

# Lecture 24:

We've made it through the Precambrian.

Now we're in the **Phanerozoic**: 544 Ma to present-day

Where we're going:

- Review marker events in Earth history
- Mesozoic (251-65 Ma) Warmth (p.245-251)
- Cenozoic (65 Ma-present) Cooling
- Pleistocene (2 Ma-present) glacial cycles (Chapter 14)
- Climate of the last millennium (Chapter 15)

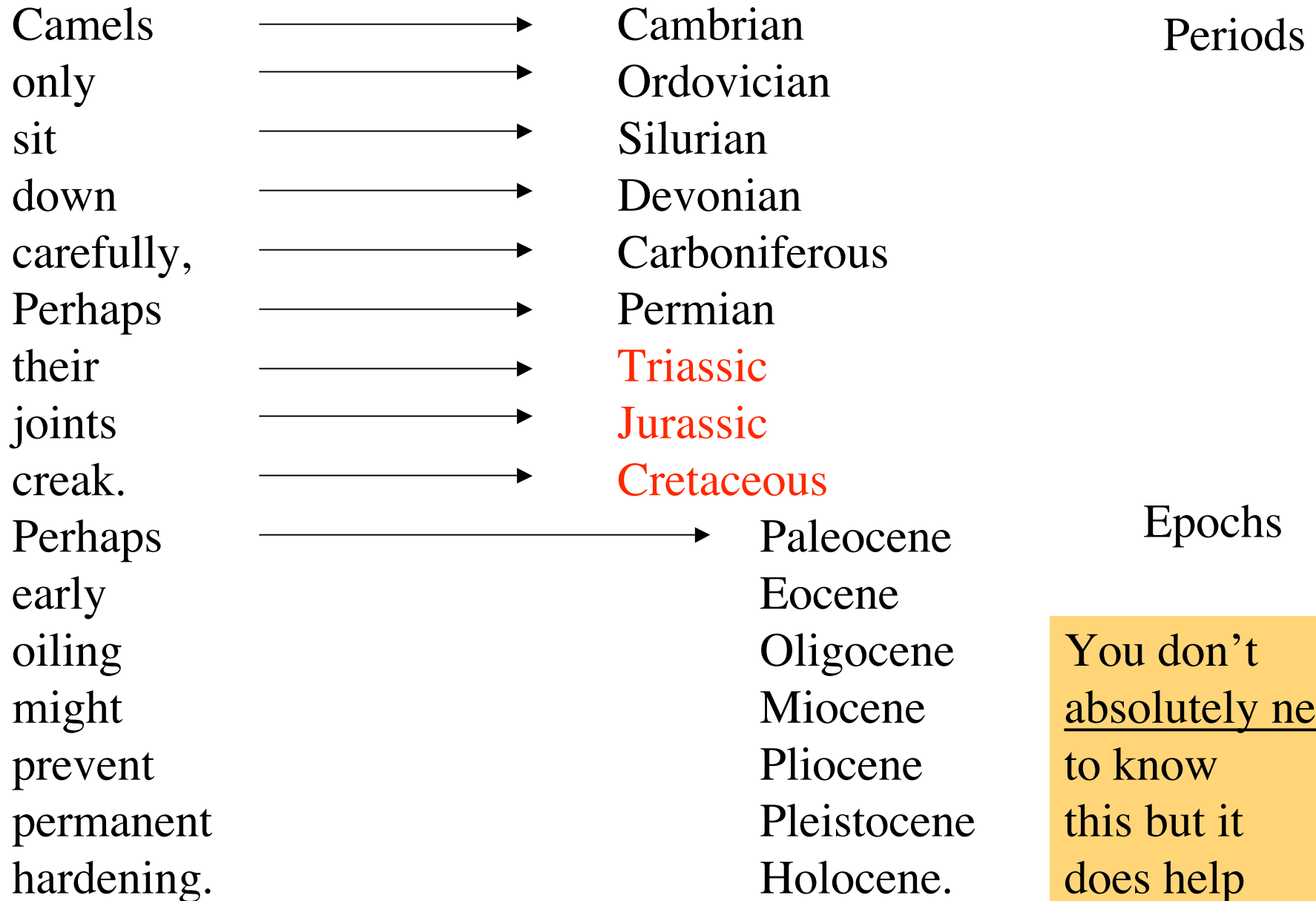
Weeks 8,9,10

- Climate of the 20th century
- Global Warming: science and policy issues

## Earth History: Review of Marker Events

- |   |   |
|---|---|
| 1. Origin of Earth  | 4.56 Ga                                     |
| 2. Origin of Life   | don't know; some time before 3.8 Ga         |
| 3. First Rise of Oxygen<br>First set of Snowball Earths   | 2.4-2.2 Ga                                  |
| 4. Second Rise of Oxygen<br>Second set of Snowball Earths | about 800-600 Ma                            |
| 5. Ediacaran fossils<br>Cambrian Explosion of fossils     | 575 Ma (perhaps as old as 590 Ma)<br>544 Ma |
| 6. Biggest Animal Extinction                              | 251 Ma                                      |
| 7. Asteroid extinction of dinosaurs                       | 65 Ma                                       |
| 8. Beginning of modern<br>glaciations/ interglacials      | 2.5 Ma                                      |
| 9. End of last ice-age                                    | 12 ka                                       |

# How I remember all the geological ages



You don't absolutely need to know this but it does help

## Mesozoic Warmth (251-65 Ma)

### The era of dinosaurs

#### Climate:

- Warmer global-mean temperature.
- Much warmer Polar Regions; no ice-caps.
- Much warmer deep ocean: 15°C vs. 2°C today.

#### Evidence:

- Lush ferns and alligators in Siberia. Dinosaurs in Alaska.
- Oxygen isotopes in oceanic carbonates

#### Cause:

- Higher CO<sub>2</sub> is leading suspect.
- sea-floor spreading rate was greater
- higher sea level (no ice caps): less land for weathering

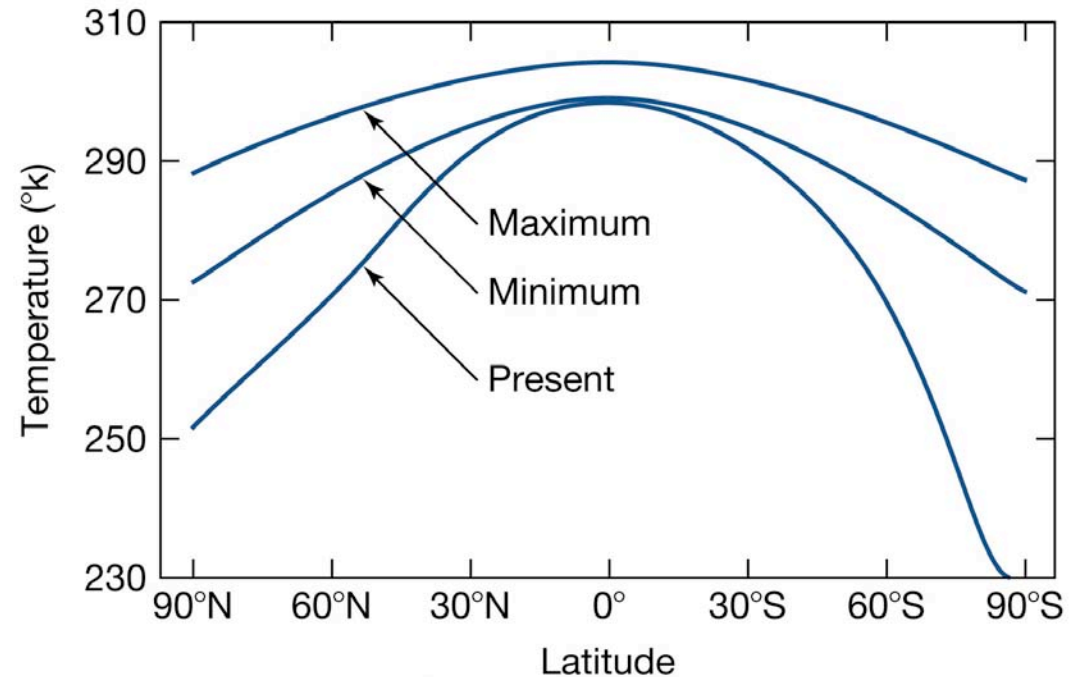


Fig 12-14. 100 Ma zonally-averaged temp

#### Mesozoic climate mystery:

The eq.-to-pole temperature gradient was very small (above Fig). Somehow eq.-to-pole heat transport was very efficient or the greenhouse effect was enhanced at the poles by high clouds.

# Carbon isotopes as CO<sub>2</sub> indicators

Organisms preferentially take up <sup>12</sup>C

But if CO<sub>2</sub> is low, photosynthesizers will extract whatever C atoms they can get, whether <sup>12</sup>C or <sup>13</sup>C

(a “**beggars can’t be choosers**” isotope rule)

At low CO<sub>2</sub>, experiments show more <sup>13</sup>C in organic matter than with abundant CO<sub>2</sub>.

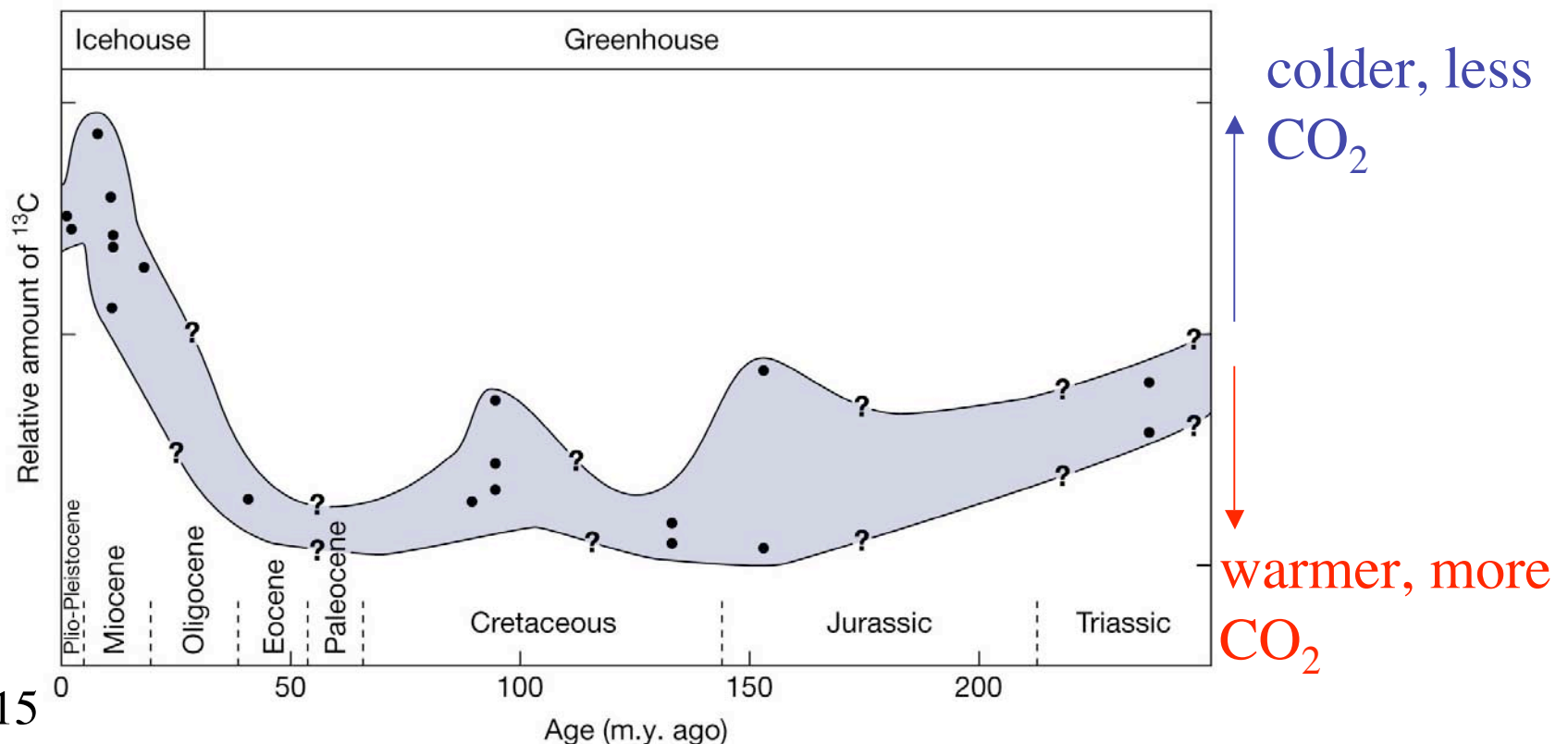
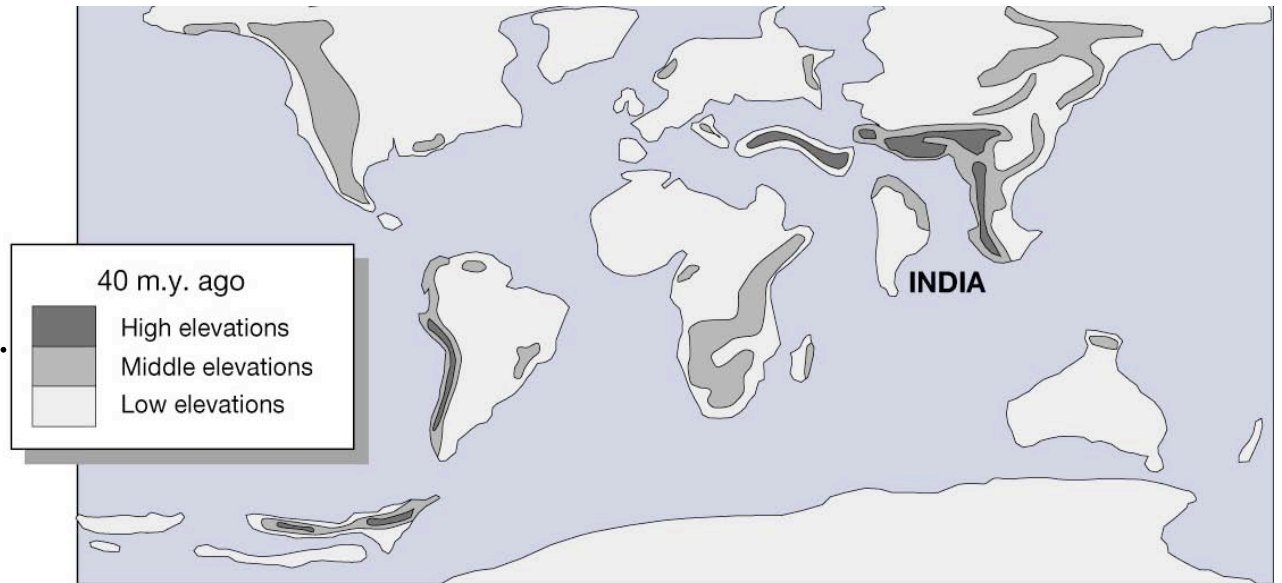


Fig 12-15

## Cenozoic cooling, 65 Ma to present

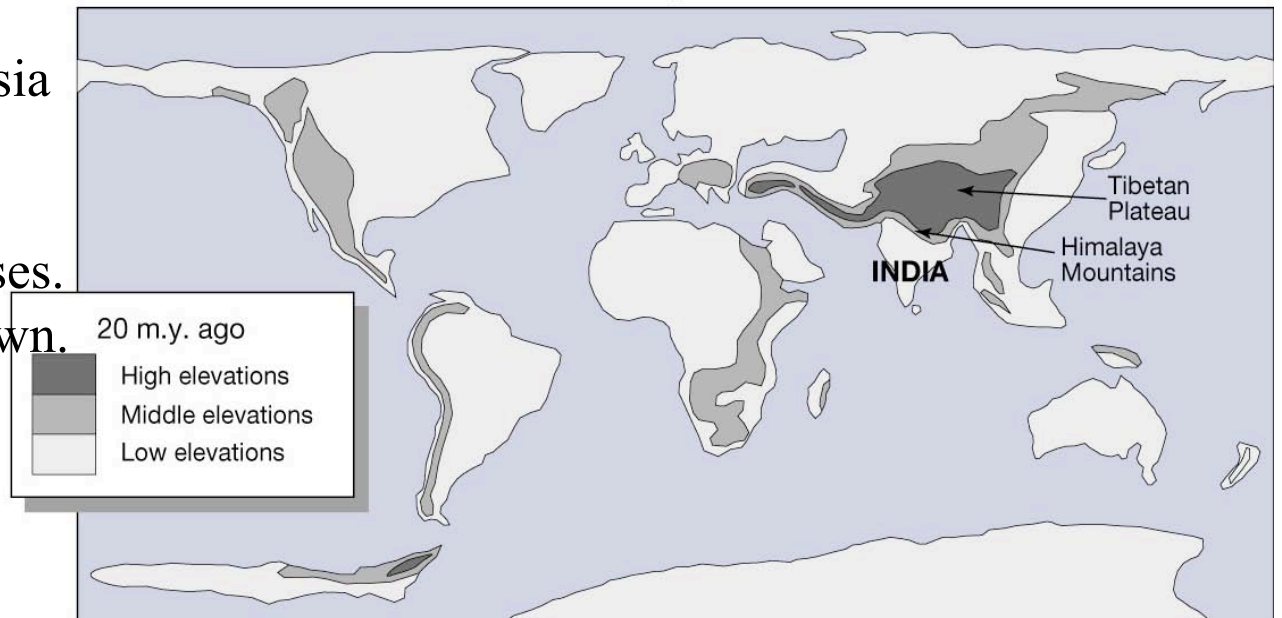
### What:

- Earth cools after 80 Ma.
- Life retreats from poles.
- Polar ice caps form.
- Eventually, ice-ages begin.

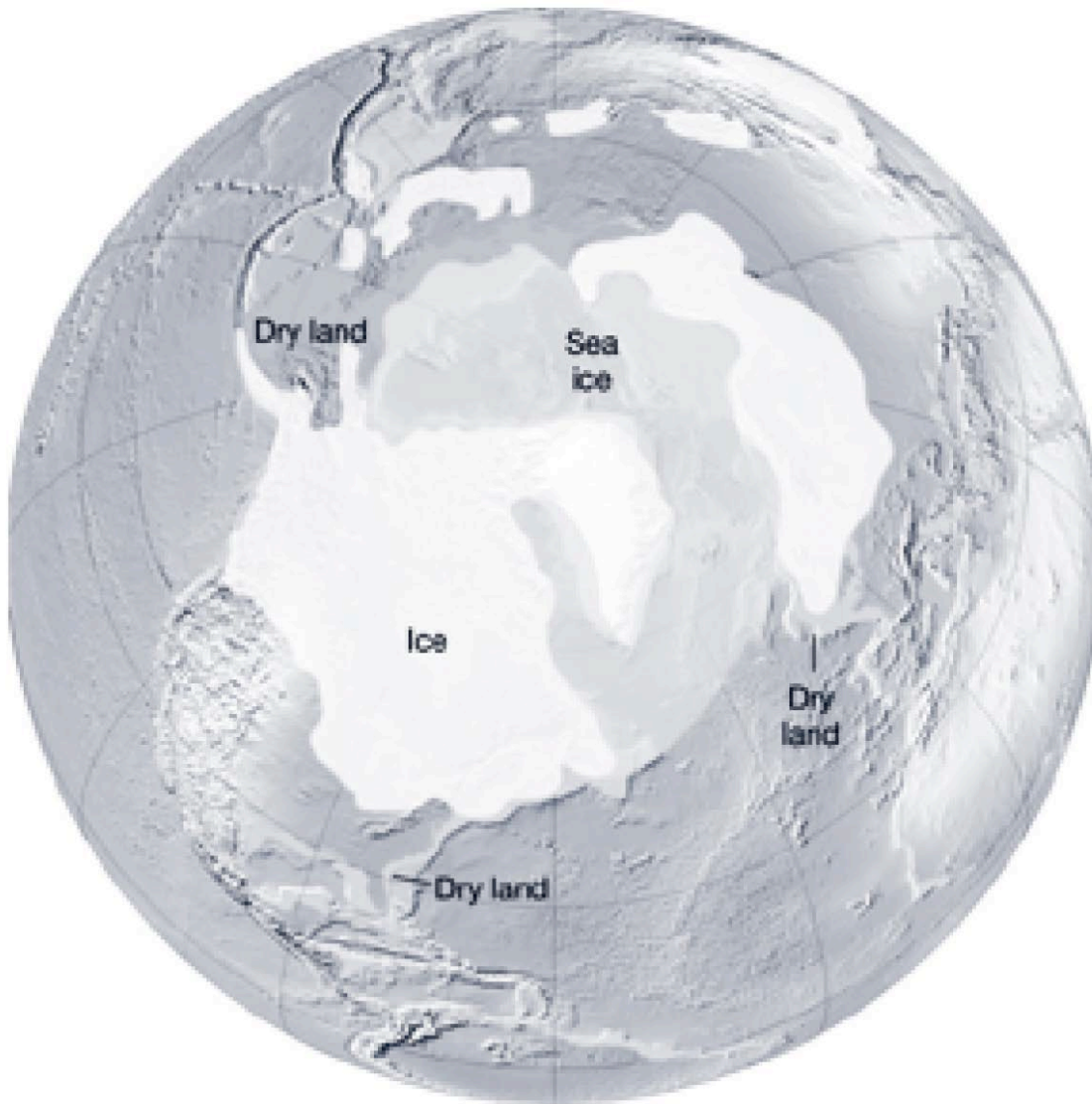


### Why (one leading theory):

- initial decrease due to slower midocean ridge spreading
- Then India collides with Asia at 40-30 Ma.
- Himalayas form.
- Silicate weathering increases.
- Atmospheric CO<sub>2</sub> goes down.



# Pleistocene (1.8 Ma-10 ka) glacial cycles



Maximum ice extent  
(Seattle under 1 km  
of ice.)

## Glacier indicators:

- striations,
- till / moraines

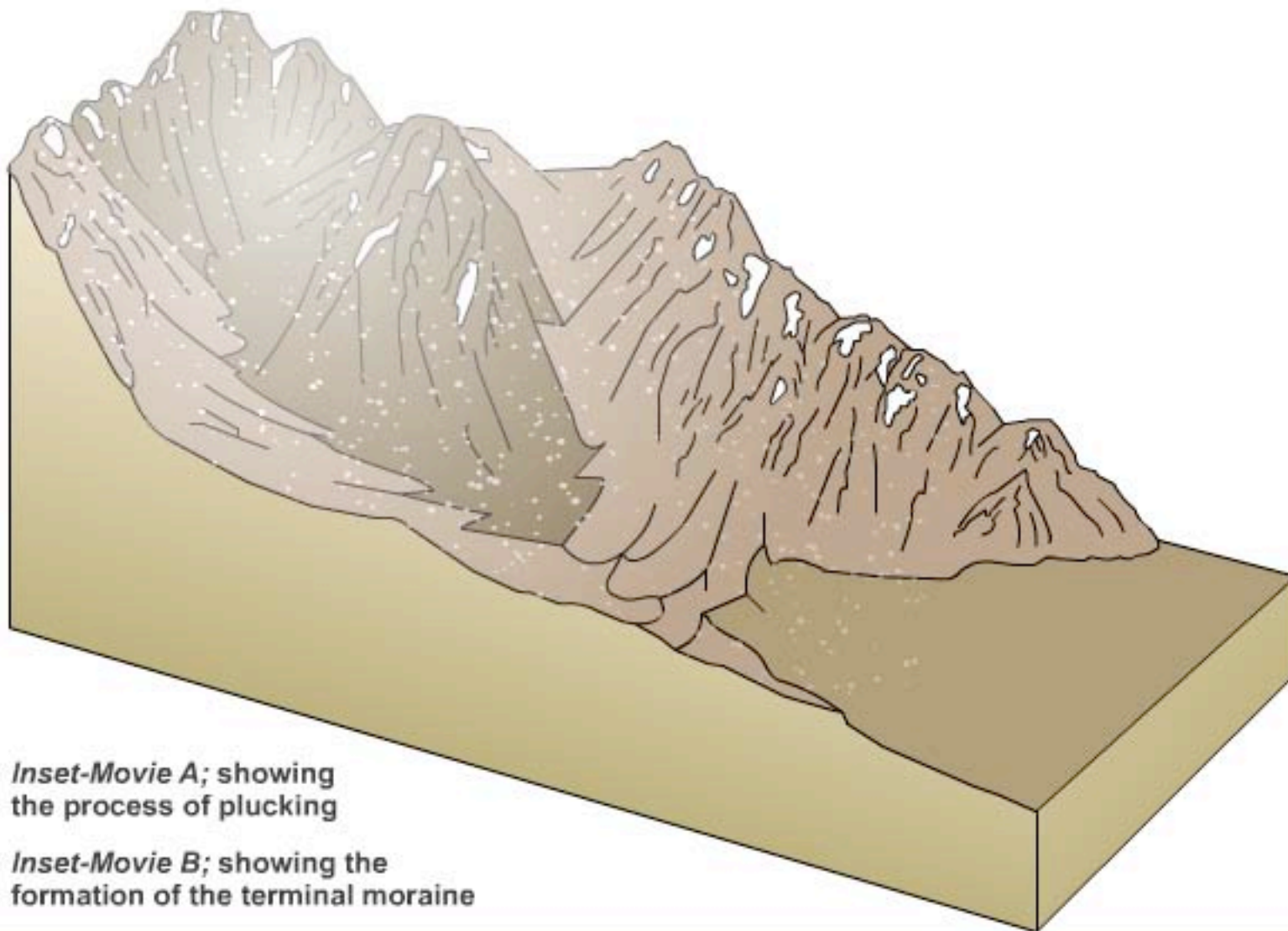
Also some of the till  
is fine silt ( $\sim 0.01$  mm)  
and gets transported and  
deposited by the wind.  
Deposits are called **loess**.

Fig 14-1

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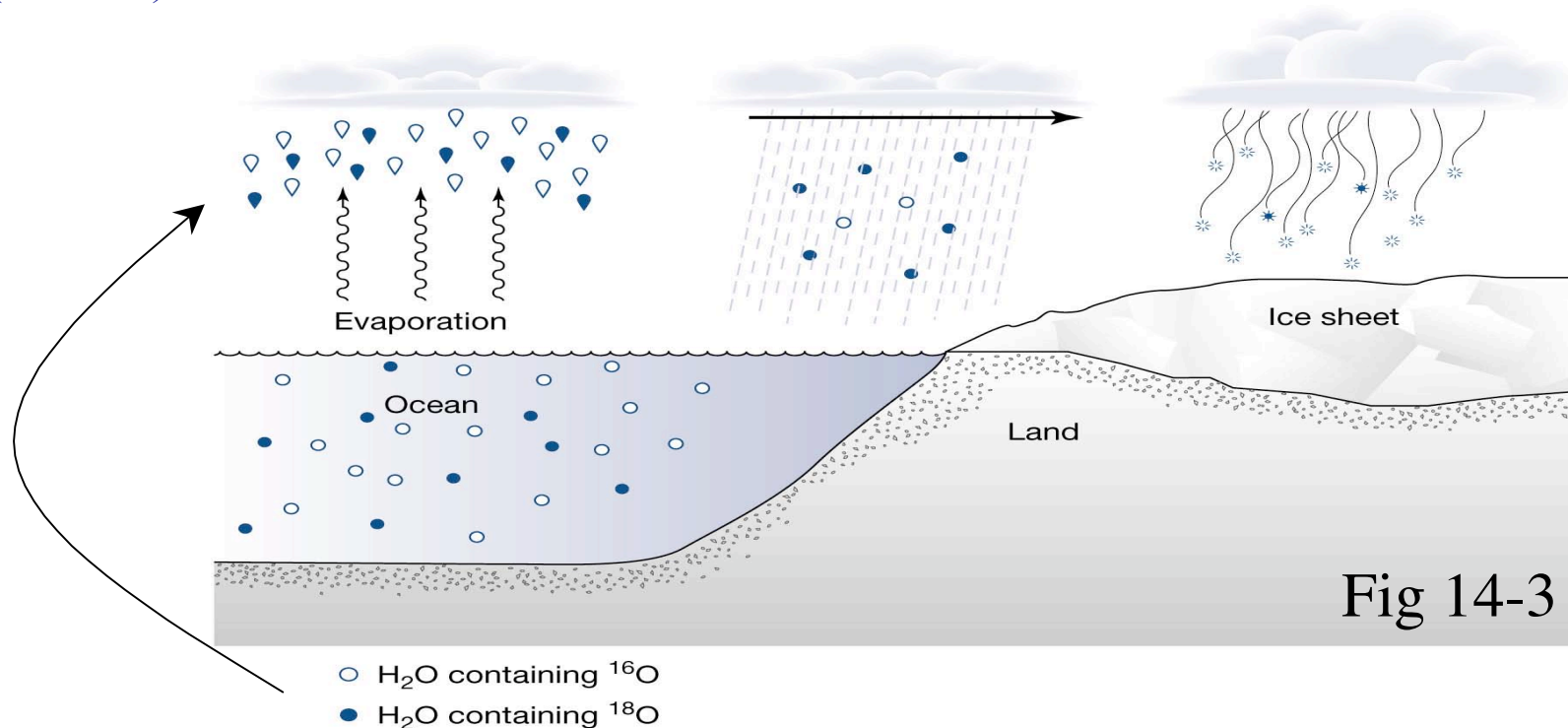
- ▶ *Inset-Movie A*; showing the process of plucking
- ▶ *Inset-Movie B*; showing the formation of the terminal moraine



# Oxygen Isotopes: Evidence for Temperature

$^{16}\text{O}$  vs  $^{18}\text{O}$   
"light"  
(normal)      "heavy"

- evaporation favors "light"  $^{16}\text{O}$
- condensation (precipitation) favors "heavy"  $^{18}\text{O}$



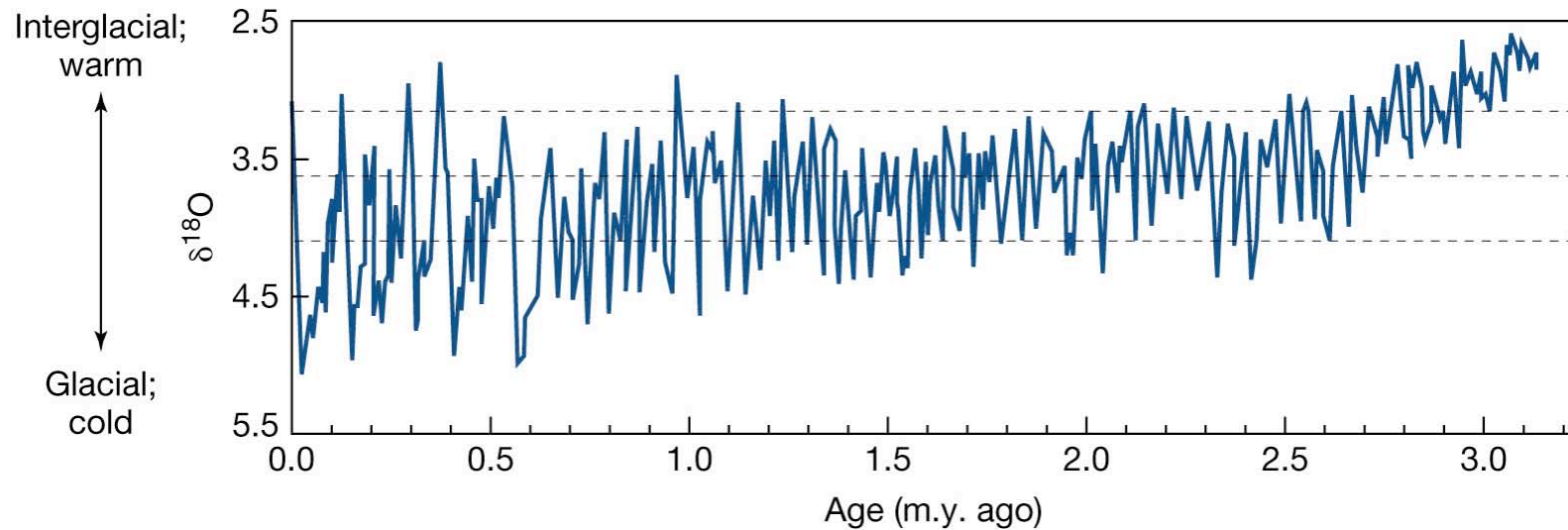
Less  $^{18}\text{O}$  in ice-cores indicates colder temperature:

Colder conditions means more precipitation en route so isotopically "lighter" snow (precipitation leaves water vapor for snow enriched in  $^{16}\text{O}$ )

More  $^{18}\text{O}$  in ocean carbonates records glacial ice volume:

More  $^{16}\text{O}$ -enriched water in ice-sheets means remaining ocean is "heavier".

## 3.5 Million Year Record of Global Ice Volume



Now

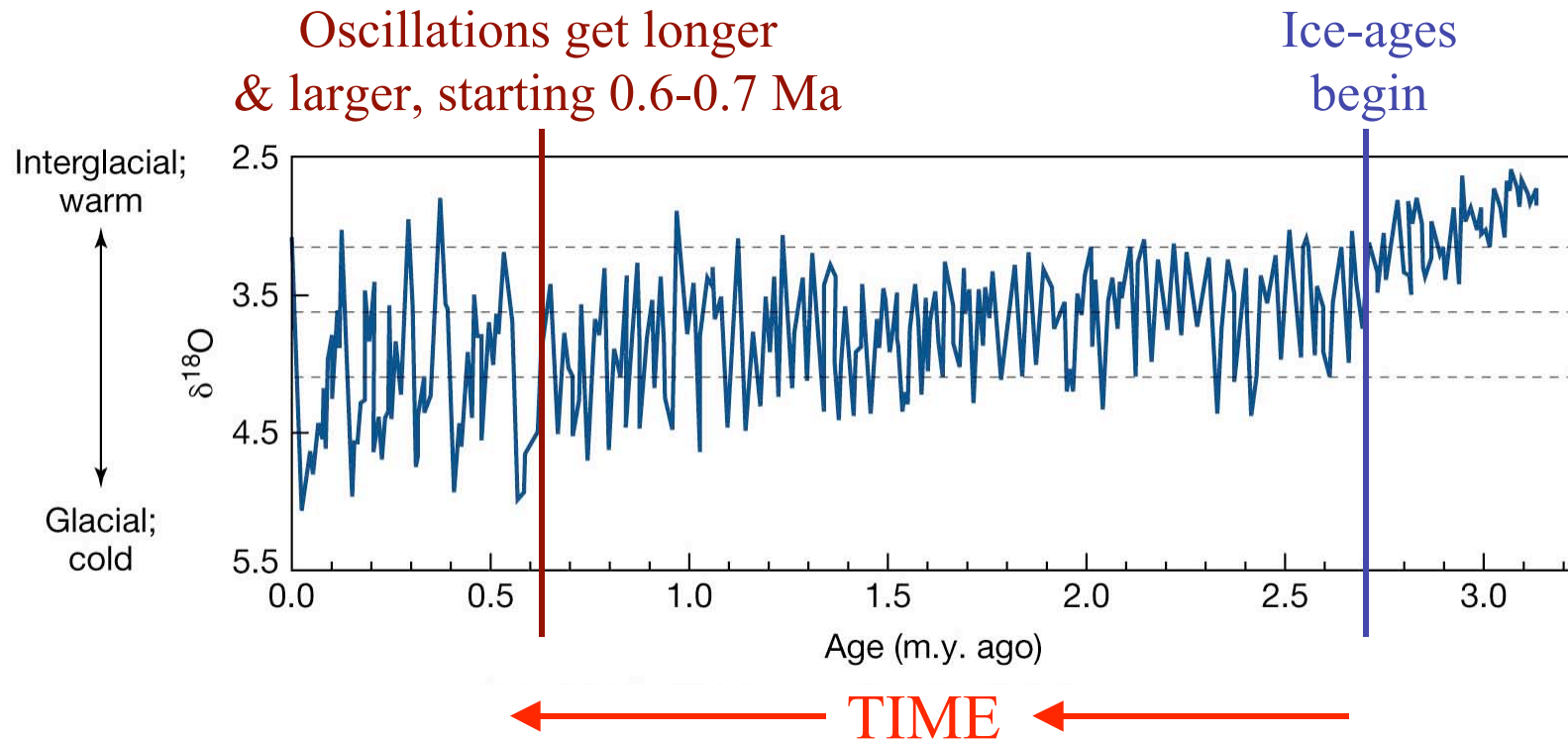
← TIME ←

### Questions

1. Is this an ocean sediment record or a polar ice-core record?

1. Ocean sediments record ice volume. Ice-core records only extend back to about 500,000 years.

## 3.5 Million Year Record of Global Ice Volume



### Questions:

2. What two major transitions do you see in this record?
3. Was sea-level lower or higher than today during the three most prominent previous interglacial periods?
3. Less ice-volume, therefore higher sea level. (May have been warmer than today as well.)