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Gastrointestinal
(revised 2011)

Functions and Regulation of GI Tract

GI 1. Identify the sources and typical amounts of fluid and nutrients entering and leaving the gastrointestinal tract daily.

GI 2. For major classes of nutrients (carbohydrates, proteins, fats), differentiate the processes of ingestion, digestion, absorption, secretion, and excretion; include the location in the GI tract where each process occurs.

GI 3. Describe the functions of splanchnic blood flow in sustaining intestinal viability and as a source/sink for material transported across the GI tract epithelium.

GI 4. Describe how the single layer of epithelial cells that lines most of the GI tract is renewed, and describe the mechanisms whereby these cells are both a barrier and selective portal for secretion and absorption.

GI 5. Understand the integrated regulation (neural, endocrine, luminal) that drives digestion and absorption of nutrients after a meal and the temporal sequence of regulatory events during digestion.

GI 6. Understand how the physical and chemical compositions of luminal contents are sensed and the cellular and systemic responses to luminal stimuli.

GI 7. Describe the major anatomical characteristics of the enteric nervous system and the major cellular divisions of enteric ganglia (sensory nerves, interneurons, and motor neurons). Given either a cross section or whole mount of the bowel wall, identify the anatomical positions and major characteristics of the myenteric and submucosal plexi.

GI 8. Know how afferent and efferent extrinsic nerves (sympathetic and parasympathetic) interact with the enteric nervous system and regulate the functions of the GI tract.

GI 9. Know the major excitatory and inhibitory motor neurotransmitters and major digestive hormones in the GI tract and how these biomediators affect function in GI tissues and cells.

GI 10. Understand the neural circuitry driving major GI reflexes and the neural pathways and neurotransmitters that accomplish reflex control of GI functions.

GI 11. Compare and contrast the regulation of gut function by nerves, hormones, and paracrine regulators.

GI 12. Understand how GI cells integrate regulatory inputs and explain how the ultimate behavior of GI tissues results from summation of inputs from multiple regulatory pathways.

GI 13. Identify the cell type and anatomical location of the endocrine cells secreting major GI hormones, such as gastrin, secretin, cholecystokinin (CCK), GLP-1, GLP-2, leptin, and motilin.

GI 14. Define the "incretin" concept, and as an example, describe the glucose-dependent release and action of an incretin from the gut.

Salivary Glands

GI 15. Describe the volume and composition of salivary fluid coming from major salivary glands.

GI 16. Understand how acinar secretions are modified by duct cells to produce the final salivary fluid that enters the buccal cavity.

GI 17. Describe the physiological function of the components of saliva.

GI 18. Describe the stimuli and neural pathways involved in promoting salivary secretion.

GI 19. State the components of the saliva important in oral hygiene.

Esophagus

GI 20. Know the normal range of resting luminal esophageal pressures, how esophageal pressure is measured in the clinic, and why luminal pressure varies with the respiratory cycle.

GI 21. Describe the afferent neuro-muscular pathways activated to initiate swallowing, the motor pathways and general targets for innervation that accomplish the swallowing reflex, and major nuclei of in the brain stem that integrate these afferent inputs.

GI 22. Understand the differences in the neural and muscular composition and function in the upper versus lower esophagus. Explicitly consider the upper and lower esophageal sphincters.

GI 23. Describe the dynamic pressure changes that occur in the regions of the esophagus after

initiation of the swallowing reflex and how these pressure changes would propel a bolus of food from the mouth to the stomach.

GI 24. Describe how dysfunction in the spatial or temporal characteristics of the esophageal pressure wave and/or sphincter relaxation can lead to swallowing defects and disorders such as heart burn, achalasia and aspiration of food.

Stomach

GI 25. Describe the storage, digestion, and motility roles of the stomach.

GI 26. Understand how the composition of gastric luminal fluid is affected by intake of a meal, as well as variable gastric secretions of acid, alkali, and attendant salts.

GI 27. Identify the proteins secreted into the gastric lumen by chief cells, parietal cells, and mucous cells. Contrast the functions and regulation of these secretions.

GI 28. Identify the gastric cell types secreting gastrin, somatostatin, histamine, and gastrin releasing peptide. Describe the stimuli that promote and inhibit release of these peptides, and their cellular targets.

GI 29. Describe the role of HCl in the gastric digestion of carbohydrates and protein, and how pepsinogen is activated.

GI 30. Describe the luminal pH of the stomach in the basal fasted state versus the time course of changes in luminal pH after a mixed meal.

GI 31. Describe the role of stomach functions in preventing pernicious anemia and peptic ulcer disease.

GI 32. Describe how parietal cells H-K-ATPase activity can be inhibited physiologically and pharmacologically.

GI 33. Describe the ion transport mechanisms and cellular enzymes needed to allow parietal cell homeostasis during gastric acid secretion.

GI 34. List the stomach cell types and secreted substances that contribute to regulation of gastric acid secretion via paracrine, hormonal, and neuroendocrine pathways. Understand the integrated feedback regulation of acid secretion via these pathways during a meal.

GI 35. List the mechanisms contributing to gastric mucosal defense and how they can be compromised by drugs or pathogens.

GI 36. Describe the role of duodenal contents in regulating gastric secretion.

GI 37. Describe local and central reflex mechanisms involved in receptive relaxation of the proximal stomach. Understand how this reflex regulates gastric pressure and compliance.

GI 38. Describe origin and propagation of electrical activity and the progression of peristaltic waves across the body and antrum of the stomach. Describe their role in mixing and propulsion of gastric contents.

GI 39. Describe how the physical and chemical composition of a meal is sensed by the stomach and duodenum to affect the rate of gastric emptying.

GI 40. Describe the function and dysfunction of gastric peristalsis, the pyloric sphincter, and duodenal feedback in controlling gastric emptying rate.

GI 41. Describe the causes of peptic ulcer disease.

Exocrine Pancreas

GI 42. List the major components secreted by the exocrine pancreas and the principal cell types involved in this secretion.

GI 43. Describe the process of digestive enzyme synthesis and packaging and how this process maintains the integrity of the pancreas.

GI 44. Describe the mechanisms by which chyme from the stomach is neutralized in the duodenum.

GI 45. Describe the mechanism by which pancreatic zymogens are activated in the small intestine.

GI 46. List the stimuli that release secretin and CCK and explain the route by which these regulatory peptides stimulate the pancreas.

GI 47. Describe the role of CFTR in pancreatic ductal secretion, and predict the consequences of cystic fibrosis on the GI system.

GI 48. Describe the mechanisms by which HCO_3^- is taken up by pancreatic ductal cells.

GI 49. State the effects of the autonomic nerves to the pancreas and vago-vagal reflexes on pancreatic secretion.

Hepatobiliary

GI 50. Describe how liver blood flow and liver architecture impact liver function.

GI 51. List the water, ionic, bile salt, and bilirubin components of bile as secreted by the liver and after modification by the gallbladder.

GI 52. Describe the cellular mechanisms for the hepatic uptake, conjugation, and secretion of bile salts and bilirubin.

GI 53. Relate the clinical characteristics of end-stage acute and chronic liver disease to the normal functions of the liver, and describe how fibrosis affects liver function.

GI 54. Describe the basis for studying liver enzymes in the circulation as a measure of liver injury.

GI 55. Describe the mechanisms whereby the gall bladder concentrates bile, and the endocrine mechanism stimulating gall bladder contraction and the secretion of bile through the sphincter of Oddi into the small intestine.

GI 56. Describe the amphipathic structure of bile salts, and describe how this property assists the solubilization and digestion of fats.

GI 57. Describe the enterohepatic circulation, including any different handling among primary and secondary bile salts, and bile acids.

GI 58. Contrast the mechanism of reabsorption of bile acids/salts in the small intestine versus the colon.

GI 59. Predict the effects of an increase in hepatic portal vein bile acid concentration on the rate of bile secretion, bile acid synthesis, and diseases of the gallbladder.

GI 60. Describe the contribution of water and ion reabsorption in the gall bladder to gall stone formation. Identify the major types of gall stones and the potential consequence of gall stone formation.

Small Intestine

GI 61. Describe how rates of absorption are affected by the macroscopic and microscopic architecture of the gut epithelium.

GI 62. Describe the sequential digestion of ingested starch by enzymes of the salivary glands, pancreas, and the intestinal apical membrane.

GI 63. Describe the sequential digestion of ingested proteins by gastric pepsin, pancreatic enzymes, and enzymes at the intestinal apical membrane. Make sure to include the role of duodenal enteropeptidase.

GI 64. Compare the membrane transport mechanisms responsible for uptake of sugars, amino acids and di-peptides by intestinal epithelial cells.

GI 65. Describe the mechanisms and molecules mediating the solubilization and digestion of lipids in the small intestine.

GI 66. Describe the mechanisms for the uptake, processing and release of lipids by the small intestinal epithelium and consequences of their malabsorption.

GI 67. Describe the composition and formation of chylomicrons, their movement across the enterocyte basolateral membrane, and the route of entry into the cardiovascular system.

GI 68. Describe common causes of steatorrhea, and predict effects of steatorrhea on absorption of fat-soluble vitamins.

GI 69 Compare the absorption of fat soluble and water soluble vitamins and give examples of diseases resulting from their malabsorption.

GI 70. Describe the location and the mechanisms that mediate the intestinal trans-epithelial movement of water, the major electrolytes, iron and calcium.

GI 71. List the diseases of enzyme and transport deficiencies leading to osmotic diarrhea.

Large Intestine

GI 72. Describe the mechanisms, localization and regulation of colonic sodium absorption.

GI 73. Describe the mechanisms mediating colonic bicarbonate and potassium transport.

GI 74. Describe the role of dietary fiber in promoting colonic motility.

GI 75. Describe the factors contributing to intestinal and colonic gas composition and the consequences of an altered colonic microflora.

GI 76. Describe the role of short chain fatty acids in colonic sodium absorption and in both colonic and body energy metabolism.

GI 77. Describe the related roles of fluid malabsorption in the small intestine versus colon on the potential to cause diarrheal disease.

GI 78. Describe the normal regeneration of the colonic epithelium from stem cells, and how this process is changed if a stem cell becomes cancerous or in the presence of inflammation.

Gastrointestinal Motility and Enteric Nervous System

GI 79. Describe the control of peristalsis by the enteric nervous system.

GI 80. Describe the characteristics of the spontaneous and stimulated electrical activity of GI smooth muscles (electrical slow waves, action potentials, and contraction).

GI 81. Describe the anatomical locations and role of interstitial cells of Cajal as slow wave pacemakers and mediators of inputs from the enteric nervous system.

GI 82. Describe the functional importance of tonic inhibitory input from enteric motor neurons in the GI tract and how loss of this form of regulation might cause inappropriate GI motility.

GI 83. Describe major motor patterns in the GI tract and their functions during fasting (migrating motor complex or MMC) and during digestion.

GI 84. Describe how extrinsic nerves (sympathetic and parasympathetic) affect motor patterns.

GI 85. Describe the role of colonic motility in facilitating the recovery of water and electrolytes.

GI 86. Describe how distension of organs affects GI reflexes and alters responses to other regulatory inputs.

GI 87. Understand how abnormal distension can cause GI pain and lead to abnormal motility.

GI 88. Describe how luminal pressure and stretch of the gut initiate reflexes in GI organs and how these inputs are integrated by intrinsic and extrinsic neural pathways (including enteric ganglia, prevertebral ganglia, spinal cord and brain) and determine whether stimuli are normal or noxious.

GI 89. Describe the function of colonic motility, in mediating formation of haustra and hasutral shuttling, mass movements through the transverse and distal colon, and defecation.

GI 90. Describe the sequence of events in the colon and anal sphincters occurring during reflexive defecation, differentiating those movements under voluntary control and those under autonomic control.

GI 91. Describe the disorders of motility that can lead to gastroparesis, achalasia, diarrhea, constipation, megacolon and irritable bowel syndrome.