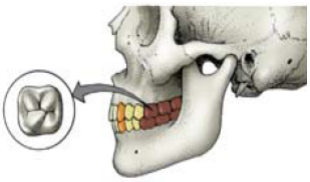
STUDY GUIDE - *Ch. 41.4 - Evolutionary Adaptations of Vertebrate Digestive Systems Correlate with Diet*
- Ch. 41.5 - Feedback Circuits Regulate Digestion, Energy Storage, & Appetite

NAME: _____

- **PHYSICALLY PRINT OUT this PDF and HANDWRITE (with a black or blue pen) your answers directly on this PDF.** *Typed or digitally-written work is **not** accepted. Do **not** answer questions on separate paper.*
- **Importantly, study guides are NOT GROUP PROJECTS!!!** *You, and you alone, are to answer the questions as you **read** your assigned textbook. You are **not** to share answers with other students. You are **not** to copy any answers from any other source, including the internet.*
- **Get in the habit of writing LEGIBLY, neatly, and in a medium-sized font.** *AP essay readers and I will skip grading anything that cannot be easily read so start perfecting your handwriting, and don't write so large you can't add all the relevant details and key elaborations in the space provided.*
- **SCAN physical documents in color and with good resolution. Then, upload your final work as PDFs to Archie.** *Avoid uploading dark, shaded, washed-out, sideways, or upside-down scans of homework. Keep completed physical study guides organized in your biology binder to use as future study and review tools.*
- **READ FOR UNDERSTANDING and not merely to complete an assignment.** ***First**, read a section quickly to get an overview of the topic covered. Then, read it a **second** time slowly, paraphrasing each paragraph **out loud** and analyzing every figure. Finally, read it a **third** time as you answer the study guide questions if assigned and start building your memory. Try to write answers out in your own words, when possible, and try to purposefully and accurately use all new terminology introduced.*

1. The digestive systems of animals display a variety of adaptations that correlate to varied diets. By studying the **dentition of a mammal's skull** (the assortment of teeth), one can determine its diet. In the dentition of animals we see an example of **form fits function.** Through natural selection, the type and shape of teeth an organism has evolved to have are adaptations that allow the organism to successfully obtain nutrients and thus better survive so as to have a chance to reproduce. Elaborate on how the type of teeth are adaptations by using the following illustrations.



Type of Organism = _____ _____ _____

Teeth Adaptations =

2. Adaptations that correlate to diet are not only seen in an animal's dentition. The size and length of digestive organs and digestive tracts differ too. **Herbivores have larger cecums** where populations of prokaryotes that digest cellulose fibers into glucose monomers with the cellulase enzyme only they can produce are housed. **Carnivorous vertebrates**, who experience large wait times in between meals and so must eat as much as possible in one sitting, **have larger, more expandable stomachs**. H**erbivores have much longer digestive tracts** than carnivores.

   Provide **two evolutionary benefits of herbivores having longer digestive tracts than carnivores**?

   1.

   2.

3. Your colon is inhabited by an immense number of bacteria. Although they produce sometimes embarrassing gases and odors, most are actually your friends. Humans and their intestinal bacteria are mutualists, both organisms having evolved a mutually beneficial relationship. They benefit by frequently receiving nutrients and a stable environment to live in. What do your **symbiotic bacteria** do for you as a human in return?

4. a. What is meant by the body's **microbiome**?

   b. What **aspects of the animal's existence does the microbiome seem to be able to influence**?

5. Analyze the relative abundance of Actinobacteria in the microbiome of a healthy adult's intestinal tract to that in a healthy stomach as shows in Figures 41.17 and 41.18.

   a. In which organ are actinobacteria found in higher relative abundance?

   b. *Think:* Suggest a possible explanation for why the microbiome composition in the two organs is different even though the intestine and stomach are directly connected.

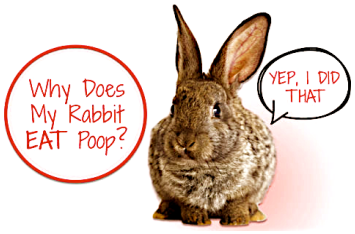
If you stated that the quantity and types of nutrients available differs in these two organs and that, therefore, different types of bacterial populations can be sustained, you are correct. In the stomach, carbohydrates, proteins, nucleic acids, lipids, and various ions are in higher abundance since they have not yet been absorbed into the human body, which occurs middle and latter parts of the small intestine. By the time the digested food reaches the colon, the ion composition has changed and there are fewer amino acids, simple sugars, nucleotide components, and lipid monomers. Bacteria better adapted to this reality will thrive in the colon while others may thrive better higher up in the digestive tract.

6. a. **Where do herbivores get most of their chemical energy from**?

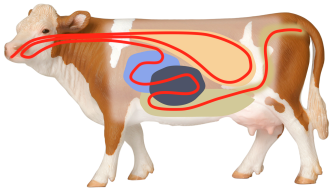
   b. Why does obtaining chemical energy from this particular carbohydrate pose a **problem for herbivores**?

   c. In what way have termites evolved a **mutualistic relationship** with bacteria that helps them survive on eating wood *(which is composed of cellulose)*?

   d. How is **coprophagy** an adaptation in animals like herbivores like rodents and rabbits?



   e. How is **regurgitating** food to rechew it an adaptation in **ruminants** like cows or sheep?



7. *Think:* People who are lactose intolerance have a shortage of lactase, the enzyme that breaks down lactose in milk. As a result, they sometimes develop cramps, bloating, or diarrhea after consuming dairy products. Suppose such a person ate yogurt that contains bacteria that produce lactase. Why would eating yogurt likely provide at best only temporary relief of the symptoms? *(Check your answer by going to **Ch.41.4 Concept Check Question #3** in Appendix A)*

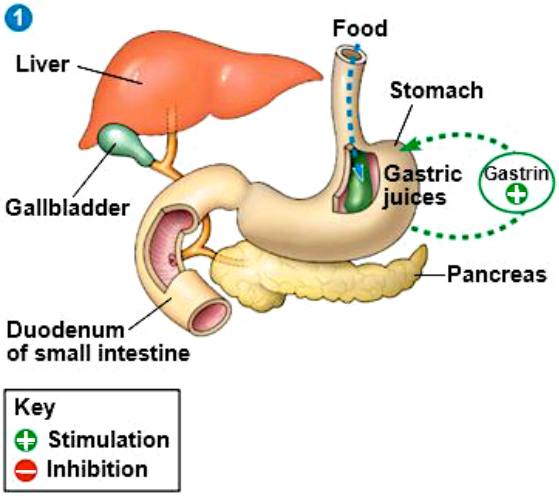
8. The nervous system helps regulate many behaviors of the nervous system. Muscular contractions, peristalsis, in the organs that make up your digestive tracts are regulated by the enteric nervous system, a network of neurons dedicated to the digestive organs. When food enters your oral cavity, the nervous system stimulates your salivary glands to release of saliva. When a bolus of food reaches the pharynx after being pushed back by the tongue, the nervous system sends messages to muscles in the tongue and throat to orchestrate swallowing. The arrival of food in the stomach triggers the nervous system too, which then helps activate churning and the release of gastric juices.

   In addition to the nervous system, the endocrine system (cells that can secrete hormones) **also plays a critical role in controlling digestion**. For example, a series of hormones released by cells of the stomach and duodenum help ensure that digestive secretions are present only when needed.

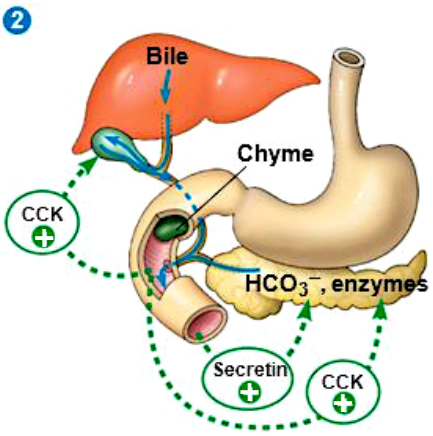
   Study Figure 41.22. **Hormones are chemical messengers that travel through the blood stream from the cells that secrete them (endocrine cells) to the target cells that have receptors for these hormones** *(even if the target cells are in the same organ as the endocrine secretory cell)*. With the help of hormones, the digestive system coordinates the secretion of digestive juices with the arrival of food in various organs along the digestive tract. *Why spend **energy secreting through exocytosis** digestive enzymes **(which also consumes energy to be built)** if there isn't any food in that compartment yet to digest?!*

   a. Let's look at the **stomach** (see figure to right). Describe **when and how gastrin is released from certain endocrine cells in the walls of the stomach** (known as G cells).

   b. Describe the **effect gastrin hormone has on key cells in the stomach**.



   c. Let's look at how the endocrine cells in the walls of the **duodenum** (the beginning of the small intestine) help prepare the small intestine so it can do its part in digestion and absorption (see figure to right). Which **hormones do the endocrine cells** (I and S cells) **in the wall of duodenum release when they come into contact with the acidic chyme as it exits the stomach**, what is the **target tissue** of these hormones, and what **action do these enzymes stimulate** in their target cells?



      1. Hormone #1 Secreted from Duodenum = _____

         Target Tissue of Hormone = _____

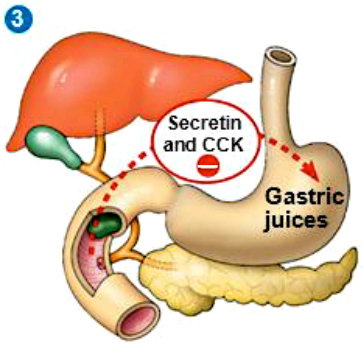
Action(s) Stimulated in Target Cells =

2. Hormone #2 Secreted from Duodenum = _____

Target Tissue of Hormone = _____

Action(s) Stimulated in Target Cells =

d. The amount of fat in chyme exiting the stomach can influence the concentration of Secretin and Cholecystokinin (CCK) released by the endocrine cells in the lining of the duodenum. What effect does **releasing a lot of Secretin and CCK from the duodenum in response to a high-fat meal** have (see figure to right)?



How is this an **adaptation**?

9. a. Which locations in the human body serve as the primary site for the storage of chemical energy?

1.

2.

b. What is the high-energy molecule that the organs you listed in 9.a. construct in order to store chemical energy? (Revisit Ch.5 to review the structure and make up of this molecule)

c. What other high-energy molecule can the body use to store chemical energy? (Revisit Ch.5 to review the structure and make up of this molecule)

d. Where is this high-energy molecule you listed in 9.c. stored in the body?

10. **Glucose is a major fuel for cellular respiration** *(the biochemical process in which cells extract chemical energy from high energy molecules like glucose and store it on ATP molecules)* **and a major source of carbon** for the making of other organic molecules in cells. Because glucose is so critical to the cells of the body, maintaining the right homeostatic concentration of glucose in the blood is essential. Two key antagonistic pancreatic hormones help maintain the proper glucose levels in the blood. **Study Figure 41.23 thoroughly!** You should know this antagonist hormone system well, **antagonistic hormones** being hormones that have opposite effects on some variable such as blood glucose concentration in this case.

a. Which **hormone is secreted by the pancreas when blood glucose levels rise** above the normal range (like after a meal in which you absorb glucose monomers into the blood)?

b. Which **pancreatic cells secrete this hormone** into the blood?

c. As you see in Figure 41.23, what are **two effects of insulin hormone in the body**?

1.

2.

d. Which **hormone is secreted by the pancreas when blood glucose levels drop** below the normal range (like after fasting or not eating for a while, cells of the body, like neurons, using up some of the blood glucose)?

e. Which **pancreatic cells secrete this hormone** into the blood?

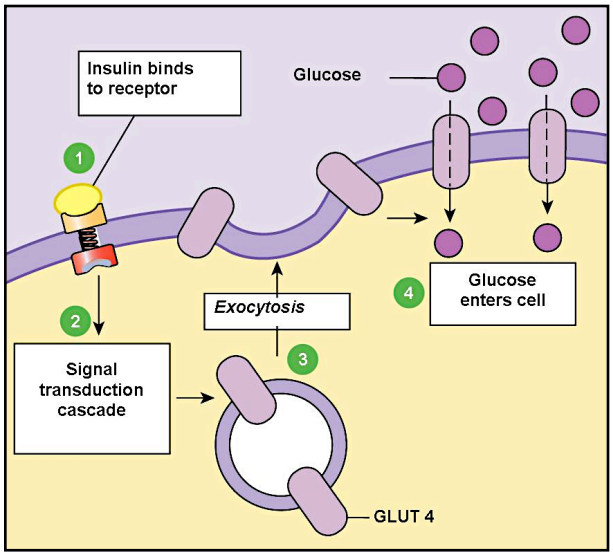
f. As you see in Figure 41.23, what are **two effects of glucagon hormone in the body**?

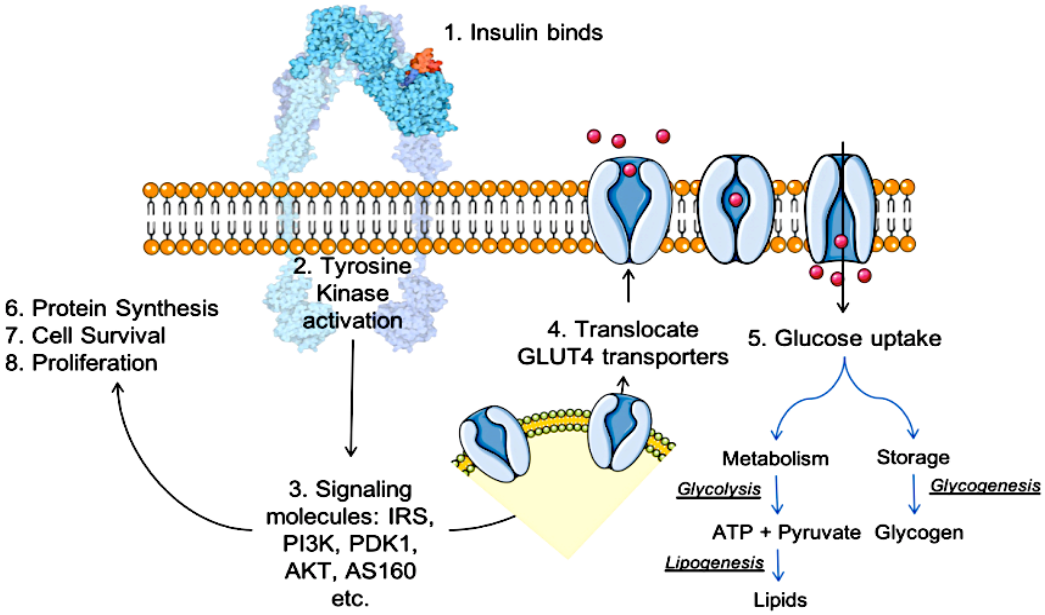
1.

2.

11. So that you know, **receptor proteins for insulin are found on almost all cells of the body, except neurons** *(the cells that make up your brain and the rest of your nervous system in the body).* In response to insulin, **most body cells - including muscle and liver cells - add extra glucose transporters** (known as **GLUT**) **to their plasma membranes to take up more glucose** when levels are too high in the blood. This way, these cells take in glucose to use for energy and a source of carbon to conduct other cellular processes with, or, in the case of liver and muscle cells, to store as glycogen.

The receptors for insulin are types of tyrosine kinase receptors, which, in turn, **active a series of events inside the cell, one of which results in pre-constructed secretory vesicles fusing with the plasma membrane. The membranes of these vesicles have GLUT transporters in them,** glucose transport proteins whose polypeptides were initially built by bound ribosomes on the surface of the Rough Endoplasmic Reticulum. Below find a simplified and a more complex model showing the consequence of insulin activating a signal transduction pathway. *Can you now explain the events that take place when insulin binds its receptor?*





Interestingly, **neurons don't need insulin to tell them to put glucose transporters** (passive carrier proteins) in their plasma membrane. Neurons permanently keep glucose carriers in their plasma membranes. This way, glucose can always diffuse (passively) from the blood and interstitial fluid (where glucose is kept higher) into the neuron, down glucose's concentration gradient, as the neuron uses up glucose during cellular respiration and biosynthesis. Neurons consume a lot of glucose, but are unable to store it like liver and muscle cells can, always needing a steady supply.

Someone with diabetes is not able to maintain proper blood glucose homeostasis. They may exhibit moments of very high blood glucose levels, yet the glucose may not get inside cells at the rates it should.

a. What occurs in the body that **leads to Type I Diabetes Mellitus**?

What is the **treatment for Type I Diabetes**?

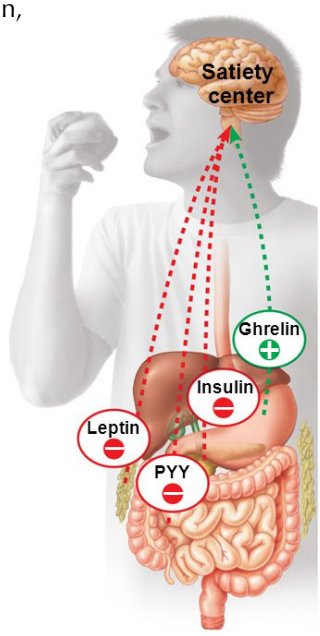
b. What occurs in the body that **leads to Type II Diabetes Mellitus**?

What are risk factors for the development of **Type II Diabetes**?

What are the **treatments for Type II Diabetes**?

12. Over-nourishment by consuming more energy than is needed for normal metabolism (cellular respiration) can lead to obesity, excessive fat storage. What kind of health problems has **obesity** been linked to?

13. Several hormone systems exist that relate to the storage and metabolism (break down) of fat molecules. These **appetite-regulating hormones** are secreted by various organs and target the satiety center in the brain, the parts of the brain that make you feel hungry or full and satiated.



a. What organ **secretes ghrelin**?

b. What feeling does **ghrelin trigger in the brain**?

c. When is **insulin from the pancreas secreted** again?

d. What feeling does **insulin trigger in the brain**?

e. What organ **secretes leptin**?

f. What feeling does **leptin trigger in the brain**?

g. What organ **secretes PPY** after meals?

h. What feeling does **PPY trigger in the brain**?

14. *Think:* Suppose you were studying two groups of people who are obese and have genetic abnormalities in the leptin pathway. In one group, the leptin levels are abnormally high; in the other group, they are abnormally low. **Explain how and why** each group's leptin levels change if they ate a low-calorie diet for an extended period? *(Check your answer by going to **Ch.41.5 Concept Check Question #2** in Appendix A)*

    Group 1's Leptin Levels =

    Group 2's Leptin Levels =

15. *Think:* An insulinoma is a cancerous mass of pancreatic beta cells that secrete insulin but do not respond to feedback mechanisms. **Explain how and why** an insulinoma would affect blood glucose levels and liver activity? *(Check your answer by going to **Ch.41.5 Concept Check Question #3** in Appendix A)*

    Blood Glucose Levels =

    Liver Activity =

16. Proceed to the TEST YOUR UNDERSTANDING section at the end of the chapter. **Study your chapter sections and all Ch.41 study guides first!** *Then, do your best to try to answer these from memory first in order to test how well you grasped the material before. If you are unsure, return to the relevant section of your chapter and restudy any pertinent material to refresh your memory. (Check some of your answers by going to the **Ch.41 Test Your Understanding** answers in Appendix A)*

    1. _____ 2. _____ 3. _____ 4. _____ 5. _____ 6. _____ 7. _____