Cheat Sheet

Table 41.1 Vitamin Requirements of Humans

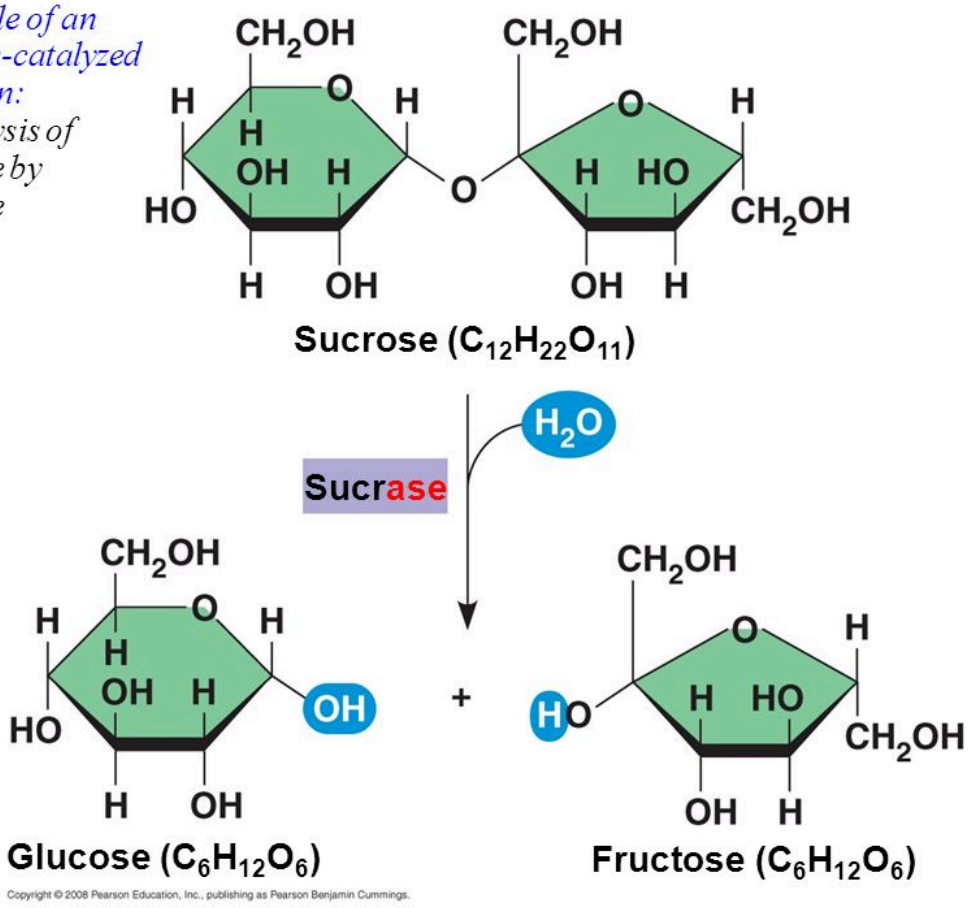
Vitamin	Major Dietary Sources	Major Functions in the Body	Symptoms of Deficiency
Water-Soluble Vitamins			
B_1 (thiamine)	Pork, legumes, peanuts, whole grains	Coenzyme used in removing CO_2 from organic compounds	Beriberi (tingling, poor coordination, reduced heart function)
B_2 (riboflavin)	Dairy products, meats, enriched grains, vegetables	Component of coenzymes FAD and FMN	Skin lesions, such as cracks at corners of mouth
B_3 (niacin)	Nuts, meats, grains	Component of coenzymes NAD^+ and $NADP^+$	Skin and gastrointestinal lesions, delusions, confusion
B_5 (pantothenic acid)	Meats, dairy products, whole grains, fruits, vegetables	Component of coenzyme A	Fatigue, numbness, tingling of hands and feet
B_6 (pyridoxine)	Meats, vegetables, whole grains	Coenzyme used in amino acid metabolism	Irritability, convulsions, muscular twitching, anemia
B_7 (biotin)	Legumes, other vegetables, meats	Coenzyme in synthesis of fat, glycogen, and amino acids	Scaly skin inflammation, neuromuscular disorders
B_9 (folic acid)	Green vegetables, oranges, nuts, legumes, whole grains	Coenzyme in nucleic acid and amino acid metabolism	Anemia, birth defects
B_{12} (cobalamin)	Meats, eggs, dairy products	Production of nucleic acids and red blood cells	Anemia, numbness, loss of balance
C (ascorbic acid)	Citrus fruits, broccoli, tomatoes	Used in collagen synthesis; antioxidant	Scurvy (degeneration of skin and teeth), delayed wound healing
Fat-Soluble Vitamins			
A (retinol)	Dark green and orange vegetables and fruits, dairy products	Component of visual pigments; maintenance of epithelial tissues	Blindness, skin disorders, impaired immunity
D	Dairy products, egg yolk	Aids in absorption and use of calcium and phosphorus	Rickets (bone deformities) in children, bone softening in adults
E (tocopherol)	Vegetable oils, nuts, seeds	Antioxidant; helps prevent damage to cell membranes	Nervous system degeneration
K (phylloquinone)	Green vegetables, tea; also made by colon bacteria	Important in blood clotting	Defective blood clotting

Table 41.2 Mineral Requirements of Humans*

	Mineral	Major Dietary Sources	Major Functions in the Body	Symptoms of Deficiency
Greater than 200 mg per day required	Calcium (Ca)	Dairy products, dark green vegetables, legumes	Bone and tooth formation, blood clotting, nerve and muscle function	Impaired growth, loss of bone mass
	Phosphorus (P)	Dairy products, meats, grains	Bone and tooth formation, acid-base balance, nucleotide synthesis	Weakness, loss of minerals from bone, calcium loss
	Sulfur (S)	Proteins from many sources	Component of certain amino acids	Impaired growth, fatigue, swelling
	Potassium (K)	Meats, dairy products, many fruits and vegetables, grains	Acid-base balance, water balance, nerve function	Muscular weakness, paralysis, nausea, heart failure
	Chlorine (Cl)	Table salt	Acid-base balance, formation of gastric juice, nerve function, osmotic balance	Muscle cramps, reduced appetite
	Sodium (Na)	Table salt	Acid-base balance, water balance, nerve function	Muscle cramps, reduced appetite
	Magnesium (Mg)	Whole grains, green leafy vegetables	Enzyme cofactor; ATP bioenergetics	Nervous system disturbances
	Iron (Fe)	Meats, eggs, legumes, whole grains, green leafy vegetables	Component of hemoglobin and of electron carriers; enzyme cofactor	Iron-deficiency anemia, weakness, impaired immunity
	Fluorine (F)	Drinking water, tea, seafood	Maintenance of tooth structure	Higher frequency of tooth decay
	Iodine (I)	Seafood, iodized salt	Component of thyroid hormones	Goiter (enlarged thyroid gland)

*Additional minerals required in trace amounts are chromium (Cr), cobalt (Co), copper (Cu), manganese (Mn), molybdenum (Mo), selenium (Se), and zinc (Zn). All of these minerals, as well as those in the table, are harmful when consumed in excess.

Example of an enzyme-catalyzed reaction: hydrolysis of sucrose by sucrase



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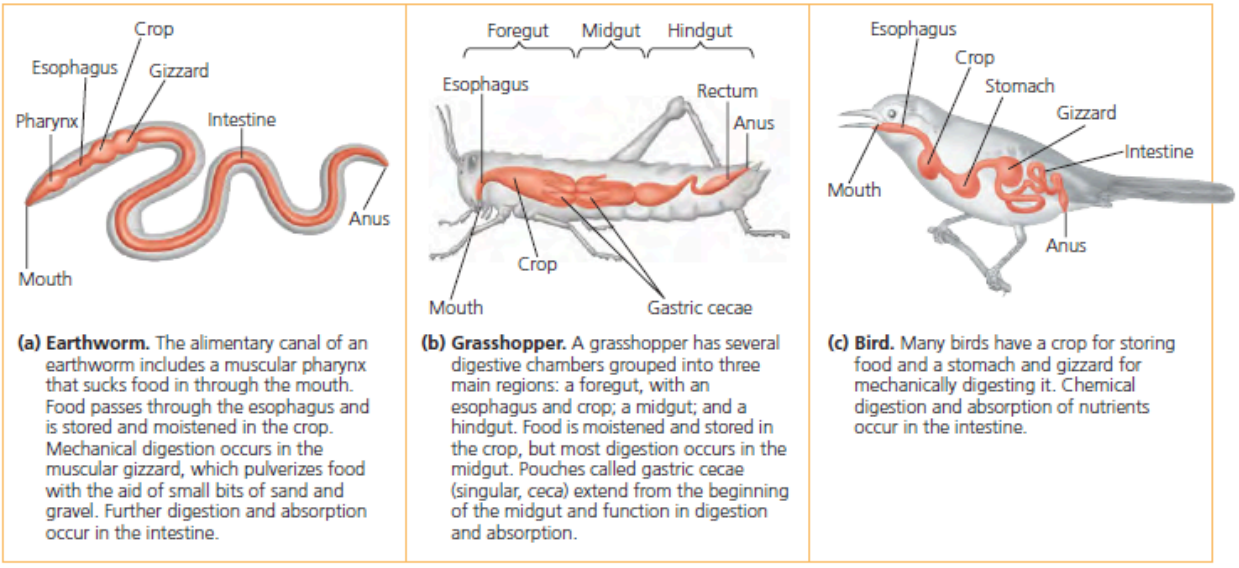
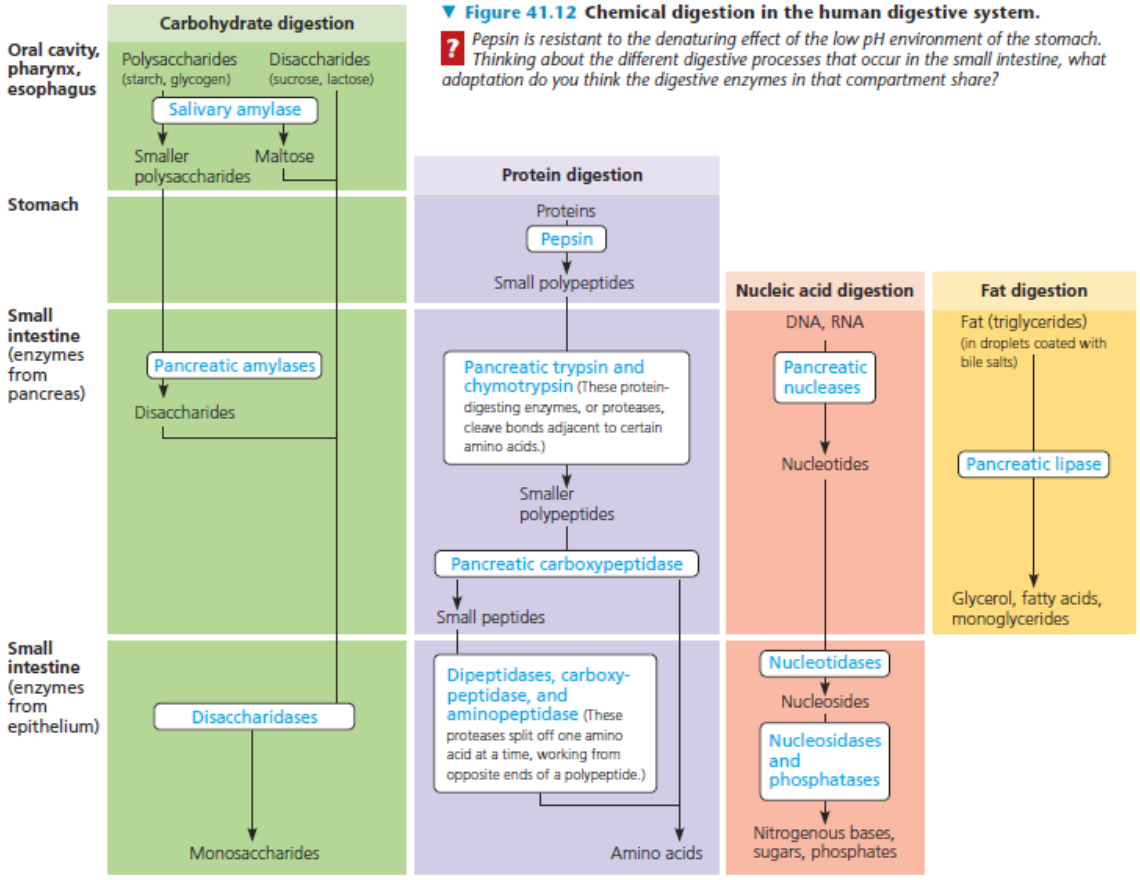


(a) Earthworm. The alimentary canal of an earthworm includes a muscular pharynx that sucks food in through the mouth. Food passes through the esophagus and is stored and moistened in the crop. Mechanical digestion occurs in the muscular gizzard, which pulverizes food with the aid of small bits of sand and gravel. Further digestion and absorption occur in the intestine.

(b) Grasshopper. A grasshopper has several digestive chambers grouped into three main regions: a foregut, with an esophagus and crop; a midgut; and a hindgut. Food is moistened and stored in the crop, but most digestion occurs in the midgut. Pouches called gastric cecae (singular, cecum) extend from the beginning of the midgut and function in digestion and absorption.

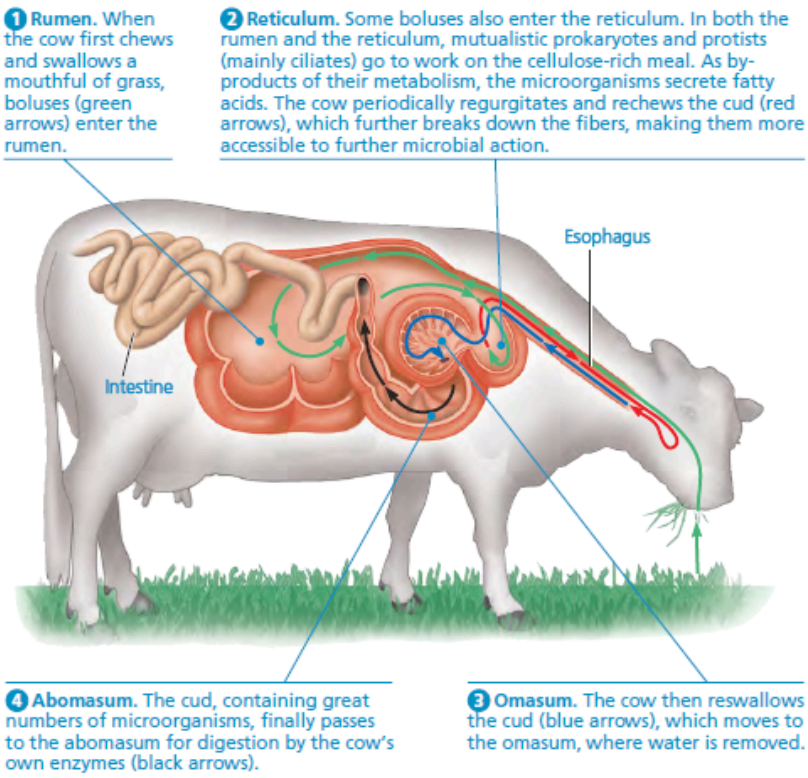
(c) Bird. Many birds have a crop for storing food and a stomach and gizzard for mechanically digesting it. Chemical digestion and absorption of nutrients occur in the intestine.

◀ **Figure 41.9 The human digestive system.** After food is chewed and swallowed, it takes 5–10 seconds for it to pass down the esophagus and into the stomach, where it spends 2–6 hours being partially digested. Final digestion and nutrient absorption occur in the small intestine over a period of 5–6 hours. In 12–24 hours, any undigested material passes through the large intestine, and feces are expelled through the anus.

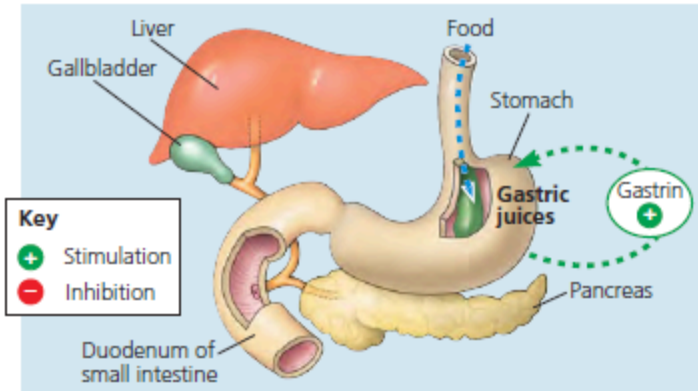


▼ **Figure 41.12 Chemical digestion in the human digestive system.**

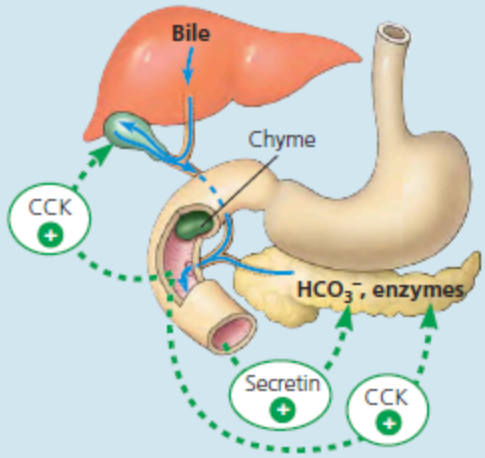
? *Pepsin is resistant to the denaturing effect of the low pH environment of the stomach. Thinking about the different digestive processes that occur in the small intestine, what adaptation do you think the digestive enzymes in that compartment share?*



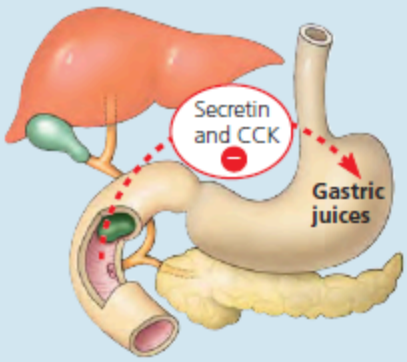
◄ Figure 41.18 Ruminant digestion. The stomach of a ruminant has four chambers. Because of the microbial action in the chambers, the diet from which a ruminant actually absorbs its nutrients is much richer than the grass the animal originally eats. In fact, a ruminant eating grass or hay obtains many of its nutrients by digesting the mutualistic microorganisms, which reproduce rapidly enough in the rumen to maintain a stable population.



1 As food arrives at the stomach, it stretches the stomach walls, triggering release of the hormone **gastrin**. Gastrin circulates via the bloodstream back to the stomach, where it stimulates production of gastric juices.



2 Chyme—an acidic mixture of partially digested food—eventually passes from the stomach to the duodenum. The duodenum responds to amino acids or fatty acids in the chyme by releasing the digestive hormones cholecystokinin and secretin. **Cholecystokinin (CCK)** stimulates the release of digestive enzymes from the pancreas and of bile from the gallbladder. **Secretin** stimulates the pancreas to release bicarbonate (HCO_3^-), which neutralizes chyme.



3 If the chyme is rich in fats, the high levels of secretin and CCK released act on the stomach to inhibit peristalsis and secretion of gastric juices, thereby slowing digestion.

Chapter 41 Questions

1. **What is nutrition?**
2. **What are herbivores?**
3. **What are carnivores?**
4. **What are omnivores?**
5. **What are essential nutrients?**
6. **What is ascorbic acid?**
7. **What are essential amino acids (name them)?**
8. **What are the difference between complete and incomplete proteins?**
9. **What are essential fatty acids?**
10. **What are vitamins?**
11. **Describe the 13 vitamins (dietary sources, functions, symptoms of deficiency).**
12. **What are minerals?**
13. **Describe the 10 required minerals for humans (sources, functions, symptoms).**
14. **What is malnutrition?**
15. **What is the most common type of malnutrition among humans?**
16. **What is anorexia nervosa?**
17. **What is epidemiology?**
18. **What is ingestion?**
19. **What are the four main types of feeding mechanisms?**
20. **What is digestion?**
21. **What is the difference between mechanical and chemical digestion?**
22. **What is enzymatic hydrolysis?**
23. **Describe the enzymatic hydrolysis of sucrose.**
24. **What are absorption and elimination?**
25. **What is a gastrovascular cavity?**
26. **What is an alimentary canal?**
27. **Describe the digestion of earthworms, grasshoppers, and birds.**
28. **What is the oral cavity?**
29. **What are salivary glands?**
30. **What is saliva?**
31. **What is a bolus?**
32. **What is the pharynx?**
33. **What is the esophagus?**
34. **What is the trachea?**
35. **What is peristalsis?**
36. **What is a sphincter?**
37. **What is the epiglottis?**
38. **What is the stomach?**
39. **Describe the components of gastric juice.**
40. **What are parietal cells?**

41. What are chief cells?
42. Why don't HCl and pepsin eat through lining of stomach?
43. What are gastric ulcers?
44. Describe the timeline of human digestion.
45. How often does churning occur?
46. What is heartburn?
47. Describe how the four main macromolecules are fully digested.
48. What is the small intestine?
49. What is the duodenum?
50. What is secretin?
51. What are trypsin and chymotrypsin?
52. What are bile salts?
53. What is bile?
54. What is jaundice?
55. What role does bile play in the destruction of red blood cells?
56. What are the jejunum and the ileum?
57. How is fructose transported across epithelial cells in small intestines?
58. What is the hepatic portal vein?
59. What does the liver do with the nutrients it receives from the hepatic portal vein?
60. How are fats transported?
61. What is the large intestine?
62. What are feces?
63. What are diarrhea and constipation?
64. What fraction of the dry weight of feces is constituted by bacteria?
65. What is the rectum?
66. How many of each type of teeth do humans have?
67. What is the microbiome?
68. How does *H. pylori* disrupt stomach health?
69. What is corticosterone?
70. What is a crop?
71. What is coprophagy?
72. What are ruminants?
73. How do giant tubeworms obtain nutrition?
74. Describe ruminant digestion.
75. What is the enteric nervous system?
76. What is gastrin?
77. In humans, what are the primary sites for energy storage?
78. What is the normal range for blood glucose levels?
79. Describe the hormonal control of digestion.
80. What is insulin?
81. What is glucagon?
82. Insulin and glucagon act on nearly all body cells except which?
83. What are pancreatic islets (islets of Langerhans)?

84. What is diabetes mellitus?
85. What are two symptoms of diabetes mellitus?
86. What are the two types of diabetes?
87. What is overnourishment?
88. What is ghrelin?
89. What is PYY?
90. What is leptin?

Chapter 41 Answers

1. Food being taken in, taken apart, and taken up
2. Dine mainly on plants and algae
3. Mostly eat other animals
4. Regularly consume animals as well as plants/algae
5. Substances that an animal requires but cannot assemble from simple organic molecules
6. Vitamin C, some animals (e.g. humans) need it from diet
7. Amino acids that animals need in prefabricated form. Many animals need isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine (human infants need histidine as well)
8. Provide all essential amino acids in proper proportions

   Deficient in one or more essential amino acids (corn lacks tryptophan/lysine, beans methionine)
9. Fatty acids that must be obtained from diet, cannot be synthesized because of lack of enzyme to form double bonds (in mammals includes linoleic acid)
10. Organic molecules that are required in the diet in very small amounts (0.01-100 mg per day)
11. See picture
12. Inorganic nutrients like iron and sulfur, required in small amounts (less than 1 to 2500 mg per day)
13. see picture
14. Failure to obtain adequate nutrition
15. protein deficiency, may arise if diet shifts from breast milk to foods that contain little protein (often have impaired physical/mental development)
16. Weight loss to a level that is unhealthy for the individual age and height, may be related to distorted body image
17. Study of human health/disease at population level
18. Act of eating or feeding
19. Filter feeding - Strain small organisms or food particles from surroundings, type of suspension feeding (removing suspended food particles from surroundings)

    Substrate feeders - animals that live in or on food source

    Fluid feeders - suck nutrient rich fluid from host

    Bulk feeders - eat relatively large pieces of food (most animals)
20. food broken down into molecules small enough for body to absorb
21. breaks food into smaller pieces
    cleaves large molecules into smaller components

22. Process of splitting macromolecules by addition of water, catalyzed by digestive enzymes
23. see picture
24. Animal's cells take up small molecules
    Undigested material passes out of digestive system
25. Digestive compartment with single opening, functions in digestion and distribution of nutrients throughout body, lined by gastrodermis (secretes chemicals that digest food)
26. Complete digestive tract, two openings (mouth/anus), food moves along canal in single direction
27. see picture
28. Mouth through which food enters
29. Release saliva with anticipation or arrival of food in oral cavity
30. Complex mixture of materials, number of vital functions. Mainly mucus (mixture of water, salts, cells, slippery glycoproteins, lubricates food for easier swallowing, protects gums against abrasion, facilitates taste and smell), contains buffers that neutralize acid and antimicrobial agents. Contains large amount of amylase (releases food particles stuck to teeth).
31. Ball of saliva and food, shaped by tongue and pushed into pharynx
32. Throat region, leads to esophagus and trachea
33. Muscular tube that connects to stomach
34. Windpipe, leads to lungs
35. Alternating waves of smooth muscle contraction/relaxation
36. Ringlike valve of muscle (at end of esophagus regulates passage of food to stomach, esophageal/cardiac sphincter, betwee stomach and intestine called pyloric)
37. Flap of tissue that is tipped down by larynx, preventing food from entering trachea
38. Located below diaphragm, stores about 2 L of food fluid, has accordion-like folds (gastric rugae) and elastic wall. Processes food in liquid suspension by secreting gastric juice (mixed with food by churning action to produce chyme (mixture of food and juice))
39. Hydrochloric acid disrupts ECM that binds cells together (pH of gastric juice is about 2, denaturing proteins). Pepsin (protease) attacks exposed bonds of proteins, works best in acidic environment.
40. Use ATP-driven pump to expel hydrogen ions into lumen. Chloride ions diffuse into lumen through membrane channels of cells.
41. Release pepsin into lumen in inactive form (pepsinogen) that is activated by HCl (clips small portion of molecule to expose active site), pepsin can activate pepsinogen as well
42. Mucus secreted by gastric cells protects against self-digestion. Cell division adds new epithelial layer every three days
43. Damaged areas of stomach lining, caused by infection by acid-tolerant bacterium *Helicobacter pylori*, curable by antibiotic
44. See picture
45. Every 20 seconds
46. Irritation caused by acid reflux from stomach (movement of chyme back into lower end of esophagus)

47. see picture
48. Longest compartment of alimentary canal, where most enzymatic hydrolysis occurs (over 6 m in humans)
49. First 25 cm of small intestine where chyme from stomach mixes with digestive juices from pancreas, liver, gallbladder, and gland cells of intestinal wall
50. Hormone released by arrival of chyme in duodenum, stimulates pancreas to secrete bicarbonate (neutralizes acidity of chyme and acts as buffer for chemical digestion in small intestine)
51. Proteases produced in active forms secreted by pancreas
52. Act as emulsifiers that break apart fat/lipid globules, major component of bile
53. Secretion of liver that is stored and concentrated in gallbladder
54. Yellowing caused by accumulation of bile pigments in skin (in some liver/blood disorders)
55. Pigments from RBC disassembly incorporated into bile pigments that are eliminated from body in feces
56. Remaining regions of small intestine where nutrient absorption occurs across lining of intestine. Folds in lining surround intestine, studded with villi, each epithelial cell on villi have microvilli. Intestinal epithelium called brush border
57. Moves by facilitated diffusion down concentration gradient from lumen to epithelium
58. Blood vessel that leads directly to liver, is where capillaries and veins that carry nutrient rich blood away from villi converge. Blood travels from liver to heart then to other tissues
59. Regulates distribution of nutrients and removes toxic substances
60. Hydrolyzed by lipase, absorbed by epithelial cells then recombined into triglycerides (some fatty accids/glycerol put directly in capillaries). Coated with phospholipids, cholesterol, and other proteins to form globules called chylomicrons that enter a lacteal (vessel at the core of each villus, part of lymphatic system) that transports fat to veins that lead to heart.
61. End of alimentary canal, includes colon, cecum, and rectum, connected to small at T-shaped junction (one arm is colon(leads to rectum/anus), other arm is cecum (pouch for fermenting ingested material, small in humans), appendix extends from human cecum, thought to be reservoir for symbiotic microorganisms
62. Wastes of digestive system, become increasingly solid as they move through colon
63. Colon is irritated so less water may be reabsorbed
    Feces move too slowly, too much water reabsorbed
64. ⅓, generate methane and hydrogen sulfide (bad odor)
65. Terminal portion of large intestine, where feces are stored, two sphincters between rectum and anus, one voluntary, one involuntary, filling of stomach increases rate of contractions in colon, causing urge to defecate
66. 8 incisors (biting), 4 canines (tearing), 8 premolars (grinding), 12 molars (crushing)
67. Collection of microorganisms living in and on the body, along with their genetic material
68. Eliminates other bacterial species
69. Stress hormone
70. Esophageal pouch, ridges in wall grind leaves, microorganisms in it break down cellulose

71. Feeding of feces and passing food through alimentary canal a second time, recovers nutrients lost first time (bacteria put in nutrients after absorption)
72. Cud-chewing animals such as deer, sheep, cattles
73. Exclusively from mutualistic chemoautotrophic bacteria living within their bodies
74. see picture
75. Network of neurons dedicated to digestive organs
76. Hormone that is secreted by stomach, transported by bloodstream, and targeted to stomach
77. Liver and muscle cells
78. 70-110 mg/100 mL
79. see picture
80. Hormone that triggers uptake of glucose from blood into body cells, suprpesses appetite
81. Promotes release of glucose into blood
82. Brain cells can always take up glucose
83. Clusters of endocrine cells in pancreas, each has alpha cells (make glucagon) and beta cells (make insulin)
84. Deficiency of insulin or decreased response to insulin in target tissues, acidic metabolites formed by fat breakdown accumulate (in severe cases because can't use glucose) (lowers blood pH and depletes sodium/potassium ions)
85. Copious urination and sugar in urine
86. Type 1 diabetes (insulin-dependent diabetes) - autoimmune disorder, immune system destroys beta cells of pancreas (appears during childhood)

    Type 2 diabetes (non-insulin-dependent diabetes) - Failure of target cells to respond normally to insulin. Blood glucose levels remain elevated, can be caused by genetics and excess body weight, seventh most common cause of death
87. Consuming more calories than the body needs for metabolism, can lead to obesity (excessive accumulation of fat)
88. Hormone that is secreted by stomach wall, triggers feelings of hunger before meals
89. Hormone secreted by small intestine after meals, suppresses appetite
90. Hormone produced by adipose tissue, suppresses apetite and appears to regulate body fat levels