SCIENCE THEATER CARD SET
EXPLORE 2 LESSON 4

Food and Agriculture Center for Science Education

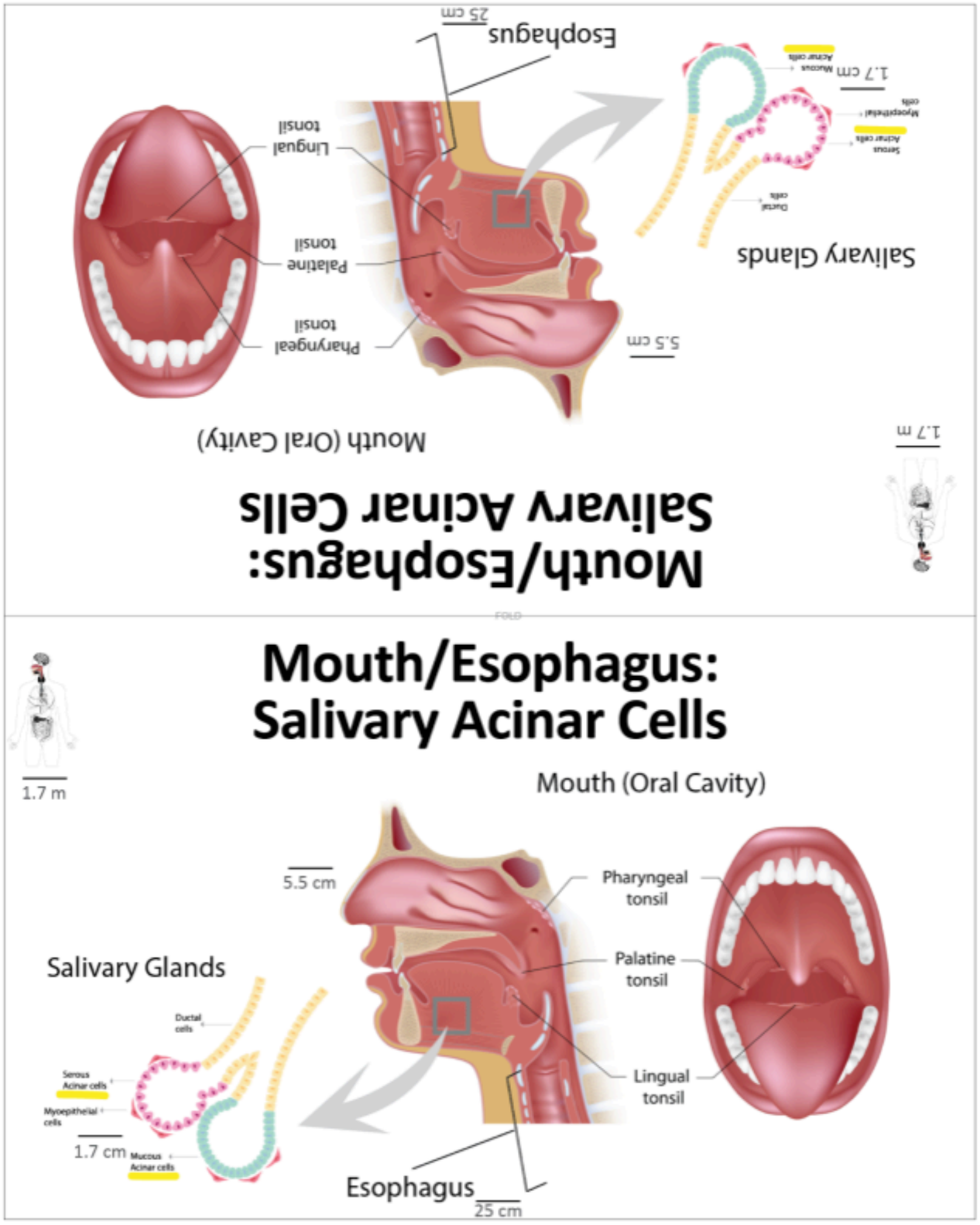
Materials

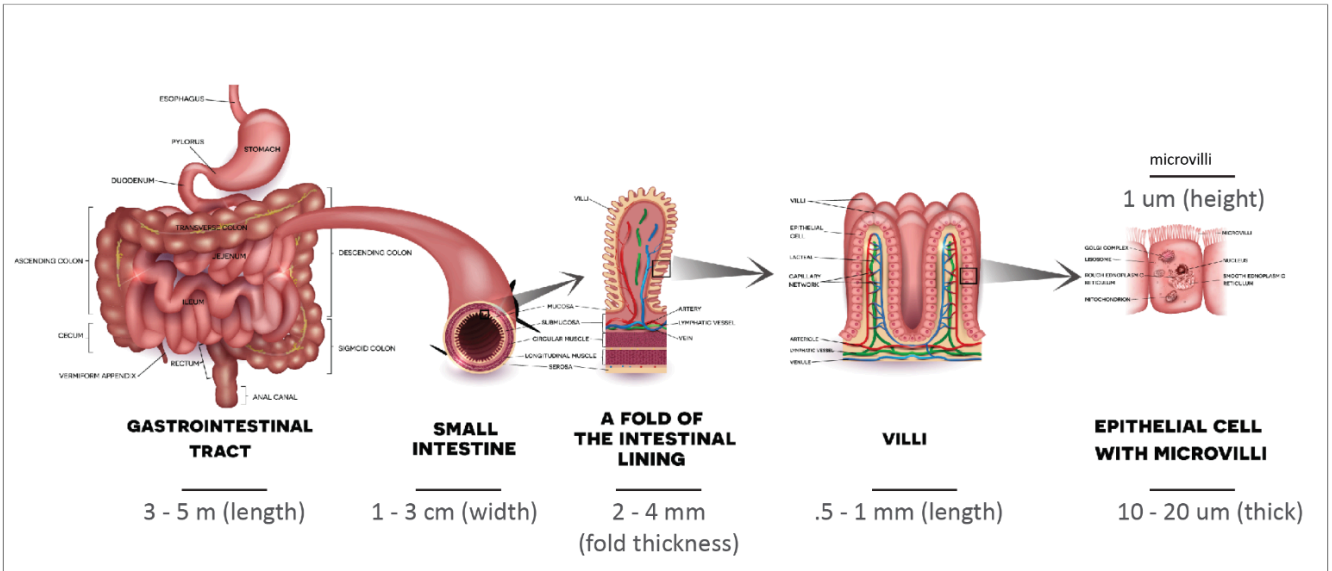
Materials included on the following pages include:

- **Table Tents** for each organ (or, in some cases, grouping of organs) represented in the model *(Pages 2-6)*
- **Tokens** for each represent relevant nutrients, stimuli, and responses represented in the model *(Pages 7-14)*
- **Role Cards** for each organ, including any specialized cells *(Pages 15-24)*

Instructions for printing and preparing materials:

- Print one copy of the materials on the following pages (printing on cardstock weight is suggested)
- Cut along dotted lines
- Fold along solid lines marked “FOLD.”





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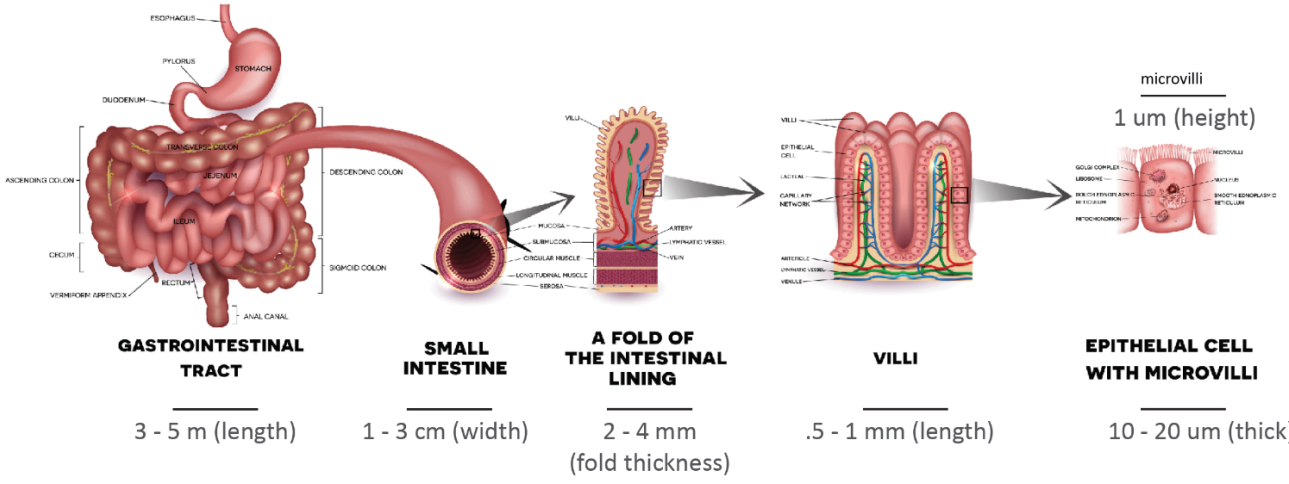
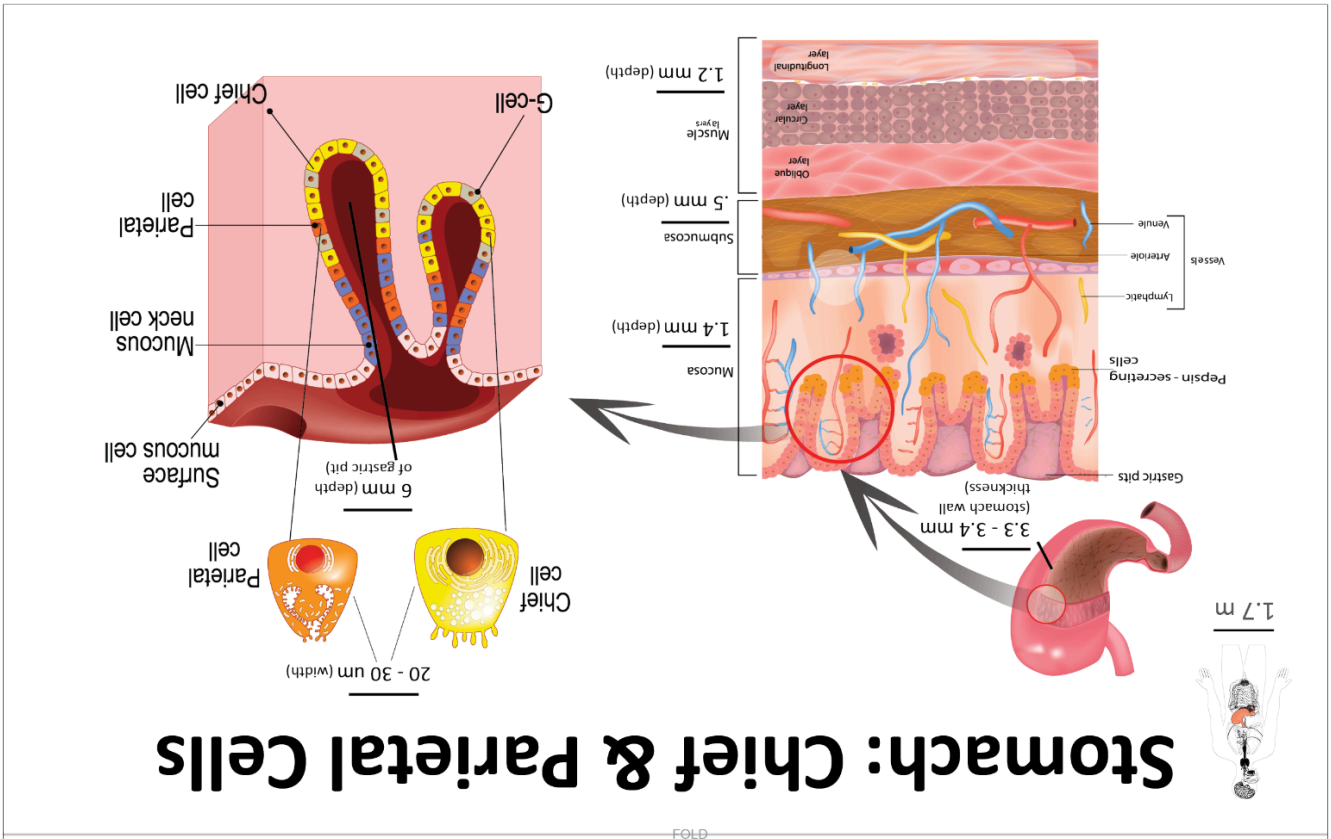
Small Intestine: Epithelial Cells

1.7 m





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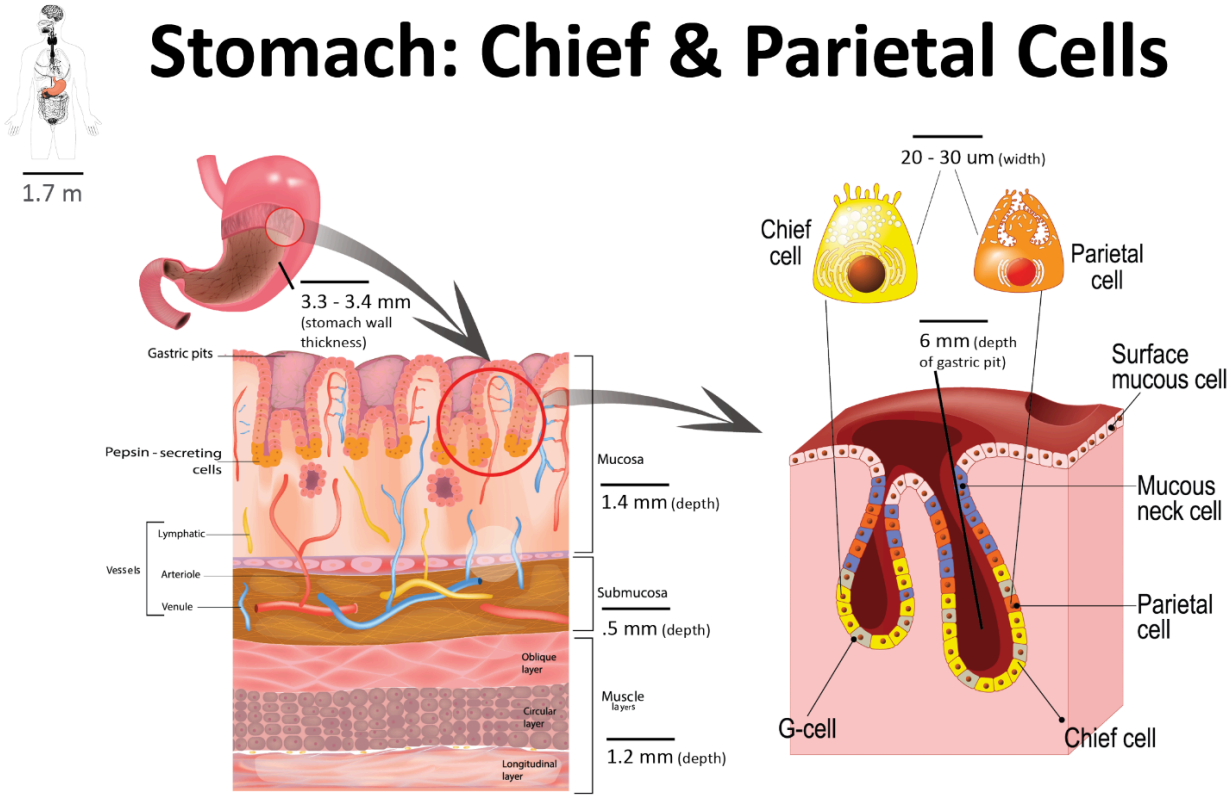

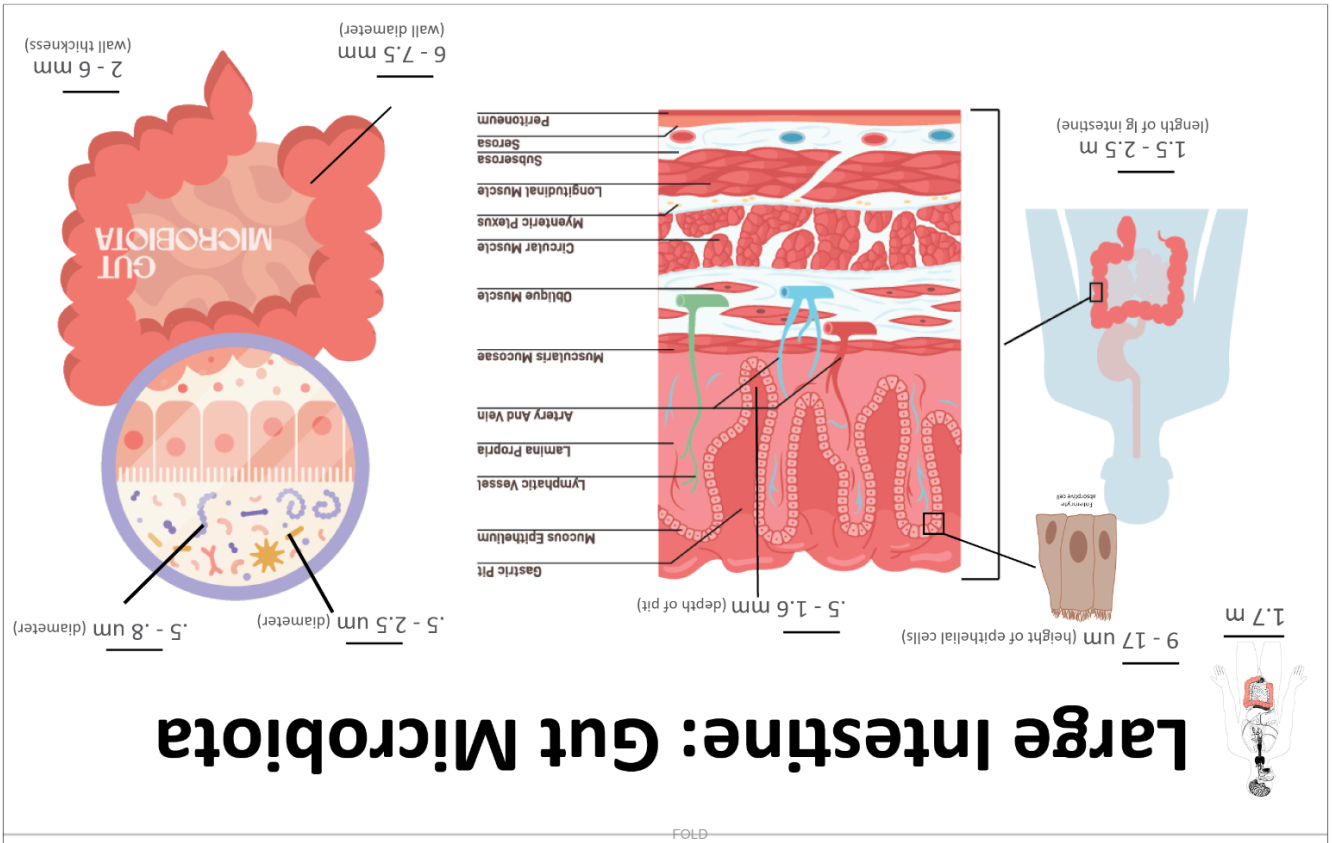

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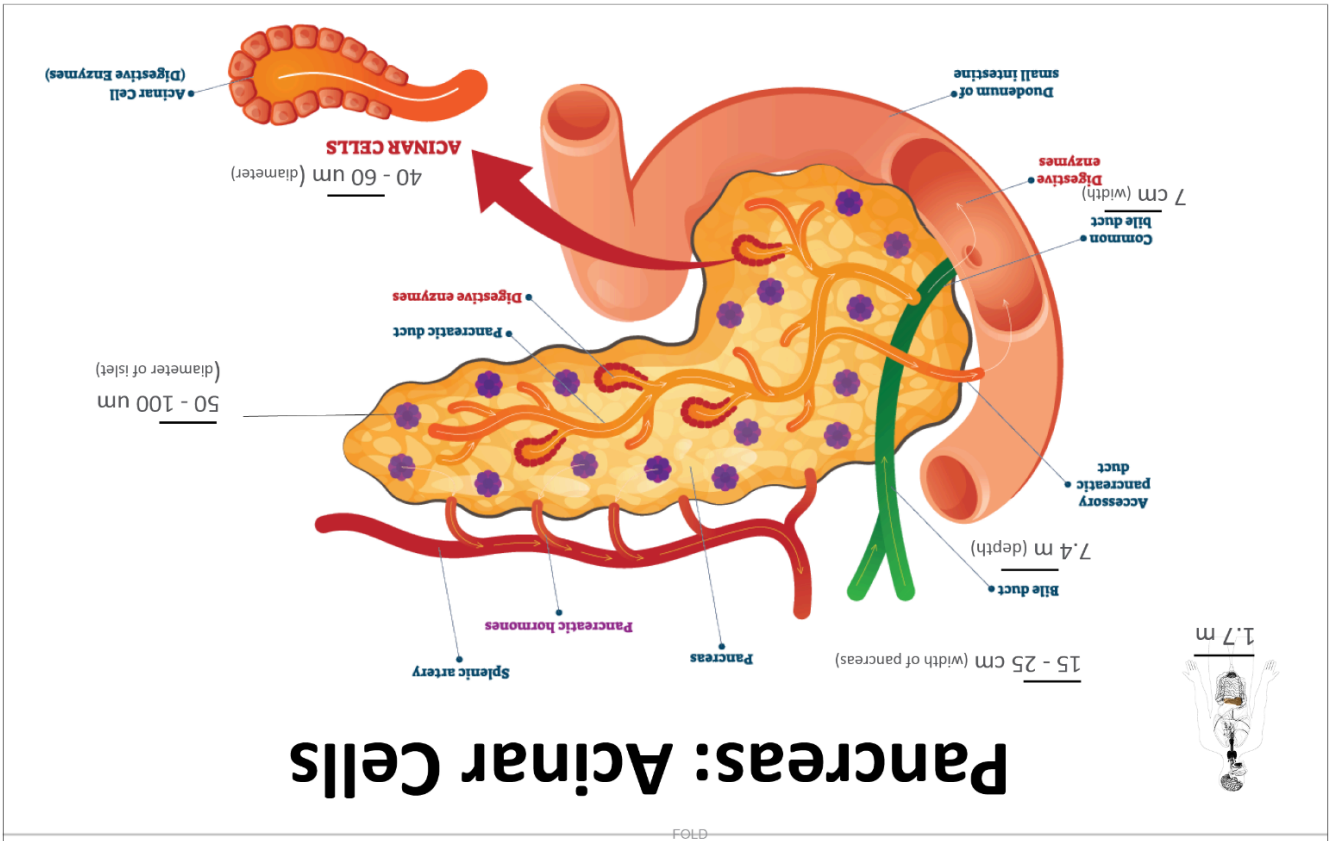


FOLD

Pancreas: Acinar Cells

1.7 m

15 - 25 cm (width of pancreas)

Pancreas

Splenic artery

Pancreatic hormones

Bile duct

7.4 m (depth)

Accessory pancreatic duct

50 - 100 um

(diameter of islet)

Pancreatic duct

Digestive enzymes

Common bile duct

7 cm (width)

Digestive enzymes

Duodenum of small intestine

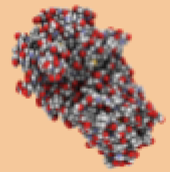
40 - 60 um (diameter)

ACINAR CELLS

Acinar Cell

(Digestive Enzymes)

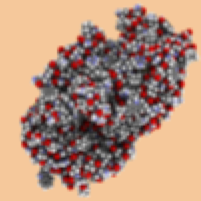
Pepsin



1.1 nm

Starting Location: Stomach - Parietal Cells

Amylase



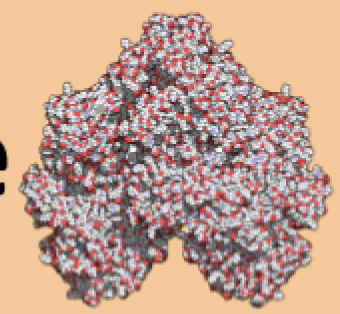
1.5 nm

Starting Location: Mouth/Esophagus - Salivary Glands

Gastric Juices

Starting Location: Stomach - Chief Cells

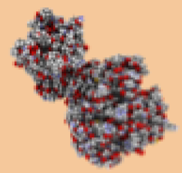
Lactase



4.88 nm

Starting Location: Small Intestine

Lipase



4.88 nm

Starting Location: Pancreas - Acinar Cells

Digestive waste products

Starting Location: Small Intestine

Breakdown (digestion) of proteins

Starting Location: Stomach

Breakdown (digestion) of lactose

Starting Location: Small Intestine

Reduce the size of fat molecules to smaller fat molecules

Starting Location: Stomach

Produce and secrete saliva

Starting Location:Mouth/Espohagus - Salivary Glands

Defecate and remove stool from the body

Starting Location: Large Intestine

Form stool

Starting Location: Large Intestine

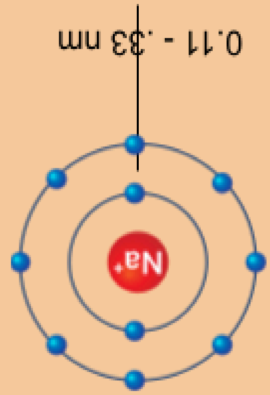
Destroy potentially harmful bacteria

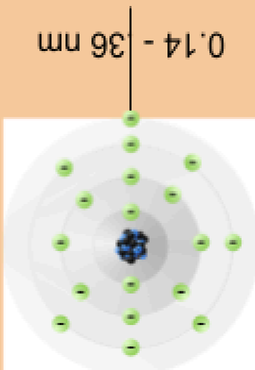
Starting Location: Stomach

Breakdown of small fat molecules into fatty acids

Starting Location: Small Intestine

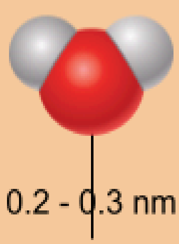
Electrolytes

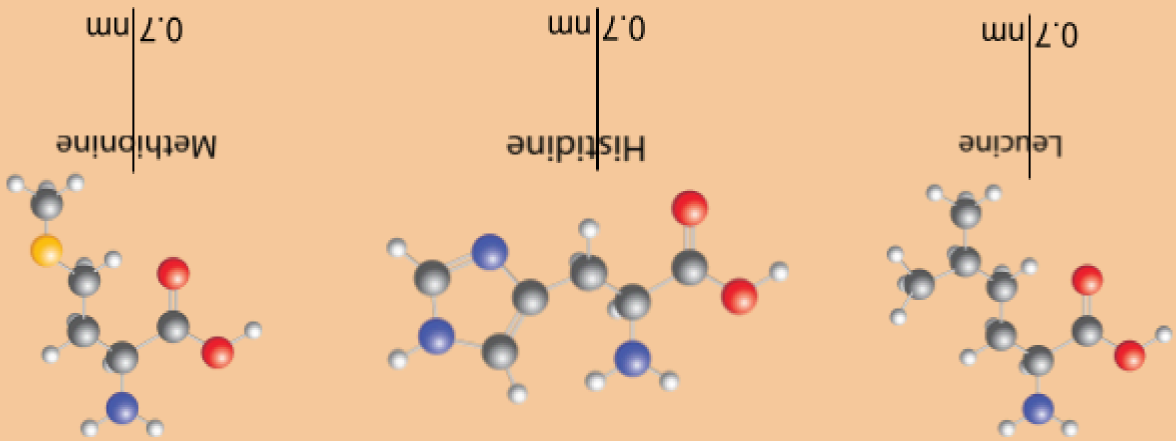




K+

Water



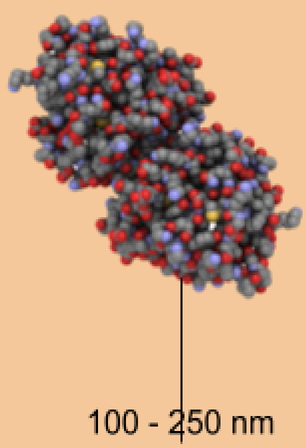


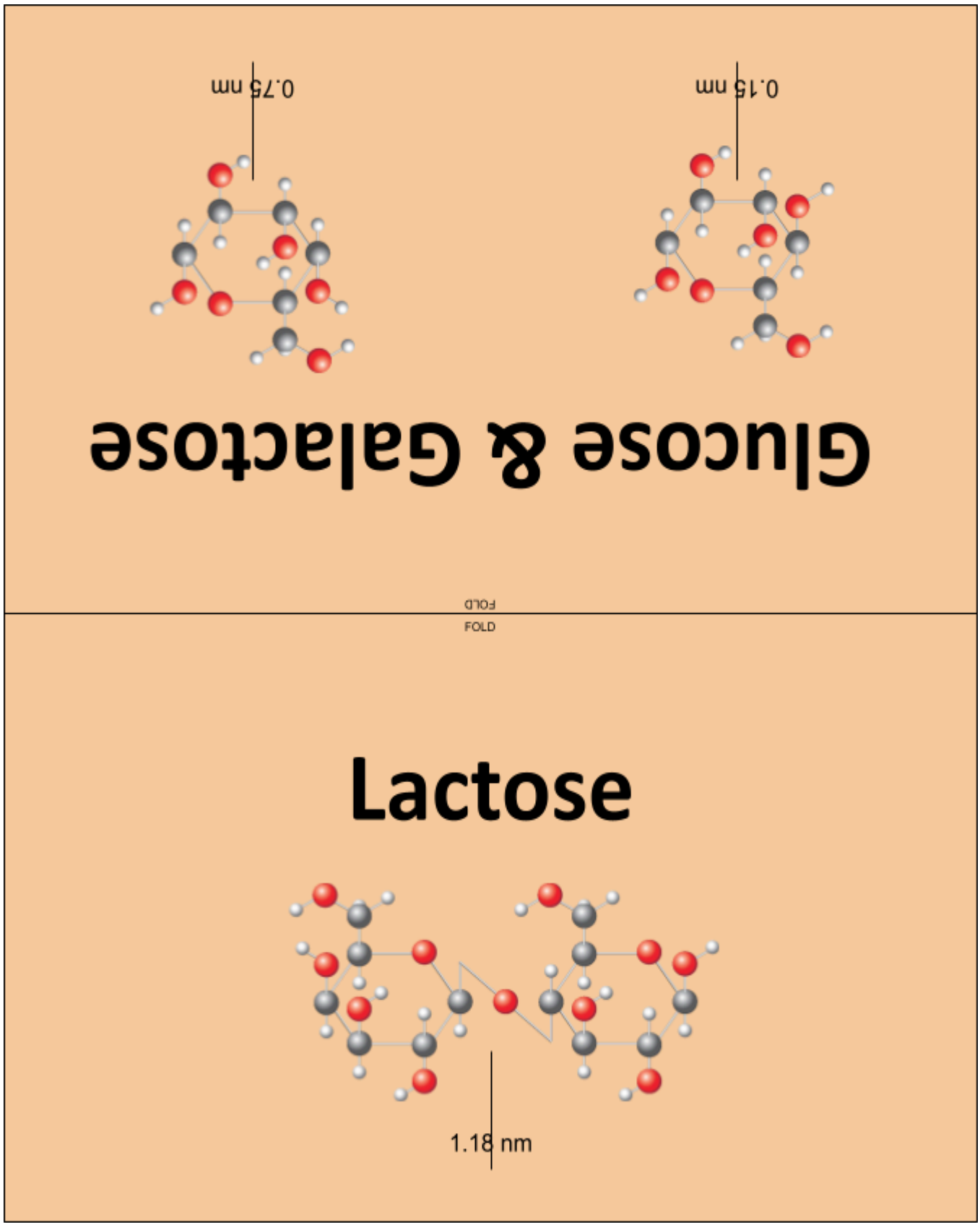
Amino Acids

FOLD

FOLD

Proteins




0.15 nm
0.75 nm
Glucose & Galactose
FOLD
FOLD
Lactose
1.18 nm

Fatty Acids

2.6 nm (one example)

FOLD

FOLD

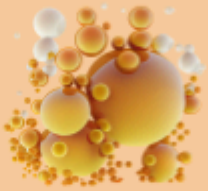
Small Fat Molecules

Few - several nm

FOLD

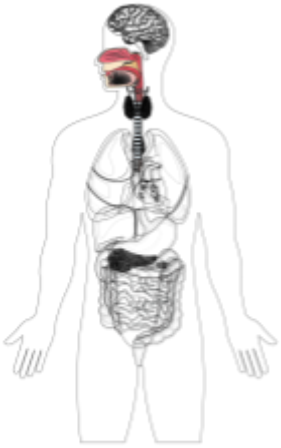
FOLD

Fat Molecules



0.1 - 15 um

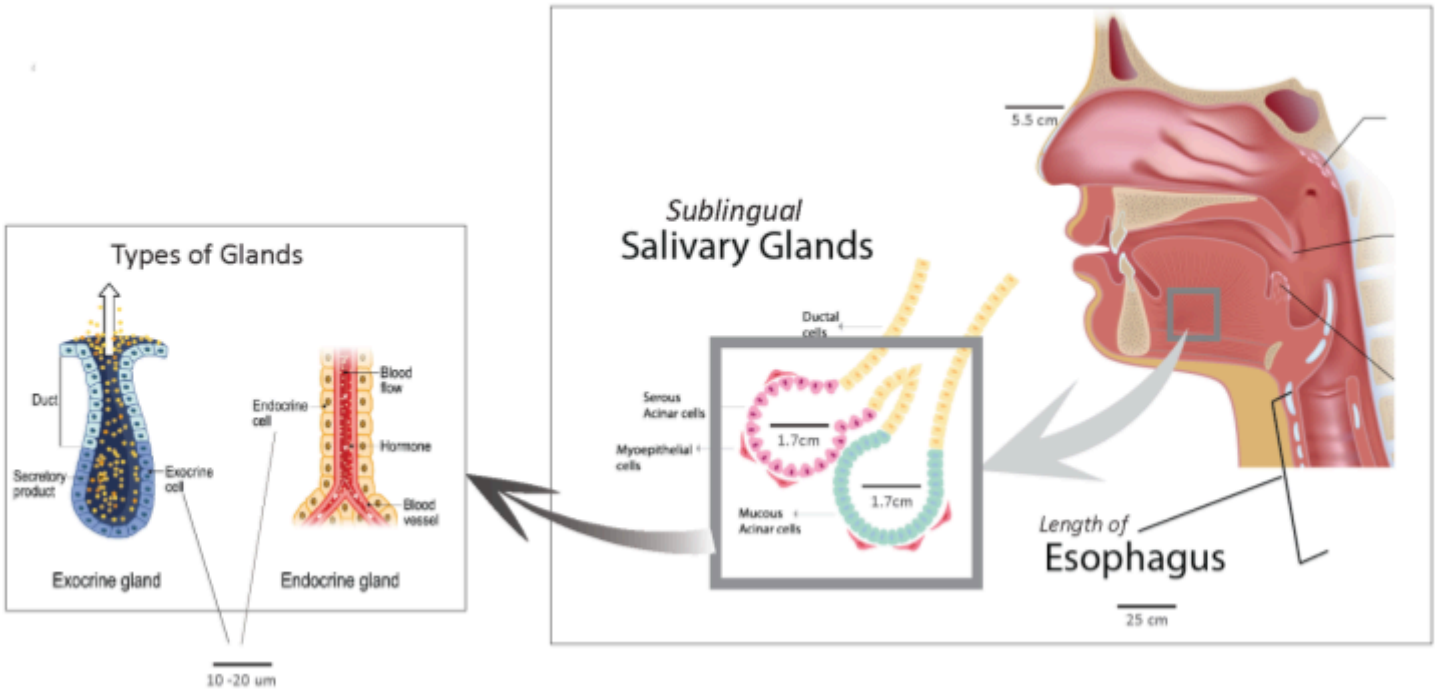
Mouth/Esophagus - Salivary Acinar Cells



The mouth is an opening and cavity that plays roles in eating, drinking, digestion, tasting, and talking. The esophagus is a muscular, tube-like organ that connects and passes food and liquid from the mouth to the stomach.

Parts of the mouth include teeth, gums, palate (roof of mouth), mucus membranes, the tongue, taste buds, and salivary glands. Teeth allow us to chew and break down large pieces of food so it can be swallowed. The tongue is technically a muscle, allowing us to lick and helps us breathe, swallow, and speak. The taste buds on our tongue bind to different kinds of molecules in food and send a signal via nerves to the brain to create the perception of taste.

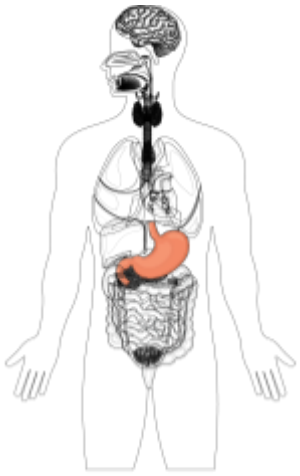
Within the mouth, three major glands produce saliva. Saliva helps to moisten food, making it easier to swallow through the esophagus. Saliva also contains specialized molecules that begin the process of digestion of food. Saliva is produced by three major salivary glands in the mouth. Each of these salivary glands contains multiple different types of cells. One specific cell type, called acinar cells, are specialized epithelial cells that produce most of the saliva in the mouth. Acinar cells also produce the enzyme amylase to begin the breakdown of molecules of starch in food.



Science Theater Actions: Mouth/Esophagus - Salivary Acinar Cells

Act 1: Digestion of Milk
Acinar cells in the salivary glands of the mouth produce saliva to moisten food and make it easier to swallow. Other cells in the salivary glands produce the amylase enzyme. ● Receive the *protein, lactose, water, electrolytes, and fats* tokens from outside the body. ● As the milk/nutrients enter the mouth, Activate the *Produce and secrete saliva* token to prepare the food for swallowing. ● Activate *amylase* to begin the digestion of complex carbohydrates (fiber) if present. ● Pass the *protein, lactose, water, electrolytes, and fat molecule* tokens to the stomach.

Stomach - Parietal Cells & Chief Cells

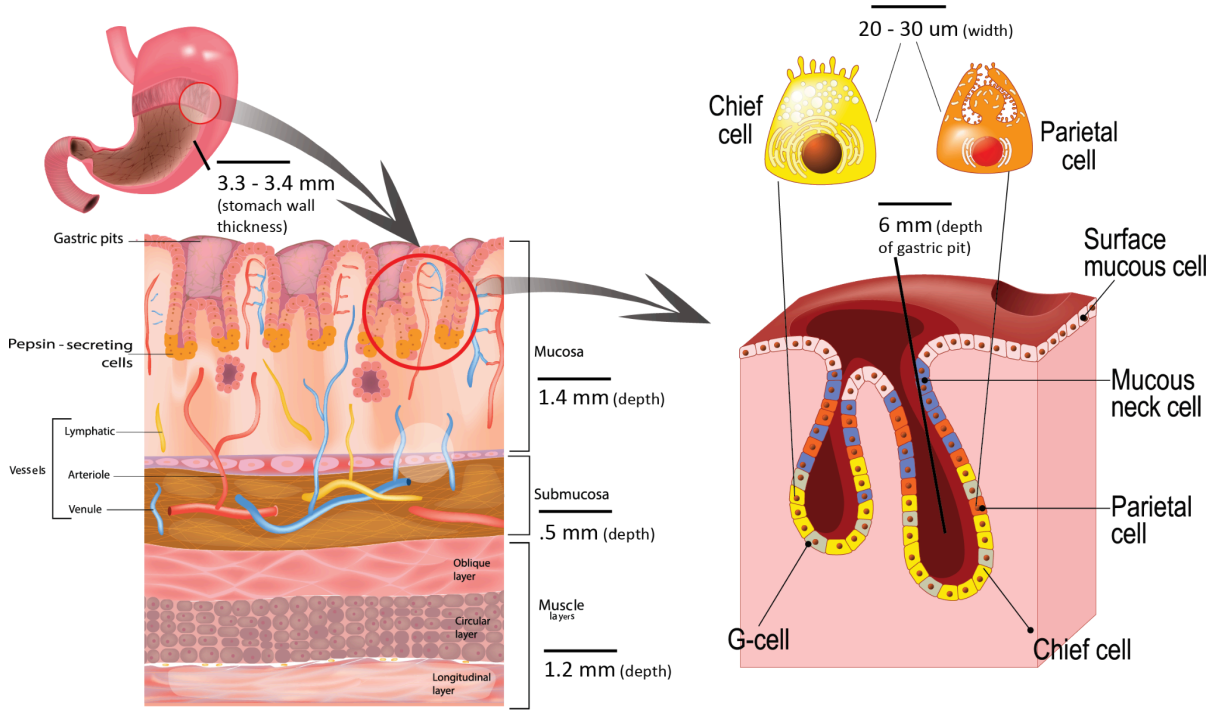


1.7 m (height)

The stomach is a digestive organ that receives food from the esophagus. The stomach is a muscular organ that contracts and produces acids and enzymes that break down food. When the stomach has broken down food, it passes it to the small intestine.

The primary functions of the stomach are to expand to hold large quantities of food and to continue food's partial digestion. The upper portions of the stomach use muscular contractions and relaxation to expand and allow more or less food to enter at different points in time. The lower portion of the stomach rhythmically contracts to mechanically break down food by churning and squeezing. The lower portion of the stomach also mixes food with gastric juices, which also breaks food down and prepares it for further digestion in the small intestine.

Two types of cells found in these glands are parietal and chief cells. Parietal cells secrete hydrochloric acid (HCl), which makes the interior of the stomach acidic to help aid in the digestion of food. HCl is one of several components of “gastric juice,” contributing to the acidic environment of the stomach, enabling the stomach to destroy potentially harmful bacteria. In an acidic environment, the enzyme pepsinogen, or pepsin, is able to break bonds of proteins in food, breaking the long chains of proteins into smaller chains of amino acids. Pepsin is secreted by the chief cells. The acidic content of the stomach also begins to break large fat molecules into smaller fat molecules.



Science Theater Actions: Stomach - Parietal Cells & Chief Cells

Act 1: Digestion of Milk

The parietal cells in the stomach release hydrochloric acid into the interior of the stomach to create an acidic environment in the stomach, which helps with the enzyme pepsin, released by the chief cells, breaking down protein molecules into amino acids.
 	
● Receive *protein*, *lactose*, *water*, *electrolytes*, and *fat molecules* from the mouth/esophagus.
● Use the *pepsin* token to activate the *digestion/breakdown of proteins.*
  ○ Replace the *proteins* token with the *amino acids* token.
● Use the *gastric juices* token to:
  ○ Activate the *destroy potentially harmful bacteria* token.
  ○ Activate the *breakdown of small fat molecules into fatty acids* token.
  ■ Replace the *fat molecules* token with the *small fat molecules* token.
● Pass the *amino acids*, *lactose*, *water*, *electrolytes*, and *small fat molecules* tokens to the small intestine.

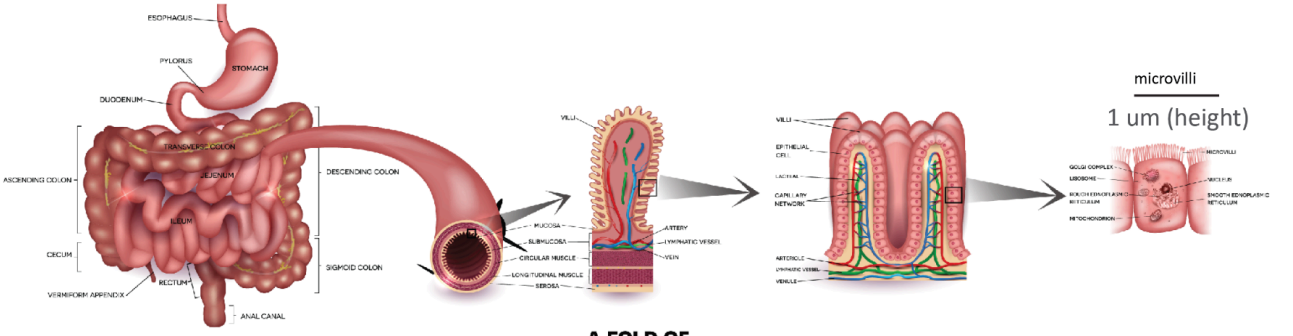
Small Intestine - Epithelial Cells

1.7 m (height)

The small intestine is a long, tube-like digestive organ that receives partially digested food and digestive juices from the stomach. It also receives bile from the liver and digestive enzymes from the pancreas. The small intestine is located below the stomach in the abdomen and is surrounded by muscles that help push the food through the organ. The principal function of the small intestine is to break down food and absorb nutrients needed for the body. It also plays a role in the immune system, acting as a barrier to any pathogens entering the digestive system to ensure no harmful bacteria enter the body.

The small intestine is a long, hollow tube. The interior surface of the small intestine is covered in small, finger-like structures called villi. The villi increase the surface area of the small intestine. The outer cellular layer of the villi is composed of a single-cell thick layer of intestinal epithelial cells. These cells function as the barrier between the inside of the intestine and the bloodstream.

To help with the digestion of food, the small intestine is connected to the pancreas by a small tube known as the pancreatic duct. This connection plays an essential role in food digestion because the pancreas releases many different digestive enzymes through the pancreatic duct into the small intestine. Small intestine epithelial cells, therefore, provide a barrier to keep the enzymes released by the pancreas within the small intestine, where they can break down food molecules. The epithelial cells also release digestive enzymes into the interior of the small intestine. For example, the enzyme lactase is released by the intestinal epithelial cells and helps break down the molecule lactose into glucose and galactose.



GASTROINTESTINAL TRACT
3 - 5 m (length)

SMALL INTESTINE
1 - 3 cm (width)

A FOLD OF THE INTESTINAL LINING
2 - 4 mm (fold thickness)

VILLI
.5 - 1 mm (length)

EPITHELIAL CELL WITH MICROVILLI
10 - 20 um (thick)

Science Theater Actions: Small Intestine - Epithelial Cells

Act 1: Digestion of Milk
Epithelial cells in the small intestine provide a barrier between the interior of the small intestine and the inside of the rest of the body. Lactase and lipase are enzymes used in the small intestine for digestion. Lactase is produced within the small intestine. ● Receive *amino acids*, *lactose*, *water*, *electrolytes,* and *small fat molecules* from the stomach. ● Use the *lactase* token to activate the *breakdown/digestion of lactose*. ● Replace the *lactose* token with *glucose and galactose* tokens. Lipase is not produced in the small intestine but is used in the small intestine. ● Receive the *lipase* from the pancreas. ● Use *lipase* to *break down the small fat molecules* into *fatty acids*. ● Replace the *small fat molecules* token with the *fatty acids* token. The water and electrolytes continue to the large intestine. ● Pass the *water* and *electrolytes* tokens onto the large intestine. Food is never 100% completely digested. Digestive waste, such as undigested fibers, proteins, and fats from other meals, moves through the small intestine. ● Pass the *digestive waste products* token to the large intestine.

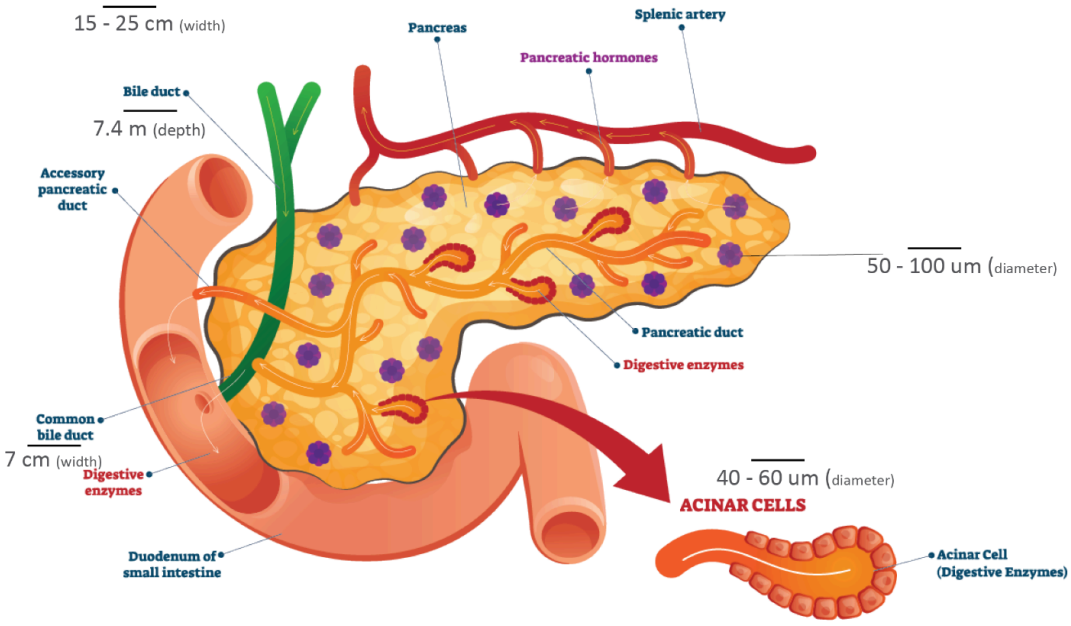
Pancreas - Pancreatic Acinar Cells

The pancreas is an organ located in the abdomen. It plays an important function in both the digestion of food and as a source of hormone molecules that control blood glucose levels.

While the pancreas has numerous types of cells for its different functions, the acinar cells of the pancreas are the cell type primarily involved in digestion.

Acinar cells synthesize and secrete multiple kinds of digestive enzymes into the interior of the small intestine: proteolytic enzymes, lipolytic enzymes, and glycolytic enzymes. Proteolytic enzymes such as trypsin, chymotrypsin, carboxypeptidase, and elastase are enzymes that digest proteins. The pancreatic lipolytic enzymes digest fats and include lipase, phospholipase, and esterase. The glycolytic (carbohydrate-digesting) enzymes are lactase and amylase, which break down starch into glucose and other smaller carbohydrates.

Pancreatic acinar cells are organized into small clusters, which form very small ducts. The ducts from many clusters of acinar cells join together and eventually lead to the pancreatic duct, which carries all of the secreted digestive enzymes to the small intestine.



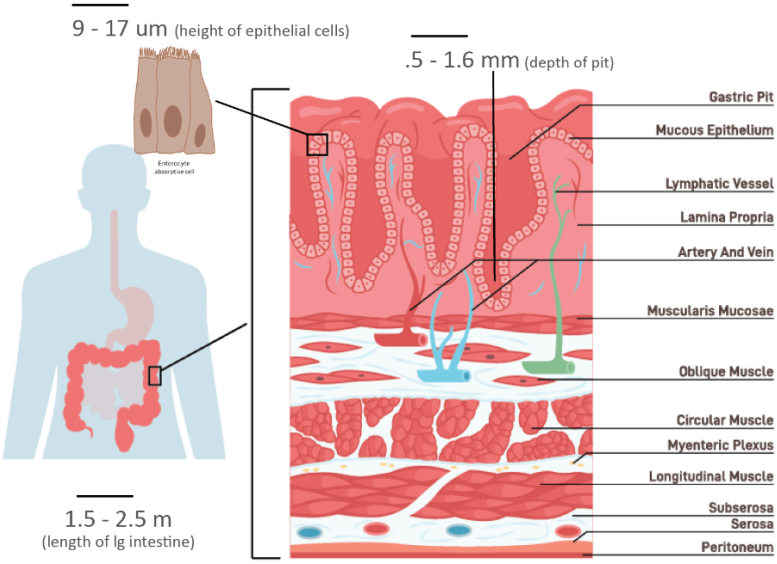
Science Theater Actions: Pancreas - Pancreatic Acinar Cells

Act 1: Digestion of Milk
Acinar cells produce and release digestive enzymes into the pancreatic duct, where they travel to the small intestine. ● Pass the *lipase enzyme* token to the epithelial cells of the small intestine.

Large Intestine - Microbiota

The large intestine is a long, tube-like organ that begins at the end of the small intestine and ends with the rectum and anus. The large intestine is the last part of the digestive tract. Unlike other organs of the digestive system, where food in the process of digestion passes through, only waste enters the large intestine. Like the small intestine, the walls of the large intestine are surrounded by different layers of smooth muscle cells that can contract to push food waste through the intestine. Within the large intestine live trillions and trillions of microbial organisms that aid the body in the digestion of fibers and in the function of the immune system. Collectively, these microbes are known as the gut microbiota.

The lining of the large intestine is lined with epithelial cells. These cells are in direct contact with the gut microbiota, which exists inside the large intestine. Fibers are not easily digested and travel lower to the large intestine. There, the microbiota help to break down these compounds with their own unique digestive enzymes that humans cannot make. The fermentation of indigestible fibers causes the production of short-chain fatty acids (SCFA) that can be used by the body as a nutrient and energy source. Sometimes, the fermentation of fibers can also produce gas, which is expelled as flatulence. After the microbiota further digest the waste in the large intestine, the remainder of the waste forms stool and is moved out of the body when defecating.



Science Theater Actions: Large Intestine - Microbiota

Act 1: Digestion of Milk
The microbiota in the gut ferment the fiber and other waste products that are not able to be broken down by enzymes in the small intestine. ● Milk does not contain indigestible fibers that the microbiota can break down with their digestive enzymes. Take no action for fibers. Water and electrolytes are reabsorbed through the epithelial lining of the small intestine, while other waste products are excreted from the body. ● Water and electrolytes exit the large intestine but remain in the body. ● Use the digestive waste products token to activate the form stool token. ● Activate the defecate and remove the stool from the body token.