Contents

Section 1: Cell Structures 1

1.1 Cell organelles 1
1.2. Transport of proteins 7

Section 2: Biological Molecules 8

2.1 Carbohydrates 8
2.2 Lipids (fats) 12
2.3 Proteins 15
2.4 Collagen and hemaglobin 17
2.5 Enzymes 19

Section 3: Cell Division 28

3.1 Basic terminologies related to cell division 28
3.2 Mitosis 29
3.3 Meiosis 34

Section 4: DNA and Genomics I 40

4.1 Structure and function of DNA 40
4.2 Semi-conservative replication of DNA 42
4.3 Experimental evidence (Meselson and Stahl experiment) 44

Section 5: DNA and Genomics II 47

5.1 Structure and function of RNA 47
5.2 Transcription 48
5.3 Post-transcriptional modifications 50
5.4 Translation 52
5.5 Mutations 54

Section 6: Genetics of Viruses 58

6.1 Viruses are obligate parasites 58
6.2 Structure of viruses 59
6.3 The lytic cycle 60
6.4 The lysogenic cycle 61
6.5 Reproductive cycle of the influenza virus 62
6.6 Reproductive cycle of the HIV virus 63
6.7 Harmful effects of viruses 64

Section 7: Genetics of Bacteria 66

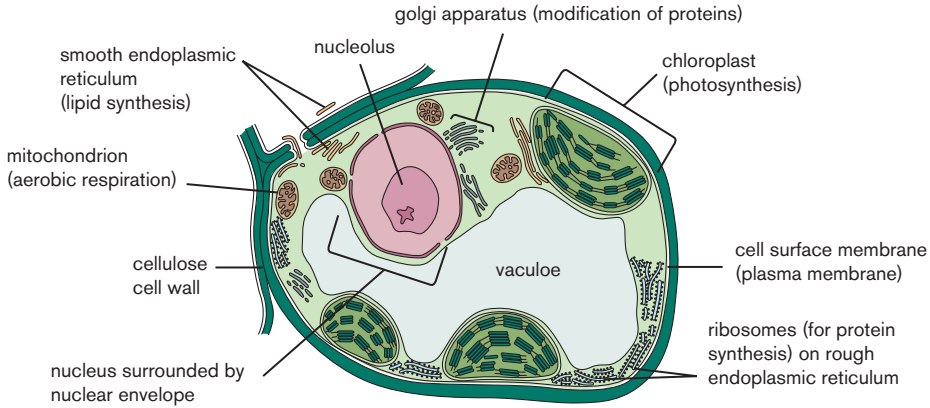
7.1 The bacterial chromosome 66
7.2 Binary fission 67
7.3 Mechanisms of horizontal gene transfer 68
7.4 Bacterial genes: operons 71

Section 8: Control and Organisation of the Prokaryotic and Eukaryotic Genome 77

8.1 Comparison between prokaryotic and eukaryotic genomes 77
8.2 Structure and function of the non-coding regions 79
8.3 Control of gene expression 82
8.4 Gene amplification 88
8.5 Proto-oncogenes and tumour suppressor genes 90
8.6 Cancer as a multi-step process 92

Section 9: Genetic Basis of Variation 94

9.1 Definitions 94
9.2 Inheritance Patterns 95
9.3 Chi-square (X^2) Test 104



Typical plant cell structure

Organelle/structure	Structure	Function
Nucleus (plural: nuclei)	▪ **Largest**, double-membrane bound organelle ▪ **Outer nuclear membrane**: continuous with **endoplasmic reticulum** ▪ **Nuclear pores**: channels for molecules to move between nucleus and cytoplasm ▪ **Nucleoplasm:** Chromosomes found within nucleoplasm of nucleus ▪ **Nucleolus** (plural: nucleoli) contains genes responsible for synthesis of ribosomal ribonucleic acid (rRNA)	▪ Contains **hereditary/genetic material (DNA)** ▪ DNA contains **genes** for control and direct activities of a cell by regulating protein synthesis

Exam Tidbits!

Nucleus

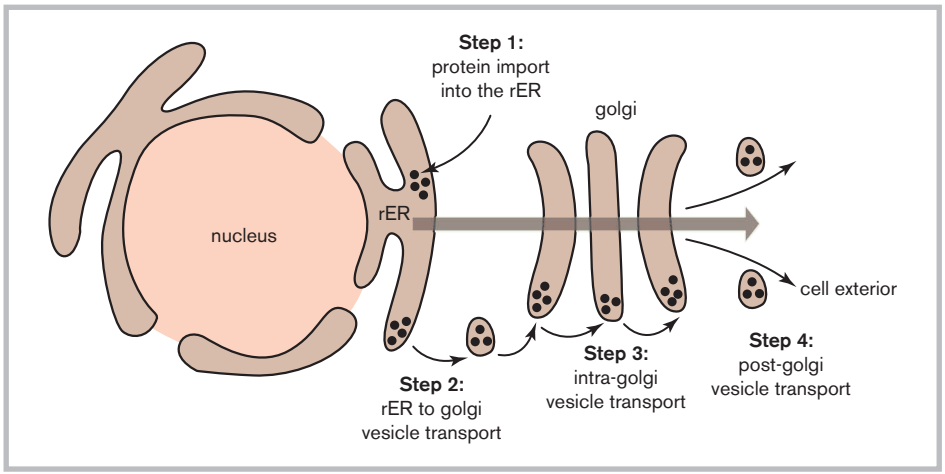
The DNA located in the nucleus is linear. Unlike the circular prokaryotic chromosomes, the linear chromosomes in eukaryotes are made up of DNA associated with proteins (e.g. histones).

Refer to Section 8: Organisation and control of prokaryotic and eukaryotic genome

Organelle/structure	Structure	Function
Smooth endoplasmic reticulum (sER)	▪ Single membrane-bound organelle. ▪ Consists of a **series of interconnected tubules and vesicles.** ▪ Does not contain any ribosomes on its surface.	▪ **Lipid synthesis and transport.** ▪ **Metabolism of carbohydrates.** ▪ **Detoxification** of drugs and poisons. ▪ Storage of **calcium ions** for muscle contraction.
Golgi apparatus/ Golgi body	▪ Single membrane-bound organelle ▪ Consists of a **stack of flattened membrane-bound sacs** called **cisternae** and associated **vesicles** ▪ The cisternae are continuously formed at one end (i.e. forming face/**cis face**) by fusion of transport vesicles that bud off from ER. ▪ The cisternae continuously breaks down at other end (i.e. maturing face/**trans face**) as secretory vesicles pinch off.	▪ **Temporar storage, packaging and transport of** secretory proteins. ▪ Proteins may be further **chemically modified** (e.g. via **glycosylation**, which involves the attachment of carbohydrate chains to form glycoproteins). ▪ Produce **lysosomes** and cell walls.
Lysosome	▪ Single membrane-bound organelle. ▪ Exist as **spherical sacs** that contain **hydrolytic enzymes** (e.g. lipases, proteases, nucleases). ▪ They work best at an **acidic pH** of 5.	▪ **Protects** organism from pathogens or derive its food source. ▪ **Digests** materials (e.g. pathogenic bacteria or food material) taken in by **endocytosis**. The products of digestion are then absorbed and assimilated by the cell. ▪ **Autophagy:** Break down worn-out organelles within a cell. ▪ **Autolysis:** Destruction of a cell when it is damaged beyond repair/dead.

Exam Tidbits!

1.2. Transport of proteins



- The amino acids are first incorporated into a polypeptide chain by the **ribosomes** attached to the **rough endoplasmic reticulum.**
- As the new polypeptide chain enters the **lumen** of the rough endoplasmic reticulum, it will **fold** into its **specific 3D configuration.**
- The protein molecule is **packaged** into **transport vesicles** which **buds off** the rER.
- **Transport vesicles** move towards the **Golgi body** and **fuse** with the **cis-face** of the Golgi body.
- **Chemical modification** of the protein occurs in the Golgi body, such as **glycosylation** or **phosphorylation.**
- The modified protein is then **packaged into secretory vesicles**, which **bud off** from the **trans face** of the
- Golgi body.
- Secretory vesicles move to and **fuse** with the **cell surface membrane (plasma membrane)**, releasing the protein via **exocytosis.**

Exam Tidbits!

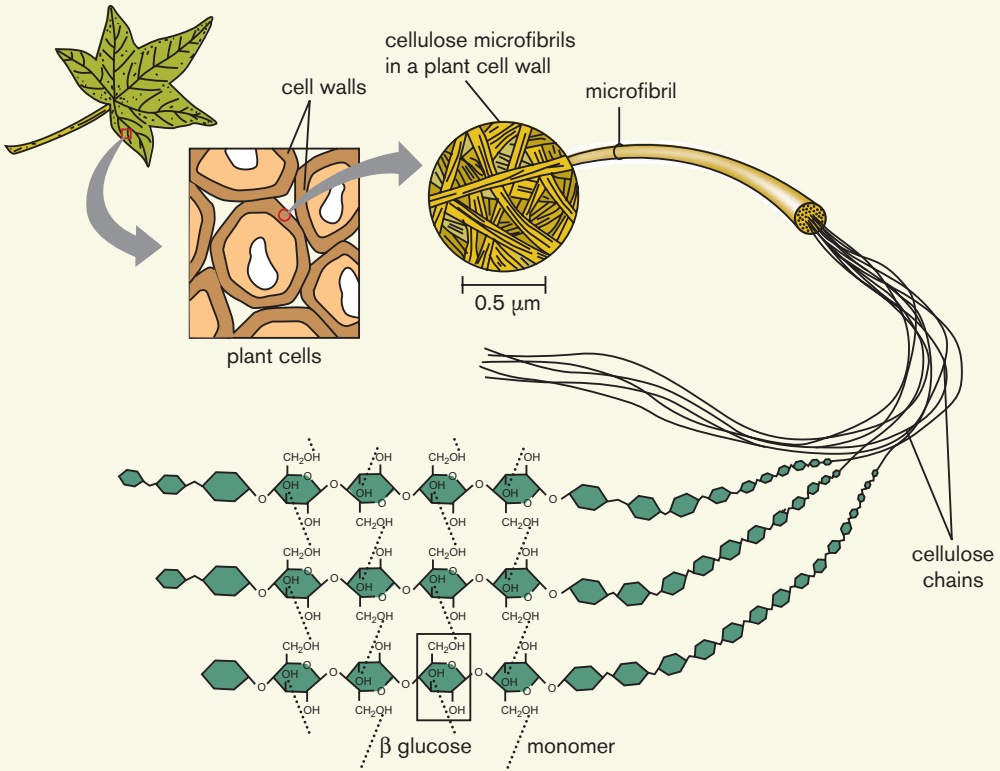
Protein transport

Although protein transport is not explictly stated in the syllabus, students have been tested on their understanding of this concept before.

For proteins that are secreted or embedded in the cell surface membrane, they follow a common pathway of transport from the rER to the Golgi body.

The difference is that proteins which are not secreted will be embedded in the cell surface membrane upon fusion of the secretory vesicles with the cell surface membrane.

Cellulose

Location and role	As major structural component of the plant cell wall.
Structure of polysaccharide	

Organisation of cellulose