Overview of cells

Generally we need a microscope to see cells, particularly to see the structures we'll be talking about

Incidentally, there are many kinds of microscopes - in lab you'll use mostly the traditional light microscope.

Others include various kinds of electron microscopes, stereo microscopes, and numerous specialized types.

Even though we don't have the best microscopes in lab, they're not bad (much better than what you can buy at most retail/toy stores). It's not because of the magnification, it's because of their resolution.

Cells, sizes & the metric system

Again, you should get some of this in lab.

In science we use the metric system. Just about anything you do in lab that needs measurements will use the metric system.

In particular, for length we have:

meter = 100 cm = 1000 mm = 1,000,000 μm = 1,000,000,000 nm

1 mm = 1,000 μm

As mentioned, the problem is that most cells are small

Cells vary a lot in size, but most of the ones we're interested are on the small side (and even if they're long, they're usually so thin we can't see them (e.g. nerve cells)).

Largest - eggs (Ostrich egg!)

Smallest - some bacteria come in at 0.2 μm

One limit to the size of cells is surface area. As cells get bigger, the surface area to volume ratio starts to decrease.

A cell 30 μm on a side has a volume of 27,000 μm^3 (30 x 30 x 30).

It has a surface area of 5,400 μm^2 (30 x 30 x 6).

Its ratio of surface area to volume is 5,400 / 27,000 = .2

A cell 10 μm on a side has a volume of 1,000 μm^3.

It has a surface area of 600 μm^2.

Its ratio of surface area to volume is 600 / 1,000 = .6

It has much more surface area available for each unit of volume, and so it can deal much better with getting oxygen, nutrients, etc.

Slide uses a slightly different approach - 27 smaller cells have a much greater combined surface area than 1 big cell of equivalent size (16,200 μm^2).

Prokaryotic & Eukaryotic cells

Organisms have two fundamentally different types of cells: prokaryotic and eukaryotic.

Prokaryotic is more primitive, and found in things like bacteria and some blue green algae.

But all cells have a plasma membrane

This provides a boundary to the cells. Keeps cell contents together, and regulates flow of materials (food, gases, etc.) in and out of the cell.

All cells also have ribosomes

Small structures that make proteins (as determined by genes, which are carried on DNA).

Prokaryotic cells do not have a nucleus

In eukaryotes the nucleus has DNA in it, so in prokaryotic cells, the DNA is in a nucleoid, a “nucleus-like” region.

Also do not have “organelles” bounded by membranes.

Frequently have a cell wall surrounding the cell membrane, and sometimes a capsule that offers even more protection and helps the bacteria stick to things.

A few other prokaryotic parts to be aware of:

pilli - short projections that (like the capsule) help the bacteria stay put.

flagella - help move the bacteria around.

Bacteria can be gram positive or gram negative depending on their cell wall structure:

Gram positive bacteria stain easier with Gram stain

Gram positive bacteria are also somewhat more susceptible to antibiotics.

Have three basic shapes - cocci, rod shaped, spiral shaped

The vast majority of bacteria are harmless or beneficial to us - we couldn't live without them:

They are in our gut helping us digest food.

They are on our skin helping ward off nastier bacteria

(Yes, a few do give us body odor).

They provide almost all the nitrogen for living organisms.

The list is endless.

But a few bacteria are responsible for a large number of human diseases:

Plague - killed between 1/4 and 1/3 of people on the planet.

Anthrax - high mortality rate and has been used in bioterrorism.

Cholera, Salmonella, Typhoid, Lyme disease - the list is endless.

Your text talks about increasing antibiotic resistance.

Due to overuse of antibiotics bacteria have evolved resistance.

Good examples of diseases that are increasingly resistant:

Staphlococcus aureus (MERS) - Flesh eating bacteria

Gonnorhea - A sexually transmitted disease; in the news recently.

Tuberculosis - Almost eradicated, now one of the three biggest killers of people in the world!

Finally - just in the last few days, a report came out about a giant bacteria:

Found in Caribbean mangrove swamps, this bacteria is about a cm long.

About 5,000 times bigger than a typical bacteria.

Also - strangely - has managed to compartmentalize its DNA into vessicles of some kind. Not a true nucleus, but a sign of evolved complexity.

Eukaryotic cells:

Have many functional organelles that are separated from the rest of the cell by membranes (membrane bound organelles).

This provides many advantages:

Toxins can be made and kept safe from the rest of the cell

Different parts of the cell can coordinate their efforts (while one organelle does one thing, another might be providing raw materials, etc.)

Amongst eukaryotes the main division is between animal cells and plant cells.

Plant cells have most of the parts animal cells do (though things like flagella are very rare)

But also have some structures that animal cells don't:

- cell walls (like in prokaryotes, a thick outer supportive layer)

- central vacuole (stores water & other stuff)

- chloroplasts (make energy!!! take light and make energy).

We'll go through all of the parts on these overheads.

Nucleus:

Has a cell's DNA, and thus controls the cell.

Directs protein synthesis. We'll cover details about chromatin and chromosomes when we do genetics.

Nucleolus is a structure that contains the parts to make up ribosomes (which are directly involved in making proteins).

Nuclear envelope separates the nucleus from the rest of the cell.

Smooth endoplasmic reticulum:

Does not have ribosomes.

Important in making lipids (including many hormones), and in storing things the cell needs.

In the liver, smooth endoplasmic reticulum has many enzymes that help break down toxins.

Functions in muscle contraction by storing and releasing Ca^{2+} ions (which indirectly cause muscle contractions).

Generally continuous with rough ER, but further out from the nucleus (see below).

Rough endoplasmic reticulum:

Has lots of ribosomes attached (the new edition has changed the picture a bit).

Functions in secreting proteins or hormones (like insulin).

Ribosomes make protein, and dump them inside the rough ER.

A small part of the rough ER separates (pinches off), with the protein in it.

This “container” travels to the Golgi apparatus for processing.

Also functions in making more membrane. Some proteins being made merge directly with the rough ER, enlarging the membrane.

Golgi apparatus:

Packages and processes the stuff made by the rough ER

Our protein, for example, is taken to the rough ER, where it merges with one of the “sacs”.

The Golgi apparatus sorts and changes the protein (chemically), and determines where it should go.

In the case of insulin, for example, it is processed further, then packaged in another vessicle (small membrane enclosed sac used for transport), and this travels to the cell membrane, merges, and dumps the contents outside.

The contents of these vessicles can also be used directly by the cell (as for example, by lysosomes).

Lysosomes:

Contain enzymes that break things down (digest).

Following our chain of events:

Rough ER --> Golgi apparatus --> Lysosome

Rough ER makes digestive enzymes, packages them and sends them to the Golgi apparatus.

Golgi apparatus modifies these, and releases active lysosomes, vessicles filled with digestive enzymes.

Lysosomes are used to break down food into usable parts, as well as to break down old or injured organelles.

Defective lysosomes can cause nasty diseases:

Tay-Sachs - a genetic disorder in which the nervous system is damaged because lysosomes can not digest lipids. Lysosomes in nerve cells swell up, and damage the nerve cells.

Vacuoles:

Do a little bit of everything. Essentially just small containers (a little bit bigger than vessicles) that can be used in a number of different ways:

Absorb food and transport it to vessicles.

Expel water (e.g Paramecium) in freshwater protists.

Help move nutrients and gases around.

Contain pigments.

Store needed chemicals.

- etc.

Other organelles

Chloroplasts:

Convert sunlight into energy.

Have an arrangement of internal membranes that further subdivide the chloroplast.

Outside membrane

Inside membrane

Contains stroma, a thick liquid

Surrounds the grana (singular granum)

The grana is where sunlight is actually converted.

Almost all life on the planet depends on this process, called “photosynthesis”.

We’ll take a closer look at photosynthesis later.

Mitochondria:

Take energy (sugar) and convert it into a form that can be used by the cell.

Both plants and animals have mitochondria (plants need to use the energy they make)

Mitochondria are a little similar to chlorplasts:

Outside membrane

Inside membrane

This is folded and has many projections called cristae.

The fluid on the inside is calls the mitochondrial matrix.

All eukaryotes rely on mitochondria for energy. Details when we do cellular respiration.

As with photosynthesis, we'll take a closer look at this later.

Internal skeleton of cells:

Something needs to exist that allows cells to hold their structure, move things around, or, in the case of single celled organisms, lets them move.

Cytoskeleton - general name for fibers made of proteins that criss-cross the cell and allow for support and movement. Three types:

Microfilaments

Intermediate filaments

Microtobules

Can be lengthened or shortened as necessary (the subunits making up microtubules can be reused).

Help provide the fundamental structure to moving parts like cilia and flagella.

Cilia and flagella

Create movement.

Cilia are many small projections that work in unison

Cause movement by beating in a coordinated fashion

For example, help propel a Paramecium.

Even in humans, help move stuff out of the lungs, or help move egg down oviducts and into the uterus.

Flagella usually are single or in pairs.

Are usually at one end of the cell and help push or pull it along.

An example would be the flagella of a sperm cell, or the flagella of an Euglena (a protist).

Cells can also move using pseudopodia:

E.g., in amoebas

Cilia, flagella, and pseudopodia are all found in human cells.

Cell surfaces

Cells need to be protected and still be able to communicate with their surroundings.

Many cells have an outside protective layer

Plant cells have cell walls that protect the cel.

This is structurally strong, and usually has cellulose in it.

Thicker cell walls (or more than one) generally give more support.

Plant cells are held together by sticky polysaccharides.

To communicate with other cells, plant cells have junctions called plasmodesmata, which allow substances to move back and forth.

Animal cells don't have cell walls, but have a sticky extracellular matrix.

Provides structure and holds cells together into “tissues”.

In addition, have three main methods of attaching to each other:

Tight junctions - provide a very tight connection to make sure nothing gets through. For example, in the intestine (if the contents of the intestine leak, it can be fatal).

Anchoring junctions - also provide tight connections, but allow for considerable stretching and stress due to movement:

Skin, heart muscle, etc.

Gap junctions - are similar to plasmodesmata - open channels that allow movement of ions or other molecules from one cell to another.