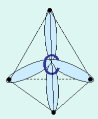
ORGANIC COMPOUNDS

– **Organic compounds** are carbon-based molecules.
- A cell is mostly water. (Hydrogen and Oxygen)
- The rest of the cell consists mainly of carbon-based molecules.
- Carbon forms large, complex, and diverse molecules necessary for life's functions.

Organic Chemistry



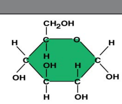
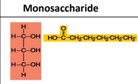
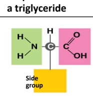
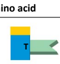
The Chemistry of Carbon

Important Latin Roots

Mono	Poly	Macro	Hydro	Lysis	Saccharide
• One	• Many	• Large	• Water	• Breaking down	• Sugar

Generation	Phylic	Phobic
• Create/ Add	• Loving	• Fearing

Figure 3.UN02

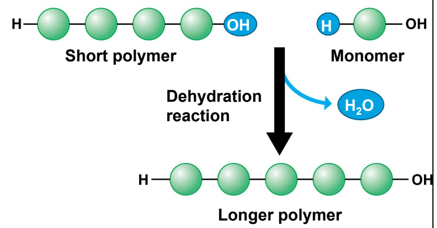
Large biological molecules	Functions	Components	Examples
Carbohydrates	Dietary energy; storage; plant structure	 Monosaccharide	Monosaccharides: glucose, fructose; Disaccharides: lactose, sucrose; Polysaccharides: starch, cellulose
Lipids	Long-term energy storage (fats); hormones (steroids)	 Components of a triglyceride	Fats (triglycerides); steroids (testosterone, estrogen)
Proteins	Enzymes, structure, storage, contraction, transport, etc.	 Amino acid	Lactase (an enzyme); hemoglobin (a transport protein)
Nucleic acids	Information storage	 Nucleotide	DNA, RNA

Big Molecules from Smaller Building Blocks

– Most **macromolecules are polymers**.

- **Polymers** are **made** by stringing together many smaller molecules called **monomers**.
- All polymers are put together the same way!

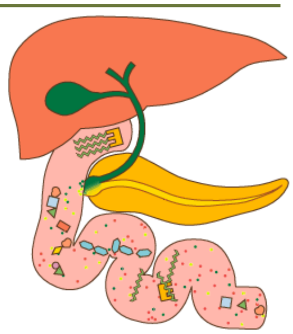
Figure 3.4a



(a) Building a polymer chain

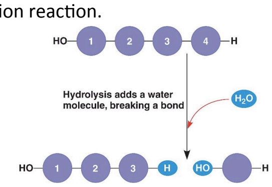
Big Molecules from Smaller Building Blocks

- Organisms also have to break down macromolecules.
- Digestion breaks down macromolecules to make monomers available to your cells.
  - Everyone digests macromolecules the same way too….



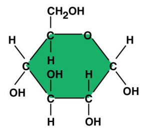
Big Molecules from Smaller Building Blocks

- **Hydrolysis**
  – Breaks bonds between monomers,
  – Adds a molecule of water, and
  – Reverses the dehydration reaction.



Carbohydrates

Figure 3.UN02a

Functions	Components	Examples
Dietary energy; storage; plant structure	 Monosaccharide	Monosaccharides: glucose, fructose: Disaccharides: lactose, sucrose: Polysaccharides: starch, cellulose

- Important for energy and as a starting point for building other molecules.
- Only need C, H, O to make them.

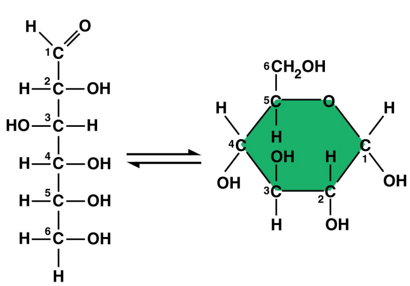
Monosaccharides

– **Monosaccharides** are
- The monomers of carbohydrates.
  – Simple sugars that cannot be broken down by hydrolysis into smaller sugars and

– Common examples are
- glucose in sports drinks and
- fructose found in fruit.

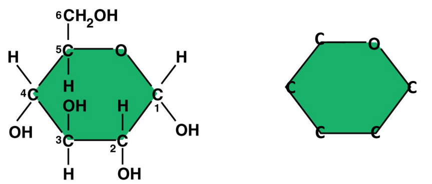
Figure 3.6a

Monosaccharides



(a) Linear and ring structures

Figure 3.6b



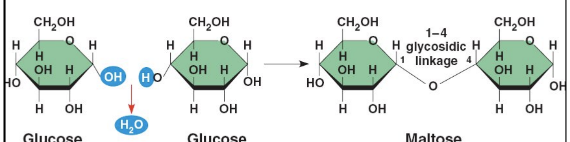
(b) Abbreviated ring structure

Disaccharides

Two — Sugar

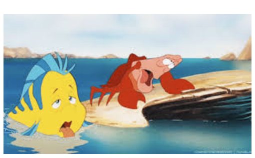
– A **disaccharide** is
- A double sugar,
- Constructed from two monosaccharides
- Formed by a dehydration reaction.

Disaccharides include
- *lactose in milk,*
- *maltose in beer,*
- *sucrose in table sugar.*

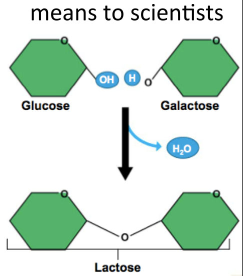


Dehydration Reaction

- What does dehydration mean to you?

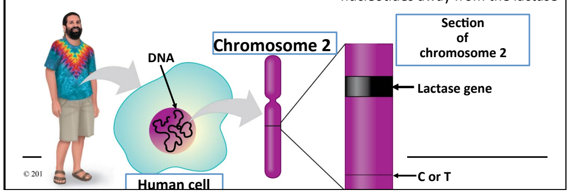


What dehydration means to scientists



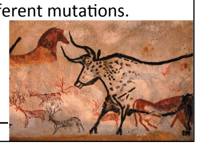
The Process of Science: Does Lactose Intolerance Have a Genetic Basis?

- **Observation**: Most lactose-intolerant people have a normal version of the lactase gene.
- **Question**: What is the genetic basis for lactose intolerance?
- **Hypothesis**: Lactose-intolerant people have a mutation but not within the lactase gene.
- **Prediction**: A mutation would be found near the lactase gene.
- **Experiment**: Genes of 196 lactose-intolerant people were examined.
- **Results**: Researchers found a 100% correlation between lactose intolerance and a nucleotide at a site approximately 14,000 nucleotides away from the lactase



Evolution Connection: The Evolution of Lactose Intolerance in Humans

- Most people are lactose-intolerant as adults.
- Lactose intolerance is found in
  - 80% of African Americans and Native Americans,
  - 90% of Asian Americans, but
  - Only 10% of Americans of northern European descent.
  - Lactose tolerance appears to have evolved in northern European cultures that relied upon dairy products.
  - Ethnic groups in East Africa that rely upon dairy products are also lactose tolerant but due to different mutations.

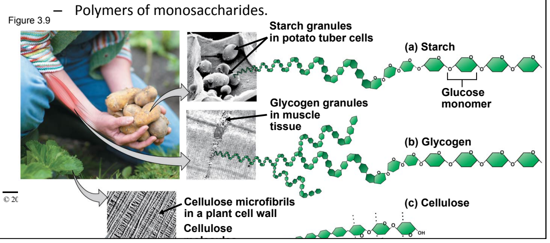


Polysaccharides

Many — Sugar

- **Polysaccharides** are
  - Complex carbohydrates
  - Made of long chains of sugar units
    - Polymers of monosaccharides.

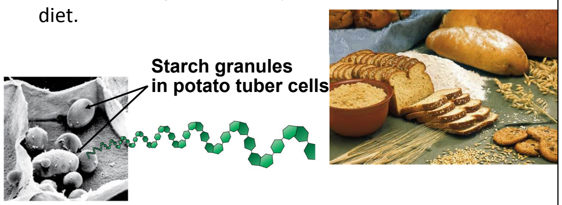
Figure 3.9



Polysaccharides

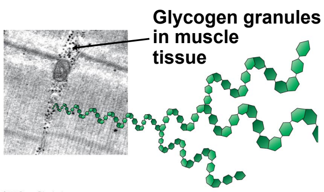
– **Starch**
- Is a familiar example of a polysaccharide,
- Used by plant cells to store energy, and
- Consists of long strings of glucose monomers.

– Potatoes and grains are major sources of starch in our diet.



Polysaccharides

– **Glycogen** is
- Used by animals cells to store energy and
- Converted to glucose when it is needed.



Polysaccharides

– **Cellulose**
- is the most abundant organic compound on Earth!
- forms cable-like fibrils in the walls that enclose plant cells, and
- cannot be broken apart by most animals.

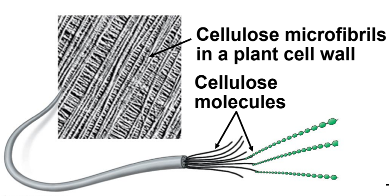


Figure 3.9d

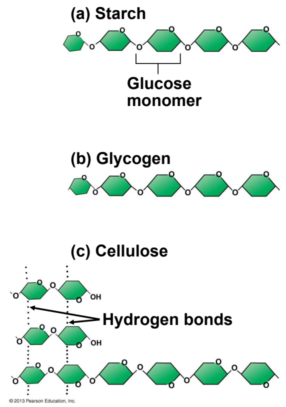
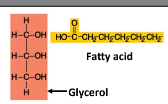


Figure 3.UN02b

Lipids

Functions	Components	Examples
Long-term energy storage (fats); hormones (steroids)	 Components of a triglyceride	Fats (triglycerides); steroids (testosterone, estrogen)

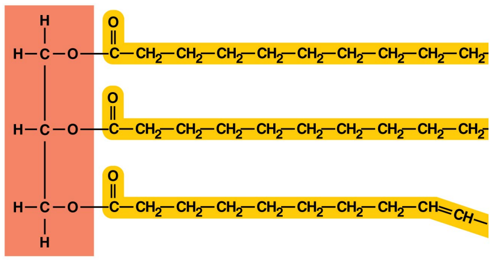
Lipids

Only need C, H, O to make a basic fat (some lipids use more elements).

Important for?

- A typical **fat**, or **triglyceride,** consists of
  - A glycerol molecule,
  - Joined with three fatty acid molecules,
  - Via a dehydration reaction.

Figure 3.11b

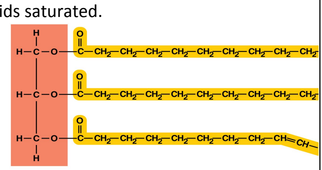


(b) A fat molecule with a glycerol “head” and three energy-rich hydrocarbon fatty acid “tails”

Fats

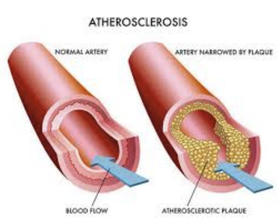
– If the carbon skeleton of a fatty acid
  - has fewer than the maximum number of hydrogens, it is **unsaturated**;
  - if it has the maximum number of hydrogens, it is **saturated**.

– A saturated fat has
  - no double bonds and
  - all three of its fatty acids saturated.



Fats

– Most animal fats
  - Have a high proportion of saturated fatty acids,
  - Can easily stack, tending to be solid at room temperature,
  - Contribute to **atherosclerosis**, in which lipid-containing plaques build up along the inside walls of blood vessels.



Fats

- Most plant oils tend to be
  - High in unsaturated fatty acids and
  - Liquid at room temperature.

Fats

- **Hydrogenation**
  - Adds hydrogen,
  - Converts unsaturated fats to saturated fats,
  - Makes liquid fats solid at room temperature, and
  - Creates **trans fat**, a type of unsaturated fat that is particularly bad for your health.

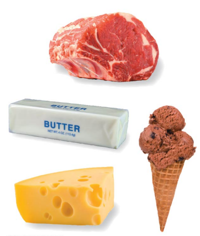
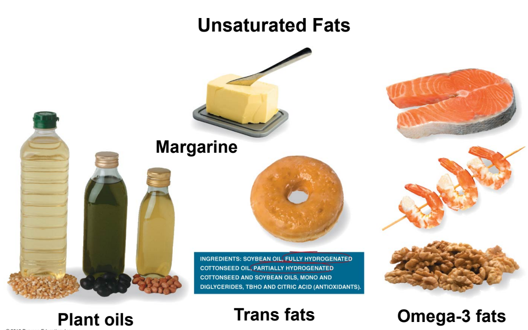


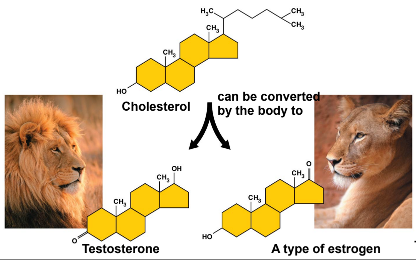
Figure 3.12b



Steroids

– Cholesterol is

- a key component of animal cell membranes (because we don't have cell walls) and
- The "base steroid" from which your body produces other steroids, such as estrogen and testosterone.



- Saturated fats:

a. have no double bonds in the fatty acids
b. are liquid at room temperature
c. are abundant in plants
d. all of the above

Proteins

- **Proteins**
  - are polymers constructed from amino acid monomers,
  - account for more than 50% of the dry weight of most cells,
  - perform most of the tasks required for life, and
  - form enzymes, chemicals that change the rate of a chemical reaction without being changed in the process.

Enzymes (help chemical reactions)

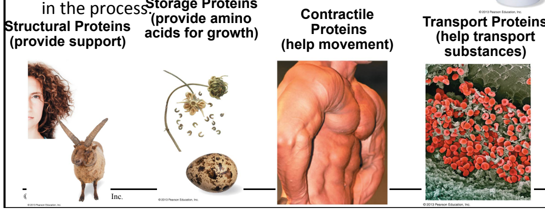
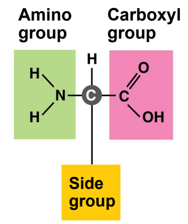


Figure 3.16a

The Monomers of Proteins: Amino Acids

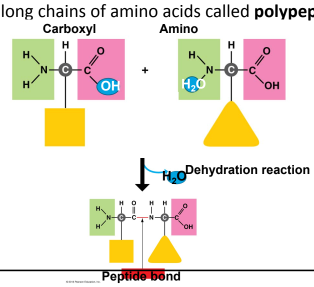
- All proteins are macromolecules constructed from a common set of **20** kinds of amino acids.
- Each **amino acid** consists of;
  - a central carbon,
  - an amino group (NH3)
  - a Carboxyl group (an acid),
  - One of 20 different "side groups"



The general structure of an amino acid

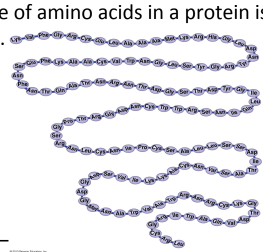
Proteins as Polymers

- Cells link amino acids together
  - by dehydration reactions,
  - forming **peptide bonds,** and
  - creating long chains of amino acids called **polypeptides**.



Proteins as Polymers

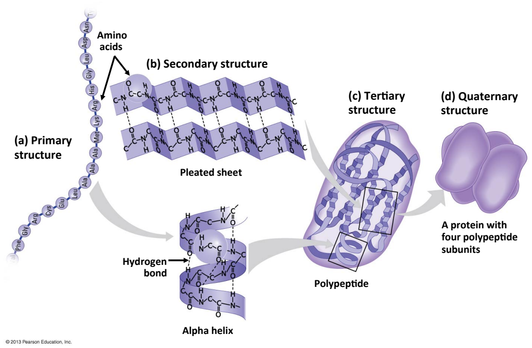
- Your body has tens of thousands of different kinds of protein.
- Proteins differ in their arrangement of amino acids.
- The specific sequence of amino acids in a protein is its **primary structure.**



Protein Shape

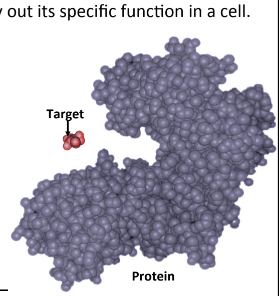
- A functional protein consists of
  - one or more polypeptide chains,
  - precisely twisted, folded, and coiled into a molecule of unique shape.
- Proteins consisting of one polypeptide have three levels of structure.
- Proteins consisting of more than one polypeptide chain have a fourth level, quaternary structure.

Figure 3.20-4



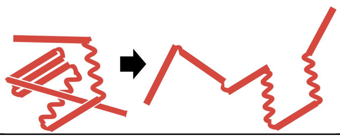
Protein Shape

- A protein's three-dimensional shape
  - typically recognizes and binds to another molecule and
  - enables the protein to carry out its specific function in a cell.



What Determines Protein Shape?

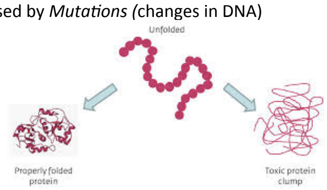
- A protein's shape is sensitive to the surrounding environment.
- An unfavorable change in temperature and/or pH can cause **denaturation** of a protein, in which it unravels and loses its shape.
- High fevers (above 104°F) in humans can cause some proteins to denature.



What Determines Protein Shape?

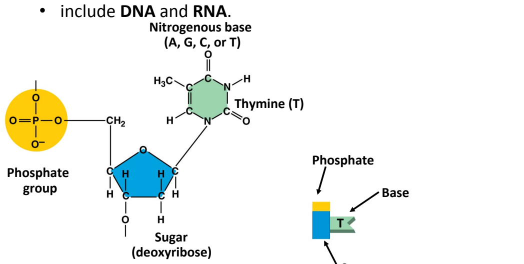
- Misfolded proteins are associated with
  - Alzheimer's disease,
  - Mad cow disease, and
  - Parkinson's disease.

  - All caused by *Mutations (*changes in DNA)



Nucleic Acids

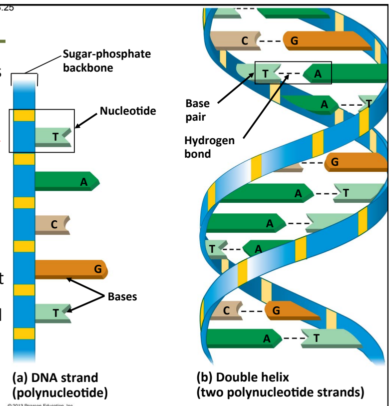
- Nucleic acids are macromolecules that
  - Are made of <u>nucleotide</u> monomers
  - provide the directions for building proteins, and
  - include **DNA** and **RNA**.

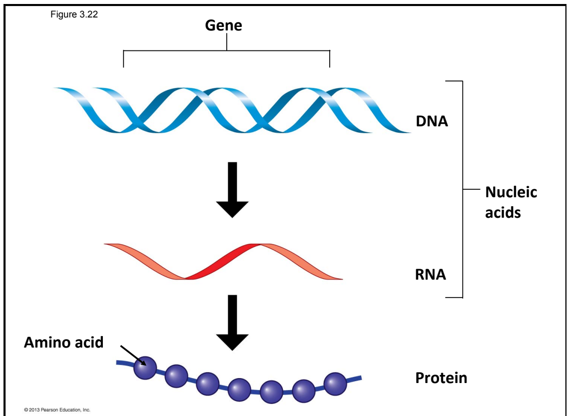


(a) Atomic structure (b) Symbol used in this book

Nucleic Acids

- DNA resides in cells in long fibers called chromosomes.
- A **gene** is a specific stretch of DNA that programs the amino acid sequence of a polypeptide.
- The chemical code of DNA must be translated from "nucleic acid language" to "protein language."



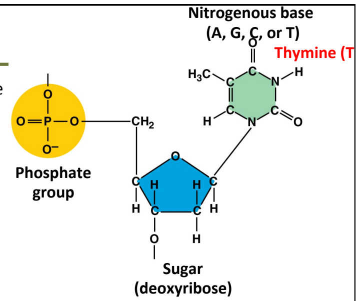


Nucleic Acids

- Nucleic acids are polymers made from monomers called **nucleotides**.
- Each nucleotide has three parts:
  1. a five-carbon sugar,
  2. a phosphate group, and
  3. a nitrogen-containing base.

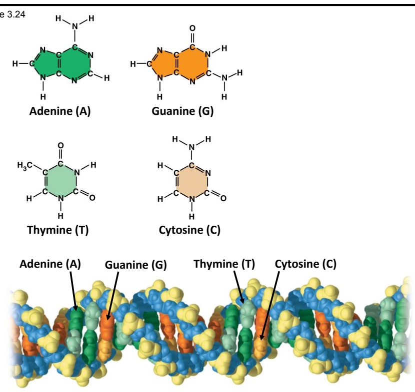
Nucleic Acids

- Each DNA nucleotide one of four possible nitrogenous bases:
  - Adenine (A),
  - Guanine (G),
  - Thymine (T), or
  - Cytosine (C).



(a) Atomic structure

Figure 3.24



Space-filling model of DNA

Nucleic Acids

- Dehydration reactions
  - Link nucleotide monomers into long chains called polynucleotides,
  - Form covalent bonds between the sugar of one nucleotide and the phosphate of the next, and
  - Form a **sugar-phosphate backbone.**
- Nitrogenous bases hang off the sugar-phosphate backbone.

Nucleic Acids

- Two strands of DNA join together to form a **double helix**.
- Bases along one DNA strand hydrogen-bond to bases along the other strand.
- The functional groups hanging off the base determine which bases pair up:
  - A only pairs with T

    and
  - G can only pair with C.

Nucleic Acids

- RNA, ribonucleic acid, is different from DNA.
  - RNA uses the sugar ribose and the base uracil (U) instead of thymine (T).
  - RNA is usually single-stranded, but DNA usually exists as a double helix.