Chapter 3
The Molecules of Microbes

Objectives: After reading Chapter Three, you should understand…
- How dehydration facilitates the formation of cellular molecules.
- The composition and function of the major macromolecules in the cell.
- The importance of the cell membrane.

Microbes are built from exactly the same molecules that are used to build plants and animals.

Carbohydrates, Lipids, Proteins, Nucleic Acids

In the simplest sense, microbes are biochemical factories = tiny sacs of chemicals that react and become “alive”.

They import raw materials, process them, and then export what they manufactured.

This is called metabolism.

We can break this complex process down into four simple steps.

1. Sense nutrients in an external environment.
   what environments?

2. Transport nutrients through the cell membrane.

3. Transform the nutrients into usable compounds.
   used for what?

4. Release end products of metabolism back into the environment.
   why?
What compounds are required for metabolism?
Carbohydrates

Contain carbon (C), hydrogen (H) and oxygen (O) (essentially “hydrates of carbon”).

**Monosaccharides** - The simplest carbohydrates (simple sugars).

Monosaccharides serve as building blocks for larger carbohydrate molecules.

1. **Glucose**

   ![Glucose structure](image1)

   Disaccharides – double sugars formed by removing water = *dehydration synthesis*.

1. **Maltose** – disaccharide of glucose (malt sugar)

   ![Maltose structure](image2)

   Found in cereal grains such as barley.

   Can be fermented by yeasts…**why is this important?**
2. **Sucrose** – disaccharide of glucose and fructose.

Otherwise known as…?

3. **Lactose** – disaccharide of glucose and galactose.

Principle carbohydrate in milk.

The production of yogurt is accomplished by two organisms, *Lactobacillus bulgaricus* and *Streptococcus thermophilus*.

These bacteria ferment lactose, causing the coagulation of proteins in milk, forming a curd.

**Polysaccharides** are large and might contain hundreds or thousands of monosaccharides…also formed from dehydration synthesis.

1. **Starch** – polysaccharide of glucose.

Favored as a nutrient source by fungi, which is why they grow well in environments containing potato- or cornstarch.
2. **Cellulose** – major component of plant cell walls (including wood).

Humans cannot digest cellulose, but what organisms can?

3. **Peptidoglycan** – major component of bacteria cell walls

Very strong due to cross-linkages among polysaccharides.

Carbohydrates serve as:

- energy sources in cells
- the basis of some microbial structures

**Smaller** compounds are easier for microbes to handle, so they will break down polysaccharides into monosaccharides for metabolism.

Which do you think would be easiest for bacteria to consume, starch or glucose?
Lipids

Like carbohydrates (contain only carbon, hydrogen and oxygen) but with a greater proportion of hydrogen.

Three basic types:

1. **Fats** – Contain high amounts of energy in their bonds and are thus rich sources of energy for microbes (and humans).

![Glycerol and Fatty acids](image)

2. **Phospholipids** – lipids that contain *Phosphorous*.

Integral components of cell **membrane** structure.
Proteins

Responsible for **structure** (cell walls) and **activity** (enzymes)

Composed of subunits called **...?**

**Twenty** different amino acids are used in different combinations to form all of the polypeptide chains (proteins) necessary for metabolism.
How do proteins form from amino acids… dehydration synthesis, of course!

The number of amino acids in a single protein might vary from as few as tens to as many as thousands.

A large number of proteins can be formed from the 20 amino acids.

In order for a protein to function, it must maintain a proper **structure**.

When the correct amino acids are linked together, electrochemical forces between them cause the chain to bend and fold, resulting in a functional protein.
Disruption of these structural configurations can inactivate the protein.

Antiseptics (alcohol, iodine), antibiotics, disinfectants, and heat work because they inactivate (denature) proteins, rendering them non-functional.

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**Nucleic acids**

DNA is transcribed into messenger RNA, which is the material that ribosomes will read in the process of producing proteins.

Ribosomes “read” the RNA (based on the sequence of DNA), recruits amino acids, and links them together to form proteins.

DNA is the stored genetic information – the blueprint for what the organism will be and do.

Why does it “replicate”?
All living organisms use two types of nucleic acids to store and/or communicate genetic information.

1. Deoxyribonucleic acid (DNA) — makes up chromosomes, stores genetic information.

2. Ribonucleic acid (RNA) — carries the genetic information (message) to site of protein synthesis (ribosomes).

Like carbohydrates and proteins, nucleic acids are large molecules composed of subunits.

Nucleic acids are composed of three major compounds: sugar, phosphate, and a base.

**Sugar** — in DNA it is a deoxyribose (five-carbon)

in RNA it is a ribose

![2-Deoxyribose and Ribose](image)

(Klug & Cummings 1997)

A **phosphate group** binds the sugars to one another.
The alternating sugar and phosphate forms the nucleic acid **backbone**.

**Bases** – attach to the sugars and form the basis of the information contained in the DNA molecule.

In DNA – adenine, cytosine, guanine, and thymine

In RNA – adenine, cytosine, guanine, uracil

It is the **sequence** of these bases that yields differing bits of information from DNA or RNA molecules (genes).

Base, sugar, and phosphate combine to form a **single strand** of the DNA molecule

…but the complete DNA molecule is **double-stranded**.
These opposing strands coil to form a double helix, like a spiral staircase.