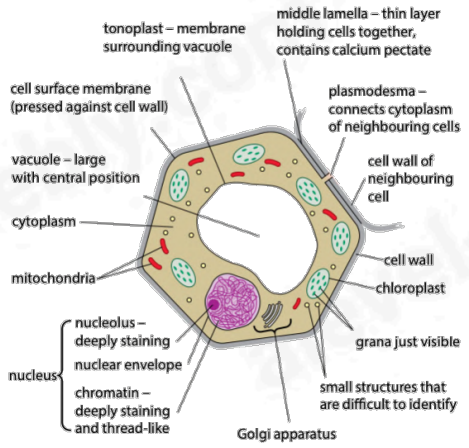
1 Cell structure

1.1 The microscope in cell studies

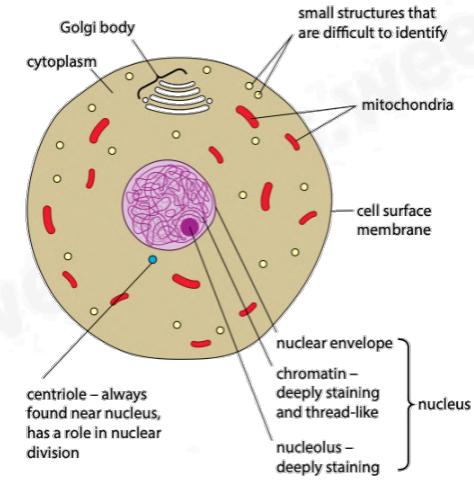
a) Differences between plant and animal cells

LIGHT MICROSCOPE

PLANT CELL

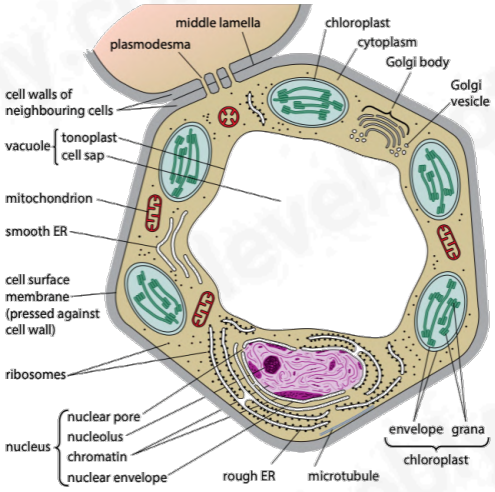


ANIMAL CELL



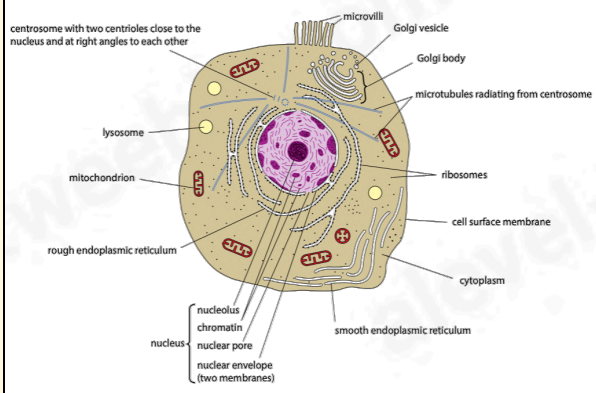
ELECTRON MICROSCOPE

PLANT CELL



ELECTRON MICROSCOPE

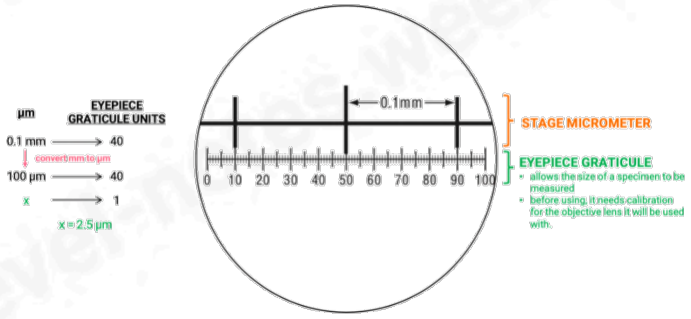
ANIMAL CELL



Images: Cambridge International AS & A Level Biology Coursebook

b, c, e) Magnification calculations

$$\text{magnification} = \frac{\text{image size}}{\text{actual size}}$$



CONVERSIONS
1 mm = 1000 or 10^3 µm
1 µm = 1000 or 10^3 nm

d) Resolution and magnification

- **magnification** – how much bigger a sample appears to be under a microscope than it is in real life
- **resolution** – the ability to distinguish between 2 separate points.
  - as resolution increases, image clarity and detail also increase

Types of microscopes

	LIGHT	ELECTRON
RESOLUTION	200 nm	SEM – 3 nm TEM – 0.5 nm
MAGNIFICATION	x1500	x250,000 – x500,000

a) Light microscopes

- limit of resolution: half the wavelength
- ribosomes (25nm) can't be seen with a light microscope as they don't interfere with the light waves

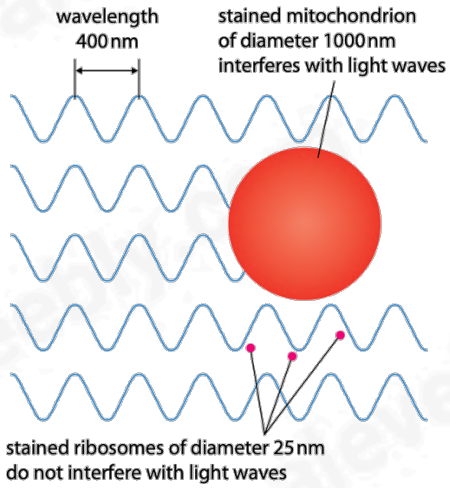


Image: Cambridge International AS & A Level Biology Coursebook

- different stains are absorbed by different cell organelles so they can be observed more clearly

b) Electron microscopes

- vacuum (electrons cannot be focused without a vacuum as they will collide with air molecules and scatter)
- water boils at room temperature in a vacuum, so the sample must be dehydrated (specimen has to be dead)

Advantages of a light microscope over an electron microscope

1) can observe living tissue
2) more portable
3) easier to use - no technical training required
4) possible to see real/natural colours and a live specimen
5) can stain particular types of tissue for better visibility

1.2 Cells as the basic units of living organisms

The cell is the basic unit of all living organisms.

The interrelationships between these cell structures show how cells function to transfer energy, produce biological molecules including proteins and exchange substances with their surroundings.

a) Electron micrographs of plant and animal cells

a) Plant cells

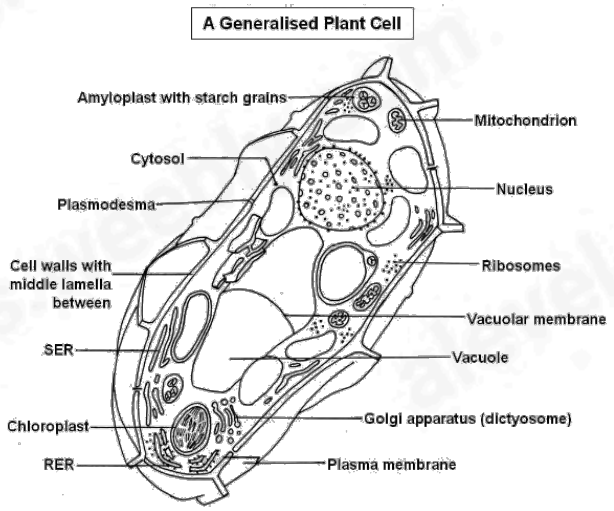


Image: https://cronodon.com/BioTech/Plant_Bodies_Cells.html

Image: https://www.tuttee.co/blog/gce-cie-biology-animal-and-plant-cell-structures-and-functions

b) Animal cells

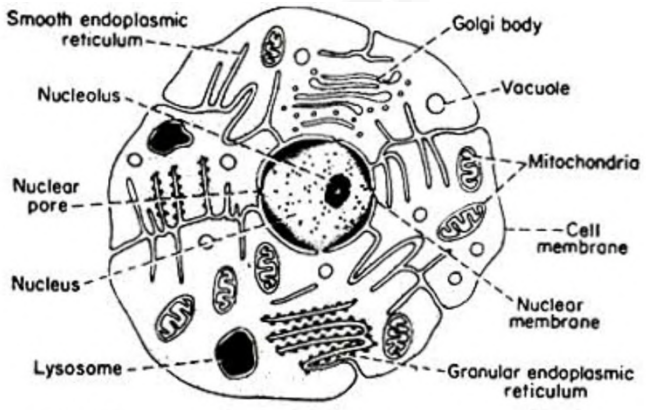


Fig. 168. Diagram of a typical animal cell under electron microscope

Image: https://brainly.in/question/1540878

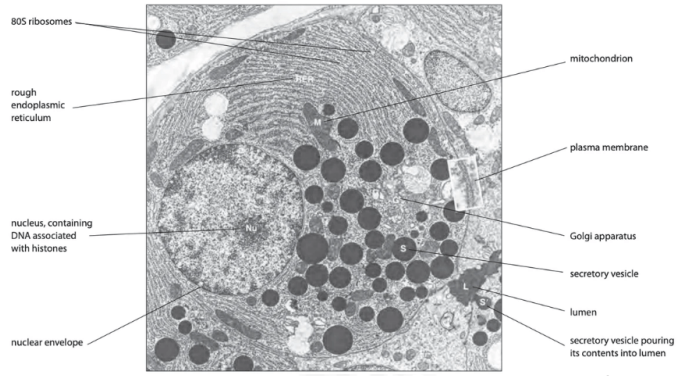


Image: https://www.tuttee.co/blog/gce-cie-biology-animal-and-plant-cell-structures-and-functions

b) Eukaryotic cell structures and their functions

1) Cell surface membrane *(phospholipid bilayer)* (7 nm)

- selectively permeable membrane that allows for the exchange of certain substances
- barrier between cytoplasm and external environment
- cell recognition (surface antigens)
- selection of substances that enter/leave cells

2) Nucleus (7 μm)

Controls cell's activities

- very dense, takes up colour the most when stained
- divides first during cell division
- surrounded by 2 membranes, known as the nuclear envelope which is continuous with the RER.

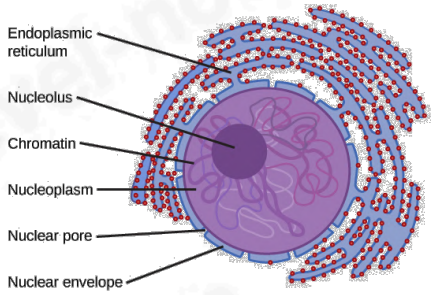


Image: https://courses.lumenlearning.com/boundless-ap/chapter/the-nucleus-and-ribosomes/

- contains:
  - a) **nuclear pores:** allow and control substances entering in *(protein to make ribosomes, ATP, some hormones, nucleotides)* and leaving *(mRNA, ribosomes for protein synthesis)* of nucleus
  - b) **nucleolus (2.5 μm):** contains loops DNA from several chromosomes and synthesises ribisomes

3) Ribosomes (25 nm)

- composed of 2 subunits

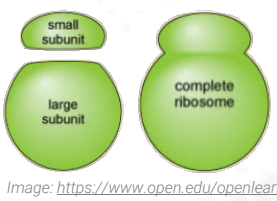


Image: https://www.open.edu/openlearn/

- carry out protein synthesis
- 80S – cytoplasm
- 70S – chloroplasts & mitochondria

4) Rough endoplasmic reticulum (RER)

- membranes that form an extended system of fluid-filled sacs (cisternae)
- single membraned organelle
- ribosomes are attached to the RER and are the site of protein synthesis
- proteins made by the ribosomes enter the sacs and are often modified as they go through them
- small sacs (vesicles) break off from the ER and join to form the golgi body

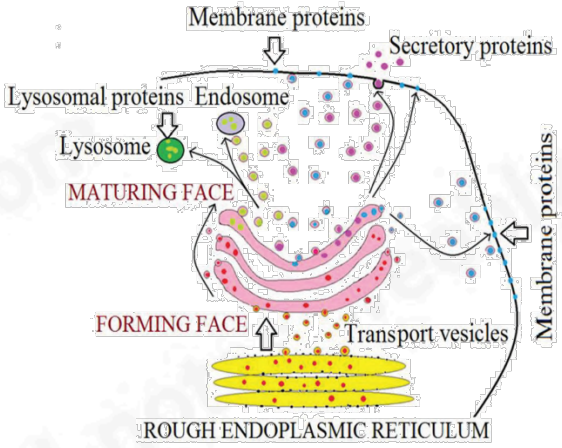


Image: Esrefoglu, Mukaddes. (2019). The Golgi Apparatus: Morphology and Function with Recent Facts. Bezmialem Science. 7. 331-338. 10.14235/bas.galenos.2019.2806.

5) Golgi body / apparatus / complex

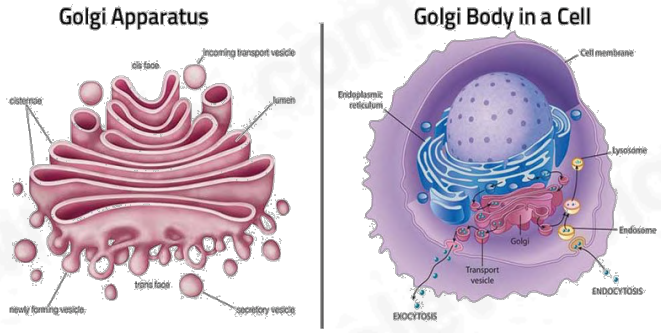


Image: https://microbenotes.com/golgi-apparatus-structure-and-functions/

- stack of flattened sacs (cisternae) formed by the vesicles which bud off from the RER
- Single membraned organelle
- Packages substances into vesicles for transport
- glycosylation
- phosphorylating proteins
- assembly of polypeptides into proteins (4º structure)
- folding proteins
- removing the 1st amino acid methionine to activate proteins

6) Smooth endoplasmic reticulum (SER)

- synthesizes lipids and steroids such as cholesterol and the reproductive hormones estrogen and testosterone.

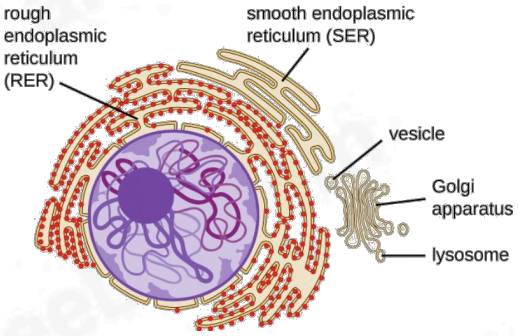


Image: https://studiousguy.com/

7) Lysosomes (0.1-1μm)

- spherical sacs surrounded by a single membrane
- not permanent structures
- no internal structure
- contain hydrolytic enzymes
- responsible for digestion/breakdown of unwanted structures e.g., old organelles
- can even digest whole cells e.g., in mammary glands after the period of lactation

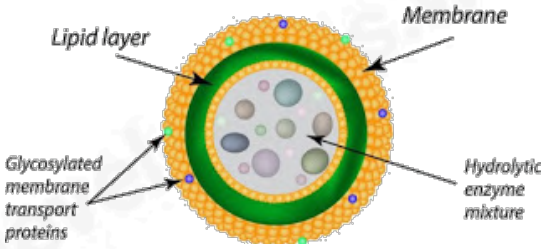


Image: https://www.ybstudy.com/2020/07/lysosomes-structure-functions.html?m=1

8) Mitochondria (0.5-10μm)

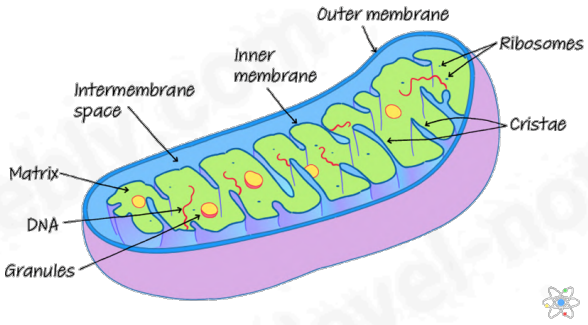


Image: https://brainly.in/question/21632838

- carries out aerobic respiration
- synthesizes ATP (adenosine triphosphate)
- more in cells that have a higher demand for energy e.g., muscle, liver, and root hair cells
- outer membrane contains a transport protein called porin
- energy released from energy-rich molecules e.g., sugars and fats during respiration is transferred to molecules of ATP
- ATP is the energy-carrying molecule in all living cells
- once made, ATP leaves the mitochondrion and can spread rapidly to all parts of the cell where energy is needed
- its energy is released by breaking ATP down to ADP (adenosine diphosphate) in a hydrolysis reaction
- *see Chapter 12.2(i) for more details*

9) Microtubules

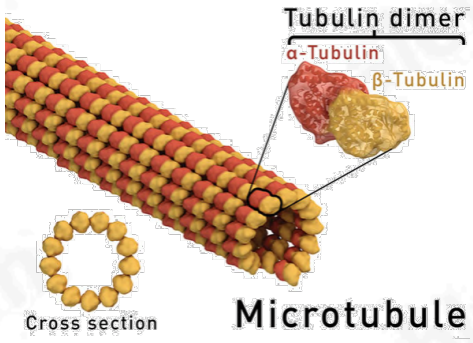


Image: https://www.microscopemaster.com/alpha-and-beta-tubulins.html

- long, rigid, hollow tubes found in the cytoplasm
- made of a protein called tubulin
- tubulin has 2 forms – α & β tubulin
- α & β tubulin molecules combine to form dimers
- many dimers are joined end to end to form protofilaments
- 13 protofilaments are in a ring to form a cylinder with a hollow center
- this cylinder is the microtubule

TUBULIN (α & β) → DIMERS → 13 PROTOFILAMENTS → MICROTUBULE

- supports and gives shapes to the cell
- the assembly of microtubules from tubulin molecules is controlled by special locations in cells called microtubule organizing centers (MTOCs)

9.5) Centrioles (and centrosomes)

9 TRIPLETS OF MICROTUBULES → CENTRIOLE

- outside the nucleus of animal cells, 2 centrioles are present close together at right angles in a region called the centrosome

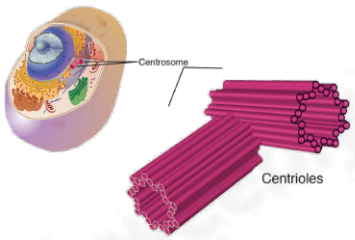


Image: https://www.microscopemaster.com/centriole.html

- centrioles are hollow cylinders about 500 nm long
- produces spindle fibers
- organizes microtubules

10) Chloroplasts (3-10µm)

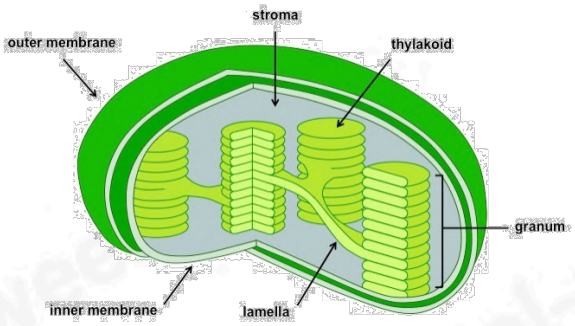


Image: https://askmicrobiology.com/do-bacteria-have-chloroplast/

- diameter 3-10 um
- carries out photosynthesis
- contains starch grains, circular DNA, and 70S ribosomes
- ATP is also produced here
- *see Chapter 13.3(a) for more details*

11) Cell wall

- gives cell definite shape
- rigid as made of cellulose
- freely permeable
- prevents cell from bursting

12) Plasmodesmata

- plant cells are linked to neighboring cells by means of fine strands of cytoplasm called plasmodesmata which pass through pore-like structures in their walls

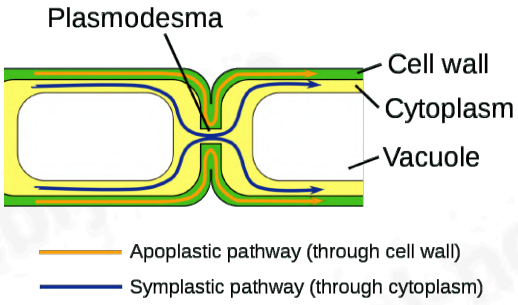


Image: https://mybody101.com/ap-bio-unit-4/

- allows the transport of water, sucrose, amino acids, ions, etc., between cells without crossing membranes
- this is called movement through the symplastic pathway
- allows communication/signaling between cells.

13) Vacuoles

- surrounded by a partially permeable tonoplast which controls exchange between the vacuole and cytoplasm

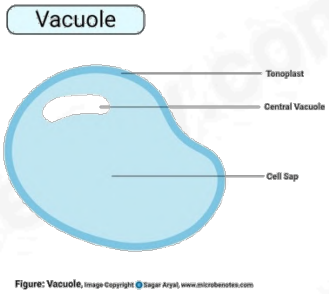


Figure: Vacuole, Image Copyright © Sagar Aryal, www.microbenotes.com

- helps regulate osmotic properties of cells
- fluid present in the vacuole consists of:

P igments
E nzymes
S tarch
O rganic molecules
M ineral salts
O xygen
C arbon dioxide

d) Structural features of prokaryotic cells

- organisms that lack nuclei or proper nuclear membranes are called prokaryotes
- unicellular
- 1-5um
- cell wall made of murein (peptidoglycan = protein + polysaccharides)
- no membranes around organelles
- 70S (smaller) ribosomes
- genetic material in the form of circular DNA
- have no ER

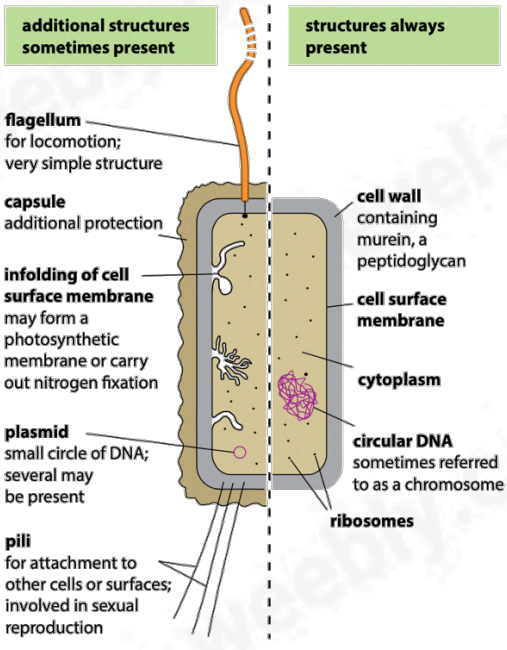


Image: Cambridge International AS & A Level Biology Coursebook

e) Differences between typical eukaryotic and prokaryotic cells

Characteristic	Prokaryotic cell	Eukaryotic cell
Size of cell	Typically 0.2-2.0μm in diameter	Typically 10-100 μm in diameter
Example	Bacteria and Archaea	Animals and Plants
Nucleus	Absent	Present
Membrane-enclosed organelles	Absent	Present; examples include lysosomes, Golgi complex, endoplasmic reticulum, mitochondria & chloroplasts
Flagella	Consist of two protein building blocks	Complex; consist of multiple microtubules
Cell wall	Usually present; chemically complex	Only in plant cells and fungi (chemically simpler)
Plasma membrane with steroid	Usually no	Yes
Cytoplasm	No cytosketeton or cytoplasmic streaming	Cytoskeleton; cytoplasmic streaming
Ribosomes	Smaller	Larger
Cell division	Binary fission	Mitosis
Number of chromosomes	One, but not true chromosome	More than one
Sexual reproduction	No meiosis; transfer of DNA fragments only (conjugation)	Involves meiosis

Prokaryotic cells, as well as eukaryotic cells, are covered with the plasma membrane, which is located on top of the cell membrane or mucous capsule. Despite of its relative simplicity, prokaryotes are typically independent cells. Table 4.1 presents the major differences between prokaryotic and eukaryotic cells.

Image: https://www.researchgate.net/fi

See Chapter 18.2 for more details

f) Viruses

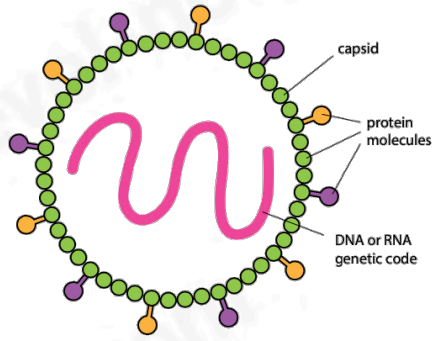


Image: Cambridge International AS & A Level Biology Coursebook

- noncellular/acellular
- protein coat
- nucleic acid core; DNA/RNA strand
- replicate inside host cells only
- show no characteristics of living organism
- symmetrical shape
- the virus DNA/RNA takes over the protein synthesizing machinery of the host cell which helps to make new virus particles
- *See Chapter 18.2(d) for more details*