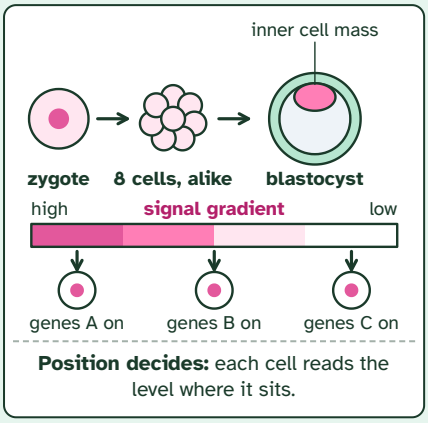
One cell, many *kinds*

What to know, what to draw and what to say. Nothing else.

THE ONE IDEA

Every cell has the same genes. Cells specialise by switching on different ones, and their size and shape suit the job.



Position decides: each cell reads the level where it sits.

B2.3.1 START HERE

From one cell to *many kinds*

- A sperm fertilises an egg to make one cell, the **zygote**. It divides by mitosis into cells that are all alike: **unspecialised**.
- By about day 5 the ball is a hollow **blastocyst**. Its inner cell mass will form the body; its outer layer helps form the placenta.
- Every cell keeps **the same genes**. **Differentiation** is each cell switching on some genes and leaving others off.
- Some cells release **signal molecules** that spread out, making a **concentration gradient**. Each cell switches on the genes that match the level where it sits.

B2.3.2 TWO PROPERTIES

What makes a *stem cell*

PROPERTY 1
Divides endlessly
Keeps making stem cells: self-renewal.

PROPERTY 2
Differentiates
Daughters follow different pathways.

- Often **one daughter stays a stem cell**: a lifelong supply.
- They could **replace damaged tissue**, as after a burn.

B2.3.3

Stem cell *niches*

NICHE 1
Bone marrow
Makes every blood cell: red, white and platelets.

NICHE 2
Hair follicle
Its bulge makes new hair and helps heal cuts.

- A **niche**: where adult stem cells live, and all round them.
- It can **maintain** its stem cells, resting, or **promote** their division and differentiation.

B2.3.4

Three levels of *potency*

- **Potency**: how many kinds of cell it can still become.
- **Embryo: totipotent** at first, but soon **pluripotent**.
- **Adult:** marrow stem cells are **multipotent**: blood cells.

POTENCY, WIDEST FIRST

Total, Plenty, Many

T **Totipotent** any cell, and the placenta

P **Pluripotent** any body cell, not the placenta

M **Multipotent** a few related cells

B2.3.5 THE RANGE IN HUMANS

Size suits the *job*

CELL	SIZE	WHAT TO SAY
Red blood cell	**About 8 µm**	Fits the narrowest capillaries.
White blood cell	**10 to 15 µm**	A little bigger than a red cell.
Sperm	**Head 5 µm**	Small and light, to swim.
Egg	**About 0.1 mm**	Large: food for the embryo.
Muscle fibre	**Several cm**	Contracts as one unit.
Neuron	**Up to 1 m**	Thin, so all near the surface.

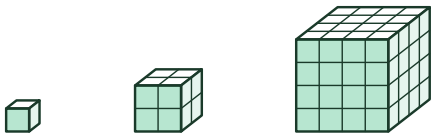
×100 000+
range of human cell sizes

0.1 mm
the egg: just visible by eye

B2.3.6

Why cells stay *small*

- Exchange rate depends on **surface area**; the need, on **volume**.
- Double the side: area ×4, volume ×8, so the **ratio halves**.
- A big cell has a **long way to its middle**, so cells divide.
- **A model:** cells are not cubes, but any shape scales the same way.



1 cm side
6 cm² ÷ 1 cm³
ratio 6 : 1

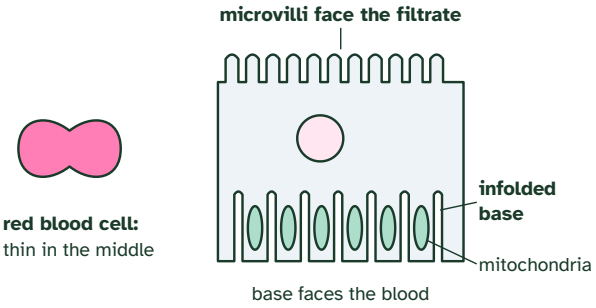
2 cm side
24 cm² ÷ 8 cm³
ratio 3 : 1

4 cm side
96 cm² ÷ 64 cm³
ratio 1.5 : 1

Shapes for *exchange*, muscle and gametes

B2.3.7 HIGHER LEVEL

Flatten, fringe, *fold*

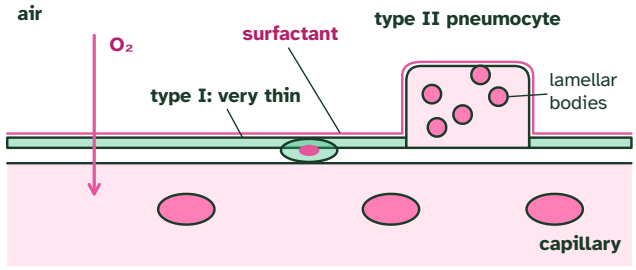


- Each raises the **surface area to volume ratio**, size unchanged.

FLATTEN	FRINGE	FOLD
Thin cells Biconcave red blood cells; type I pneumocytes.	**Microvilli** Brush border of proximal convoluted tubule cells.	**Invagination** Their base folds in; mitochondria power active transport.

B2.3.8 HIGHER LEVEL

Two cells, one *wall*



Type I most of the surface
Extremely thin (about 0.1 µm over a capillary), so gases diffuse a **very short distance**.

Type II fewer and thicker
Cytoplasm full of **lamellar bodies**: vesicles that release **surfactant** onto the lining.

- Surfactant lowers surface tension: alveoli **do not stick shut**.
- One tissue, **two cell types**: two jobs need two adaptations.

B2.3.9 HIGHER LEVEL

Is a muscle fibre a *cell*?

- Both are packed with **contractile myofibrils**: the stripes.

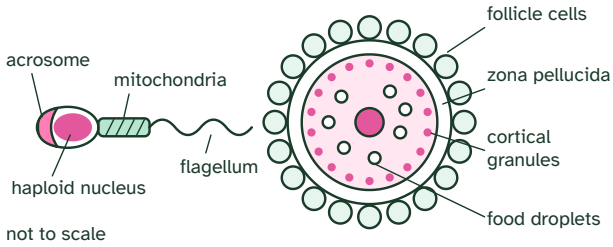
	STRIATED FIBRE	CARDIAC MUSCLE
Branching	None: one cylinder.	Branched; joined at **intercalated discs**.
Length	Several cm.	Much shorter cells.
Nuclei	Hundreds, at the edge.	One, sometimes two.
Why	Contracts its whole length at once.	Spreads the signal: the heart squeezes as one.

YES, A CELL
One membrane
Continuous, as in any cell.

NO, NOT A CELL
Many nuclei
Made by fusing many cells.

B2.3.10 HIGHER LEVEL

Small and fast, big and *stocked*



- Both human gametes are **haploid**, with one set of chromosomes.
- **Sperm:** **acrosome** enzymes digest a way in; mitochondria make ATP for the flagellum.
- **Egg:** large, with **lipid and protein** food; cortical granules let only one sperm in.

WATCH OUT

Six mistakes that *cost marks*

- ✕ **Specialised cells keep all their genes.** Unused ones are switched off.
- ✕ **Pluripotent means any body cell.** Multipotent means a few kinds.
- ✕ **A niche is a place, not a cell type.** It controls the stem cells in it.
- ✕ **A bigger cell has more surface, not less.** It is the area per unit of volume that falls.
- ✕ **Microvilli are not cilia.** They do not beat; they add surface.
- ✕ **Type II cells do not exchange gases.** Their job is surfactant.

COVER THE SHEET

Can you *answer these?*

1. Explain how a signal gradient makes embryo cells differ.
2. State the two properties of stem cells.
3. Outline what a stem cell niche does, with two examples.
4. Distinguish totipotent, pluripotent and multipotent cells.
5. Compare the sizes of a sperm and an egg cell.
6. Calculate the surface area to volume ratio of a 3 cm cube.
7. Describe three ways cells raise their ratio. HL
8. Explain how the two pneumocytes are adapted. HL
9. Discuss whether a striated muscle fibre is a cell. HL
10. Outline two adaptations each of sperm and egg. HL

IN THE EXAM

Name the feature, then link it to its job ("extremely thin, so a short diffusion distance"); in a ratio sum, **show area and volume** before you divide.

GO FURTHER

Animated figures, a dry lab and a marked Check are in the full guide online.