

Exercise walk-through

1.1

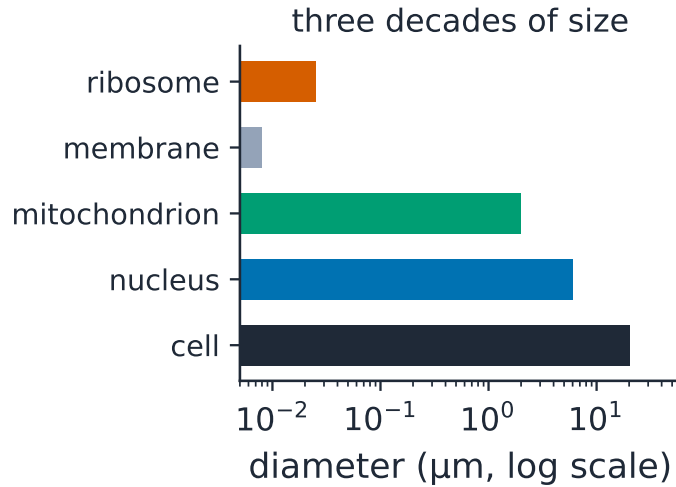
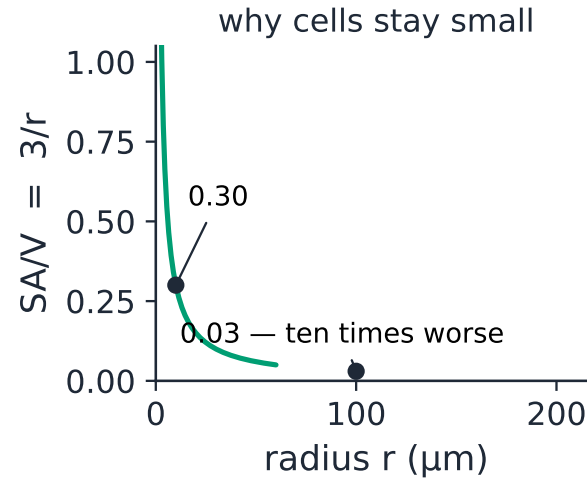
Cell organisation and organelles

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 lentil.
- 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.

Exercises 2.1-2.3

2.1 Compute SA/V for a 5 μm bacterium. [3]

2.2 How many 25 nm ribosomes span one 20 μm cell diameter? [3]

2.3 Why does the ER fold so much membrane into the cytoplasm? [3]

Exercises 2.1-2.3

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2.1

- $3/2.5 = 1.2 \mu\text{m}^{-1}$ – four times the hepatocyte's service ✓.
-

2.2 How many 25 nm ribosomes span one 20 μm cell diameter? [3]

2.2

- $20/0.025 = 800$ ✓.
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2.3 Why does the ER fold so much membrane into the cytoplasm? [3]

2.3

- $SA/V = 3/r$ falls as cells grow; folding membrane raises effective surface without raising volume.

Exercise 3.1

3.1 A hepatocyte (20 μm) and a reticulocyte (5 μm).

Compute SA/V for both and state which has more membrane service per unit cytoplasm. The hepatocyte packs ~1000 mitochondria: give the surface argument for why energy demand scales with volume but ATP synthesis scales with inner membrane. State one design consequence for large secretory cells. [7]

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3.1

- Hepatocyte $3/10 = 0.3$; reticulocyte $3/2.5 = 1.2$ – the small cell has $4\times$ the membrane service ✓.
- Demand (protein synthesis, pumping) scales with volume; the electron-transport chain lives on inner membrane, so mitochondria multiply to supply area.
- Consequence: secretory cells fold membrane (ER) and/or stay small or flat.

Exercise 3.2

3.2 A (fictional) patient lacks one lysosomal hydrolase.

Explain the mechanism from missing enzyme to cell death. State why the disease is called a storage disease. Name the compartment's working pH and why it differs from the cytosol.

[6]

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3.2

- Substrate cannot be dismantled at pH 4.8 → accumulates → lysosome swells → cell dies of failed recycling.
- Storage disease: the undigested substrate is stored in swollen lysosomes.
- pH $\approx$ 4.8; proton pumps keep it acidic so hydrolases are active only inside, protecting the cytosol (pH $\sim$ 7.2).