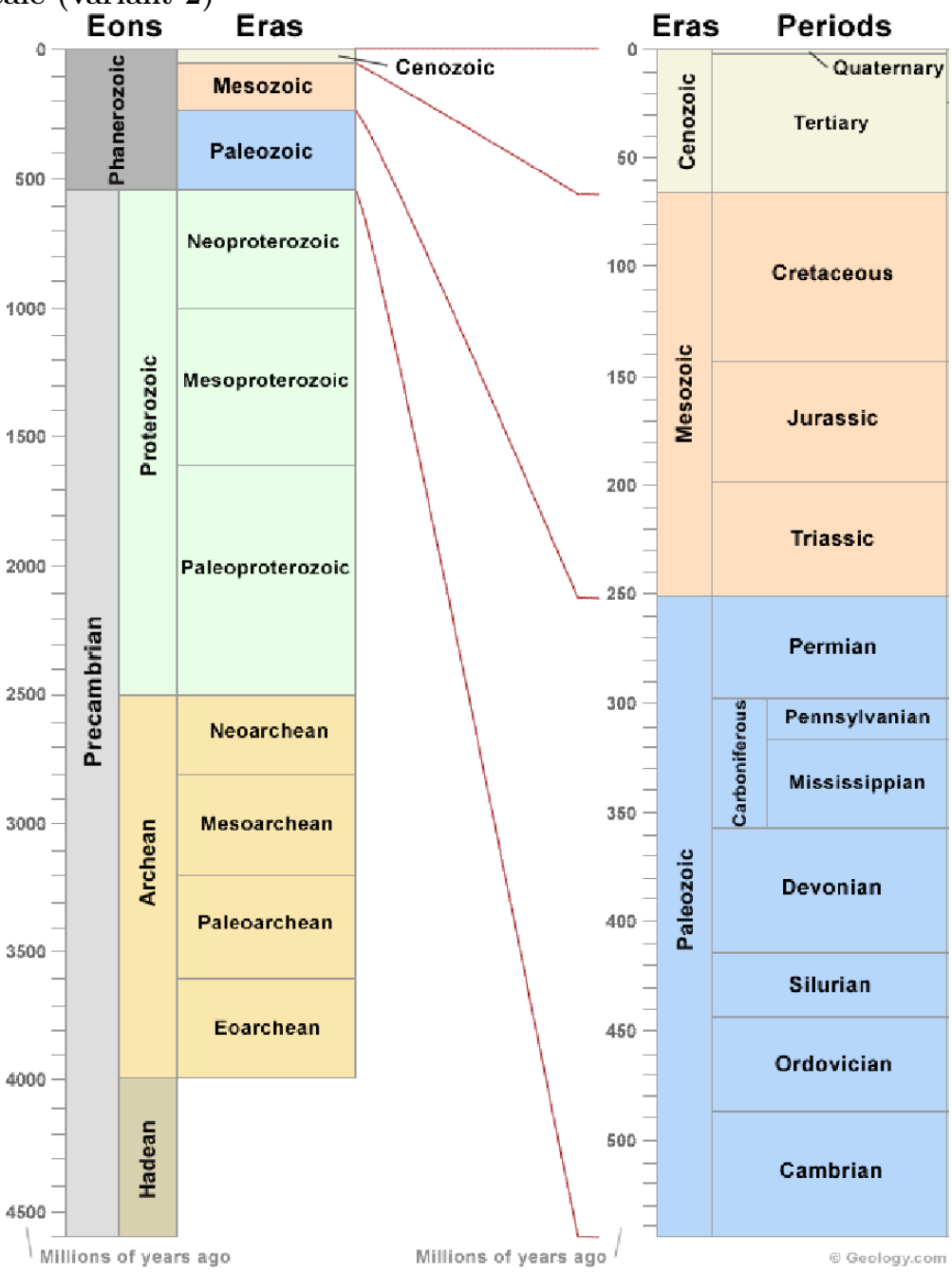
Stratigraphy and radioactivity work together



Geological scale



Geological scale (variant 2)



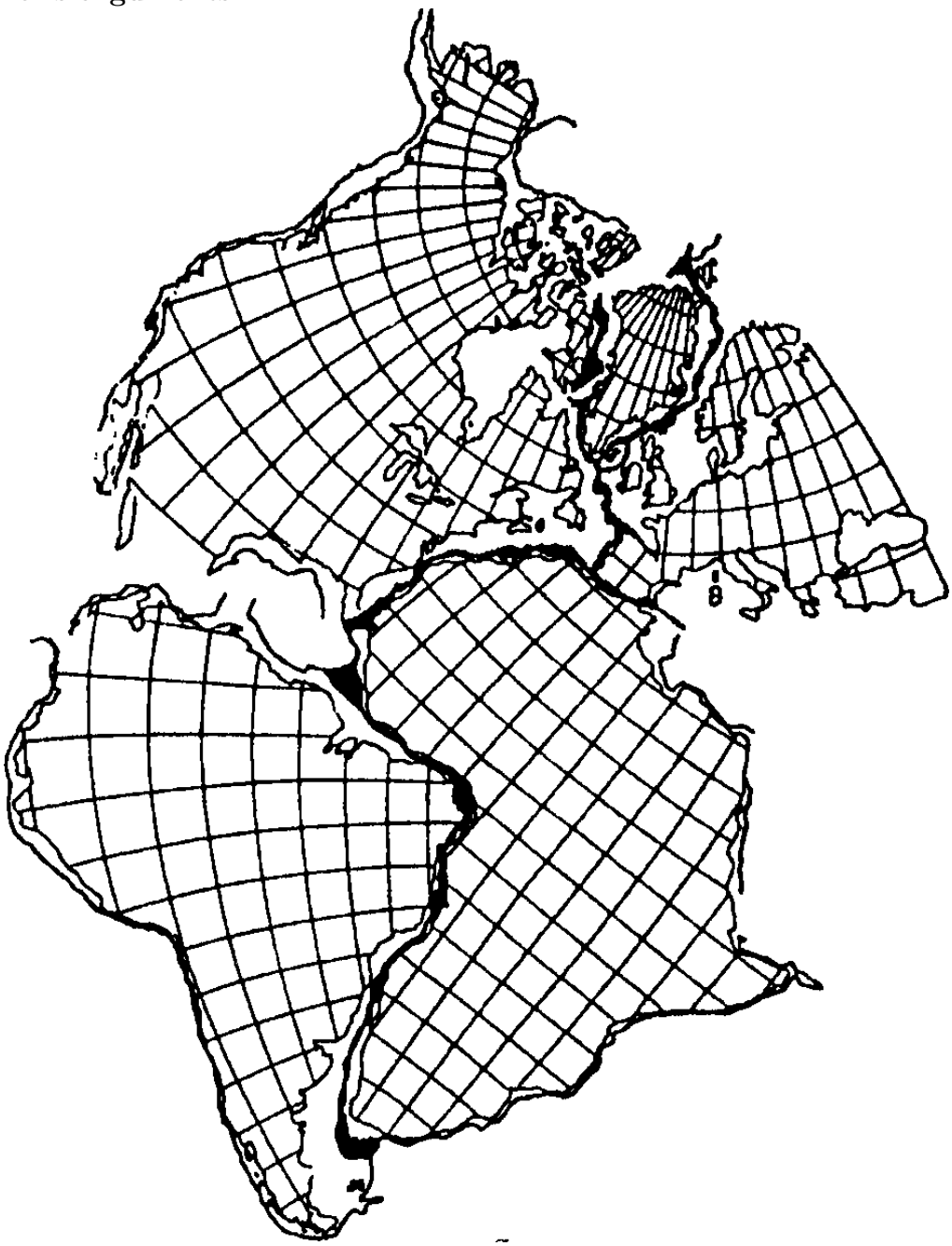
I want you to memorize eras and Mesozoic/Cenozoic periods.

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

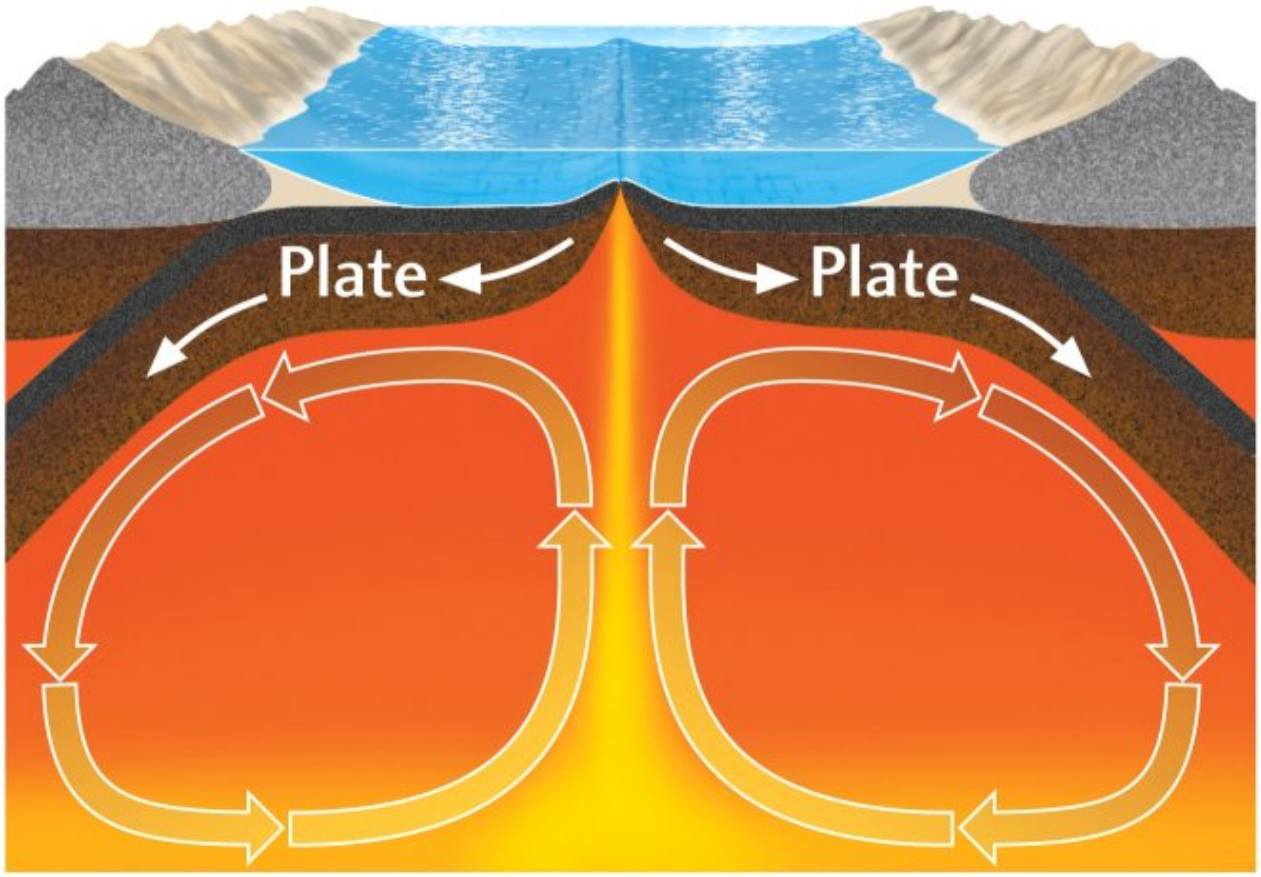
- The driving force of floating continents is a **mantle convection**
- In ocean ridges, new ocean cortex is constantly forming and expanding
- In ocean trenches and continental ridges, different plates are colliding and often forming mountains

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

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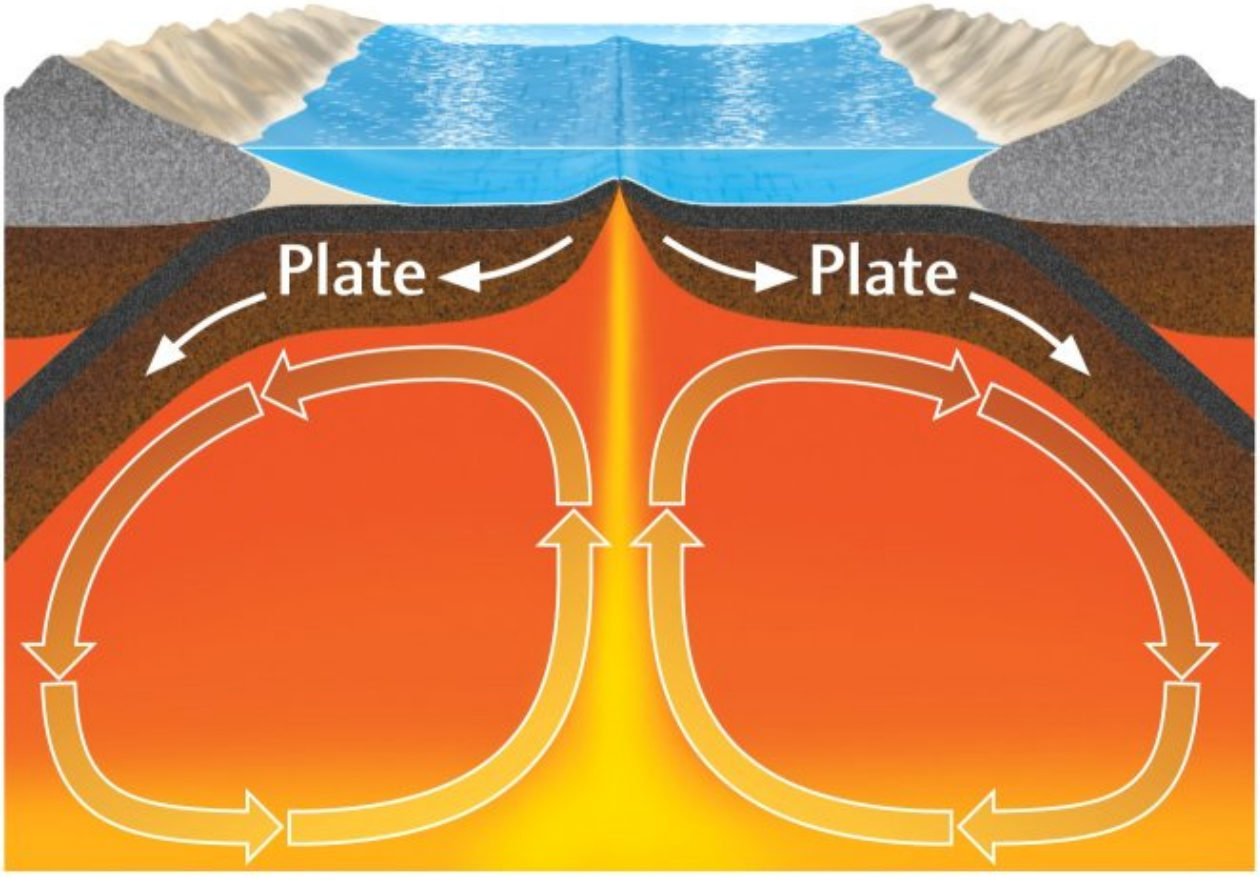
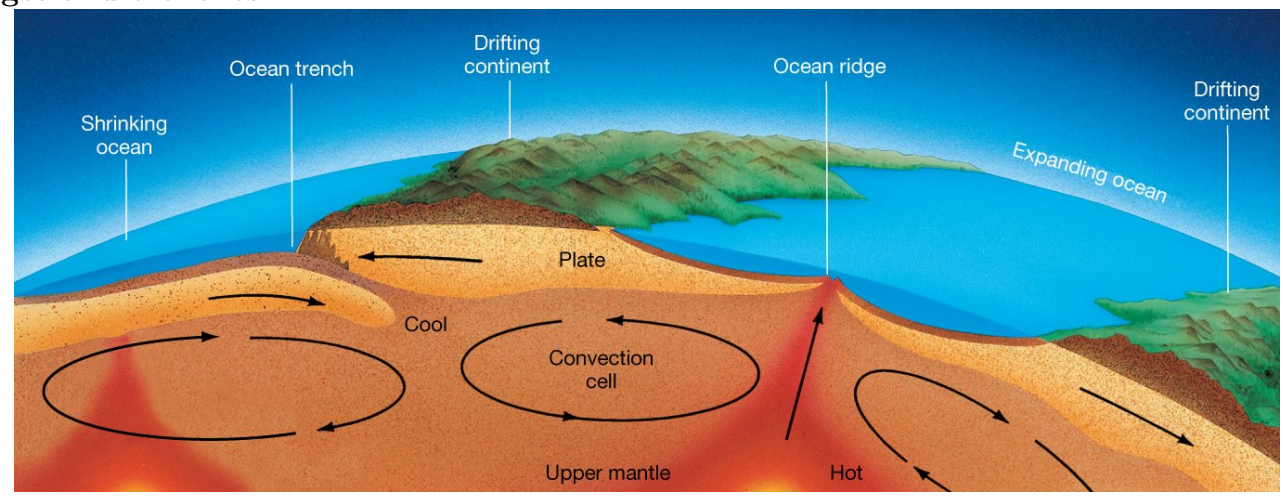
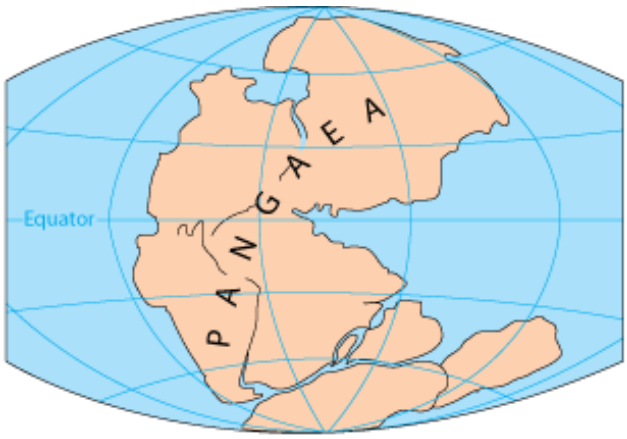
Mantle convection



Ridges and trenches

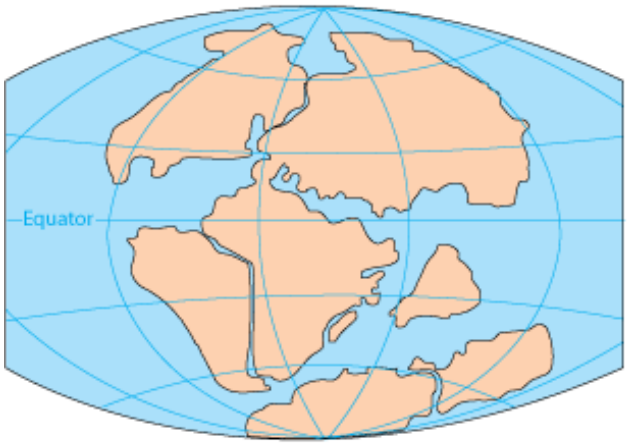


The result of mantle convection

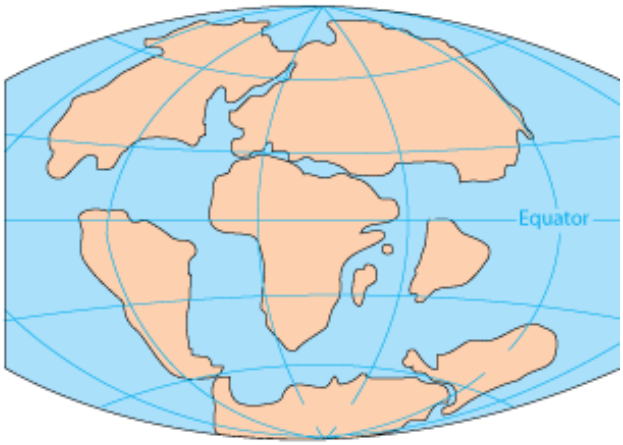


PERMIAN
250 million years ago

TRIASSIC
200 million years ago

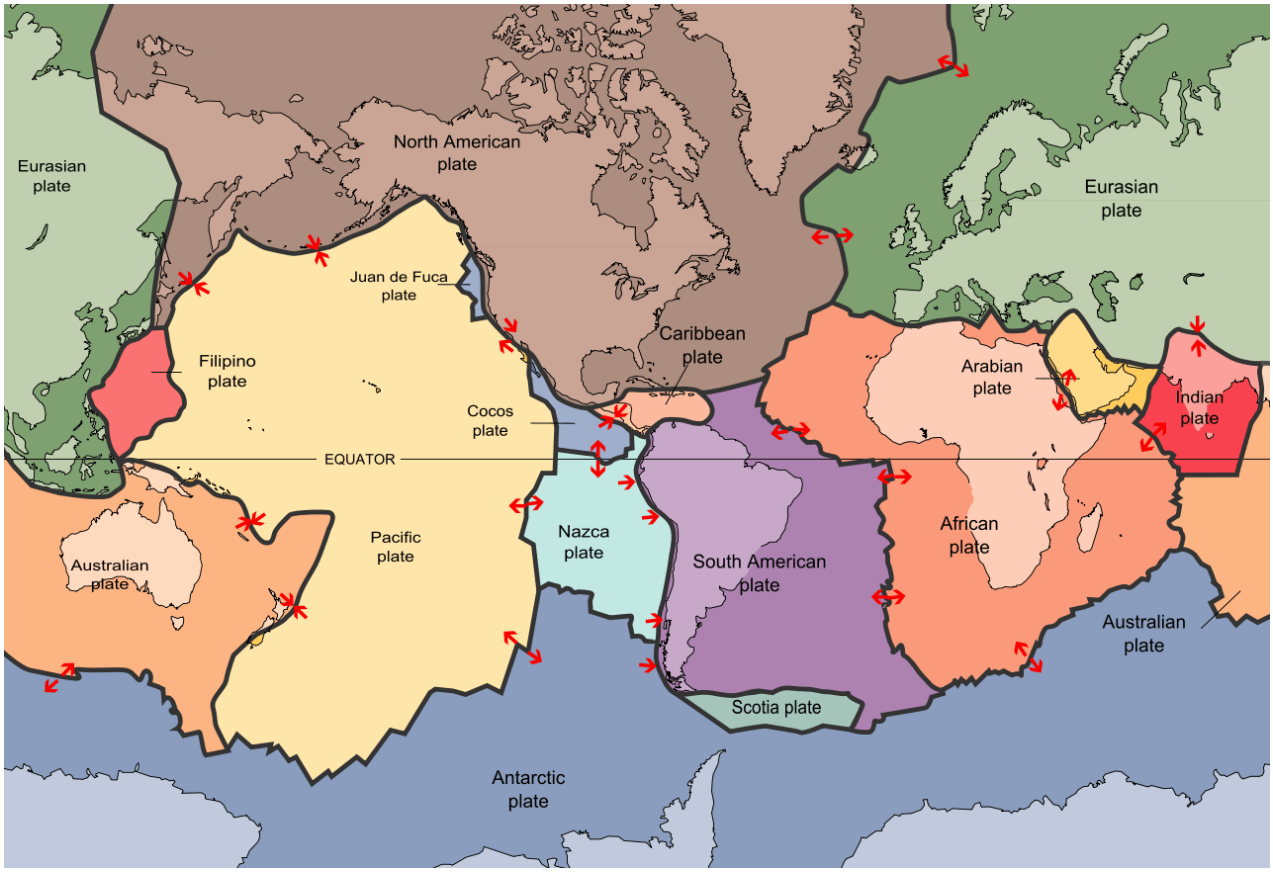


JURASSIC
145 million years ago



CRETACEOUS
65 million years ago

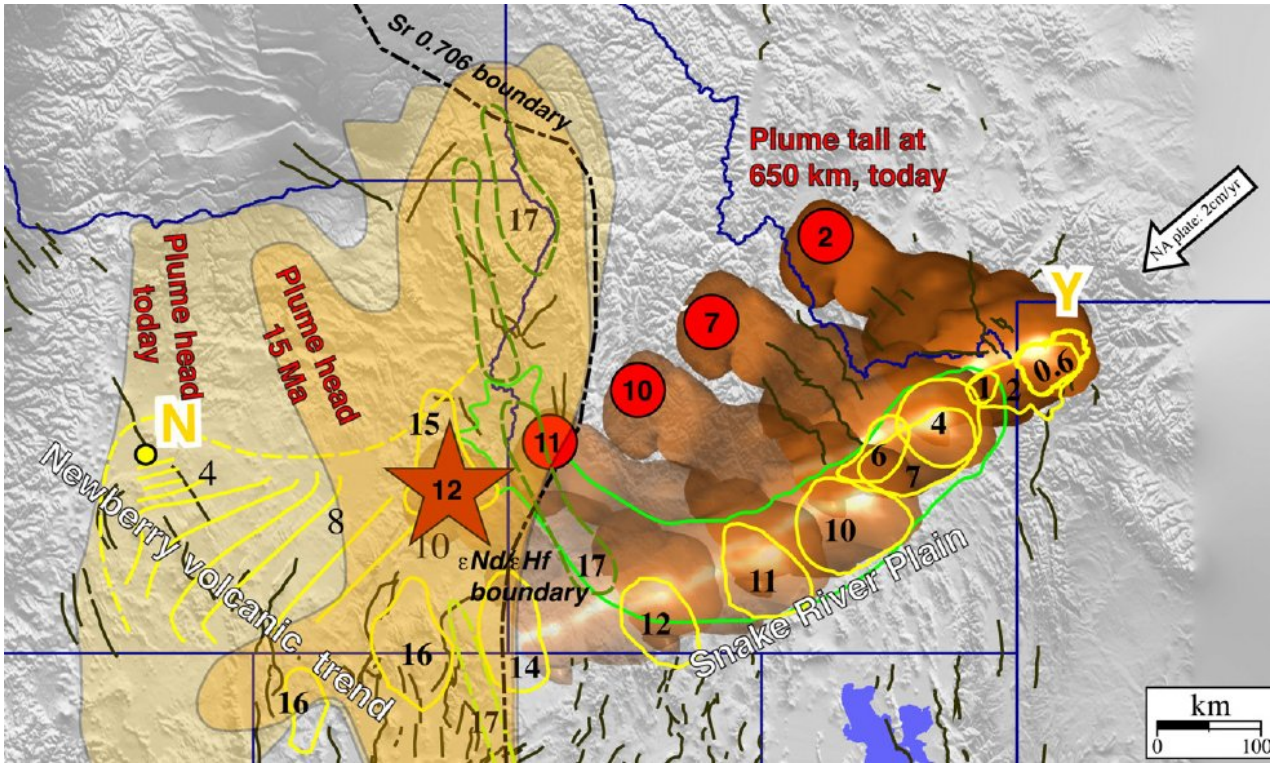
Tectonic plates



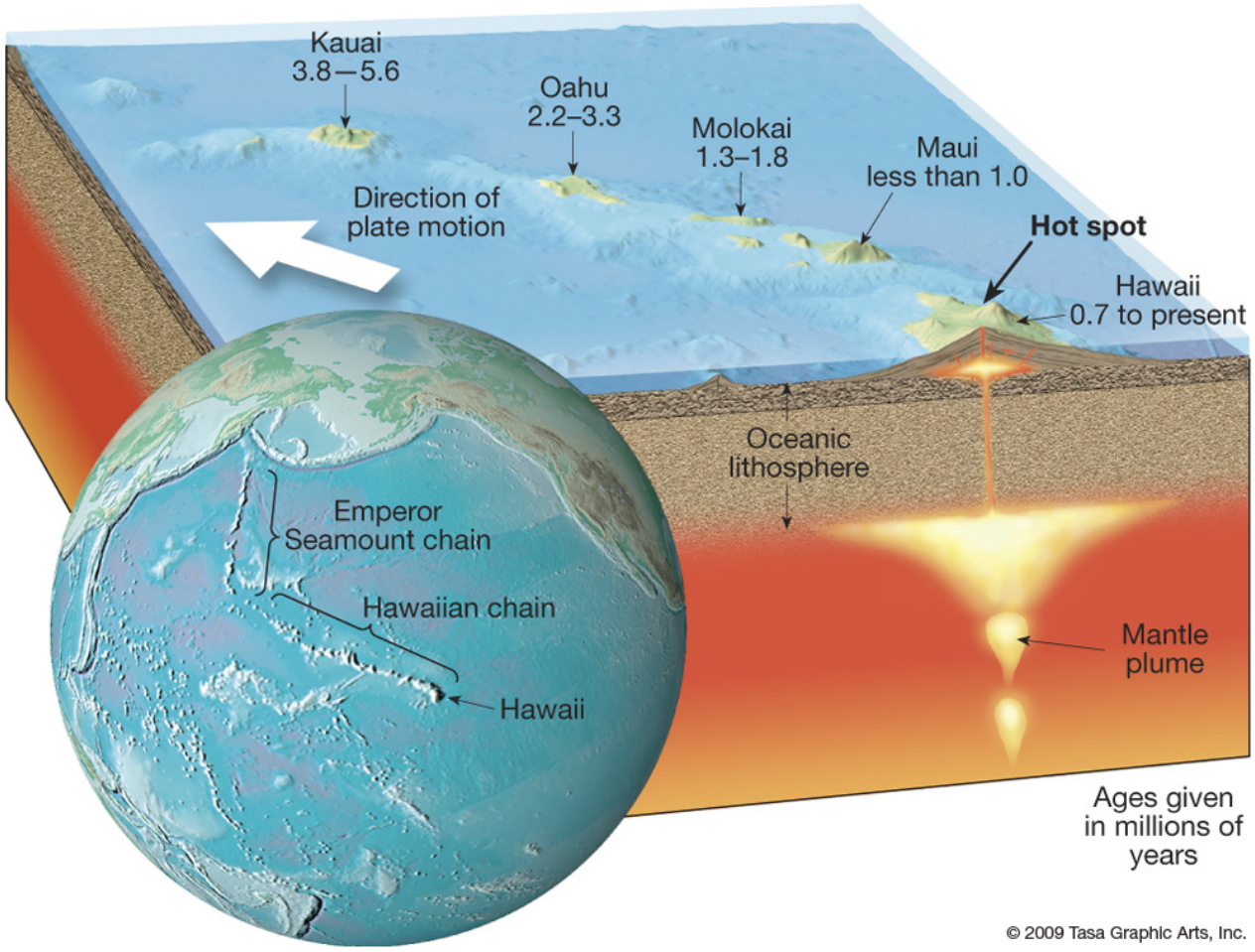
Two living examples of continental drift on U.S. territory

- Yellowstone hotspot
- Hawaiian hotspot

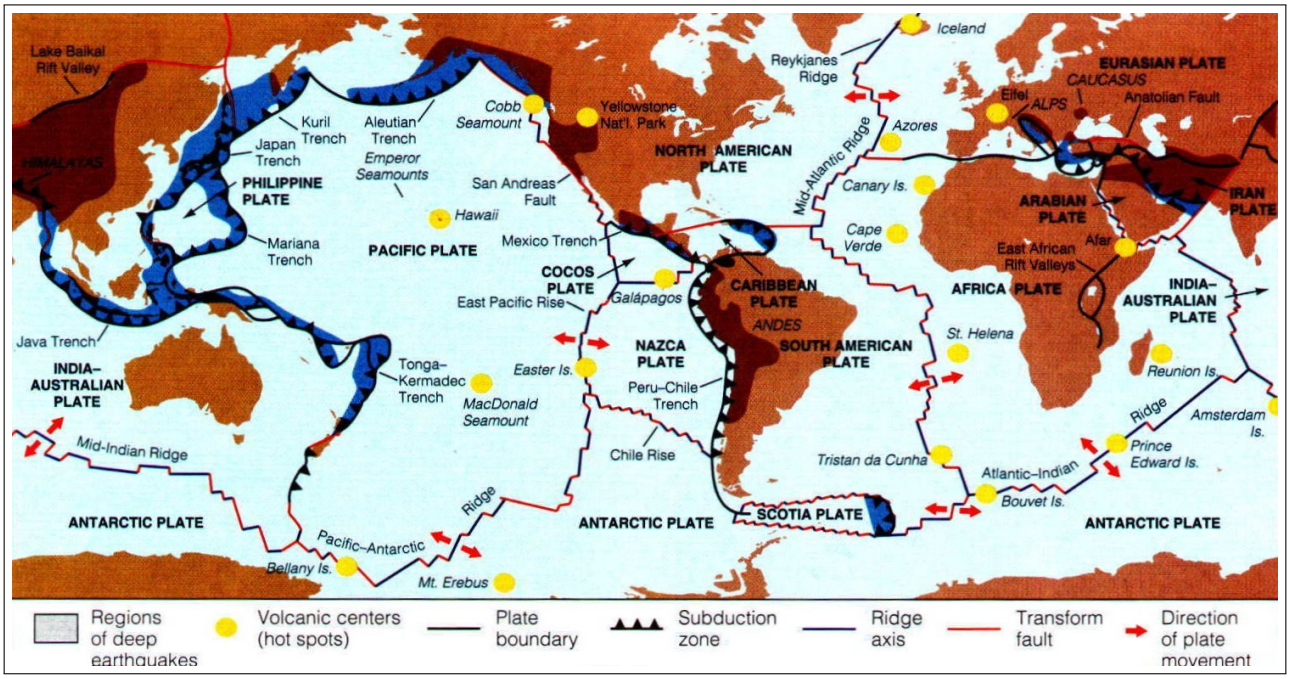
Yellowstone hotspot



Hawaiian hotspot



Hotspots, trenches, ridges and plates



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

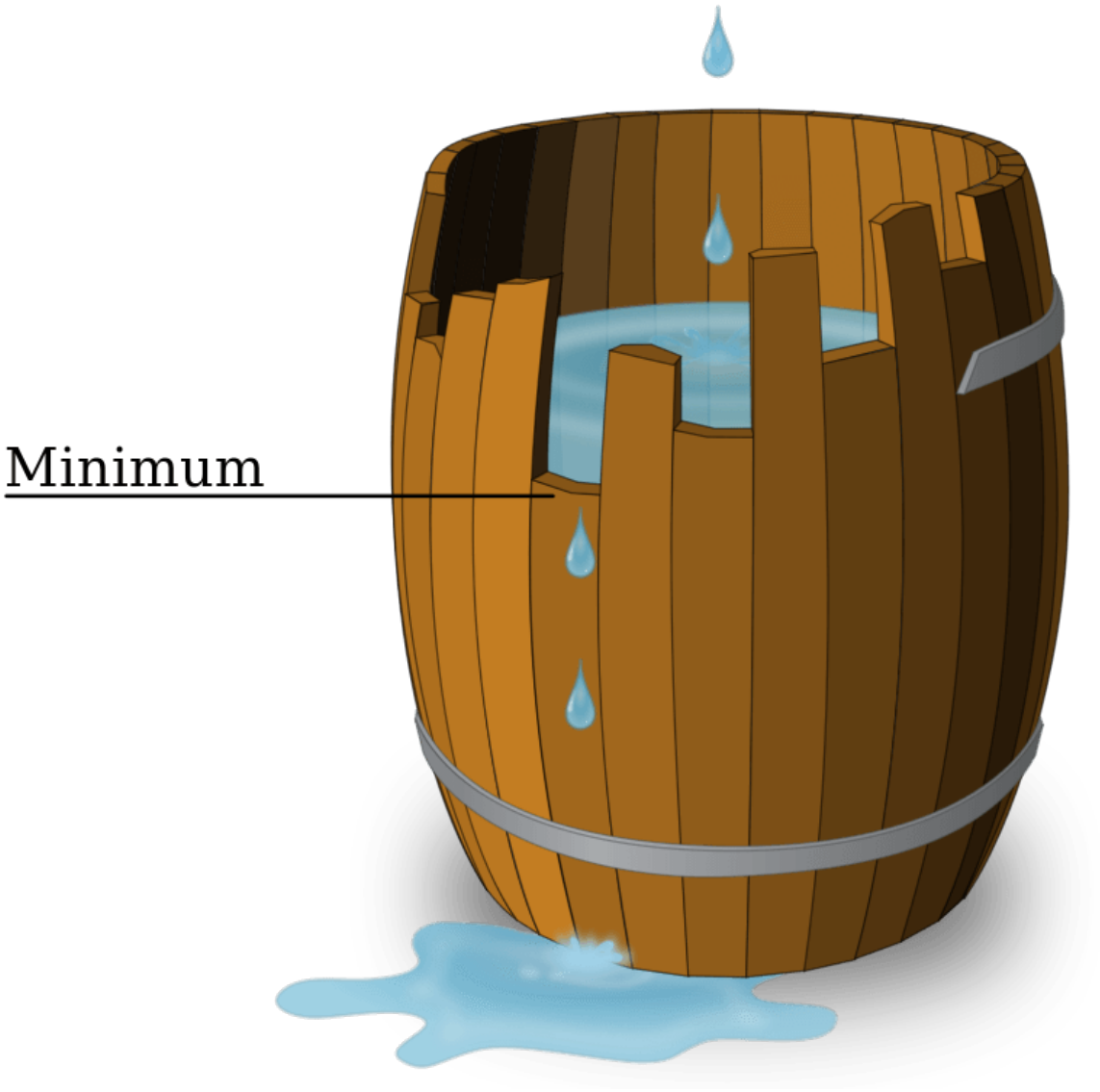
- Direct
  - Collecting
  - Hunting
  - Plowing
  - Tree cutting
- Indirect
  - Grazing
  - Polluting
  - Melioration
  - Recreation

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

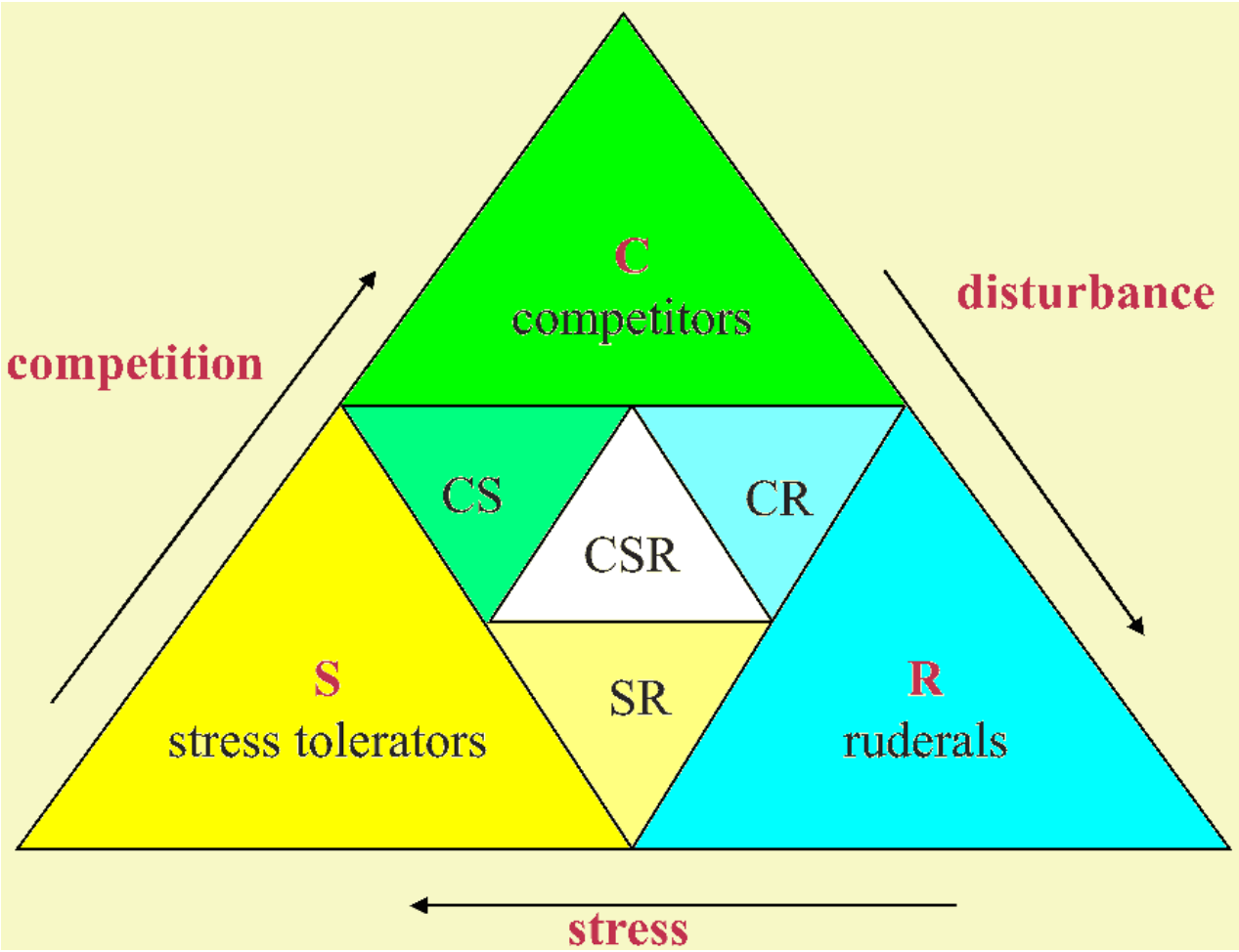
Features of ecosystem

- 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

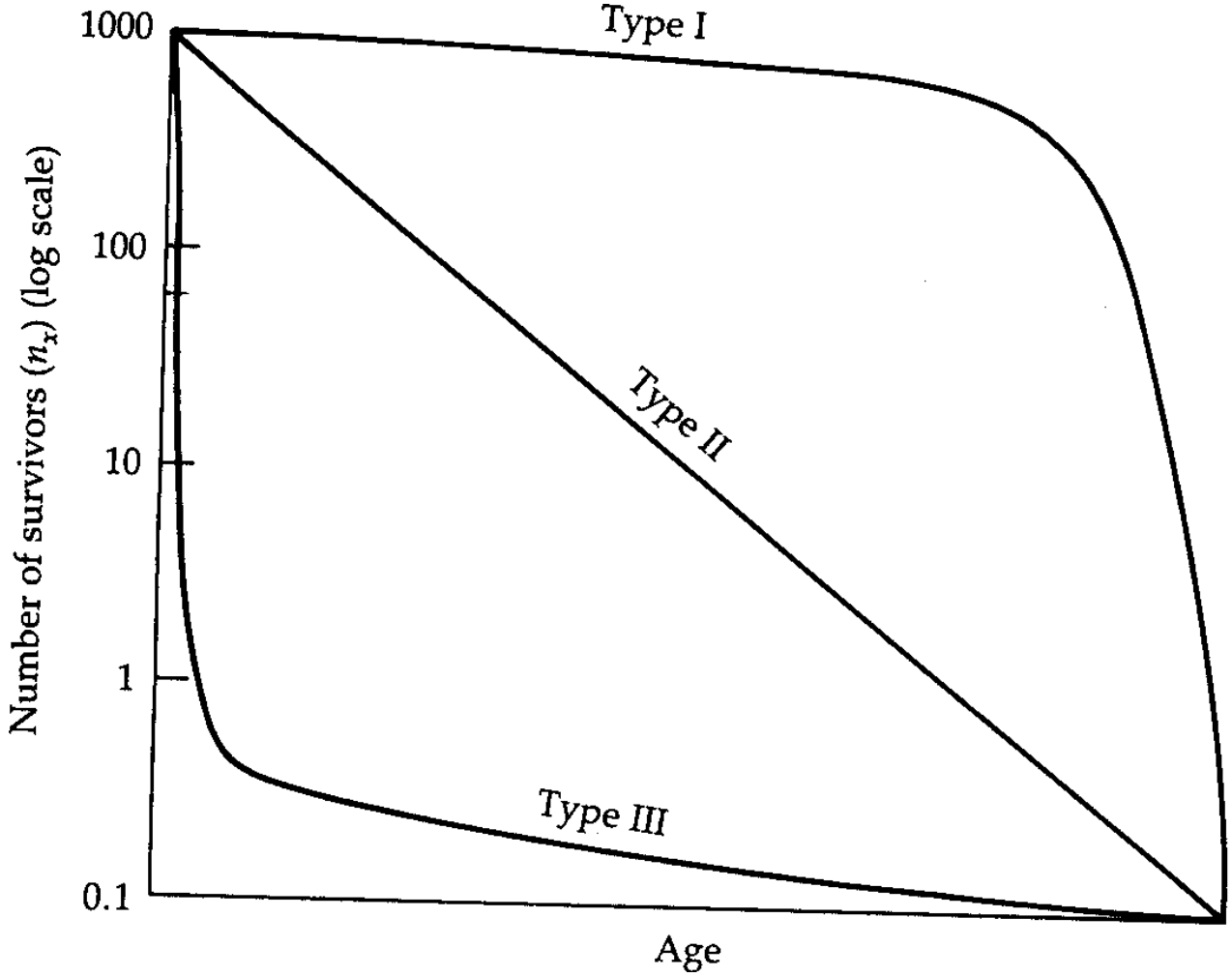
Populations

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

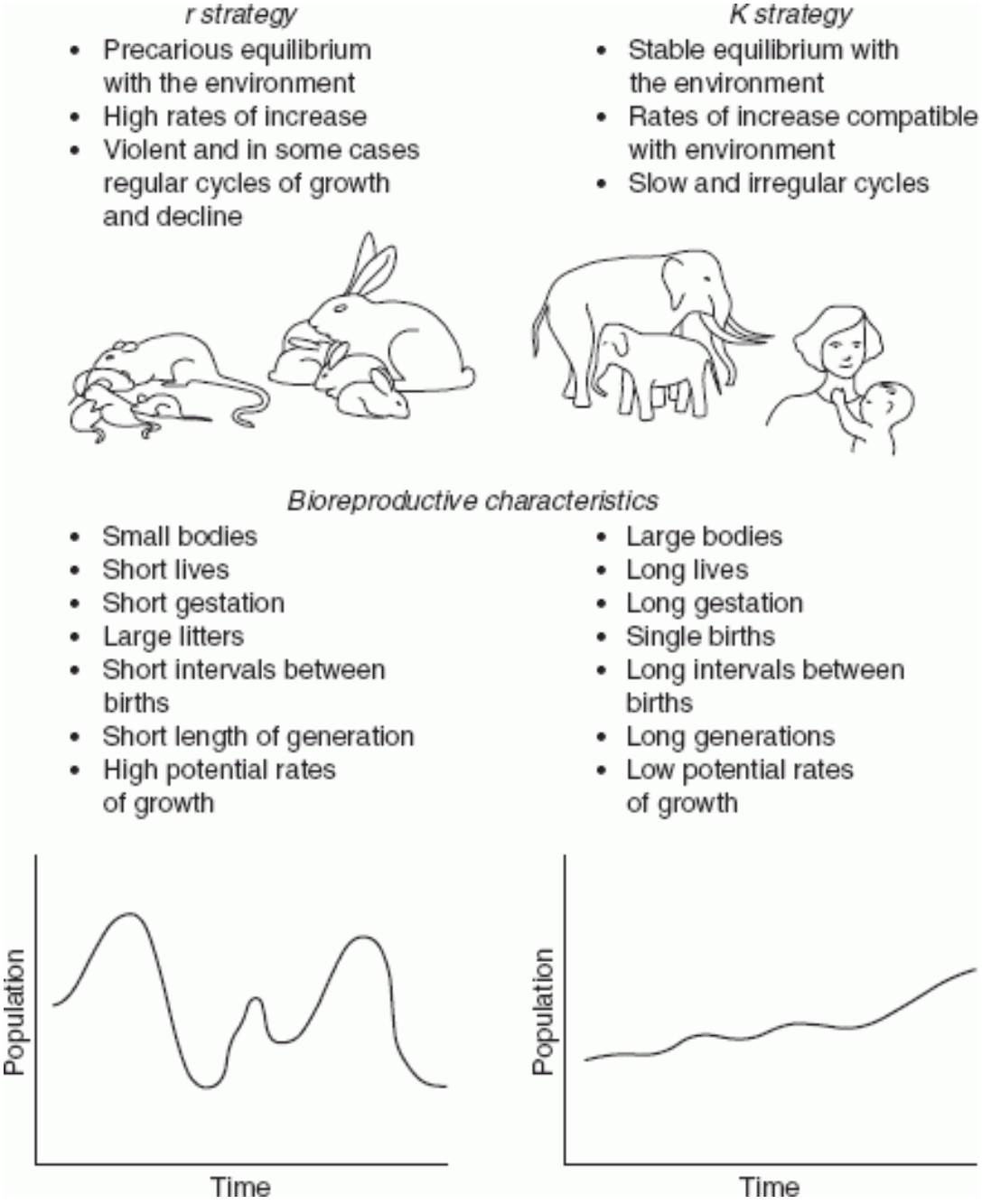
Grime's triangle



Survivorship curves


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

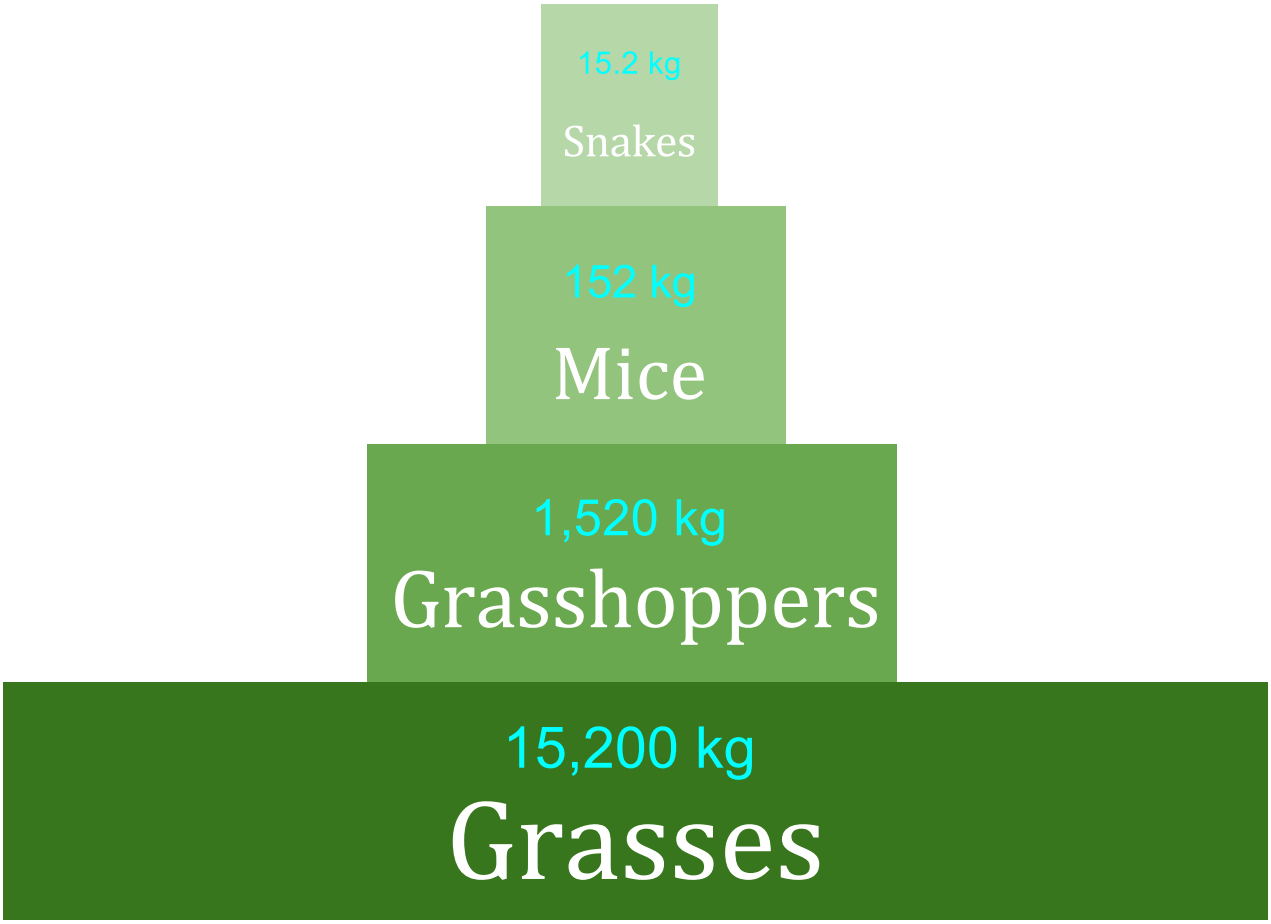
Strategies



Food webs

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

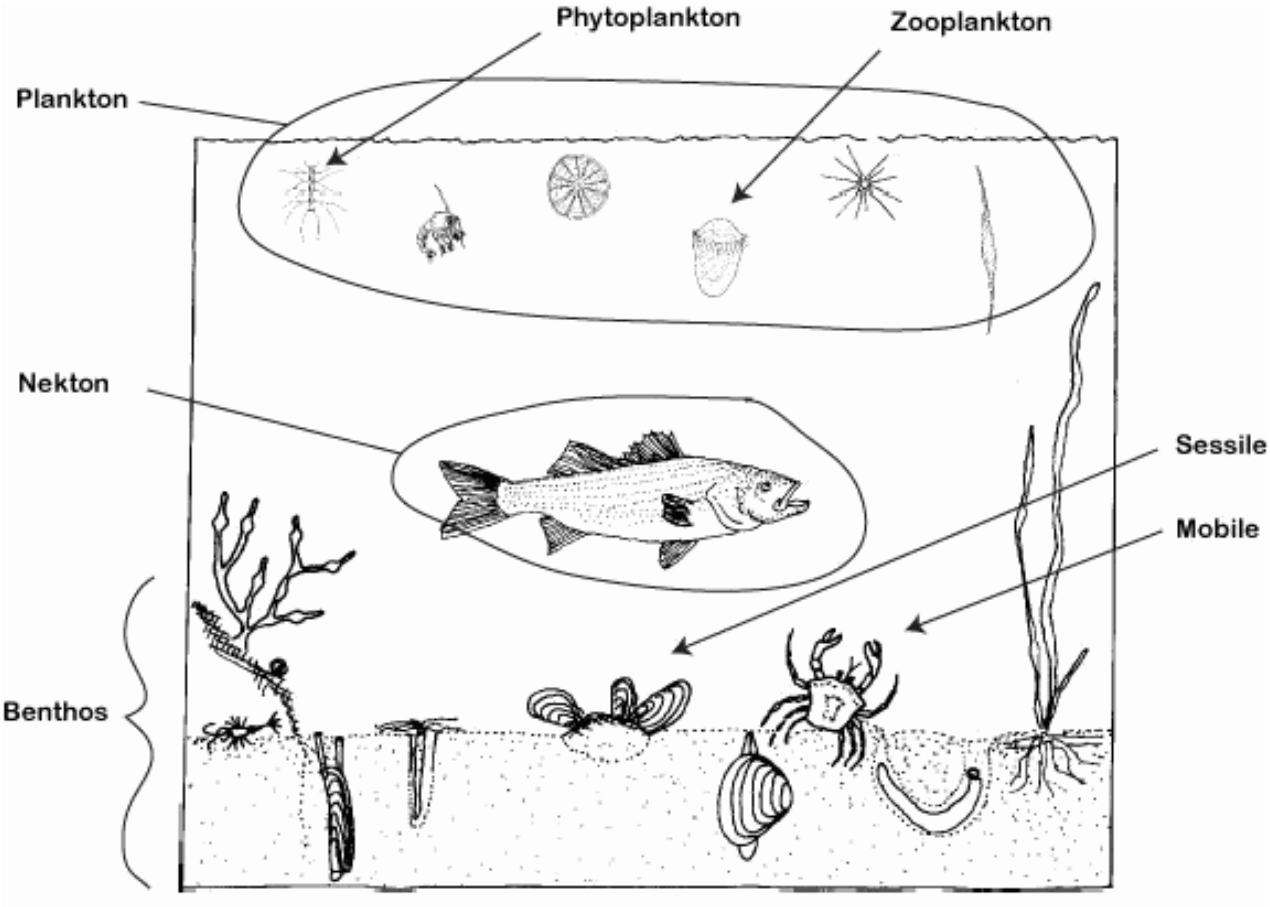
Energy and biomass pyramid (terrestrial)



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

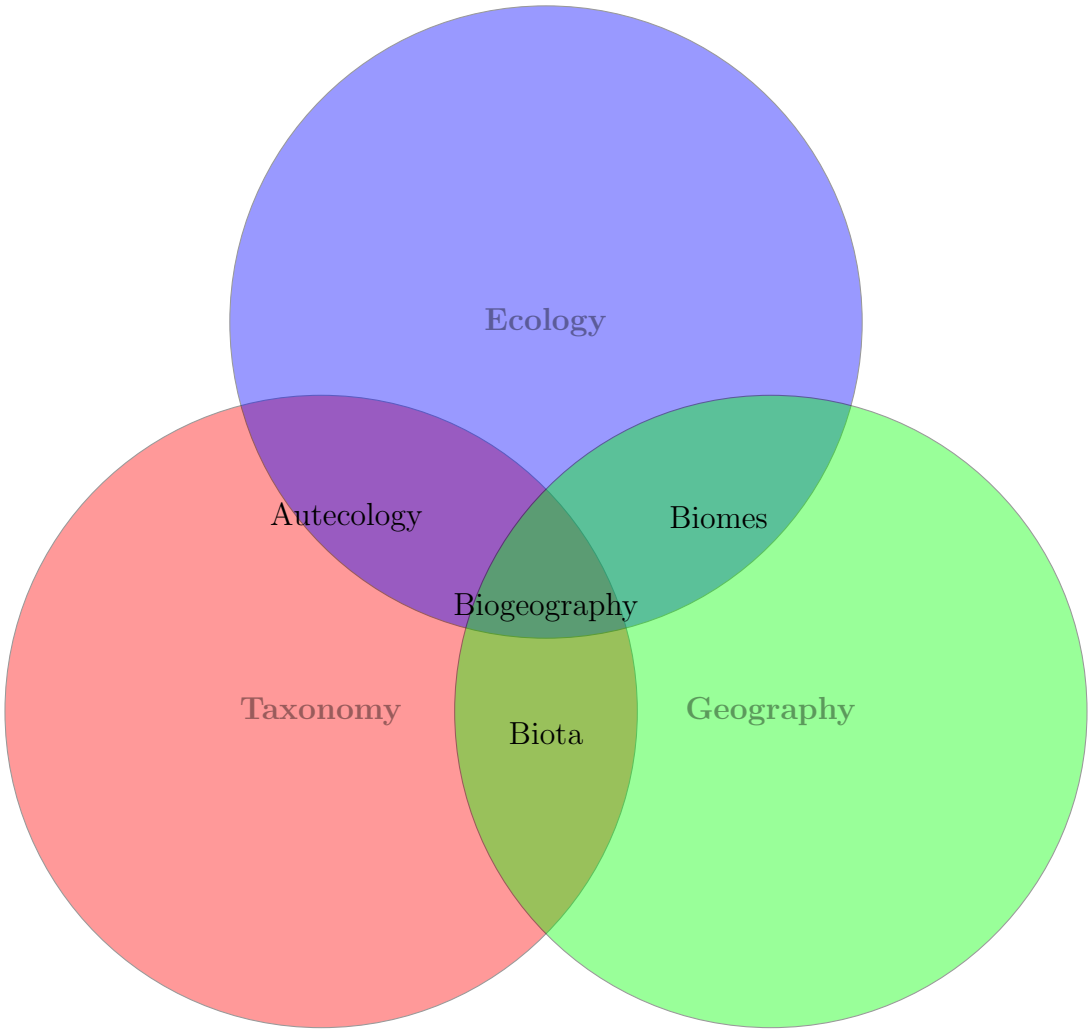
[1] A. Shipunov. *Biogeography* [Electronic resource]. 2014—onwards. Mode of access: `http://ashipunov.info/shipunov/school/biol_330`

[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

14 Taxonomy

14.1 Basic principles



Two corner stones

- The diversity around us has a structure

- This structure is hierarchical

How to describe hierarchy

- With ranks

  Simple, efficient, practical. However, for every name you will need to remember a rank*. Also, number of ranks is restricted so some potentially useful information will be ignored. Last but not least, no clear definition of any rank exists. The working definition is "*we call this* genus *because in the neighbor* family *we apply the genus rank to similarly segregated groups*".

  *There are multiple workarounds, e.g. endings and numerical ranks.

- With trees

  More objective, no need to remember rank, no restrictions for numbers of levels. However, you should remember the graphic object instead of text, interpretation is not easy, conflicts are not simple to resolve. As a result, it is much easier to become lost with trees than with ranks.

Many current approaches try to cross ranks and trees.

Names and ranks

- Ranks (including species) are very useful practically but do not have explicit criteria
- 7 basic ranks: species, genus, family, order, class, phylum, kingdom
- Names of species are binomial. This is again extremely useful but will result in instability—binomial names are not perfect IDs

Priority, starting dates and conservation

- Names only look like meaningful words. In fact, they are IDs. So it is impossible is to change name if it looks "incorrect", like *Simmondsia chinensis* (jojoba) which does not grow in China.
- The earlier name is always preferred. Good rule, but adds to the instability of names.
- Starting dates allow to disregard all names published before 1753 (for plants) or 1758 (for animals)
- Conservation allows to disregard older names if the newer name is conserved

Summary

- There are seven main taxonomic ranks
- Subspecies are geographical races

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`

[3] Biological classification. `http://en.wikipedia.org/wiki/Biological_classification`

Outline

15 Taxonomy

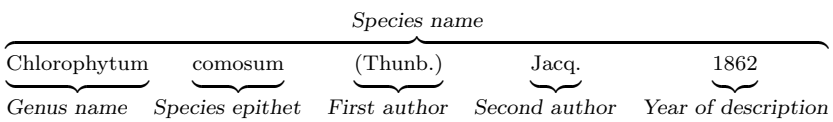
15.1 Names

Who is *Homo troglodytes*, or why binomial system is not very well made?

- This is a chimp (*Pan troglodytes*) if we move it into *Homo* genus.
- If we move chimp to human genus, its name should be "*Homo troglodytes*"
- Linnaeus described **another** "*Homo troglodytes*" so some biologists want to name chimp "*Homo arboreus*".
- However, this older name is **invalid** because it was proved that it was based on the materiel consisting of orang and human bones mixture.
- So quite fortunately, there is no conflict. There are plenty of these conflicts in less famous situations.
- The worst is that moving species from one genus to another is based on the **opinion** but results in **name change**!

Names and endings examples

English	Latin	Example 1	Example 2
Kingdom	Regnum	Vegetabilia	Animalia
Phylum	Phylum	Spermatophyta	Chordata
Class	Classis	Angiospermae (Magnoliopsida)	Mammalia
Order	Ordo	Liliales	Primates
Family	Familia	Asparagaceae	Hominidae
Genus	Genus	*Chlorophytum*	*Homo*
Species	Species	*Chlorophytum comosum* (Thunb.) Jacq. 1862	*Homo sapiens* L.



For Further Reading

References

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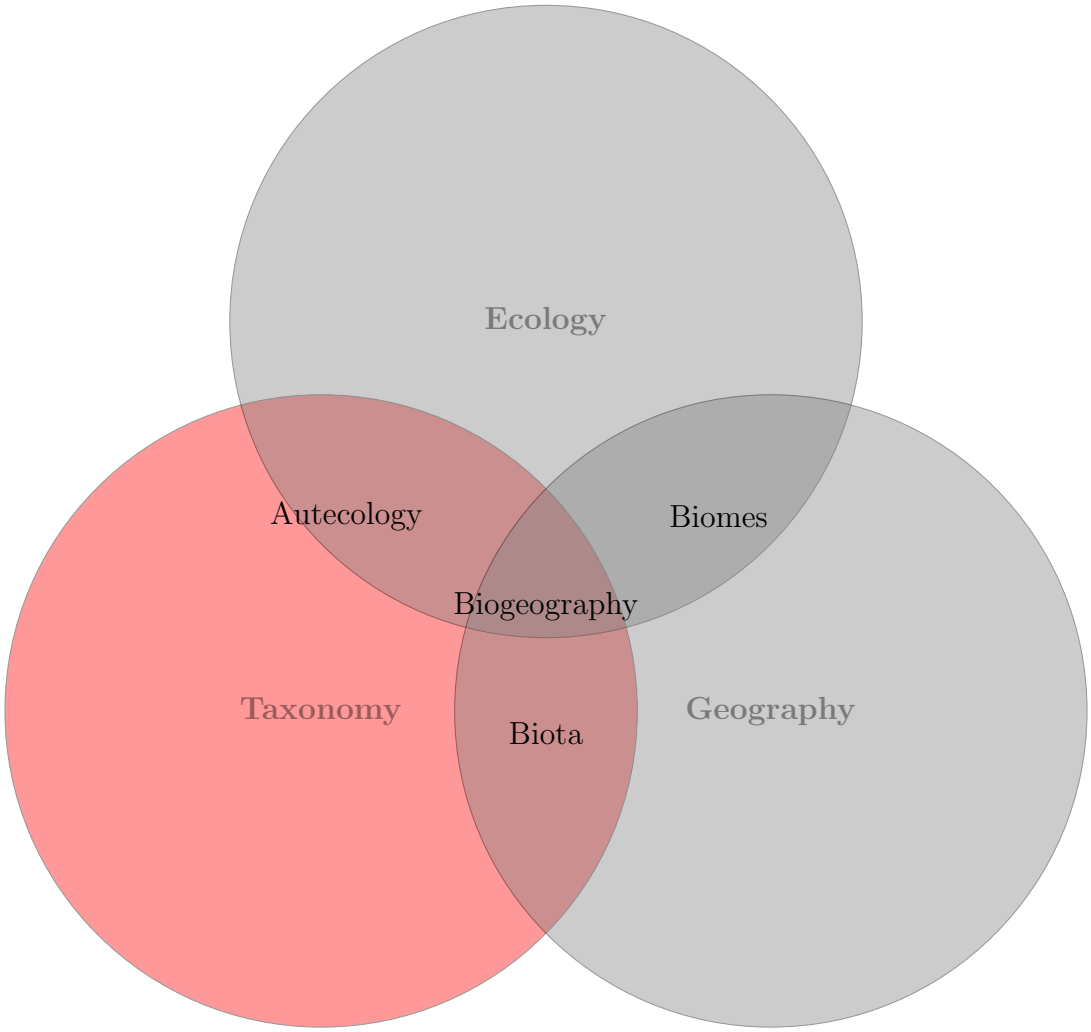
Outline

16 Taxonomy

16.1 Basic principles



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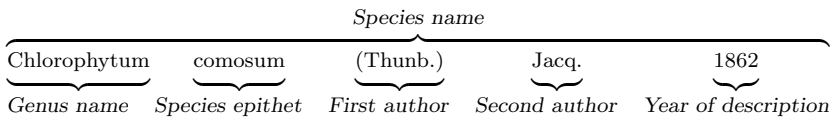

Synonyms, homonyms and hemihomonyms

How many species? 2,000,000 described; the feasible estimation is 4–5,000,000. There are also 20,000,000 names—most of them are *synonyms* and *homonyms*.

- **Synomyms** are younger names, we can use it but it is better to avoid them
- **Homonyms** are same names for different taxa (like two *Homo troglodytes*), we must eliminate one of them
- **Hemihomonyms** are "legal homonyms", same names under different codes of nomenclature, e.g. *Oenanthe* (bird) and *Oenanthe* (plant).

Miscellanea

- Intermediate ranks.
- Subspecies and cultivars. Many subspecies are "geographical races". Cultivars are result of artificial selection.
- Shortcuts: "sp." (one species, unknown omitted), "spp." (many species), "s. l." (wide sense), "s. str." (strict sense), "i. s." (position unknown)

Taxonomy workflow

- Collection
- α-taxonomy: species description
- β-taxonomy: work with existing descriptions.

Summary

- There are seven main taxonomic ranks
- Subspecies are geographical races

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

17 Taxonomy

17.1 Methods

How to describe the natural order: principles of classification

- Traditional method (mind model), phenetic (multivariate statistics), and cladistic (phylogenetic, now mostly molecular—objective but based on few samples)
- Results: ranked classifications, cloud ordinations, trees (dendrograms)
- Conversion from clouds to classification: hiatus
- Conversion from tree to classification raises the problem of monophyletic, paraphyletic and polyphyletic groups
- Time estimation from fossils and molecules might replace ranks

How to describe hierarchy

- With ranks

  Simple, efficient, practical. However, for every name you will need to remember a rank*. Also, number of ranks is restricted so some potentially useful information will be ignored. Last but not least, no clear definition of any rank exists. The working definition is "*we call this* genus *because in the neighbor* family *we apply the genus rank to similarly segregated groups*".

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- With trees

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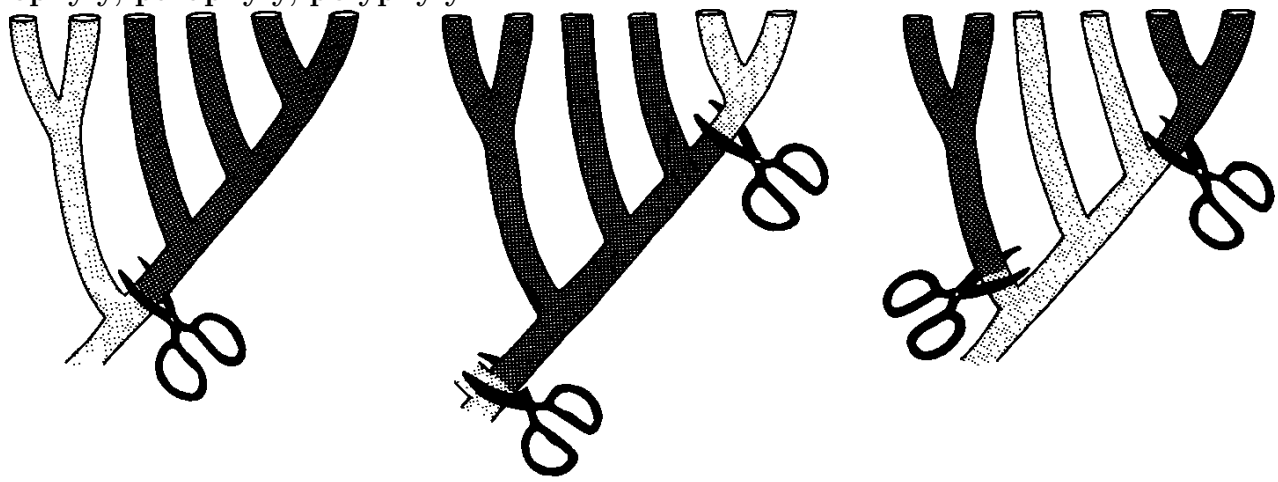
Many current approaches try to cross ranks and trees.

Monophyly, paraphyly, polyphyly



Monophyletic	Paraphyletic	Polyphyletic
one and only one cut	one cut below the group and one or more cuts higher up	more than one cut below the group
One branch	A piece of a branch	More than one piece of a branch

17.2 The structure of diversity

Overview: the "pyramid" and treemap (Latin names)

http://ashipunov.info/shipunov/os/os-en.htm

Closer view: the treemap (English names)

http://ashipunov.info/shipunov/school/biol_330/intr_biogeogr_trop_biol/images/src/synat_en.svg

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

18 Taxonomy

18.1 The structure of diversity: treemaps

Species diversity

http://ashipunov.info/shipunov/school/biol_330/intr_biogeogr_trop_biol/images/src/species.svg

Treemap of Life

http://ashipunov.info/shipunov/school/biol_330/intr_biogeogr_trop_biol/images/src/synat_en.svg

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

19 Taxonomy

19.1 The structure of diversity: treemaps

Treemap of arthropods

http://ashipunov.info/shipunov/school/biol_330/intr_biogeogr_trop_biol/images/src/arthropods.svg

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

20 Taxonomy

20.1 The structure of diversity: treemaps

Treemap of plants

http://ashipunov.info/shipunov/school/biol_330/intr_biogeogr_trop_biol/images/src/plants.svg

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

21 Taxonomy

21.1 The structure of diversity: treemaps

Treemaps

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

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

Please rate, 1 to 5

1. March 6 Zoo and Stainback Hwy roadside (W)
2. March 7 Hawaii Tropical Botanical Garden (W)
3. March 7 Onomea Bay Trail (W)
4. March 8 Akaka Falls State Park (W)
5. March 8 Punaluu Black Sand Beach (V)
6. March 9 Saddle Road: Kaumana Trail and Pu'u O'o trail (V)
7. March 9 Puu Waawa Cinder Cone State Park (L)
8. March 9 Kaloko-Honokohau National Historic Park (L)
9. March 10 Muliwai Trail in Waipio Valley (W)
10. March 10 Hakalau Beach park (W)
11. March 11 Hawaii Volcanoes National Park (V)
12. March 12 Kona Kamakahonu Beach snorkeling (L)
13. March 13 Maunakea (V)
14. March 13 Kaumana Caves (W)
15. March 14 Rainbow Falls (W)
16. March 14 Hilo shopping (W)

By Wednesday,please bring photographssplit by folders(plus one comment file per folder)on USB flash drive

22 Biogeography of the World

22.1 Distribution: the basic concept

Species distribution

- Range

  Restricted with climate, history and natural barriers

- Disjunction

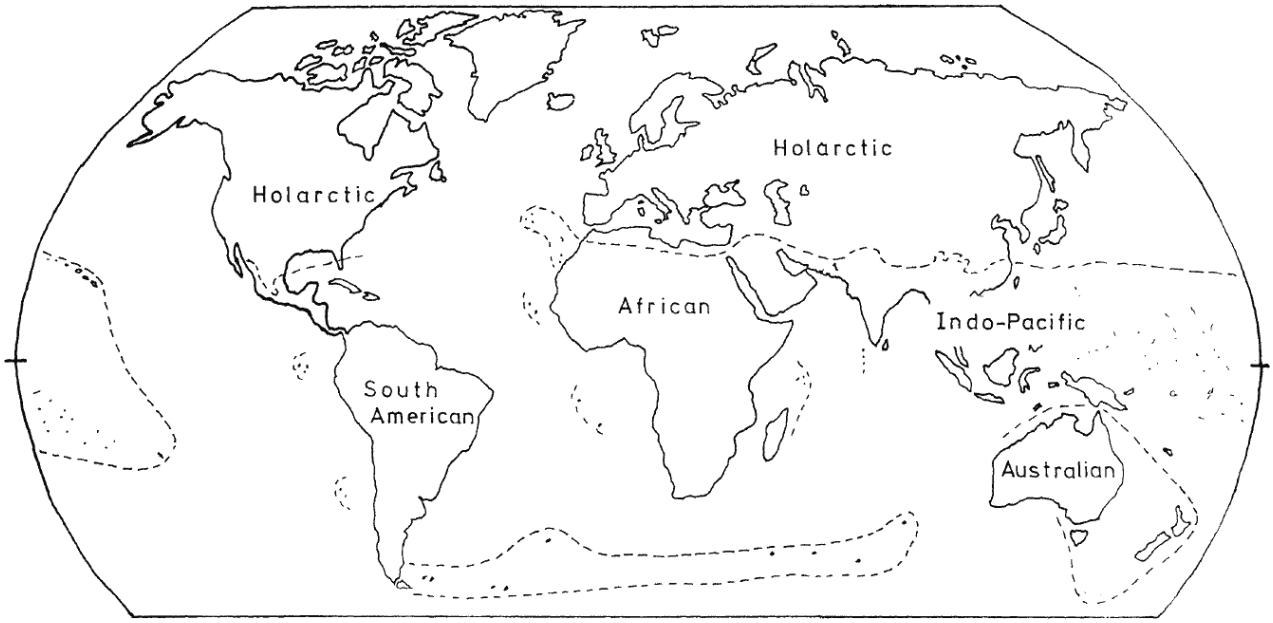
  Examples: East Asia/East Coast; Pacific (West Washington/North Idaho)

- Endemics

  Every species is endemic to some region. What is important, is the size of region. There also species endemic only to Earth: cosmopolitan species like braken fern (*Pteridium*).

22.2 Floristic kingdoms and faunistic provinces

Contemporary look on plant biogeography: five kingdoms (Cox, 2001)



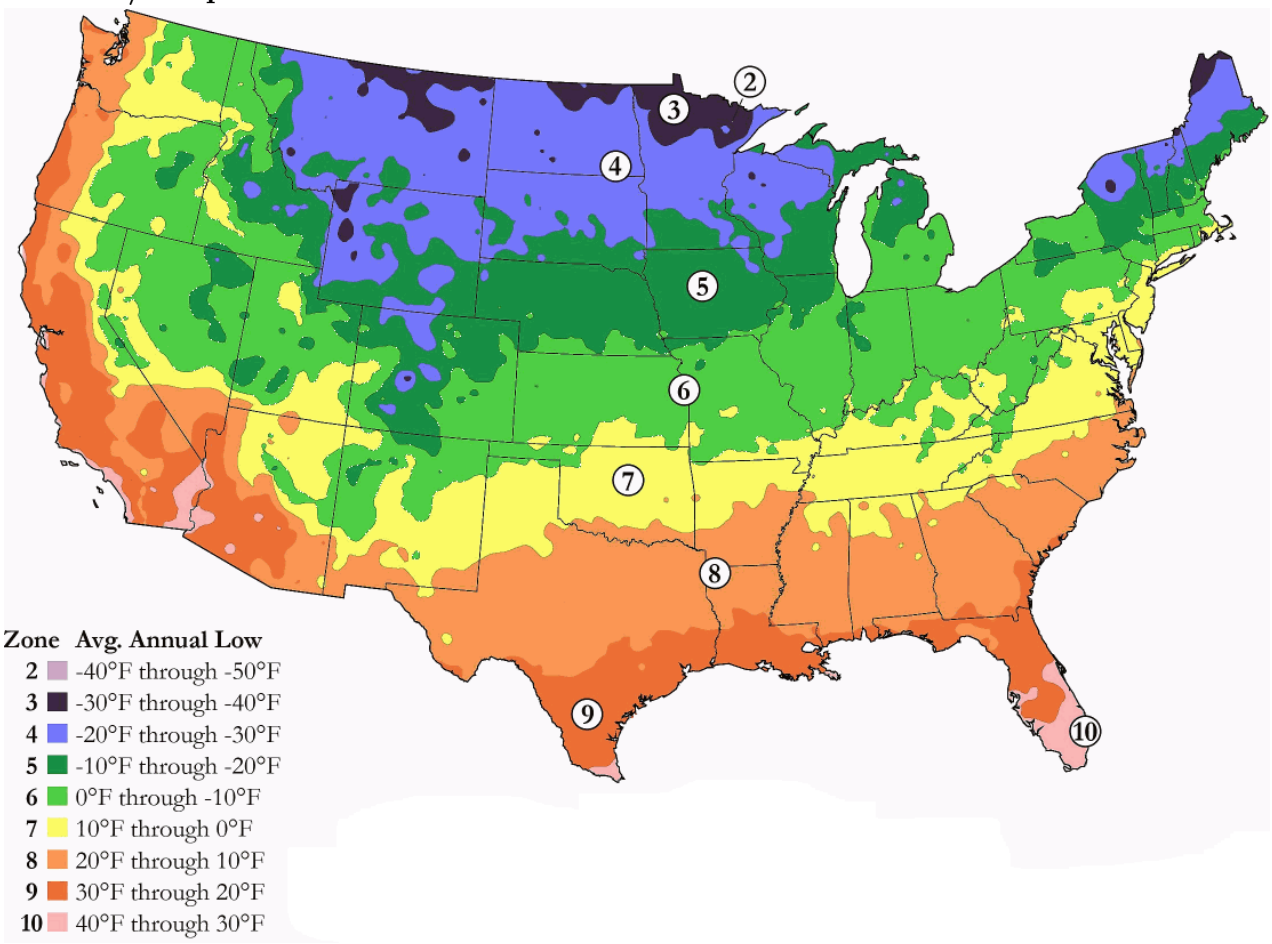
Contemporary look on animal biogeography: 10 provinces (Holt et al., 2013)

Our approach: 5 regions

- Holarctic (I and II)
- Neotropical
- African and Madagascan
- Indo-Pacific
- Australian

22.3 Holarctic region I: Nearctic North America

Climate/temperatures: hardiness zones



Climate/precipitation


WINTER MAXIMUM
FALL MAX.
SUMMER MAXIMUM
WINTER MAXIMUM
WINTER MAX.
SUMMER MAXIMUM
WINTER MAXIMUM
Tropic of Cancer
SUMMER MAXIMUM
SUMMER MAXIMUM
ANNUAL PRECIPITATION
Cm. (In.)
Under 25 (10)
25-50 (10-20)
50-100 (20-40)
100-150 (40-60)
150-200 (60-80)
Over 200 (80)

Ecoregions

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 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`

Outline

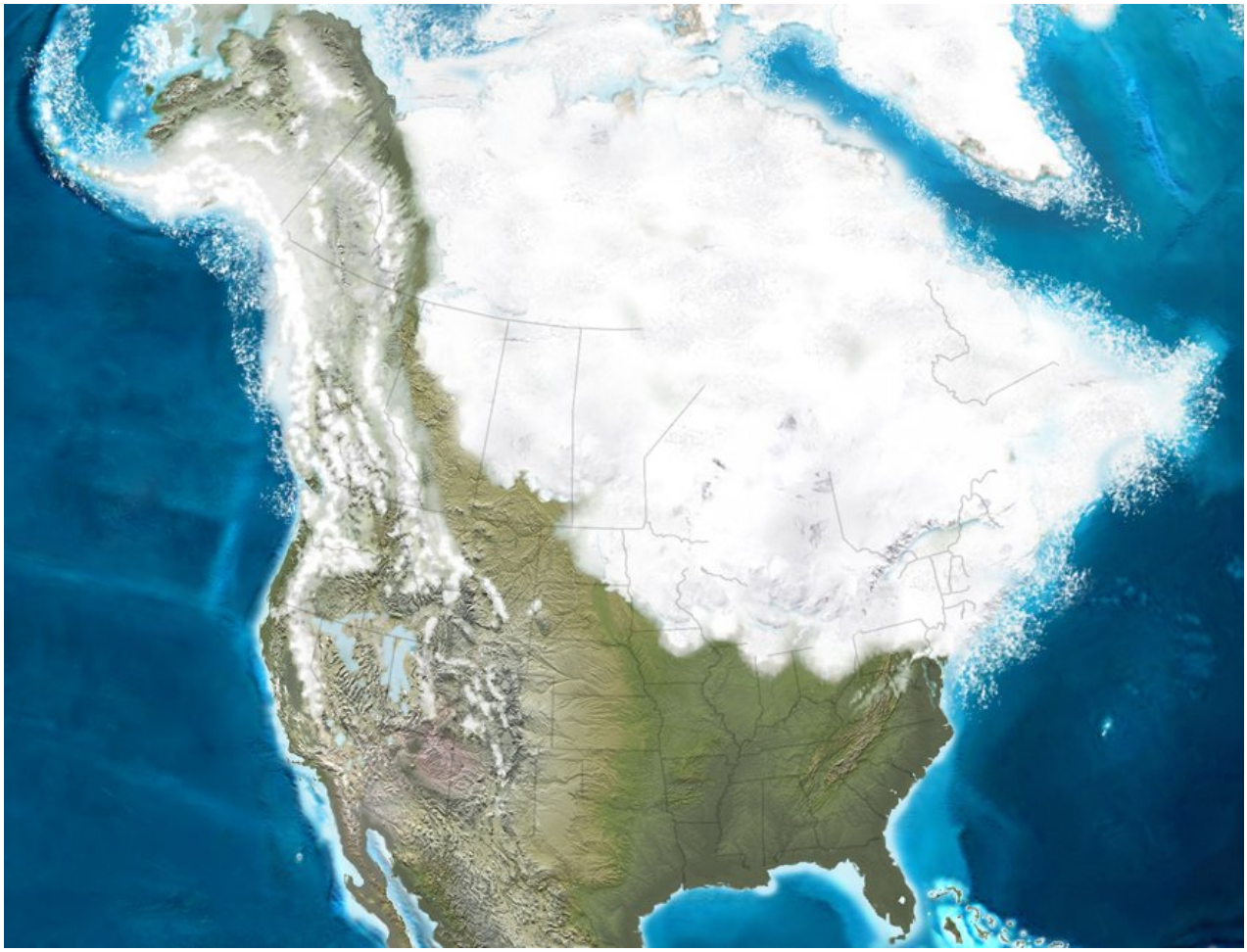
23 Biogeography of the World

23.1 Holarctic region I: Nearctic North America

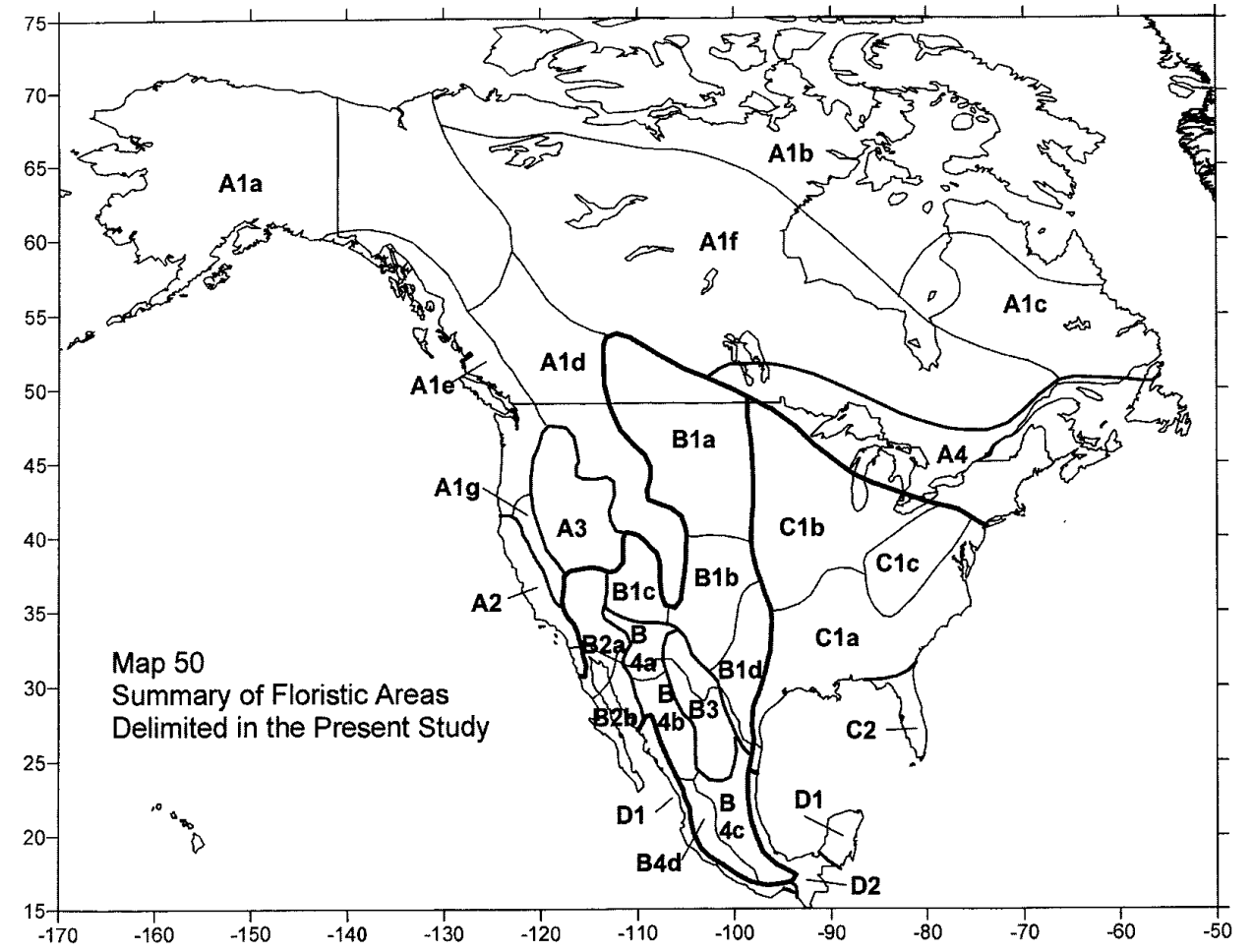
Ecoregions


1.0 ARCTIC CORDILLERA
CORDILLERA ÁRTICA
CORDILLÈRE ARCTIQUE
2.0 TUNDRA
TUNDRA
TOUNDRA
3.0 TAIGA
TAIGA
TAÏGA
4.0 HUDSON PLAIN
PLANICIE DE HUDSON
PLAINE D' HUDSON
5.0 NORTHERN FORESTS
BOSQUES SEPTENTRIONALES
FORÊTS SEPTENTRIONALES
6.0 NORTHWESTERN FORESTED MOUNTAINS
MONTAÑAS BOSCOSAS NOROCCIDENTALES
MONTAGNES FORESTÉES DU NORD-QUEST
7.0 MARINE WEST COAST FOREST
BOSQUE COSTERO OCCIDENTAL
FORÊT MARITIME DE LA CÔTE OCCIDENTALE
8.0 EASTERN TEMPERATE FORESTS
BOSQUES TEMPLADOS DEL ESTE
FORÊTS TEMPÉRÉES DE L'EST
9.0 GREAT PLAINS
GRANDES PLANICIES
GRANDES PLAINES
10.0 NORTH AMERICAN DESERTS
DESIERTOS DE NORTEAMÉRICA
DESÉRTS DE L'AMÉRIQUE DU NORD
11.0 MEDITERRANEAN CALIFORNIA
CALIFORNIA MEDITERRÁNEA
CALIFORNIE MÉDITERRANÉENNE
12.0 SOUTHERN SEMI-ARID HIGHLANDS
ELEVACIONES SEMIÁRIDAS MERIDIONALES
HAUTES TERRES SEMI-ARIDES MÉRIDIONALES
13.0 TEMPERATE SIERRAS
SIERRAS TEMPLADAS
SIERRAS TEMPÉRÉES
14.0 TROPICAL DRY FORESTS
SELVAS CÁLIDO-SECAS
FORÊTS TROPICALES SÈCHES
15.0 TROPICAL WET FORESTS
SELVAS CÁLIDO-HÚMEDAS
FORÊTS TROPICALES HUMIDES
ARCTIC OCEAN
OCÉANO ÁRTICO
OCÉAN ARCTIQUE
PACIFIC OCEAN
OCÉANO PACÍFICO
OCÉAN PACIFIQUE
Hudson Bay
Bahía de Hudson
Baie d' Hudson
ATLANTIC OCEAN
OCÉANO ATLÁNTICO
OCÉAN ATLANTIQUE
Gulf of Mexico
Golfo de México
Golfe du Mexique
Échelle Escala Scale
0 200 400 600 800 MI
0 400 800 1200 Km
Projection Azimutal de Equi-aire de Lambert
Proyección Azimutal de Equi-área de Lambert
Lambert Azimuthal Equal Area Projection
Region boundary Level I
Límite de regiones Nivel I
Limite de régions Niveau I
International boundary
Límite internacional
Limite internationale

Glaciation

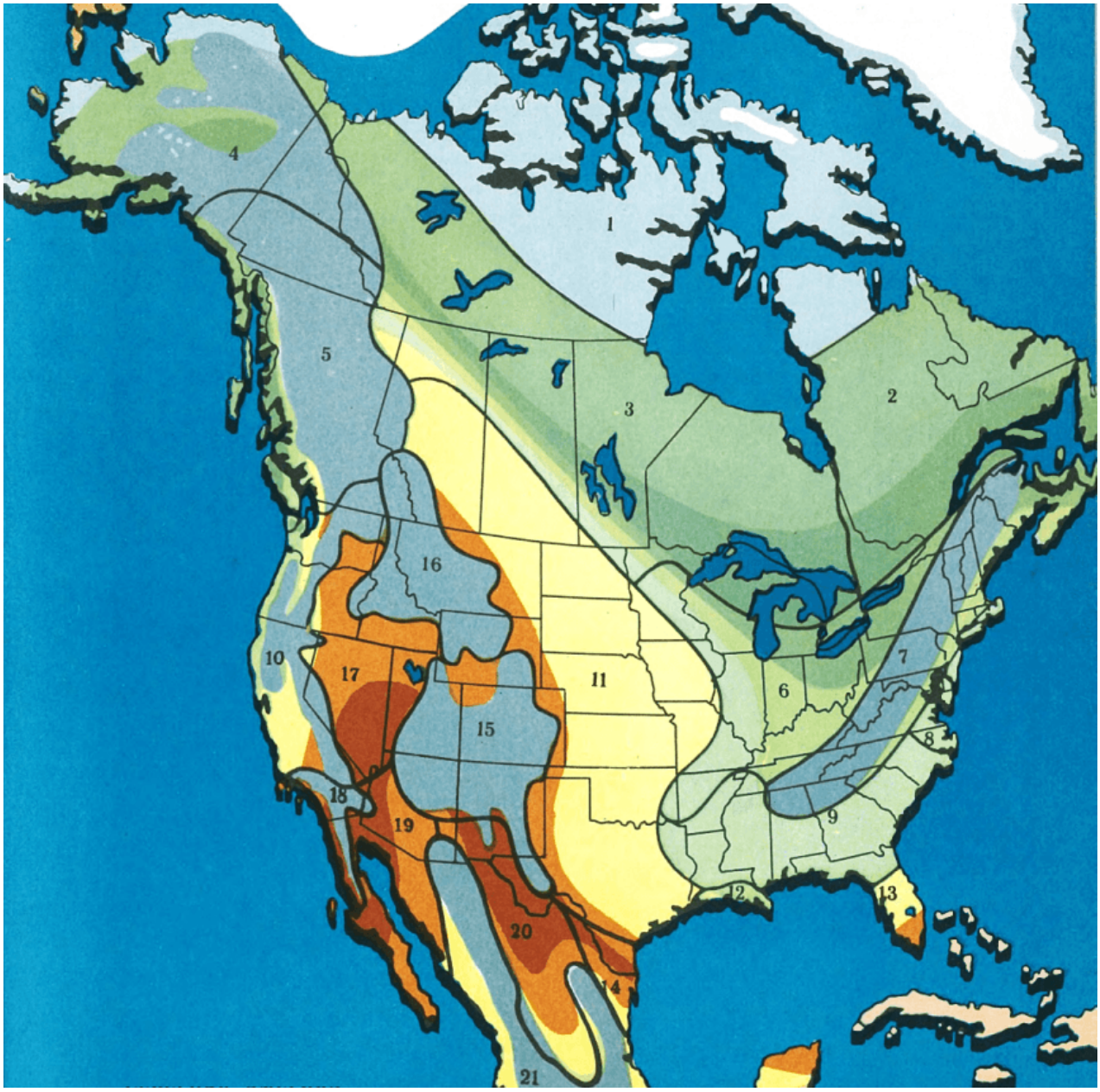


Plant distribution (McLaughin, 2007)



Map 50. Floristic areas of North America delimited in this study: Northern Region (A), Cordilleran-Arctic Province (A1), Alaskan Subprovince (A1a), Eskimoan Subprovince (A1b), Labradoran Subprovince (A1c), Rocky Mountain Subprovince (A1d), Vancouverian Subprovince (A1e), Hudsonian Subprovince (A1f), Sierra Nevadan Subprovince (A1g), Californian Province (A2), Great Basin Province (A3), Canadian Province (A4); Southwestern Region (B), Great Plains Province (B1), Saskatchewan Subprovince (B1a), Kansan Subprovince (B1b), Colorado Plateau Subprovince (B1c), Comanchian Subprovince (B1d), Sonoran Province (B2), Mojavian Subprovince (B2a), Sonoran Subprovince (B2b), Chihuahuan Province (B3), Madrean Province (B4), Apachian Subprovince (B4a), Sierra Madre Occidental Subprovince (B4b), Central Mexican Highlands Subprovince (B4c), Novogalician Subprovince (B4d); Eastern Region (C), Carolinian Province (C1), Austroriparian Subprovince (C1a), Illinoian Subprovince (C1b), Appalachian Subprovince (C1c), Floridian Province (C2); and Neotropical Region (D), Dry Neotropical Province (D1), Humid Neotropical Province (D2).

Biogeographical regions



North America: 21 region

1. Arctic Islands and Greenland
2. Labrador, Sr. Lawrence Valley
3. Canadian Northwest
4. Alaska
5. Yukon and British Columbia
6. Great Lakes and Central Lowlands
7. Appalachians
8. East Coast
9. Coastal Lowlands

10. Central Pacific Coast Ranges
11. Great Plains
12. Mississippi delta
13. South Florida
14. South Texas
15. South Montane region
16. North Montane region
17. Great Basin
18. Southern California
19. Sonora
20. Chihuahua
21. Mexican Sierras

Region 1. Tundra

- Very similar to Eurasia, almost all species are same
- Few mammals (reindeer, musk ox, lemmings), only migratory birds, no reptiles and amphibians
- Forest border is supported mostly by lowest temperatures and permafrost
- Lichens and mosses are more competitive than flowering plants

Regions 2 and 3. Taiga: boreal conifer forests

- Again, very similar to Eurasia
- Typical trees: deciduous *Larix* (larch) and evergreen *Picea* (spruce); North American boreal forests are richer thank Eurasian.
- Forest interleaves with "muskegs", swampy areas shaped mostly by peatmoss (*Sphagnum* spp.)
- Food chains are based on large herbivores (deers, moose, elks).
- Many warm-blood vertebrates will follow the **Bergman rule**: representative of northern species are bigger, and representatives of tropical species are smaller.
- Plus fact which is still unexplained: for some reason, American species of many genera are bigger in size than Eurasian (moose, bears, beavers and many others including plants)

Regions 4 and 5: wet northwest

- Anomalous high temperatures and precipitation rates. **However**: almost no rain in July-September so broadleaved trees are not surviving there.
- Flora and fauna have many connections with Siberia and Eurasian East due to Beringian land-bridge. However, some elements (like porcupines) are clearly Neotropical.
- Rich coastal life: salmon, seabirds, bears, walruses, sea otters (the only species of marine weasels)
- Vast amount of conifer species, e.g. different cedars like *Pseudotsuga*; and ferns

Sea otter (*Enhydra lutris*)

For Further Reading

References

[1] I. Sanderson. *The Continent We Live On*. 1961. Mode of access: `http://www.biodiversitylibrary.org/item/71734#page/7/mode/1up`

[2] North America. `http://en.wikipedia.org/wiki/North_America`

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

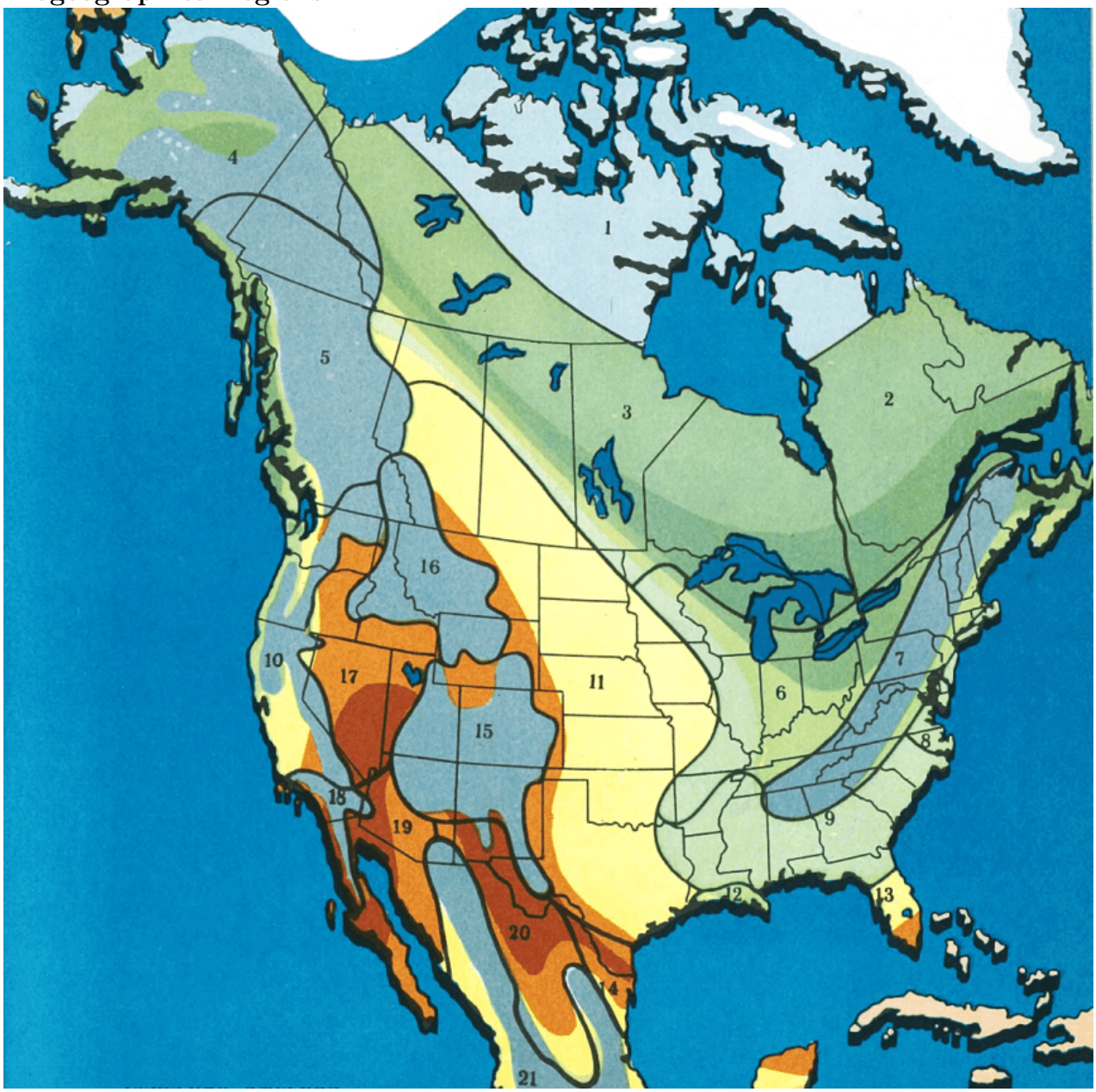
[4] A. Shipunov. *Introduction to Biogegraphy and Tropical Biology* [Electronic resource]. 2017—onwards. Mode of access: `http://ashipunov.info/shipunov/school/biol_330/intr_biogeogr_trop_biol/intr_biogeogr_trop_biol.pdf`

Outline

24 Biogeography of the World

24.1 Holarctic region I: Nearctic North America

Biogeographical regions



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11. Great Plains
12. Mississippi delta
13. South Florida
14. South Texas
15. South Montane region
16. North Montane region
17. Great Basin
18. Southern California
19. Sonora
20. Chihuahua
21. Mexican Sierras

Regions 6, 7 and 8: eastern states

- Eastern USA forests are much closer to Neogene than most of Eurasian forests: much richer and also contain the dominant level (tulip tree, *Liriodendron*; sweet gum, *Liquidambar*; black tupelo, *Nyssa* (a bit smaller)) which disappeared in Europe
- Striking diversity of autumn colors
- Hot spots of animal diversity in Appalachians (crayfish, salamanders, tree frogs, butterflies and many others)
- Appalachians are "destroyed" mountains, consequently they have many caves and rich underground life
- One piece of Appalachians is going west to Great Plains: Ozark plateau
- Many Neotropical elements (opossum, tanager birds, troupials like red-winged blackbird, hummingbirds and others)
- China/Japan — East coast disjunctions for many plant genera (like *Magnolia* or *Trillium*, shrubby blueberry *Vaccinium*, the latter occurrs also in westernmost Europe and Caucasus) and even species
- Swampy/sandy Atlantic shore hosts unusual things: swamp false cypress (*Chamaecyparis*) forests; and nesting places for living fossil **horseshoe crab** (*Limulus polyphemus*), marine invertebrate closest to extinct trilobites

Red-winged blackbird, *Agelaius phoeniceus*

Regions 9 and 12: Southern "pine belt"

- The "African" piece embedded in North American continental plate (**Piedmont** and coastal planes) consists of extremely hard minerals so it is almost impossible to make a proper river bed here. As a result, rivers becoming swamps, mostly swamp pine forests with *Pinus palustris* as a dominant species.
- These warm, shallow swamps on poor soils have many unusual plant and animal species: Venus fly-trap (*Dionaea*), Spanish moss (*Tillandsia*), bald cypress (*Taxodium*) with azaleas (*Rhododendron* spp.), water tortoises, alligators and many species of rodents.
- Again, even more elements are Neotropical like Xyris (yellow-eyed grass; with South American canter of distribution on the Guiana shield).

Yellow-eyed grass, *Xyris*

Region 13: South Florida

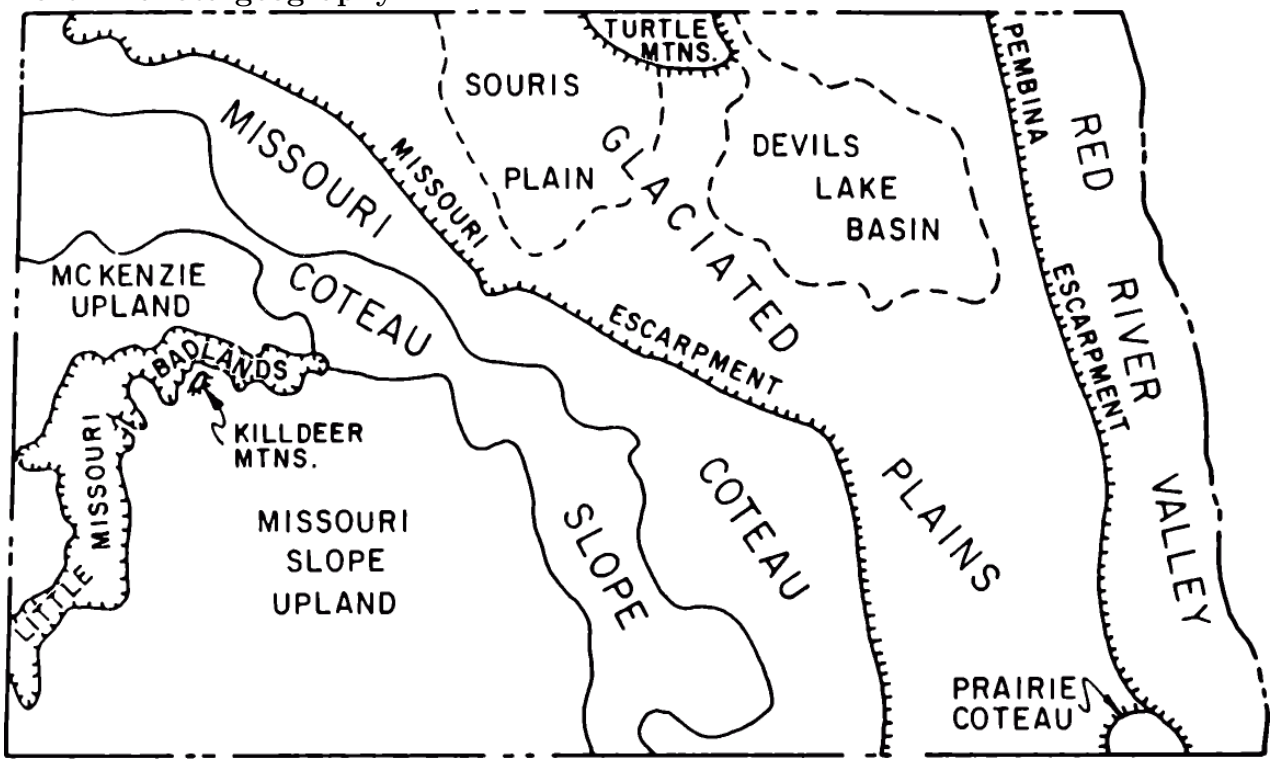
- Everything from lake Okeechobee to the south is a part of Neotropics
- Lowland of different origin: basement is a part of Antilles microcontinent together with Cuba, Hispaniola and Puerto-Rico, plus materials washed out of Appalachians
- Humid region rich of wetlands like Everglades rich of Araceae family representatives and mangrove forests of black (*Avicennia germinans*), white (*Laguncularia racemosa*) and red (*Rhizophora mangle*) mangroves. All these mangroves have seeds germinated on the mother plant.
- Hammocks are "islands" in the "sea" of wetlands, usually covered with threes and shrubs, mostly of tropical origin (Guanica dry forest is similar to well-developed Florida hammock)
- Rich freshwater animal life: flamingos, alligators, freshwater fish from Poeciliidae family (like mosquito larvae-eating *Gambusia*) and many others.

- Florida coast is one of few places supporting big population of sea cows: manatees

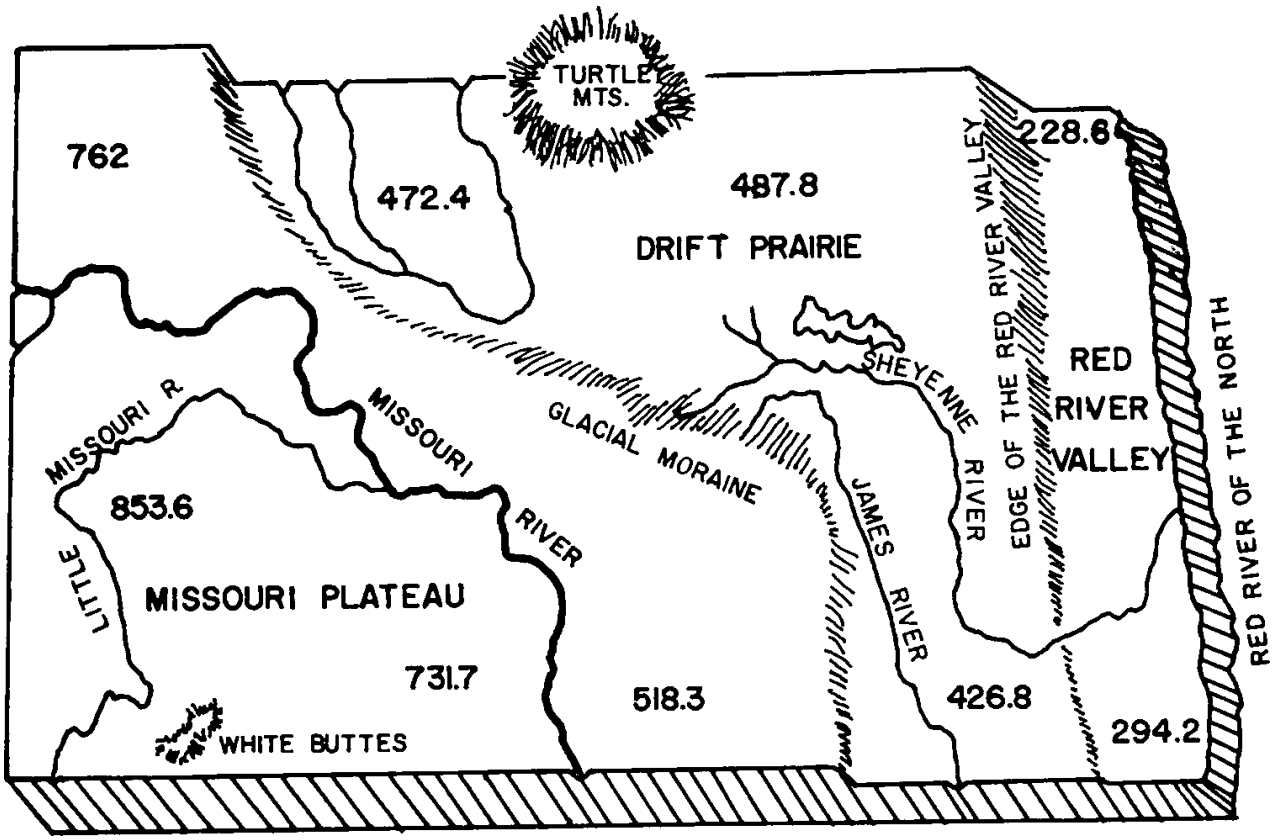
Region 11: Great Plains

- From southeast of Alberta to Edwards Plateau in Texas. The eastern border is determining mostly by precipitation whereas western border are Rocky Mountains.
- Most important landmarks: Badlands, Nebraska sandhills, Llano Estacado (Texas uplands). Black Hills is an unique formation (continental plate uplift) having many western elements in flora and fauna. The prairie itself is mostly combination of grasslands, hills and forested coulees. Oak savanna is also frequent (in North Dakota, nearby Towner and in the Ransom county).
- Historically supported with hoofed animals, mostly bisons (*Bison bison*) and pronghorns (*Antilocapra americana*, unique North American antelope), now with agriculture.
- Rich life of rodents: prairie dogs, gophers, many species of mice and others.
- Aster family (Compositae) and grass family (Gramineae) are dominants. Typically split into tall-grass (eastern, humid) and short-grass (western, dry) prairies. Rich flora of Compositae and presence of multiple shrubs (like snowberries, *Symphoricarpos*) are typical to American grasslands.
- In North Dakota, we have: continental divide, the region of numerous prairie potholes (result of delayed melting of ice), extremely flat Devils Lake region (not even a lake but flooded plane), the second self-drainage basin in North America, wide Red River valley (remaining of Great Lake Agassiz), and "glacier garbage" Turtle Mountains.

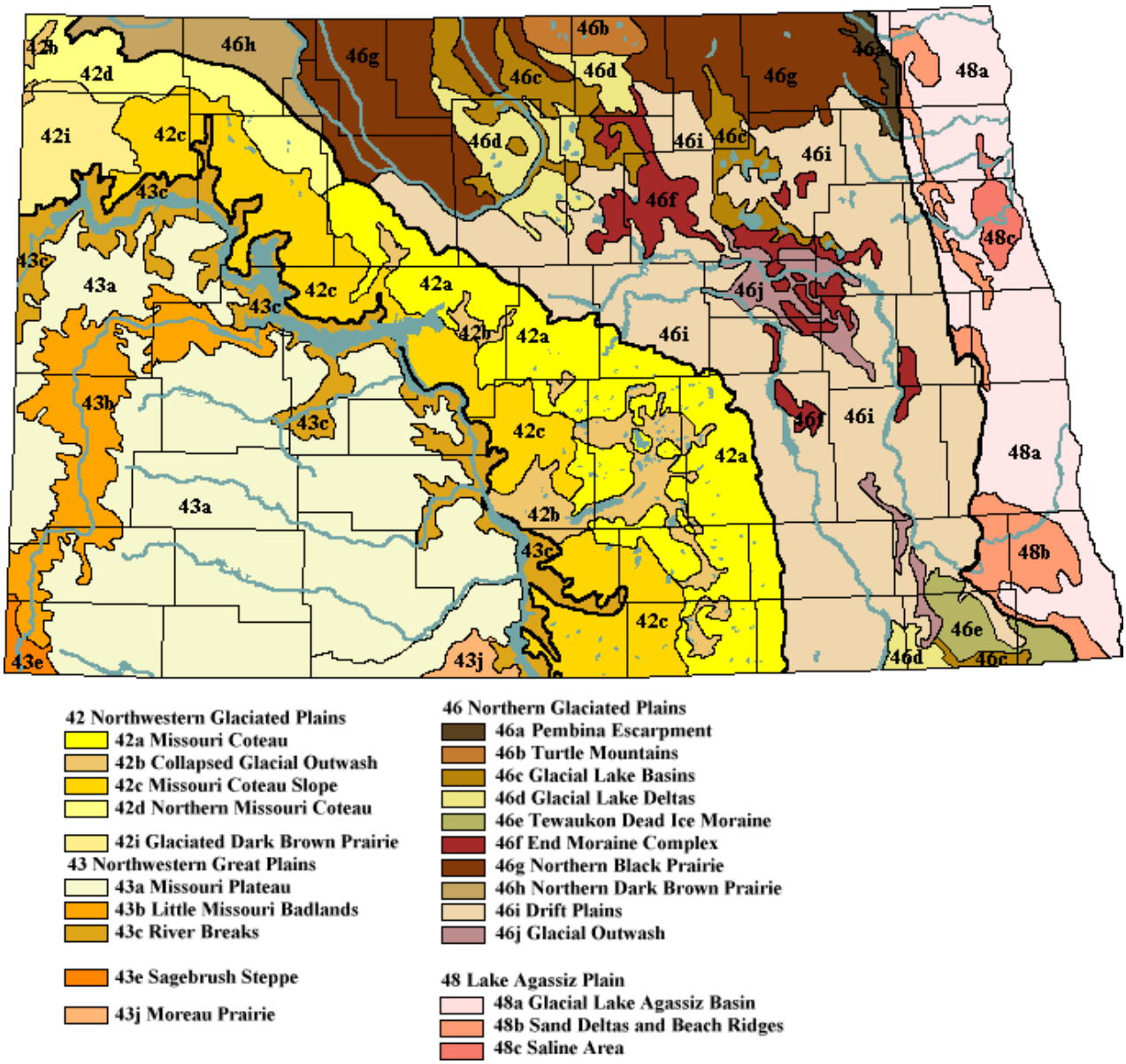
North Dakota geography



North Dakota geography (anothe view)



North Dakota ecoregions



Region 14: South Texas

- Parkland: green savanna with cactus, mesquite (*Prosopis*) and acacia (*Acacia*) domination. Similar to African savannas.
- Sea coast supports rich birds life; this is the wintering place for many northern birds.
- Many native species have Neotropical connections (like nine-banded armadillo, *Dasypus novemcinctus* which now is moving to the north again)

Regions 10 and 18: California

- Unique region with similarities to Mediterranean ans South Africa (The Cape)
- Hot, dry summers and more or less humid winters; almost no precipitation in July–October.
- Cascade mountain range will make Oregon coastline more humid but this effect disappears in "core" California.

- Multiple endemics, including several plant families and many genera (for example, cobra lily, *Darlingtonia*, redwoods, *Sequoia* and *Sequoiadendron*, *Washingtonia* palm)
- The center of several species "explosions", e.g., for oaks (*Quercus*) and manzanita (*Arctospaphylos*)
- Animals: many endemic primitive species like mountain "beaver" *Aplodontia rufa* and shrew mole *Neurotrichus gibbsii*
- The southern part (Baja California) is almost Neotropical.

Mountain "beaver" *Aplodontia rufa*

Shrew mole *Neurotrichus gibbsii*

Regions 19, 20 and 21: southern deserts

- Sonora to the west, Chihuahua to the east and Mexican Sierras between
- Closest analogs are Spanish and north African deserts
- High temperatures, precipitation increases on higher altitudes. As a consequence, desert in valleys and forest on the mountains
- Plants are mostly succulents from Cactaceae (like saguaro *Carnegiea gigantea*, barrel cactus (*Ferocactus*) and Arizona queen of the night *Peniocereus greggii*),and several smaller families (most important are agaves and yuccas from Asparagaceae, and ocotillos from Fouquieriacae). In eastern deserts, cacti are partly replaced with *Acacia* and *Parkinsonia* (Palo Verde) legume trees.
- Many desert animals are cactus-specific like bats, elf owl or cactus wren. Famous roadrunners (*Geococcyx*) and Antelope Jack (*Lepus alleni*) are among fastest living things (20 and 44 mph, respectively).
- Specific groups are gila monster (together with beaded lizard), Helodermatidae; *Phrynosoma* horned lizard; and rattlesnakes, *Crotalus* which are able for thermoreception.
- Mexican Sierras have many Neotropical groups like jaguars (*Panthera onca*), cacomistles (*Bassariscus*) and coati (*Nasua*).

Arizona queen of the night ***Peniocereus greggii***)

Regions 15, 16 and 17: Rocky Mountains and Great Basin

- Great Basin is the one of two closed basins in North America, the bottom of two great dried lakes, **Lake Lahontan** (Nevada) and **Lake Bonneville** (Utah).
- Great Basin has very low precipitation: this is the true desert. Mountain ranges are more humid, especially the northern part where *Pinus ponderosa* is dominating but there are no broadleaf trees dominated (the only exception are aspen *Populus tremuloides* forests). Another widespread ecosystem is the sagebrush (*Artemisia tridentata* mostly) semi-desert.
- Only few endemic species; plants and animals typically came from surrounding regions. Northern mountain range has several species exhibiting the "Seattle/North Idaho" disjunction. However, Yellowstone and Mono Lake support an amazing diversity of extremophile prokaryotes (like *Aquifex* which is the source of PCR DNA polymerase).
- Most interesting plant and animal species: puma (cougar, *Puma concolor*), sage grouse (*Centrocercus urophasianus*), spiny lizards (*Scleroporus*, same family as horny lizard), tailed frog (*Ascaphus montanus*) and bristlecone pines (*Pinus aristata* and *Pinus longaeva*, the latter is the oldest living thing, 5,000 years old).

For Further Reading

References

[1] I. Sanderson. *The Continent We Live On*. 1961. Mode of access: `http://www.biodiversitylibrary.org/item/71734#page/7/mode/1up`

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

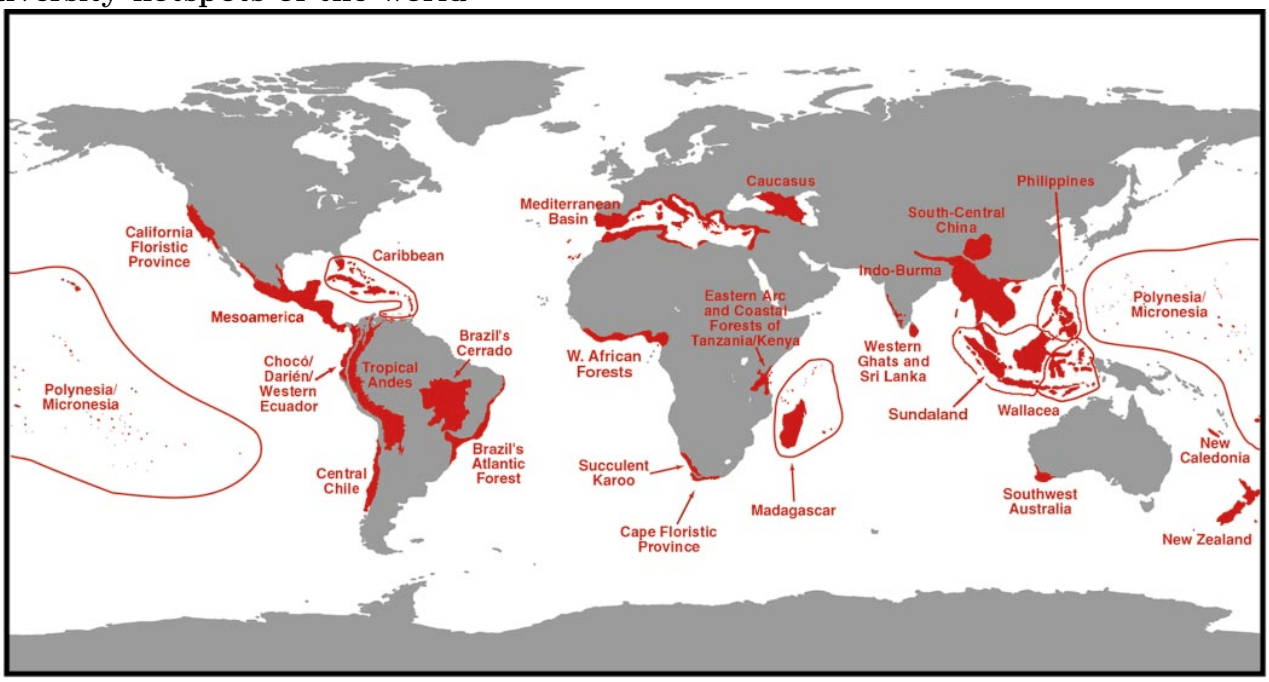
[3] A. Shipunov. *Introduction to Biogegraphy and Tropical Biology* [Electronic resource]. 2017—onwards. Mode of access: `http://ashipunov.info/shipunov/school/biol_330/intr_biogeogr_trop_biol/intr_biogeogr_trop_biol.pdf`

Outline

25 Biogeography of the World

25.1 Biogeography rules

Biodiversity hotspots of the world



(From Myers at al., 2000)

Biogeography rules

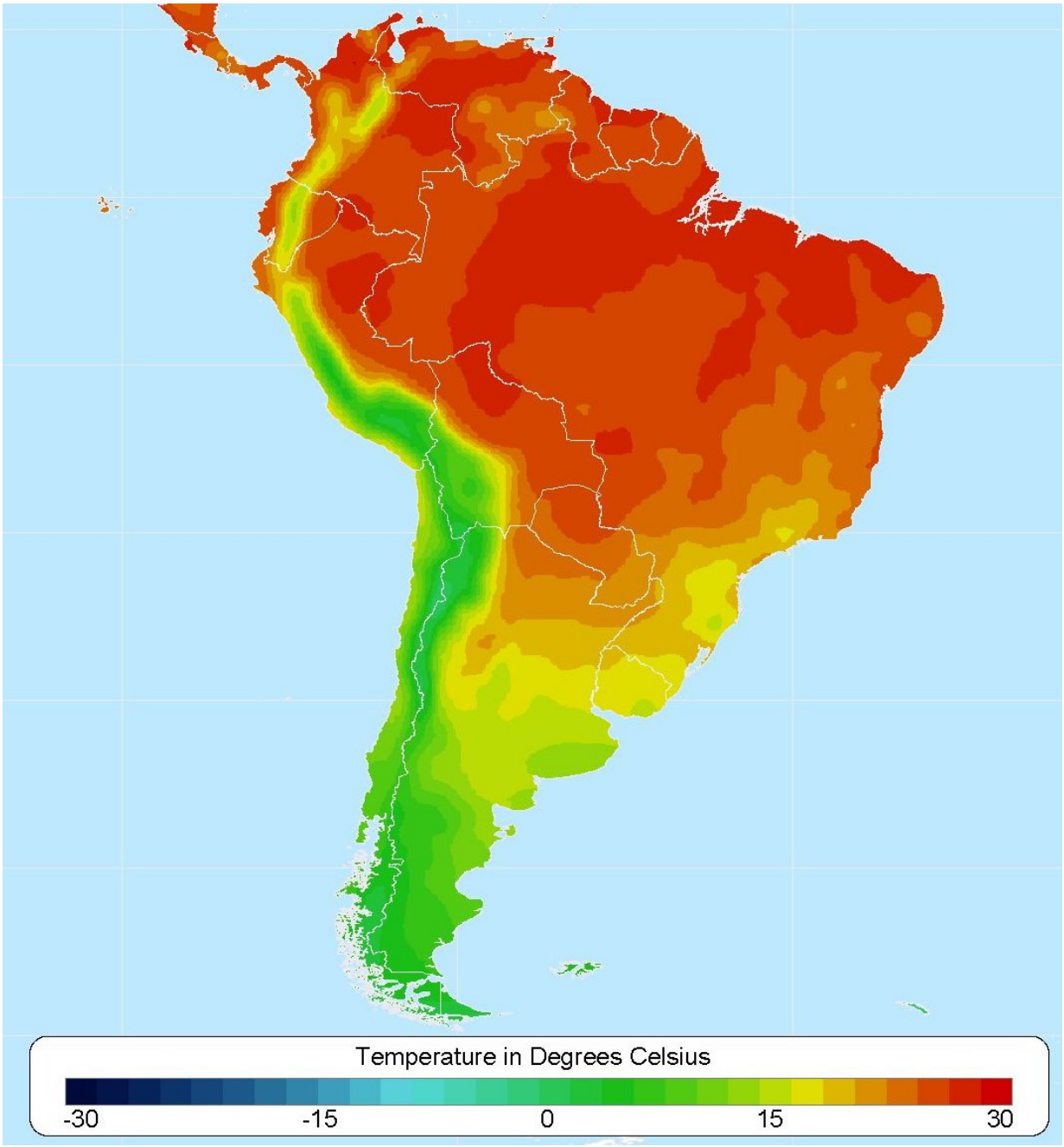
- Allen's rule: endoterms minimize surface in cold climates and maximize in warm climates
- Bergmann's rule: northern are bigger
- Carlquist's rule: island plants ten to be woody
- Flight rule: island insects and birds often do not fly

- Foster's rule: island species tend to be either giants or dwarves
- Gloger's rule: pigmentation increases in humid climates
- Rapoport's rule: latitudinal ranges are smaller at lower latitudes

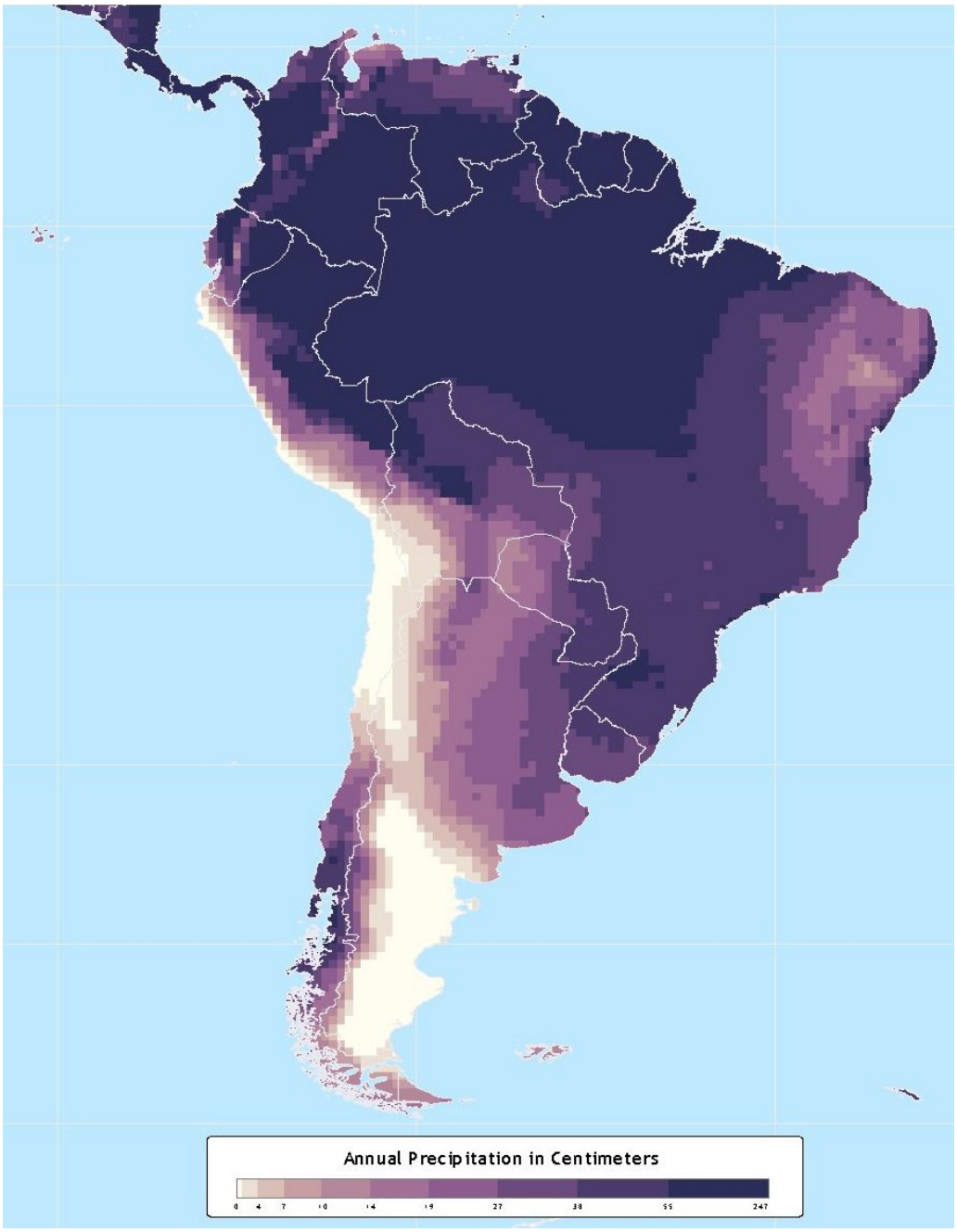
25.2 Biogeography of South America, or Neotropics

[Southern, tropical, low, new Andes, Amazon and Parana]

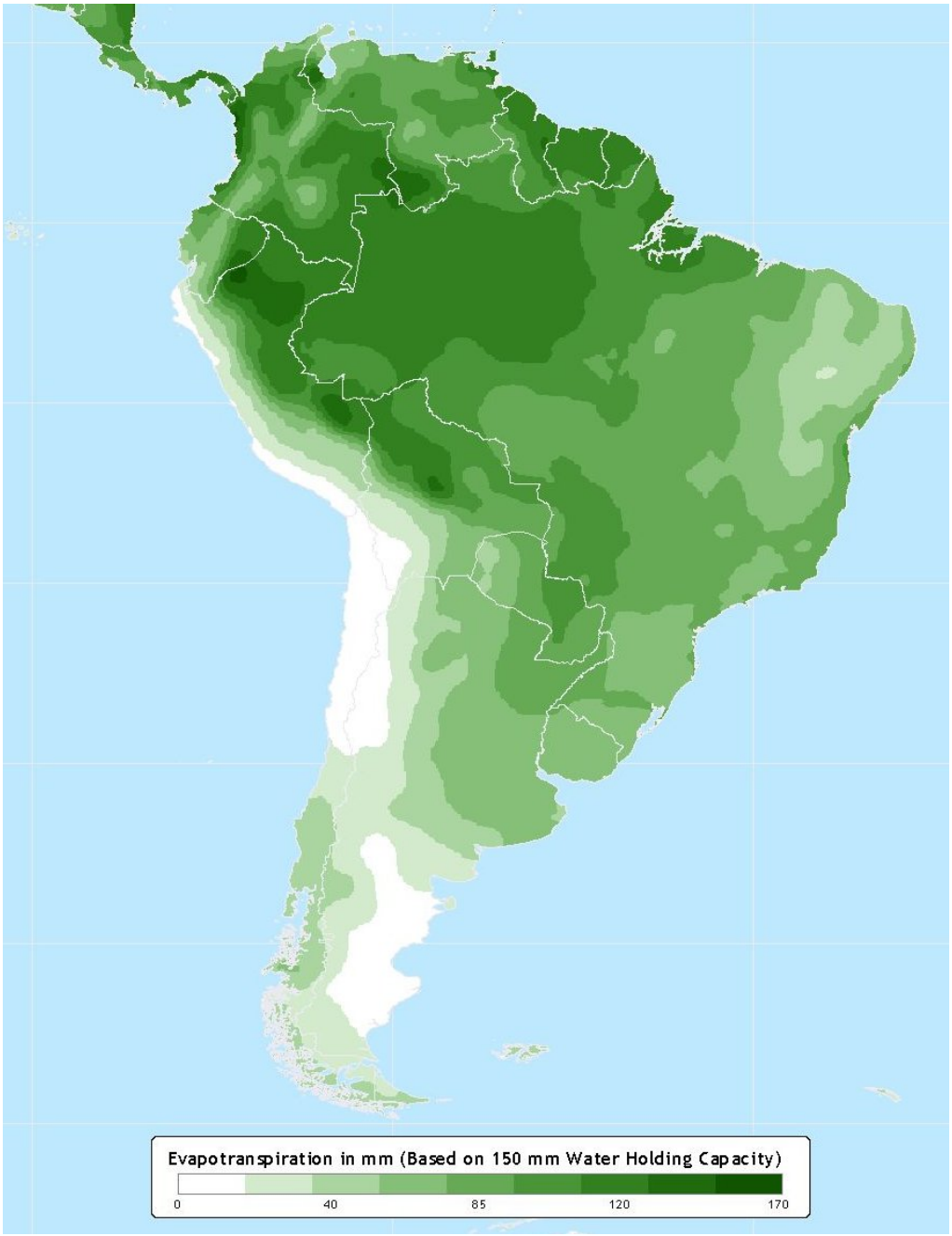
South America: temperatures



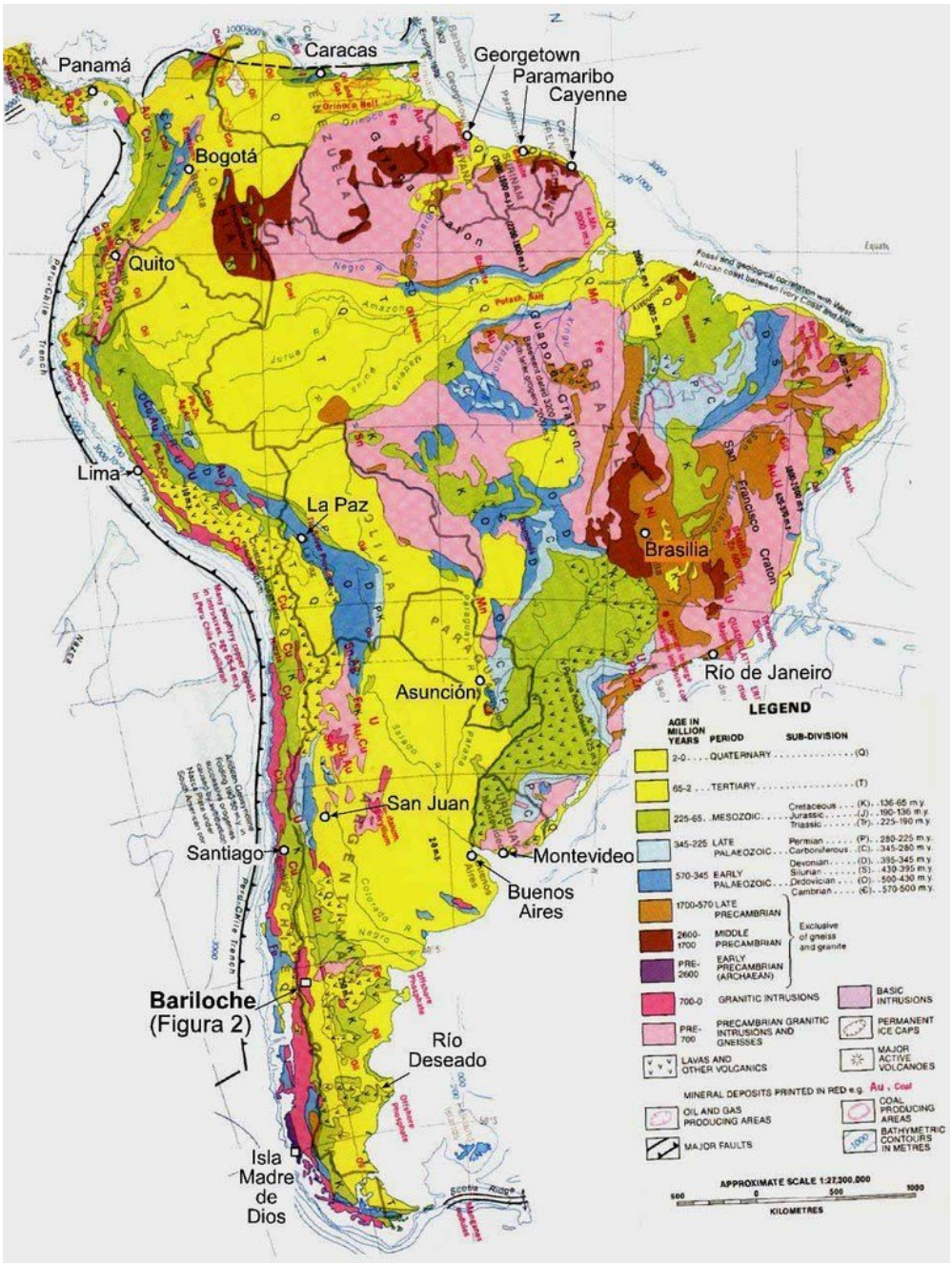
South America: precipitation



South America: evapotranspiration

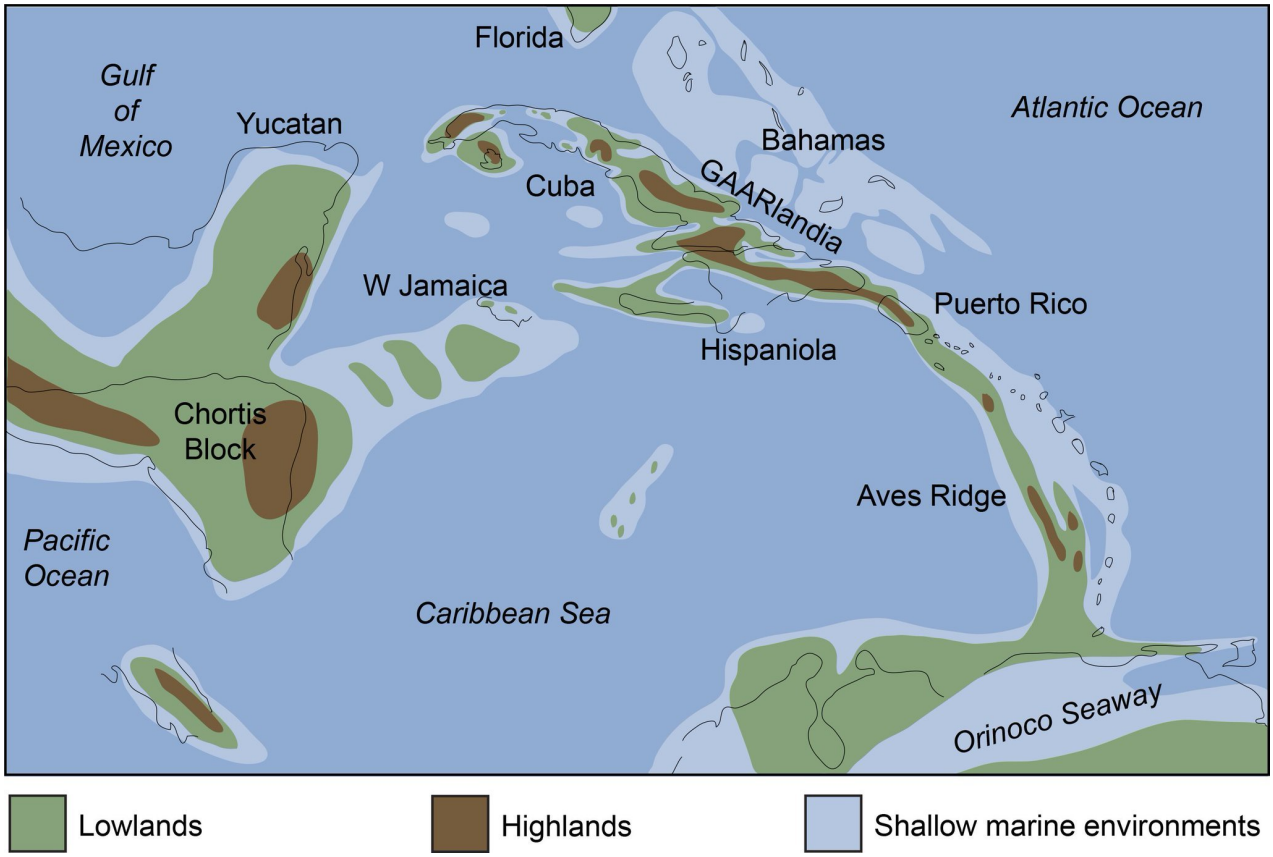


South America: geology



South America: ecoregions

GAARlandia concept



South America: 13 biogeographical regions

1. Tropical Central America
2. West Indies
3. Venezuela and Guiana Shield
4. Amazonian Basin
5. Brazilian Northeast and Plateau
6. Brazilian Atlantic Forest
7. Gran Chaco
8. North and Central Andes (Columbia, Ecuador and Peru)
9. Pampas
10. Atacama desert
11. *Galapagos Islands*
12. Patagonia and Juan Fernandez
13. *South American Antarctic Islands*

Regions 1 and 2: Tropical Central America and West Indies

- Central America is similar to West Indies. The most pronounced difference is the richer fauna and especially flora: many endemic species, genera (like *Haptanthus*) and even families.
- Cuba, Hispaniola and Puerto Rico are micro-continents and have unique biogeographical features, like *Buxus* hotspot on Cuba, or one of most primitive placental mammals, *Solenodon* on Hispaniola and Cuba.
- Central America served as a bridge for the American flora and fauna. Many temperate groups migrated through Central American mountains to the north or south.

Regions 3 and 4: Venezuela, Guiana Shield and Amazonia

- Llanos are northern grasslands in South America; they cover the big part of Venezuela
- Guiana Shield is the famous "lost world" with a high level of endemism in both plant and animal groups plus the highest waterfall on Earth, Angel Falls.
- **Amazonia** is a geologically new region, speciation processes are just starting there. Nevertheless, the diversity is overwhelming.
- The most famous plant and animal representatives are:
  - *Victoria regia* giant waterlily, chocolate tree (*Theobroma cacao*) and Brazil nut (*Bertholletia excelsa*), papaya (*Carica papaya*) and guarana (*Paulinia cupana*)
  - *Morpho* butterfly, *Theraphosa blondi* giant birdeater spider, and leafcutter ants (*Atta colombica*)
  - Four-eyed (*Anableps*) and piranha (*Hydrolycus*) fish
  - Trumpeter (*Psophia*), hoatzin (*Opisthocomus*) and toucans (*Ramphastos*) birds
  - Anteaters like tamandua, tree anteater (*Tamandua tetradactyla*), American tapir (*Tapirus terrestris*), giant capybara (*Hydrochoerus*), specific Platyrrhini monkeys, *Desmodus* vampire bats and *Bradypus* sloths.

For Further Reading

References

[1] South America. `http://en.wikipedia.org/wiki/South_America`

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Outline

26 Biogeography of the World

26.1 Biogeography of South America, or Neotropics

South America: 13 biogeographical regions

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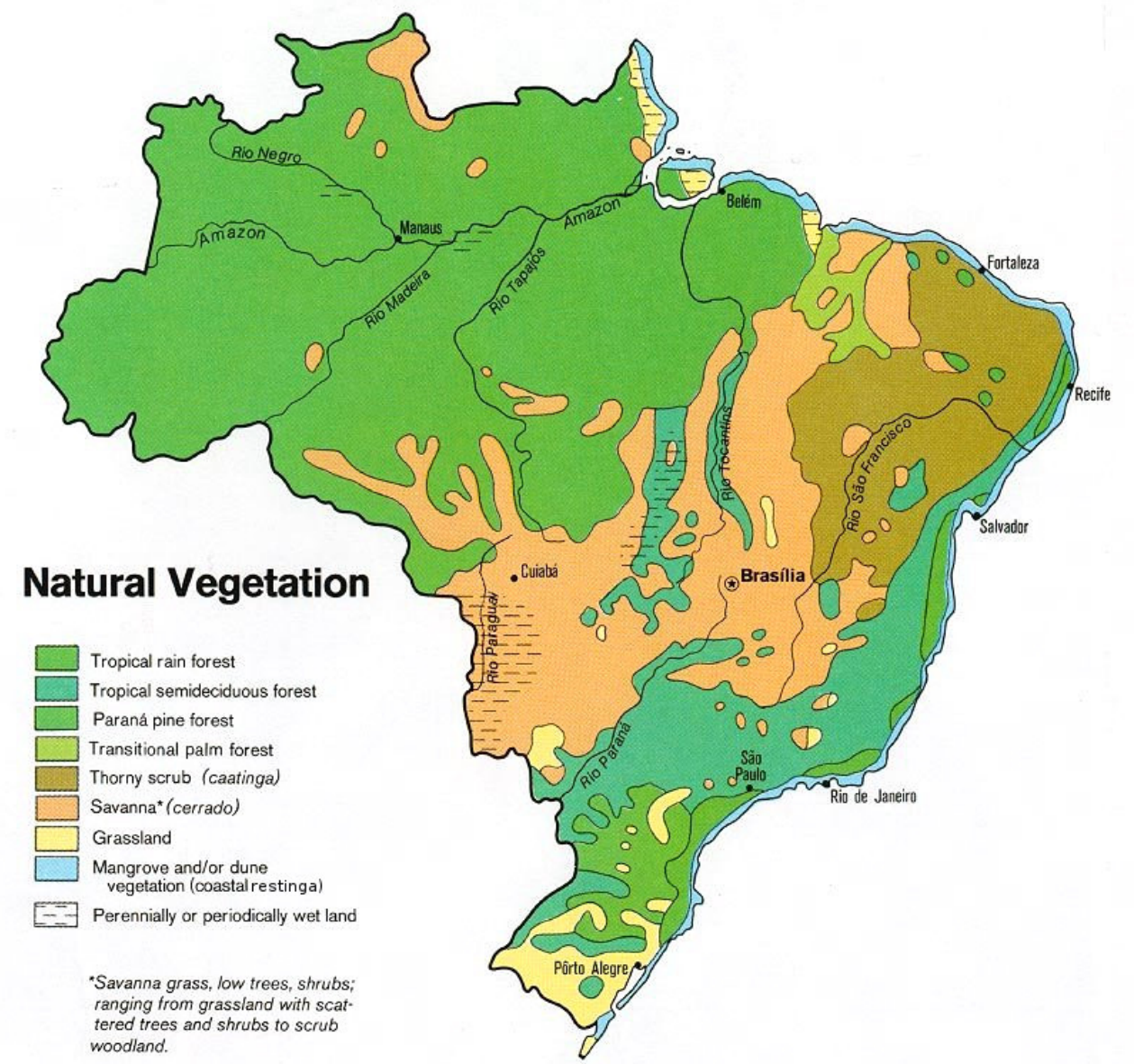
Regions 5 and 6: Brazilian Northeast, Brazilian Plateau and Brazilian Atlantic Forest

- Drier, sometimes semi-desert regions. Brazilian Northeast is extremely species-poor comparing with Amazonia (somehow, analogous to Dekkan Plateau in India).
- Unusual dry spiny forest, *caatinga* with domination of cactuses and legumes. One of native plants, cashew (*Anacardium occidentale*) is widely cultivated.
- Located inside plateau (*cerrado*) is one of the most splendid natural attractions on Earth—Iguazu waterfall.
- The home of many agricultural plants like peanuts (*Arachis hypogaea*) and bromeliad pineapples (*Ananas comosus*).
- Atlantic forest (*mata Atlantica*) consists of Amazon-like but more seasonal forest plus some unusual ecosystems like *restinga* (coastal semi-forest).

Brezilian vegetation types



Regions 7 and 9: Gran Chaco and Pampas

- The west of region—Bolivian yungas, Andes foothills rich of plantations, homeland of quinine tree, *Cinchona*
- To the east, in Grand Chaco, there are contrasted dry and wet periods: wetlands in rain season and semi-deserts otherwise, dominated with "palo borracho", "drunken tree" *Ceiba speciosa*
- Rich fauna (e.g., most species of armadillos including the giant tatu carreta *Priodontes maximus*) and maned wolf *Chrysocyon brachyurus*; and the second center of Cactaceae distribution
- Famous Gondwana lungfishes have one representative in South America, *Lepidosiren*. Two other genera live in Africa and Eastern Australia. Another Gondwana group, ratite birds, have representative in Pampas: American nandu (*Rhea americana*)
- Pampas, like llanos is another grassland region of South America

Region 8: North and Central Andes

- Unusual, rich alpine regions with the domination of specific plant groups like *Aragoa*, *Puya raimondii*, balsa (*Ochroma lagopus*), the tree with a lightest wood
- **Páramo**—specific alpine wetlands dominated with *Espeletia*, the amazing life form from aster family
- **Puna**—alpine grasslands, suppourted with large camelid herbivores like guanaco (*Lama guanicoe*) and alpaco (*Vicugna pacos*)
- One of highest diversity hotspots of birds (1,500 species versus 700 for **all** North America)
- The homeland of great South American civilizations

Region 10: Atacama desert

- The driest place on Earth: zero precipitation level
- Systematically broken by El Niño when cold Humboldt current is deviating from the coast
- Frequent earthquakes
- Dense fogs (fog density in "lomas" is sometimes up to 200–300 mm)
- Extremely rich marine/coastal (e.g., Humboldt's penguin *Spheniscus humboldtii*), and very poor terrestrial life

Region 12: Patagonia

- The southern temperate region with flora similar to Australia and New Zealand (!)
- Conifer forests (*Araucaria araucana*, *Libocedrus*, *Saxegothaea*) domination
- In more humid regions, the main dominant is birch-like *Nothofagus* (same genus as in New Zealand)
- Many giant Patagonian animals (like giant xenarthran *Megatherium* and *Glyptodon*) are now extinct

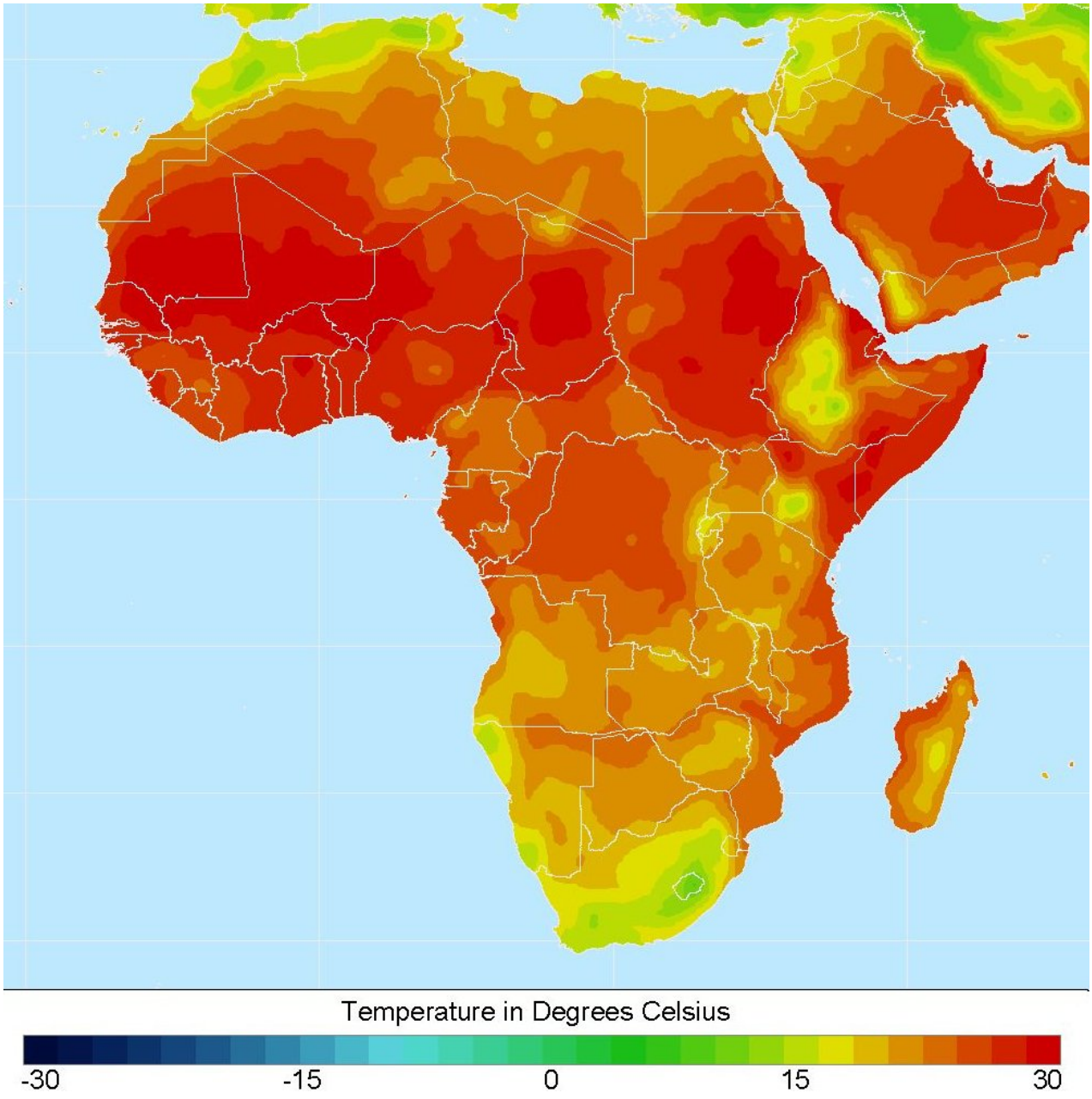
Summary for South America

- Low and narrow, wettest continent
- Part of Gondwana: many groups which are also distributed in Australia, New Zealand and Africa
- Isolated for most of Cenozoic: unique groups of plants and animals (e.g., Xenarthra)

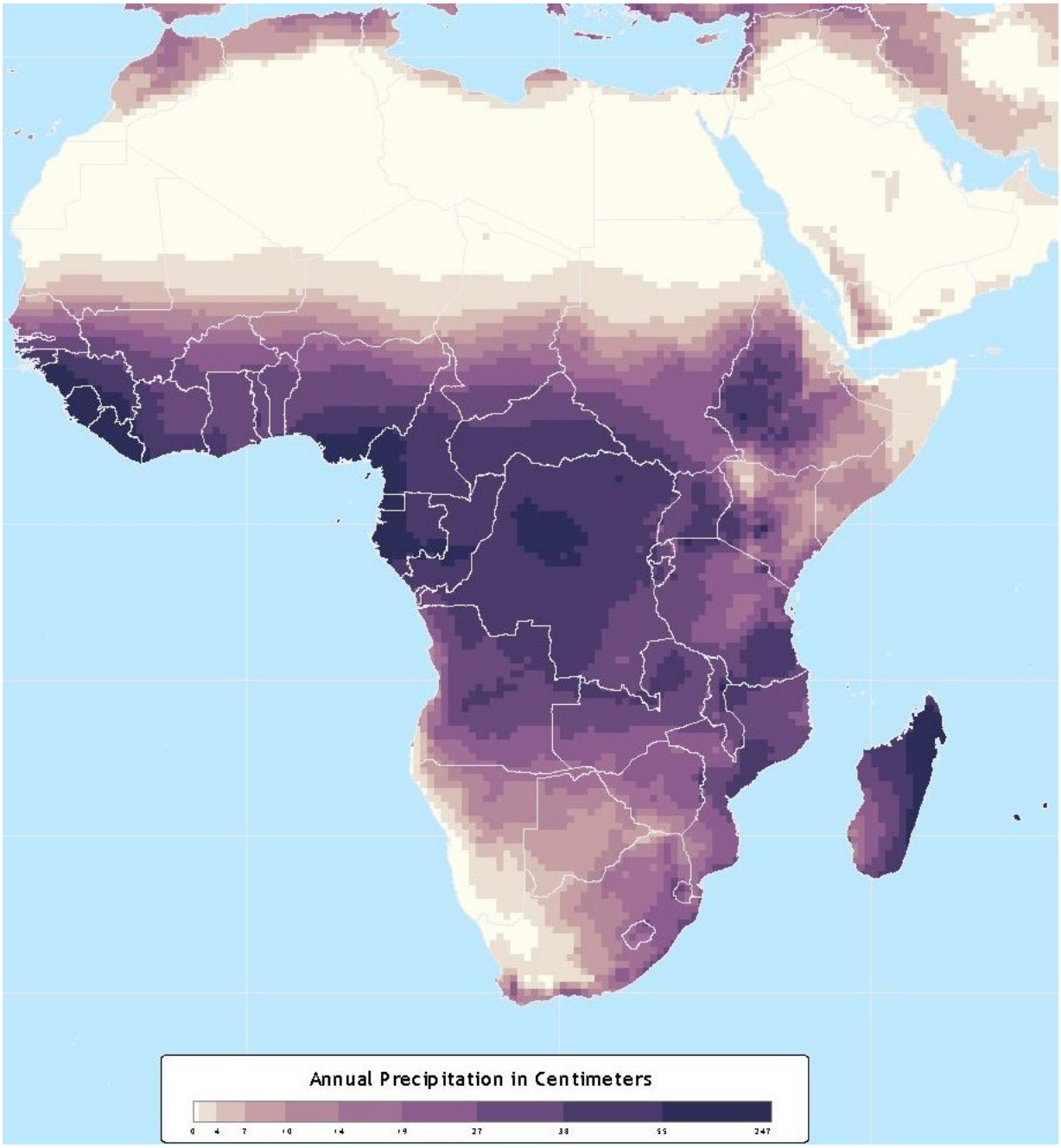
26.2 Biogeography of Africa

(we exclude Mediterranean Africa)

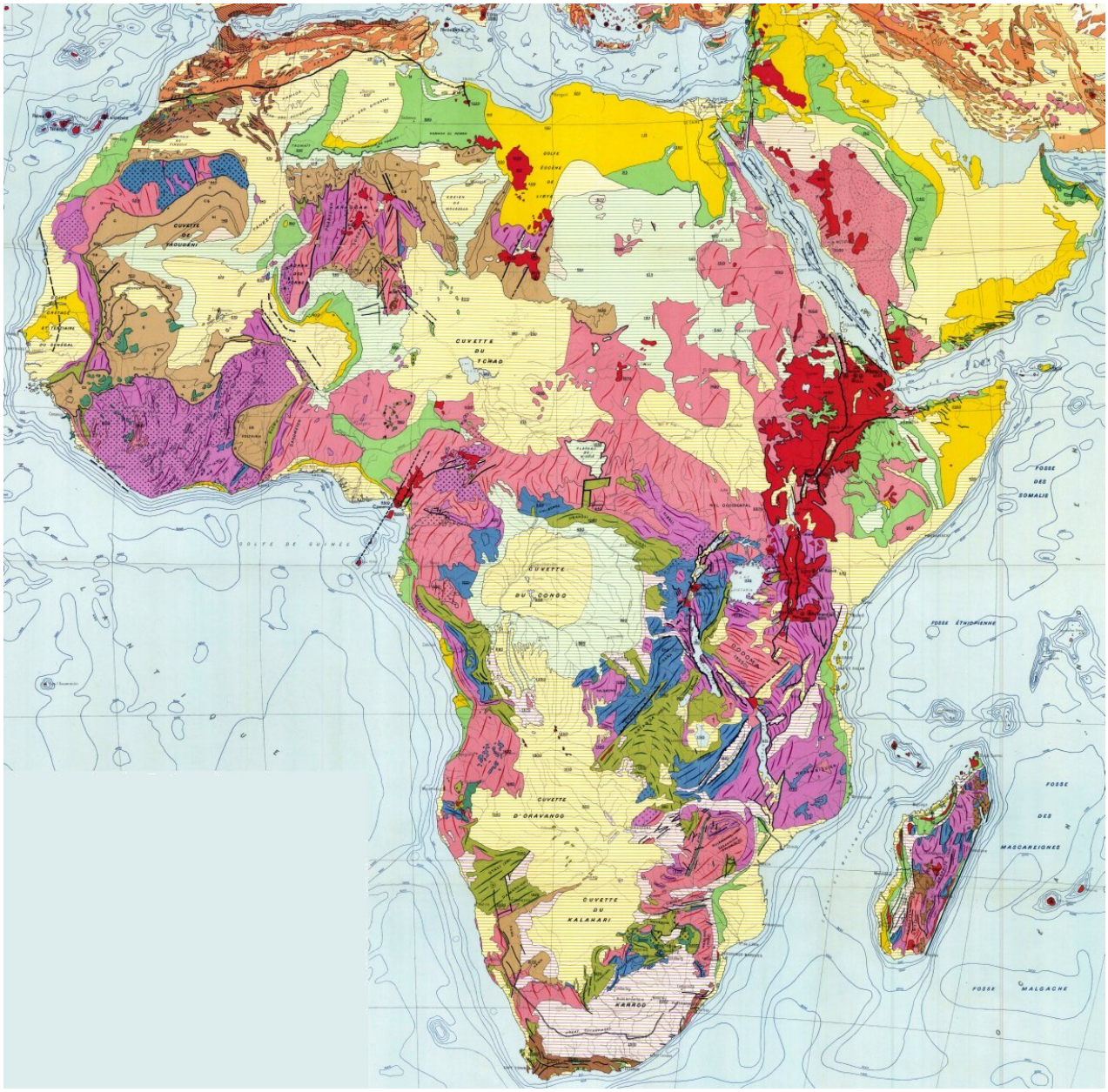
Africa: temperatures



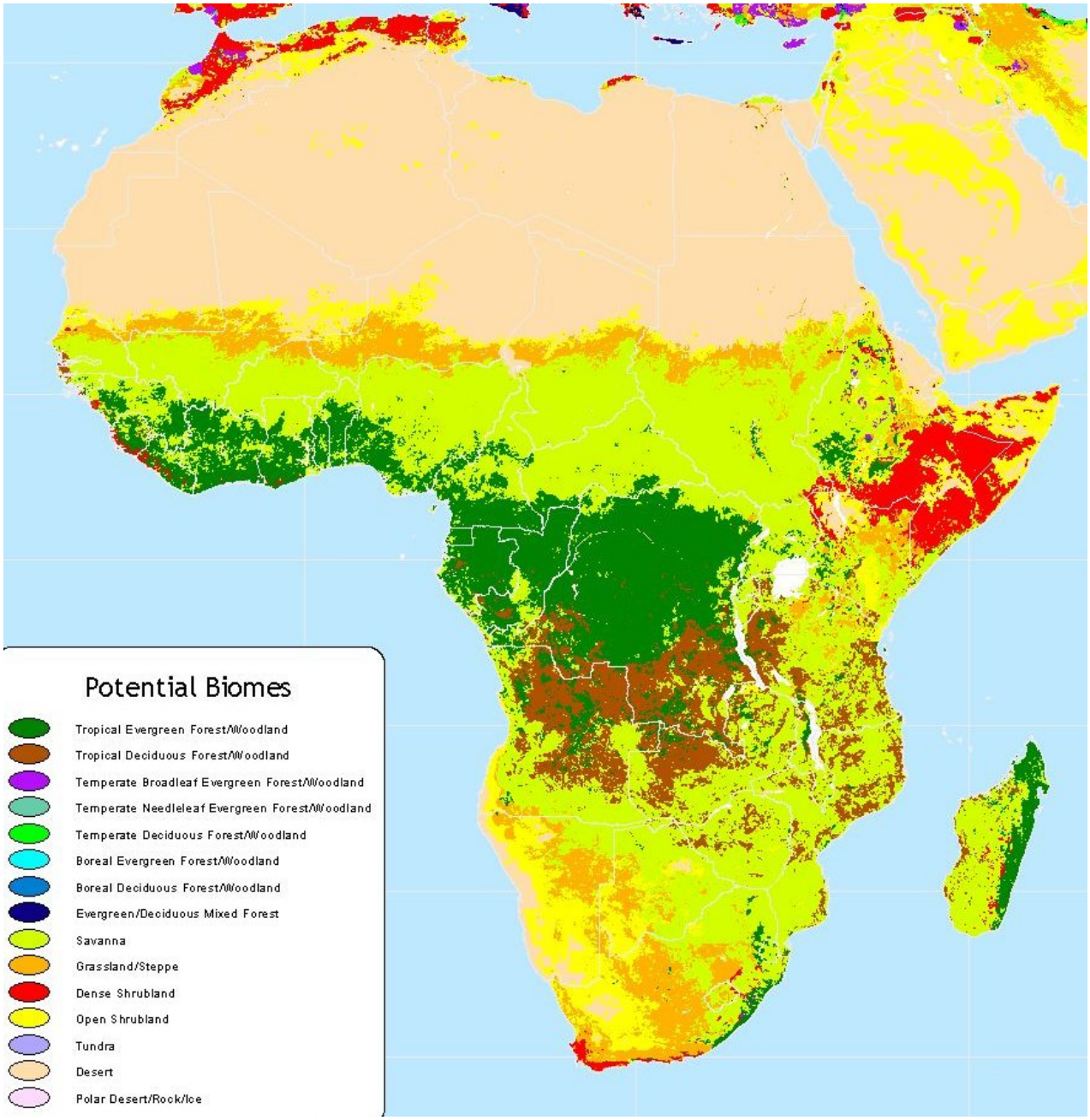
Africa: precipitation



Africa: geology



Africa: potential biomes



Africa: biogeographical regions

Africa: 8 biogeographical regions

1. Sahara
2. Northern savanna belt
3. Ethiopian highlands
4. Kongo forests
5. Eastern savannas
6. Kalahari and other southern deserts
7. Cape
8. Madagascar

African regions: the most significant bio-markers

1. **Sahara**: date palm (*Phoenix dactylifera*), dum palm (*Hyphaene*)
2. **Northern savanna (Sudan and Guinea) belt**: African *Acacia* trees, oryx antelopes (*Oryx*) and cheetah (*Acinonyx jubatus*)
3. **Ethiopian highlands**: gelada baboon (*Theropithecus gelada*) and walia ibex (*Capra walie*)
4. **Kongo forests**: three species of anthropoid apes, *Gorilla gorilla* (*Gorilla beringei* occurs in the next region) and *Pan troglodytes* and *Pan paniscus* and hornbill birds (Bucerotidae).
5. **Eastern great savannas**: the Great African Grassland fauna ("Safari" fauna) including African elephants (*Loxodonta africana*), lions (*Panthera leo*), giraffes (*Giraffa camelopardalis*) and rhinos (*Ceratotherium* and *Diceros*). This fauna has a lot of connections with Old World faunas (except Australia).
6. **Kalahari and other southern deserts**: *Welwitschia mirabilis*, unique gymnosperm, also aloe (like *Aloe arborescens*) and cactus-like spurges (*Euphorbia*)
7. **Cape**: amazing diversity of plant species, especially from Protea family (Proteaceae).
8. **Madagascar**: indri (*Indri indri*), tenrecs (Tenrecidae), giraffe weevil (*Trachelophorus giraffa*), panther chameleon (*Furcifer pardalis*), pygmy chameleon (*Rhampholeon*), Lac Alaotra bamboo lemur (*Hapalemur alaotrensis*), crowned lemur (*Eulemur coronatus*), fossa (*Cryptoprocta ferox*), Verreaux's sifaka (*Propithecus verreauxi*), Ward's Flycatcher (*Pseudobias wardi*), Crested Drongo (*Dicrurus forficatus*).

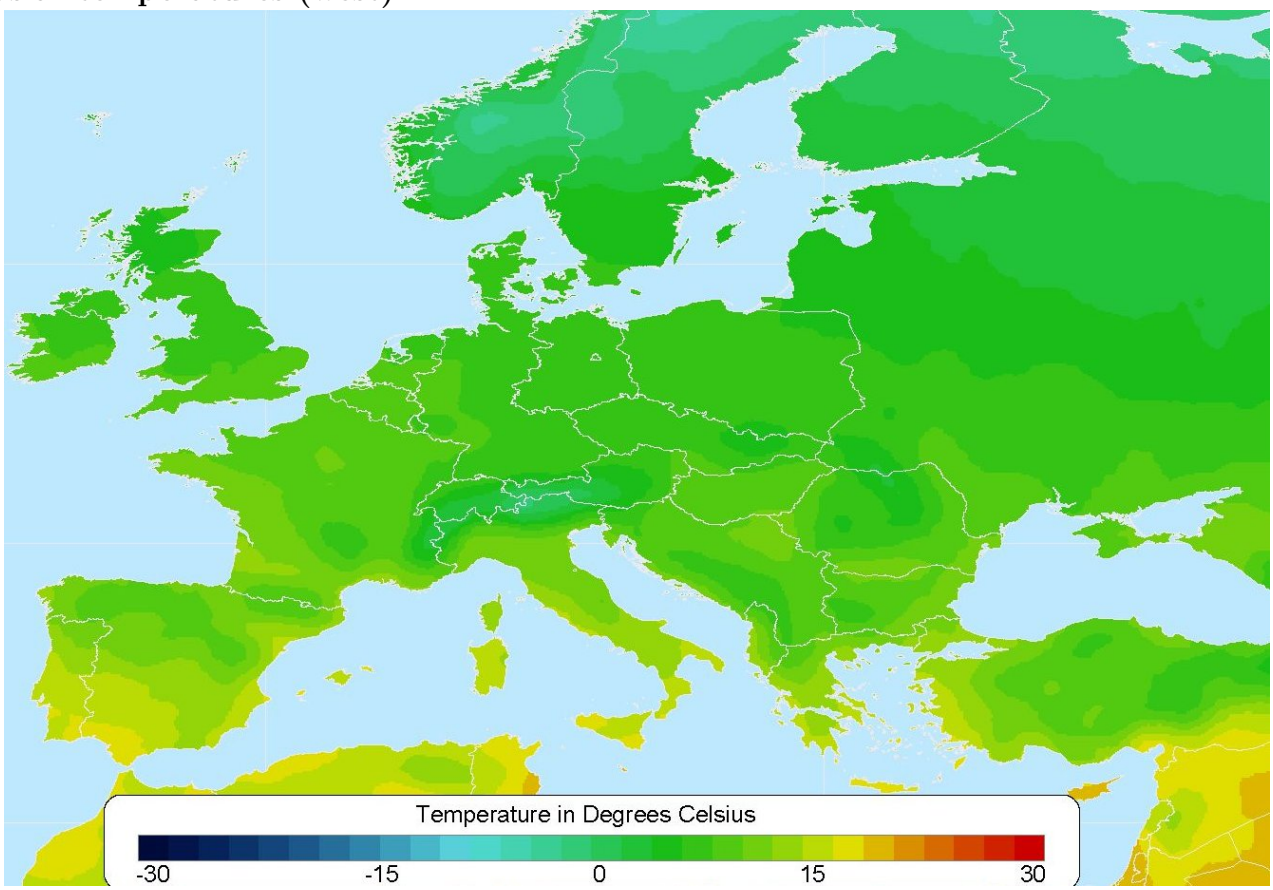
Summary for Africa

- High, uniform and dry continent
- Homeland for the **majority** of recent plant and animal groups ("tropical pump"), e.g., Afrotheria (elephants Proboscidea, elephant shrews Macroscelidea, hyraxes Hyracoidea, tenrecs Tenrecidae with golden moles Chrysochloridae, sea cows Sirenia and aardvarks Tubulidentata). All World grassland fauna originated in Africa. The third example of cosmopolitan mammal with African savanna origin are humans (genus *Homo*).

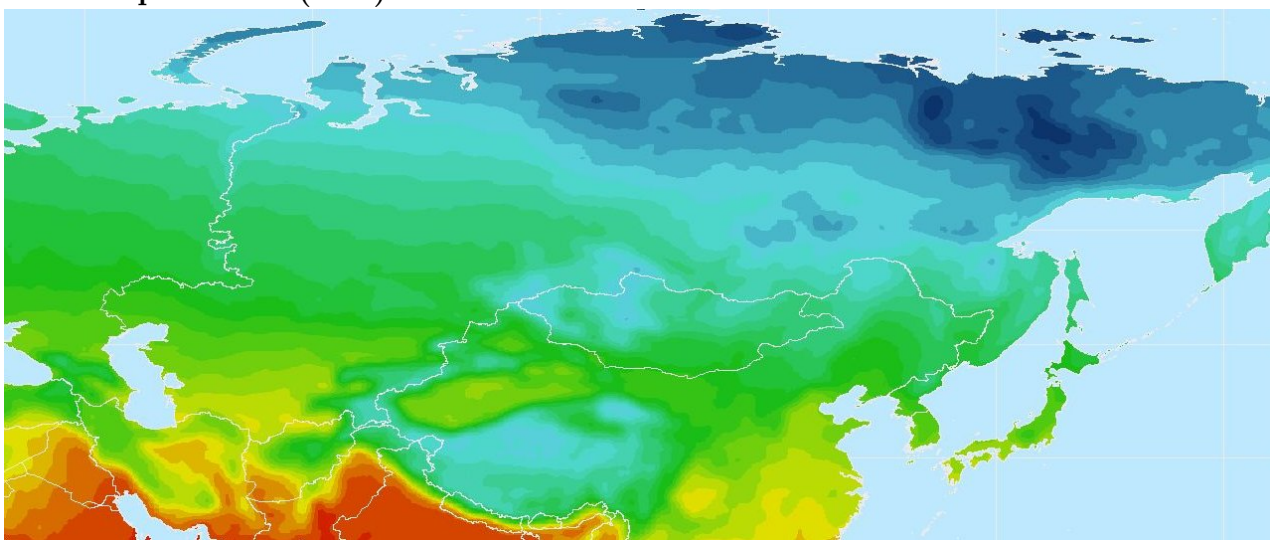
26.3 Biogeography of Holarctic Eurasia

Note latitudinal mountain ranges

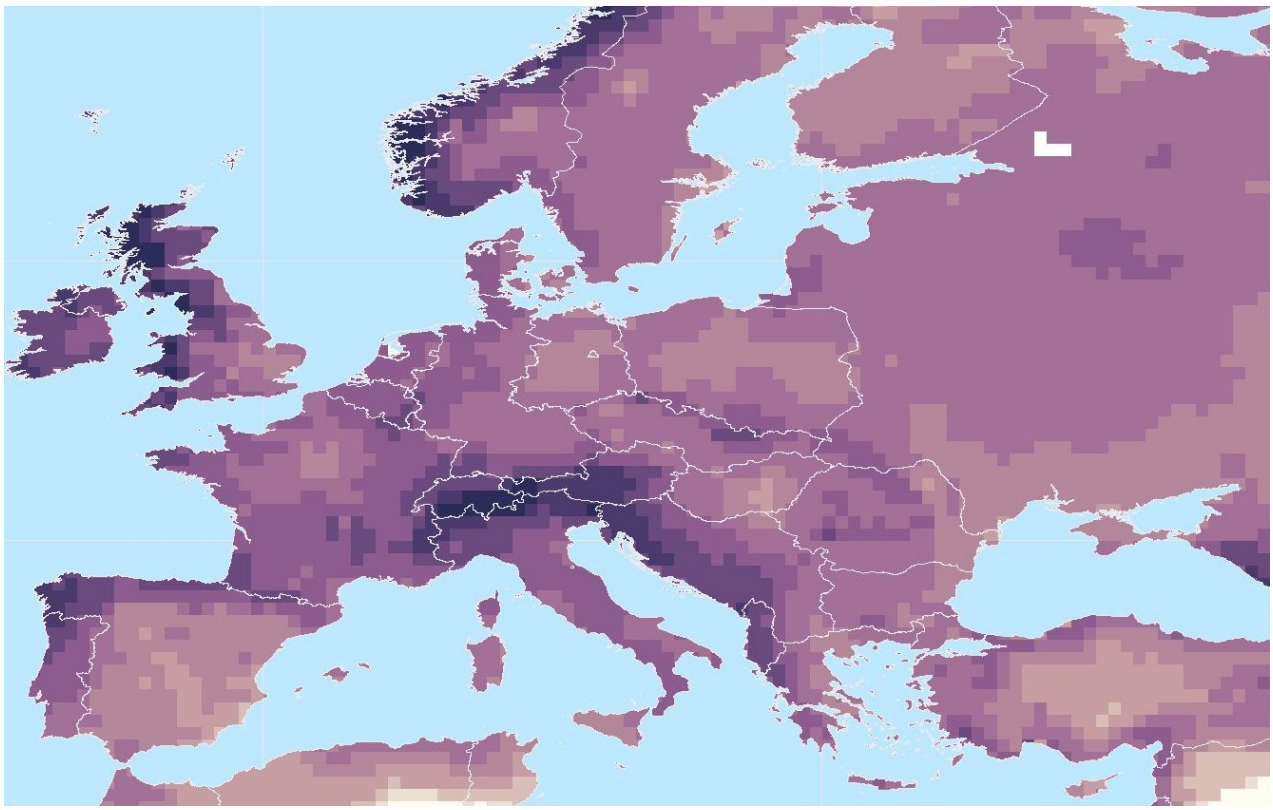
Eurasia: temperatures (west)



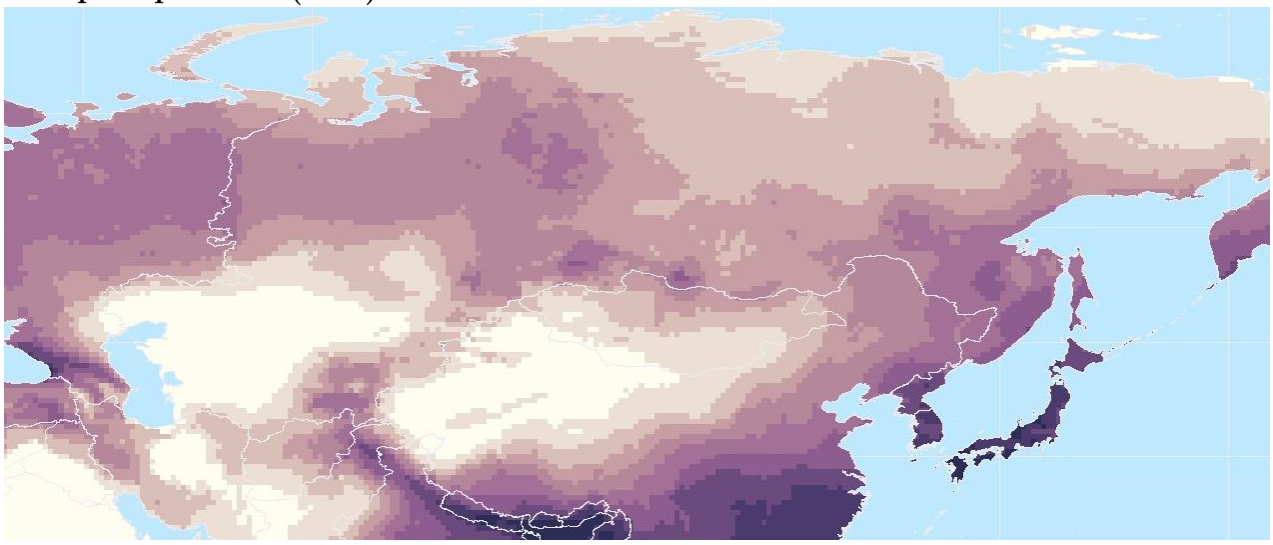
Eurasia: temperatures (east)



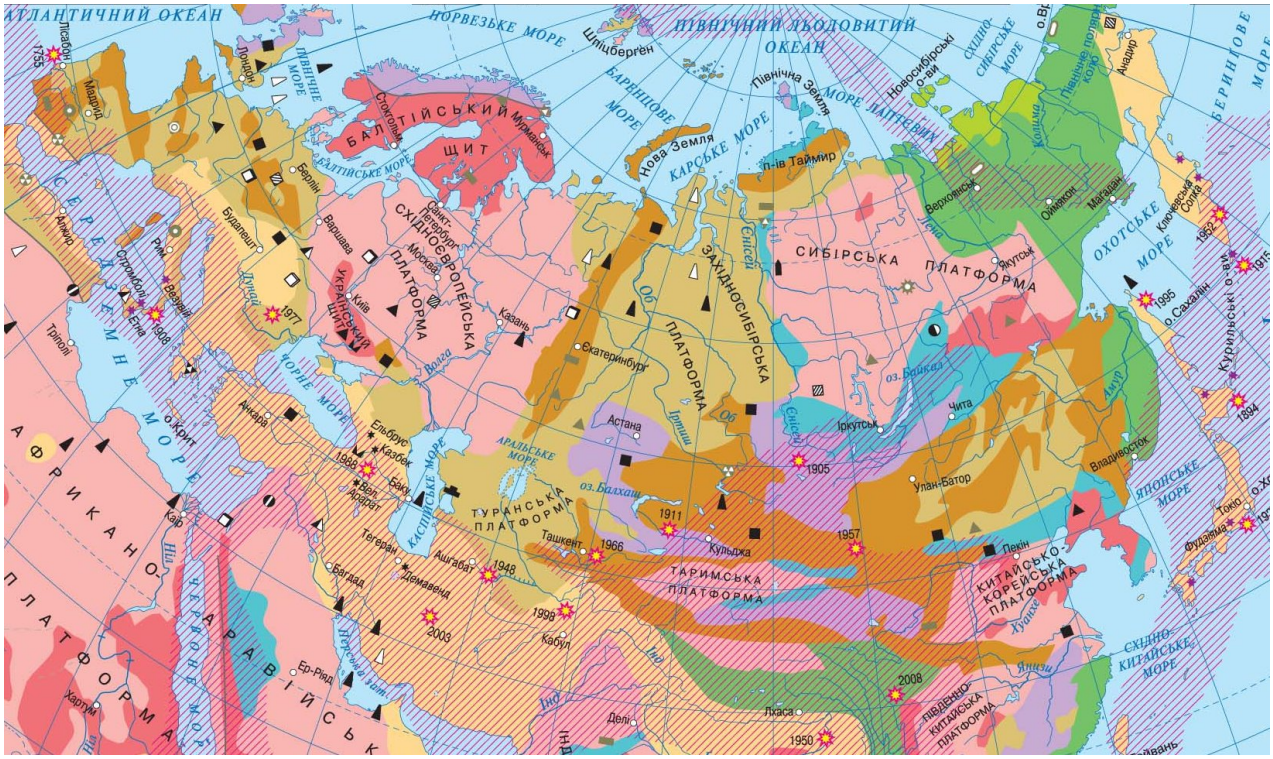
Eurasia: precipitation (west)



Eurasia: precipitation (east)

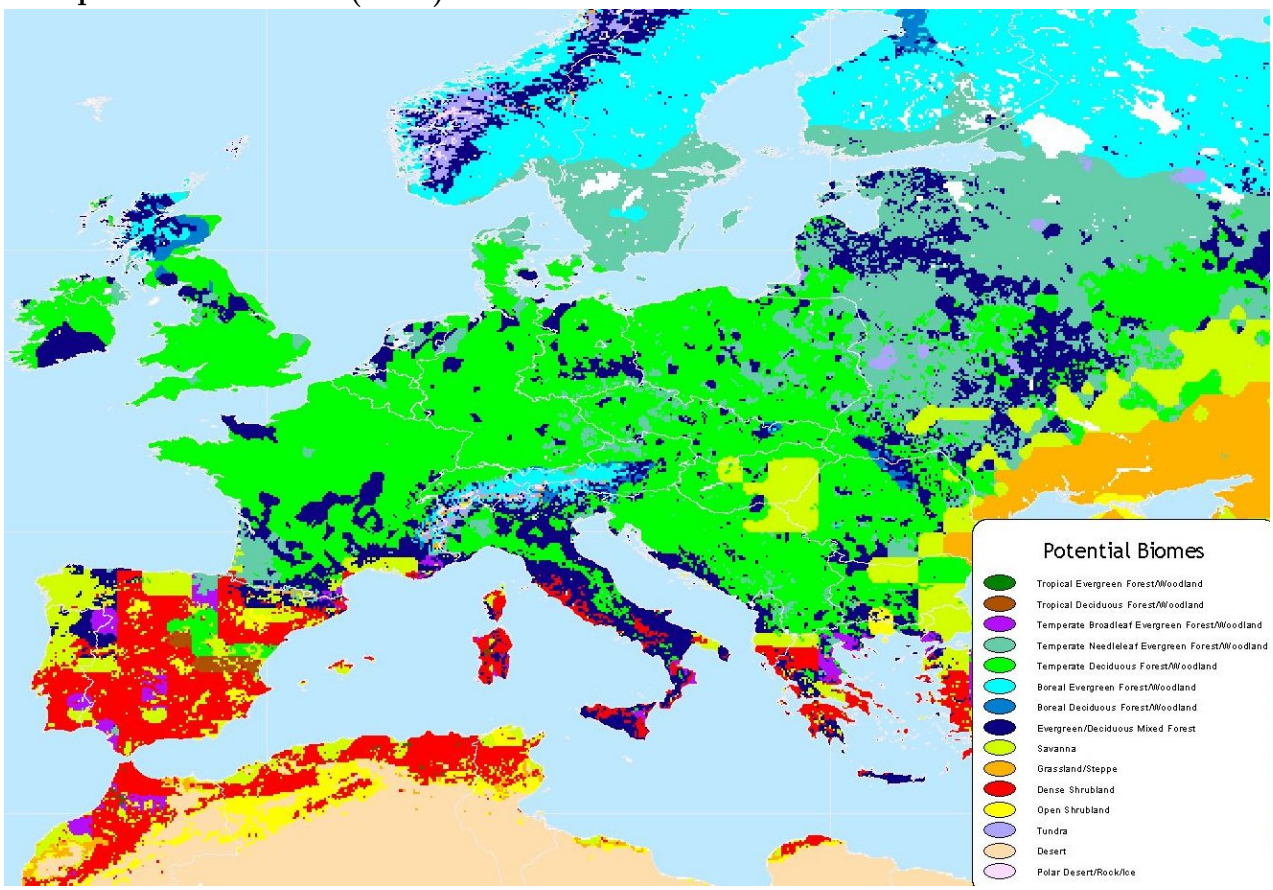


Eurasia: geology

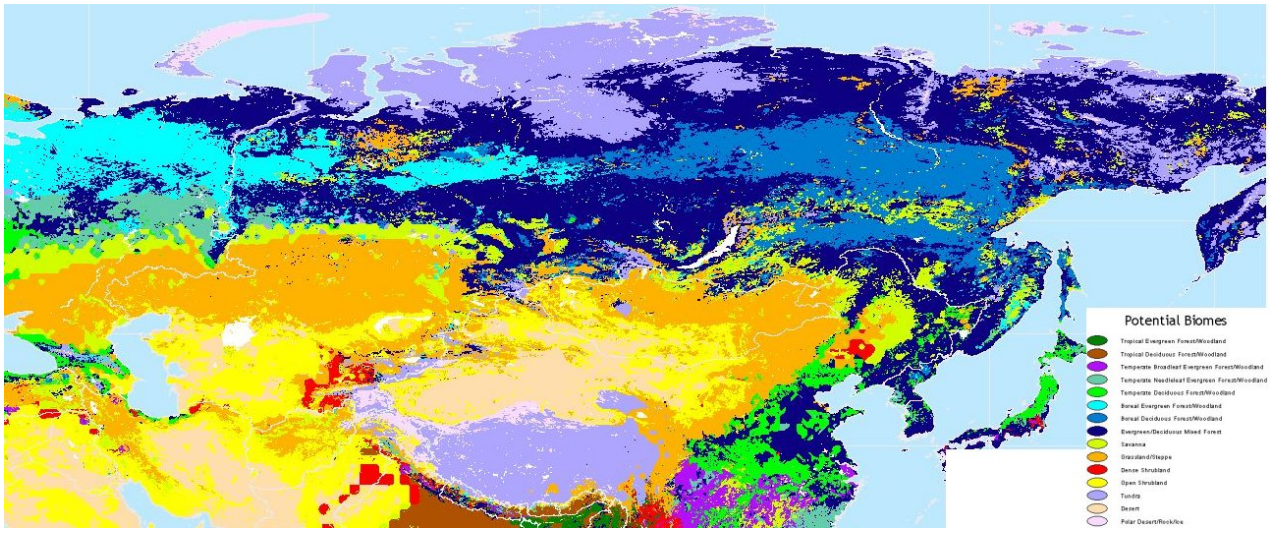


Several continental platforms and mountains on the places of collision

Eurasia: potential biomes (west)



Eurasia: potential biomes (east)



Huge "belts"

Glaciation in North America vs. Eurasia

Note the Beringian land bridge between Eurasia and North America, and compare the relative size of glaciated regions

Eurasia: biogeographical regions

Holarctic Eurasia: 10 biogeographical regions

1. European mixed forests
2. Alps, Pyrenees, Balkans and Caucasus
3. Mediterranean region
4. Steppes: from Hungary to China
5. Taiga: from Scandinavia to Kamchatka
6. Tundra
7. East Asian mixed forests: Manchuria, Korea and Japan
8. Arabian deserts
9. Central Asian cold deserts and Tibet
10. China plain

Eurasian regions: similar to North America, but not the same

1. European mixed forests: like East Coast but less diverse
2. Alps, Pyrenees, Balkans and Caucasus: like Appalachians but more diverse and more alpine (and similar also with Rockies)
3. Mediterranean region: similar to California, and also to Cape region of Africa, has rich and distinct “ethereal oil” flora
4. Steppes: very similar to North American grasslands (same genera are dominating) but more uniform, more “grassy”, less Aster family and shrubs
5. Taiga: from Scandinavia to Kamchatka: very similar to Canadian taiga but less diverse, from other point, this is a place of active hybridisation and speciation
6. Tundra: simply the same with Canadian tundra
7. East Asian mixed forests: even more similar to the East Coast, the second part of East America / East Asia disjunction
8. Arabian deserts: similar to Chihuahua desert but no cactuses

9. Central Asian cold deserts and Tibet: the most similar region is Great Basin, but dominated plan groups are different, instead of Aster family the amaranth family (Amaranthaceae) makes most of species

   Landscapes could be strikingly similar: compare Coyote Buttes, UT and Zhangye National Geopark, Sunan!

10. China plain: somewhat similar to southern states (Louisiana, Alabama) but covered with loess soils (like Iowa).

Summary for Holarctic Eurasia

- Eurasia is extremely heterogeneous continent split in two main biogeographical parts (Holarctic and Indo-Pacific) bordering in Himalayas and North Indochina.
- Biogeographically, Holarctic Eurasia is almost non-distinct from North America. Same groups, same ecosystems.
- More continental and rich of latitudinal barriers, less glaciated

For Further Reading

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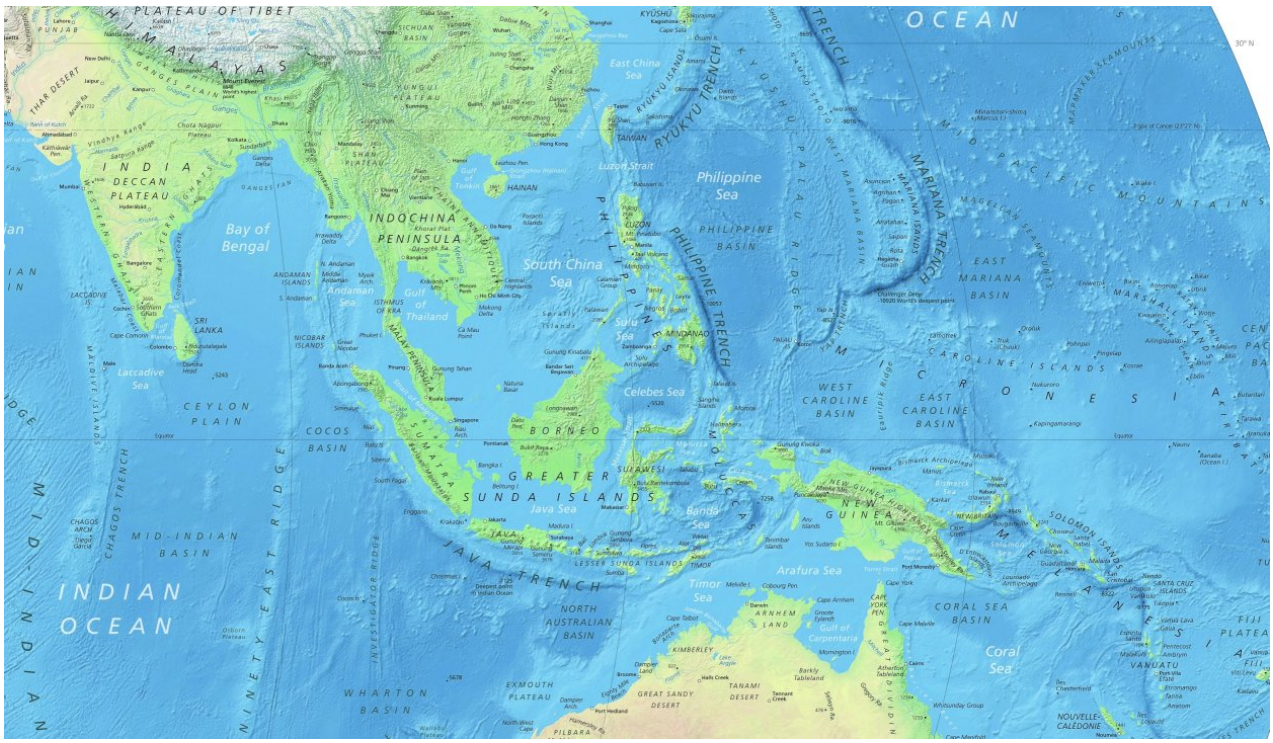
Outline

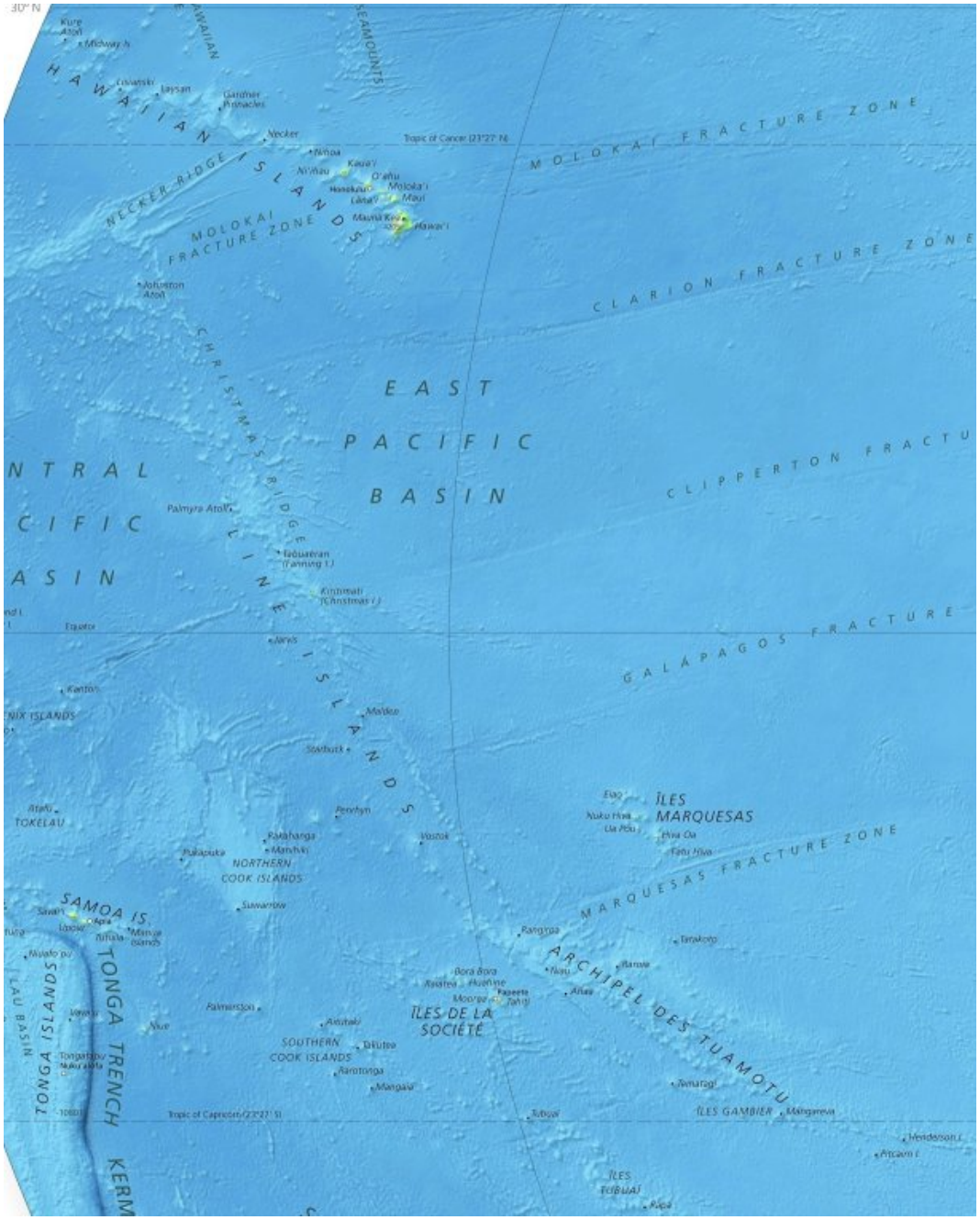
27 Biogeography of the World

27.1 Biogeography of Indo-Pacific region

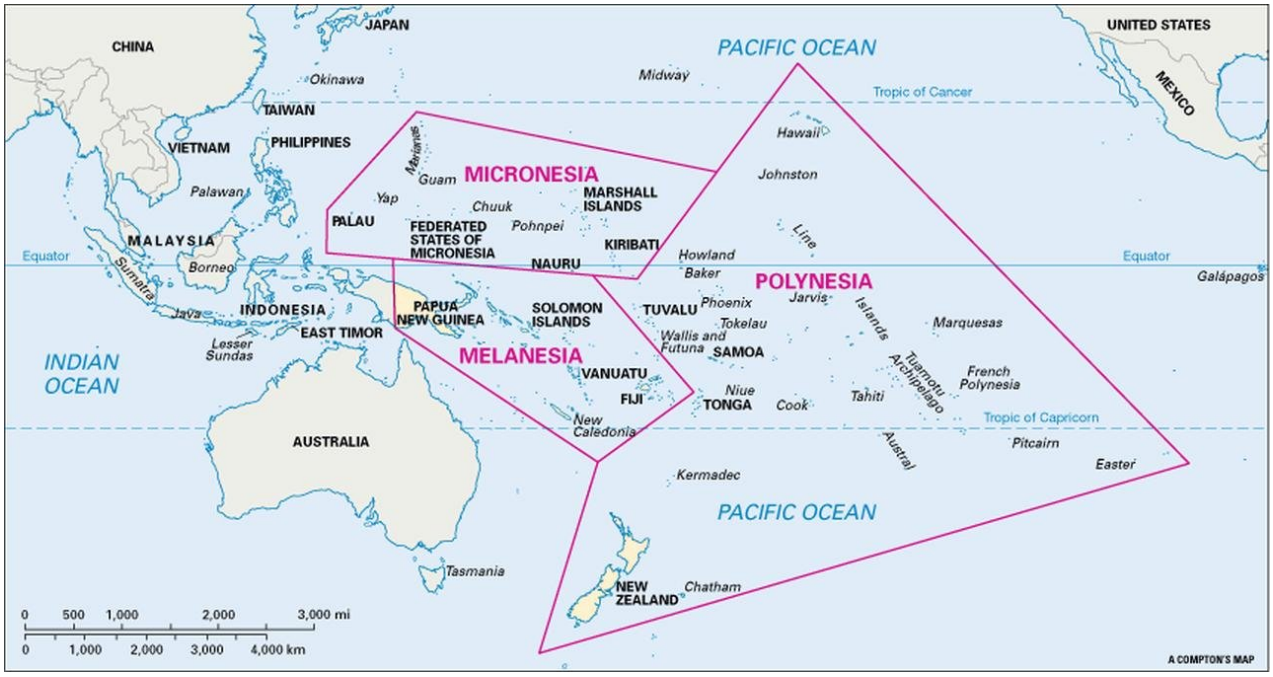
Western Indo-Pacific



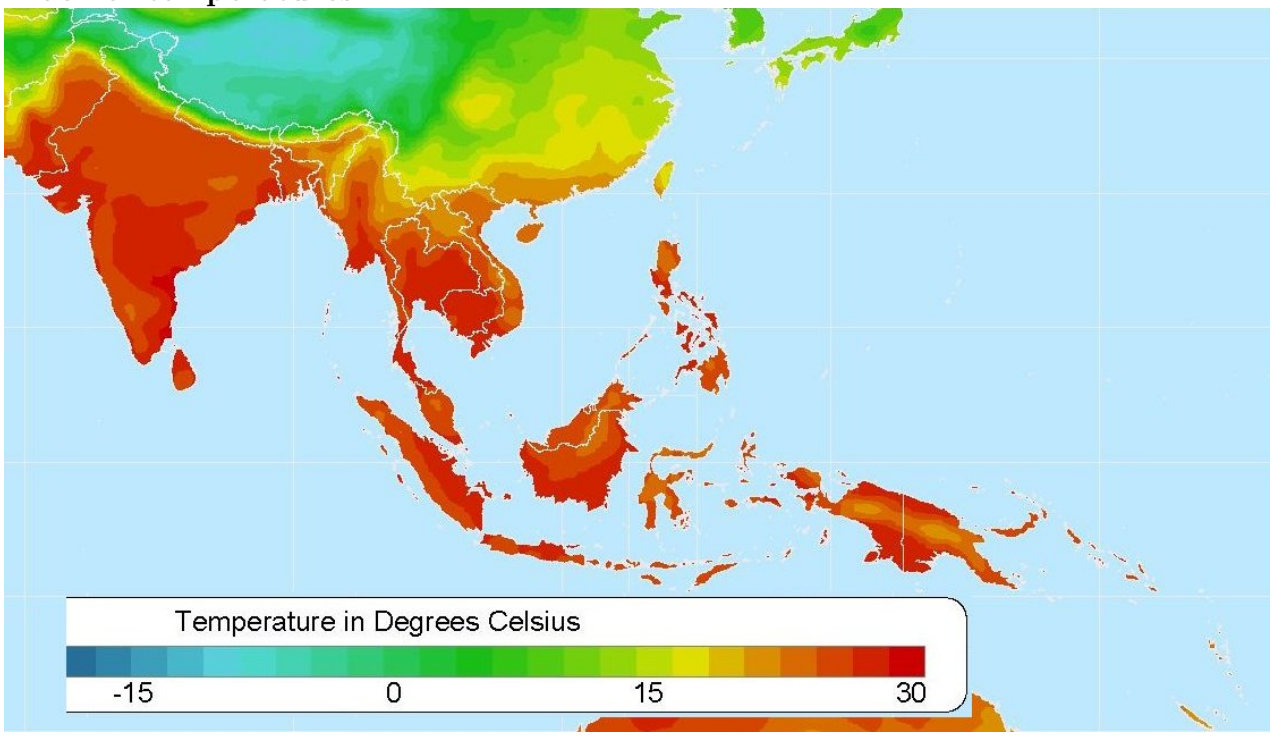
Eastern Indo-Pacific



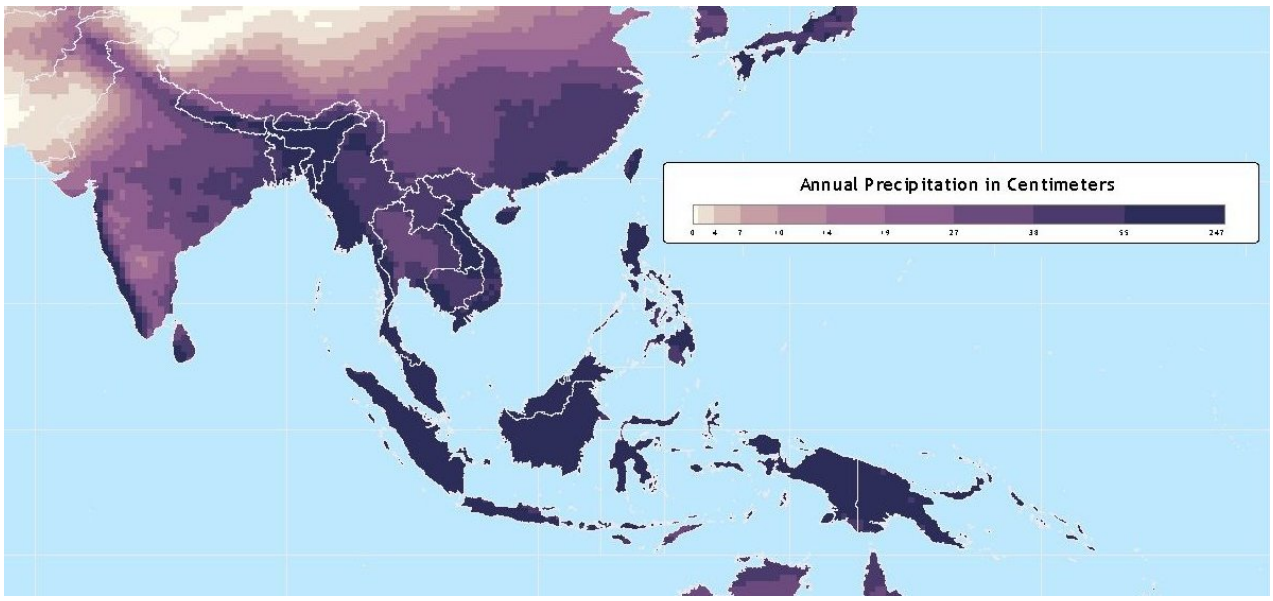
Oceania cultures



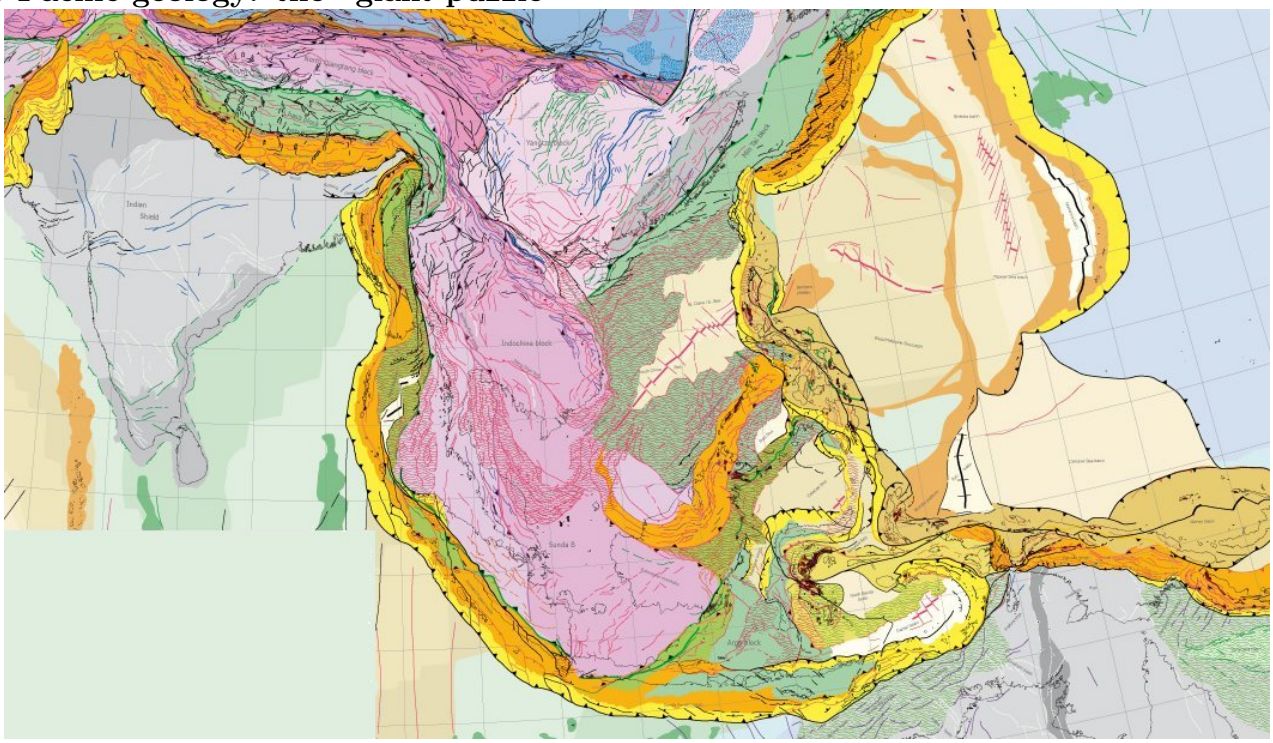
Indo-Pacific: temperatures



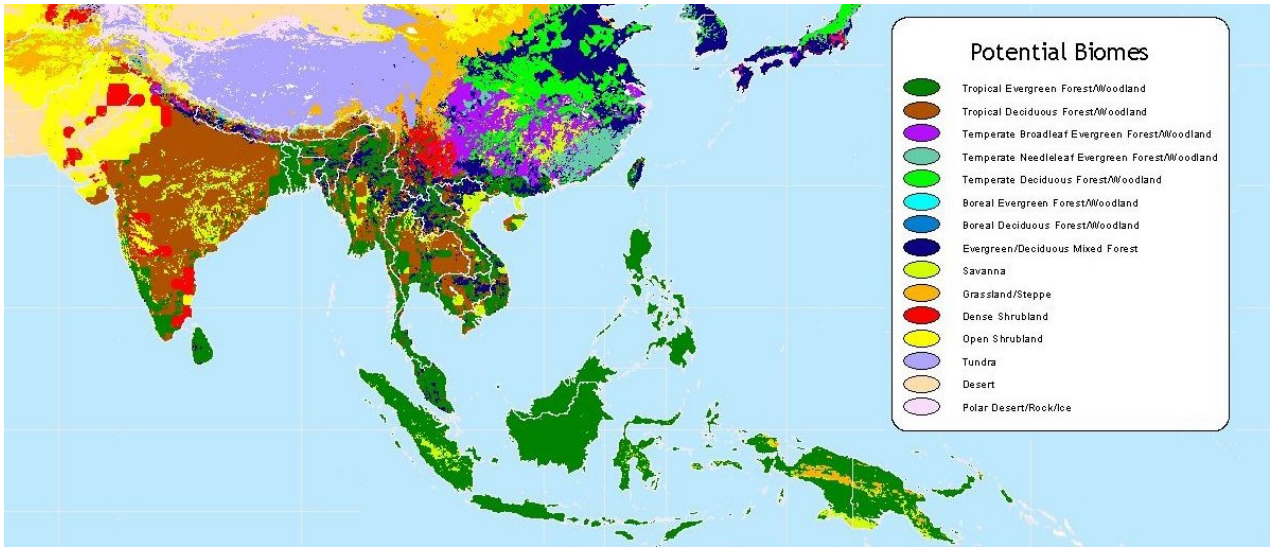
Indo-Pacific: precipitation



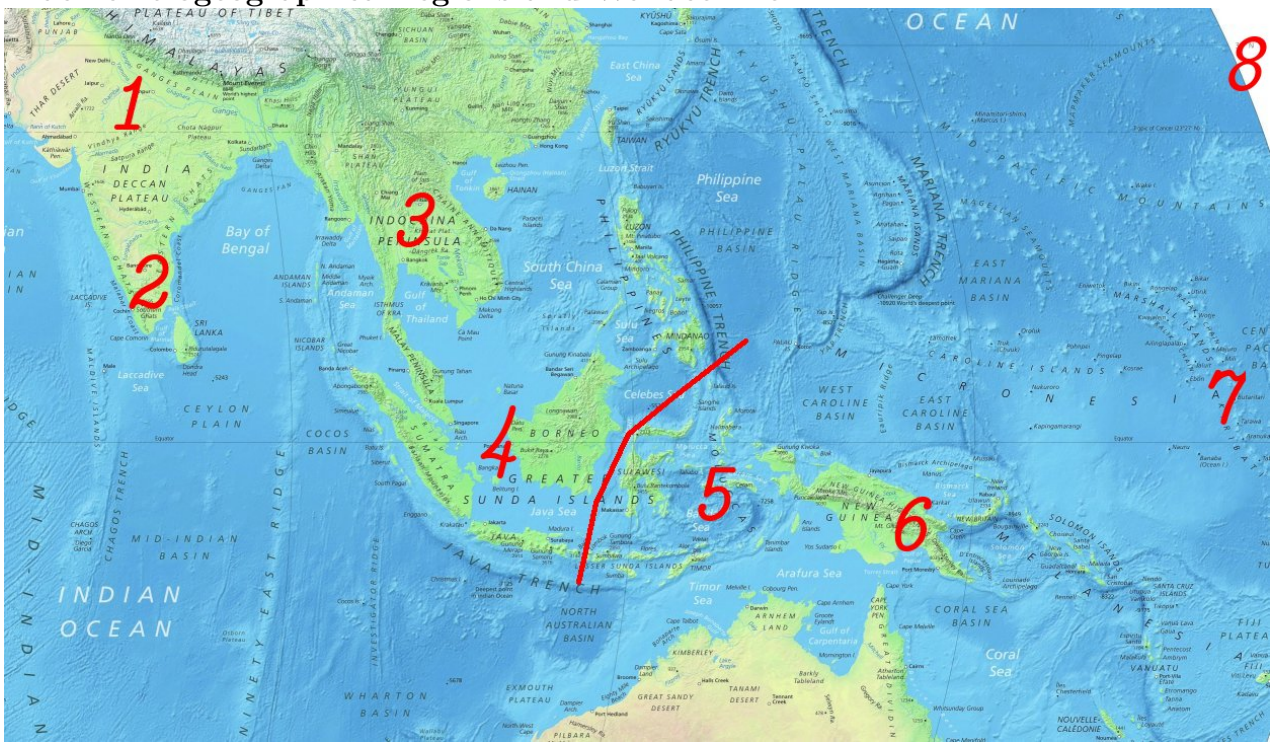
Indo-Pacific geology: the "giant puzzle"



Indo-Pacific: potential biomes



Indo-Pacific: biogeographical regions and Wallace line



Indo-Pacific: 8 biogeographical regions

1. North India
2. Deccan Plateau and South India
3. Sundaland: Indochina
4. Sundaland: Malay archipelago
5. Wallacea
6. New Guinea and Melanesia

7. Coral Pacific Islands
8. Volcanic Pacific Islands

Indo-Pacific regions: key features

1. **North India**: Asian lions (*Panthera leo persica*) and tigers (*Panthera tigris*)
2. **Deccan Plateau and South India**: the most "African" fauna outside of Africa, e.g., Asian elephant (*Elephas maximus*) (smaller ears and less skinny), Indian rhinoceros (*Rhinoceros unicornis*) and multiple species of antelopes like gazelles (*Gazella gazella*); also, many "true" Asian elements like king cobra (*Ophiophagus hannah*), the largest venomous snake.
3. **Indochina**: domestication center of many animals like cattle (e.g., wild gaur *Bos gaurus*) and chicken, Red Junglefowl (*Gallus gallus*). Terrestrial leeches (Haemadipsidae).
4. **Malay archipelago**: one of the most species-rich regions of the World. Unique animals: orangutans (*Pongo pygmaeus* and *Pongo abelii*), gibbons (family Hylobatidae), flying lemurs (order Dermoptera), flying lizards (*Draco volans*) and even flying frogs (*Rhacophorus*)! Hornbills (family Bucerotidae, substitute of South American toucans) and scaly anteaters (order Pholidota) are common with African biota. Lots of epiphytes (e.g., orchids) but no bromeliads. Pitcher vine *Nepenthes* (some in symbiosis with tree shrews, order Scandentia) is also specific to the region. Famous island Krakatoa exploded in 1883 is located here, between Java and Sumatra.
5. **Wallacea**: border between Sundaland and Sahul; islands which have never been connected with Asia (some of them like Sulawesi are disputable) and therefore "stepstones to Australia". Most famous is Komodo, the island of Komodo dragon (*Varanus komodoensis*), the largest terrestrial reptile (up to 3.1 m)
6. **New Guinea and Melanesia**: have multiple Australian elements like echidna (*Zaglossus*) but also placental mammals (like Muridae, mice) and endemic groups (like birds of paradise, family Paradisaeidae).
7. **Coral Pacific Islands**: very poor soils and consequently poor biota
8. **Volcanic Pacific Islands like Hawaii**: recently radiated flora and ornithofauna (like Hawaiian honeycreepers, Drepanididae) and relatively poor terrestrial fauna.

Summary for Indo-Pacific

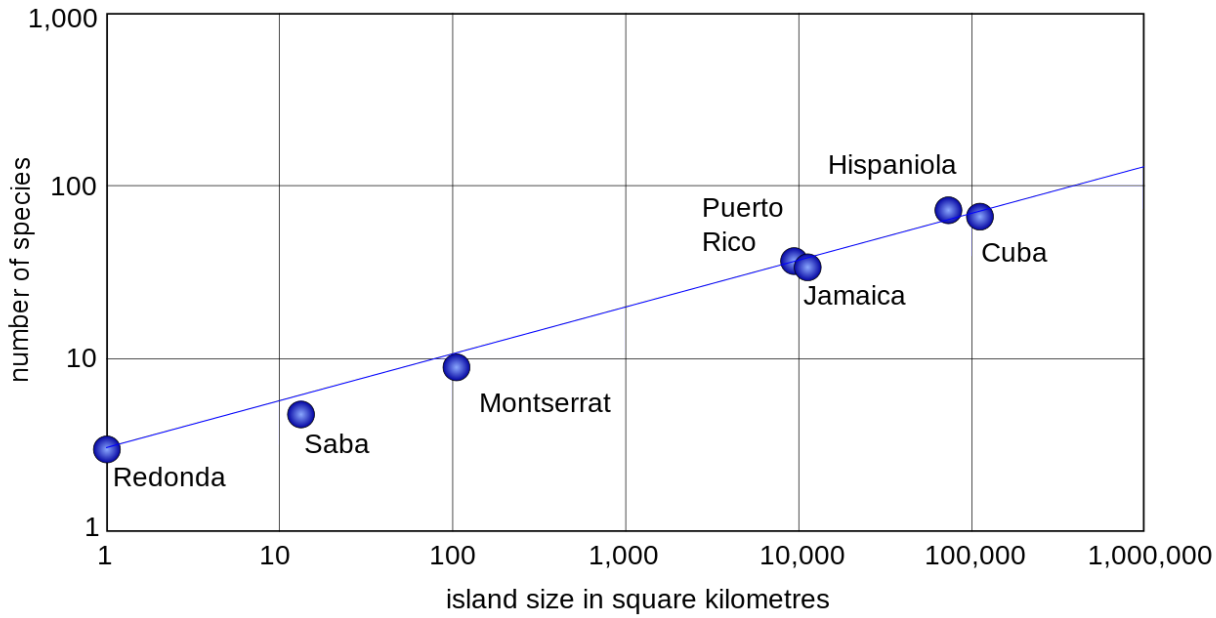
- Geological "puzzle", region with extremely complex history
- Humid and rich
- Numerous borders (like Wallace line) and connections (like Madagascar / Indonesia disjunctions)

27.2 The basics of island biogeography

The basics of island biogeography

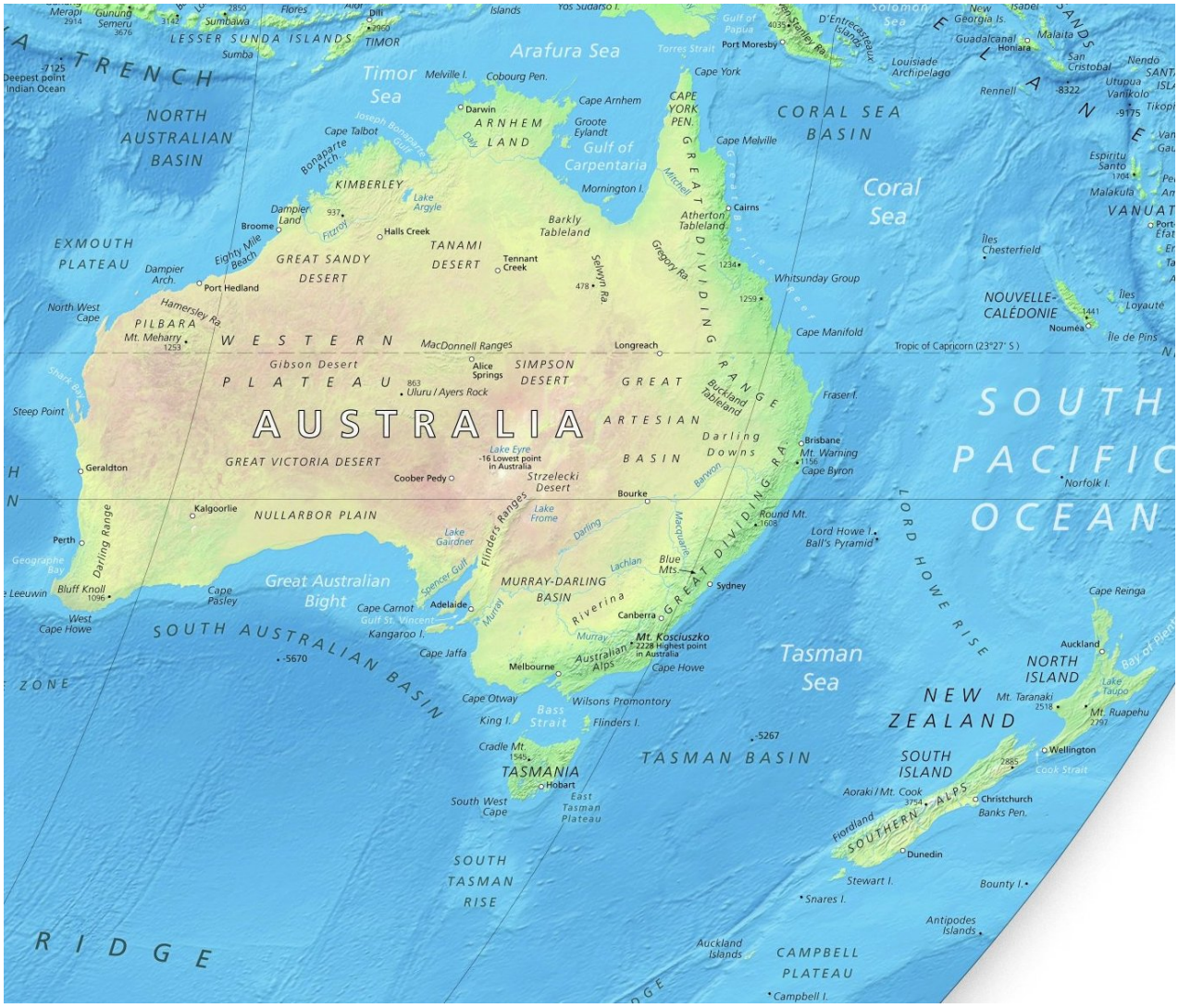
- Immigration and extinction
- Distance effect
- Species-area curve and the effect of island size

Species-logarea line for reptiles and amphibians in Caribbean

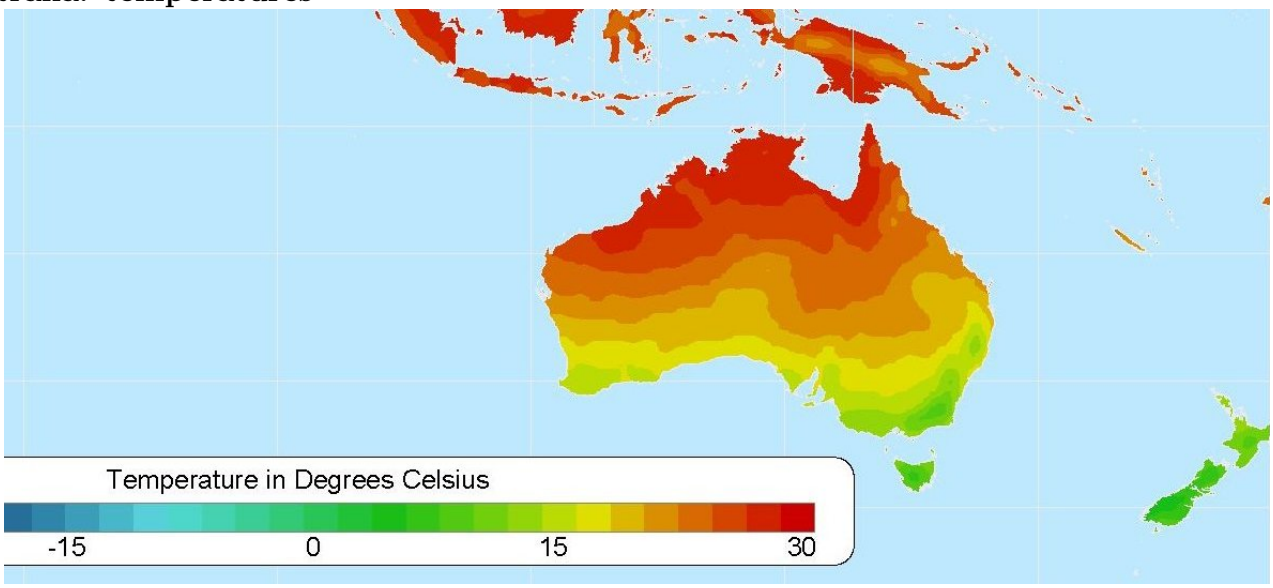


27.3 Biogeography of Australian region

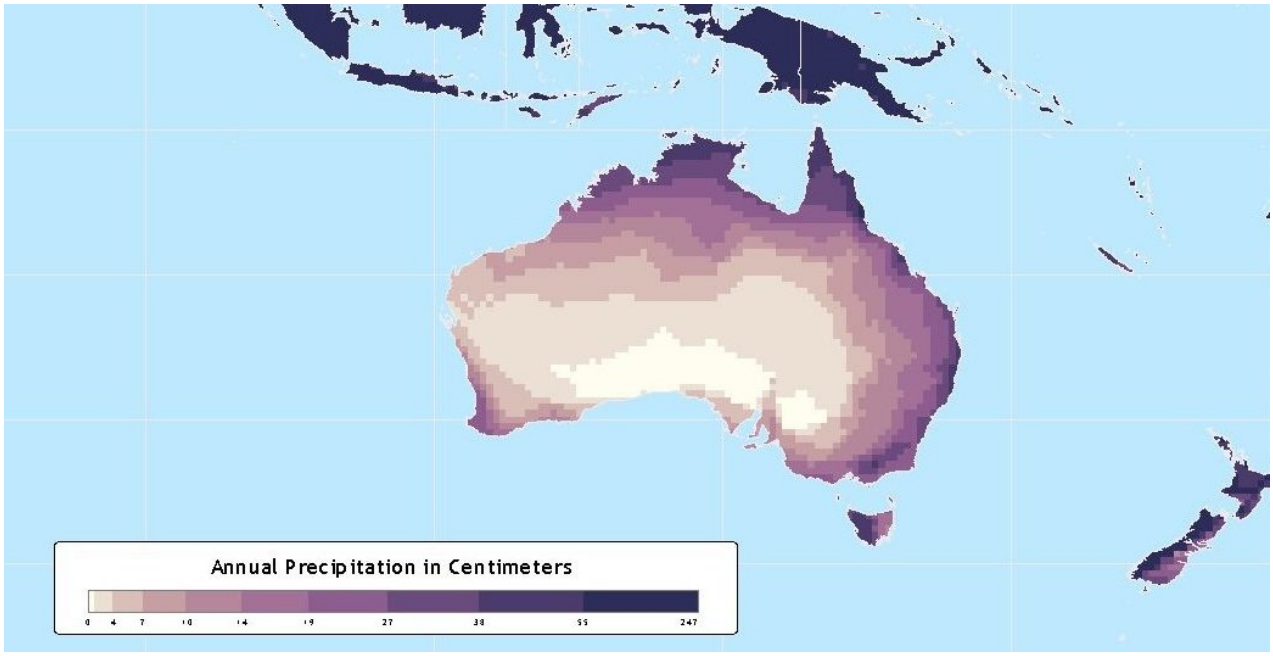
Australian region



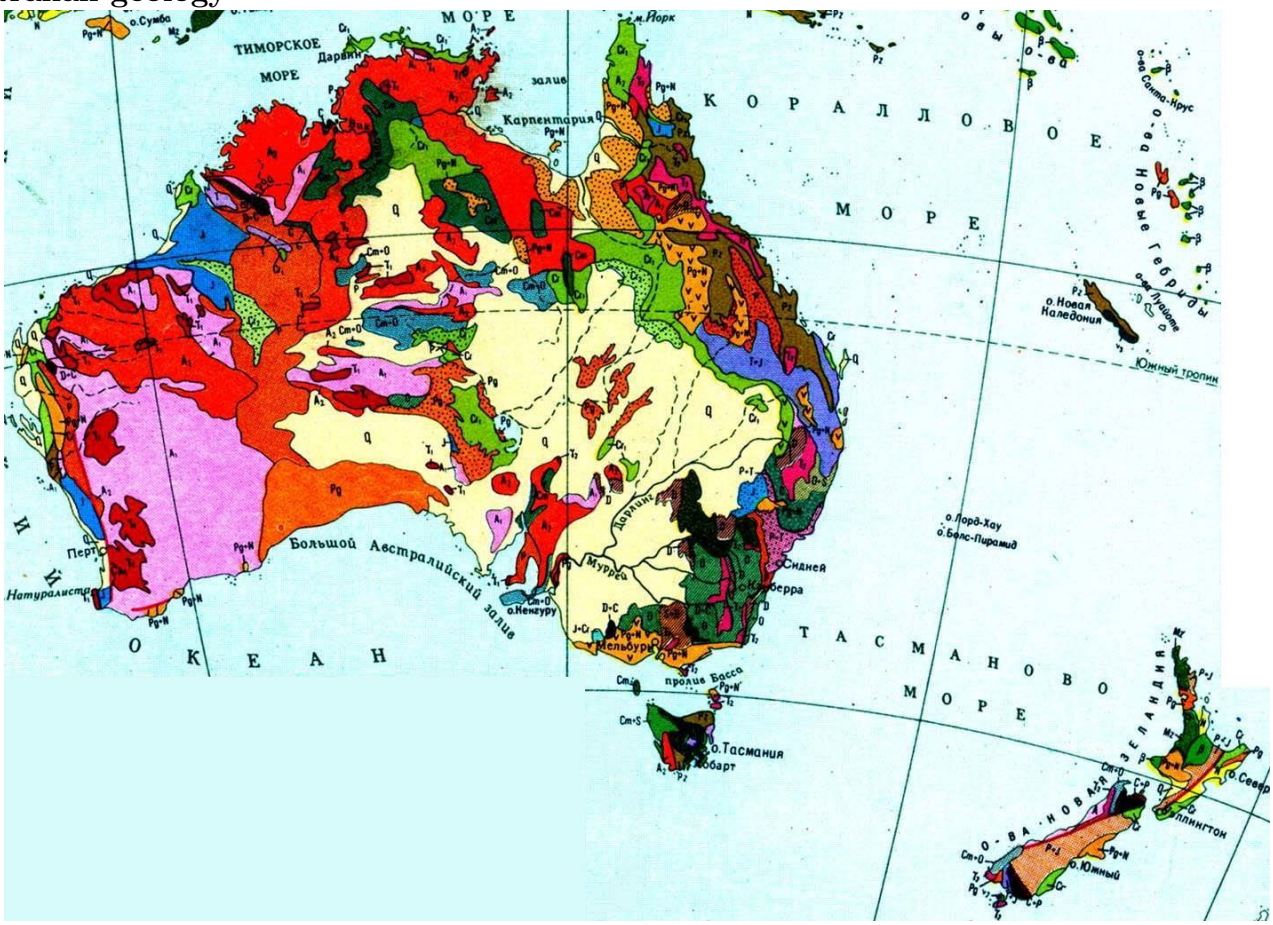
Australia: temperatures



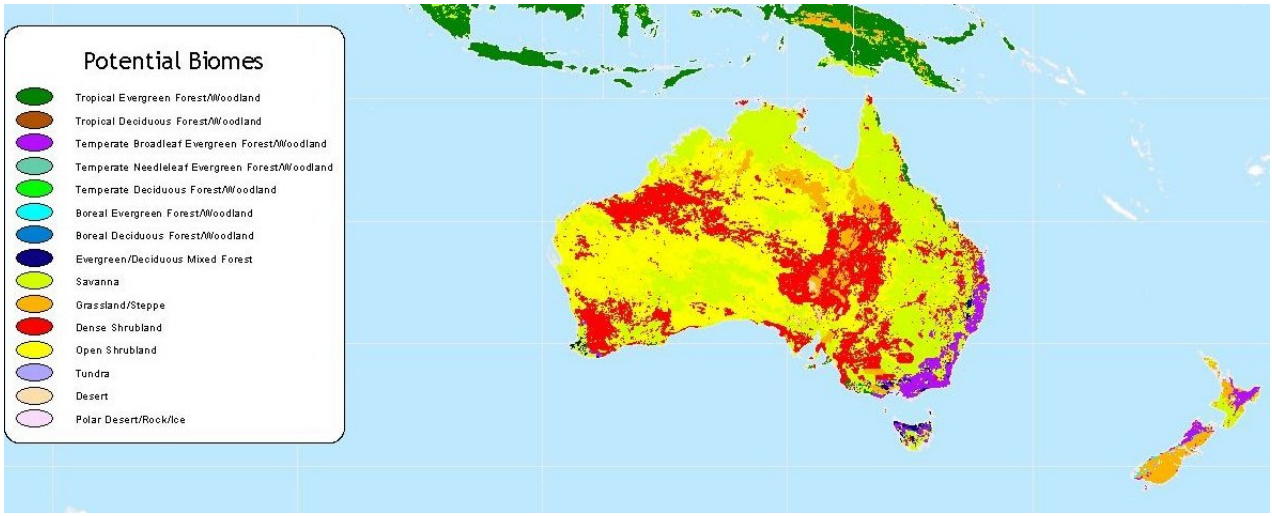
Australia: precipitation



Australian geology



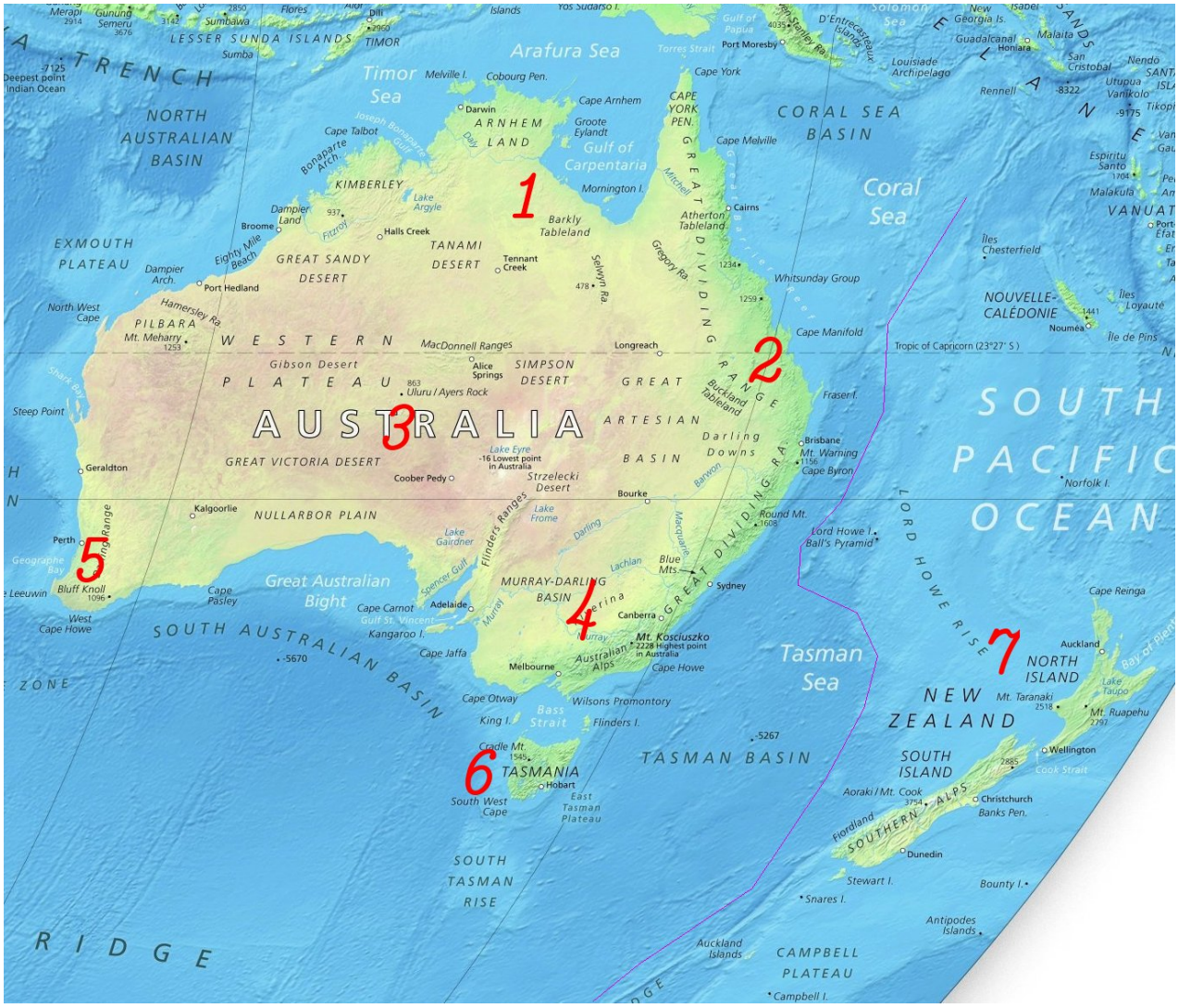
Australia: potential biomes



Australian: 7 biogeographical regions

1. Tropical North
2. Tropical East: Queensland
3. Desert Center
4. Australian core: South and Southeast
5. Australian Southwest
6. Tasmania
7. Zealandia, partly submerged microcontinent: New Zealand, Lord Howe and New Caledonia

Australian: 7 regions



Thin line is a border of Zealandia

Australian regions: key features

1. **Tropical North**: climate similar to Gran Chaco in South America, developed rain and extremely dry seasons. Billabongs (shallow drying lakes) are common. The east of region is Australian grasslands, home of many bird species like emu (*Dromaius novaehollandiae*), malleefowl (*Leipoa ocellata*), numerous cockatoo parrots (Cacatuoidea) and Rainbow bee-eaters (*Merops ornatus*). Extinct "marsuplial hippo", *Diprotodon*, also lived here.

2. **Queensland**: One of three richest regions. Wet forests. Cuscuses (*Phalanger*) there replace monkeys, *Agathis* conifer substitute for angiosperm tree dominants. Forest "ostrich" cassowary (*Casuarius*)

3. **Desert Center**: similar to Sahara. Species-poor. Bowerbirds (Ptilonorhynchidae) are probably most famous animals here.

4. **Australian core**: "all what you know about Australia", platypus (*Ornithorhynchus anatinus*), koala (*Phascolarctos cinereus*), kangaroo (*Macropus giganteus*) and other marsupials, Proteaceae and Myrtaceae plants like *Banksia* and *Eucalyptus*, each with many species. Home of living fossil Wollemi pine, *Wollemia nobilis*. Among birds, many "non-singing" passerines like lyrebird (*Menura novaehollandiae*).

5. **Australian Southwest**: Very small but rich region with high endemism. Many interesting marsupials like numbats (*Myrmecobius fasciatus*, replacement of anteater), the only Australian pitcher plant (*Cephalotus follicularis*), grass trees (*Xanthorrhoea*), moloch lizard (*Moloch horridus*) and many others.

6. **Tasmania**: the temperate variant of Australian biota, the only glaciated (50%) region. Most famous representatives are two marsupial carnivores, Tasmanian devil (*Sarcophilus harrisii*) and (now extinct) Tasmanian wolf (or tiger) (*Thylacinus cynocephalus*). Lots of unusual plants like Huon pine, *Lagarostrobos* or *Tasmannia*.

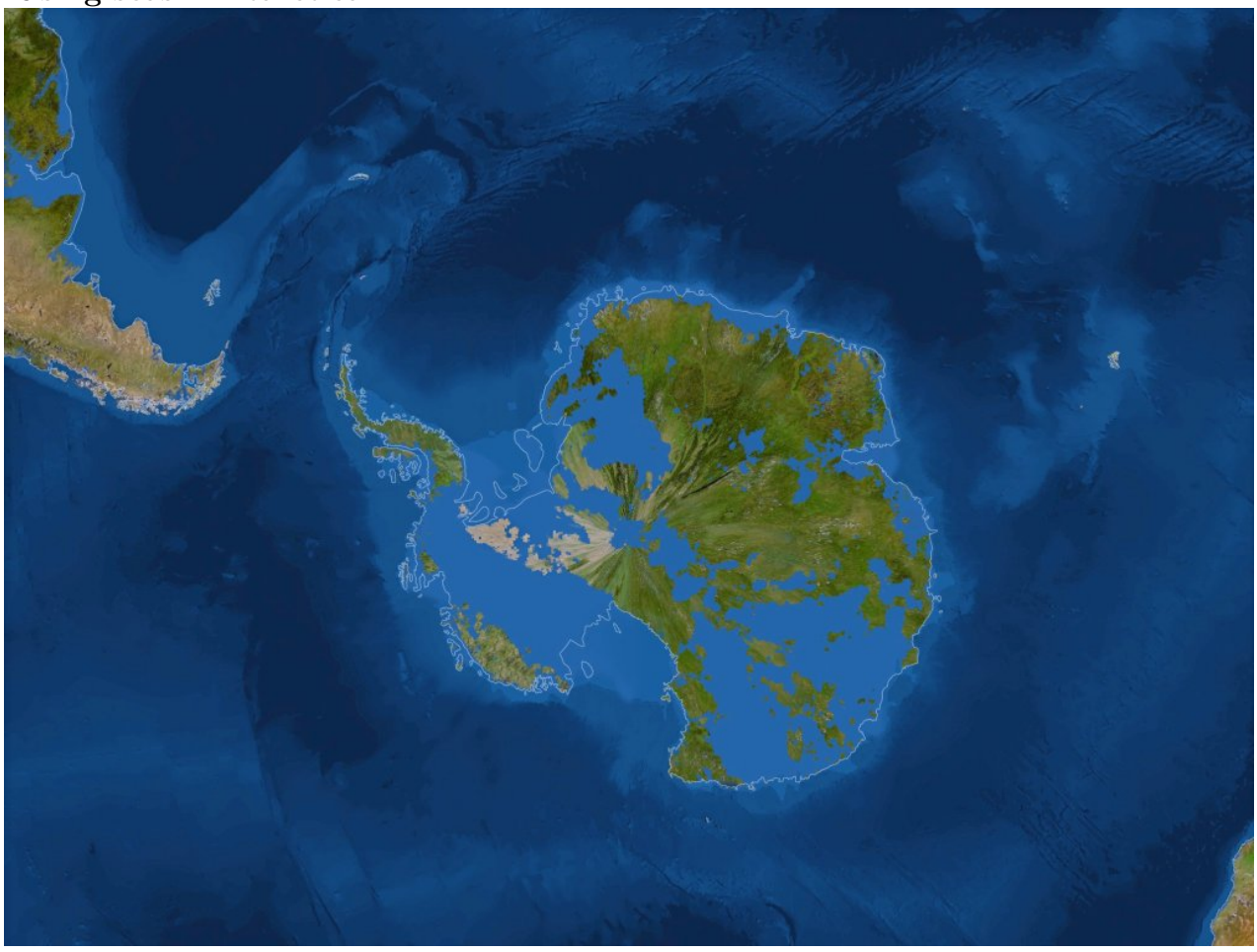
7. **Zealandia**: shatters of microcontinent, probably close to the extinct biota of Antarctic. **No mammals**. Extinct moa (*Dinornis*) and extant kiwi bird (*Apteryx*). Tuatara (*Sphenodon*). The most primitive flowering plant (*Amborella*).

Summary for Australia

- The most biogeographically isolated region
- High and dry: similar to Africa
- New Zealand (Aotearoa) has multiple "Holantarctic" connections

27.4 Rising seas

Rising seas: Antarctica



Rising seas: Asia

Rising seas: Australia

Rising seas: Europe

Rising seas: North America

Rising seas: South America

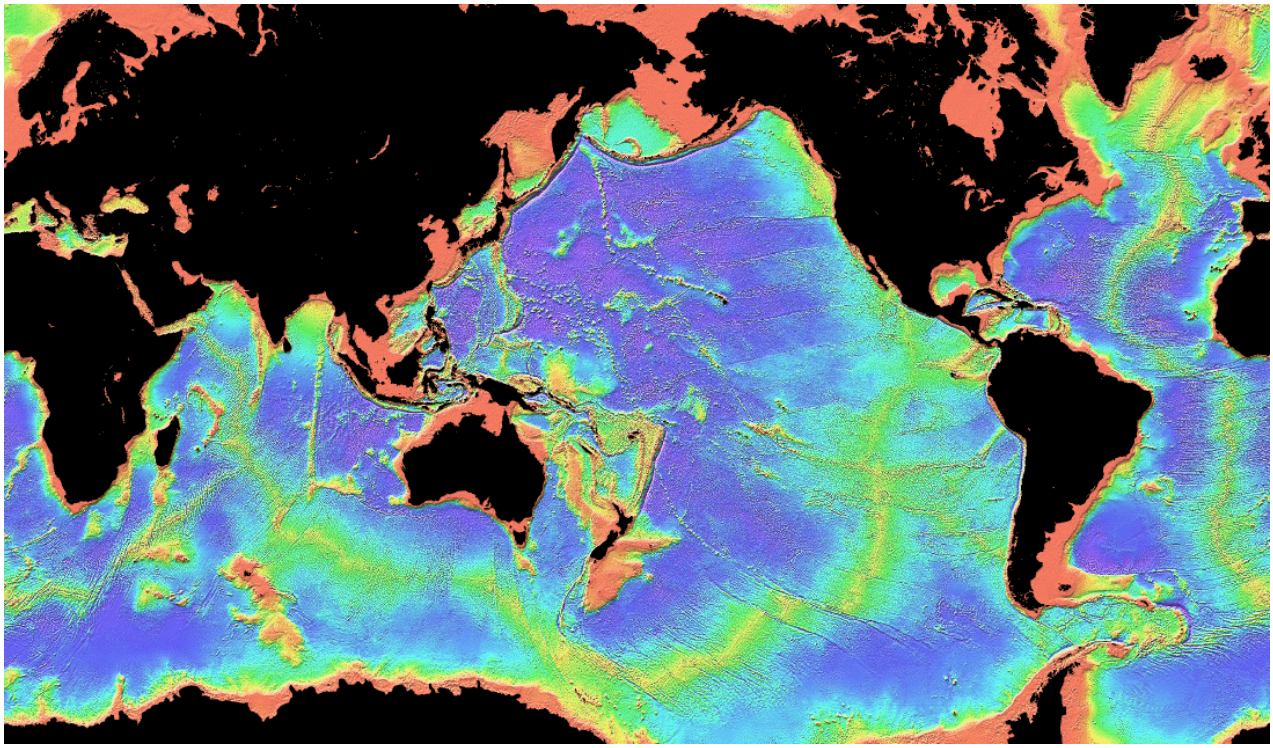
Rising seas: Africa

27.5 Very basics of Ocean biogeography

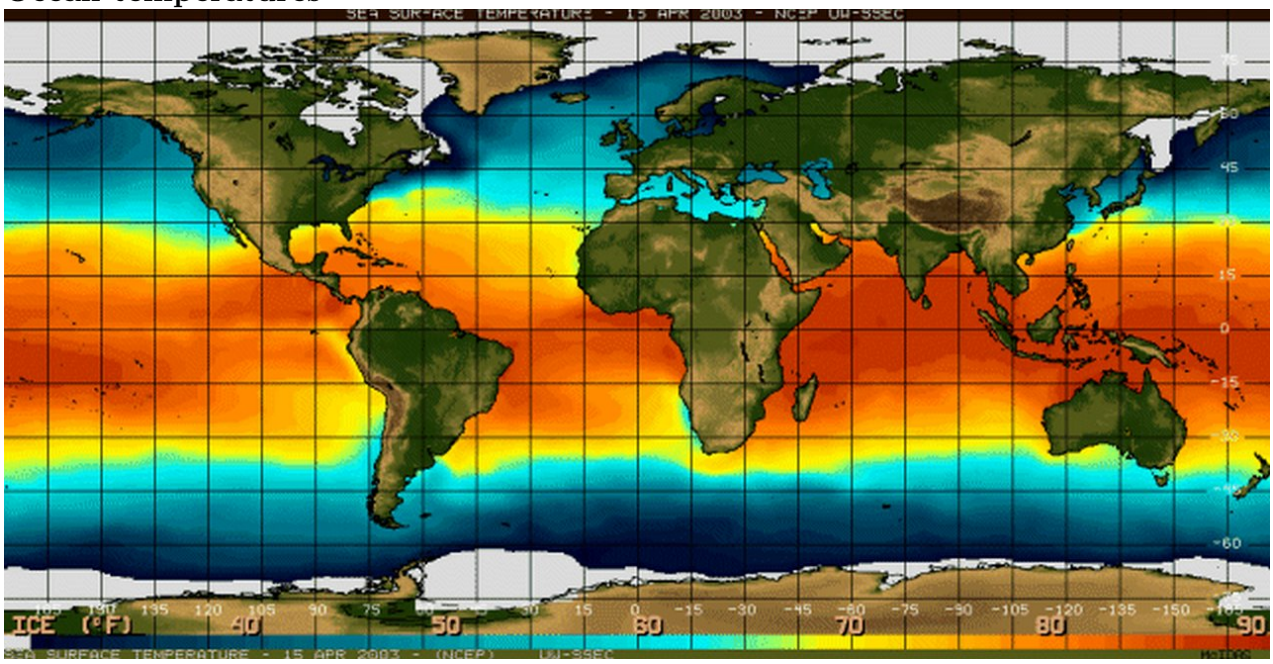
Biogeography of Ocean

- Diversity in 3D space
- Rich cool and poor tropical waters
- Rich coastal and poor open ocean waters
- Whereas surface biogeography of ocean is determined by continents and currents, biogeography of abyssal is unique.

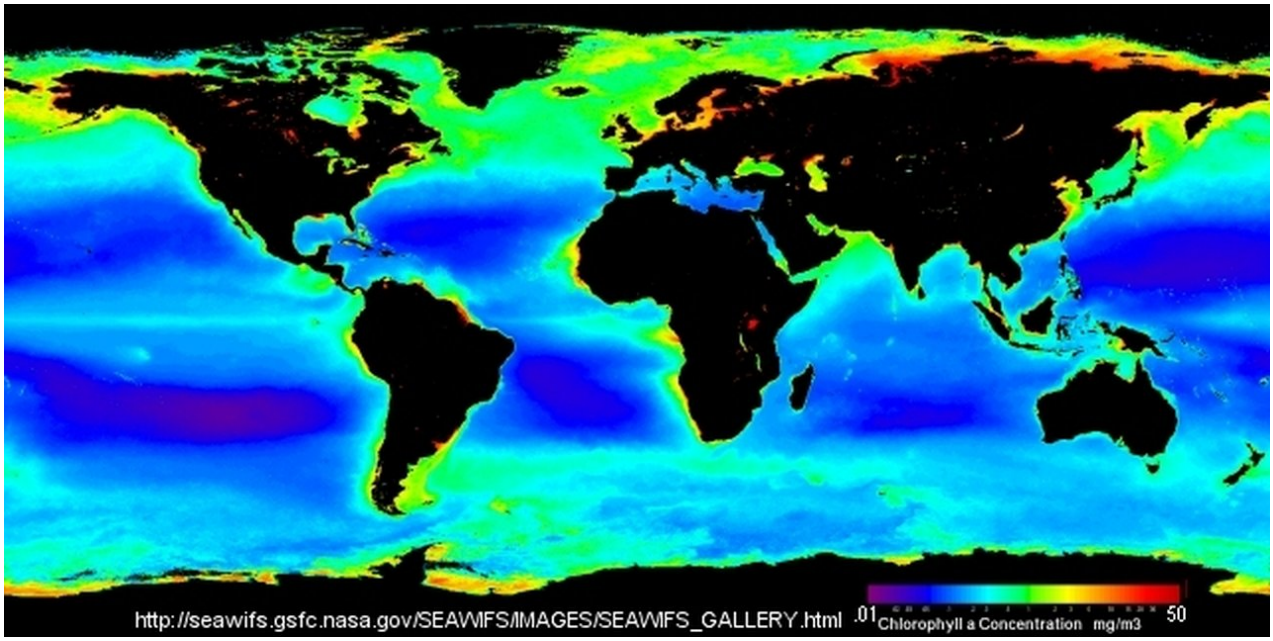
Ocean depths



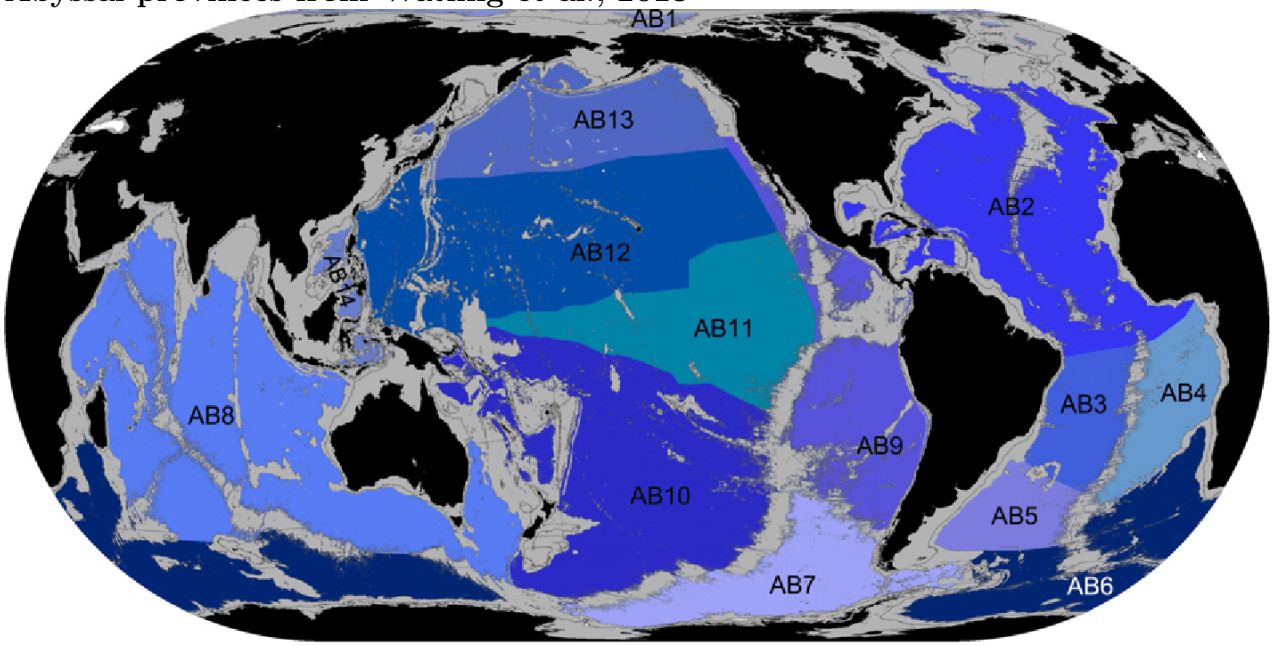
Ocean temperatures



Ocean productivity



Abyssal provinces from Watling et al., 2013



AB1: Arctic Basin
AB2:North Atlantic
AB3: Brazil Basin
AB4: Angola, Guinea, Sierra Leone Basins
AB5: Argentine Basin
AB6: Antarctica East
AB7: Antarctica West
AB8: Indian
AB9: Chile, Peru, Guatemala Basins
AB10: South Pacific
AB11: Equatorial Pacific
AB12: North Central Pacific
AB13: North Pacific
AB14: West Pacific Basins

Short anonymous absolutely voluntary survey

1. What do you **like** most in biogeography course (except the trip ;-)?
2. What do you **dislike** most in biogeography course?
3. Please grade (1—bad, 5—excellent):
   (a) Lectures

(b) The trip

(c) Presentations

(d) Exams

4. Please recommend something for the next Biogeography class.

For Further Reading

References

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