Digestion and Absorption

Ingested food, food present in the digestive tract, is external to the body

Breakdown of food to its component parts (degradation) is termed digestion

Both physical and chemical processes involved

Movement of the digested materials into the body proper is termed absorption

Reactions and conversions necessary to transform the absorbed material to provide energy, build tissues, and synthesize secretions is term intermediary metabolism

Maintenance of intermediary metabolism requires digestion and absorption

I. The digestive tract

A. Animals can be classified by their diet

1. Carnivorous- meat eating

2. Herbivorous- plant eating

3. Omnivorous- both

4. Evolutionarily, digestive tract have developed to accommodate diet.

B. Parts

1. Mouth

   a. Point of food entry into digestive tract

   b. Mass of food entering termed bolus
c. First site of reduction of food size

d. First addition of body fluids

1. Saliva to facilitate movement and digestion

2. Contains teeth and tongue

   a. Structures which aid in digestion

2. Teeth

   a. Increase number and reduce size of food

      1. Increases surface area to volume ratio

      2. Increases chemical and bacterial digestion

   b. Types

      1. Incisors

         a. Sometimes called nippers

         b. Used for cutting food

      2. Canine

         a. Also called fangs, eye teeth or tusks

         b. Used for cutting and tearing

      3. Premolars

         a. Used for grinding food

   4. Molars

      a. Also used for grinding
b. Together with premolars called cheek teeth

5. Numbers and times for permanent teeth varies with species (table 1; Reece page 272)

6. Age of horse can be approximated by condition of teeth

c. Tongue

a. Muscle organ used to maneuver food within mouth

b. Moves food to molar cheek teeth surface

c. Moves food into the esophagus

d. Can, in some species, seize food and bring it into the mouth

e. The upper, rough surface of the tongue are mounds of tissue called papillae

1. Give traction to food movement

2. Useful in grooming

3. Tastebuds located within the vallate (Figure 1; Reece page 43)

3. Pharynx

a. Common pathway for air and food

b. Food is prevented by reflex reactions triggered by the swallowing process Figure 2; Reece page 276
4. Esophagus

a. Muscular tube connecting the pharynx with the stomach
b. Both ends normally closed
c. Upper end by a true sphincter (cranioesophageal)
d. Lower end by physiological action

5. Stomach

a. Dilated storage organ of digestive system
b. Site of the beginning of true digestion
c. Interior anatomy (figure 3; Reece page 277)

Varies with specie (ruminant vs, non-ruminant)

1. All have four regions
d. Esophageal
   1. Connects with esophagus
   2. Nonglandular
   3. In ruminants – site of fermentation
e. Cardiac glands
   1. Secrete mucus
   2. Protective coating of stomach
f. Fundic glands
1. Sometimes called the gastric glands

2. Secretes mucus

3. Secrets HCl (hydrochloric acid)

4. Secrets pesinogen

5. Specialized cells for secretion
   Chief cells
   Parietal cells

6. Major site of digestion in stomach

g. Pyloric region
   1. Secrets mucus
   2. Secretes the hormone gastin
   3. Connects stomach to small intestine

5. Small intestine (Figure 4; Reece 278)
   a. Major site of digestion and absorption in non-ruminate species
   b. Three functional regions

Duodenum
   1. Has large loop allowing for cross over from right to left side of body
2. Receives pancreatic secretions through pancreatic duct

Involved in digestion

3. Receives bile from common bile ducts

Secreted from liver or gallbladder

Jejunum

Ileum

c. Crosssectional anatomy (Figure 5; page 279)

Mucosa

1. Innermost region

epithelial

Contains folds (villi) to increase surface area

About 600 times more area that a smooth cylinder of comparable size

Direct contact with lumen

Site of secretion

Site of absorption

Submucosa

1. Connect tissue

2. Contains blood, lymph and
nerve supply

3. Nerve network (Meissner’s plexus)

Controls secretions of epithelial cells

Controls blood flow to intestines

Sensor functions

Stretch receptors

Muscle regions

1. Circular muscle

2. Longitudinal muscle

3. Nerve plexus (Auerbach’s plexus)

Located between muscle layers

Important in movement

Together with submucosal nerves comprise the enteric nerve system

Entire length of intestine from stomach to anus

Has own pacemaker cells

Similar to heart

Also connects with autonomic
6. Large intestines

   a. Two sections

      1. Cecum and colon

      2. Structure varies widely between species

      3. Site of attachment of small intestine (ileum) varies with species

         Horse-cecum- ileocecal junction

         Dog-colon-ileocolic junciton

         Pig and ruminents-cecum/colon- ileocececocolic junction

   b. In most species (nonruminants) the site of fermentation

      Fermentation occurs after enzyme digestion

      Usually in cecum

   c. In ruminants major site of fermentation is the forestomach area

      Fermentation is after enzymatic digestion

   d. The colon

      Three regions

      Ascending, transverse, and descending

      Arrangement varies widely between

      Figures 6-9; Reec pages 284-285

      Colon terminates at anus
Separated by sphincter

Region of colon in pelvis termed rectum

Dilatable to store feces prior to expulsion

7. Accessory Glands

a. Supply secretions to the digestive tract for digestion or protection

b. Glands

Salivary glands (Figure 10; Reece page 286)

Three major paired glands

Parotids

Sublingual

Mandibular

Also smaller areas not as well defined

Products

Serous

Watery fluid

Enzymatic-digestive

Mucous

Viscous

Protective

Pancreatic gland
Both endocrine and exocrine functions

Hormones - endocrine

Digestive enzymes – exocrine

Transported to small intestine for function

Liver

Numerous functions

Digestive bile and bile salts

Blood cleaning - fixed macrophages (kupffer cells)

Hepatic portal system

Other functions

Composition of food stuffs

Six major groups

Carbonhydrates

Proteins

Fats

water
inorganic salts (minerals)

vitamins

essential food group - product that must enter body through diet

body can not make on its own

Carbohydrates

Based on sugars with 5 or 6 carbon units

Classes

Monosaccharides

Ribose, glucose, fructose and galactose

Disaccharides

Sucrose, maltose and lactose

Broken down to simple sugars by digestion

Polysaccharides

Starch, glycogen, and cellulose

Starch is the food reserve of most plants

Easily digested (broken down to simple sugars)

Glycogen is the food reserve in animals

High complex branched structure of glucose (Figure 11; Reece page 290)

Can be degraded to glucose as needed
Cellulose is a structural component of plants

Can only be broken down by cellulose-splitting microorganisms

Ruminants - forestomachs

Non-ruminant (simple herbivore) - cecum

Proteins

Highly complex

High molecular weights

Large amount of amino acids

Dietary classifications

High quality protein - supplies all essential amino acids in proper proportions

Low quality protein - does not supply all essential amino acids and/or in wrong proportions

Lipids

Fats and related substances

Neutral fat (triglycerides)

Phospholipids

Includes a phosphate

Important to cell structure

Membrane structure
sphingomyelin

blood coagulation

Cholesterol

High molecular weigh alcohol

80% formed in body conjugated to form bile salts

used in digestion

together, proteins, carbohydrates and lipids are term proper foods

food which supply energy

Accessory Foods

Foods which are necessary to maintain life but do not supply energy

Minerals

Inorganic

Two classes

Dietary- require large intact in diet (Ca, P)

Tract minerals- (Z,n, Cu)

See tables Reece pages 293-4

Vitamins

Chemically unrelated compounds

All act as metabolic catalysts

Functions see Reece page 295-6
Physical and Mechanical Factors in Digestion

Food Intact

Prehension

Act of seizing and conveying food to mouth

In domestic farm animals mainly using lips teeth and tongue

Pigs also use snout

Mastication

Breaking food down in mouth- chewing

Varies between species

Herbivores usually longer than carnivores

Bolus formed by process

Combine with saliva

Deglutition

Swallowing

Three stages

Mouth – voluntary

Pharynx – reflex

Esophagus-reflex

Sequence (figure 12; Reece page 298)

Respiration is inhibited
The glottis is closed
Larynx pulled up and forward
Epiglottis folds on glottis
Bolus food moves from mouth to the pharynx
Soft palate elevates sealing nasal cavity
Pharynx contracts moving food into esophagus
Peristaltic wave in esophagus moves food bolus toward stomach

V. Digestive Secretions and Their Functions

A. Secretions

1. saliva
   a. facilitates mastication and deglutition
      1. by lubrication
   b. volumes vary by specie
      1. herbivores greater
      2. cow 100-200 L /day
   3. 80% of water entering stomach comes from salivation
      a. fluid for cooling
      b. in ruminants, buffer component
      c. digestive enzyme
1. amylase

2. under parasympathetic and sympathetic control

2. gastric

a. secretions

1. pepsinogen- lumen

a. parietal cells

b. fundic region

c. enzyme

active form produced upon exposure to HCl

2. HCl- lumen

a. neck chief cells

b. fundic region

3. Gastrin- blood stream

a. homone

b. stimulates pepsinogen and HCl release

b. regulation

1. stimulation

a. acetycholine

b. gastrin

c. histamine
d. secretin

intestinal hormone

pepsinogen only

2. inhibition

a. decrease of pH below 2 within stomach

b. from duodenum

presence of fatty solution

presence of acid

presence of hypertonic solutions

3. mechanisms

a. neural

inhibition of gastrin cells

inhibition of parasympathetic pathway

b. hormonal

secretin and CCK (cholocystokinin)

occupy gastrin sites on parietal cells

stimulate release of gastric inhibitory
polypeptide (GIP)

inhibits all gastric secretions

3. Pancreatic

a. only exocrine secretions directly involved in digestion

b. secretions

1. HCO3

a. neutralizes HCl and acids of fermentation

2. digestive enzymes

a. transported to small intestines

b. secreted as proenzymes

c. types

protein digestion

proteases

fat digestion

lipase

carbohydrate digestion

amylase

d. regulation

1. autonomic

parasympathetic stimulates enzyme secretion
2. Hormonal

- Gastrin
  stimulates the release of enzymes

- Secretin
  first hormone discovered
  stimulates the release of HCO3

- CCK
  stimulates release of enzymes

4. Biliary

  a. Bile
     1. Bile salts
     2. Bilirubin
     3. Cholesterol
     4. Lechthin
     5. Electrolytes (salts)

  b. Secreted by hepatic cells

  c. Amount needed exceeds amount secreted

  d. Recycled by liver
     1. Bile salts synthesized by cholesterol
     2. Stored in gallbladder or directly secreted to intestine
3. aid in digestion of fats

VI. Ruminant Stomach

A. animals which regurgitate and remasticate their food are termed ruminants

B. types

1. ruminantia
   a. domestic animals

2. Tylopoda
   a. lack omasum (figure 12; Reece page 312)

C. Stomach adapted for fermentation

1. diet is of plant material (cellulose)

2. requires microbial enzymes for digestion

3. regurgitation and remastication reduce size of material to be digested by fermentation

4. fermentation proceeds enzymatic digestion

D. Rumination

1. The process of bringing food back from the stomach to the mouth for further mastication

2. ruminate cycle
   a. regurgitation
      1. movement of a food bolus back to mouth
      2. begins with respiratory inspiration
         a. moves food back into esophagus
3. reverse peristaltic action moves food to mouth

4. fluids removed and reswallowed

b. remastication

1. period of mastication depend on diet

c. reinsalivation

1. for lubrication

2. addition of amalyse

d. redegulutition

1. swallowing

e. number of cycles dependent on specie and diet

E. Gas production and Eructation

1. gases

a. CO2

1. during fermentation of carbohydrates

2. during deamination of amino acids

3. in cattle, 60-70% of gas

b. Methane

1. reduction of CO2 by methane producing bacteria

2. in cattle, 30-40% of gas

   a. gas production .5 – 1 L/min
c. Eructation

1. removal of gas via the esophagus to pharynx

2. occurs once / minute

E. Chemistry and Microbiology of Rumen

1. Bacteria – 80% of rumen metabolism
   
a. $10^{11}$ bacteria / mL

2. Protozoa- 20% of rumen metabolism
   
b. $10^6$ protozoa / mL