Mono Lake:
(terminal lake)

Result of humans re-directing/closing off water flow to/from bodies of water. Over time, evaporation has caused a buildup of salt concentration, actually saltier than oceans, no fish can survive its water.

Chapter 2

Environmental Systems

Earth is a single interconnected system

A System is a set of interacting components connected in such a way that **a change in one part of the system affects one or more other parts of the system**.

Food Web:

- Solar energy
- Producers
- Consumers
- Decomposers

(ex. bacteria & fungi)

Interdependence: all organism are a part of a network that *depend on one another for energy* and raw material

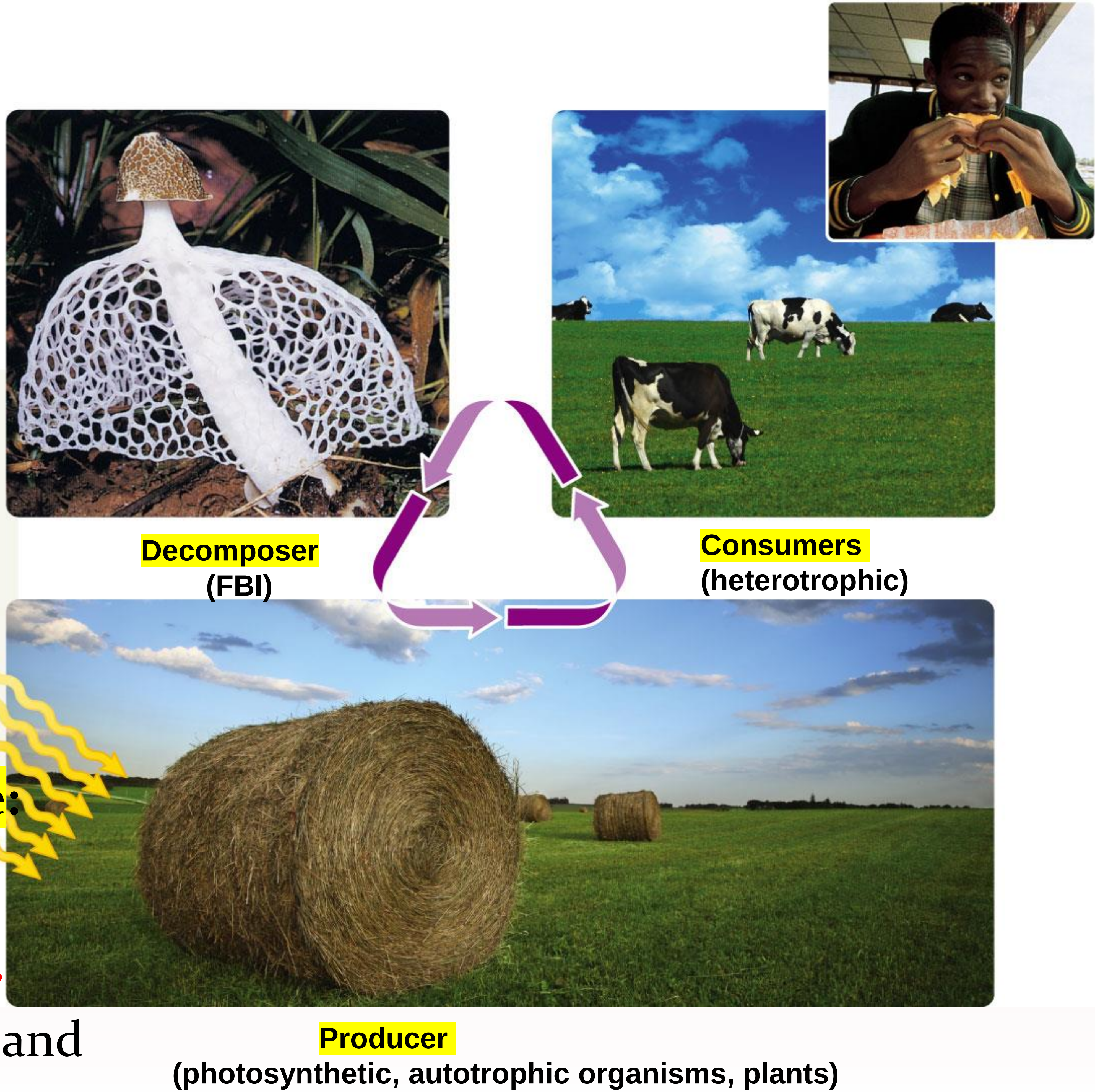

Fig. 1-6, p. 5

Environmental systems may be defined by the researchers point of view...

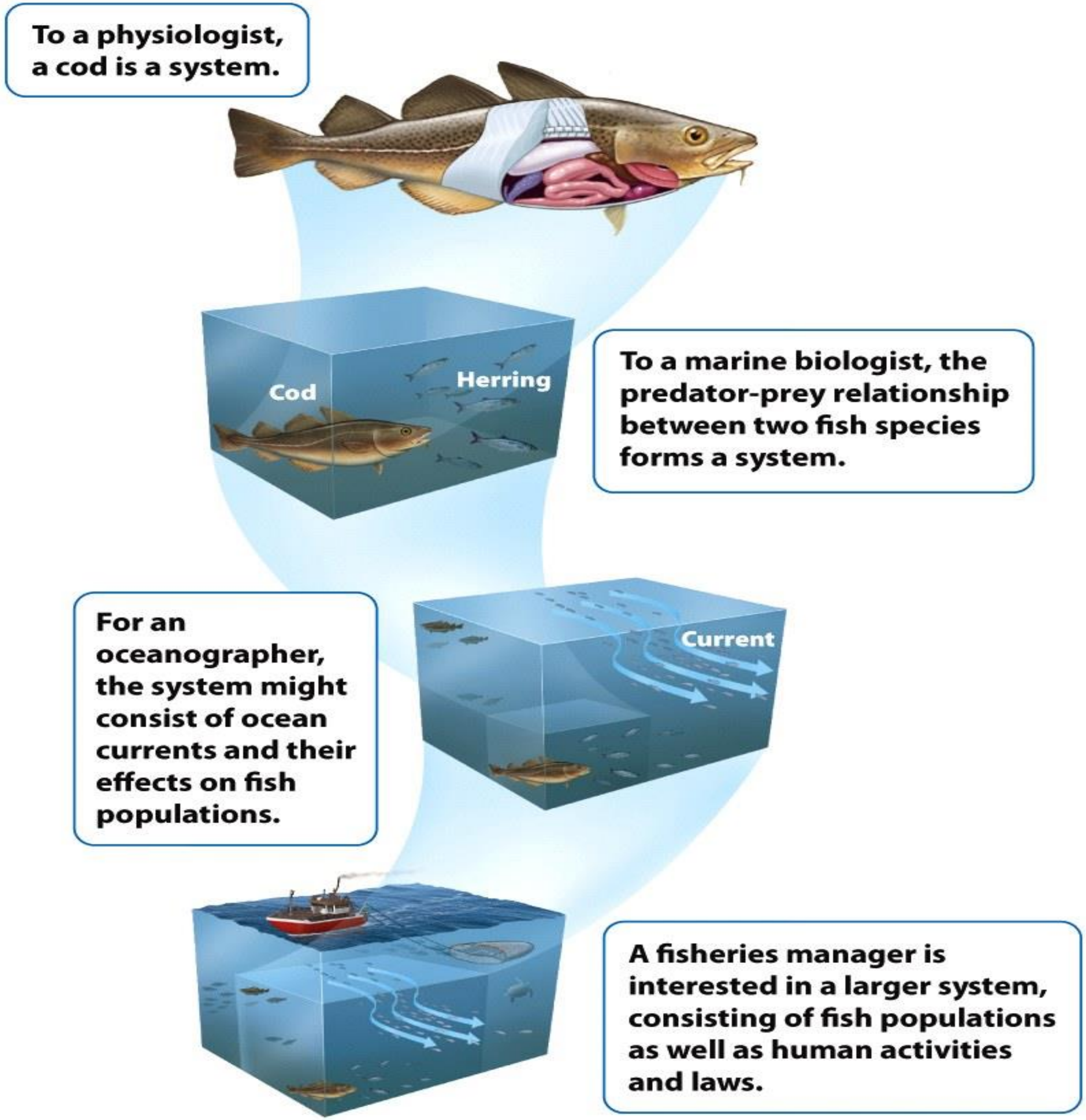

Figure 2.1
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All environmental systems consist of matter

- **Matter-** anything that occupies space and has mass.
- **Mass-** a measure of the amount of matter an object contains.
- **Weight-** the force that results from the action of gravity on mass.

Atoms and Molecules

- **Atom-** the smallest non-living particle that can contain the chemical properties of an element.
- **Element-** a substance composed of atoms that cannot be broken down into smaller, simpler components. Elements can be solid, liquid or gas.
- **Periodic Table-** lists all the elements currently known.
- **Molecules-** particles containing more than one atom.

Atoms and Molecules

- **Compounds-** molecules that contain more than one element.
- **Atomic Number-** the number of protons in the nucleus of a particular element
  - *unique to the element, does not change....change the atomic #, change the element*
- **Mass Number-** the total number of protons and neutrons in an element.
  - Mass # - Atomic # = # of neutrons
- **Isotopes-** atoms of the same element that have different numbers of neutrons to protons, and therefore different atomic masses.

Radioactivity

- **Radioactive decay-** the spontaneous release of material from the nucleus of an unstable isotope.
  - Radioactive decay changes the radioactive element into a different element.

    Ex. Uranium-235 decays to form Thorium-231.
  - Uranium is called the parent and thorium the daughter.

Radioactivity

- **Half-life-** the time it takes for one-half of the original radioactive parent atoms to decay.
  - Some elements that undergo radioactive decay emit harmful radiation.
  - Knowledge of the half-life allows scientists to determine the length of time that a radioactive element may be dangerous.

(Ex). Depleted nuclear fuel in air generated by nuclear power plant (period of time that people & environment must be protected from the effects/emissions)

***if a radioactive isotope has a half life of 10,000yrs…which means that 10,000yrs from today a sample will be half as radioactive, another 10,000yrs will be ¼ radioactive and so forth

Half-Life…

1. Total years = X x n

X= # of half-lives based on fraction of decay

n = set # of years for ½ of the element to decay

***the element loses half of its radioactivity every n years.

2. Amt. remaining = (original amt.) x (.5^X)

X=half lives

Radioactivity – half life

- How long (in yrs) will it take 10g of Uranium to decay 1/8 of its original substance if it has a half life of 10,000yrs?

present 1/2 1/4 1/8

- 10g --- 5g --- 2.5g---1.25g

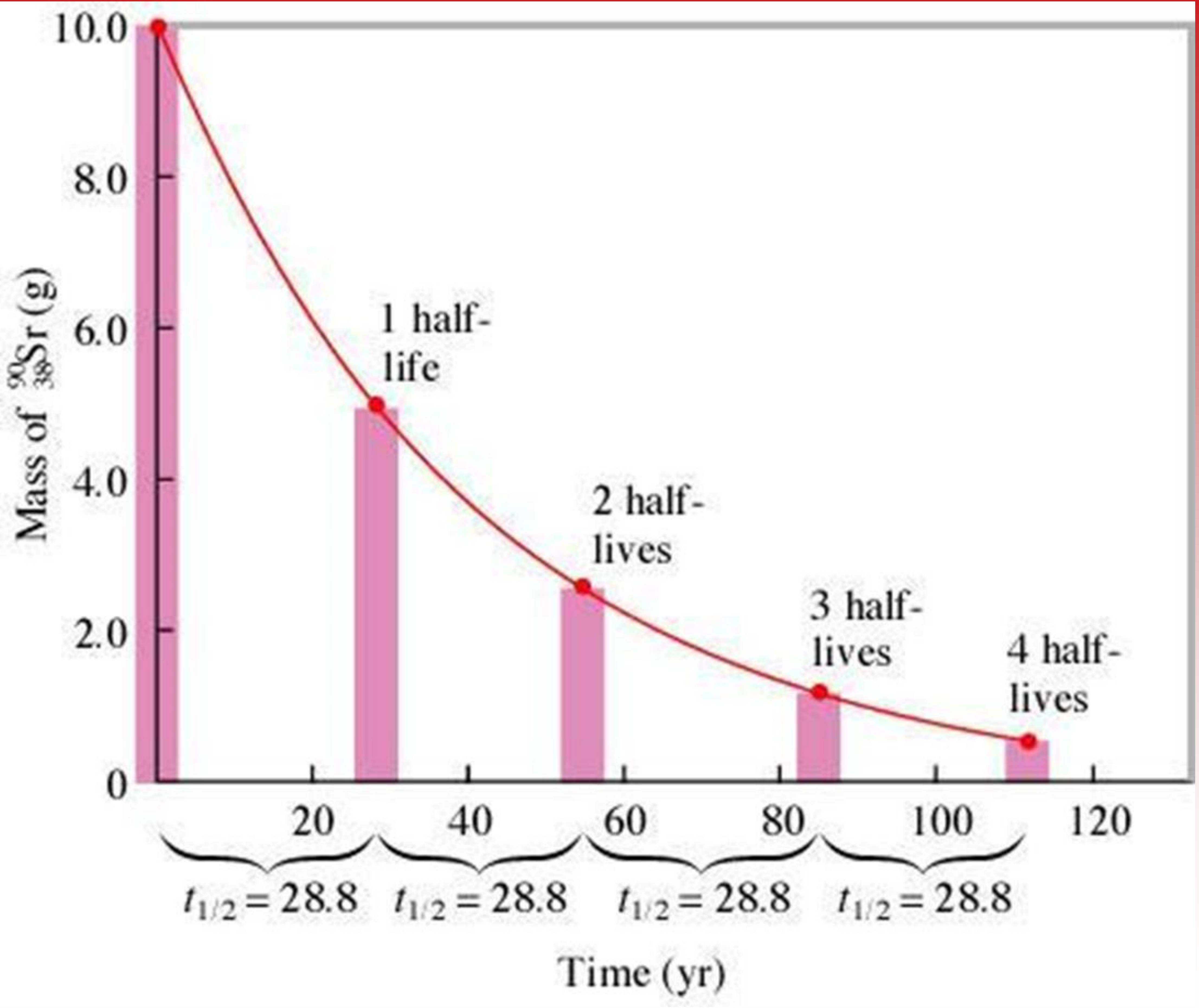
1 half life 2 half life 3 half life

X x n = total years

- 3 half lives x 10,000yrs = 30,000yrs to degrade 10g U

1. You have 450g of a radioactive substance. It has a half-life of 285 years. After 1,625 year, what mass remains??

2. Strontium-90 is a radioactive waste product from nuclear reactors. It has a half-life of 33 years. How many years will it take for a quantity of strontium-90 to decay 1/16 of its original mass???



10.0
8.0
6.0
4.0
2.0
0
Mass of $^{90}_{38}Sr$ (g)
1 half-life
2 half-lives
3 half-lives
4 half-lives
20
40
60
80
100
120
$t_{1/2} = 28.8$
$t_{1/2} = 28.8$
$t_{1/2} = 28.8$
$t_{1/2} = 28.8$
Time (yr)

Chemical bonds

- **Covalent bonds-** elements that form compounds by sharing electrons.

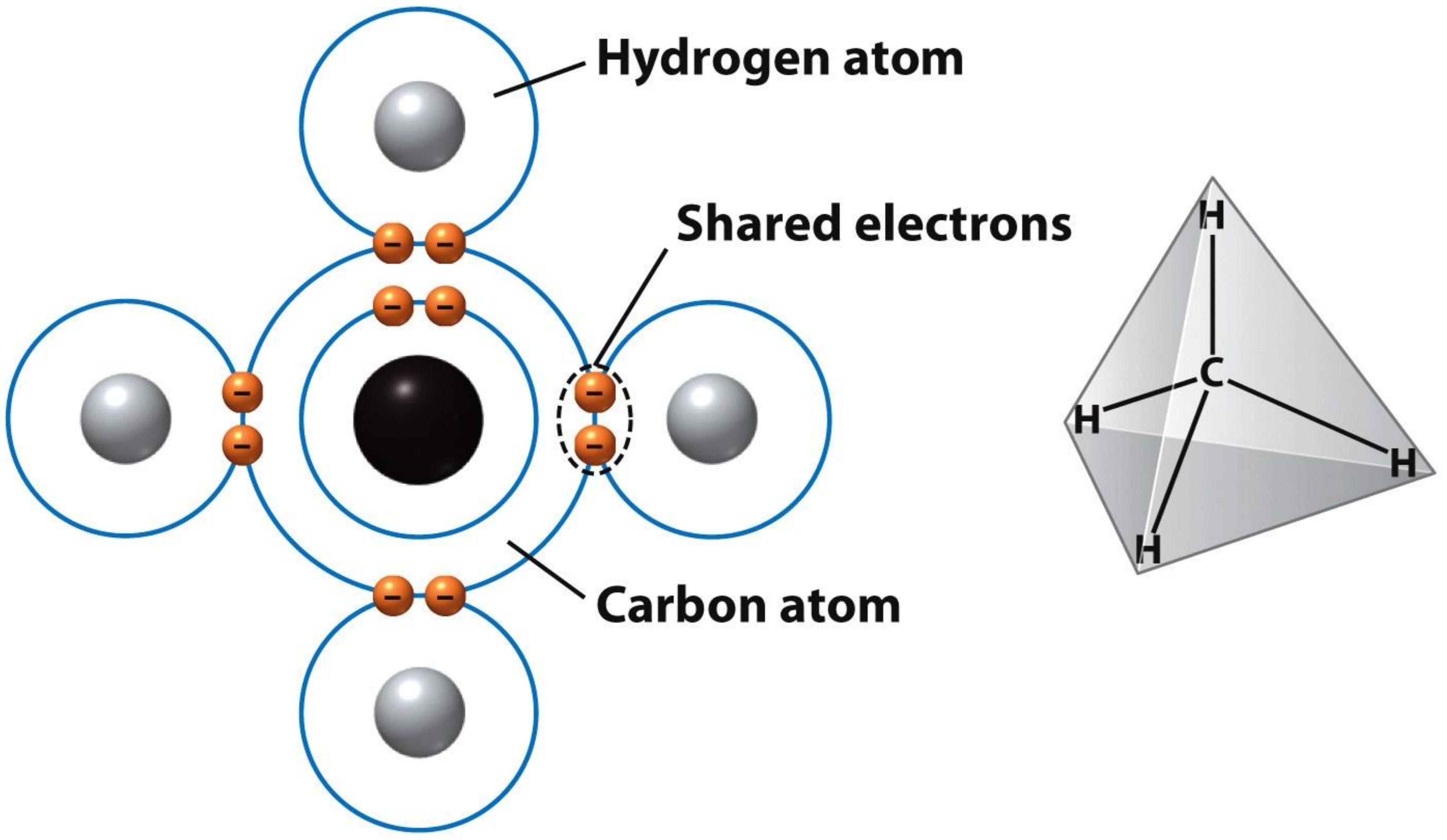


Figure 2.3
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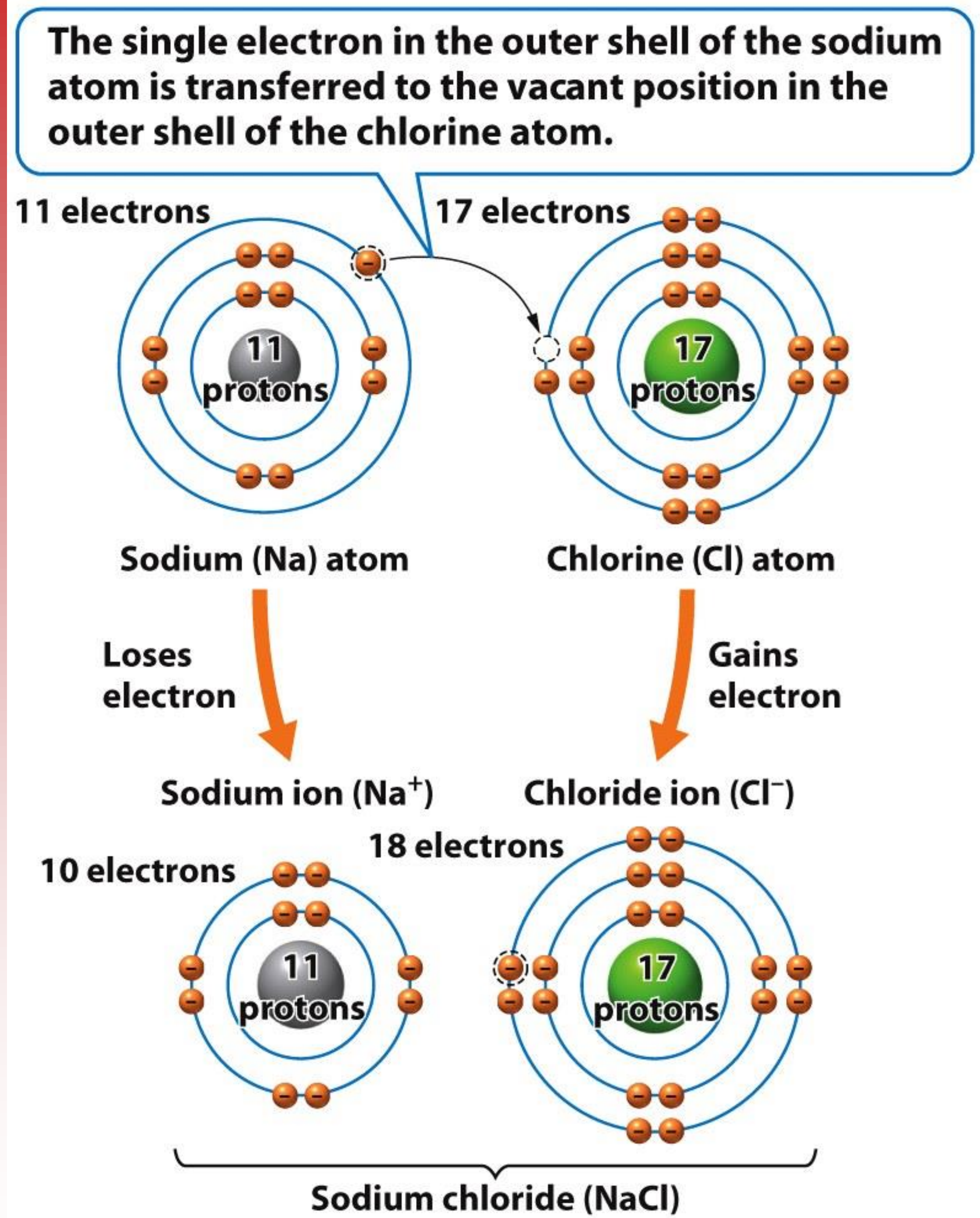
Chemical bonds

- **Ionic bonds-** elements that form compounds by transferring electrons from one element to another.
  - When this transfer happens, one atom becomes electron deficient (positively charged) and one atom becomes electron rich (negatively charged)



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Chemical bonds

- **Hydrogen bonds-** a *weak chemical bond* that forms when hydrogen atoms that are covalently bonded to one atom are attracted to another atom on another molecule.
  - Water is known as a polar molecule, one side is more positive and the other side is more negative.

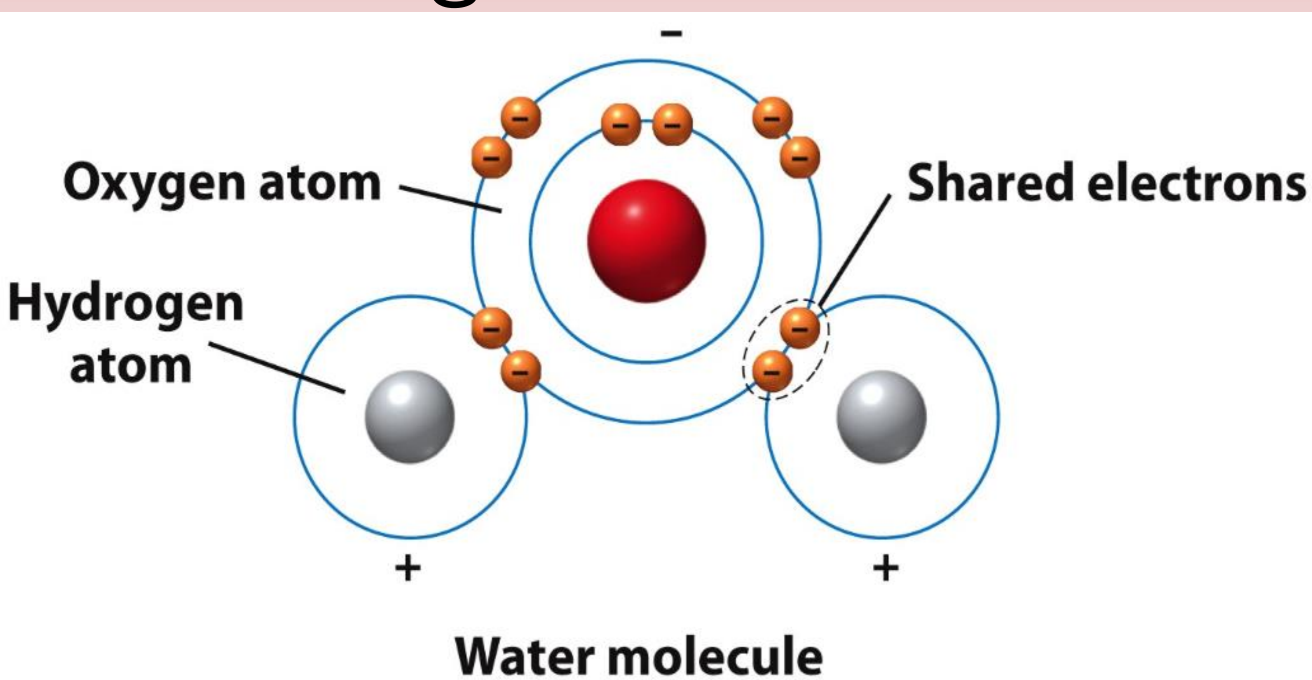

Figure 2.5a
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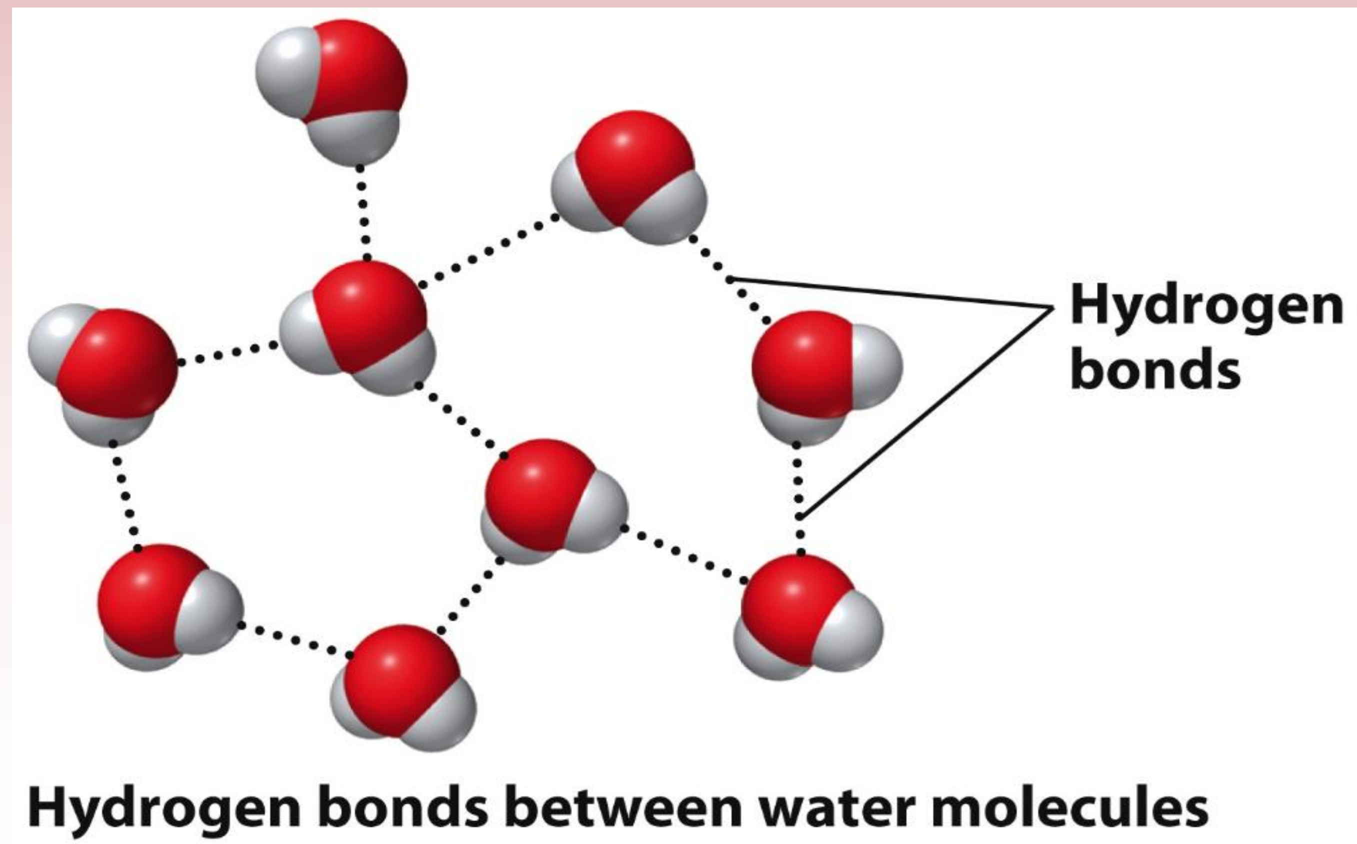

Figure 2.5b
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Properties of water

- **Surface tension-** the result from the cohesion of water molecules at the surface of a body of water.
- **Capillary action-** when adhesion of water molecules to a surface is stronger than cohesion between the molecules. (**movement of water**, ex. water moving through soil)

Figure 2.6
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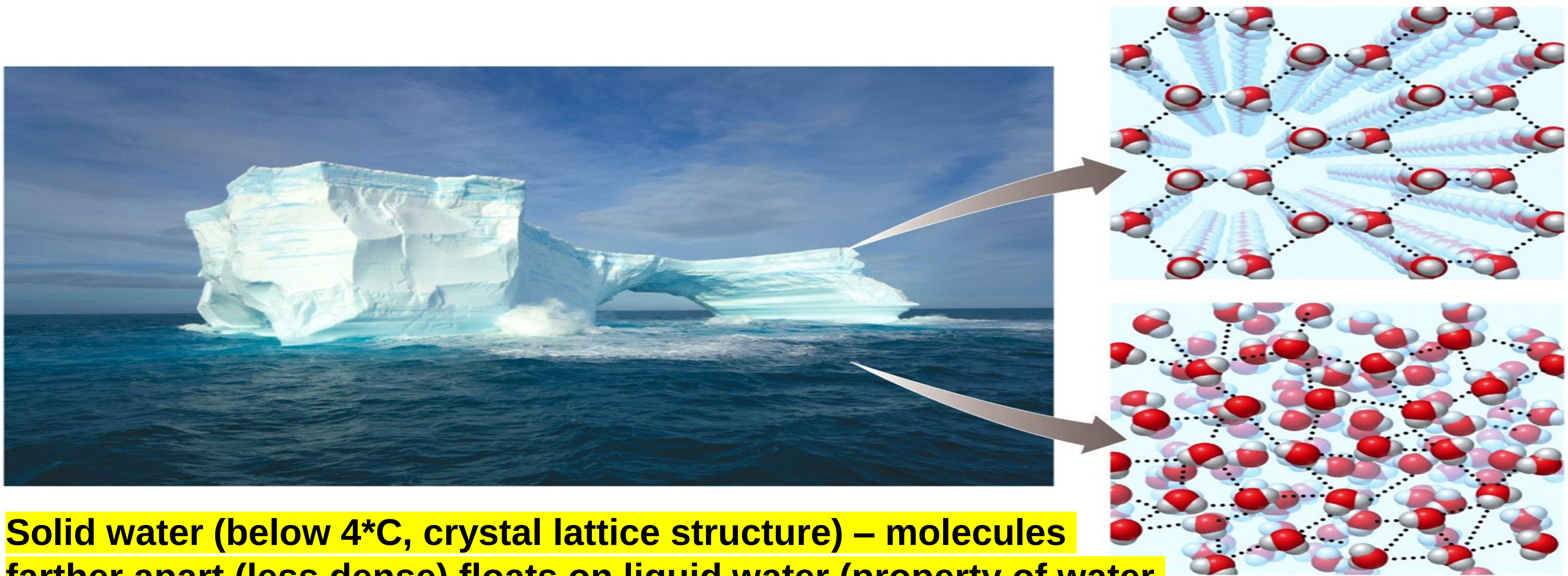
- Boiling and freezing- at Earth's surface, water boils at 100 degrees Celsius (212*F) and freezes at 0 degrees Celsius (32*F)
- Water as a universal solvent- many substances dissolve well in water because their polar molecules bond easily with other polar molecules.



Solid water (below 4*C, crystal lattice structure) – molecules farther apart (less dense) floats on liquid water (property of water

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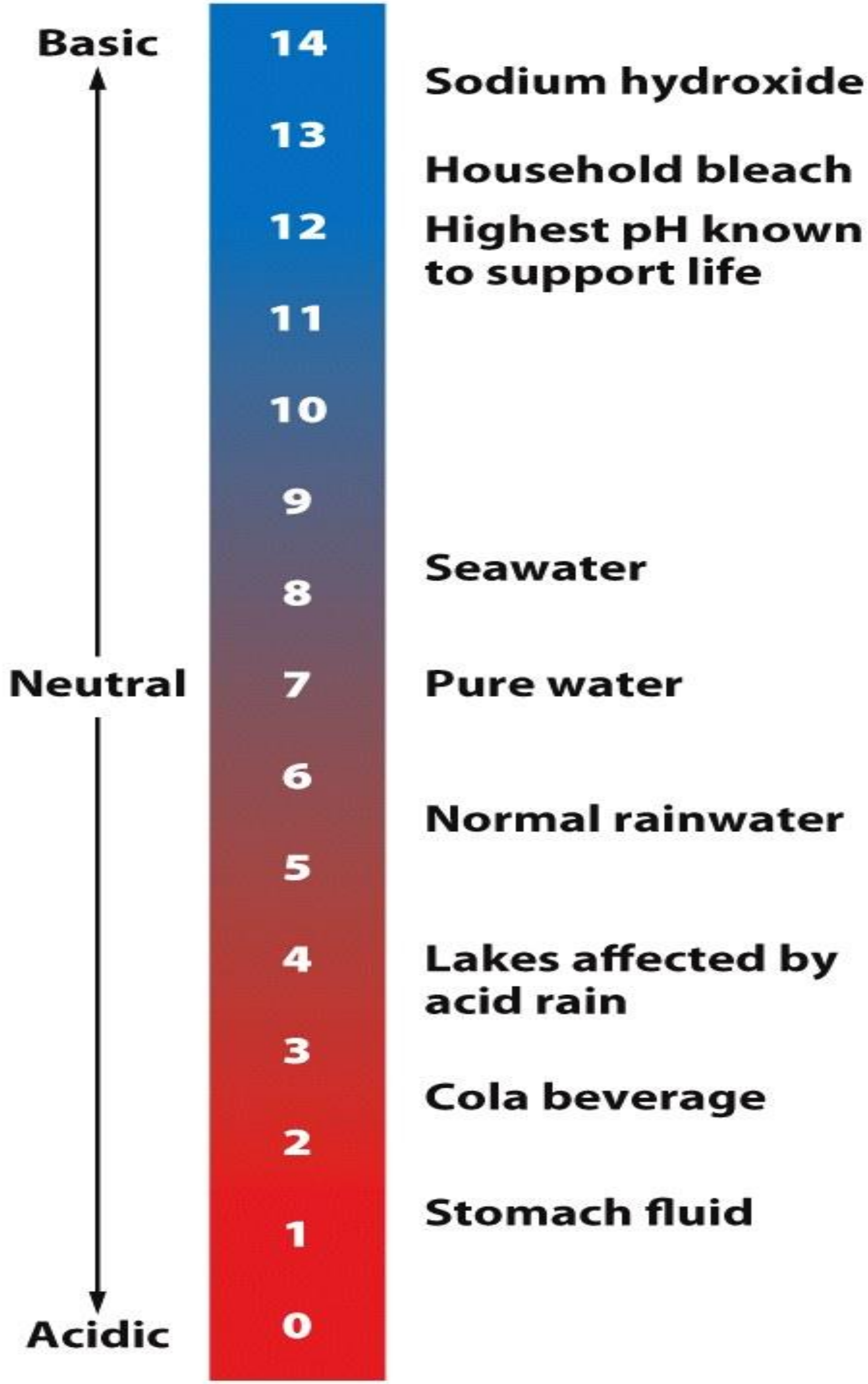
acids, bases, and pH

- **Acid-** a substance that contributes hydrogen ions to a solution.
- **Base-** a substance that contributes hydroxide ions to a solution.



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pH- a way to indicate the **strength of acids and bases.**
(Acid – closer to 0, stronger
Base – closer to 14, stronger)

0-6.9 Acidic

7 Neutral

(equal hydronium to hydroxide ions)

7.1 – 14 Basic

Measured in log of 10….

Ex. pH of 4 is 100x the concentration of hydrogen ions than a pH of 6.

pH of 8 is 1000x the concentration of 11

Chemical reactions and the conservation of matter

- **Chemical reaction-** occurs when atoms separate from the molecules they are a part of or recombine with other molecules.
- **Law of conservation of matter-** matter (atoms) cannot be created nor destroyed; it can only change form (conserved).

Figure 2.9
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Forest burns seems like it is disappearing, but it changes form from vegetation to water vapors, carbon dioxide, and solid particles (ashes)

Biological molecules and cells

- **Inorganic compounds-** compounds that do not contain carbon or do contain carbon, but only carbon bound to elements other than hydrogen.
  - ex. NH_3, NaCl, H_2O, and CO_2
- **Organic compounds-** (living matter) compounds that have carbon-carbon and carbon-hydrogen bonds.
  - Basis of the biological molecules important to life…Macromolecules (carbs, lipids, nucleic acids, & proteins)

Organic compounds – biological macromolecules

- **Carbohydrates-** compounds composed of carbon, hydrogen, and oxygen atoms. Ex. $C_6H_{12}O_6$ – glucose (simple sugar)
  - Simple sugar (monosaccharides, single sugar – quick energy)
  - Complex sugars (polysaccharides, many sugars – starches, cellulose – longer energy)
- **Proteins-** made up of long chains of nitrogen-containing organic molecules called amino acids (building blocks).
  - Structural support, energy storage, internal transport, defense, enzyme…etc.
- **Nucleic Acids-** organic compounds found in all living cells.
  - DNA (blueprint to genetic material) vs. RNA (synthesis of protein
- **Lipids-** smaller biological molecules that do not mix with water. Ex. fats, waxes and steroids.

Biological molecules and cells

- **Cells-** the smallest living structural and functional component of organisms.
    - single cells- Ex. bacteria and some algae (prokaryotic)
    - multicellular- Ex. bring shrimp (Eukaryotic)

Life's Organization:

Nature is organized on many levels, starting from nonliving materials to the entire living world.

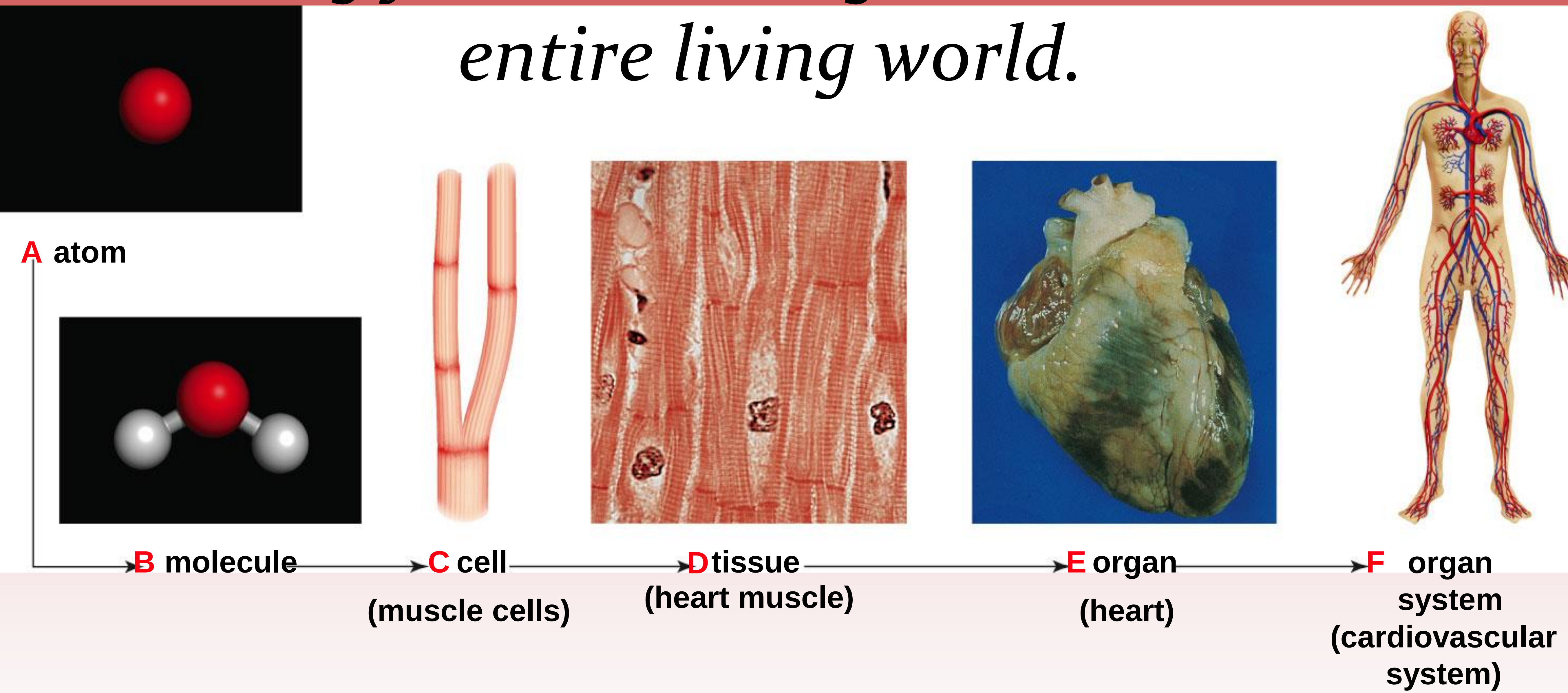

Fig. 1-5a, p. 4

Super small to super large!!!!

Fig. 1-5b, p. 5

Forms of Energy

- **Energy-** the ability to do work. (kW-h *kilowatt-hour*)
  - Energy = power X time
  - Work (joules)= force X distance
- **Power-** the rate at which work is done. (kilowatts)
  - Power = energy / time

TABLE 2.1 Common units of energy and their conversion into joules

Unit	Definition	Relationship to joules	Common uses
calorie	Amount of energy it takes to heat 1 gram of water 1°C	1 calorie = 4.184 J	Energy expenditure and transfer in ecosystems; human food consumption
Calorie	Food calorie; always shown with a capital C	1 Calorie = 1,000 calories = 1 kilocalorie (kcal)	Food labels; human food consumption
British thermal unit (Btu)	Amount of energy it takes to heat 1 pound of water 1°F	1 Btu = 1,055 J	Energy transfer in air conditioners and home and water heaters
kilowatt-hour (kWh)	Amount of energy expended by using 1 kilowatt of electricity for 1 hour	1 kWh = 3,600,000 J = 3.6 megajoules (MJ)	Energy use by electrical appliances, often given in kWh per year

Table 2.1
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Forms of Energy

- **Kinetic energy-** energy of motion.
- **Potential energy-** energy that is stored (at position/location)
- **Chemical energy-** potential stored in chemical bonds.
- **Temperature-** the measure of the average kinetic energy of a substance.

Figure 2.12
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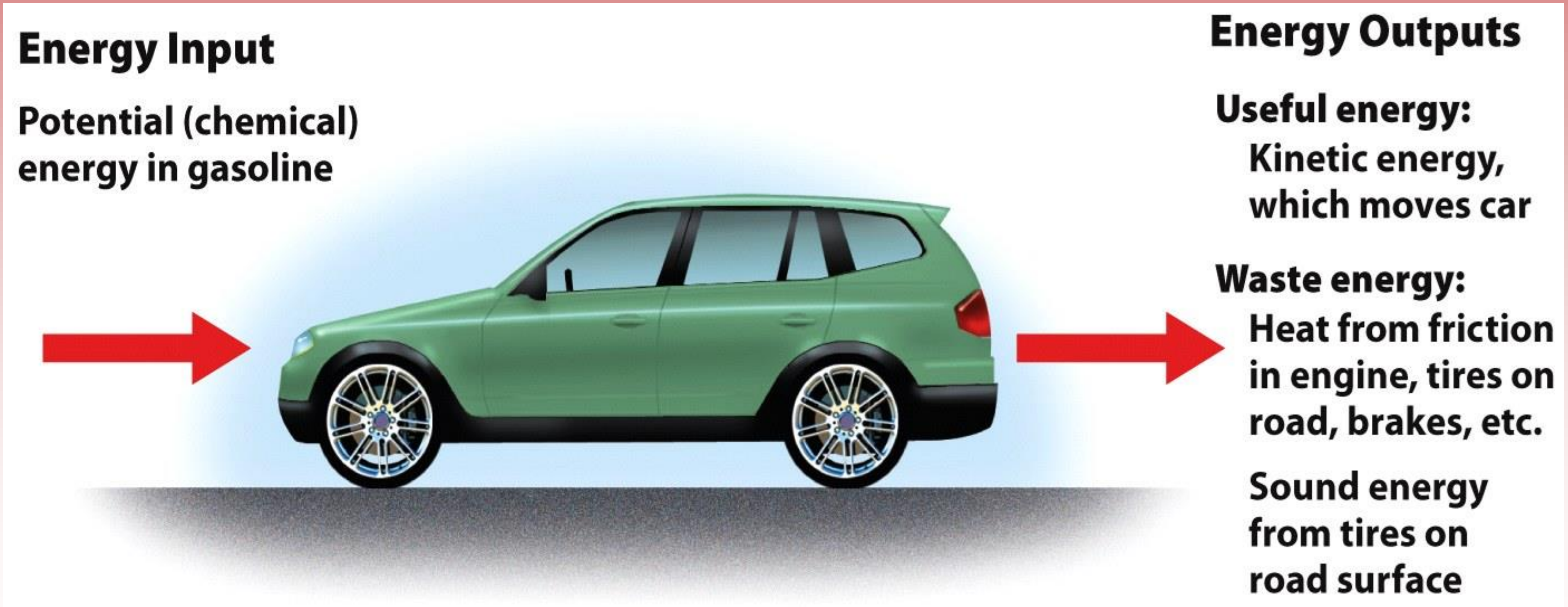
Water stored behind dam – potential
Potential converted to kinetic…
Water flows through gates - kinetic

First law of thermodynamics

- Energy is neither created or destroyed, changed form.
- You can't get something from nothing.
- Organism needs usable energy by "eating" – sun/food



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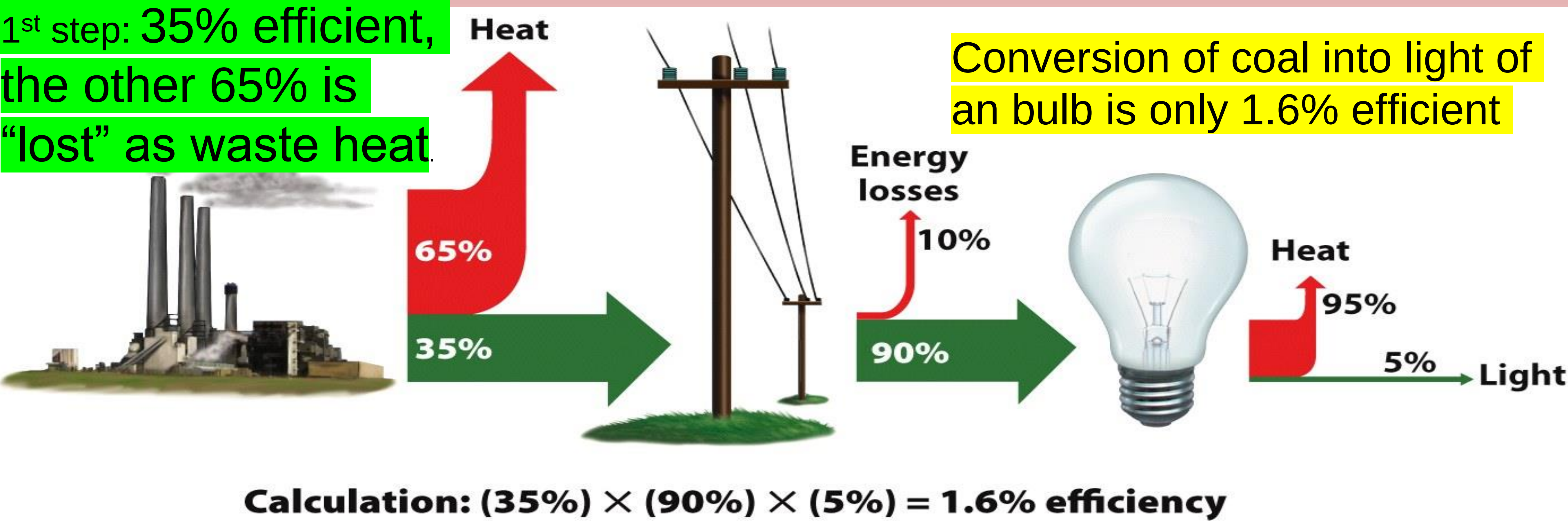
Second law of thermodynamics

- When energy is transformed, the quantity of energy remains the same, but its ability to do work diminishes (some energy is converted into a less usable form, such as waste heat…not useful to do work).

1st step: 35% efficient, the other 65% is "lost" as waste heat.

Conversion of coal into light of an bulb is only 1.6% efficient



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Second law of thermodynamics

- **Energy Efficiency-** the ratio of the amount of work that is done to the total amount of energy that is introduced into the system
- **Energy quality-** the ease with which an energy source can be used for work.
- **Entropy-** all systems move toward randomness rather than toward order.
  - This randomness is always increasing in a system, unless new energy from the outside of the system is added to create order.
  - All living things work against entropy by using energy to maintain order.
  - All systems move toward increased entropy

Energy conversions underlie all ecological processes (fundamental component of all environmental systems)

Organisms rely on a continuous input of energy in order to survive, grow and reproduce.

Amount of available energy determines which organism can live in that natural system (locations)...

Rainforest – abundant energy from sun and moisture (rain) for plants to make use of energy

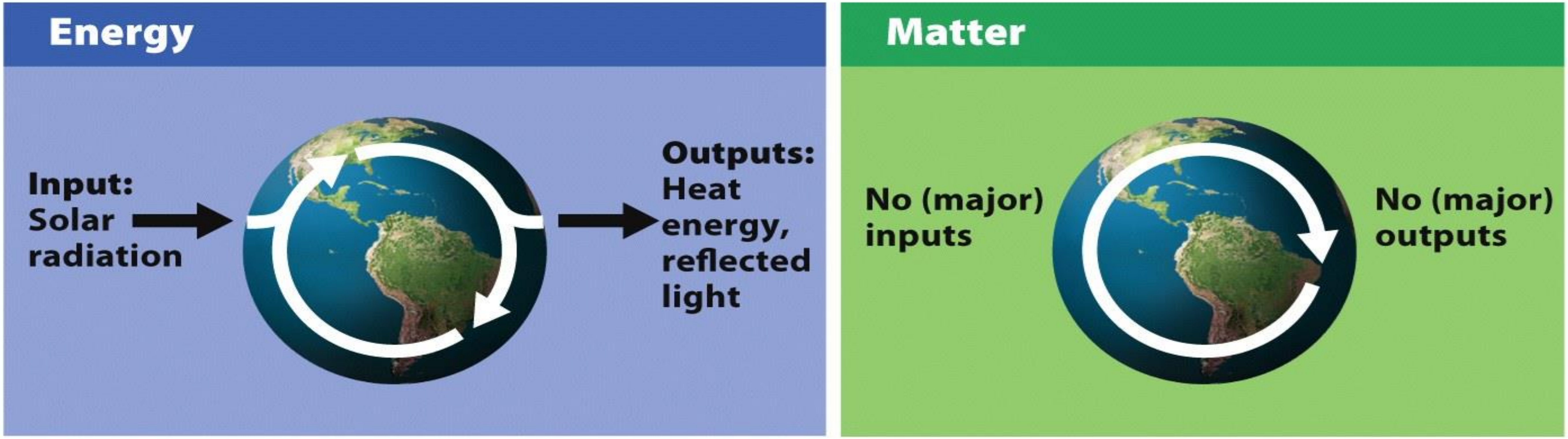
Artic tundra – less energy available, growth is slower & do not reach large sizes.

Deep-vent oceans – plants cannot live, no solar energy penetrates, eels, anglerfish, squid can due to feeding on dead organisms that sink from above

System analysis shows how matter and energy flow in the environment

- **Open system-** exchanges of matter or energy occur across system boundaries.

- **Closed system-** matter and energy exchanges across system boundaries do not occur.



(a) Open system

(b) Closed system

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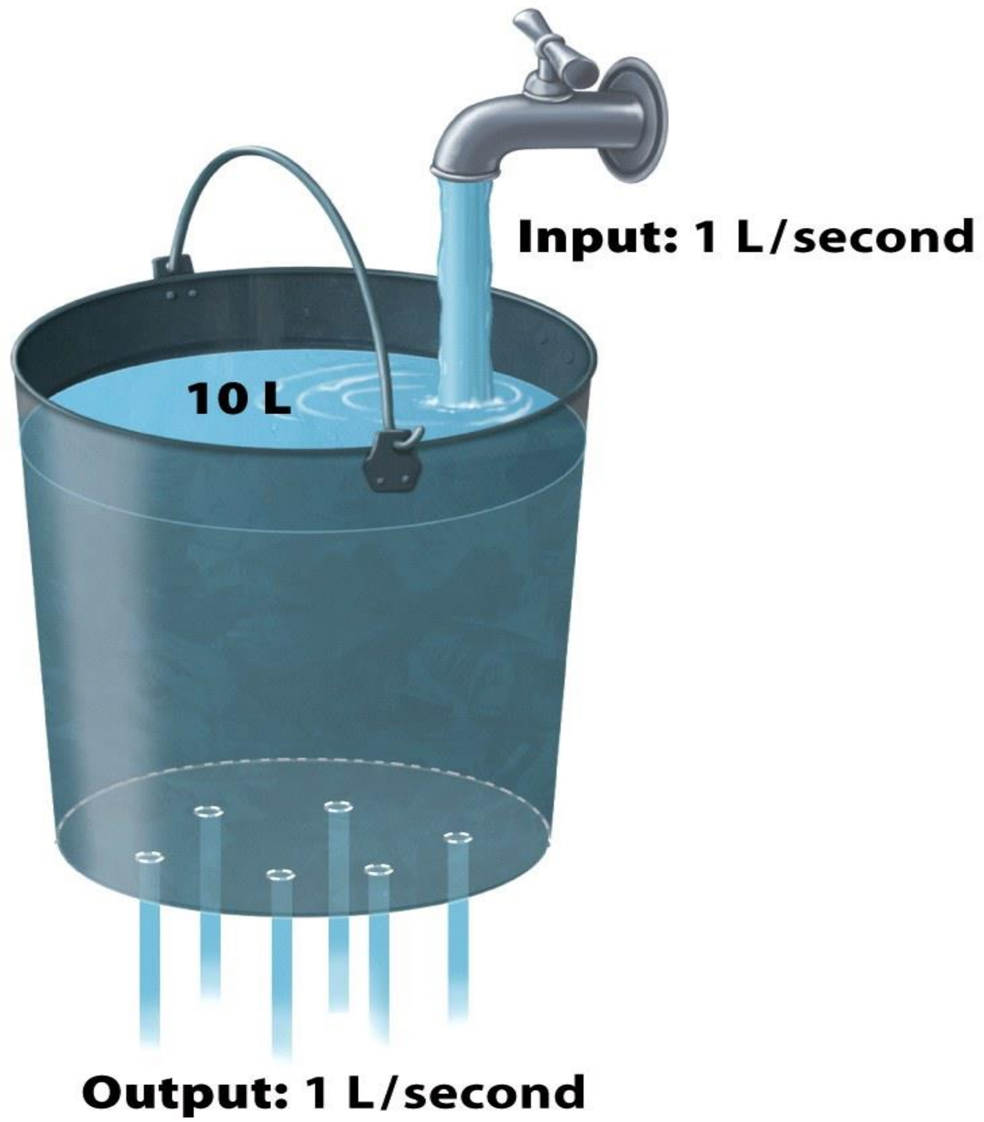
Earth is an open system due to energy (sun), but closed system due to matter (very little matter enters/leaves Earth)

steady states

- **Steady state-** in a system, when input equals output it is said to be in a steady state.

Systems approach to studying the **flow of matter and energy** in the environment enables scientists to recognize complex relationships.



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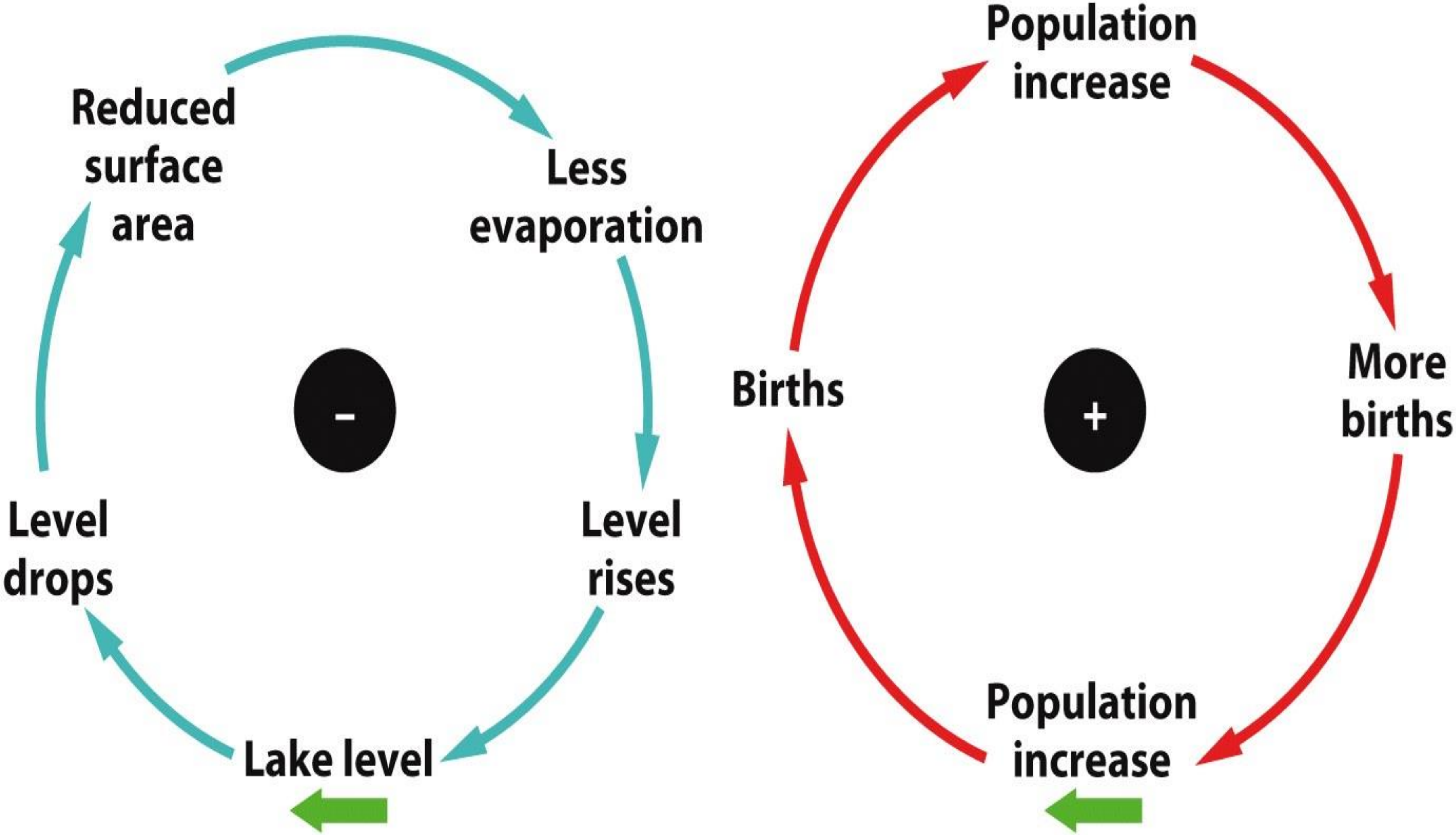
steady states

- **Negative feedback loops-** when a system responds to change by returning to its original state, or at least by decreasing the rate at which the change is occurring.
- **Positive feedback loops-** when a system responds to change by increasing the rate at which the change is occurring *(triggering change in a forward direction, intensifying)*



(a) Negative feedback loop

(b) Positive feedback loop

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Natural systems change across space and over time

Anthropogenic (**humans**) change in an environmental system is often very visible positive or negative…change in rivers *(redirect water sources)*, air that as been polluted *(automobile &/or greenhouse gas emissions),* sprawling *(taking over wild areas for civilizations),* deforestation &/or overhunted/overharvesting to extinction, creating habitat for species to thrive

Throughout Earth's history, small natural changes have had large effects on complex systems, but **human activities have increased** both the PACE and the INTENSITY of these natural environmental changes (ex. Mono Lake).