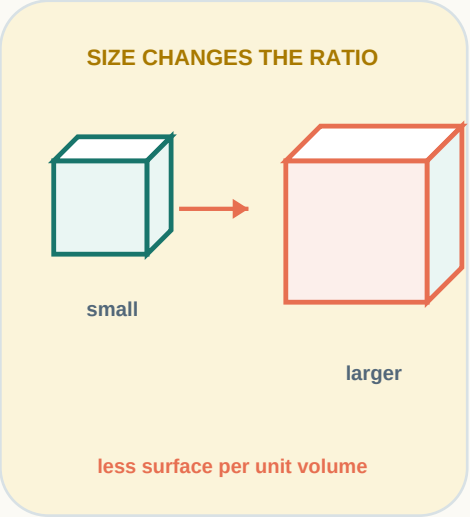
AP BIOLOGY | UNIT 2

TOPIC 2.2

Cell Size

Cell size is constrained by the amount of membrane available for exchange relative to the demands of the cytoplasm.



THE CORE CAUSAL CHAIN

SIZE RISES → same shape

VOLUME → grows faster

SA:V FALLS → less membrane per volume

EXCHANGE → becomes limiting

BY THE END, YOU SHOULD BE ABLE TO...

1. Calculate and compare surface-area-to-volume ratios.
2. Explain why exchange becomes harder as cells grow.
3. Connect cell shape, folds, and division to efficient exchange.

BIG IDEA

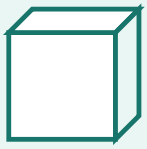
Surface area controls exchange capacity; volume reflects cellular demand. Efficient cells keep the two in balance.

1 Why surface area-to-volume ratio matters

For similar shapes, surface area scales with length squared while volume scales with length cubed.

COMPARE THREE CUBES

SIDE = 1 UNIT

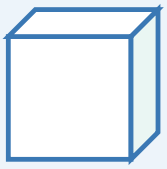


SA = 6 x 1^2 = 6

V = 1^3 = 1

SA:V = 6:1

SIDE = 2 UNITS

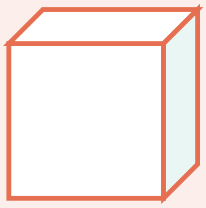


SA = 6 x 2^2 = 24

V = 2^3 = 8

SA:V = 3:1

SIDE = 4 UNITS



SA = 6 x 4^2 = 96

V = 4^3 = 64

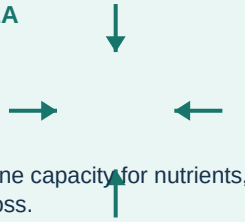
SA:V = 1.5:1

WHAT CHANGES AS SIZE INCREASES?

MEMBRANE SURFACE	increases	but not as fast as volume
INTERNAL DEMAND	increases faster	more cytoplasm needs resources
DIFFUSION DISTANCE	often increases	materials travel farther

CAPACITY VS. DEMAND

SURFACE AREA



Sets the membrane capacity for nutrients, gases, water, and wastes to cross.

VOLUME

cell demand

Represents the metabolically active cytoplasm that must be supplied and maintained.

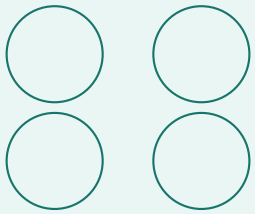
AP SCOPE NOTE

For a cube: surface area = 6L^2 and volume = L^3. Compare ratios, not total surface area alone.

2 How cells maintain efficient exchange

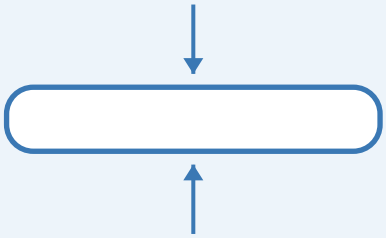
Cells stay small or alter shape and membrane geometry to increase surface area or reduce diffusion distance.

REMAIN SMALL



A smaller cell has more membrane surface relative to each unit of cytoplasm.

FLATTEN OR ELONGATE



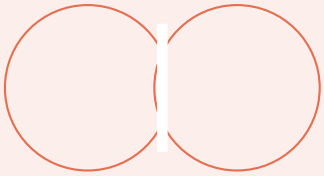
A thin shape increases surface exposure and shortens internal diffusion distance.

ADD FOLDS OR PROJECTIONS



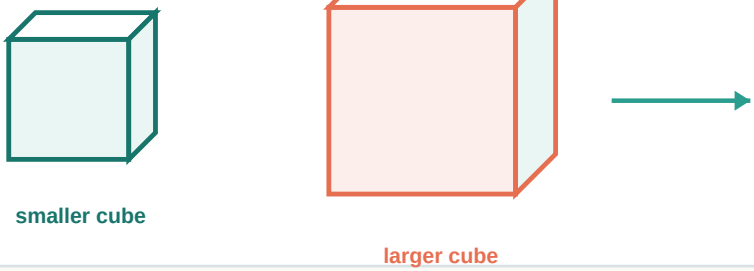
Microvilli, root hairs, and membrane folds add surface with little extra volume.

DIVIDE



Cell division replaces one large cell with smaller cells that have higher SA:V ratios.

AGAR-CUBE DIFFUSION MODEL



If dye penetrates the same distance in the same time, the smaller cube has a larger fraction of its volume reached. This models why diffusion serves smaller cells more effectively.

COMMON ERROR

A larger cell has more total surface area but less surface area relative to its volume. The ratio is the limiting relationship.