Characteristics of Living Things and Microscopes

7.1 Life is Cellular
The Discovery of the Cell

What is the cell theory?

The cell theory states:
- All living things are made up of cells.
- Cells are the basic units of structure and function in living things.
- New cells are produced from existing cells.
Early Microscopes

It was not until the mid-1600s that scientists began to use microscopes to observe living things.

In 1665, Englishman Robert Hooke used an early compound microscope to look at a nonliving thin slice of cork, a plant material.

Under the microscope, cork seemed to be made of thousands of tiny, empty chambers that Hooke called “cells”. The term cell is used in biology to this day.

Today we know that living cells are not empty chambers, but contain a huge array of working parts, each with its own function.
Early Microscopes

In Holland, Anton van Leeuwenhoek examined pond water and other things, including a sample taken from a human mouth. He drew the organisms he saw in the mouth—which today we call bacteria.
The Cell Theory

Soon after Leeuwenhoek, observations made by other scientists made it clear that **cells** were the basic units of life.

In 1838, German botanist Matthias Schleiden concluded that all plants are made of cells.

The next year, German biologist Theodor Schwann stated that all animals were made of cells.

In 1855, German physician Rudolf Virchow concluded that new cells could be produced only from the division of existing cells, confirming a suggestion made by German Lorenz Oken 50 years earlier.
The Cell Theory

These discoveries are summarized in the cell theory, a fundamental concept of biology.

The cell theory states:
- All living things are made up of cells.
- Cells are the basic units of structure and function in living things.
- New cells are produced from existing cells.
Exploring the Cell

How do microscopes work?
Exploring the Cell

How do microscopes work?

Most microscopes use lenses to magnify the image of an object by focusing light or electrons.
Light Microscopes and Cell Stains

A typical light microscope allows light to pass through a specimen and uses two lenses to form an image.

The first set of lenses, located just above the specimen, produces an enlarged image of the specimen.

The second set of lenses magnifies this image still further.

Because light waves are diffracted, or scattered, as they pass through matter, light microscopes can produce clear images of objects only to a magnification of about 1000 times.
Light Microscopes and Cell Stains

Another problem with light microscopy is that most living cells are nearly transparent, making it difficult to see the structures within them.

Using chemical stains or dyes can usually solve this problem. Some of these stains are so specific that they reveal only compounds or structures within the cell.
Light Microscopes and Cell Stains

Some dyes give off light of a particular color when viewed under specific wavelengths of light, a property called fluorescence.

Fluorescent dyes can be attached to specific molecules and can then be made visible using a special fluorescence microscope.

Fluorescence microscopy makes it possible to see and identify the locations of these molecules, and even to watch them move about in a living cell.
Electron Microscopes

Light microscopes can be used to see cells and cell structures as small as 1 millionth of a meter. To study something smaller than that, scientists need to use electron microscopes.

Electron microscopes use beams of electrons, not light, that are focused by magnetic fields.

Electron microscopes offer much higher resolution than light microscopes.

There are two major types of electron microscopes: transmission and scanning.
Electron Microscopes

Transmission electron microscopes make it possible to explore cell structures and large protein molecules.

Because beams of electrons can only pass through thin samples, cells and tissues must be cut first into ultra thin slices before they can be examined under a transmission electron microscope.

Transmission electron microscopes produce flat, two-dimensional images.
Electron Microscopes

In scanning electron microscopes, a pencil-like beam of electrons is scanned over the surface of a specimen.

Because the image is of the surface, specimens viewed under a scanning electron microscope do not have to be cut into thin slices to be seen.

Scanning electron microscopes produce three-dimensional images of the specimen’s surface.
Electron Microscopes

Because electrons are easily scattered by molecules in the air, samples examined in both types of electron microscopes must be placed in a vacuum in order to be studied.

Researchers chemically preserve their samples first and then carefully remove all of the water before placing them in the microscope.

This means that electron microscopy can be used to examine only nonliving cells and tissues.
Prokaryotes and Eukaryotes

How are prokaryotic and eukaryotic cells different?
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Prokaryotic cells do not separate their genetic material within a nucleus.

In eukaryotic cells, the nucleus separates the genetic material from the rest of the cell.
Prokaryotes and Eukaryotes

Although typical cells range from 5 to 50 micrometers in diameter, the smallest *Mycoplasma* bacteria are only 0.2 micrometers across, so small that they are difficult to see under even the best light microscopes.

In contrast, the giant amoeba *Chaos chaos* may be 1000 micrometers in diameter, large enough to be seen with the unaided eye as a tiny speck in pond water.

Despite their differences, all cells contain the molecule that carries biological information—DNA.

In addition, all cells are surrounded by a thin, flexible barrier called a cell membrane.
Prokaryotes and Eukaryotes

Cells fall into two broad categories, depending on whether they contain a nucleus.

The **nucleus** is a large membrane-enclosed structure that contains the cell’s genetic material in the form of DNA. The nucleus controls many of the cell’s activities.
Prokaryotes and Eukaryotes

**Eukaryotes** are cells that enclose their DNA in nuclei.

**Prokaryotes** are cells that do not enclose DNA in nuclei.
Prokaryotes

Prokaryotic cells are generally smaller and simpler than eukaryotic cells.

Despite their simplicity, prokaryotes grow, reproduce, and respond to the environment, and some can even move by gliding along surfaces or swimming through liquids.

The organisms we call bacteria are prokaryotes.
Eukaryotes

Eukaryotic cells are generally larger and more complex than prokaryotic cells.

Most eukaryotic cells contain dozens of structures and internal membranes. Many eukaryotes are highly specialized.

There are many types of eukaryotes: plants, animals, fungi, and organisms commonly called “protists.”