



Physics. *You work it out.*

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Comparing Cells

A Level
P P P

Part A Bacteria vs sperm cells

Which of the following statements are correct for both bacterial cells and sperm cells? Select all that apply.

- ☐ The cell can divide.
 - ☐ The cell has a nucleus.
 - ☐ The cell can carry out respiration.
 - ☐ The cell has a cell wall.
 - ☐ The cell contains DNA.
-

Part B Blood, kidney, or testis?

Three samples of cells were taken from the same healthy human: one sample from the blood, one sample from a kidney, and one sample from a testis.

Each sample contained five cells, three of one type and two of a different type. None of the cells were dividing.

In each sample, the mean number of chromosomes per cell was calculated. The results are shown in the table below.

Match the sample to the tissue type.

Sample	Mean number of chromosomes per cell	Tissue
1	18.4	<input type="text"/>
2	32.2	<input type="text"/>
3	46.0	<input type="text"/>

Items:

- kidney
- testis
- blood

In the blood sample above, how many of the cells were red blood cells?

In the testis sample above, how many of the cells were sperm cells?

Part C Cell types and genes

A student compared the properties of different cells from one healthy human.

Which of the following statements are correct? Select all that apply.

Assume that no mutations occur.

- ☐ A cheek cell contains the same alleles as an embryonic stem cell.
 - ☐ A white blood cell contains the same number of DNA bases as a mature red blood cell.
 - ☐ A sperm cell contains the same genome as a cheek cell.
 - ☐ An embryonic stem cell produces all of the same proteins as a white blood cell.
-

Question elements adapted with permission from NSAA 2019 Section 1 Q55, NSAA 2020 Section 2 Q54, and NSAA 2021 Section 1 Q79

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Zygote Cleavage

A Level



A zygote (fertilised egg cell) is spherical and has a volume of $0.12 \mu\text{m}^3$.

In the initial stages of development, the zygote undergoes several rounds of cleavage. During cleavage, cells divide by mitosis but do not grow. Assume that when cells undergo cleavage, the daughter cells are spherical and are identical to each other.

Part A Volume

After three rounds of cleavage, what will the volume of each cell be?

What is the ratio of the volume of the zygote to the volume of one of the cells after three rounds of cleavage? Express the ratio in its simplest form (e.g. 3 : 1).

Part B Diameter

What is the ratio of the diameter of the zygote to the diameter of one of the cells after three rounds of cleavage? Express the ratio in its simplest form (e.g. 3 : 1).

The volume of a sphere is given by $\frac{4}{3}\pi r^3$, where r is the radius.

Part C Chromosome number

If the zygote is a human zygote with no chromosomal abnormalities, how many chromosomes will each cell have after three rounds of cleavage?

Assume that no mutations occur during cleavage.

Adapted with permission from NSAA 2020 Section 2 Q59

Gameboard:

STEM SMART Biology Week 16

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Liver Cells and White Blood Cells

A Level

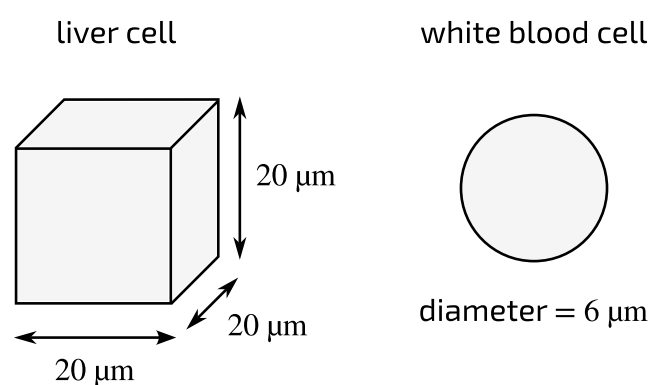


Figure 1: A schematic of two healthy adult human cells: a liver cell (approximately cube-shaped) and a white blood cell (approximately sphere-shaped). The cells are not dividing.
The cells are not shown to scale.

Part A Liver cell mitochondrial volume

A study estimates that mitochondria account for 12% of the volume of each type of cell. Using this estimate, calculate the volume that mitochondria occupy in an adult liver cell.

Give your answer to 2 significant figures.

Part B White blood cell mitochondrial volume

A study estimates that mitochondria account for 12% of the volume of each type of cell. Using this estimate, calculate the volume that mitochondria occupy in an adult white blood cell.

The volume of a sphere is given by $\frac{4}{3}\pi r^3$, where r is the radius.

Give your answer to 2 significant figures.

Part C Cell statements

Which of the following statements are correct? Select all that apply.

- ☐ The larger number of mitochondria in the liver cell will produce more lactic acid than those in the white blood cell.
 - ☐ The liver cell is larger and so will contain a greater mass of nuclear DNA than the white blood cell.
 - ☐ The white blood cell will contain a greater mass of nuclear DNA than a fully differentiated red blood cell.
 - ☐ None of the above statements are true.
-

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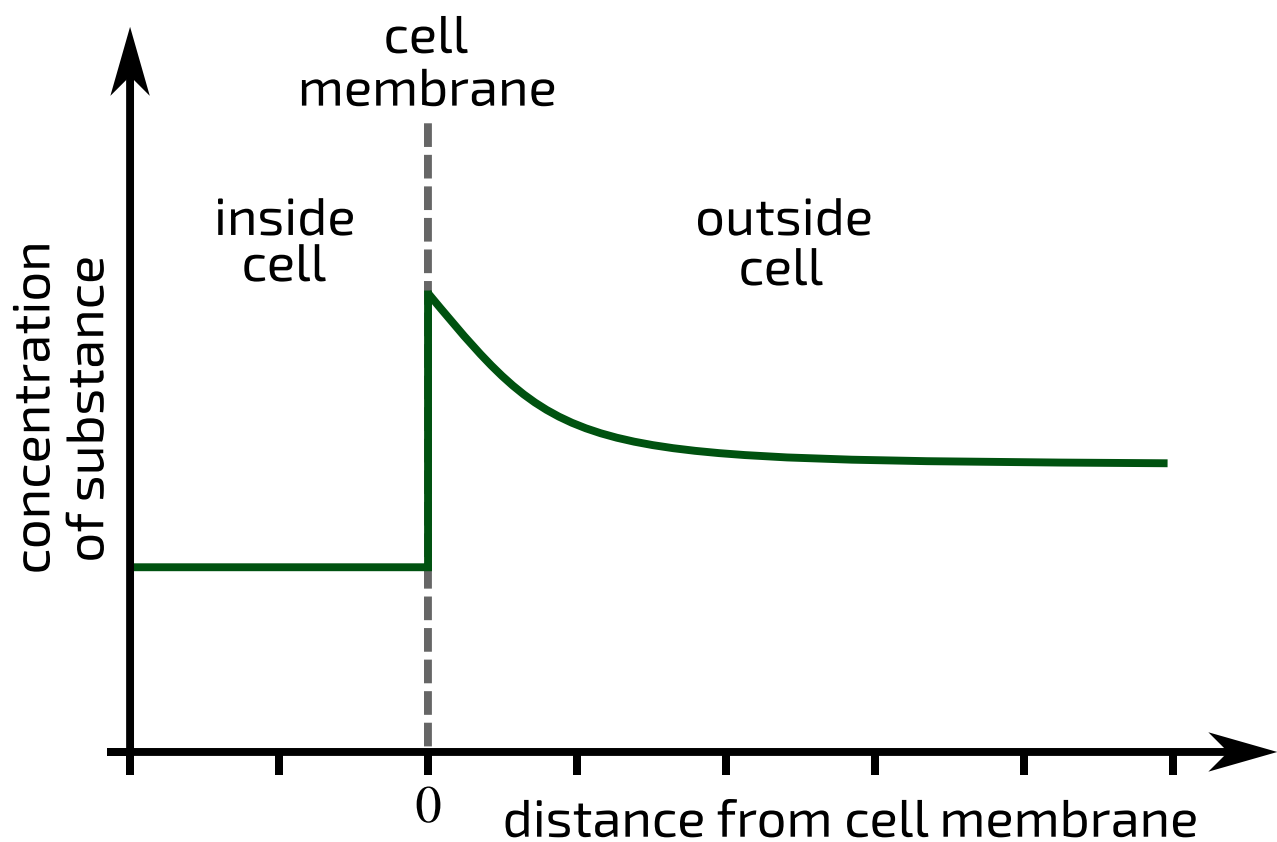


Membrane Concentration Gradients

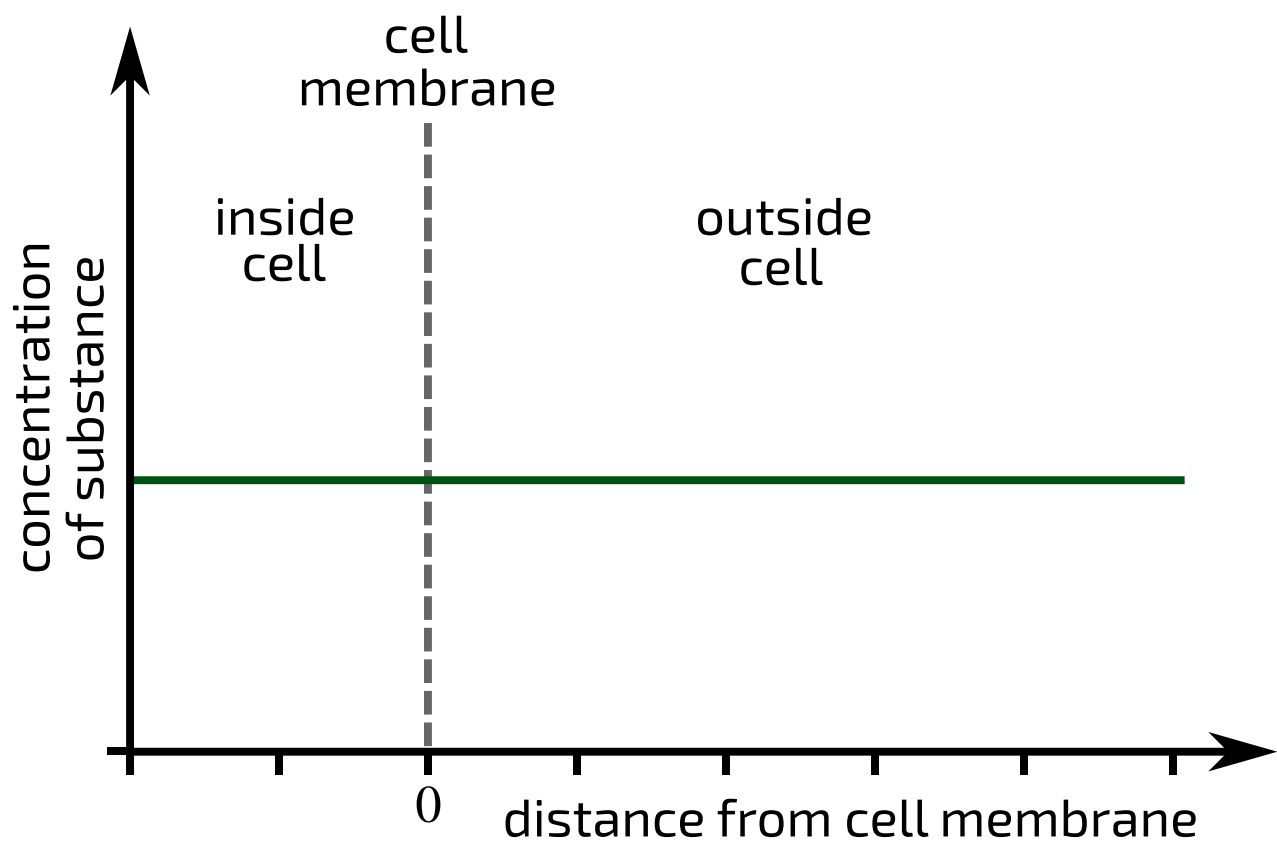
A Level



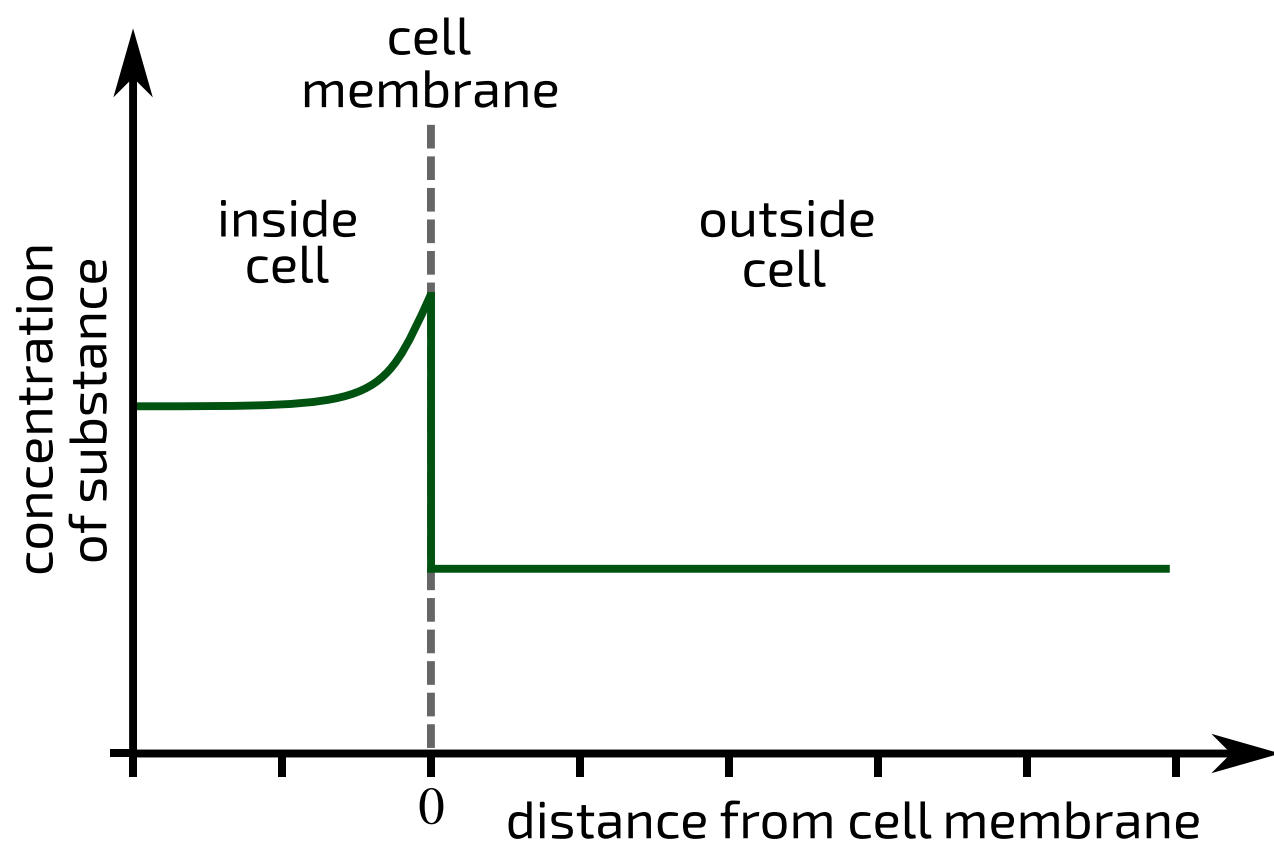
The graphs below show the concentrations of substances at different distances from the cell membrane. The concentrations shown are maintained over time.



A



B



C

Part A Active transport

Which of the images above show the concentration of a substance that moves across the membrane by active transport?

- ☐ A
- ☐ B
- ☐ C

Part B Passive transport

Which of the images above show the concentration of a substance that moves across the membrane by passive transport?

- ☐ A
- ☐ B
- ☐ C

Part C Forms of passive transport

Which of the following are forms of passive transport?

- ☐ Simple diffusion
 - ☐ Primary active transport
 - ☐ Secondary active transport
 - ☐ Osmosis
 - ☐ Facilitated diffusion
-

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Osmotic Effects

A Level



Part A Sugar solutions

A cell from the epithelium of an animal was removed. The cytoplasm of this cell can be considered as a 2% sugar solution. The living cell was placed in a 4% sugar solution.

Which of the following statements are correct? Select all that apply.

- ☐ Water moved out of the cell by osmosis.
- ☐ Osmosis was most rapid when the cell was first placed in the solution.
- ☐ At equilibrium, the sugar concentration in the cell was 6%.
- ☐ Water continued to move across the cell membrane after equilibrium was reached.
- ☐ Sugar moved into the cell by osmosis.
- ☐ Water moved into the cell by osmosis.

Part B K^+ concentrations

The table below shows the concentration of potassium ions in several different locations.

Location	Concentration of potassium ions
bacterial cell cytoplasm	30 mmol dm^{-3}
mammalian blood plasma	$4\,000\text{ }\mu\text{mol dm}^{-3}$
mammalian heart cell cytoplasm	$1.0 \times 10^2\text{ mmol dm}^{-3}$
seawater	$3.0 \times 10^4\text{ }\mu\text{mol dm}^{-3}$
yeast cell cytoplasm	300 mmol dm^{-3}

Which of the following statements are correct? Select all that apply.

- ☐ There is no concentration gradient for potassium ions between a bacterial cell and seawater.
- ☐ A mammalian heart cell needs energy from respiration in order to obtain more potassium ions from blood plasma.
- ☐ If a yeast cell is placed in seawater then it will lose potassium ions by osmosis.
- ☐ If a yeast cell is placed in seawater then it will gain water by osmosis.
- ☐ A mammalian heart cell has a higher concentration of potassium ions than a yeast cell.

Part C Catalase catalysis

Catalase is an enzyme found inside plant and animal cells. When catalase is added to hydrogen peroxide, bubbles of oxygen gas are formed.

Red blood cells were placed into either pure water or blood plasma, and were placed in the dark.

Plant cells were placed into either water or 0.5 mol dm^{-3} sucrose solution, and were placed in the dark.

Hydrogen peroxide was then added to each of the four experimental setups.

Assume that hydrogen peroxide and catalase do not cross the cell surface membrane.

In which experimental setup will oxygen bubbles form? Select all that apply.

- ☐ red blood cells in plasma
 - ☐ plant cells in a 0.5 mol dm^{-3} sucrose solution
 - ☐ red blood cells in pure water
 - ☐ plant cells in pure water
 - ☐ none of the above
-

Why did the cells need to be placed in the dark for the researchers to investigate osmotic effects on cells? Select all that apply.

- ☐ In the light, blood cells would produce oxygen by respiration, and so oxygen bubbles would form regardless of any interaction between catalase and hydrogen peroxide.
 - ☐ Catalase is denatured by light.
 - ☐ In the light, plant cells would produce oxygen by respiration, and so oxygen bubbles would form regardless of any interaction between catalase and hydrogen peroxide.
 - ☐ Hydrogen peroxide only breaks down into water and oxygen in the dark.
 - ☐ In the light, blood cells would produce oxygen by photosynthesis, and so oxygen bubbles would form regardless of any interaction between catalase and hydrogen peroxide.
 - ☐ In the light, plant cells would produce oxygen by photosynthesis, and so oxygen bubbles would form regardless of any interaction between catalase and hydrogen peroxide.
-

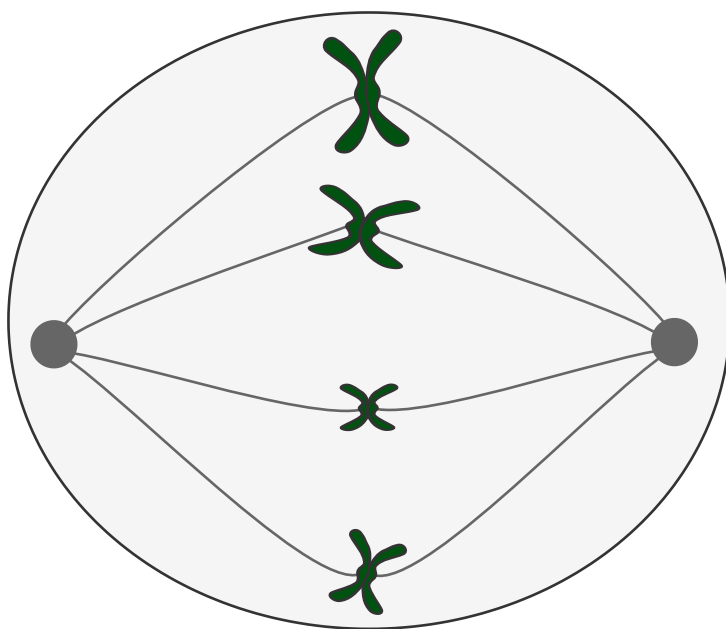


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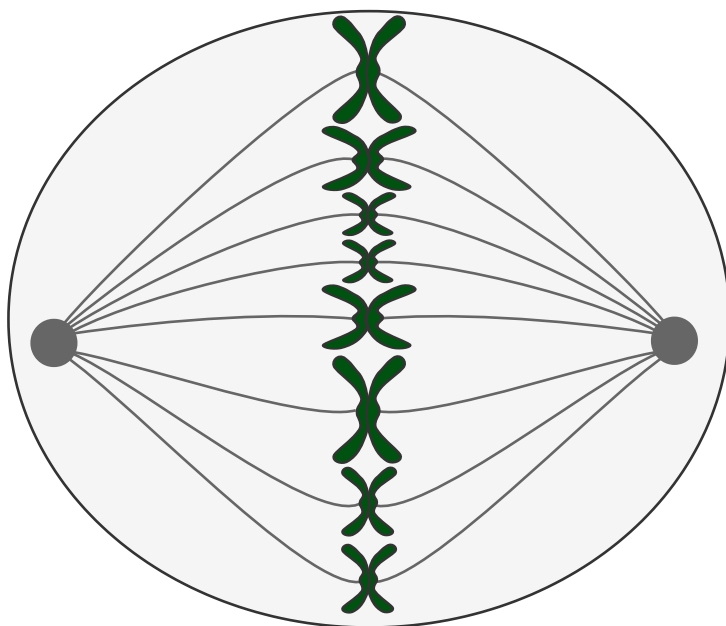
Mitosis and Meiosis

A Level
C C C

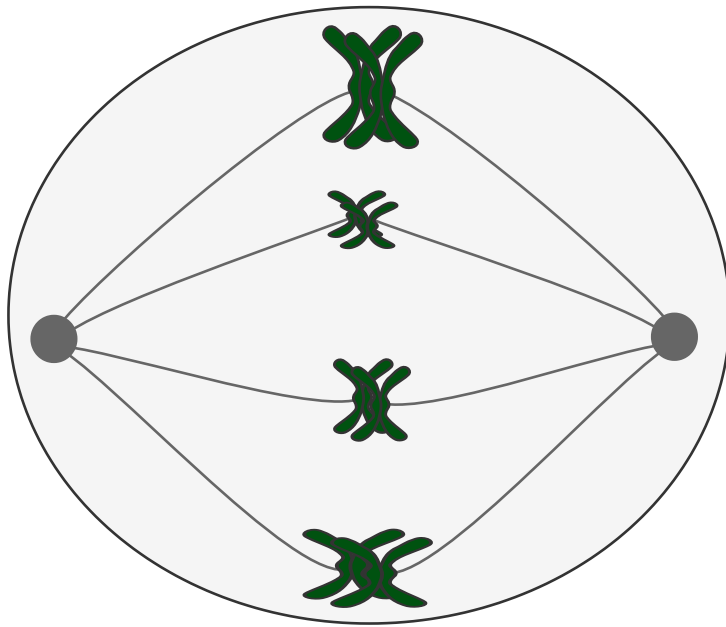
The images below show cells from the same organism undergoing different types of cell division.



A



B



C

Part A Mitosis or Meiosis?

Match the cell above to the type of cell division.

- cell A:
- cell B:
- cell C:

Items:

mitosis

meiosis I

meiosis II

Part B Cell division phases

Which phase of cell division are all of these cells undergoing?

Part C Chromosome numbers

How many chromosomes would a normal sperm cell from this species have?

How many chromosomes would a normal zygote from this species have?

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