WUHS Biology: Matter & Energy Unit

Week 2 – What happens to molecules during combustion?

M&E Unit – W2 Driving Question

- **Driving Question: What happens to molecules during combustion?**
- What happens to the atoms in molecules during combustion?
- What happens to energy in molecules during combustion?
- How does what we can observe during combustion (e.g., heat & light) relate to the changes happening at the molecular level?

Image Source

Recap of Week 1

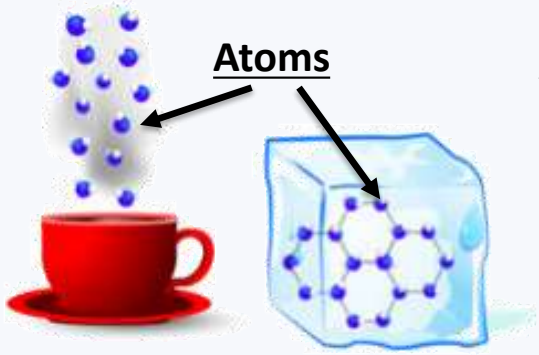
Any physical substance (solid, liquid, gas) that takes up space is called matter. All matter is made from atoms.

If something loses atoms, it loses mass. If it gains atoms, it gains mass.

Atoms cannot be created or destroyed. Atoms can only be moved from one substance to another.

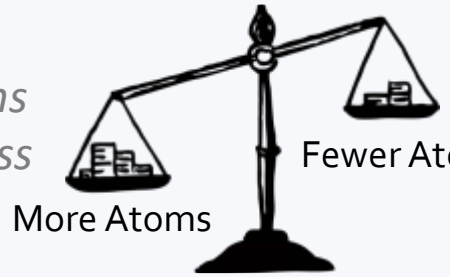
Different kinds of atoms are called elements. In biology, atoms do not change; they always remain as the same element (e.g., carbon is always carbon).

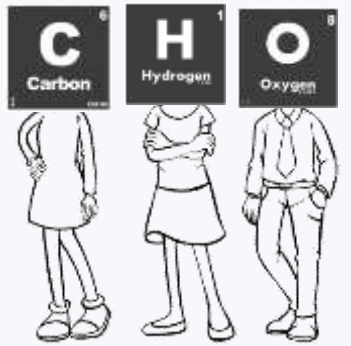
A group of atoms bonded to each other is called a molecule. Atoms in one molecule can be rearranged to form a different molecule.



All solids, liquids, & gases are made of atoms.

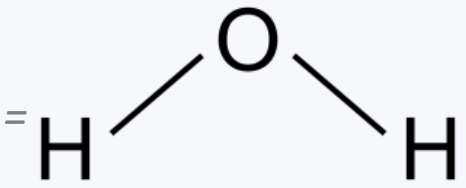
More atoms = more mass





Elements = Types of Atoms

A group of bonded atoms = a molecule.



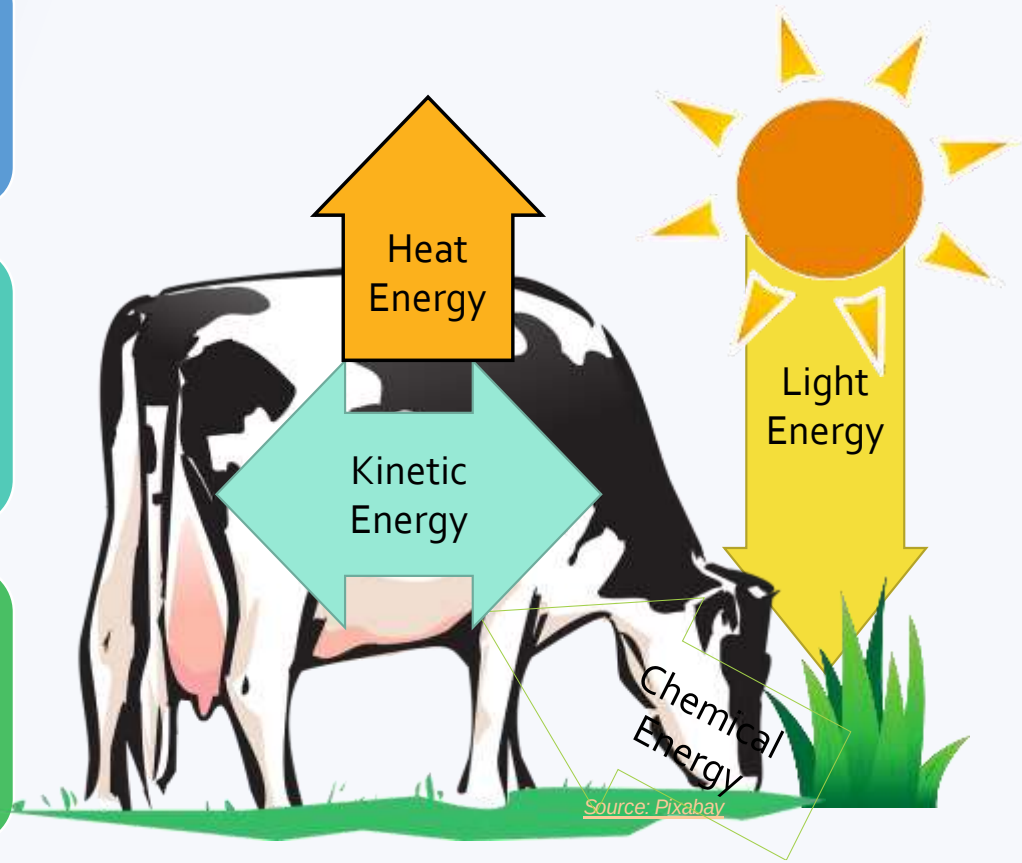
Recap of Week 1

Energy is how matter changes.

Matter and energy are two different things – matter cannot become energy; energy cannot become matter.

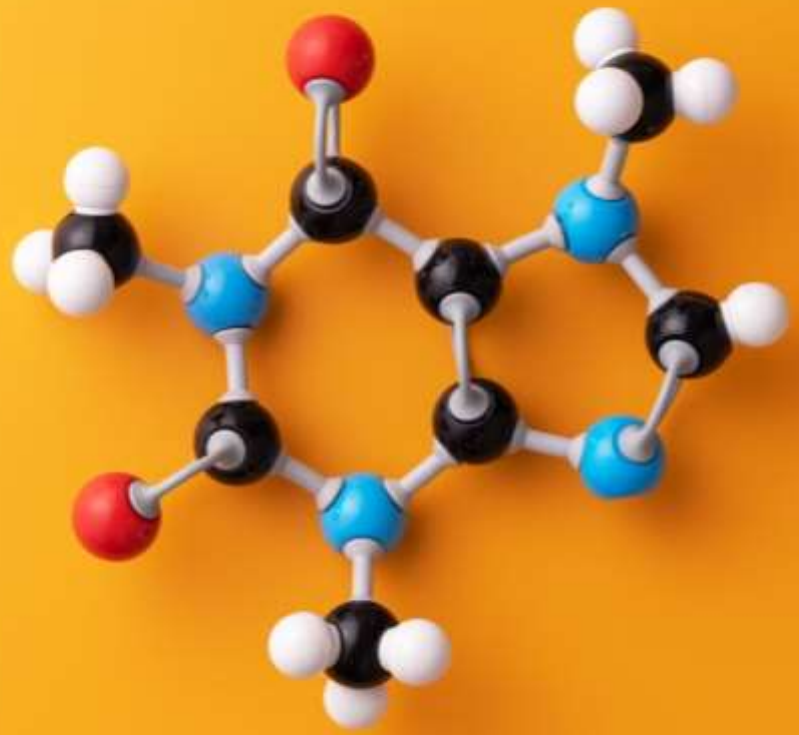
Energy cannot be created or destroyed, but energy can be transformed. For example, light energy can be transformed into heat energy.

Four common forms of energy are light, heat, chemical energy (found within molecules), and kinetic energy (motion).



Energy is how matter changes. Energy can exist as heat, light, motion, or chemical energy.

In this model of a molecule, the spheres represent atoms.



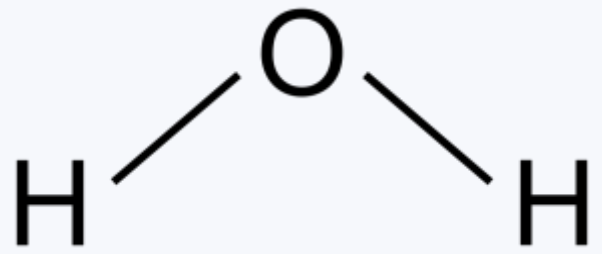
The gray sticks connecting the atoms represent chemical bonds.

Chemical Energy

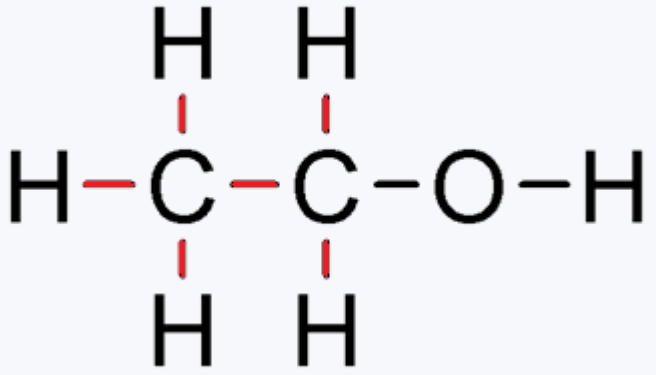
- **All matter is made from tiny particles called atoms.**
  - Different kinds of atoms are called elements.
  - Atoms can bond to each other to form molecules.
- **Atoms in molecules remain bonded to each other because of chemical energy.**
  - A chemical bond forms when two atoms become attracted to each other.
  - Chemical energy is energy stored between atoms that holds these particles together in molecules.

High Energy Bonds

- **For example, a water molecule is an oxygen atom bonded to two hydrogen atoms.**
  - Chemical energy forms the bonds between these atoms.
  - Chemical energy is what holds the atoms together in this molecule.
- **Not all chemical bonds are the same.**
  - Some chemical bonds are stronger than others.
- **<u>High-energy bonds</u> store more chemical energy than low-energy bonds.**
  - Examples of high energy bonds include the bonds between two carbon atoms (C-C), and the bonds between carbon and hydrogen atoms (C-H).

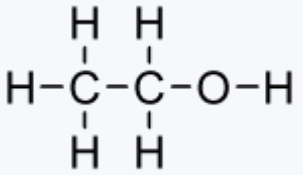


The lines between each atom in a water molecule represent chemical bond energy.



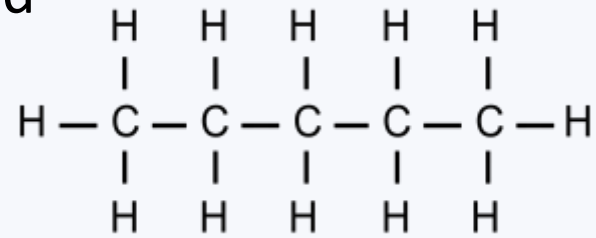
The C-C and C-H bonds in this ethanol molecule are "high-energy bonds".

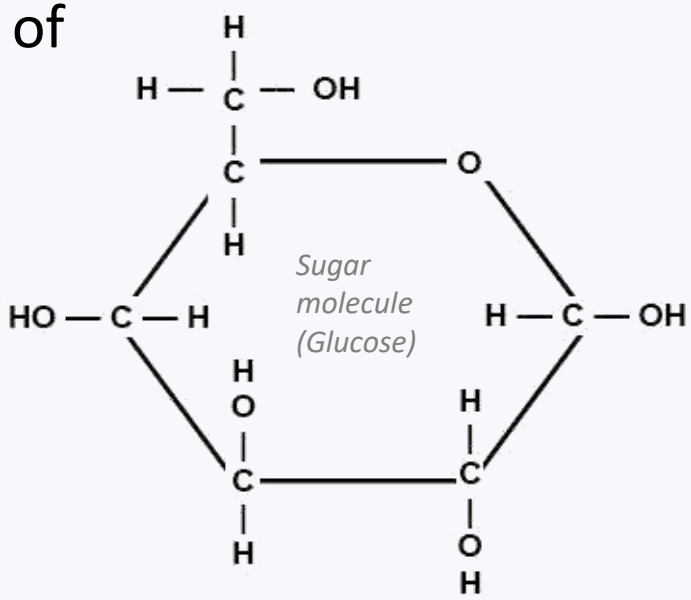
High Energy Bonds



Ethanol molecule

- **The greater the amount of C-C and C-H bonds, the higher the chemical energy of a substance.**
  - Substances used as <u>fuels</u> (such as sugar, gasoline, ethanol, and fat) tend to have large amounts of C-C and C-H bonds.
- **For example, ethanol and gasoline are both substances that can be used to power automobiles.**
  - Both ethanol and gasoline molecules have large amounts of high-energy bonds (C-C and C-H).
- **Sugar molecules also have large numbers of high energy bonds.**
  - This is why the cells in our body primarily use sugar as a source of chemical energy to power bodily activities.

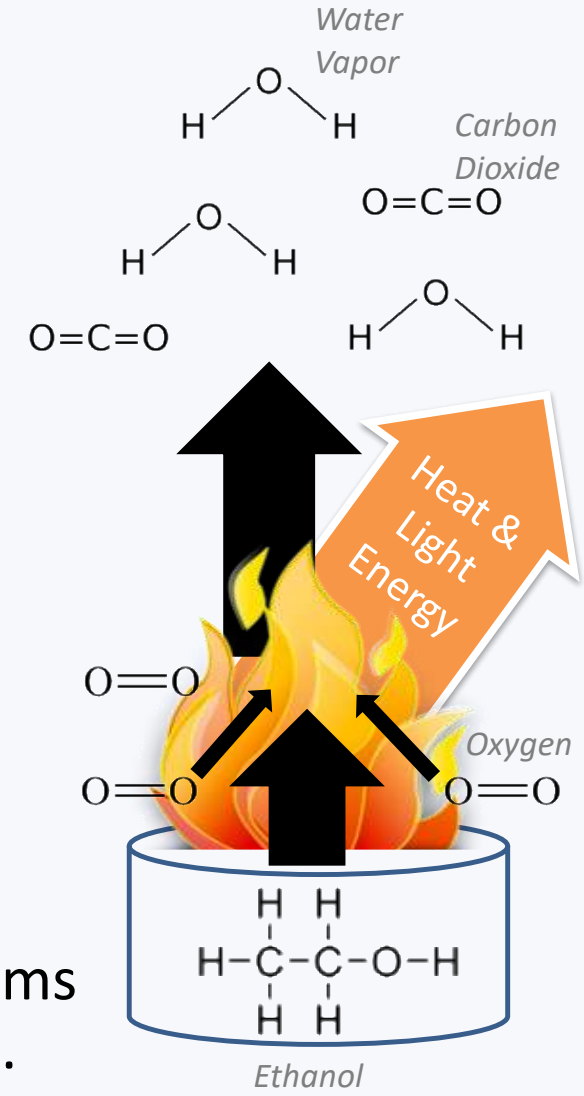

Gasoline molecule



Sugar molecule (Glucose)

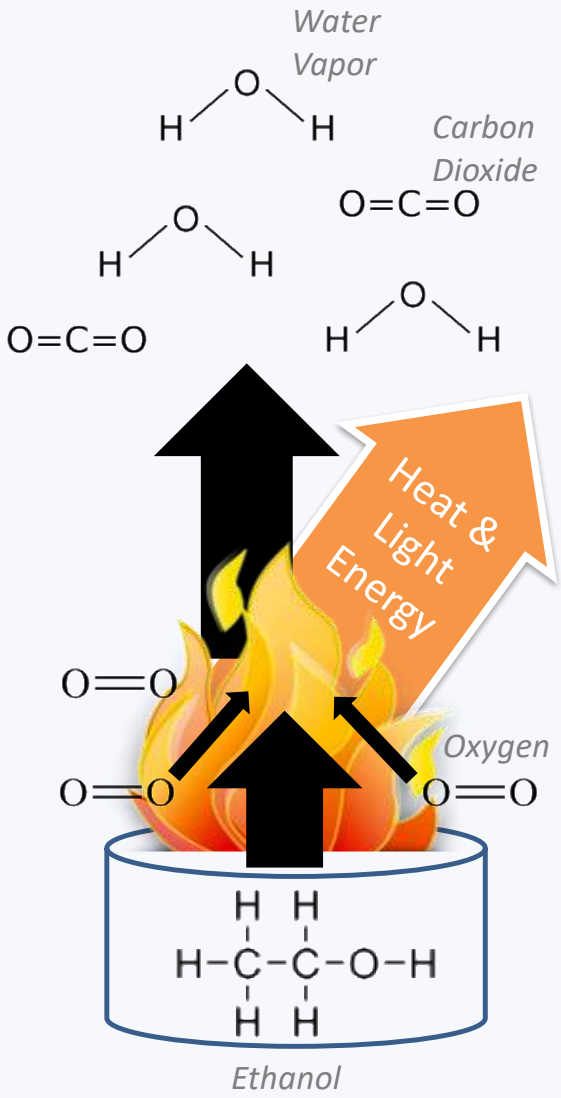
Combustion

- **Whether a molecule contains high energy bonds primarily determines whether that substance is combustible.**
  - For example, ethanol and gasoline are combustible because they contain large amounts of C-C and C-H bonds.
  - In contrast, water and carbon dioxide do not have any high energy bonds; this is why these substances don't burn.
- **When a substance is combusted, the atoms in its molecules are rearranged with atoms in oxygen to form CO_2 and H_2O.**
  - Combustion is a kind of "rearrangement reaction" where atoms in the fuel and oxygen are rearranged to form water and CO_2.



Combustion

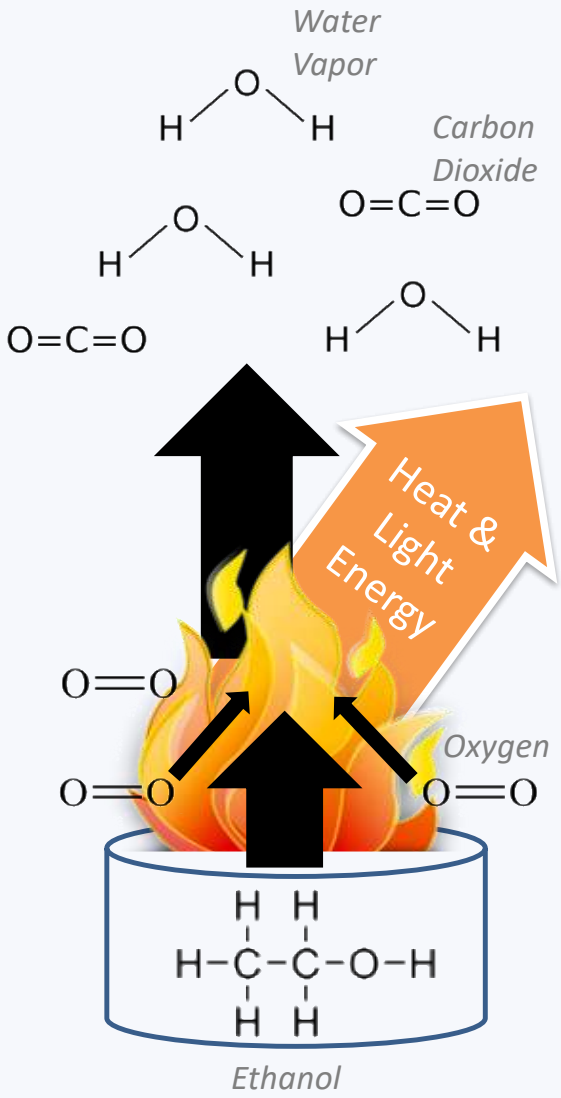
- **For example, when ethanol is combusted, the atoms in ethanol molecules are rearranged with atoms in oxygen (O_2) to form CO_2 and H_2O.**
  - Ethanol molecules can store more chemical energy than water and carbon dioxide, which do not have any high energy bonds.
  - As a result, there is "leftover energy" after these molecules are rearranged during combustion.
- **This "leftover energy" can be observed as the heat, light, and motion of the flame.**
  - A fire's flames are the release of excess energy that occurs when ethanol and oxygen are rearranged into carbon dioxide and water.



Combustion Clarifications

- **No atoms are being destroyed during combustion.**
  - The number of atoms in the ethanol and oxygen is the same as the number of atoms in the water vapor and carbon dioxide.
  - All of the atoms that were found in ethanol and oxygen are now found in carbon dioxide and water.

- **No energy is being created or destroyed.**
  - The amount of chemical energy in the ethanol is the same as the amount of light, heat, and motion energy coming from the fire.
  - The total amount of energy stays the same – this energy is just being transformed into new kinds of energy.
  - Eventually all the energy will form heat, which dissipates into space.
  - No energy is every destroyed because energy is indestructible.



Why is a spark needed?

- **You probably know from experience that a spark is needed to start a fire.**
  - Why would this be necessary?
- **Combustible molecules like ethanol and gasoline do not spontaneously combust by themselves.**
  - An initial input of energy is needed to rearrange atoms in molecules.
- **A spark provides the initial energy needed to start the rearrangement reaction of combustion.**
  - The heat & light energy of the fire comes from the transformation of the chemical energy from high energy bonds, not the spark.

Image Source: Wikimedia

Revising Our Claims

- **Revisit your ideas from Part 1.**
  - How could you improve your responses to our Driving Questions?
- **What happens to molecules during combustion?**
- What happens to the atoms in molecules during combustion?
- What happens to energy in molecules during combustion?
- How does what we can observe during combustion (e.g., heat & light) relate to the changes happening at the molecular level?

Image Source

Looking Ahead: Part 3 Investigation

- **In Part 3 you will use physical models to investigate how atoms are rearranged to form new molecules during combustion, and how chemical energy is transformed into heat and light as a result.**

Key Points

- **Atoms in molecules remain bonded to each other because of chemical energy.**
  - A chemical bond forms when two atoms become attracted to each other.
  - Chemical energy is energy stored between atoms that holds these particles together in molecules.
- **High-energy bonds store more chemical energy than low-energy bonds.**
  - Bonds between carbon atoms (C-C) and between carbon and hydrogen atoms (C-H) are high energy bonds.
- **The greater the amount of C-C and C-H bonds, the higher the chemical energy of a substance.**
  - Substances used as fuels (such as sugar, gasoline, ethanol, and fat) tend to have large amounts of C-C and C-H bonds.

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Key Points

- **Ethanol and gasoline are combustible because they contain large amounts of C-C and C-H bonds.**
  - Water and carbon dioxide do not burn because they lack high energy bonds.
- **When a substance is combusted, the atoms in its molecules are rearranged with atoms in oxygen to form CO_2 and H_2O.**
  - Combustion is a kind of “rearrangement reaction”.
  - Ethanol molecules can store more chemical energy than water and carbon dioxide, which do not have any high energy bonds.
  - When atoms in ethanol & oxygen rearrange to form CO_2 & H_2O, there is “leftover energy” – this can be observed as the heat, light, and motion.
- **No atoms are destroyed, and no energy is created during combustion.**
  - The amount of matter & energy going into a reaction equals what comes out.

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Key Vocab

- **A chemical bond forms when two atoms are attracted to each other.**
- **Chemical energy is energy stored between atoms that holds these particles together in molecules.**
- **High-energy bonds (such as C-C and C-H bonds) store more chemical energy than low-energy bonds.**
- **Combustion is a kind of "rearrangement reaction" where atoms in the fuel and oxygen are rearranged to form water and CO_2.**

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