Exercise walk-through

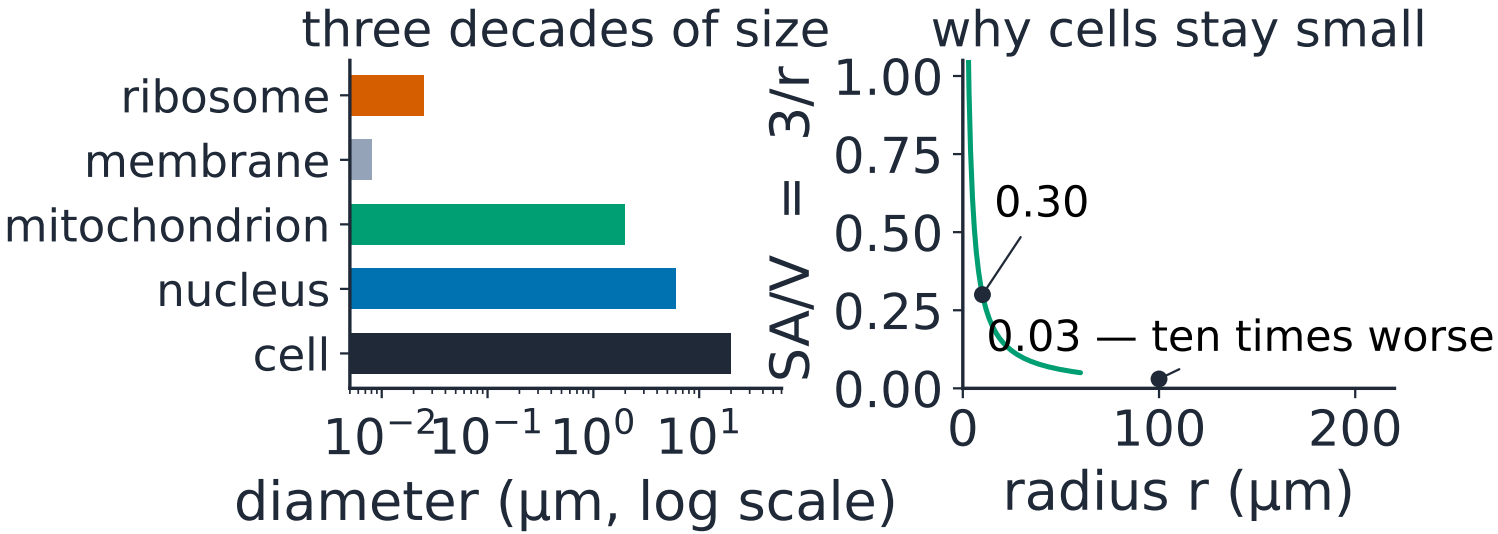
1.1
Cell organisation and organelles

University Medicine

Organelles: a factory of compartments

1. **Ladder Ribosome** 25 nm, membrane 8 nm, **mitochondrion** 2 µm, **nucleus** 6 µm, cell 20 µm - three decades; a ribosome is to a cell as a cell is to a 1.6 cm marble.
2. **Ratio** A 20 µm cell has SA/V $= 0.3$; a 200 µm oocyte 0.03 - ten times worse, which is why big cells are rare and membrane-folded.
3. **Packing** 2.2 m of DNA (6.4×10^9 bp $\times$ 0.34 nm) packs into a 6 µm nucleus: a linear factor of about 10^5.

Three decades of size



From 25 nm **ribosome** to 20 µm cell - and $SA/V = 3/r$ halves with every doubling of radius.

Exercise 2.1

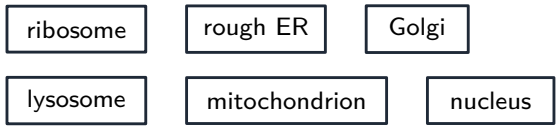
2.1 Match each organelle shown to its job. [3]

ribosome | rough ER | Golgi

lysosome | mitochondrion | nucleus

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2.1

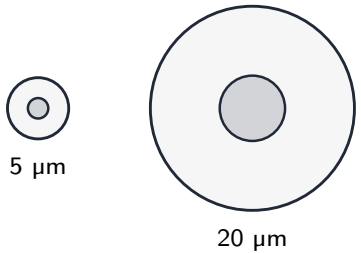
ribosome: makes proteins; nucleus: stores DNA

rough ER: makes proteins for export; Golgi: sorts and labels them

lysosome: breaks material down; mitochondrion: makes ATP

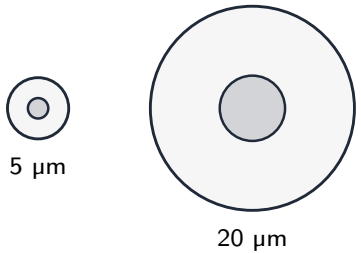
Exercise 2.2

2.2 Find SA/V for a cell 5 µm across. Compare it with a 20 µm cell. [2]



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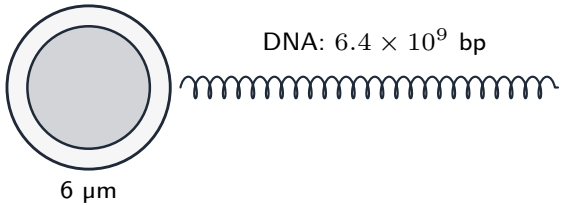
2.2

$r = 2.5$ µm: $3/2.5 = \mathbf{1.2}$ µm^{-1}

4 times the 20 µm cell's 0.3

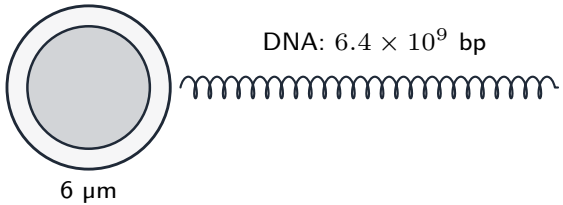
Exercise 2.3

2.3 A human cell has 6.4×10^9 base pairs; each is 0.34 nm long. Find the DNA length, and how many times it is longer than a 6 µm nucleus. [3]



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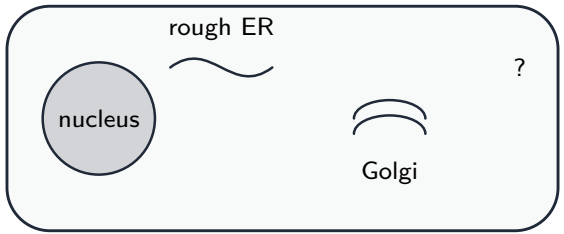
$6.4 \times 10^9 \times 0.34 \times 10^{-9}$ m

$\approx \mathbf{2.2}$ m

$2.2/(6 \times 10^{-6}) \approx \mathbf{3.6} \times \mathbf{10^5}$ times

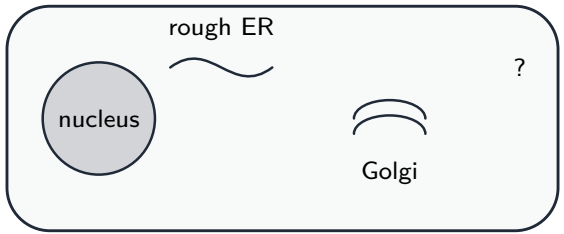
Exercise 2.4

2.4 Give the route of insulin from where it is made to where it leaves the cell. [2]



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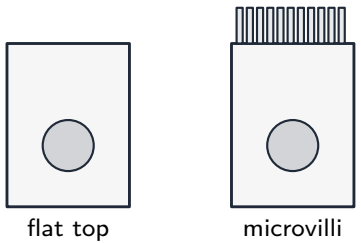
ribosomes on the rough ER → inside the ER → Golgi

→ secretory vesicle → fuses with the membrane: exocytosis

Exercise 3.1 (a)

3.1 Gut lining cells absorb food through their top surface. Their membrane there is folded into **microvilli** , as shown.

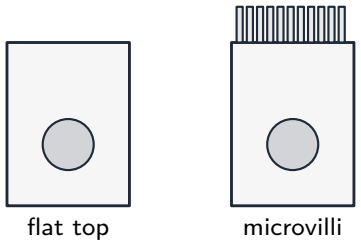
(a) A cell's radius doubles. By what factor do its surface area and its volume change? [2]



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(a) area $\times 4$; volume $\times 8$

Exercise 3.1 (b)

3.1 Gut lining cells absorb food through their top surface. Their membrane there is folded into **microvilli** , as shown.

(b) Use (a) to explain why a cell cannot just grow larger to absorb more. [2]

Exercise 3.1 (b)

3.1 Gut lining cells absorb food through their top surface. Their membrane there is folded into **microvilli** , as shown.

(b) Use (a) to explain why a cell cannot just grow larger to absorb more. [2]

(b) demand grows with volume but supply grows with area, so each unit of volume gets half the membrane: the cell would be short of supply

Exercise 3.1 (c)

3.1 Gut lining cells absorb food through their top surface. Their membrane there is folded into **microvilli** , as shown.

(c) Microvilli raise the top surface 20 times. If absorption is proportional to area, how much faster does the cell absorb? [1]

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(c) about **20** times

Exercise 3.1 (d)

3.1 Gut lining cells absorb food through their top surface. Their membrane there is folded into **microvilli** , as shown.

(d) Give one other place in the cell where membrane is folded to make more surface, and what that surface is for. [2]

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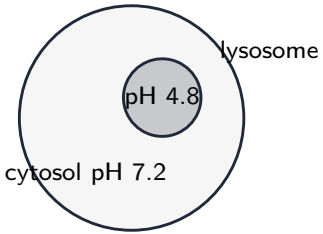
(d) Give one other place in the cell where membrane is folded to make more surface, and what that surface is for. [2]

(d) the inner mitochondrial membrane (cristae), which carries the electron transport chain that makes ATP

Exercise 3.2 (a)

3.2 A (fictional) child with muscle weakness lacks one lysosomal enzyme. The lysosome and the cytosol are shown.

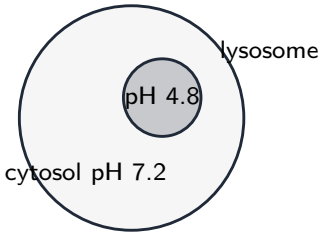
(a) Explain, step by step, how one missing enzyme damages the cells. [3]



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(a) Explain, step by step, how one missing enzyme damages the cells. [3]



(a) the enzyme's substrate is not broken down; it builds up in the lysosomes, which swell; the cell cannot recycle its parts and its function fails

Exercise 3.2 (b)

3.2 A (fictional) child with muscle weakness lacks one lysosomal enzyme. The lysosome and the cytosol are shown.

(b) Lysosomal enzymes work best at pH 4.8 and hardly at all at pH 7.2. Why does this protect the cell if a lysosome leaks? [2]

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(b) a leaked enzyme meets pH 7.2 in the cytosol, where it is almost inactive, so it does not digest the cell

Exercise 3.3 (a)

3.3 A student measures organelles in electron micrographs of three cell types. The results, as a percentage of cell volume, are shown.

(a) Suggest what each cell type is, with a reason. [3]

cell	rough ER	mitochondria	nucleus
X	20%	5%	yes
Y	2%	30%	yes
Z	0%	0%	no

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(a) X: a secreting cell, e.g. a plasma cell, because of the large rough ER; Y: a high-energy cell, e.g. heart muscle, because of the many mitochondria; Z: a red blood cell, with no nucleus and no mitochondria

Exercise 3.3 (b)

3.3 A student measures organelles in electron micrographs of three cell types. The results, as a percentage of cell volume, are shown.

(b) Cell Y has a volume of 5000 μm^3. Find the volume of its mitochondria. [1]

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(b) $0.30 \times 5000 = \mathbf{1500}$ µm^3

Exercise 3.3 (c)

3.3 A student measures organelles in electron micrographs of three cell types. The results, as a percentage of cell volume, are shown.

(c) Cell Z has no mitochondria. How does it make ATP, and why can it not repair its proteins? [2]

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(c) by glycolysis only, in the cytosol; with no nucleus and no ribosomes it cannot make new proteins

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(d) cell Y: it depends most on mitochondrial ATP, while Z does not use mitochondria at all