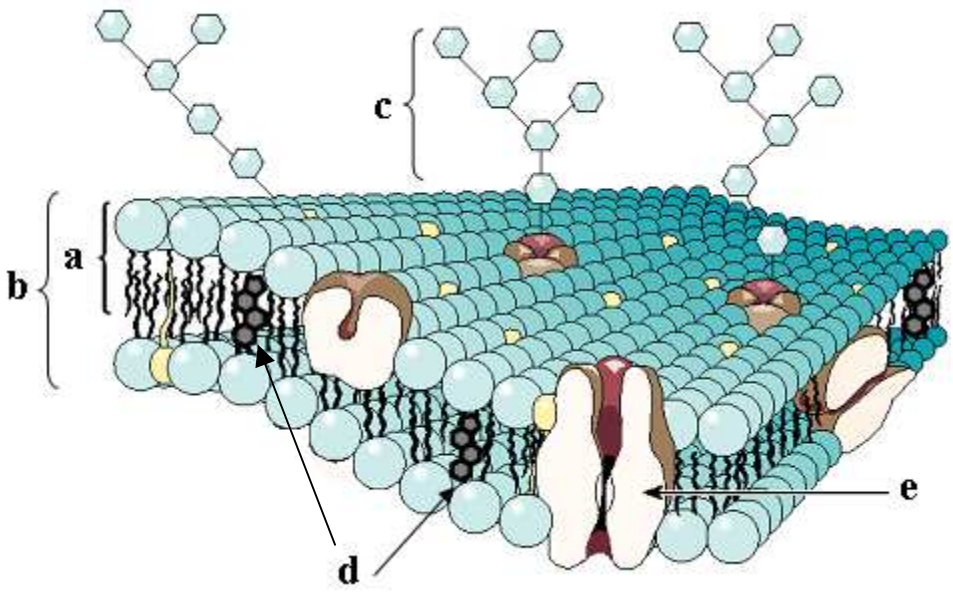
Review for Quiz on the Structure and Function of Eukaryotic Cells, Answers

2. Label the diagram of a 'typical' cell membrane:



a) phospholipid
b) phospholipid bilayer
c) carbohydrate group
d) cholesterol molecules
e) channel or carrier protein (aka. integral or transmembrane protein)

3. Regarding the cell membrane (see handout on Abiogenesis Theory):

a) Describe the basic steps of Abiogenesis theory that lead to the creation of membranes and cells.

- according to Abiogenesis theory, the atmosphere of the early Earth contained ammonia (NH_3), hydrogen sulfide (H_2S), water vapour (H_2O), methane gas (CH_4) and very little oxygen (O_2)
- there was a great deal of lightning and volcanic activity. The energy from these sources caused the simple molecules to react with one another and form amino acids, sugars and other organic molecules
- the polar organic molecules dissolved in the oceans and then were concentrated on the surface of the ocean or along the ocean shore
- gradually, the organic molecules in the water reacted with one another and formed RNA and phospholipids
- phospholipids have a polar phosphate group and two non-polar fatty acid chains, so one end of the molecule is attracted to water (hydrophilic) and the other end is repelled by water (hydrophobic).
- when there were a lot of phospholipids in the ocean, they stuck together and aligned themselves with one another to form a bilayer membrane which enclosed a drop of ocean water. This is called a vesicle.
- over millions of years, the chemicals in the water inside the vesicles continued to react with each other and formed proteins and nucleic acids. Some of the proteins became part of the vesicle membranes and eventually the fluid mosaic membrane formed
- at some point, vesicles became capable of controlled reproduction and life began

b) Explain how the structure of phospholipid molecules is ideal for the formation of membranes.

- phospholipids contain glycerol, two fatty acids and one phosphate group. The fatty acid groups are non-polar while the phosphate group is polar. This means that one end of the phospholipid is non-polar and hydrophobic (water-fearing) while the phosphate end of the molecule is polar and hydrophilic (water-loving).
- when phospholipid molecules are close together, the polar phosphate group is attracted to the polar phosphate groups of other phospholipid molecules and to water. the non-polar fatty acid groups are attracted to each other and repelled by the water. This causes the phosphate groups to align facing out to the water and in to the centre of the vesicle, while the hydrophobic fatty acids stay together in the middle between the polar groups.
- the dual-polarity of phospholipids allows them to form "phospholipid bilayers" and this is the basis for vesicle membranes, which developed into cell membranes.

c) Explain how the structure of cell membranes is critical to the function of cells.

- because it is made of phospholipids (see answer above), the phospholipid bilayer of the cell membrane has a polar outside, a non-polar (hydrophobic) middle and a polar inside. This creates a barrier so that polar and ionic substances can not pass easily through the middle of the cell membrane which is non-polar
- the phospholipid bilayer creates a barrier that separates the cytoplasm on the inside of the cell from its watery environment
- this separation allows the cytoplasm (ICF or intracellular fluid) to have a different composition from the water outside the cell (ECF or extracellular fluid)
- the phospholipid bilayer and membrane proteins control what moves into and out of the cell and this creates the internal conditions that the cell needs to survive

d) Why are 'modern' cell membranes described as a 'fluid mosaic'?

- "modern" cell membranes are composed of phospholipids, proteins, cholesterol and many other substances
- these substances are dispersed through the membrane in a mosaic and they can move laterally (from side to side) so they are called "fluid mosaics"

e) What three major macromolecules make up 'modern' cell membranes?

- "modern" cell membranes are composed of phospholipids, proteins and cholesterol
- cell membranes also contain glycolipids and glycoproteins (lipids and proteins with carbohydrate groups attached) and these are important for cellular recognition and communication

f) Explain how the saturation of phospholipids affects the fluidity of a cell membrane.

- when phospholipids contain saturated fatty acids, the fatty acid chains are very straight and pack together tightly so the membrane is more solid and not very flexible and fluid
- when the phospholipids contain unsaturated fatty acids, the fatty acid chains have many C = C double bonds, which makes them kinky and bent. Unsaturated fatty acids do not pack together tightly which makes the membrane less solid, more flexible and more fluid

  Aside: there is a theory that if the cell membrane is more unsaturated, the phospholipids are more loosely packed so it is easier for the proteins in the membrane to change shape. This allows the protein channels and carrier proteins to work better, and this may help to protect against some diseases.

g) What three MAIN ways can substances move into, and out of, cells? Describe each.

You can organize your answer as: passive transport, active transport and bulk transport.

You can also organize your answer by the mechanism of transport. I answered this way, just to show you that there are many acceptable ways to organize information and answer questions:

- substances can move into a cell by simple diffusion. Non-polar molecules move easily through the hydrophobic middle of the cell membrane. Very small polar molecules such as water can also move through the membrane by simple diffusion (osmosis).
- substances can move into the cell assisted by a protein molecule. If the substance moves from an area of high concentration to an area of lower concentration, no energy is required and this is called facilitated diffusion. If the substance moves from an area of lower concentration to an area of higher concentration, energy is required and this is called active transport.
- substances can also move into a cell by endocytosis, either pinocytosis (cell drinking, when the cell engulfs a droplet of extracellular fluid) or phagocytosis (cell eating, when the cell engulfs particles along with some extracellular fluid). The substance is taken in inside a vesicle and the formation of the vesicle requires energy, so endocytosis is a type of active transport.

4. Complete the chart below to summarize the types of transport across a membrane.

	Type of molecules transported	Membrane proteins involved?	Transport down or up the concentration gradient?	Is energy required?
Simple Diffusion	non-polar or small polar	no	always down	no
Facilitated Diffusion	polar or ionic	yes	always down	no
Osmosis	water	no	always down	no
Active Transport	polar or ionic	yes	up	yes

5. Although we don't know how, at some point chemistry became biology and groups of molecules became alive as cells. What are the seven characteristics of living things? **MRS GREN:**
   - **M**ovement (it is able to change its position eg. plants grow toward the sun)
   - **R**espiration (it is able to obtain energy from food, usually requires O_2)
   - **S**ensitivity (it is able to sense and respond to changes in its environment)
   - **G**rowth (it gets larger over time)
   - **R**eproduction (it is able to produce offspring)
   - **E**xcretion (it is able to get rid of wastes such as CO_2 & urine)
   - **N**utrition (it is able to utilize chemical material as food)

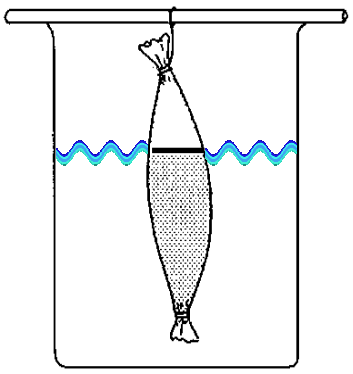
6. If an animal cell is placed in a hypertonic solution:

a) Which solution has a higher solute concentration, the ICF or ECF? ECF
b) Which solution has a higher concentration of water, the ICF or ECF? ICF
c) In which direction will water move, into or out of, the cell? out of cell
d) Describe what will happen to the ***animal*** cell: the cell will shrivel up (crenate)

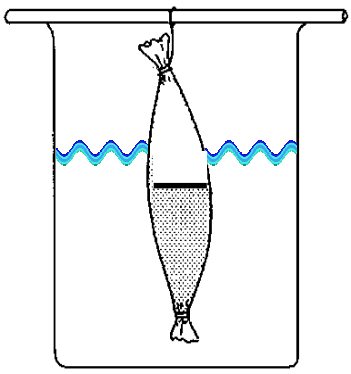
7. If an animal cell is placed in a hypotonic solution:

a) Which solution has a higher solute concentration, the ICF or ECF? ICF
b) Which solution has a higher concentration of water, the ICF or ECF? ECF
c) In which direction will water move, into or out of, the cell? into the cell
d) Describe what will happen to the ***animal*** cell: the cell will swell up and may burst (cytolysis)

8. A piece of dialysis tubing was filled with an unknown solution and suspended in a solution containing 5% sodium chloride solution. After 15 minutes, the level of the solution in the dialysis tubing was much lower, as shown in the diagram.



Beginning of experiment



Dialysis tubing after 15 minutes

Based on these results, which of the following is the unknown solution?

a) 10% glucose solution
b) 5% glucose solution
c) pure distilled water* (correct answer)

Defend your answer (on next page).

Answer to Question 8: The dialysis tubing must have contained pure distilled water. Water moves by diffusion from an area of higher concentration to an area of lower concentration. Because the water level in the tubing went down, water left the tube, so the water in the tube must have been more concentrated than the water in the beaker.

The salt solution is 5% sodium chloride so it is 95% water. The only solution which has a higher water concentration is pure, distilled water, which is 100% water.

9. Complete the chart below to identify ONE of the methods by which the following substances could move across the cell membrane (there is more than one correct answer for some substances):

Substance	Most likely method of crossing the membrane	Active or Passive?	Is Energy Required?
a calcium ion Ca^{2+}	facilitated diffusion or active transport	either	yes/no
water	simple diffusion or osmosis	passive	no
CO_2	simple diffusion	passive	no
fragments of dead cells	endocytosis or exocytosis	active	yes
a chloride ion $C\ell^{1-}$	facilitated diffusion or active transport	either	yes/no
glucose	facilitated diffusion or active transport	either	yes/no
a large protein molecule	endocytosis or exocytosis	active	yes
estrogen (a steroid hormone)	simple diffusion	passive	no
O_2	simple diffusion	passive	no

10. Three significant differences between prokaryotic cells and eukaryotic cells are:
- both types of cells have a cell membrane which separates their internal cytoplasm (ICF) from their external environment (ECF). Prokaryotes and eukaryotes both have DNA as their genetic material and ribosomes which make proteins
- prokaryotic cells do not have a membrane-bound nucleus or any other membrane-bound organelles. They include bacteria and others (more to come:)
- eukaryotic cells have a membrane-bound nucleus and many other membrane-bound organelles. They include animals, plants and others (more to come:)

11. What structures/organelles are found in ALL cells?

The structures that are found in prokaryotic and eukaryotic cells (both plant and animal) include:
- ribosomes
- cell membrane
- some type of DNA structure (nucleus, nucleoid or simple DNA)

12. See answer to question 17

13. Compare and contrast:

a) passive transport and active transport
- both passive and active transport are ways that materials can move from the outside of a cell to the inside, or from the inside of a cell to the outside
- passive transport does not require energy. Substances move down a concentration gradient from an area of higher concentration to an area of lower concentration. Passive transport can be simple diffusion, osmosis (the simple diffusion of water) or facilitated diffusion which involves a protein channel or carrier.

- active transport requires energy. Substances move against a concentration gradient from an area of lower concentration to an area of higher concentration. Active transport involves a carrier protein that changes shape and pushes the substance into or out of the cell. Bulk transport (endocytosis and exocytosis) is also active transport because it requires energy, but bulk transport is an entirely different mechanism so it does not need to be discussed in this answer.

b) facilitated diffusion and active transport

- both facilitated diffusion and active transport require a protein channel or carrier molecule to assist the movement of substances through the cell membrane
- facilitated diffusion involves a transport protein that enables substances to move through the cell membrane from an area of higher concentration to an area of lower concentration so no energy is required (it is passive)
- active transport involves a transport protein that enables substances to move through the cell membrane from an area of lower concentration to an area of higher concentration so energy is required (it is active)

c) active transport and bulk transport

- both require energy, so both are types of active transport
- active transport is very specific, a specific transport allows a specific substance to move through the membrane from an area of lower concentration to an area of higher concentration
- bulk transport is usually less specific, a "bubble" of ICF or ECF (with or without particles) is packaged within a vesicle and moved into or out of the cell by endo or exocytosis. Substances may be moved up or down a concentration gradient.

14. Endosymbiosis Theory

a) The main idea is that mitochondria and chloroplasts were once free-living bacteria that were engulfed by an early eukaryotic cell. Both the bacteria and the host cell benefitted (symbiosis).

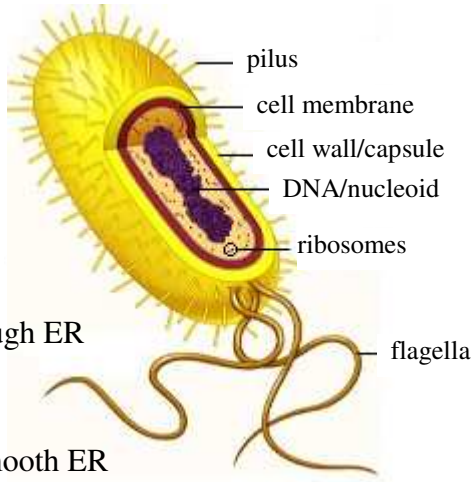
b) Possible steps: The primitive eukaryotic cell engulfed an aerobic bacteria. The bacteria continued living inside the eukaryotic cell: it benefitted from a 'safe' place to live while the eukaryotic cell benefitted by using some of the energy produced by the bacteria. Over time, the bacteria and eukaryotic cell became dependent on each other and could no longer live apart, at which point the bacteria are considered to be an organelle within the cell: the mitochondria. Later, a eukaryotic cell with mitochondria engulfed a cyanobacteria which continued to live on, inside the cell eventually becoming a chloroplast.

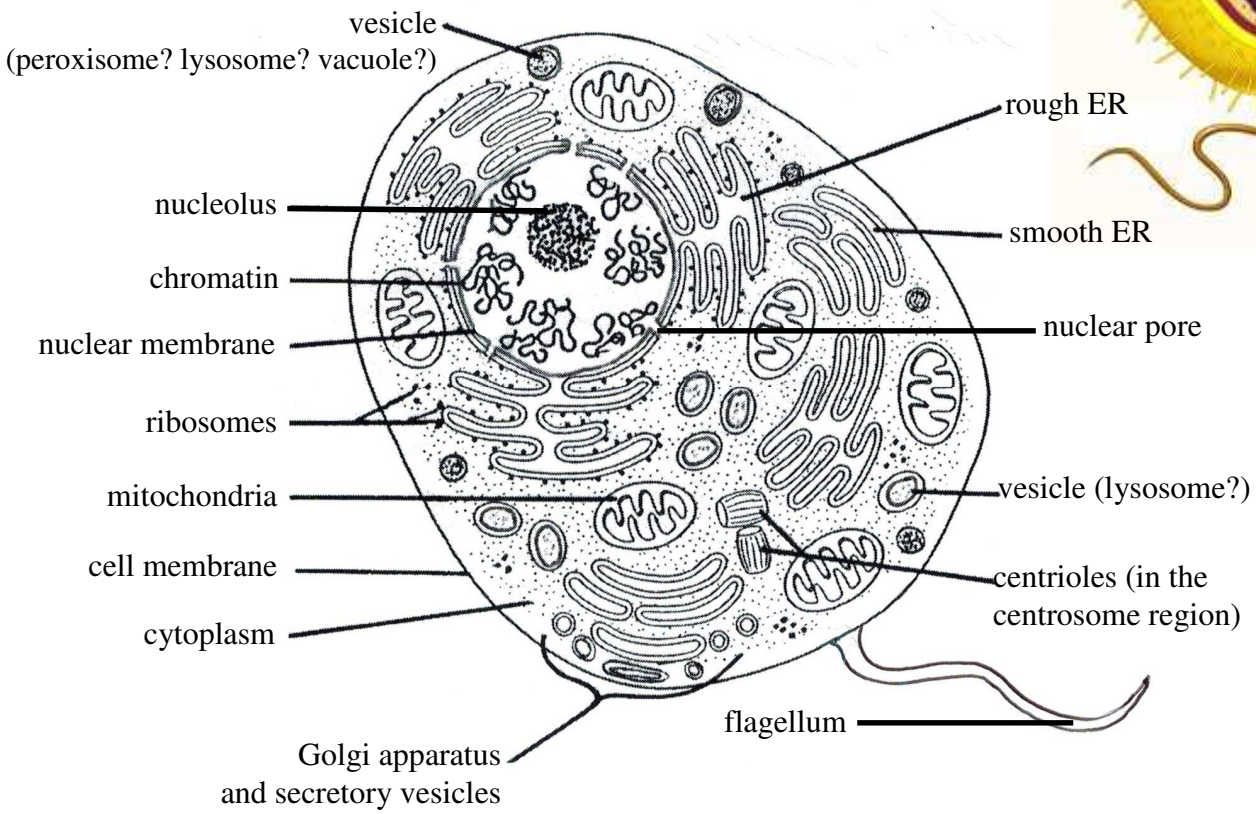
c) The organelles most likely incorporated into eukaryotic cells by endosymbiosis are the mitochondria and chloroplasts (plastids).

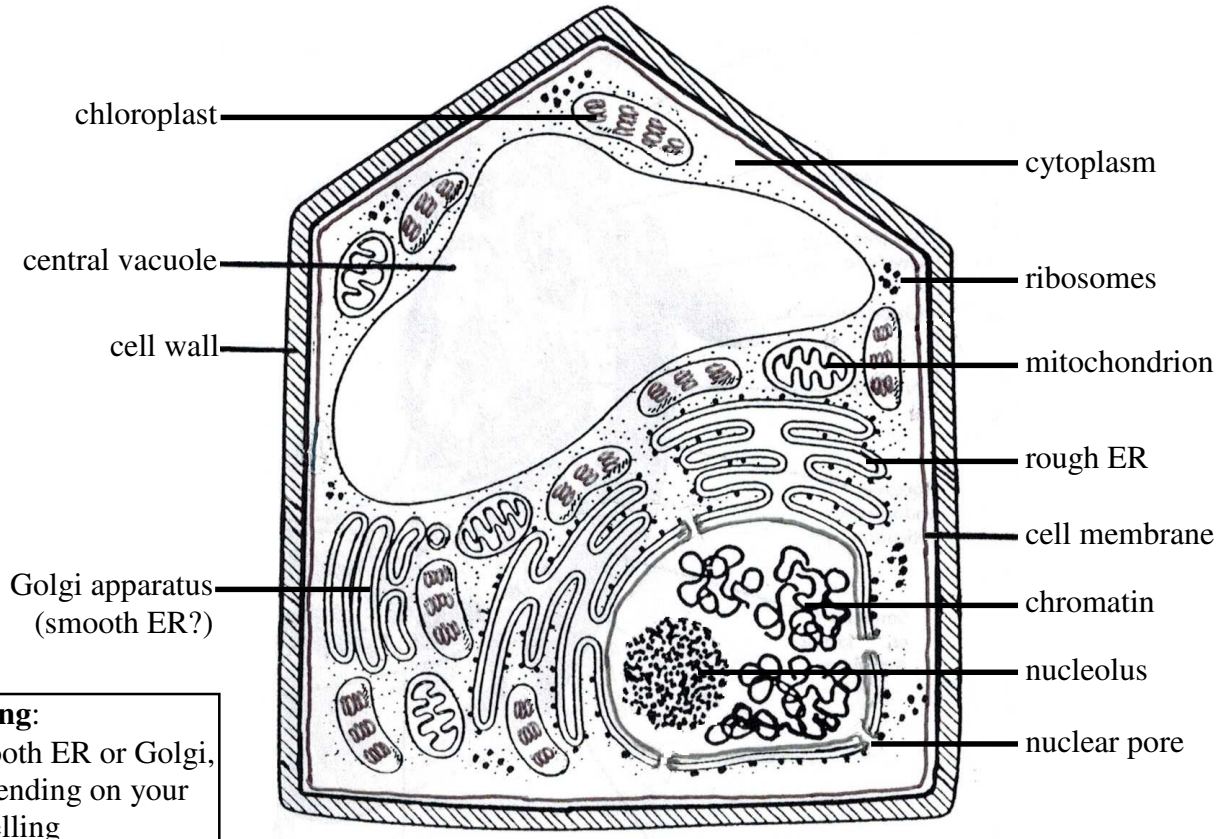
d) Three pieces of evidence that support Endosymbiosis Theory are that both chloroplasts and mitochondria (any of):

- are quite small, about the size of a bacterial cell
- have their own ribosomes which are similar to bacterial ribosomes and very different from eukaryotic (the host cell's) ribosomes
- have their own loop of DNA, similar to the loop of DNA found in bacterial cells
- have a double membrane, the outer membrane is similar to the cell membrane of eukaryotic cells while the inner membrane is more similar to bacterial membranes

15. Label the following generalized diagrams of typical bacterial, animal and plant cells (assume that the cell membranes are phospholipid bilayers)







Missing:
- smooth ER or Golgi, depending on your labelling
- cytoskeleton

16. Write the letter of the appropriate cell part beside each description. Some cell parts may be used more than once and some may not be used at all.

Description of Cell Part or Function		Cell Parts (in alpha. order)
V.	The organelle that manufactures proteins.	**A.** cell membrane
N.	Organelles that store starch. They do not contain coloured pigments.	**B.** cell wall
K.	The microtubules and microfilaments that give cells their shape.	**C.** central vacuole
G.	Uncoiled chromosomes. The form that DNA takes when the cell is not dividing.	**D.** centrioles(s)
E.	The region within plant and animal cells from which microtubules and microfilaments originate.	**E.** centrosome
I.	Small hair-like projections on the cell surface that move with a sweeping motion.	**F.** chloroplast(s)
M.	Flattened stacks of membranes that process and then package proteins into secretory vesicles.	**G.** chromatin
Q.	Small openings that connect the nucleus with the cytoplasm.	**H.** chromoplast(s)
C.	The organelle that stores water, salts and sugars in plant cells.	**I.** cilia
R.	The area in the cell where ribosomes are manufactured.	**J.** cytoplasm
S.	The membrane-bound structure where the majority of a cell's DNA is found.	**K.** cytoskeleton
X.	A series of membranes and tubules where steroids and phospholipids are made.	**L.** flagellum
T.	A specialized vesicle for breaking down long chain fatty acids and alcohol.	**M.** Golgi apparatus
A.	This structure controls the movement of substances into and out of the cell.	**N.** leucoplast(s)
H.	These organelles contain colourful pigments in only certain parts of plants.	**O.** lysosome(s)
W.	A series of membranes which has ribosomes embedded on its surface.	**P.** mitochondria
L.	Long, whip-like projections which are used for locomotion by animal cells.	**Q.** nuclear pore(s)
D.	A set of two microtubules found at right angles to one another in animal cells.	**R.** nucleolus
J.	The contents of the cell, excluding the nucleus.	**S.** nucleus
F.	Organelles that contain DNA, ribosomes and chlorophyll.	**T.** peroxisome(s)
P.	The organelle where cellular respiration takes place and ATP is produced.	**U.** plastids
Y.	Small vesicles in animal cells which are used for storage.	**V.** ribosome(s)
O.	Vesicles that contain digestive enzymes and break down and recycle worn out organelles.	**W.** rough ER
		X. smooth ER
		Y. vacuole(s)

17. Using the list of cell parts in the chart above, list all cell parts which:

a) contain DNA: **F, H, N, P, S, U**

b) are considered vesicles: **C, O, T, Y**

c) are surrounded by two membranes: **F, H, N, P, S, U**

d) are found only in plant cells: **B, C, F, H, N, U**

e) are found only in animal cells: **D, I, L**