¶ 6.1



Welcome to Lecture 6

Environmental Science 101 B

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The Final Lecture: At a Glance

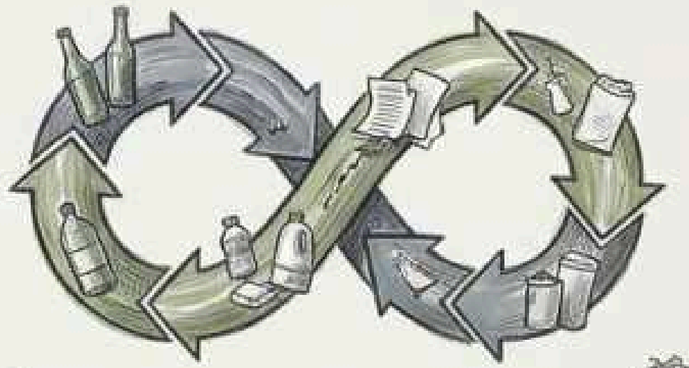
¶ 6.2



Pollution

Air, Water, Land

Waste



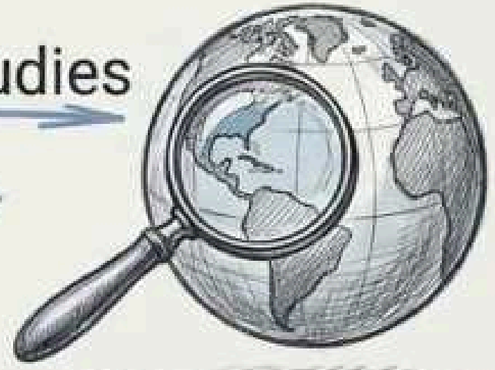
The Scope of the Problem



Policy Tools

Economic & Political Solutions

Case Studies



Successes like the Ozone Layer & persistent challenges

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Defining Pollution Origins

¶ 6.3

Core Definition: Addition of a substance or energy to the environment in quantities that harm people or ecosystems.

Point Sources

Identifiable origin



Examples: Smokestacks, discharge pipes.

Nonpoint Sources

Diffuse area



Examples: Fertilizer runoff from fields, oil washed off roads.

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The Deadly Reality of Air Pollution



Dec 1952

A cold, still fog traps coal smoke over London for 5 days.

Aftermath

Thousands die initially; later studies suggest the toll reached 10,000+.

1956

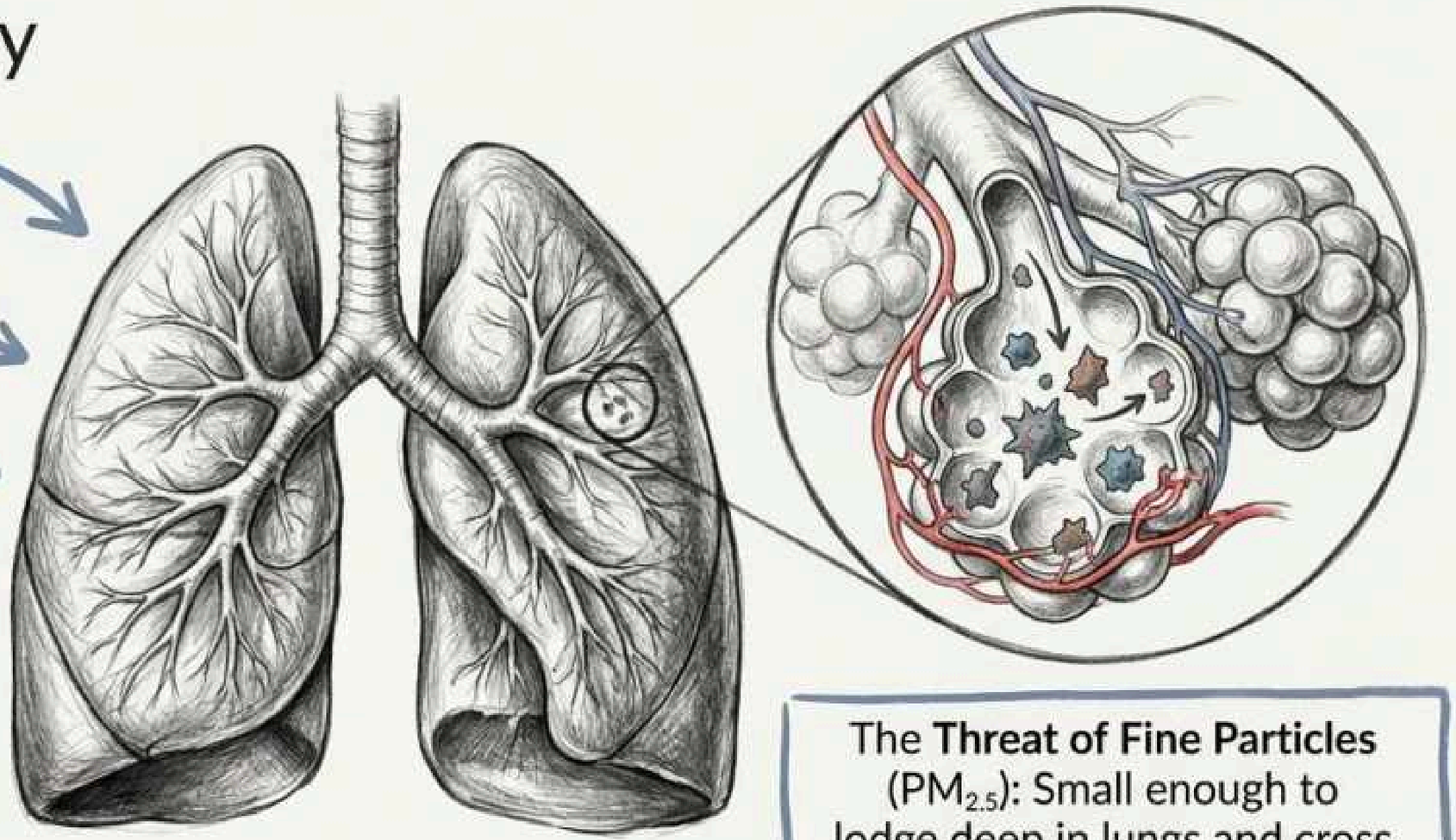
The tragedy catalyzes Britain's Clean Air Act.

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Modern Air Pollutants and Human Biology

¶ 6.5

- SO_2 & Soot (from coal) ✓
- NO_x (from vehicles) ✓
- CO (Carbon monoxide) ✓
- Ground-level O_3
- **Lead** (Pb)



The **Threat of Fine Particles** ($PM_{2.5}$): Small enough to lodge deep in lungs and cross into the bloodstream.

Global Impact: WHO attributes millions of premature deaths per year to air pollution, primarily in poorer countries.

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Smog and The Ozone Paradox

¶ 6.6



Stratosphere

Acts as a protective layer.

$$NO_x + \text{Organic Vapors} + \text{Sunlight} \longrightarrow O_3 \text{ (Ground-Level Ozone)}$$

Troposphere (Ground Level)



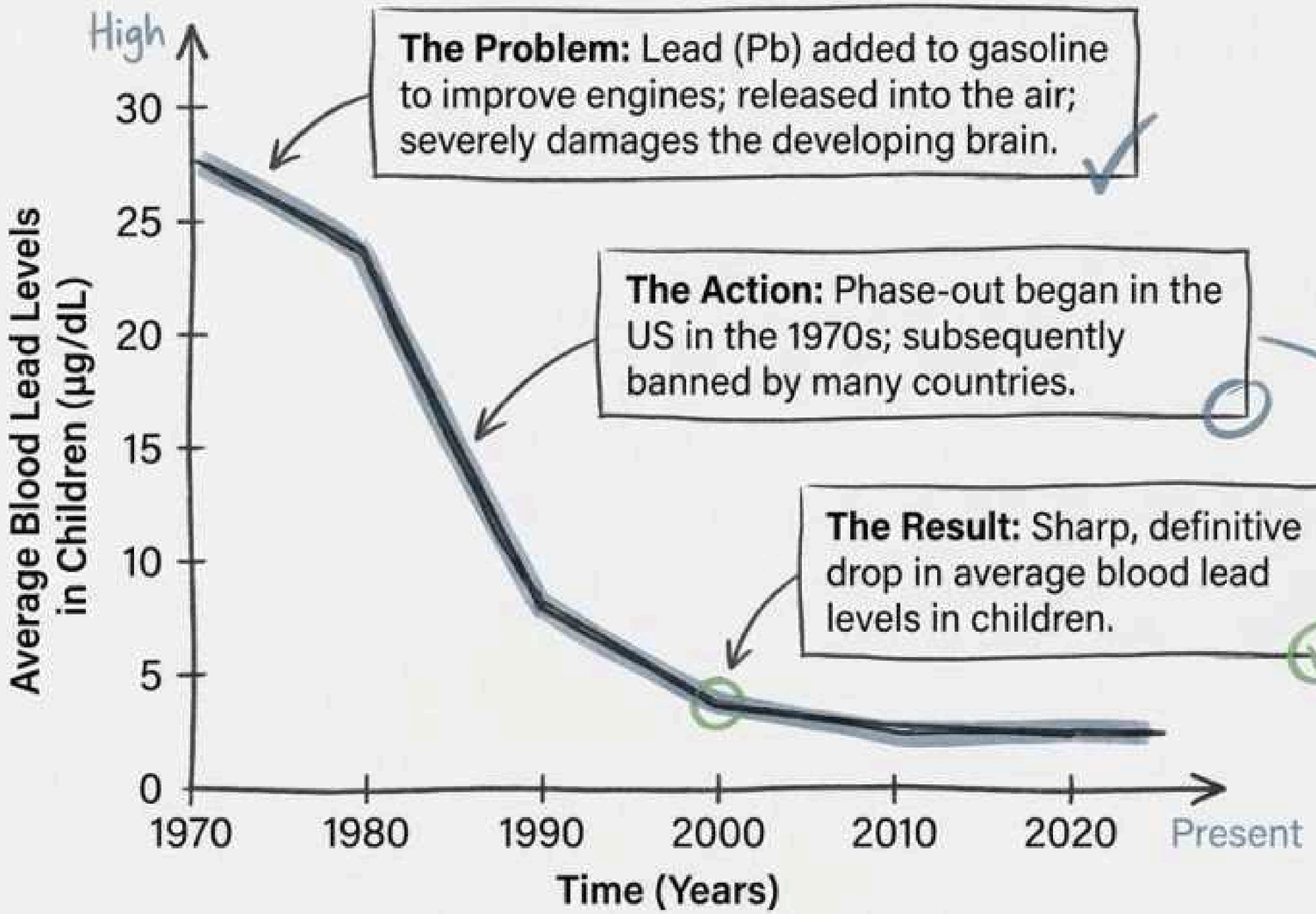
Acts as a harmful pollutant (irritates lungs, damages crops).

Key Takeaway: The same molecule is helpful or harmful depending purely on location. Context decides.

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Success Story: The Phasing Out of Lead

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The Problem: Lead (Pb) added to gasoline to improve engines; released into the air; severely damages the developing brain.

The Action: Phase-out began in the US in the 1970s; subsequently banned by many countries.

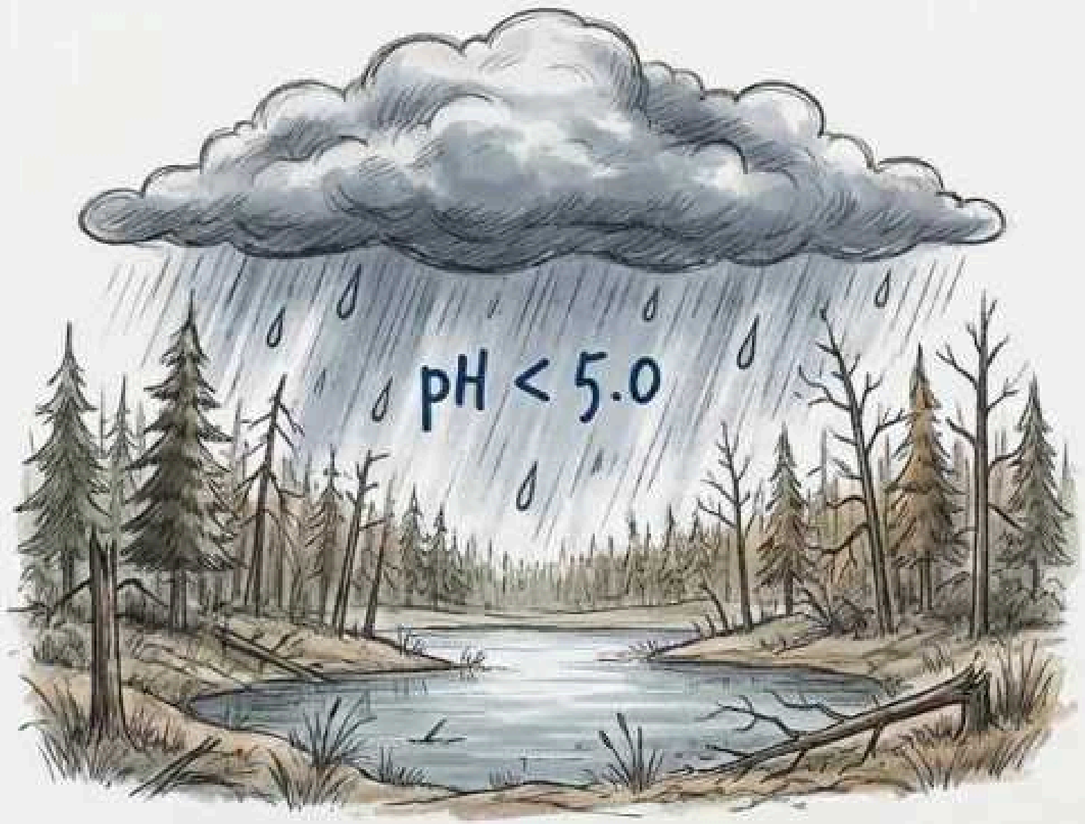
The Result: Sharp, definitive drop in average blood lead levels in children.



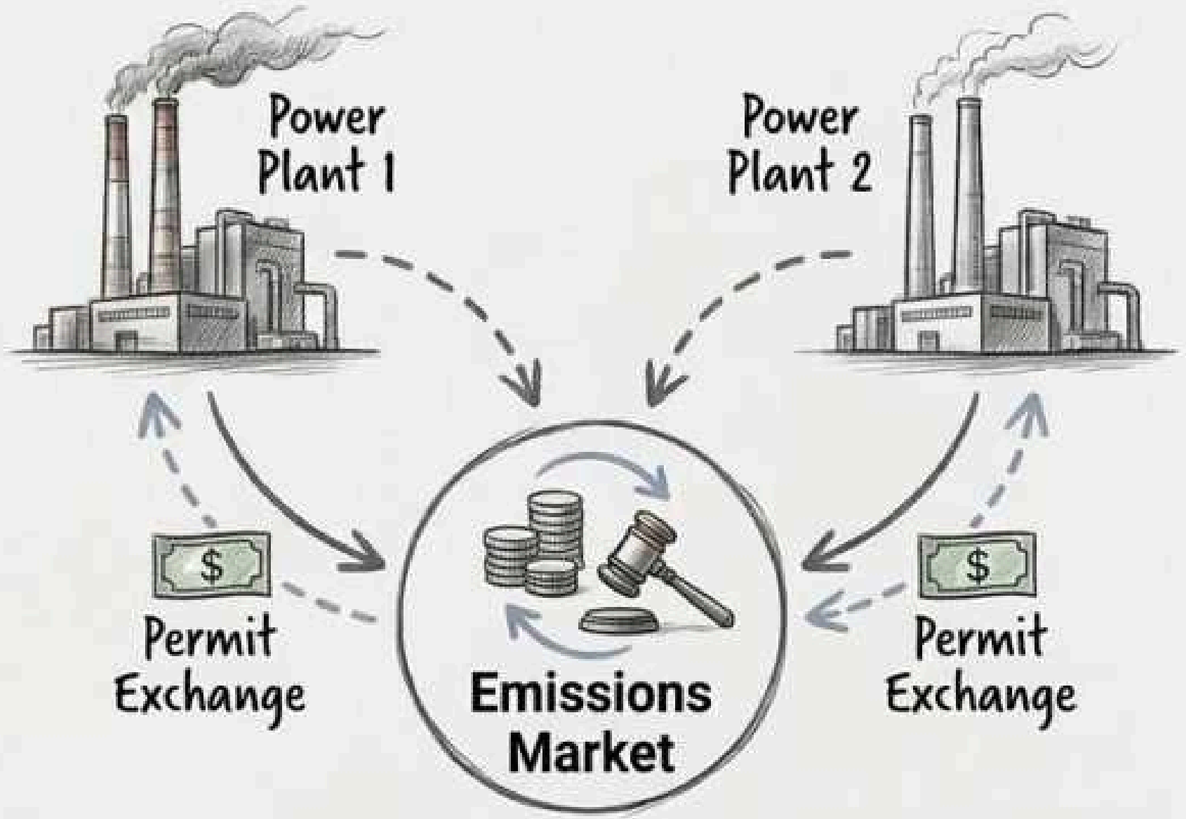
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Success Story: Acid Rain and Cap-and-Trade

¶6.8



The Physical Problem: Power plant SO_2 and NO_x form atmospheric acids, which fall as rain, damaging lakes and forests.



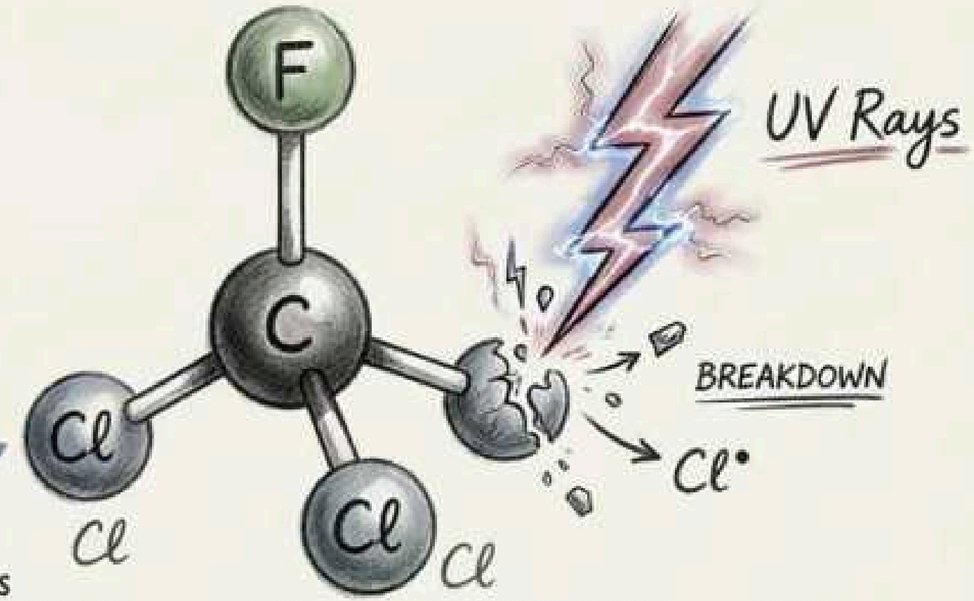
The Policy Action (1990): Amendments to the US Clean Air Act created a cap-and-trade market for sulfur dioxide.

The Outcome: Emissions plummeted faster and at a lower cost than experts predicted.

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The Best Known Success: The Ozone Layer

¶ 6.9



Scientific Hypothesis



1974: Mario Molina and Sherwood Rowland warn that CFCs (refrigerators, spray cans) will reach the stratosphere and destroy ozone.



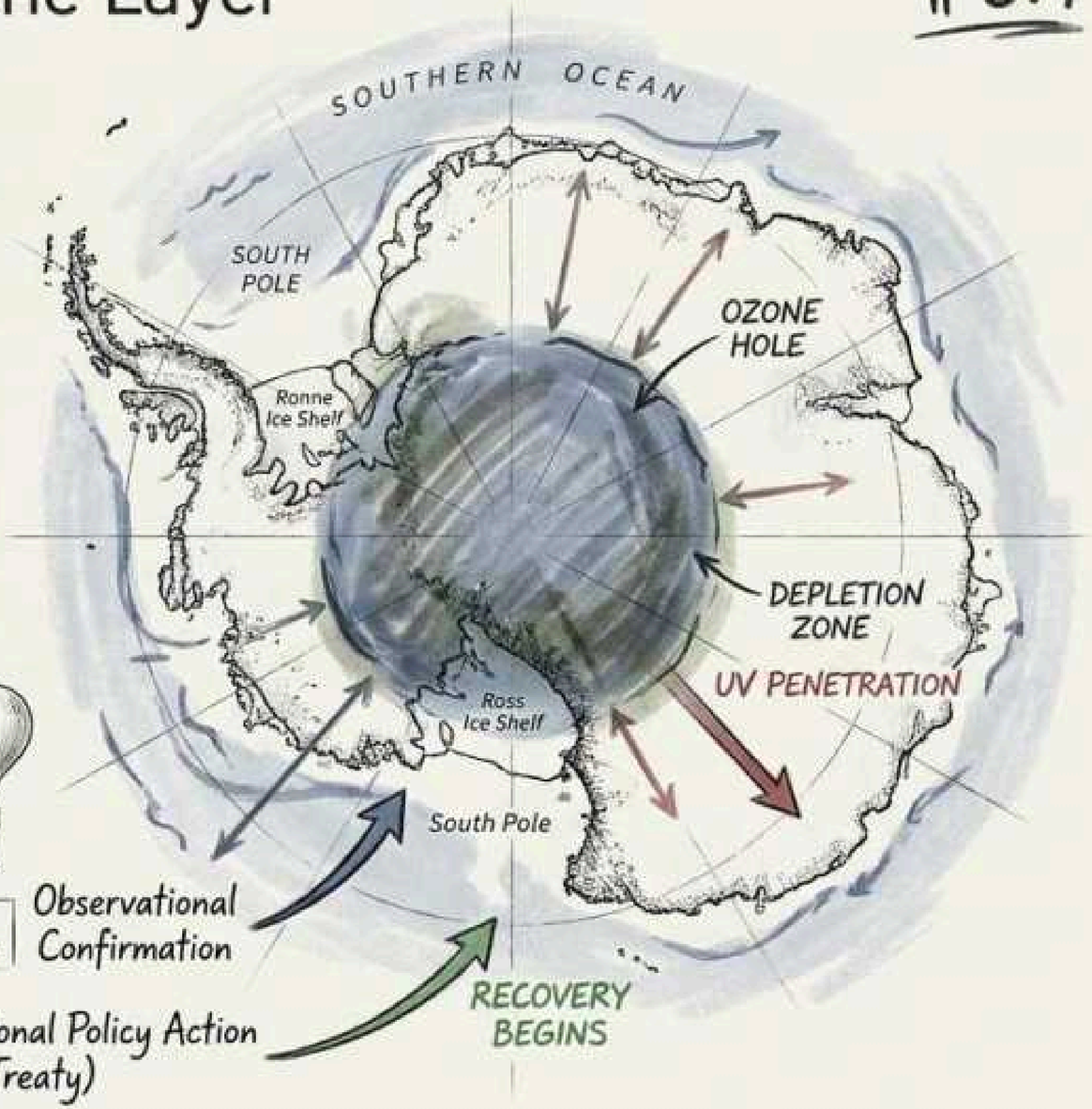
1985: Scientists officially report an ozone hole over Antarctica.

Observational Confirmation



1987: The Montreal Protocol is enacted to phase out these chemicals globally.

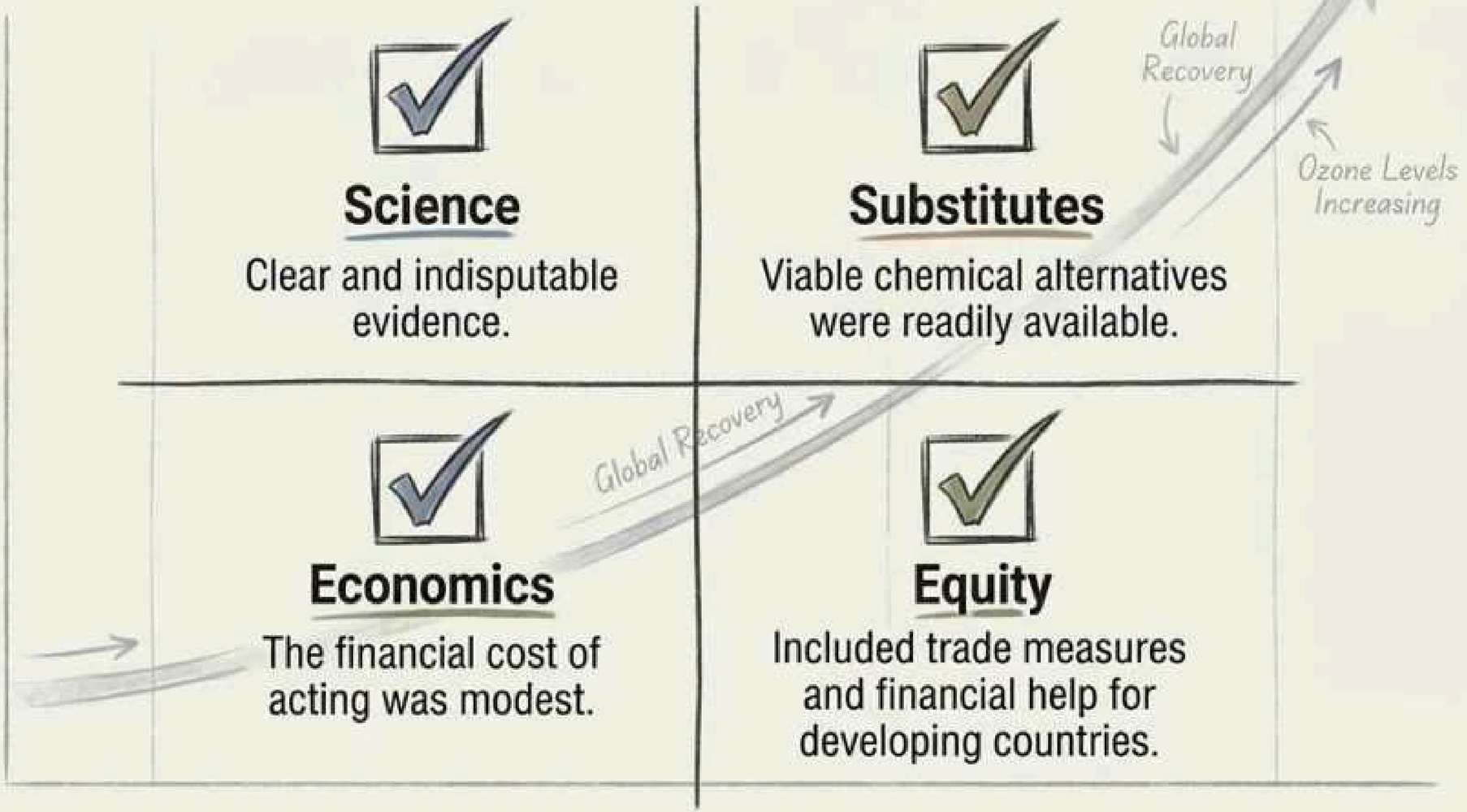
International Policy Action (Global Treaty)



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Why the Montreal Protocol Worked

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The Outcome: The ozone layer is recovering; expected to return to 1980 levels over most of the world by mid-century.

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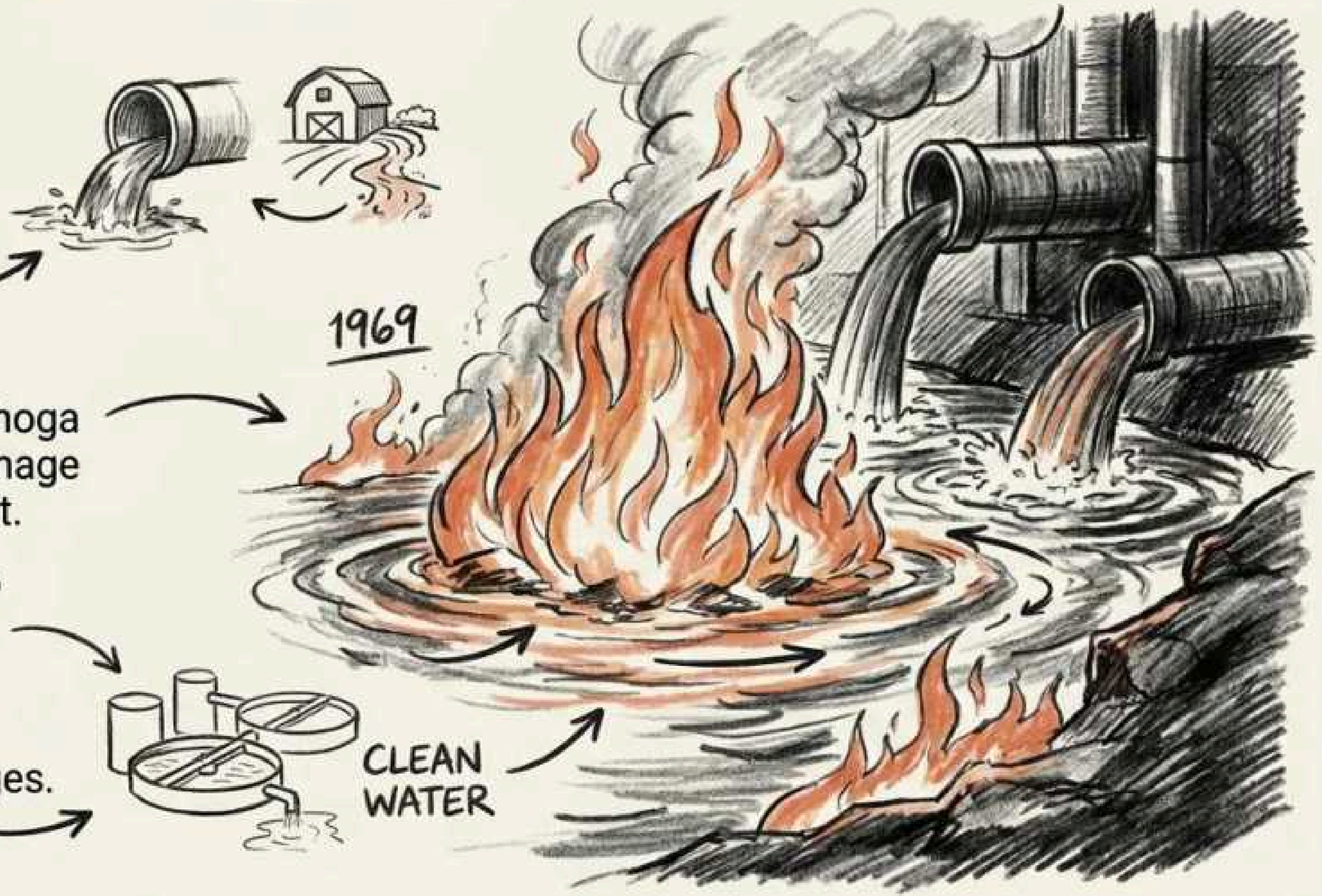
Water Pollution and The Clean Water Act

¶ 6.11

The Sources:
Sewage, factories, farms, mining, and urban runoff. Untreated sewage actively carries disease.

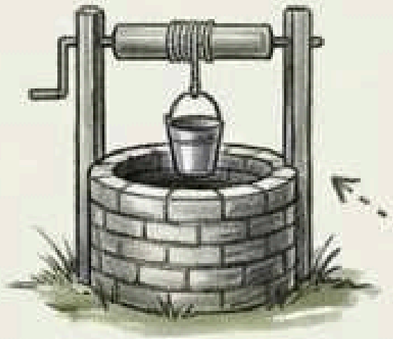
The Tipping Point (1969):
Oil and debris on Ohio's Cuyahoga River catch fire, creating an image that galvanized public support.

The Action (1972):
The Clean Water Act passes, setting strict standards and requiring permits for discharges.



The Global Safe Water Crisis

¶ 6.12



Protected Wells

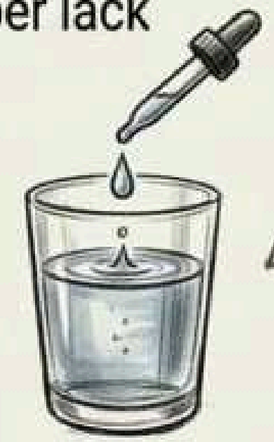


Latrines

The Scope:
> 2×10^9 people lack safely managed drinking water; an even larger number lack safe sanitation.

The Threat:
Diarrheal disease from unclean water remains a leading killer of young children.





Chlorination

These low-cost interventions prevent massive amounts of illness at minimal cost.



Handwashing

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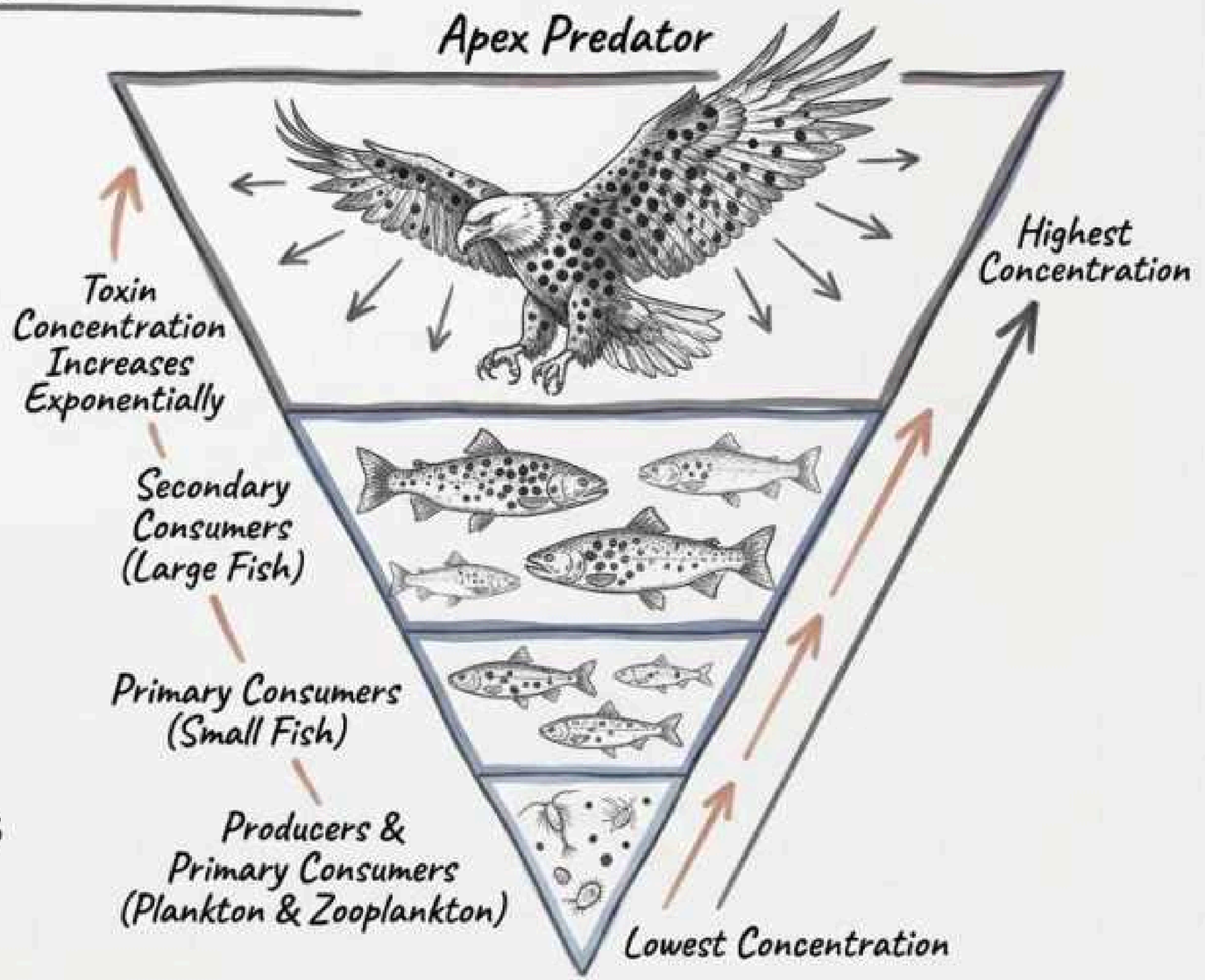
Toxic Chemicals: Biomagnification

¶ 6.13

Persistence:
Toxins that organisms cannot easily break down or excrete.

Bioaccumulation:
A substance builds up in the tissues of a single organism over its lifetime.

Biomagnification:
The toxin becomes exponentially more concentrated at each step up the food chain. Top predators carry the heaviest loads.



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The Classic Case: DDT

¶ 6.14

The Double-Edged Sword: Highly effective against mosquitoes and crop pests, but biomagnified rapidly in food chains.

The Impact: Thinned the eggshells of apex birds (eagles, ospreys, and peregrine falcons).

The Reversal: Rachel Carson exposed the damage in *Silent Spring* (1962); the US banned most uses in 1972, leading to the rapid recovery of the bird populations.



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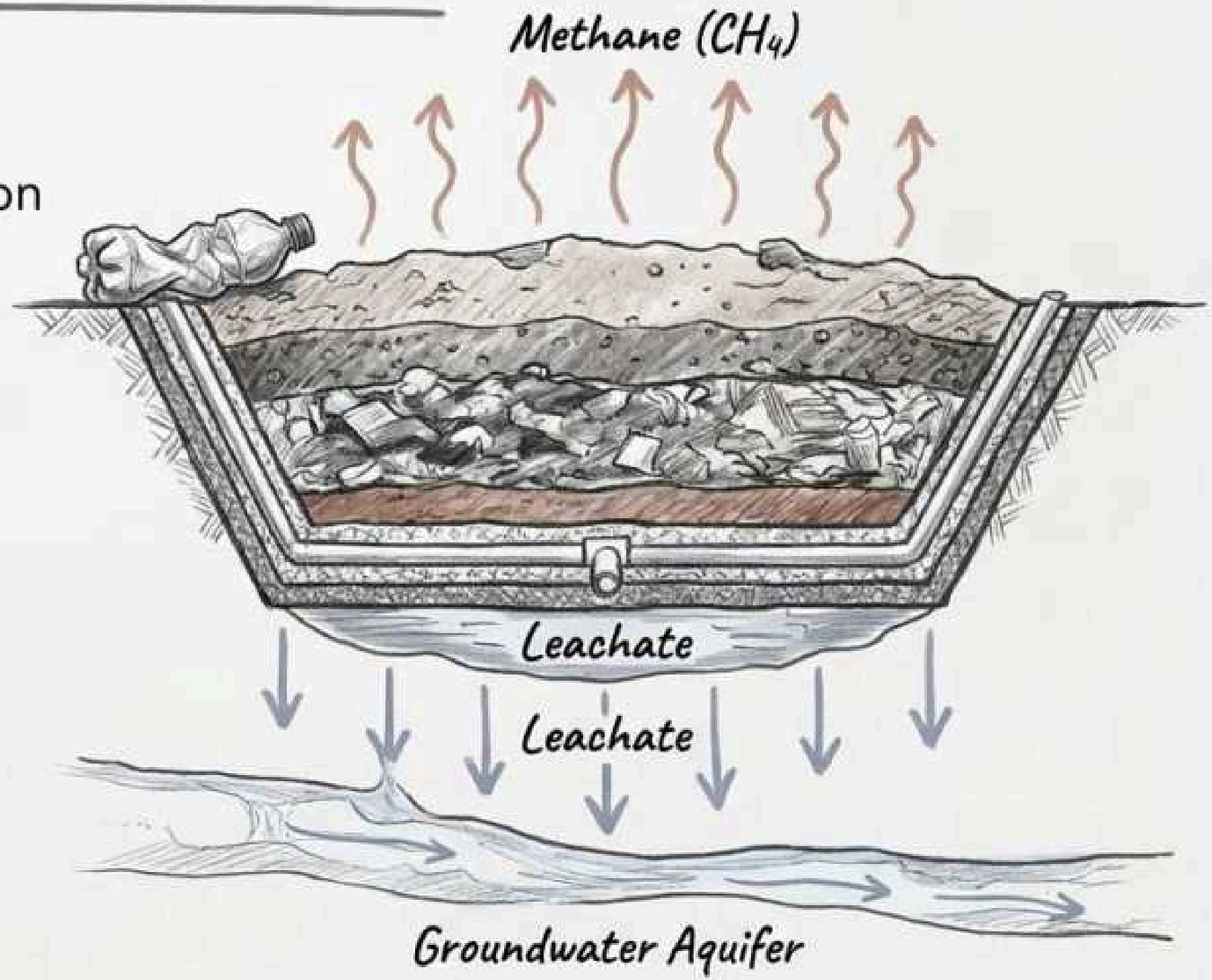
Solid Waste: Landfills and Plastics

¶ 6.15

The Math:
~ 2 kg of municipal waste per person per day in wealthy nations.

Landfill Hazards:
Leaks toxic liquids into groundwater and releases methane (CH_4).

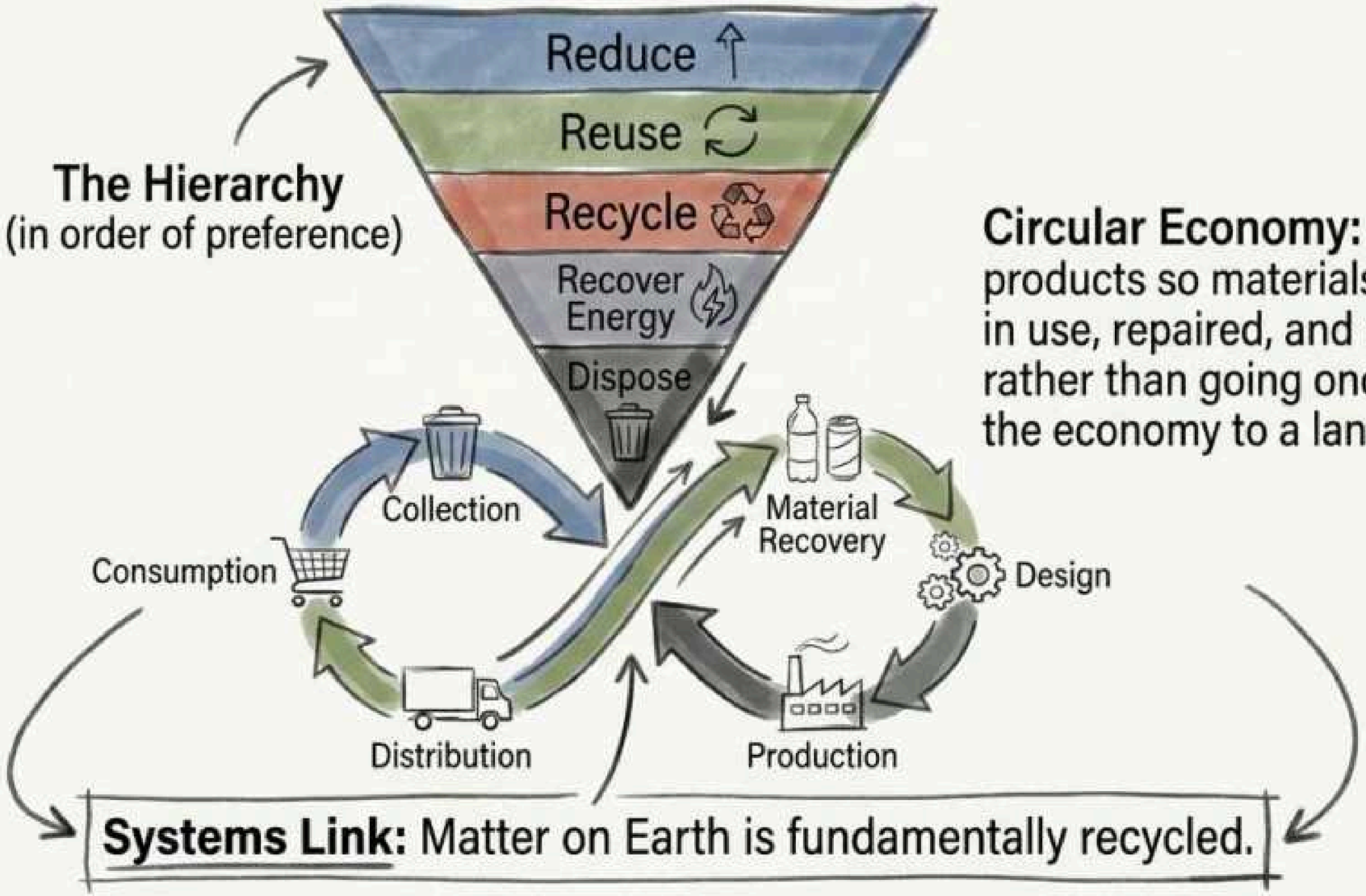
The Plastic Problem:
Endures for centuries. Only a tiny fraction of all plastic ever made has been recycled.



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The Waste Hierarchy and Circular Economy

¶ 6.16



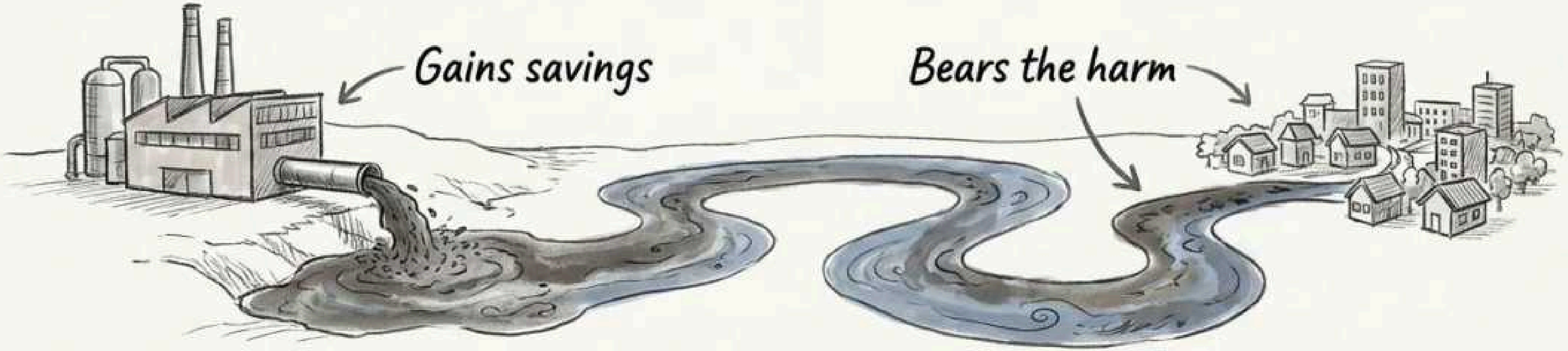
Circular Economy: Designing products so materials are kept in use, repaired, and recovered, rather than going once through the economy to a landfill.

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¶ 6.17

Why Problems Persist: Economic Externalities

$$Cost_{Social} = Cost_{Private} + Externality$$



The Concept:
Costs that a producer imposes on others but does not pay.

Tragedy of the Commons:
Identified by Garrett Hardin (1968). Users of a shared resource gain individually from taking more, while the cost of depletion is spread among everyone.

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¶ 6.18

Society's Policy Tools

Regulate



Set limits or ban practices outright.

Tax / Price



Make the polluter pay for emissions.

Markets



Create cap-and-trade systems.

Incentives



Remove harmful subsidies, protect property rights, fund research, provide information.



Community Management

Elinor Ostrom proved communities can effectively manage effectively manage shared resources without top-down control by setting clear rules and monitoring them.

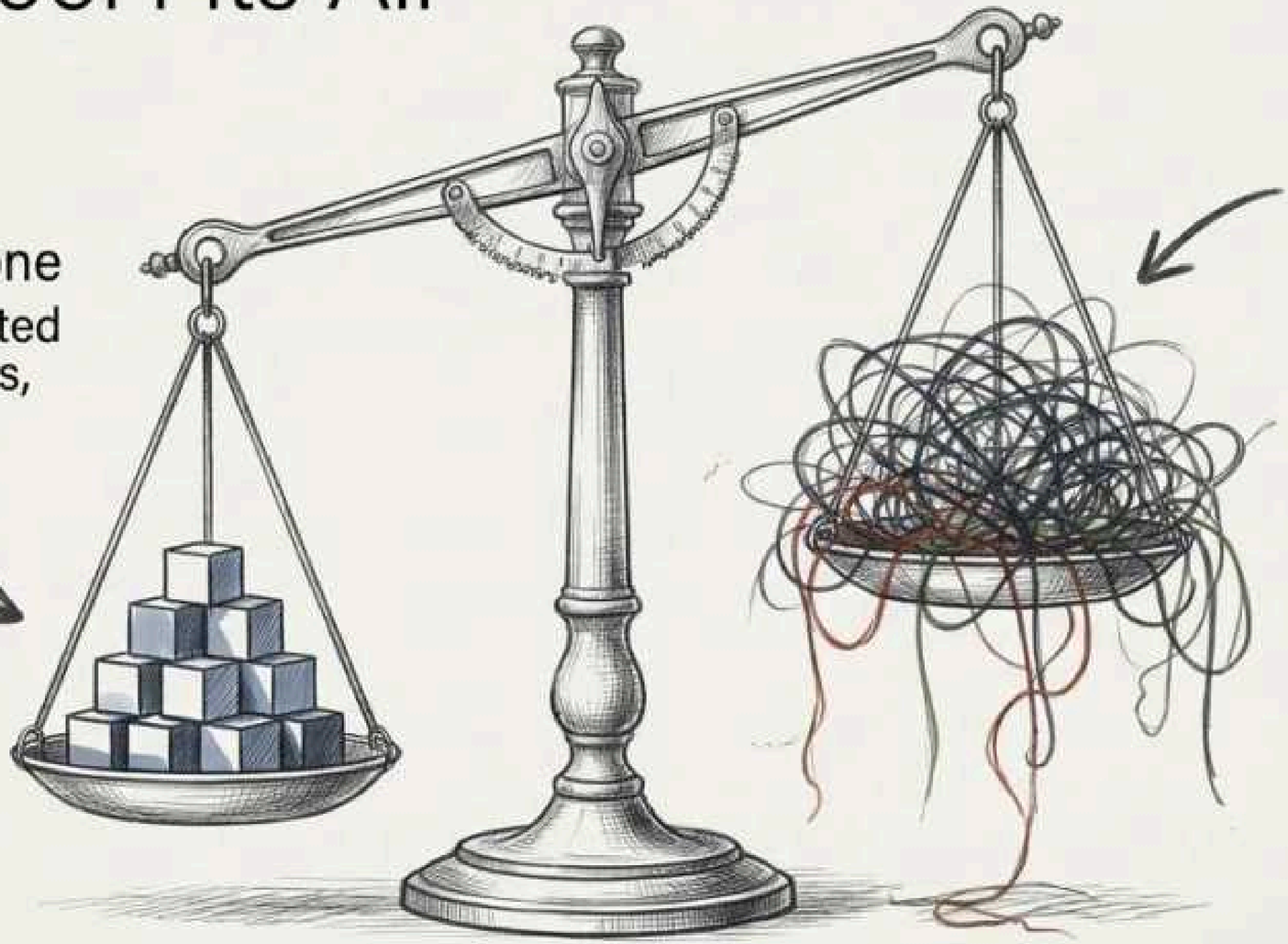


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No Single Tool Fits All

¶ 6.19

Clear Successes:
Lead, Acid Rain, Ozone
(Characterized by targeted causes, clear substitutes, and modest costs).



Harder Problems:
Climate Change, Plastic Pollution
(Characterized by diffuse causes and ubiquitous societal reliance).

The Requirement: Historically, informed citizens, careful science, and sustained effort are the absolute drivers of environmental action.

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¶ 6.20

Final Assignment

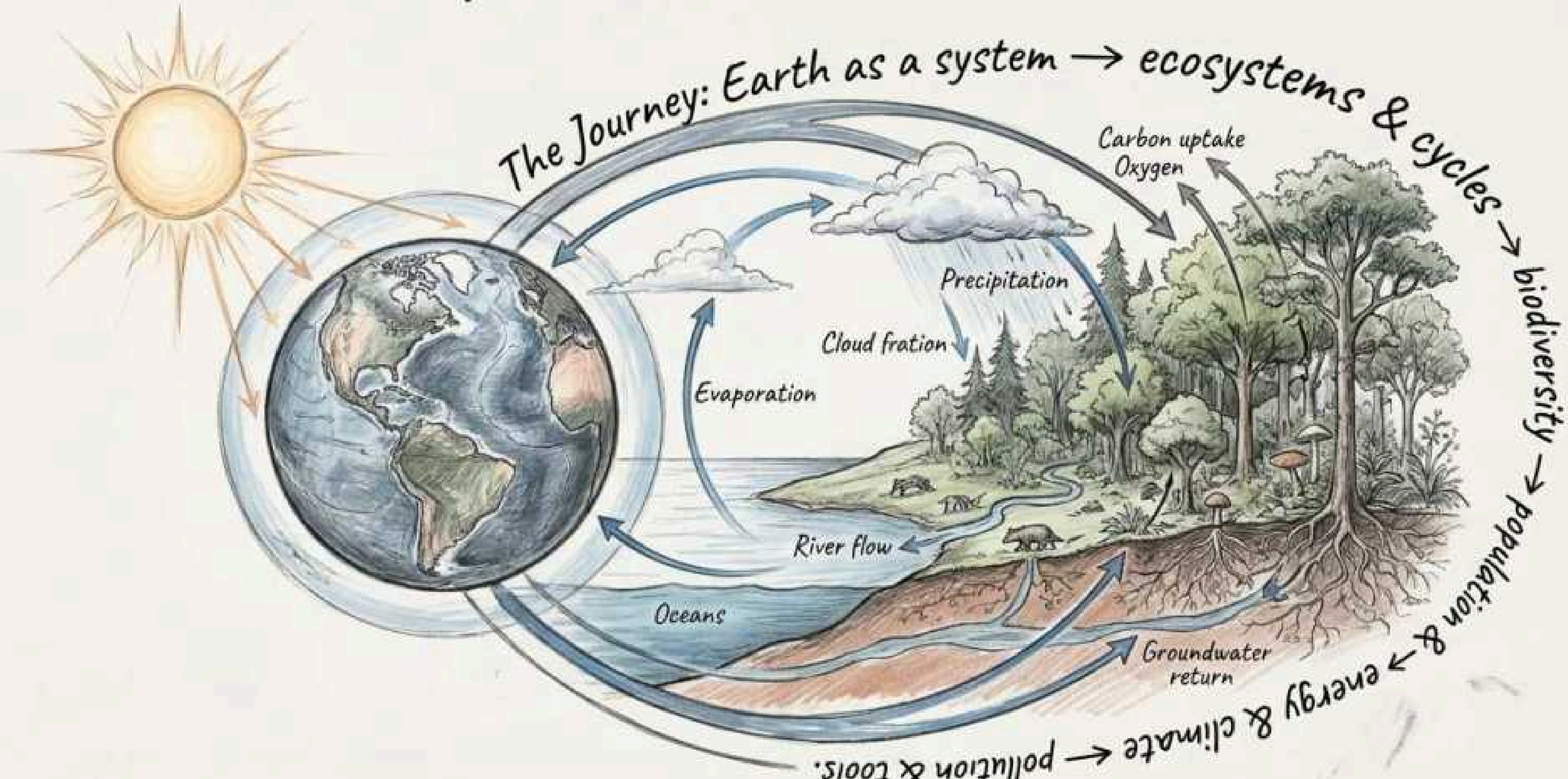
Task: Choose one **environmental problem** from this course (e.g., ocean dead zones, **extinction, climate change**).

- ☐ Part 1: Describe its cause using the systems ideas from Lecture 1.
- ☐ Part 2: Compare two policy tools you might use against it.
- ☐ Part 3: Give one strength and one weakness for each tool.

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Course Complete: Environmental Science 101 B



Keep asking where things come from and where they go.

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