Week 2: Chemistry and Nucleotides

Carbon

- Name: Carbon
- Atomic Number: 6
- Symbol: C
- Valency: 2, 4
- Valence Electrons: 4

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Agenda

1. Welcome and Questions
2. Basic Chemistry
3. Nucleotides the Building Blocks of DNA
4. What Must the Genetic Molecule Be Able to Do?
Atoms

- Atoms of the various elements differ in number of subatomic particles.
- An element’s **atomic number** is the number of protons in its nucleus.
- **Atomic mass**, the atom’s total mass, can be approximated by the mass number.
- **Opposite charges attract and like charges repel**.
Atoms

- Atoms are composed of subatomic particles
- Relevant subatomic particles include
  - **Neutrons** (no electrical charge)
  - **Protons** (positive charge)
  - **Electrons** (negative charge)
- Neutrons and protons form the **atomic nucleus**
- Electrons form a cloud around the nucleus
Atoms

• **Electrons are not randomly distributed around nucleus**

• An **orbital** is the three-dimensional space where an electron is found 90% of the time

• Each electron shell consists of a specific number of orbitals

• **Valence electrons** are those in the outermost shell, or **valence shell**
  • 8 electrons
  • Filled outer shell very stable

• Elements with a full valence shell are chemically inert
The formation and function of molecules depend on chemical bonding between atoms.

- Atoms with incomplete valence shells can share or transfer valence electrons with certain other atoms.

- These interactions usually result in atoms staying close together, held by attractions called chemical bonds.

- A covalent bond is the sharing of a pair of valence electrons by two atoms.

- In a covalent bond, the shared electrons count as part of each atom’s valence shell.
Chemical Bonds

• In a **nonpolar covalent bond**, the atoms share the electron equally

• In a **polar covalent bond**, one atom is more electronegative, and the atoms do not share the electron equally
  • Dipole or slightly charged ends

• Polar and nonpolar repel each other
  • Oil and water

• **Ionic Bonds** loss and gain with charged atoms

• Magic number is 8 in outer shell
Hydrogen Bonds

- A **hydrogen bond** forms when a hydrogen atom covalently bonded to one electronegative atom is also attracted to another electronegative atom.
- In living cells, the electronegative partners are usually oxygen or nitrogen atoms.
Nucleotides

- DNA is a heteropolymer
  - Made up from many subunits called monomers that are linked together
    1. Deoxyribose sugar
    2. Nitrogenous base
    3. Phosphate
  - Has four different subunits
    - Adenosine triphosphate (ATP), guanosine triphosphate (GTP), cytidine triphosphate (CTP), thymidine (dTTP)
Polynucleotide Chain

The beginning of a building of the DNA molecule

A polymer: polynucleotide chain is formed by the 5' phosphate on one nucleotide forming a bond to the 3' hydroxyl on the sugar of another nucleotide releasing two phosphates.

Forms a linear chain that might be a million nucleotides long (bases).
What was known by Watson and Crick

What must the genetic molecule do.
1. Encode information
2. Be able to direct exact copies of itself for inheritance
3. Be stable so as not to lose information
4. Be able to mutate
   1. At a very low level
   2. For evolution

From chemical analysis by Chargaff
1. The amount of A always = T and the amount of G always = C.
2. G did not always = C

There are two polynucleotide chains of equal length that interact to form a chain

From Franklin and Wilkins that the molecule was a regular helix (X-ray crystallography)
Watson and Crick

• Watson and Crick did no experiments
  • Used a picture of X-ray they saw in Wilken’s lab and Chargaff’s rule
  • Focused on building a model of a molecule that could do all four necessary genetic functions.

• Original Watson and Crick Paper