IDP Biological Systems
Gastrointestinal System

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Overall Learning Objectives
1. Characterize the important anatomical features of the GI system in relation to GI function.
2. Describe the molecular and cellular mechanisms underlying GI motility. Highlight the neural and endocrine regulatory mechanisms. Characterize the different types of GI motility in different segments of the GI tract.
3. Define the major characteristics and temporally relate the cephalic, gastric, and intestinal phases of GI tract regulation.
4. For carbohydrates, proteins, fats, vitamins, minerals, and oral drugs, differentiate the processes of ingestion, digestion, absorption, secretion, and excretion, including the location in the GI tract where each process occurs.
5. Contrast the sympathetic and parasympathetic modulation of the enteric nervous system and the effector organs of the GI tract.
6. Describe the similarities and differences in regulating gastrointestinal function by nerves, hormones, and paracrine regulators. Include receptors, proximity, and local vs. global specificity.
7. Understand the basic mechanisms underlying several common GI disorders and related treatment strategies.

Learning Objectives for Specific Hours:

Hour 1 – Essential Concepts: Cellular transport mechanisms and Mechanisms of Force Generation
1. Describe the composition of cell membranes and how distribution of phospholipids and proteins influence membrane permeability of ions, hydrophilic, and hydrophobic compounds.
2. Using a cell membrane as an example, define a reflection coefficient, and explain how the relative permeability of a cell to water and solutes will generate osmotic pressure. Contrast the osmotic pressure generated across a cell membrane by a solution of particles that freely cross the membrane with that of a solution with the same osmolality, but particles that cannot cross the cell membrane.
3. List the typical extracellular fluid and intracellular concentrations of Na⁺, K⁺, H⁺ (pH), Cl⁻, and Ca²⁺.
4. Explain Fick’s First Law of Diffusion, i.e. how changes in the concentration gradient, surface area, and distance will influence diffusional movement of a compound.
5. Understand how a resting membrane potential is generated and how it will change during an increase or decrease in the permeability to Na⁺, K⁺, or Cl⁻.
6. Explain how the mobilization of calcium initiates contractions in smooth muscle. Describe the roles of actin, myosin, and ATP in smooth muscle contraction.
7. Define an action potential, and diagram a smooth muscle action potential.
8. Define phasic and tonic contractions.

Hour 2 – Introduction to the GI tract and GI Motility

The student should be able to:
1. Provide an overview of the basic functions of the GI system and describe the anatomical features that subserve these functions.
2. Describe the processes of digestion, absorption, secretion, and motility in relation to the different segments and associated organs of the GI tract.
3. Identify the approximate normal volumes of fluid entering and leaving the gastrointestinal tract daily.
4. Illustrate the basic cellular and molecular mechanisms of GI smooth muscle action potentials and generation of GI motility.
5. Describe the basic anatomy of the neuromuscular systems of the gut, and contrast sympathetic and parasympathetic modulation of GI motility.
6. Describe the terms “long reflex” and “short reflex” with respect to the GI tract.
7. Illustrate the cellular, neural, and endocrine mechanisms that regulate electrical activity and the generation of motility in GI smooth muscle.

Hour 3 – Ethics in Graduate Education: The Graduate Student’s Responsibilities.

Hour 4 – Essential Concepts: Autonomic Nervous System

Hour 5: Cephalic Phase of Digestion; Mouth and Esophagus

The student should be able to:
1. State three types of stimuli that increase salivary secretion.
2. Contrast the plasma and saliva concentrations of Na⁺, Cl⁻, and HCO₃⁻ at low secretion rates and high secretion rates and the principal cell types involved in each secretion rate.
3. Describe the components of saliva and their functions.
4. State the stimulus for swallowing and the point at which the swallowing sequence is independent of voluntary control.
5. Describe the origin and consequence of high basal tone found in the upper and lower esophageal sphincters.
6. Describe the pressure changes that occur in the esophagus as a bolus of food moves from the pharynx to the stomach, including the pressures immediately oral and aboral to the bolus, and the pressures in the upper and lower esophageal sphincters.

7. Contrast primary and secondary peristalsis based on the initiating event, voluntary control, reflex propagation, and regions of the pharynx and esophagus involved.

8. Name common factors that affect esophageal pressure

9. Describe the esophageal sensations caused by acid, temperature, and distention.

Hour 6: Gastric Phase of Digestion; Stomach

The student should be able to:

1. Describe the storage, digestion, and motility roles of the stomach.
2. Identify the mechanism and consequence of receptive relaxation of the stomach.
3. Describe the origin and form of electrical activity and progression of peristaltic waves across the body and antrum of the stomach, including their role in mixing and propulsion of gastric contents and how frequency is altered by the volume of gastric contents.
4. Describe how meal contents and duodenal feedback affect gastric emptying.
5. Identify the protein component of chief cell secretions.
6. Identify which cells secrete HCl in the stomach, the mechanism of acid production and secretion, and what endogenous signals, including potentiation, affect HCl secretion. Describe different pharmacological strategies for limiting HCl secretion in the stomach.
7. State the stimuli for pepsinogen release and the mechanism for activating pepsinogen, and describe the digestion products of pepsin activity.
8. Identify the stimuli that increase gastrin release and decrease gastrin release.
9. Describe how acid, lipids, and solutions of high osmolarity in the duodenum affect gastric secretion, including the signaling mechanisms.
10. Identify the role of the stomach in preventing pernicious anemia.
11. Describe the causes of peptic ulcers.
12. Describe the role of the stomach, if any, in the digestion and absorption of carbohydrates, proteins, lipids, as well as absorption of vitamins, minerals, and ions.

Hours 7 and 8: Regulation of Drug Absorption

1. Define pharmacodynamics and pharmacokinetics.
2. Describe what drug properties facilitate absorption into cells, and what properties of cells affect absorption.
3. Explain how pH affects the movement of weak acids or weak bases between body compartments.
4. Name five mechanisms of drug transport into cells and explain each.
5. Describe the advantages and disadvantages of different routes of drug administration.
6. Discuss factors that affect drug distribution throughout the body.
Hours 9 and 10: Regulation of Hepatic Drug Metabolism and Excretion

1. Name the different pharmacokinetic properties that determine the duration of drug action.
2. Describe the factors contributing to a steady-state drug concentration in the plasma.
3. List the major mechanisms of drug metabolism and routes of elimination.
4. Explain how drug metabolism can affect drug action.
5. Describe how drugs are chemically altered by cytochrome p-450
6. Describe how drug-induced enzyme induction and inhibition can alter responses to drugs.

Hour 11: Intestinal Phase of Digestion; Small Intestine

The student should be able to:

1. Describe the role of microvilli, the unstirred layer, and tight junctions in determining the rate at which glucose, amino acids, water, lipids, and electrolytes are absorbed.
2. Identify the factors and regulatory mechanisms that determine pH in the proximal small intestine.
3. State the stimuli for and consequences of cholecystokinin release.
4. Describe the characteristics of the basal electrical rhythm (BER) of the small intestine and its relation to smooth muscle contractile activity.
5. State the function of the interstitial cells of Cajal.
6. Contrast the patterns of intestinal motility during the absorptive phase (segmentation) and the post-absorptive phase between meals (migrating motility complex or MMC).
7. Contrast the influence of sympathetic versus parasympathetic nervous activity on modulating small intestinal motility.
8. Describe the effects of distention on small intestinal motility.
9. Identify the mechanisms of carbohydrate digestion and absorption in the small intestine.
10. Identify the mechanisms of protein digestion and absorption in the small intestine.
   Contrast the secondary active transport of di- and tri-peptides with that of amino acids, including the ion used as the energy source.
11. Identify the mechanisms of lipid digestion and absorption in the small intestine.
   Describe the composition and formation of chylomicrons and their route of entry into the cardiovascular system.
12. Identify the mechanisms of absorption of fat soluble vitamins, water soluble vitamins, and the role of intrinsic factor in vitamin B12 absorption.
13. State the function of Peptide YY.

Hour 12: Exocrine Pancreas, Liver, and Gallbladder

The student should be able to:
1. List the major ionic and protein components secreted by the pancreas. Contrast plasma and pancreatic concentrations of Na\(^+\), Cl\(^-\), and HCO\(_3\)^- at low and high secretion rates, and the principal cell types involved.
2. Describe the mechanism by which chyme from the stomach is neutralized in the duodenum.
3. Describe the mechanism of activation of pancreatic zymogens in the small intestine.
4. Discuss the stimuli for secretin and CCK release, and the cellular mechanisms by which they control pancreatic secretion.
5. Describe pancreatic secretion during the cephalic, gastric, and intestinal phases of digestion.
6. Identify the role of the CFTR in pancreatic ductular secretion, and predict the consequences of cystic fibrosis on the GI system.
7. List the major components of bile and explain how it is modified in the gall bladder. Identify the role of secretin on the hepatic production of bile.
8. Describe the cellular mechanisms for the hepatic uptake, conjugation, and secretion of bile.
9. Describe how CCK affects bile release from the gall bladder, including effects on the sphincter of Oddi.
10. Describe how the molecular structure of bile acids assists in the digestion of lipids.
11. State the difference between primary and secondary bile acids.
12. Explain the conditions for the formation of emulsifications and micelles in the duodenum.

Hour 13: Colon

The student should be able to:

1. Describe the pathways, if any, by which ions, water, iron, and calcium are absorbed and secreted in the small intestine and colon.
2. Describe how aldosterone affects ion absorption/secretion in the colon.
3. Define “dietary fiber” and list sources commonly found in the U.S. diet.
4. Describe the electrical changes in GI smooth muscle that occur with constipation and diarrhea.
5. Describe the sources of gas formation within the G.I. tract.
6. Explain the consequences of severe vomiting and diarrhea and treatment strategies.

Hour 14: Review of Case Studies and General Review of Lectures 1-9
Hours 15 and 16: Section Exam