Chapter 2

Environmental Systems

Earth is a _____ _____ _____.

It is all a matter of scale:

Figure 2.1

All environmental systems consist of _____.

- *Matter:* _____ _____ _____.
- *Mass:* _____ _____.
- *Weight:* _____ _____.

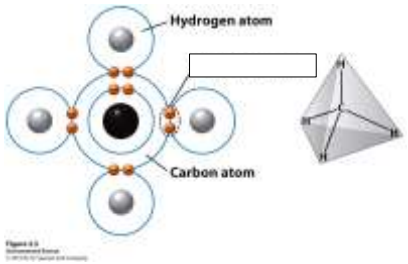
- *Atom:* _____ _____.
- *Element:* _____ _____ _____.
- *Periodic Table:* _____ _____.
- *Molecules:* _____ _____

- *Compounds:* _____
  _____
  _____.
- *Atomic number:* _____
  _____.
- *Mass number:* **the total number of protons and neutrons in an element.**
- *Isotopes:* _____
  _____
  _____
  _____
  _____.

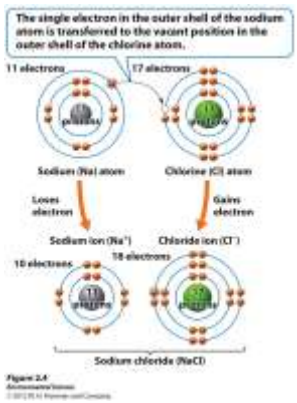
- *Radioactive decay:* _____
  _____
  _____.
  - **Radioactive decay changes the radioactive element into a different element. For example, Uranium-235 decays to form Thorium-231.**
  - _____
    _____.

- *Half-life* _____
  _____
  _____
  - **Some elements that undergo radioactive decay emit radiation harmful to living things.**
  - _____
    _____
    _____
    _____.

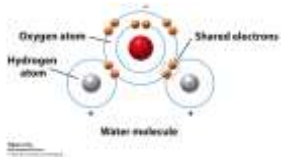
- *Covalent bonds:*
  _____.
  _____

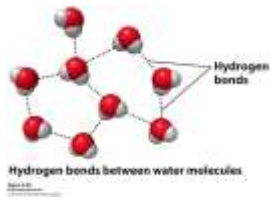


- *Ionic bonds:* _____
  _____
  _____.
  - **When this transfer happens, one atom becomes electron deficient (positively charged) and one atom becomes electron rich (negatively charged).**



- *Hydrogen bonds:* _____
  _____
  _____
  _____
  _____.
  - **Water is known as a *polar molecule*. One side of the molecule is more positive and the other side is more negative.**





Hydrogen bonds between water molecules

- *Surface tension:* _____
  _____
  _____
- *Capillary action:* _____
  _____
  _____
  _____
  _____

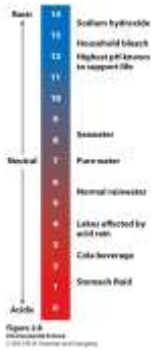
- *Boiling and freezing:* _____
  _____
  _____
- *Water as a solvent:* _____
  _____
  _____
  _____.

- **Why does ice float in water?**
- **Water is at its maximum density at 4˚ C.**
- **When water freezes at 0˚ C, the resulting ice is _____dense than the water around it, and _____.**

- *Acid:* _____ _____.
- *Base:* _____ _____.

- **pH is a way to indicate the strength of acids and bases.**
  -
  - _
  - _
  - _
  - _

- **The pH scale is a _____ scale.**
- **A change of 1 pH unit (e.g., from pH 5 to pH 4)_____ _____change in acidity.**
- **A change of two pH units (e.g., from pH 5 to pH 3)_____ _____change in acidity.**

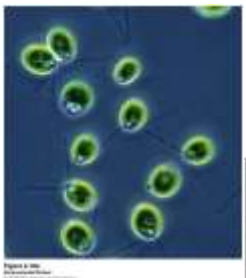


- *Chemical reaction:* _____ _____ _____ _____
- *Law of Conservation of Matter:* _____ _____ _____ _____

- *Inorganic compounds:* _____
  - **For example, NH_3, NaCl, H_2O, and CO_2**
- *Organic compounds:* _____

- *Carbohydrates:* _____
  - **For example, $C_6H_{12}O_6$.**
- *Proteins:* _____

- *Nucleic Acids:* **organic compounds found in all living cells.**
  - **DNA**
  - **RNA**
- *Lipids:* **biological molecules that do not mix with water. For example, fats, oils, waxes, and steroid hormones.**



Energy is a fundamental component of all environmental systems.

- **Energy is the ability to do work.**

TABLE 2.1 Common units of energy and their conversion into joules

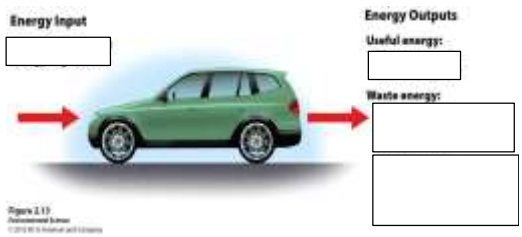
Unit	Definition	Relationship to joules	Common uses
calorie	Amount of energy it takes to heat 1 gram of water 1°C	1 calorie = 4.184 J	Energy expenditure and transfer in ecosystems; human food consumption
Calorie	Food calorie, always shown with a capital C	1 Calorie = 1,000 calories = 1 kilocalorie (kcal)	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

- Energy **is** _____.
- Power _____.
  - **energy = _____X_____**

- *Kinetic energy:* _____.
- *Potential energy:* _____.
- *Chemical energy:* _____
- _____.
- *Temperature:*_____
  _____
  _____
  _____.

- *Energy is neither* _____.
- **"You can't get something from nothing."**



Energy *and* Mass are *Conserved:*

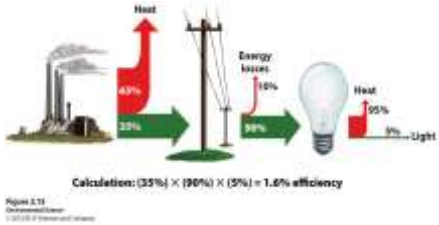
$$6\,CO_2 + 6\,H_2O \xrightarrow{\text{light}} C_6H_{12}O_6 + 6\,O_2$$

Reactants	*Products*
Carbon atoms	Carbon atoms
Hydrogen atoms	Hydrogen atoms
Oxygen atoms	Oxygen atoms

Photosynthesis

Reactant Energy → Product Energy + Light Energy

- **When energy is transformed, the quantity of energy remains _____, but its ability to do_____.**



- *Energy efficiency:*_____
_____
_____
_____
_____.

(a) Traditional fireplace

(b) Modern woodstove

- *Energy quality:* _____
_____
_____
_____.
- *Entropy:* _____
_____
_____.
  - **Randomness is *always* increasing in a system, unless new energy from the outside of the system is added to create order.**

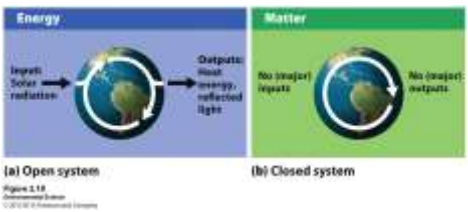
Energy conversions underlie all ecological processes.

Energy flows into ecosystems from the sun and the movement of wind and water.

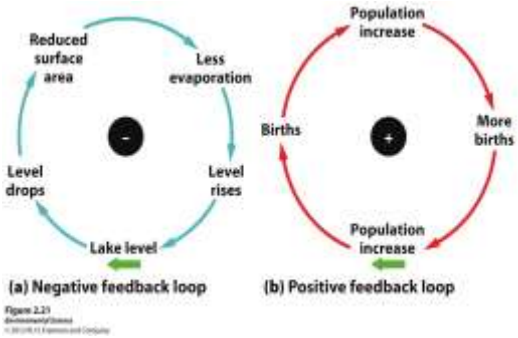
System analysis shows how matter and energy flow in the environment:

_____ *versus* _____ Systems

- *Open system:* _____
  _____
  _____.
- *Closed system:* _____
  _____
  _____.



- *Steady state:*_____
  _____
  _____



Natural systems change across space and time.

- *Negative feedback loops:*_____
  _____
  _____
  _____
  _____.
- *Positive feedback loops:*_____
  _____
  _____
  _____
  _____.

"Throughout Earth's history, 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 . . ."