Lecture 1.02: The Search for Life on Mars

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BIO 181, General Biology for Majors

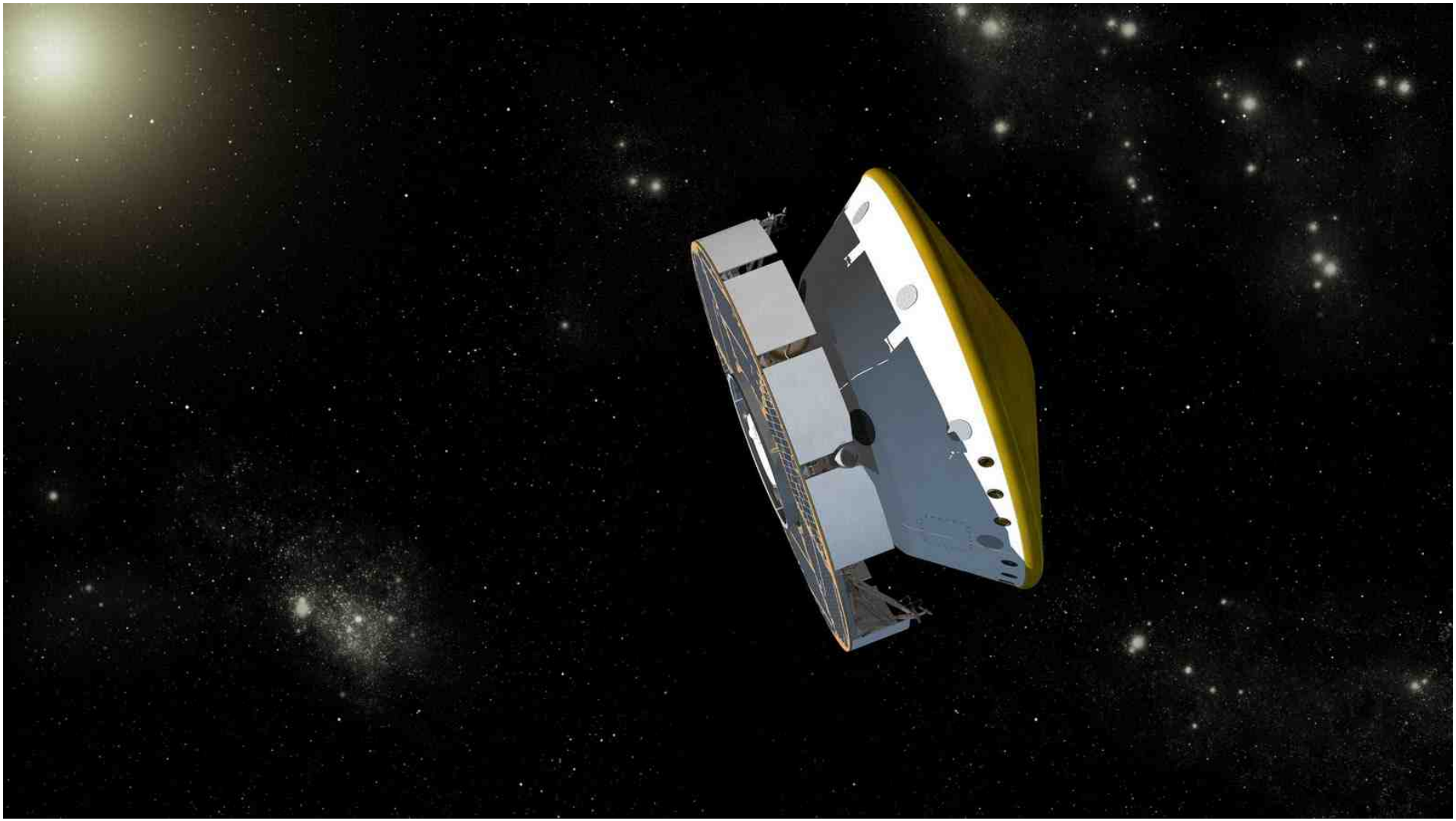
Outline

1. The Mars Science Laboratory Mission
   - Mission profile
   - Mission goals
2. What is life?
3. Chemistry of Life
   - Chemistry basics
   - Metabolism basics

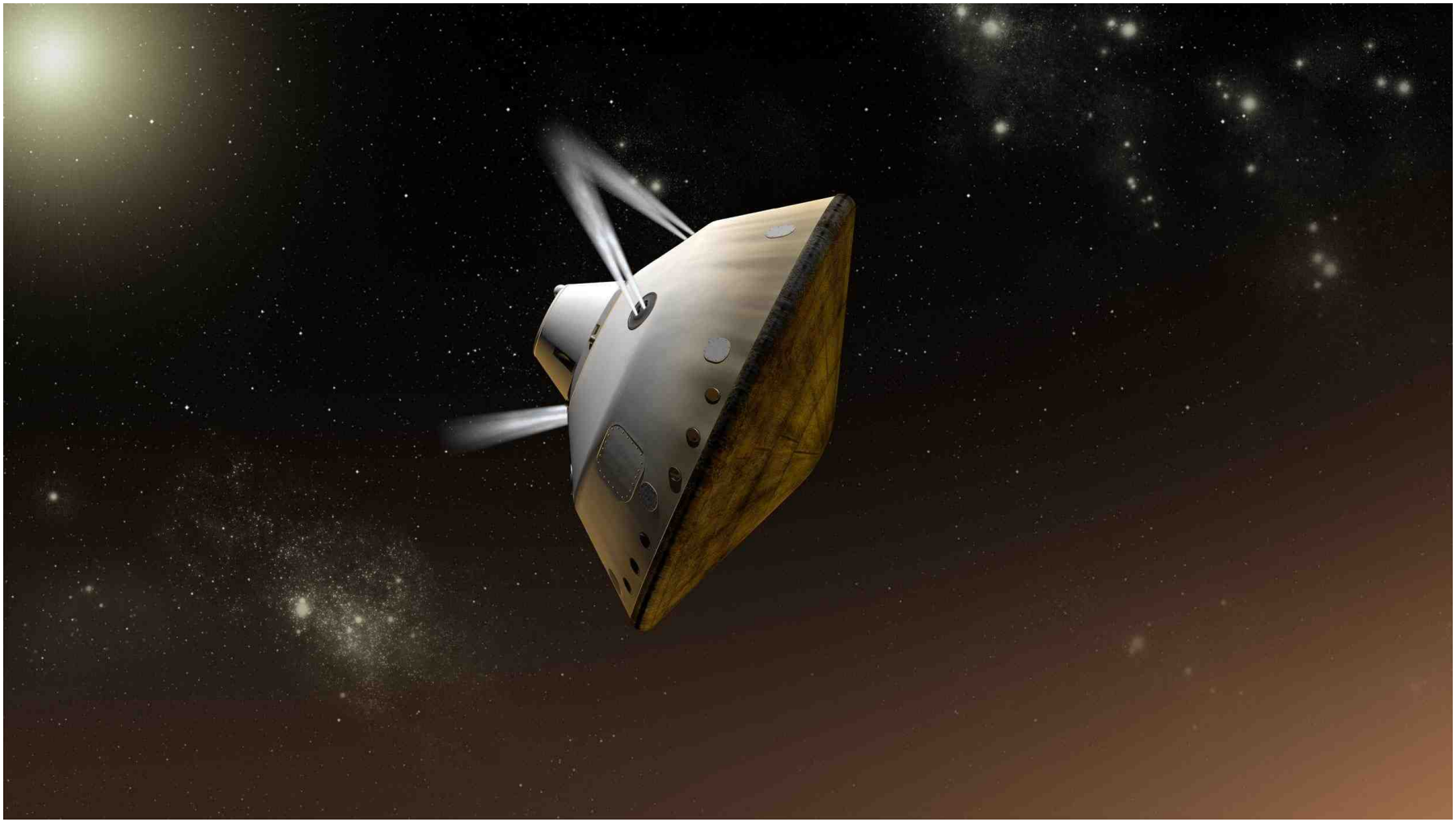
Mars Science Laboratory (MSL) Launch

Launched November 26, 2011 at 8:02 AM MST

MSL cruise configuration



MSL early Entry-Descent-Landing (EDL)



EDL parachute phase

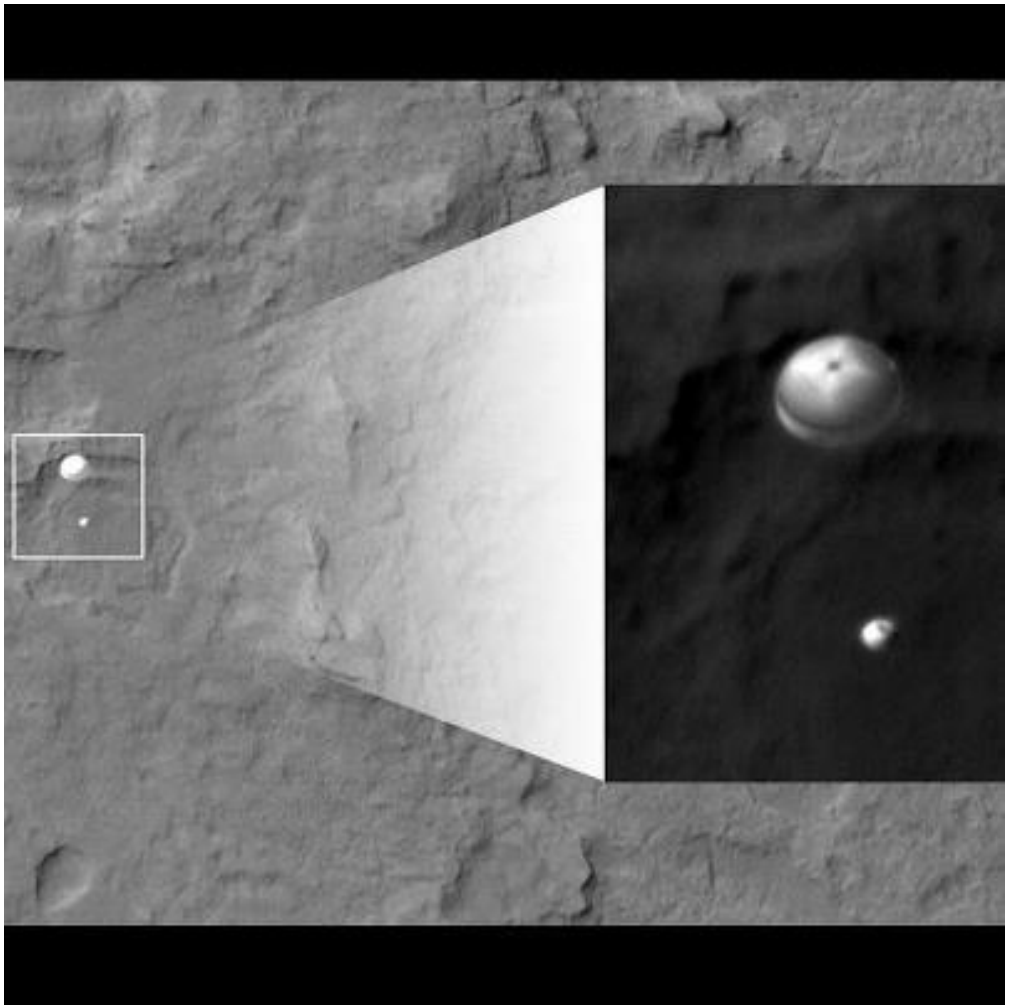
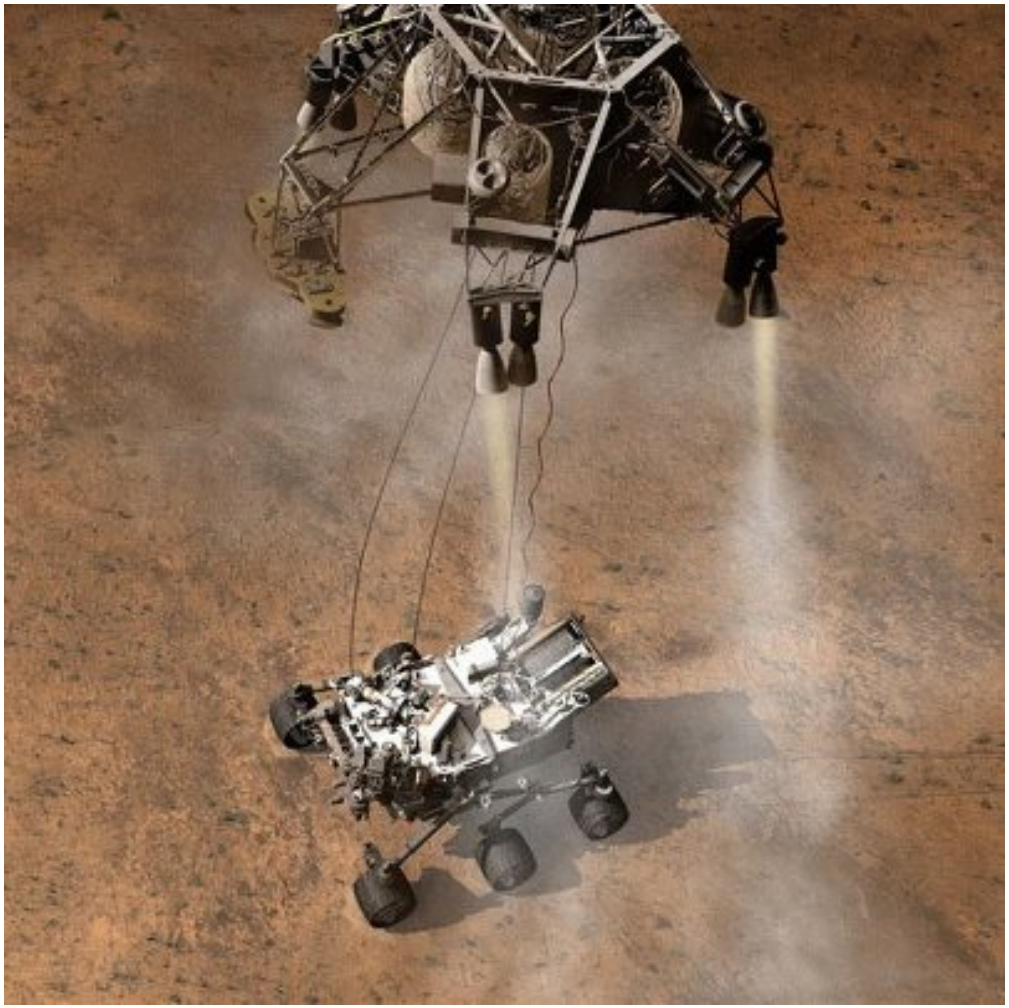


Image from HiRISE camera on Mars Recon Orbiter

EDL powered descent phase

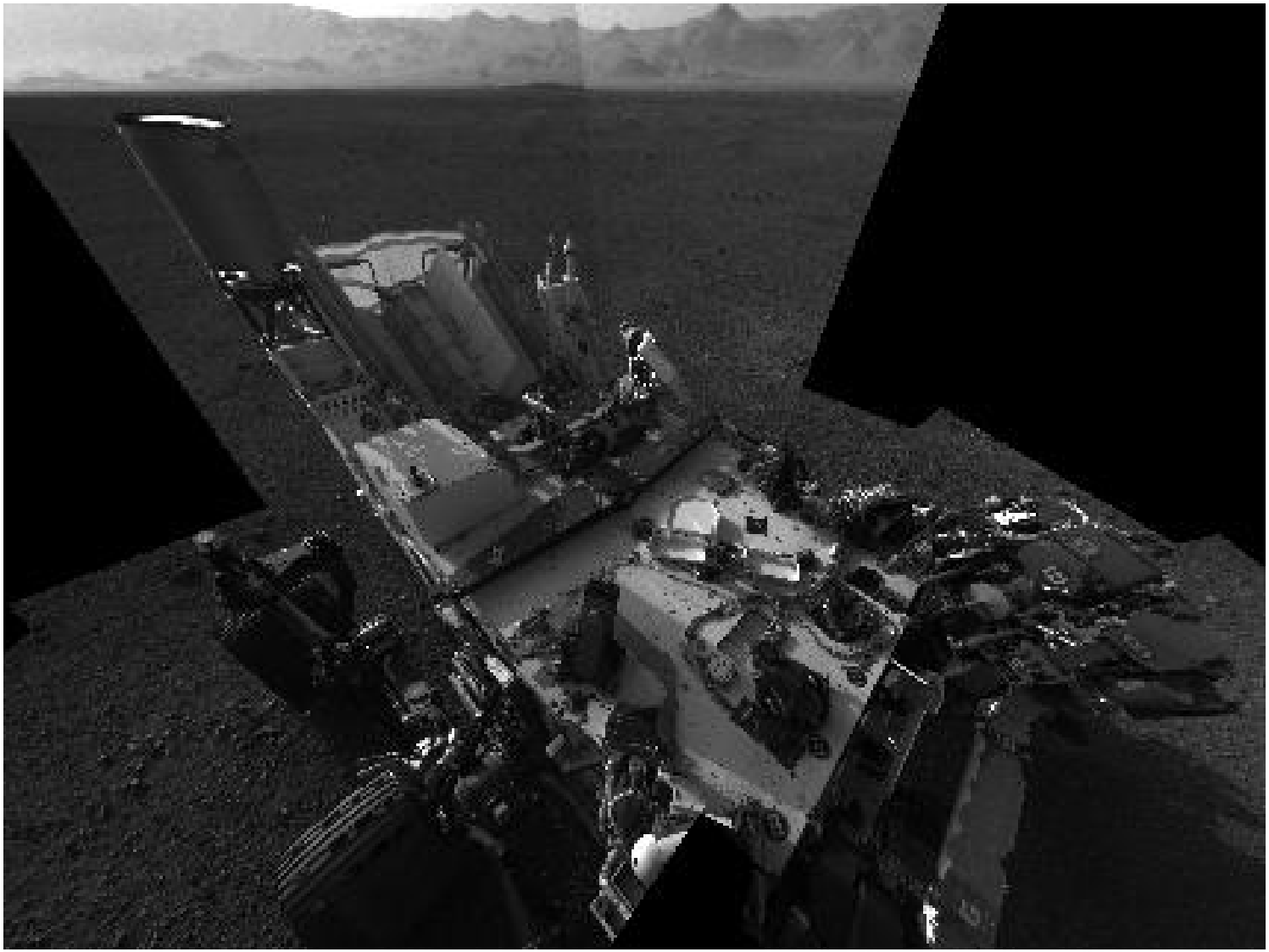
Mars Curiosity Rover hangs by tether to descent rocket platform

Landing Curiosity on Mars

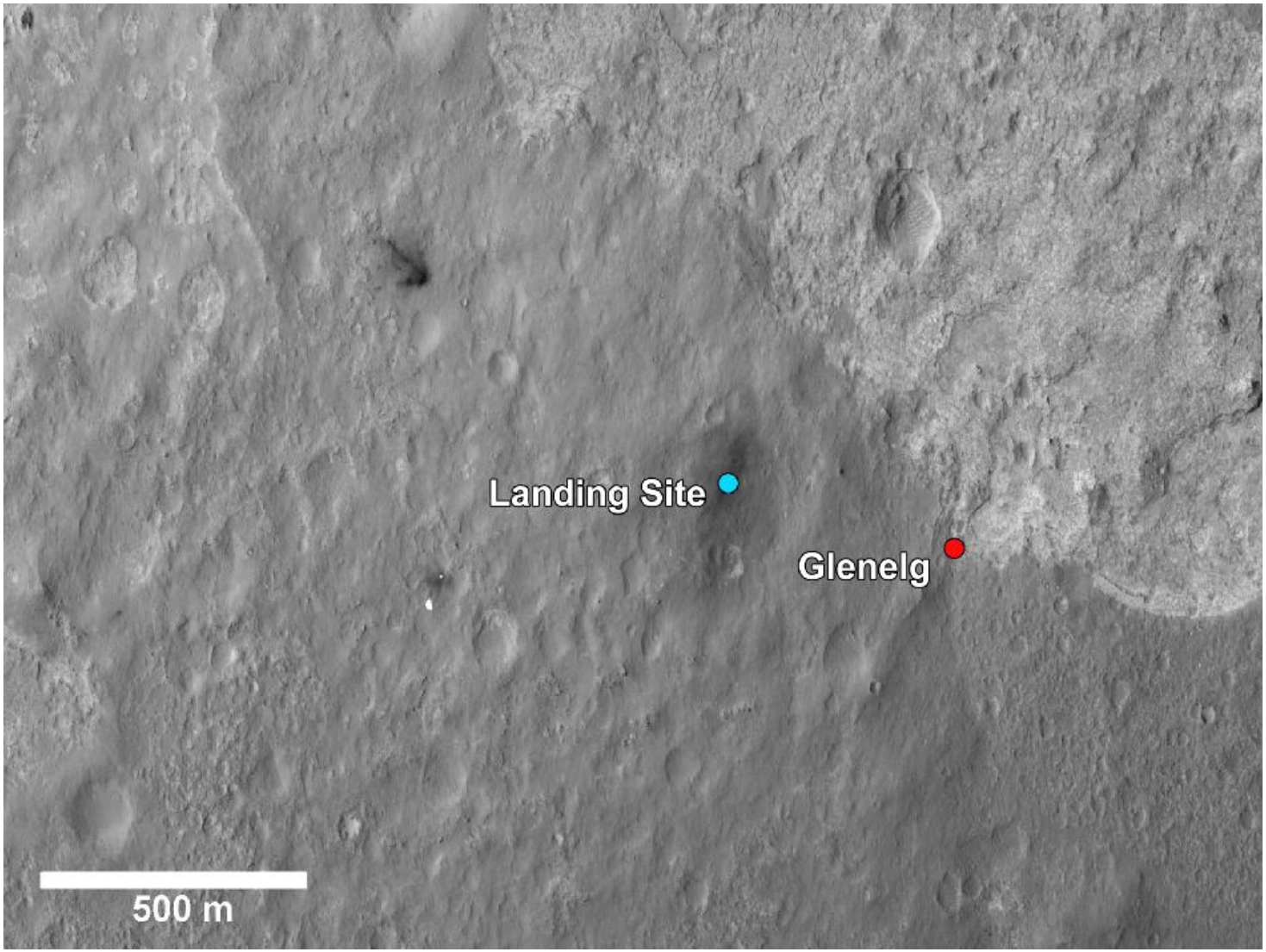


Touchdown, 10:32 PM PDT, August 5, 2012

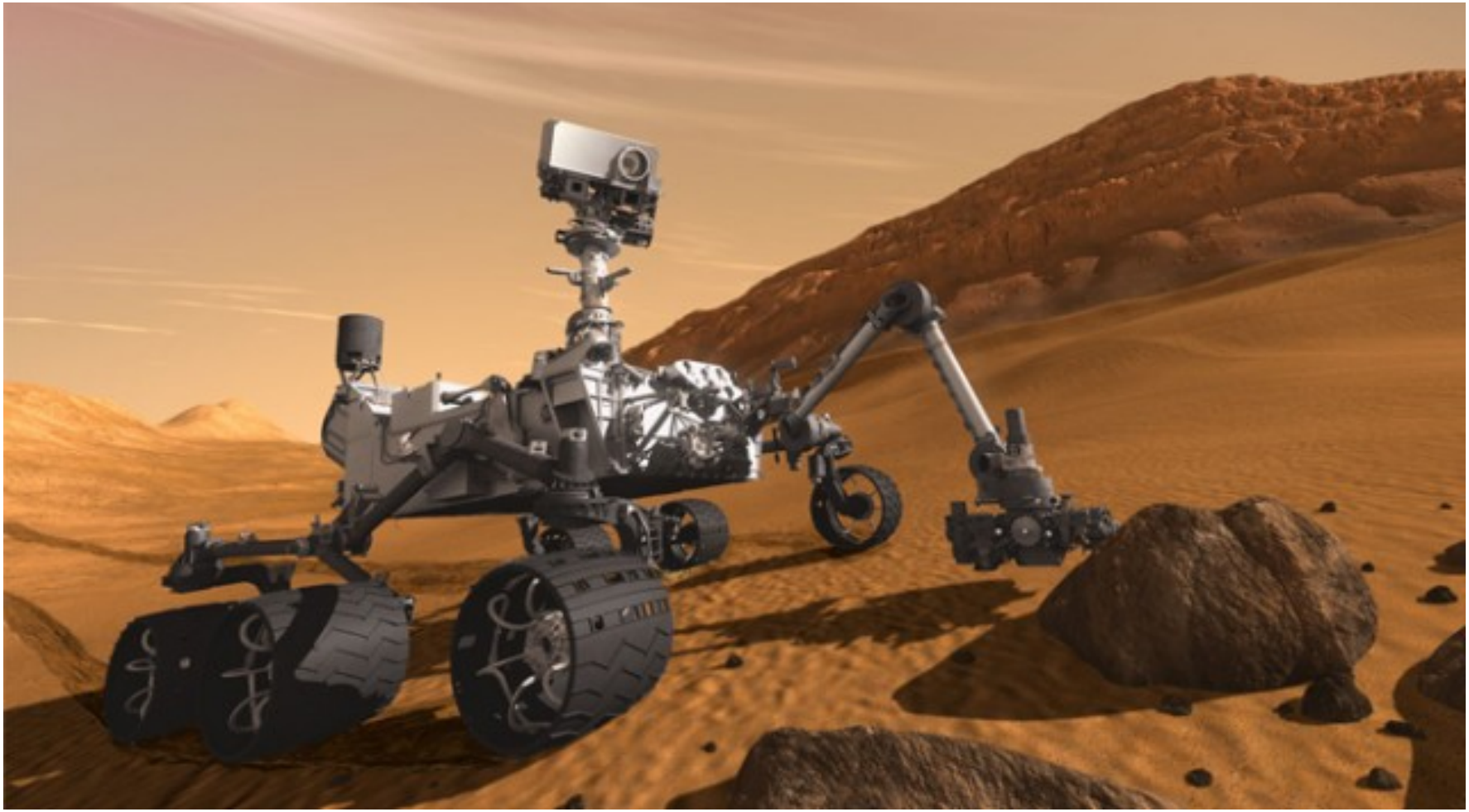
View of Curiosity's deck inside Gale Crater



Curiosity's first roadtrip



Curiosity's Mission



A primary goal: search for evidence of life on Mars

Presumably not what we're looking for

We've been here before; it generally looks like this

So what kind of creatures would we look for?

We're looking for evidence of microbial life

Definition: Microbe

A **microbe** or **microorganism** is any living organism too small to see with the naked eye

What is life? What are its properties?

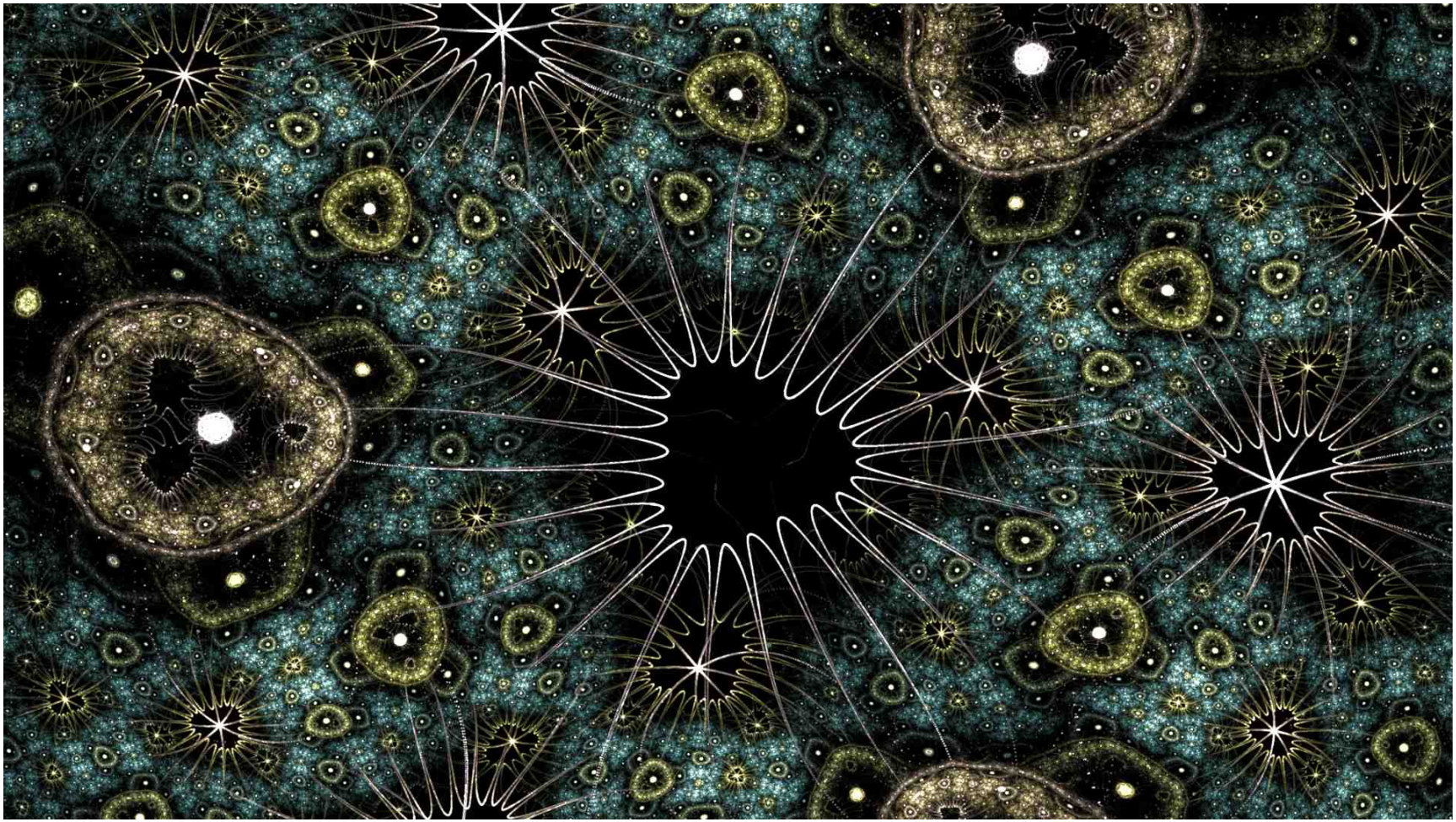


Image from thargor6.deviantart.com/art/Lifeforms-288419642

Properties of life

- **Reproduction:** Living things have the ability to reproduce themselves
- **Homeostasis:** Living things can maintain a constant internal environment at disequilibrium with the surrounding environment
- **Metabolism:** Living things manage their own energy and matter
- **Evolution:** Living things have the ability to evolve and adapt to their environment
  Remember the word **RHEM**.
- Physically, living things are constructed of
  - Organic compounds
  - Polar solvent (water)

Organic compounds

Definition: Organic compound

An **organic compound** is any compound that contains the element carbon except for CO_2 and CO.

CO_2 and CO are not included because the carbon in these compounds is fully **oxidized**. As we'll see later in the course, this fact means that CO_2 and CO cannot be used to drive a metabolism, but all other carbon compounds can.

What's a compound?

Compounds

Definition: Compound (chemical)

A **chemical compound** is a substance composed of 2 or more different elements in a fixed proportion

Example: water (H_2O); key word is **substance**. A compound is not a molecule.

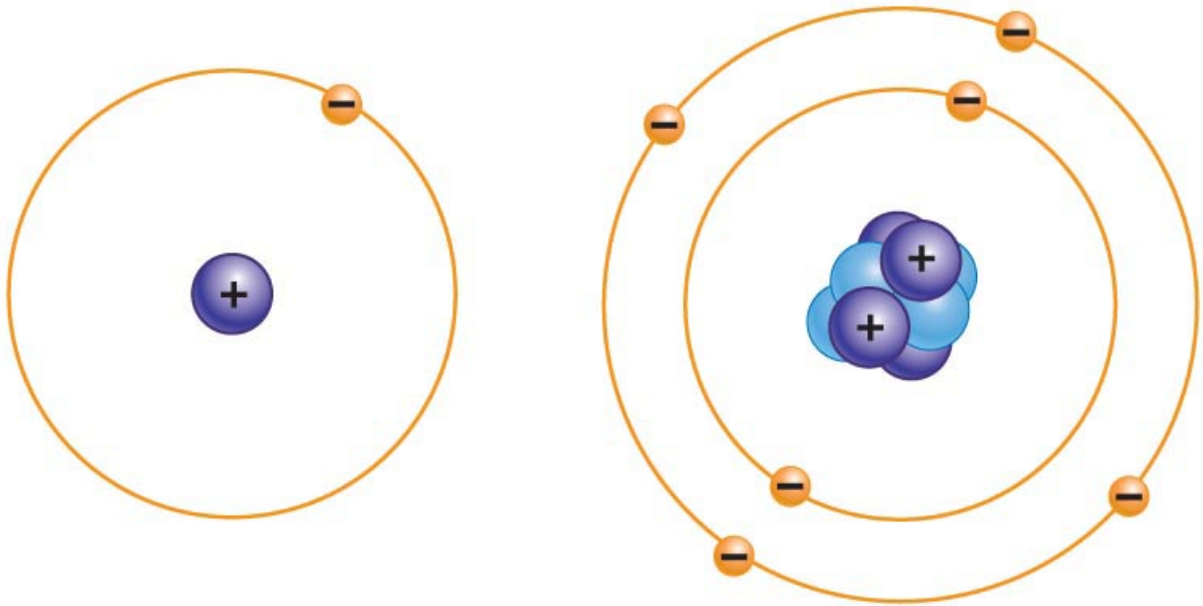
Elements

Definition: Element

An **element** is any substance that cannot be broken down by normal chemical means into another substance

Example: carbon; note "**substance**" again. An element is not an atom. The periodic table is a table of the elements, not the atoms.

What is an atom?

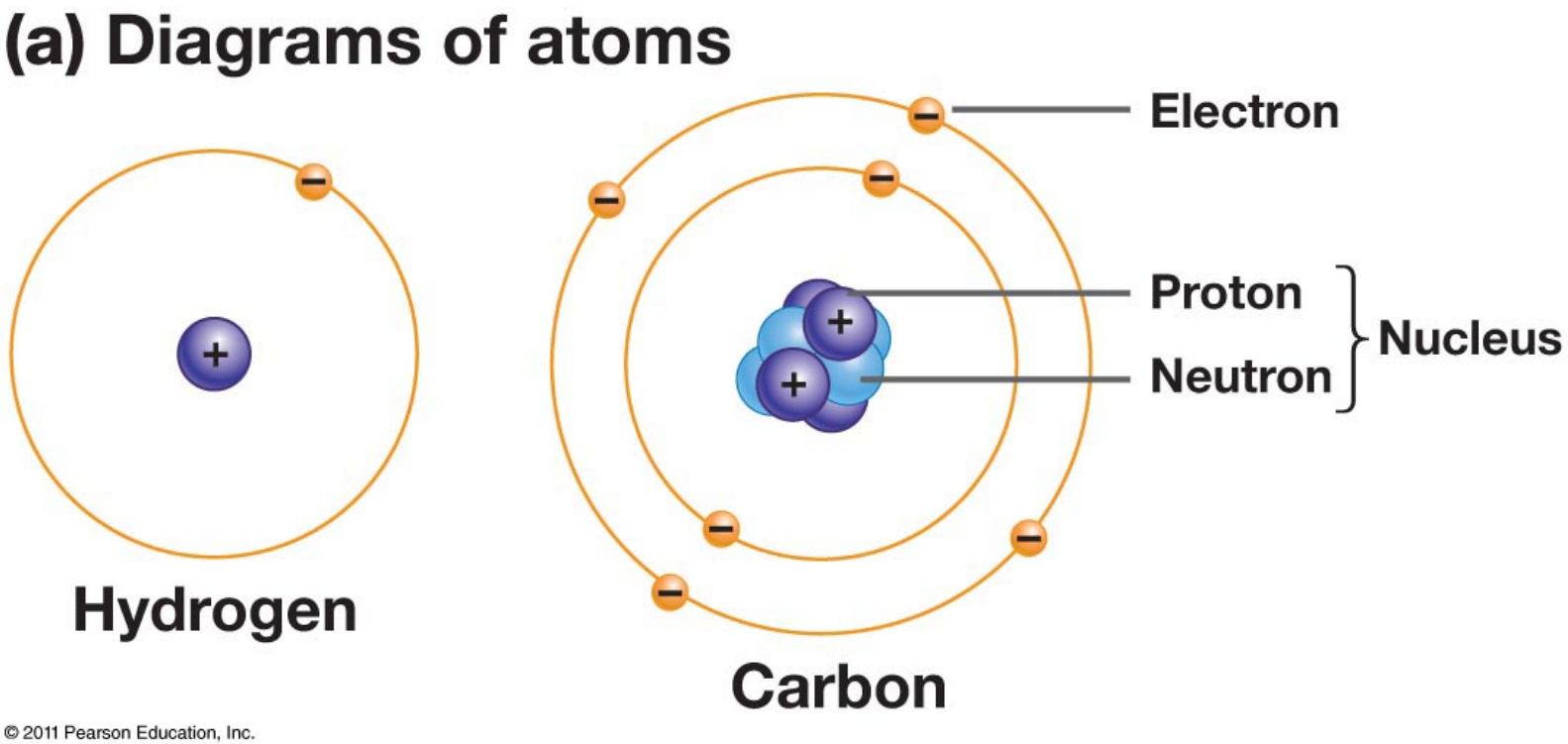


What are the blue, purple and yellow(ish) objects in these diagrams?

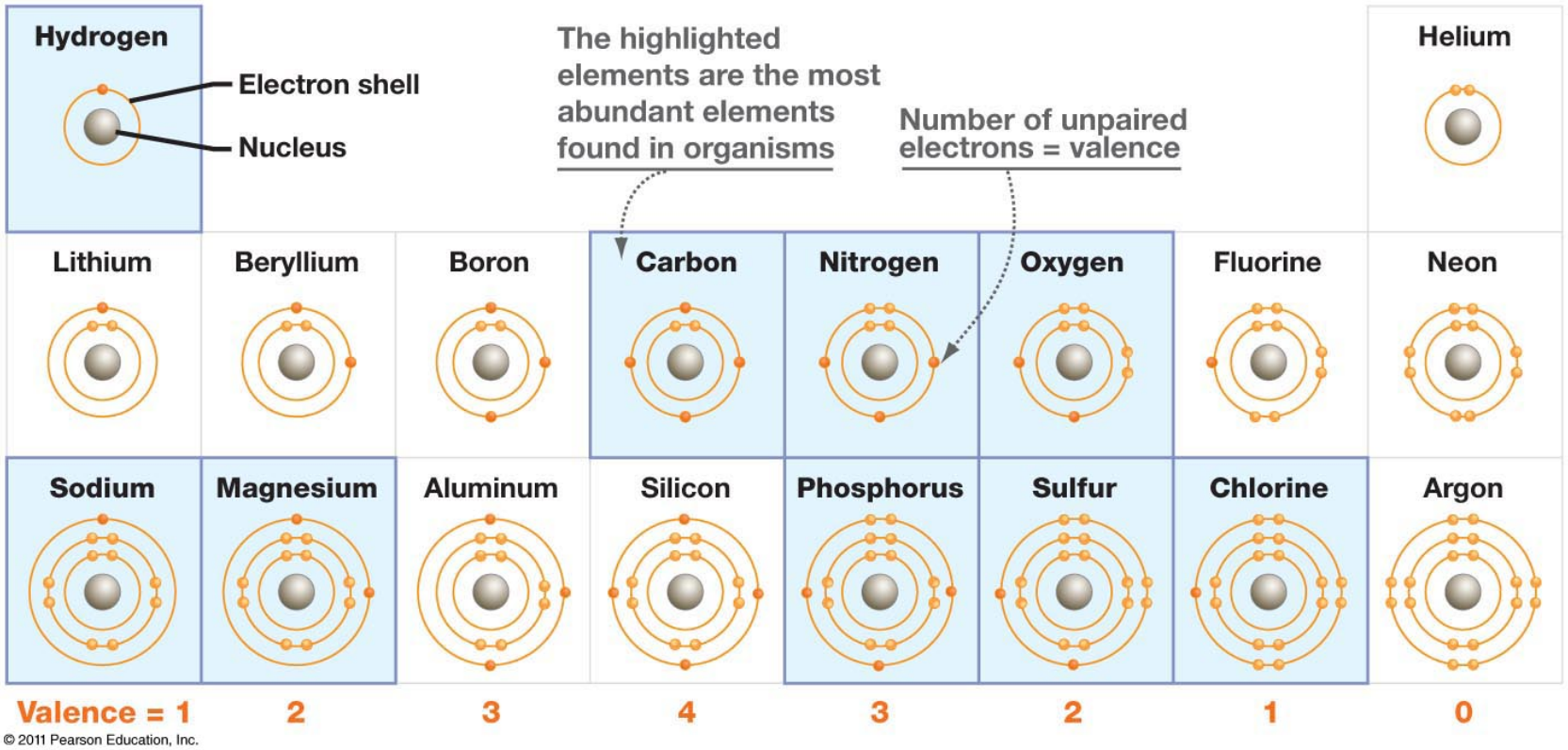
What is an atom?

Definition: Atom

An **atom** is the smallest electrically neutral unit of an element. It cannot be decomposed into simpler elements by normal chemical means.



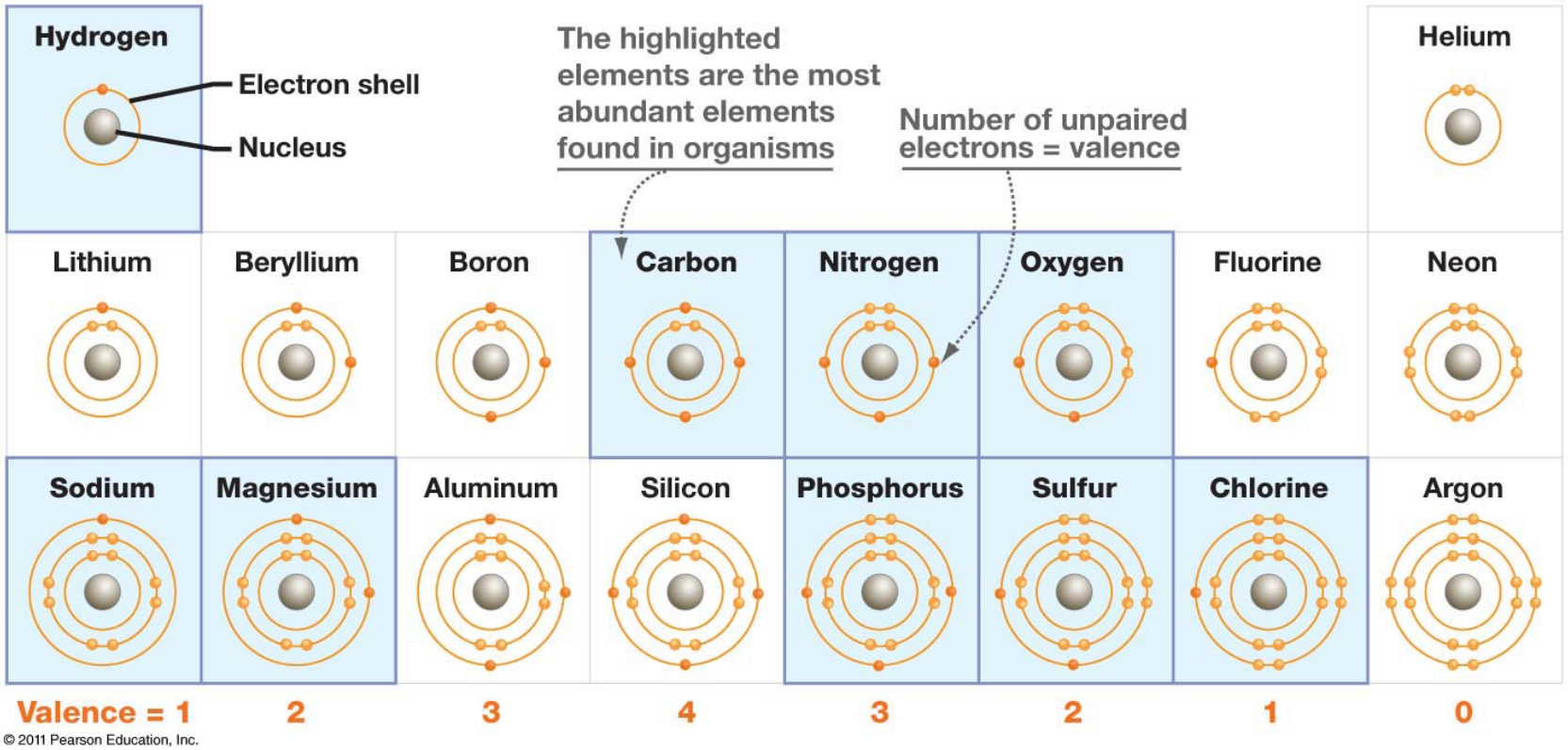
Elements of life



Living things mostly C,H,N,O,P,S and ions Na^+, K^+, Mg^{2+}, Ca^{2+} and Cl^-.

What is the most abundant element in living things?

Elements of life

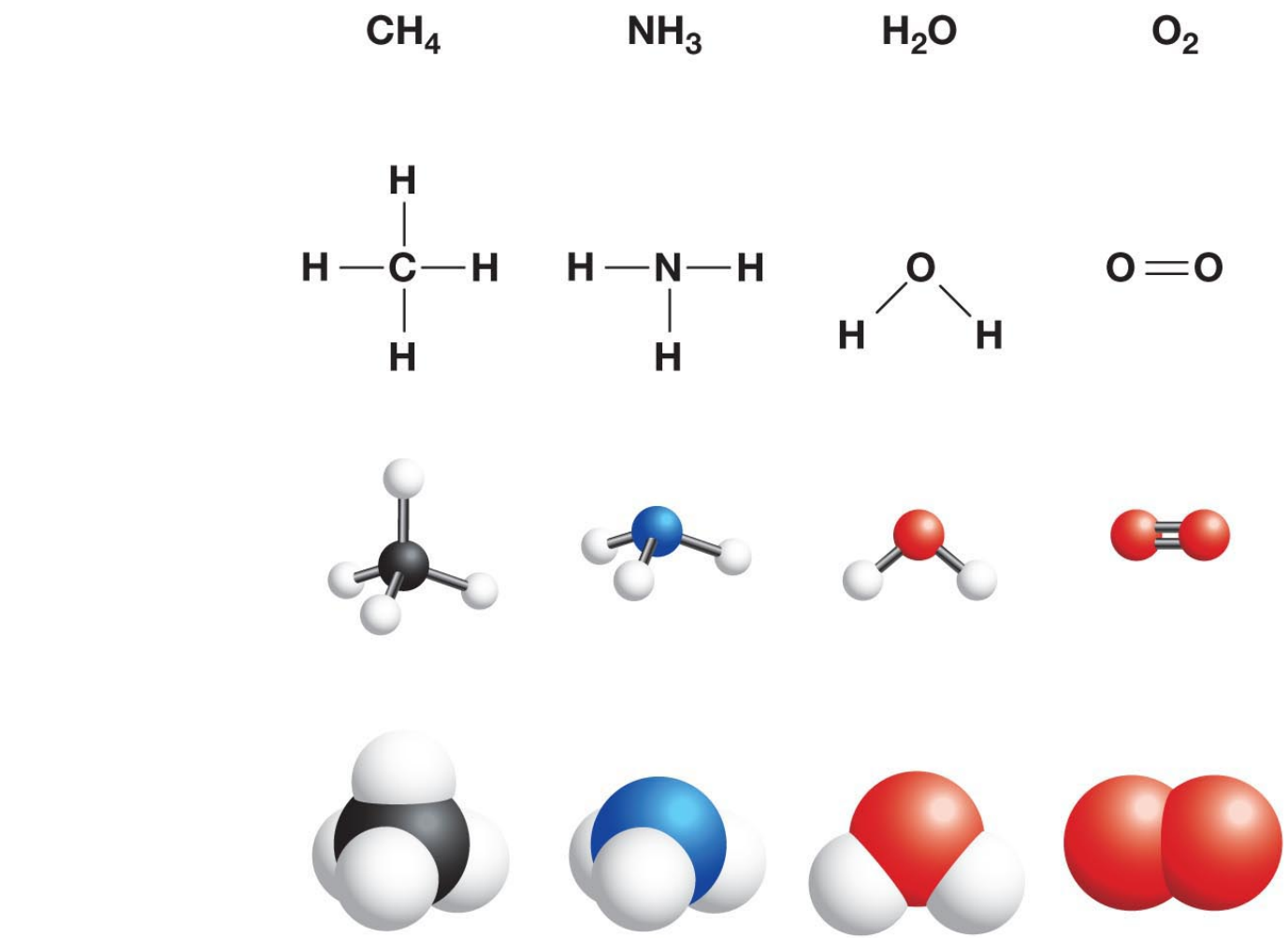


Living things mostly C,H,N,O,P,S and ions Na^+, K^+, Mg^{2+}, Ca^{2+} and Cl^-.

What is the most abundant element in living things?

O (60%), C (18%) by mass

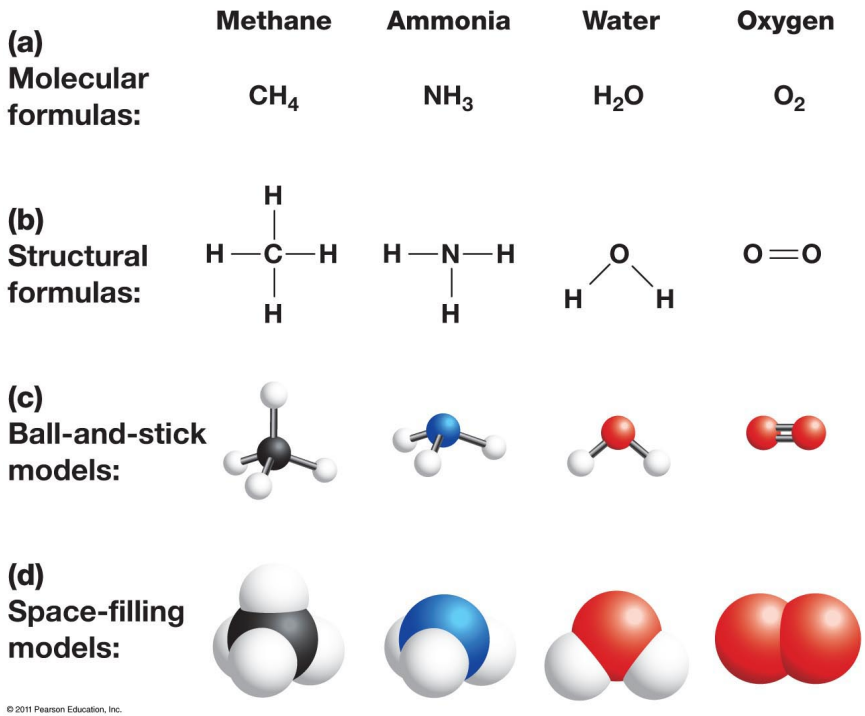
These are all types of what?



Molecules

Definition: Molecule

A **molecule** is the smallest electrically neutral structural unit of an element or compound; consists of atoms bonded together with strong (covalent or ionic) bonds.



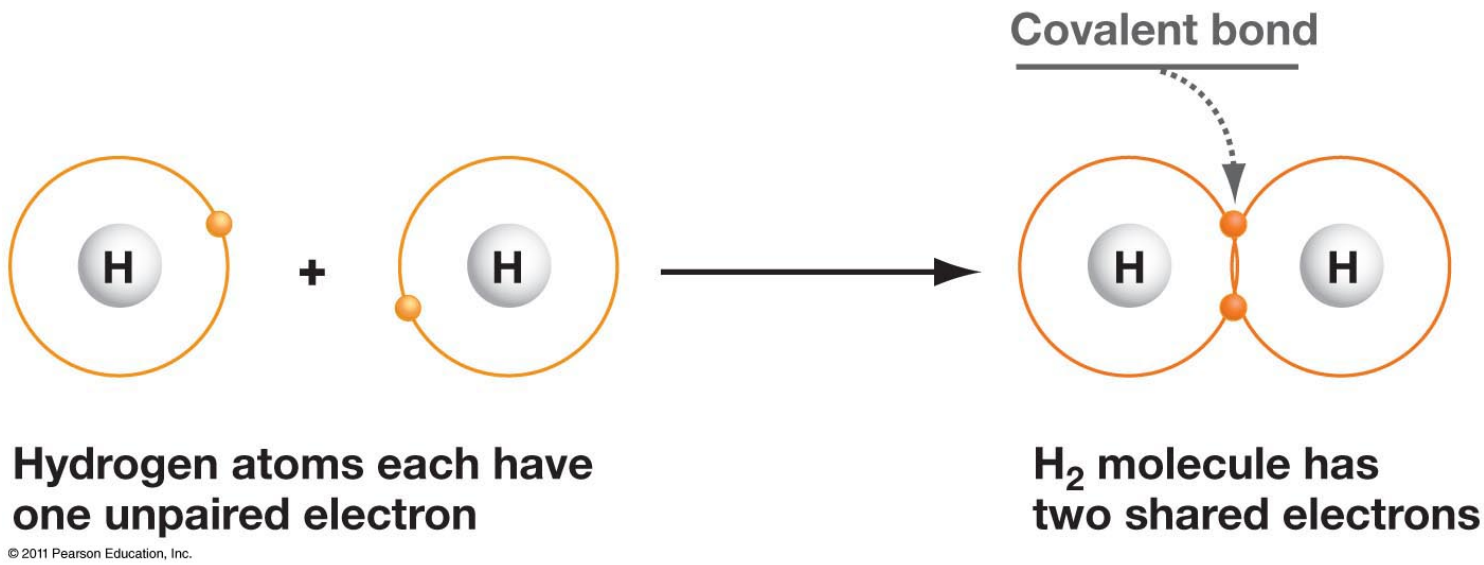
Metabolism = changing chemical bonds

Principle 1

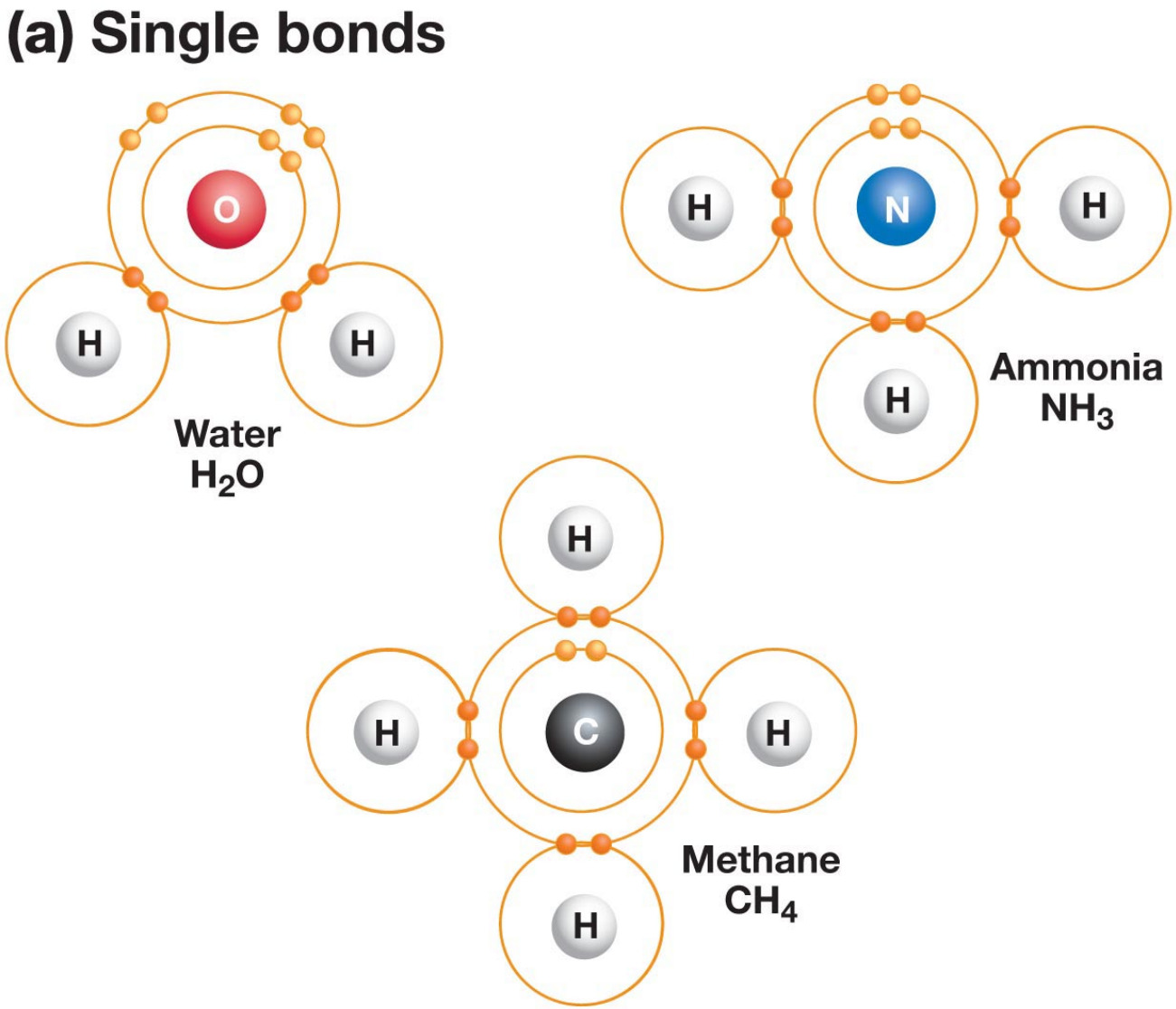
Atoms with a full outer shell (called the **valence shell**) tend to be inert.

Principle 2

Atoms with spaces available for electrons in the valence shell will react with other atoms until the valence shell is filled.

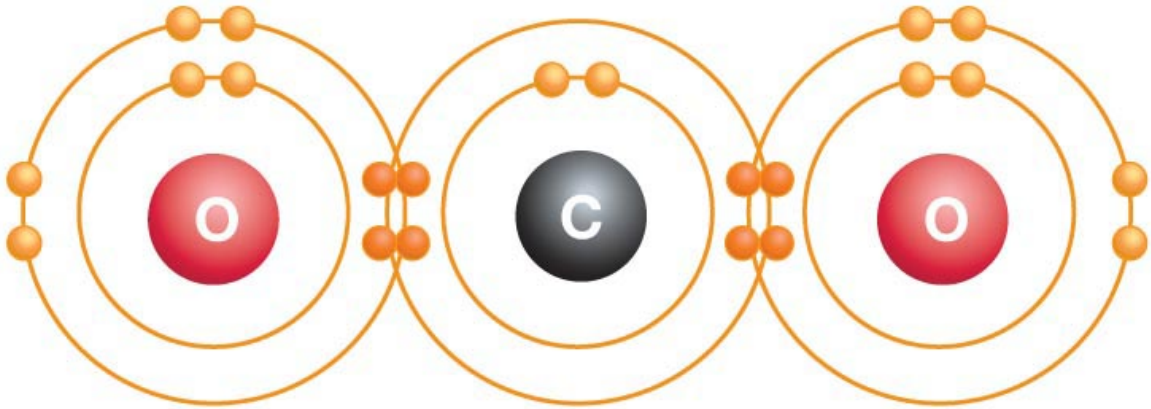


Examples of covalent bonds



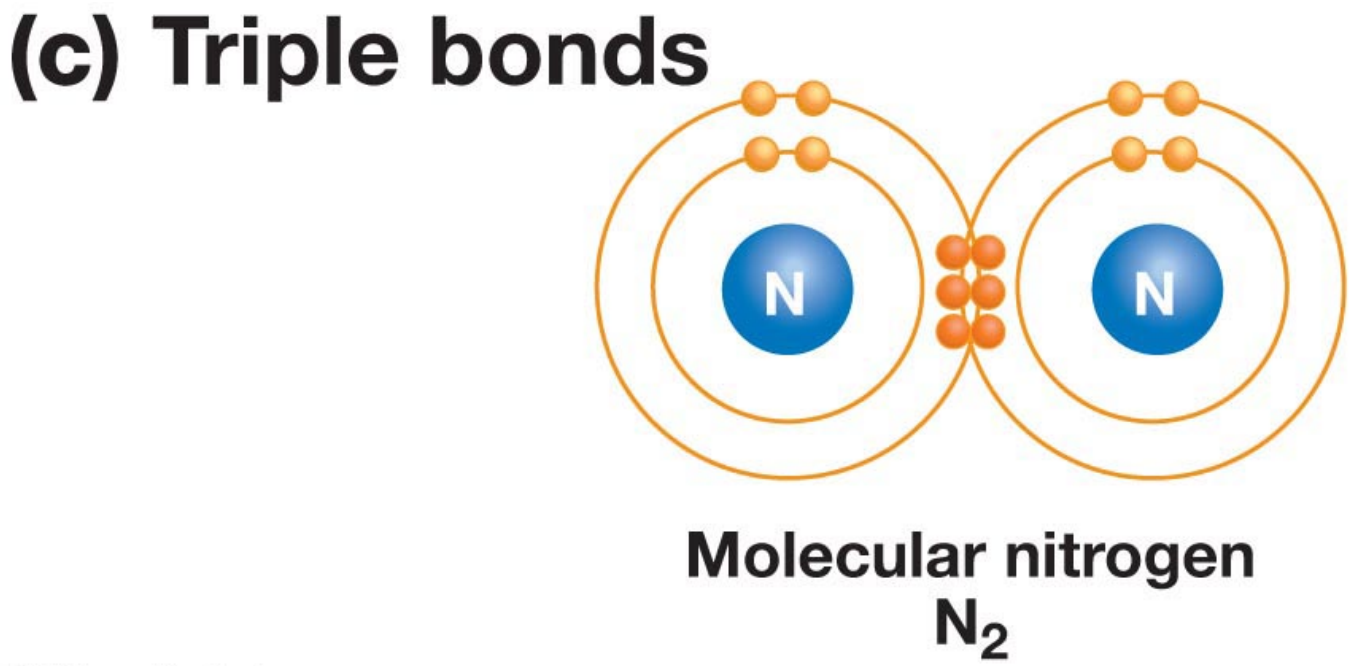
Examples of covalent bonds

(b) Double bonds

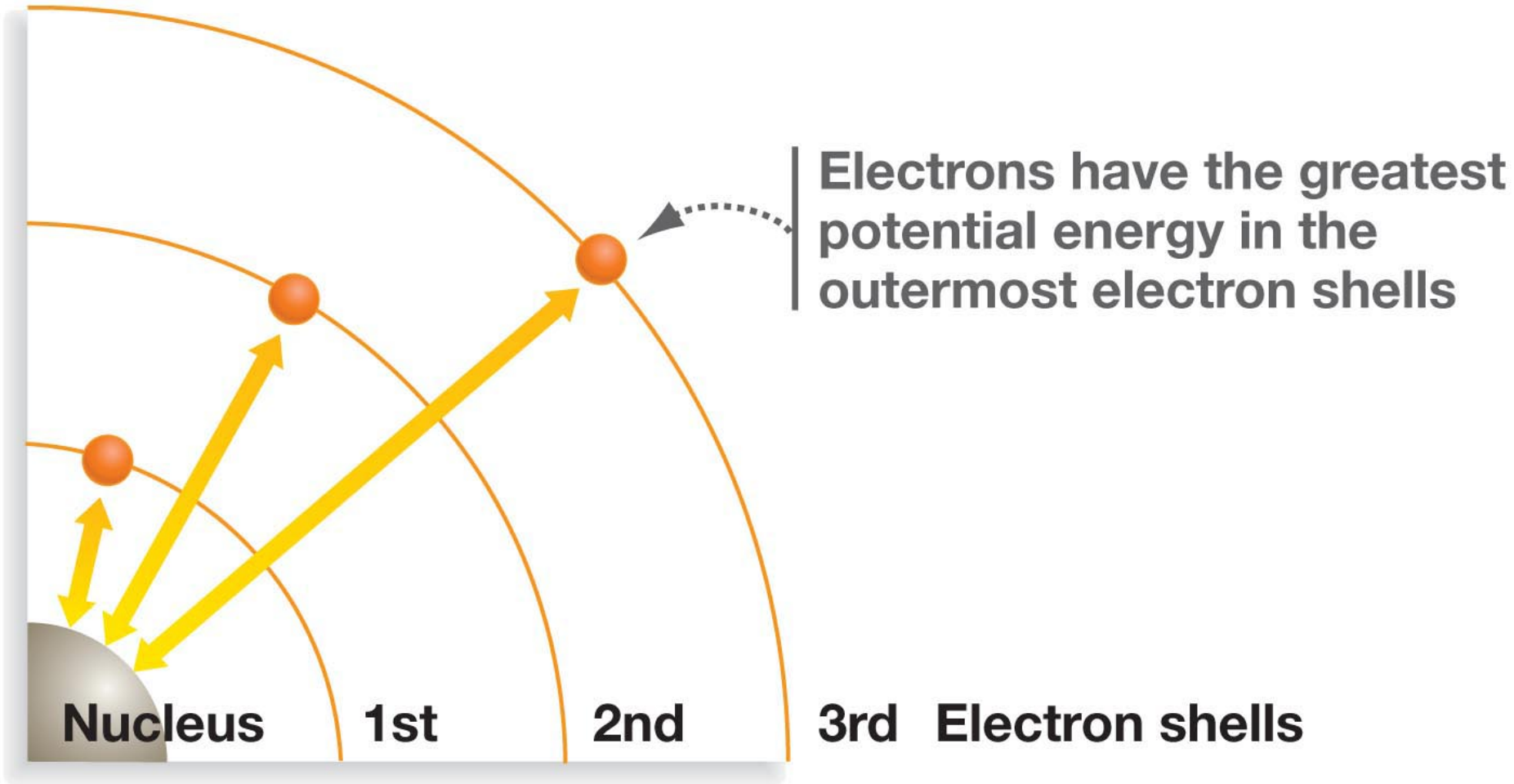


Carbon dioxide
CO_2

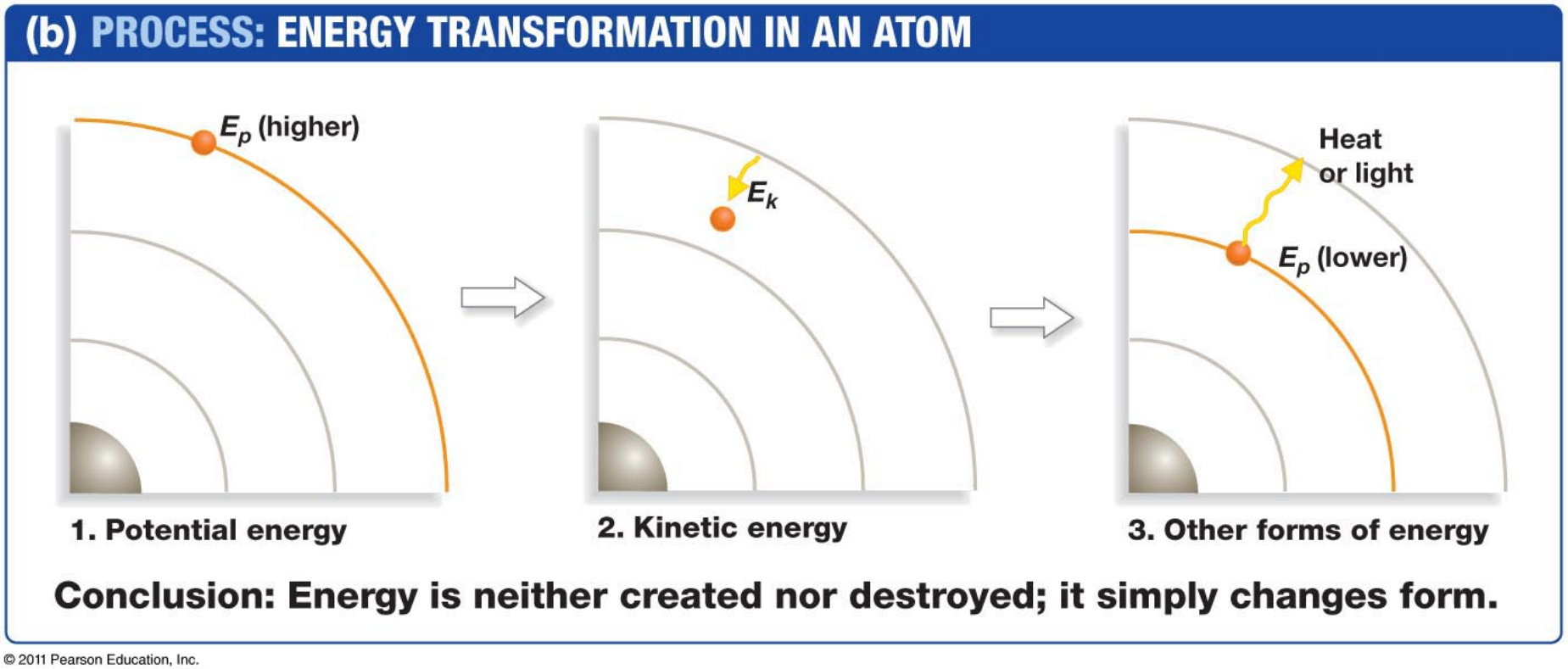
Examples of covalent bonds



Electrons hold chemical potential energy



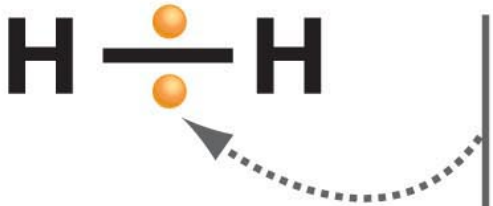
The basis of metabolism



Metabolism is the management of electron potential energy

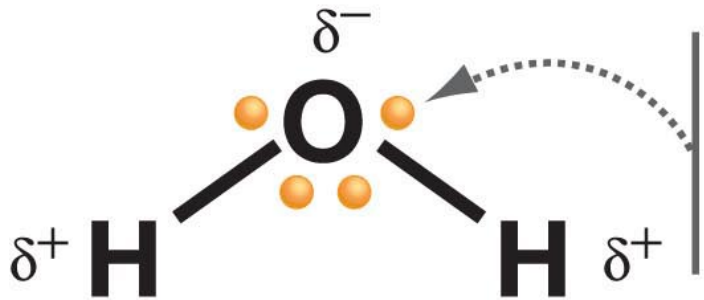
Not all covalent bonds are the same

(a) Nonpolar covalent bond in hydrogen molecule



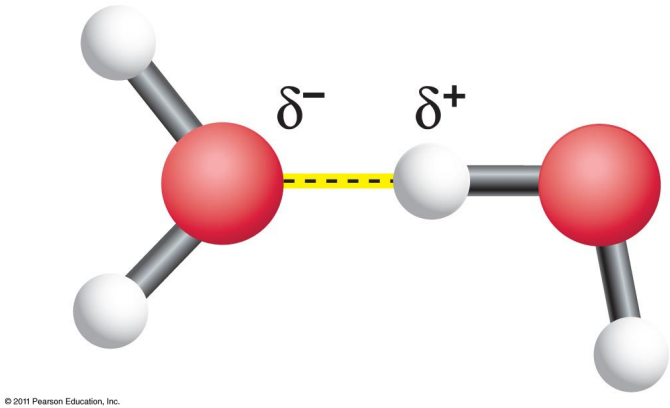
Electrons are shown to be superimposed on the bond to indicate that they are halfway between the two atoms, shared equally

(b) Polar covalent bonds in water molecule



Electrons are not shared equally (O is more electronegative than H), so partial charges exist on the O and H atoms

Hydrogen bonds between water molecules

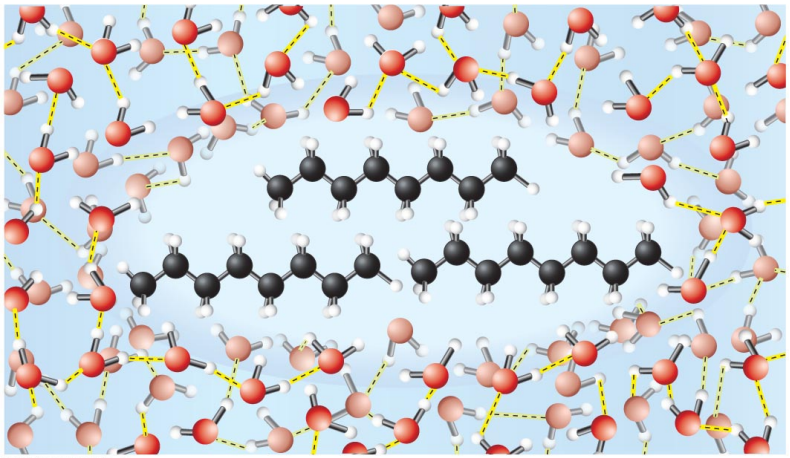


Definition: hydrogen bonds

A **hydrogen bond** is a weak electrostatic interaction between two molecules or parts of the same molecule caused by the attraction between an atom with a slight positive charge and one with a slight negative charge.

Why is life based on a polar solvent?

(b) Nonpolar molecules do not dissolve in water.



Andrew Pohorille (NASA Ames Research Center)

"...[the] solvent must promote self-organzation of organic matter into functional structures ...[which are] mostly based on non-covalent interactions [like hydrogen bonds]...Hydrophobic interactions are responsible ...for many self-organization phenomena in biological systems, such as the formation of [membranes] and protein folding."