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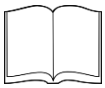
|---|---|---|
| Subject Code | Biology 1 | Fundamentals of Biology 1 |
| Learning Guide Code | 2.0 | Nutrition and Digestion |
| Lesson Code | 2.2 | Human Digestive System |
| Time Frame | | 30 minutes (1 session) |



## MATERIALS NEEDED

To complete this learning guide, you need the following:
1. Pen and paper
2. Biology: A global Approach by Campbell et al. (2015).
3. Laptop Computer/Internet-ready gadgets
4. Stable internet connection
5. Moodle account

## TARGET

After completing this learning guide, you are expected to:

- identify and describe the parts of the human digestive system and give the functions of each.

## HOOK

**5 minutes**

In the previous module, we discussed the digestive systems of various organisms from single-celled amoeba to multi-celled cattle. Using the knowledge, you gained in the past session and a good recollection of your Grade 5 Basic Anatomy, try to identify the parts of the human digestive system by answering the quiz found in the site below. **This is optional and non-graded.**

"Digestive System Labelling Interactive": https://www.purposegames.com/game/digestive-system-labeling-interactive-game

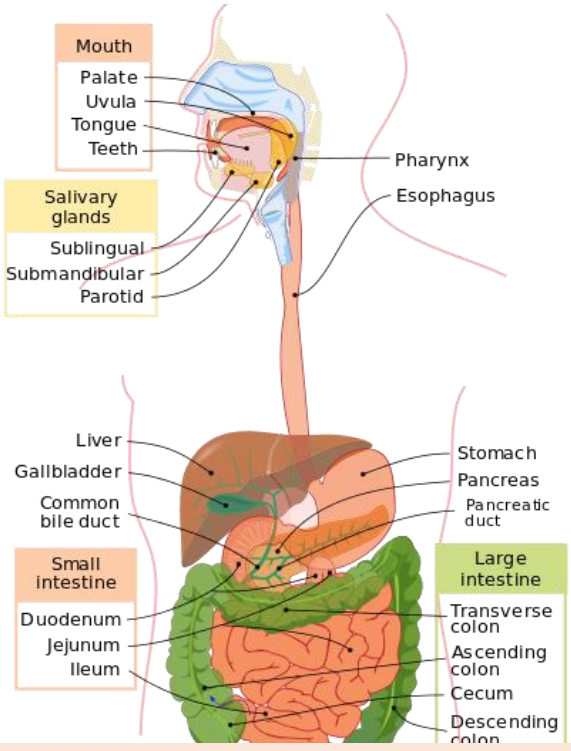
## IGNITE

**19 minutes**

Let us start with a short recap of what was discussed in the preceding module. We now know that food processing has four stages and those are ingestion, digestion, absorption, and elimination. Similar to other animals, humans also process food following those steps. They also have a **complete digestive system** and an **alimentary canal** *(which is also called a digestive tract or gastrointestinal tract)* that runs from the mouth to the anus. This alimentary canal has attached **accessory organs** that further aid in food processing. They are called accessory organs for the following reasons: (1) they are not part of the alimentary canal; (2) they never come in contact with ingested food; and (3) they don't have part in mechanically breaking down food. Nevertheless, they play roles in chemically digesting them. We will see that later in this module.

If we are to trace the alimentary canal, we will begin with the mouth, then the esophagus, the stomach, the small intestine, large intestine, rectum, and anus. Again, we see how more efficient an alimentary canal is compared to a gastrointestinal cavity. The former has specialized compartments. Some of these compartments have sphincters in their junctions. **Sphincters** are circular muscles that control the passage of materials from one compartment to another.

We now begin exploring the alimentary canal in detail. As we go along the discussion, use FIGURE 1 as your reference so you will know which part we are now, where it is located, what it looks like, and what could be the reason behind its structure that complements its function.




## The Oral Cavity, Pharynx, and Esophagus

Ingestion and the initial steps of digestion happen in the **mouth or oral cavity**. In it we find the teeth, the salivary glands, and the tongue. The **teeth**, which come in different shapes, play a major role in mechanically tearing food into smaller pieces and so increase the surface area for enzymes to act. The **salivary glands** have ducts that open to the oral cavity and secrete saliva which moistens the food for easier swallowing. Saliva is composed of mucus, electrolytes, antibacterial compounds, and various enzymes. Mucus is primarily responsible for protecting the mouth from abrasion and from drying out. Enzymes like amylase breakdown starch and glycogen into smaller polysaccharides or even disaccharides. Electrolytes have buffering action. They maintain the saliva within a certain range of pH only. That in turn, prevents minerals in the teeth from dissolving. Antibacterial enzymes like lysozyme destroy microorganisms. On the other hand, the **tongue** helps form a food bolus, the mass of food that

**FIGURE 1.** The gastrointestinal tract, also called the digestive tract, alimentary canal, or gut, is the system of organs within multicellular animals that takes in food, digests it to extract energy and nutrients.

Mariana Ruiz, Jmarchn (2006, December 17). Retrieved from: https://upload.wikimedia.org/wikipedia/commons/c/c5/Digestive_system_diagram_en.svg. This work has been released into the **public domain** by its author.

has been chewed and mixed with the saliva, (Britannica.com) and propel it down to the pharynx.

The **pharynx** is the part of the throat behind the mouth. It leads into two passageways: the trachea and the esophagus. Swallowing of food bolus has to be carefully coordinated so that it does not end up entering the wrong tube. The **act of swallowing** has three phases. The first stage is the **oral phase** which is the formation of food bolus and the movement of it toward the back of the mouth with the help of the tongue. The second phase is the **pharyngeal phase** which includes the closing of vocal folds and the movement of the larynx upward so that it tips the epiglottis down to cover it. The third phase is the **esophageal phase** which is the movement of food bolus in the esophagus to the stomach through rhythmic smooth muscle contractions called **peristalsis**. The esophagus has two sphincters: the **upper esophageal sphincter** and the **lower esophageal sphincter.** From the descriptive term upper, the upper esophageal sphincter is found at the beginning part of the esophagus. It is composed of skeletal muscle that is usually contracted to keep air from entering the digestive tract. The other sphincter is found in the lower end of the esophagus just before the stomach. It is also closed most of the time to avoid reflux of stomach acid. When the lower esophageal sphincter malfunctions or is not completely closed, it will cause chyme, (a term we will encounter in the next section) to move up the esophagus and causes what is commonly known as heartburn.

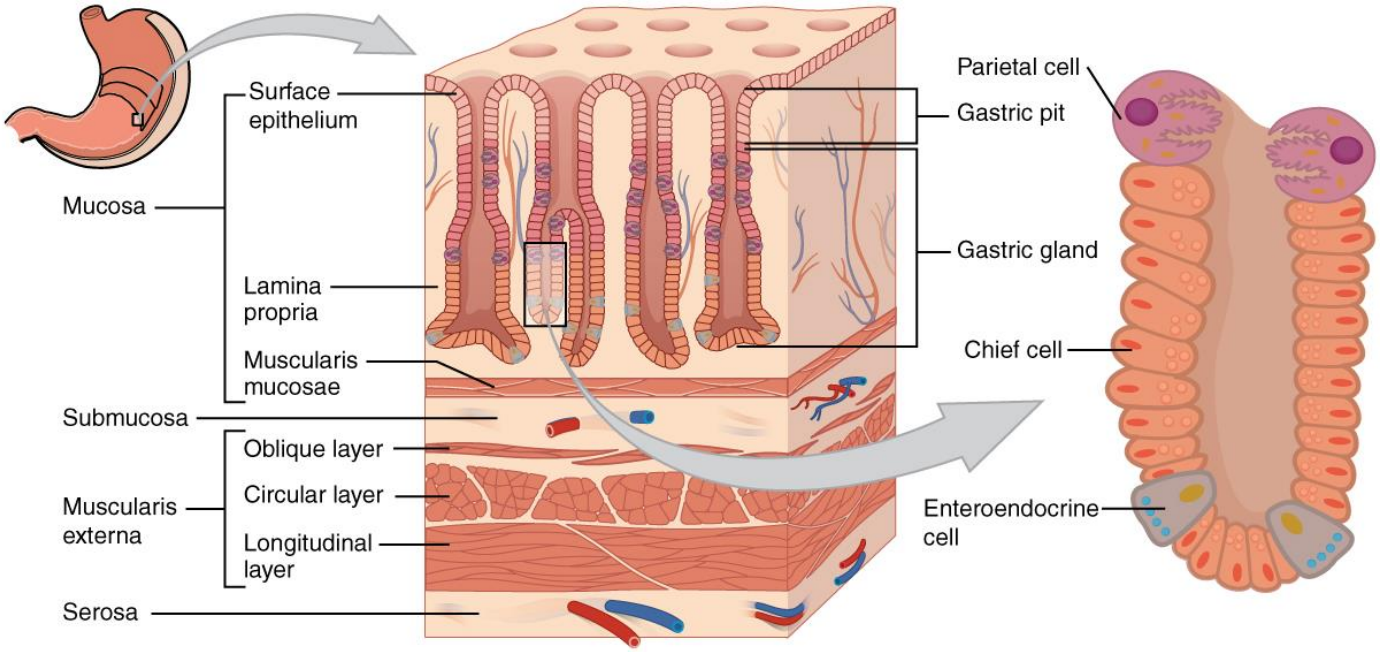



**FIGURE 2.** Histology of the Stomach. The stomach wall is adapted for the functions of the stomach. In the epithelium, gastric pits lead to gastric glands that secrete gastric juice. The gastric glands (one gland is shown enlarged on the right) contain different types of cells that secrete a variety of enzymes, including hydrochloric acid, which activates the protein-digesting enzyme pepsin. Anatomy and Physiology by Rice University. (n.d.). Retrieved from: https://opentextbc.ca/anatomyandphysiology/chapter/23-4-the-stomach/. The contents of the book is licensed under Creative Commons Attribution 4.0 International License.

## Stomach

The **stomach** is a hollow muscular organ found just beneath the diaphragm. It is the widest and most flexible part of the digestive tract. The outside of it is made up of connective tissues. Beneath that are three layers of muscles.

Inside are many folds *(looking like a corrugated cardboard)* that increase the surface area of the stomach. These folds are called **rugae**. As the stomach fills, the rugae straightens, permitting the stomach to expand.

When balls of food bolus enter the stomach upon the control of the lower esophageal sphincter, gastric juices produced by gastric glands meet them and mix them together through thousands of strong muscle contractions to form a paste-like substance called **chyme**. The **gastric glands** of the stomach have three types of cells, each with their own function. The **parietal cells** are responsible for actively pumping hydrogen ions into the lumen *(cavity)* of the stomach. At the same time, chloride ions diffuse to the lumen as well through certain channels in the parietal cells. It is only in the lumen that these two ions combine and **hydrochloric acid** is produced. For this reason, stomach cells do not get digested even if hydrochloric acid is a very strong acid, so strong that it can even melt a metal.

It breaks the extracellular matrix that holds cells together of meat or plant material. Its strong acidic properties denature (destroy the functional shape) proteins thus further exposing peptide bonds. It also denatures microorganisms that might have attached to the food and entered the stomach. Meanwhile, **chief cells** secrete pepsin in an inactive form called **pepsinogen**. Pepsinogen becomes pepsin (activated form of pepsinogen) only after hydrochloric acid alters the molecule. Activated pepsin can also activate other pepsinogen to make them pepsin, so more of them are produced. **Pepsin** is a protease (protein-digesting enzyme) that destroys the peptide bonds already exposed by the hydrochloric acid. As a result, proteins are broken down into smaller polypeptides. Further protein digestion happens in the small intestine. **Mucous cells** secrete mucus which protects the cells lining the stomach. After two to six hours of mechanical and chemical digestion, the **pyloric sphincter** located at the junction of the stomach and small intestine opens to let chyme flow through the small intestine. The sphincter allows chyme to pass through slowly and one at a time only.

"The stomach's muscular action is part of physical digestion, like chewing, swallowing, and peristalsis. Breaking the food up into smaller pieces is essential to allow access to all the nutrients; if it stayed in a big ball, we'd only be able to absorb the nutrients on the surface. But don't overlook the stomach's contribution to chemical digestion – it's what really helps break down the food you eat." (Odya and Norris, 2017)

**THINK IT OVER**

Why should chyme be released in the small intestines in small amounts only? (non-graded)

## Small Intestine

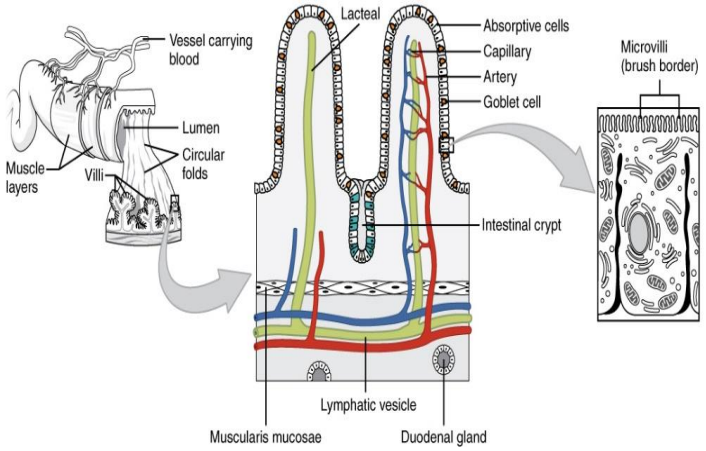



**FIGURE 4.** Histology of the Small Intestine. The absorptive surface of the small intestine is vastly enlarged by the presence of circular folds, villi, and microvilli. Anatomy and Physiology by Rice University. (n.d.). Retrieved from:

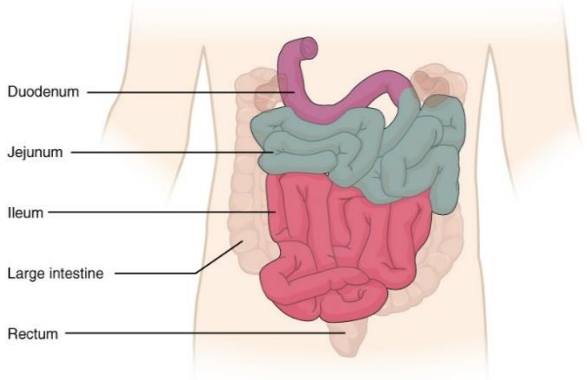



**FIGURE 3. Small Intestine.** The three regions of the small intestine are the duodenum, jejunum, and ileum. Anatomy and Physiology by Rice University. (n.d.). Retrieved from: https://opentextbc.ca/anatomyandphysiology/chapter/23-5-the-small-and-large-intestines/The contents of the book is licensed under Creative Commons Attribution 4.0 International License.

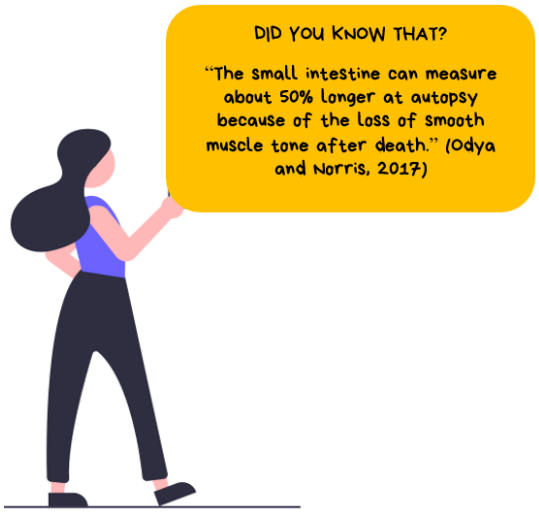
The small intestine is both an endocrine gland and a digestive organ, producing and secreting hormones that control digestion. It is the longest compartment of the alimentary canal spanning a length of over six (6) meters or 20 feet. Three sections share this length. They are the **duodenum** (0.3m or 1ft), the **jejunum** (1-2m or 3-6 ft), and the **ileum** (2-4m or 6-12 ft). The first section does most of the digestion. The last two sections specialize in water and nutrient absorption. It is termed as "small intestine" because of its small diameter, around 2.54 cm (1 inch) compared with the long intestine which has a diameter of 7.62cm (3 inches). Besides its long length, numerous villi, tiny finger-like projections, line the entire length of the small intestine. This multiplies the surface area available for enzymatic secretion and nutrient absorption. Each villus has one capillary bed with one arteriole, and one venule, and a lymphatic capillary called **lacteal** at its center. A mucosal epithelium with epithelial cells covers the villi. Further, each epithelial cell has many **microvilli**, a structure similar to that of the villi although a lot smaller.

Following the journey of the food bolus, now a chyme, it exits the stomach via the pyloric sphincter. It goes to the first part of the small intestine, the duodenum. Here, the chyme is mixed with secretions of gland cells in the intestines and the accessory organs: pancreas, liver, and gallbladder. The **pancreas** secretes a basic solution that is bicarbonate-rich and which neutralizes the acidity of the chyme. Other enzymes like trypsin and chymotrypsin (protease) are also secreted in their inactive form. Similar to pepsin, they are only activated after a reaction and when they are already in the lumen of the small intestine. Meanwhile, the **liver** makes bile (a mixture of fluid, electrolytes, and organic molecules) and stores it temporarily in the **gallbladder** until it is secreted along with the pancreatic secretion. The bile is amphipathic in nature, meaning it has both a hydrophilic and hydrophobic side. They act as emulsifiers, breaking down large fat molecules into smaller pieces called micelles, much as detergent breaks up grease. These micelles assemble such that its hydrophilic part is toward the watery chyme.

**DID YOU KNOW THAT?**

"Live-donor transplantation, a procedure in which a healthy person donates a portion of his or her liver to a recipient whose liver is failing, has been performed since 1989. Typically, the liver doubles in size in both the donor and the recipient within only 3 to 4 weeks. Rapid replication of hepatocytes is the mechanism of growth." (Odya and Norris, 2017)

With this arrangement, they can remain suspended and lipases (fat-digesting enzymes) can digest them. After the pancreas, the gallbladder, and some intestinal glands and cells have released their secretions, the chyme is further digested and then nutrients are absorbed.




There are many ways on how nutrients are absorbed. For example, the sugar, fructose, can be absorbed from the intestinal lumen to the epithelial cells via facilitated diffusion. Other molecules like amino acids, small peptides, vitamins, and most glucose molecules are actively transported. Once they pass the microvilli of epithelial cells, they move to the capillary bed at the center of the villi. The capillaries and veins now carry this nutrient-rich blood to the **hepatic portal vein**, a vein that is connected to the liver. In the liver, the blood is processed before it goes to the heart and gets distributed throughout the body.

**Fats**, (more technically known as triglyceride) however, have a special way of being absorbed and transported. They first need to be emulsified by the bile for lipase to act. Lipase will break them into parts such that a monoglyceride and fatty acids result as a product. In this form, they can now be absorbed by the epithelial cells. Once inside the epithelial cells, they recombine to regain their original formation (triglyceride). Then they are coated with phospholipids, cholesterol, and proteins to form globules called chylomicrons. These chylomicrons move into the lacteals. The lacteals, in turn, join with larger lymphatic vessels and eventually lead into larger veins that return the blood back to the heart.

## Large Intestine

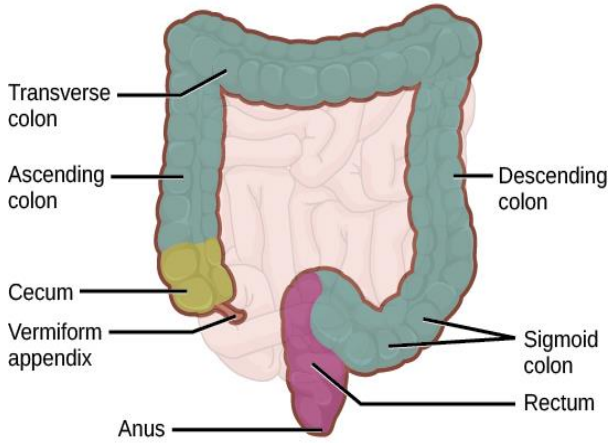



**FIGURE 5. The large intestine reabsorbs water from undigested food and stores waste until it is eliminated.** Molnar, Charles and Gair, Jane. (n.d.). Retrieved from: https://opentextbc.ca/biology/chapter/11-2-digestive-system/. The contents of the book is licensed under Creative Commons Attribution 4.0 International License.

The **large intestine** is about six (6) feet long. It frames the small intestine. The **cecum** is the first part of the intestine. Remember this part from the last module you studied? Opposite to pseudoruminants, human cecum is reduced. It also has a finger-like extension called **appendix** which does not directly help with digestion but has a role in immune system. It houses a particular type of tissue that contains white blood cells, the armies of the body. Furthermore, studies claim that the appendix contains a collection of beneficial gut bacteria that is readily available to occupy the intestines after an infection, when even the good bacteria are wiped out by drug treatments. Beyond the cecum and moving upward is the first section of the large intestine, the **ascending colon**, across is the **transverse colon**, and downward is the **descending colon** and at the near end is the **sigmoid colon**. When chyme from the small intestines enter the large intestine, it is now called **feces**. As the feces move in the large intestine through peristalsis, water is further removed from it through osmosis. The feces are made up of undigested material, remnants of digestive secretions, pigments and bacteria. Finally, when the feces reach the **rectum** and weigh about five to eight (5-8) ounces, stretch receptors in it signal the brain for the need to defecate. The feces are eliminated from the body through the contraction of anal sphincter in the **anus**.

**DID YOU KNOW THAT?**

"Your intestines are home to unimaginably large numbers of bacteria, including hundreds of species. Trillions of tiny (prokaryotic) cells ingest some of the undigested material in your feces, producing molecules that have a well-known odor. It's nothing to be embarrassed about, and nothing to be proud of, either." (Odya and Norris, 2017)

Here is a site discussing the human digestive system with incorporated short clips.

**Note: You are not required to access this site.**

The Digestive System: https://www.stem.org.uk/resources/elibrary/resource/36133/digestive-system

## NAVIGATE

**5 minutes**

**This is a graded assessment**:

# What am I?

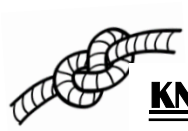
Make a riddle about one part of the digestive system. Your riddle should include a description of the part, its location in the body, and its function. Put your answer on the given space below. Take a screenshot of it and submit via moodle.

You will be graded using the rubrics below.

**RUBRICS**

**TOTAL NUMBER OF POINTS: 5 POINTS**

| CRITERIA | POINTING SYSTEM | | |
|---|---|---|---|
| **Content** | **2 points** | **1 point** | **0 point** |
| | Students were able to write a riddle with complete elements (part description, location, and function). | Students were able to write a riddle with two elements (part description, location, and function). | Students were able to write a riddle but did not include any of the required elements (part description, location, and function). |
| **Idea** | **1 point** | **0.5 point** | **0 point** |
| | Students used creative words, and all the clues had something to do with the answer. | Students did not so much use creative words and most clues had something to do with the answer. | Students was not creative and clues had nothing to do with the answer |
| **Spelling/Grammar** | **1 point** | **0.5 point** | **0 point** |
| | Students had no errors in grammar or spelling. | Students had 2 or 3 errors in grammar or spelling. | Students had more than 3 errors in grammar or spelling. |
| **Submission/Compliance** | **1 point** | **0.5 point** | **0 point** |
| | The student submitted the output on or before the deadline. | The student submitted the output beyond the given deadline. | The student did not submit any output. |



## KNOT

**1 minute**

Our digestive system mainly breaks down large pieces of food by mechanical or physical ways so that nutrients can be absorbed and energy can be obtained. We have a complete digestive system that is composed of specialized compartments and perform specific jobs. These are the mouth, esophagus, stomach, small intestine, and large intestine. Accessory organs like the liver, pancreas, and gallbladder, work in synergy with these compartments to primarily aid in chemical digestion. Peristalsis move the food along our alimentary canal, and strategically located sphincters control their rate of passage.

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**Book**

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**Online Resources**

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**Videos**

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**Images**

Histology of the Small Intestine. The absorptive surface of the small intestine is vastly enlarged by the presence of circular folds, villi, and microvilli. (n.d.). Retrieved from: https://opentextbc.ca/anatomyandphysiology/chapter/23-5-the-small-and-large-intestines/.

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The large intestine reabsorbs water from undigested food and stores waste until it is eliminated. (n.d.). Retrieved from: https://opentextbc.ca/biology/chapter/11-2-digestive-system/.

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