Organic compounds

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Lesson Objectives

Explain why **carbon** is essential to life on Earth.

Describe the structure and function of carbohydrates.

Describe the structure and function of lipids.

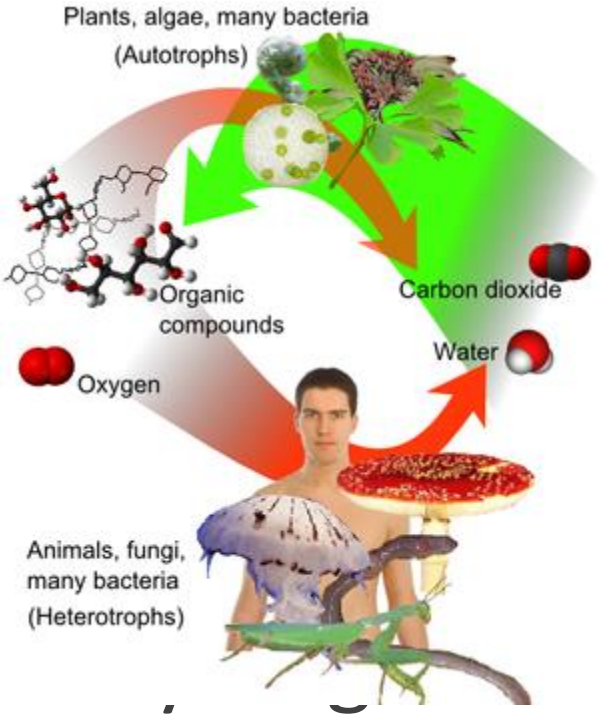
Describe the structure and function of proteins.

Describe the structure and function of nucleic acids.

Introduction

Organic compounds are chemical substances that:

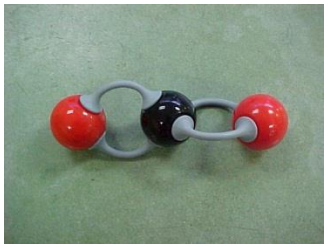
- Make up organisms
- Help organisms carry out life processes



All contain the elements carbon

- Carbon is the major element
  - Without carbon, life as we know it would cease to exist

THE SIGNIFICANCE OF CARBON



Nearly 10 million carbon-containing organic compounds are known

Types of carbon compounds in organisms include carbohydrates, lipids, proteins, and nucleic acids

Carbon can bond with a wide variety of other elements forming a variety of very large and complex molecules

- including hydrogen, oxygen, and nitrogen

Carbon can also bond to other carbons

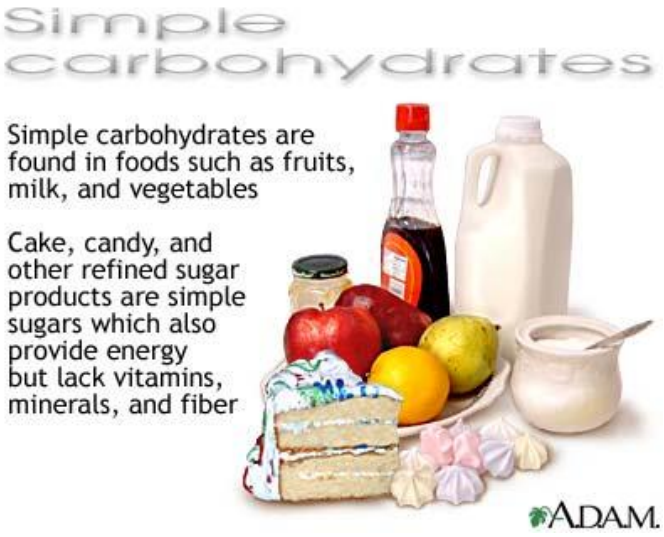
- may form single, double, or even triple bonds Handout Charts to fill in…..

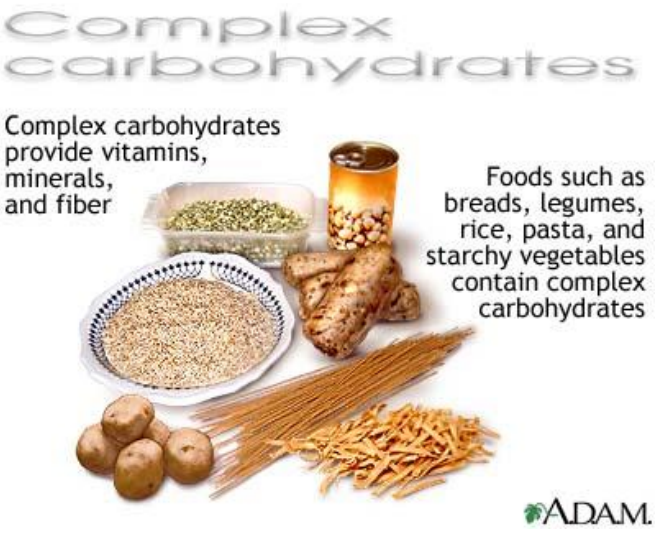
CARBOHYDRATES

Contain only carbon, hydrogen, and oxygen

The most common of the four major types of organic compounds

All consist of one or more smaller units called monosaccharides.

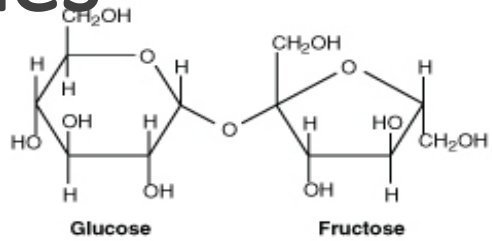




Monosaccharides	Formula	Where found
Fructose	$C_6H_{12}O_6$	Fruits
Glucose	$C_6H_{12}O_6$	From digestion of other carbohydrates
Galactose , or ribose	Galactose: $C_6H_{12}O_6$ Ribose: $C_5H_{10}O_5$	Galactose: milk Ribose: DNA, RNA
Disaccharides	**Formula**	**Where found**
Sucrose	$C_{12}H_{22}O_{11}$	Table sugar
Lactose	$C_{12}H_{22}O_{11}$	Milk
Maltose	$C_{12}H_{22}O_{11}$	Malt sugar
Polysaccharides	**Where found**	**Function**
Starch	Potatoes	Used by plants to store energy
Glycogen	In human liver cells	Used by animals to store energy
Cellulose	Cell walls of plants	Used by plants to form rigid walls around cells
Chitin	Exoskeleton of some insects	Used by some animals to form an external skeleton

Monosaccharides and Disaccharides

(Simple Carbohydrates)



KEY: C = carbon, H = hydrogen, O = oxygen

NOTE: Each unlabeled point where lines intersect represents another carbon atom.

Common Monosaccharides:

- glucose ($C_6H_{12}O_6$), fructose ($C_6H_{12}O_6$)

Two monosaccharides bonded together form a disaccharide.

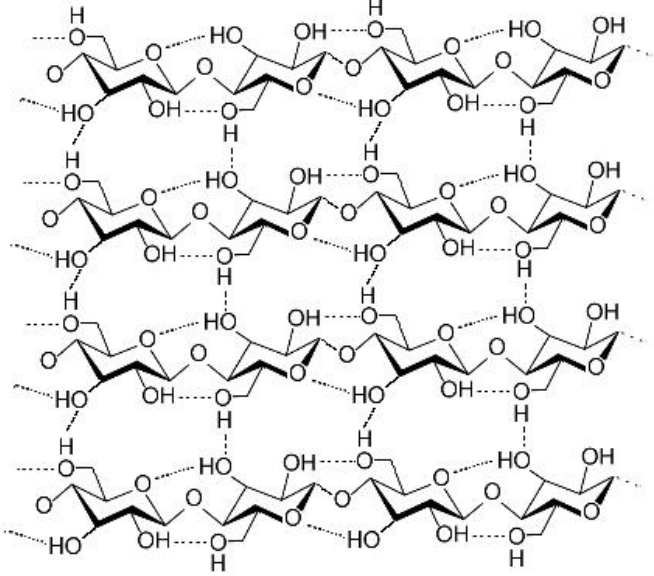
- Sucrose (table sugar)

Both monosaccharides and disaccharides are known as simple sugars and provide energy to living cells…

Another monosaccharide, fructose, has the same chemical formula as glucose, but the atoms are arranged differently. Molecules with the same chemical formula but with atoms in a different arrangement are called isomers.

Compare the glucose and fructose molecules can you identify their differences?.... The only differences are the positions of some of the atoms. These differences affect the properties of the two monosaccharides.

Polysaccharides
(Complex Carbohydrates)



Two or more monosaccharides bond together, form a carbohydrate called a **polysaccharide**

- May contain a few monosaccharides to several thousand monosaccharides
- Main functions are to store energy and form structural tissues (cell walls, exoskeletons)

Table 1.2: **Complex Carbohydrates**

Complex Carbohydrate	Function	Organism
Amylose	Stores energy	Plants
Glycogen	Stores energy	Animals
Cellulose	Forms cell walls	Plants
Chitin	Forms external skeleton	Some animals

These complex carbohydrates play important roles in living organisms.

The Compounds of Life

	Composition (elements present)	Function	Examples	Monomer
Carbohy-drates	Carbon, Hydrogen, and Oxygen C,H,O	Provide energy to living cells; form structural tissue	Glucose Fructose Sucrose Glycogen Cellulose	Mono-saccharides
Lipids				
Proteins				
Nucleic acids				

LIPIDS

Contain carbon, hydrogen, and oxygen

- include substances such as fats and oils
- Monomer→ fatty acids & glycerol

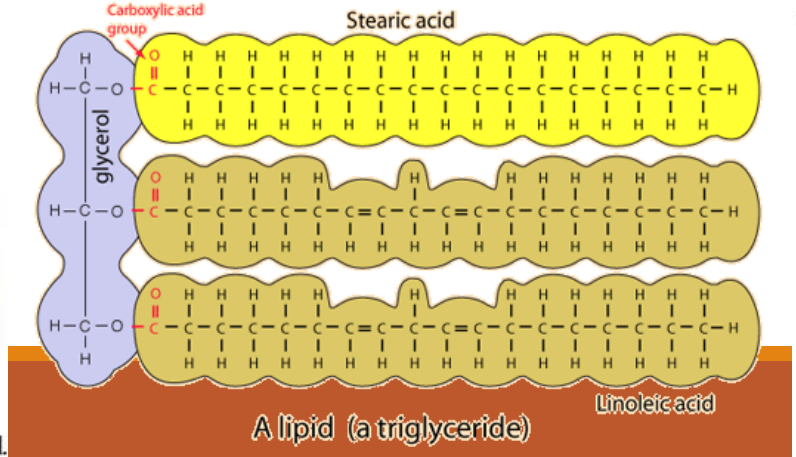
Lipid molecules consist of glycerol & 3 fatty acids

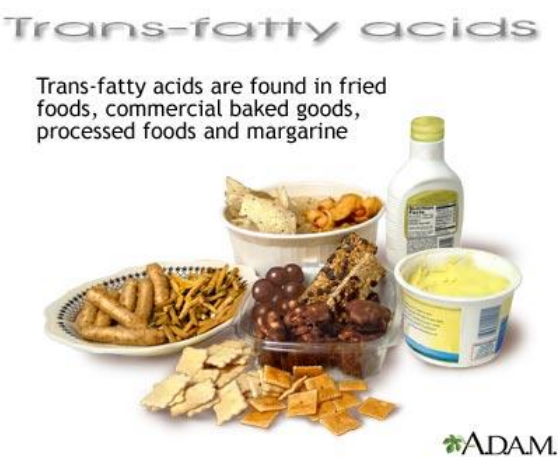
- Other types of lipids can contain additional molecules.

All lipids are hydrophobic; non-polar

Are they soluble in water????

FUNCTION: stores energy, forms cell membranes, carries messages…





Types of Lipids

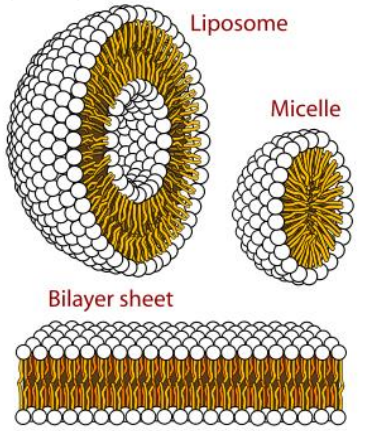
Lipids may consist of fatty acids alone or in combination with other compounds; several types of lipids consist of fatty acids combined with a molecule of alcohol:

- **Triglycerides** are the main form of stored energy in animals. This type of lipid is commonly called fat
- **Phospholipids** are a major component of the membranes surrounding the cells of all organisms
- **Steroids** (or sterols) have several functions. The sterol **cholesterol** is an important part of cell membranes and plays other vital roles in the body. Other steroids are male and female sex hormones

Bilayer sheet= phospholipids bilayer

Hydrophobic tails

Hydrophilic heads



Saturated Fatty Acids

Saturated fatty acids are solids at room temperature

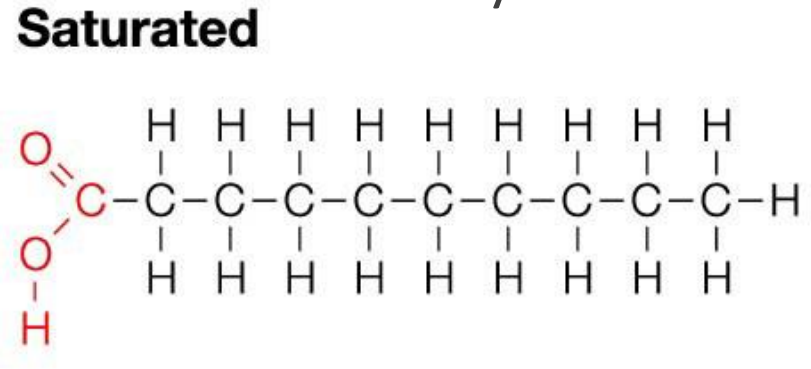
Saturated refers to the placement of hydrogen atoms around the carbon atoms

Saturated fatty acid, have a COOH group; all the C atoms (other than the C in the -COOH group) are bonded to two or more H atoms with single bonds

- they form straight chains

Structure allows saturated fatty acids to be packed together tightly; dense storage of chemical energy

- fatty tissues of animals contain mainly saturated fatty acids



Unsaturated Fatty Acids

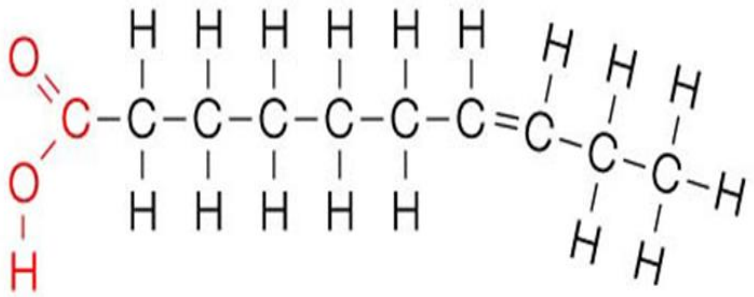
Unsaturated fatty acids are liquids at room temperature

Unsaturated fatty acid, also have a COOH group; some carbon atoms are not bonded to as many hydrogen atoms as possible because they are bonded to one or more additional groups, including double and triple bonds between carbons

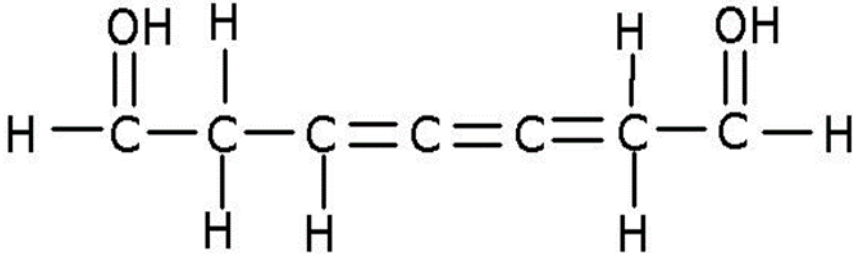
- they cause the chain to bend - do not form straight chains

Unsaturated fatty acids are found mainly in plants, especially in fatty tissues such as nuts and seeds.

Unsaturated



-- monounsaturated



Polyunsaturated fatty acid

One double carbon bond means monounsaturated fatty acid
Two or more double bonds means polyunsaturated fatty acid

Type of Lipid	Characteristics	Where found
Triglycerides	Main form of stored energy in animals	vegetable oil (typically more unsaturated) animal fats (typically more saturated)
Saturated	Form straight chains b/c carbon atoms are bonded to as many H atoms as possible; store energy in compact form; solid at room temperature	Animals use these to store energy
Unsaturated	Form bent chains b/c some C atoms are not bonded to as many H atoms as possible; store energy; liquid at room temperature	Plants use these to store energy
Phospholipids	Major component of cell membranes	Liver, peanuts
Steroids	Serve as chemical messengers and have other roles	found in plants, animals, and fungi

Lipids and Diet

Humans need lipids for many vital functions, such as storing energy and forming cell membranes; also supply cells with energy

- a gram of lipids supplies more than twice as much energy as a gram of carbohydrates or proteins

Human body can manufacture most of the lipids it needs

Essential fatty acids, must be consumed in food

- include omega-3 and omega-6 fatty acids

Excess dietary lipids can be harmful

- lead to unhealthy weight gain
- increase the risk for health problems such as cardiovascular disease

Omega- 3 in (Coldwater fish like tuna, salmon, lake trout, mackerel, shrimp are rich sources of omega3. Plant sources include flaxseed oil and pumpkin seed oil. Omega 3 fatty acids are highly concentrated in the brain and appear to be particularly important for cognitive and behavioral function. In fact, infants who do not get enough omega 3 fatty acids from their mothers during pregnancy are at risk for developing vision and nerve problems. Omega-3 fatty acids are good for heart. They reduce triglyceride levels, raise levels of HDL (”good”) cholesterol, and manage blood pressure.); Omega- 6 in (Omega-6 fatty acids are beneficial as well. They help regulate inflammation and blood pressure as well as heart, gastrointestinal, and kidney functions. Good dietary sources of omega-6 fatty acids include cereals, eggs, poultry, most vegetable oils, whole-grain breads, baked goods, and margarine.) The dietary lipids of most concern are saturated fatty acids, trans fats, and cholesterol. For example, cholesterol is the lipid mainly responsible for narrowing arteries and causing the disease atherosclerosis.

The Compounds of Life

	Composition (elements present)	Function	Examples	Monomer
Carbohy-drates-	Carbon, Hydrogen, and Oxygen C,H,O	Provide energy to living cells; form structural tissue	Glucose Fructose Sucrose Glycogen Cellulose	Mono-saccharides
Lipids	Carbon, hydrogen, and Oxygen C,H,O	Hydrophobic --form cell membranes Store energy	Fats, Oils, Waxes, Steroids	Glycerol & 3 Fatty Acids (for fats & oils)
Proteins				
Nucleic acids				

PROTEINS

Contain carbon, hydrogen, oxygen, nitrogen

Made of smaller units called **amino acids (monomers)**.

- 20 different common amino acids make proteins
- Small proteins can contain just a few hundred amino acids.
  - Yeast proteins average 466 amino acids.
- The largest known proteins are the titins, found in muscle, which are composed from almost 27,000 amino acids.

Functions of Proteins

Essential part of all organisms; that serve many functions

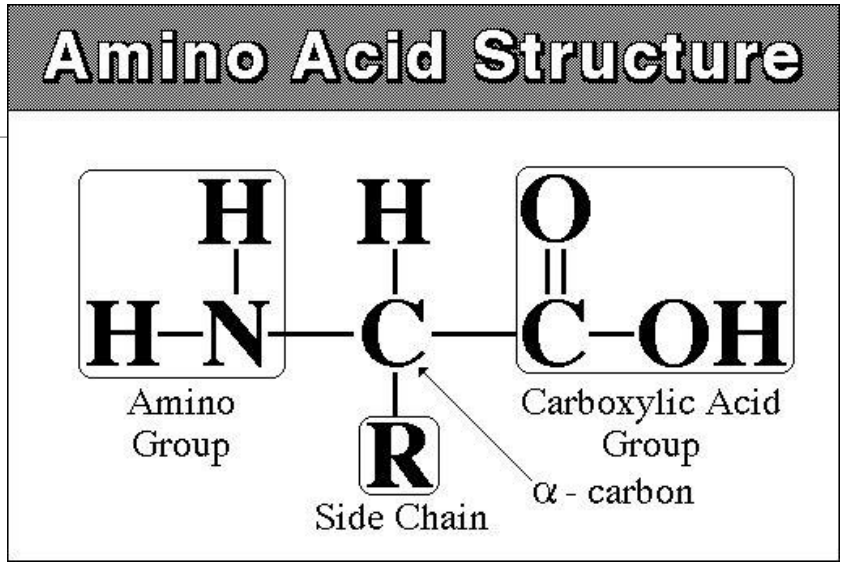
- provide a scaffolding that maintains the shape of cells
- make up the majority of muscle tissues
- some are enzymes that speed up chemical reactions in cells
- others are antibodies
- Still other help carry messages or materials in and out of cells or around the body

Most important traits of proteins, allowing them to carry out these functions, is their ability to bond with other molecules. They can bond with other molecules very specifically and tightly

Amino Acid Structure

Same basic structure

- 'R' group; amino group (NH_2); and carboxyl group (COOH)

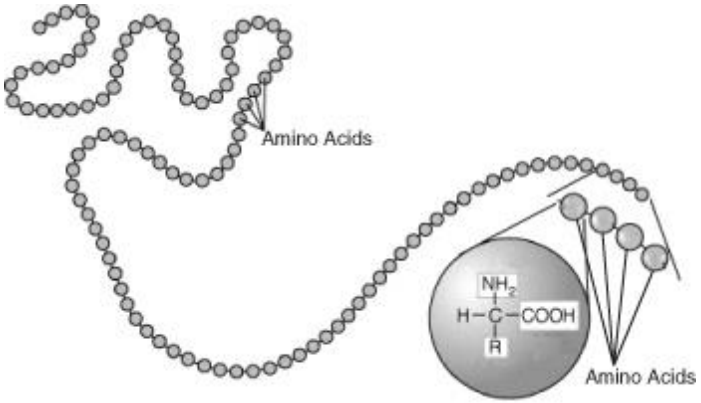


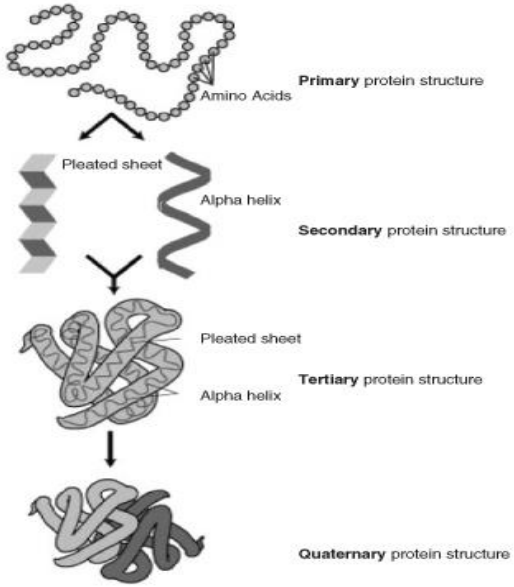
Amino acids are molecules containing an amino group (shown here as H2N), a carboxylic acid group and a side chain "R" group that varies between different amino acids.

Protein Structure

Amino acids can bond together to form short chains called **peptides** or longer chains called **polypeptides**

Protein consists of one or more polypeptide chains





Polypeptides may have as few as 40 amino acids or as many as several thousand. The order of amino acids, together with the properties of the amino acids, determines the shape of the protein, and the shape of the protein determines the function of the protein. KEY: H = hydrogen, N = nitrogen, C = carbon, O = oxygen, R = variable side chain.

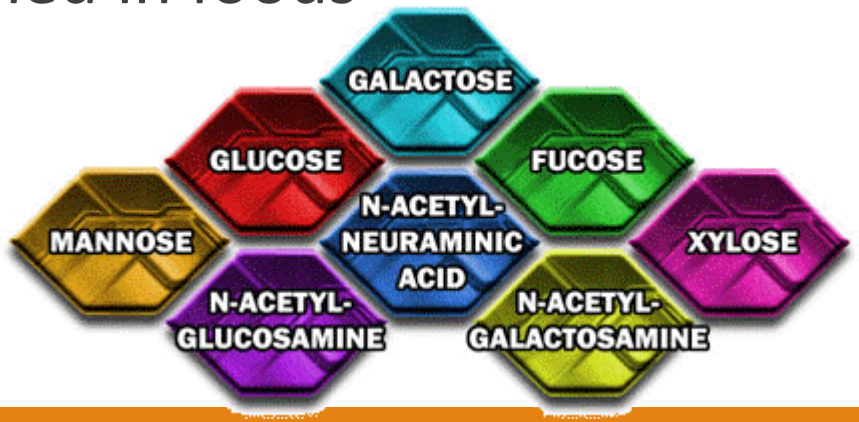
Proteins and Diet

Proteins in the diet are necessary for life

- Dietary proteins are broken down into their component amino acids when food is digested
- Cells can then use the components to build new proteins

Humans are able to synthesize all but eight of the twenty common amino acids.

These eight amino acids, called **essential amino acids**, must be consumed in foods



Protein Denaturation

Definition: ~~the change in the shape of protein molecules~~ without _denaturation we could not eat many delicious foods; _*is* _necessary for survival so we can break down proteins we eat into components our bodies can use; _*changes or halts* _the shape of the protein molecule/cellular function.

Is caused by _extreme conditions—heat, acid (change of pH), or force____40°C_____

The Compounds of Life

	Composition (elements present)	Function	Examples	Monomer
Proteins	Carbon, Hydrogen, Oxygen, and Nitrogen C,H,O,N	Maintain cell shape; Make muscle tissue; Speed up chemical reactions; Carry messages	Enzymes Antibodies	Amino Acid
Nucleic acids				

NUCLEIC ACIDS

Contain carbon, hydrogen, oxygen, nitrogen, and phosphorus

- made of smaller units called **nucleotides**.

Nucleic acids are found not only in all living cells but also in viruses

Types of nucleic acids include:

- **deoxyribonucleic acid (DNA)**
- **ribonucleic acid (RNA)**.

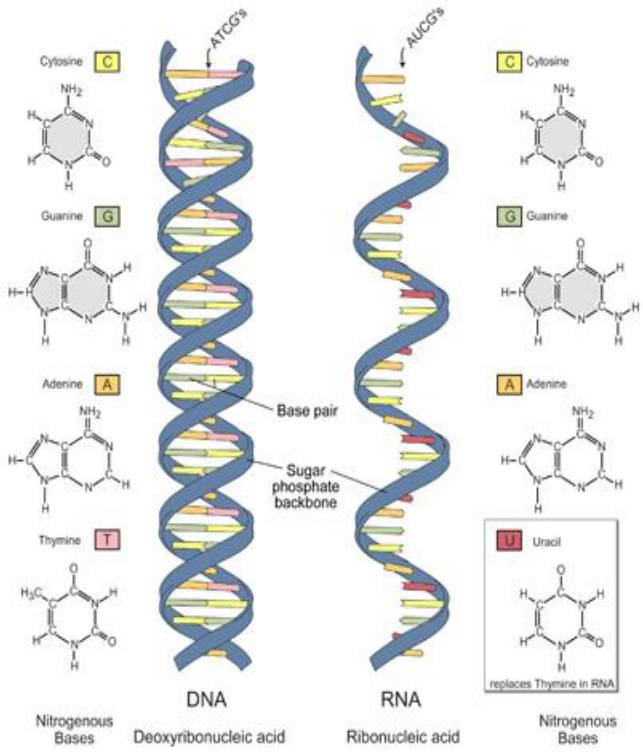


Image adapted from: National Human Genome Research Institute.

Structure of Nucleic Acids

Consists of one or two chains of nucleotides held together by chemical bonds

Each individual nucleotide unit consists of three parts:

- a base (containing nitrogen)
  - four bases: Adenine, Guanine, Cytosine, and Thymine in DNA, or Uracil in RNA
- a sugar
  (deoxyribose in DNA, ribose in RNA)
- a phosphate group (containing phosphorus)

RNA consists of a single chain of nucleotides,
DNA consists of two chains of nucleotides

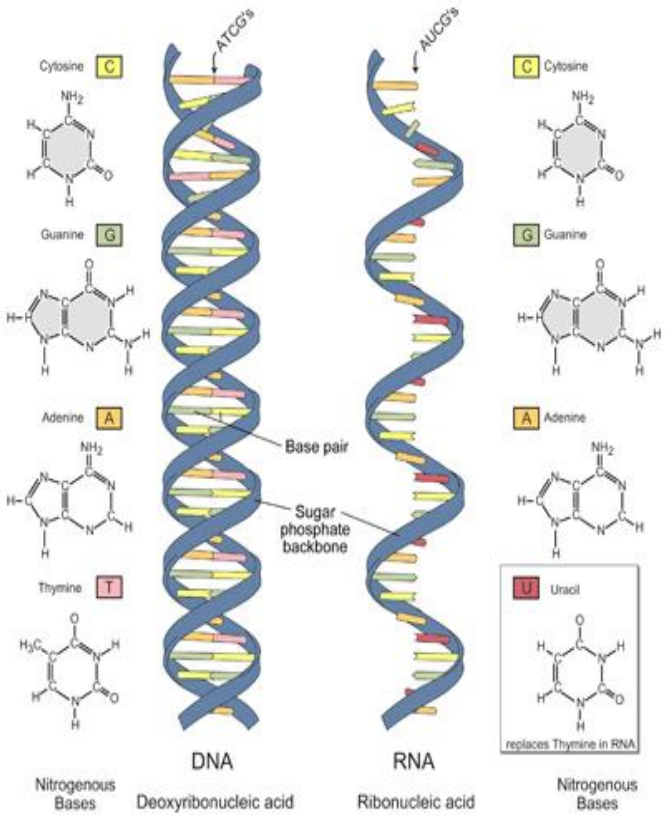


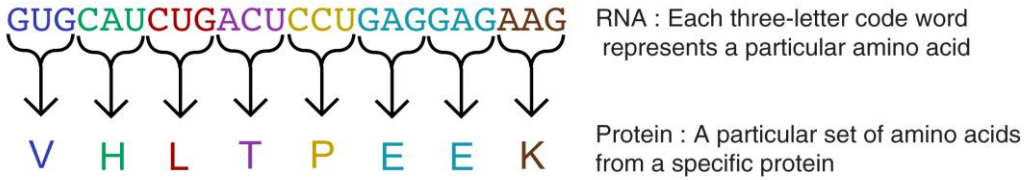
Image adapted from: National Human Genome Research Institute.

Role of Nucleic Acids

Order of bases in nucleic acids is highly significant

- bases are like the letters of a four-letter alphabet
- ‘‘letters” can be combined to form ‘‘words”
- groups of three bases form words of the genetic code
- each code word stands for a different amino acid
- series of many code words spells out the sequence of amino acids in a protein

Information is passed from a body cell to its daughter cells when the cell divides. It is also passed from parents to their offspring when organisms reproduce.

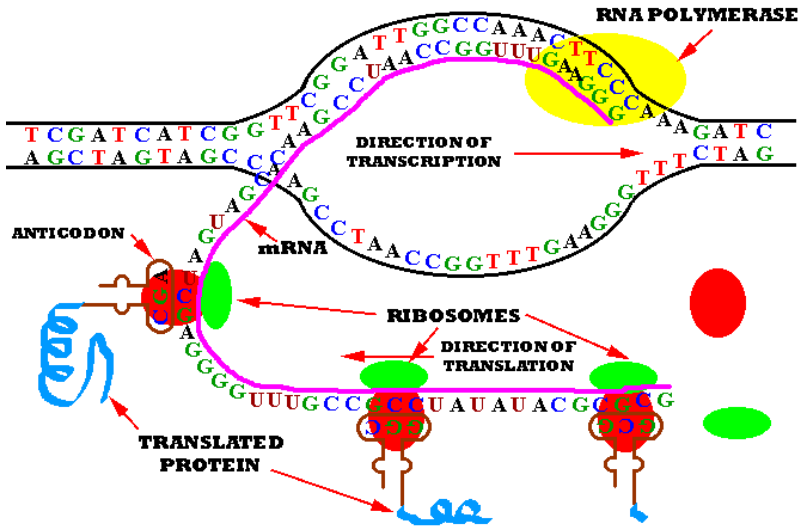


How RNA codes for Proteins

DNA and RNA have different functions relating to the genetic code and proteins

Like a set of blueprints, DNA contains the genetic instructions for the correct sequence of amino acids in proteins

RNA uses the information in DNA to assemble the amino acids and make the proteins.



The Compounds of Life

	Composition (elements present)	Function	Examples	Monomer
Nucleic acids	Carbon, Hydrogen, Oxygen, Phosphorus, and Nitrogen C,H,O,P,N	Pass on traits Code for amino acids	Deoxyribo-nucleic acid (DNA) Ribonucleic acid (RNA)	Nucleotides

THANK YOU FOR LISTEN