Concepts of Biology: BIOL 111
Study guide for Exam 5

Alexey Shipunov

Lectures 31–36

Contents

1 Questions and answers **1**
1.1 Exam 4 . . . 1

2 Where we are **4**
2.1 Life cycles . . . 4
2.2 From Carboniferous to Permian . . . 5

3 How plants got their seeds **7**
3.1 Origin of seed plants . . . 7

4 Where we are **8**
4.1 Origin of seed plants . . . 8

5 Jurassic park **11**
5.1 From Triassic to Cretaceous . . . 11
5.2 Jurassic and Cretaceous flora and fauna . . . 14

6 Where we are **17**
6.1 Jurassic park . . . 17

7 Mesozoic-Cenozoic extinction **28**
7.1 The raise and fall of giant reptiles . . . 28

8 Where we are **35**
8.1 End of Cretaceous ecological crisis . . . 35
8.2 Cenozoic era . . . 36
8.3 Ecogeography: origin of biomes . . . 41

9 Origin of us **43**
9.1 Just another ape . . . 43

10 Future evolution **52**
10.1 Dougal Dixon and his “After Man” book . . . 52

11 Movies **62**

Outline

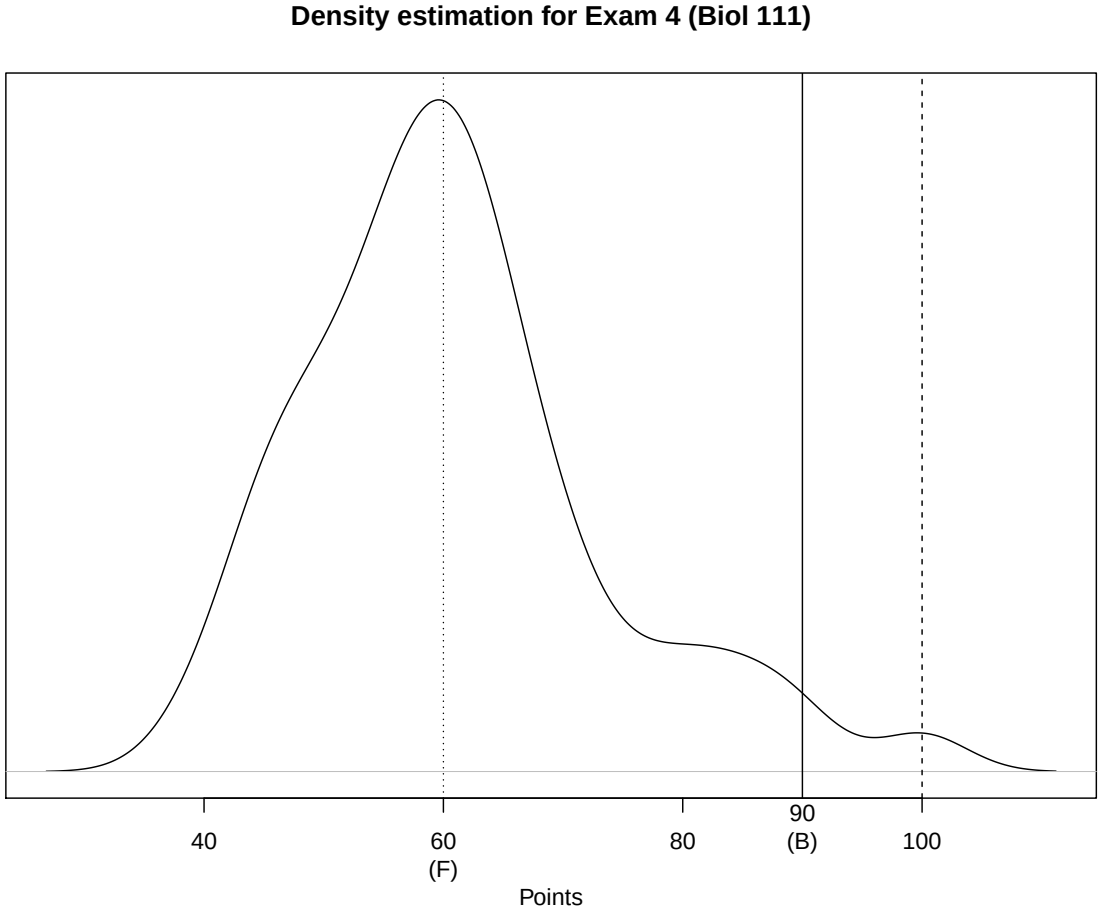
1 Questions and answers

1.1 Exam 4

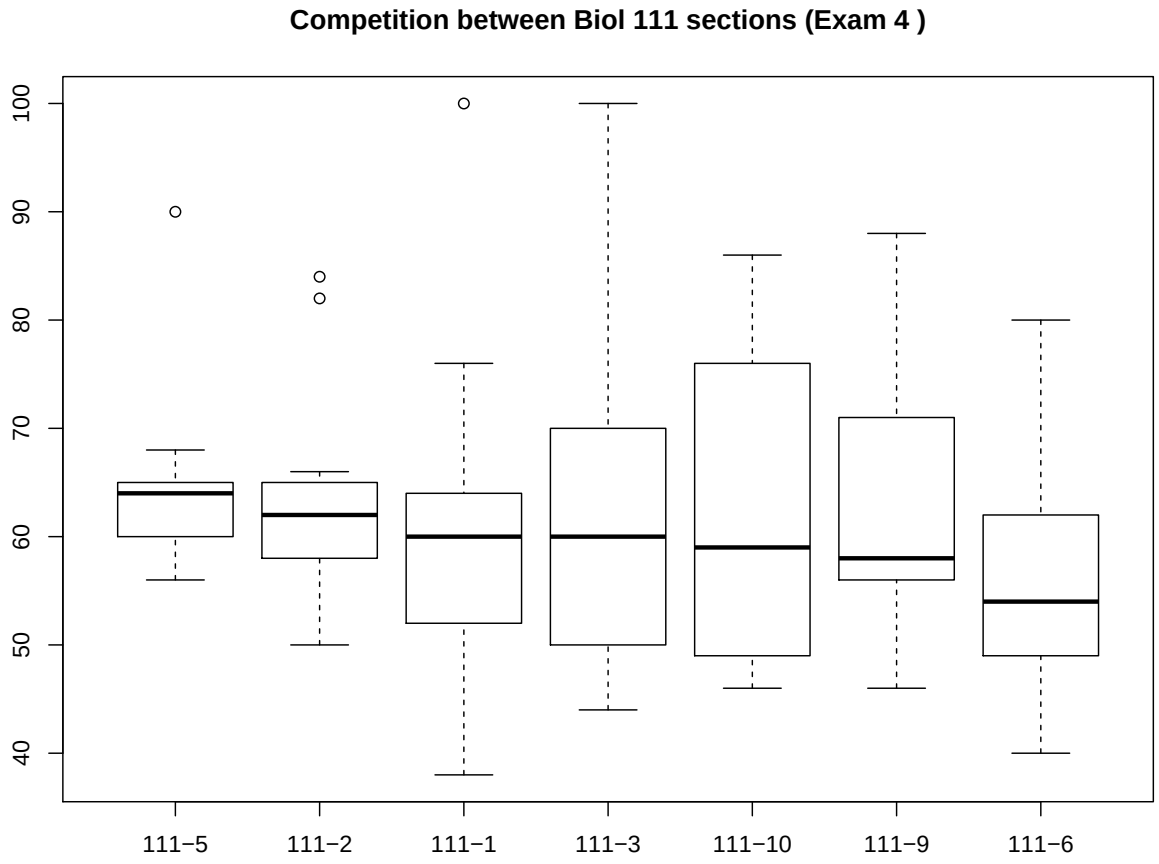
Results of Exam 4: statistic summary

```
Summary:
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's
  38.00   52.00   60.00   60.94   66.00  100.00      12
Grades:
   F    D    C    B  max
< 60 < 70 < 80 < 90  100
```

Results of Exam 4: the curve



Results of Exam 4: sections



Results of Exam 4: two questions

A. Roughly speaking, you have 23 father's and 23 mother's chromosomes. In the each of your *gametes*, there are _____ chromosomes:

(a) 23 are from your father, 23—from mother

(b) 11 mother's and 12 father's

(c) **From 1 to 23 are father's and from 23 to 1 are mother's**

B. In meiosis, X-shaped chromosomes:

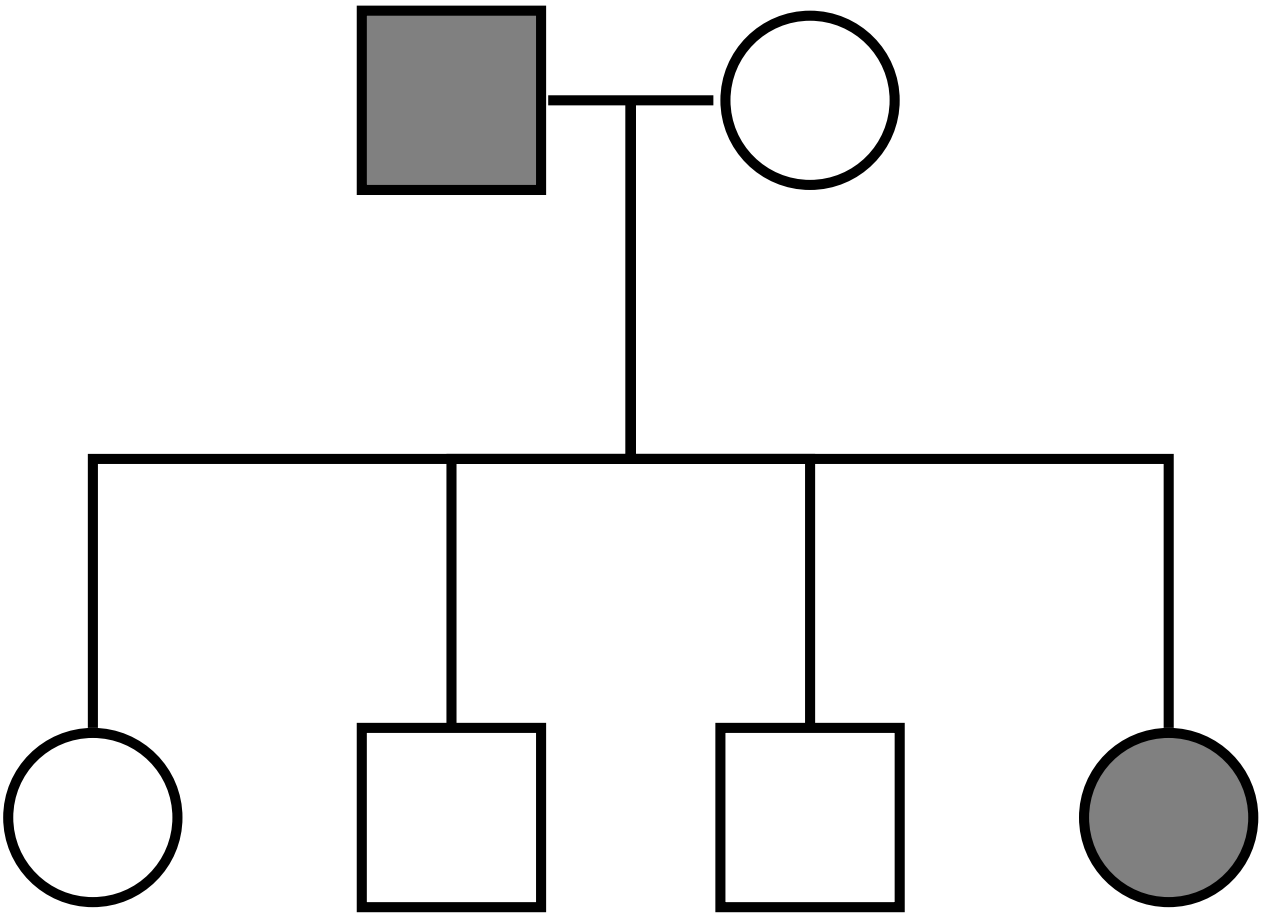
(a) Never split

(b) Split in anaphase I

(c) **Split in anaphase II**

Results of Exam 4: second pedigree

44. Is the disease from the pedigree chart below:



(a) Dominant

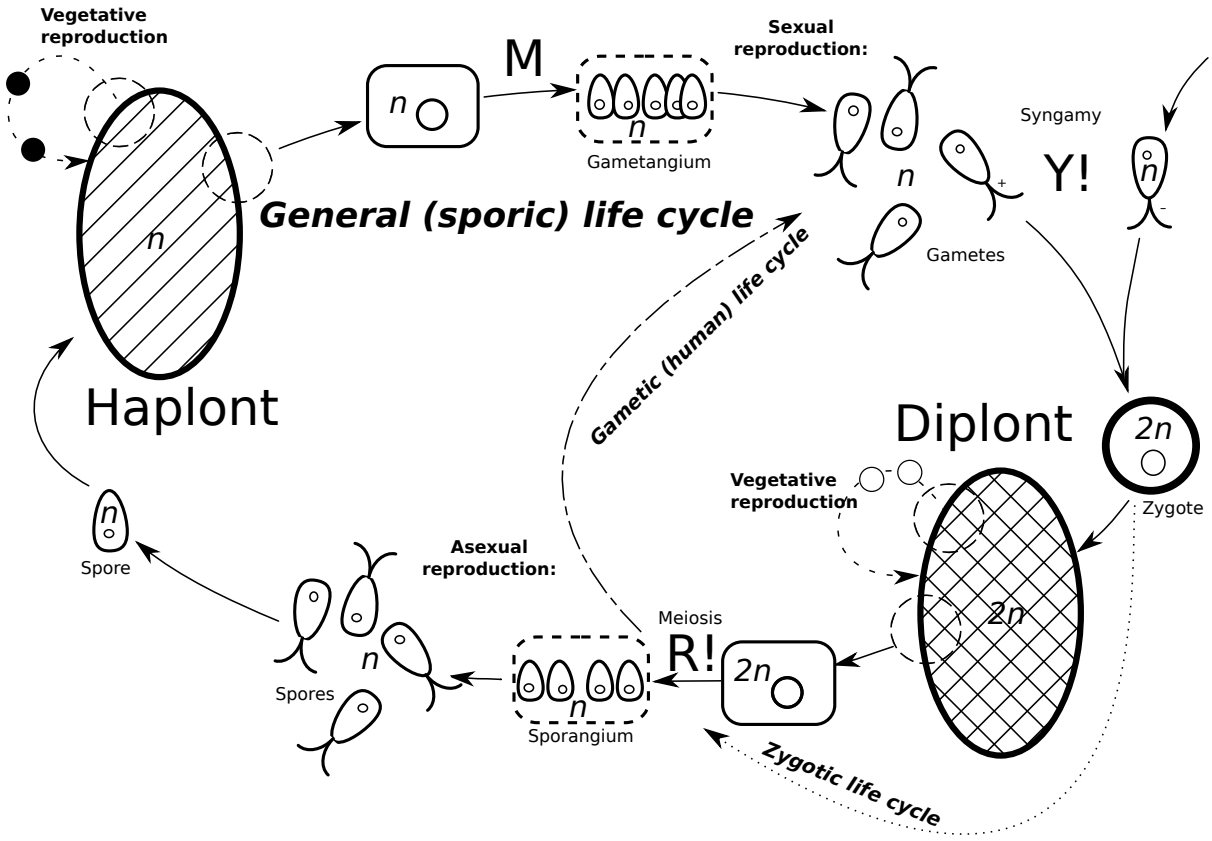
(b) Recessive

(c) **I need more information**

2 Where we are

2.1 Life cycles

Life cycle of multicellular organism

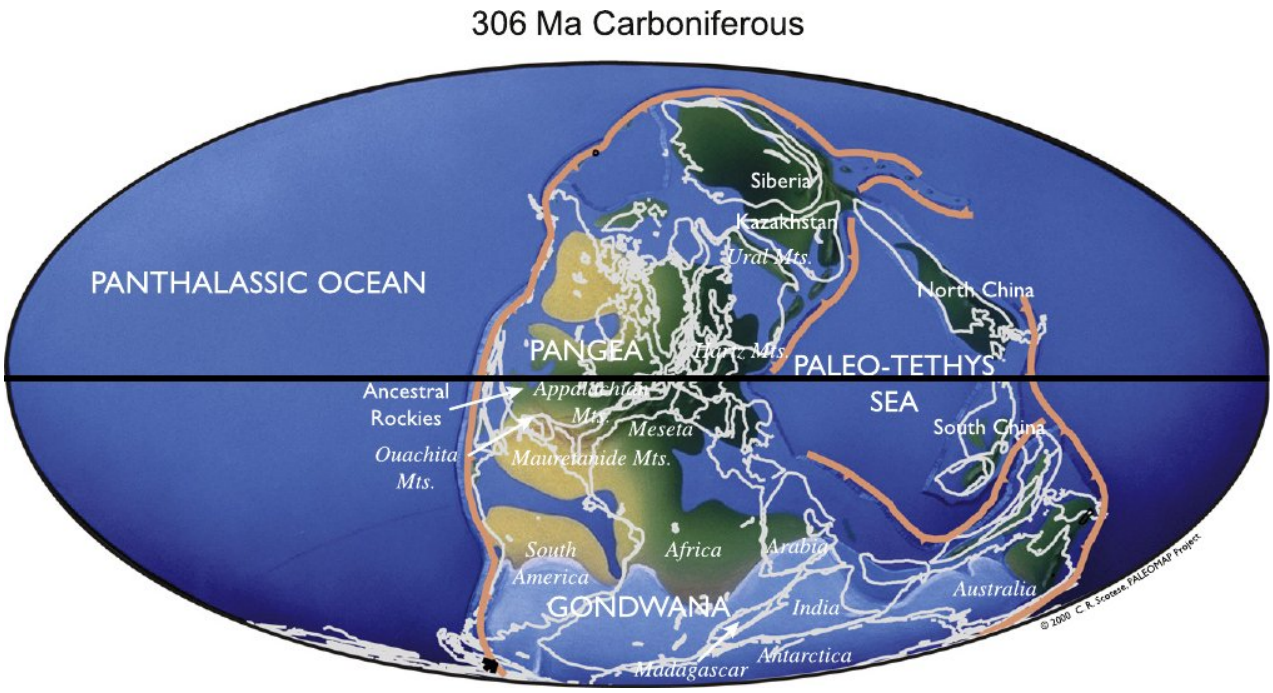


2.2 From Carboniferous to Permian

From Carboniferous to Permian

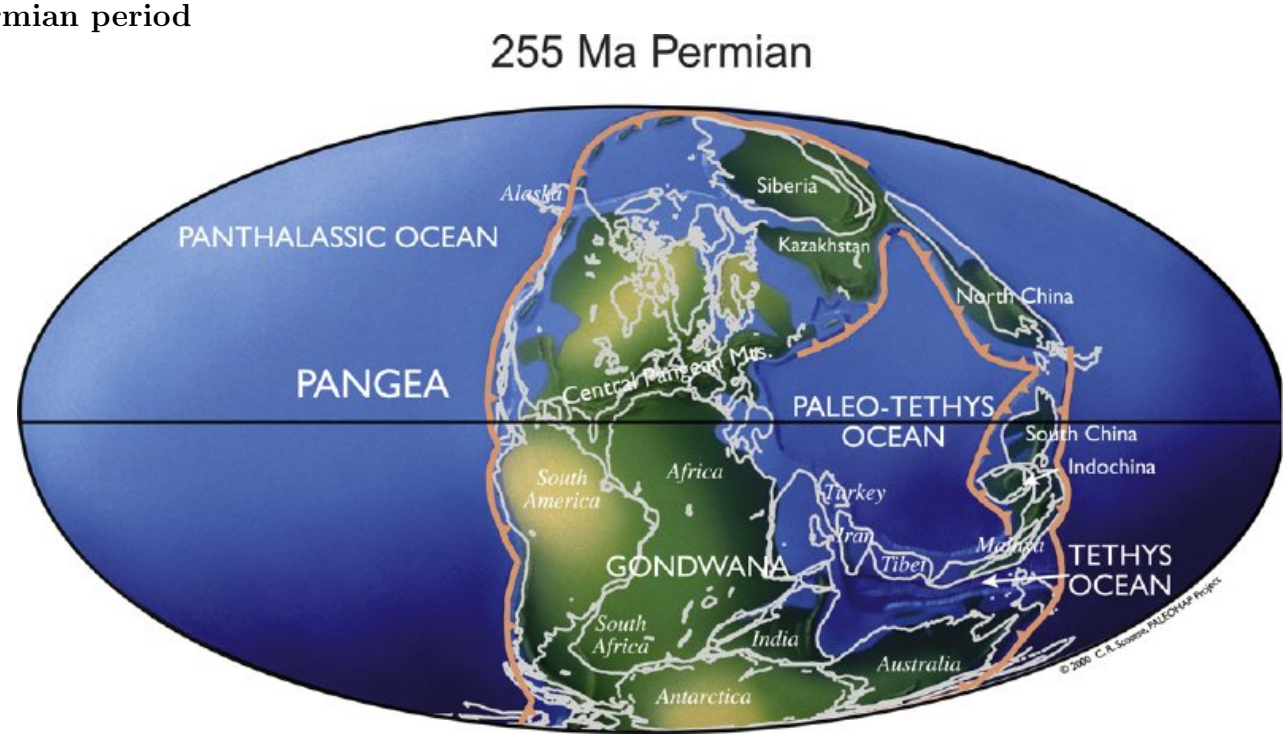
- Devonian period: 419 Mya
- Carboniferous period: 358 Mya
- Permian period: 299–252 Mya

Carboniferous period



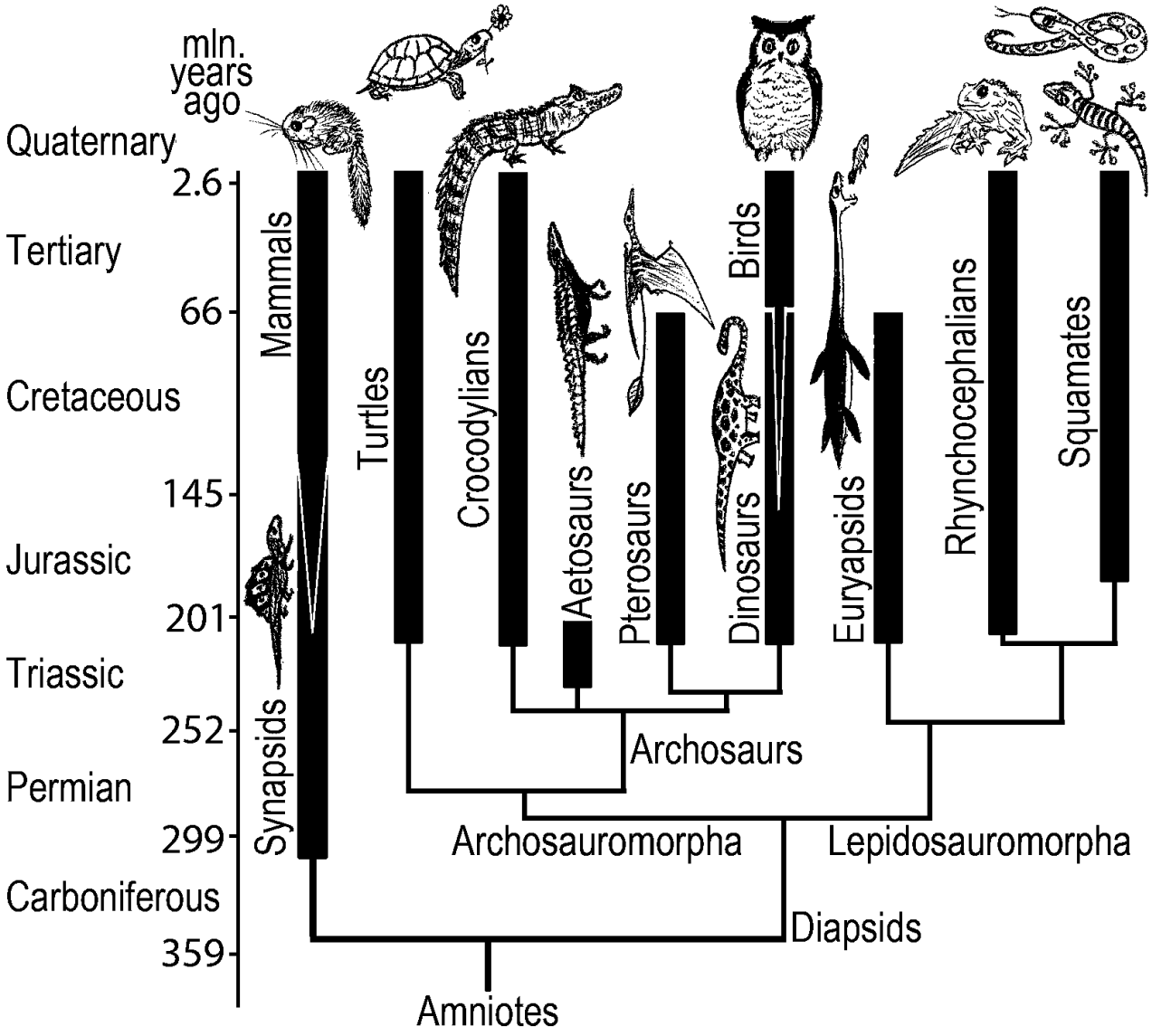
- Hot, wet tropical climate in Europe and North America (Laurasia), dry arctic forests in Siberia (Angarida)
- Pteridophyte and primitive seed plants forests dominated tropics, insects started to fly
- Reptiles appeared

Permian period



- Last period of Paleozoic era, ended with a mass extinction in the sea and also on land
- Pangea formed, with a giant central desert
- Primitive synapsid reptiles dominated the land

Following the movie: reptiles, mammals and birds



3 How plants got their seeds

3.1 Origin of seed plants

Life cycle of land plants

- Sporic life cycle with interleaving generations
- Diploid stage grow directly on the haploid stage and even is the parasite of it (e.g., in mosses)
- Originates from the life cycle of algae: diploid stage was an adaptation to the distribution of spores
- Eventually, diploid stage begin to dominate the life cycle

The conflict between size and reproduction

- Competition for the light resulted in growing up; growing up resulted in *secondary thickening*—trees appeared

- Seed plants started as trees, and these trees were diploid stage
- Haploid stage still existed and probably was a minute *prothallium*
- Diploid stage followed the K-strategy (slow and smart) whereas haploid prothallium followed the r-strategy (random explosions)
- This is a conflict: diploid stage cannot adapt better because free haploid stage was too cranky, it became a hindrance on the way of evolution
- Decision: take haploid stage on the diploid stage and grow it inside

For Further Reading

References

[1] Reptiles. `http://en.wikipedia.org/wiki/Reptile`

[2] Permian. `http://en.wikipedia.org/wiki/Permian`

Outline

4 Where we are

4.1 Origin of seed plants

Life cycle of land plants

- Sporic life cycle with interleaving generations
- Diploid stage grow directly on the haploid stage and even parasitizes on it (e.g., in mosses)
- Originates from the life cycle of algae: diploid stage was an adaptation to the distribution of spores
- Eventually, diploid stage begin to dominate the life cycle

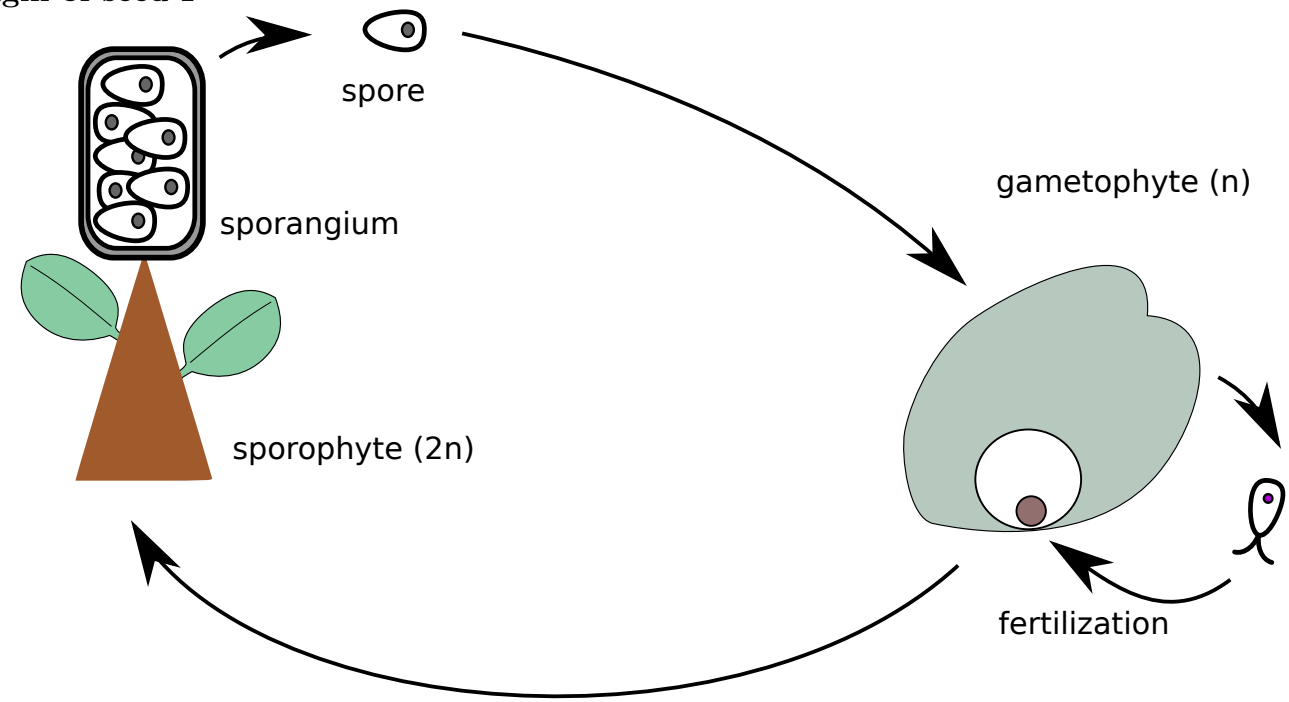
The conflict between size and reproduction

- Competition for the light resulted in growing up; growing up resulted in *secondary thickening*—trees appeared
- Seed plants started as trees, and these trees were diploid stage
- Haploid stage still existed and probably was a minute *prothallium*
- This is a conflict: diploid stage cannot adapt better because free haploid stage was too cranky, and birth control is impossible
- Decision: take haploid stage on the diploid stage and grow it inside

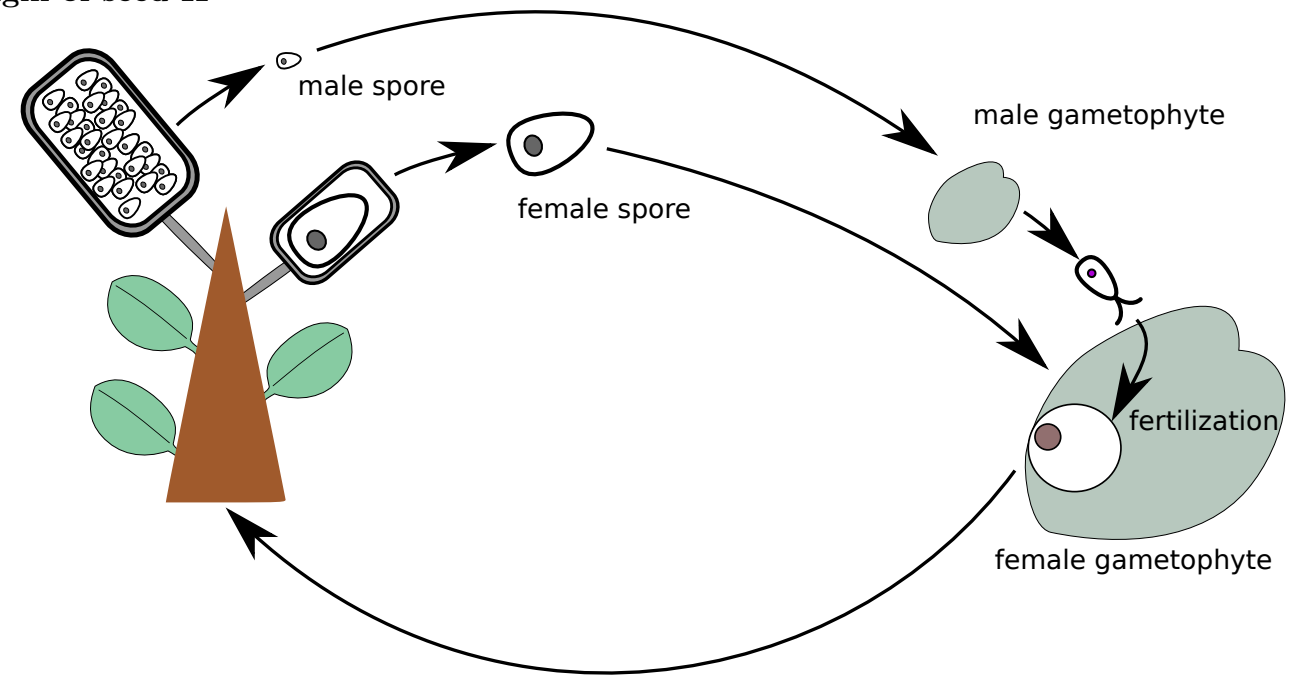
The seed

- Seed is the chimeric organ of three parts: mother diploid tissue (seed coat), daughter diploid (embryo) and female haploid stage (endosperm)
- Main problems: need for pollination, extremely slow growth (two years in pine tree, up to five years in cycads)

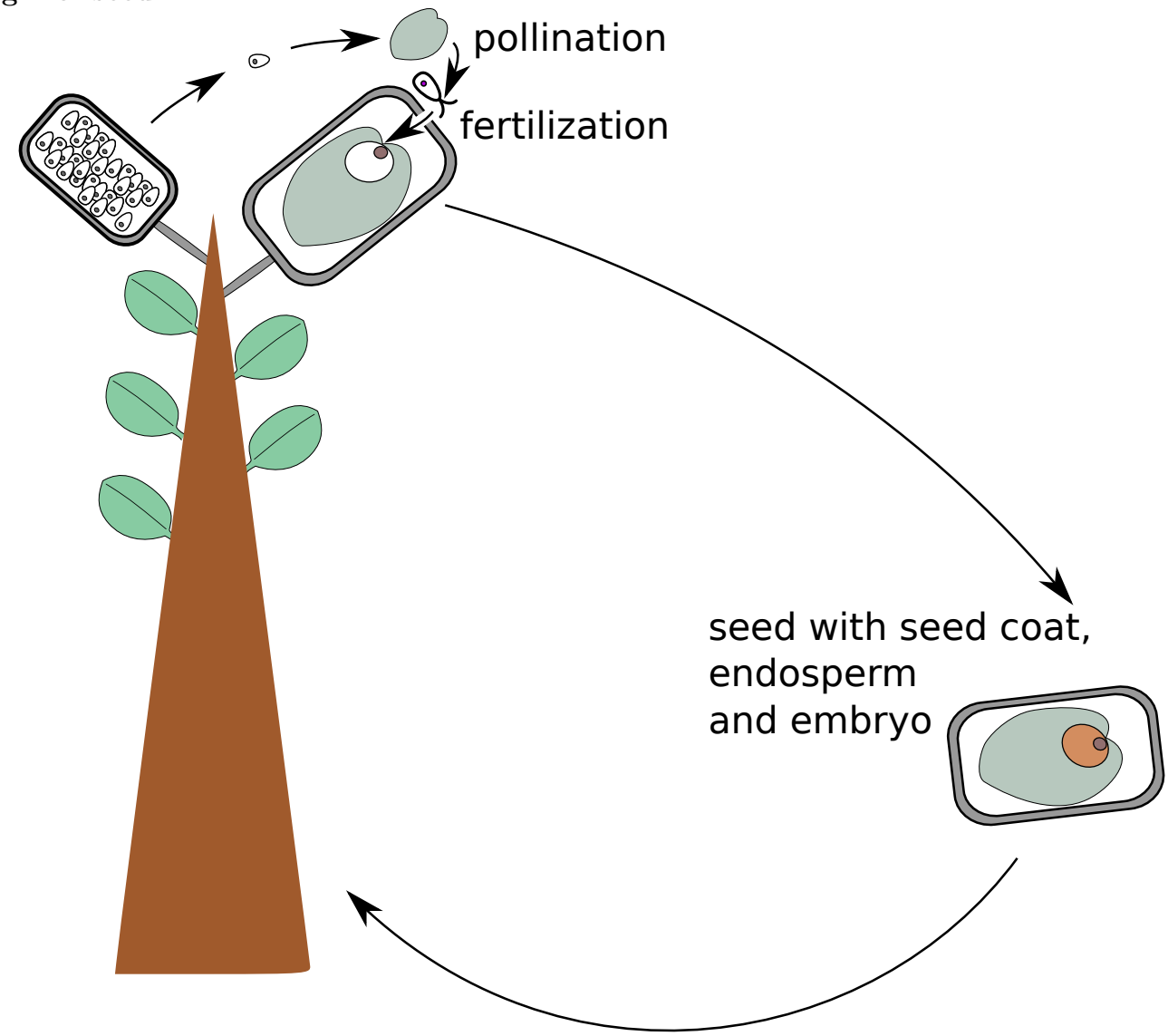
Origin of seed I



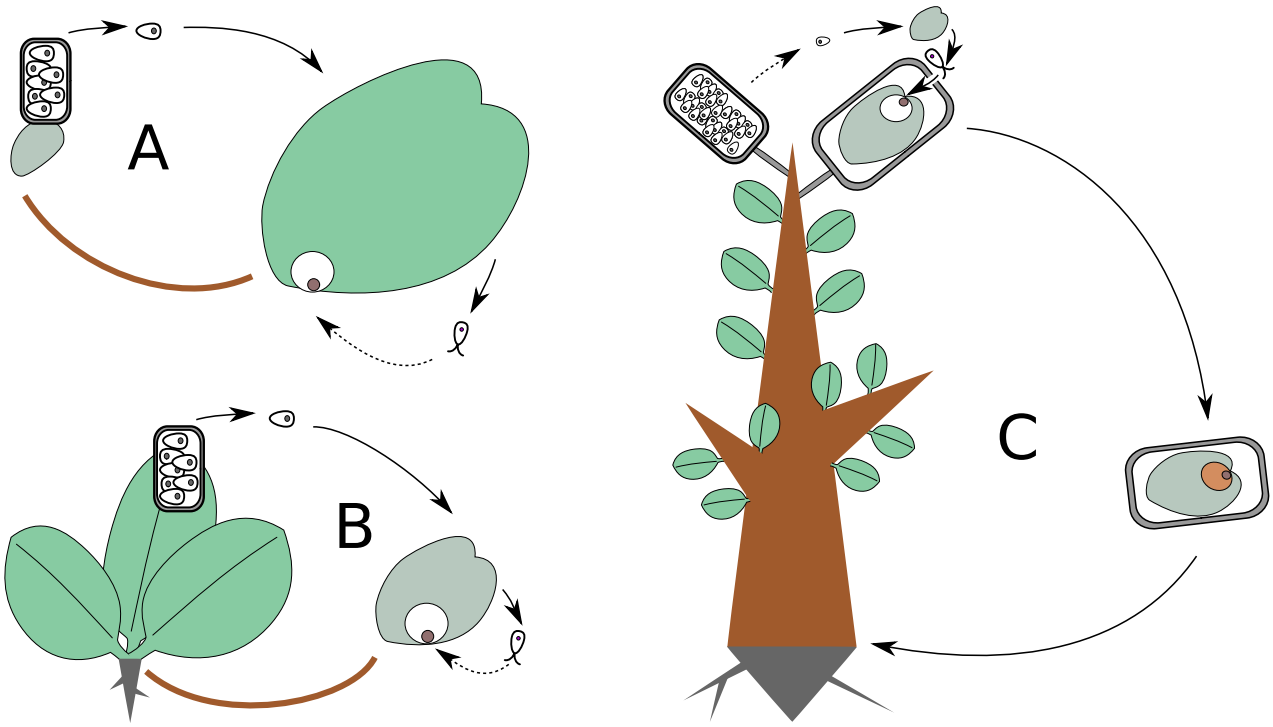
Origin of seed II



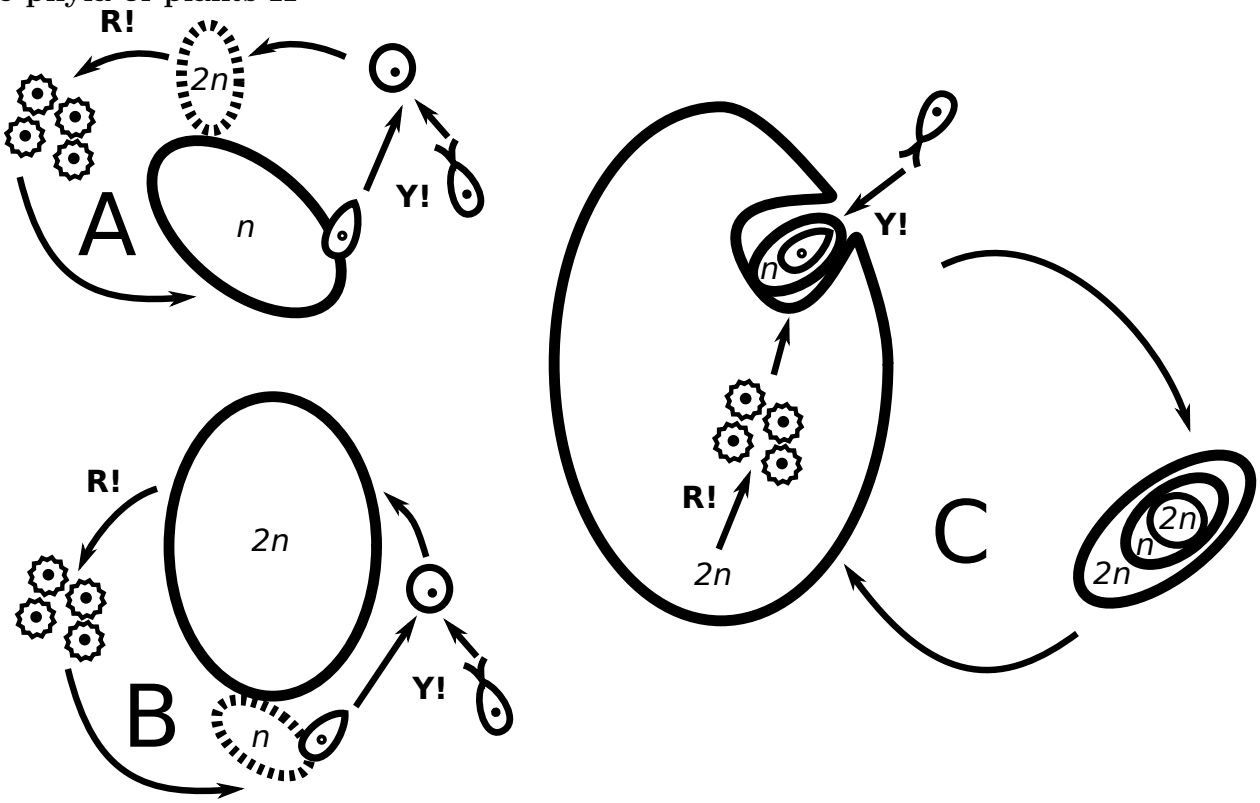
Origin of seed III



Three phyla of plants I



Three phyla of plants II



5 Jurassic park

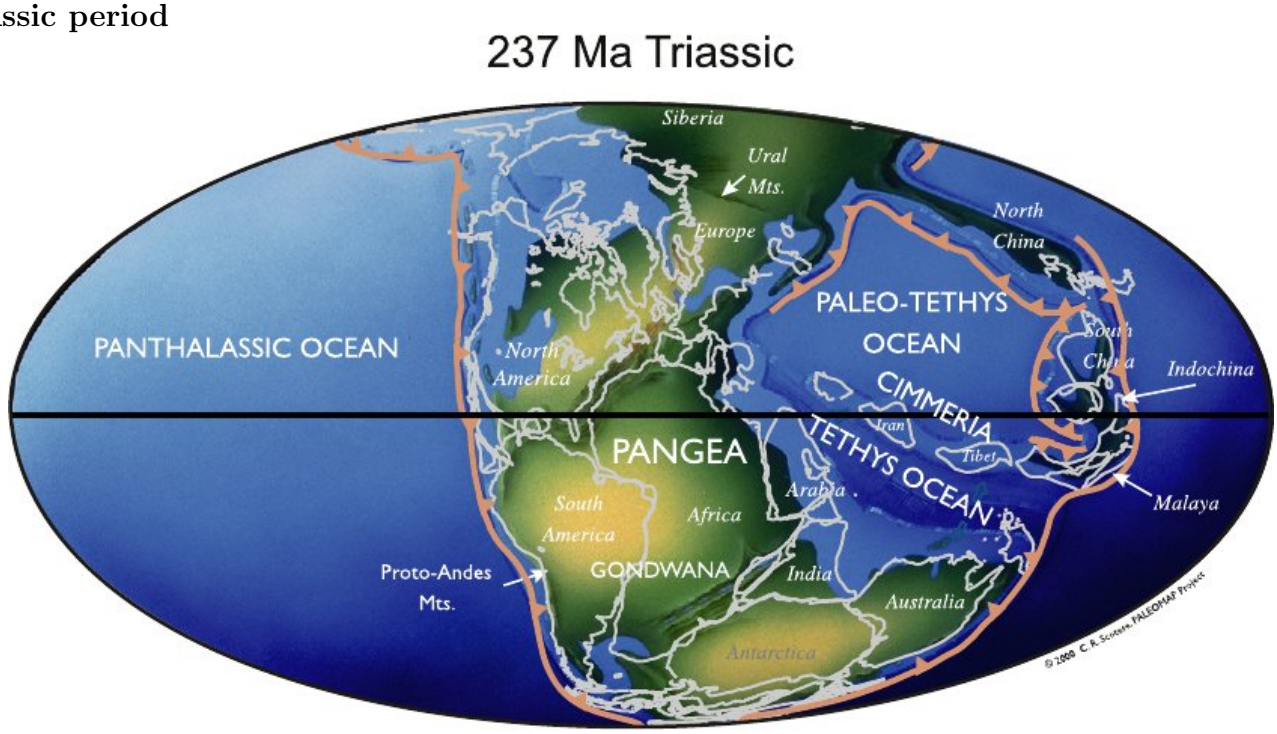
5.1 From Triassic to Cretaceous

From Triassic to Cretaceous

Mesosoic era:

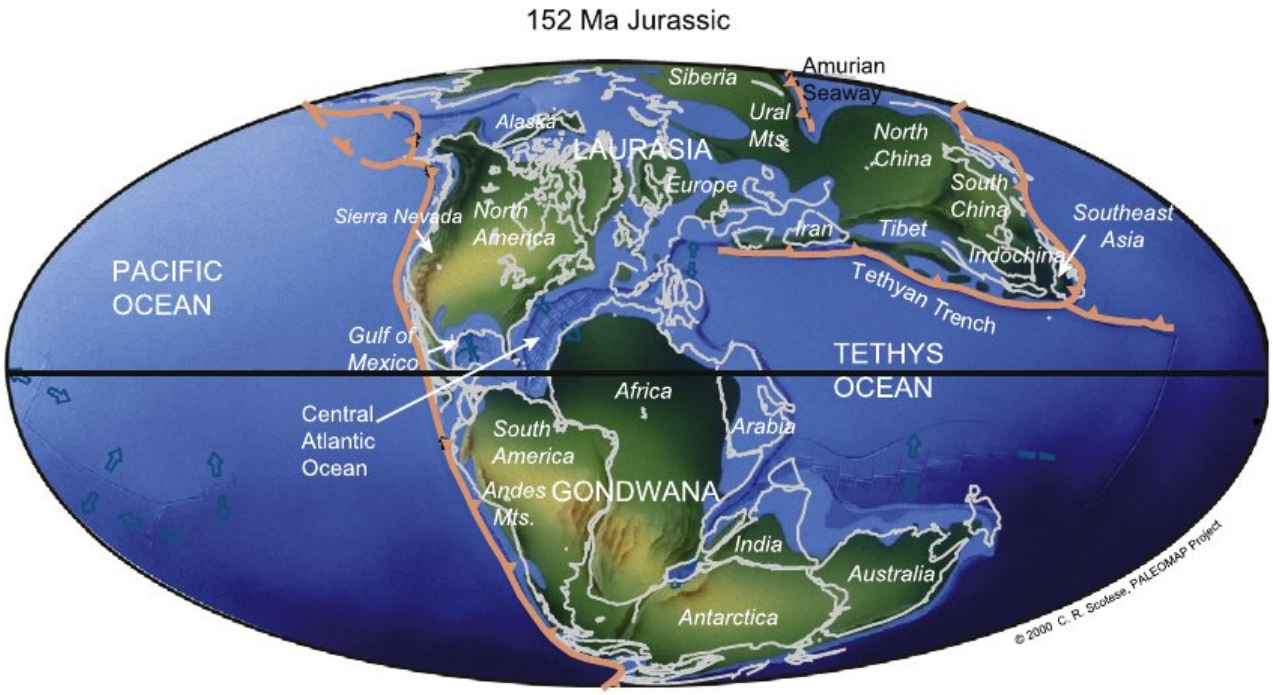
- Triassic: starts 252 Mya
- Jurassic: starts 201 Mya
- Cretaceous: starts 145 Mya, ends 66 Mya

Triassic period



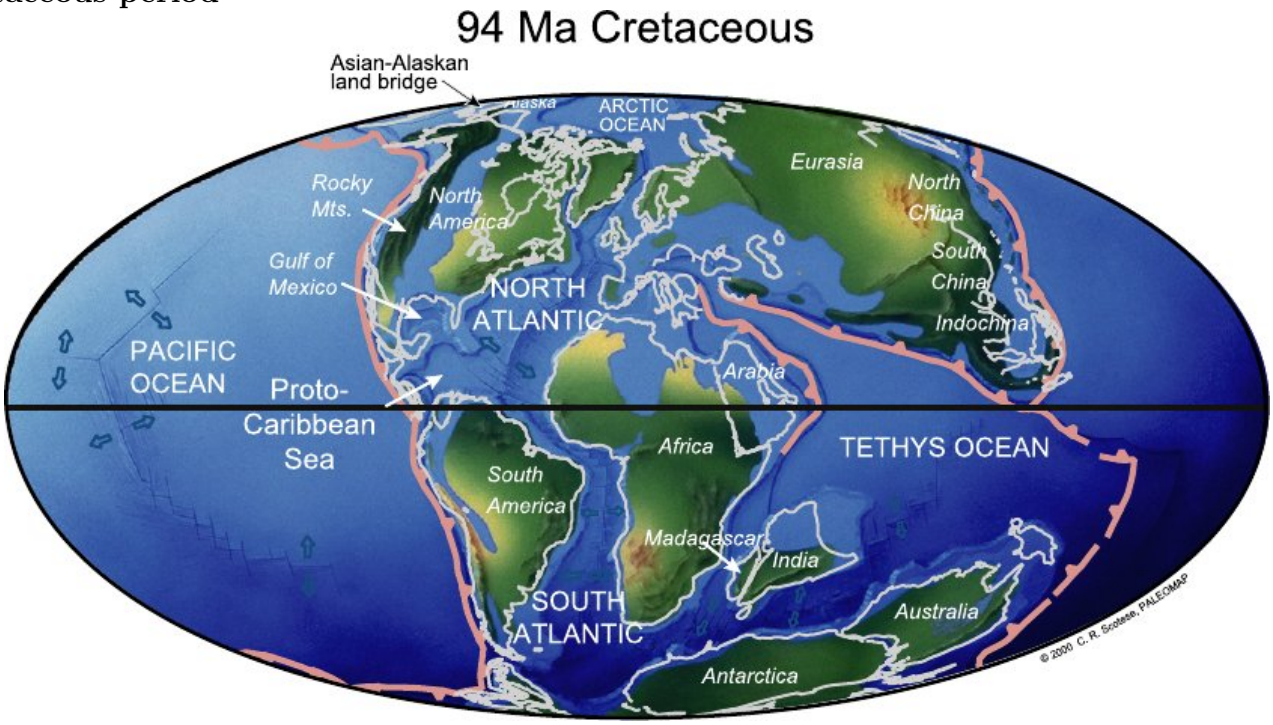
- Pangea broke (part of Africa adhered to North America)
- Climate becoming wetter
- Grasshopper-like insects radiated
- Synapsid reptiles declined, dinosaurs and pterosaurs appeared

Jurassic period



- Atlantic ocean and Rocky mountains appeared
- Peak of dinosaur diversity
- Birds appeared as a lineage of small flying dinosaurs
- In the sea, ammonites and primitive fish dominated

Cretaceous period



- High level of water (second high after Devonian), warm climate even on North and South poles, sea in North Dakota
- Flowering plants appeared and rapidly colonized all land

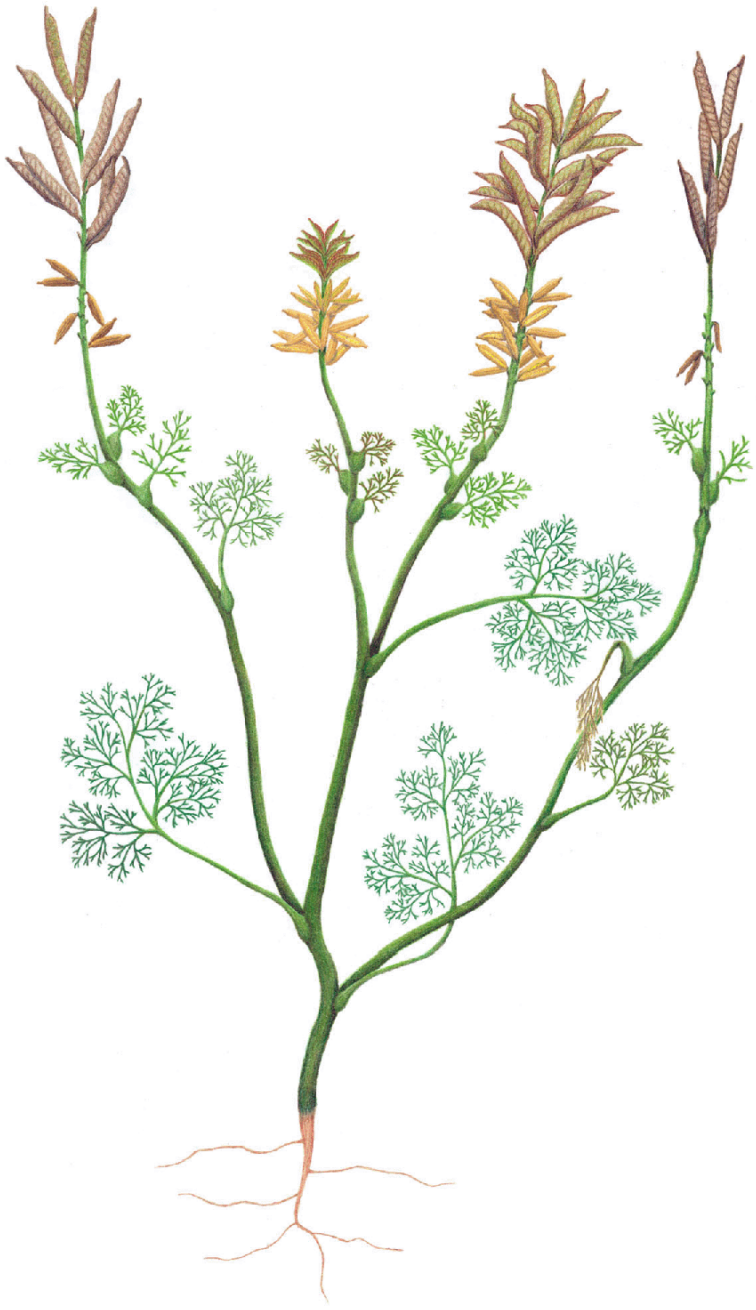
- Butterflies and flies appeared
- Terrestrial dinosaurs slowly declined and finally disappeared in the very end of period

5.2 Jurassic and Cretaceous flora and fauna

Terrestrial flora

- Spermatophyta
  - Non-angiosperm seed plants ("gymnosperms")
  - Magnoliopsida (angiosperms, flowering plants)
- Pteridophyta

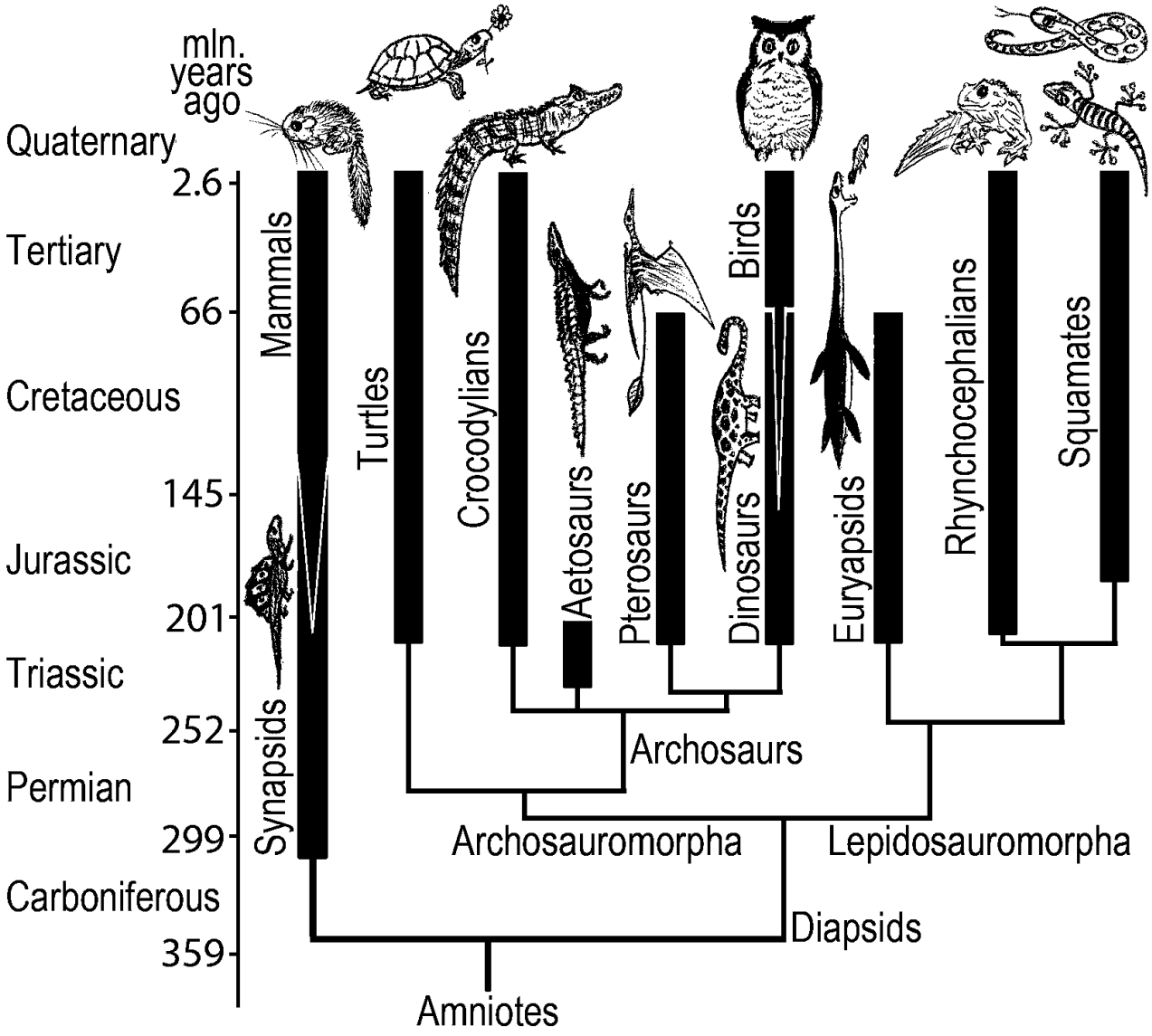
Archaefructus **(discovered in 2002, Yixian)**



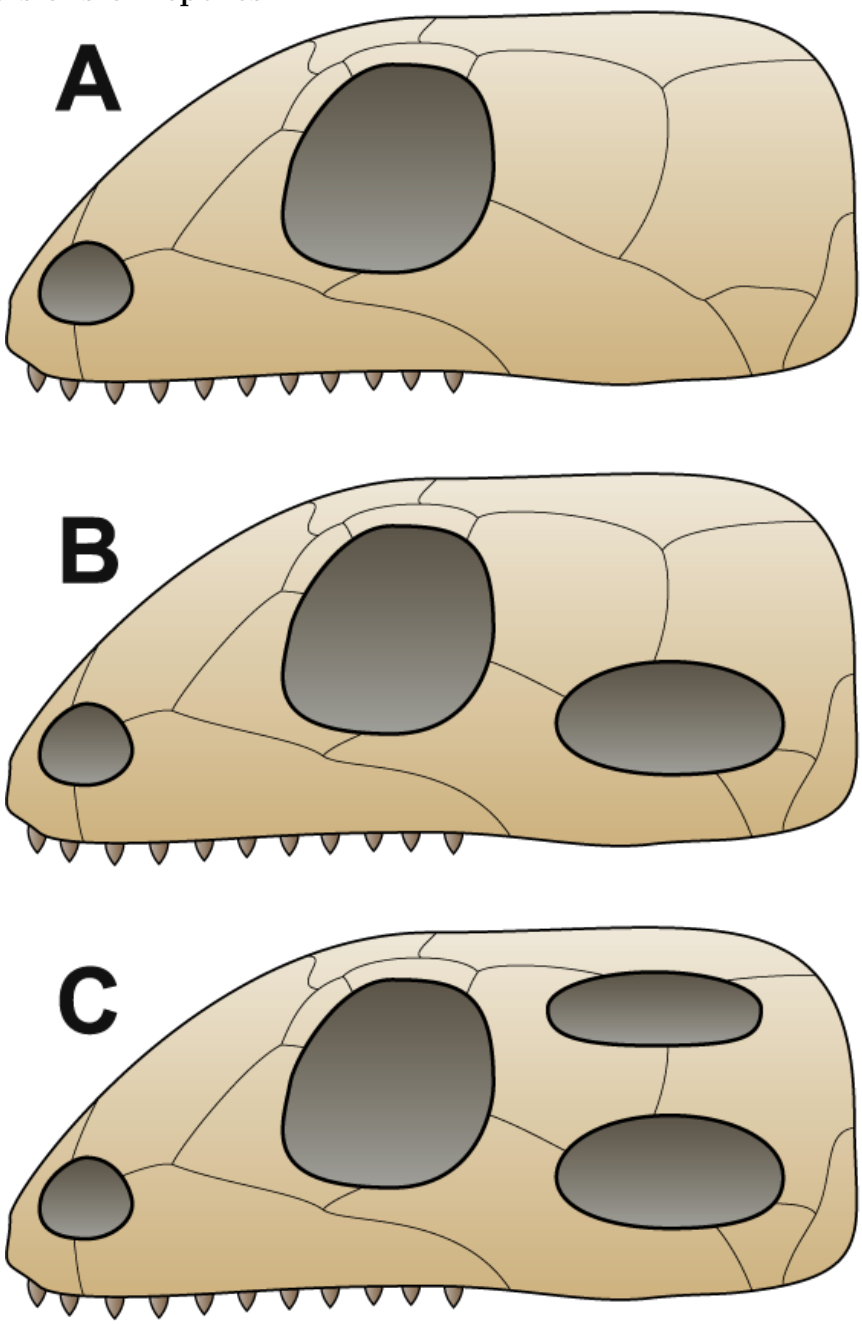
Terrestrial fauna

- Amphibia
- Reptilia
  - Synapsida: ancestors of **mammals**, e.g., pelycosaurs
  - Anapsida: **turtles** and many extinct lineages like pareiasaurs from Permian, now frequently united with diapsids
  - Diapsida: the most diverse reptilian group
- Aves (departed from Diapsida)
- Mammalia (in transition from synapsid reptiles to core mammals)

Reptiles, mammals and birds



Subdivisions of reptiles



A Anapsid skull

B Synapsid skull

C Diapsid skull

For Further Reading

References

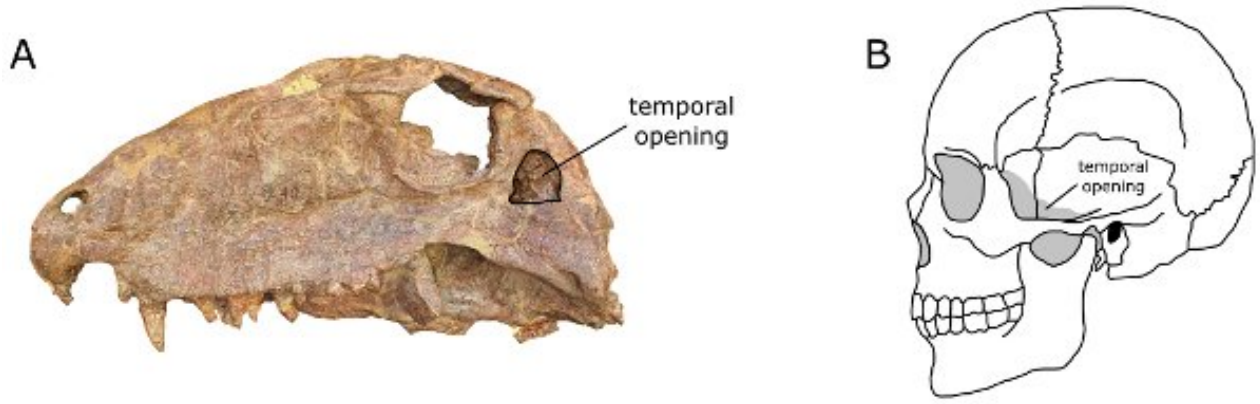
[1] Seed. `http://en.wikipedia.org/wiki/Seed`

[2] Reptiles. `http://en.wikipedia.org/wiki/Reptile`

6 Where we are

6.1 Jurassic park

Why mammals are synapsids



Tricodont proto-mammal

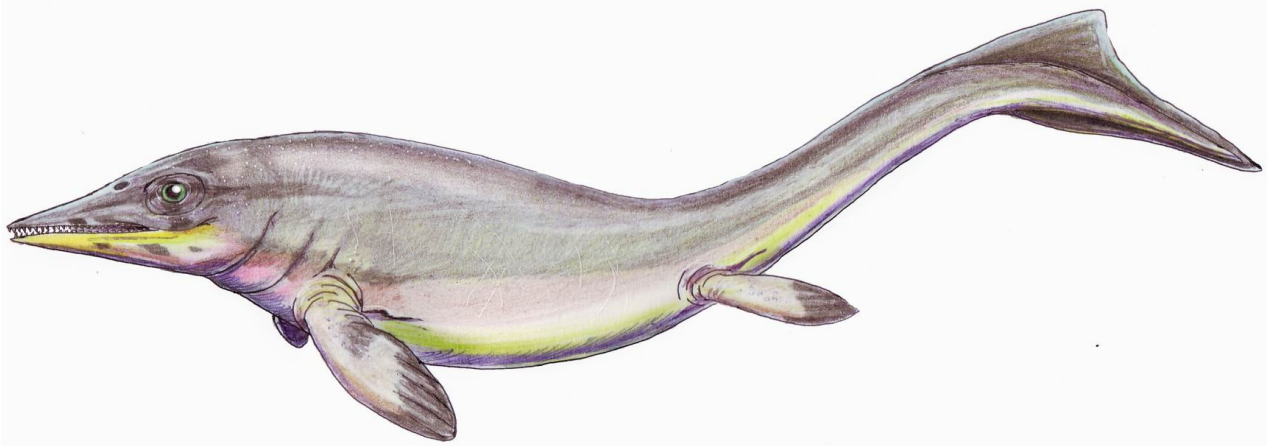
Diapsid reptiles

- Ichthyosauria: marine, dolphin-like reptiles
- Sauropterygia: placodonts and plesiosaurs

  These two first groups are called "euryapsids"

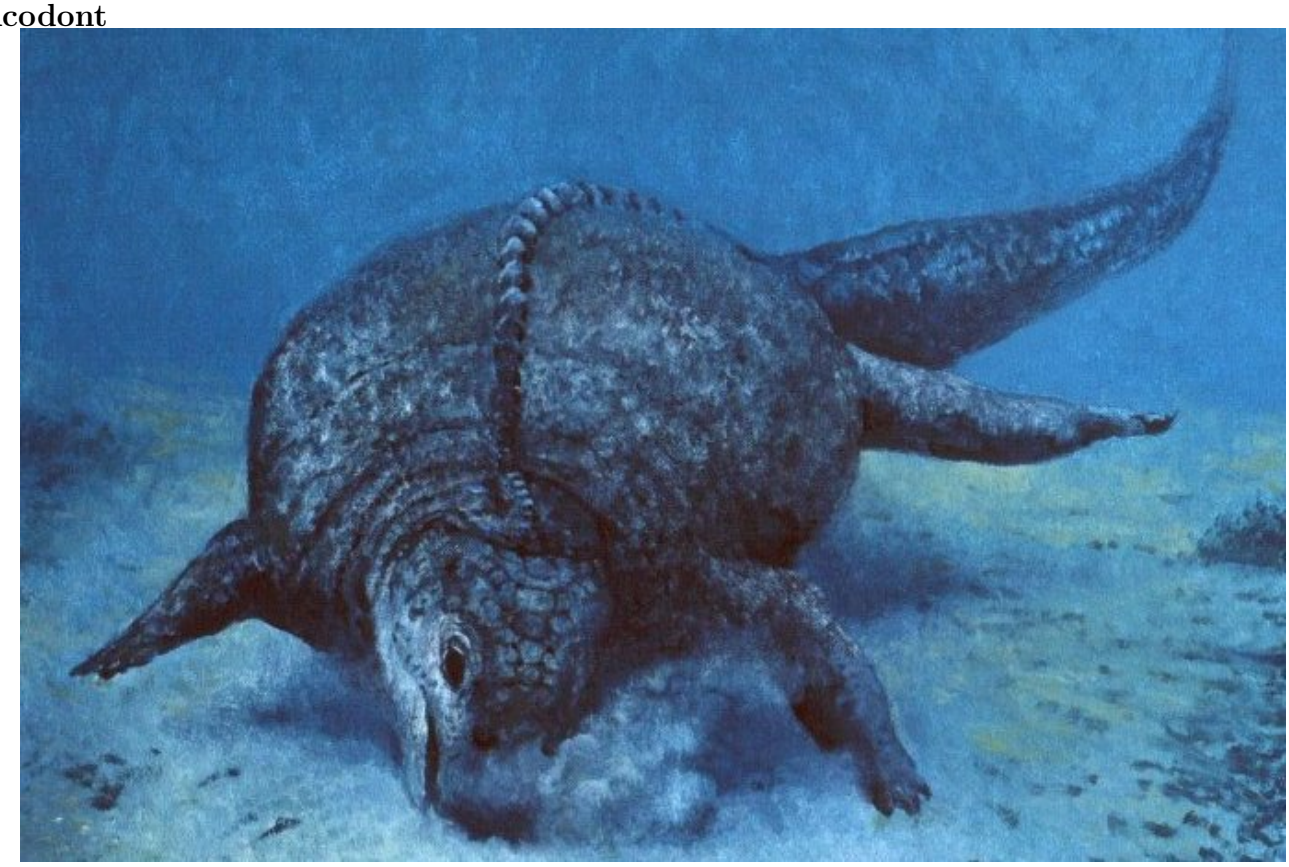
- Lepidosauria: lizards, snakes and extinct mosasaurs
- Archosauromorpha: proterosuchids, aetosaurs, crocodiles, dinosaurs (including ancestors of birds)

Ichthyosaur



Ichthyosaurs were viviparous. Note also the vertical fin.

Placodont



Covered with skin plates, eat mollusks.

Plesiosaurs

Mosasaur

Archosauromorph reptiles

- Proterosuchia, Aetosauria: basal archosauromorphs
- Crocodylomorpha: advanced behavior, four-chambered heart
- Pterosauria: archosaur "bats", some with fur-like cover. Note that skin membrane is not very effective wing.
- Dinosauria: bipedal archosaurs:
  - Ornithischia: "bird-hipped", include ankylosaurs and stegosaurs, ornithopods (like *Iguanodon*), pachycephalosaurs and ceratopsids (but not birds!)
  - Saurischia: "lizard-hipped":

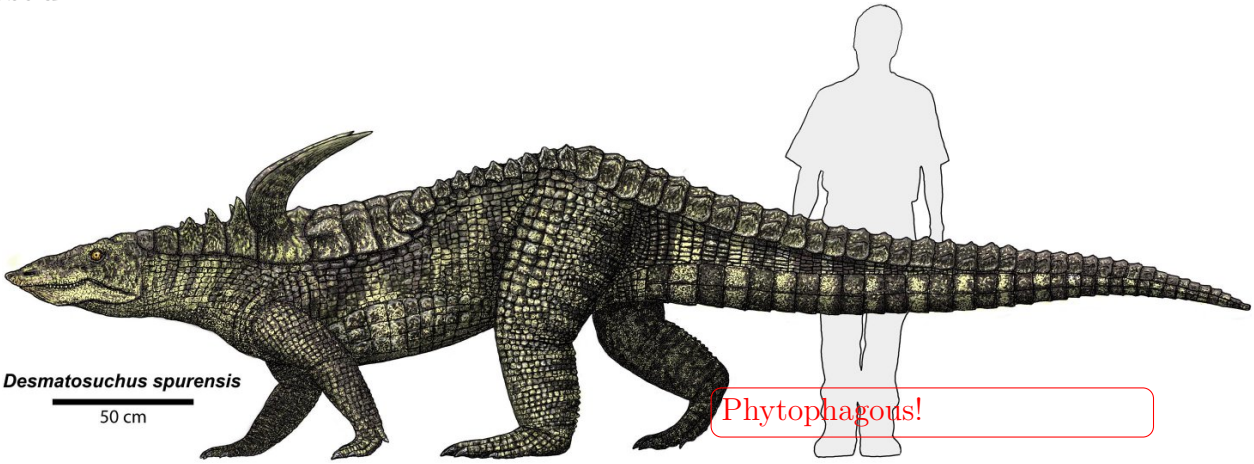
A. Theropoda: true bipedal, carnivorous or insectivorous, mostly feathered: Ceratosauria ("southern carnivores"), Allosauroidea and relatives, including *T. rex*, Maniraptora and descendants

B. Sauropodomorpha: secondary quadrupedal, small heads, long necks, long tails; largest dinosaurs

Proterosuchid

Chasmatosaurus from movie

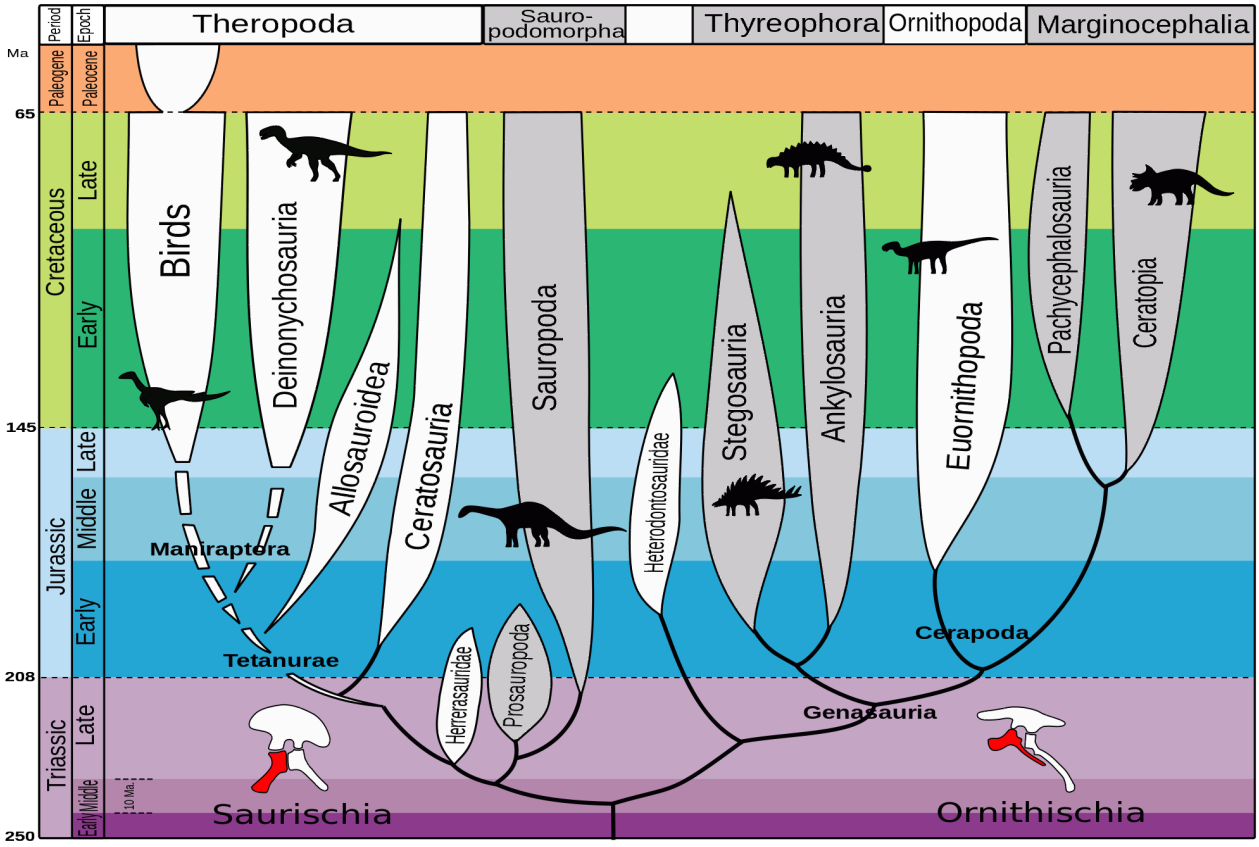
Aetosaur



Phytophagous!

***Dsungaripterus* pterosaur**

Dinosaurs in time



Early ornitischian *Tianyulong*

Allosaurioid *Yutyrannus* from China

Feathered, warm-blooded, social

Theropoda: *Tarbosaurus* and *Gallimimus*

Early maniraptor *Gigantoraptor*

Late maniraptor *Microraptor*

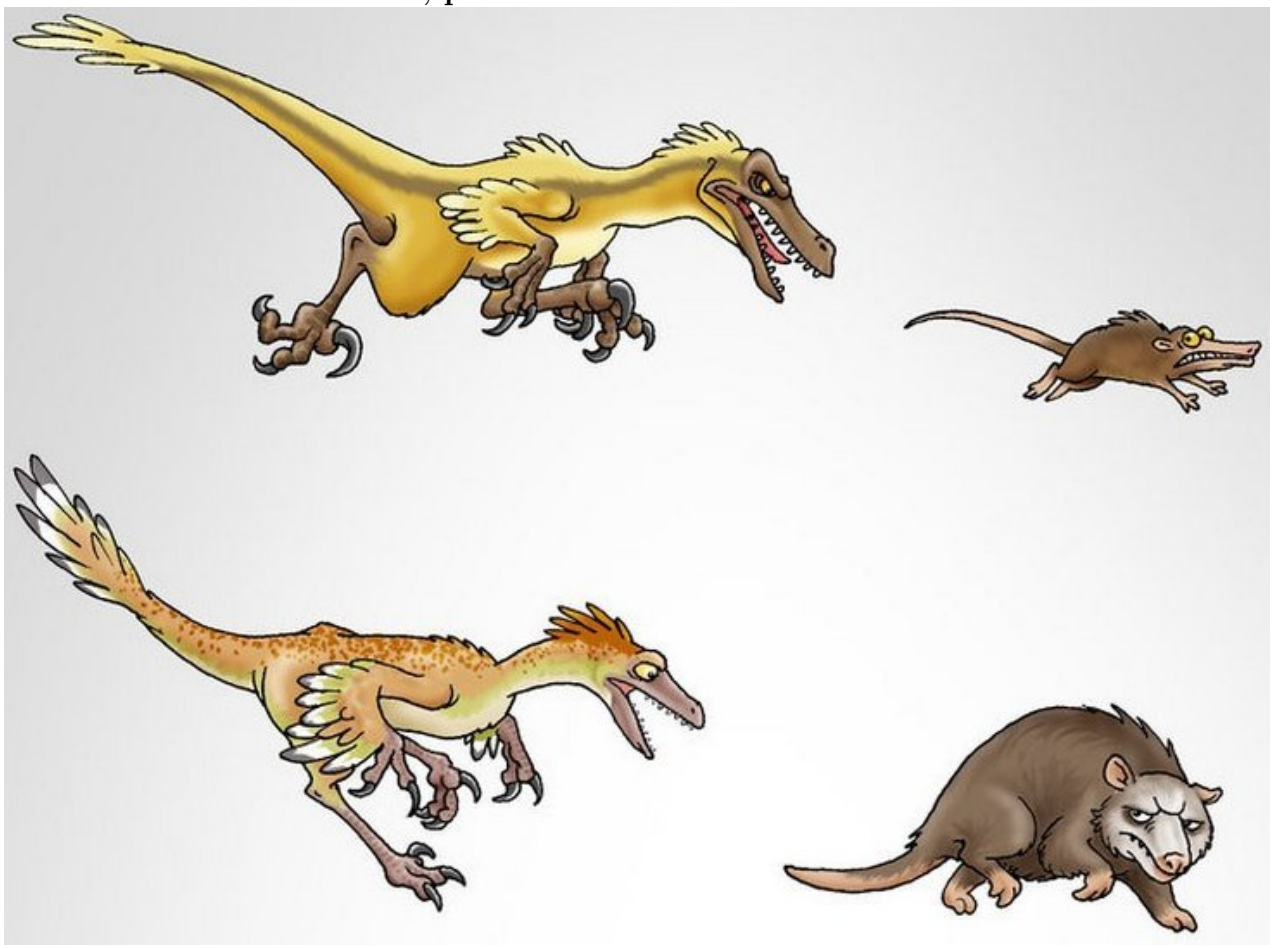
Archosauromorph reptiles

- Proterosuchia, Aetosauria: basal archosauromorphs
- Crocodylomorpha: advanced behavior, four-chambered heart
- Pterosauria: archosaur "bats", some with fur-like cover. Note that skin membrane is not very effective wing.
- Dinosauria: bipedal archosaurs:
  - Ornithischia: "bird-hipped", include ankylosaurs and stegosaurs, ornithopods (like *Iguanodon*), pachycephalosaurs and ceratopsids (but not birds!)
  - Saurischia: "lizard-hipped":
    A. Theropoda: true bipedal, carnivorous or insectivorous, mostly feathered: Ceratosauria ("southern carnivores"), Allosauroidea and relatives, including *T. rex*, Maniraptora and descendants
    B. Sauropodomorpha: secondary quadrupedal, small heads, long necks, long tails; largest dinosaurs

7 Mesozoic-Cenozoic extinction

7.1 The raise and fall of giant reptiles

Reptiles and mammals cartoon, part I



Reptiles and mammals cartoon, part II

Mesozoic-Cenozoic extinction

Two extinctions:

- Most of large archosauromorphs, plus plesiosaurs and ichthyosaurs. Crocodiles, birds, mammals, amphibians survived.
- Shelled cephalopods (belemnites, ammonites) and many other marine groups

Plants and insects were not affected at all.

Why they were so big

- To digest plants (cellulose), higher temperature will help. Dinosaurs developed size-related **endotermy**.
- To escape from predators, the prey should grow big.
- As a result, in Jurassic park all herbivores were giants.
- Turtles are an exception, but they live on a very little fuel and are over-armored to escape predators.

Mammals in Jurassic

- They fed mostly on insects
- Their chewing system is not yet developed to the level when they can live on plants

- By the law of ecological pyramid (i.e., 10000 grasses – 100 rabbits – 1 fox), terrestrial ecosystems do not support more than three floors of feeding chain.
- As a result, **small predator ("fox") ecological niche was empty: there was no constant supply of food**

"Every worm has his weak spot": egg problem

- Eggs need warming. Physical laws allow egg to be warmed to the center only if it is not exceed $\approx$ 0.5 m in diameter.
- Forces of evolution pushed dinosaurs to grow as big as possible, but egg size was limited.
- As a result, dinosaur young were vulnerable to everybody who would want to feed on them. Fortunately, the small predator did not exist.

How small predator niche was finally filled

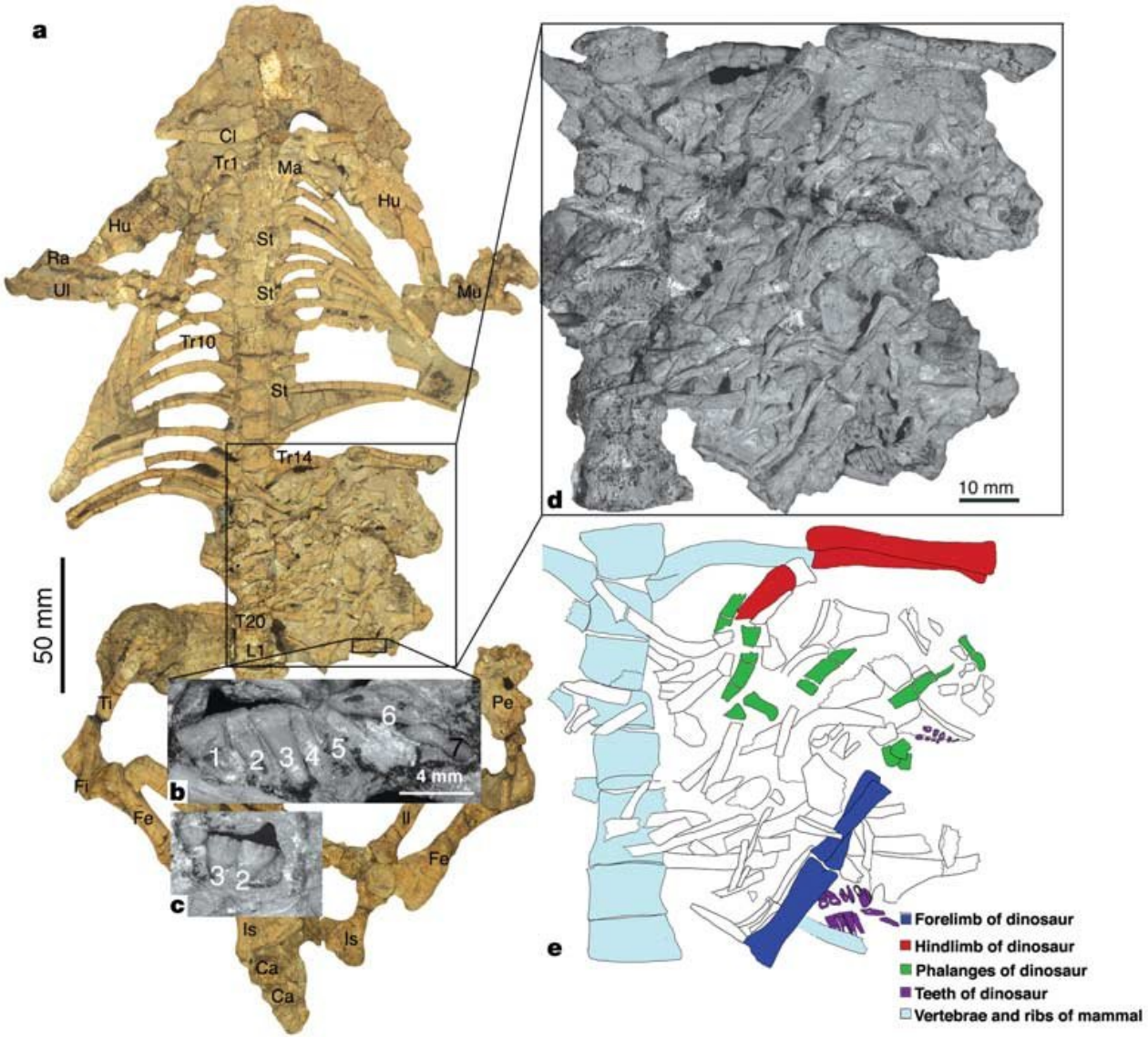
- First herbivorous mammals (multituberculates) appeared in the Middle Cretaceous
- From that point, small predators will have the constant food source
- As a result, they appeared shortly after. They were not only mammals but also snakes and small archosauromorphs.

Multituberculate mammal: first small herbivore

Dinosaurs decline: the theory

- Small predator will occasionally feed on dinosaur young which turn many species to the route of extinction. Moreover, new species do not appear.
- Dinosaur lineages slowly declined towards the late Cretaceous.

Dinosaurs decline: the proof



In 2005, Chinese paleontologists find the tricodont mammal skeleton with young dinosaur in the stomach

The hero: *Repenomamus robustus* (reconstruction)

Snakes also help in dinosaur extinction

Pterosaurs?

- To escape the competition with better organized birds, they also pushed to be larger and larger.
- At some point, they faced the same "dinosaur problem": they cannot defend their young...

Asteroid?

Asteroid?

- 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 was internal.
- But yes, asteroid could be the " straw that breaks the camel's back"

Summary

For Further Reading

References

[1] Dinosaurs. `http://en.wikipedia.org/wiki/Dinosaur`

[2] Ecological crisis. `http://en.wikipedia.org/wiki/Ecological_crisis`

Outline

8 Where we are

8.1 End of Cretaceous ecological crisis

Cretaceous extinction of giant fauna

8.2 Cenozoic era

From Paleogene to Quaternary

Cenozoic era:

- Paleogene: starts 66 Mya

  Includes:

  - Paleocene
  - Eocene
  - Oligocene

- Neogene: starts 23 Mya

  Includes:

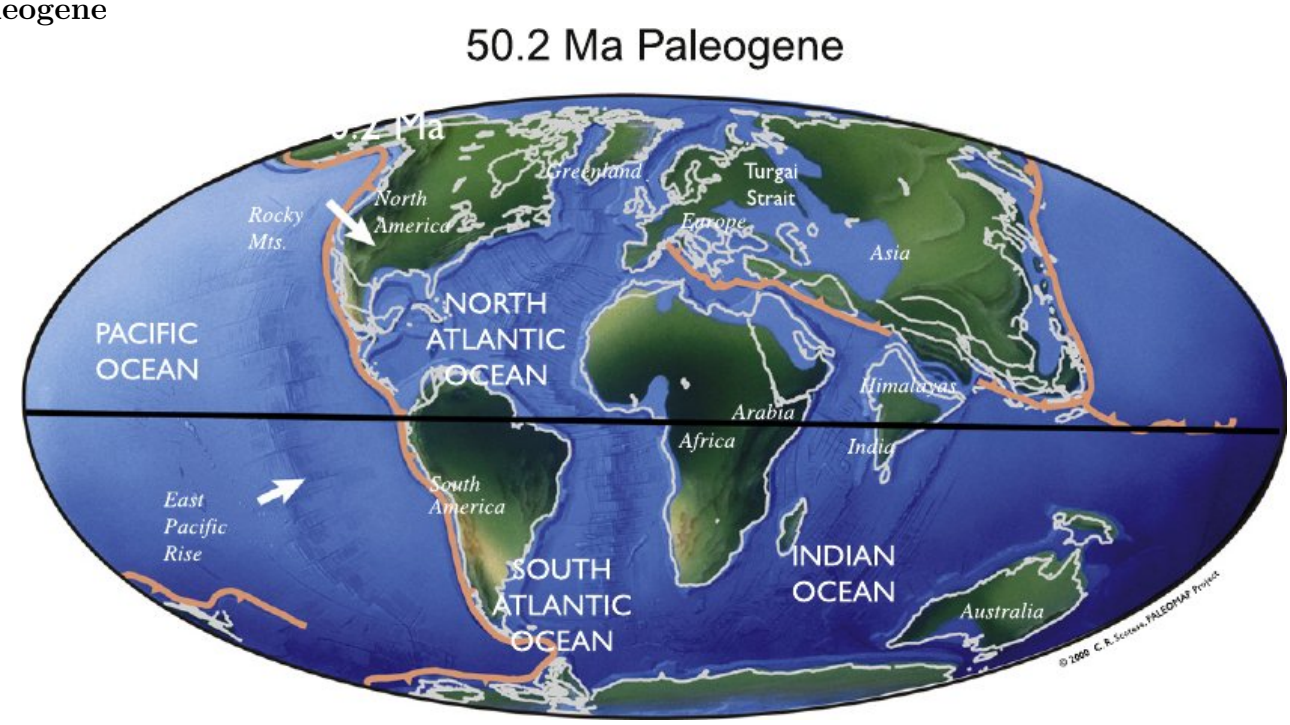
  - Miocene
  - Pliocene

- Quaternary: starts 2.5 Mya

  Includes:

- Pleistocene
- Holocene

Paleogene

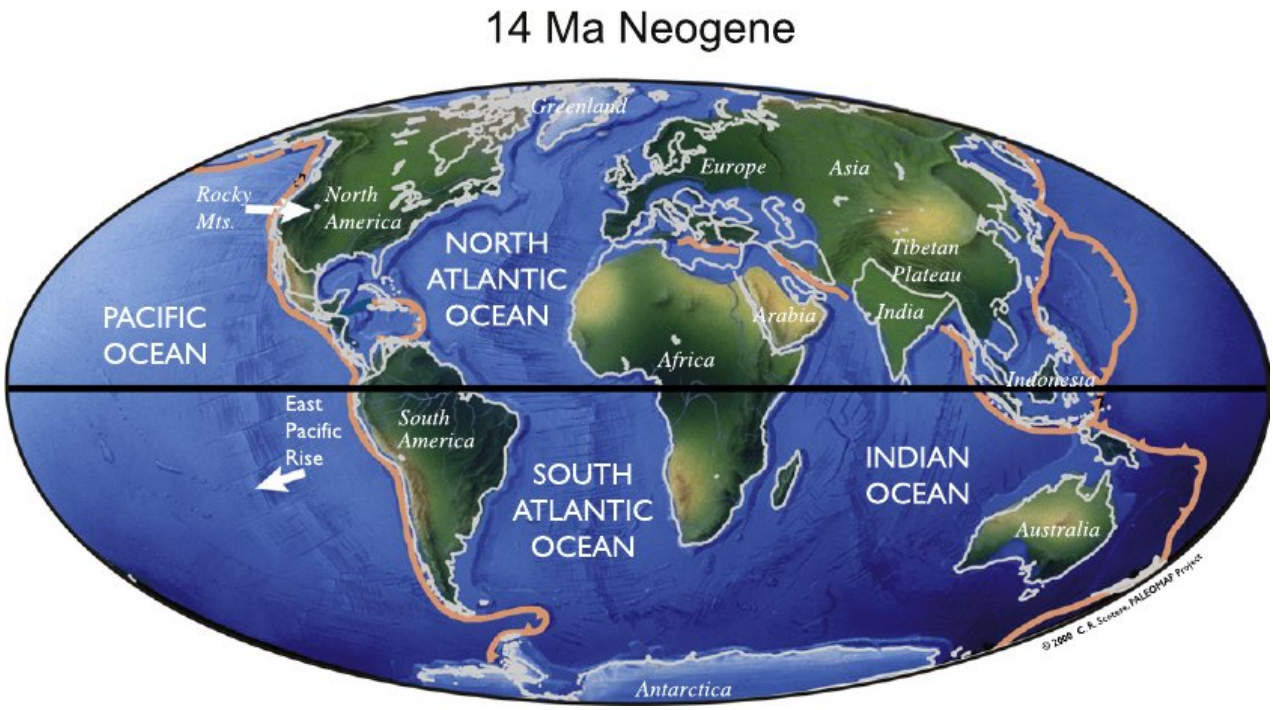


- Warm, even climate
- South America isolated, Tethys sea is slowly closing, India moves to Asia
- Mammals fill the big size class

Paleogene: when most of mammal orders appeared

Paleogene: when aliens temporarily took empty niches

Neogene



- Colder and drier
- Ice covers Antarctic, Americas united
- Grasses and hoofed mammals form grasslands

Quaternary

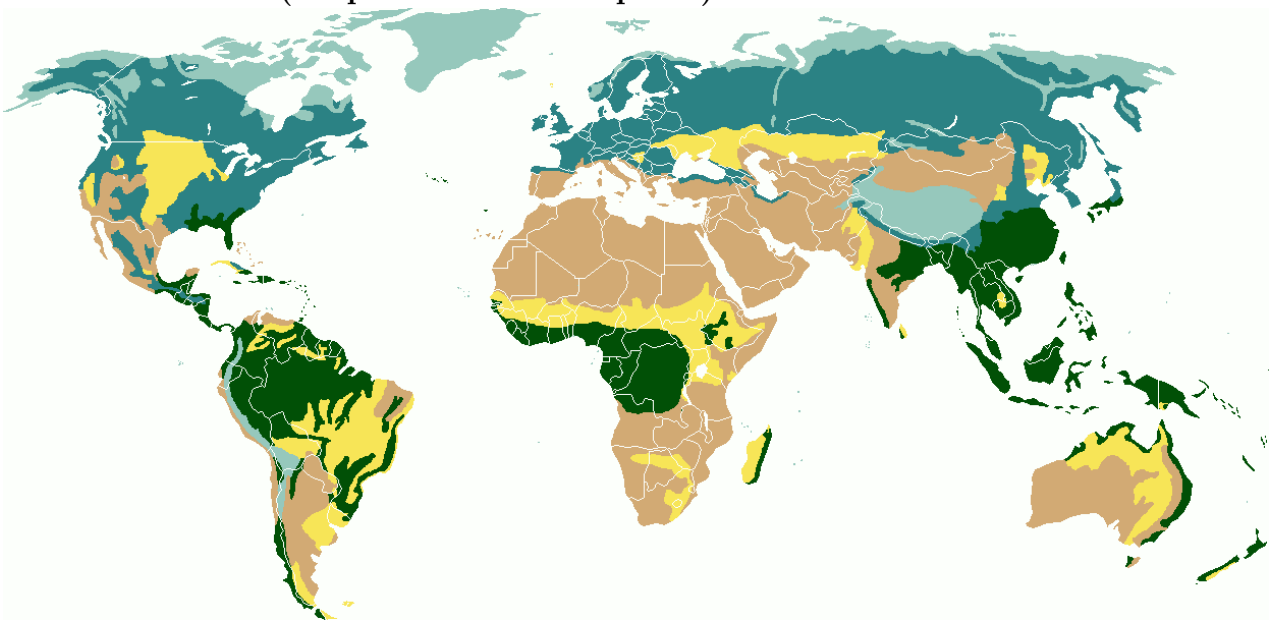
- Great glaciation again (the last was in Carboniferous)
- Rocky Mountains and Himalayas
- Humans

8.3 Ecogeography: origin of biomes

Ecogeography

- The science which study the distribution of main ecosystems (biomes)
- Biomes are mostly based on vegetation

Map of Earth biomes (simplified from Wikipedia)



Tundra, boreal forests, grasslands, deserts, tropical forests

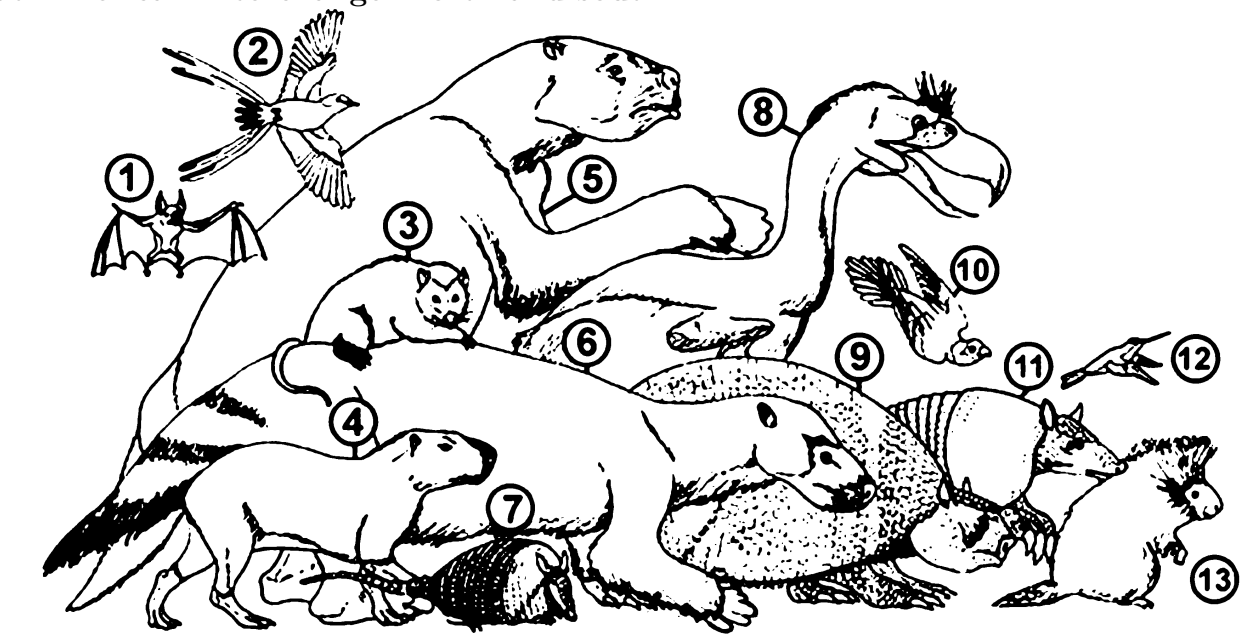
Origin of biomes

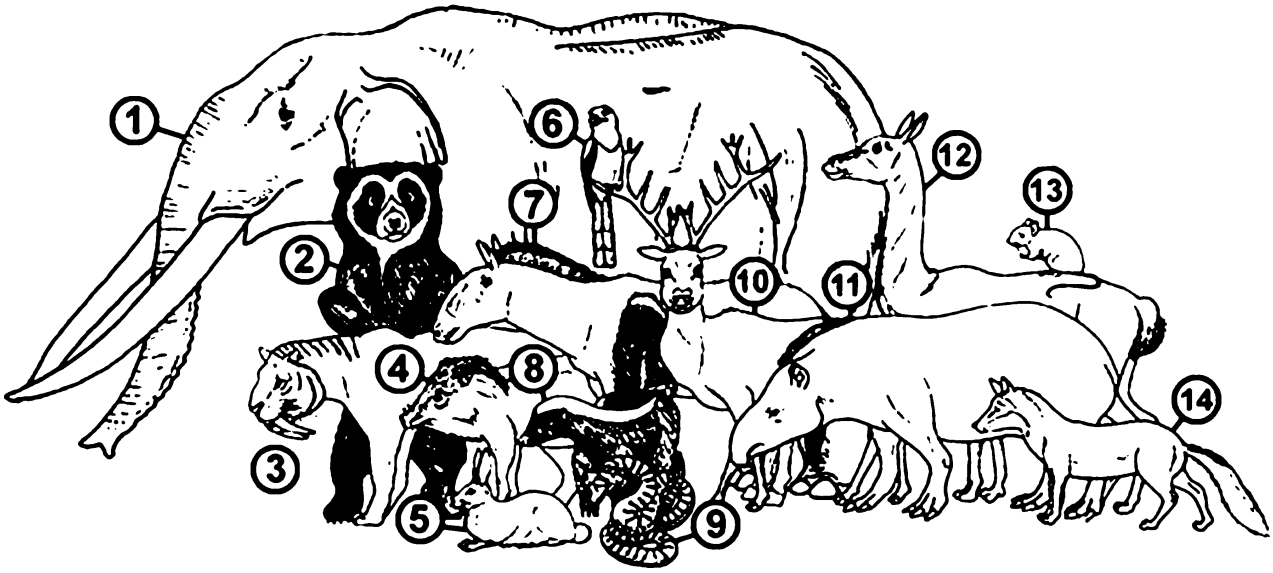
- Tundra: Quaternary, the newest biome
- Boreal forests: Paleogene, note the dominance of conifers
- Grasslands: Neogene, supports by both animals and plants
- Deserts: Permian (very old!)
- Tropical forests: Paleogene, "made" by plants and insects

Biogeography: Great American Interchange

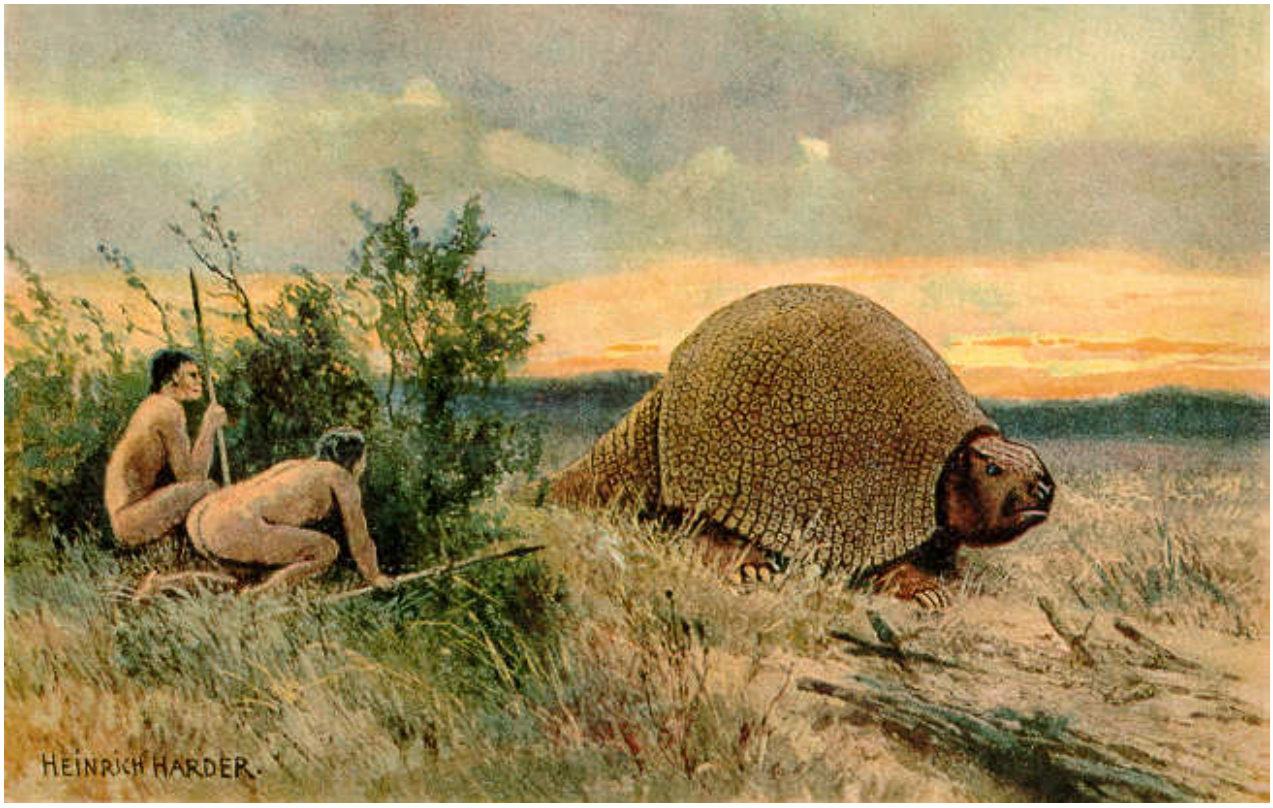
- Before Neogene, South America was an isolated continent like Australia now and keeps very unusual fauna
- Formation of the Isthmus of Panama led to the dramatic exchange in fauna between South and North Americas
- More advanced northern animals invaded South America but some of southern species (like armadillo, porcupines, opossums, giant sloth) became very successful on the North.

Great American Interchange: north and south





Some of this fauna lives now or was exterminated by early humans



9 Origin of us

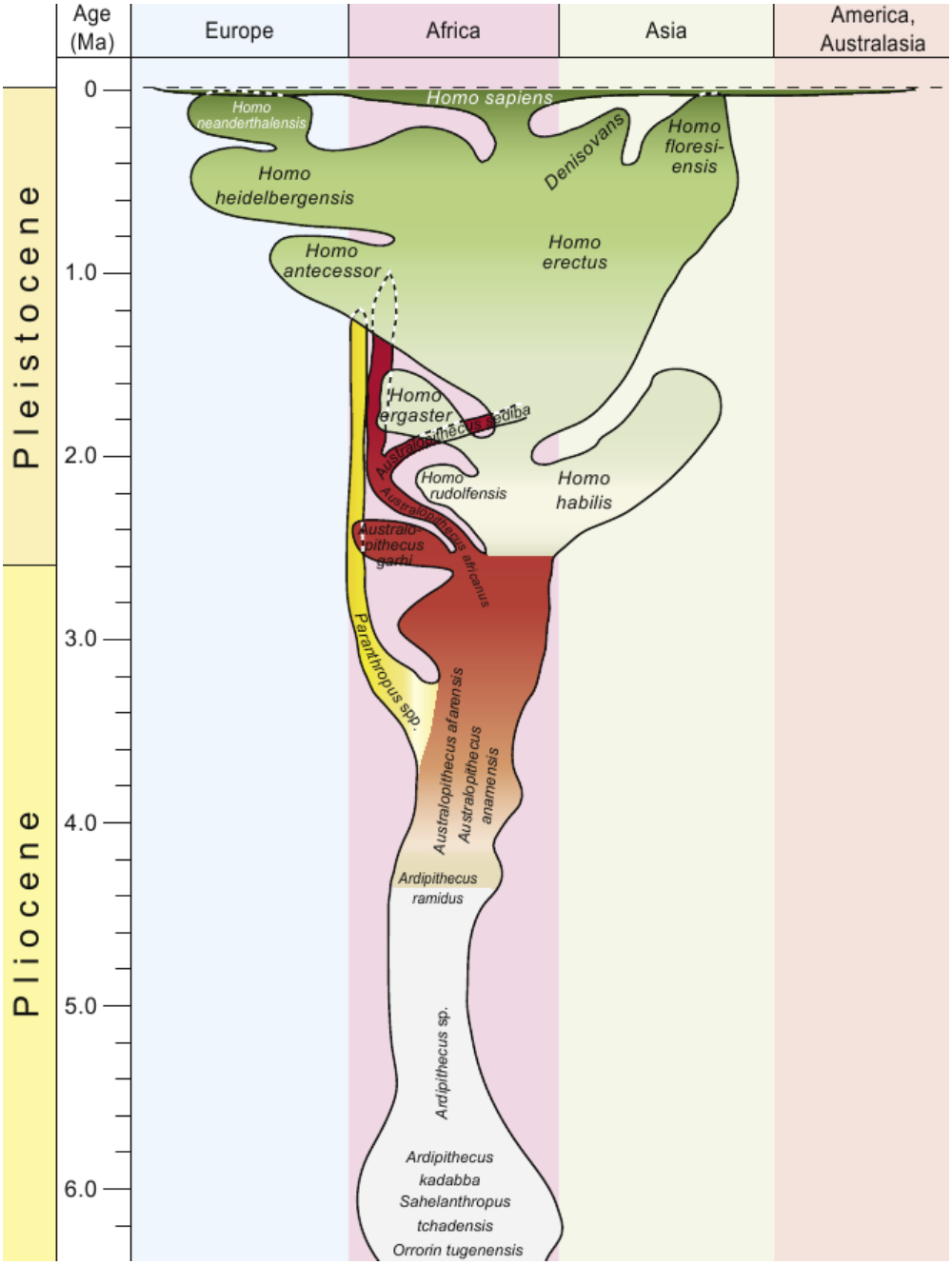
9.1 Just another ape

We and monkeys

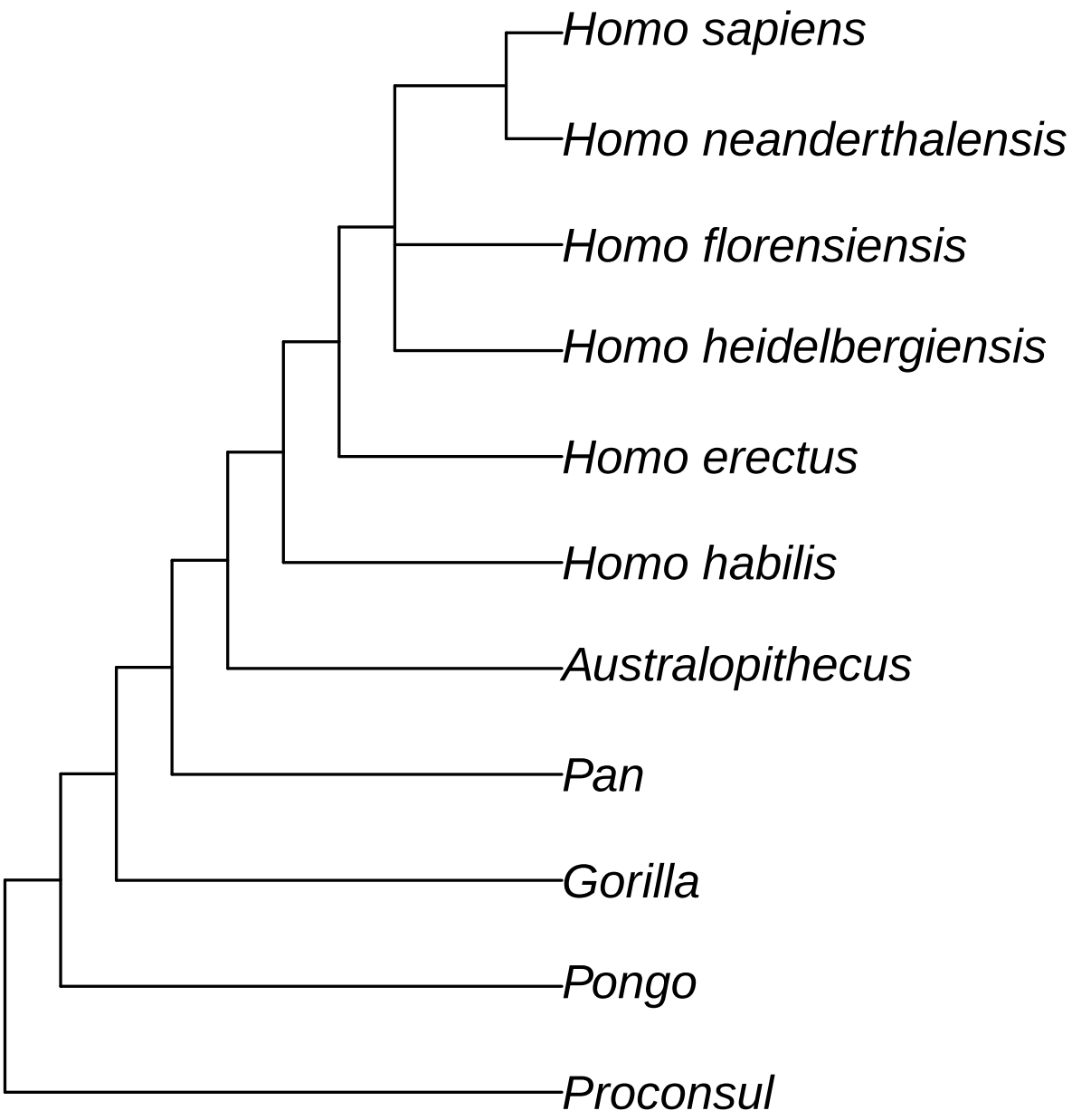
- It is scientifically correct to call us “monkeys” since we belong to the same order, Primates
- More strictly, humans and their relatives belong to the family Hominidae (hominids)

We and monkeys

Time and space of Hominidae evolution

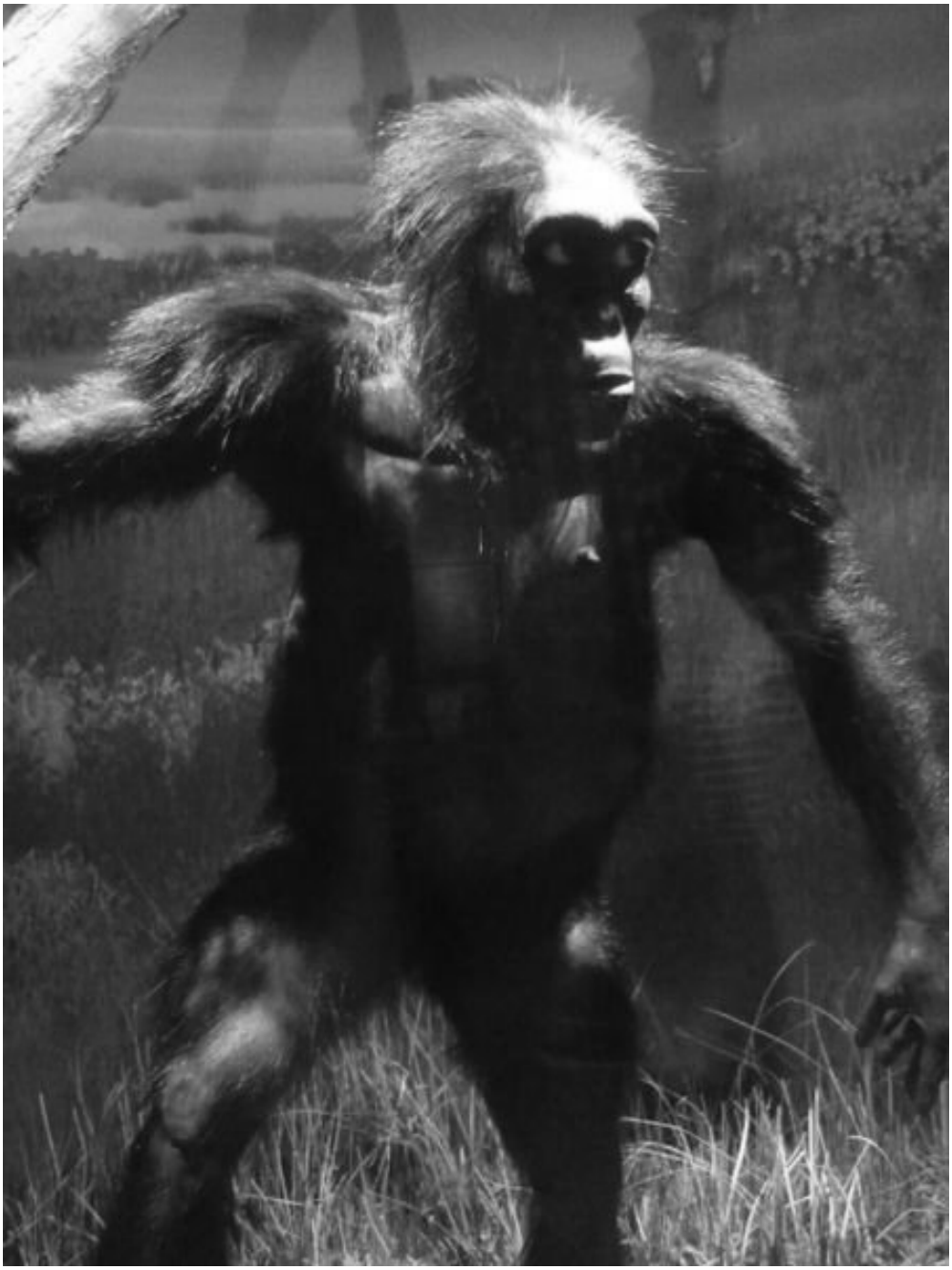


Phylogenetic tree of hominids (simplified)

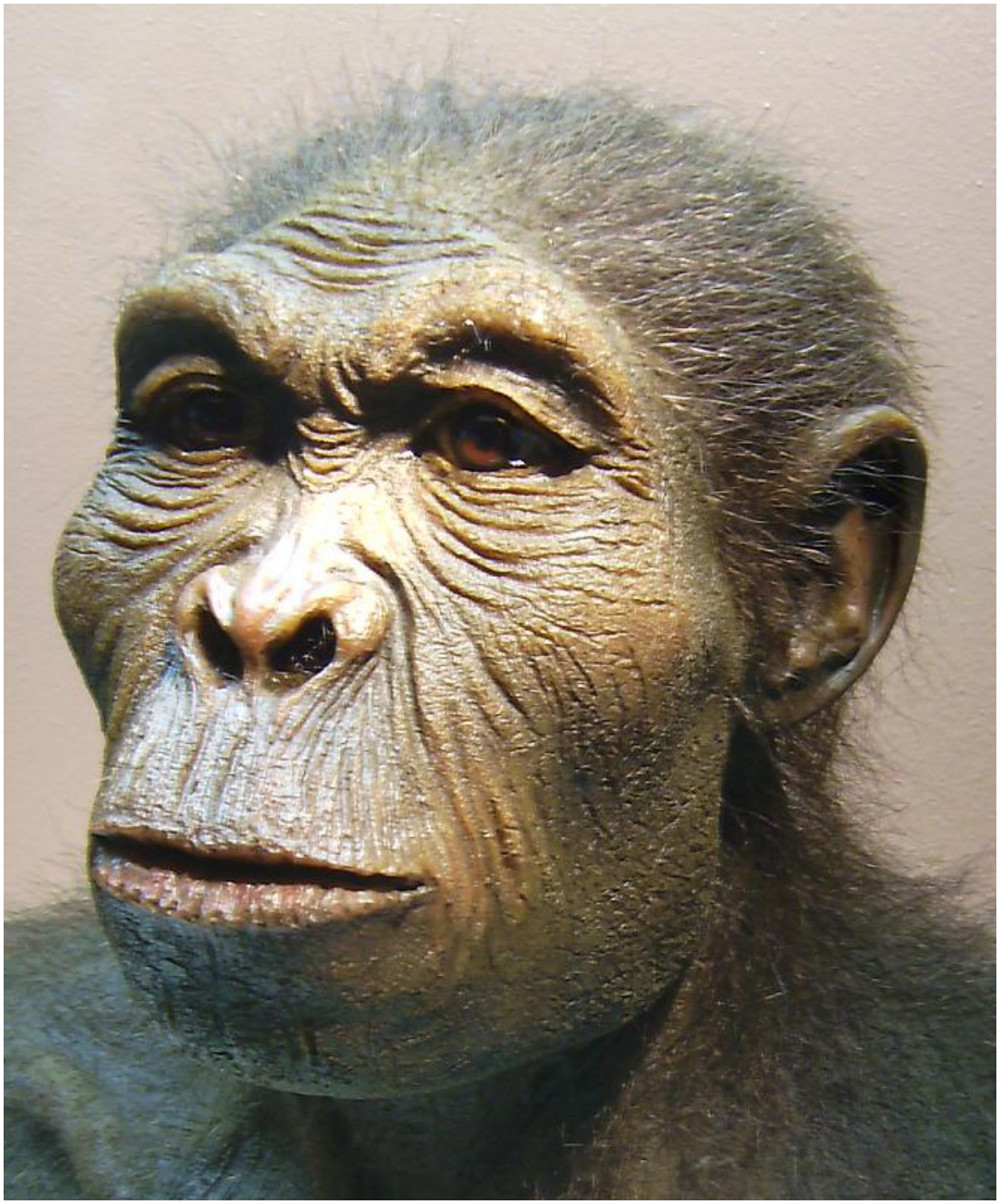


Please note that some terminal groups exchanges their genes (e.g., Neanderthals with modern humans)

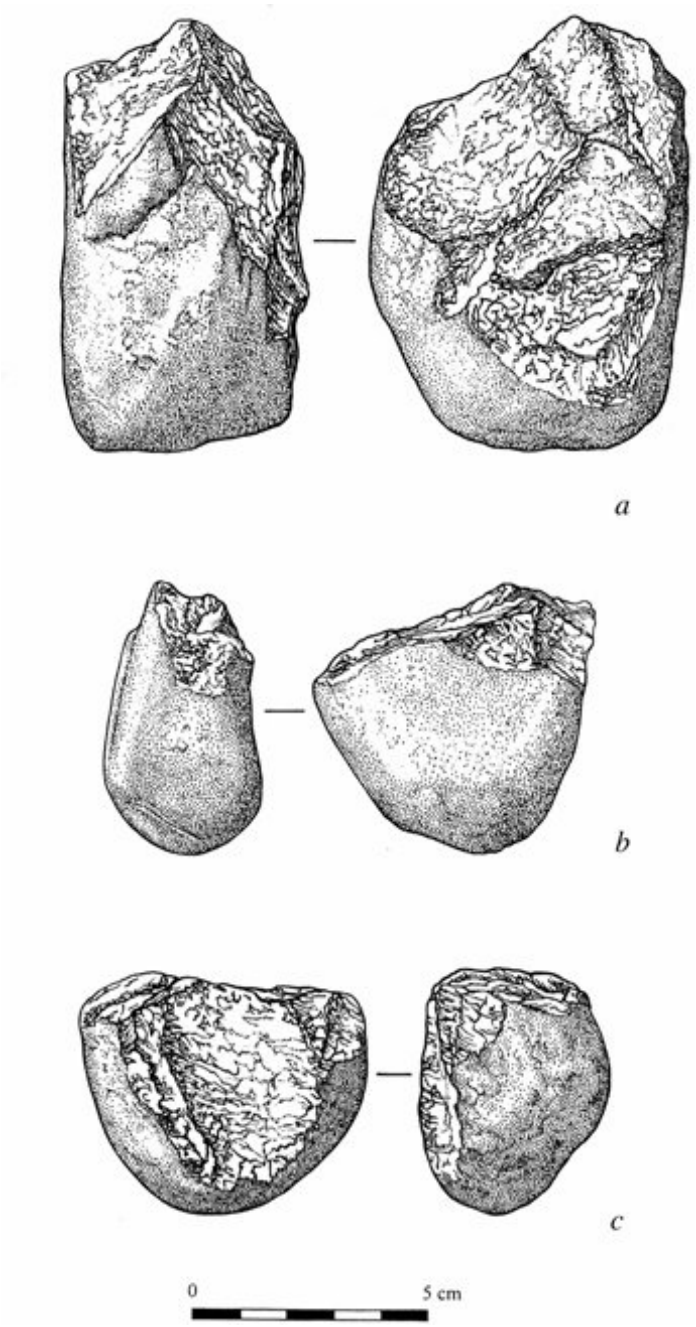
Step I: still a monkey—*Australopithecus* spp.



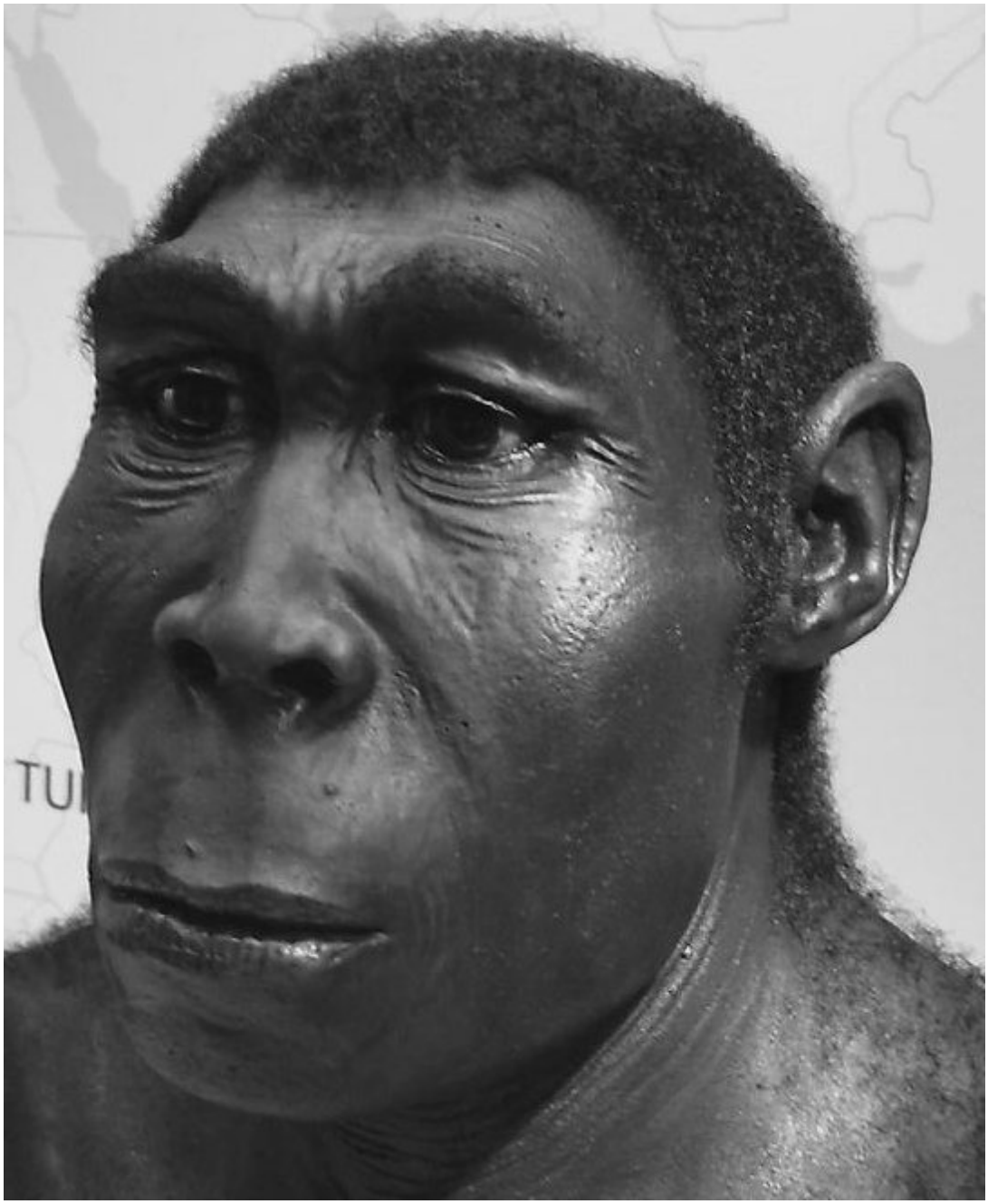
Step II: tool-maker—*Homo habilis*



... and his tools



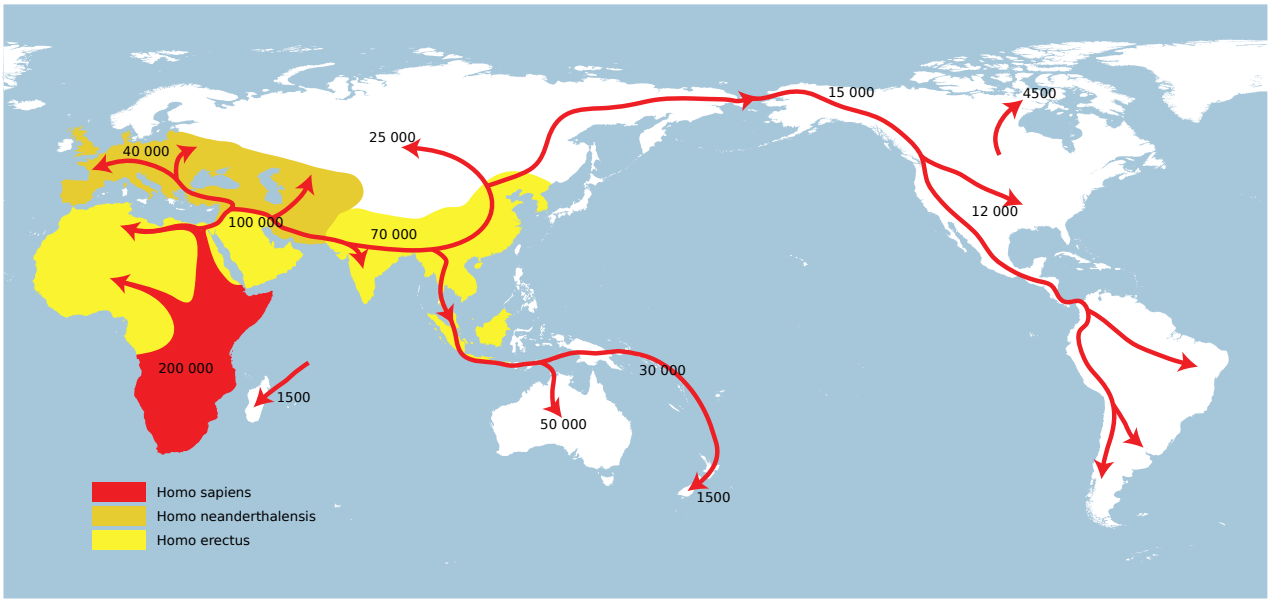
Step III: fire-maker—*Homo erectus*



Step IV: grave-maker—*Homo neanderthalensis*

Step V: *Homo sapiens* play the "Evolution" game

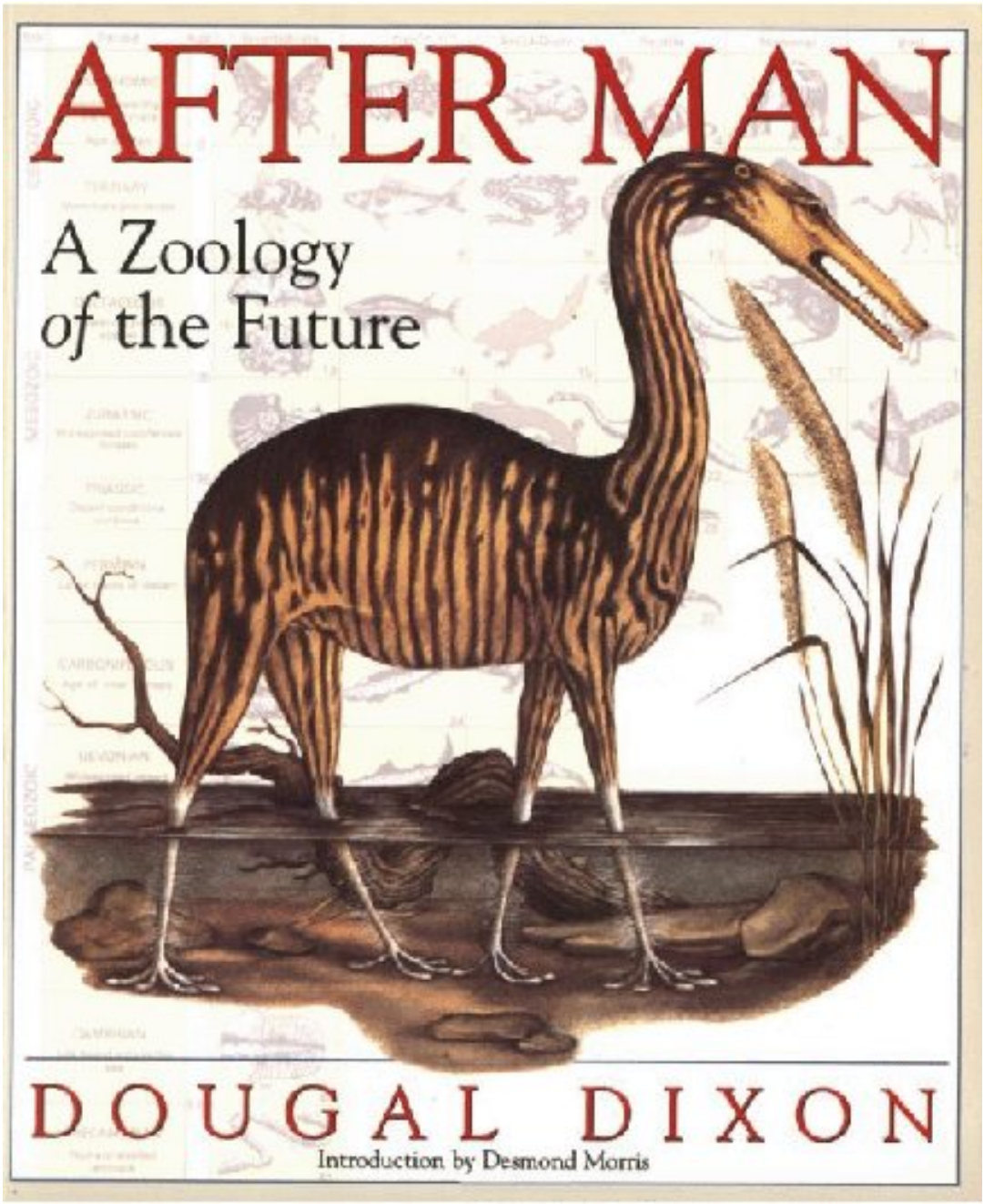
We all are out of Africa



10 Future evolution

10.1 Dougal Dixon and his “After Man” book

D. Dixon. After man. Zoology of the Future. 1981



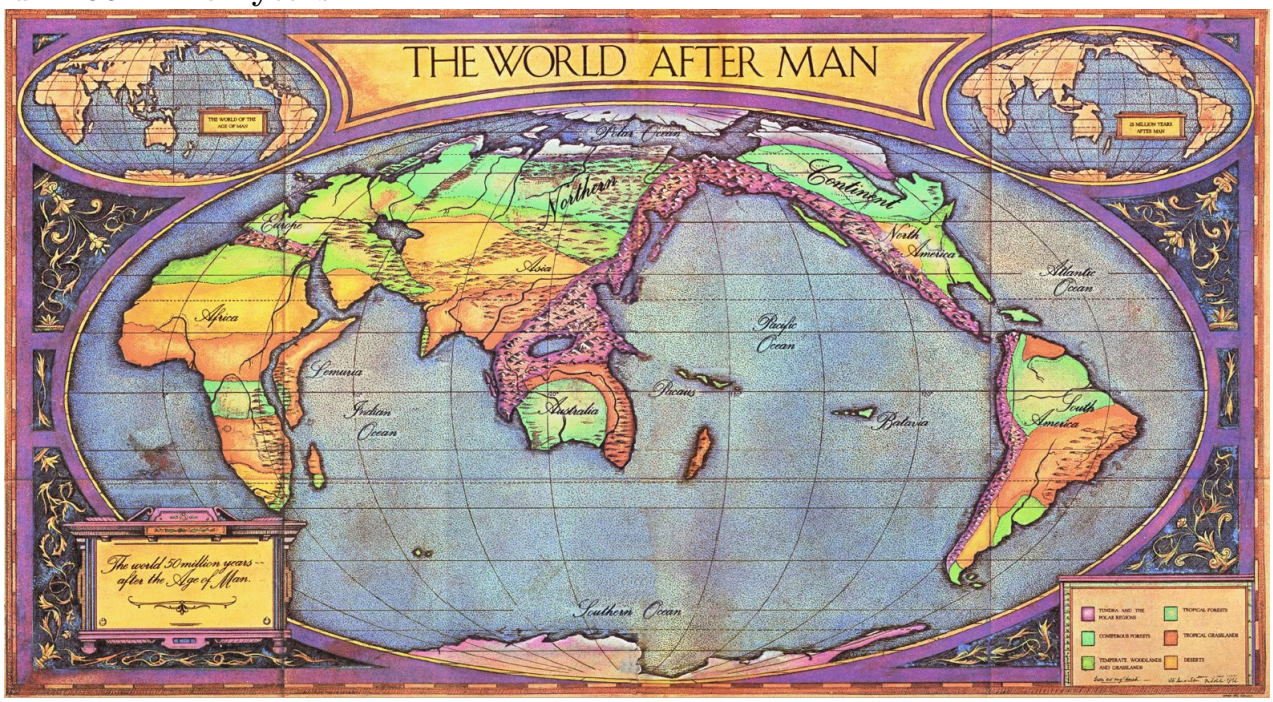
Two main assumptions

- No big mammals left: exterminated by humans
- Humans just disappeared from Earth

Some results

- Rodents and hares will radiate and fill niches of big hoofed mammals and their predators
- In many places, previously "neglected" groups will fill new ecological niches

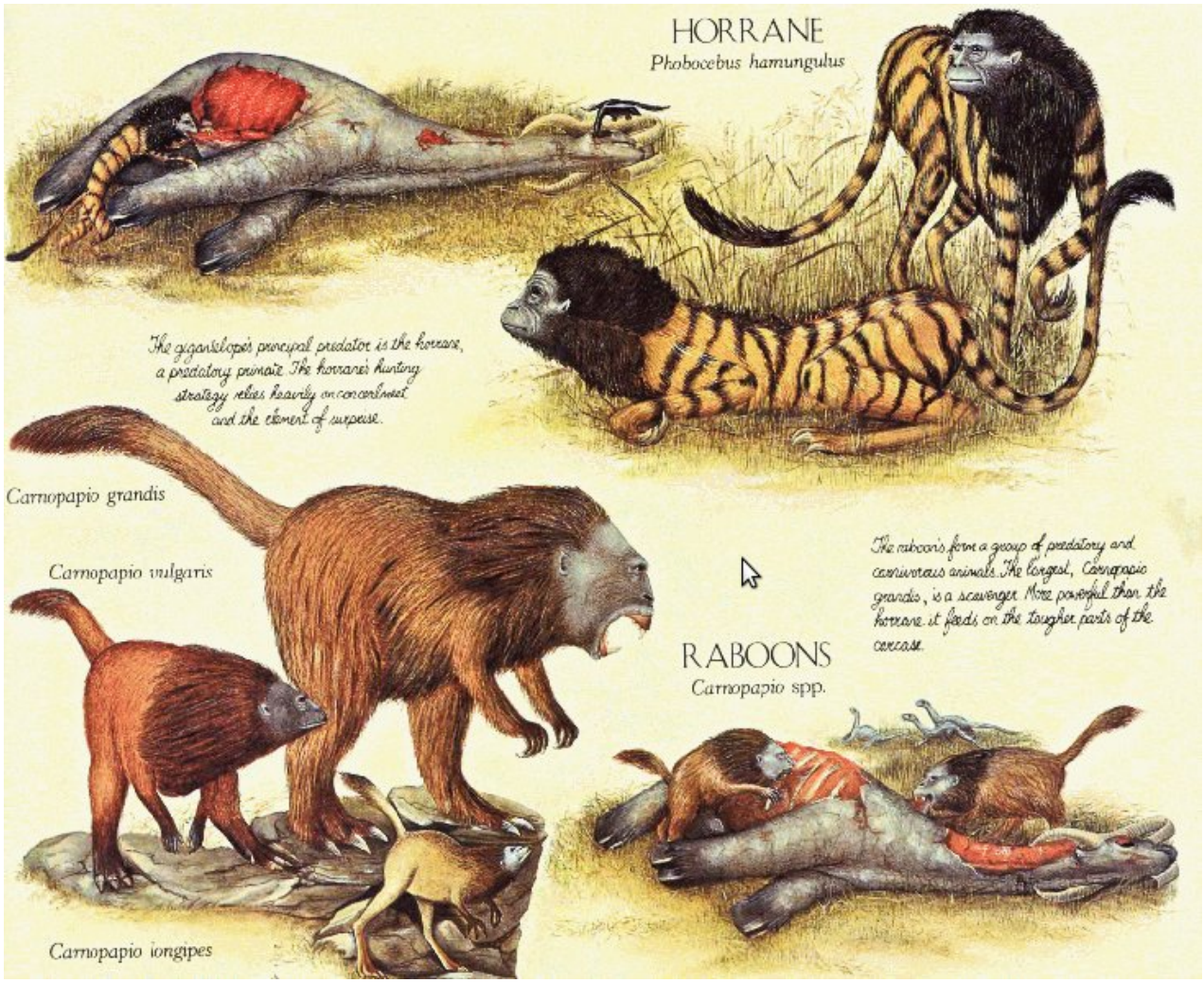
World in 50 million years



“Hoofed hares” and “wolf rats”

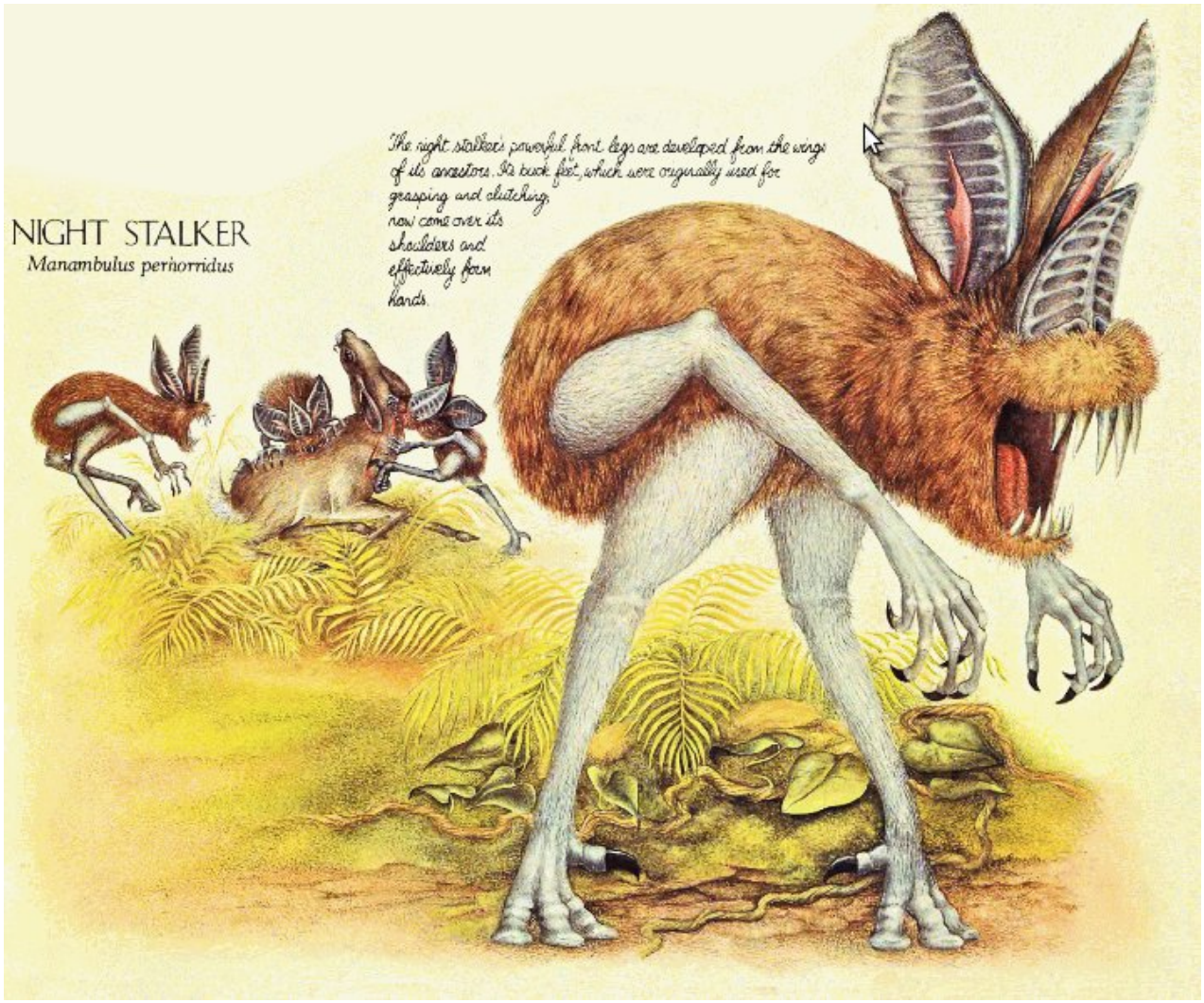
Tropical "monkey cat"

Carnivorous primates

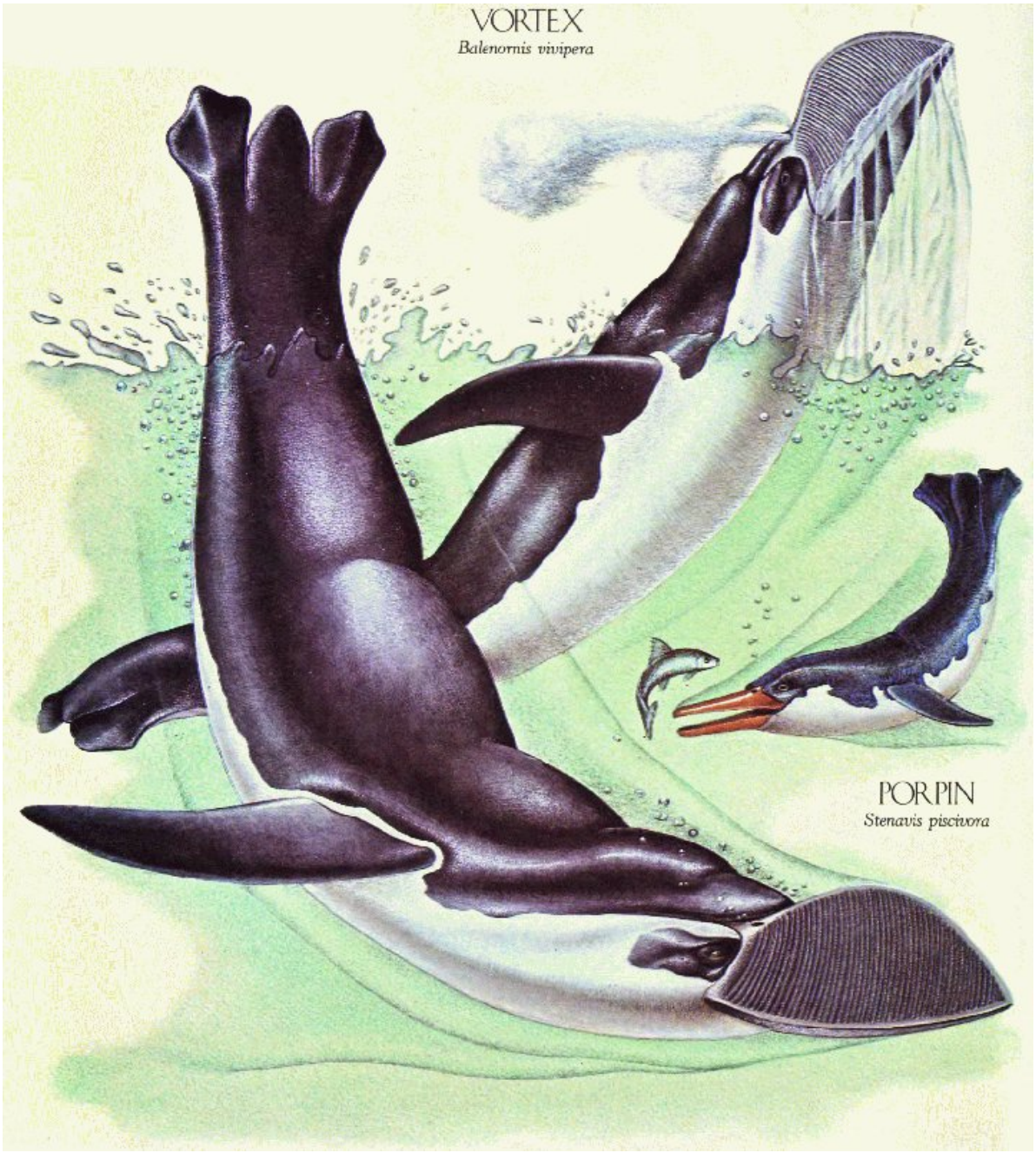


Mammal ectoparasite

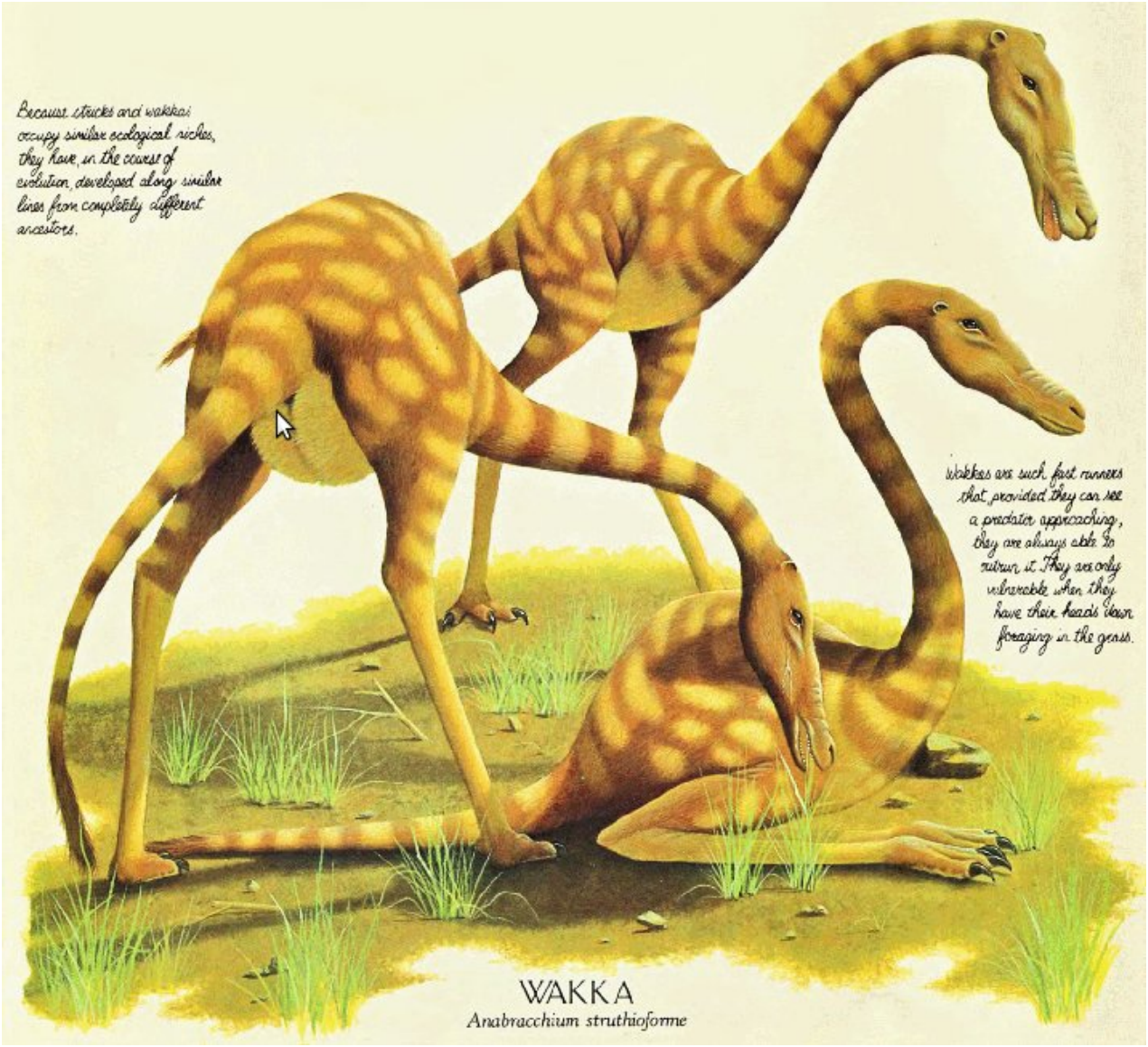
Oceanian terrestrial bats



Penguin whale



Bipedal mammal herbivore



Short anonymous absolutely voluntary survey

A. What do you **like** most in Biology 111?

B. What do you **dislike** most in Biology 111?

C. **Which lab** do you remember most of all?

D. Please grade (1—bad, 5—excellent):

   (a) Lectures
   (b) Labs
   (c) Exams

E. **How** to improve textbook?

For Further Reading

References

[1] Great American Interchange. http://en.wikipedia.org/wiki/Great_American_Interchange

[2] Ecogeography. http://en.wikipedia.org/wiki/Biome

[3] Human evolution. http://en.wikipedia.org/wiki/Human_evolution

[4] Homo. http://en.wikipedia.org/wiki/Homo

[5] D. Dixon. After man. Zoology of the Future. http://www.sivatherium.narod.ru/library/Dixon/main_en.htm

11 Movies

- (voluntary) BBC: Walking with dinosaurs, https://en.wikipedia.org/wiki/Walking_with_Dinosaurs
  - New blood
  - Time of titans, first half
- BBC: Walking with beasts, https://en.wikipedia.org/wiki/Walking_with_Beasts
  - New dawn
  - Next of kin, second half