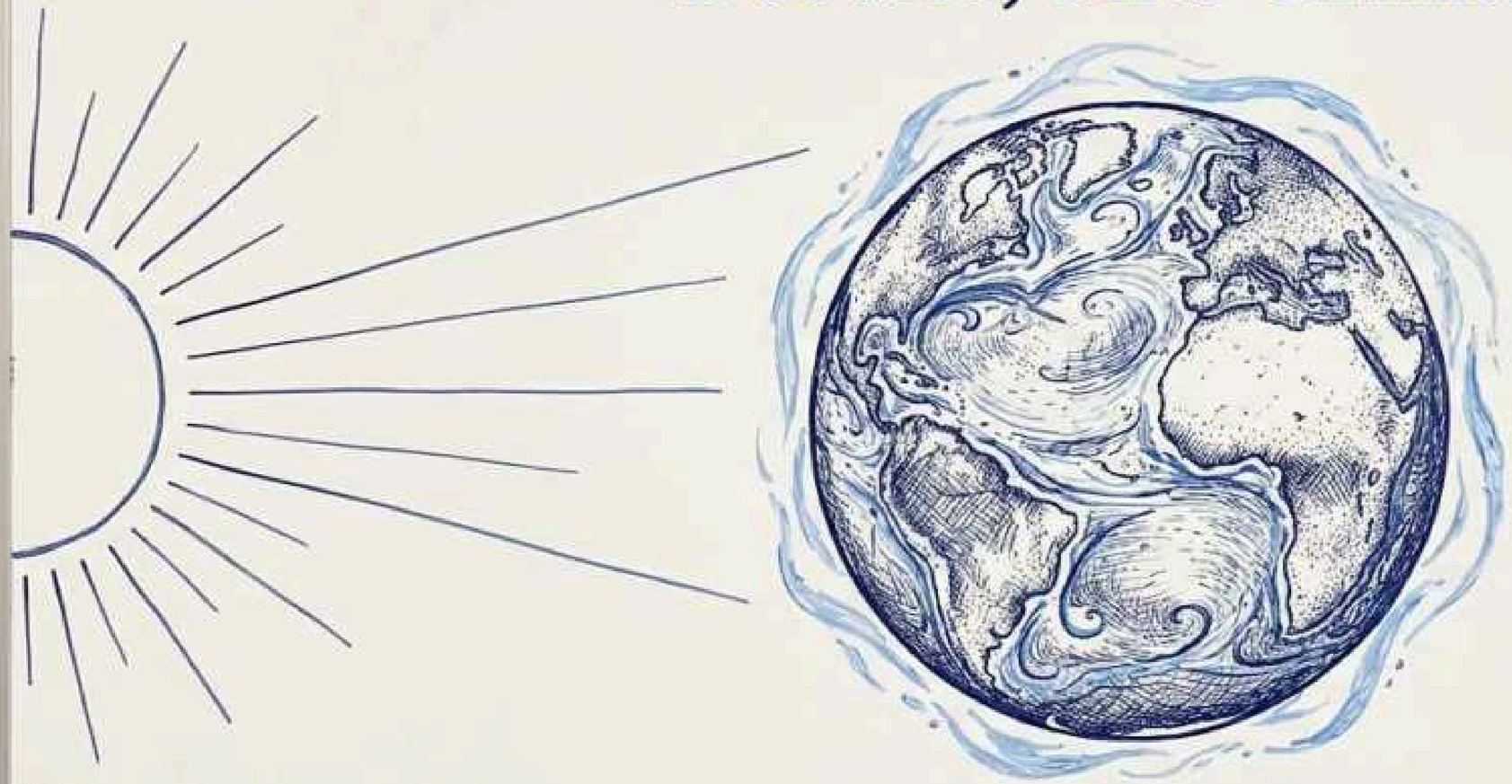
Lecture 6: The Atmosphere, Oceans, and Climate

¶ 6.1



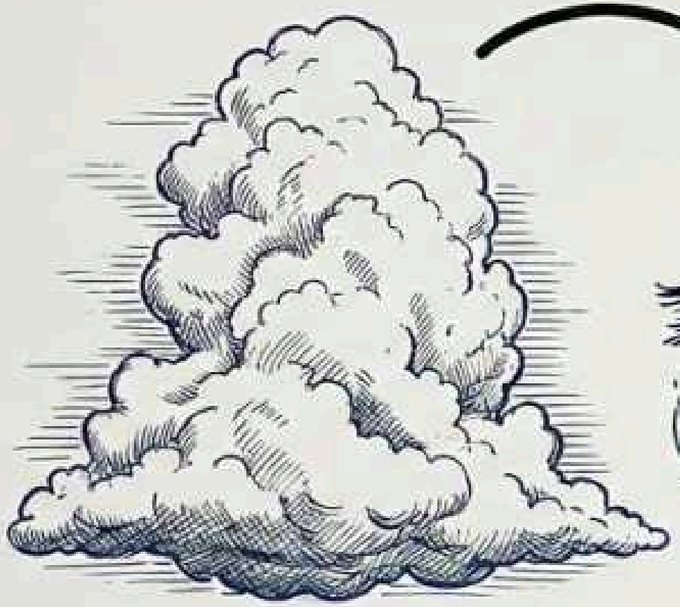
Geology 101 B

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The Fluid Layers of the Planet

¶ 6.2

Today's Trajectory:





$$\Delta T_{eff} = f(CO_2, CH_4, H_2O\ldots)$$

$$E_{in} = S \cdot (1-\alpha)$$

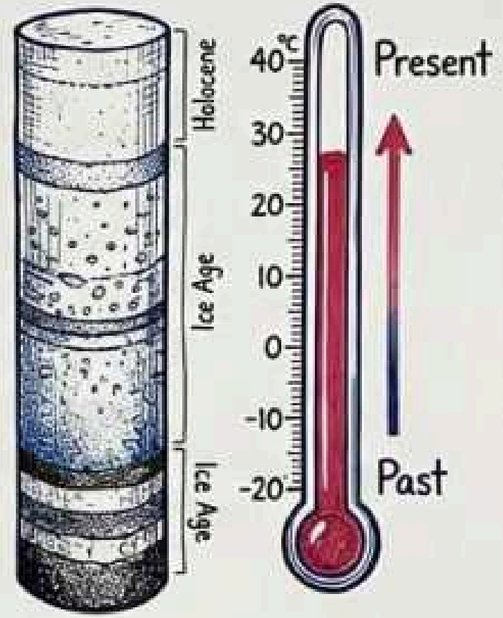
$$E_{out} = \varepsilon \cdot \sigma \cdot T^4$$

$$\Delta T_{eff} = \varepsilon \left(\frac{\varepsilon \cdot \sigma \cdot T^4}{1-\alpha \cdot h} - \varepsilon T^4 \right)$$

$$= f(CO_2, CH_4) \cdot (1-\alpha_{ice})$$

$$= \varepsilon \cdot \frac{\sigma \cdot T^4}{1-g}$$

$$T_{surface} \approx \frac{T_{eff}}{1-g}$$



1. The Atmosphere & Air Circulation

2. Ocean Circulation & Water

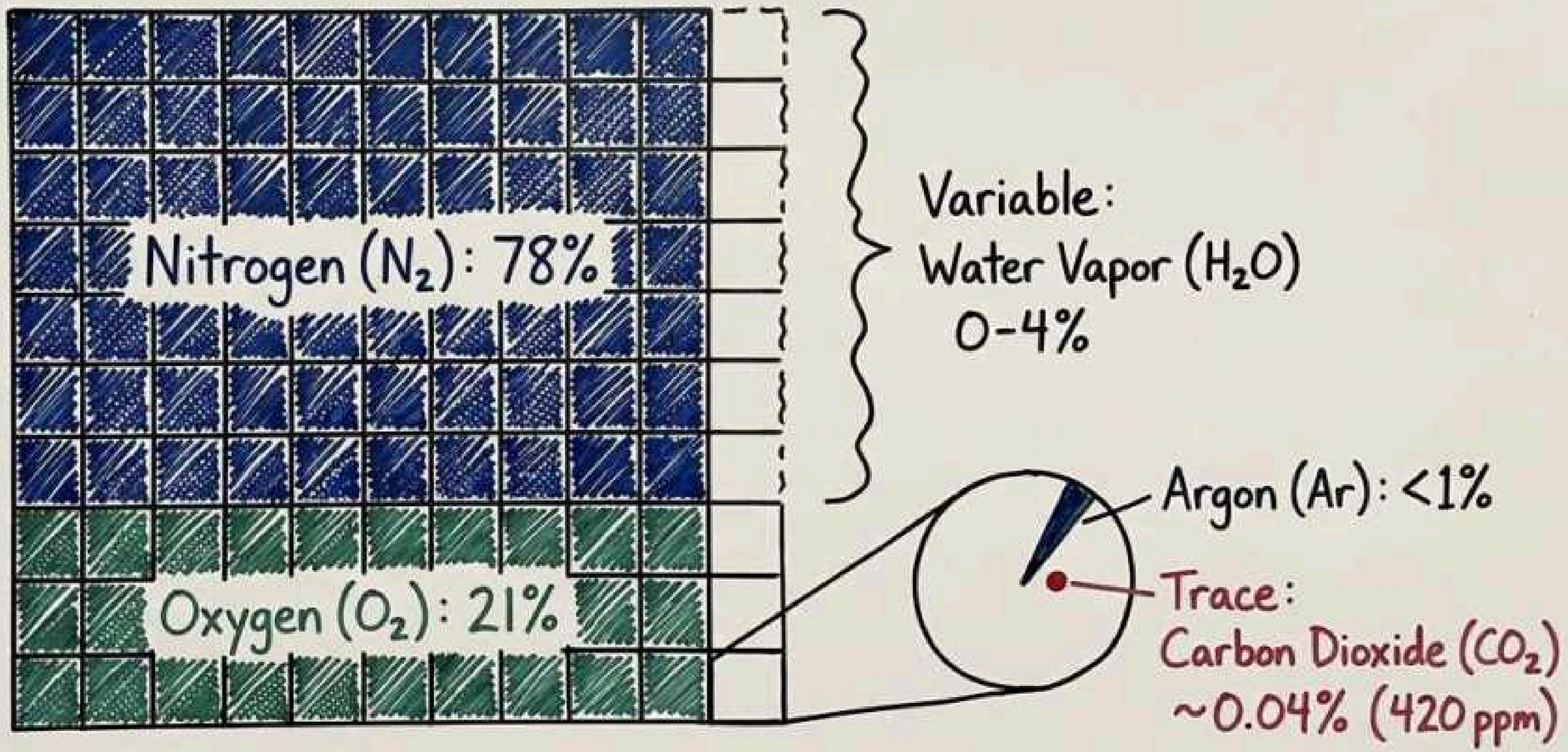
3. Calculating the Greenhouse Effect

4. Past Climate & Present Changes

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The Thin Skin of Gas (by volume)

¶ 6.3

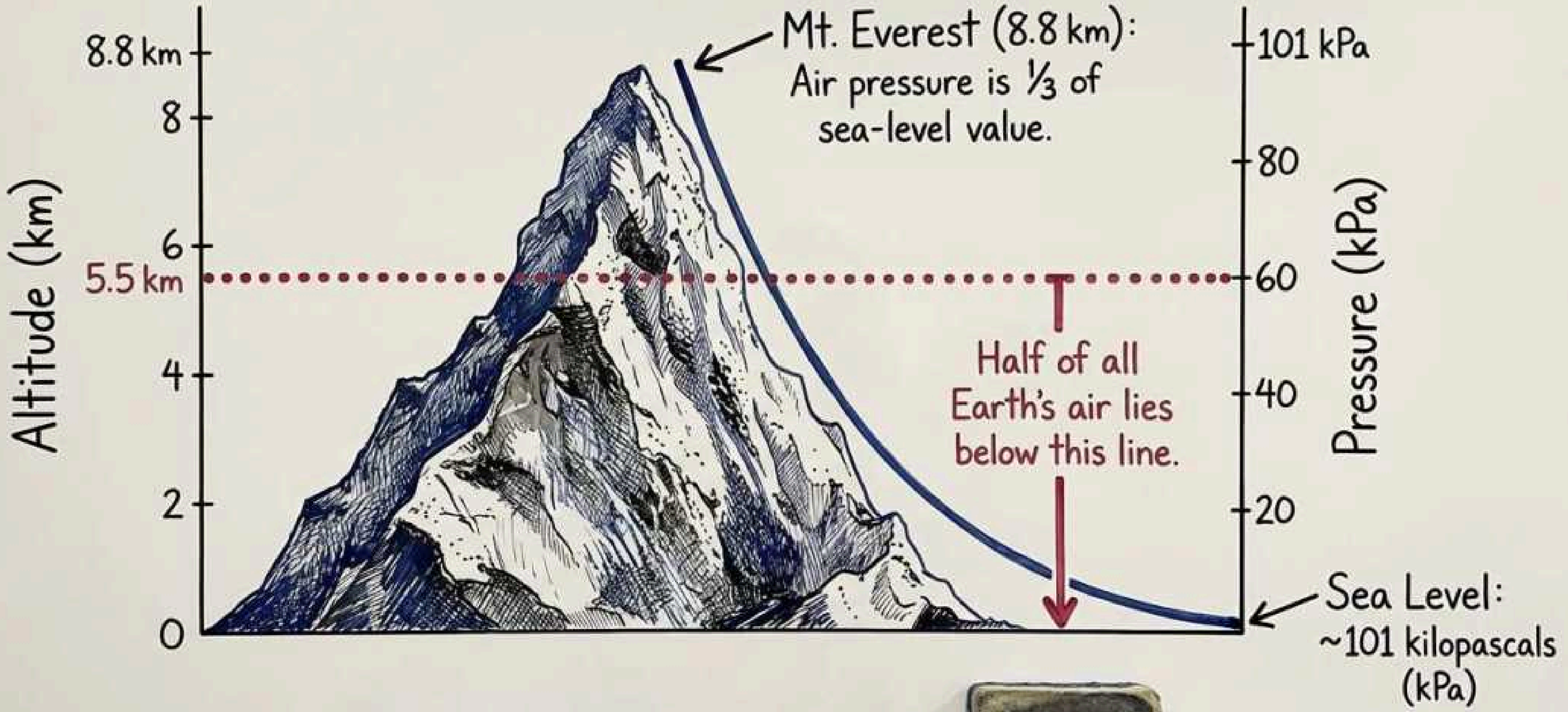


The atmosphere is mostly empty space between molecules.

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Air Pressure & Altitude

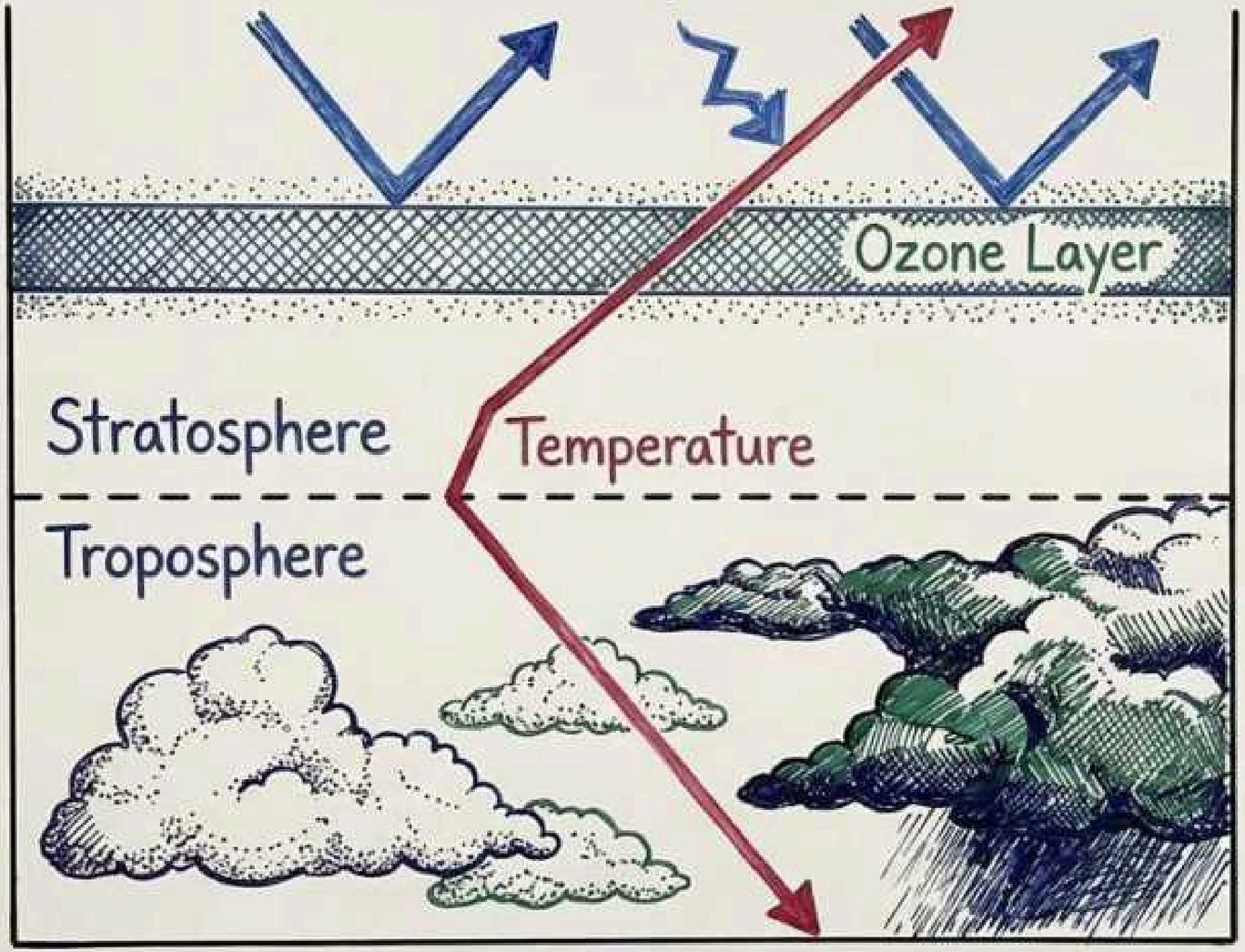
¶ 6.4



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Layers of the Atmosphere

¶ 6.5



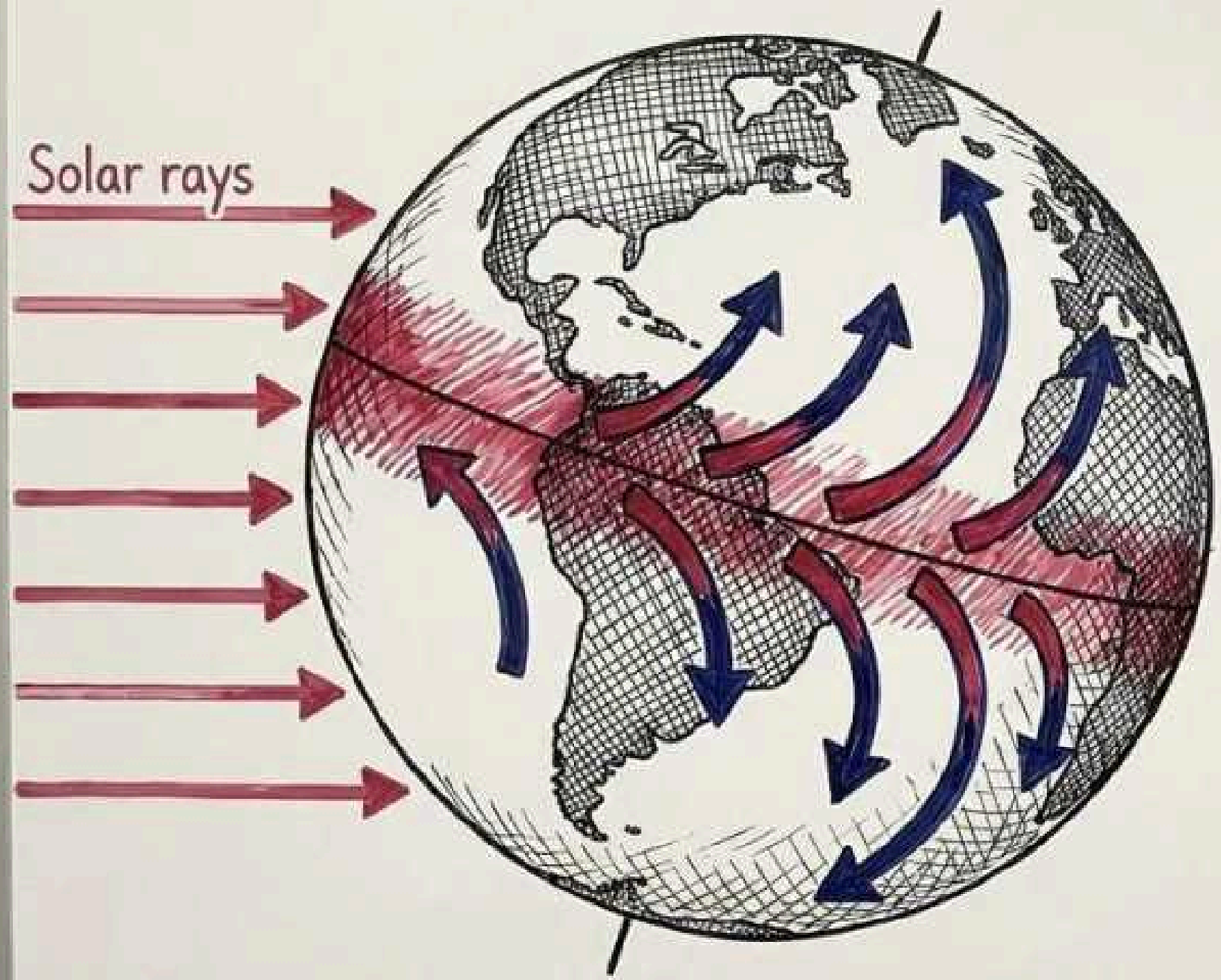
Stratosphere:
Temperature rises.
Ozone layer absorbs UV radiation.

Troposphere
(Average 12 km deep):
Temperature drops (~6.5°C per km).
All weather occurs here.

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Uneven Heating & The Coriolis Effect

¶ 6.6



Direct hits: The Sun heats the equator more intensely than the poles.

The Coriolis Effect: Earth's rotation bends moving air.

Northern Hemisphere: Bends Right.

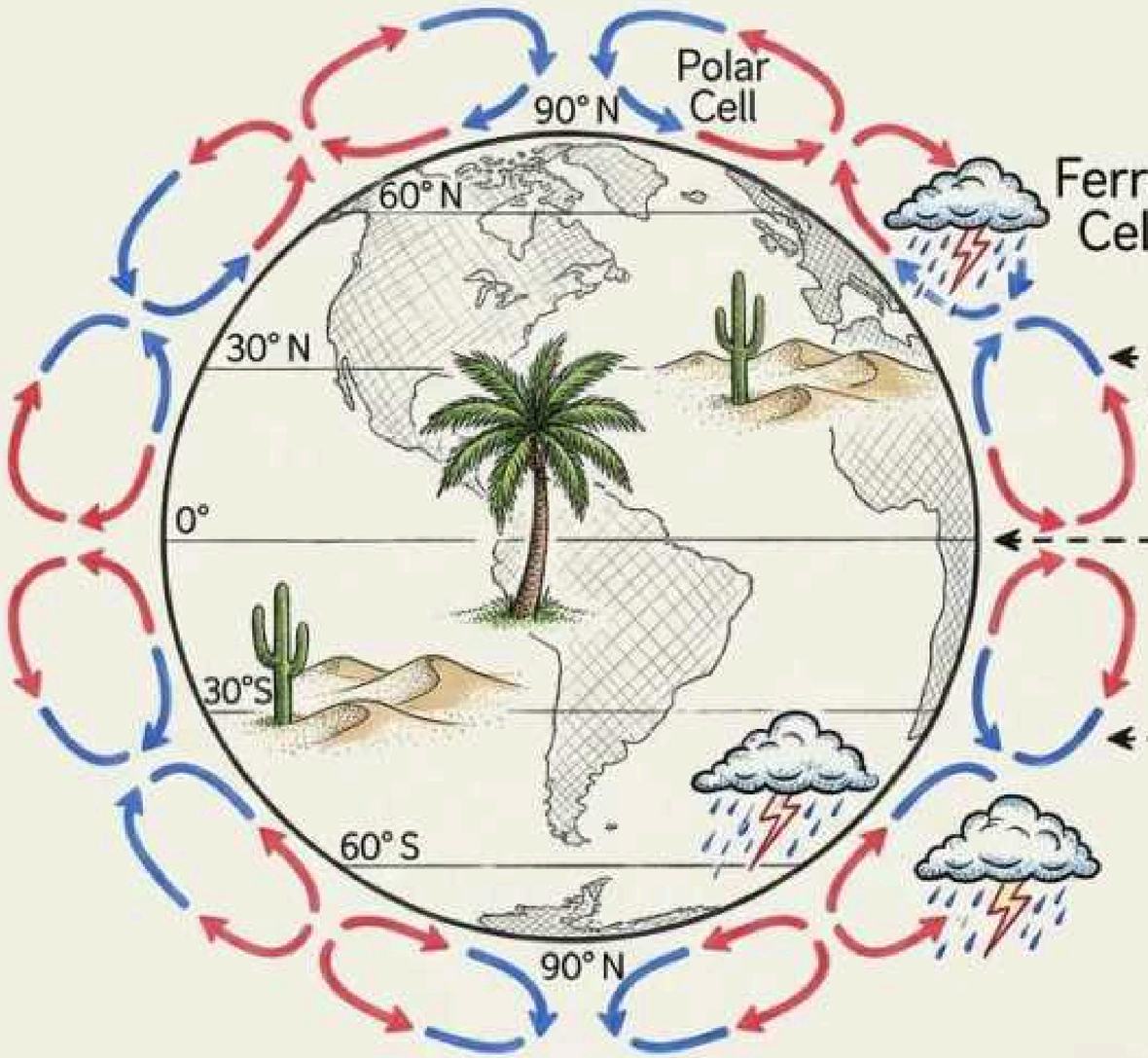
Southern Hemisphere: Bends Left.

Result: Steady Trade Winds.

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Global Circulation Cells

¶ 6.7



Equator (0°):
Rising warm air →
Heavy rain (Rainforests)

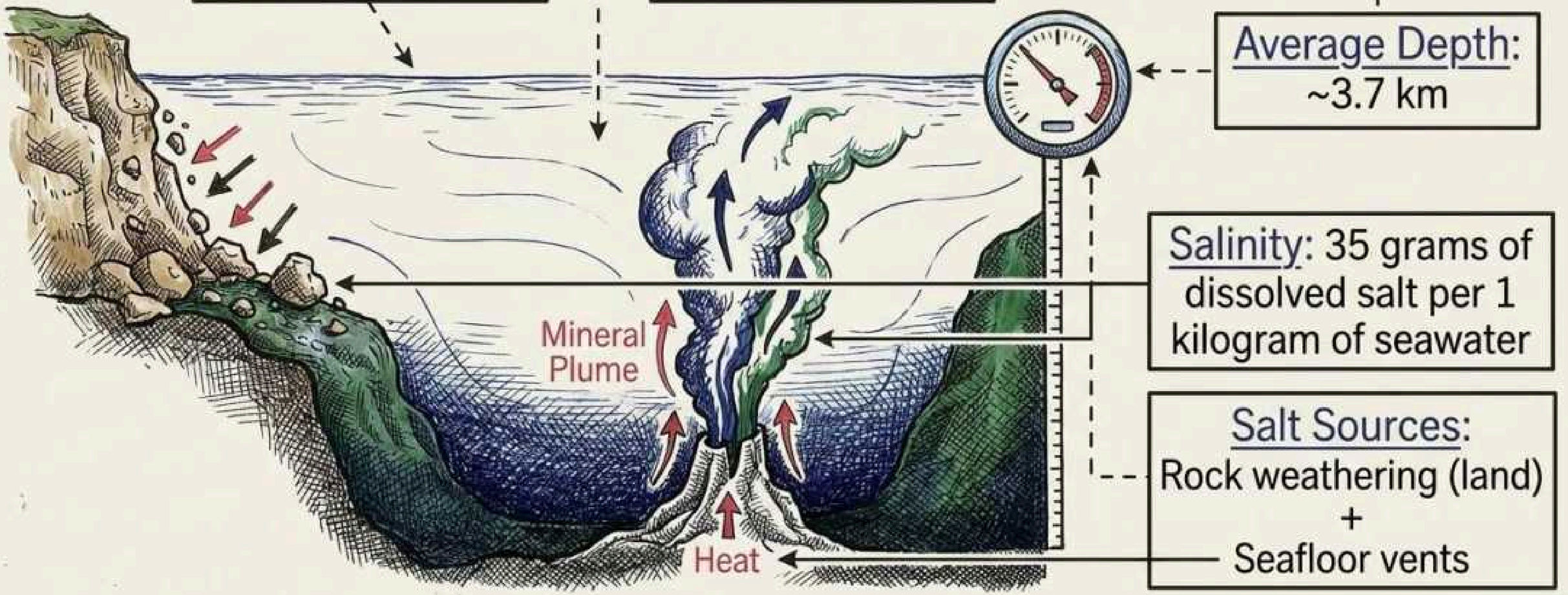
Subtropics (30° N/S):
Descending dry air →
Cloudless (Deserts)

Middle Latitudes:
Cold/warm air clash →
Storm tracks & Jet streams

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The Oceans at a Glance

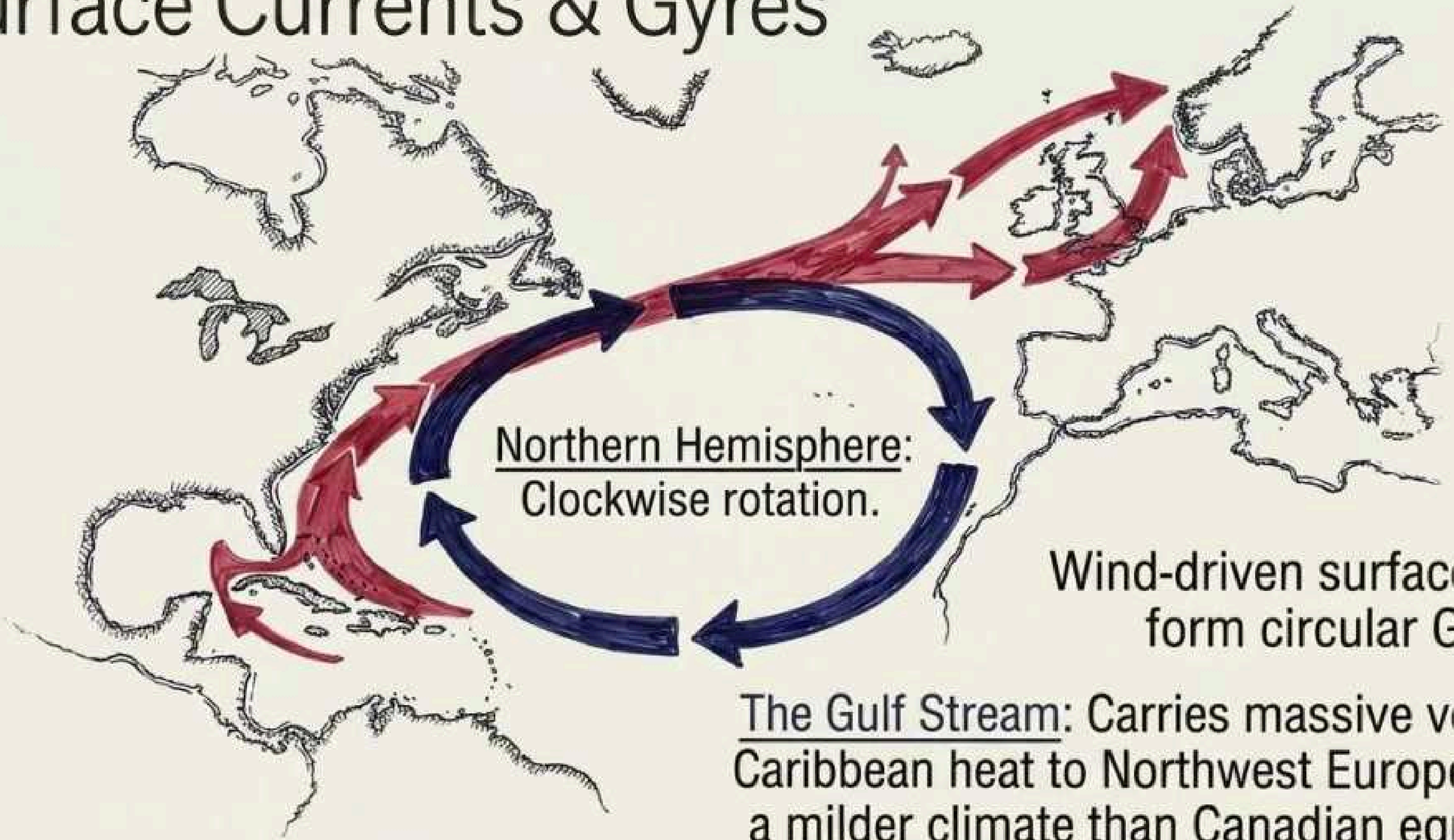
¶ 6.8



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Surface Currents & Gyres

¶ 6.9



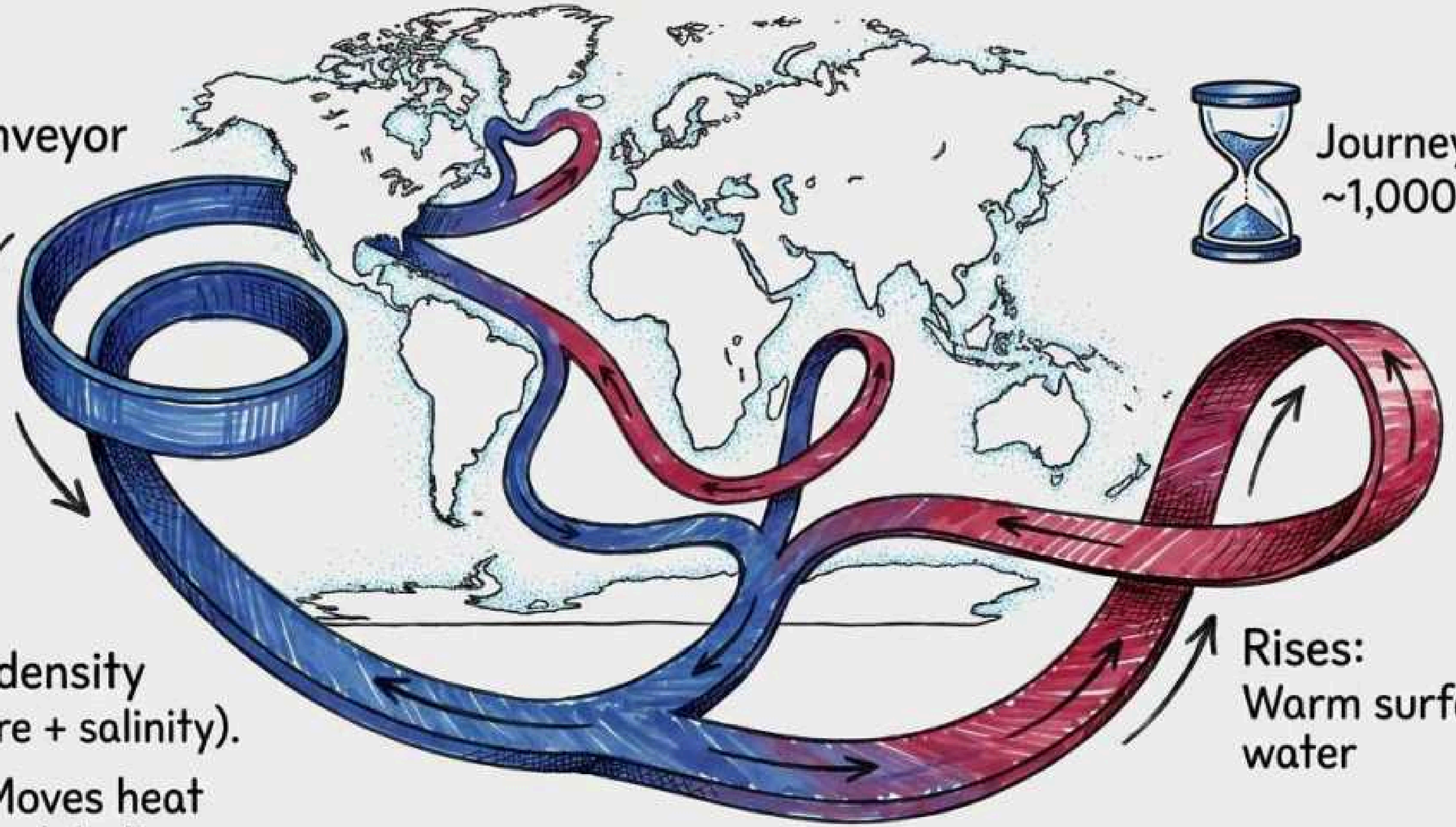
Wind-driven surface currents form circular Gyres.

The Gulf Stream: Carries massive volumes of Caribbean heat to Northwest Europe, creating a milder climate than Canadian equivalents.

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The Thermohaline Circulation

¶ 6.10



Global Conveyor Belt

Sinks:
Cold, dense, salty water.

Journey Time:
~1,000 years.

Rises:
Warm surface water

- Driven by density (temperature + salinity).
- Function: Moves heat and carbon globally.

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Ocean Heat Capacity

¶ 6.11

The top 3 meters of ocean



Total heat of the entire atmosphere

High Heat Capacity: Oceans hold far more heat than the air.

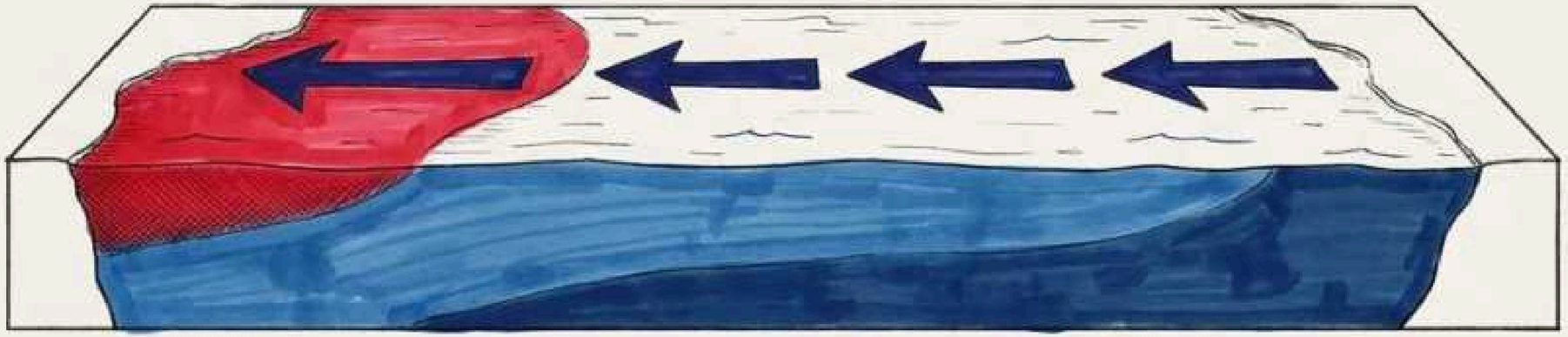
Result: Mild coastal climates and the absorption of human-trapped heat since the 1900s.

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El Niño

¶ 6.12

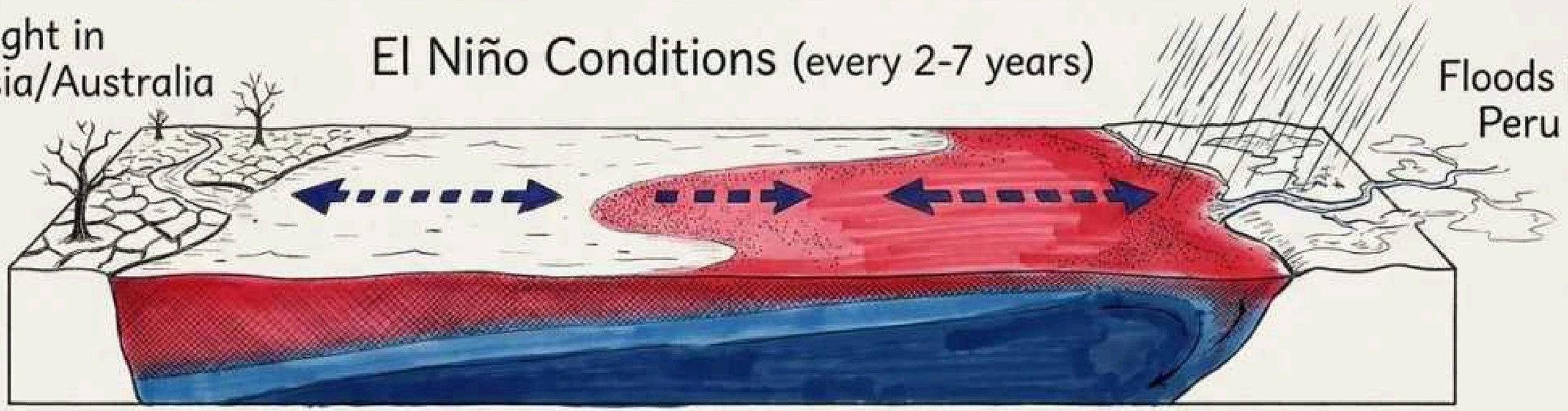
Normal Conditions



Drought in Indonesia/Australia

El Niño Conditions (every 2-7 years)

Floods in Peru

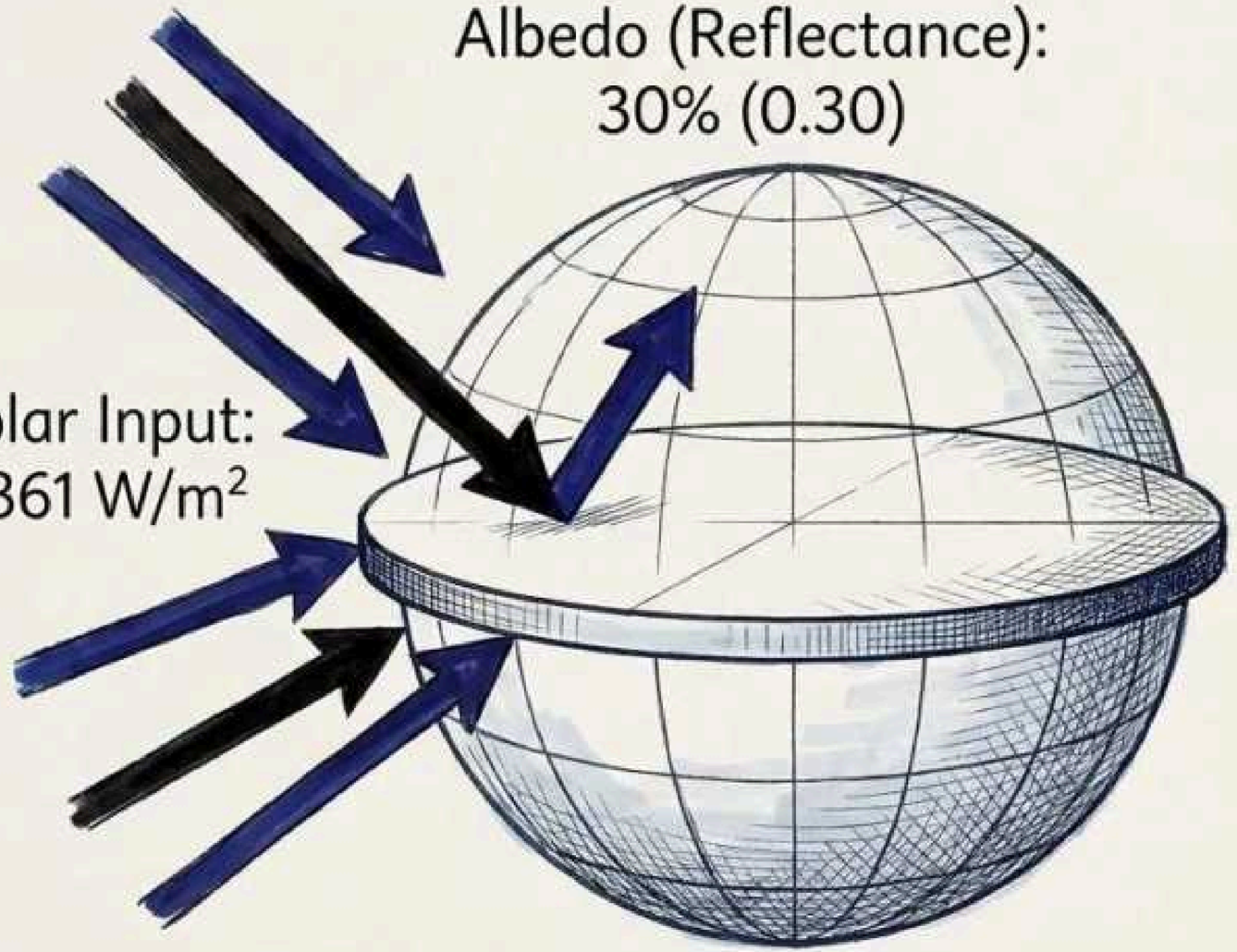


The main source of year-to-year variation in global weather.

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The Greenhouse Effect - Energy Balance

¶ 6.13



Energy In = Energy Out
(At equilibrium)

Absorption area:

Total sphere surface area is 4x its 2D cross-section.

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Stefan-Boltzmann Calculation

¶ 6.14

Absorbed Energy: $\frac{1{,}361 \times 0.70}{4} \approx 238\ W/m^2$

Stefan-Boltzmann Law: $238 = \sigma \times T^4$

Result: $T = 255$ Kelvin

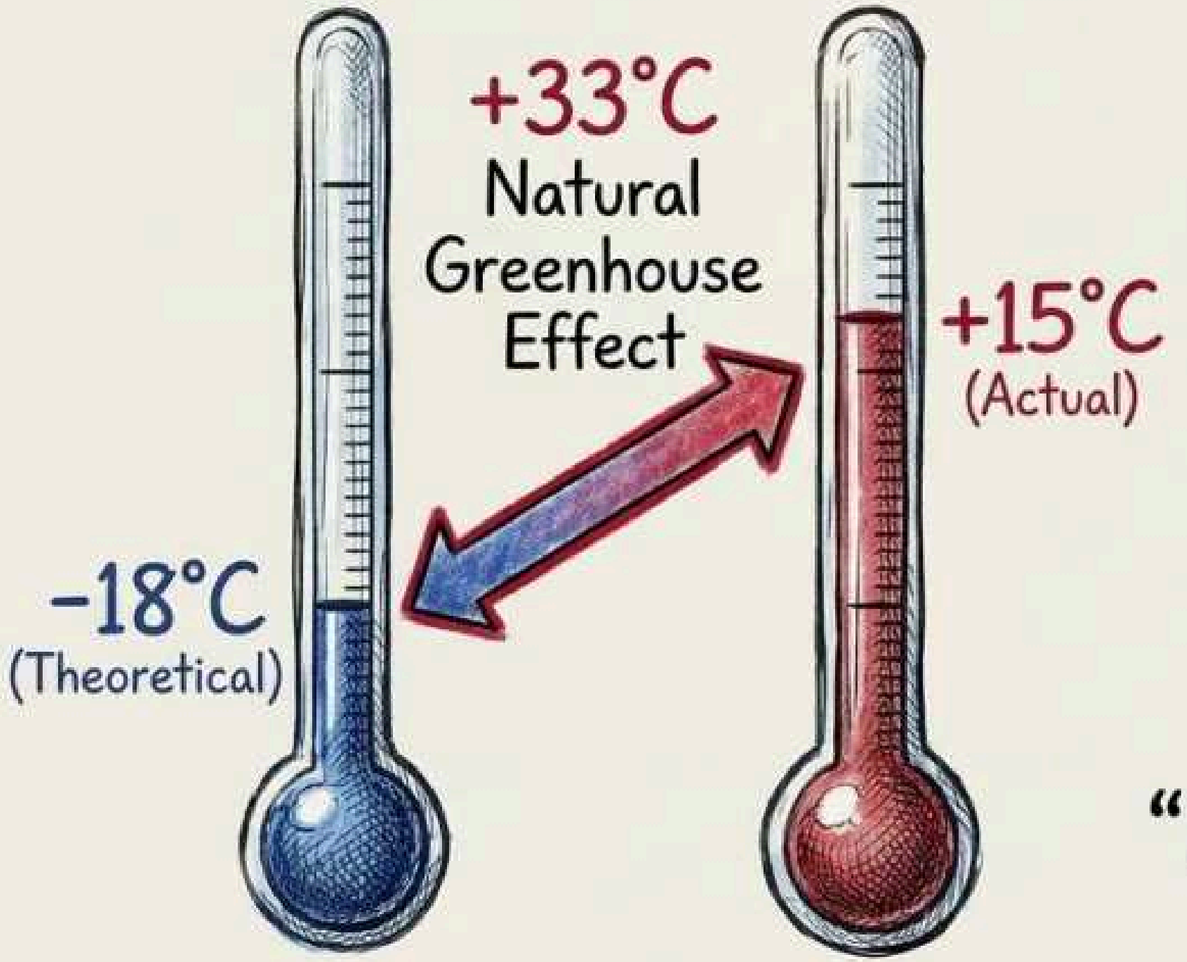
$255\ K = -18°C$

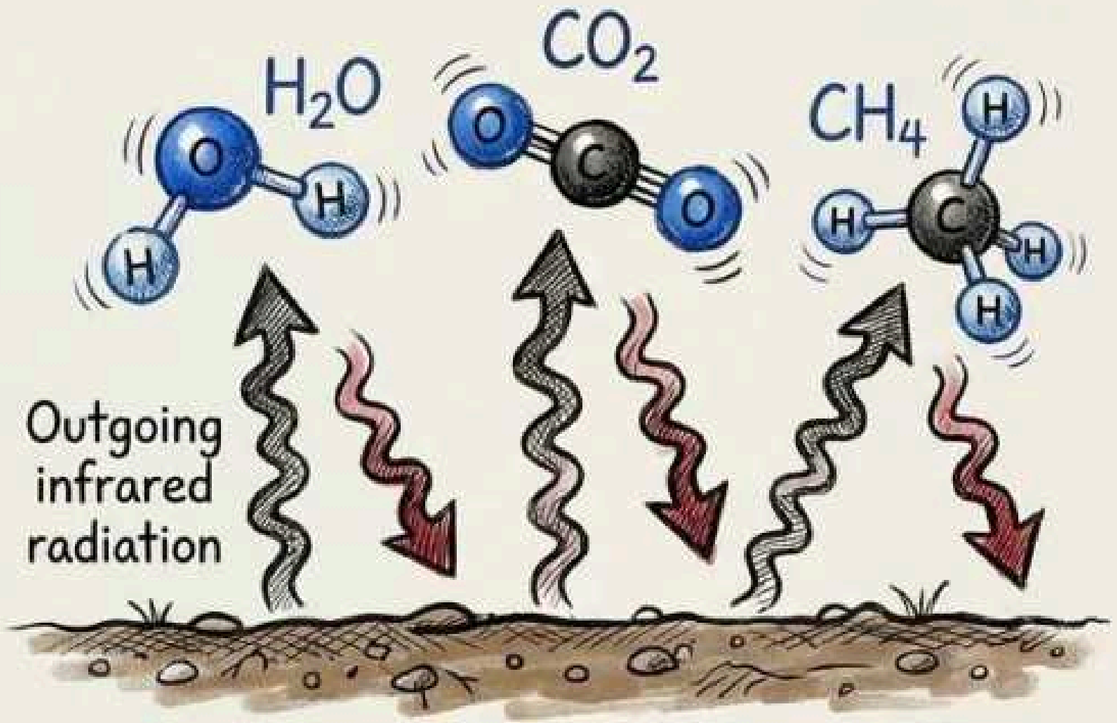
A planet with no greenhouse gases would be completely frozen.



The Natural Greenhouse Effect

¶ 6.15



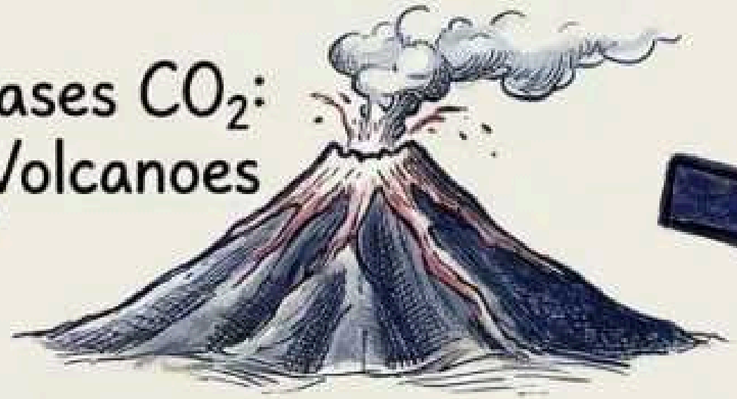


"Not a theory about pollution.
It is why Earth is livable."

The Carbon Cycle Thermostat

¶ 6.16

Releases CO_2:
Volcanoes





Removes CO_2:
Rock weathering
(slow)



Storage: Washed to sea



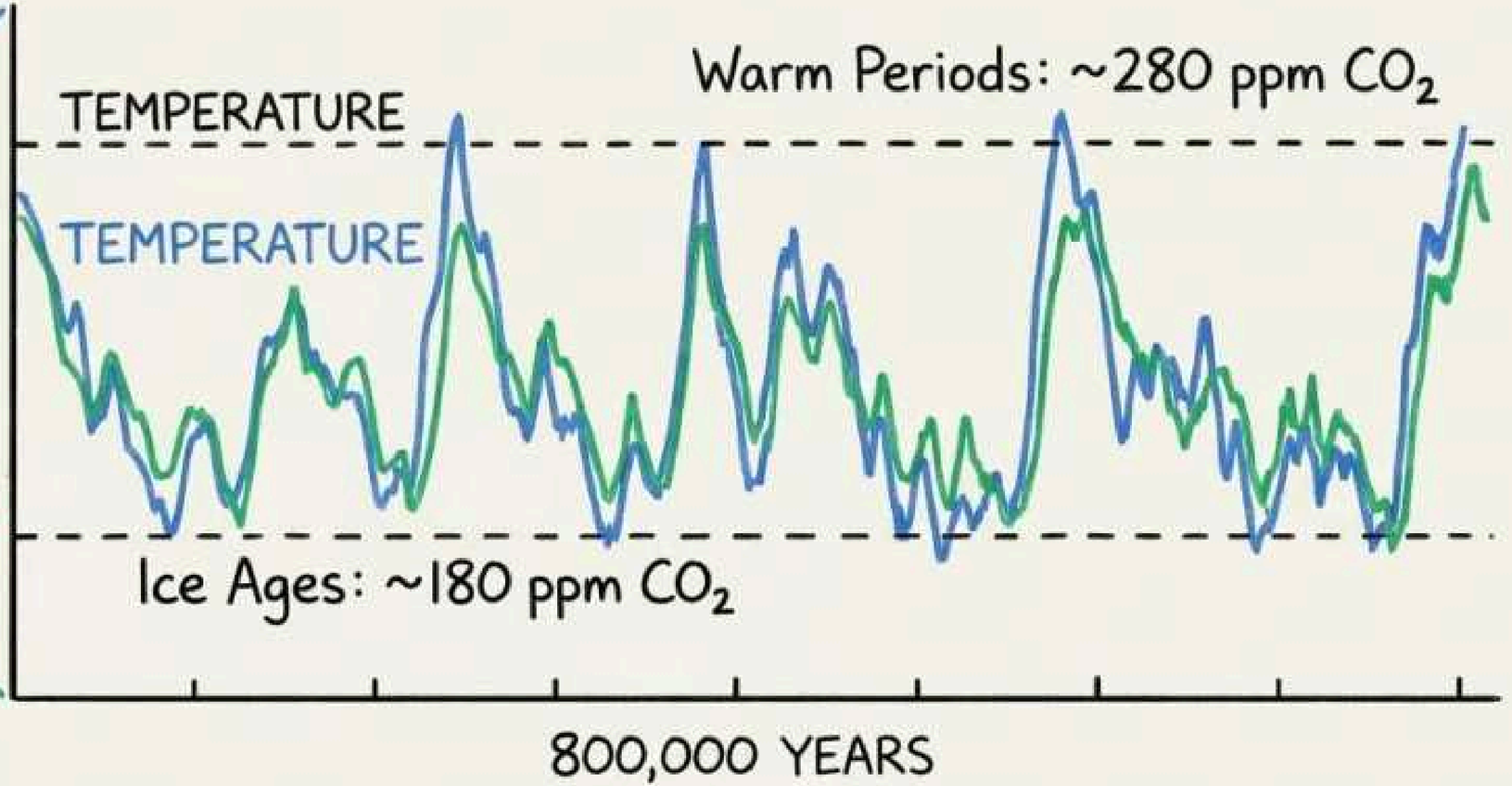
Locked in shells
and limestone

A millions-of-years
feedback loop acting as
Earth's thermostat.

PAST CLIMATE IN ICE CORES

¶ 6.17





Record: Trapped in Antarctic & Greenland ice bubbles.
Orbital cycles start the swings; CO_2 amplifies them.

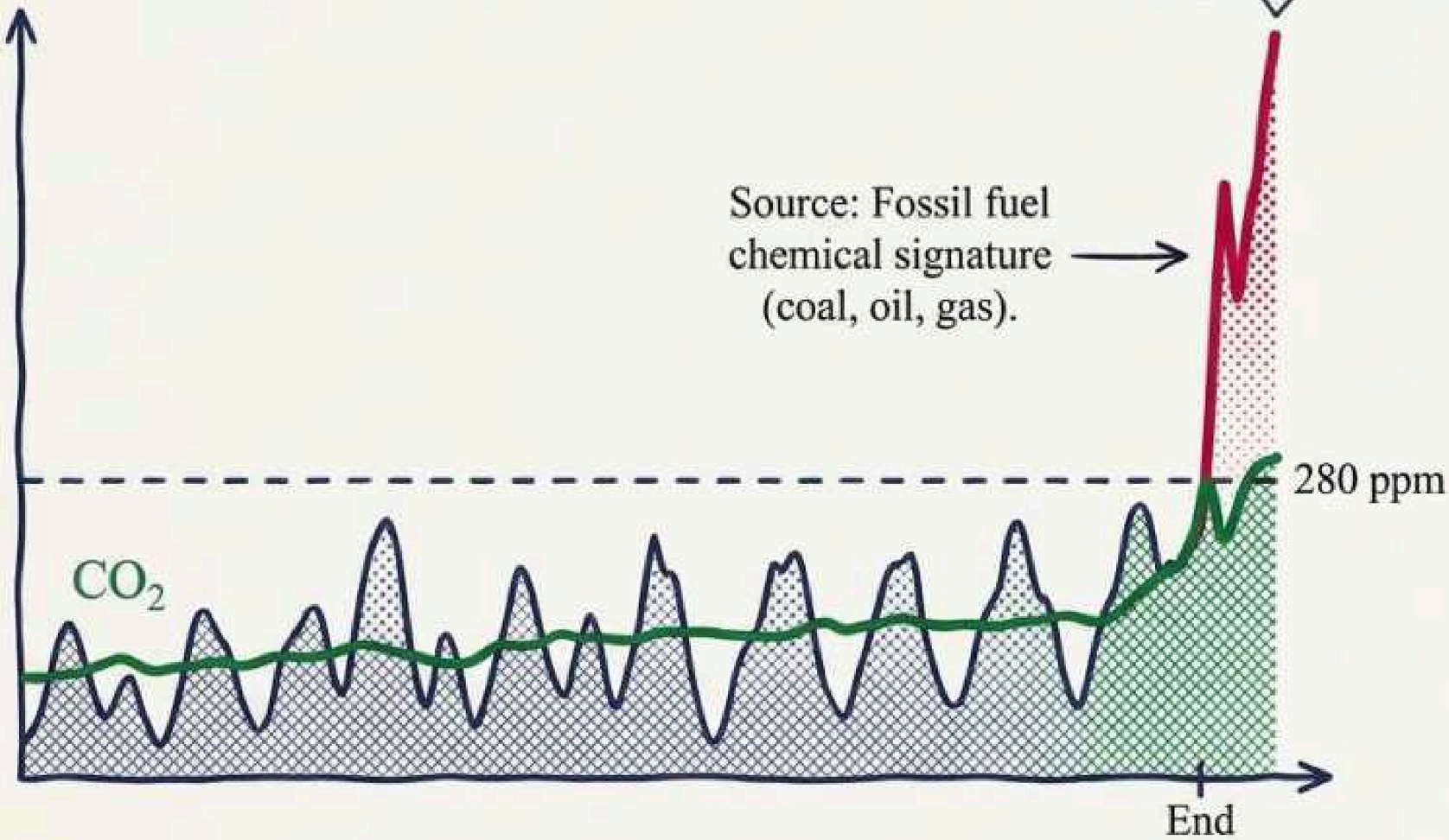
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Today's Climate Shift

¶ 6.18

Today's CO_2 Level:
~420 ppm
(50% above pre-industrial)

Source: Fossil fuel chemical signature (coal, oil, gas).



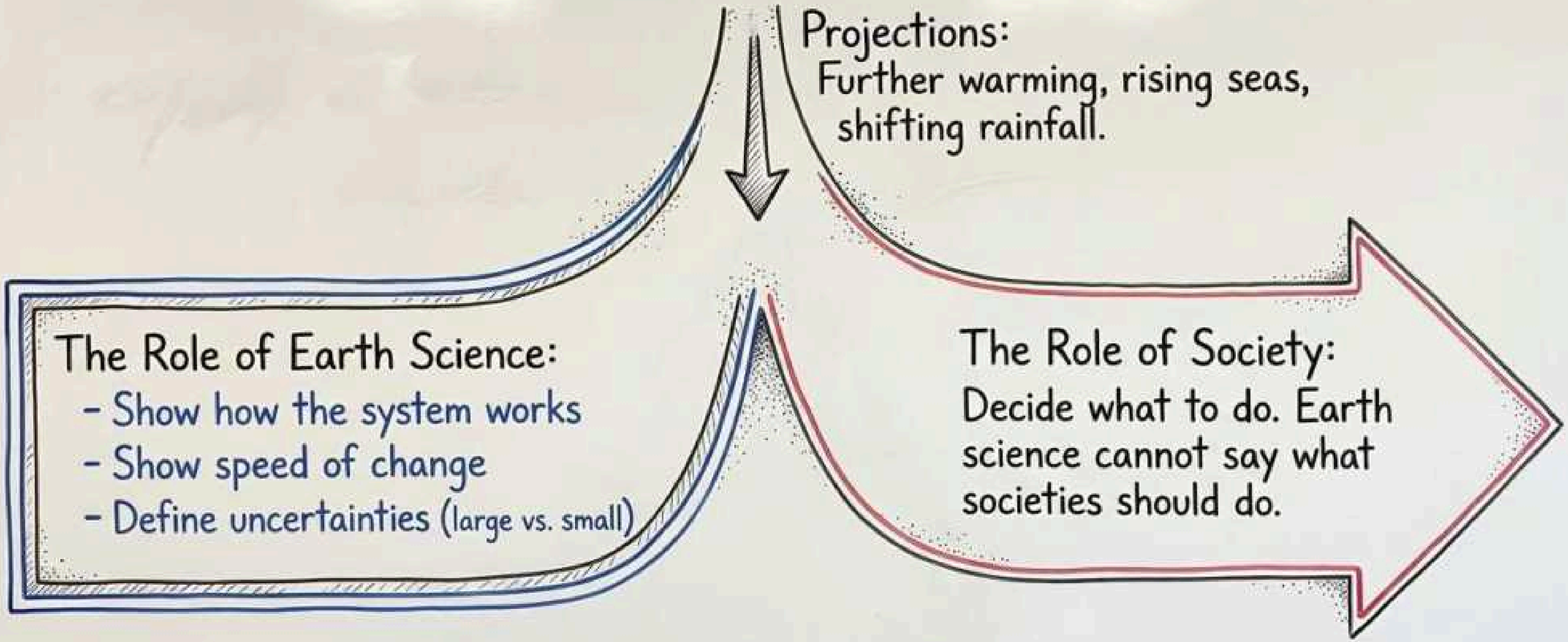


Impact: Global average temperature up +1.1 to +1.2°C since late 1800s.

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Science and Choice

¶ 6.19

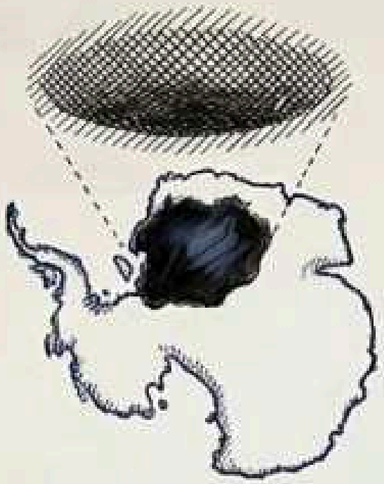


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The Ozone Layer (A Success Story)

¶ 6.20









1970s
Chemists link CFCs to stratospheric ozone destruction.

1985
Ozone hole discovered over Antarctica.

1987
Montreal Protocol signed to phase out CFCs.

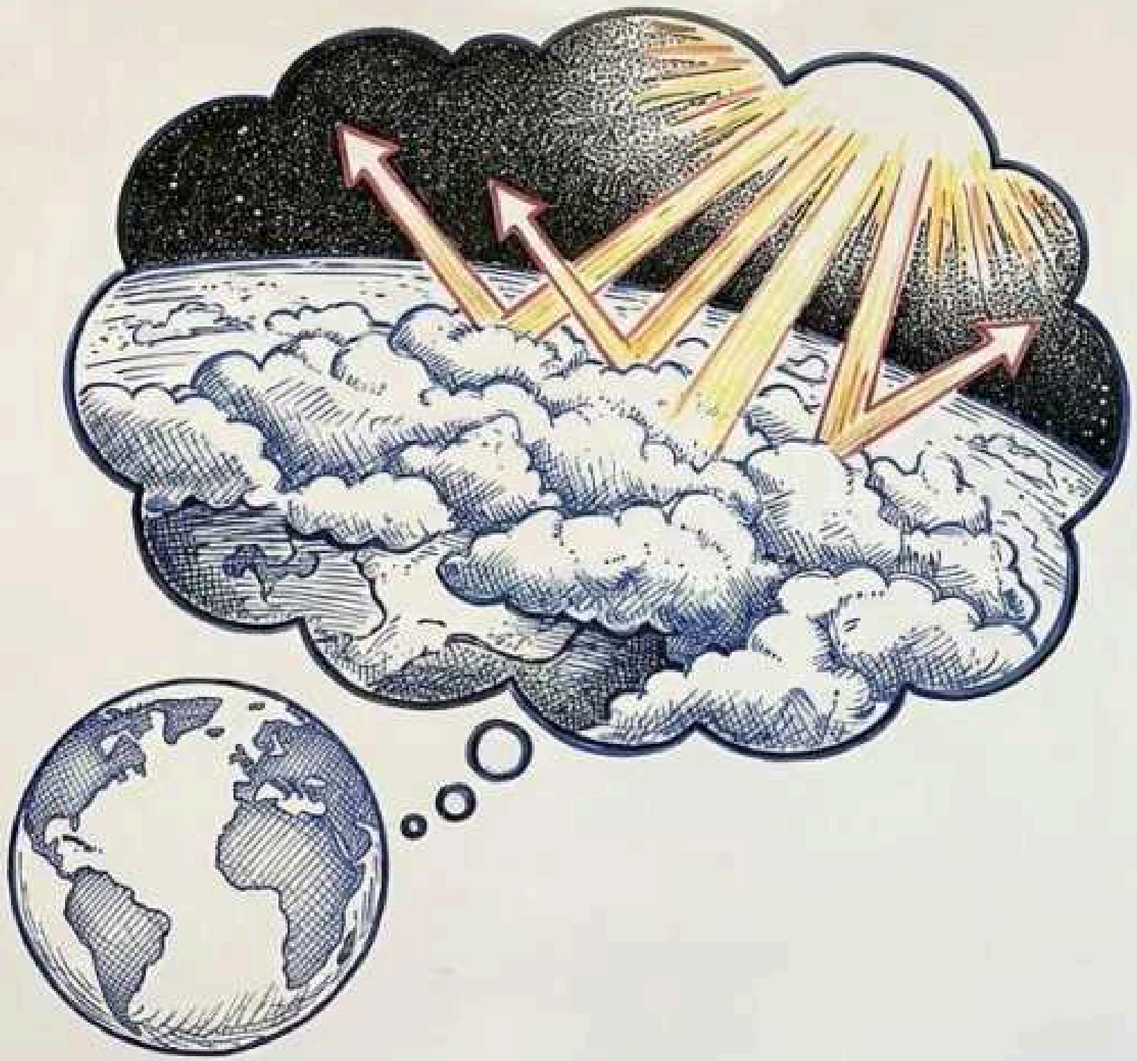
Today
The ozone layer is recovering.

"A model of science leading to action."

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The Final Question

¶ 6.21



Challenge Problem:

Suppose Earth's Albedo rises from 0.30 to 0.32 (more cloud & ice).

Without changing anything else, would the effective temperature rise or fall? [_____]

Roughly by how much? [_____]

(Hint: Use the Stefan-Boltzmann method from ¶ 6.13 & 6.14).

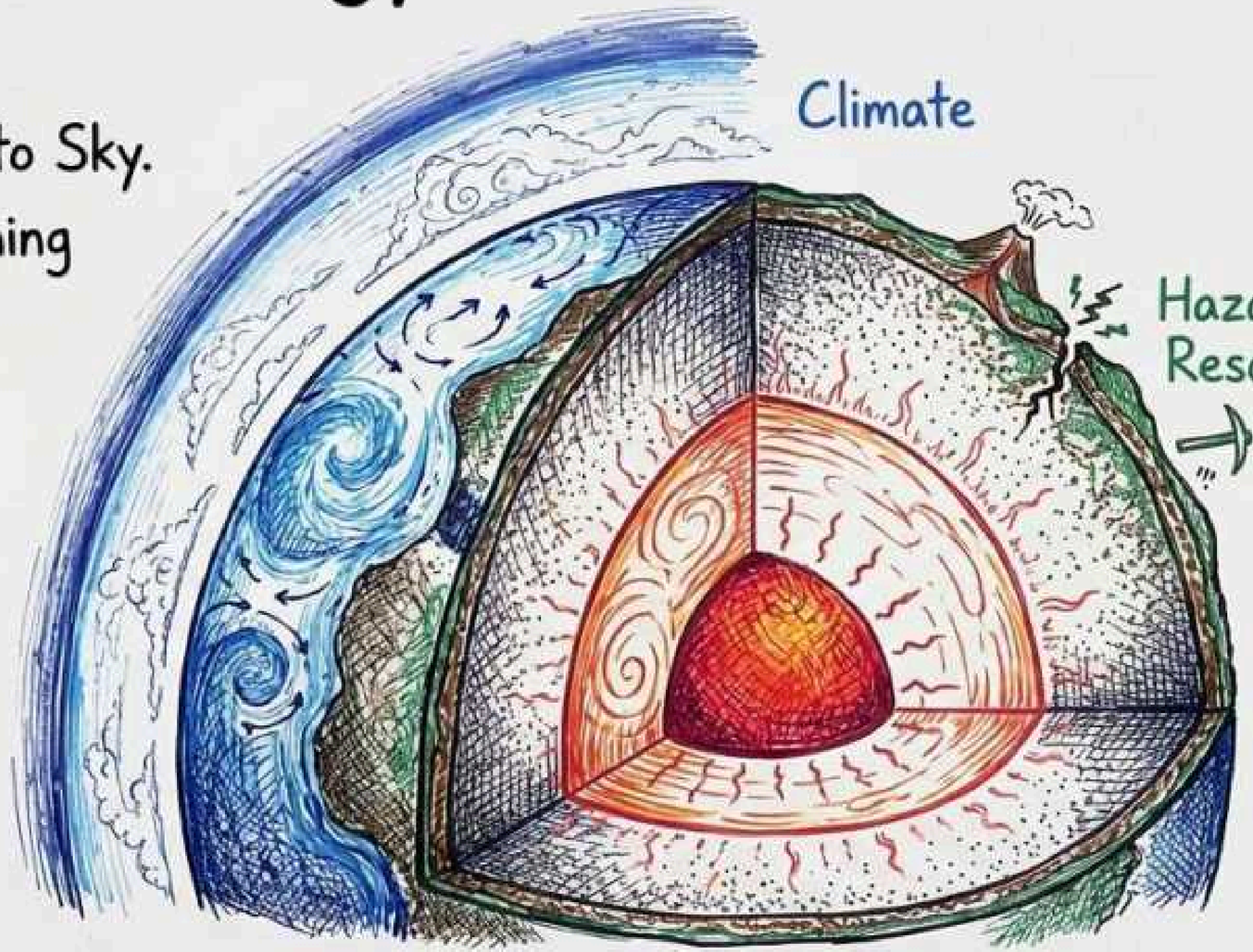
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End of Geology 101 B

¶ 6.22

From Core to Sky.

From Beginning to Present.



Earth Science equips us to understand:

Hazards
Resources
Climate.

Thank you for watching.

What will you build with it?

Questions: garyanderson@mail.grokbot.com | X: @garyanderson