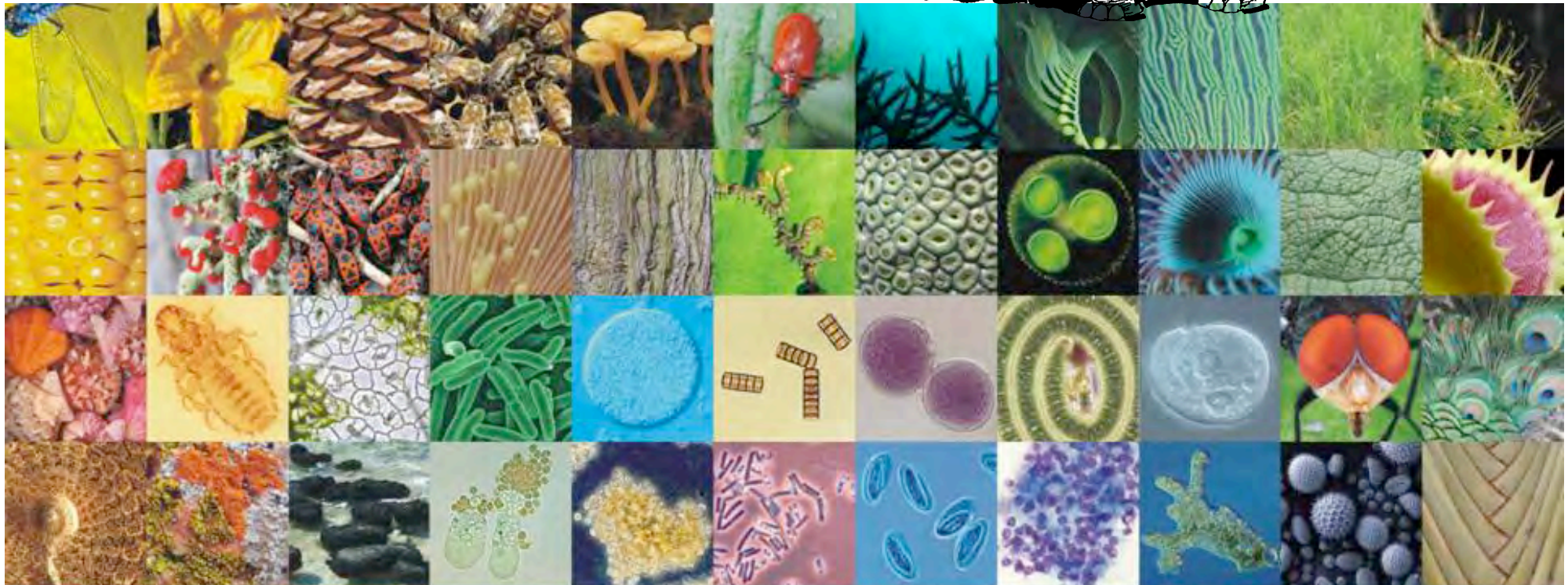
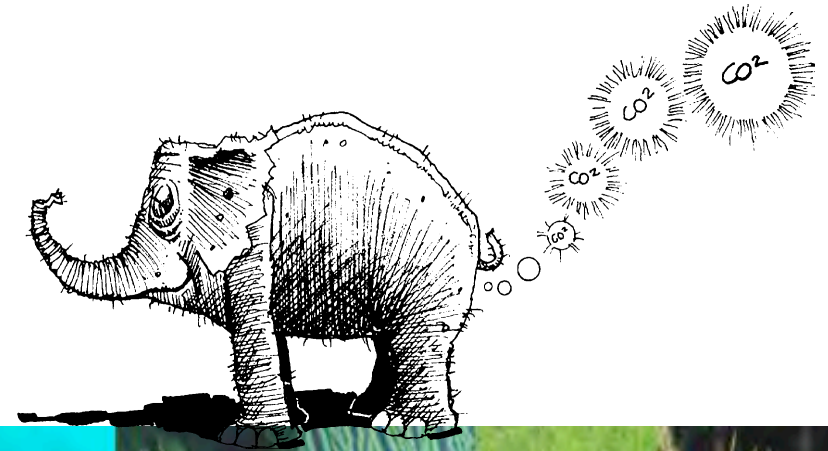
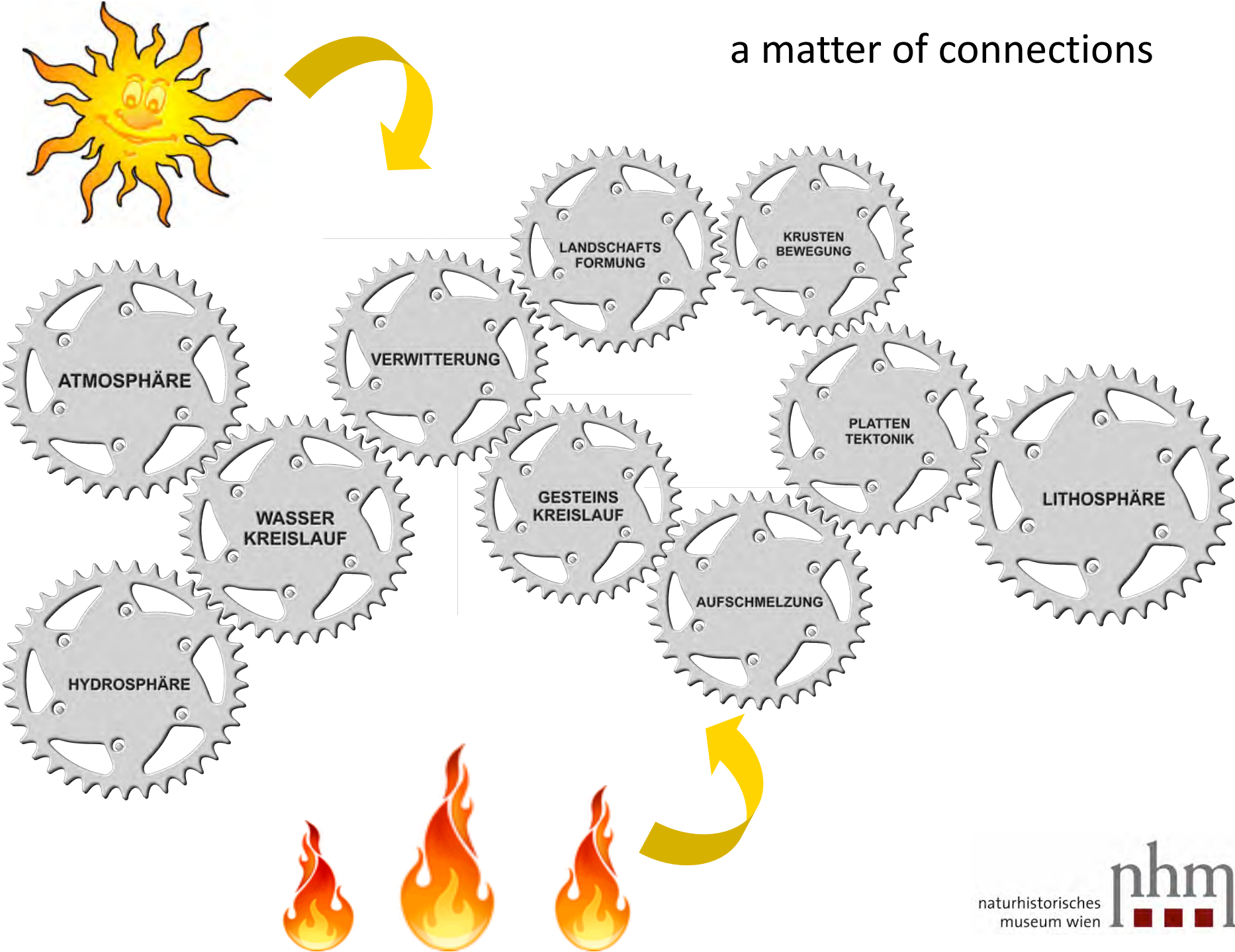


Evolution – the geological point of view

Mathias Harzhauser



a matter of connections





the earth as system: 1. lithosphere



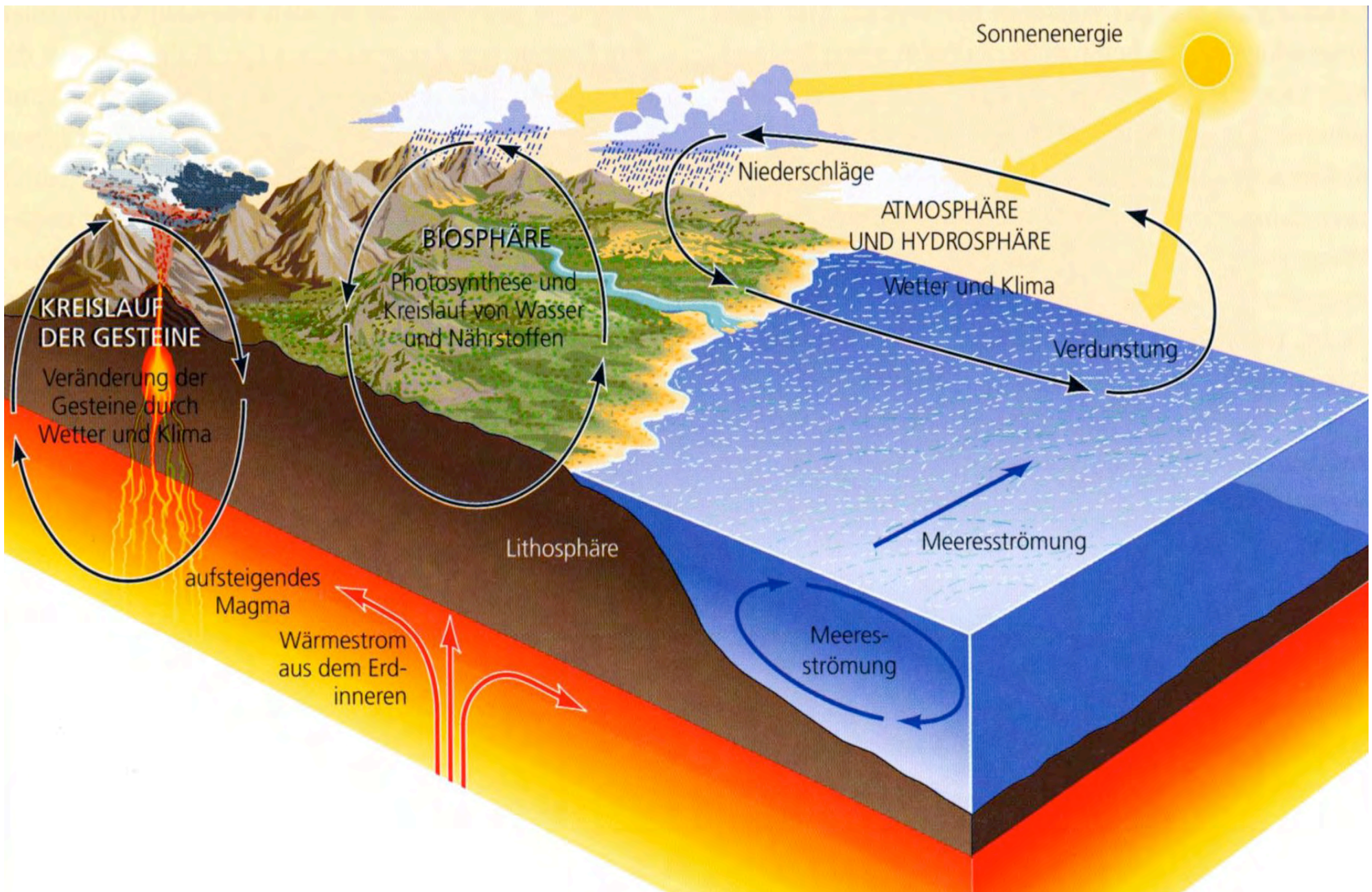
the earth as system: 2. atmosphere



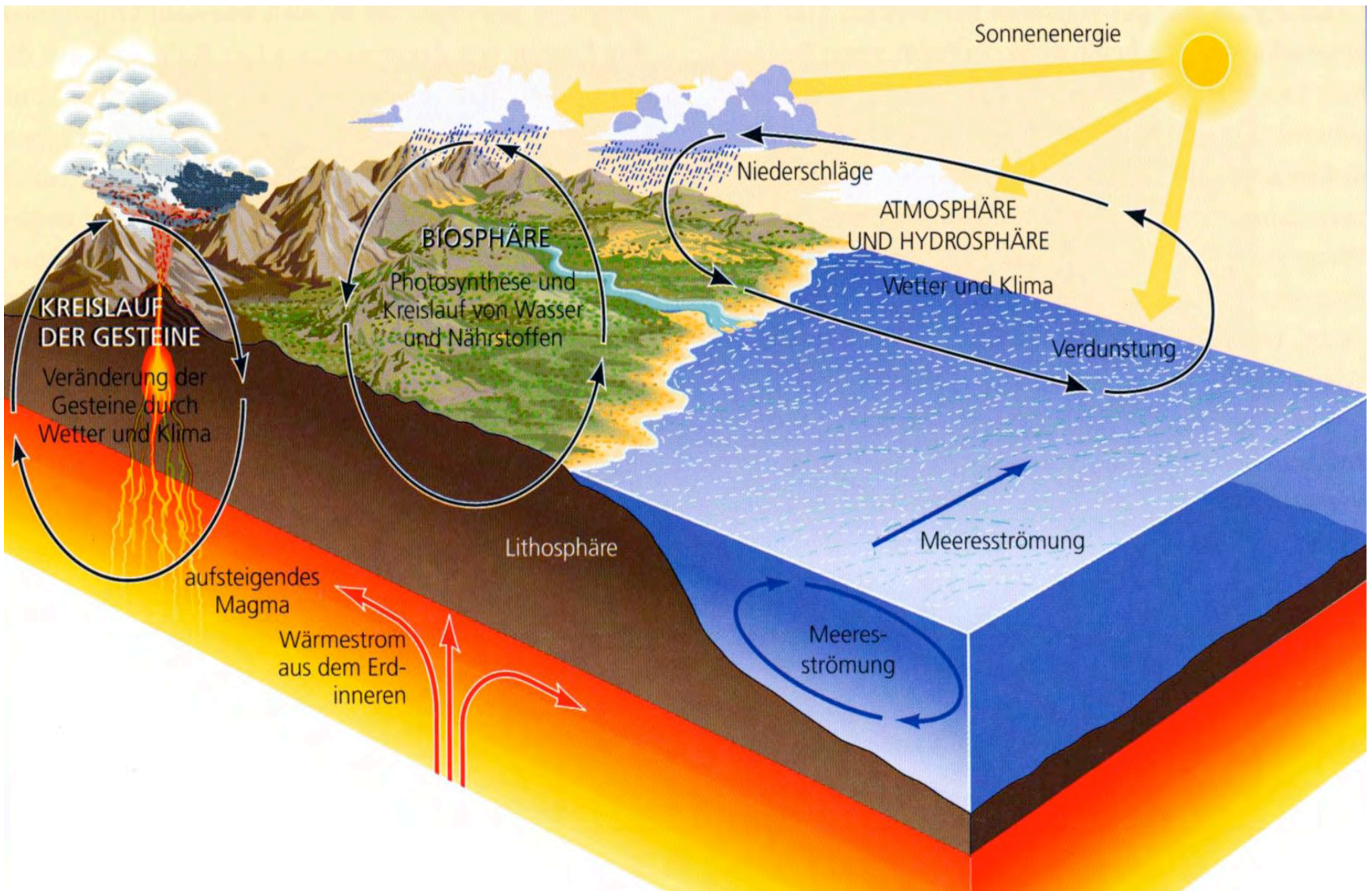
the earth as system: 3. hydrosphere



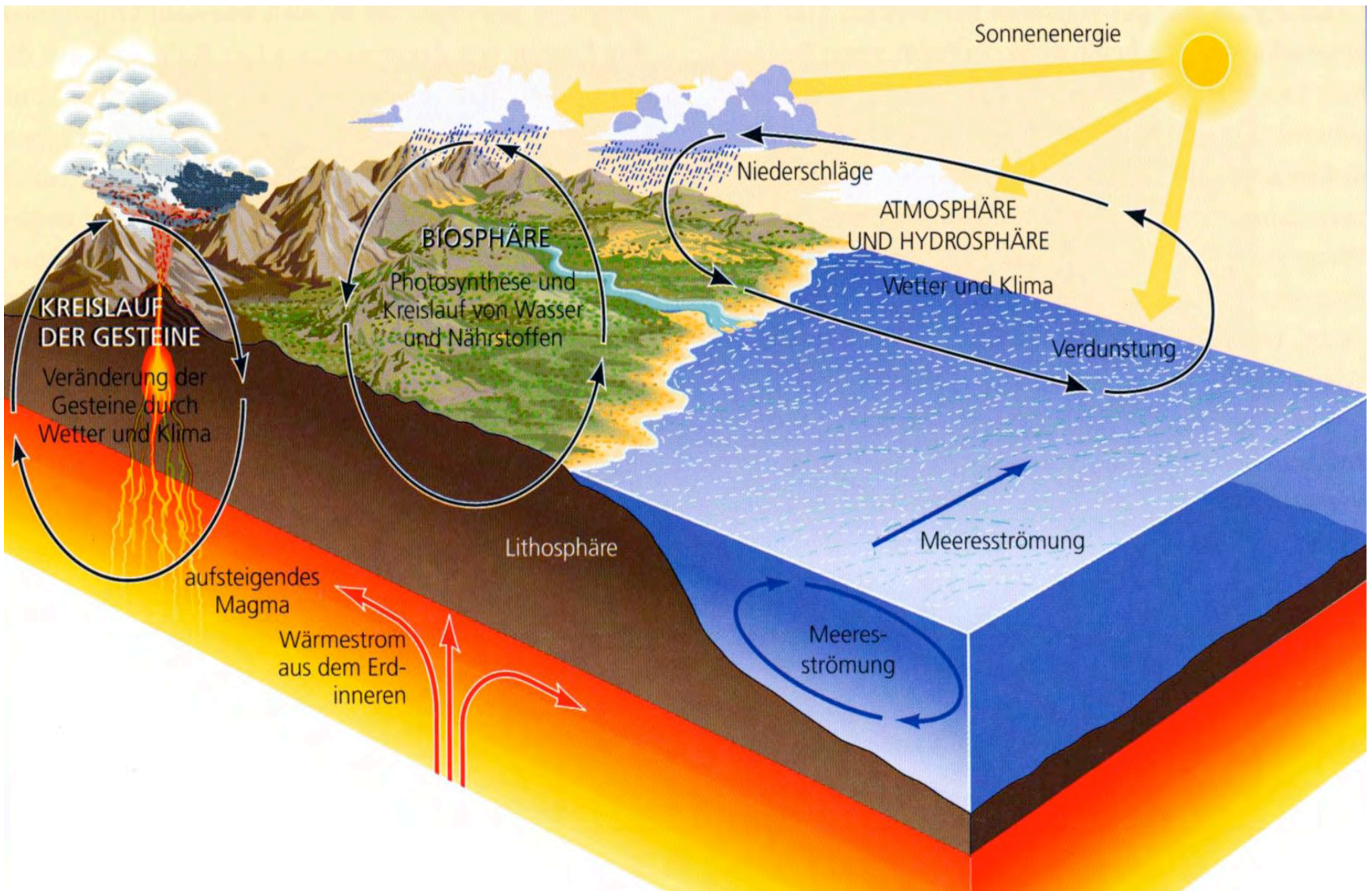
the earth as system: 4. biosphere



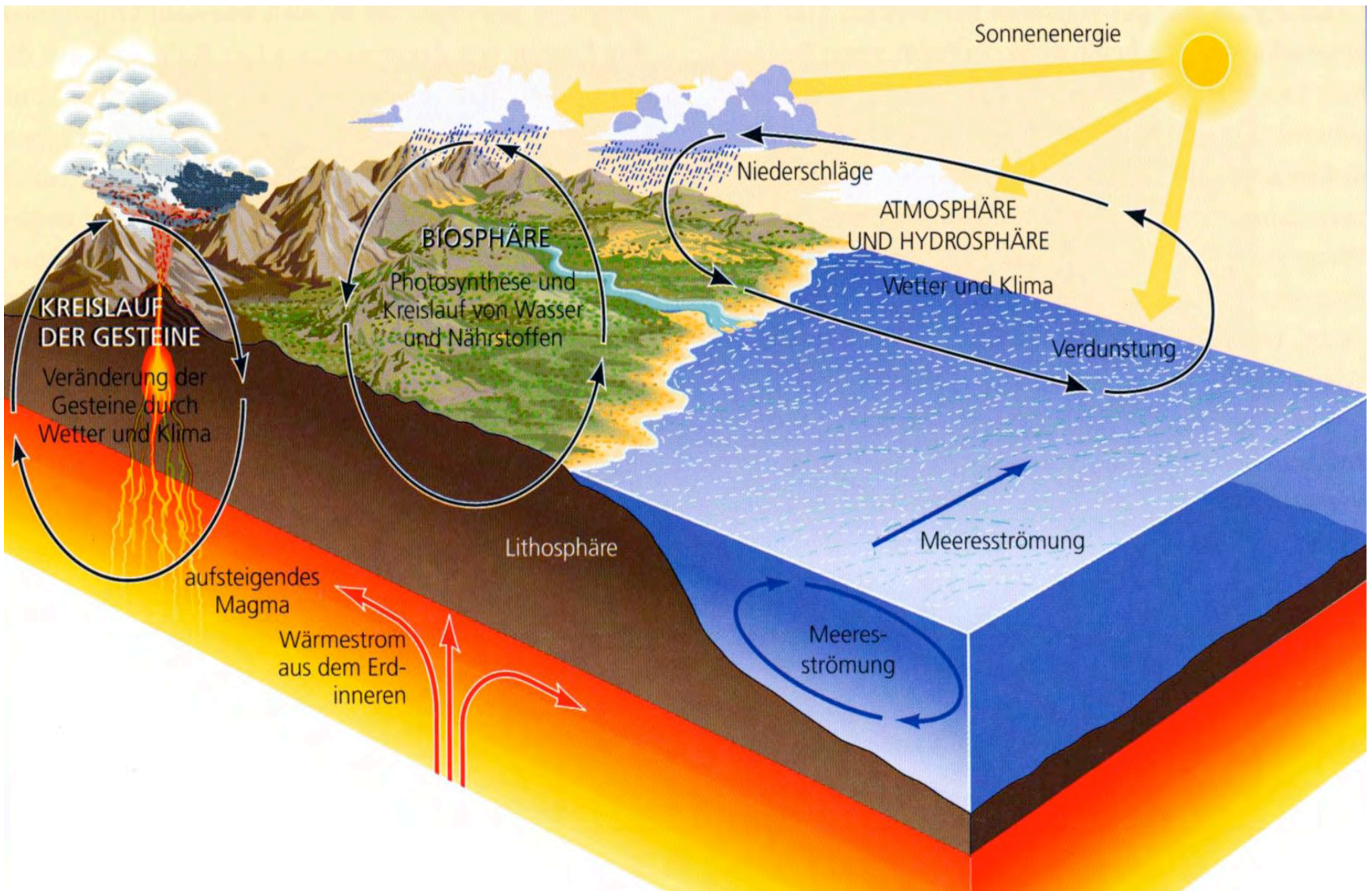
storage periods



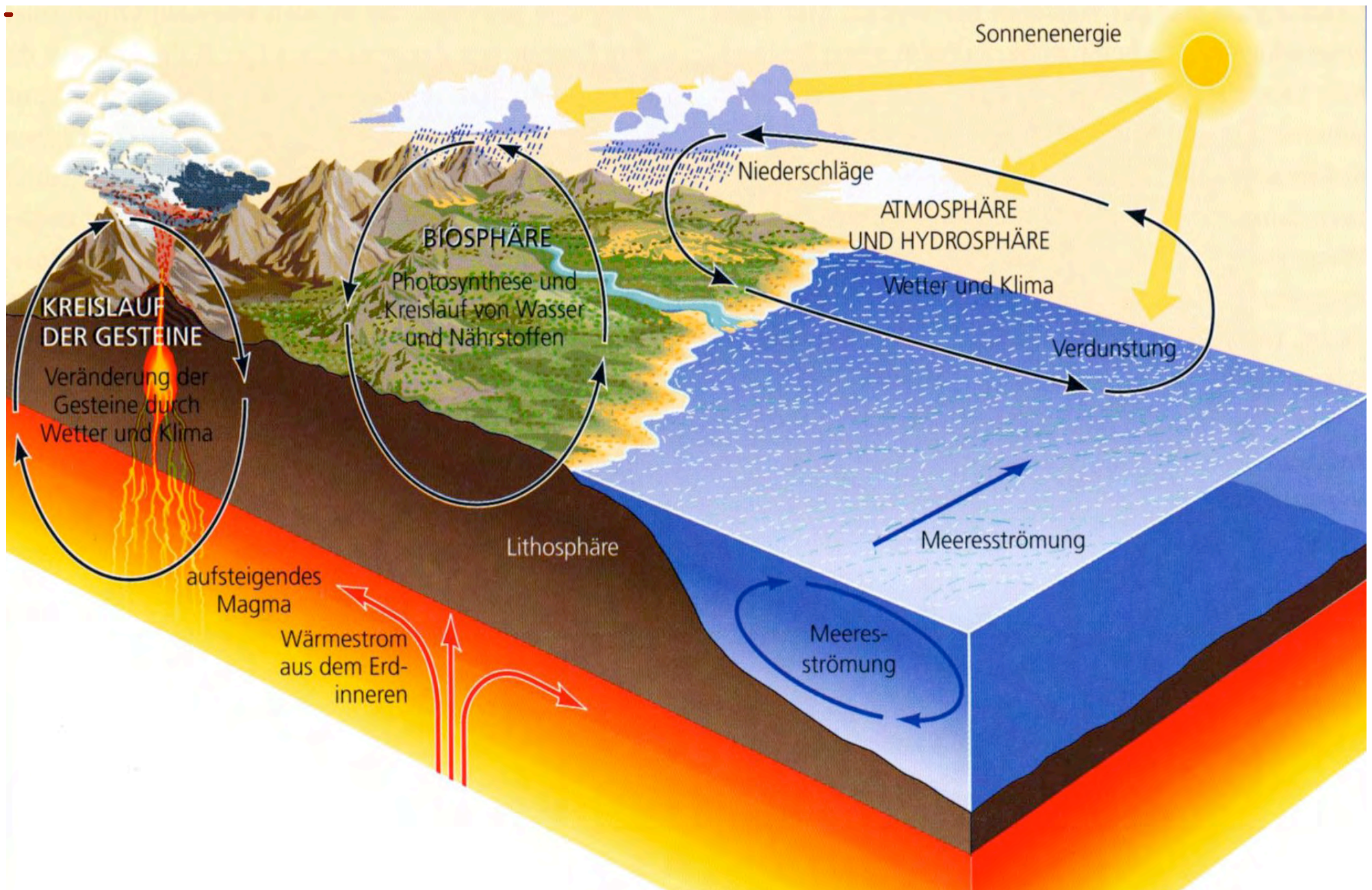
atmosphere: hours and days



biosphere: up to 100 years

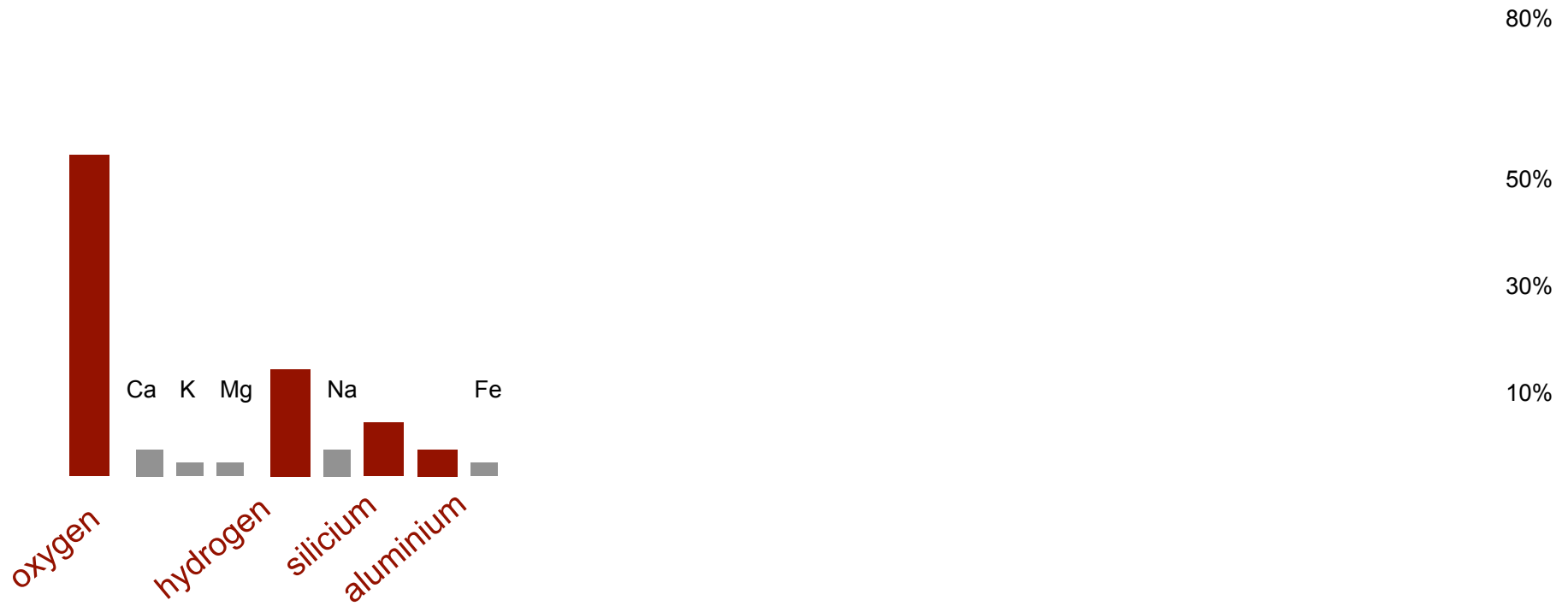


hydrosphere: up to 2000 years



lithosphere: ~ 200 million years and more

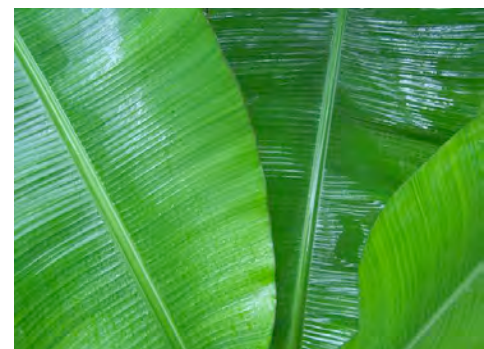
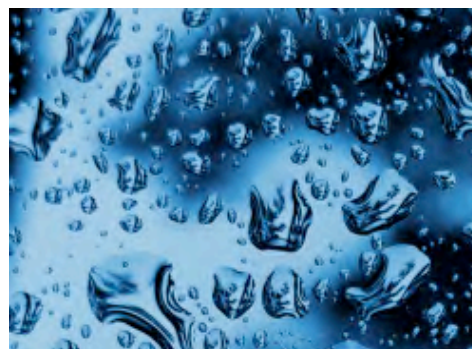
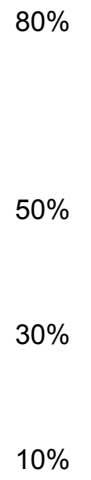
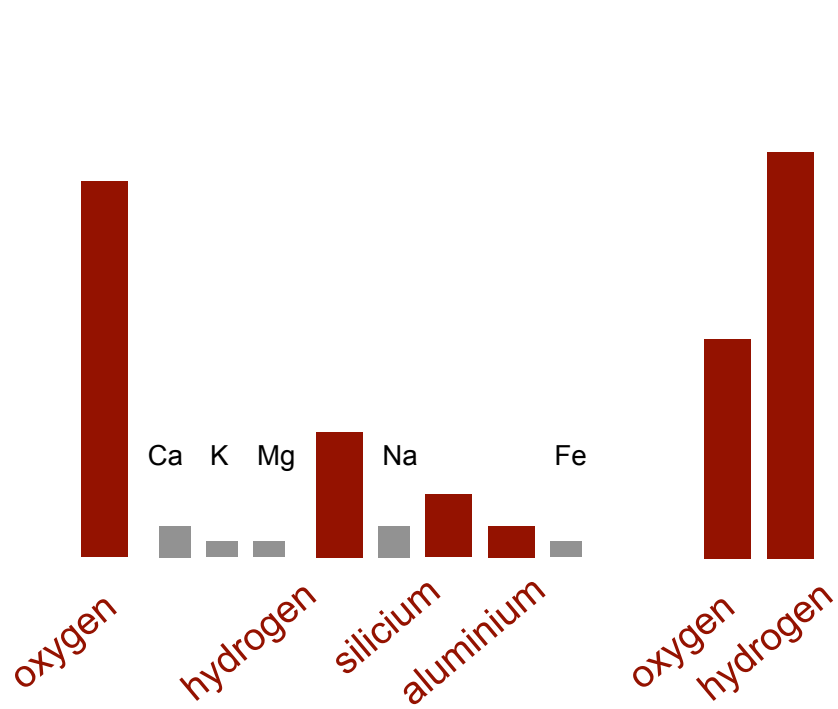
lithosphere



the reservoirs

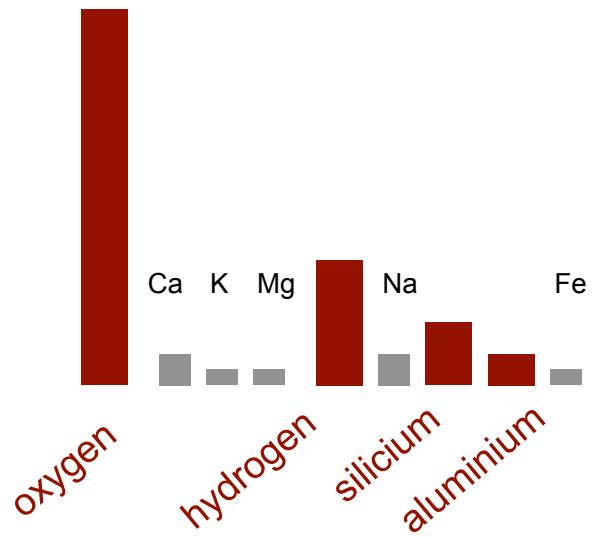
lithosphere

hydrosphere

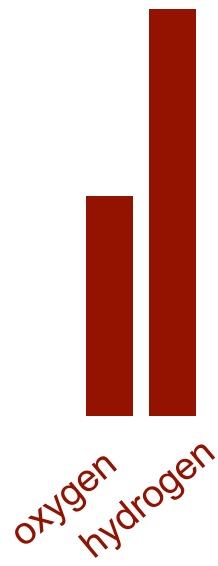


the reservoirs

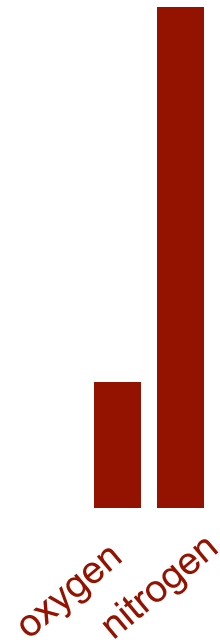
lithosphere



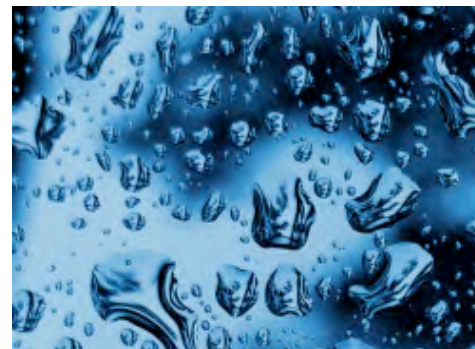
hydrosphere



atmosphere

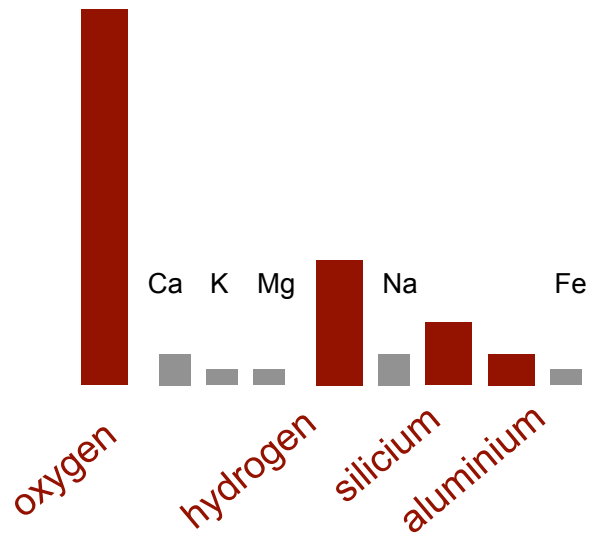


80%
50%
30%
10%

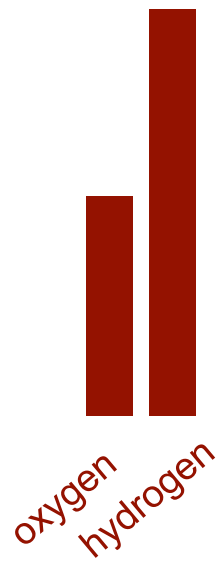


the reservoirs

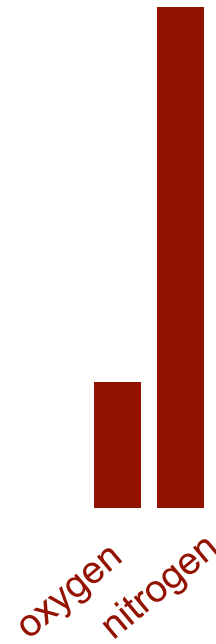
lithosphere



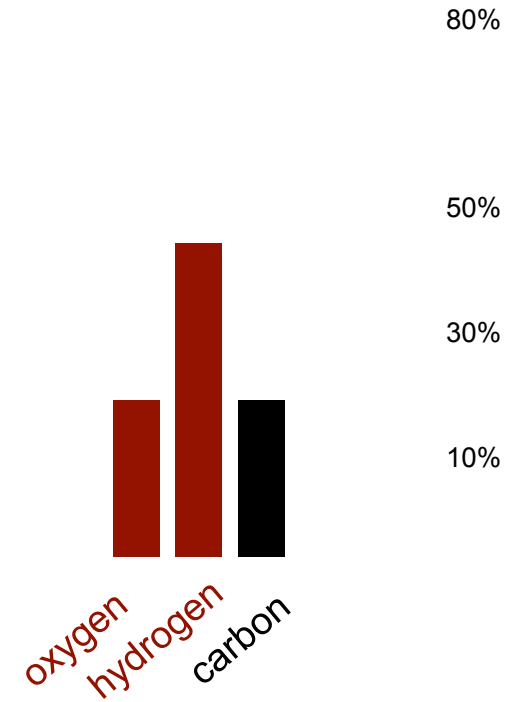
hydrosphere



atmosphere

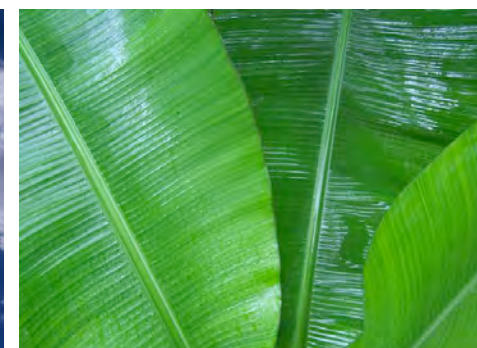


biosphere

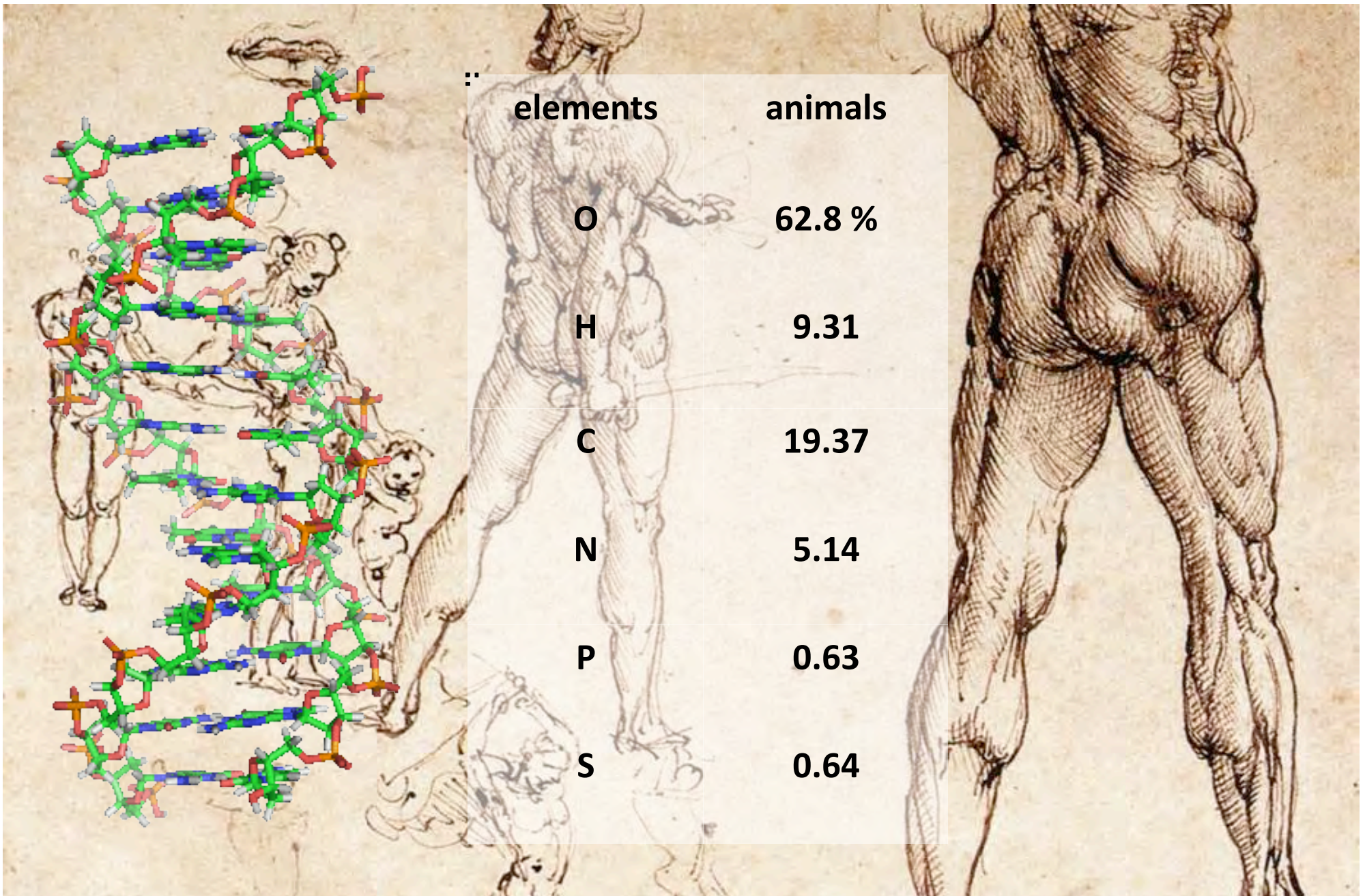


the reservoirs

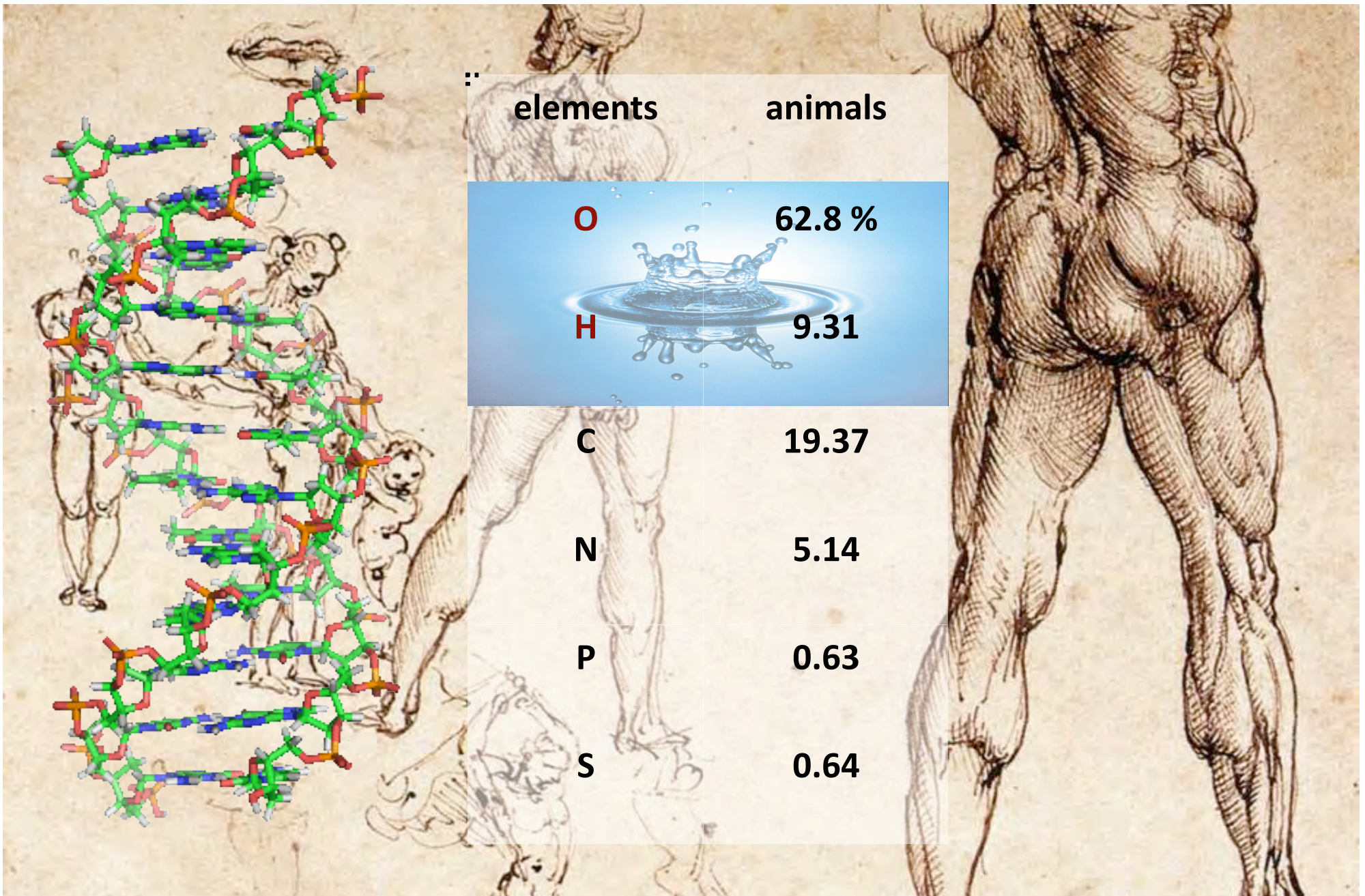
?



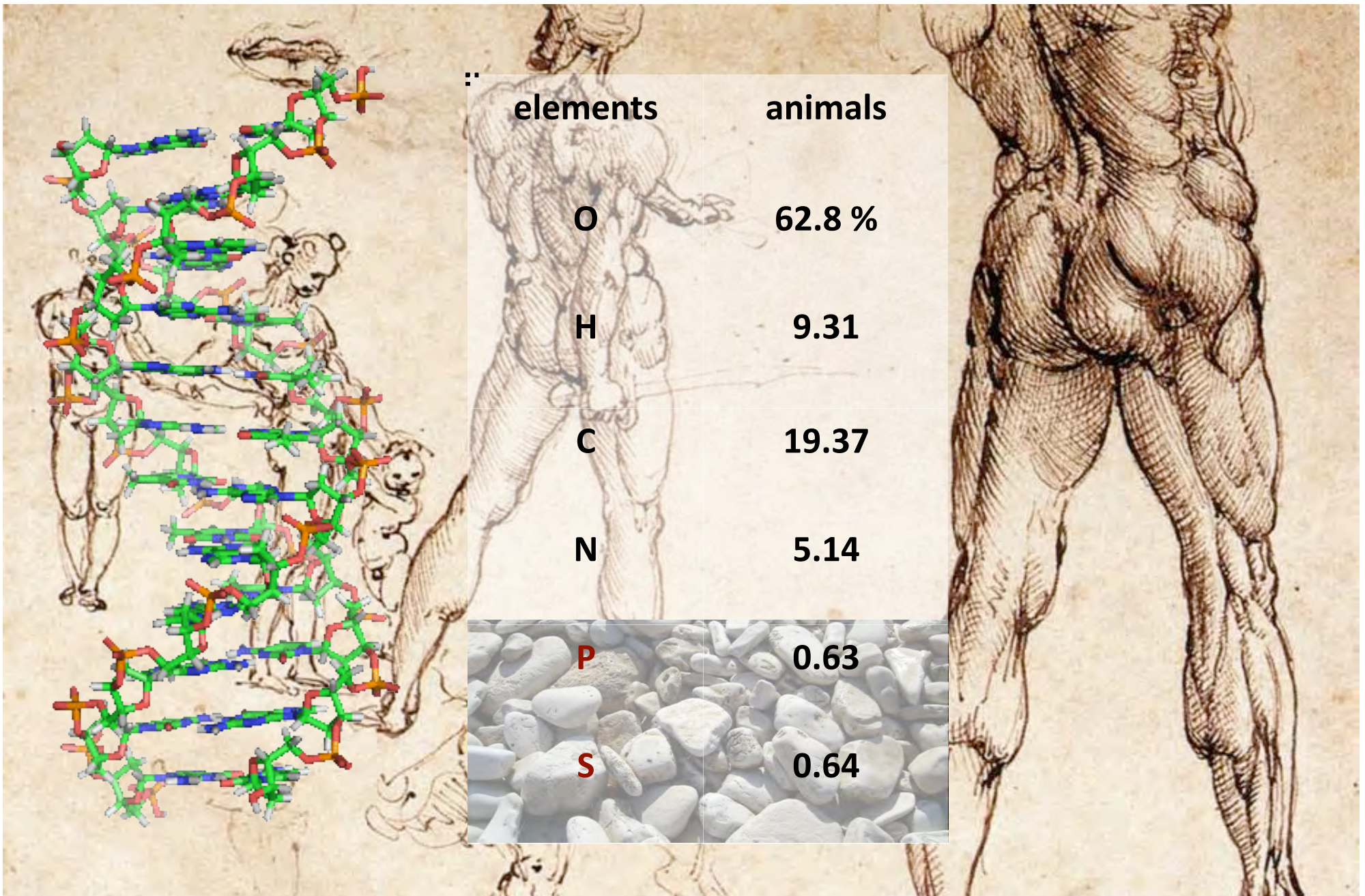
what/when/how



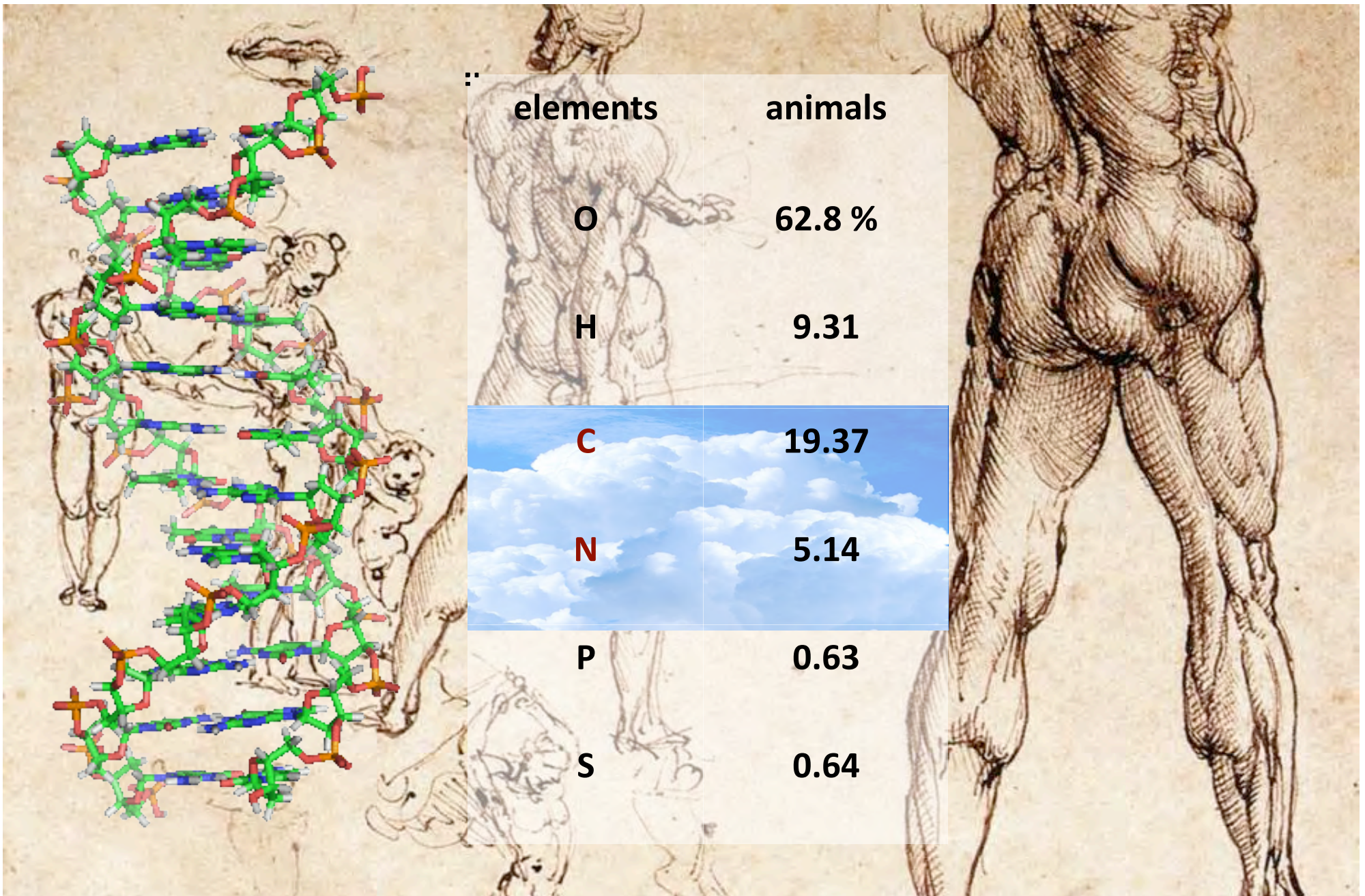
elements of life



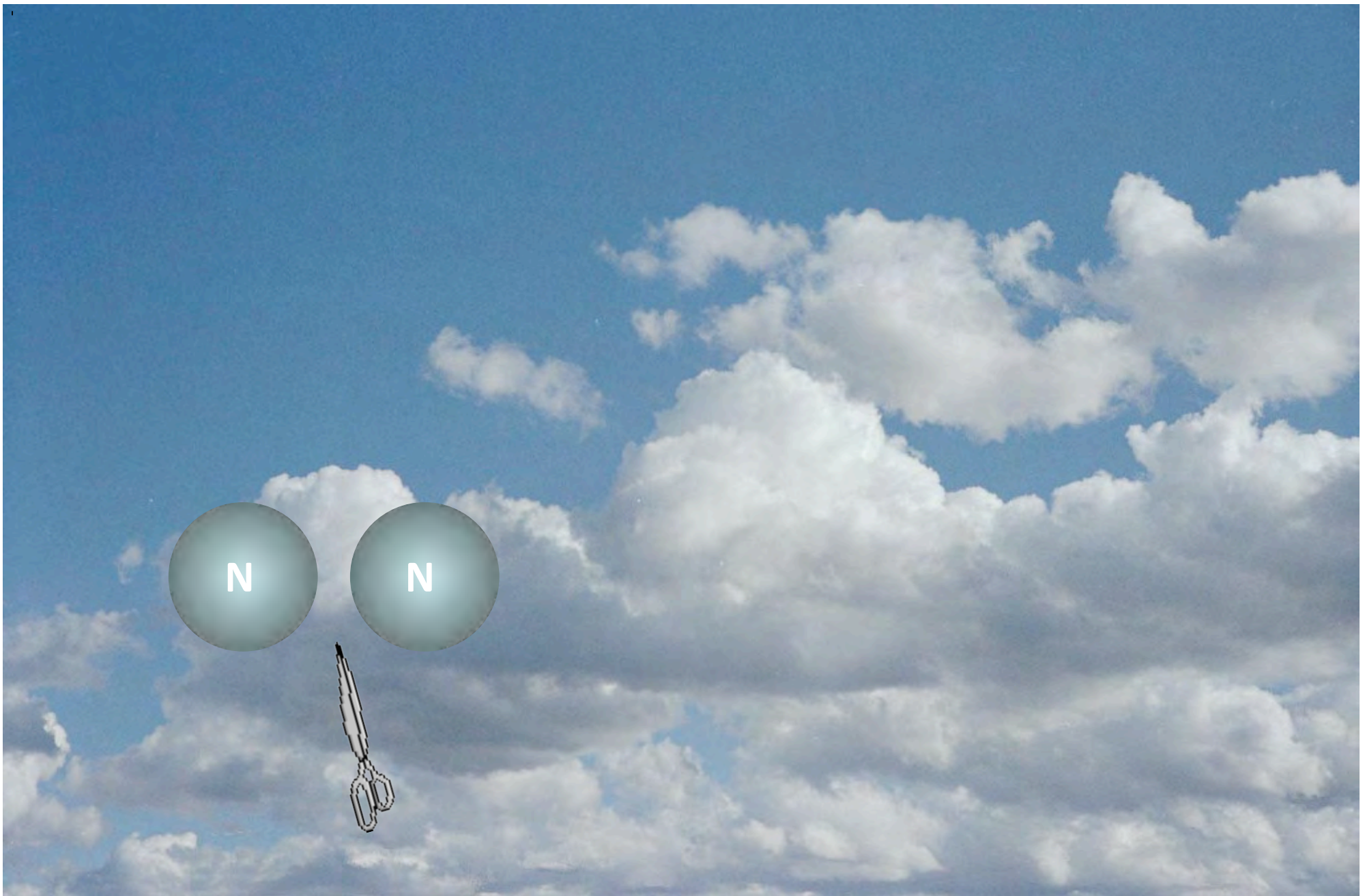
elements of life



elements of life



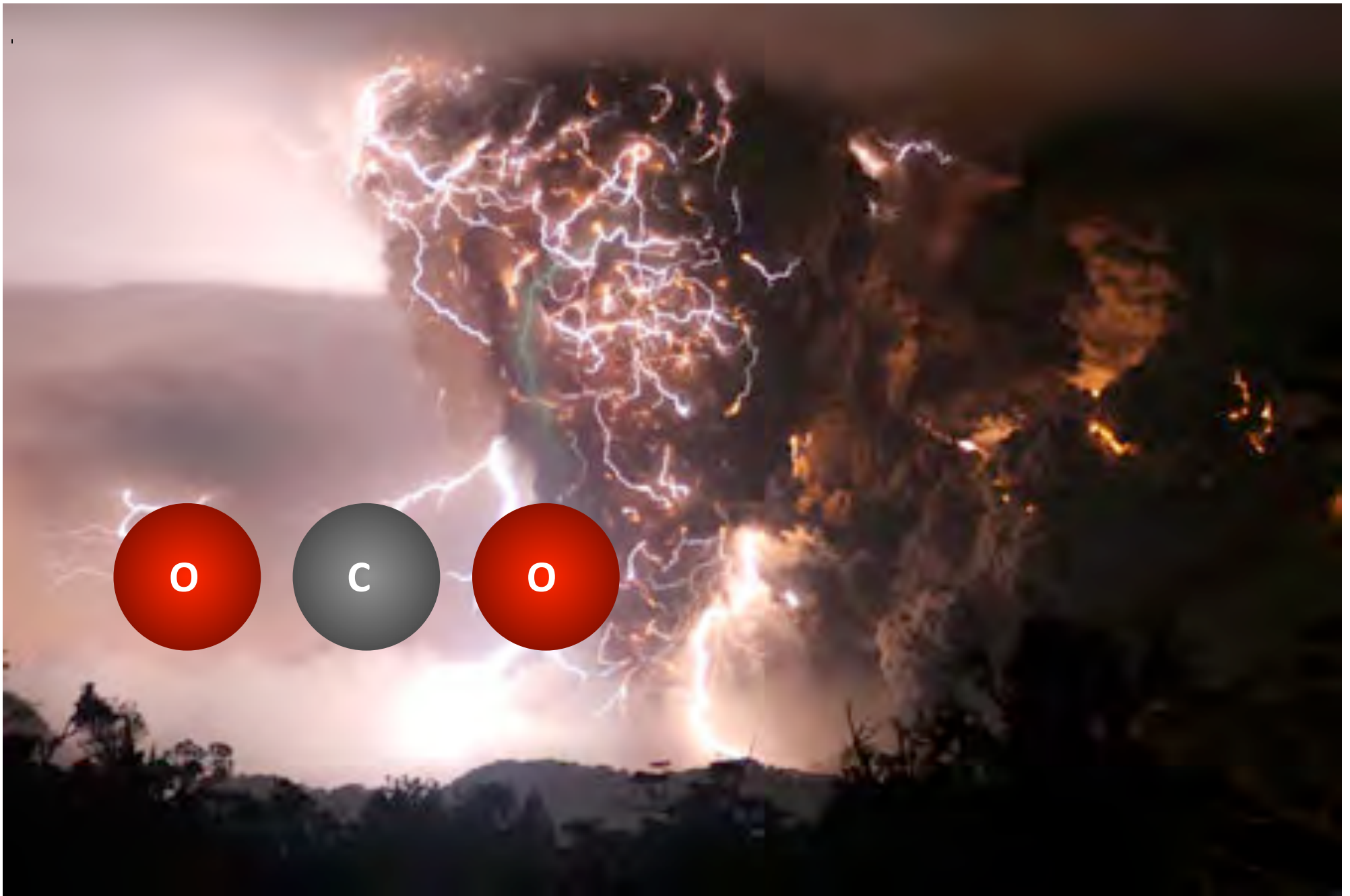
elements of life



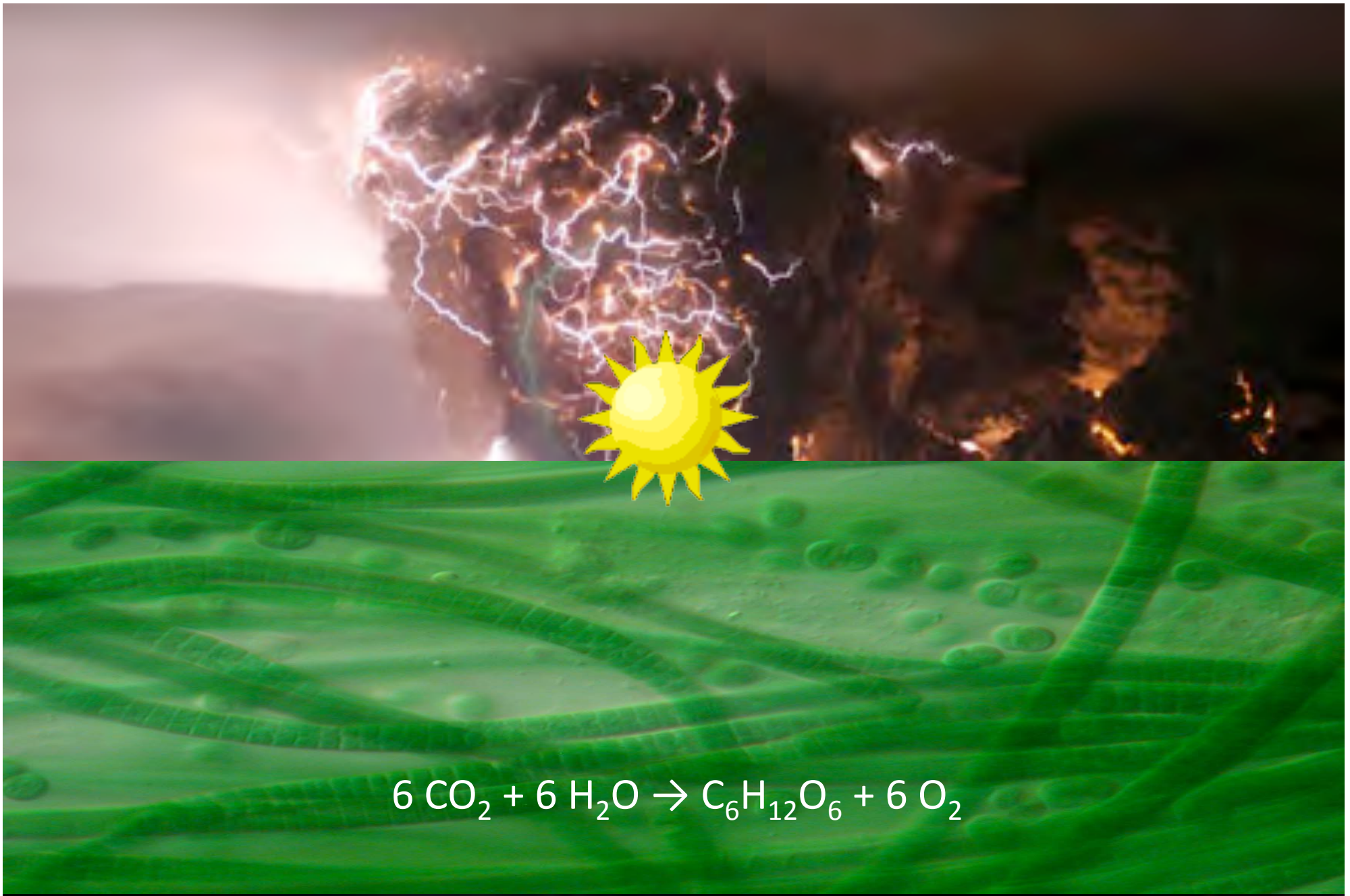
nitrogene: 78% in atmosphere – molecular triple bond



lightning cracks N_2 (*no lightning = no life*)



volcanogenic CO₂



origin of photosynthesis!

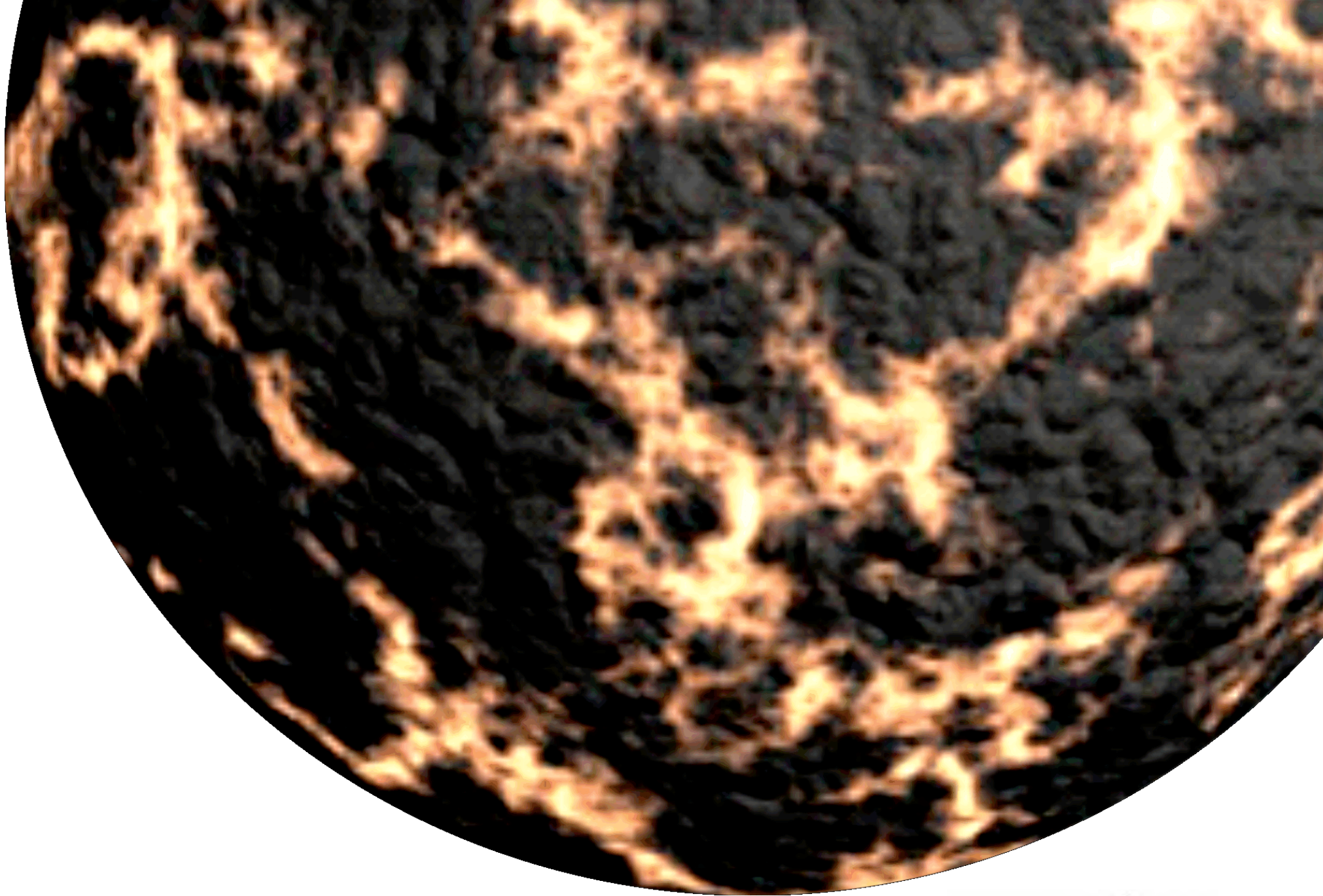


this needs atmosphere, water and weathering!

a step back...



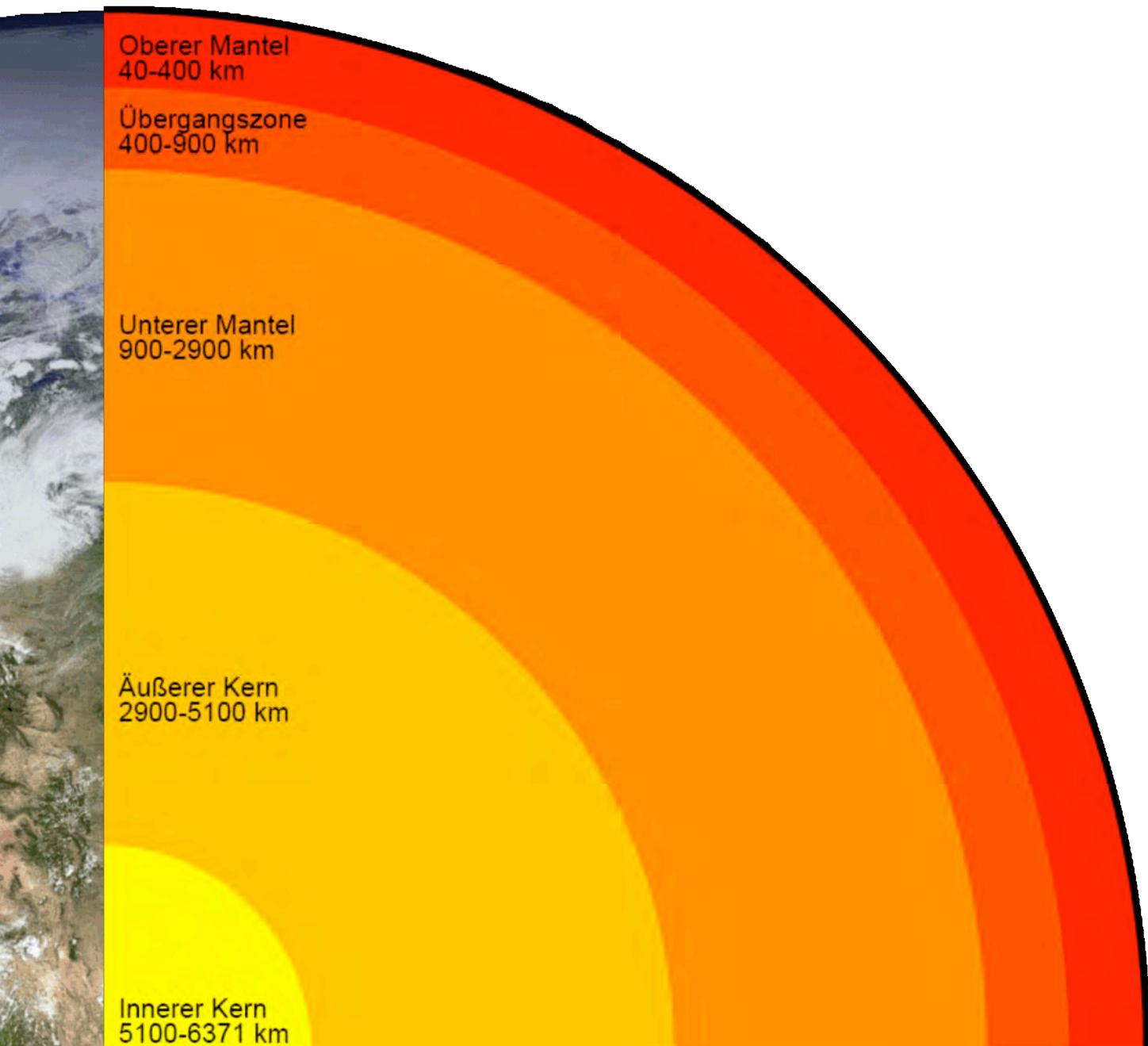
the timing: birth of solar system, 4.6 billion years



the timing: formation of earth, 4.6 billion years



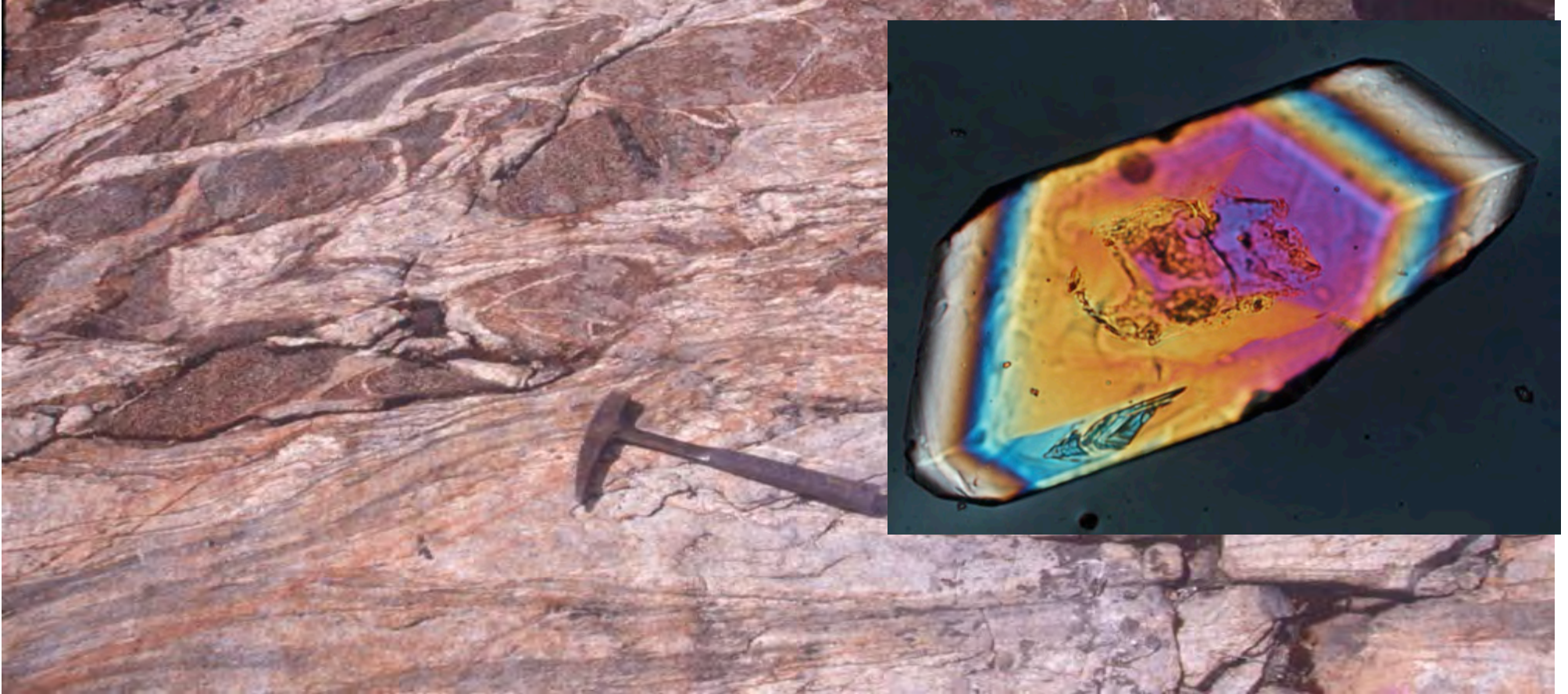
the timing: big impact – Theia, 4.527 billion years



the timing: separation of crust and core



the timing: liquid water, 4.2 billion years



oldest zircons (= weathered sand): 4,4 billion years



the timing: weathering brings salt into the ocean



car

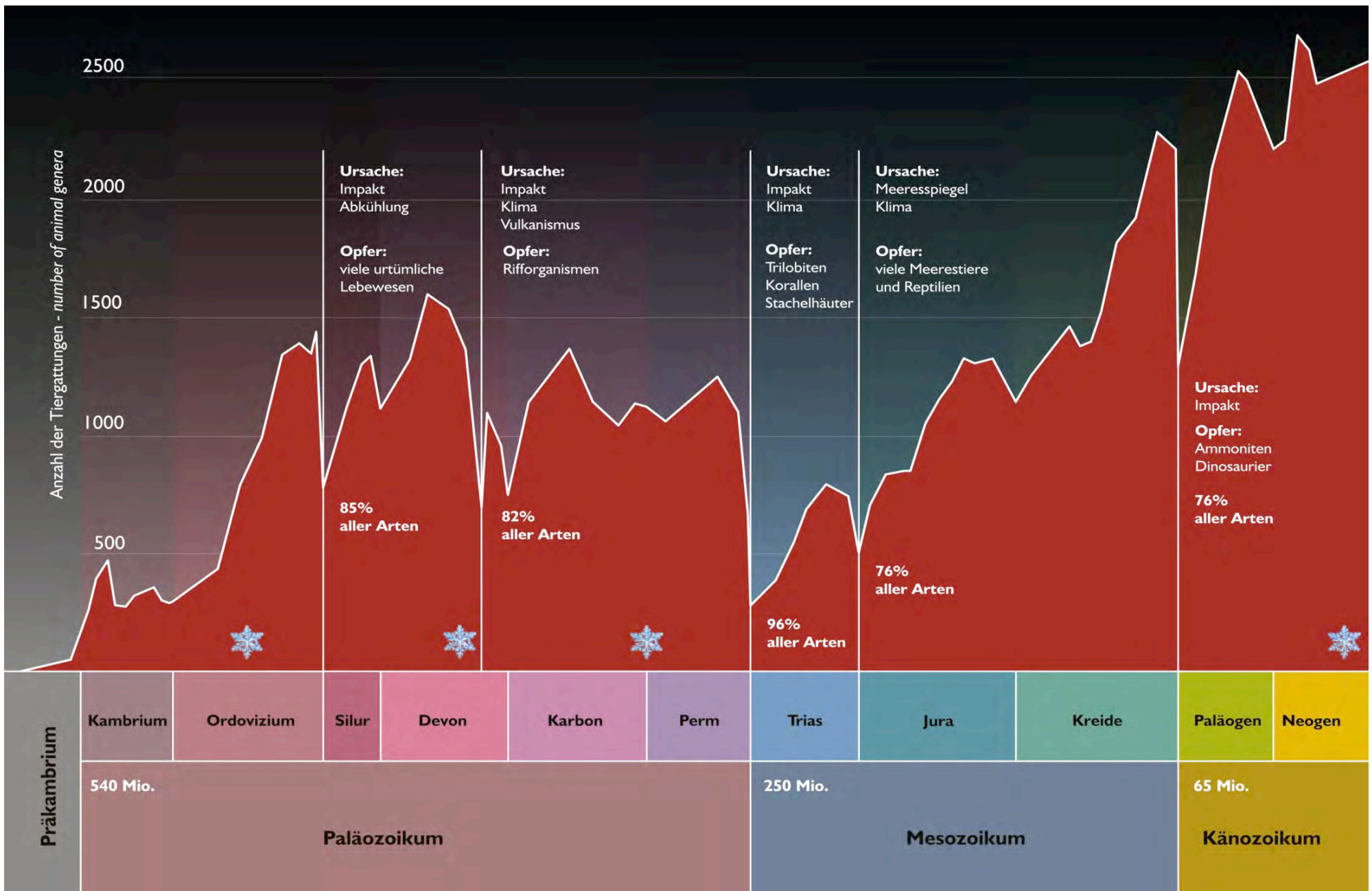
early atmosphere



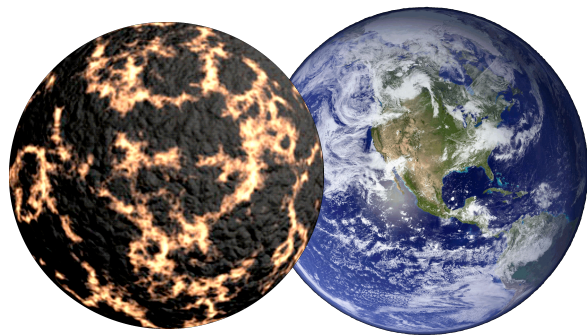
30% lower luminosity

methane: greenhouse gas

the origin of biodiversity

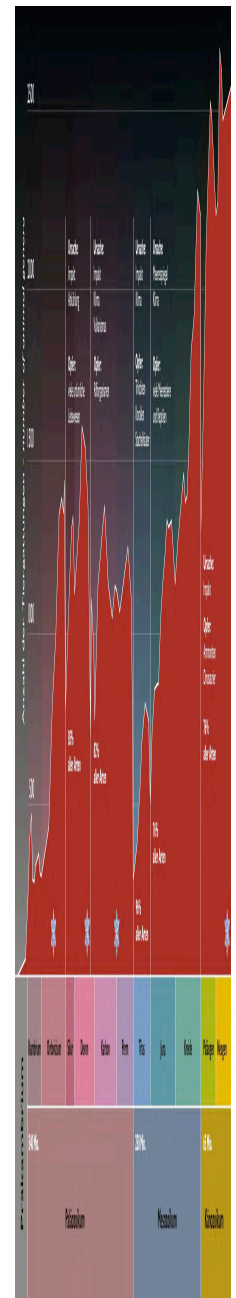


the origin of biodiversity



4.6 billion years

the origin of biodiversity

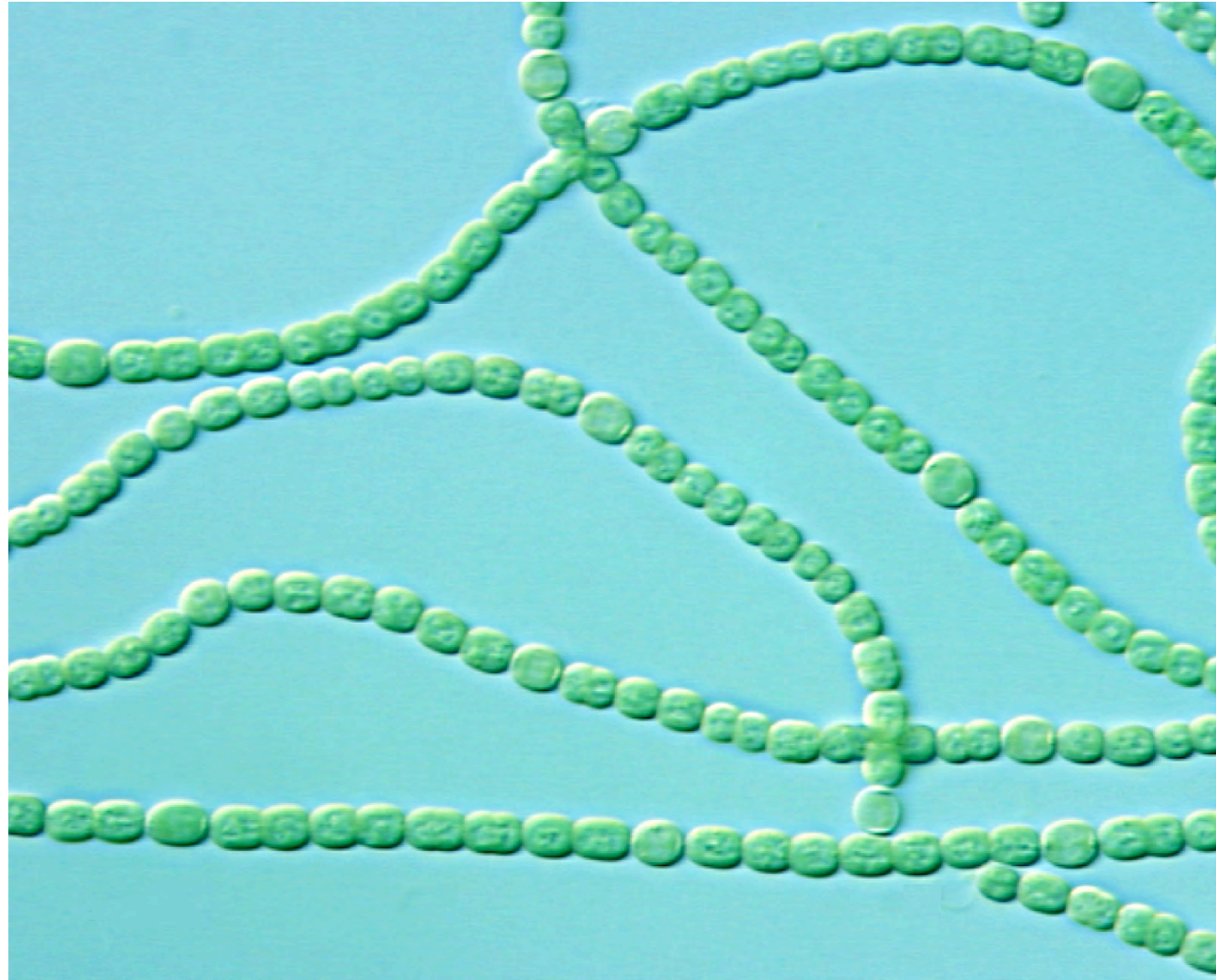




the origin of biodiversity



geochemical indications: 3,8 billion years



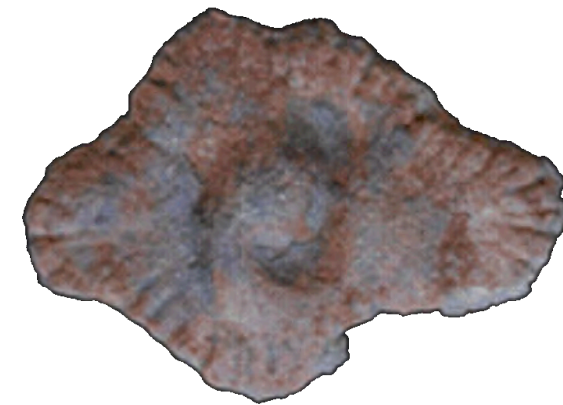
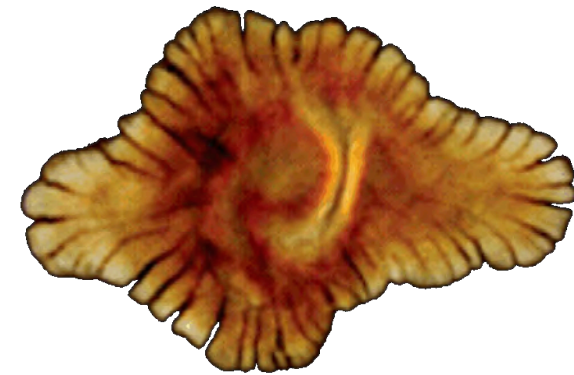
oldest fossils: prokaryotes: 3.5



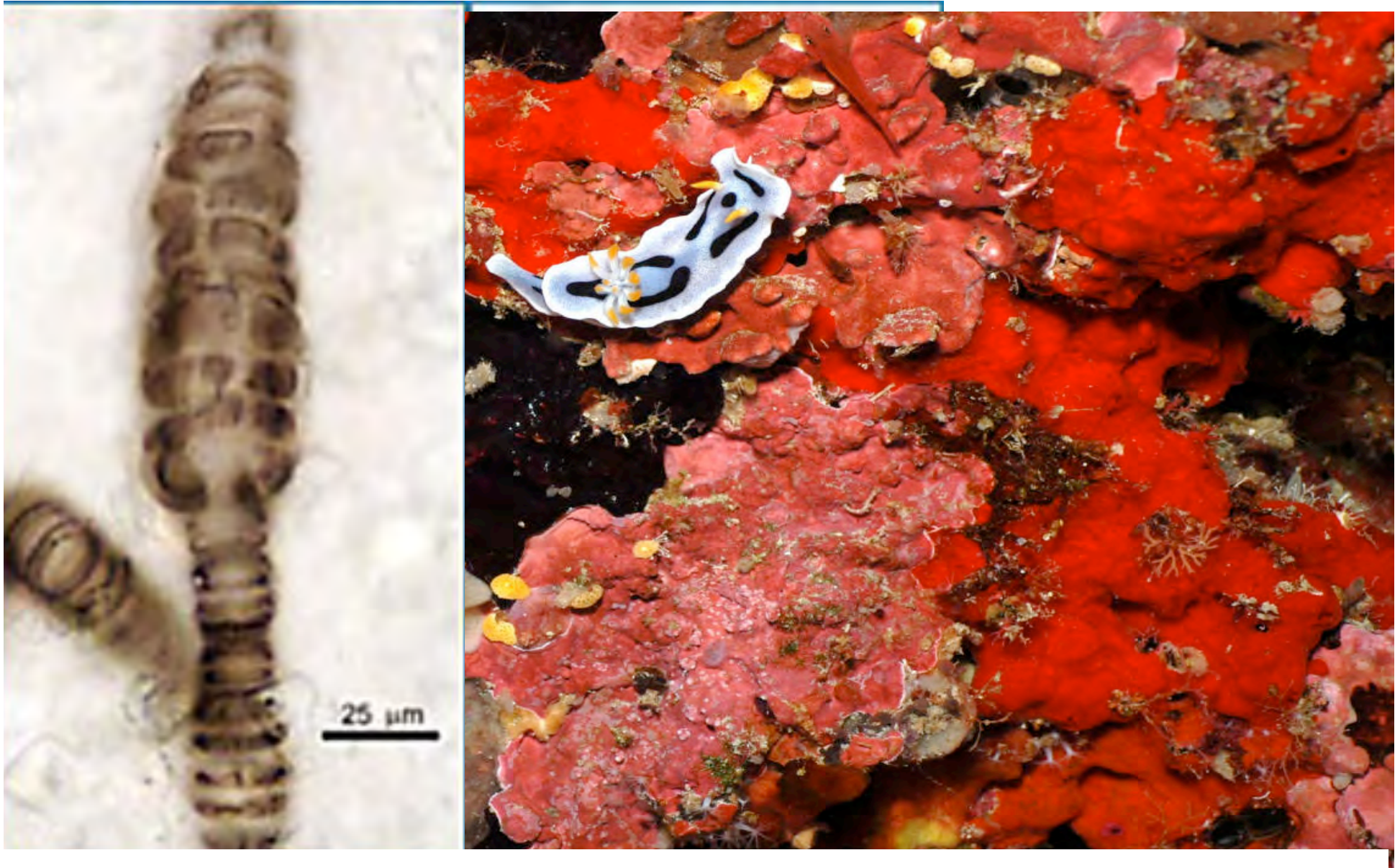
photosynthesis at least 2.5 b.y. old (probably older)



great oxidation event: 2.4- 2.3 b.y.

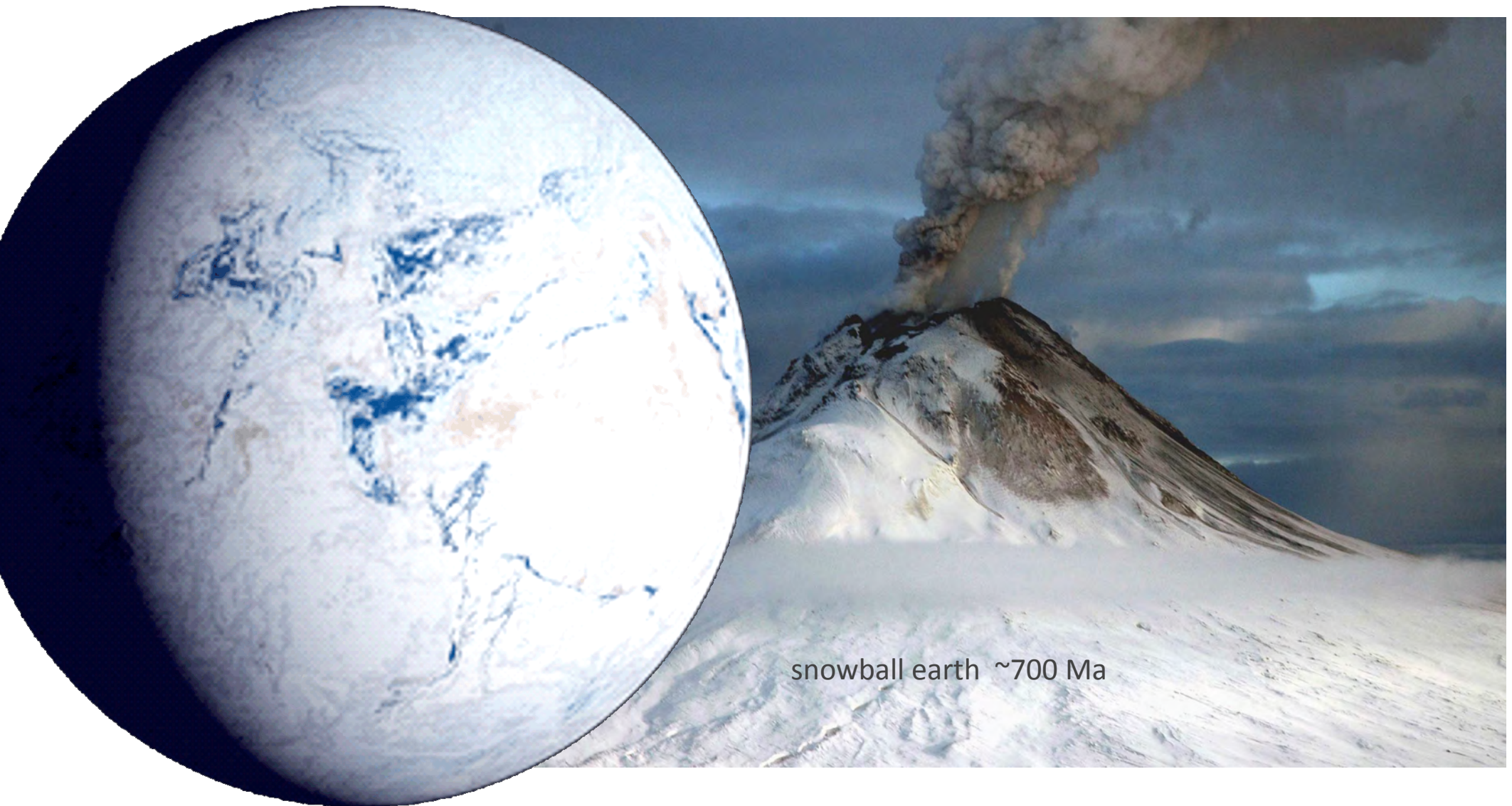


complex colonial life: 2.1 b.y.



eukaryotes: *Bangiomorpha pubescens* – red algae

SEX! 1.2 billion years old



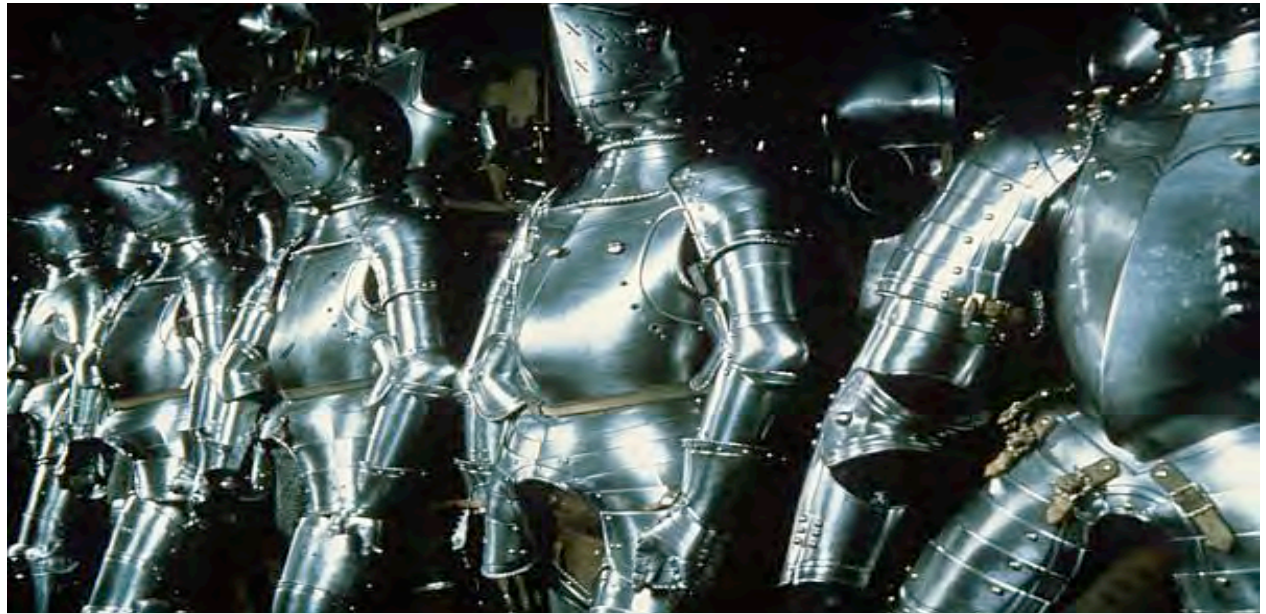
snowball earth ~700 Ma

increasing oxygen production and
biological removal of CO₂

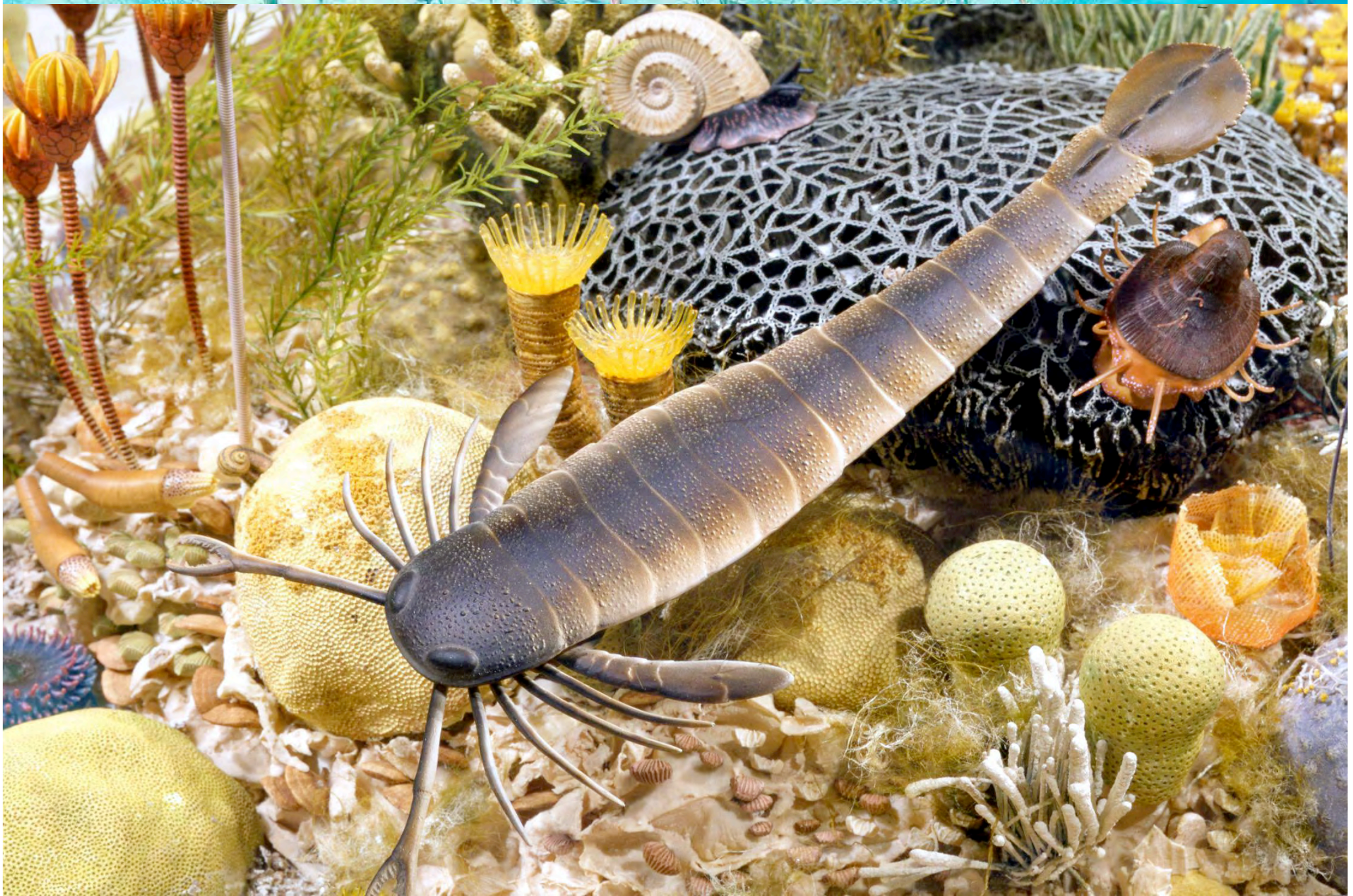
= cooling



Cambrian radiation – 540 Ma



Cambrian radiation – the arms-race of life begins



hotspots of biodiversity

Silurian reefs ~430 Ma

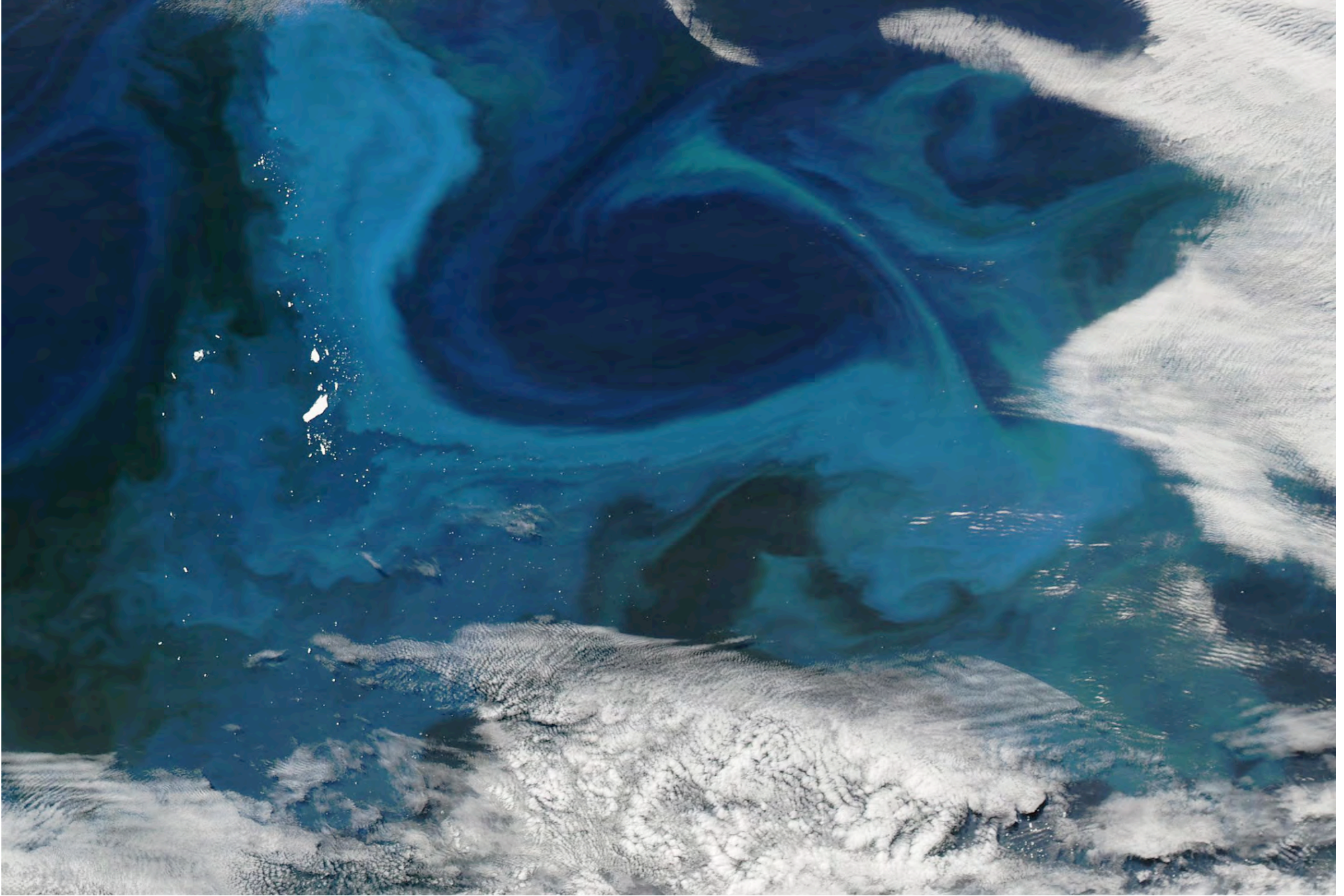


hotspots of biodiversity

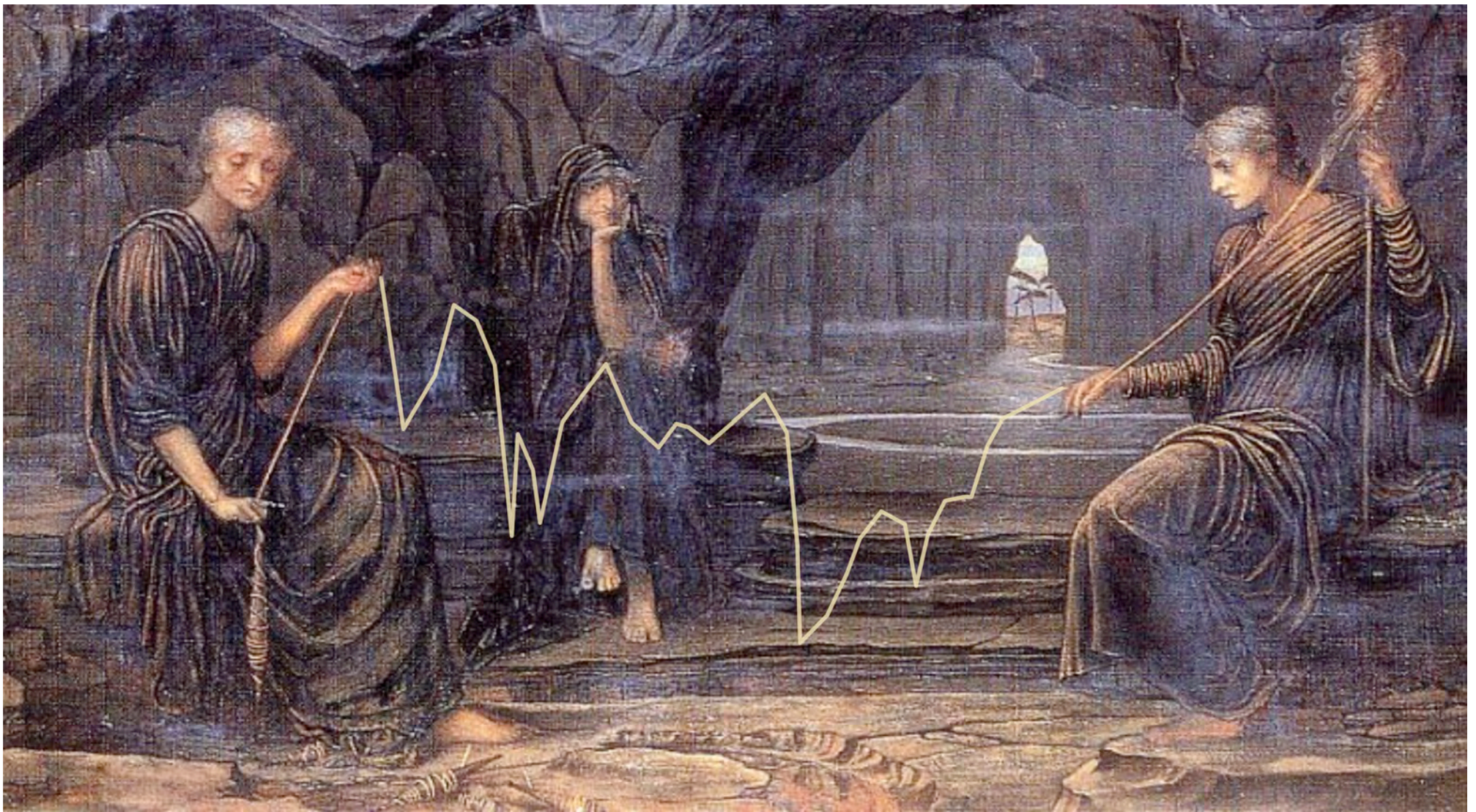
first forests ~380 Ma
= first soils



major mobilization of nutrients!



major mobilization of nutrients!



Präkambri

540 Mio.

Paläozoikum

250 Mio.

Mesozoikum

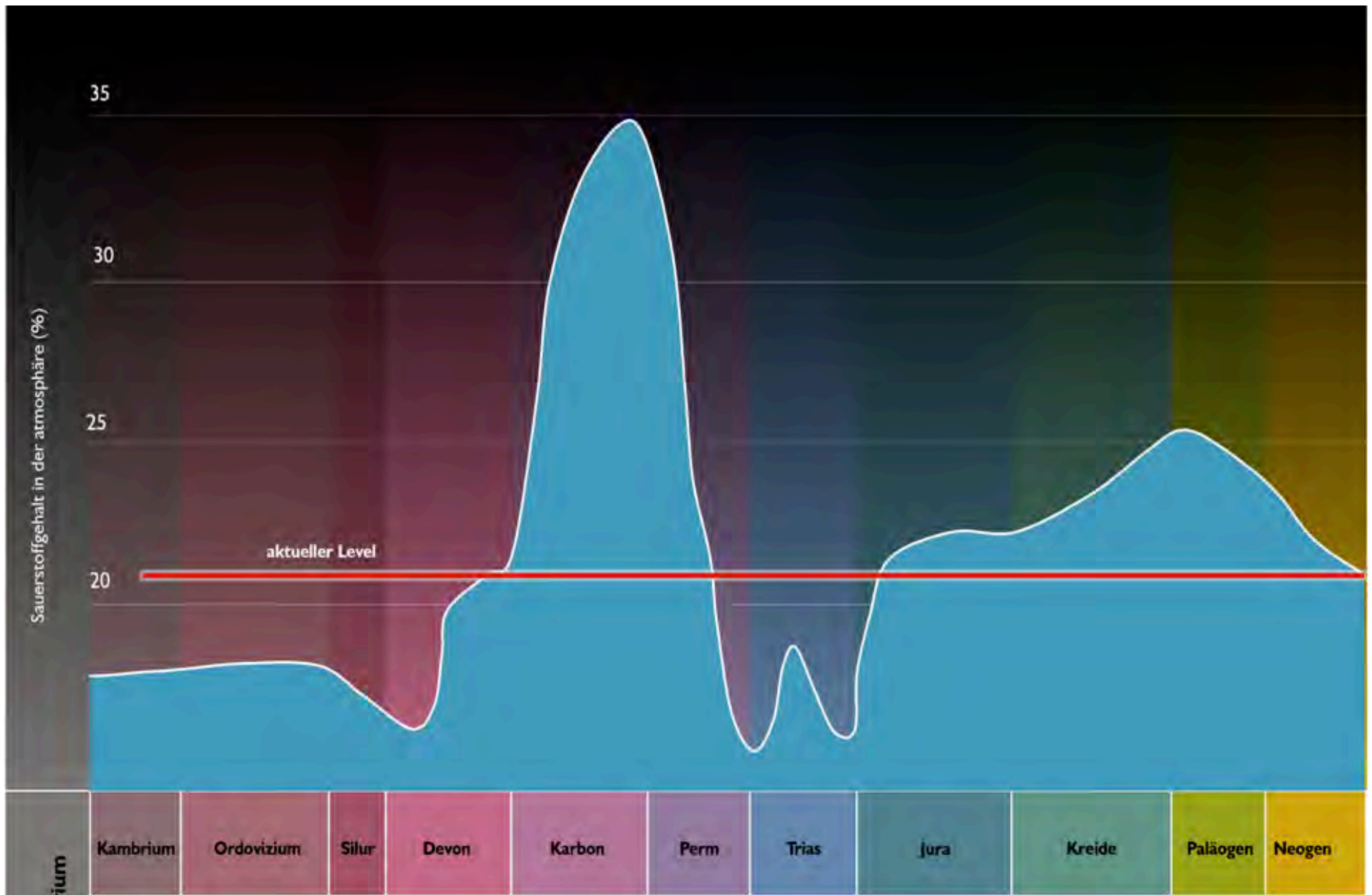
65 Mio.

Känozoikum

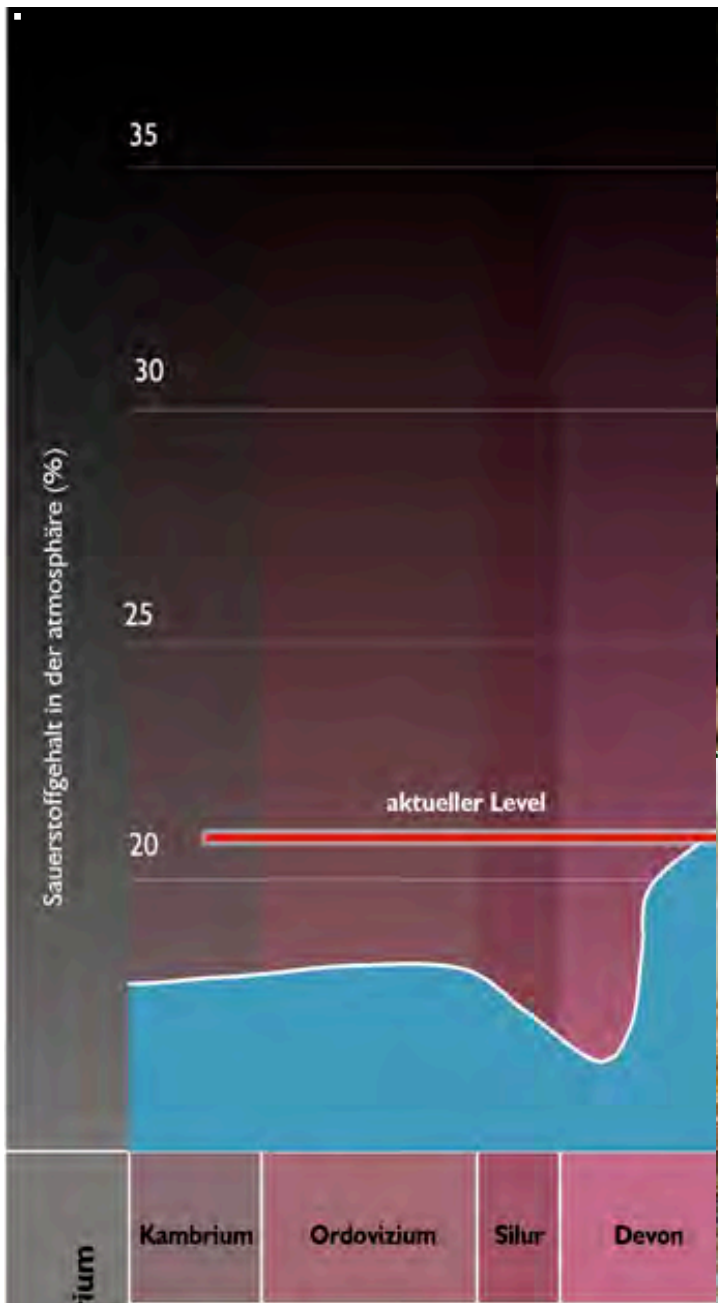
the goddesses of destiny at work



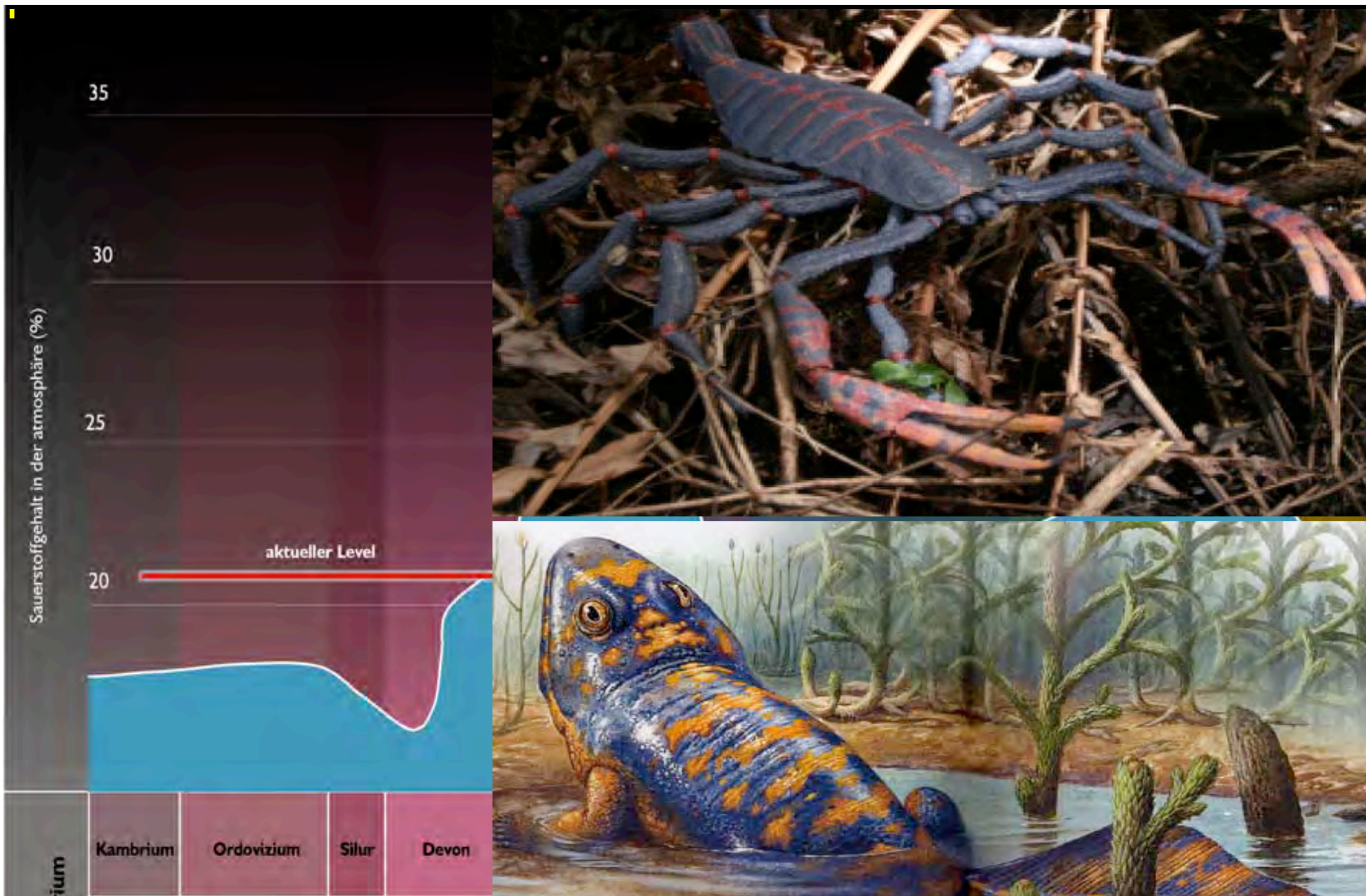
less subtle...



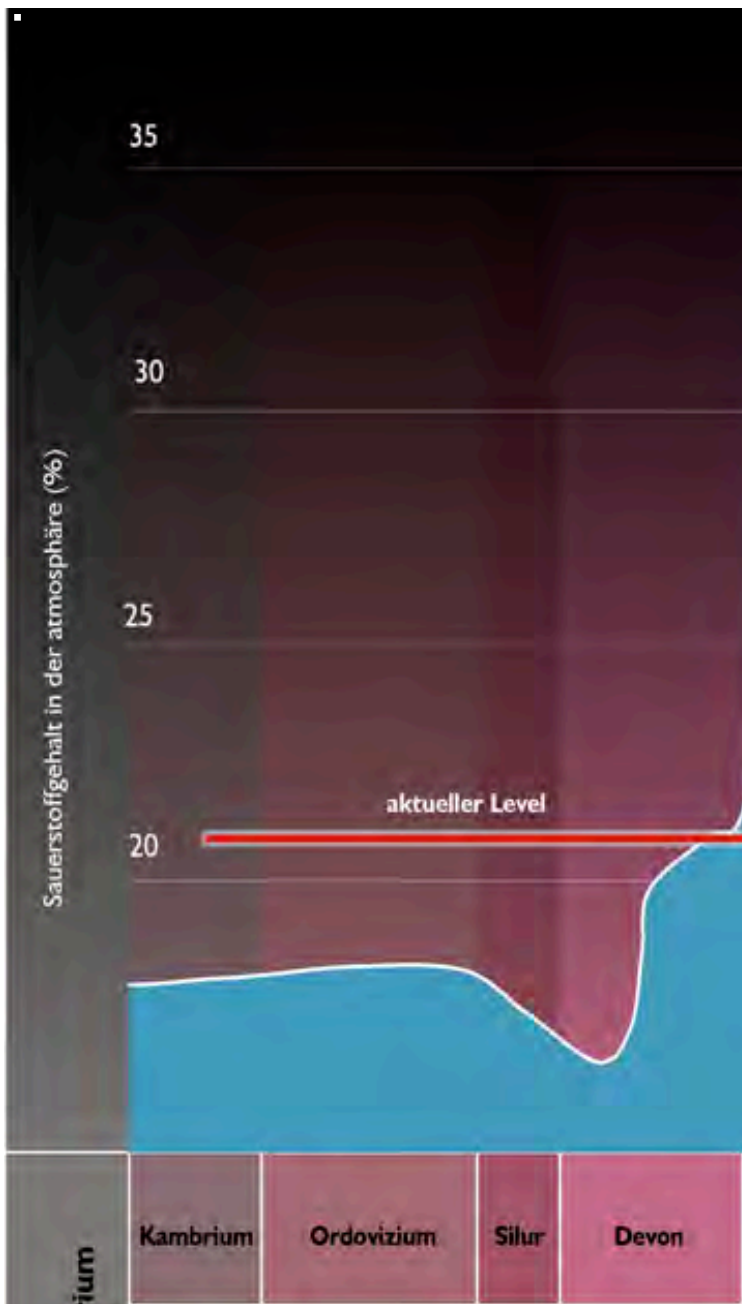
.. and subtle ...



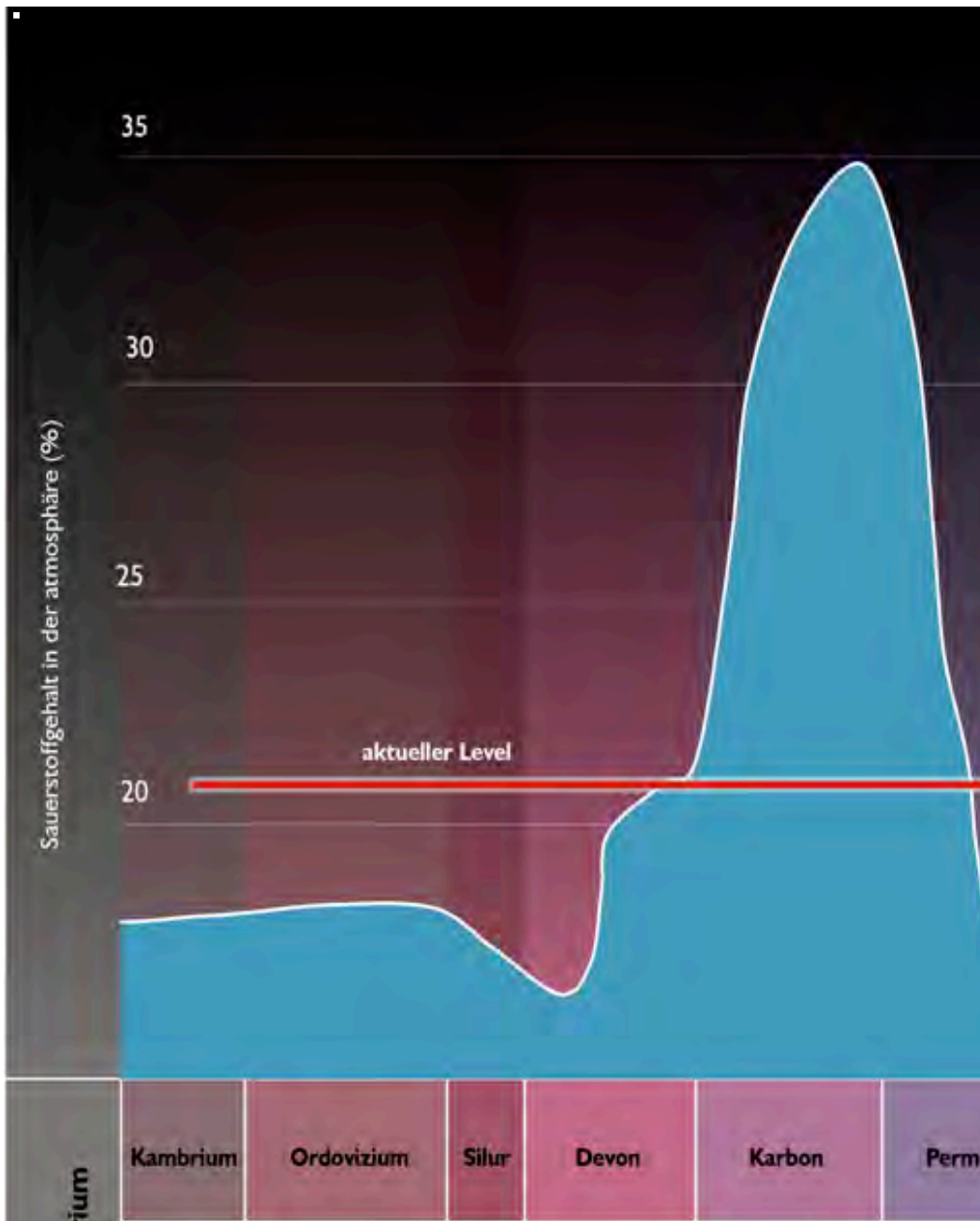
oxygen content of the atmosphere



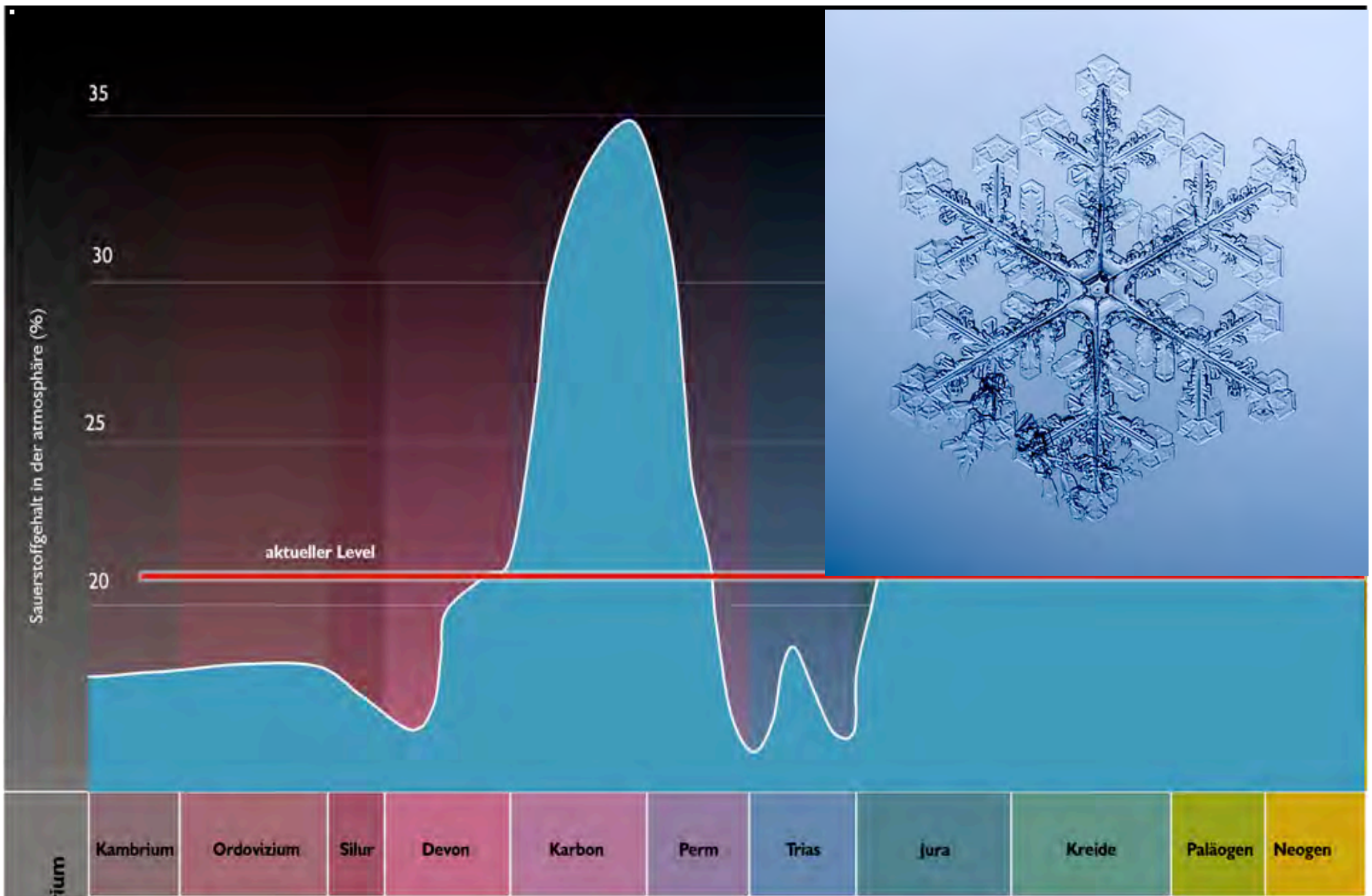
oxygen content of the atmosphere



oxygen content of the atmosphere



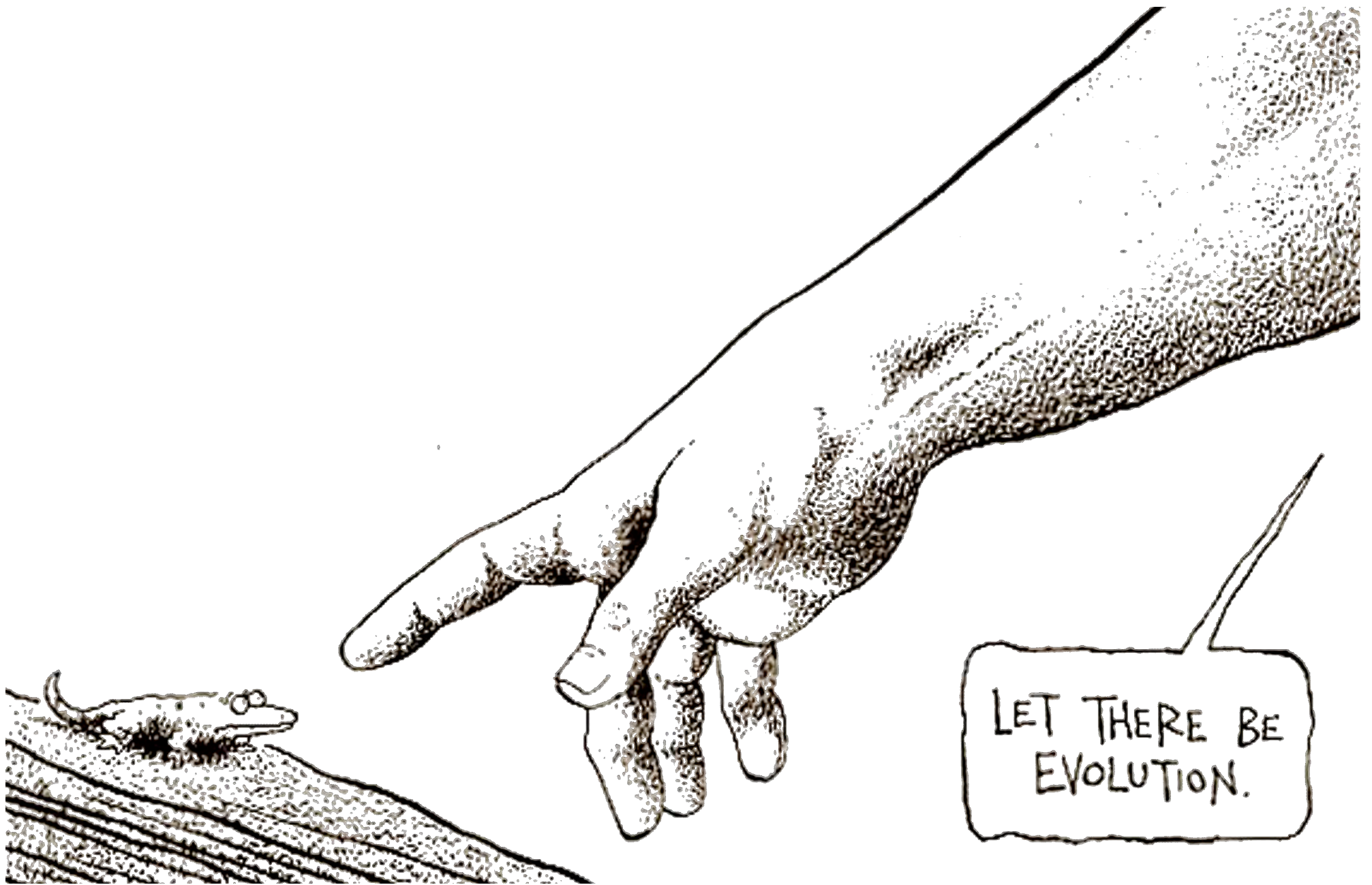
oxygen content of the atmosphere



oxygen content of the atmosphere

PHAL
DZEA





thank you!