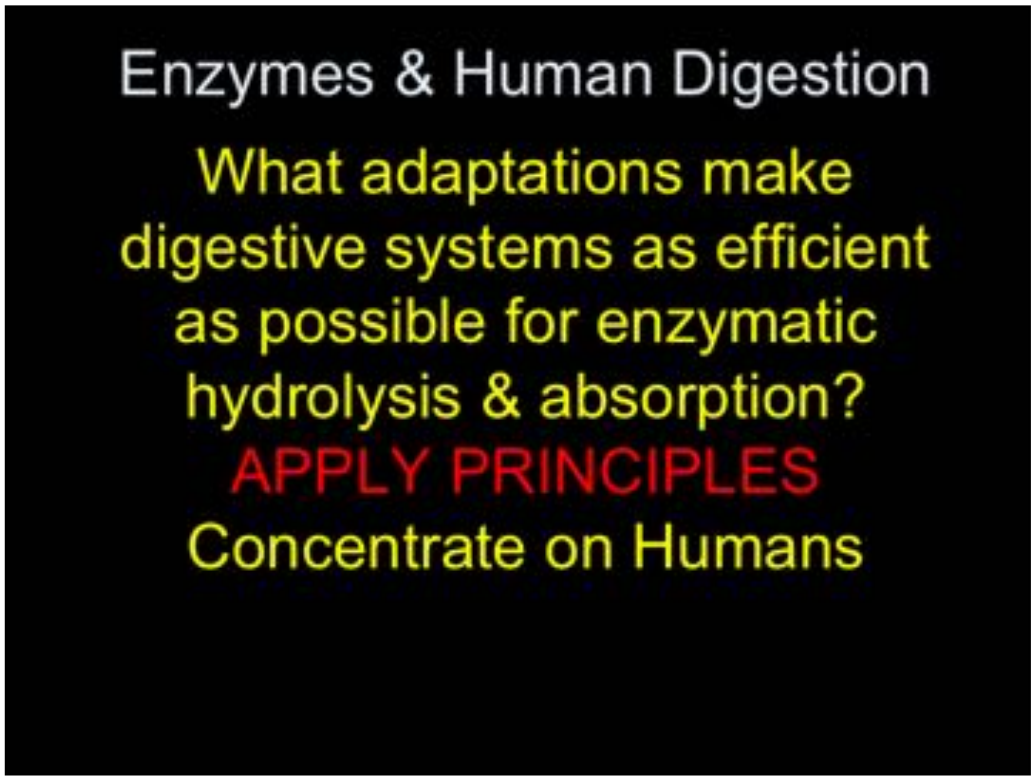
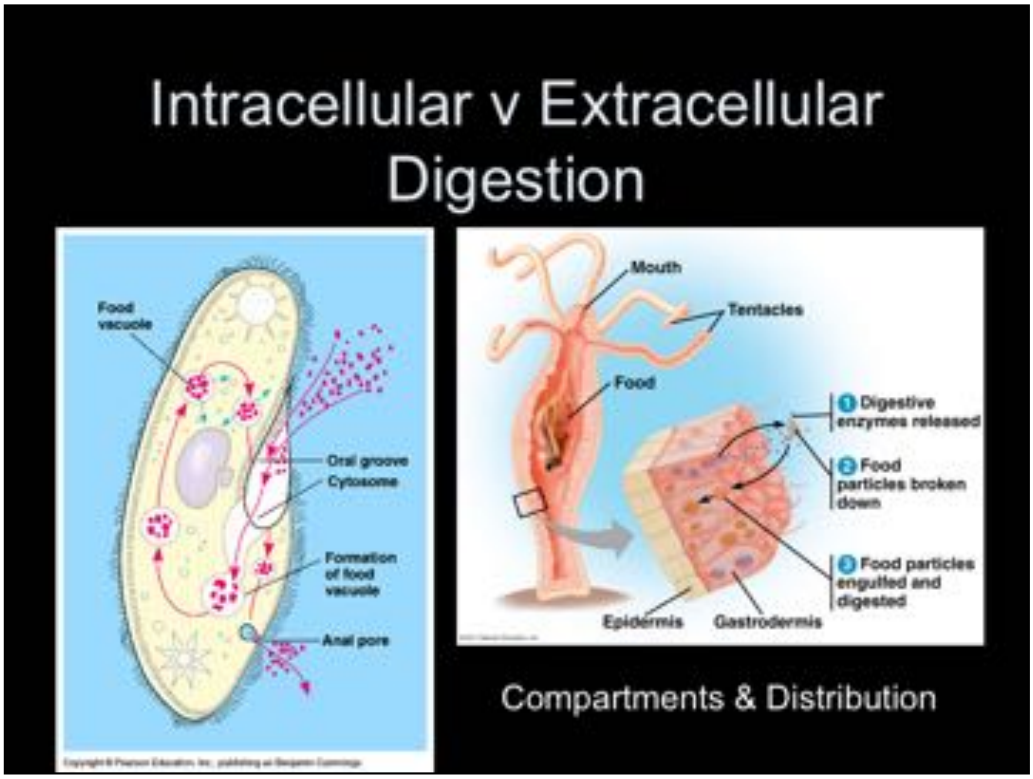
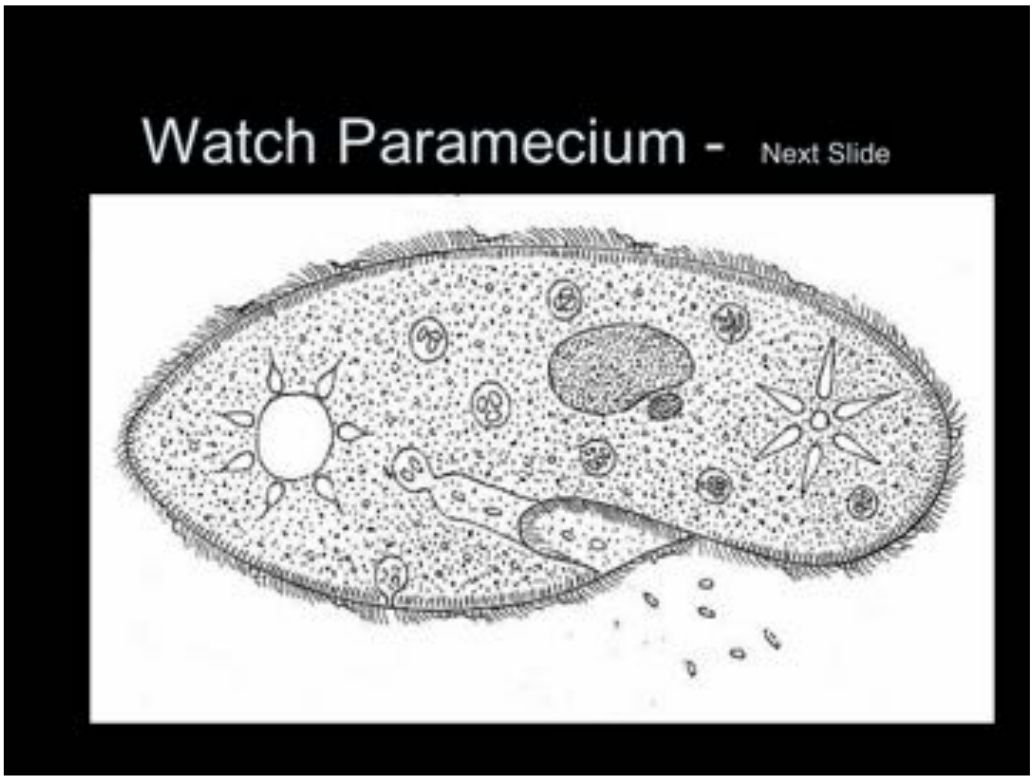
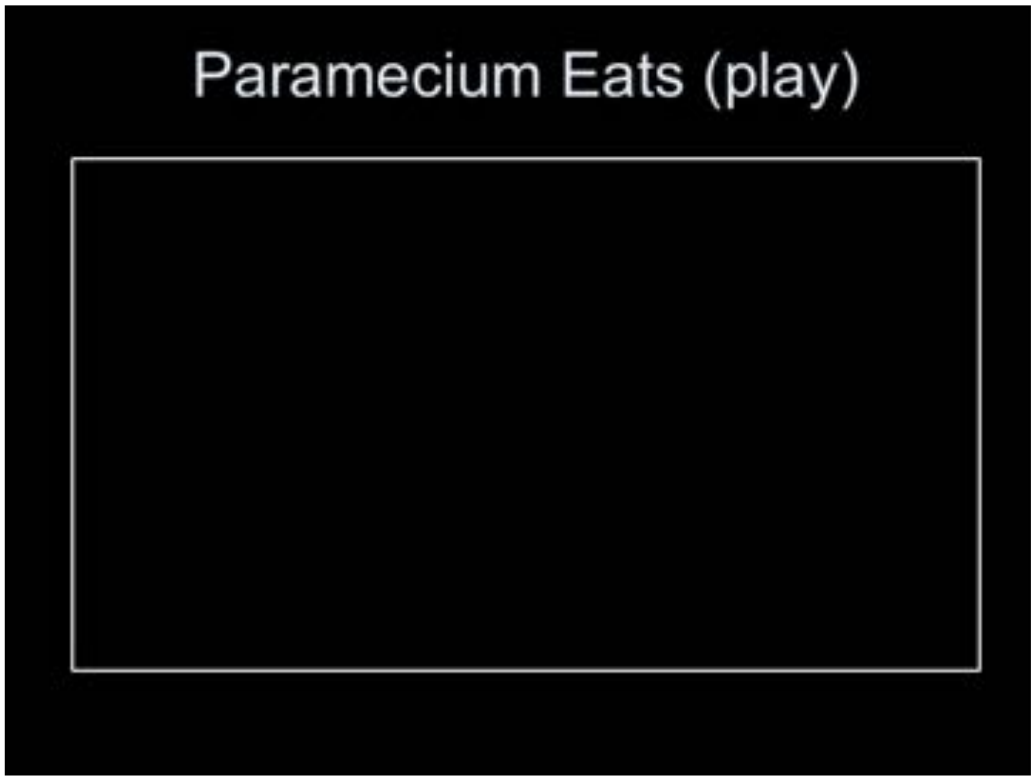

Enzymes & Human Digestion
What adaptations make digestive systems as efficient as possible for enzymatic hydrolysis & absorption?
APPLY PRINCIPLES
Concentrate on Humans


Intracellular v Extracellular Digestion
Food vacuole
Oral groove
Cytosome
Formation of food vacuole
Anal pore
Mouth
Tentacles
Food
1 Digestive enzymes released
2 Food particles broken down
3 Food particles engulfed and digested
Epidermis
Gastrodermis
Compartments & Distribution


Watch Paramecium -
Next Slide



Can also use the DVD of the paramecium eating


Ingestion: Suspension Feeder
Food is already tiny
Baleen
Humpback whale, a suspension feeder

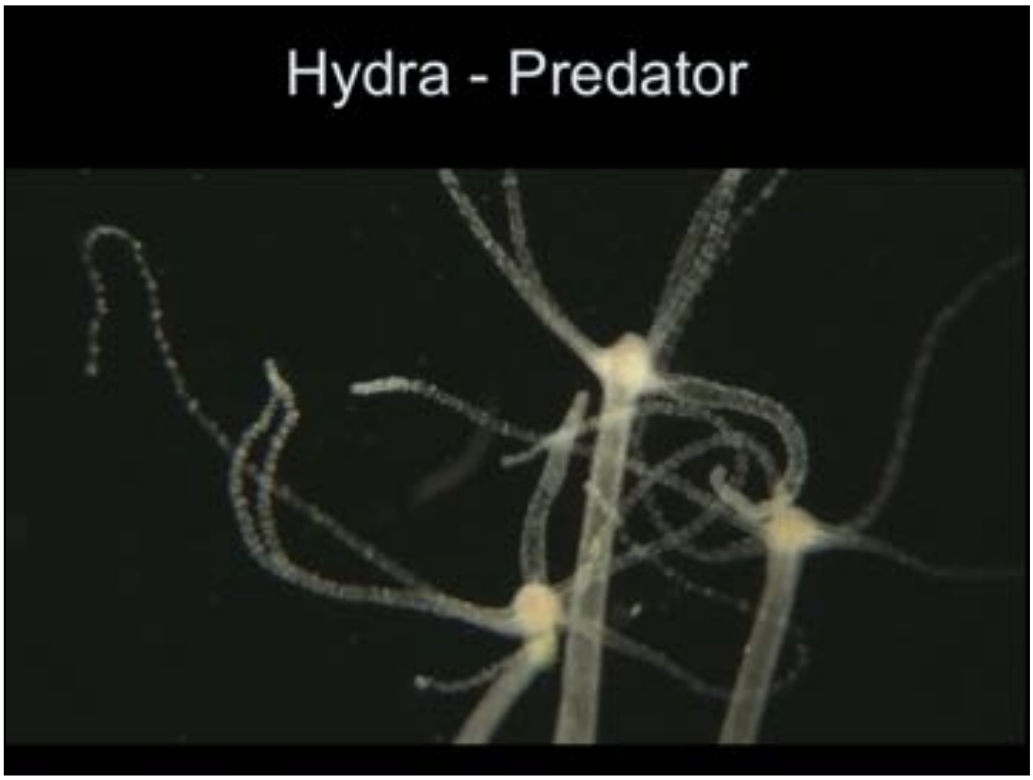

Sponges Eats


Ingestion: Fluid Feeder
Food is already dissolved
Mosquito, a fluid feeder


Substrate Feeder:
Leaf-miners in Arabadosis


Ingestion: Bulk Feeders
Why are chunks a problem?
Rock python, a bulk feeder
Watch: Snake eats egg – Next Slide


Snake's Solution:
HUNDREDS MORE
FREE VIDEOS
AVAILABLE AT
www.orsm.net
orsm.net


Hydra - Predator


Nematocysts

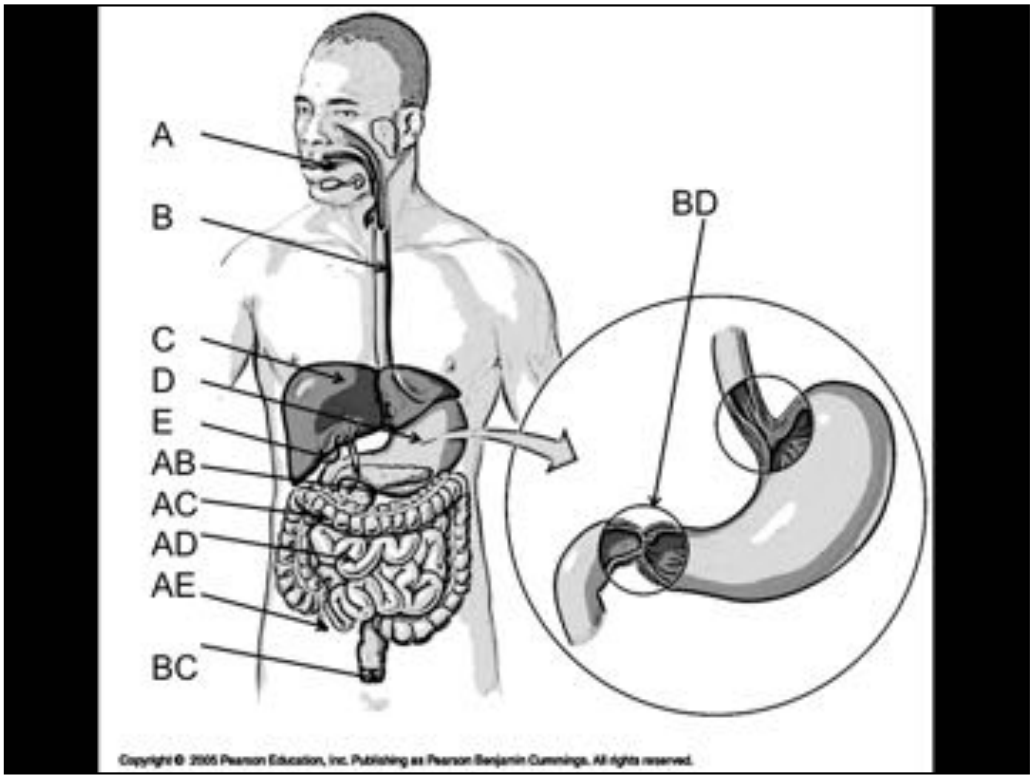

Land Planarian eat snail
PREDATORY FLATWORM
HUNT NO. 1
2014 CHAM TY Production. All rights reserved

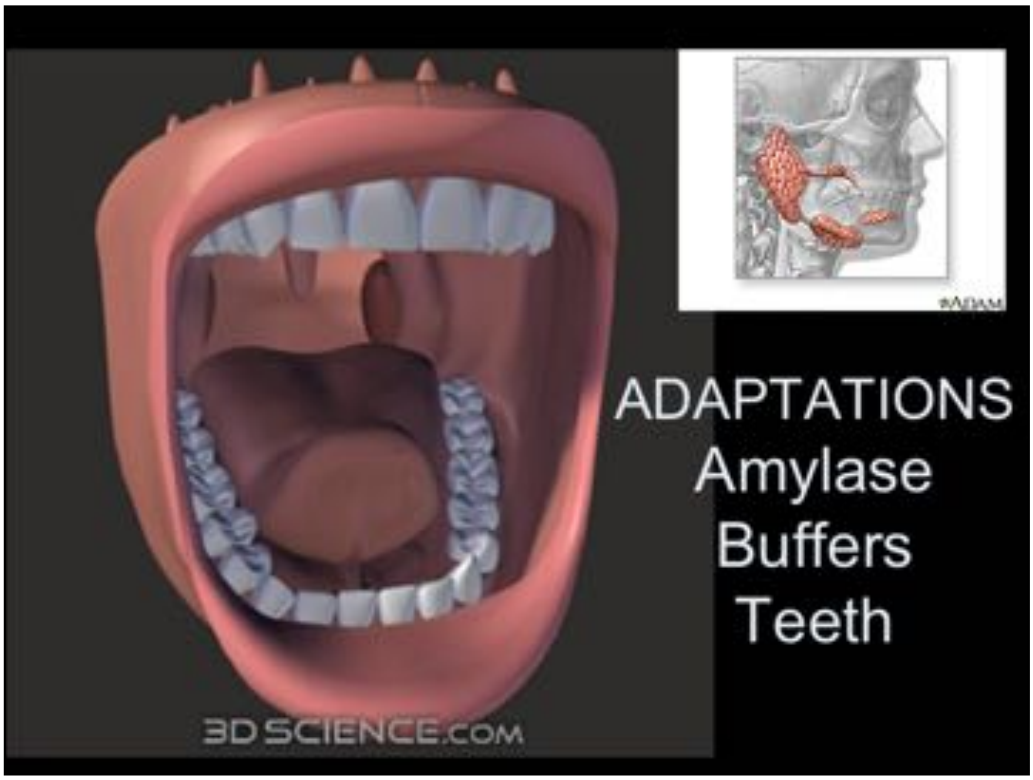
The genus is Phagocata. As of 1970 there were only two species of polypharyngeal Phagocata in North America (there are other species of the genus that have only one pharynx). segment.
www.martinmicroscope.com

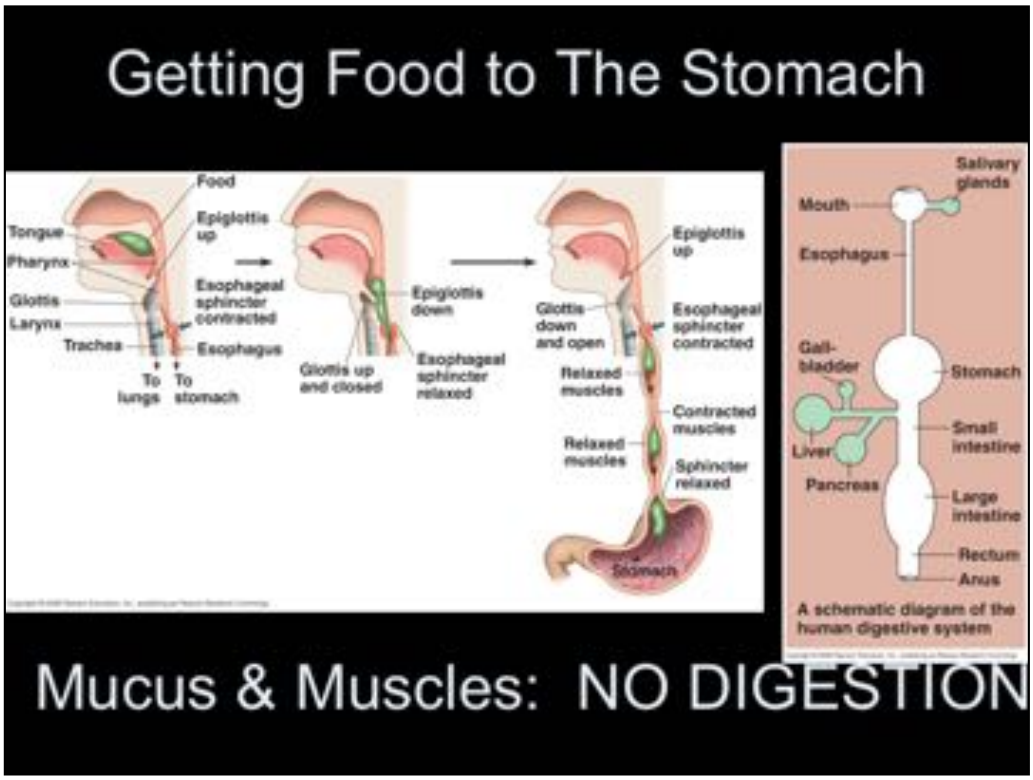
https://www.youtube.com/watch?v=eUmOJ6fWN9w

Regular planaria:
https://www.youtube.com/watch?v=0L_mJoG4nts&list=PLZ46QsbiUsPPtdXtlPKHkRaKyRG8LZurl&index=3


National Geographic
Digestive System Overview

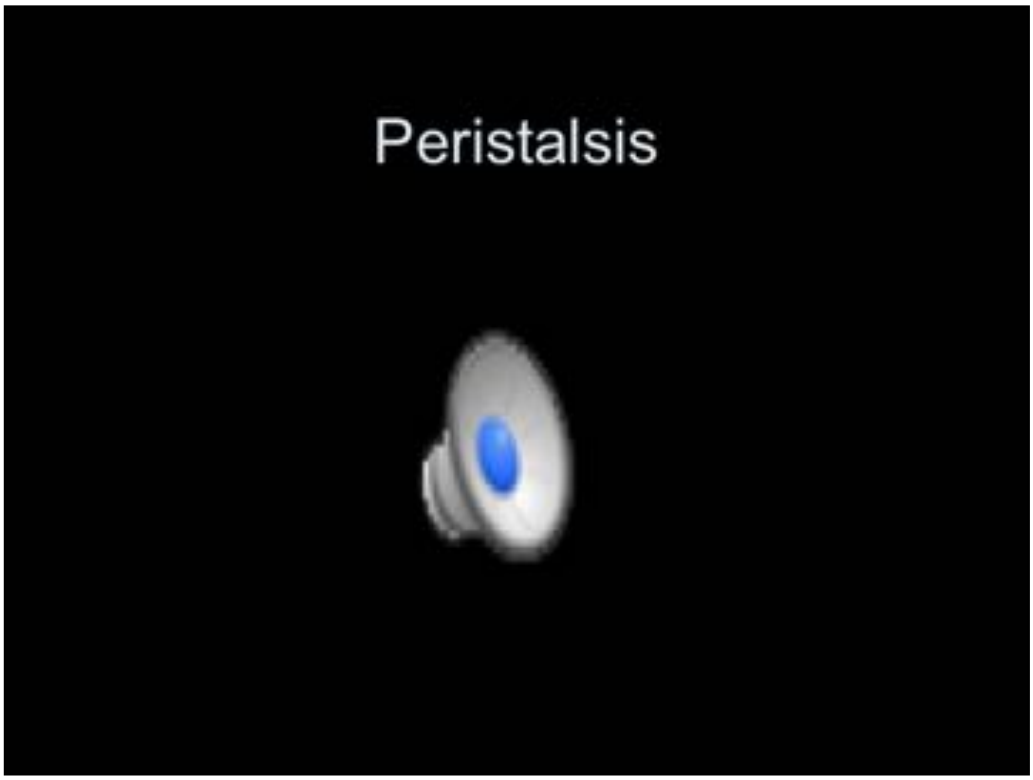

A
B
C
D
E
AB
AC
AD
AE
BC
BD
Copyright © 2005 Pearson Education, Inc. Publishing as Pearson Benjamin Cummings. All rights reserved.

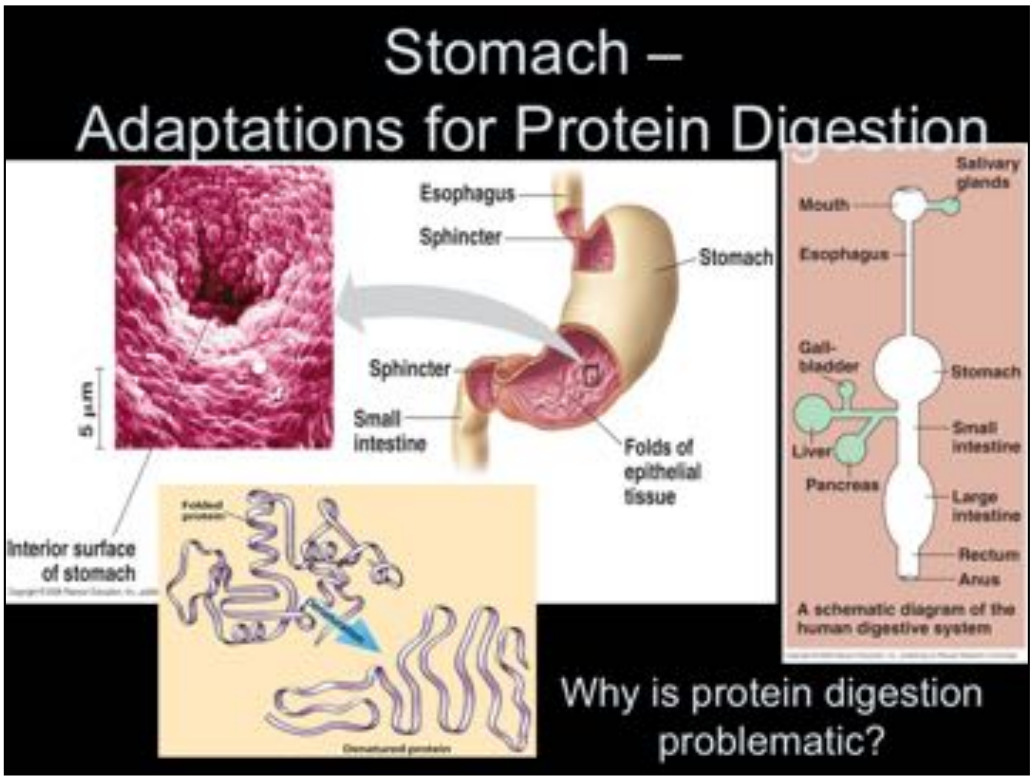

ADAPTATIONS
Amylase
Buffers
Teeth
3D SCIENCE.COM

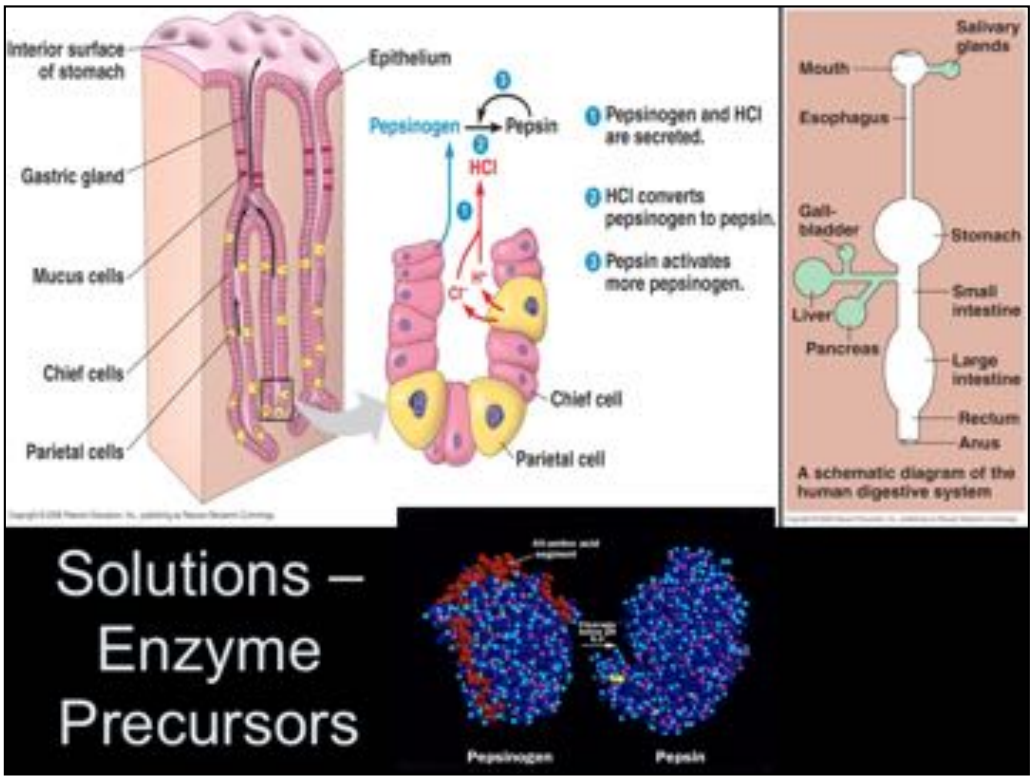


Next Watch National Geographic Section

2:20 (sections)


Peristalsis


Stomach –
Adaptations for Protein Digestion
Esophagus
Sphincter
Stomach
Sphincter
Small intestine
Folds of epithelial tissue
5 µm
Interior surface of stomach
Salivary glands
Mouth
Esophagus
Gall-bladder
Stomach
Liver
Small intestine
Pancreas
Large intestine
Rectum
Anus
A schematic diagram of the human digestive system
Why is protein digestion problematic?



Precursors

Replace lining

Separate HCl and pepsinogen

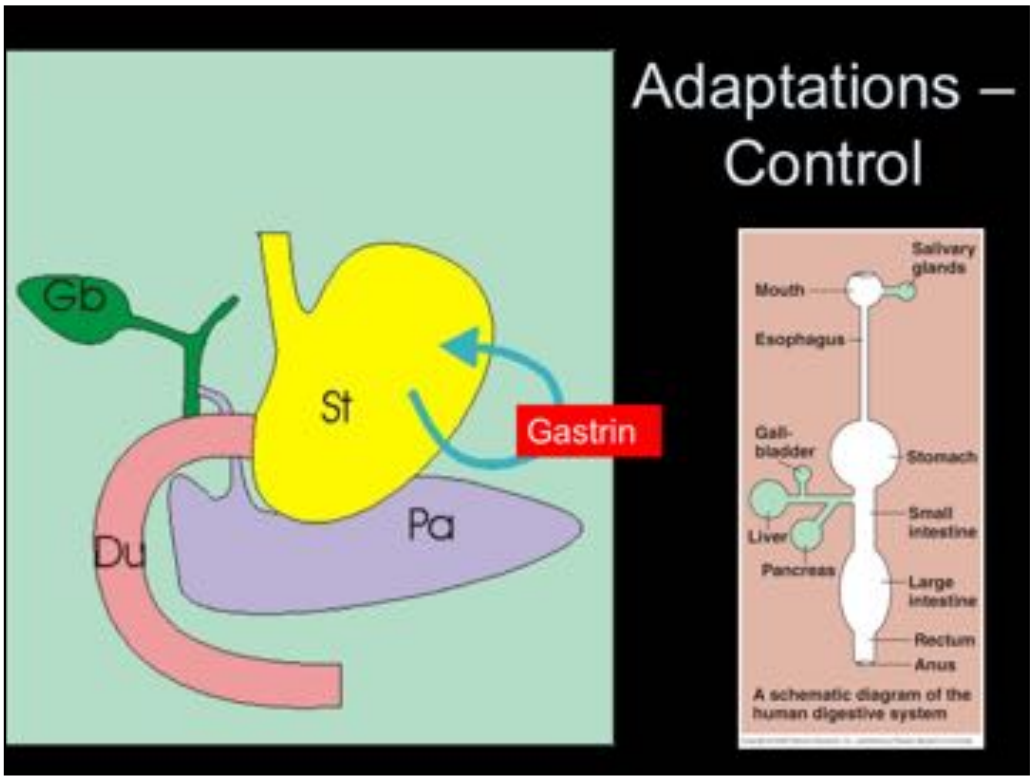
Low pH

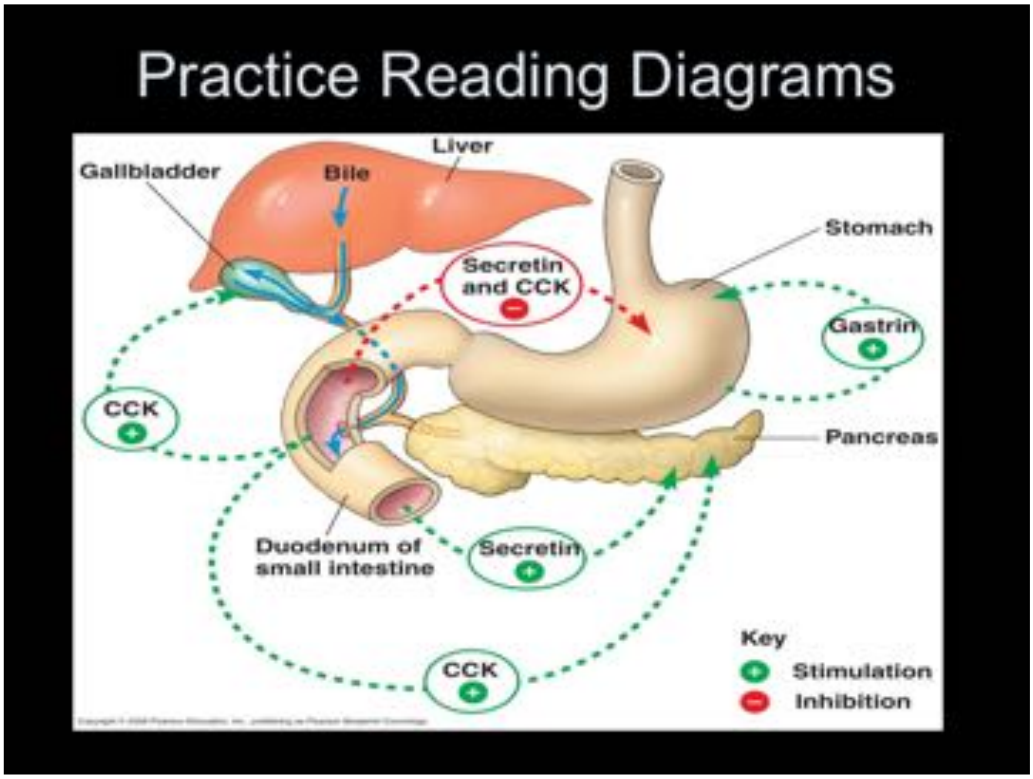
Low pH denatures proteins and exposes bonds to the enzyme

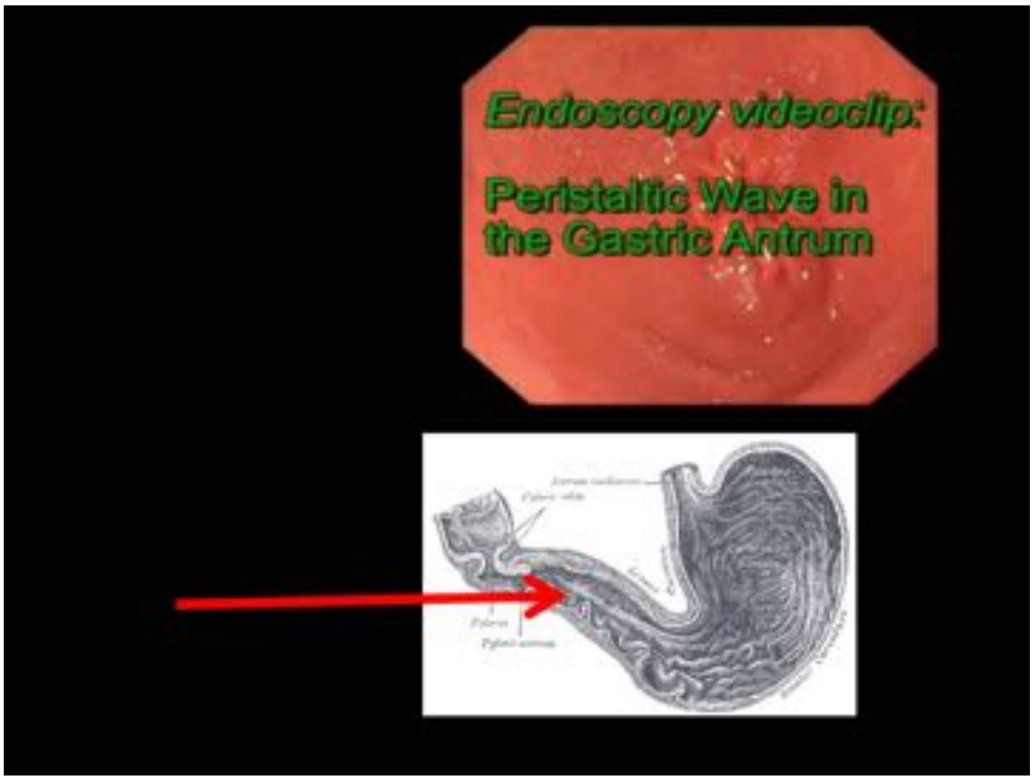
Mucus

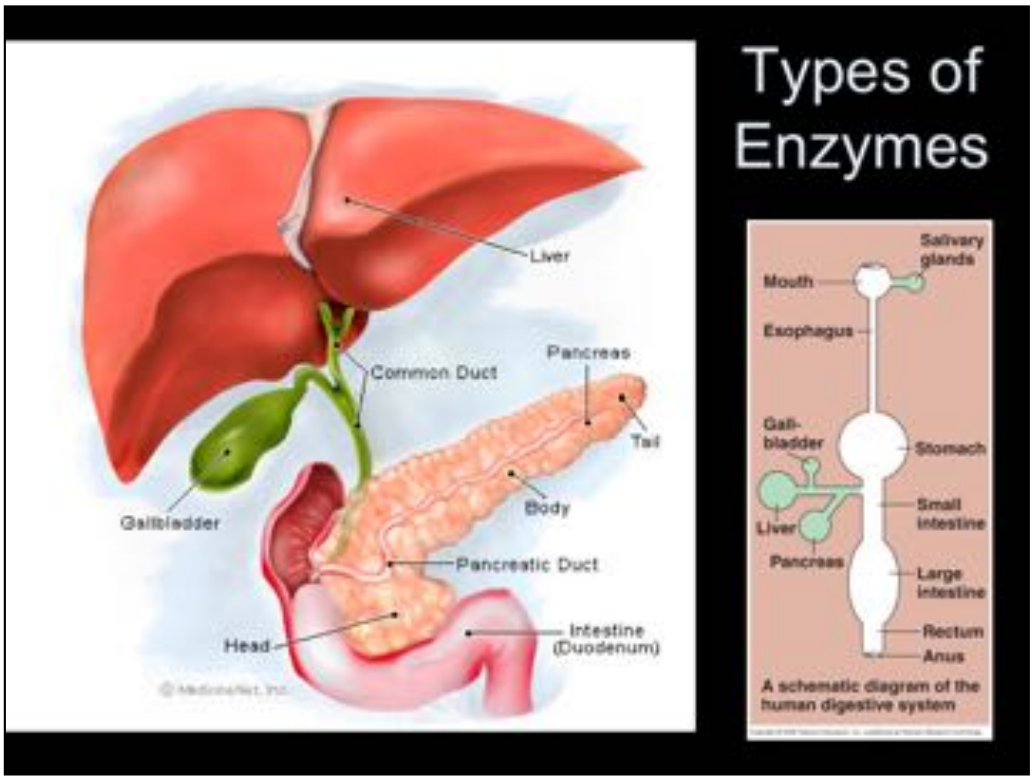
Discuss ulcers – bacteria and antibiotics – Nobel Prize 2005

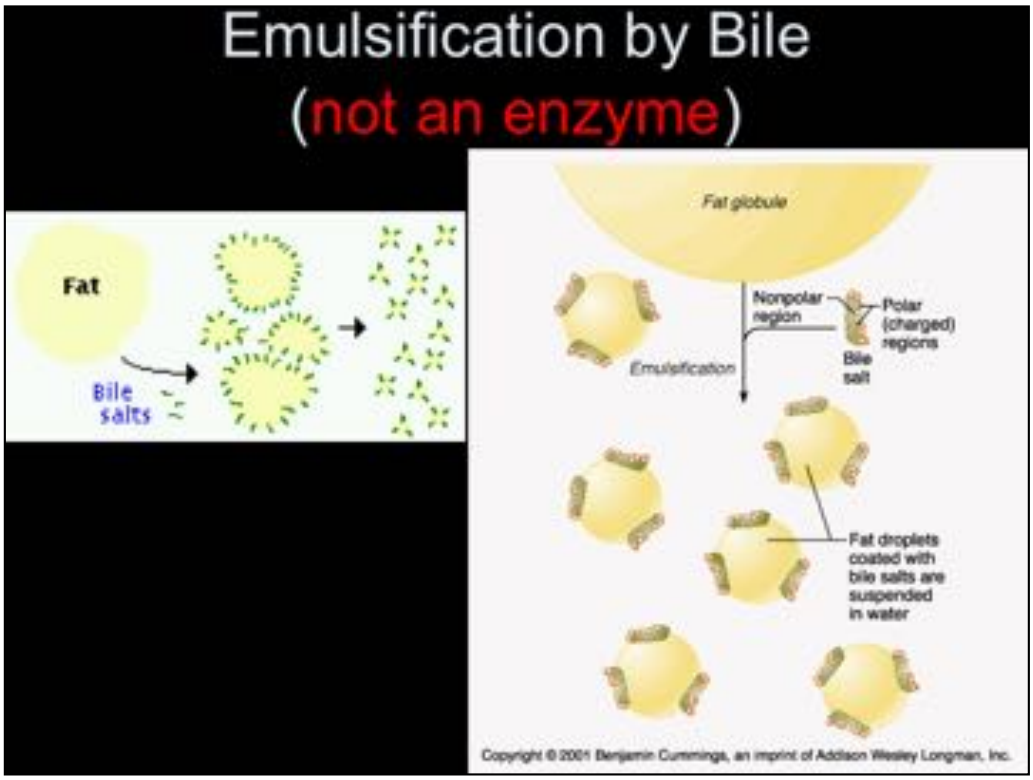
Control - Gastrin


Adaptations – Control
Gb
St
Gastrin
Du
Pa
Salivary glands
Mouth
Esophagus
Gall-bladder
Stomach
Small intestine
Liver
Pancreas
Large intestine
Rectum
Anus
A schematic diagram of the human digestive system

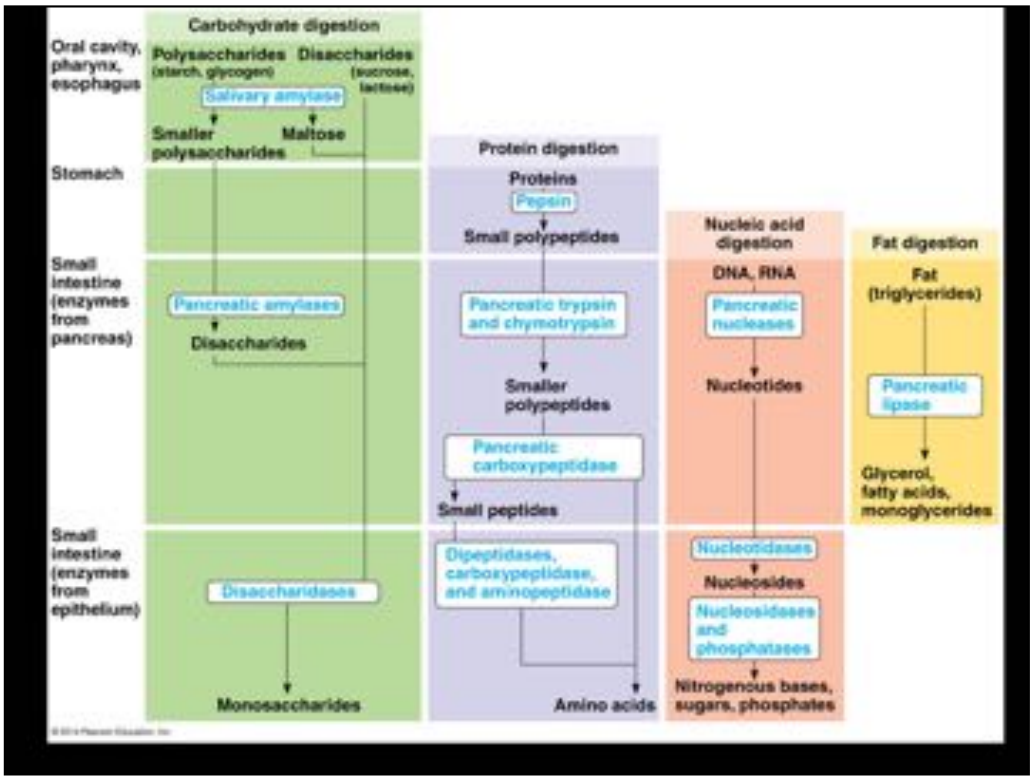

Practice Reading Diagrams
Liver
Gallbladder
Bile
Stomach
Secretin and CCK
Gastrin
CCK
Pancreas
Duodenum of small intestine
Secretin
CCK
Key
Stimulation
Inhibition

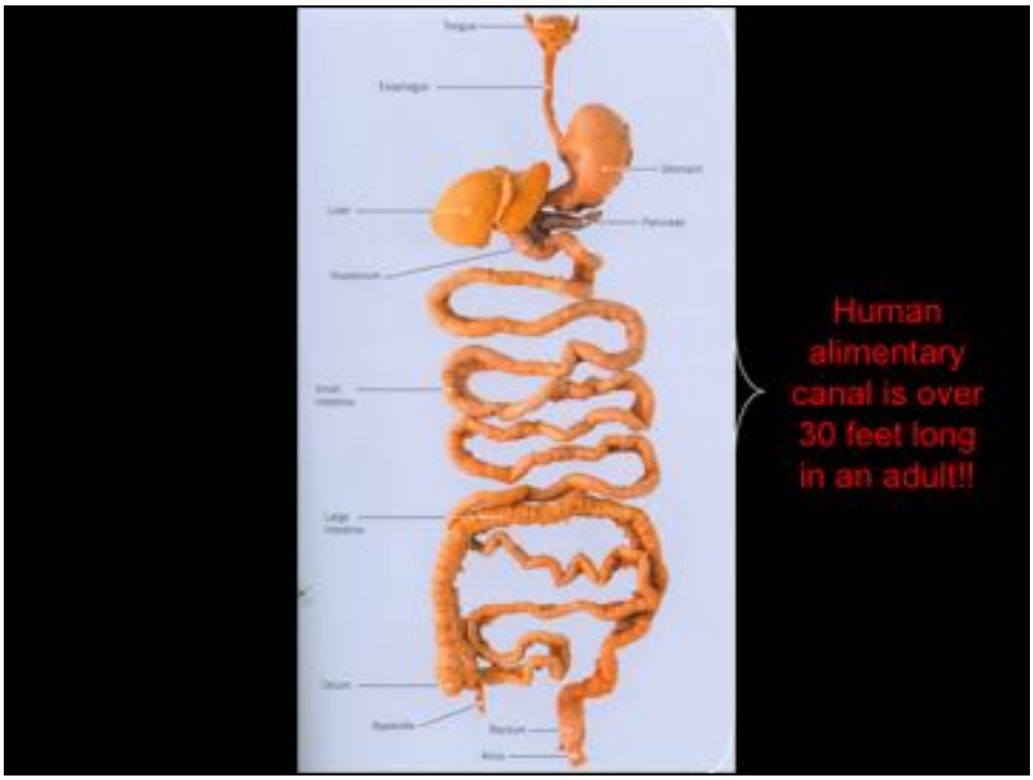

Endoscopy videoclip:
Peristaltic Wave in
the Gastric Antrum

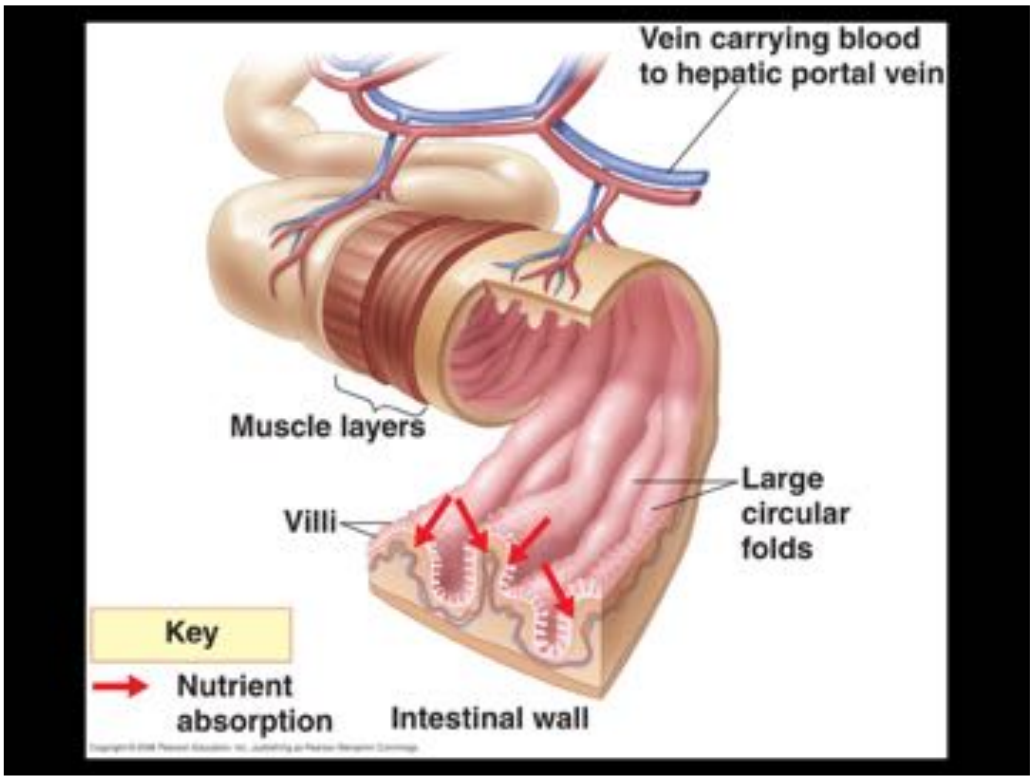

Types of Enzymes
Liver
Common Duct
Pancreas
Tail
Gallbladder
Body
Pancreatic Duct
Head
Intestine (Duodenum)
Salivary glands
Mouth
Esophagus
Gall-bladder
Stomach
Small intestine
Liver
Pancreas
Large intestine
Rectum
Anus
A schematic diagram of the human digestive system

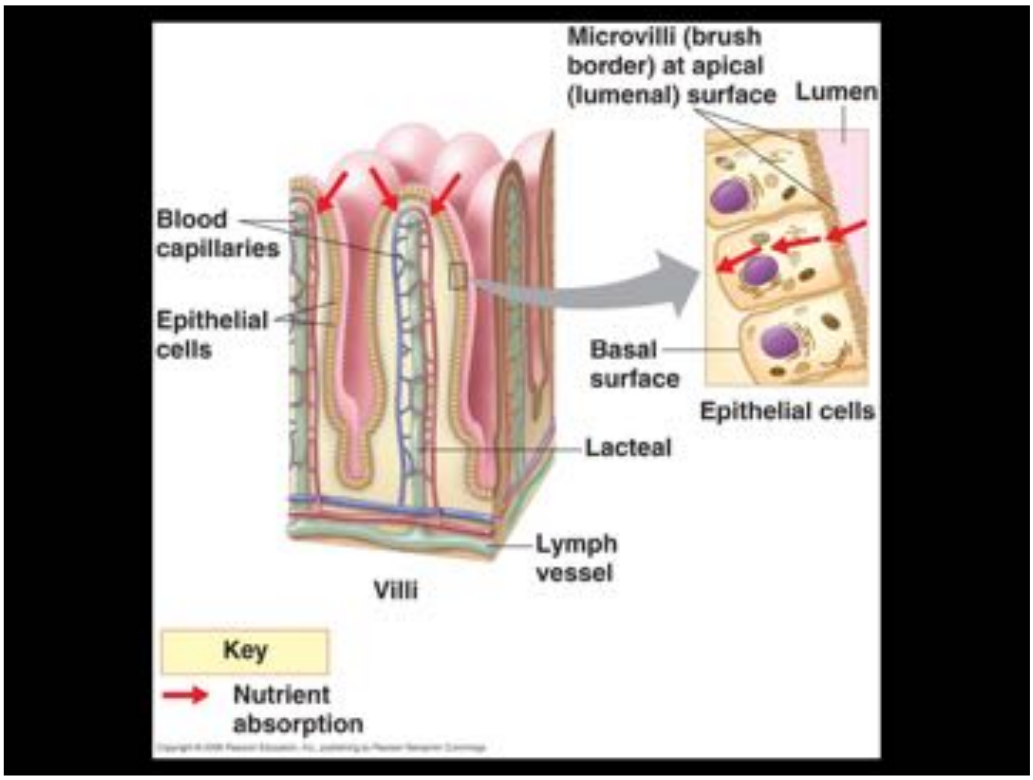

Emulsification by Bile
(not an enzyme)
Fat
Bile salts
Fat globule
Nonpolar region
Polar (charged) regions
Bile salt
Emulsification
Fat droplets coated with bile salts are suspended in water
Copyright © 2001 Benjamin Cummings, an imprint of Addison Wesley Longman, Inc.

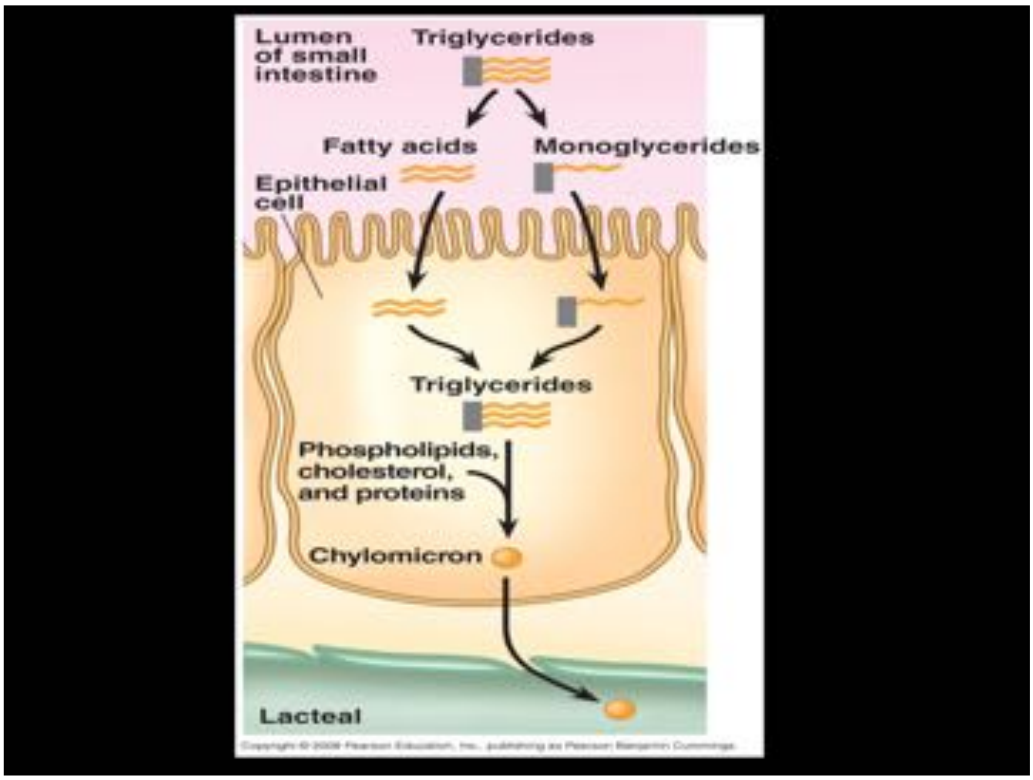

Watch National Geographic
Video Clip –
Bile release into small
intestine
at time 10:00

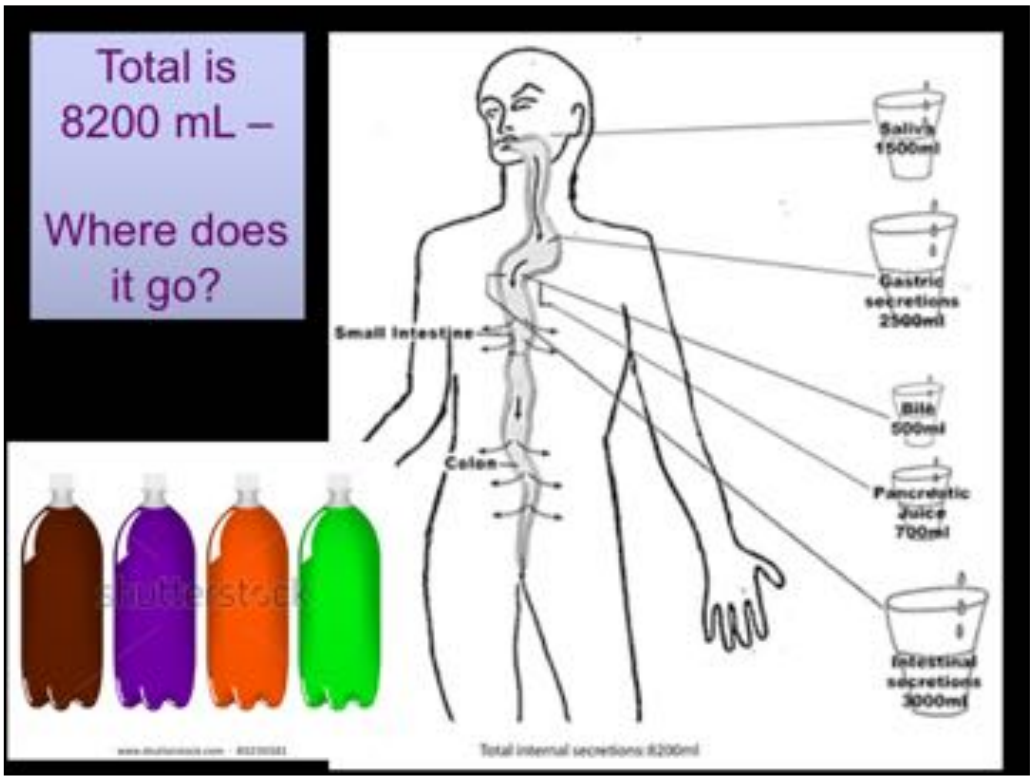

Carbohydrate digestion
Protein digestion
Nucleic acid digestion
Fat digestion
Oral cavity, pharynx, esophagus
Polysaccharides (starch, glycogen)
Disaccharides (sucrose, lactose)
Salivary amylase
Smaller polysaccharides
Maltose
Stomach
Proteins
Pepsin
Small polypeptides
DNA, RNA
Fat (triglycerides)
Small intestine (enzymes from pancreas)
Pancreatic amylases
Disaccharides
Pancreatic trypsin and chymotrypsin
Smaller polypeptides
Pancreatic nucleases
Nucleotides
Pancreatic lipase
Glycerol, fatty acids, monoglycerides
Pancreatic carboxypeptidase
Small peptides
Small intestine (enzymes from epithelium)
Disaccharidases
Monosaccharides
Dipeptidases, carboxypeptidase, and aminopeptidase
Amino acids
Nucleotidases
Nucleosides
Nucleosidases and phosphatases
Nitrogenous bases, sugars, phosphates


Human alimentary canal is over 30 feet long in an adult!!

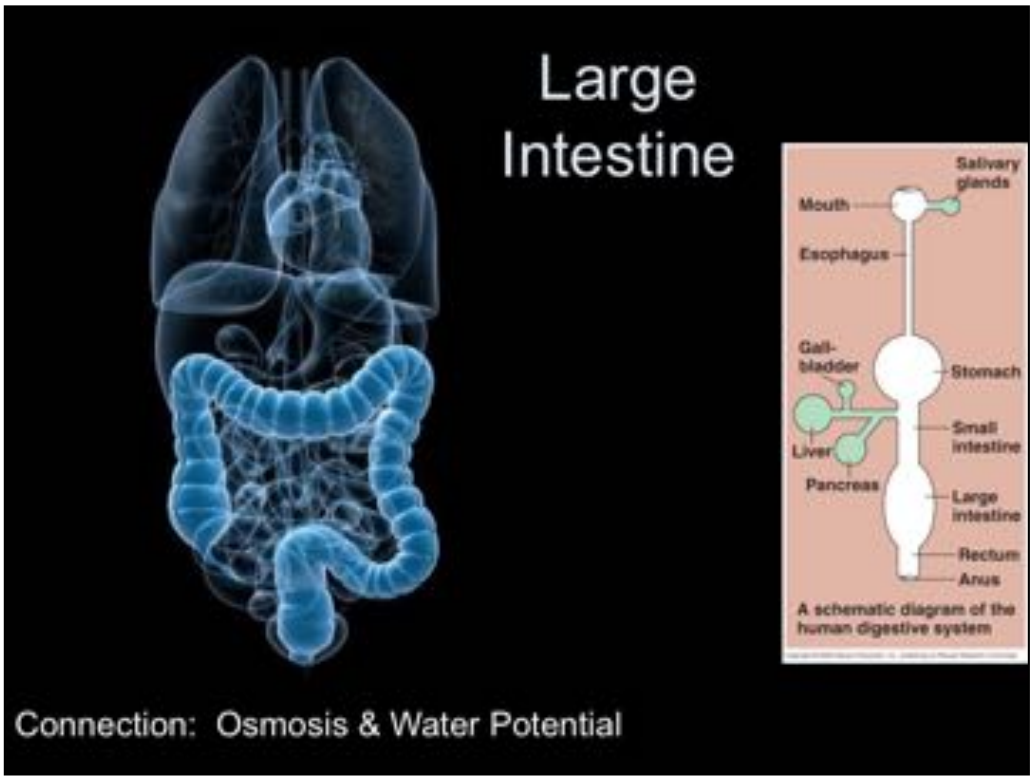

Vein carrying blood to hepatic portal vein
Muscle layers
Villi
Large circular folds
Key
Nutrient absorption
Intestinal wall


Microvilli (brush border) at apical (lumenal) surface
Lumen
Blood capillaries
Epithelial cells
Basal surface
Epithelial cells
Lacteal
Lymph vessel
Villi
Key
Nutrient absorption


Lumen of small intestine
Triglycerides
Fatty acids
Monoglycerides
Epithelial cell
Triglycerides
Phospholipids, cholesterol, and proteins
Chylomicron
Lacteal



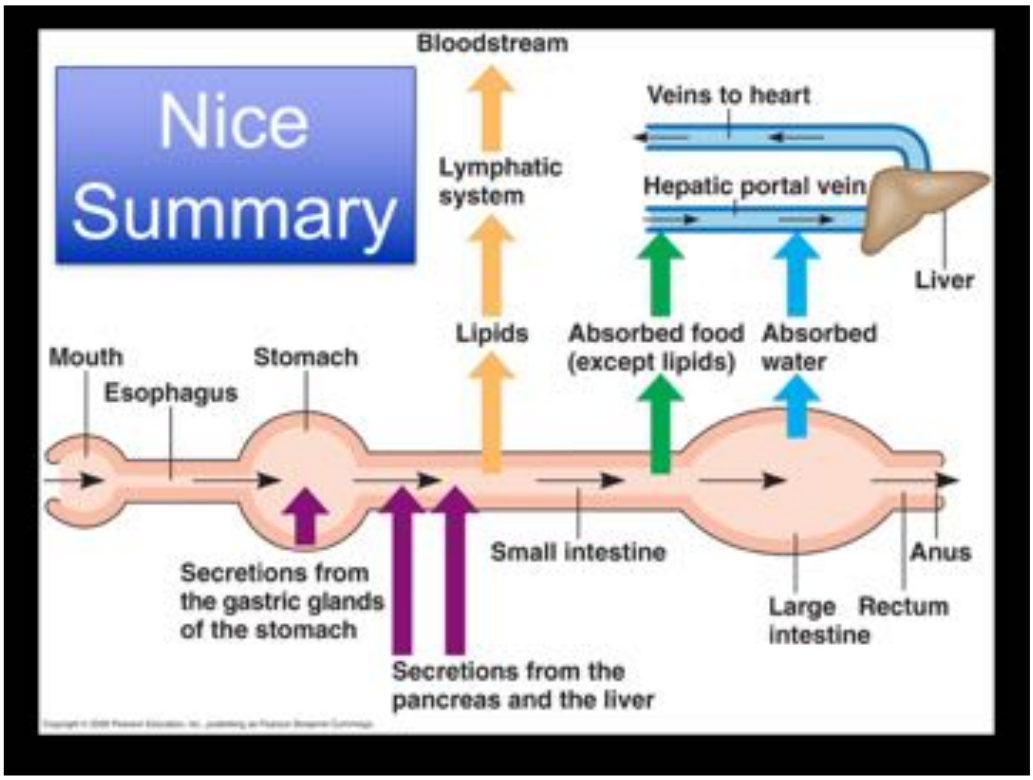
Get some empty 2 L soda bottles

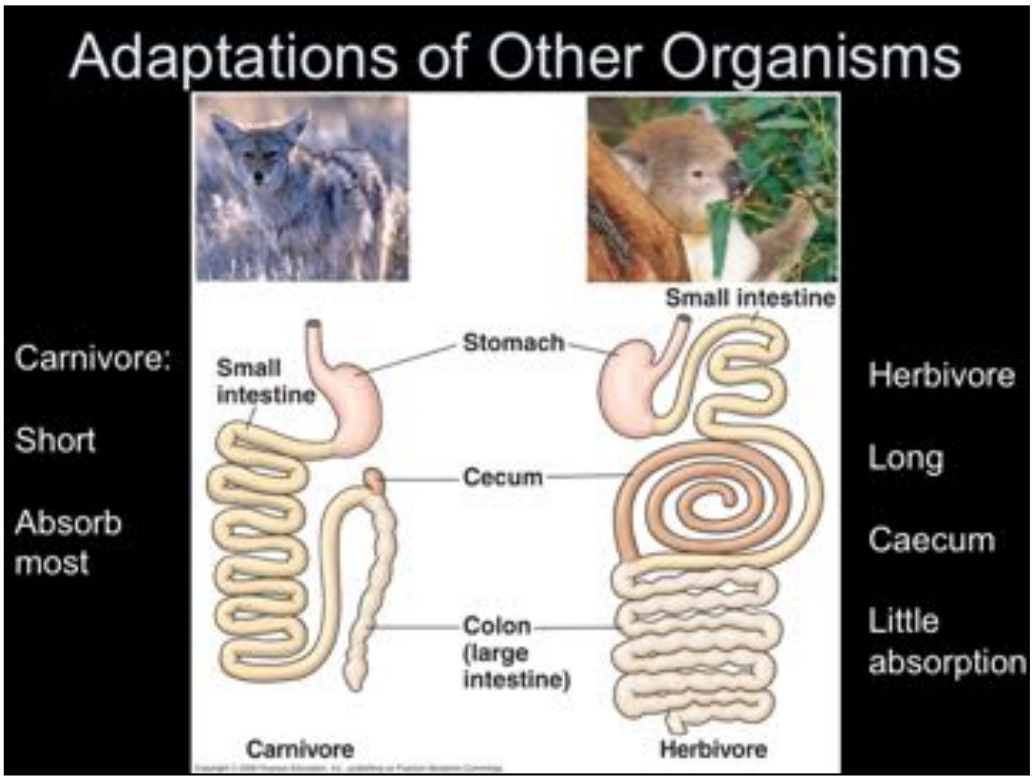

Large Intestine
Salivary glands
Mouth
Esophagus
Gall-bladder
Stomach
Liver
Small intestine
Pancreas
Large intestine
Rectum
Anus
A schematic diagram of the human digestive system
Connection: Osmosis & Water Potential

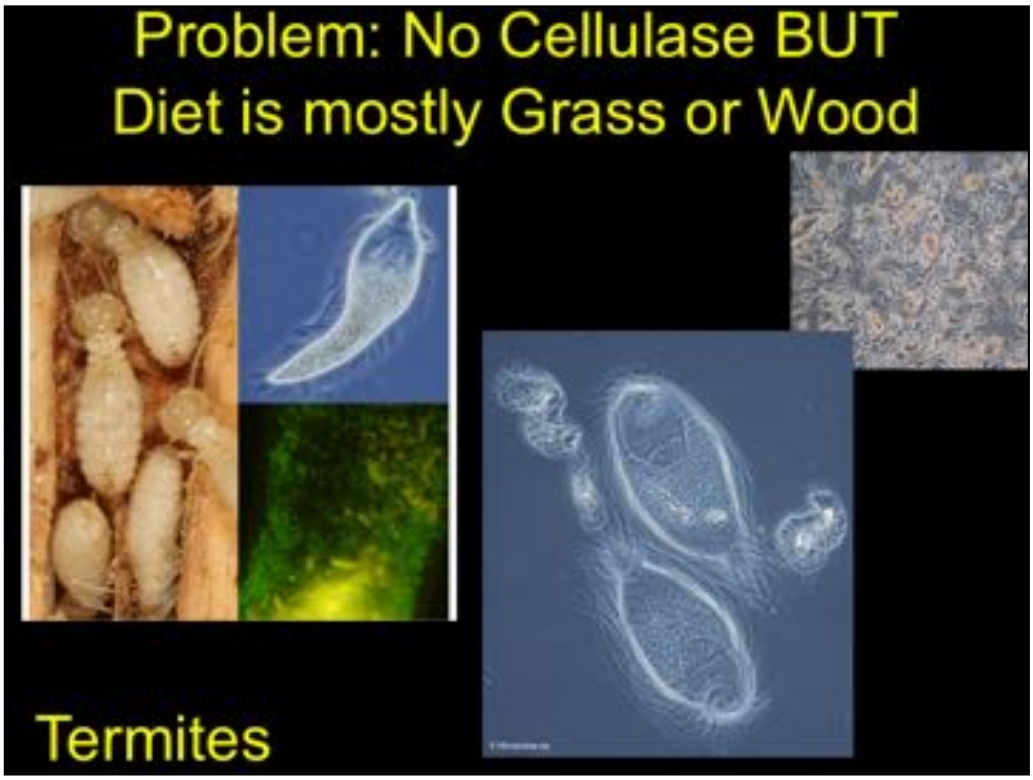
Why do you get diarrhea?

Osmotic diarrhea? -- Lactose intolerance is an example. Lactose high, water stays in lumen, lose water in stools

Inflammation – damage to the lining; (bacteria, viruses, parasites, autoimmune problems (iBS))


Nice Summary
Bloodstream
Lymphatic system
Veins to heart
Hepatic portal vein
Liver
Lipids
Absorbed food (except lipids)
Absorbed water
Mouth
Esophagus
Stomach
Small intestine
Anus
Large intestine
Rectum
Secretions from the gastric glands of the stomach
Secretions from the pancreas and the liver


Adaptations of Other Organisms
Carnivore:
Short
Absorb most
Herbivore
Long
Caecum
Little absorption
Small intestine
Stomach
Small intestine
Cecum
Colon (large intestine)
Carnivore
Herbivore



3. Cellulose degradation

Protists reside in the termite gut ingest wood particles in the form of cellulose and degrade it within their cells. Cellulolytic protists known as Trichonympha and mixotricha produce cellulases and various glycolytic enzymes that can break down cellulose and convert it into an intermediate product, malate (2). In addition, they carry specific anaerobic energy- generating organelle, hydrogenosome, where transferred malate from the cytoplasm is further fermented to produce CO_2, H_2, and acetate with the help of hydrogenase enzyme. During this fermentation process, ATP is also produced in the way and stored as energy available for both microbes and termite (2). From

https://microbewiki.kenyon.edu/index.php/Termite_gut

http://www.nytimes.com/2008/11/14/science/14visuals.html

n the termites' gut lives an amoeba-like microbe called a protist, and inside each protist live some 10,000 members of an obscure bacterium.

The microbes in the termites' gut are very hard to cultivate outside their termite host and so cannot be studied in the lab. The Japanese scientists, led by Yuichi Hongoh and Moriya Ohkuma at the RIKEN Advanced Science Institute in Saitama, have cut through this problem.

They extracted the protist's bacteria directly from a termite's gut, collected enough to analyze their DNA, and then decoded the 1,114,206 units of DNA in the bacterium's genome.

By comparing the DNA sequence of the bacterium's genes with other decoded genes already in public databases, the Japanese team was able to figure out what each gene did. It could then reconstruct all the biochemical reactions of which the bacterium is capable, as shown in the figure above.

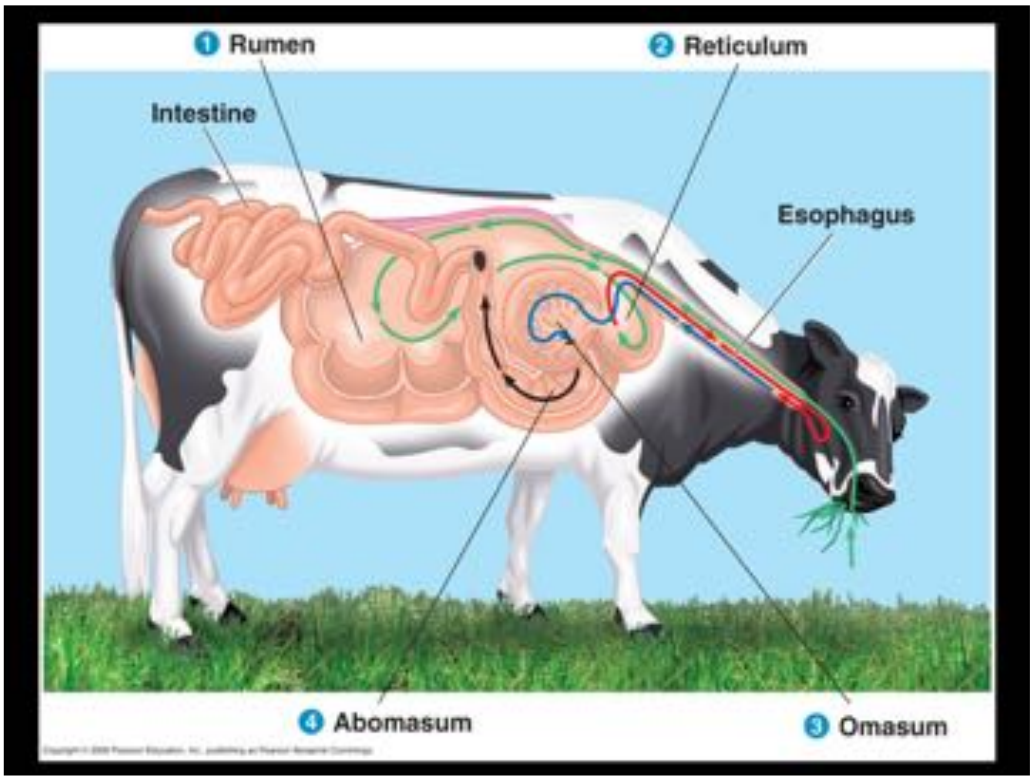
They found that in the bacterium's biochemical repertoire is the ability to convert nitrogen (shown as N2 , to the right of center in the figure) into ammonium and hydrogen. Unlike nitrogen, which is very unreactive, ammonium is easily incorporated into biochemical reactions.

The bacterium can also import urea (shown in the yellow border, at 5 o'clock), a waste product produced by its protist host. Since it takes a lot of energy to fix nitrogen, the bacteria probably use urea as their main nitrogen source as long as their host is making enough, and switch to nitrogen as a backup, the Japanese scientists say.

The overall process whereby this troika of species makes a meal of wood is shown in the graphic at left: the termite chews the wood into particles that are absorbed by the amoeba. The amoeba breaks down the cellulose of the wood and gets the nitrogen it needs from its bacteria. The net result is that the two microbes digest wood into sugars and other nutrients of use to the termite.

Dr. Caroline Harwood, an expert on microbes and biofuels at the University of Washington, Seattle, said the new research was a " tour de force of genome sequencing" that "solves the mystery of where the termite gets its nitrogen." Understanding how the termite's gut microbes digest cellulose would be of major significance for biofuels, she said, and the Japanese group's whole genome approach could further this goal.

http://www.riken.jp/en/research/rikenresearch/highlights/6214/



Think of this as the problem is lacking enzymes for cellulose → What is the solution/adaptation?

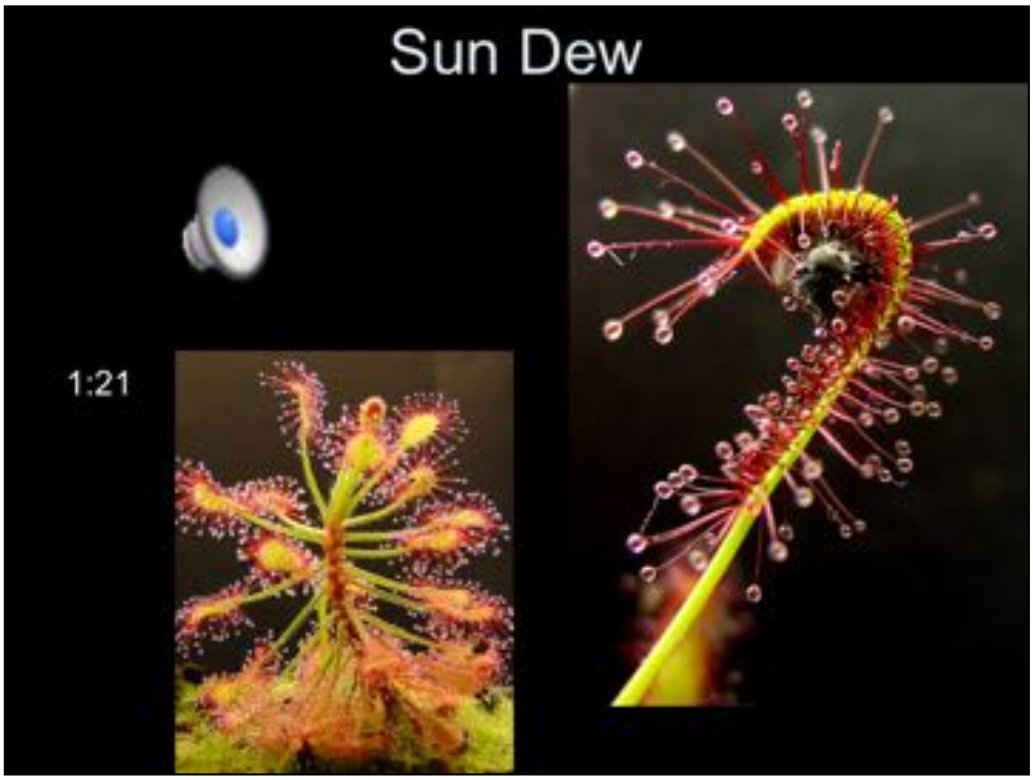
http://classroom.sdmesa.edu/eschmid/Lecture7-Microbio.htm

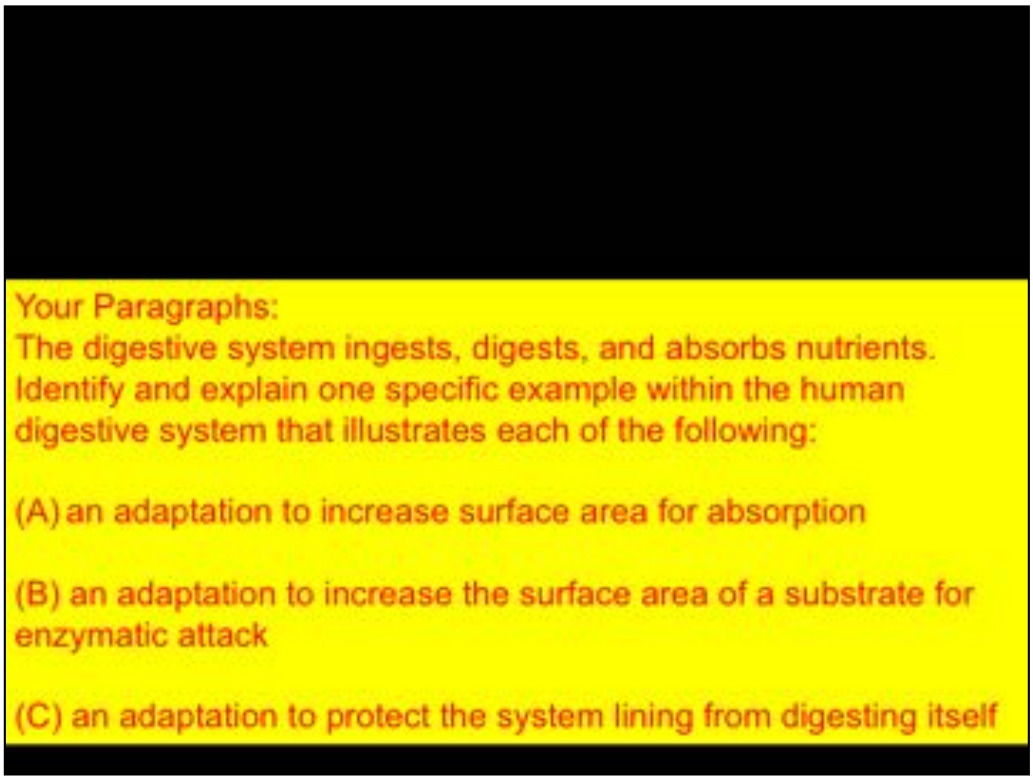

Play Video –
A Cow's Digestive System
1:40

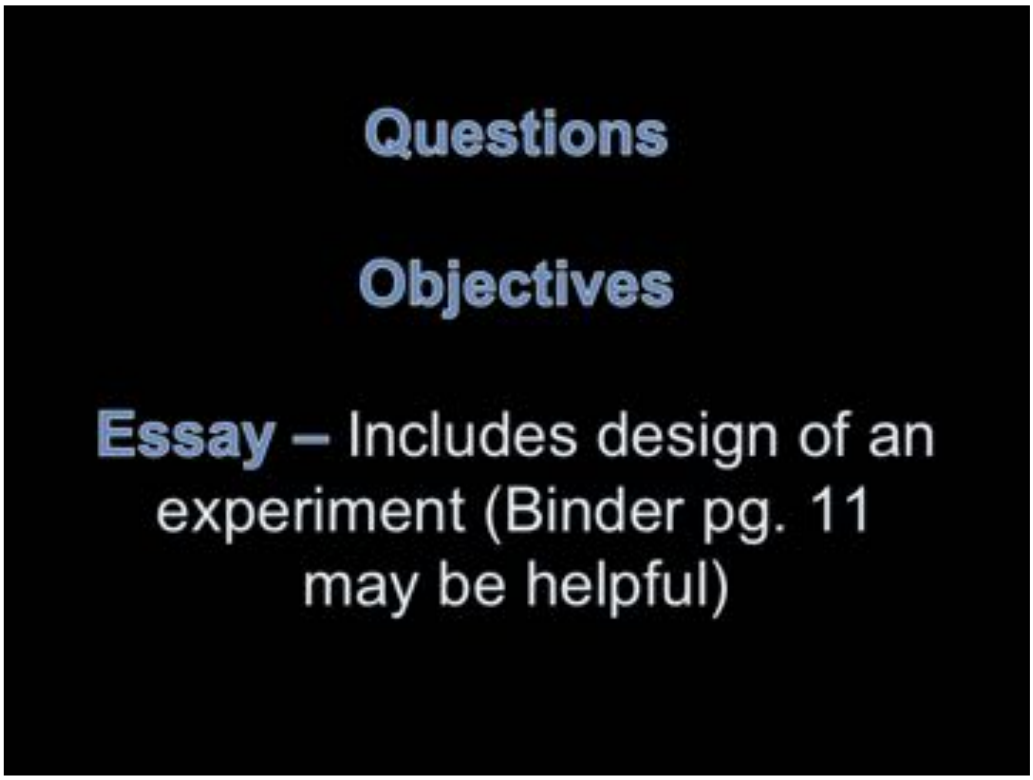

How do we know this?
Evolve: A Fistulated Cow
4:10

Eat their poop


What about plants? Do they need digestive enzymes?
Venus Fly Trap
BBC one
2:51

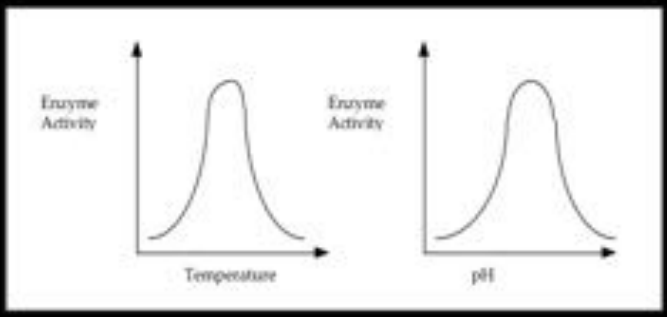

Sun Dew
1:21


Your Paragraphs:
The digestive system ingests, digests, and absorbs nutrients. Identify and explain one specific example within the human digestive system that illustrates each of the following:
(A) an adaptation to increase surface area for absorption
(B) an adaptation to increase the surface area of a substrate for enzymatic attack
(C) an adaptation to protect the system lining from digesting itself


Questions
Objectives
Essay – Includes design of an experiment (Binder pg. 11 may be helpful)

Essay #145

The effects of pH and temperature were studied for an enzyme-catalyzed reaction. The following results were obtained.

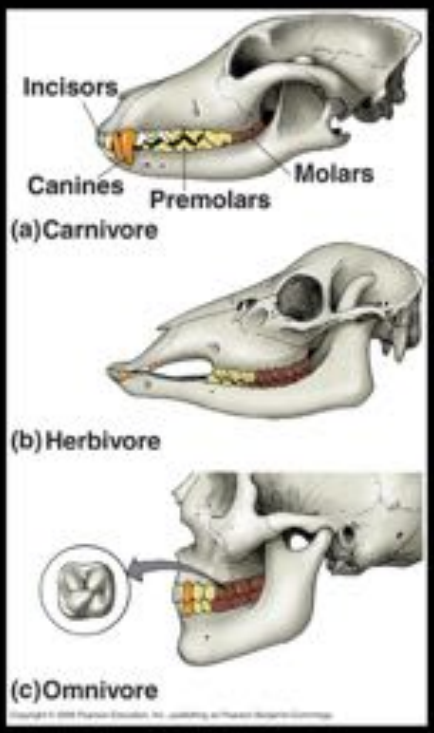


a) How do (1) temperature and (2) pH affect the activity of this enzyme? In your answer, include a discussion of the relationship between the structure and the function of this enzyme, as well as a discussion of how structure and function of enzymes are affected by temperature and pH.

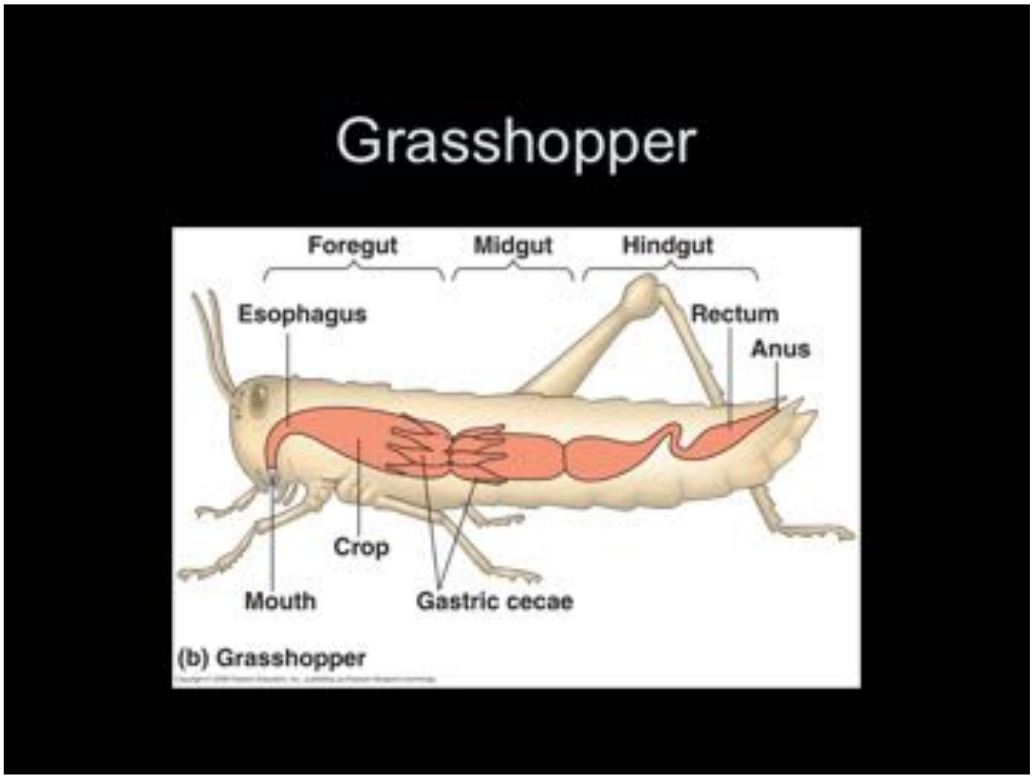
(b) **Describe** a controlled experiment that could have produced data shown for either temperature or pH. Be sure to state the hypothesis that was tested here. (You may identify a specific enzyme and use it in your experiment.)

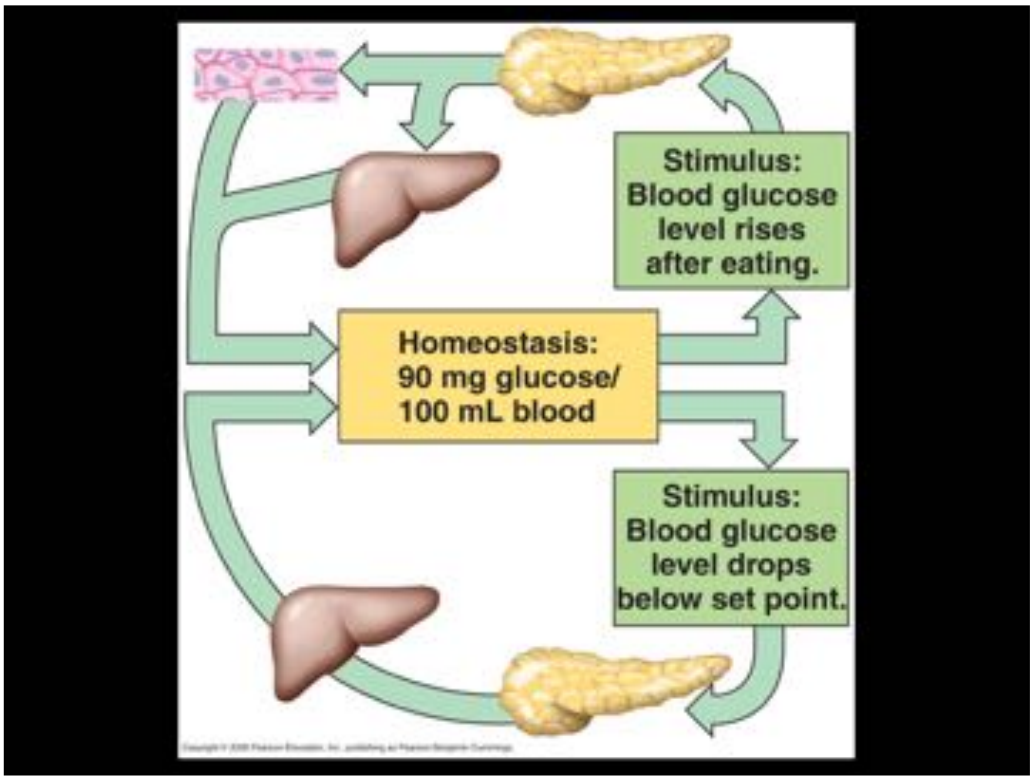

Pitcher Plant

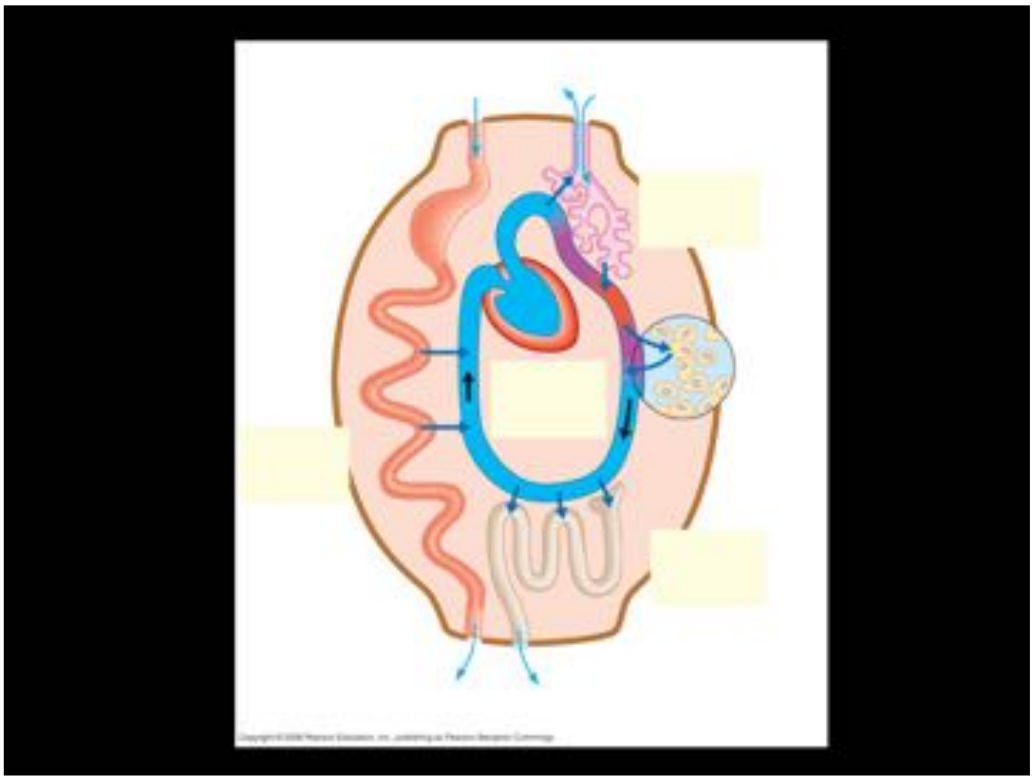
Explore Skeletons

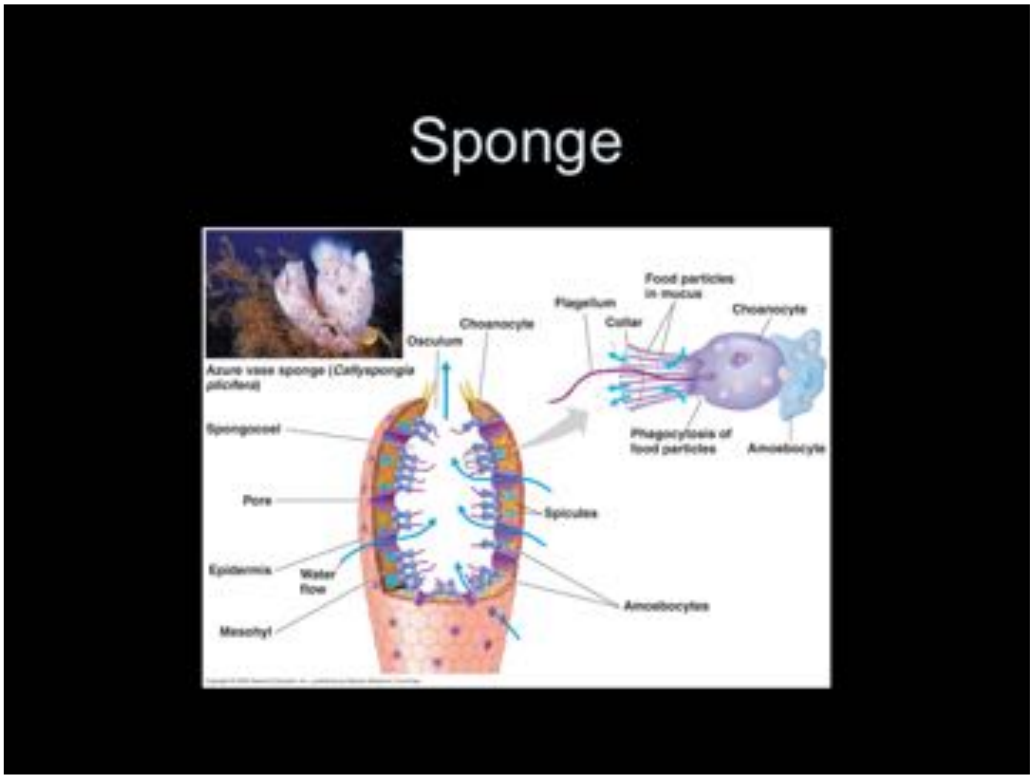


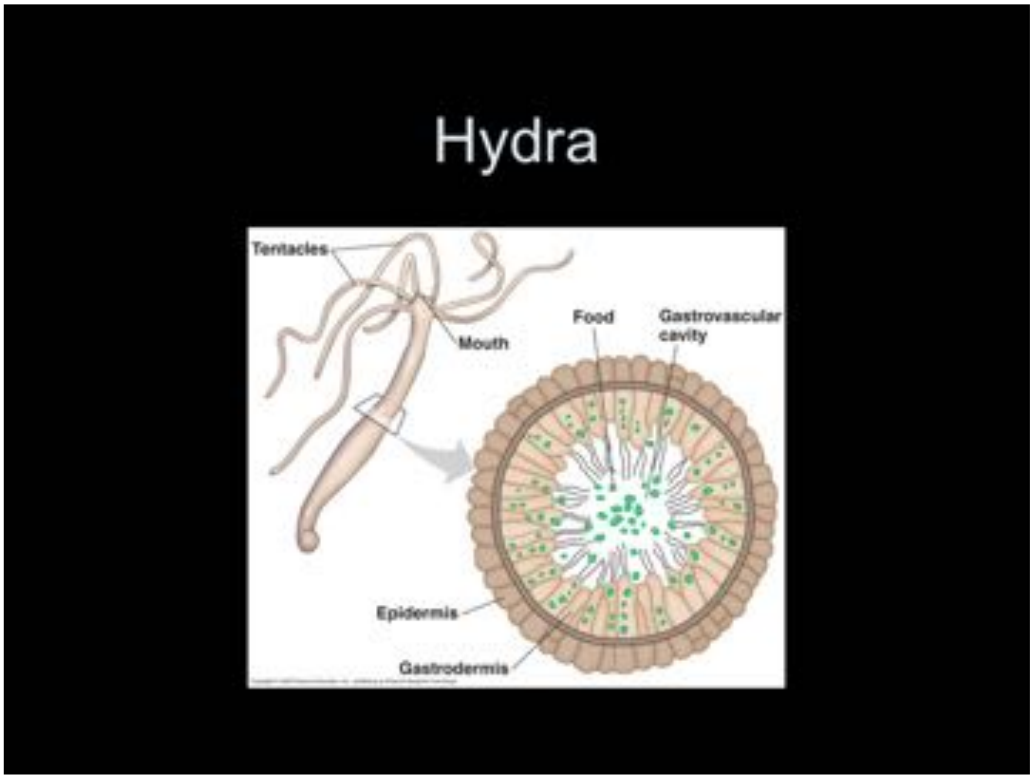

Watch Video: Snake Eats an Agg
Skeleton Adaptations

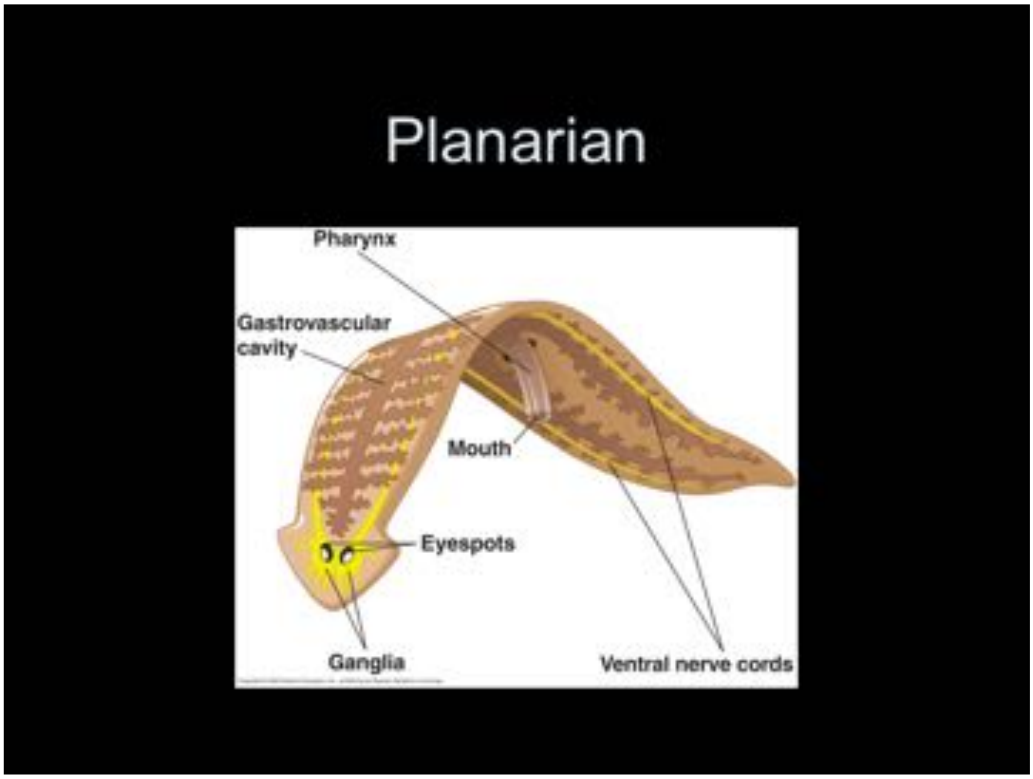

Grasshopper
Foregut
Midgut
Hindgut
Esophagus
Rectum
Anus
Crop
Mouth
Gastric cecae
(b) Grasshopper

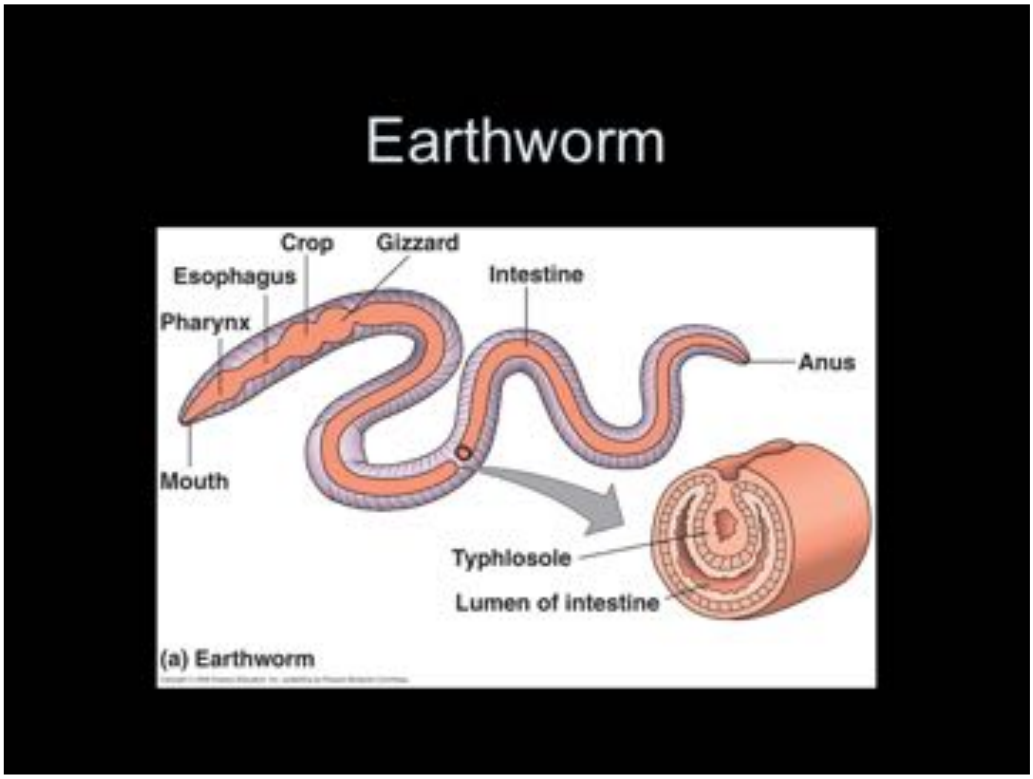

Stimulus:
Blood glucose
level rises
after eating.
Homeostasis:
90 mg glucose/
100 mL blood
Stimulus:
Blood glucose
level drops
below set point.

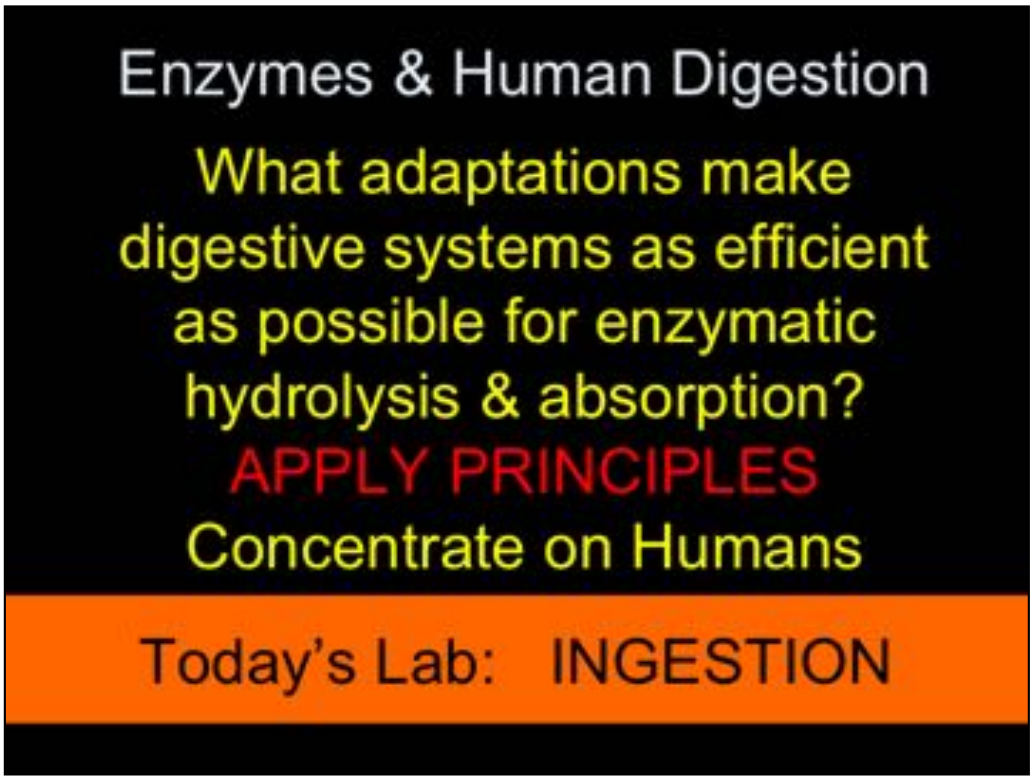


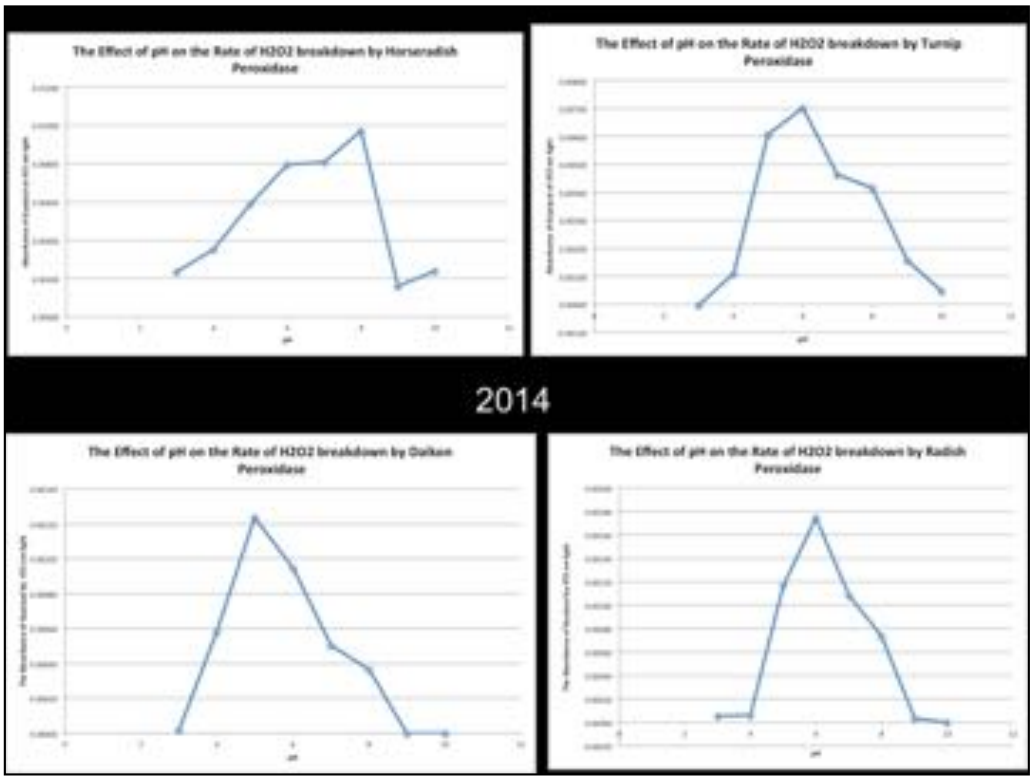

Sponge
Azure vase sponge (Callyspongia plicifera)
Osculum
Choanocyte
Spongocoel
Pore
Epidermis
Water flow
Mesohyl
Spicules
Amoebocytes
Food particles in mucus
Flagellum
Collar
Choanocyte
Phagocytosis of food particles
Amoebocyte


Hydra
Tentacles
Mouth
Food
Gastrovascular cavity
Epidermis
Gastrodermis


Planarian
Pharynx
Gastrovascular cavity
Mouth
Eyespots
Ganglia
Ventral nerve cords


Earthworm
Crop
Gizzard
Esophagus
Intestine
Pharynx
Anus
Mouth
Typhlosole
Lumen of intestine
(a) Earthworm


Enzymes & Human Digestion
What adaptations make digestive systems as efficient as possible for enzymatic hydrolysis & absorption?
APPLY PRINCIPLES
Concentrate on Humans
Today's Lab: INGESTION


The Effect of pH on the Rate of H2O2 breakdown by Horseradish Peroxidase
The Effect of pH on the Rate of H2O2 breakdown by Turnip Peroxidase
2014
The Effect of pH on the Rate of H2O2 breakdown by Oalkon Peroxidase
The Effect of pH on the Rate of H2O2 breakdown by Radish Peroxidase