

BIOL 1030 - TOPIC 15 LECTURE NOTES

Topic 15: Animal Nutrition - Digestive System (Ch. 41)

- I. Function – break down food into organic molecules small enough to be used by cells
 - A. carbohydrates → monosaccharides (simple sugars) [major energy source]
 - B. proteins → amino acids [minor energy source; major building blocks]
 - C. lipids → fatty acids and glycerol [major energy source; major building blocks]
 - D. also absorbed: various vitamins and minerals, and water
- II. Types of digestion in animals
 - A. intracellular only – no digestive cavity
 1. cells take in and break down their own food
 2. found in sponges
 - B. extracellular – digestive cavity or tube (true digestive system)
 1. mechanical digestion: may include some type of grinding mechanism (if this occurs, it typically happens first)
 2. chemical digestion (hydrolysis – breaking polymers by adding water)
 - carbohydrates: amylases
 - proteins: acid digestion, plus proteases
 - lipids: emulsification by bile; lipases
 3. incomplete digestive system
 - one opening (serves as mouth and anus)
 - gastrovascular cavity** with no specialization
 - examples: jellyfish, some flatworms
 4. complete digestive system
 - two openings (mouth and anus) with mostly one-way passage of food
 - digestive tract (**alimentary canal**) typically broken into specialized regions
 - examples: earthworms, vertebrates
 - C. none – some parasites absorb food already digested by others (example: tapeworms)
- III. Food sources
 - A. herbivores – eat plants (and sometimes photosynthetic protists) exclusively (example: cows); food tougher to digest due to cellulose
 - B. carnivores – eat animals (and sometimes protists and bacteria) exclusively (example: cats) – food typically easier to digest
 - C. omnivores – eat both plants and animals (example: humans) – must have adaptable digestive system
- IV. Vertebrate digestive system
 - A. mouth
 1. all jawed vertebrates except birds have teeth
 - carnivores have more pointed, sharp teeth for capture, cutting, tearing, and shearing; meat needs little chewing
 - herbivores have large, flat teeth for grinding plant material
 - omnivores have both types, sharp in front and flat in back
 2. food is moistened and lubricated with saliva (also some digestion begins)
 - saliva made by three pairs of salivary glands
 - empty through ducts into mouth
 - contain amylase (start starch digestion)
 - tongue mixes food with saliva
 - B. swallowing – a reflex under some voluntary control
 1. pressure on back of mouth triggers swallowing
 2. in mammals, soft palate elevates to seal off nasal cavity
 3. pressure on pharynx stimulates receptors to signal swallowing center in brain
 4. swallowing center signals muscles to contract, raising larynx to and closing glottis with epiglottis, sealing off trachea
 5. net result is food kept out of respiratory tract, instead directed to esophagus
 - C. esophagus
 1. upper portion skeletal muscle, used to push food toward stomach as part of swallowing reflex
 2. lower 2/3 smooth muscle; propel food toward stomach in rhythmic peristaltic waves
 3. passage to stomach controlled by a **sphincter** (a ring of smooth muscle at the junction of two organs that constricts passage between the organs when contracted)
 - D. stomach
 1. saclike portion of digestive tract, may be subdivided and further specialized
 - interior considered continuous with body exterior; is convoluted, allowing stomach volume to expand considerably as needed
 - from exposed inner layer out: epithelium, mucosa (connective tissue), then complex layer with muscles, blood vessels, and nerves

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2. epithelial cells secrete mucus, protecting and lubricating stomach and facilitating food movement
3. function: acid digestion of proteins
 - parietal cells in mucosa secrete HCl → gastric juice in stomach has pH of ~2
 - chief cells in mucosa secrete pepsinogen, activated to pepsin (a very active protease) at low pH
 - result is acid denaturing of proteins plus hydrolysis by pepsin
 - acid also kills most bacteria
 - no significant digestion of carbohydrates or lipids in stomach
 - no major food absorption in stomach (only water, alcohol, some drugs like aspirin)
 - mixture of gastric juice and food called chyme
4. ulcers – problems with acid damaging the epithelial cells
 - rarely in stomach (gastric ulcers); >90% are duodenal ulcers (first segment of small intestine)
 - most involve *Helobacter pylori* bacteria weakening protective mucus layer; these respond to antibiotics
5. leaving the stomach
 - pyloric sphincter controls movement from stomach to small intestine
 - only small amounts of chyme can be passed along at one time for efficient digestion
- E. small intestine – site of terminal digestion and absorption
 1. primary organ of digestion; 6 m long in humans
 2. divided into three segments: duodenum (first 25 cm in humans), jejunum, then ileum
 3. active digestion mainly in duodenum, food absorption into bloodstream mainly in jejunum and ileum
 4. digestion involves
 - pancreatic juice (from pancreas): bicarbonate (neutralizes stomach acid), amylases, proteases, and lipases
 - bile from liver (emulsifies fat) – may be temporarily stored in a gall bladder
 5. specializations of epithelium for absorption
 - small projections called villi, with cytoplasmic projections called microvilli
 - greatly increases absorptive surface area (over 300 m² in humans)
 - brush border enzymes for final disaccharide digestion
 - active transport of monosaccharides and amino acids; passed across to blood capillaries
 - food in blood first taken to liver (main body filter for toxic substances)
 - free fatty acids and monoglycerides converted to triglycerides in epithelial cells, then combined with proteins to make chylomicrons that are passed to lymphatic capillaries (enter bloodstream at veins in the neck)
 6. exit into large intestine through ileocecal valve (no sphincter)
 7. overall food and water absorption is very efficient
 - human daily intake: about 800 grams of solids, and a total solid plus food volume of 2 L
 - add to that about 7 L added by body during digestion, or 9 L total volume
 - at end, only 50 grams of solids and 100 mL of liquid leave as feces
 - fluid absorption 99% efficiency; if faulty, rapid dehydration occurs
- F. large intestine (colon)
 1. actually shorter than small intestine, but wider, with no villi
 - first segment is cecum; in some, this is expanded and serves as a fermentation chamber or storage (human cecum not expanded; narrow, vestigial appendix at end with no function)
 - has ascending, transverse, and descending portions
 - ends in rectum
 - in all vertebrates except eutherian mammals, there is a common cavity for emptying reproductive, urinary, and digestive tracts, the cloaca
 2. large intestine has no digestive function, and only 4% of absorption occurs there
 3. major absorptions sodium, vitamin K, water
 4. primary function is a refuse compactor (wastes into feces)
 5. bacteria thrive there and ferment the wastes (produce about ½ L of gas per day in humans)
 6. expulsion of feces
 - pass into rectum by peristaltic contractions
 - exit controlled with two sphincters
 - first smooth muscle, opens involuntarily
 - second actually skeletal muscle under voluntary control
- V. mutualistic symbioses within digestive systems
 - A. microbial digestion of cellulose
 1. most animals lack cellulase (silverfish an insect that is an exception)
 2. termites have protozoans that produce cellulase
 3. horses, rodents, and lagomorphs have bacteria in cecum that digest cellulose (rodents and lagomorphs practice coprophagy to get the nutrients)

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4. ruminants (cows, deer, etc.) have divided stomach with a fermentation vat (rumen) where protozoans and bacteria aid in cellulose digestion; they regurgitate and rechew this cud after fermentation
- B. vitamin K
1. intestinal bacteria provide all mammals with vitamin K (essential for blood clotting)
 2. antibiotics can kill intestinal bacteria, vitamin K supplements may be needed until bacteria are reestablished
 3. birds do not have the bacteria to do this, must get vitamin K in their diet
- VI. human nutrition
- A. human energy requirement 1300-5000 kcal/day
- B. excess energy stored as glycogen in liver and muscles, and as fat in adipose cells
- C. obese = at least 20% above normal weight for a certain height
1. limited mainly to wealthy
 2. once obese, basal metabolism may be altered and gaining weight becomes easier
 3. hormone leptin and its perception likely involved
 - leptin secreted by adipose tissue, decreases appetite in mice
 - genetically obese mice lack leptin and respond to leptin injection
 - genetic factors in human obesity more likely leptin perception; obese humans make plenty of leptin
- D. food also provides essential nutrients, substances necessary for health that the body cannot manufacture
1. vitamins: essential organic substances required in trace amounts – humans require at least 13 different ones
 2. essential amino acids – humans have 8: lysine, lysine, tryptophan, threonine, methionine, phenylalanine, leucine, isoleucine, valine (add histidine in children)
 3. essential minerals: calcium, phosphorus, iodine, cobalt, zinc, molybdenum, manganese, selenium, iron
 4. too much of some of the essential nutrients can be damaging or even deadly
- E. fiber in diet of humans aids speed of food passage through colon; low fiber diets correlated with elevated level of colon cancer