NAME _____ CLASS _____ DATE _____

IB BIOLOGY · B2.3

Cell specialization

Notes to fill in alongside the guide. Each numbered block matches a chapter of the guide, and of the lesson slides. Write in the gaps, answer the cues, annotate the figures, and sum up each section in your own words.

BY THE END YOU CAN

- [ ] Explain how a zygote's unspecialised daughter cells become specialised, and how gradients of signals switch on different genes B2.3.1
- [ ] State the two properties of stem cells: they divide again and again, and they can differentiate along different pathways B2.3.2
- [ ] Describe two stem cell niches in adults, bone marrow and the hair follicle, and what a niche does B2.3.3
- [ ] Distinguish totipotent, pluripotent and multipotent stem cells, with an example of each B2.3.4
- [ ] Compare the sizes of human cells, from red blood cells to neurons B2.3.5
- [ ] Calculate surface area to volume ratios and explain why they limit the size of cells B2.3.6
- [ ] Explain how flattening, microvilli and infolding increase the surface area to volume ratio of a cell B2.3.7
- [ ] Explain the adaptations of type I and type II pneumocytes B2.3.8
- [ ] Compare cardiac muscle cells with striated muscle fibres, and discuss whether a fibre is a cell B2.3.9
- [ ] Explain the adaptations of human sperm and egg cells B2.3.10

01 From one cell to many kinds

B2.3.1

CUES

Predict: A signal molecule is made at one end of an early embryo. A cell near that end and a cell at the far end have exactly the same genes. Why do they end up different?

What is meant by zygote?

What is meant by blastocyst?

What is meant by differentiation?

NOTES

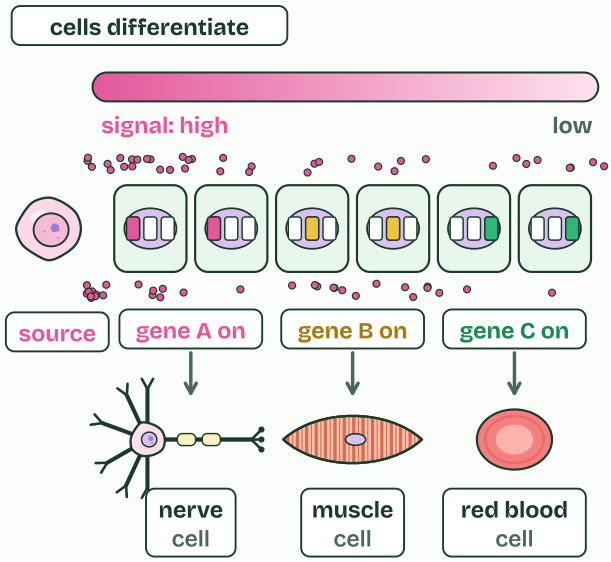
1. When a sperm fertilises an egg, the result is a single cell, the _____.
2. After about five days the ball of cells has become a hollow _____, with an outer layer that will help form the placenta and an inner cell mass that will form the body.
3. Every one of these cells has the same genes. They become different by _____: each cell switches on some of its genes and leaves others off.
4. Some cells release signal molecules that spread through the embryo, so there is a _____: a high concentration near the source and a low one far away.
5. The _____ divides by mitosis into unspecialised cells, then a blastocyst.
6. Every cell has the same genes; _____ is switching on different ones.

What is meant by gradient?

Your own notes

ANNOTATE THE FIGURE

Number the 5 steps on the figure and note what happens at each: 1 zygote; 2 unspecialised; 3 blastocyst; 4 switches on different genes; 5 differentiate.



SPOT THE MISTAKE

What do students often get wrong about production of unspecialized cells following fertilization and their development into specialized cells by differentiation? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 01 in two or three sentences of your own.

02 Cells that can still choose

B2.3.2

CUES

Predict: A stem cell divides and both daughters differentiate into red blood cell precursors. If this happened every time, what would go wrong?

What is meant by stem cell?

What is meant by self-renewal?

NOTES

1 A _____ is different in two ways.

2 It can divide again and again, for as long as the body needs, and keep making stem cells: this is _____.

3 A stem cell divides. One daughter _____; the other starts to specialise.

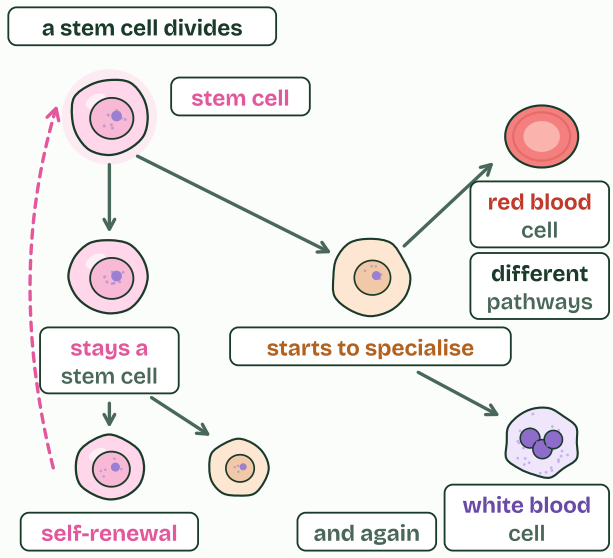
4 The stem cell can do it _____: self-renewal.

5 The other daughter's line can go down _____, here a red or a white blood cell.

Your own notes

ANNOTATE THE FIGURE

Number the 3 steps on the figure and note what happens at each: 1 stays a stem cell; 2 again and again; 3 different pathways.



SPOT THE MISTAKE

What do students often get wrong about properties of stem cells? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 02 in two or three sentences of your own.

03 Where stem cells live

B2.3.3

CUES

Predict: A patient loses a lot of blood in an accident. What happens in the bone marrow over the following days?

What is meant by niches?

NOTES

1 Adult stem cells are kept in special places called _____.

2 After heavy bleeding or an infection, signals from the niche speed this up. _____ A bulge in the side of each follicle holds stem cells.

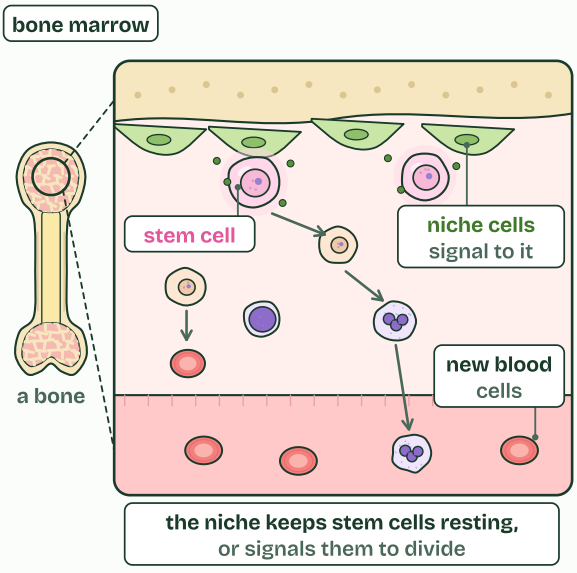
3 Bone marrow: _____.

4 Hair follicle bulge: _____.

Your own notes

ANNOTATE THE FIGURE

The figure shows it as Bone marrow and Hair follicle. Note what changes each time.



SPOT THE MISTAKE

What do students often get wrong about location and function of stem cell niches in adult humans? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 03 in two or three sentences of your own.

04 How many doors are open?

B2.3.4

CUES

Predict: Why would researchers who want to grow new nerve cells for a damaged spinal cord prefer pluripotent cells to bone marrow stem cells?

What is meant by totipotent?

What is meant by pluripotent?

What is meant by multipotent?

NOTES

1 The zygote and the cells of the first few divisions are _____: any one of them could make a whole organism, placenta included.

2 Within days, the cells of the inner cell mass are _____: they can become any cell of the body, but not the placenta.

3 Stem cells in adult tissue are _____.

4 _____: the zygote and the first cells; any cell, placenta included.

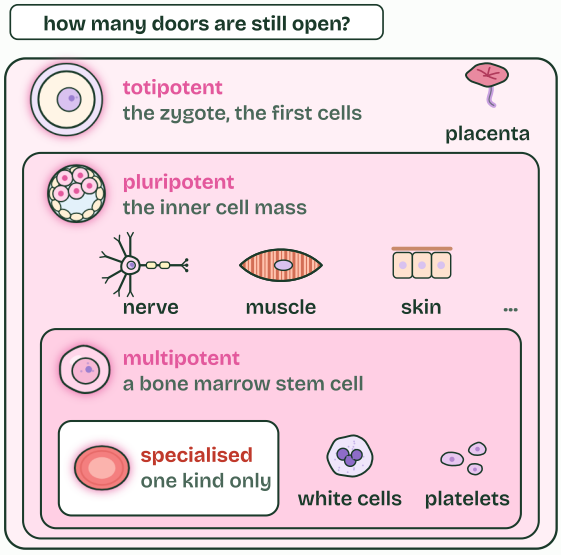
5 _____: the inner cell mass; any body cell.

6 _____: adult stem cells such as bone marrow; a few related cells.

Your own notes

ANNOTATE THE FIGURE

Label each part and say what it does: zygote, inner cell mass, bone marrow stem cell, red blood cell.



REMEMBER IT

Potency, widest first

T Total	P Plenty	M Many
T	P	M

SPOT THE MISTAKE

What do students often get wrong about differences between totipotent, pluripotent and multipotent stem cells? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 04 in two or three sentences of your own.

05 Small, large and very long

B2.3.5

CUES

Predict: Why can a neuron be a metre long, when cells generally have to stay small?

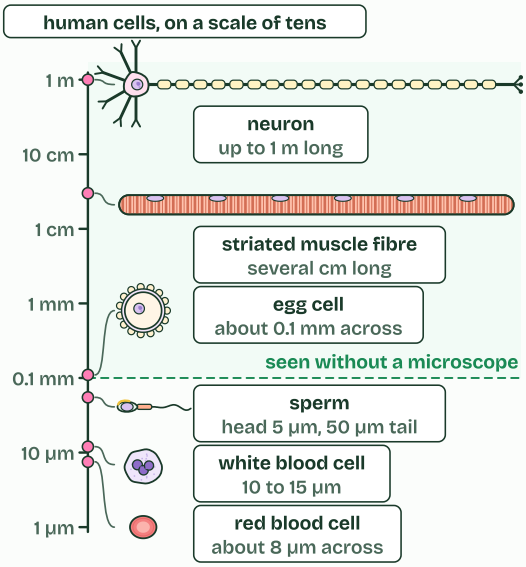
NOTES

1. A _____, about 8 µm across, is small enough to squeeze through the narrowest capillaries.
2. A _____ is a little bigger, at 10 to 15 µm.
3. A _____ has a head only about 5 µm long, small and light to swim, with a tail about ten times that.
4. The _____, about 0.1 mm across, is one of the few human cells you can just see with the naked eye: it carries food for the embryo's first days.
5. A _____ can run several centimetres, the length of the muscle, so it contracts as one.
6. And a _____ that runs from the base of your spine to your toe has a single fibre up to a metre long, carrying a signal the whole way without a break.

Your own notes

ANNOTATE THE FIGURE

Label the key parts and add a note on what it shows.



SPOT THE MISTAKE

What do students often get wrong about cell size as an aspect of specialization? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 05 in two or three sentences of your own.

06 Why cells stay small

B2.3.6

CUES

Predict: A cube of side 4 cm. What is its surface area to volume ratio?

What is meant by surface area to volume ratio?

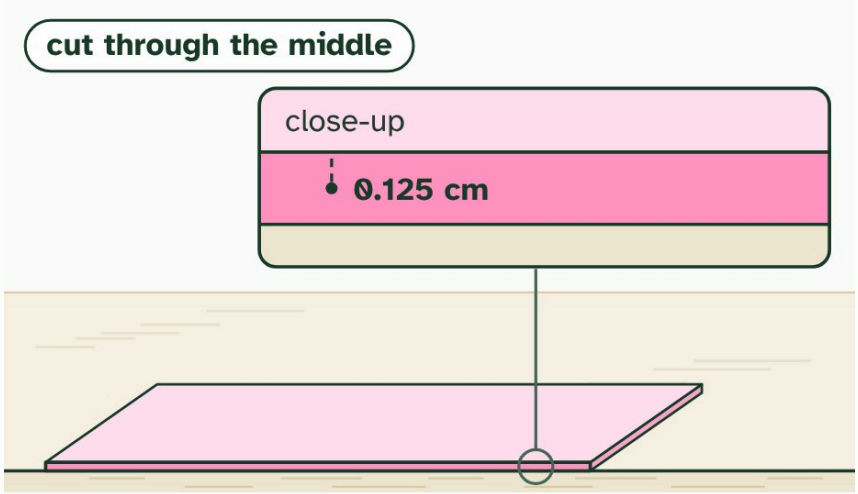
NOTES

1. So the rate of exchange depends on the cell's _____.
2. But the need for exchange depends on how much cytoplasm is using it up: the _____.
3. Model it with cubes: a cube of side 1 cm has a surface area of 6 cm^2 and a volume of 1 cm^3, a _____ of 6 to 1.
4. Cubes are a _____: real cells are not cubes, but the same scaling applies to any shape.

Your own notes

ANNOTATE THE FIGURE

Annotate this still from the animation (Bigger cells, slower supply): what is happening, and why?



shape	cube	sheet
surface area / cm^2	96	528
volume / cm^3	64	64
surface area : volume	1.5 : 1	8.25 : 1
centre to nearest face / cm	2	0.125
middle after soaking	pale	dyed

SPOT THE MISTAKE

What do students often get wrong about surface area-to-volume ratios and constraints on cell size? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 06 in two or three sentences of your own.

07 Flatten it, fold it, fringe it

B2.3.7 HL

CUES

Predict: Why are the folds at the base of a kidney tubule cell packed with mitochondria?

What is meant by biconcave?

What is meant by proximal convoluted tubule?

What is meant by invagination?

NOTES

1 Cells that exchange a lot have shapes that raise their ratio without making them smaller. _____ A red blood cell is a disc that is thinner in the middle than at the rim, a _____ shape.

2 **Microvilli.** The cells lining the _____ of the kidney have thousands of tiny finger-like projections of membrane facing the fluid in the tubule: a brush border that reabsorbs glucose, amino acids and salts. _____ On their other side, facing the blood, the membrane is folded deeply inwards, an _____, with mitochondria packed between the folds to power active transport.

3 Flattening: red blood cells, _____; type I pneumocytes, very thin.

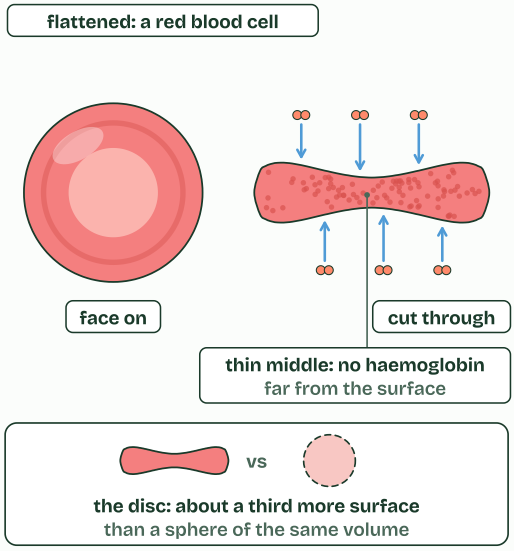
4 Microvilli: _____.

5 Infolding: _____.

Your own notes

ANNOTATE THE FIGURE

The figure shows it as Flattened and Microvilli and folds. Note what changes each time.



SPOT THE MISTAKE

What do students often get wrong about adaptations to increase surface area-to-volume ratios of cells? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 07 in two or three sentences of your own.

08 Two cells, one wall

B2.3.8 HL

CUES

Predict: Babies born very early often have trouble breathing. Which cell is most likely not yet working properly?

What is meant by pneumocytes?

What is meant by lamellar bodies?

What is meant by surfactant?

NOTES

1 The wall of each alveolus in the lungs is lined by two kinds of cell, the _____. _____ cover most of the surface.

2 _____ are fewer and thicker.

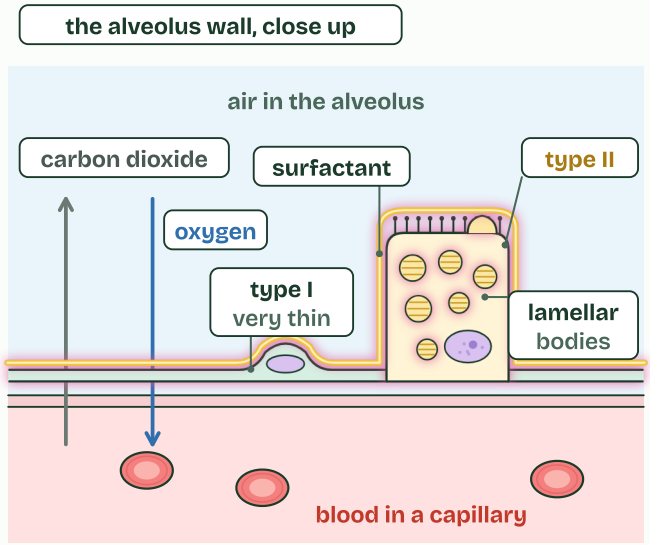
3 Their cytoplasm is full of _____, vesicles of _____ that they release onto the lining.

4 Type II: many _____, secrete surfactant.

Your own notes

ANNOTATE THE FIGURE

Label each part and say what it does: type I pneumocyte, type II pneumocyte, lamellar bodies, surfactant.



SPOT THE MISTAKE

What do students often get wrong about adaptations of type I and type II pneumocytes in alveoli? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 08 in two or three sentences of your own.

09 Is a muscle fibre a cell?

B2.3.9 HL

CUES

Predict: Why might branching suit heart muscle better than skeletal muscle?

What is meant by myofibrils?

What is meant by intercalated discs?

NOTES

1 Both kinds of muscle are packed with _____, bundles of the proteins that contract, giving both a striped look.

2 A _____ in a skeletal muscle is a single long cylinder, often several centimetres, with no branches and hundreds of nuclei just under its membrane.

3 _____ is made of shorter cells, each with one nucleus (sometimes two), that branch and join end to end at _____.

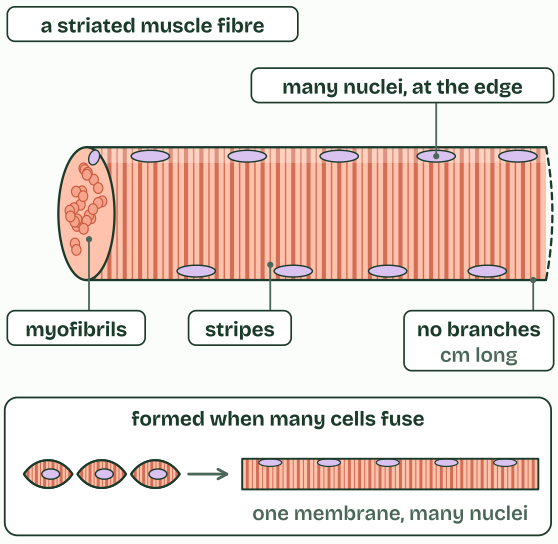
4 Both: contractile _____.

5 Cardiac: branched cells, one nucleus each, joined by _____.

Your own notes

ANNOTATE THE FIGURE

The figure shows it as Striated fibre and Cardiac muscle. Note what changes each time.



SPOT THE MISTAKE

What do students often get wrong about adaptations of cardiac muscle cells and striated muscle fibres? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 09 in two or three sentences of your own.

10 Small and fast, big and stocked

B2.3.10 HL

CUES

Predict: A man's sperm have normal heads and tails but few mitochondria in the midpiece. What problem would you expect?

What is meant by acrosome?

What is meant by zona pellucida?

What is meant by cortical granules?

NOTES

1 A _____ must swim and fuse.

2 Its head holds a haploid nucleus, tightly packed, and a cap, the _____, full of enzymes that digest a way through the layers round the egg.

3 Its midpiece is packed with mitochondria that make ATP for a long _____ that beats to drive it along.

4 The _____ is huge by comparison and does not move.

5 Its cytoplasm is rich in food, droplets of lipid and protein, for the embryo's first days. It is surrounded by a jelly-like layer, the _____, and a layer of follicle cells.

6 Just under its membrane are _____, which release their contents as soon as one sperm enters, so that no other can follow.

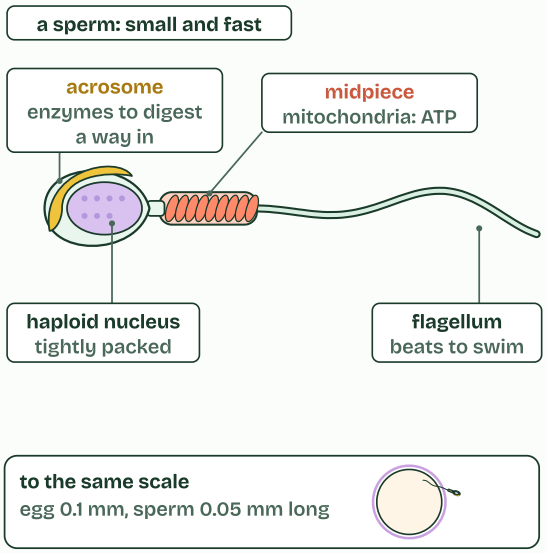
7 Sperm: _____, haploid nucleus, mitochondria, flagellum; little cytoplasm.

8 Egg: large, food stores, haploid nucleus, _____, cortical granules.

Your own notes

ANNOTATE THE FIGURE

The figure shows it as Sperm and Egg cell. Note what changes each time.



SPOT THE MISTAKE

What do students often get wrong about adaptations of sperm and egg cells? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 10 in two or three sentences of your own.

Check yourself

The check for this guide is online: a fresh paper of past-paper style questions from the exam bank on B2.3 each time, marked as you go, and saved to your Exam practice progress when you are signed in. Scan the code, or type the link.

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How this was made. The course structure, the activities and the teaching choices come from my own classroom, my presentations and my years of teaching IB and AP Biology. I use Claude, an AI, to help write and build the interactive guides, lesson plans, slides and practice questions, and to draw the diagrams and code the interactives. I direct the work and review it against the IB and AP specifications before it goes live.