

Study Guide - Cells

Key differences between prokaryotic and eukaryotic cells.

Be able to match each of the cell components featured in the lecture notes with its primary function(s).

Functions of rough and smooth ER and examples for cells specializing in these functions. Know an example for organs with cells specializing in these functions.

HIV entry into nucleus.

Know how the information stored in DNA is transferred out of the nucleus and converted into proteins, i.e. know the components, functions, and interactions of the endomembrane system, including nuclear envelope, ER, transport vesicles, Golgi apparatus, lysosomes, plasma membrane.

Lysosomal disease Tay-Sachs.

Metabolic roles of mitochondria and chloroplasts.

Key differences between plant and animal cells as featured in the lecture notes.

Origin and independent genome of mitochondria and chloroplasts in eukaryotic cells (the endosymbiont theory).

Cells

Fig. 6.1 A cell with its cytoskeleton illuminated by fluorescence microscopy

Properties of cells

1. Cells are the fundamental unit of life. A cell is the “simplest collection of matter that can live”.
2. All current cells come from pre-existing cells.
3. Cells organize the metabolism of life and carry the genetic “blueprints” of life from one generation to the next.

Size difference between *eukaryotic* and *prokaryotic* cells

Eukaryotic versus Prokaryotic Cells (compare Figs. 6.9 and 6.6)

Both have *cytoplasm* or *cytosol*

Both have *plasma membrane* surrounding the cell

<i>Eukaryotic</i> cells:	<i>Prokaryotic</i> cells:
Have membrane-bounded nucleus (with DNA) and membrane-bounded organelles	No membrane-bounded nucleus (DNA is concentrated in “nucleoid”) No membrane-bounded organelles

Fig. 6.9 Overview of a Eukaryotic Cell (characterized by membrane-bounded organelles)

- Plasma membrane
- Nucleus: Store genetic information (as DNA)
- Endomembrane system: Utilize information to make proteins when needed (DNA to RNA to protein) and export some of these proteins from the cell (Fig. 5.25)
- Mitochondria: Break down energy-rich food molecules to provide energy for cellular work

The Nucleus (Fig. 6.10)

Pores allow information transfer into and out of the nucleus:

- RNA moves out (for protein synthesis)
- Some regulatory factors move in
- Unfortunately, some viruses get in too (have “stolen” the password for entry)

Example of HIV entry into the nucleus - See the following article:

Segura-Totten M, Wilson KL (2001) HIV - Breaking the rules for nuclear entry. *Science* **294** (5544): 1016-1017

Ribosomes are the site of protein synthesis in the cell.

Fig. 6.11 - Free ribosomes make proteins for use in the same cell (that don't need to be wrapped in a membrane vesicle).

Bound ribosomes make proteins that become wrapped in membrane vesicles for export (secretion) to other cells or for use in membrane vesicles in the same cell.

The Endomembrane System (Fig. 6.16) for the synthesis and transport/export of proteins

Flow of proteins, and membrane, through endomembrane system: tracking an insulin molecule.

After DNA for insulin in nucleus is copied into mRNA and exported:

1. Insulin is produced by ribosomes on the rough ER
2. Enters the inside of the flat sacks of rough ER and moves on the inside to the outermost ER membrane
3. Packaged into transport vesicles and transferred to near side of the Golgi apparatus
4. Transport vesicles fuse to form the first flat sacks of Golgi apparatus
5. Processed in Golgi apparatus into the mature protein
6. Packaged into transport vesicles at the opposite side of the Golgi apparatus and transported to plasma membrane

One additional organelle produced by the Golgi apparatus is the **lysosome** (used e.g. for digestion of no-longer-needed materials).

The Rough (with ribosomes) and Smooth (without ribosomes) Endoplasmic Reticulum (Fig. 6.12)

Functions of rough ER and smooth ER

Rough ER (with ribosomes)

- Synthesizes proteins destined for secretion from cell (secretory glands like the pancreas and pituitary gland have a lot of rough ER in their cells). Figs. 45.7 & 45.8 Peptide/protein hormones of the pituitary gland.
- Synthesizes proteins needed for digestion in lysosomes

Smooth ER (without ribosomes)

- Produces certain lipids for secretion (e.g. steroids; testes, ovaries, and adrenal glands have a lot of smooth ER)
- Detoxifies drugs (has enzymes in its membranes that do this; liver cells have a lot of smooth ER)

Golgi apparatus – “refinery” / “processing plant” (Fig. 6.13)

Arriving transport vesicle from ER, flattened membrane sacs, & departing transport vesicles.

Fig. 45.8 - The protein hormones FSH, LH, & TSH become glycosylated in the Golgi apparatus, i.e. the active hormone is a glycoprotein.

Lysosomes – digestive organelles – for intracellular digestion (Fig. 6.14)

Digesting food particles brought into cells & digesting old mitochondria and other organelles.

- A lysosome is a membranous sac of hydrolytic enzymes.
- Lysosomal enzymes can break down proteins, fats, polysaccharides, and nucleic acids.
- Lysosomes also use enzymes to recycle organelles and macromolecules.

Lysosomal storage diseases - See top of p. 108 in the textbook for **Tay-Sachs** (lipid accumulation) and, if interested, the following websites (extra info from websites not for the exam!):

http://www.pompe.com/patient/learning/pc_eng_pt_lsds.asp

http://en.wikipedia.org/wiki/Tay-Sachs_disease

The Endomembrane System recap (Fig. 6.16)

for the synthesis and transport/export of proteins

A continuous internal membrane system that includes the

1. *Outer membrane* of the *nuclear envelope*
2. *Rough* or *smooth* endoplasmic reticulum (*ER*)
3. *Transport vesicles* between ER & Golgi
4. *Golgi apparatus*
5. *Transport vesicles* between Golgi & plasma membrane
6. *Lysosomes* or *Plasma membrane*

Fig. 6.11 - Free ribosome make proteins that don't need to be wrapped in a membrane vesicle (for use in the same cell). Bound ribosomes make proteins that get wrapped in ER or Golgi vesicles for use in lysosomes or for secretion (export to other cells: example insulin); proteins get sugar "tags" (in Golgi apparatus) for target cells or organs.

The Cytoskeleton (Fig. 6.1)

A network of tubules and fibers inside the cell that provide structure and a trafficking network - for example to guide the vesicles of the endomembrane system to the right place.

Fig. 6.21: The movement of vesicles along "tracks" formed by the cytoskeleton

Fig. 6.9: Most basic components & functions of plant and animal cells are the same.

Unique features of plant cells:

Chloroplasts (for photosynthesis as in primary producers)

Cell wall and central vacuole (for structural support)

Mitochondria - the cell's powerhouses

Occur in nearly all eukaryotic cells – plant, animal, fungi, protists (single-celled organisms)

Contain proteins and enzymes responsible for *oxidative respiration* – conversion of the energy in energy-rich food molecules (sugars and others) into ATP energy

Chloroplasts - solar energy collectors/converters

Occur in plants and algae

Contain proteins and enzymes responsible for photosynthesis – conversion of solar energy into sugar energy

Both mitochondria and chloroplast have their own DNA. Why?

It's as if they were independent little organisms trapped by the eukaryotic cell.

Fig. 26.13: A model of the origin of eukaryotes through serial endosymbiosis.

Infolding of cell membrane creates endomembrane system

Engulfing of aerobic heterotrophic prokaryote creates mitochondria (with their own DNA).

Engulfing of photosynthetic prokaryote creates chloroplasts (with their own DNA).

Suggested readings from the textbook (Campbell and Reece's BIOLOGY, Seventh Edition).

A Tour of the Cell

Chapter 6

Concepts **6.2** Eukaryotic cells have internal membranes that compartmentalize their functions (details on cell diameter not needed for exam), **6.3** The eukaryotic cell's genetic instructions are housed in the nucleus and carried out by the ribosomes (without the details on nucleolus - not needed for exam), **6.4** The endomembrane system regulates protein traffic and performs metabolic function in the cell (details on cis/trans faces and vacuoles not needed for exam). pp. 98-108

[Concept **6.5** will be discussed as part of the lectures on respiration and photosynthesis (but not the part on peroxisomes)]

Concept **6.6** The cytoskeleton is a network of fibers that organizes structures and activities in the cell - only p. 112.