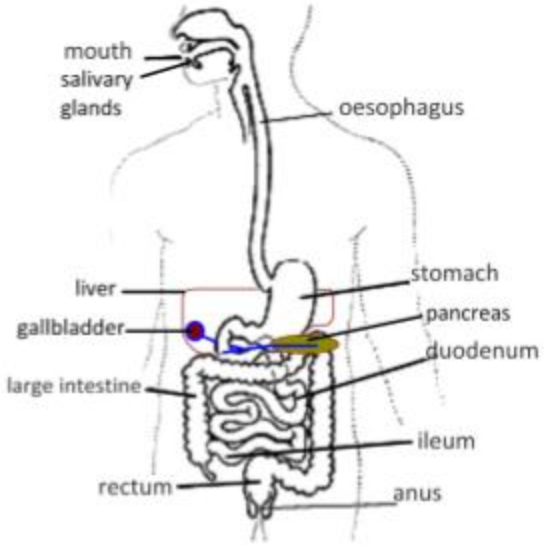
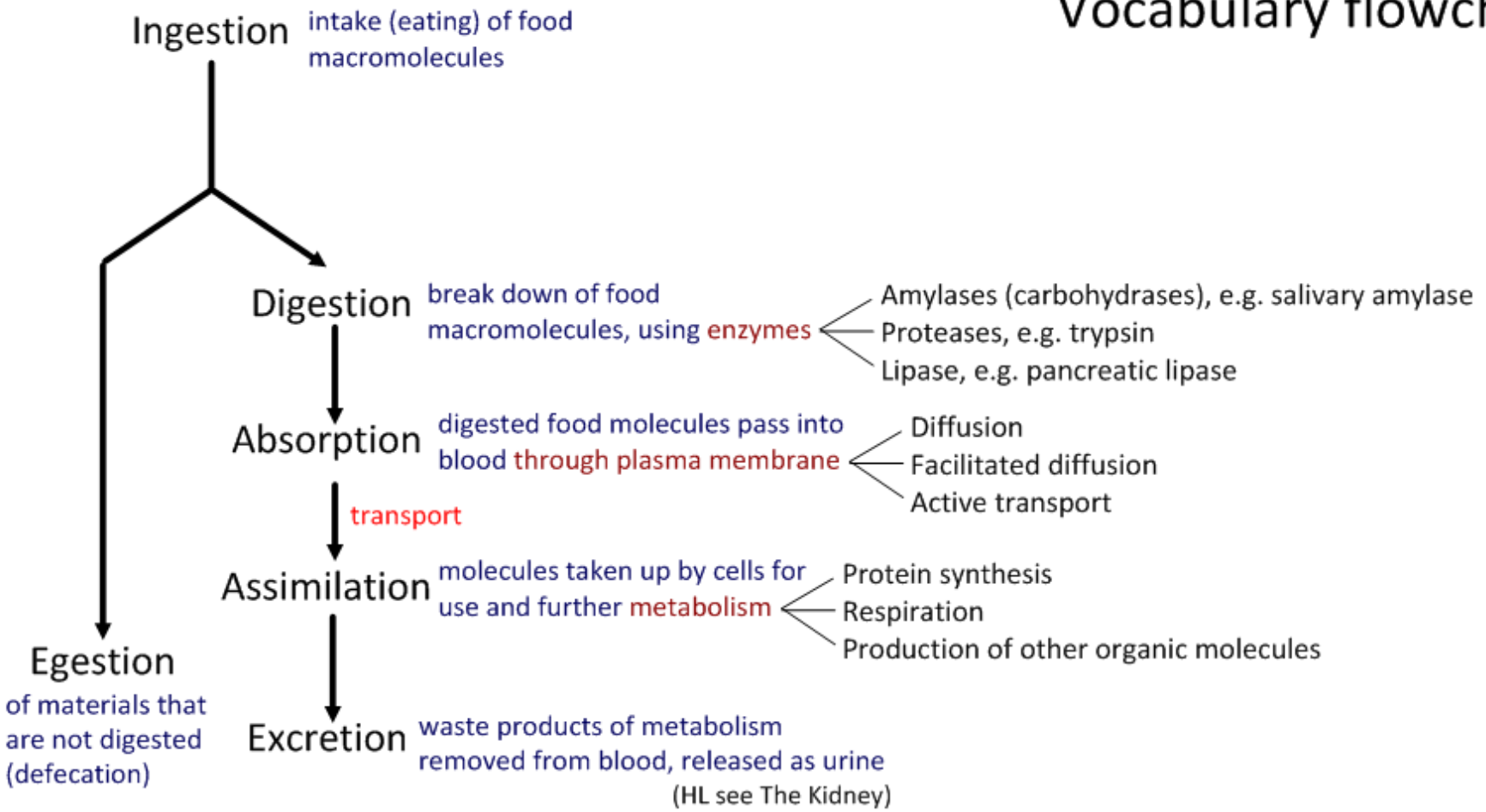


Digestion (core)

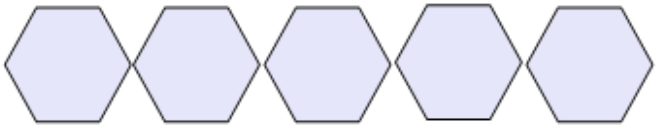
Stephen Taylor
Bandung International School

Vocabulary flowchart

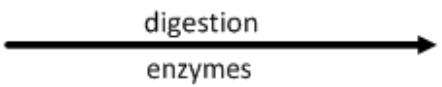


Large food molecules need to be digested before the nutrients can be absorbed:

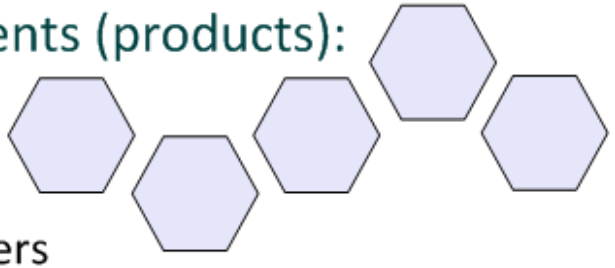
Food molecules (substrates):



macromolecules
large/ polymers



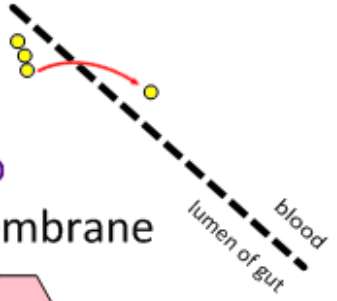
Nutrients (products):



monomers
single units

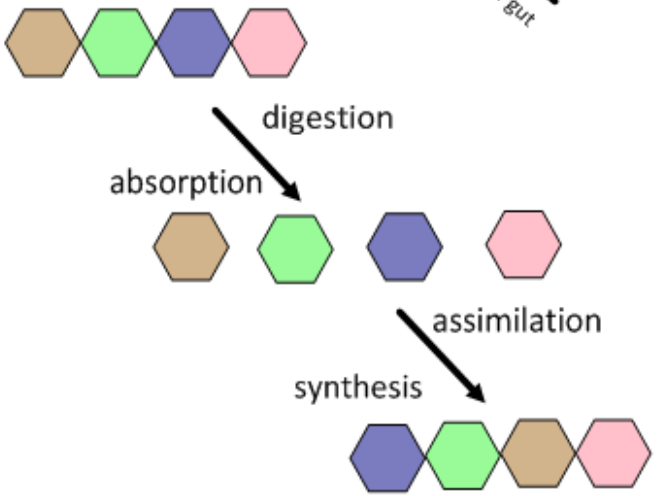
Why is digestion necessary?

Macromolecules are too large to be absorbed through plasma membrane



Polymers are insoluble.
Diffusion across membranes requires that molecules are dissolved in a solution.

Macromolecules in the food source may not be as useful in the human body - but the component molecules can be digested, absorbed, assimilated and reassembled into more useful configurations in the body's cells.



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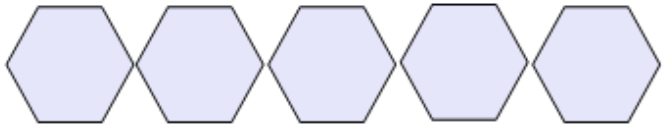
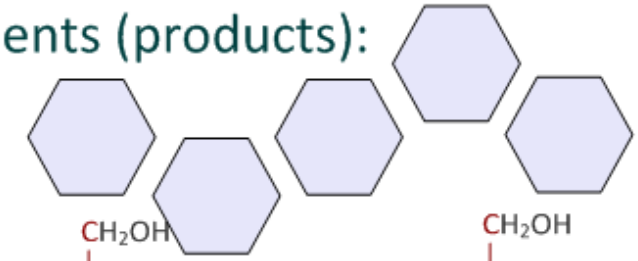
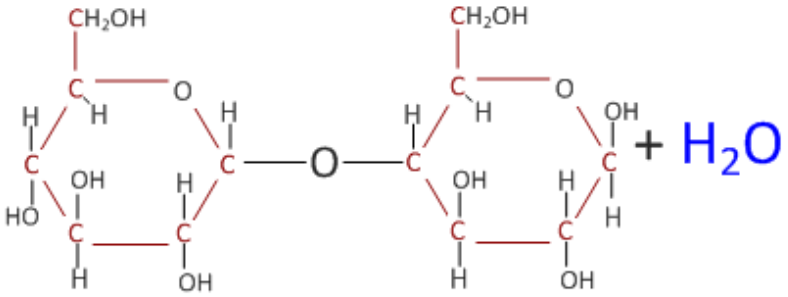


digestion

enzymes

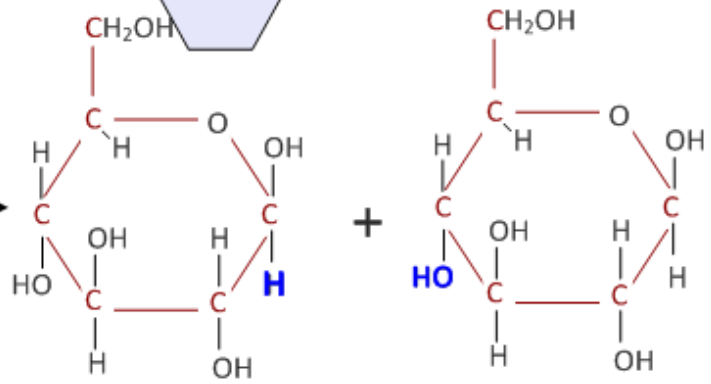
Nutrients (products):



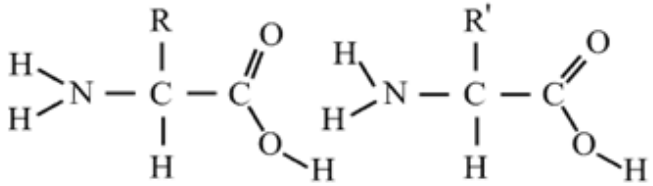


hydrolysis*

enzyme



Time to revise hydrolysis!



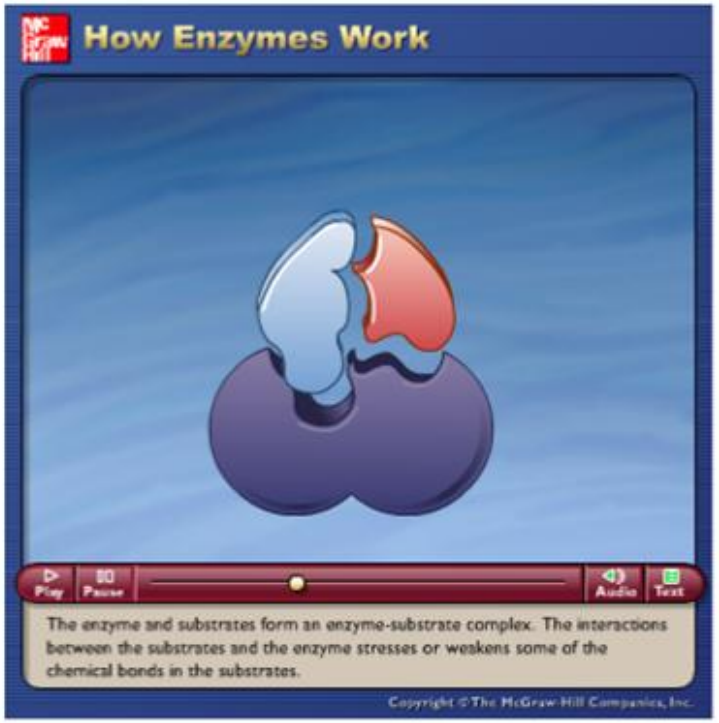
http://www.biotopics.co.uk/as/aminocon.html

Remember:

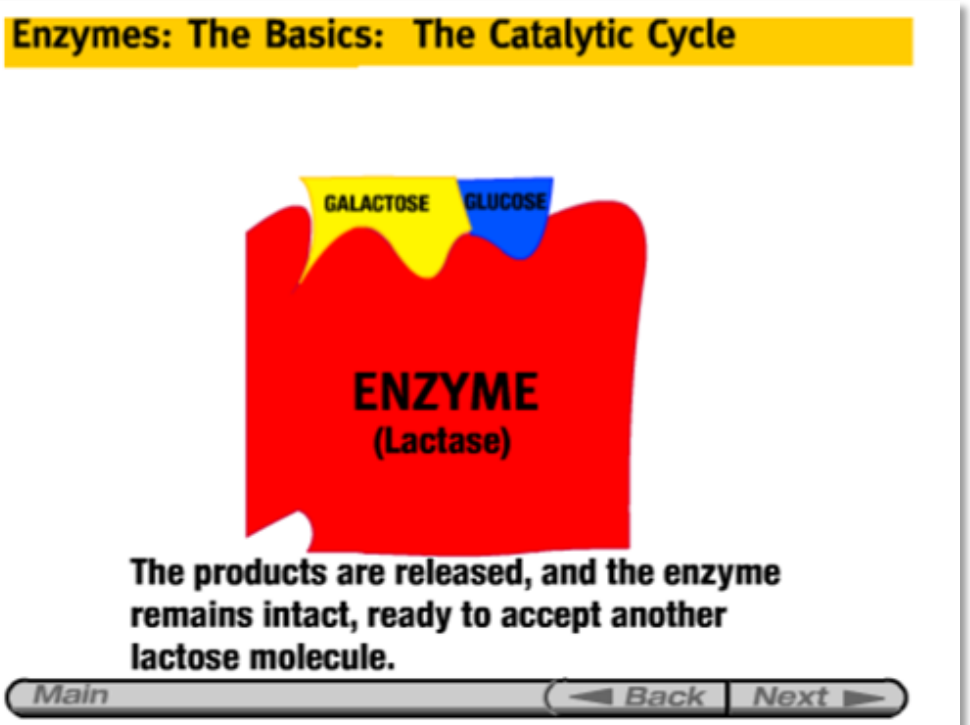
hydrolysis (water-splitting) is the reaction used to break down large organic molecules (carbohydrates, lipids and proteins).

Enzymes are needed in these reactions.

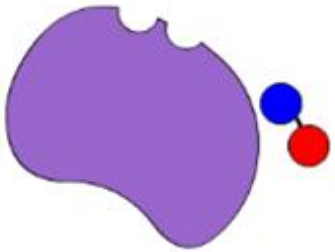
Revising enzyme activity:



http://highered.mcgraw-hill.com/sites/0072495855/student_view0/chapter2/animation__how_enzymes_work.html

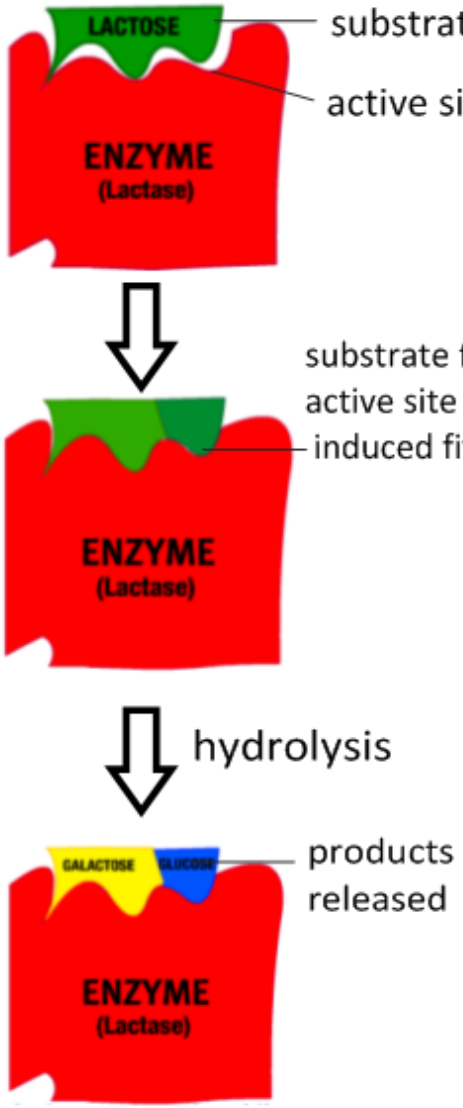


http://programs.northlandcollege.edu/biology/Biology1111/animations/enzyme.swf



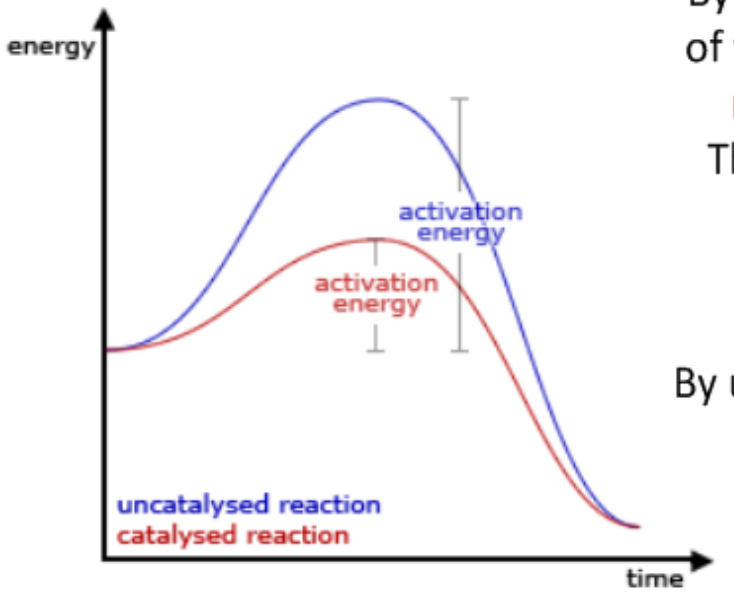
And plenty of animations at:
http://www.kscience.co.uk/animations/anim_2.htm

Enzymes are essential in digestion



images from:
http://programs.northlandcollege.edu/biology/Biology1111/animations/enzyme.swf

Enzymes are biological catalysts - globular proteins that increase the rate of a reaction by lowering activation energy. Digestive enzymes are released into the gut from glands and are used in catabolic reactions - they break down larger molecules.

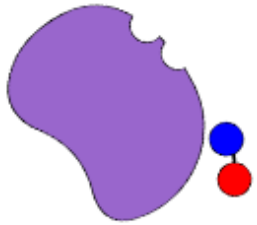


http://upload.wikimedia.org/wikipedia/en/a/af/Catalyst_effect.png

By lowering the activation energy of the reaction, the reaction does not require high temperatures. This is ideal in living things - high temperatures would cause damage to cells and proteins.

By using an enzyme, reactions can occur more quickly at body temperature.

Human digestive enzymes:

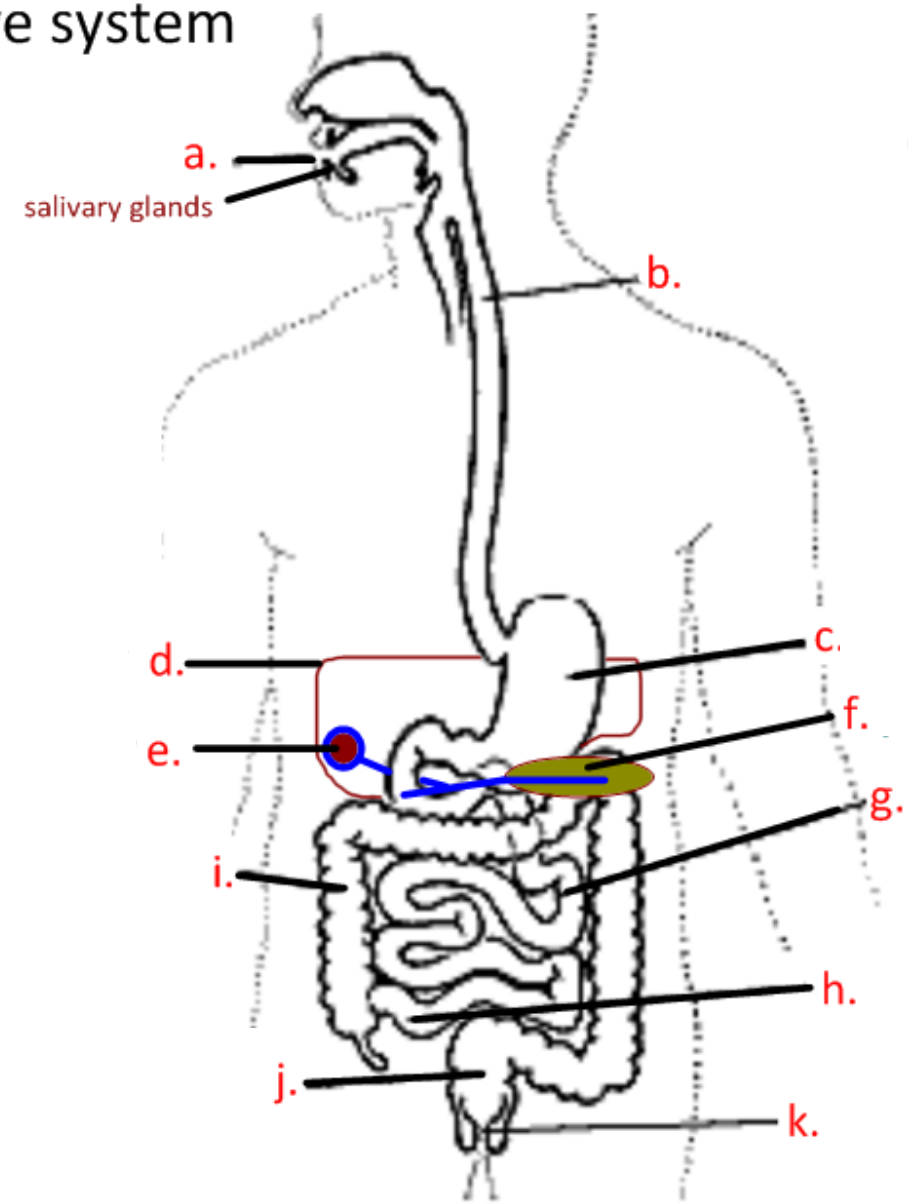


	Amylase	Protease	Lipase
macromolecule	carbohydrates	proteins	lipids/fats
example	salivary amylase	trypsin	pancreatic lipase
substrate	starch	polypeptides	triglycerides
products	maltose	amino acids	fatty acids & glycerol
source	mouth (salivary glands)	duodenum (small intestine)	pancreas
optimum pH	7-7.8	8	7.2-7.5

Question: where might we find enzymes with an optimum pH of 2?

Label the digestive system

Parts of the digestive tract are labelled in brown. Food does not pass through parts labelled in green.



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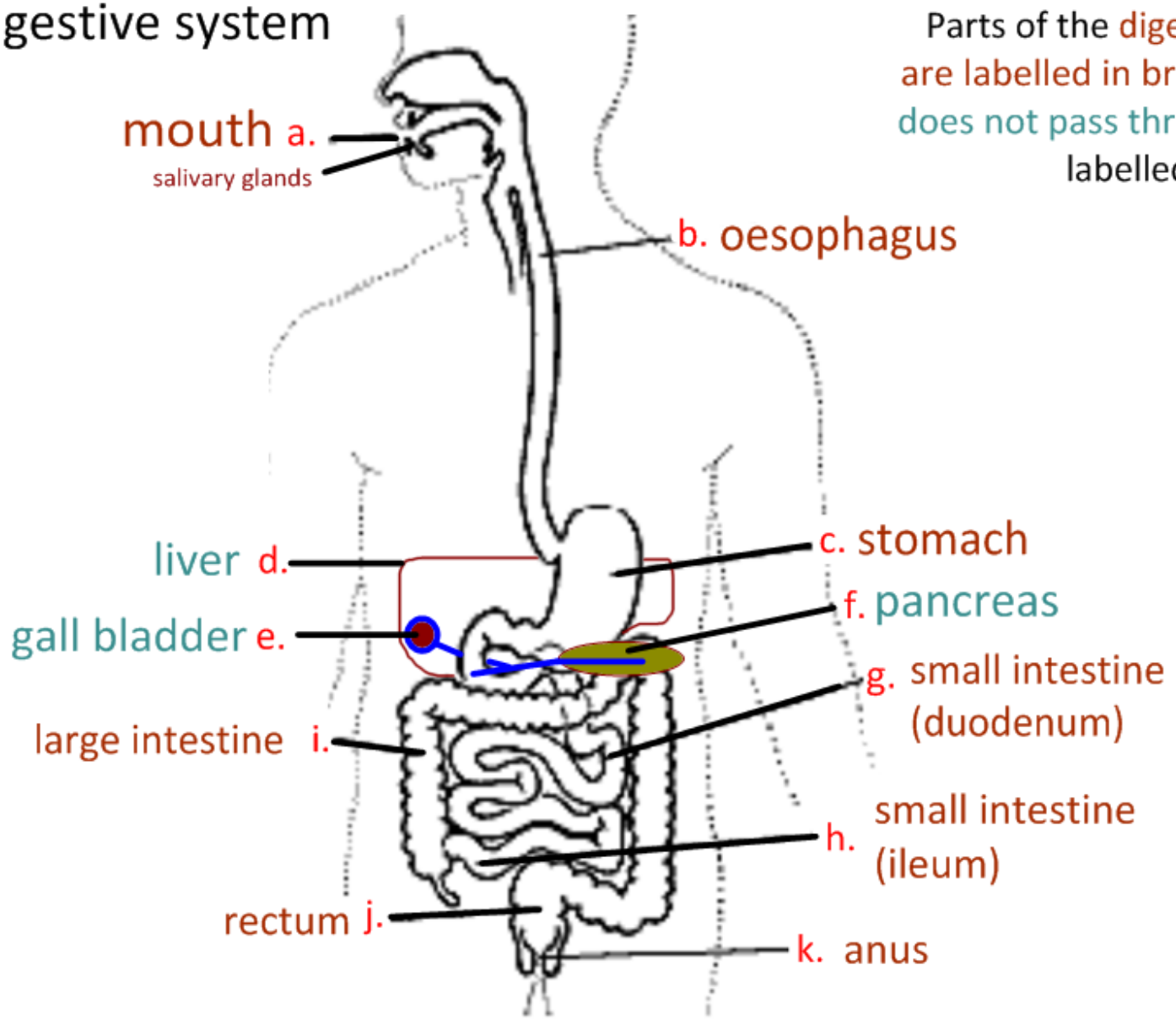
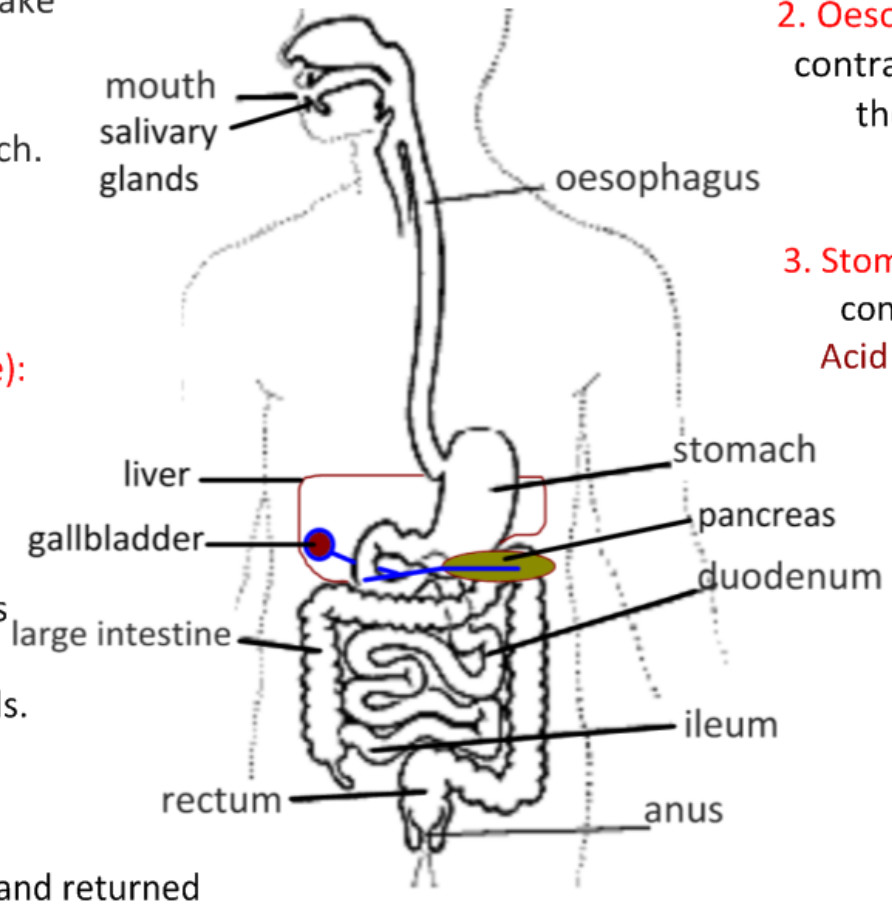


What happens in digestion?

1. Mouth: chewing (mechanical digestion)
Saliva moistens food to make a bolus for swallowing. Salivary amylase begins chemical digestion of starch.



2. Oesophagus: a wave of muscle contractions (peristalsis) pushes the bolus into the stomach .

3. Stomach: muscular contractions continue mechanical digestion. Acid kills bacteria. Pepsin begins digestion of proteins.

4. Duodenum (small intestine):
Bile from the liver and gall bladder neutralises acid and emulsifies fats. Pancreatic amylase and lipase digest carbohydrates and fats. Trypsin digests polypeptides to amino acids.

5. Ileum (small intestine):
Lower half of small intestine absorbs nutrients into the blood, via the villi.

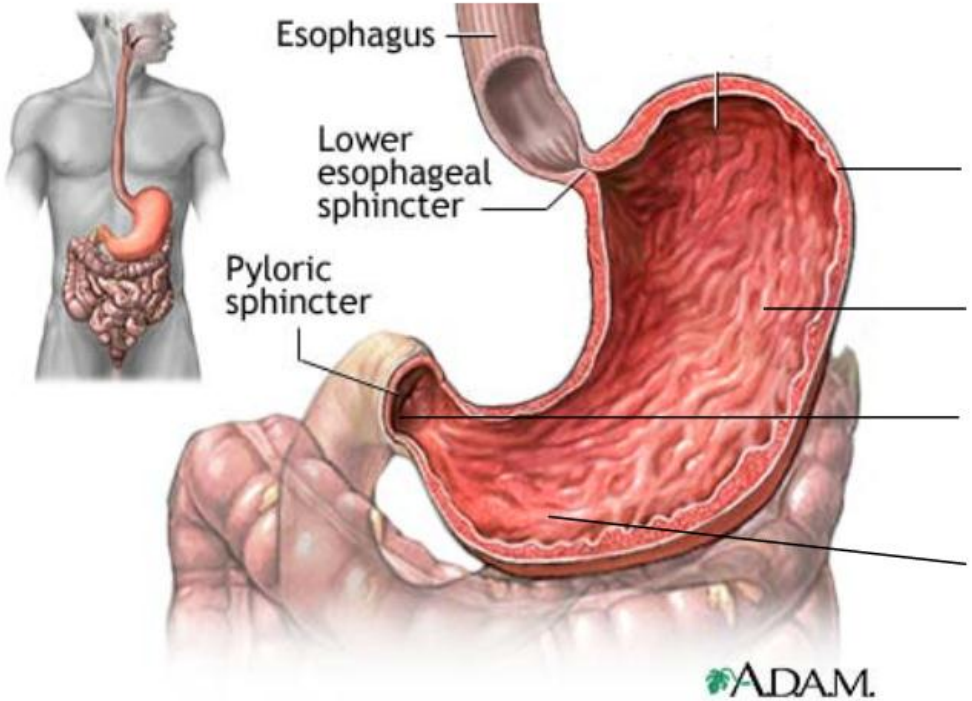
6. Large intestine:
Water is reclaimed and returned to the blood, leaving semi-solid faeces. This is stored in the rectum.

7. Egestion
Faeces (containing undigested food, dead cells and other waste) is forced out of the anus.

The Stomach

Hydrochloric acid in the stomach lowers the pH to around 2, killing bacteria and denaturing proteins. Pepsin enzyme starts protein digestion. Muscular actions aid mechanical digestion. Stretch receptors in the muscular wall trigger release of enzymes.

http://www.youtube.com/watch?v=Uzl6M1YlU3w



http://www.nlm.nih.gov/MEDLINEPLUS/ency/imagepages/19223.htm

muscular walls contract for mechanical digestion and mixing enzymes with the food

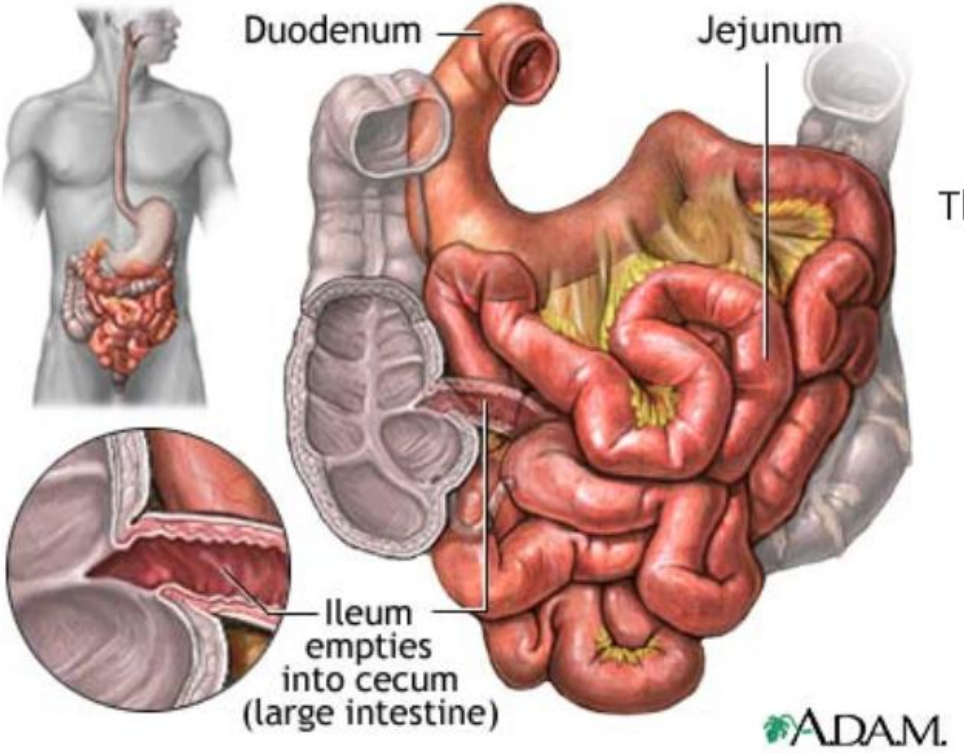
gastric pits release gastric acid, protective mucus and enzymes

muscular spincters control entry of food exit of chyme (partially digested mixture)

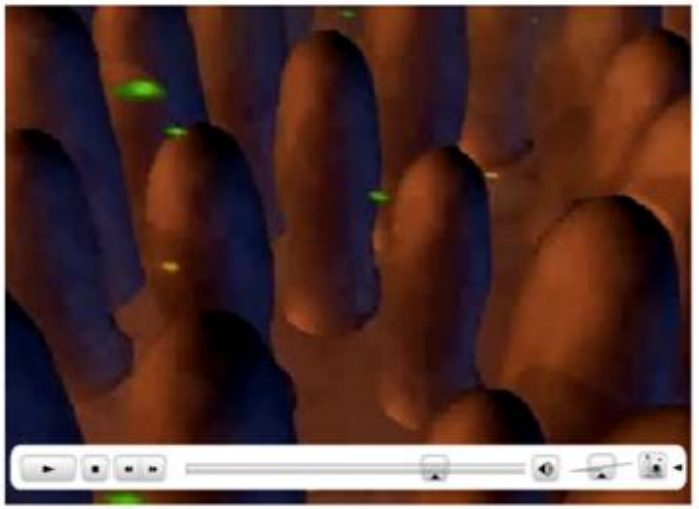
lumen - space in which food is stored while inside the stomach

Small Intestine

The small intestine completes digestion of food molecules.
Chyme enters the duodenum (first section).
Bile from the gallbladder and liver is emptied into the duodenum, neutralising the acid and emulsifiying fats.
Pancreatic enzymes are released (amylase, trypsin).
Enzymes are further released into the jejunum.



http://www.nlm.nih.gov/medlineplus/ency/imagepages/19221.htm



http://www.youtube.com/watch?v=bNMsNHqxszc

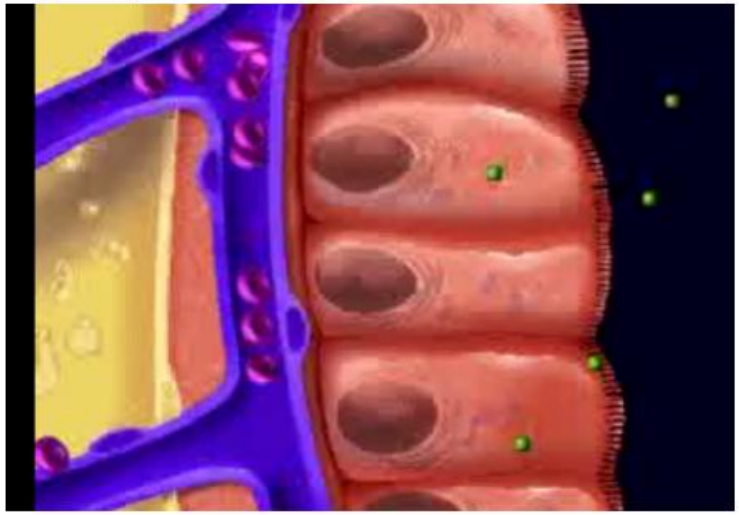
The ileum is the last stage of the small intestine. Here, absorption of digested food moelcules takes place. Villi (finger-like projections) increase the surface area for absorption and have a rich blood supply.

A wave of muscle contractions (peristalsis) keeps the mixture of digested and undigested food moving through the intestine.

Absorption and Assimilation

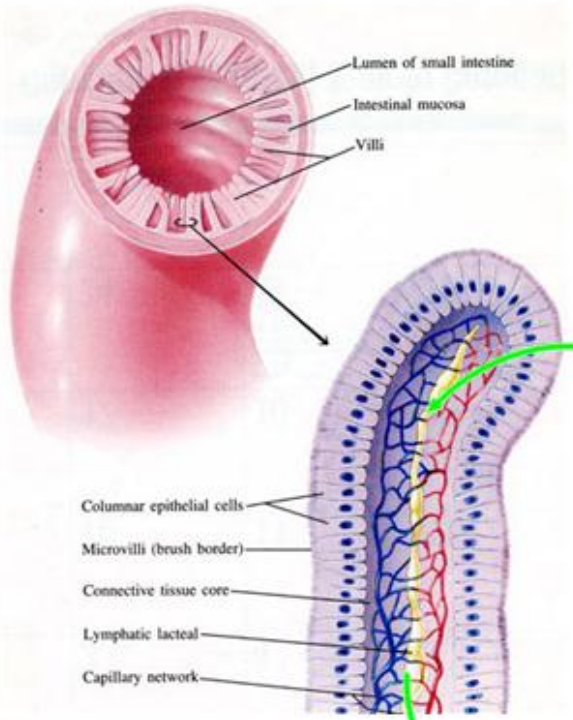
Digestion breaks down large food molecules into smaller molecules
Absorption is the uptake of these molecules into the blood.
Once in the blood, they are carried to the tissues where they are assimilated - taken in to be used.

Absorption:

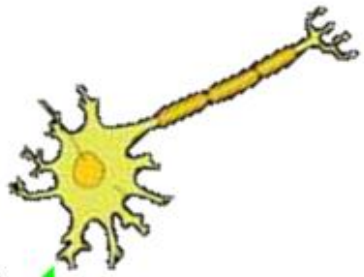


http://www.youtube.com/watch?v=P1sDOJM65Bc

http://www.mcatzone.com/uploads/gloss/villus.jpg



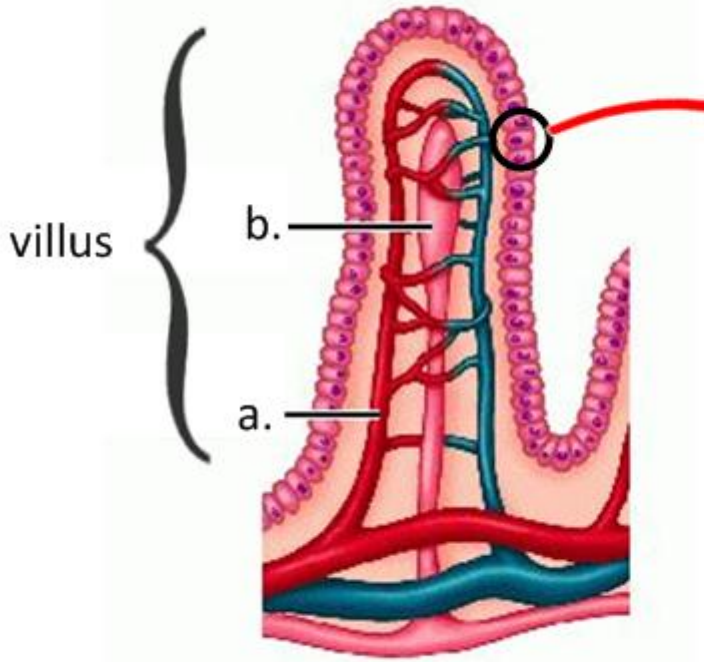
absorption into blood
(or lacteals)



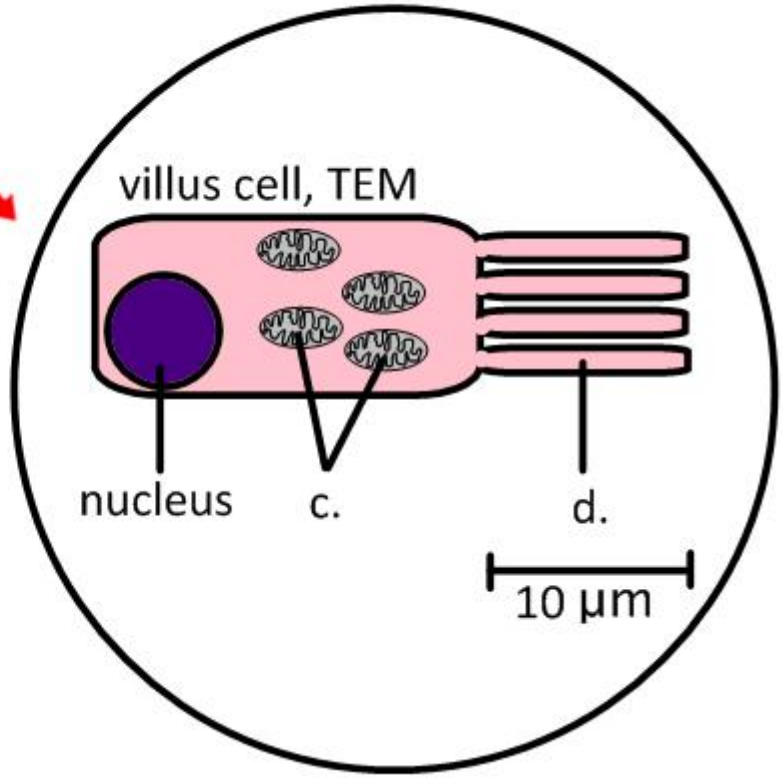
assimilation
(uptake and use by cells)

transport

Label these villus structures and state their function:



http://medical-dictionary.thefreedictionary.com/arachnoid+villi



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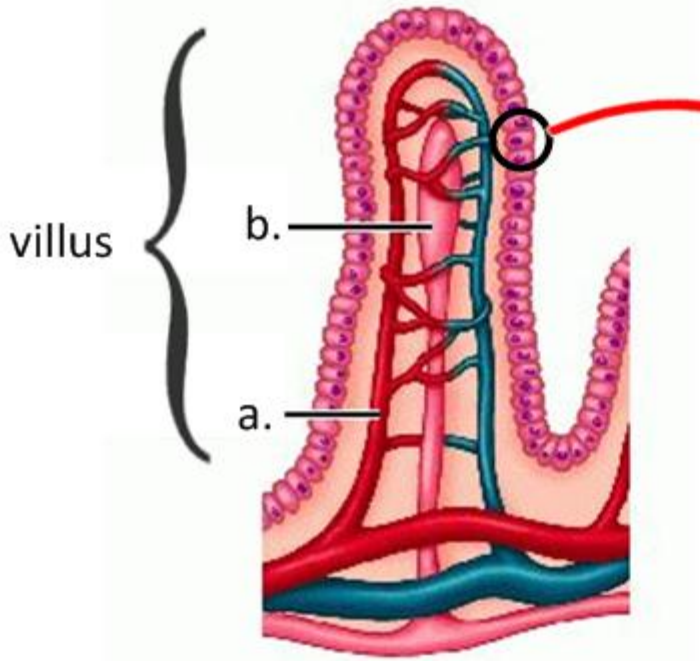
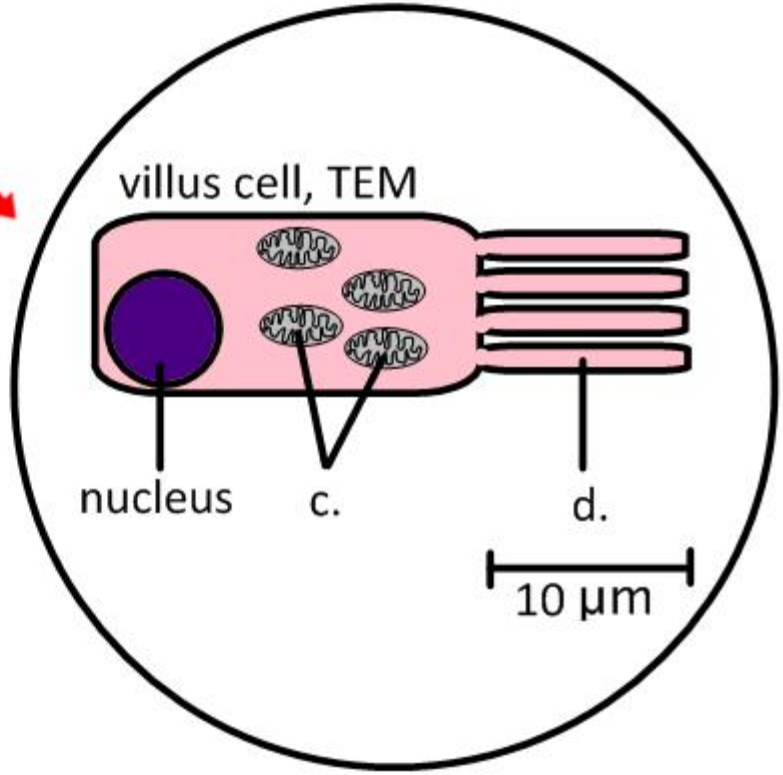
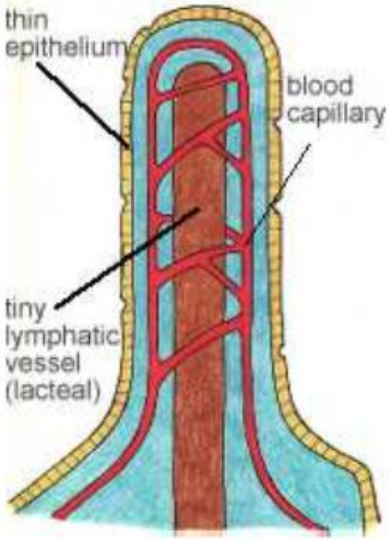




a. Capillary - carries blood to and from villus, maintains concentration gradient
b. Lacteal - transports lipoproteins (fats) to circulatory system
c. Mitochondria - generate ATP for active transport of digested food molecules
d. Microvilli - increase surface area for absorption of digested food molecules

Quick review - print this page and calculate the magnification of the TEM image.

Villi



http://www.bbc.co.uk/scotland/education/bitesize/standard/img/biology/villus.jpg

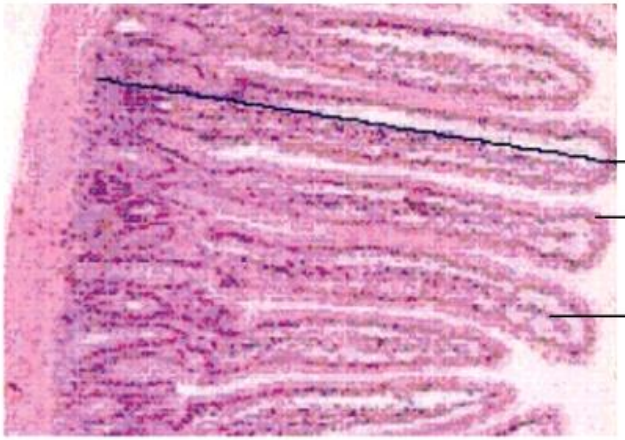
The villi are finger-like projections in the small intestine which absorb the products of digestion.

The large number of these villi creates a huge surface area for absorption of digested food molecules.

Epithelial (surface) cells have microvilli - tiny finger-like hairs to increase the surface area further still.*

A single layer of epithelial cells means a short diffusion path: diffusion is faster and more efficient.

A rich blood supply maintains a concentration gradient down which nutrients can diffuse across the membranes.



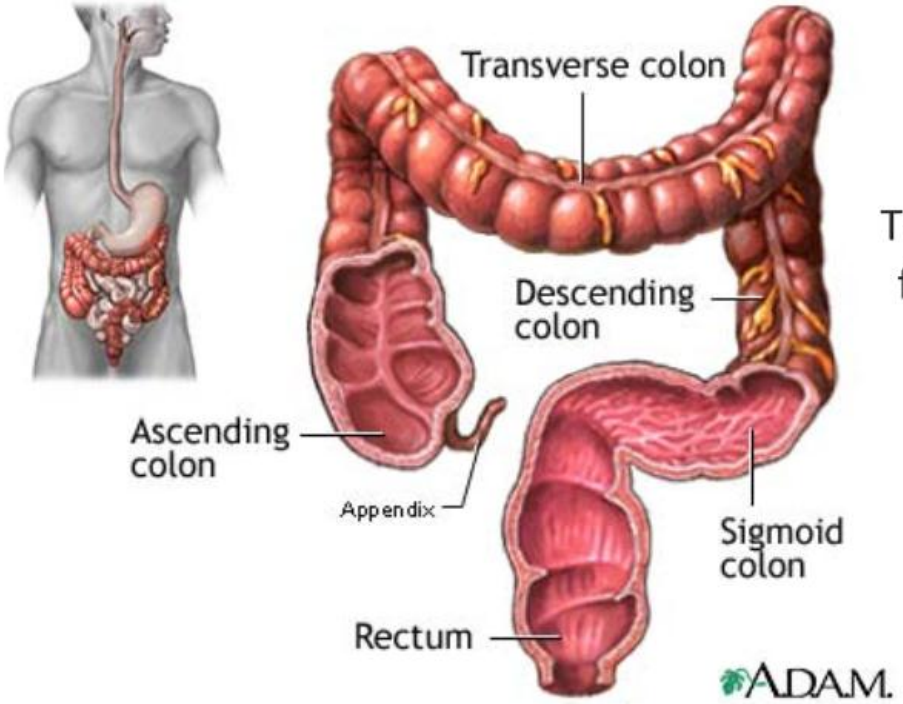
http://www.scielo.br/img/revistas/rhc/v59n6/a07fig02.gif

Lymph vessels (lacteals) close to the surface allow lipids to be eaily absorbed.

only include microvilli if you can see them on a diagram or image.

The Large Intestine

Once absorption has taken place in the ileum, the undigested food is pushed into the large intestine. The job of the large intestine is to reclaim as much water as possible to the blood, before allowing egestion of the solid faeces.



http://assets.aarp.org/external_sites/adam/graphics/images/en/19220.jpg

Everthing comes down to poo:

http://www.youtube.com/watch?v=jsVgi8hoFFc

The large intestine (colon) maximises surface area for absorption of water by being long and folded. Mucus is secreted to lubricate the passage of the faeces and muscle contractions keep the faeces moving.

A diet rich in fibre helps clear out waste products and dead cells, reducing the risk of colon cancer.

Materials which are not absorbed are egested as faeces

(HL link - not in the Core)

Lignin and cellulose - from plant foods

Dietary fibre (cellulose) cannot be digested but is essential for good health. Look it up.

Dead cells from the intestine

Remember apoptosis - programmed cell death? This is where they end up.

Bacteria

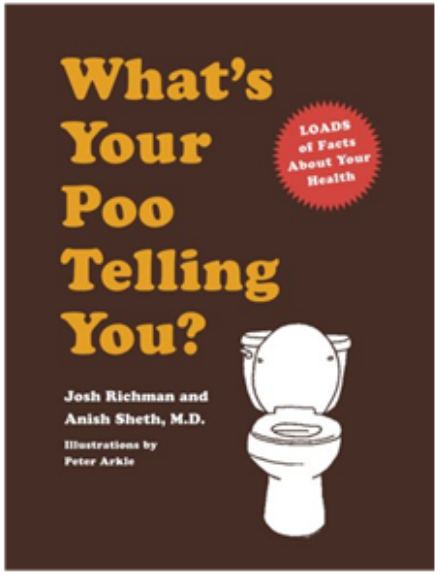
This includes natural bacteria from your gut, as well as potential pathogens.

Bile pigments

Produced by the liver when recycling red blood cells. Gives a brown colour.

"You want to hear what the stool, the poop, sounds like when it hits the water," Oz instructs. "If it sounds like a bombardier, you know, 'plop, plop, plop,' that's not right because it means you're constipated. It means the food is too hard by the time it comes out. It should hit the water like a diver from Acapulco hits the water." Oz makes a "swoosh" sound -- the sound of an Olympian excrement champion.

http://www.huffingtonpost.com/2008/03/12/what-does-your-poo-say-ab_n_91223.html



Further reading:

http://www.amazon.com/Whats-Your-Poo-Telling-You/dp/0811857824

Challenge questions:

1. An egg and cucumber sandwich contains carbohydrates, proteins, lipids and fibre. Create a branching flow-chart that explains the pathways of each of the nutrients following ingestion.

2. Create a Bio-links mind map to link the concepts in this subtopic to as many as you can that we have studied already in the Biology course.

For more IB Biology resources visit:

http://sciencevideos.wordpress.com

Cartoon: **http://www.eatologies.com/2009/02/22/baby-blues-digestion/**