

B2.3 Cell specialization

Unspecialized cells

→ A zygote, following fertilization and further development, will turn into specialized cells by differentiation.

→ The cells in the zygote and embryo are unspecialized stem cells.

→ As the cells continue to divide, they begin to specialize in structure and function

→ Morphogens are signaling molecules that direct cell fate decisions

→ Morphogens control proliferation, differentiation during embryonic development to determine the formation of tissues and organs

Properties of stem cells

- Can divide repeatedly and differentiate into a specific cell type.
- They are found in the bone marrow, skin and liver

Totipotent, pluripotent and multipotent stem cells

There are three main types of stem cells present at various stages of human development:

Totipotent – Can form any cell type, as well as extra-embryonic (placental) tissue (e.g. zygote)

Pluripotent – Can form any cell type (e.g. embryonic stem cells)

Multipotent – Can differentiate into a number of closely related cell types (e.g. haematopoietic adult stem cells)

However, pluripotent stem cells are most prevalent in the early embryonic development of a multicellular organism.

Surface area to volume ratio

A small surface area to volume ratio has important implications for processes involving transport into and out of cells across membranes. For e.g. activities like gas exchange and transport of useful or waste material can be done more efficiently, replacement of damaged cells, flexibility.

Please fill in the table below:

Cube size	Surface area	Volume	Surface area to volume ratio
2 cm cube	$2 \times 2 \times 6 = 24 \text{ cm}^2$ (2 cm x 2 cm x 6 sides)	$2 \times 2 \times 2 = 8 \text{ cm}^3$ (height x width x depth)	24 to 8 = 3:1
3 cm cube			
4 cm cube			
5 cm cube			

Higher Level

Adaptations to increase surface area-to-volume ratios of cells

Examples of cells that are specialized for exchange of materials and have adaptations to increase the SA:V ratio include:

Sperm cells: 50µm long, which is longer than most cells, but are also extremely narrow reducing resistance when swimming towards the egg.

Egg cells: 110µm in diameter which is the largest of any human cell. It allows large quantities of food reserves to be stored in the cytoplasm (see yolk in eggs)

Adaptations of cells that maximize the SA: volume ratio

Cells are specialized for exchange processes. Kidney cells are able to re-absorb useful substances rapidly.

Red blood cells have the unique ability to load and unload millions of O₂ rapidly.

**We will see more of these adaptations later on in pneumocytes in alveoli, cardiac muscle cells, egg and sperm cells as well as muscle fibres.*