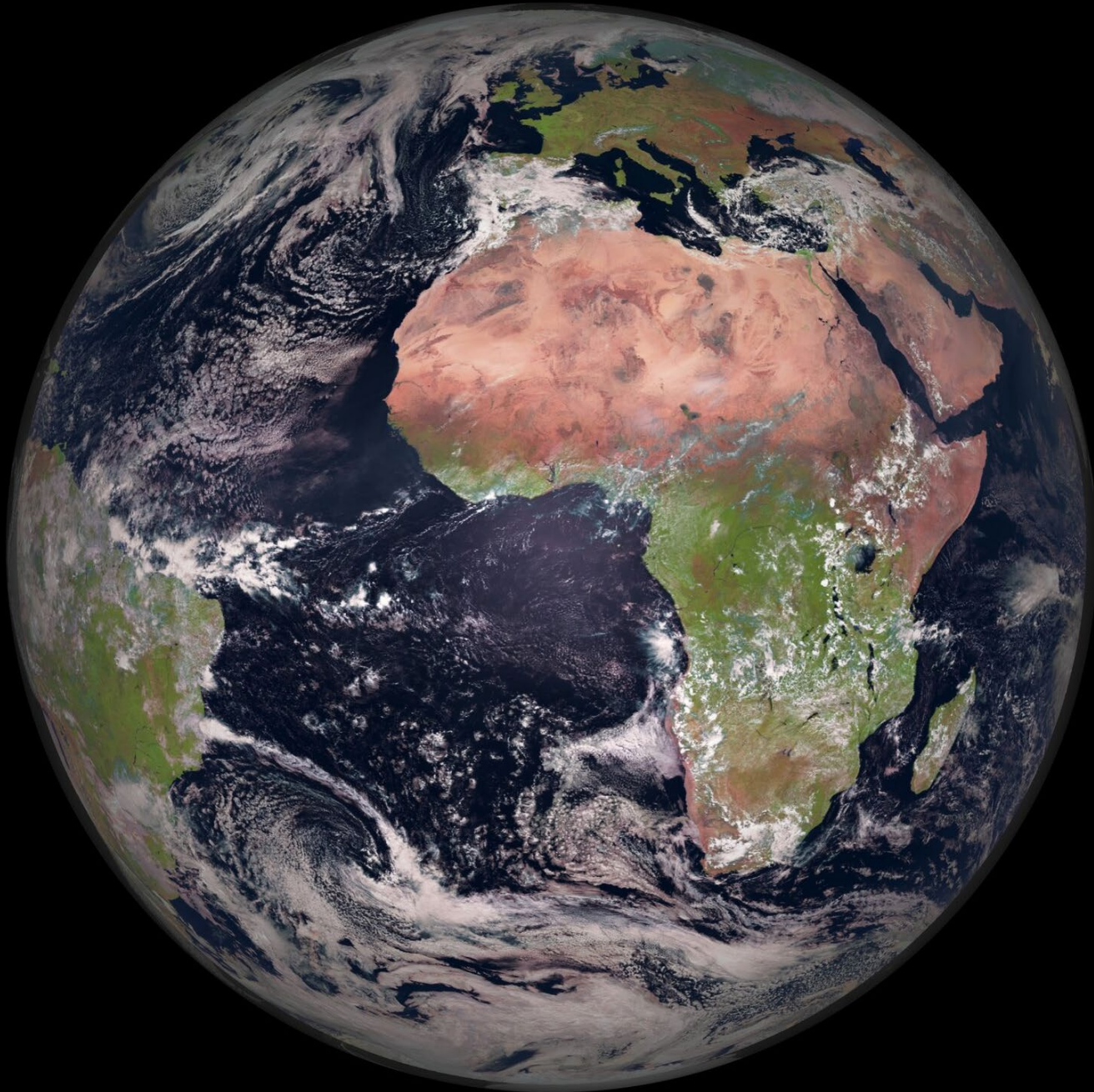


Natural to Human Systems



Key terms

- Open vs Closed systems
- Biogeochemical cycles
- Feedbacks
 - Positive vs Negative
- Nitrification
- Greenhouse Gases (GHG)
- Photosynthesis
- Ocean acidification
- Box models
 - Sink, stock, inflow, outflow

Room temp

vs.

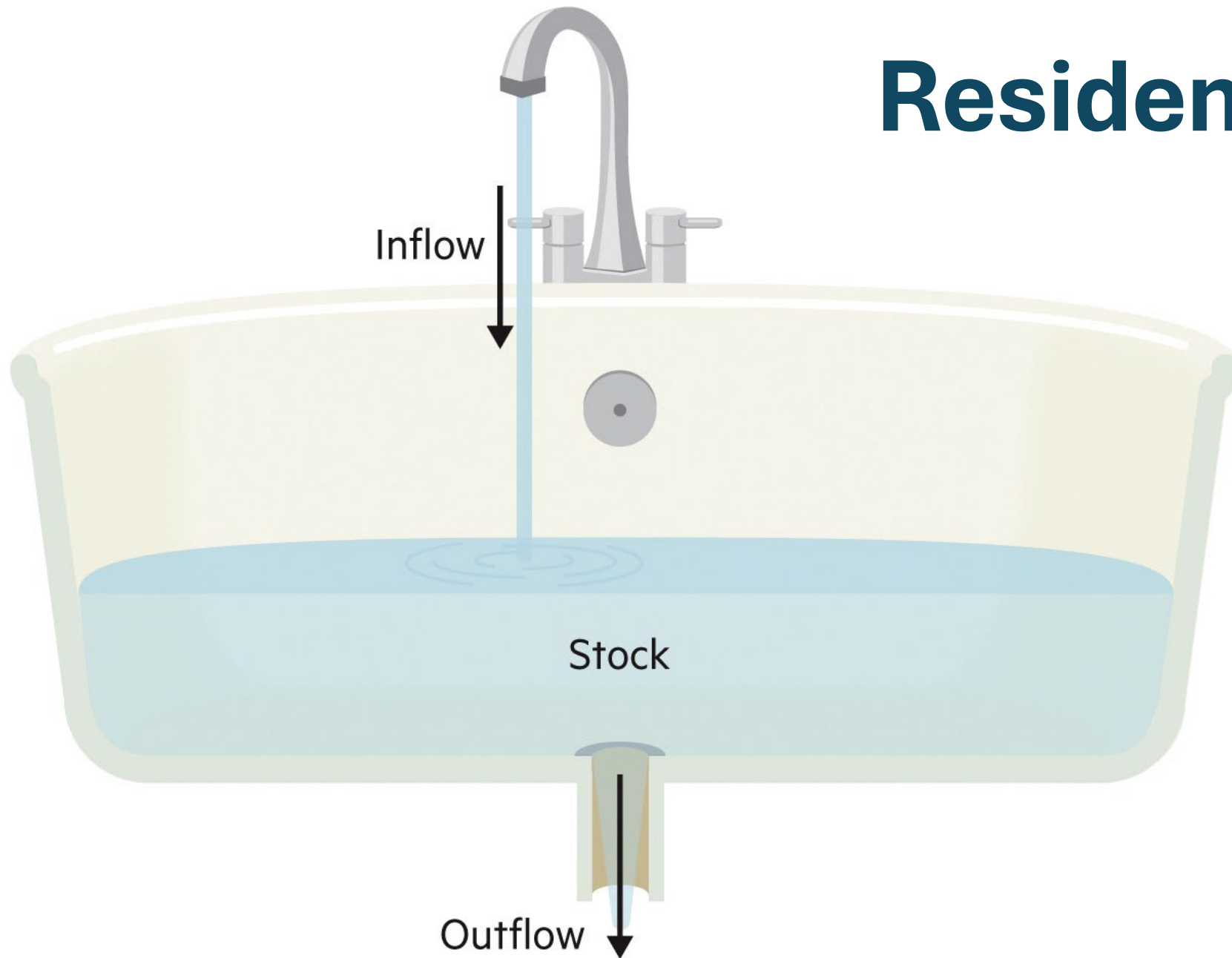
On ice



System Types

- **Open** – A system that exchanges material and energy with its surroundings.
- Sun's energy
 - Some is absorbed/received
 - Some is reflected
- **Closed** – Most of the Earth's material is continuously recycled.
- Mass/material is neither gained or lost just changed.
- Rock and Water cycles

Residence Time = ?



$$rT = S/F$$

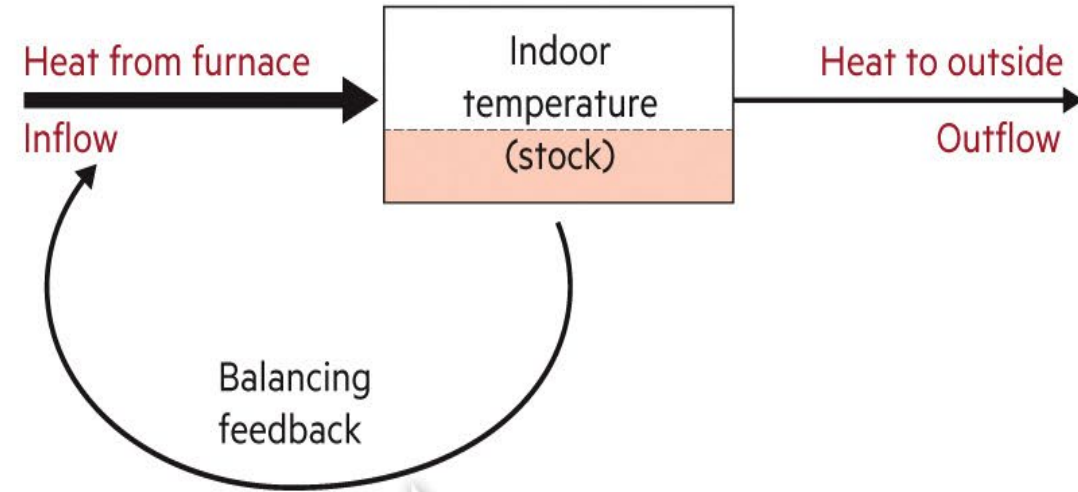
S = size of
stock

F = rate of
transfer

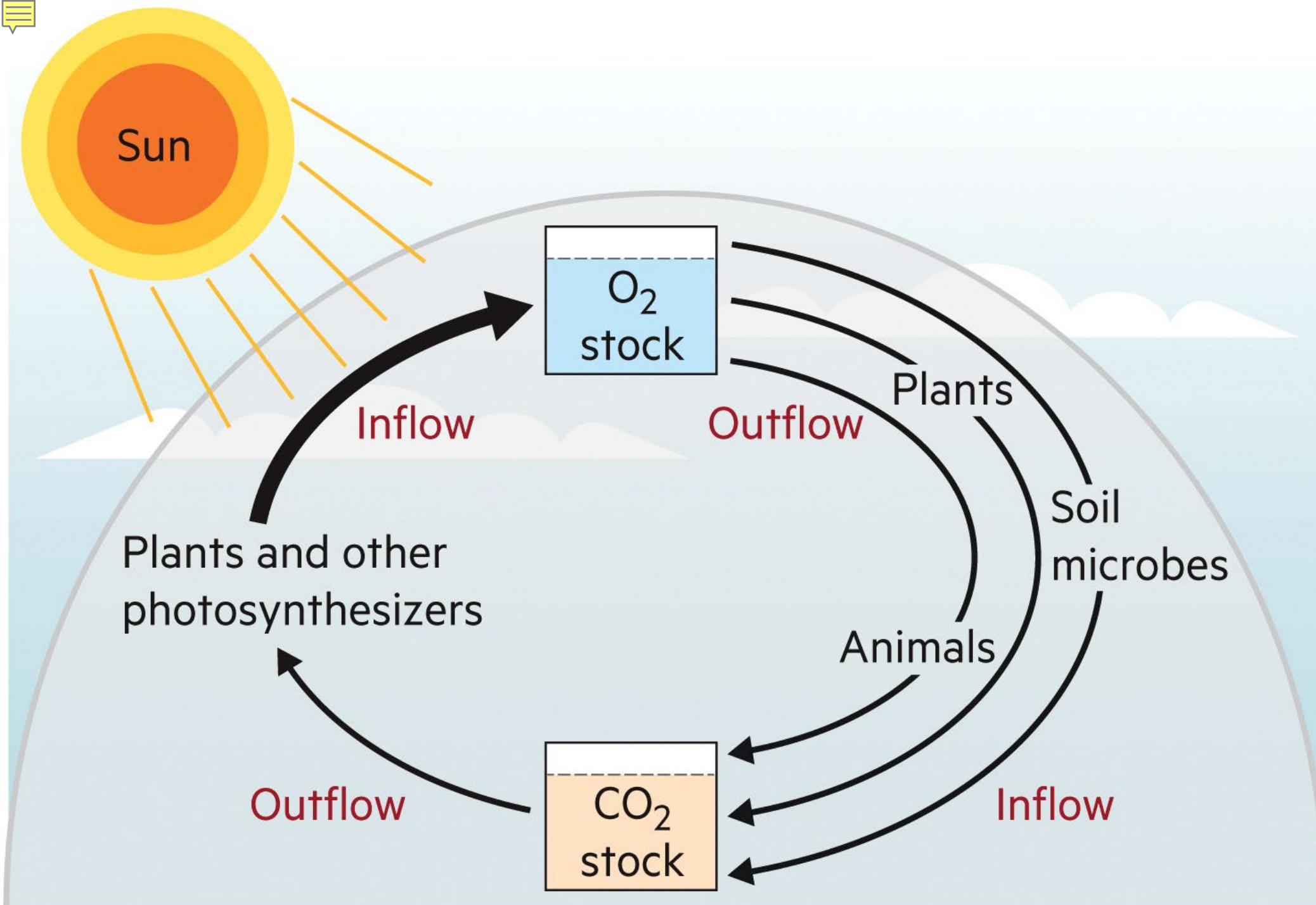
Heating or Cooling a room

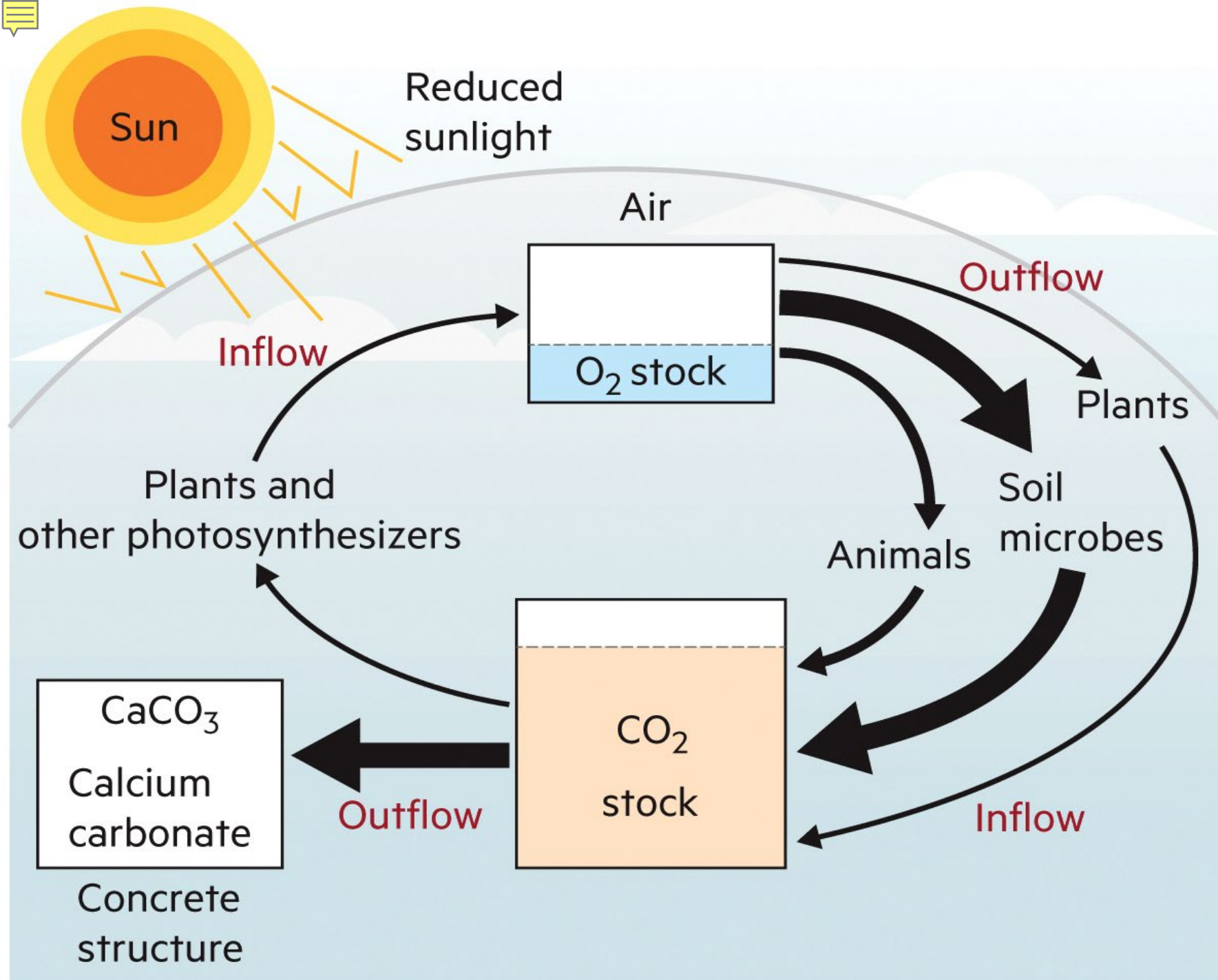


Steve Cukrov/Shutterstock



Thermostat reads discrepancy between its setting and the indoor temperature and signals furnace to adjust accordingly.







System Interactions

**Solar Radiation -
Exothermic**

Atmosphere

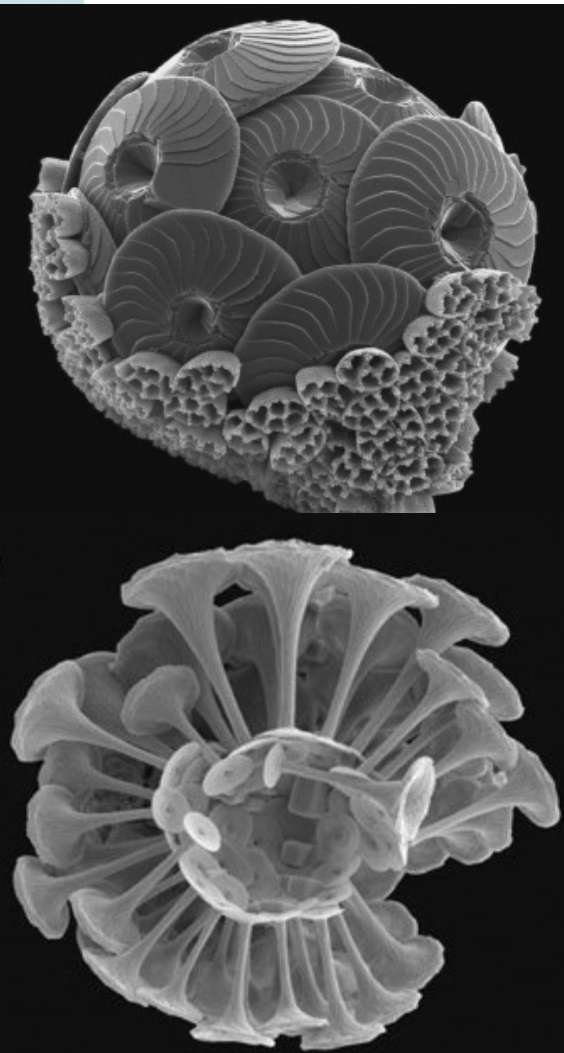
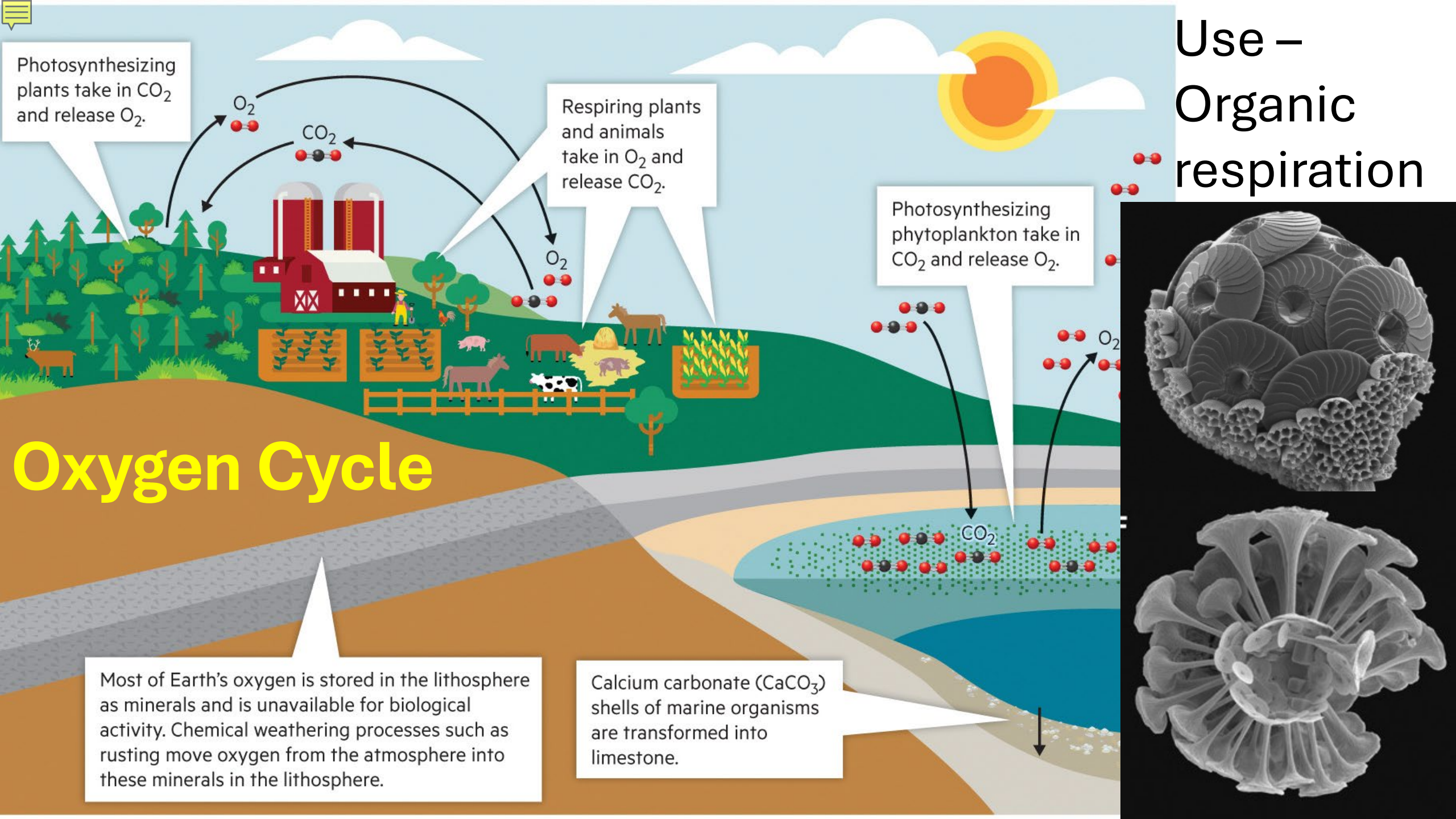
Hydrosphere

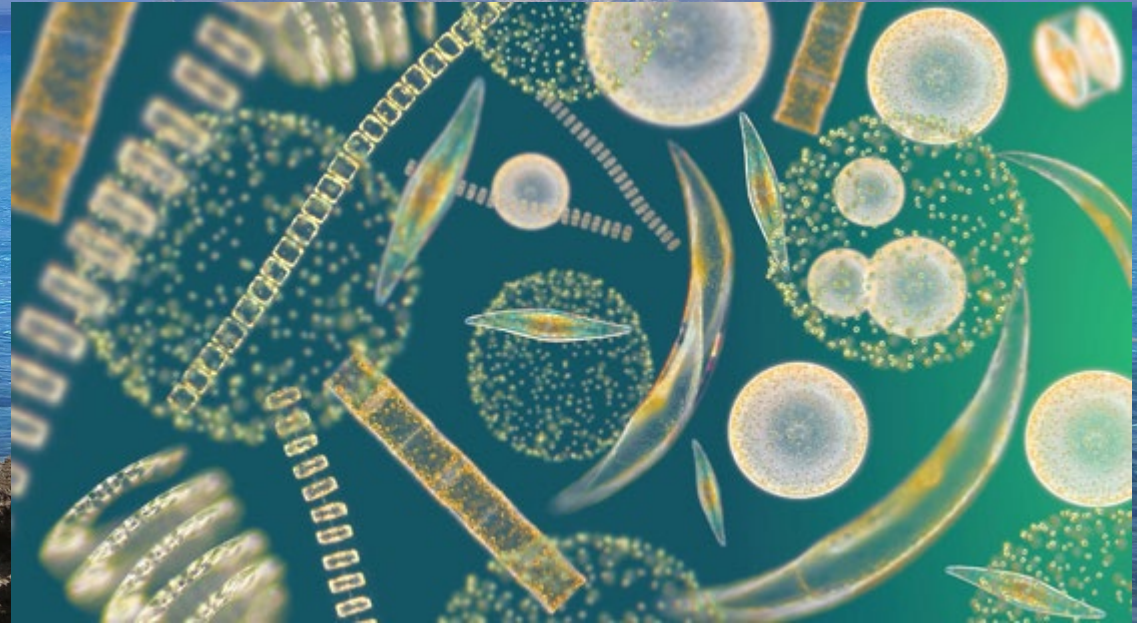
Biosphere

Lithosphere

Earth's Hot Core –









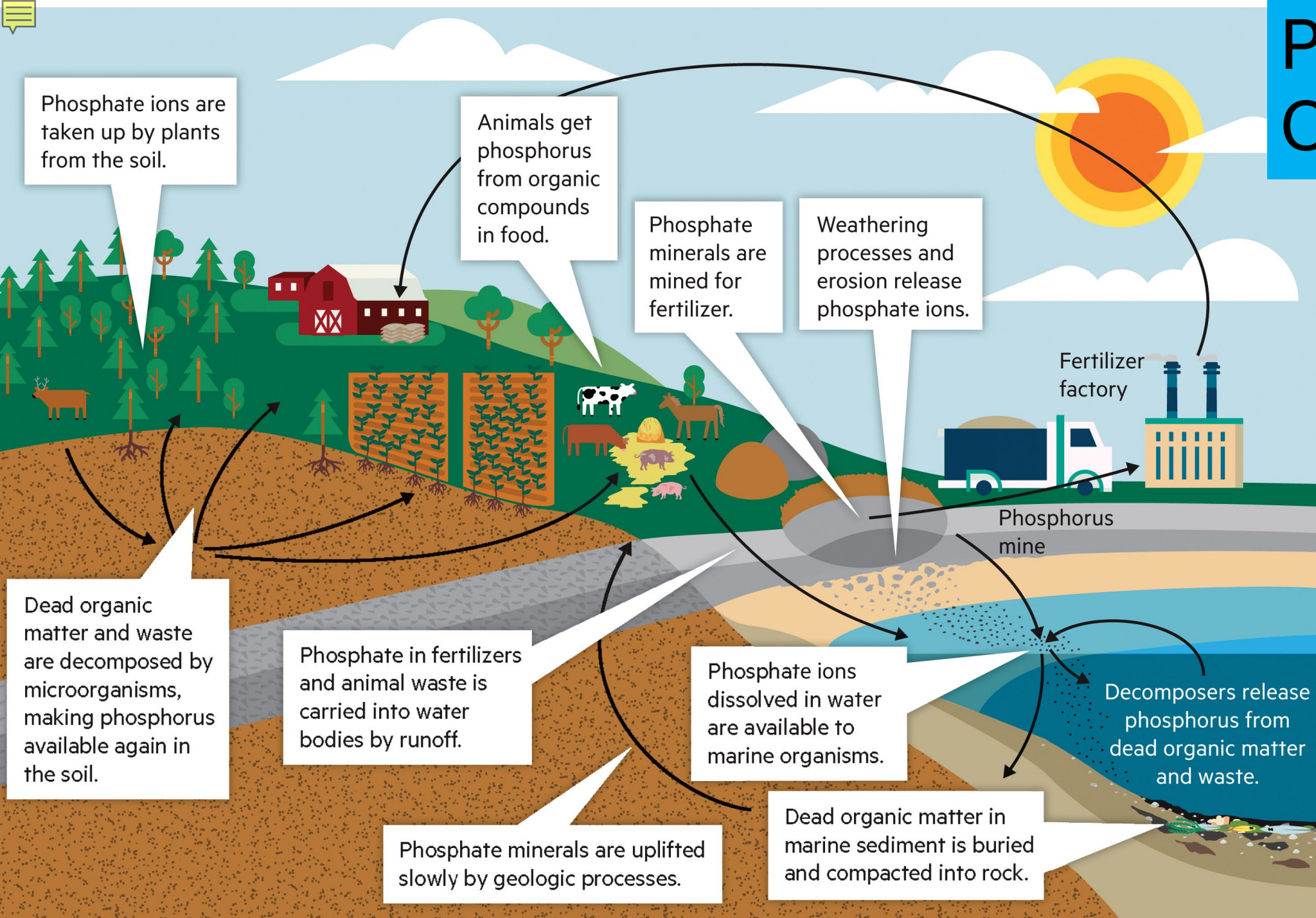
Calcite
 CaCO_3

Limestone
made of
 CaCO_3





Phosphorus Cycle



Use:
Fertilize



“If you cannot grow it, You have to mine it”

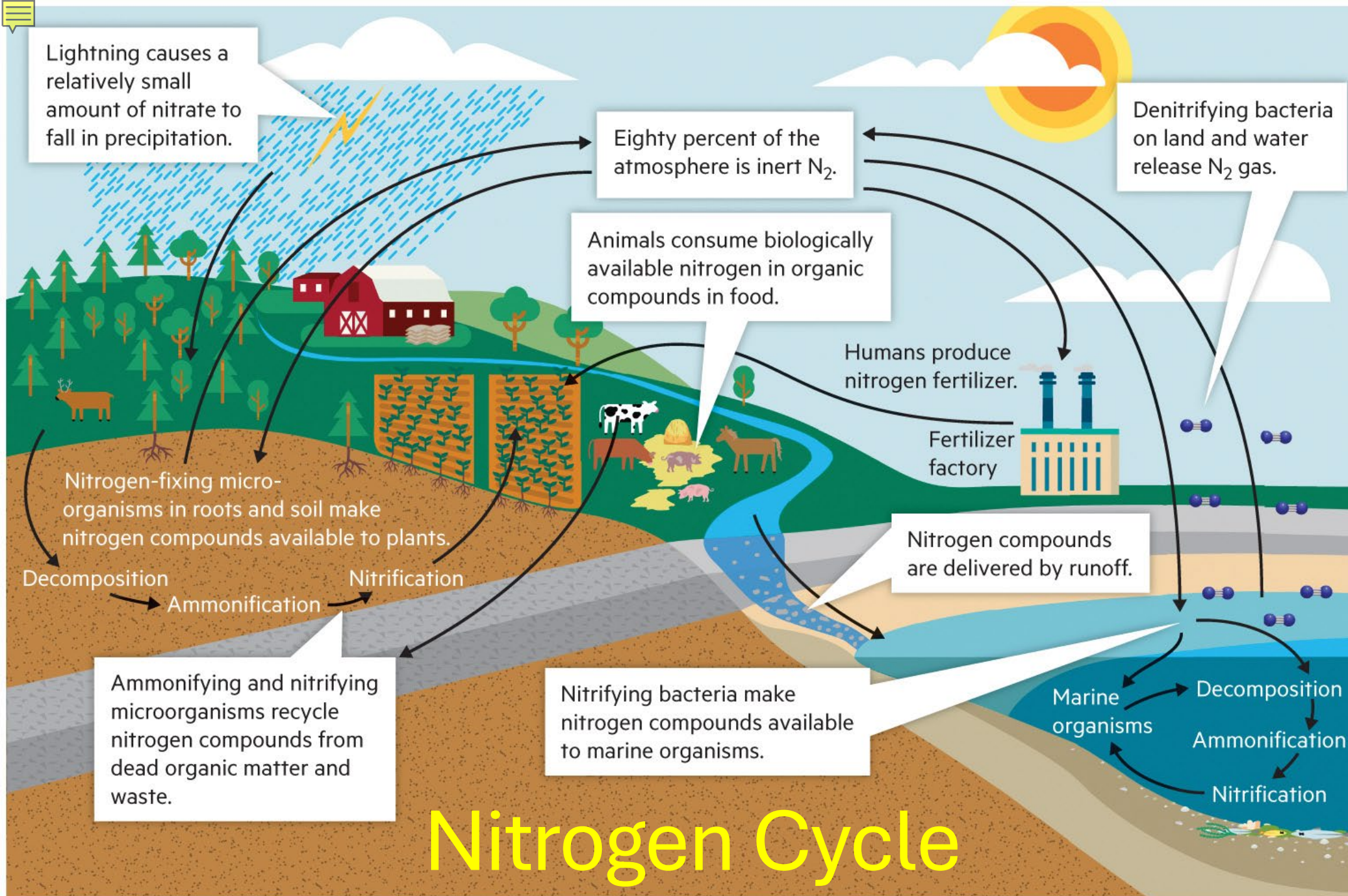


Otiki/Shutterstock



Criniger Kolio/Shutterstock

Use – Fertilizer





Nitrogen Conversion Processes

(a)



Dark Moon Pictures/Shutterstock

(b)



Dr Jeremy Burgess/Science Source

(c)

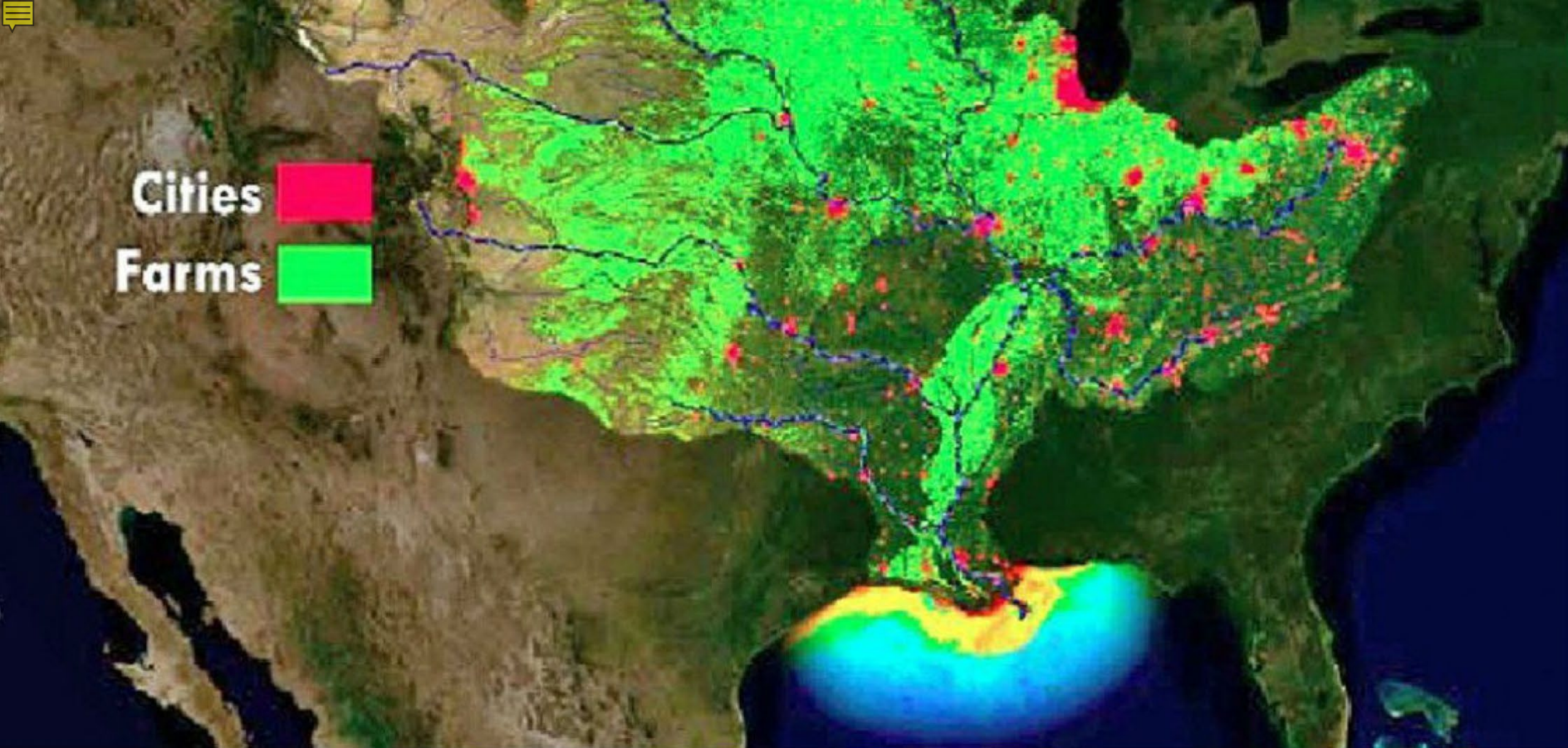


Mycelium/Shutterstock

(d)

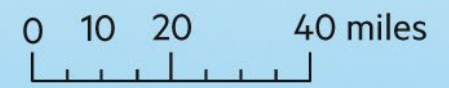


Kevin Britland/Alamy Stock Photo

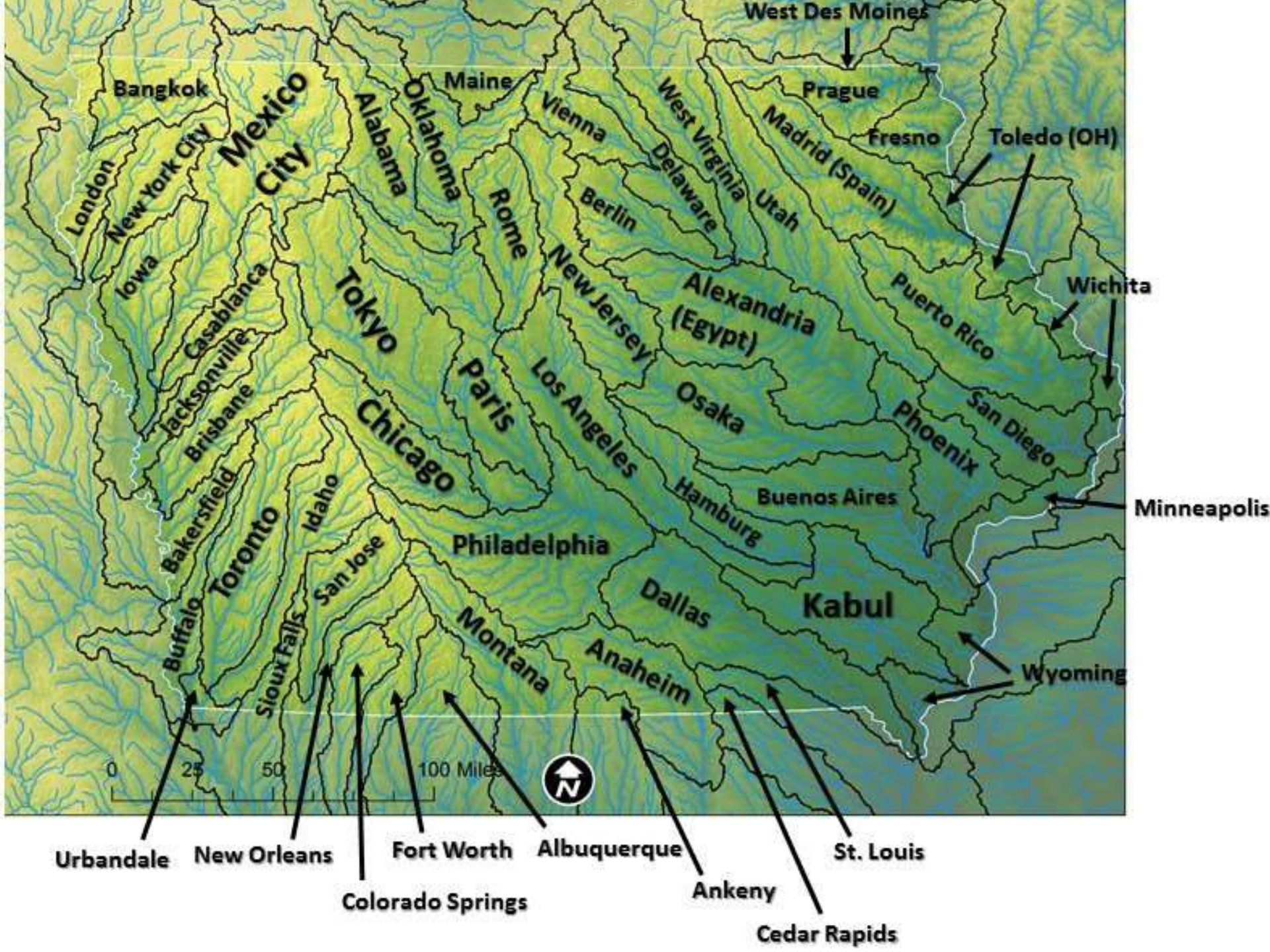


Cities 
Farms 

Externalities



Courtesy of



Population, from
294,122
to with animals
3,289,237

Statewide
24 million pigs
3 million people
8:1

Chris
Jones
U Of Iowa
IIHR



Lynn Betts, USDA Natural Resources Conservation Service

No-Till Farming

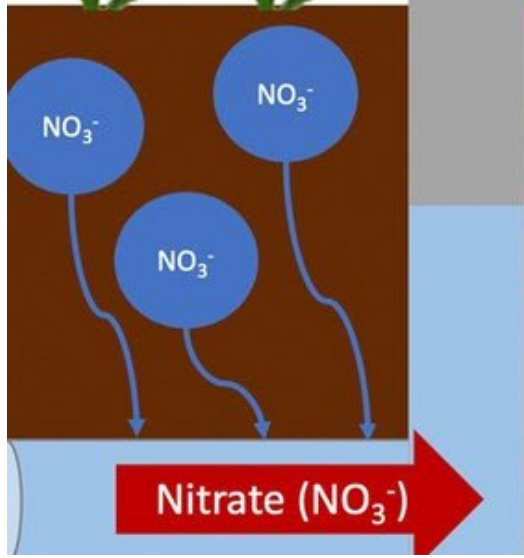


Lynn Betts, USDA Natural Resources Conservation Service

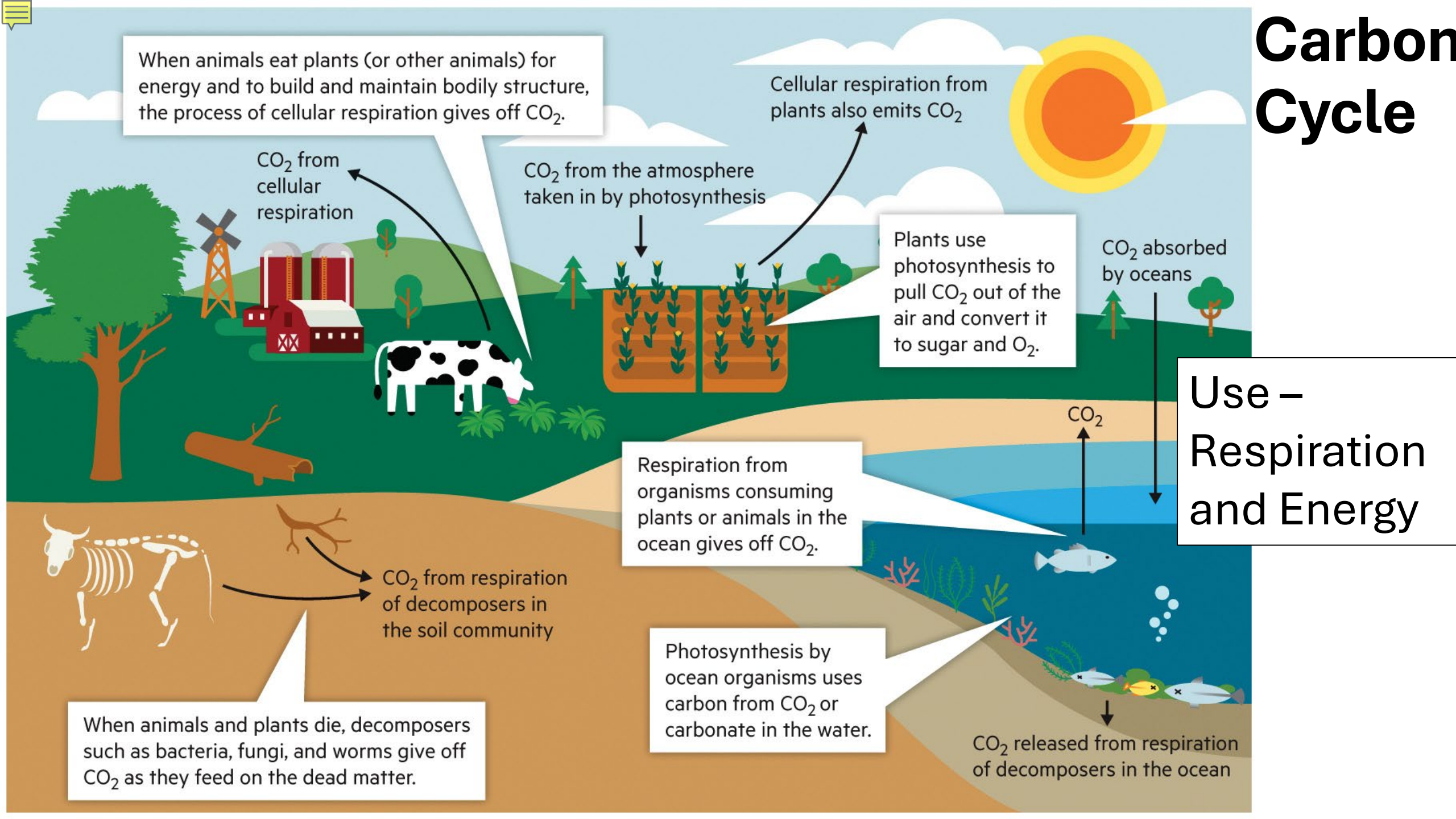
Vegetation Buffers

Bioreactors

What is a “Typical” Woodchip Bioreactor?

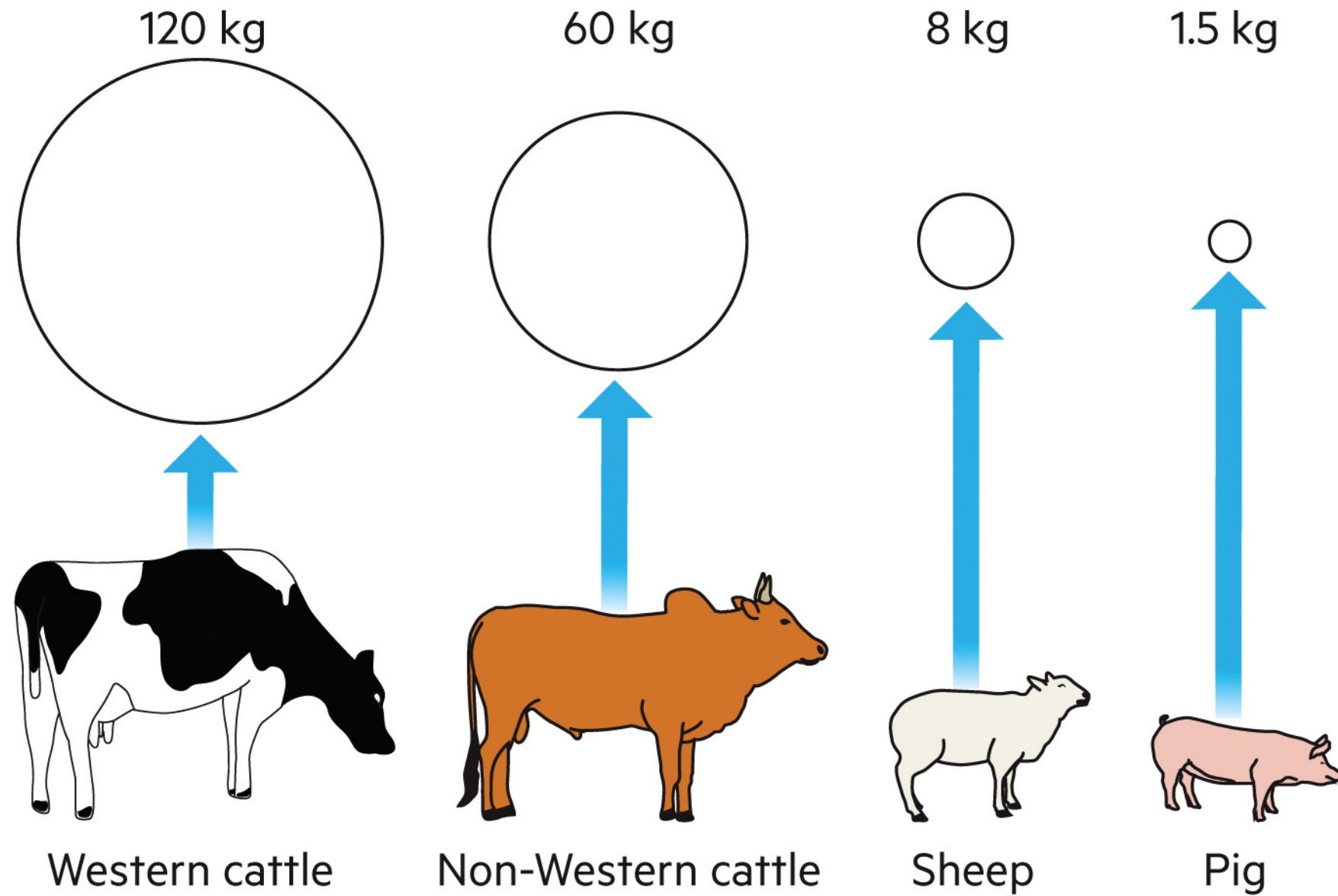


Carbon Cycle





Mass of Methane Emitted Annually



Moving Carbon from the Biosphere to atmosphere

Methanogens-
Mirco-organisms that convert C to Methane (CH_4) in anoxic environments.

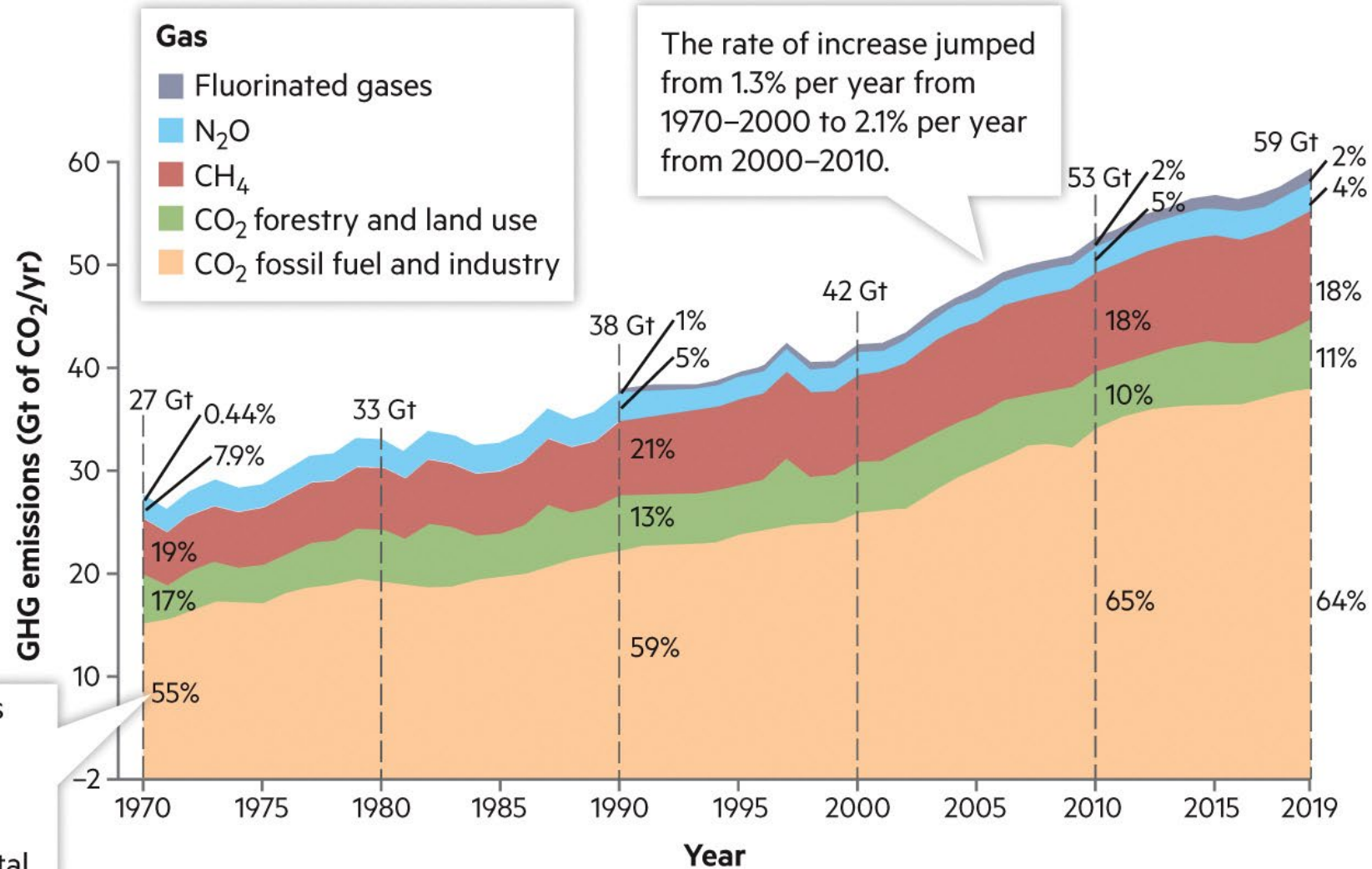
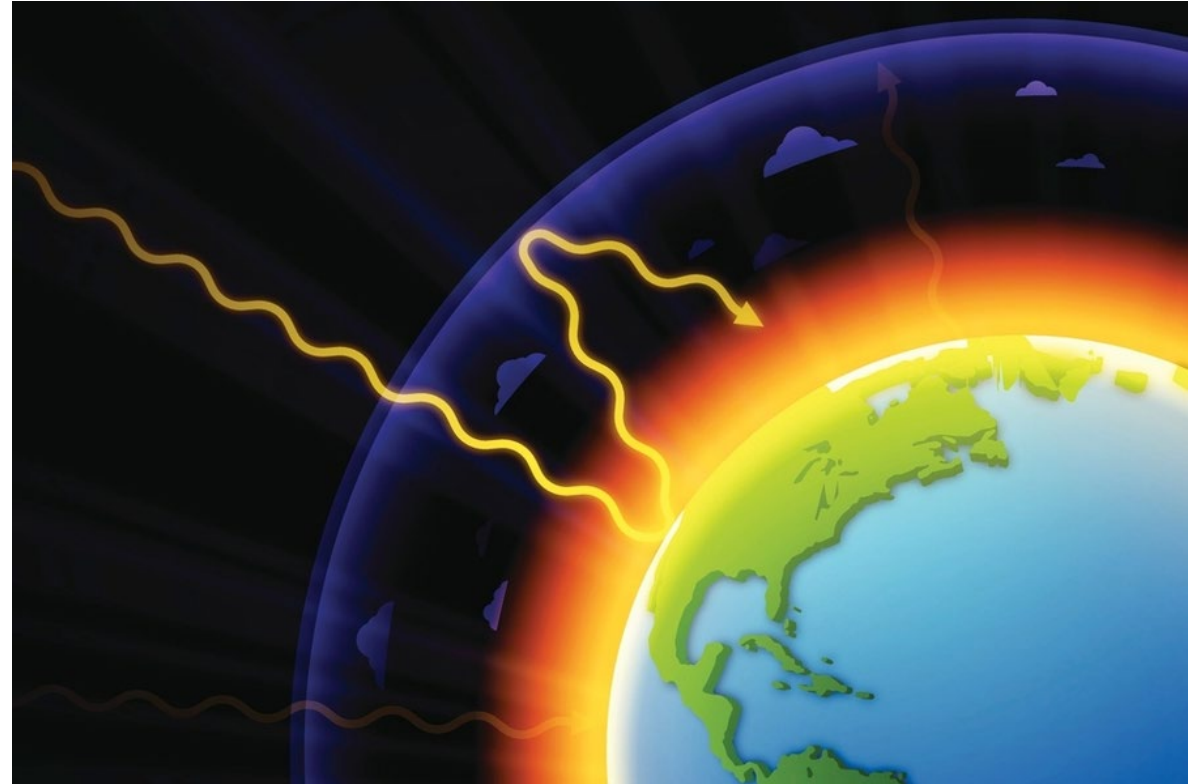


Figure SPM.1 IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland.



Greenhouse Gases (GHG)

- Carbon Dioxide CO_2
- Methane CH_4
- Nitrous oxide N_2O
- Water vapor H_2O_v
- Fluorinated gas synthetic gases hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3).



Positive Feedback

AT A GLANCE

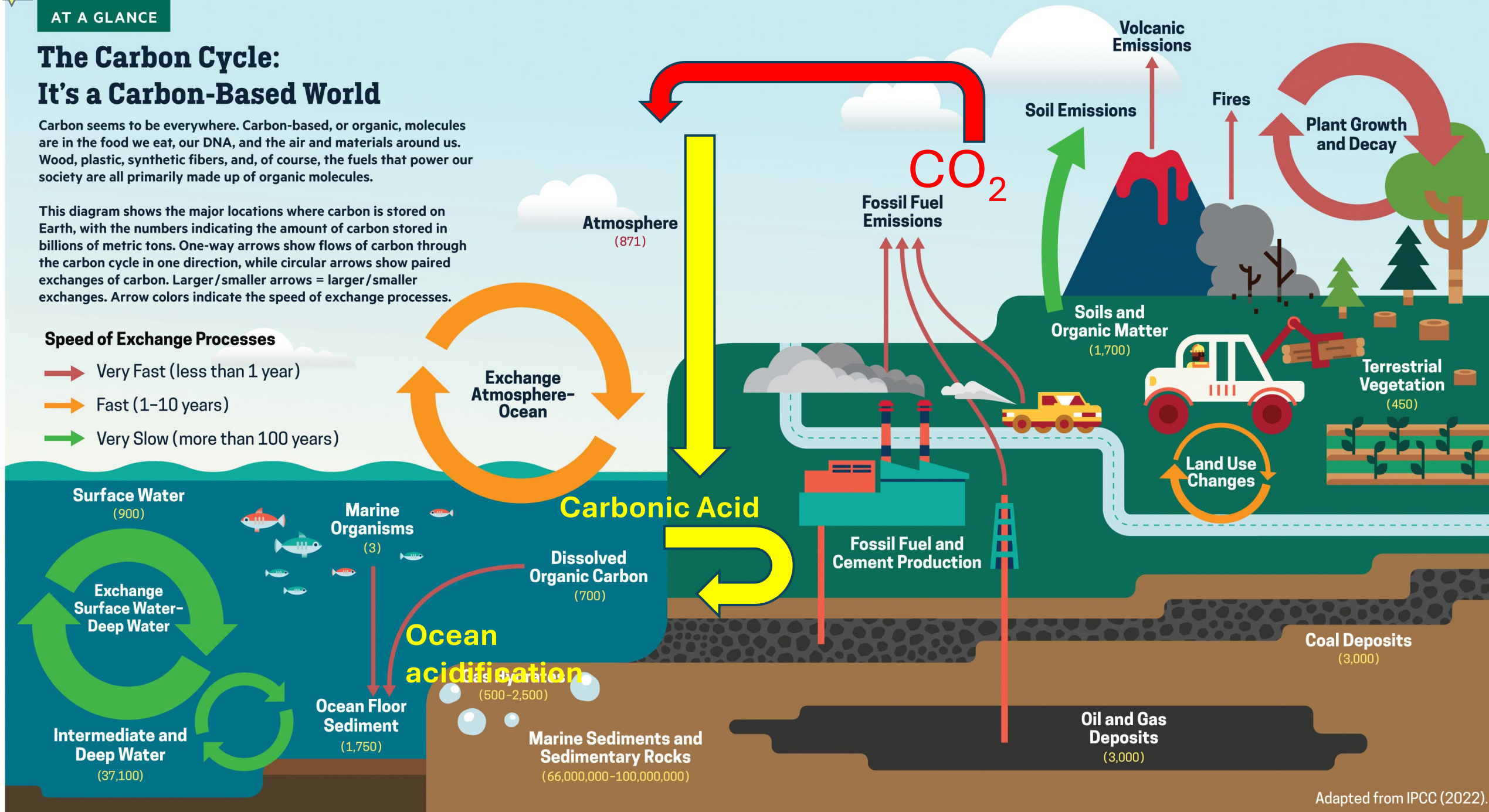
The Carbon Cycle: It's a Carbon-Based World

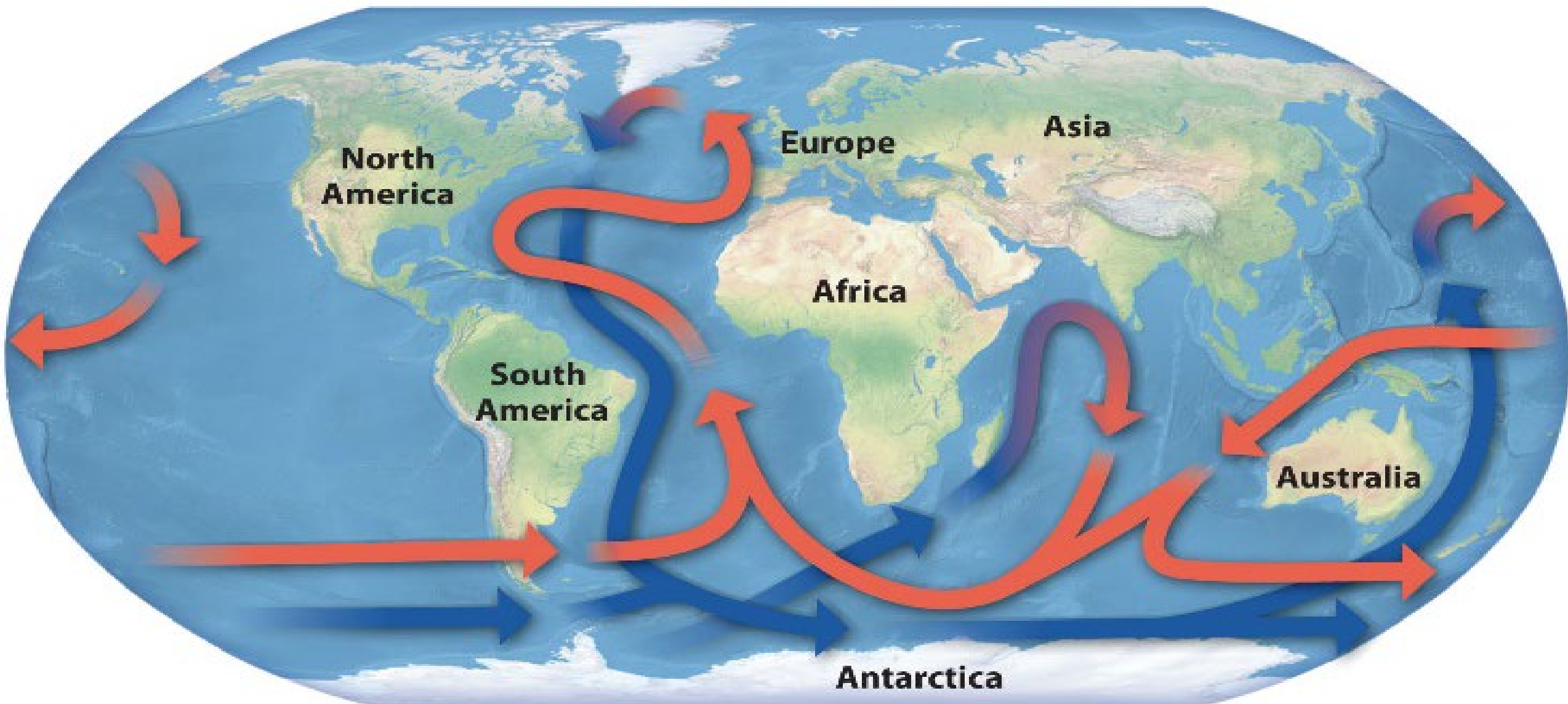
Carbon seems to be everywhere. Carbon-based, or organic, molecules are in the food we eat, our DNA, and the air and materials around us. Wood, plastic, synthetic fibers, and, of course, the fuels that power our society are all primarily made up of organic molecules.

This diagram shows the major locations where carbon is stored on Earth, with the numbers indicating the amount of carbon stored in billions of metric tons. One-way arrows show flows of carbon through the carbon cycle in one direction, while circular arrows show paired exchanges of carbon. Larger/smaller arrows = larger/smaller exchanges. Arrow colors indicate the speed of exchange processes.

Speed of Exchange Processes

- Very Fast (less than 1 year)
- Fast (1-10 years)
- Very Slow (more than 100 years)





Ocean thermohaline circulation involves sinking of cold, salty water at the poles (shown in blue). This sinking water produces deep cold currents and shallow warm surface currents (shown in red).

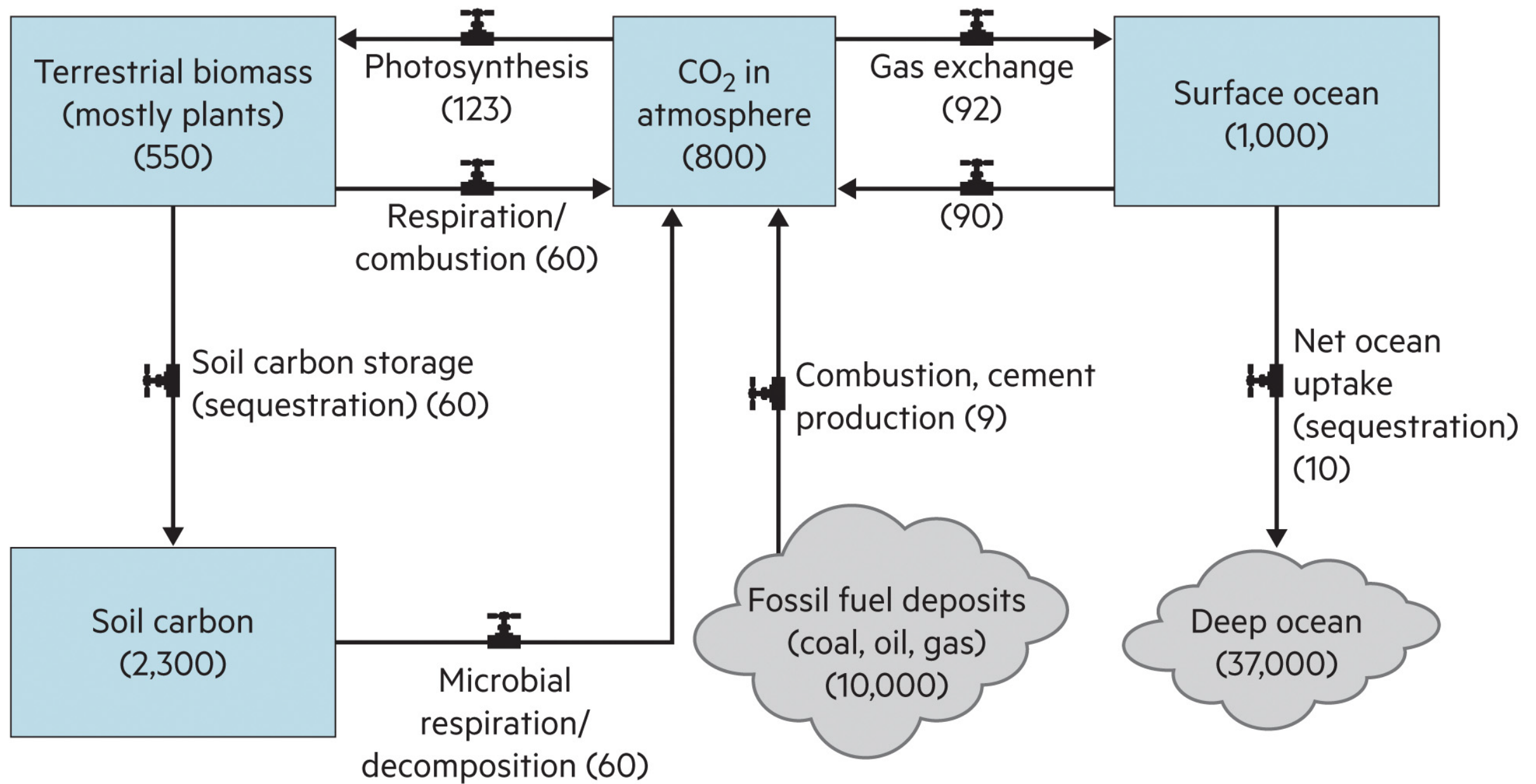
CO_2



Carbonic acid

CO_2





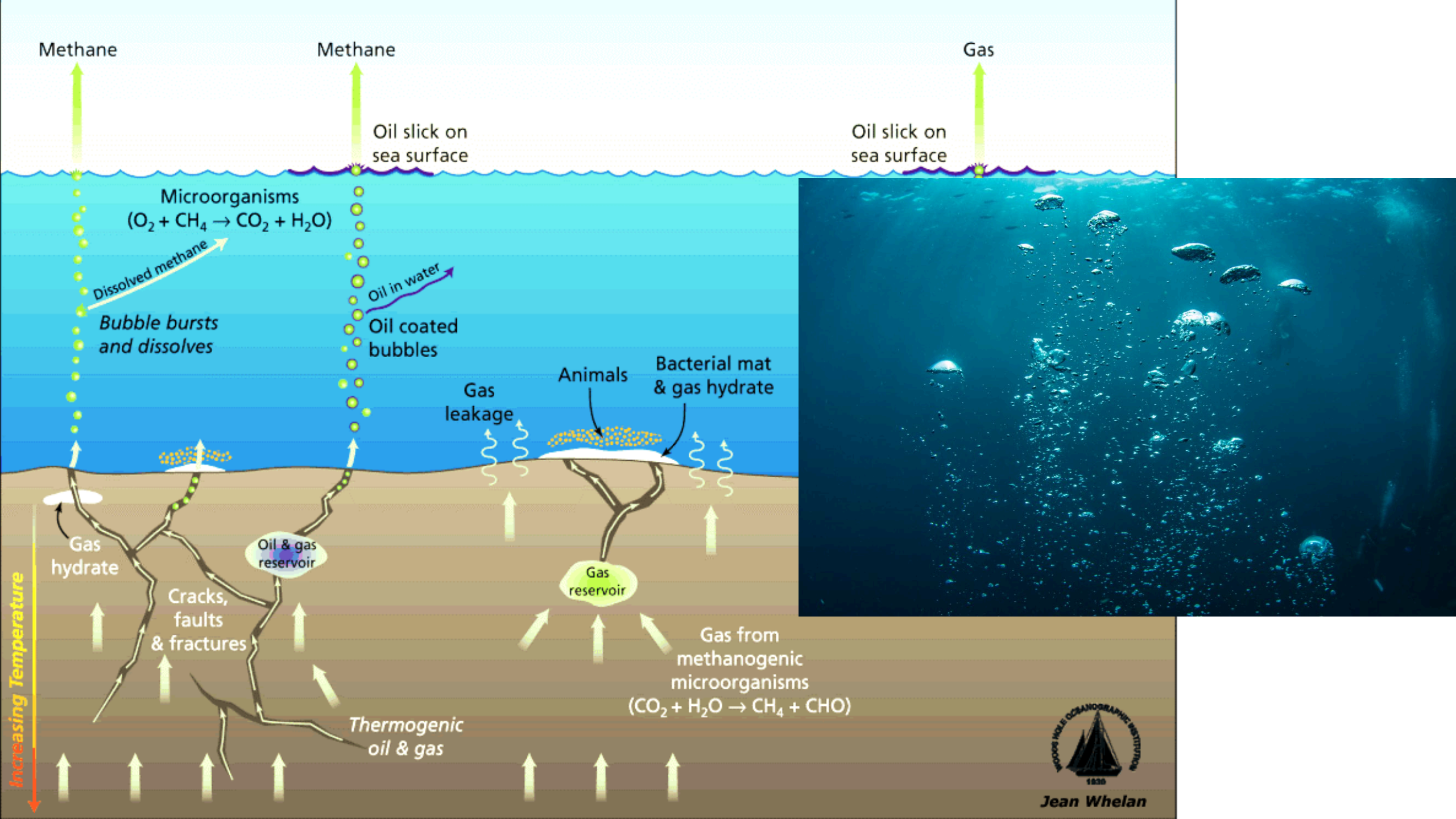


Room temp

vs.

On ice





Systems Thinking

The Iceberg

A tool for guiding systems thinking

Events

What occurred?

A dead zone formed in the Gulf of Mexico.

Patterns/trends

What long-term patterns have been observed?

The dead zone forms every spring when fertilizer runoff washes into the gulf from the Mississippi River.

Underlying structures

What causes these long-term trends?

What interactions occur between system components?

Farmers apply synthetic nitrogen fertilizers to their fields in the spring.

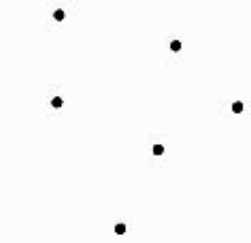
Mental models

What do people think and feel about the system?

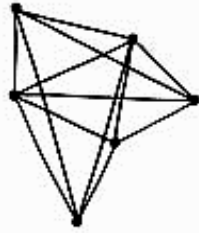
What traditional/established ways of thinking uphold the system?

Rapid crop growth spurred by synthetic fertilizers is more important than preserving natural systems.

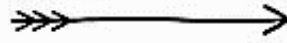
TOOLS OF A SYSTEM THINKER



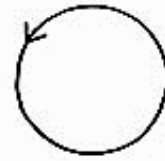
DISCONNECTION



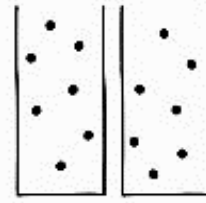
INTERCONNECTEDNESS



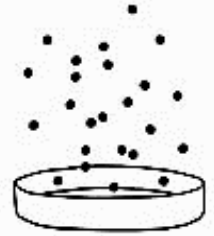
LINEAR



CIRCULAR



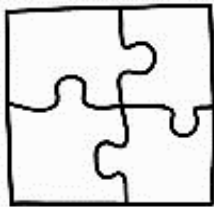
SILOS



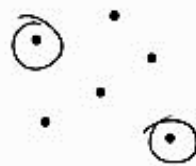
EMERGENCE



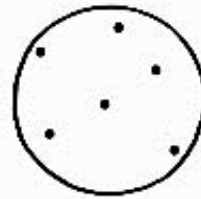
PARTS



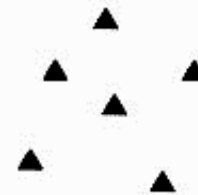
WHOLE



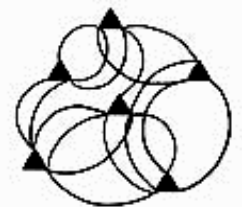
ANALYSIS



SYNTHESIS



ISOLATION



RELATIONSHIPS