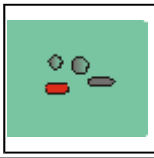
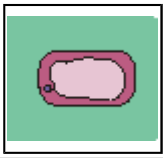
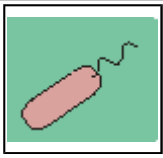
How Cells Get Around the SA/V Problem

Central Problem #4: How can a cell gain the advantages of growing larger while avoiding the inefficiencies of increased size?

To be successful, a larger cell must compensate for the supply problems created by a lower surface area / volume ratio.

SOLUTION	EXPLANATION	GRAPHIC	EXAMPLES
Avoidance			
Avoid the problem - stay small	Small size maximizes surface area to volume, allowing the most efficient import/export possible. Small cells can gather nutrients and reproduce extremely rapidly		small bacteria, yeasts
Geometric Solutions			
-	Increase Surface Area		
Elongate or flatten out	A sphere has a low SA/V ratio. Cells that are drawn out (e.g. cylinder), or flattened have much more membrane per unit of cytoplasm		bacillus bacteria, red blood cells
Fold the surface membrane	Extending the outer surface of a cell into folds, fingers or indentations can increase the total surface area by a factorof several times		amoeba, intestinal cells with microvilli.
-	Decrease effective volume		
Hollow out centre of cell	A cell with a large water-filled vacuole in the center has much less active cytoplasm than its measurements would suggest. Its metabolic demands are therfore not as great.		mature plant cells
Increasing rate of supply			
Seek out areas where nutrient concentration is high	Mobile cells can avoid areas with sparse nutrients (low diffusion rates) and actively seek areas where diffusion rates will be high.		Protists, some algae
Actively acquire bulk nutrients	By taking in food in vacuoles, cells increase their total imports and provide themselves with small, extremely rich bubbles of nutrients. The high concentration of nutrients in a vacuole will significantly increase diffusion rates.		Amoeba, Paramecium, intestinal epithelium
Improve transportation of nutrients within cell	By moving nutrients rapidly away from the membrane, concentrations gradients across the membrane can be maintained.		cyclosis in leaf cells
Improving efficiency to reduce demand			

Division of labour within cell	By partitioning areas of cytoplasm to specialize in only one function, a cell can develop much more efficient enzyme systems, can avoid possible conflicts between chemical processes, and can add a whole new level of feedback and control. The complex organelles of higher cells allow them to divide labour effectively.		eukaryotic cells
Division of labour between cells	By joining together, cells can remain relatively small while forming an organism that gains the advantages of large size. Each cell can then specialize to carry out one or two of the basic life processes, while maintaining a mutually dependent relationship with all the other cells.		plants, animals, most fungi, some algae