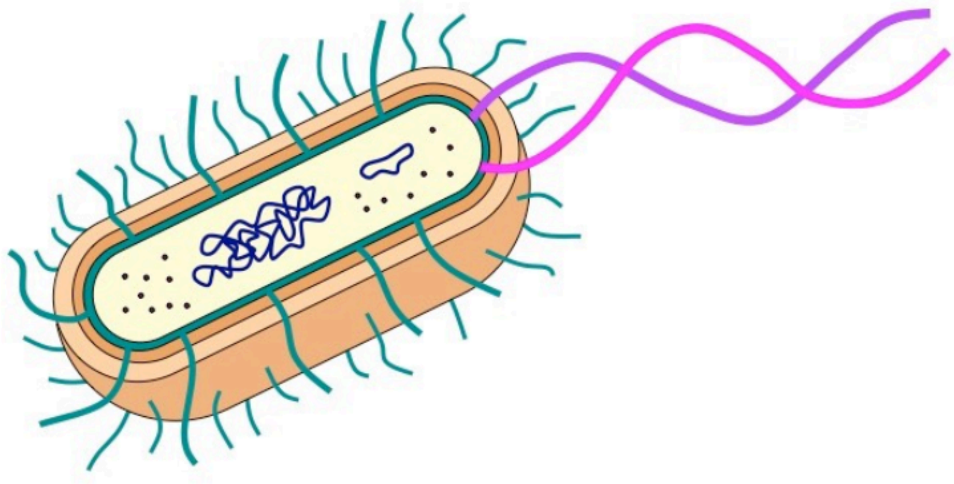
Year 12 HL

IB BIOLOGY

A2.2 Structure of Cells



A2.2.1—Cells as the basic structural unit of all living organisms	NOS: Students should be aware that deductive reason can be used to generate predictions from theories. Based on cell theory, a newly discovered organism can be predicted to consist of one or more cells
A2.2.2—Microscopy skills	Application of skills: Students should have experience of making temporary mounts of cells and tissues, staining, measuring sizes using an eyepiece graticule, focusing with coarse and fine adjustments, calculating actual size and magnification, producing a scale bar and taking photographs
A2.2.3—Developments in microscopy	Include the advantages of electron microscopy, freeze fracture, cryogenic electron microscopy, and the use of fluorescent stains and immunofluorescence in light microscopy
A2.2.4—Structures common to cells in all living organisms	Typical cells have DNA as genetic material and a cytoplasm composed mainly of water, which is enclosed by a plasma membrane composed of lipids. Students should understand the reasons for these structures.
A2.2.5—Prokaryote cell structure	Cell wall, plasma membrane, cytoplasm, naked DNA in a loop and 70S ribosomes. The type of prokaryotic cell structure required is that of Gram-positive eubacteria such as **Bacillus and Staphylococcus**. Students should appreciate that prokaryote cell structure varies. However, students are not required to know details of the variations such as the lack of cell walls in phytoplasmas and mycoplasmas.
A2.2.6—Eukaryote cell structure	a plasma membrane enclosing a compartmentalized cytoplasm with 80S ribosomes; a nucleus with chromosomes made of DNA bound to histones, contained in a double membrane with pores; membrane-bound cytoplasmic organelles including mitochondria, endoplasmic reticulum, Golgi apparatus and a variety of vesicles or vacuoles including lysosomes; and a cytoskeleton of microtubules and microfilaments
A2.2.7—Processes of life in unicellular organisms	homeostasis, metabolism, nutrition, movement, excretion, growth, response to stimuli and reproduction.
A2.2.8—Differences in eukaryotic cell structure between animals, fungi and plants	cell walls, differences in size and function of vacuoles, presence of chloroplasts and other plastids, and presence of centrioles, cilia and flagella.
A2.2.9—Atypical cell structure in eukaryotes	Use numbers of nuclei to illustrate one type of atypical cell structure in aseptate fungal hyphae, skeletal

	muscle, red blood cells and phloem sieve tube elements.
A2.2.10—Cell types and cell structures viewed in light and electron micrographs	**Application of skills:** Students should be able to identify cells in light and electron micrographs as prokaryote, plant or animal. In electron micrographs, students should be able to identify these structures: nucleoid region, prokaryotic cell wall, nucleus, mitochondrion, chloroplast, sap vacuole, Golgi apparatus, rough and smooth endoplasmic reticulum, chromosomes, ribosomes, cell wall, plasma membrane and microvilli.
A2.2.11—Drawing and annotation based on electron micrographs	Application of skills: Students should be able to draw and annotate diagrams of organelles (nucleus, mitochondria, chloroplasts, sap vacuole, Golgi apparatus, rough and smooth endoplasmic reticulum and chromosomes) as well as other cell structures (cell wall, plasma membrane, secretory vesicles and microvilli) shown in electron micrographs. Students are required to include the functions in their annotations
A2.2.12—Origin of eukaryotic cells by endosymbiosis	Evidence suggests that all eukaryotes evolved from a common unicellular ancestor that had a nucleus and reproduced sexually. Mitochondria then evolved by endosymbiosis. In some eukaryotes, chloroplasts subsequently also had an endosymbiotic origin. Evidence should include the presence in mitochondria and chloroplasts of 70S ribosomes, naked circular DNA and the ability to replicate. NOS: Students should recognize that the strength of a theory comes from the observations the theory explains and the predictions it supports. A wide range of observations are accounted for by the theory of endosymbiosis.
A2.2.13—Cell differentiation as the process for developing specialized tissues in multicellular organisms	Students should be aware that the basis for differentiation is different patterns of gene expression often triggered by changes in the environment.
A2.2.14—Evolution of multicellularity	Students should be aware that multicellularity has evolved repeatedly. Many fungi and eukaryotic algae and all plants and animals are multicellular. Multicellularity has the advantages of allowing larger body size and cell specialization

A2.2 Cell Structure

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A2.2.2—Microscopy skills
A2.2.3—Developments in microscopy
A2.2.4—Structures common to cells in all living organisms
A2.2.5—Prokaryote cell structure
A2.2.6—Eukaryote cell structure
A2.2.7—Processes of life in unicellular organisms
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A2.2.12—Origin of eukaryotic cells by endosymbiosis
A2.2.13—Cell differentiation as the process for developing specialized tissues in multicellular organisms
A2.2.14—Evolution of multicellularity

A2.2.1—Cells as the basic structural unit of all living organisms

The Cell Theory

Proposed by

The cell theory is made of three parts:

1.

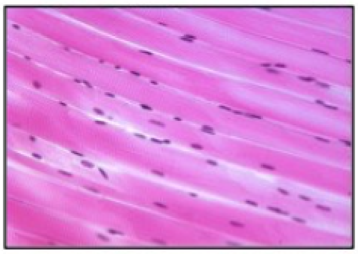
2.

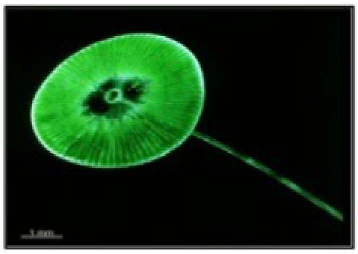
3.

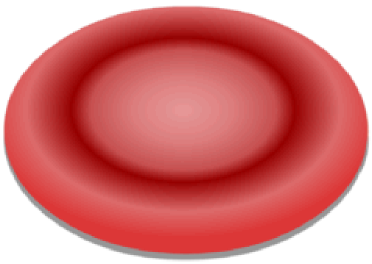
Give one piece of evidence for each of these statements?

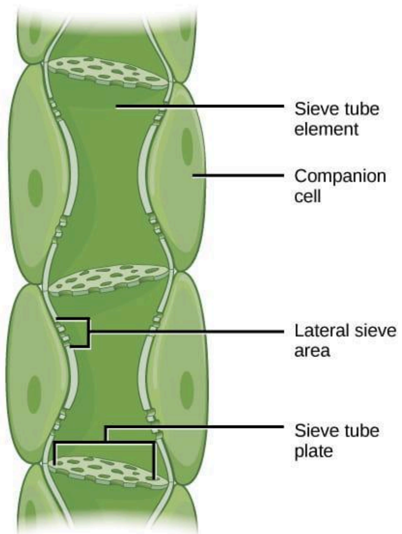
A2.2.9—Atypical cell structure in eukaryotes

What are some exceptions to the cell theory?





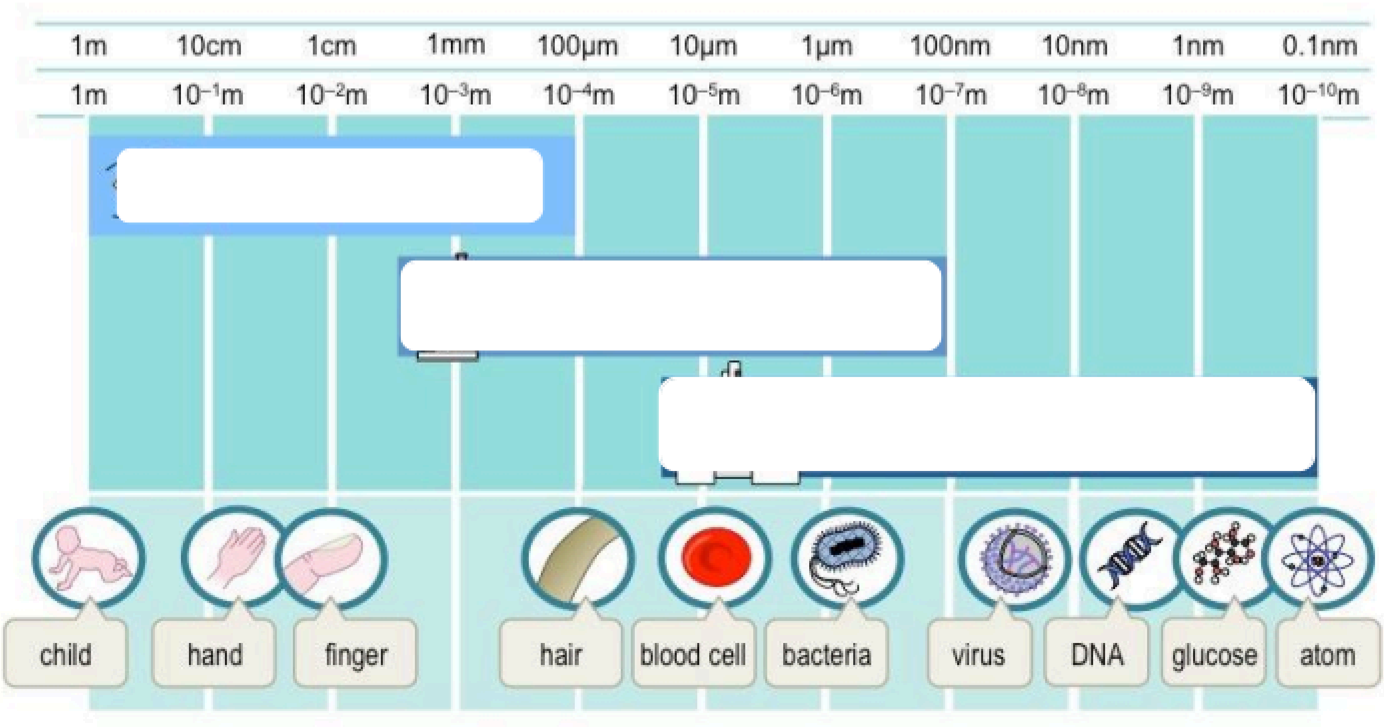




A2.2.2—Microscopy skills
A2.2.10—Cell types and cell structures viewed in light and electron micrographs
A2.2.11—Drawing and annotation based on electron micrographs

Application of skills: Students should have experience of making temporary mounts of cells and tissues, staining, measuring sizes using an eyepiece graticule, focusing with coarse and fine adjustments, calculating actual size and magnification, producing a scale bar and taking photographs

Task: Compare Light and Electron Microscopes



Task: Complete the comparison table

	Light	**Electron**
Cost to purchase and operate		
Complexity to use and prepare		
Magnification		

Specimen Requirements		

A2.2.3—Developments in microscopy

	What is it?	Advantage
electron microscopy		
freeze fracture		
cryogenic electron microscopy		
use of fluorescent stains and immunofluorescence in light microscopy		

A2.2.7—Processes of life in unicellular organisms

Functions of life

At IGCSE we use MRSGREN to help us remember the characteristics of living things. At IB we use different terms.

Define each term and give examples of how unicellular organisms carry out these processes.

metabolism

reproduction

sensitivity (response to)

homeostasis

excretion

nutrition

growth

Term		Definition		Example
Metabolism		Produce offspring, either sexually or asexually		Pupil changes size due to light levels
Reproduction		Exhibit the removal of waste products		Mitosis, Meiosis and Binary Fission
Sensitivity		Undertake essential chemical reactions		Plants take in water and carbon dioxide from the environment
Homeostasis		Responsive to internal and external stimuli		Respiration
Excretion		Exchange materials and gases with the environment		Body Temperature Regulation
Nutrition		Maintain a stable internal environment		Puberty

Growth		Can move or change shape or size		Urea and Urine

A2.2.12—Origin of eukaryotic cells by endosymbiosis

The Endosymbiont Theory

Watch the video "Endosymbiont Theory in Plain English" https://www.youtube.com/watch?v=bBjD4A7R2xU *and then answer the questions:*

What is the meaning of these words?

Endo

Symbiosis

Endosymbiosis

List some examples of symbiosis seen in the video:

What do the following represent?

Big Tony

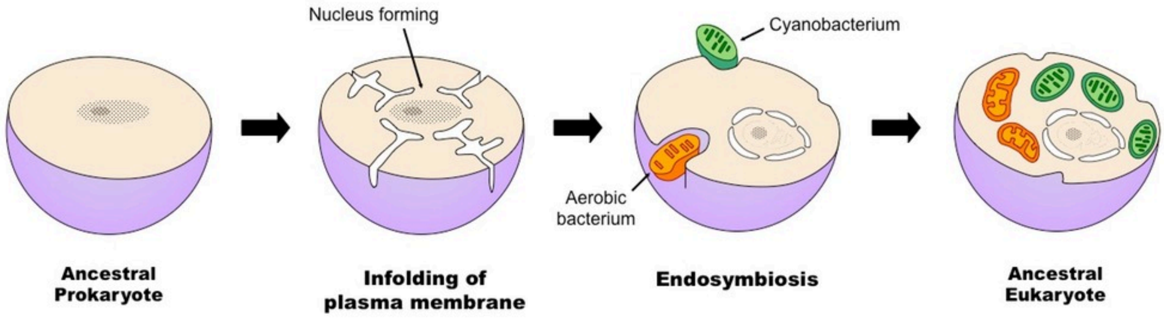
Little Jon

Little Jim

What benefit does endosymbiosis give to each of the cells in the relationship?

What is the evidence for this theory?

Use the diagram below to explain how endosymbiosis was believed to have occurred:



Look at the animation here: http://www.sumanasinc.com/webcontent/animations/content/organelles.html

List 4 pieces of evidence which suggest that mitochondria and chloroplasts were once free-living prokaryotes:

A2.2.13—Cell differentiation as the process for developing specialized tissues in multicellular organisms
A2.2.14—Evolution of multicellularity

Cell differentiation is a crucial process in the development of multicellular organisms. It involves the specialization of cells into different types with distinct structures and functions. Through cell differentiation, cells acquire specific characteristics that allow them to perform specialized roles within various tissues and organs. Here's an explanation of how cell differentiation leads to the development of specialized tissues in multicellular organisms:

Totipotency and Stem Cells: In the early stages of embryonic development, cells possess totipotency, meaning they have the potential to give rise to any cell type in the body. These totipotent cells are called stem cells. Stem cells divide and differentiate into various cell types during the development process.

Gene Expression and Cell Fate: Cell differentiation is controlled by the regulation of gene expression. Every cell in an organism's body contains the same set of genes, but only specific genes are activated or expressed in each cell type. This differential gene expression determines the cell's fate and the specific proteins it produces, which subsequently shape its structure and function.

Signalling and Induction: During development, cells communicate with each other through signalling molecules. Inductive signals from surrounding cells or the extracellular matrix influence the fate of nearby cells. These signals trigger specific genetic programs within the cells, directing them to adopt particular developmental pathways and differentiate into specific cell types.

Morphogen Gradients: Morphogens are signalling molecules that form concentration gradients within developing tissues. These gradients provide positional information to cells, guiding their differentiation based on their proximity to the source of the morphogen. Cells exposed to different concentrations of morphogens activate different genes, leading to distinct developmental outcomes.

Cell-Cell Interactions: Cell-cell interactions play a crucial role in cell differentiation. Adjacent cells influence each other's fate through direct contact, cell adhesion, and the exchange of signalling molecules. These interactions provide positional cues and influence the differentiation of neighbouring cells.

Epigenetic Modifications: Epigenetic modifications, such as DNA methylation and histone modifications, can also contribute to cell differentiation. These modifications can alter the accessibility of certain genes, influencing their expression and ultimately determining cell fate.

Symbiotic Associations: Another hypothesis suggests that multicellularity originated from symbiotic associations between different types of cells. Mutualistic relationships between cells with complementary functions could have provided advantages and eventually led to the development of more complex multicellular organisms.

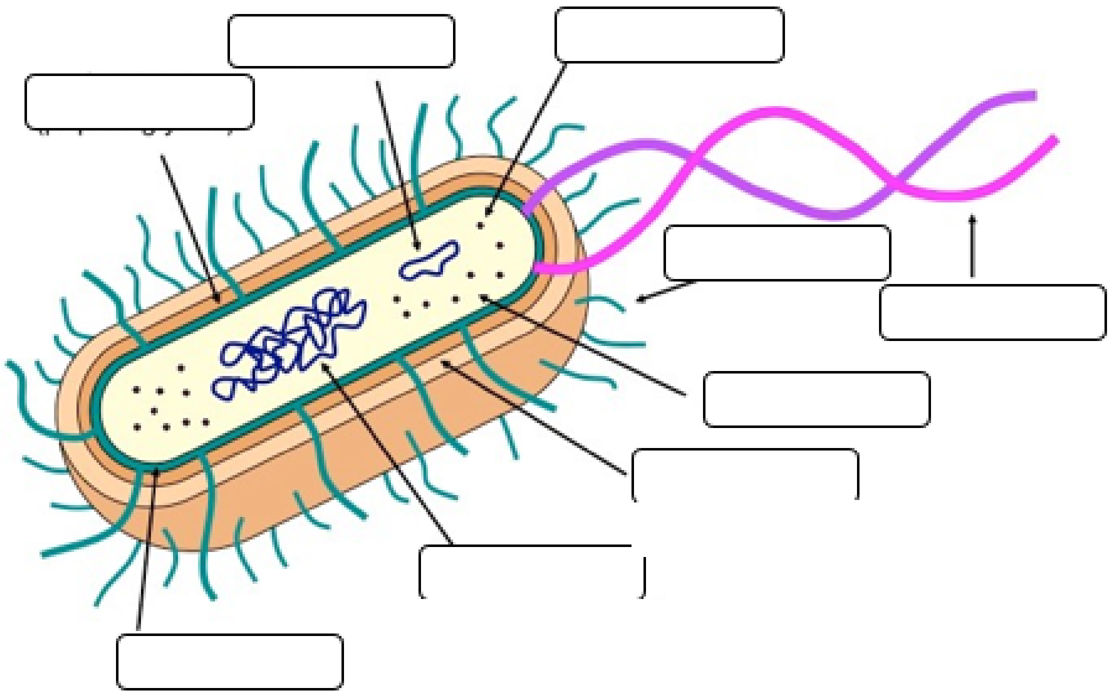
Cellular Specialization: Multicellularity involves the division of labour among different cell types, with each specialized for specific functions. The evolution of multicellularity required the development of mechanisms for cell differentiation, where some cells became specialized for reproduction, while others assumed roles in feeding, defence, or structural support.

A2.2.4—Structures common to cells in all living organisms
A2.2.5—Prokaryote cell structure

Prokaryotic Structure

Task: State the features of a prokaryotic cell:

Prokaryotic cells are capable of a wide variety of metabolic activities.

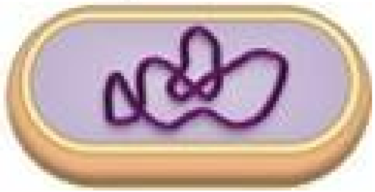


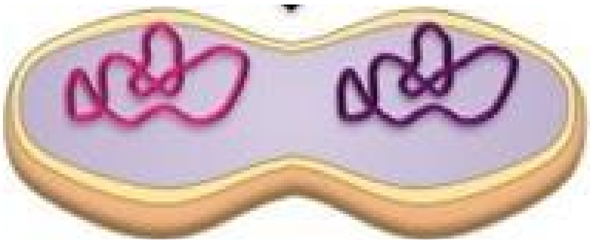
Task: Draw and label a prokaryotic cell.

Task: Match the structure with its description

Structure		**Description**
Cytoplasm –		complexes of RNA and protein that are responsible for polypeptide synthesis (prokaryote ribosome = 70S)
Pili –		autonomous circular DNA molecules that may be transferred between bacteria
Flagella –		Hair-like extensions that enable adherence to surfaces (attachment pili) or mediate bacterial conjugation (sex pili)
Slime capsule –		internal fluid component of the cell
Cell wall –		a thick polysaccharide layer used for protection against desiccation (drying out) and phagocytosis
Cell membrane –		Long, slender projections containing a motor protein that enables movement (singular: flagellum)
Plasmids –		rigid outer covering made of peptidoglycan; maintains shape and prevents bursting (lysis)
Ribosomes –		region of the cytoplasm where the DNA is located (DNA strand is circular and called a genophore)
Nucleoid –		Semi-permeable and selective barrier surrounding the cell

Place these in the correct order:





How do prokaryotic cells reproduce?

_________ _________ is a form of asexual reproduction used by prokaryotic cells

In the process of binary fission:

The circular DNA is c_______ in response to a replication signal

The two DNA loops attach to the m__________

The membrane elongates and pinches off (cytokinesis), forming _____ cells

Create a factsheet and 3 questions ranging in difficulty based on Gram-positive eubacteria *Bacillus* and *Staphylococcus.*

Task: Match the classification of each kingdom to it’s correct description

A2.2.8—Differences in eukaryotic cell structure between animals, fungi and plants

Compare animals, plants and fungi in regards to cell walls, differences in size and function of vacuoles, presence of chloroplasts and other plastids, and presence of centrioles, cilia and flagella.

	Animal	Plant	Fungi
Cell Wall			
Size and Function of Vacuole			
Chloroplasts and plastids			
Centrioles			
Cilia			
Flagella			

Cyanobacteria are aquatic and photosynthetic, that is, they live in the water, and can manufacture their own food. Because they are bacteria, they are quite small and usually unicellular, though they often grow in colonies large enough to see. They have the distinction of being the oldest known fossils, more than 3.5 billion years old, in fact! It may surprise you then to know that the cyanobacteria are still around; they are one of the largest and most important groups of bacteria on earth.

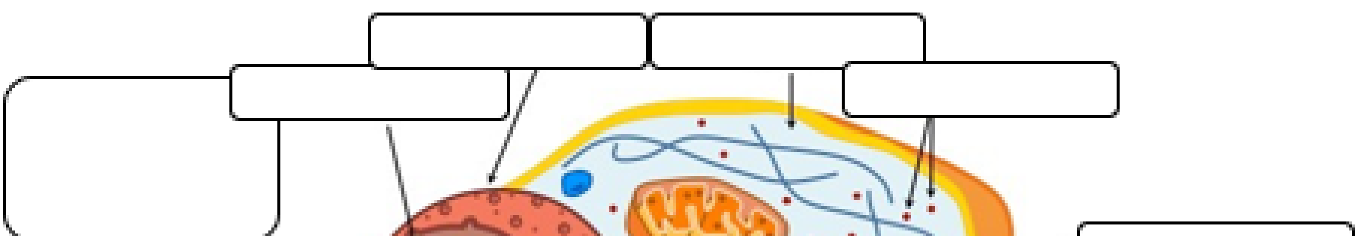
Many Proterozoic oil deposits are attributed to the activity of cyanobacteria. They are also important providers of nitrogen fertilizer in the cultivation of rice and beans. The cyanobacteria have also been tremendously important in shaping the course of evolution and ecological change throughout earth's history. The oxygen atmosphere that we depend on was generated by numerous cyanobacteria during the Archaean and Proterozoic Eras. Before that time, the atmosphere had a very different chemistry, unsuitable for life as we know it today.

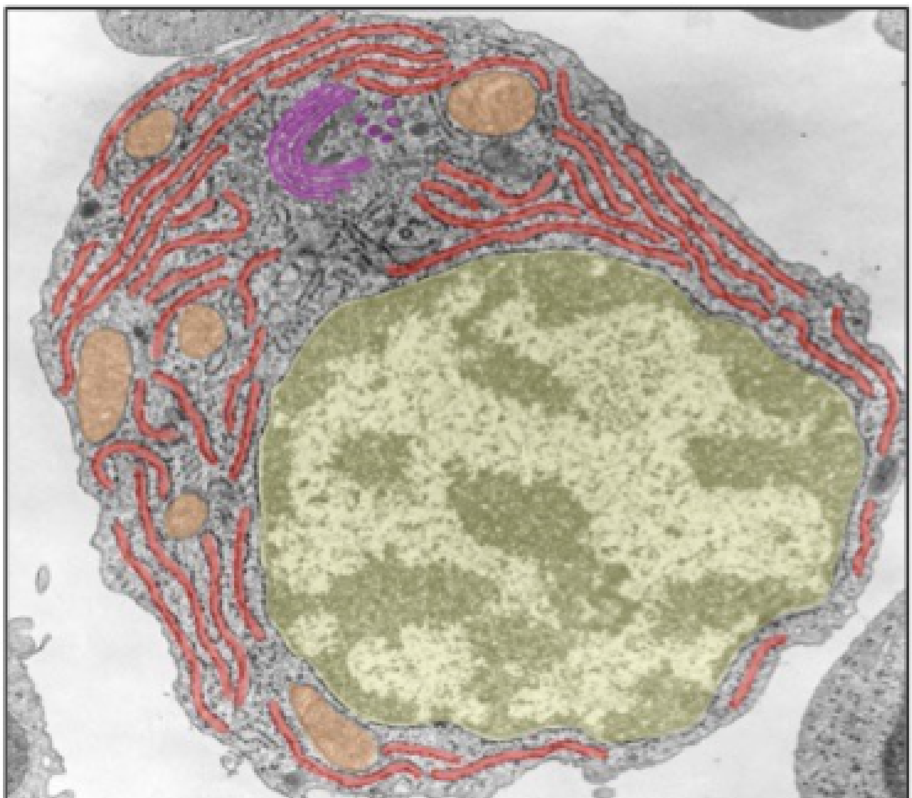
The other great contribution of the cyanobacteria is the origin of plants. The chloroplast with which plants make food for themselves is actually a cyanobacterium living within the plant's cells. Sometime in the late Proterozoic, or in the early Cambrian, cyanobacteria began to take up residence within certain eukaryote cells, making food for the eukaryote host in return for a home. This event is known as endosymbiosis, and is also the origin of the eukaryotic mitochondrion.

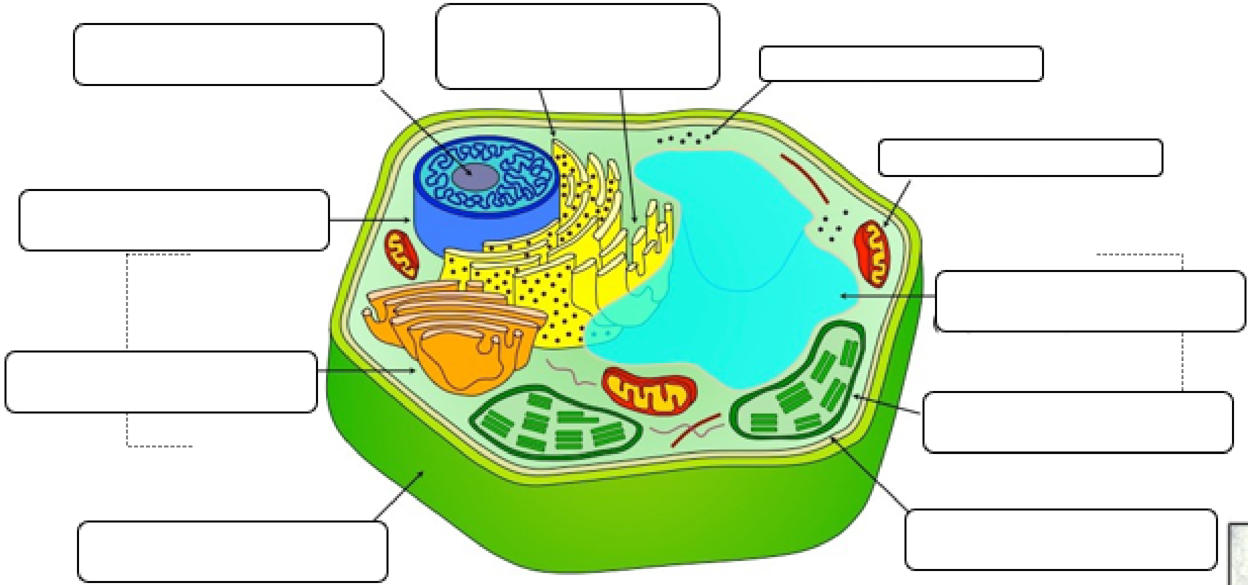
Because they are photosynthetic and aquatic, cyanobacteria are often called "blue-green algae". This name is convenient for talking about organisms in the water that make their own food, but does not reflect any relationship between the cyanobacteria and other organisms called algae. Cyanobacteria are relatives of the bacteria, not eukaryotes, and it is only the chloroplast in eukaryotic algae to which the cyanobacteria are related.

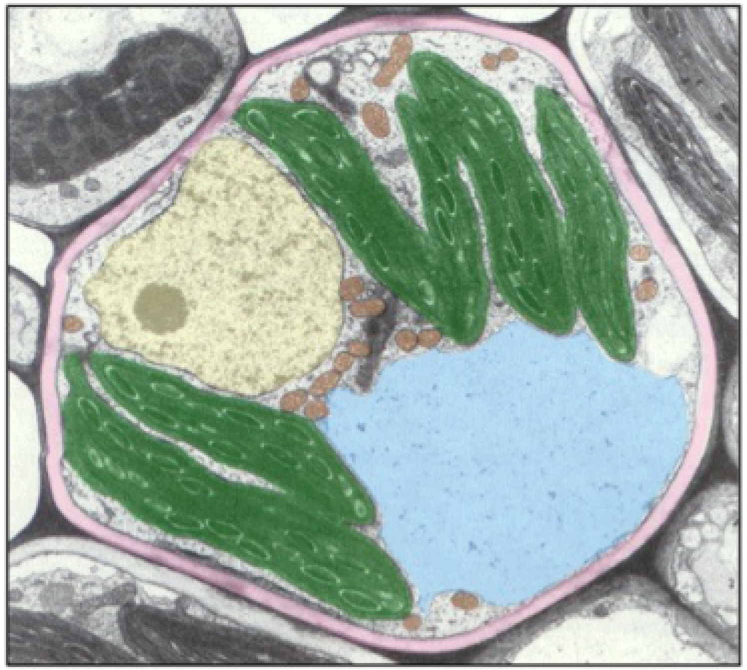
1. List two examples of how cyanobacteria have played an important role in the evolution of life on Earth.
2. What is endosymbiosis?
3. Cyanobacteria are also known as blue-green algae. Is the term ‘algae’ appropriate for cyanobacteria? Why or why not?

A2.2.6—Eukaryote cell structure





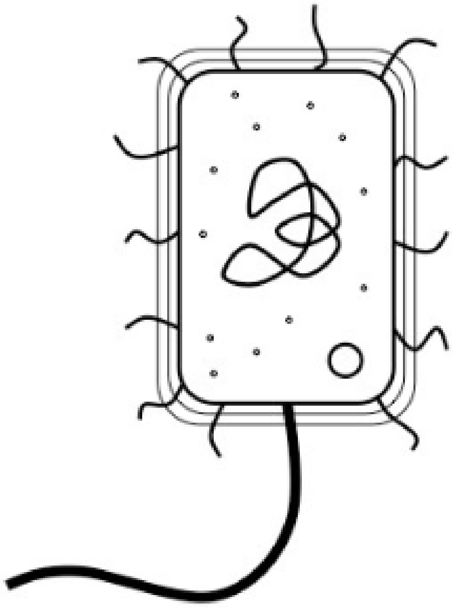




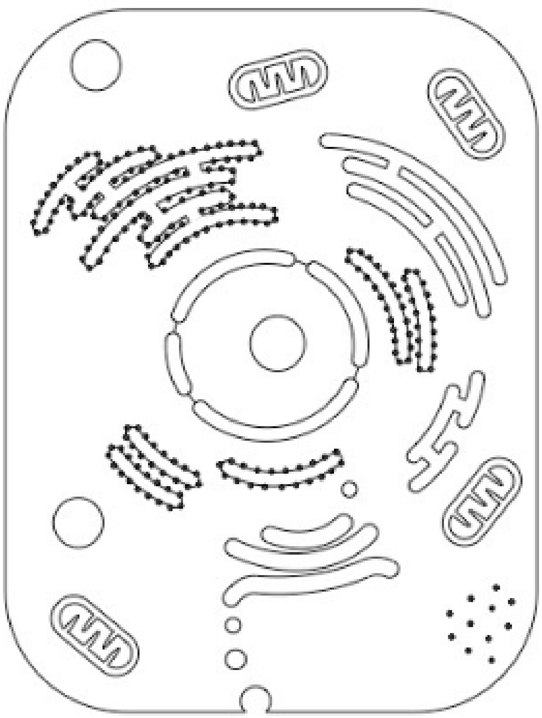
Task: Draw and label a plant and animal cell

Checkpoint Quiz

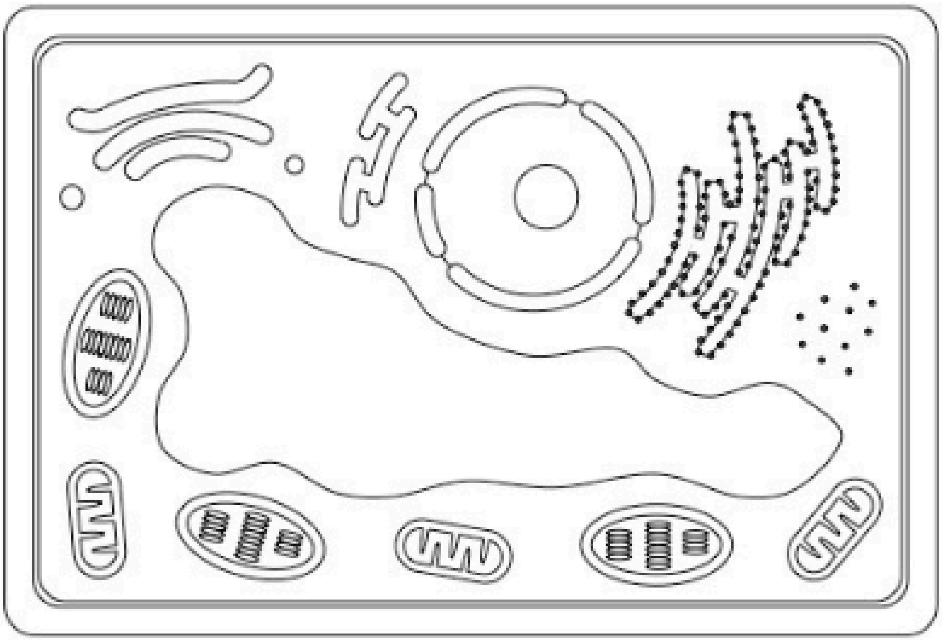
1. Label the prokaryotic cell below (9 marks)



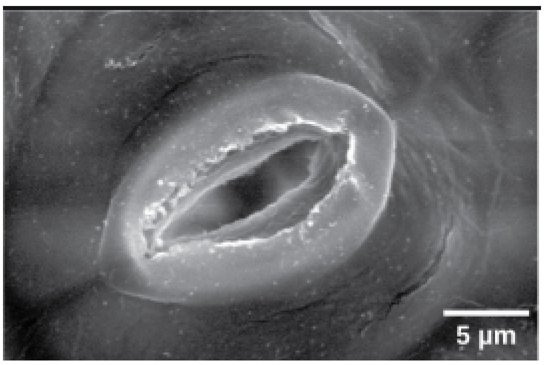
2. Label the animal cell below (10 marks)

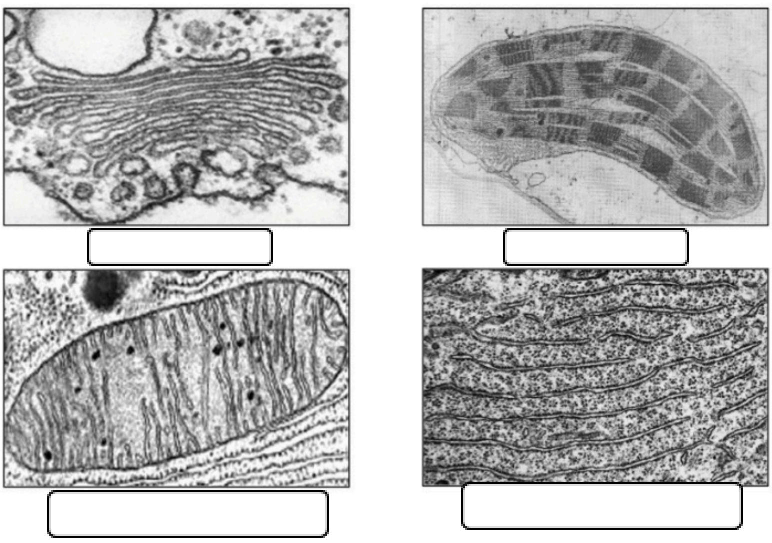


3. **Label the plant cell below (11 marks)**



4. **Calculate the widest width of the stoma below (show all your working) (6 marks)**





Cell Ultrastructure Functions

Starter: Draw and label a prokaryotic, eukaryotic animal and eukaryotic plant cell
Task: Make flashcards for the below structures and their associated functions (Use a key to illustrate whether the organelles are prokaryotic, eukaryotic, both, plant or animal)
Task: Construct a prokaryotic, eukaryotic animal and eukaryotic plant cell using coloured card and paper (be creative)

1. Which of the following is a characteristic of organelles?

A. They are only found in eukaryotic cells

B. They are only found in prokaryotic cells

C. They are sub-cellular structures

D. They are all membrane bound

(Total 1 mark)

2. When viewing an exocrine cell of the pancreas using a light microscope which structures would **not** be visible?

I. The rough endoplasmic reticulum (rER)

II. Mitochondria

III. Nucleus

IV. 80s ribosomes

A. I only

B. I and II only

C. I and IV only

D. IV only

(Total 1 mark)

3. Which of the following structures are present in **both** plant and animal cells?

I. Cell wall

II. Chloroplast

III. Mitochondrion

A. I only

B. I and II only

C. I and III only

D. III only

(Total 1 mark)

4. In viewing an electron micrograph of a cell, ribosomes, pili and a single circular chromosome are observed. What other structure is likely to be present?

A. The rough endoplasmic reticulum (rER)

B. Mitochondria

C. A nuclear membrane

D. A plasmid

(Total 1 mark)

5. By what process do most bacteria divide?

A. Mitosis

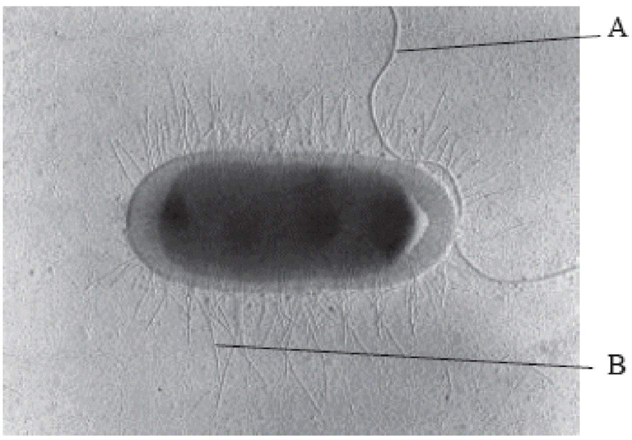
B. Meiosis

C. Conjugation

D. Binary fission

(Total 1 mark)

6. The electron micrograph below shows an image of a cell.



[Source: www.microbiology.umaryland.edu/images/bact_em.jpg]

(a) Identify the structures labelled A and B in the electron micrograph above and state **one** function of each.

A: Name ....

Function ....

B: Name ....

Function ....

(2)

(b) Deduce which type of cell is shown in the diagram, giving reasons for your answer.

....

....

....

....

(2)

7.

(a) Draw and label the ultrastructure of a pancreatic exocrine cell as seen when using an electron microscope.

(5)

(b) State **one** function for each of the following organelles.

(i) Ribosomes

....

(ii) Rough endoplasmic reticulum

....

(iii) Golgi apparatus

....

(3)

1. C

[1]

2. C

[1]

3. D

[1]

4. D

[1]

5. D

[1]

6. (a) *Both name and function required to achieve* ***[1]****.*

A: *name*: flagella/flagellum

function: used for locomotion / beats in whip-like action to propel cell;

B: *name*: pili/pilus

function: used for adhesion (to another cell/surface) / transfer of genetic material (between cells);

ECF, for one mark, can be applied if both parts of the pair are reversed. 2

(b) bacterium / bacteria / prokaryote;

reason: ***[1 max]***
as no nuclear membrane / no nucleus;
as pili present;
as no mitochondria / membrane bound organelles;
as mesosomes / small size / circular DNA;
(Do not accept naked DNA or no histone.)

2 max
Reject reasons if cell type is incorrectly identified.

6. (a) *Award* ***[1]*** *for each structure clearly drawn and correctly labelled. Whole cells not necessary.*
(plasma) membrane—single line surrounding cytoplasm;
nucleus — with a double membrane and pore(s) shown;
mitochondria(ion) — with a double membrane, the inner one folded into internal projections, shown no larger than half the nucleus;
rough endoplasmic reticulum—multi-folded membrane with dots / small circles on surface;
Golgi apparatus—shown as a series of enclosed sacs with evidence of vesicle formation;
ribosomes — dots/small circles in cytoplasm/ribosomes on rER;
lysosome;
Award ***[0]*** *if plant cell is drawn. Award [3 max] if any plant cell structure (e.g. cell wall) is present.* 5 max

(b) *Award **[1 max]** for each organelle. Mark first answer only.*

(i) translation / produces polypeptides / proteins / protein synthesis;

(ii) support of ribosomes / site of protein synthesis / synthesis of proteins for secretion / folding of polypeptides;

(iii) produces glycoproteins / processing of proteins / forms lysosomes / formation of vesicles (for exocytosis);

3 max