Educator's Guide and Script For
Human Body:
The Digestive and Renal Systems

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INTRODUCTION:

The goal of this program is to present an upper level high school or introductory pre-med or pre-nursing school overview of the anatomy and physiology of the digestive system. Using the latest in 3-D graphics, medical imaging and for the first time detailed cadaver dissection, this program is designed to maximize student learning. Beginning with an overview of the importance of food in providing energy for the body to live work and play, the program then goes into the digestive tract's major and minor organs. The next two chapters examine how food is processed through the upper and lower digestive tracts. Then, internal ailments are discussed, followed by a cadaver dissection of the liver, gall bladder, pancreas and renal system The program ends with a discussion of nutrition, including the three major food groups - protein, carbohydrates and fats.

ADVANCED VOCABULARY DEFINITIONS:

- **Abdominal cavity**: The part of the body between the bottom of the ribs and the top of the thighs, containing most of the digestive and urinary systems
- **Amino acids**: The building blocks of proteins. Twenty amino acids are necessary for normal metabolism and they are divided into two groups: non-essential amino acids produced by the body, and essential amino acids that must be obtained through food
- **Anus**: The excretory opening at the end of the digestive tract
- **Ascending colon**: The part of the large intestine that ascends from the cecum to the transverse colon
- **ATP**: Adenosine triphosphate: a nucleotide derived from adenosine that occurs in muscle tissue; the major source of energy for cellular reactions
- **Bladder**: A hollow, distensible organ of the urinary tract that receives urine from the kidneys and stores it until urination
- **Carbohydrates**: A major class of foods that includes sugars and starches
- **Carnivore**: Meaning 'meat eater,' it is an organism that derives its energy and nutrient requirements from a diet consisting mainly or exclusively of animal tissue
- **Cecum**: The first portion of the large intestine

- **Chyme**: a semi-liquid mass of partially digested food that passes from the stomach through the pyloric sphincter into the duodenum
- **Colon**: The part of the large intestine between the cecum and the rectum; it extracts moisture from food residues before they are excreted
- **Descending colon**: the part of the large intestine that descends from the transverse colon to the sigmoid colon
- **Digestive juices**: Acids, enzymes and other chemicals produced by the body to break down the food we eat into nutrients that can be absorbed and used
- **Duodenum**: The part of the small intestine between the stomach and the jejunum
- **Epigastric**: The upper central region of the abdomen
- **Esophagus**: The passage between the pharynx, the upper part of the throat, and the stomach
- **Gall bladder**: A muscular sac attached to the liver that stores bile (secreted by the liver) until it is needed for digestion
- **Gastroenteritis**: Also known as stomach flu, it is an inflammation of the stomach and intestines
- **Glucose**: A simple monosaccharide, sugar, it is a principle source of energy for cellular metabolism
- **Herbivores**: Any animal that feeds chiefly on grass and other plants
- **Hydrochloric acid**: The main component of gastric acid which acts as a barrier against microorganisms to prevent infections and is important for the digestion of food.
- **Ileum**: The part of the small intestine between the jejunum and the cecum
- **Jejunum**: The part of the small intestine between the duodenum and the ileum
- **Kidneys**: The kidneys are paired organs, which have the production of urine as their primary function
- **Large intestine**: The last part of the digestive tract. It is divided into the cecum, colon and rectum, and is concerned especially with the re-absorption of water
- **Lipids**: Lipids are a broad group of naturally-occurring molecules which includes fats, waxes, sterols, fat-soluble vitamins
- **Liver**: It is a large and complicated reddish-brown glandular organ located in the upper right portion of the abdominal cavity; secretes bile and functions in metabolism of protein and carbohydrate and fat; synthesizes substances involved in the clotting of the blood
- **Lymph**: A colourless, watery, bodily fluid carried by the lymphatic system, that consists mainly of white blood cells
- **Metabolism**: Metabolism is the set of chemical reactions that happen in living organisms to maintain life
- **Nausea**: A feeling or sensation of unease and discomfort leading to the urge to vomit
- **Nutrients**: Any substance that can be metabolized by an animal to give energy and build tissue
- **Omnivores**: Species that eat both plants and animals as their primary food source
- **Pancreas**: A gland near the stomach which secretes a fluid to help with food digestion and also the hormone insulin which helps the body process glucose

- **Peristaltic action**: A radially symmetrical contraction of muscles which propagates in a wave down the muscular tube
- **Proteins**: One of three major classes of food or source of food energy abundant in animal-derived foods
- **Rectum**: The final straight portion of the large intestine before the anus
- **Small intestine**: Part of the gastrointestinal tract (gut) following the stomach and followed by the large intestine, and is where the vast majority of digestion and absorption of food takes place
- **Transverse colon**: The part of the large intestine that extends across the abdominal cavity and joins the ascending to the descending
- **Toxins**: Poisonous substances produced during the metabolism and growth of certain microorganisms and some higher plant and animal species
- **Ureters**: The muscular tubes that propel urine from the kidneys to the urinary bladder
- **Urinary system**: The organ system that produces, stores, and eliminates urine. In humans it includes two kidneys, two ureters, the bladder, the urethra, and the penis in males
- **Urine**: The fluid produced by the kidneys. It consists of excess water and the toxic waste products from food
- **Villi**: Finger-like projections of the lining of the small intestine that increase the surface area available for absorption

SCRIPT

HUMAN BODY: THE DIGESTIVE SYSTEM:

The miracle of all miracles on this planet is the human body. Now see it in a way never revealed before.

Eating and drinking, then digesting, finally excreting waste. It's an endless cycle, a cycle that has vital connections to all of the body's major systems. Join me, Dr. Mark Reisman, as we explore the human digestive system, a chemical processing plant that is unmatched in the animal kingdom.

Introduction

We need to eat to survive. During a person's lifetime, they will eat seven and a half tons of meat, nine and half tons of eggs, twenty-three tons of dairy products, four and three-quarter tons of fats, seven and three quarter tons of flour and cereals and 27 and a half tons of fruits and vegetables.

Food and the Bioweb of Energy

All that eating is in the service of providing energy for the body's muscles to carry out life's activities - from the involuntary beating of your heart, to the vigorous coordinated actions
of sports, to passively sitting at your computer. Interestingly, 10% of that energy is used in digesting food itself.

Unlike plants, which get their energy from the sun, animals need to eat organic material found in their environment. Most animal species have evolved to eat and digest specific foods. Buffalo are herbivores, plant eaters. They need to find grasses to eat, grass that is easily found in the great American prairies. Not so for wolves. Wolves are unable to digest grass. They are carnivores - meat eaters. For them, other animals, such as buffalo, are food. In the great web of life on planet Earth, everything - plants, animals and microbes - is food for something else.

Finally there are omnivores, animals that have mastered survival by eating a diversity of many things, such as the bear, which eats berries, plant roots, fish and other mammals. But the king of all omnivores is the human species. We eat and digest almost everything. When we learned to control fire, we learned to cook, greatly expanding what has become food for us.

For example, take the potato. We could eat it, eat it like an apple, but once inside our bodies our digestive system would not be able to extract any nutrients. In short a raw potato is not food for us. However if we cook it, that's a different story.

Digestive Organs

The digestive tract is made up of major and minor organs. Let's look at the major organs first. When food enters the digestive system, obviously it enters through the first major organ - the mouth. From there, it moves into the esophagus by swallowing.

The muscles in the esophagus are so strong that they can propel food into the stomach, even if a person, like Michelle, were standing upside down.

The food is now in the abdominal cavity, a cavity that starts just below the ribs and ends at the top of the pelvis. It contains the rest of the body's digestive organs.

From the stomach, the food which is now largely in a liquid form called chyme, passes to the small intestine. Most nutrients are extracted here. Then the remains of the food, which is now pretty much waste, moves into the large intestine, then to the rectum, and finally to the anus, where the remains are excreted as stool.

And there are more digestive organs located in the abdominal cavity. The liver, the largest of the body's internal organs, sits to the right of your stomach. Below the liver is the gallbladder. And below the stomach is the pancreas.

Food Processes and the Upper Digestive Tract

So how long does it take this French fry to make it through the system? I chew it for a few seconds. I swallow. Then the French fry passes through the esophagus in about 5 to 6 seconds. In the stomach, food tends to hang around quite a bit little longer, depending on the amount of food you have consumed and how much fat it contains. Time in the stomach varies. But after four hours, all food should have left your stomach. Next, in the small intestine, digestion continues and absorption of nutrients into the bloodstream begins. Give or take another 5 to 6 hours and it's ready to move to the large intestines. Somewhere around 20 to 30 hours after eating this French fry, all traces are completely gone. Where it all started, the human mouth, is an interesting and complex organ.

The processing of food into usable nutrients for the body is both mechanical and chemical. Mechanical digestion begins when you chew your food with your teeth and move it around on your tongue, moving it around, mixing it with saliva.

Miraculously, your body always knows how much saliva to produce, and what kind, and an enzyme called ptyalin found in saliva gives the stomach a "head start" in digesting the food, food that moves through the esophagus after swallowing.

In the esophagus, no digestion takes place. But as we can see, mucus from the esophagus keeps the food wet as it moves down to the stomach.

It's an expandable 'J' shaped muscle bag about the size of a fist when empty and when full, expands to the size of a typical boxing glove.

The stomach lies in the abdominal cavity. One way to look at the human body is to view it as a series of descending cavities. Starting with the skull cavity, moving on down to the chest, or thoracic cavity, where we find the lungs and heart. Next, separated by the diaphragm, we move down to the abdominal cavity, and finally to the pelvic cavity, where the reproductive organs are housed. The esophagus essentially moves food through the chest cavity to the abdominal cavity where it finds the first of the abdominal organs. Let's take a unique look at these abdominal organs starting with the stomach. Here, I am exposing the stomach. By moving the liver we can clearly see where the esophagus connects to the stomach. This is where heartburn occurs.

In the stomach, a combination of mechanical and chemical action furthers the breakdown of food into simpler and smaller chemical units. The stomach does this by mixing food, water and powerful digestive solutions such as Hydrogen Chloride. Remarkably, the stomach produces mucus that lines its walls and protects it from its own digestive juices. After about two to four hours, the food is now in a thin liquid form called chyme. Little by little, the chyme moves out of the stomach and into the small intestine.

The small intestine is called small not because it's short. In fact, for a typical adult its length exceeds 20 feet, like this rope. It's called small because it's only an inch and a half

in diameter. Incredibly, the body is able to pack all this tubing into the relatively small abdominal cavity by folding. Even more incredible is that the wall of the small intestine is covered with finger like protrusions called *villi*. *Villi* increase the actual surface area of the small intestine to the size of a tennis court, thus greatly expanding the small intestine's capability of sending nutrients into the bloodstream. The first part of the small intestine is the duodenum.

Here, we can see the connection between the stomach and the beginning of the small intestine. For anatomical and medical classification the small intestine is broken into three distinct zones: First, duodenum, then jejunum, and then the ileum.

First, chyme enters the duodenum along with bile and other digestive juices from the pancreas. Then, combined with the digestive juices from the small intestine itself, the original food is further broken down into nutrients that can be absorbed into the blood and lymph systems. Now we are at the highly coiled jejunum. It is redder and thicker than the duodenum. As we keep moving down, the chyme finally enters the ileum. All along the small intestine nutrients are passing across its wall into the bloodstream. As I am demonstrating here, smooth muscle contractions, called peristalsis, move the chyme through the small intestine.

Now we come to where the small intestine meets up with the large intestine. Notice how small in diameter the small intestine has become compared to the large intestine.

The Lower Digestive Tract

The last section of the digestive tract is the large intestine. It is divided into three parts. First, the cecum, the pouch-like entrance. By the time food enters here, almost all the nutrients essential for bodily functions have been absorbed. What remains are waste products from the digestive processes, and water. From the cecum, the waste products move into the approximately 5 foot long colon. Segmented in appearance, the colon is divided into the ascending colon, the transverse colon, and the descending colon. As the liquid waste moves through the colon, much of the water is reabsorbed into the body along with some vitamins produced by the digestive bacteria. The last part of the journey that started many hours ago as food on your plate finally enters the third part of the large intestine: the rectum and anus. Together they are less than 6 inches long, but have strong wall muscles that, through powerful waves of peristaltic action, can push the fecal material out of the body.

Internal Disorders

Dr. Mark Reisman and patient
One of the most common ailments doctors see, are complaints of a stomach ache.
Hi Chris.
Hi.
How you been doing?
Pretty crappy. My stomach's been hurting a lot lately.

What I'd like to do is just touch your belly. If I hurt you, let me know, OK? Does it hurt when I press over here?
No.
Or over here?
Yeah.
It does hurt a little bit more over here. OK, good. What I'd like you to do is take a deep breath. I'm going to feel for your liver here on the right side. Deep breath please. And let it go. Perfect, perfect. And now I'm going to see if your spleen is enlarged. I'm going to feel here on the left side. Deep breath. And out. And one of the signs of a real sick belly is if it hurts when I let my hand go. So I'm going to press down. And does that hurt at all?
No not much.
OK, I'm going to release now. How about now?
No.
OK. Well, we're going to do some more tests.

But generally, gastroenteritis or 'stomach flu' is usually a viral illness. When the patient comes in with a 'stomach ache' or abdominal pain, two important things are the location and the associated symptoms. If this patient's pain is epigastric, in the left lower quadrant, with the associated symptoms of nausea, vomiting, and diarrhea, it's likely a viral illness. Right lower quadrant pain can be concerning for appendicitis. Right upper quadrant pain can be gallbladder. However, epigastric pain associated with reflux can be GERD, ulcer, or esophageal irritation.

Laboratory testing and imaging can help define what the problem is. In this patient's case of the common flu the important thing will be hydration and management of the nausea with antiemetic medication. The illness will likely pass on its own.

Anatomy and Physiology of the Liver, Gall Bladder and Pancreas

Moving back into the abdominal cavity we find the largest internal organ in the body: the liver. Weighing approximately 3 1/2 pounds, the liver has many functions. It helps balance blood sugar. It removes toxins from the blood. It stores vitamins, and produces bile, which is moved along to the gallbladder, the greenish pear-shaped sac seen here. The gallbladder stores the bile and releases it into the very top of the small intestine. Bile is essential for the breakdown of fats.

Another organ that produces digestive juices is the pancreas. Unlike the other organs of digestion, the pancreas doesn't look like your typical sac and tube. It looks like the structure demonstrated here. In addition to providing digestive juices, it has a second function, which is to produce and send hormones into the body, making it part of the endocrine system. Much like the gallbladder, the pancreas connects to the upper part of the small intestine.

Renal System

Even more important in the short term to the well-being of your body is water. You can only go a few days without drinking, or eating foods that are rich in water such as an apple. Apples, by the way, are over 85% water. Did you know that 60% of your body weight is water and over 60% of that is contained in your cells.

The food and eventually the nutrients in the digestive tract are always in water solutions. And as any athlete knows, the body loses water through perspiration. When you exhale, water leaves the body as vapor. At the same time, in both cases, toxins are also leaving the body. But the most important organs in the body's water system are the kidneys, also called the renal or urinary system.

Kidneys are paired, bean-shaped organs that are found on either side of the spine in the abdominal cavity. They lay behind the digestive organs near the upper part of the cavity. Their primary function is removing waste products from the blood. How does the system do this? As blood enters the kidneys, microscopic filtering units remove waste - minerals and salts - and excess water. The resulting liquid is called urine. Urine flows from the kidneys through each ureter into the bladder. The bladder is a hollow muscular organ, centrally located in the pelvic cavity. It stores urine until a certain volume is reached, at which time impulses are sent to the brain, which in turn produce a conscious need to urinate. The urethra then conducts the urine outside of the body. Let's take a real-life look at the organs of the renal system.

We're going to explore the renal system. And before we explore the renal system, let's take the opportunity to orient ourselves with this specimen. Here we have the diaphragm, which is separating the chest or thorax from the abdomen, and below we have the pelvis. We have the opportunity in this specimen to remove all of the digestive tract, that being the intestines, the liver, the pancreas, and the spleen. And where we are now is what is called the retro-peritoneal space. The retroperitoneal space lies behind all of those digestive organs. So let us take a look at what we see in this retroperitoneal space. First we see the aorta coming down and then bifurcating, or splitting, into the right and into the left side. Now, let's specifically concentrate on the renal system. What we see here are these two large organs called the kidneys. So let's look at the kidneys more specifically. Here is the right kidney and the left kidney. And the kidneys derive their blood flow from the renal arteries. As I mentioned, the kidneys are an excretory organ, and what they do is they take out the excess of protein metabolism, waters and salt. And the way they do that is by filtering the blood through the kidney itself. The outer layer called the cortex, the inner layer called the medulla, and what they do is once they've taken the blood and removed the various by-products, they excrete them into this system called the ureteral system. Here you see the ureter exiting from the left kidney and flowing across the retroperitoneal space of the abdomen over the pelvic brim - this is the pelvic brim over here - and then entering into the bladder. You see the same on the right side here, with the ureter again, you can see it leaving the kidney, and ultimately traversing the retroperiteneal space and entering into the pelvis, and entering below into the bladder.

Acute renal colic, commonly known as a kidney stone, is probably the most excruciatingly painful event a person can endure. Striking without warning, the pain is often described as being worse than childbirth, broken bones, gunshot wounds, burns, or surgery. Most are made up of calcium, and visible on an X-Ray. This one is 5 millimeters.

In general, smaller stones are more likely to pass spontaneously in less than a day. Calculi larger than 7 mm are unlikely to pass unassisted. We treat with Pain medicine and hydration. The overall lifetime rate of kidney stones in the general population is approximately 12% for men and 4% for women and rising in the U.S.

Nutrition

Let's take one last look at the digestive system, this time from the perspective of food, food that our couple is about to eat. Food that, through the body's biochemical processes, converts the various offerings on the plate to substances the body can use. The most general name for these substances is nutrients. And the overall name for the processes that convert food into nutrients is metabolism. The main course for Kira is chicken and Tyler is having steak. Each of these meats are rich in protein, protein that digestion breaks down into amino acids, 20 different essential amino acids that the body reassembles into new proteins, which are used to rebuild the body's structural components, such as the musculoskeletal system. Proteins are one of the three major food groups. A second is fats, also called lipids. The butter on their bread is rich in fats. Fats can provide the body with energy and are critical for the absorption of vitamins. Carbohydrates, the third major food group, are the main source of energy for the body. Carbohydrates are found in many foods. Table sugar is the most obvious, but there are carbohydrates in fruits and most vegetables, such as potatoes, carrots, and peppers. One of the key steps in digestion is breaking these carbohydrates into a simple sugar: glucose. Glucose is stored and converted to ATP. ATP, when put in contact with oxygen delivered by the respiratory system, releases energy that is used to power all of the body's active systems, from the nervous system to digestion itself. Because no single food can be broken down into all of the nutrients the body requires for good health, we all need to eat a balanced variety of foods. Failure to do so can result in disease and overweight.

It's really a miracle. I need energy, fuel to power my body, and all I have to do is eat this apple or this granola bar, and the body's digestive and renal system do all the rest. Thanks for watching, I'm Dr. Mark Reisman.

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