Welcome to ENVS 101 B: Lecture 1

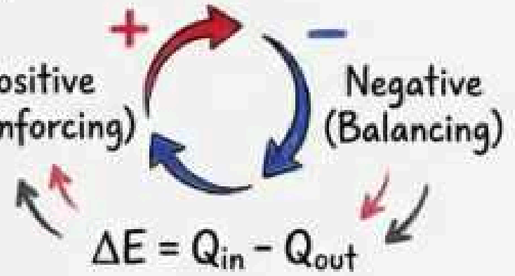


Gemini Notebook

Earth as a System: Energy and Matter

¶ 1.2

Systems & Feedback



Sunlight & Heat Balance

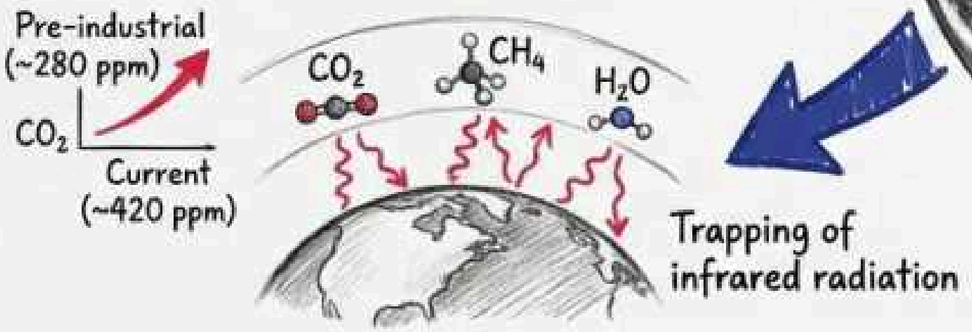


Incoming Solar Radiation (S)

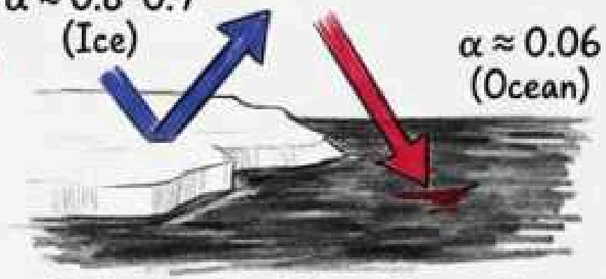
Outgoing Longwave Radiation (L)

$S(1-\alpha) \approx \sigma T^4$

Greenhouse Effect



Albedo

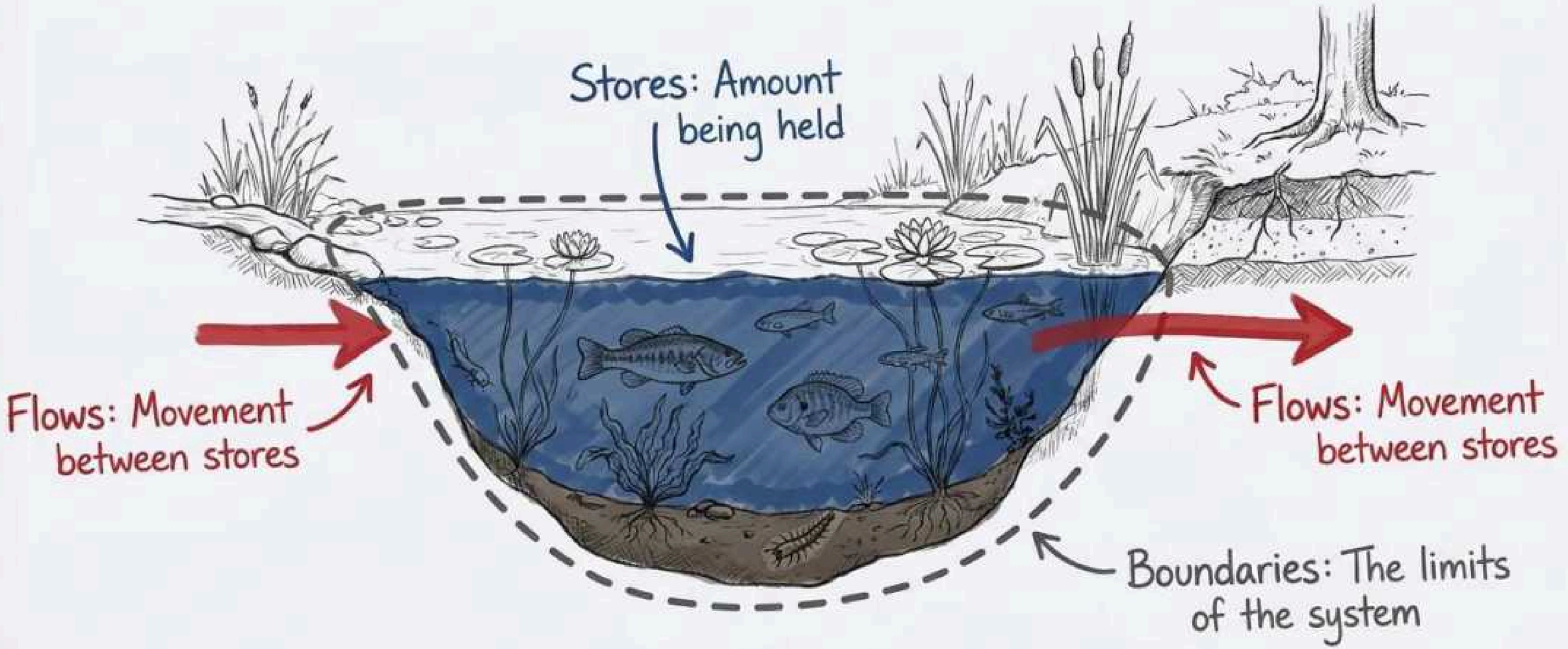


Reflectivity of Earth's surface

Foundational for all later topics (Food Webs → Climate Change).

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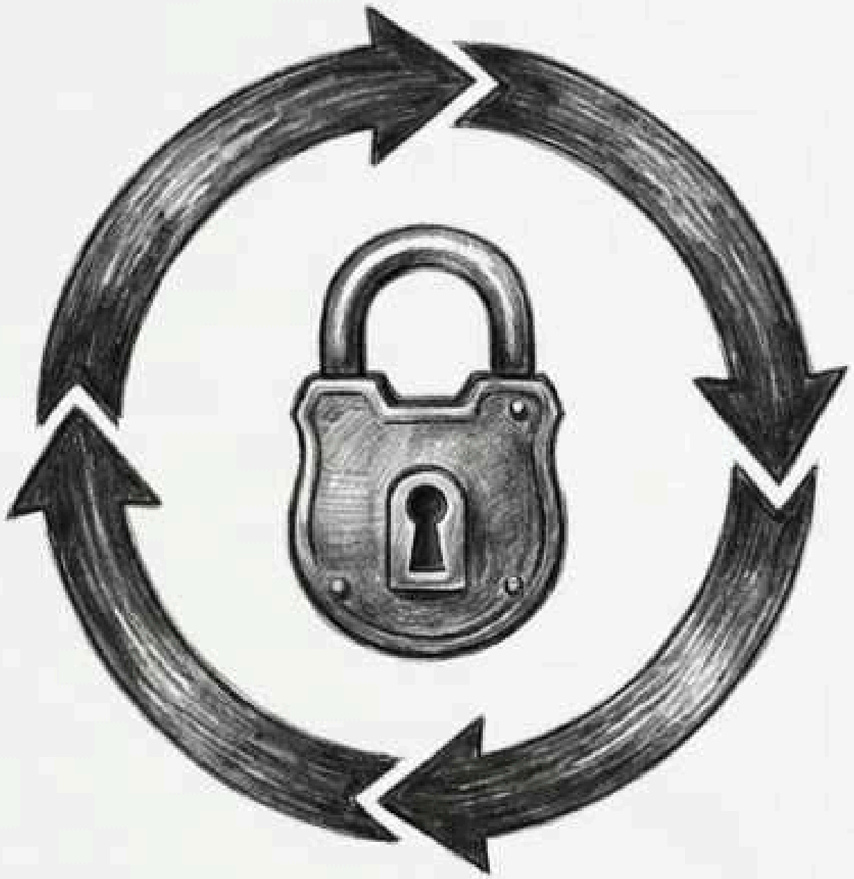
Defining a System: Parts Interacting as a Whole



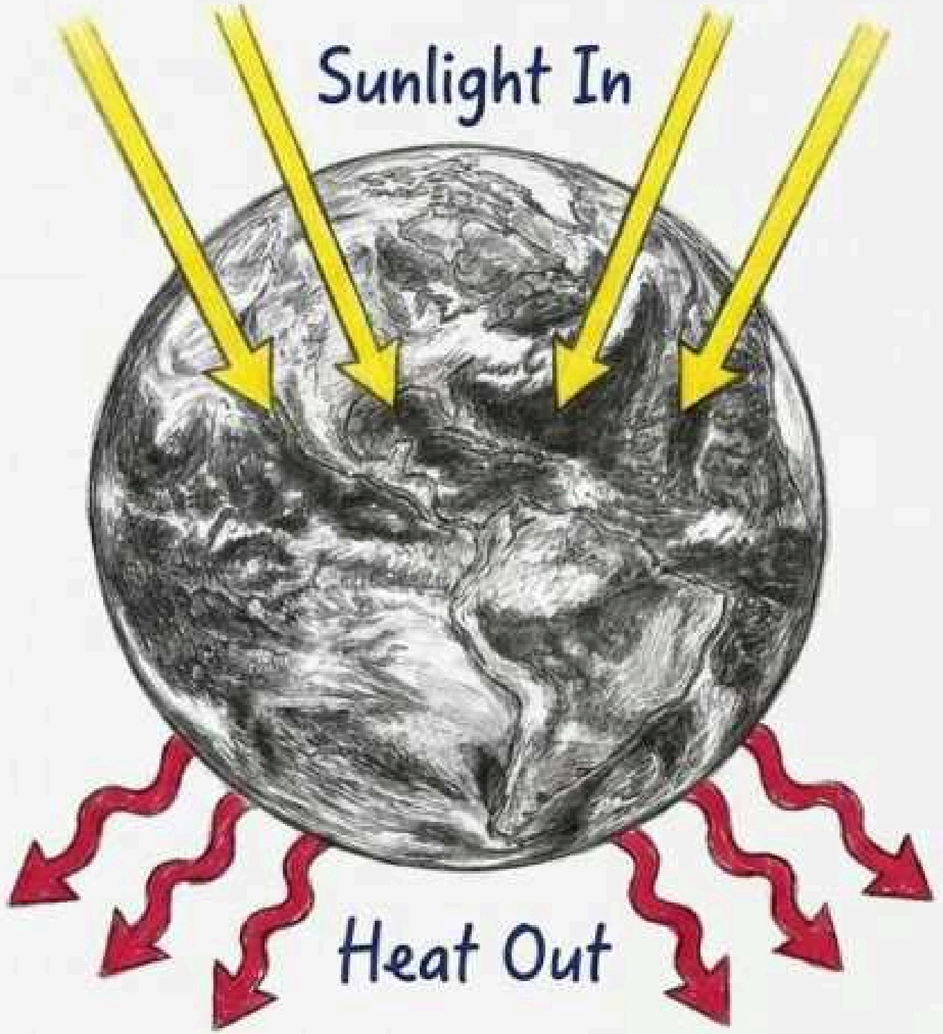
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Earth's Boundaries: Matter vs. Energy

¶ 1.4



Matter: Almost Closed
(Atoms Recycled)



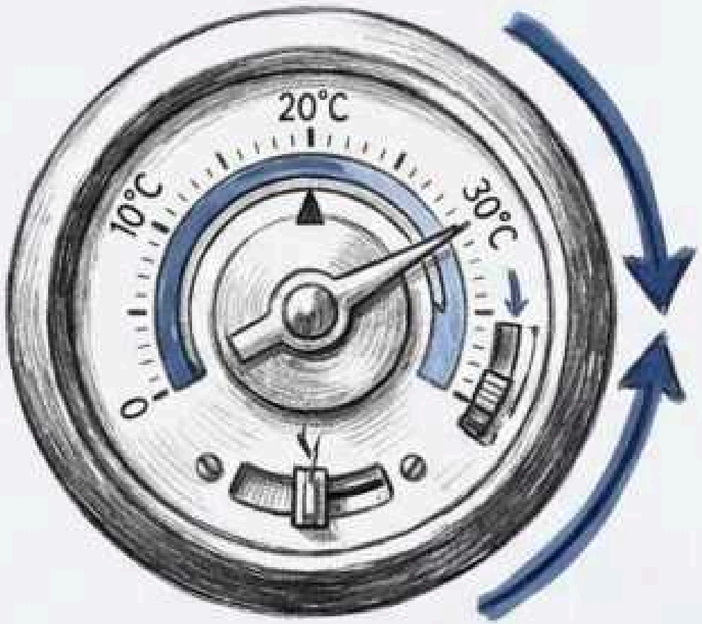
Energy: Open System

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Systems are Governed by Feedback

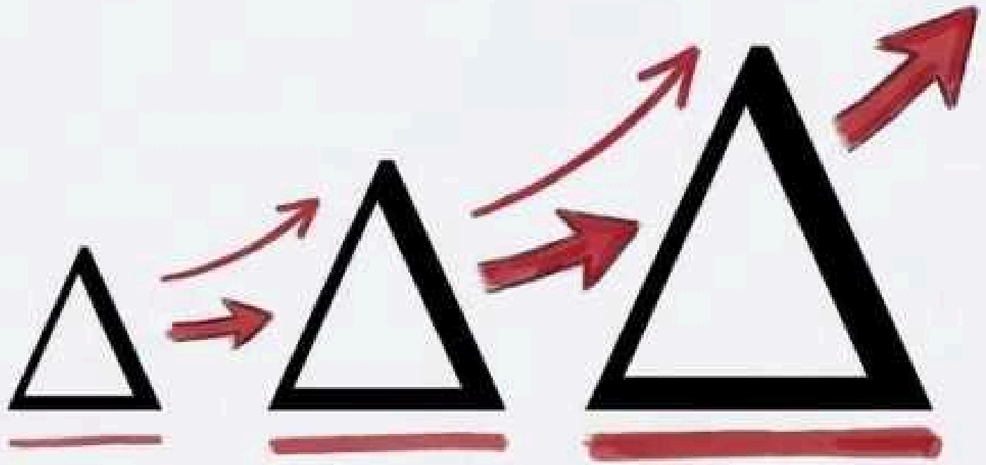
¶ 1.5

Negative Feedback



Reduces change →
Keeps system stable

Positive Feedback

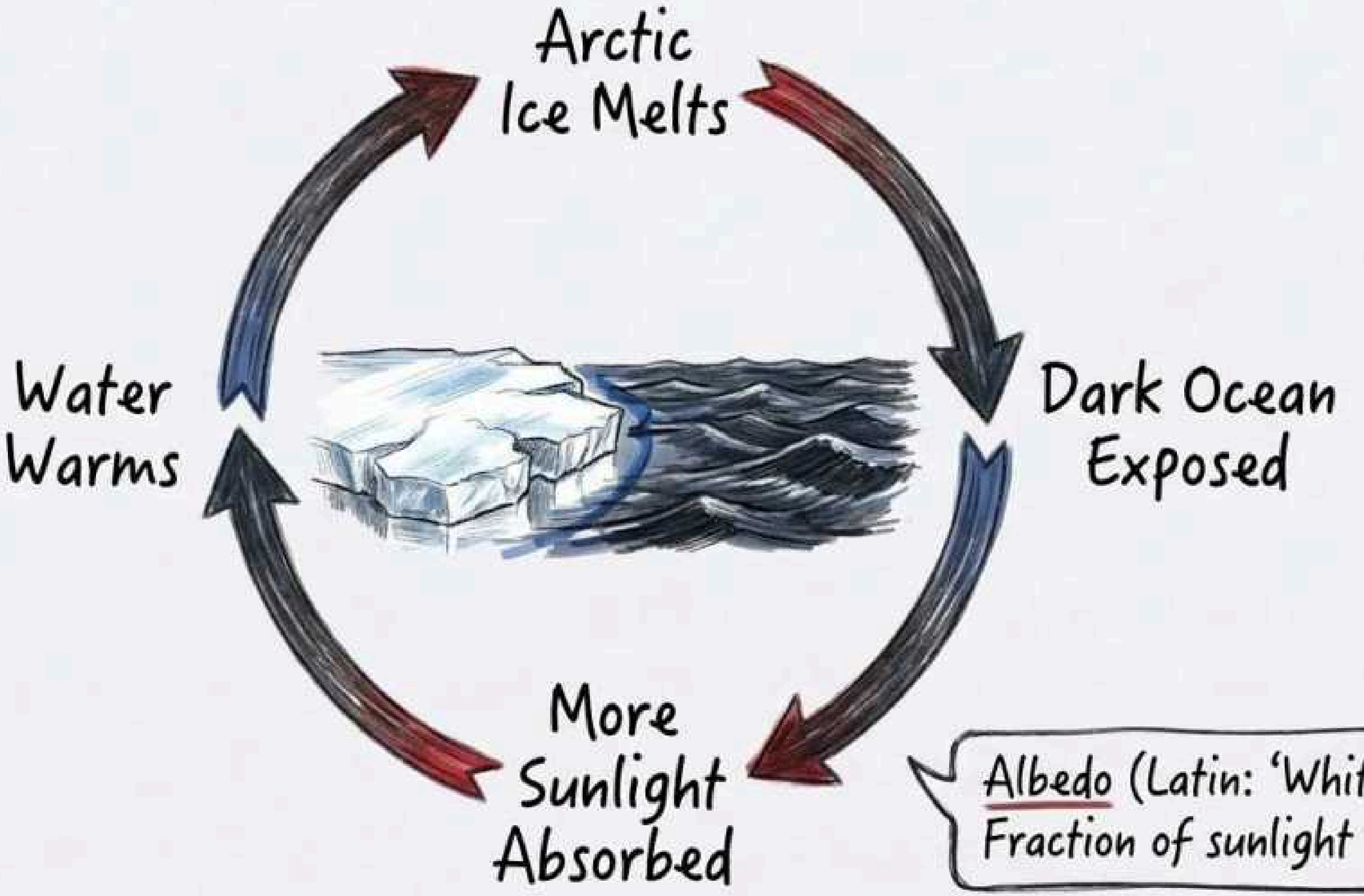


Amplifies change → Pushes system away from start

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Positive Feedback: The Ice-Albedo Effect

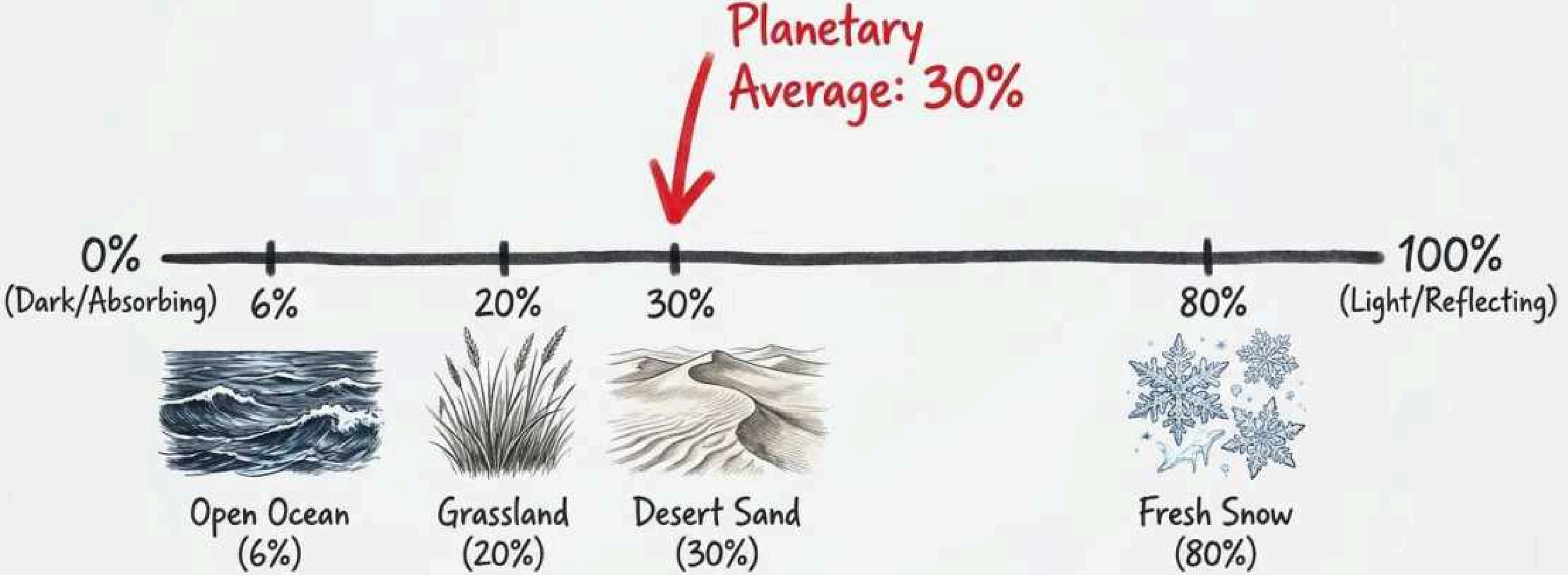
¶ 1.6



Albedo (Latin: 'Whiteness') = Fraction of sunlight reflected.

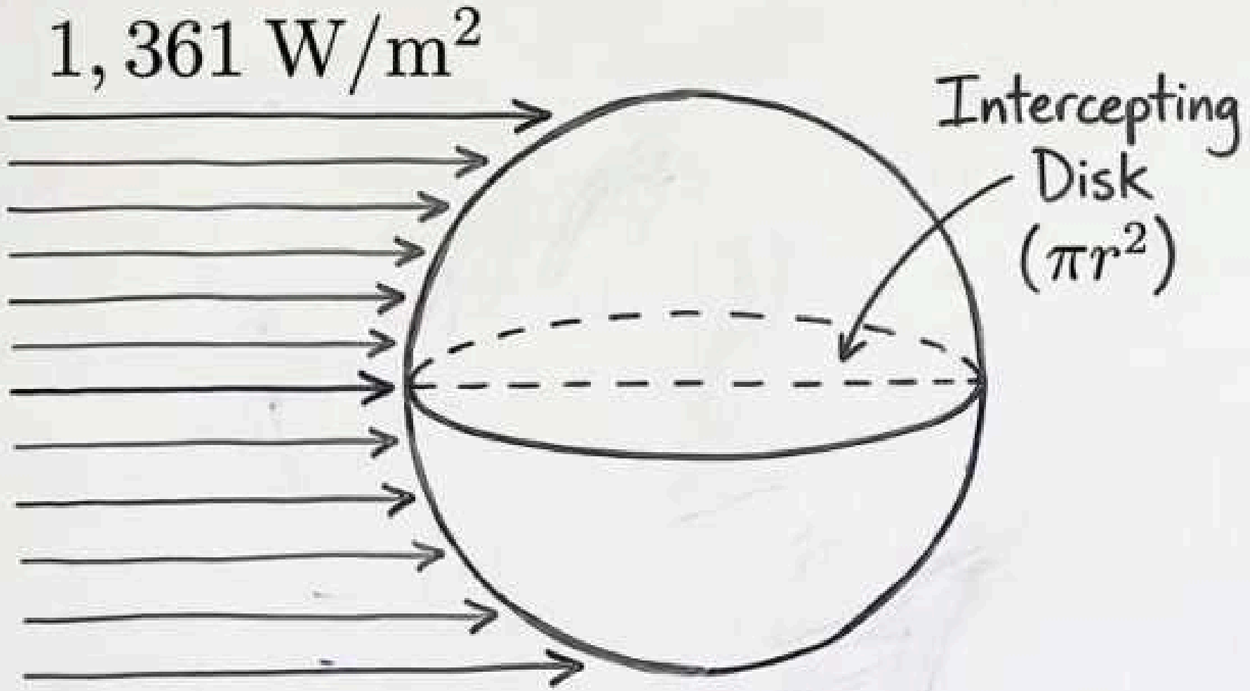
Albedo Values Across Surfaces

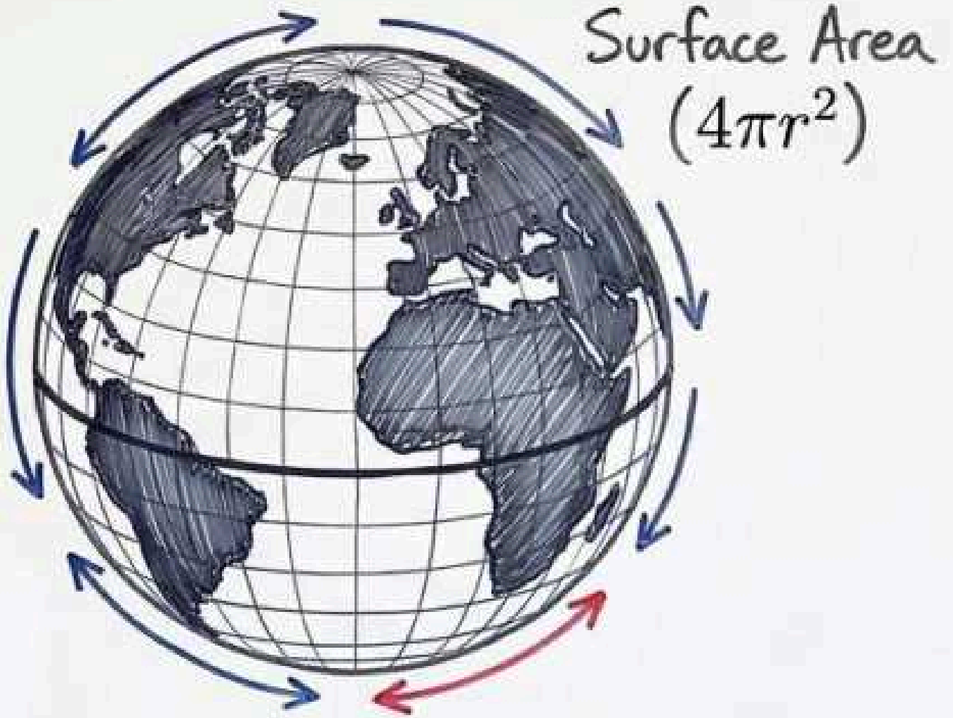
¶ 1.7



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Calculating Incoming Solar Energy (Insolation)

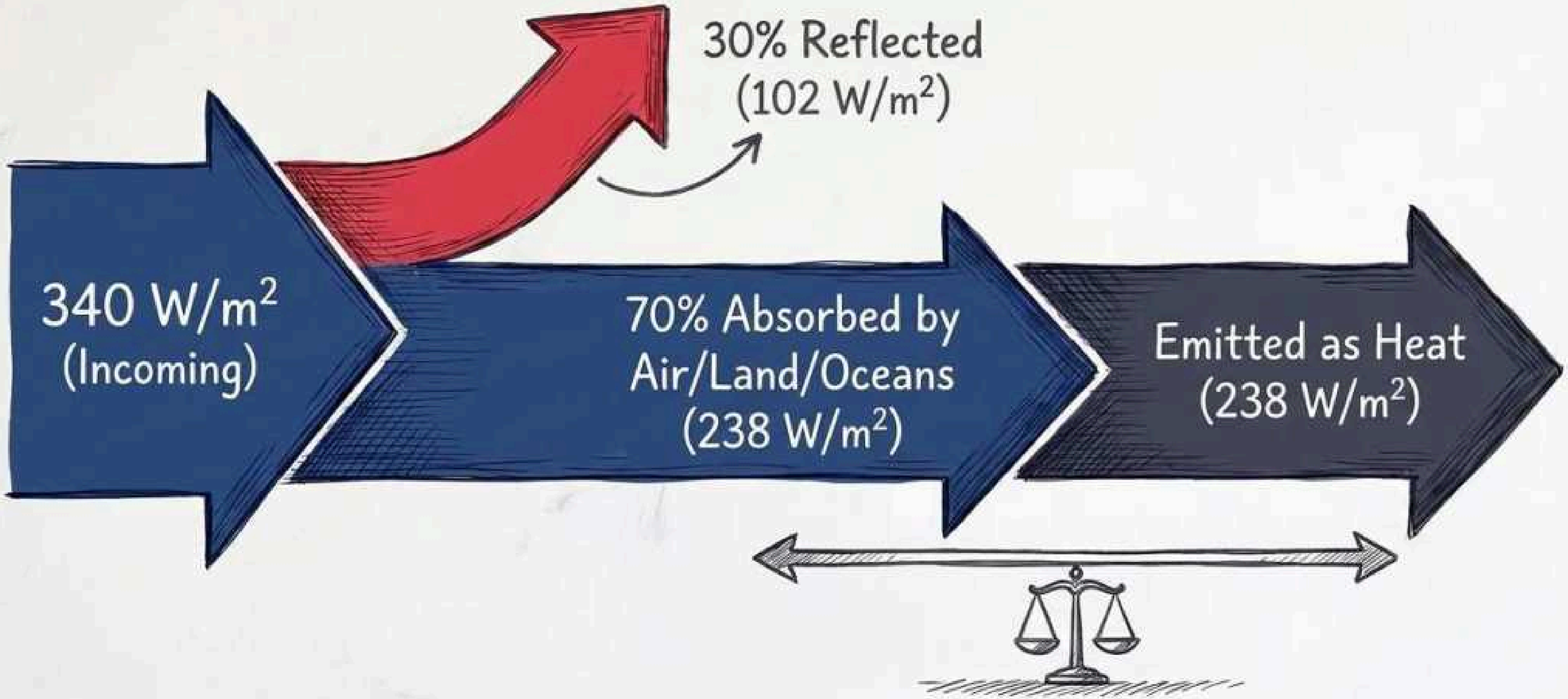




$$1,361 \div 4 \approx 340\ \frac{\mathrm{W}}{\mathrm{m^2}}$$

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In Balance: Energy In = Energy Out

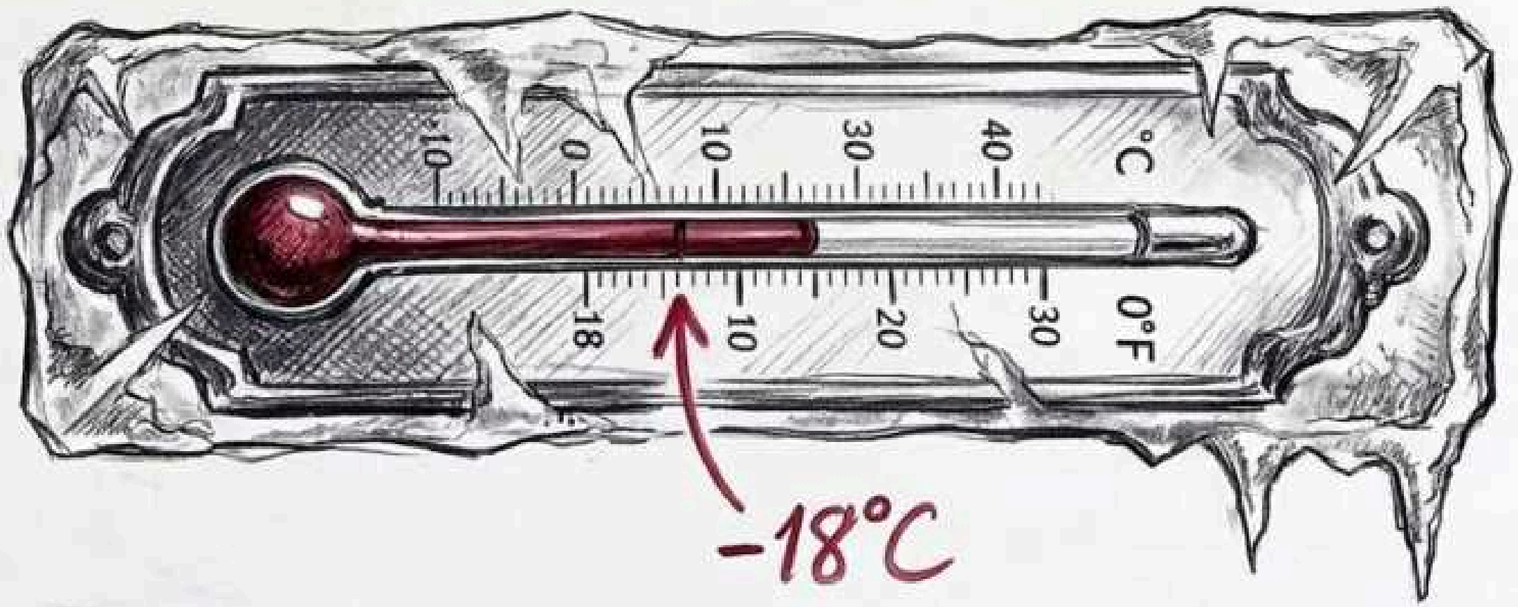


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Calculating Earth's Baseline Temperature

$$E = \sigma T^4$$

If $E = 238\ \mathrm{W/m^2}$, then $T = 255\ \mathrm{K}$ or $-18°\mathrm{C}$



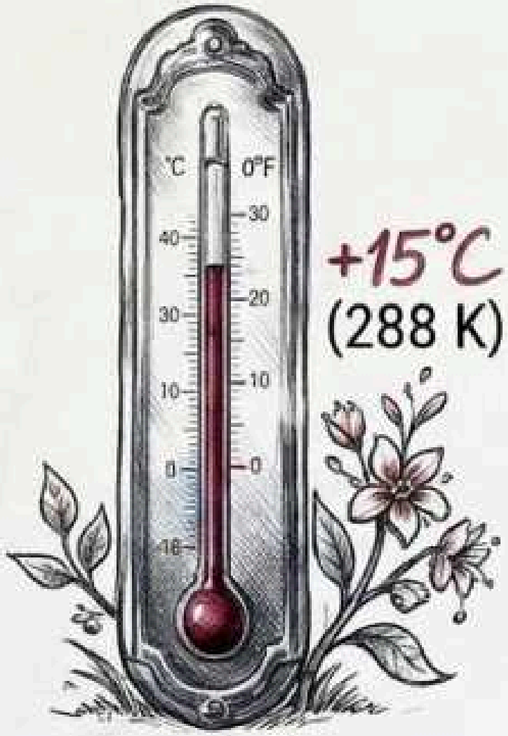
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The 33-Degree Difference



−18°C
(255 K)

Calculated:
Frozen Earth



+15°C
(288 K)

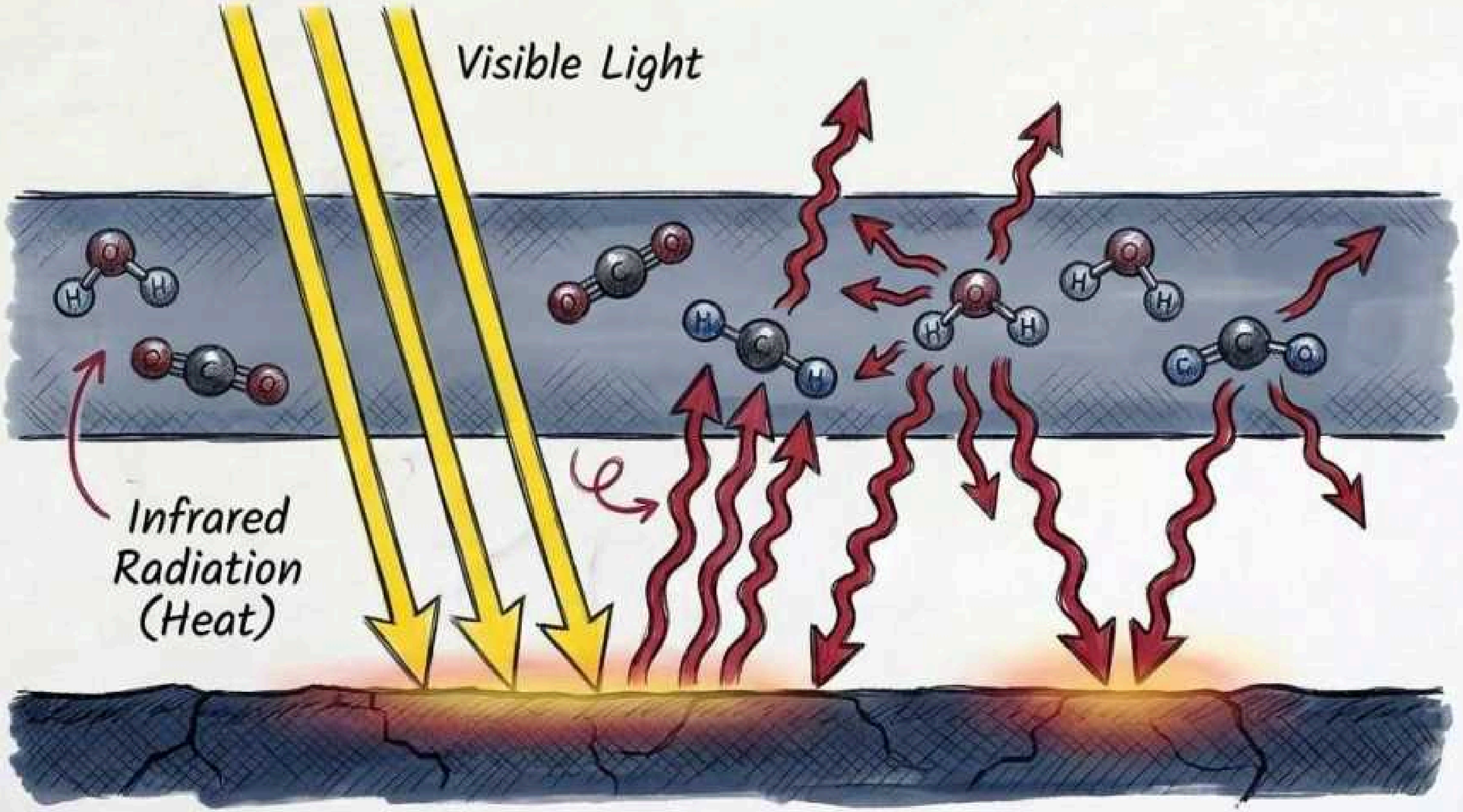
Actual:
Habitable Earth

The Natural Greenhouse Effect (+33°C)

Not a pollution problem—a basic requirement for life.

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How the Atmosphere Warms the Surface



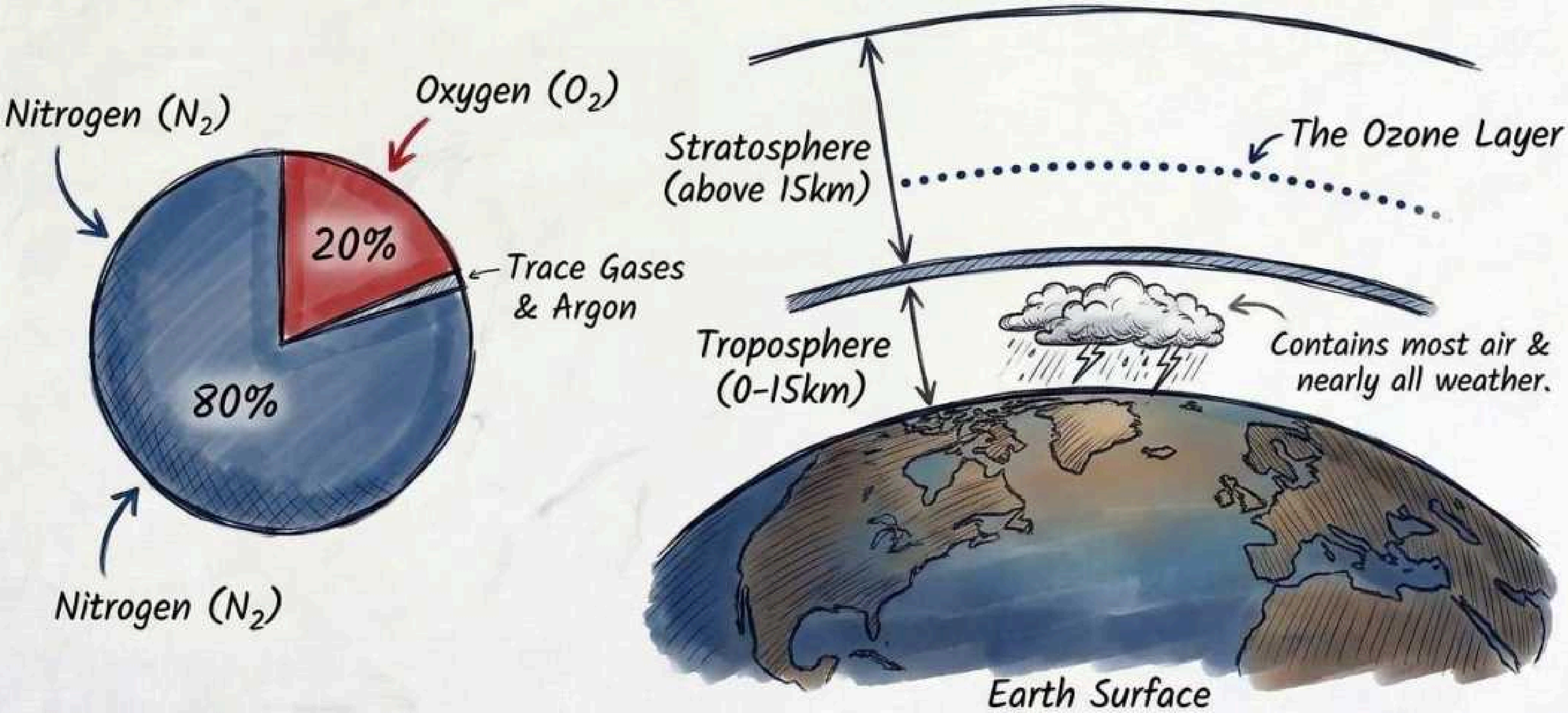
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Greenhouse Gases: Amplifiers vs. Drivers

The Amplifier	
Water Vapor (H_2O)	The strongest total effect. Amount in air is controlled entirely by temperature. It reacts to the system.
The Drivers	
CO_2, CH_4, N_2O	Persist for years/centuries. Amount is controlled by chemistry and human activity. They set the stage for the system.

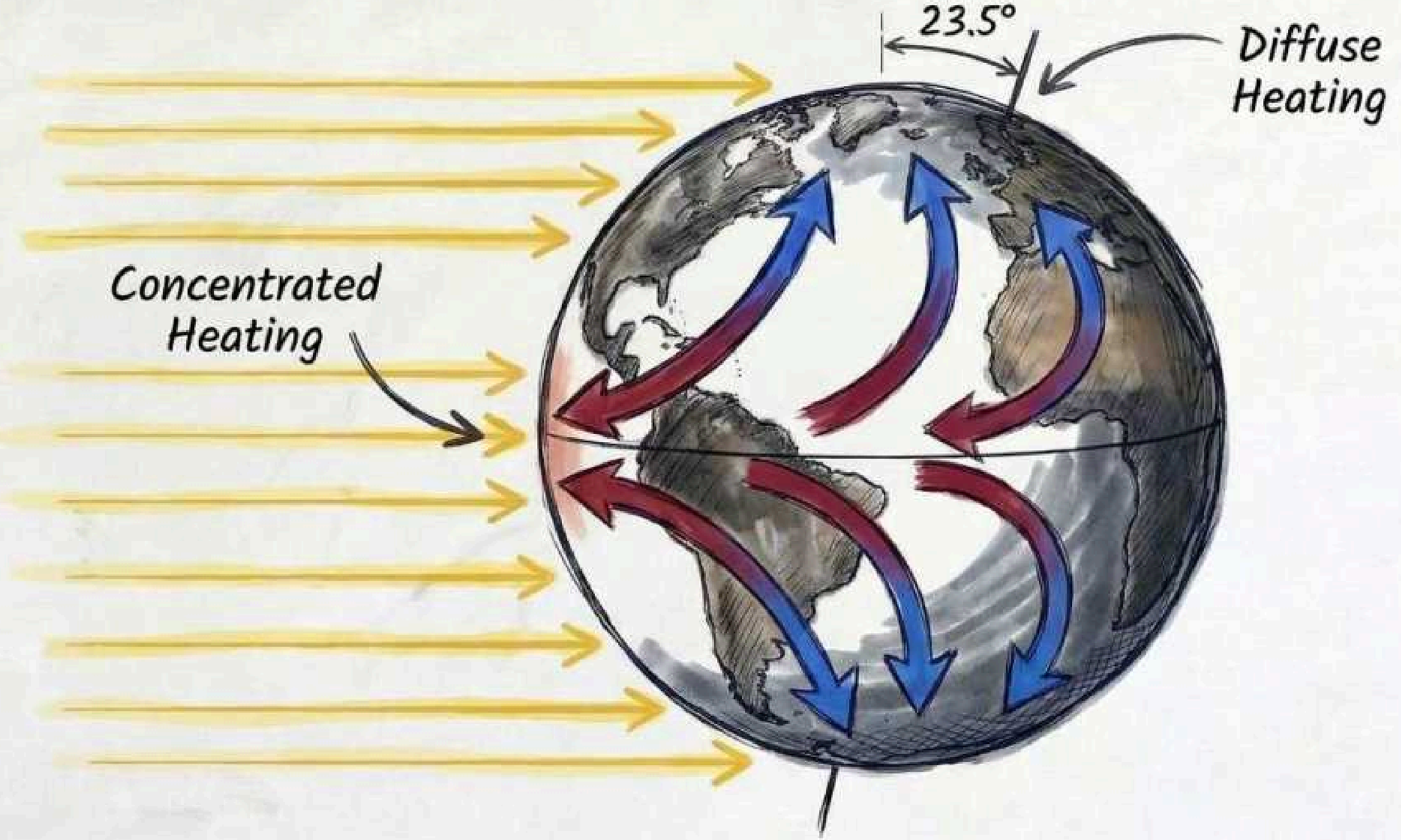
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The Atmosphere: A Thin Shell



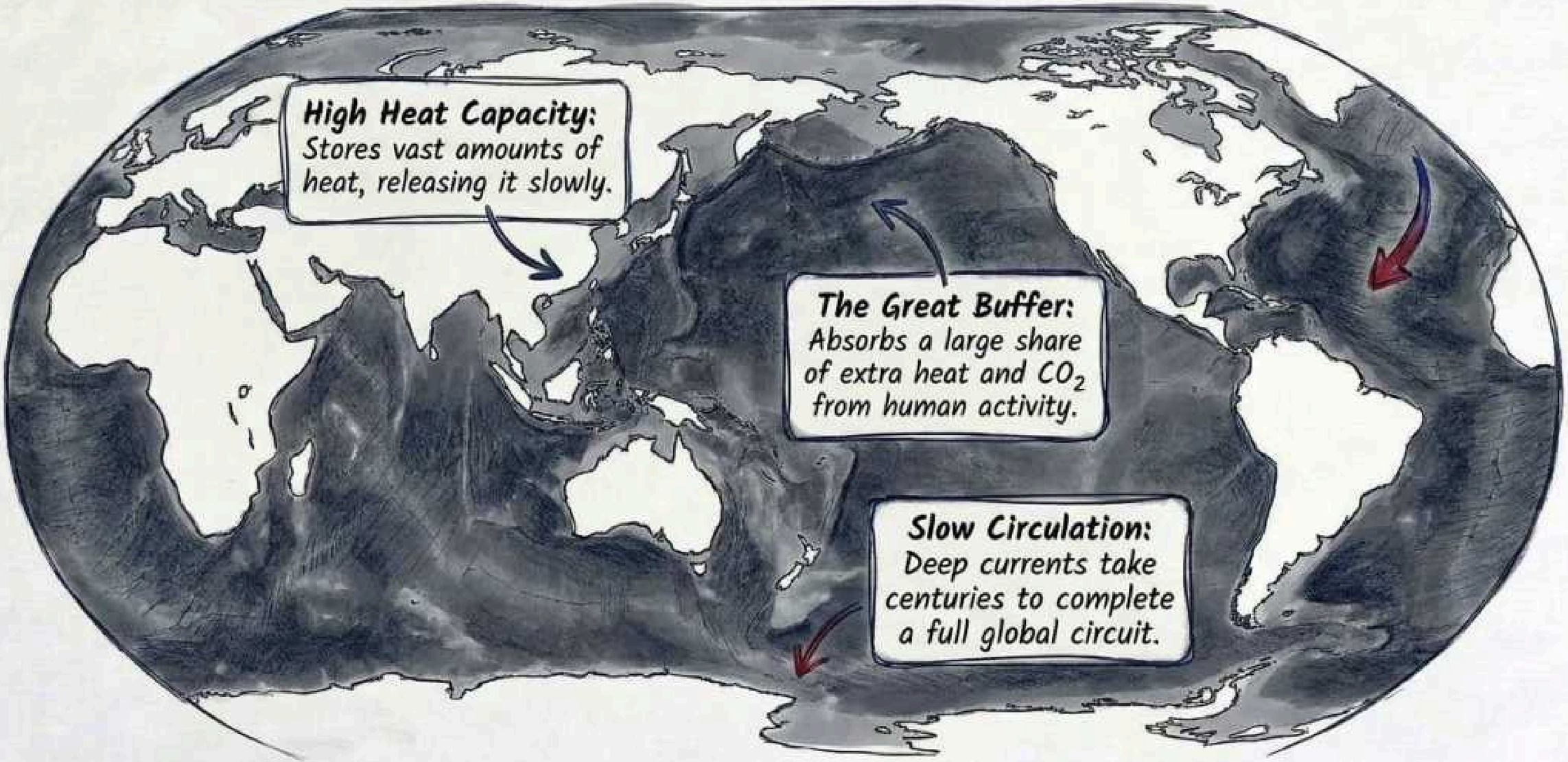
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Driving Winds, Currents, and Seasons



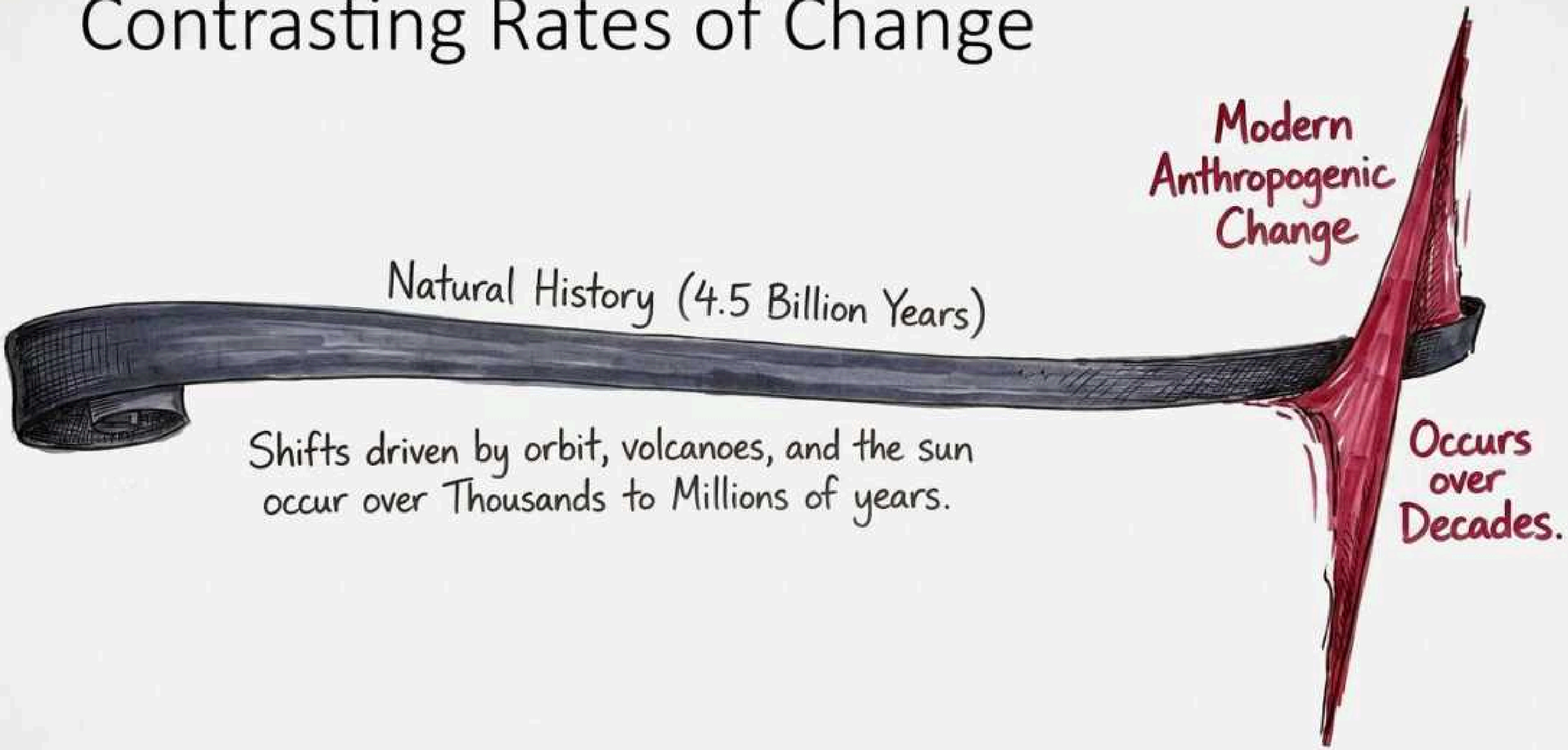
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The Ocean: Heat and Carbon Storehouse



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Contrasting Rates of Change

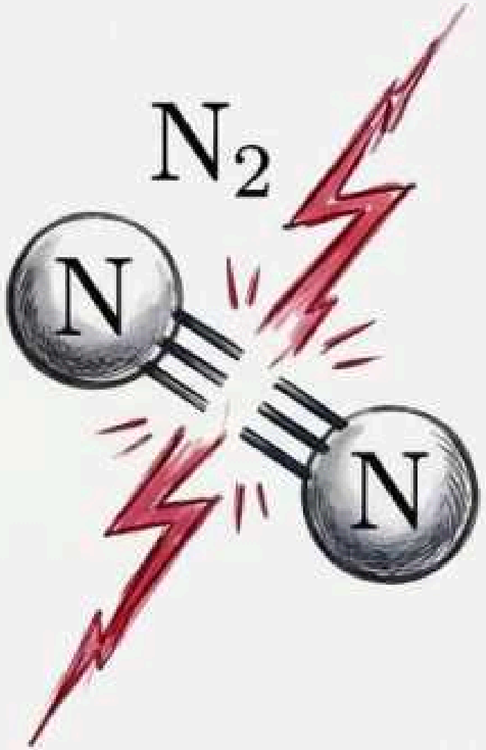


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The Anthropocene: Human Activity as a Planetary Force



We move more rock and soil annually than all rivers combined.



We fix more nitrogen from the air than all natural land processes.



We have raised atmospheric CO_2 by about half.

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A Diagnostic Framework for Systems

Q1: Stores

What is being held?

Q2: Flows

What is moving?

Q3: Feedbacks

Are they positive or negative?

Q4: Time Scale

How fast does the system respond?

The analytical lens for forests, fisheries, climate, and pollution.

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Application: Shifting the Albedo

Given:

Albedo rises from 0.30 → 0.31 (due to more reflective cloud cover).

Energy In = 340 W/m^2.

Find:

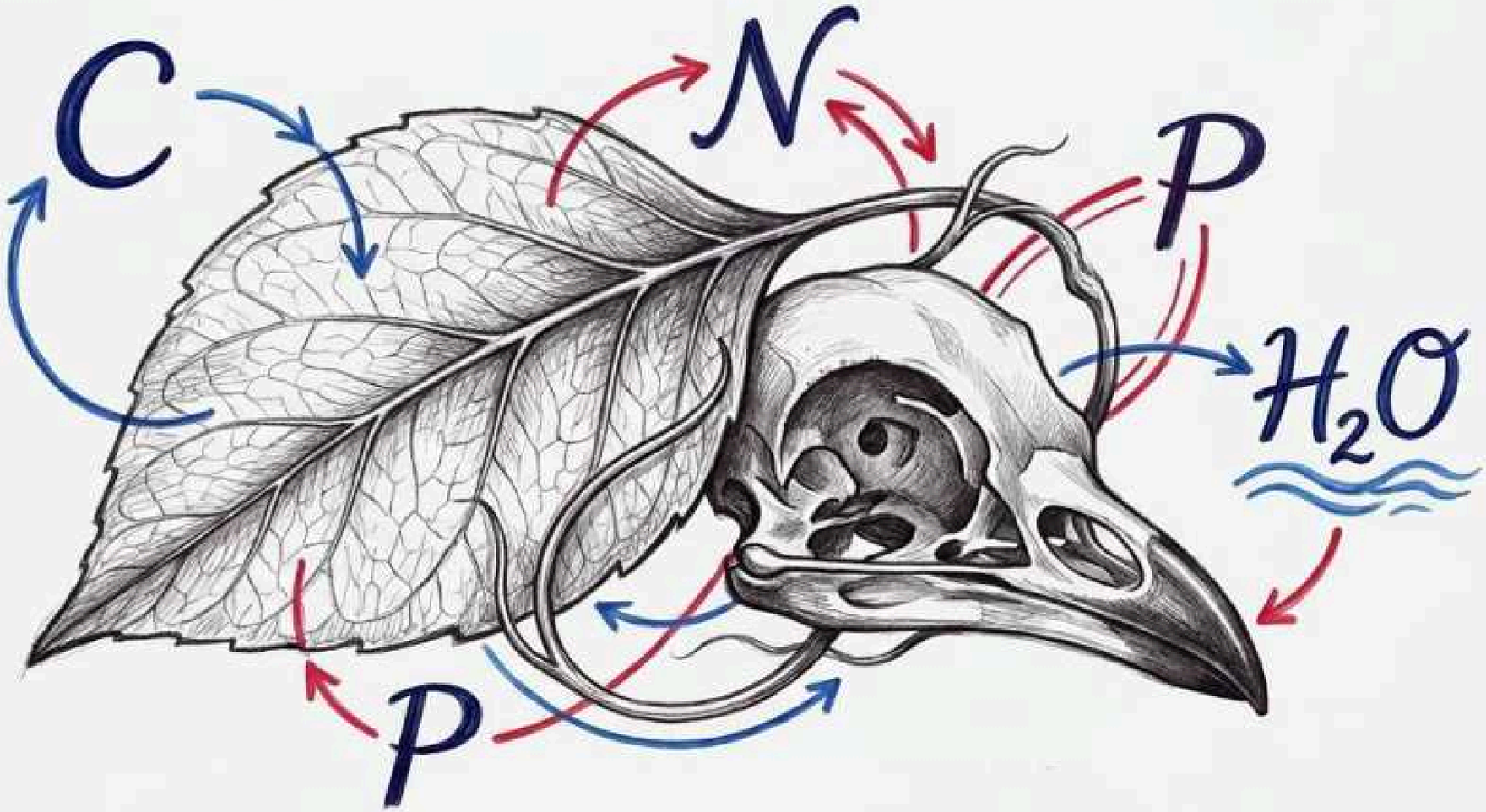
Calculate the new absorbed sunlight (W/m^2).

Concept Check:

- Would the planet's temperature rise or fall?
- What feedback mechanism might amplify this specific change?

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Next Up: Energy and Matter in Living Things



Tracing the cycles from sunlight, to plants, to animals.

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