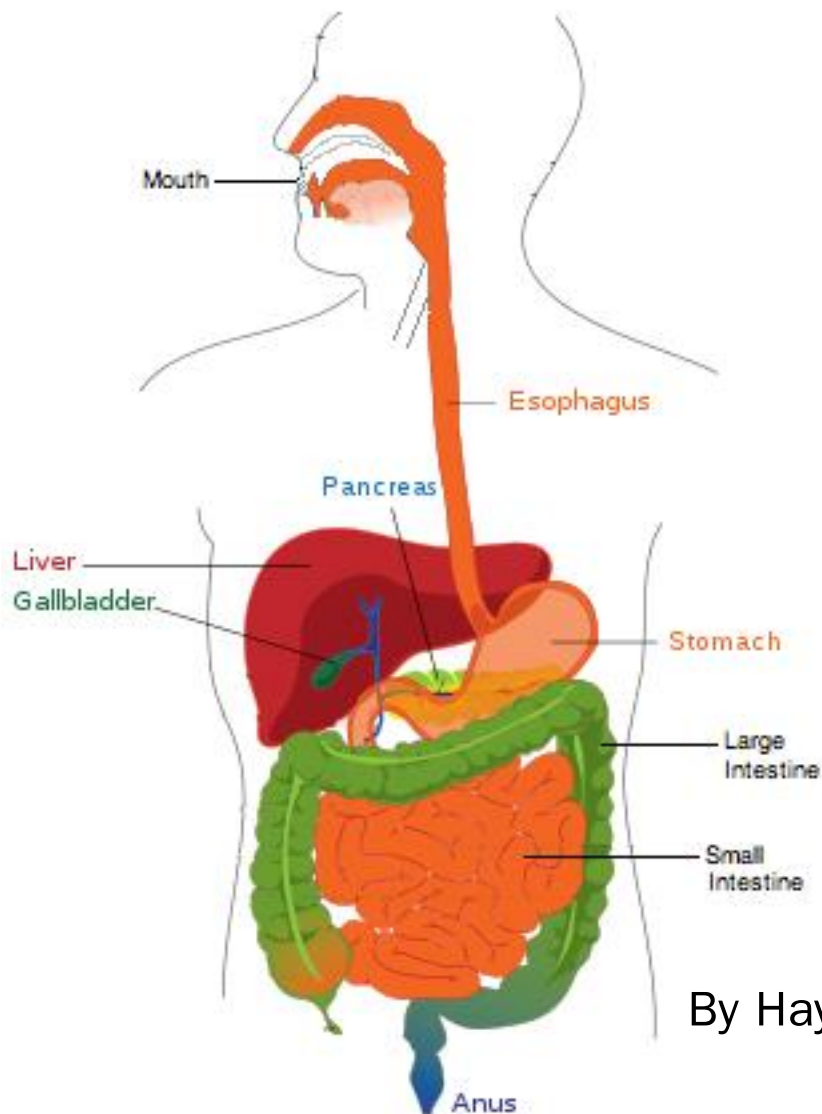


Human Physiology

Lecture 13 – Wednesday 23/3/2016

“Organization of the Digestive System” with Dr.

Othman AlShboul



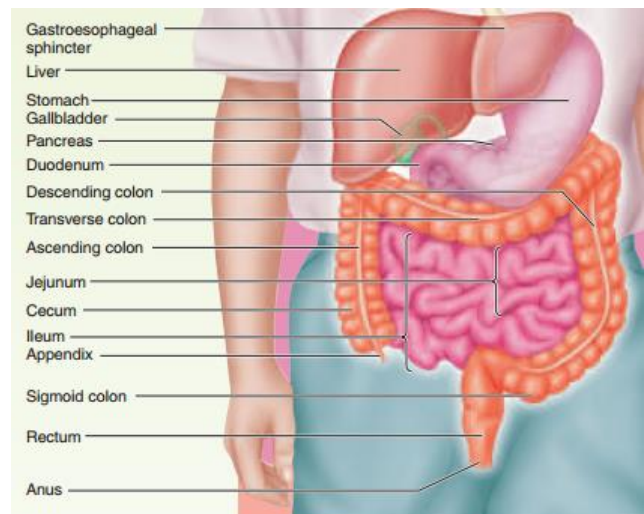
By Haytham Otoom

PSU

Digestive System (الجهاز الهضمي)

- It is also called the **Gastro-intestinal System**. (“Gastro”=stomach).
- It is composed of the **Digestive Tract & the Accessory Organs**.
- Its main function is to bring essential nutrients into the internal environment so they are available to the cells of the body // in other words, breaking large complex nutrients into simpler ones so that they can be used by the body.
- The digestive tract is one long tube (with some modifications along the way)... and the GI (Gastrointestinal) organs are, from the top to the bottom:

- Mouth or the **oral cavity**
- **Pharynx**
- **Esophagus**
- **Stomach**
- **Small intestine** (duodenum, jejunum, ileum)
- **Large intestine** (cecum, appendix, colon, rectum)
- **Anus** or the **anal cavity**

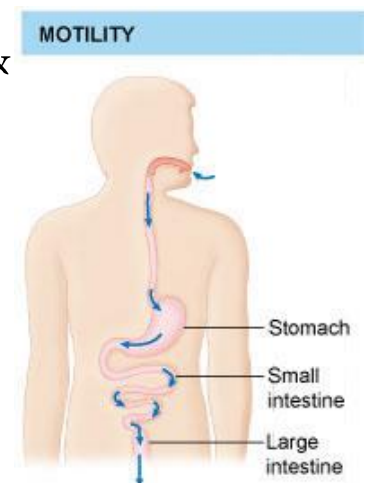


- Some organs are part of the Digestive System but are considered **accessory**, because they are located outside the digestive tract. They perform their functions by releasing products or hormones into the tract. Such organs are:
 - **Salivary glands, exocrine glands & the biliary system (liver and gallbladder, responsible for releasing bile)**

The Basic Digestive Processes

The work of the digestive system is divided into 4 processes;

1. **Motility (تحريك)**: physically breaking down large food material & moves food along the tract // the muscular contractions of the digestive tract. These contractions are important for digestion & absorption. There are two types of movements:
 - a. **Propulsive (دفعي)**: propelling or pushing the contents from the oral to the anal cavity through the GIT.

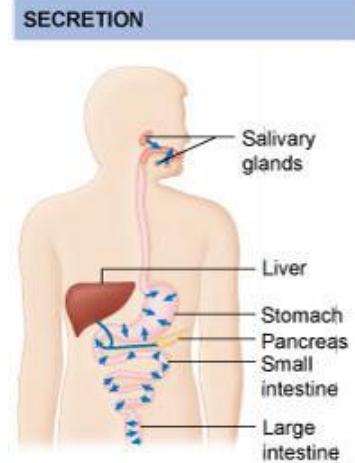


b. **Mixing:** repeating contraction and relaxation that breaks the contents down without pushing them. It facilitates digestion by mixing the food with digestive juices like enzymes, and it facilitates (تسريع أو تسهيل) absorption by exposing the food to the surfaces of the digestive tract.

Note: at the ends of the tract, there are skeletal muscles that perform motility.

2. **Secretion:** the release of digestive enzymes that allow chemical digestion. Secretion requires stimulation by nerves or hormones in order to begin & also depends on the amount of energy available to the body. The “digestive juice” that is secreted consists of:

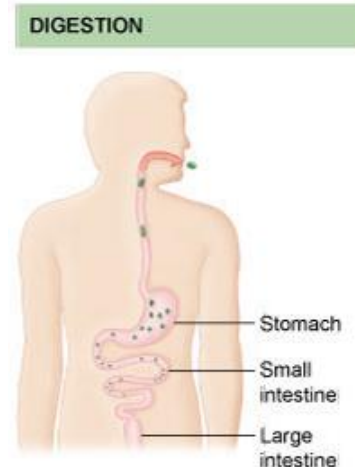
- Water & electrolytes
- Enzymes
- Bile salts
- Mucus**, which is very important for lubrication (تقليل الاحتكاك)
- Buffers**, which are important for maintaining the pH/acid-base balance



3. **Digestion:** the (biochemical) breakdown of complex nutrients into simple nutrients. It could be mechanical or chemical. The process basically breaks down **polymers** into **monomers** by **hydrolysis** (splitting a polymer by adding H_2O to a covalent bond).

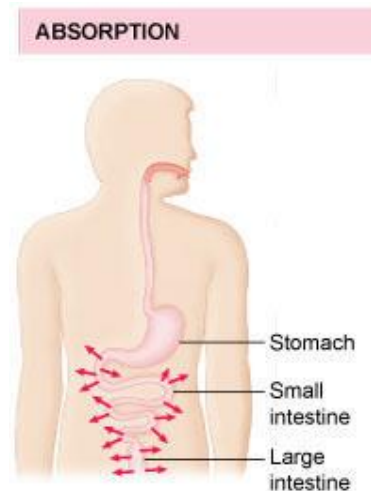
So the reactions that take place are:

- Carbohydrates:** poly/disaccharides \Rightarrow monosaccharides (like glucose, galactose, fructose)
- Proteins:** polypeptide \Rightarrow amino acids
- Fat:** triglyceride (glycerol + 3 fatty acid tails) is broken down into \Rightarrow monoglycerides & free fatty acids.

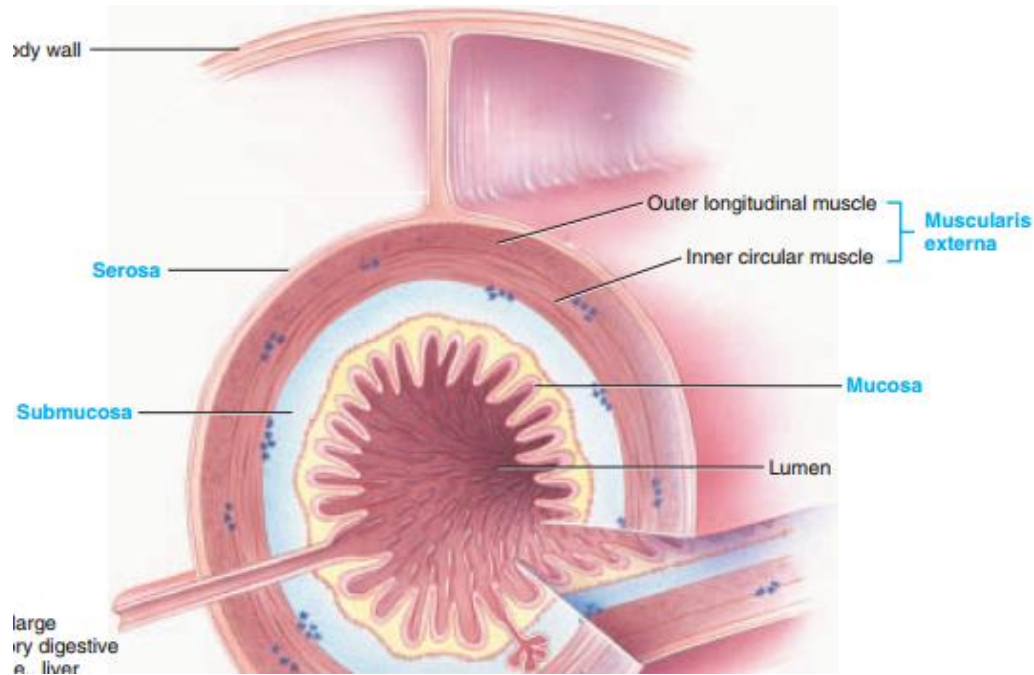


4. **Absorption:** taking in the simple nutrients (along with water, vitamins, and electrolytes) that are a result of digestion from the lumen into the blood/lymph.

The simple nutrients that are stored in the body are stored as complex ones again; for example, glucose is stored as glycogen. Most of the absorption takes place in the small intestine.



The wall of the digestive tract is important as it is divided into different layers, and each layer has a different function. Starting from the innermost (من الداخل الى الخارج):



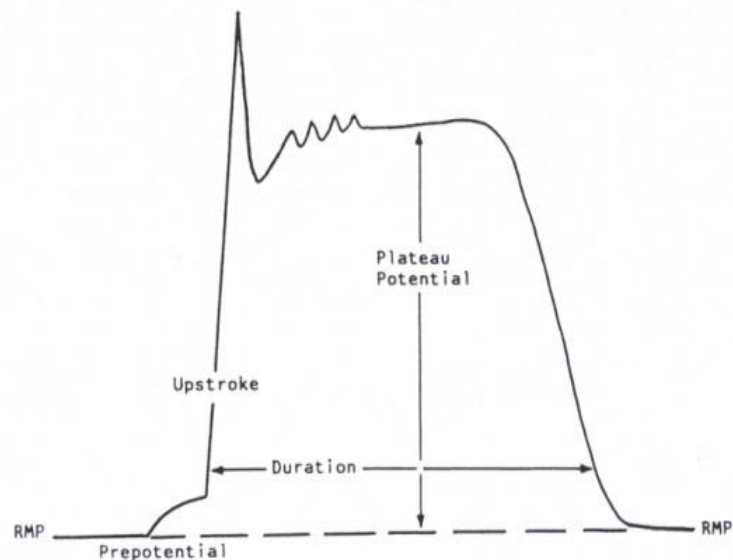
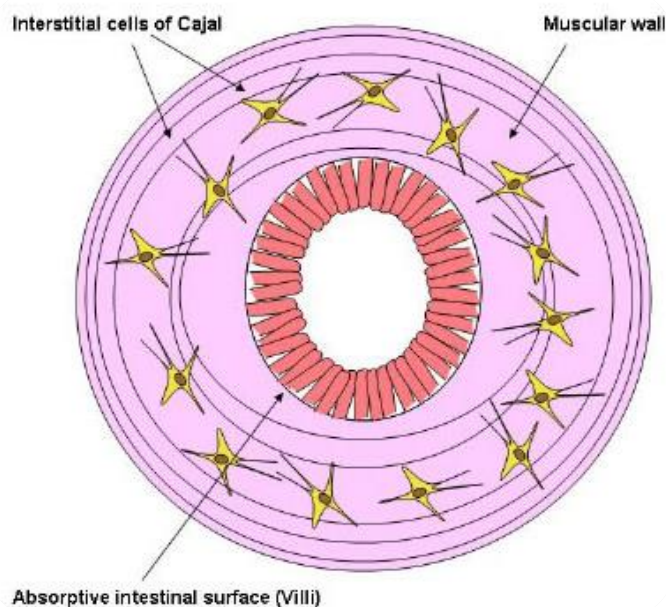
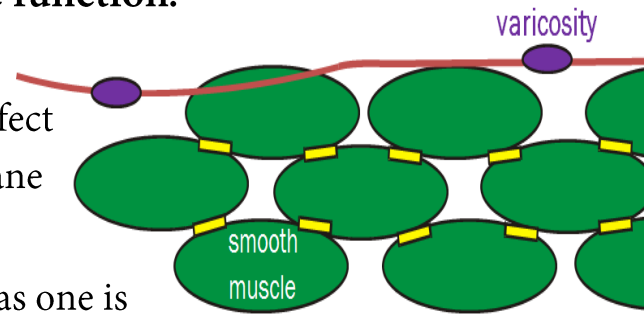
1. **Mucosa:** a layer composed of cells that are exocrine, endocrine & epithelial (releases mucus, so it protects the tract & lubricates it)
2. **Submucosa:** a thick layer of connective tissue that contains blood & lymph vessels along with nerves.
It serves to give the digestive tract elasticity and distensibility (قابلية التمدد)
3. **Muscularis externa:** 2 layers of smooth muscle.
 - a. the first or inner layer is circular in shape, and its function is contraction that results in decreasing the diameter of the lumen (which helps in digestion).
 - b. the second or outer layer is longitudinal in shape, and it contracts which causes shortening of the tract or tube (which helps in motility -> pushing food out).
4. **Serosa:** a layer of connective tissue that secretes a water & slippery fluid that lubricates the outside of the digestive tract.

The function of the digestive tract can be regulated using (1) autonomous (voluntary // does not require the nervous system stimulation) smooth muscle function, (2) neural regulation, and finally using (3) hormones.

Autonomous smooth muscle function:

Smooth muscle cells are connected by gap junctions.

- Gap junctions cause them to work together and affect one another; changing the excitability (or membrane potential) of one cell affects the neighbouring cell.
- A collection of smooth muscles working together as one is called a **functional syncytium**
- There are two types of smooth muscles;
 - **Tonic SM:** they contract for long periods of time, like the SM found in the fundus and in the sphincters (e.g. between the stomach & the duodenum)
 - **Phasic SM:** they have a “twitch-like” contraction which is caused by action potential. (“twitch-like”: contract, relax, contract, relax // like the SM found in the antrum, esophagus & the intestine).
- These smooth muscles have a different type of change in membrane potential; the change in their potential is rhythmic & spontaneous (تلقائي). Such change is considered a **slow wave potential** (it also has other names like **basic electrical rhythm** or **pacesetter potential**).
- This “slow wave” is generated by a special type of cells called the **Interstitial Cells of Cajal (ICC)**. They are called pacemakers because they regulate the rhythm of the contraction of the smooth muscles.



Neural Regulation

2 sets of nerves regulate the function of the digestive system; the **intrinsic nerve plexuses** and the **extrinsic nerves**.

The intrinsic nerve plexus (“plexus” is a collection of neurons)

- Intramural (within the wall of the digestive tract)
- It contains as many neurons as the spinal cord.
- The 2 major or important networks are the submucous plexus and the myenteric plexus – and together they form the **enteric nervous system** (“enteric” means its related to the digestive system)

The extrinsic nerves

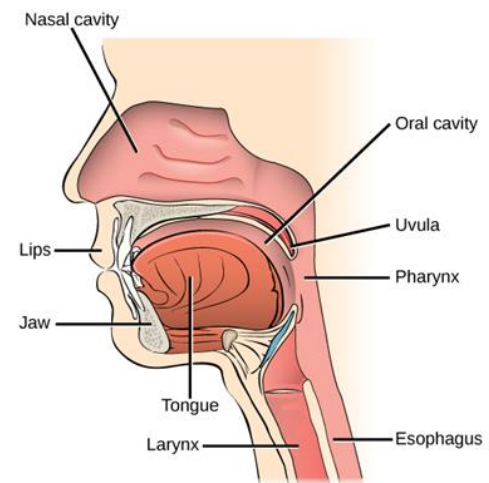
- It works either directly on the smooth muscle cells or glands, or indirectly using the enteric nervous system.

Parts of the Digestive System that are involved in swallowing & chewing

The Mouth or oral cavity

Components and their function:

- **Lips:** useful for talking/speech, guiding the food in the mouth, and for its sensory receptors (using the lips we can tell if food is cold/hot, and feel pain)
- **Palate:** separating the mouth from the nasal passages. It contains an important part called the **uvula** which prevents food from entering the respiratory system.
- **Tongue:** a skeletal (voluntary) muscle – that helps in guiding food within the mouth, helps in talking/speech, and contains the taste buds.



Chewing takes place in the mouth. What happens during chewing?

- Grinding/breaking food into smaller pieces & mixing food with saliva, and stimulating taste buds (براعم التذوق) which leads to an increase in salivary, gastric, pancreatic & bile secretion.
- Chewing is voluntary – and is a rhythmic reflex (activates the skeletal muscles in the area of the mouth as a response to pressure of the food). After chewing is done, the food is called **bolus**.

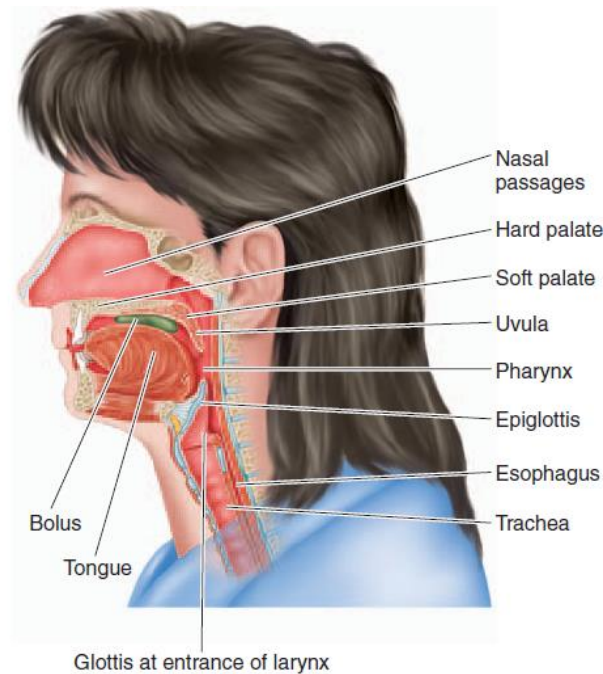
What is the saliva?

- Saliva is 99.5% water, and the remaining 0.5% is composed of electrolytes & proteins (amylase, mucus and lysozyme).
- It begins the digestion of carbohydrates using s.amylase (“s” means salivary). If amylase reaches the stomach, it is inactivated by the gastric acid.
- Using lysozyme, it acts a bactericidal agent (kills bacteria entering the mouth)
- It is responsible for oral hygiene // keeping the mouth & teeth clean.
- It contains bicarbonate buffers that maintain the acid-base balance by neutralizing acids. It is entirely under neural regulation (not hormones).

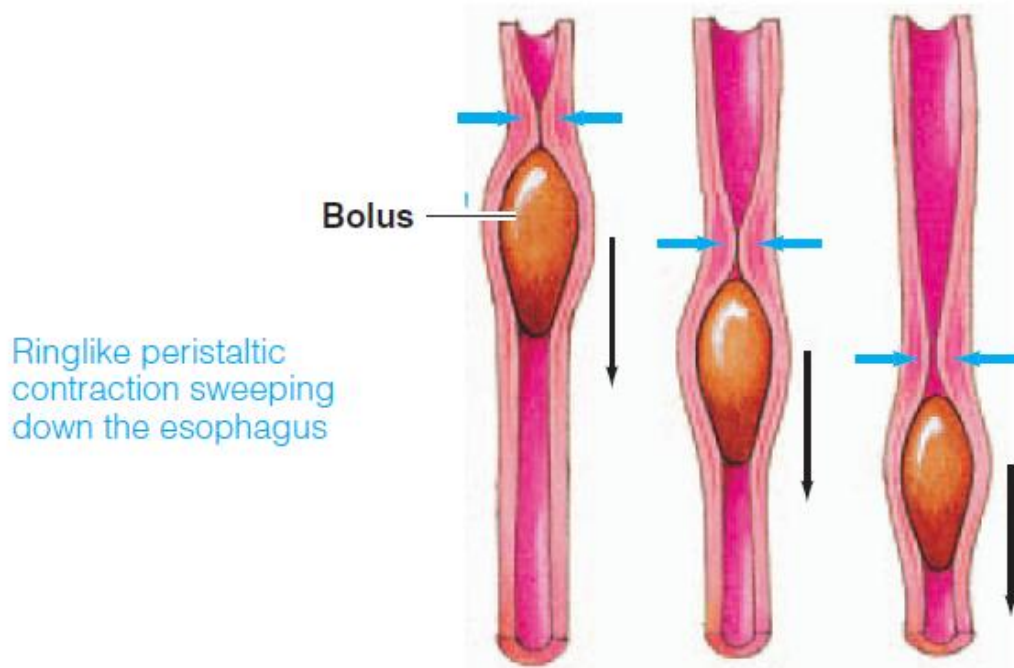
It is important to note that no absorption takes place in the mouth, with an exception like **nitroglycerin**. Nitroglycerin can be absorbed using the veins under the tongue, and it causes vasodilation (توسع) of the blood vessels.

The Pharynx & the Esophagus

- **Swallowing**, also known as **deglutition**, is the process where materials pass from the mouth -> pharynx -> esophagus. Swallowing is a voluntary process.
- It is an **all or none** mechanism. Even though it is started by our own will; once it is started it cannot be stopped.
- It is divided into 2 steps or stages: the oropharyngeal stage & the esophageal stage.
- **Oropharyngeal stage:** the stage where we ensure that food enters the esophagus, not the respiratory system. You cannot possible swallow food & respire at the same time.
 - This is coordinated by the swallowing center in the brain; the swallowing center inhibits respiration.
 - The tongue is also important, as it prevents food from re-entering the mouth.



- The epiglottis, uvula, and vocal folds both work to prevent food from entering the airways. The epiglottis is pressed down, uvula is elevated (lifted up), and the vocal folds join tightly to prevent food from entering airways.
- **Esophageal stage:** the stage of **peristalsis** (the rhythmic contraction of muscles that pushes food down the tract). It starts once food passes the pharyngoesophageal sphincter (the sphincter between pharynx & esophagus).



- The esophagus secretes mucus to lubricate the movement of bolus.
- If the rhythm of contractions is not properly maintained, food from the stomach (which is acidic) can go backwards into the esophagus & cause a burning/painful sensation [called the **acid reflux**]
- The sphincter between the esophagus & the stomach is called the gastroesophageal sphincter.