Full Name:	Civics group: 21S	Index no.:	Date:

Core Idea 1: The Cell and Biomolecules of Life

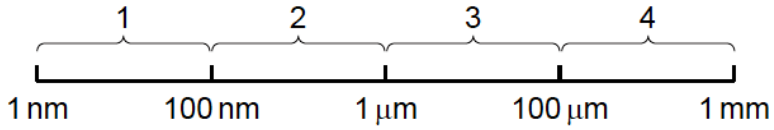
Tutorial 1

Cell Ultrastructure

MCQ
ANSWERS

1	2	3	4	5	6	7	8	9	10
D	C	B	B	A	B	A	C	C	C
11	12	13	14	15	16				
B	D	A	A	B	A				

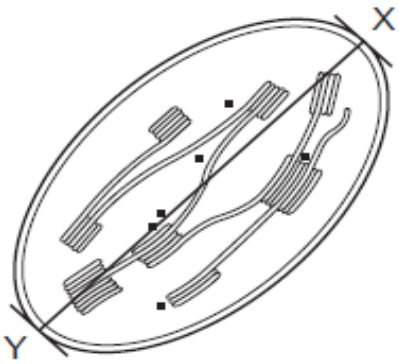
1 Which size ranges can be viewed using a light microscope?



A 4 only
B 1 and 2 only
C 2 and 3 only
D 3 and 4 only

Refer to diagram on lecture notes pg 6

2 The diagram shows a chloroplast drawn from an electronmicrograph.



The length of the chloroplast from X to Y is 5000 nm.

Unit is in nm, hence indicate actual size of chloroplast.

What is the magnification of the drawing of the chloroplast?

A x100
B X1000
C X10 000
D X100 000

Working:
Magnification
= **image / actual**
= 5.7 cm / 5000 nm
= 5.7 x 10^{-2} **m** / 5000 x 10^{-9} **m**
= 1.14 x 10^{4}
~ x 10 000

3 The electronmicrograph is of a chloroplast.

The length of the chloroplast image along the line shown is 90 mm. The magnification of the organelle is x300,000.

What is the actual length of the chloroplast?

A 0.3 µm
B 3.0 µm
C 30 µm
D 300 µm

Working:
Actual size
= image / magnification
= 90 mm / 300,000
= 90,000 µm / 300,000
= 0.3 µm

mm is x10^{-3} m, µm is x10^{-6} m

4 You are told that the cells on a microscope slide are plant, animal, or bacterial. You look at them through a microscope and see cell walls **and** membrane-bound organelles. You conclude that the cells are

A Bacteria cells
B Plant cells
C Bacteria and plant cells
D Bacteria, plant, and animal cells

indicate either Plant cells (cellulose cell wall) or bacterial cell (peptidoglycan cell wall)

- ***from Qn cannot tell what type of material the cell wall is made up of without the use of specific dye staining***
- ***Presence of cell wall eliminate animal cell (which has no cell wall) from answer.***

confirmed Plant cells (prokaryotes e.g. bacteria lack membrane-bound organelles)

5 Which features enable an organism to be identified as a prokaryote?

1 cell wall → both eukaryote (plant cells) & prokaryote (bacteria) have cell wall
2 circular DNA → only prokaryote (bacteria) has circular DNA; eukaryote has linear DNA
3 nucleus → only in eukaryotic cell; prokaryote does not have membrane-bound nucleus but has nucleoid – region where the DNA / genetic material is located.
4 ribosomes → both prokaryote and eukaryote have ribosome but it is 70S ribosomes in prokaryote, 80S ribosomes in eukaryote

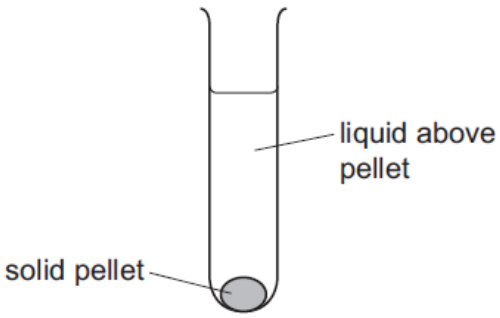
A 2 only
B 3 only
C 1 and 4 only
D 2 and 4 only

6 A scientist carried out an experiment to separate the organelles in an animal cell by mass.

The scientist mixed the cells with a buffer solution which had the same water potential as the cells. He then broke the cells open with a blender to release the organelles.

The extracted mixture was filtered and then spun in a centrifuge at a high speed to separate the heaviest organelle. This sank to the bottom, forming a solid pellet, 1.

Nucleus



The liquid above pellet 1 was poured into a clean centrifuge tube and spun in the centrifuge at a higher speed to separate the next heaviest organelle. This organelle sank to the bottom, forming a solid pellet, 2.

→ mitochondria

He repeated this procedure twice more to obtain pellet 3 and pellet 4, each containing a single organelle.

lysosomes ER, Golgi

What is the function of the organelle extracted in pellet 2?

A digestion of old organelles – 3
B production of ATP
C production of mRNA – 1
D synthesis of protein – 4

In-class activity

Arrange the following organelles in the order that they will be separated via cell fractionation:

Endoplasmic reticulum, chloroplasts, nucleus, ribosomes, lysosomes, mitochondria

Answer:
nucleus → chloroplast → mitochondria → lysosomes → endoplasmic reticulum → ribosomes & other cell debris

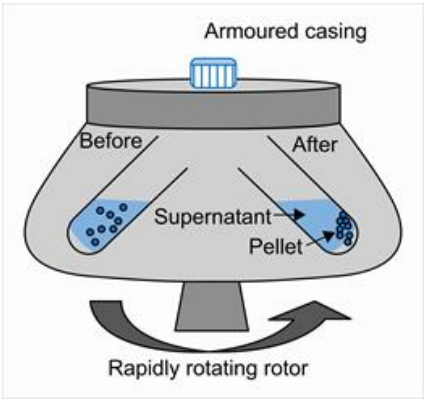
Thinking questions:
1. What do 70S and 80S mean?
2. And why does 30S+50S not add up to 80S, and 40S+60S not add up to 100S?

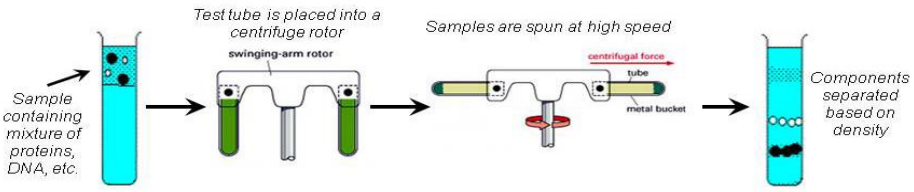
1 What do 70S and 80S mean?

S = sedimentation coefficient of a particle (its behaviour during a sedimentation process – centrifugation)

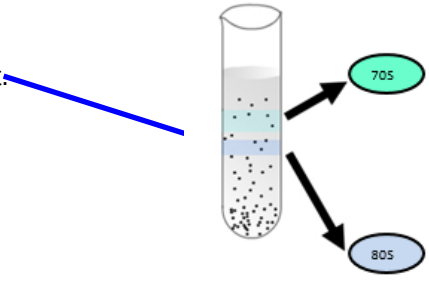
What is centrifugation?

Application of the centripetal force for the **sedimentation** of mixtures with a centrifuge



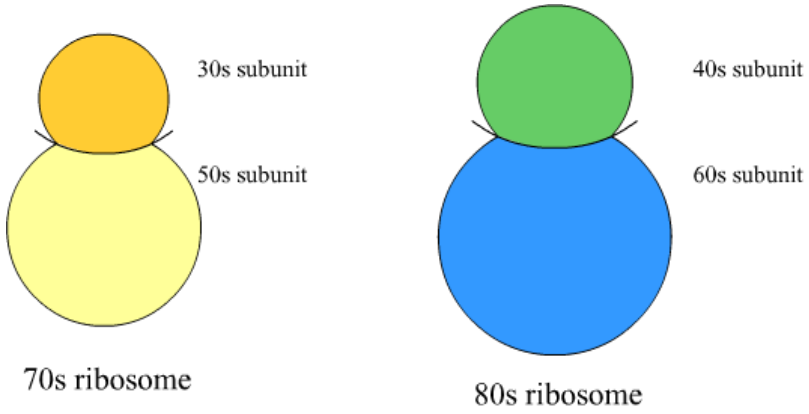


Bigger particles sediment **faster** and have higher sedimentation coefficient.



2 And why does 30S+50S not add up to 80S, and 40S+60S not add up to 100S?

Sedimentation coefficients are <u>not</u> additive (they do not add up together). This is because they represent a rate of sedimentation, and the rate of sedimentation of a molecule depends upon its size and shape, rather than simply its molecular weight.



7 The electronmicrograph shows part of two cells.

Starch granule in chloroplast – may be shiny in appearance

Chloroplast (plant cell → eukaryote)

Cellulose cell wall (both eukaryotic & prokaryotic cells have cell walls)

Cell surface membrane (found in both prokaryote & eukaryote)

Which of the labelled features enable these cells to be identified as eukaryotic?

A W only
B X only
C W and X only
D W, X and Y

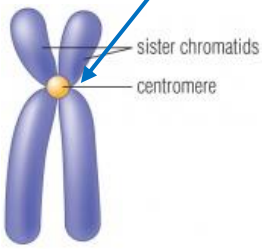
8 The electronmicrograph shows part of a cell.

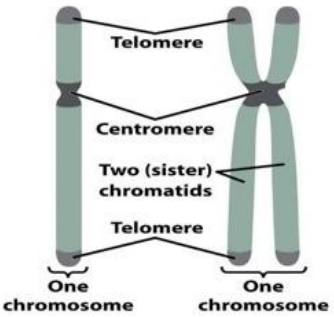
Which organelles shown in the electronmicrograph have more than one membrane?

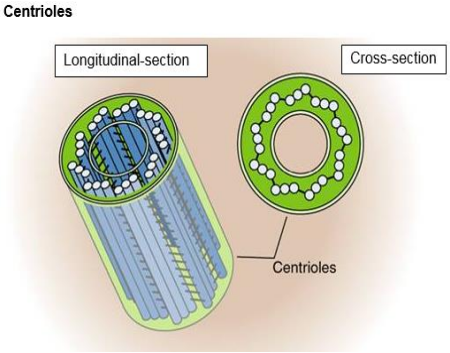
A 1, 2 and 5
B 1, 3 and 5
C 2, 3 and 4
D 3, 4 and 5

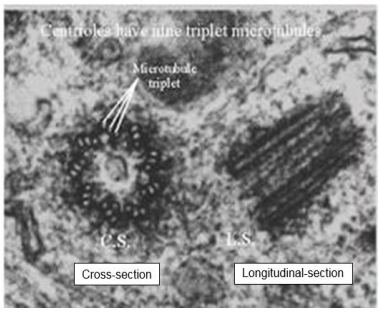
9 What is the function of nucleoli?

A formation and breakdown of the nuclear envelope → by cyclin-dependent kinases (not in syllabus)
B formation of centromeres → centromere is found on chromosome and it is a region where sister chromatids join (you will learn in nuclear division later)
C formation of ribosomes (this is an A level equivalent question and question is given as-is. You should note that it is more accurate to state that the function of nucleoli is the production of rRNA and partial assembly of ribosomal subunits).
D formation of the spindle during nuclear division → centrioles



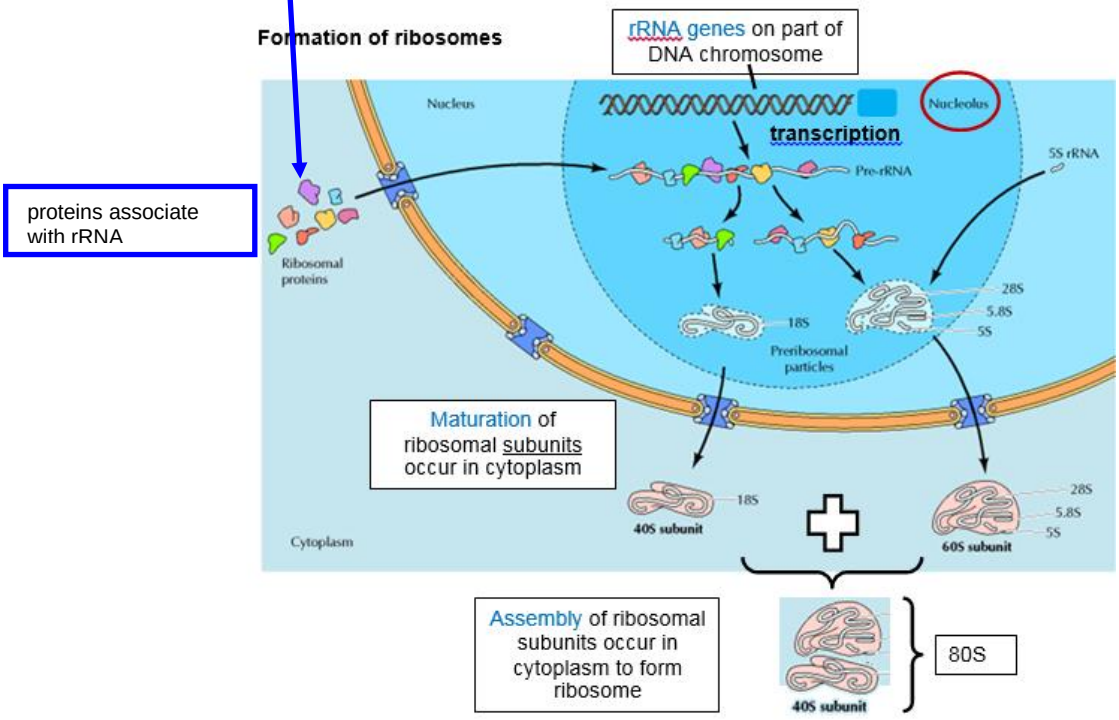




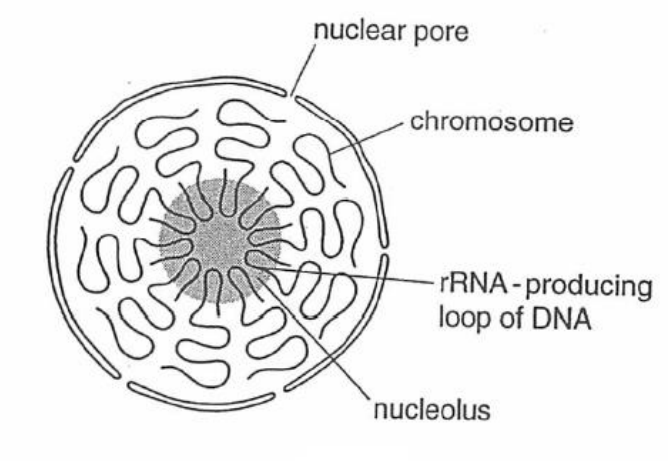


Electronmicrograph of centrioles

Please examine this diagram carefully: Note that rRNA is synthesised in nucleolus (in nucleus). rRNA combines with ribosomal proteins which pass through the nuclear pore of nuclear envelope to form ribosomal subunits. Ribosomal subunits then move out from the nucleus to the cytoplasm via the nuclear pores. The big and small ribosomal subunits attached together in the cytoplasm to form fully functional 80S ribosomes.



Nucleolus contains rRNA genes (see lecture note pg 22)



A diagrammatic structure of nucleolus

[The ribosomal RNA genes in human cells are located near the tips of 5 different chromosomes (total: 10 chromosomes / 5 pairs of homologous chromosomes)]

10 Which cell organelles contain DNA?

1 centriole [non-membrane bound organelle – exist as a pair of rod-like structure, positioned with their longitudinal axis at right angles to each other. Each cylinder is made up of 9 triplets of microtubules (polymers of tubulin subunits which are proteins in nature) arranged in a ring.

2 mitochondrion [double-membrane bound organelle, evolved from prokaryotic cells based on endosymbiotic theory. **Contain circular DNA**, 70S ribosomes]

3 nucleolus [non-membrane bound organelle containing the **rRNA gene** (DNA)]

4 ribosome [non-membrane bound organelle, made up of 2 ribosomal subunits. Ribosomal subunit is composed of **rRNA** and protein]

A 1 and 2
B 1 and 4
C 2 and 3
D 3 and 4

11 Which statement is correct?

A Prokaryotes and chloroplasts have circular DNA ✓ where genes carrying the code for cell walls are located. ➔ chloroplasts do not have genes coding for cellulose cell wall, due to (1) it only has genes coding for proteins needed within the chloroplast itself and (2) plant cell walls are made up of cellulose, which is a carbohydrate, not a protein. Only proteins are encloded by genes.

B Prokaryotes and chloroplasts have 70S ribosomes that are the sites for translation and polypeptide synthesis.

C Prokaryotes and mitochondria have an outer membrane and a separate inner, folded membrane where ATP synthesis occurs. ➔ Statement true only for mitochondria. Prokaryote has a cell surface membrane which has infoldings called mesosome where ATP synthesis occur

D Prokaryotes and mitochondria have double-stranded linear DNA where genes carrying coded information are located. ➔ Prokaryotes and mitochondria have circular DNA.

12 A gland cell capable of producing large quantities of sex hormone testosterone would be likely to have well developed

Steroid (lipid)

A Lysosome
B Centrioles
C Rough endoplasmic reticulum
D Smooth endoplasmic reticulum

13 Where are cisternae found in a cell?

1 endoplasmic reticulum
2 Golgi body
3 mitochondrion

Students often get confused with the terms "cisternae" and "cristae". **Cristae** in mitochondria.

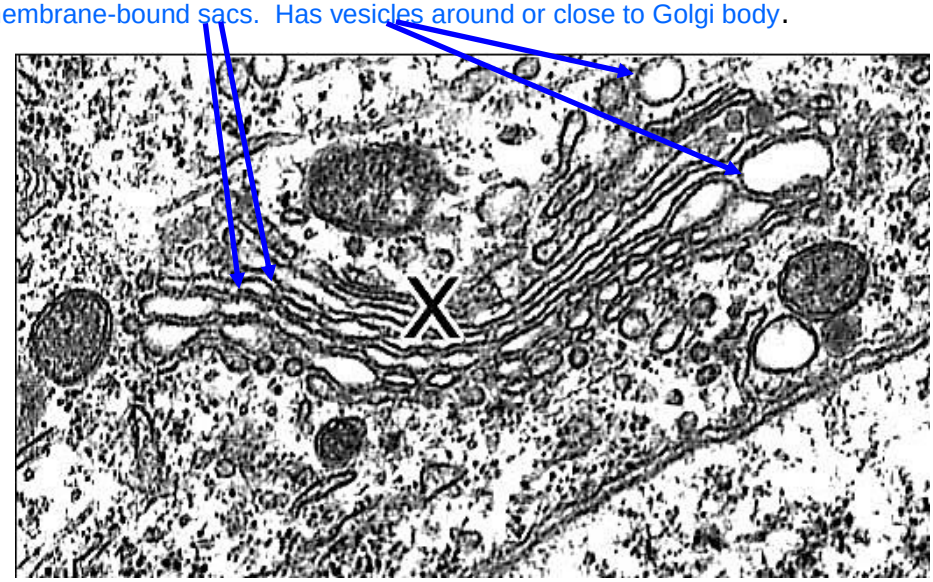
A 1 and 2
B 1 and 3
C 1 only
D 2 and 3

14 Which of the following statements correctly characterize(s) bound ribosomes?

1 Bound ribosomes are enclosed in their own membrane. ➔ ribosomes have no membrane
2 Bound ribosomes are structurally different from free ribosomes. ➔ no structural different between free or bound ribosomes. In eukaryotes, they are 80S ribosomes, made up of 2 subunits and each subunit is composed of rRNA and proteins.
3 Bound ribosomes are concentrated in the cisterna space of rough endoplasmic reticulum. ➔ bound ribosomes found on the surface of rough ER not in the cisterna space inside the RER.
4 Bound ribosomes generally synthesize membrane proteins and secretory proteins. ➔ and also, hydrolytic enzymes in lysosomes. Proteins that are used within the cell itself are synthesised by free ribosomes instead.

A 4 only
B 1 and 3
C 2 and 4
D 3 and 4

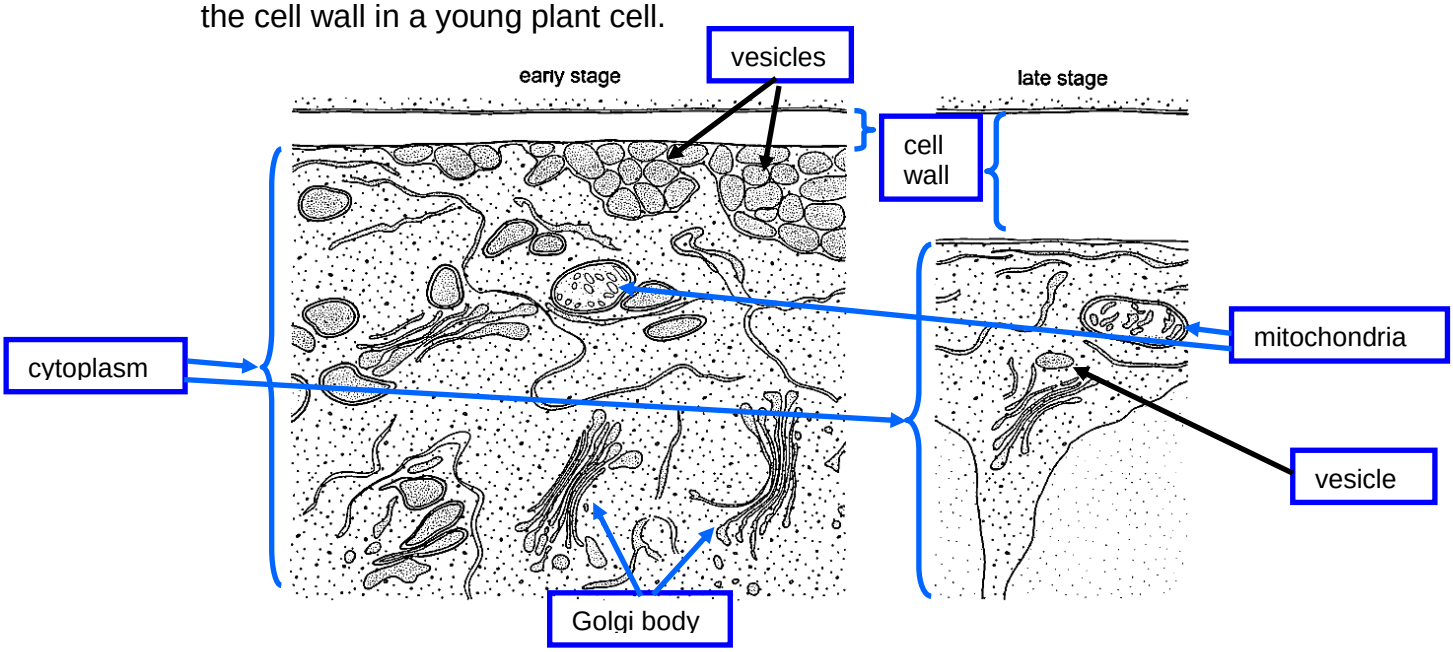
15 The electron micrograph below depicts organelle X ➔ characterised by stacks of flattened membrane-bound sacs. Has vesicles around or close to Golgi body.



Which of the following options is not a function of organelle X?

A Chemical modification of proteins
B Synthesis of steroids ➔ Golgi body involves in processing (not synthesising) steroids (lipids). Synthesis of steroids in smooth endoplasmic reticulum (SER). Golgi body is involved in synthesis of sphingomyelin which is a lipid bit not a steroid.
C Formation of secretory vesicles
D Formation of lysosomes

16 The photo electron micrographs show early and late stages in the development of the cell wall in a young plant cell.



Which statement describes the events leading to the development of the cell wall?

A Complex carbohydrates assembled in the Golgi body are exported to the cell wall by the Golgi vesicles.

B Enzymes in the cell surface membrane synthesise the cell wall components from soluble carbohydrates brought by the Golgi vesicles. ➔ While there are enzymes in the cell surface membrane (called cellulose synthase) that help to synthesis cellulose, the enzymes are not shown in the. Students are required to use the information in the diagrams to answer this question. Also, the soluble carbohydrates needed by cellulose synthase are not brought by Golgi vesicles, they are just soluble in the cytoplasm.

C Polysaccharides are exported to the cell wall and synthesized into wall components by the Golgi body. ➔ the phrasing suggests that the cell wall is synthesised by the Golgi itself, which is incorrect. The Golgi body only synthesises the complex carbohydrates that are needed to make the cell wall.

D Ribosomes synthesise glycoproteins (factually inaccurate!) that are exported by Golgi vesicles to be used in the cell wall. ➔ ribosomes synthesise proteins which enter into the lumen of rough endoplasmic reticulum, where carbohydrates are added to proteins to form glycoproteins.

Important knowledge to note:

Enzymes present in the Golgi lumen modify the carbohydrate (or sugar) portion of glycoproteins by adding or removing individual sugar monomers. In addition, the Golgi apparatus manufactures a variety of macromolecules on its own, including a variety of polysaccharides:

Cellulose is synthesized at the cell surface by enzymes (cellulose synthase) embedded in the plasma membrane.

Other cell wall polysaccharides (i.e. hemicellulose & pectins) – complex carbohydrates are synthesized in Golgi apparatus and then transported in vesicles to the cell surface.

STRUCTURED QUESTIONS

QUESTION 1

(9700 / s2017 / QP21 / Q1 adapted)

Each of the statements **A** – **C** describes a structure found in eukaryotic cells.

(a) Identify the structure that is described in each statement. [3]

(i) A thread-like structure composed of DNA and histone proteins.

.....

1 chromatin / chromosome

(ii) The structure in which rRNA is synthesised and combined with proteins.

.....

1 nucleolus

(iii) The structure occur in pairs at each pole and their position is important in determining the polarity of the cells during mitosis.

.....

1 centrioles

Note: Centrioles divide before mitosis and move to opposite poles of a cell.

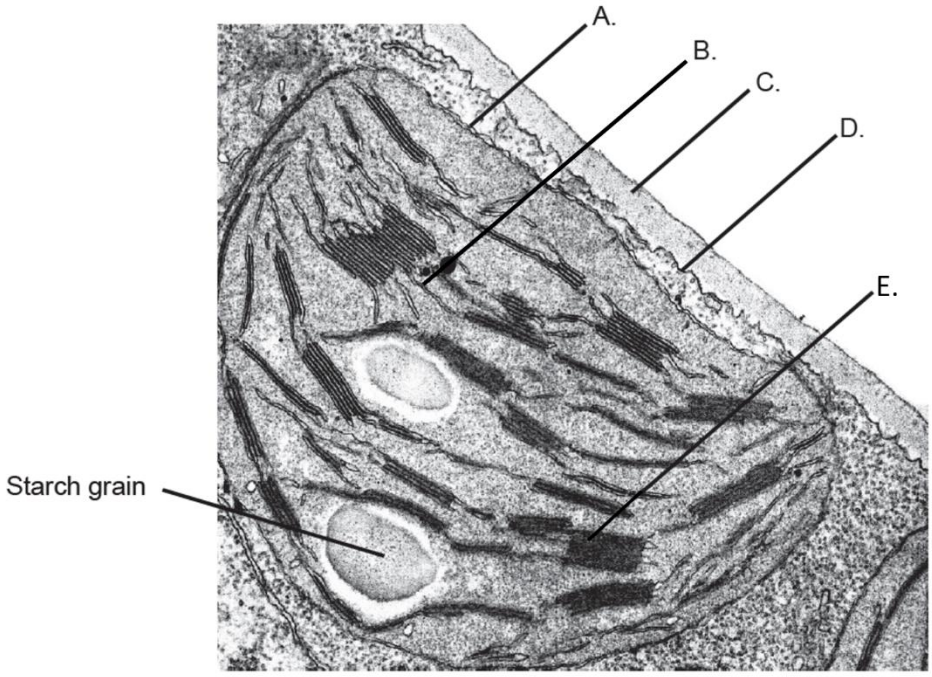
(b) One theory about the evolution of organelles is the endosymbiotic theory. This theory suggests that the mitochondria and chloroplasts found in eukaryotic cells represent formerly free-living bacteria that were absorbed into a larger cell.

Outline the evidences that support the theory that mitochondria evolved from prokaryotic cells.

..... [3]

1 Circular DNA
2 70S ribosomes
3 Enclosed by double membrane
4 Similar in size to prokaryotic cells
5 No introns in the mitochondrial genome *[to be covered in later topics]*
6 Mitochondrial DNA is not associated with histones *[to be covered in later topics]*

[*ignore reference to plasmids (may be present in prokaryotic cells but no plasmids in mitochondria)]*



[Source: adapted from Eldon Newcomb, http://botit.botany.wisc.edu/about.html]

Fig. 1.1

(c) Name the parts of a plant cell labelled **A** to **E** in Fig. 1.1.

…….. [5]

A: Chloroplast envelope
B: Intergranal lamella (reject lamellae)
C: <u>Cellulose</u> cell wall
D: Plasma/cell surface membrane (reject cell membrane)
E: Thylakoid (reject granum)

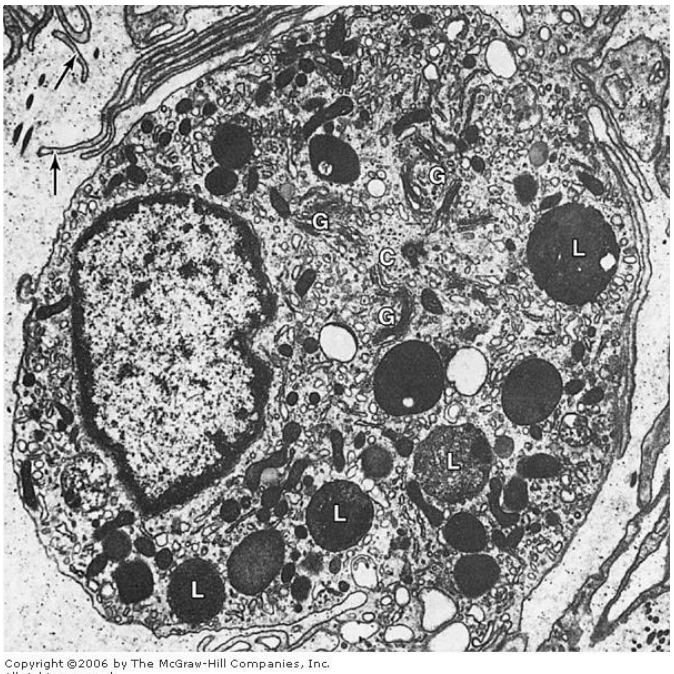


Fig. 1.2

(d) Fig. 1.2 shows an electronmicrograph of lysosomes (labelled **L**).

With reference to Fig.1.2 and your own knowledge, describe the structural differences between lysosomes and ribosomes.

…….. [2]

1 Lysosomes are larger than ribosomes.
2 Lysosomes are membrane bound but ribosomes are not.

QUESTION 2

9648 / 2010 / P1 / Q1

Fig. 2 is an electron micrograph of part of an animal cell.

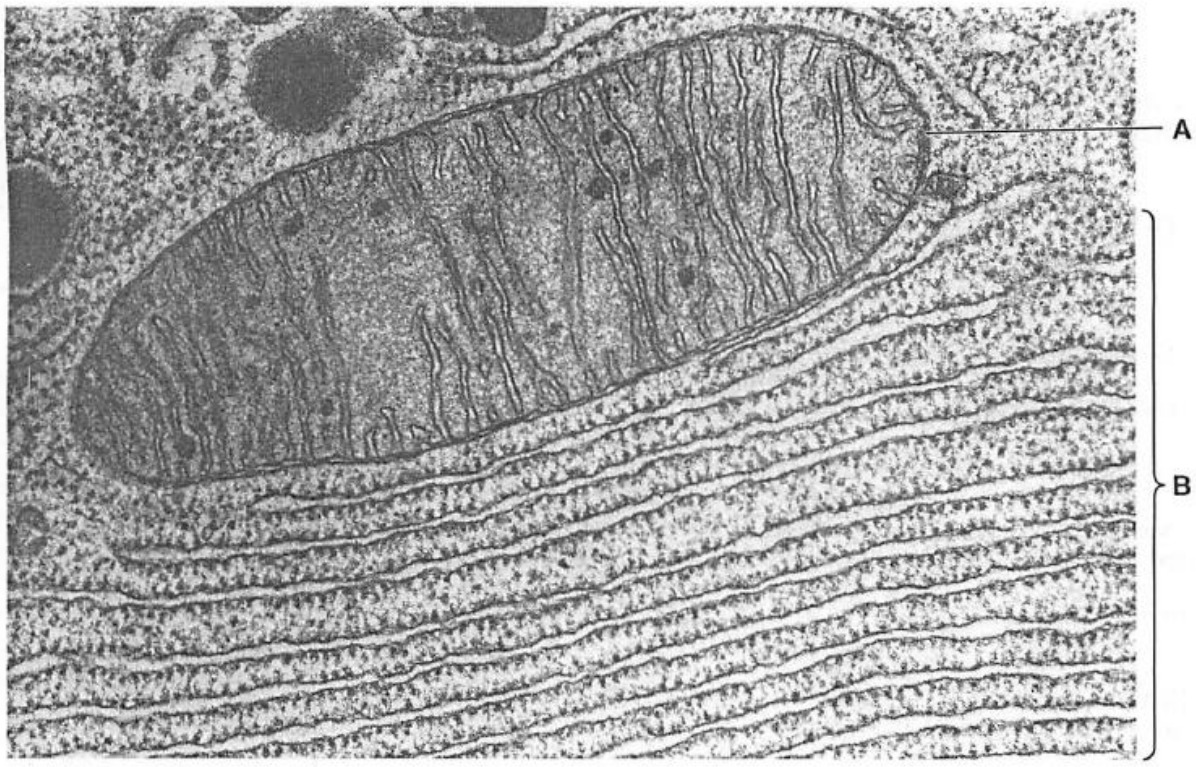


Fig. 2

(a) Identify the organelles labelled **A** and **B**.

In each case, state **two** visible features that enabled your identification.

…… [6]

1 A is mitochondrion
2 Presence of cristae
3 Double membrane organelle
[**REJECT**: mitochondrion is rod-shaped, reference to cisternae which is a term used in ER]

4 B is rough endoplasmic reticulum

5 Presence of ribosomes
6 Parallel stacks of **cisternae**

[**REJECT**: references to sac-like or tube-like structures as not visible on the diagram, e.g "sac", "**network** of flattened membrane-bound sacs"]

Examiner's comment: Candidates confused cristae with cisternae. Candidates must ensure that when asked for "visible features" that they only state features that they can see on the electron micrograph. Some listed sacs or tubes as features of the rER. These are not clearly visible on the diagram and reflect what the candidate had learnt rather than what they could see. Some weaker candidates identified **B** as smooth ER or Golgi apparatus. They suggested that there were 'no ribosomes', presumably interpreting the cisternae inside out. Candidates should be given the opportunity to interpret a variety of electron micrographs as part of their course to prepare them for questions such as this. Those few who misidentified the organelles often had difficulties in (b). It was not uncommon for misconceptions regarding respiration to surface here, with references to energy being 'produced in the mitochondria', rather than being 'released'.

(b) (i) State the main function of each organelle.

…… [2]

A – Synthesis of ATP during aerobic respiration
B – Protein synthesis at ribosomes on rER and chemically modified in lumen of rER / transport of protein / vesicle formation

(ii) Explain how the functions of the two organelles, **A** and **B**, are linked.

…… [2]

1 ATP synthesized by A is used for protein synthesis during translation e.g. amino acid activation, translocation of ribosomes on mRNA, peptide bond formation (state at least one example after you have completed translation topic later in the year)
2 Ribosomes on B synthesizes respiratory enzymes needed for aerobic respiration.

(c) *8875 / N2015 / P2 / Q3 (a)* Describe the difference in the structure and function of the nucleus and the nucleolus.

…… [2]

1 [Structure]
The nucleus is double-membrane bound while the nucleolus is not membrane bound ;
2 [Function]
Nucleus is the site of mRNA and tRNA synthesis while nucleolus is the site of rRNA synthesis/partial assembly of ribosomal subunits ;

(d) What are the main differences between rough endoplasmic reticulum and smooth endoplasmic reticulum?

…… [3]

1 rER has ribosomes associated with it but sER does not.

2 rER is a network of flattened membrane sacs but sER is a network of fine membranous tubules.

3 rER is involved in post-translational modification of polypeptides, sorting and transporting polypeptides while sER is involved in synthesis of lipids, detoxification of drugs and poisons and storage of calcium ions (in muscle cells).

Note: The site of protein synthesis is considered to be at ribosomes, NOT the rER.

(e) Suggest two advantages to eukaryotic cells of membrane-bound organelles.

…… [2]

1 Provides a boundary between the cytoplasm and specific contents within the membrane-bound organelles so that separate **compartments** can be formed within a cell ;

2 This allows different biochemical pathways to occur simultaneously within different membrane-bound organelles, such that their intermediates do not interfere with each other.

3 Also allows for specific conditions to exist within each membrane-bound compartment for their functions, e.g. low pH within lysosomes for optimal activity of the hydrolytic enzymes / high local concentration of enzymes and their substrates for more efficient reactions; [Give at least one example to illustrate the point, for the marl]

- **END OF PAPER -**