Anatomy and Physiology II
Final Review – part 1

1. Mix and match with terms from the back pages of this review. Mix and match may include diagrams of the digestive system.

2. What is digestion?
Breaking down food so it can be absorbed by the body.

3. Be able to describe the following layers of the digestive track: mucosa, epithelium, lamina propria, muscularis mucosae, submucosa, muscularis, and serosa.
Mucosa: Inner most layer of the GI track, three layers: Epithelium, Lamina propria, & Muscularis mucosae.
Epithelium: Inner most layer of the mucosa, in direct contact with the contents of the GI Track. Has exocrine glands that secrete digestive enzymes and mucus into the gut.
Lamina propria: Layer of areolar connective tissue that surrounds the epithelium, contains MALT, mucosa associated lymphoid tissue a system of lymph nodes that helps protect the body form pathogens that penetrate the mucosa of the gut.
Muscularis mucosae: A thin layer of smooth muscle that surrounds the lamina propria.
Submucosa: A layer of areolar connective tissue between the mucosa and the muscularis, contains the submucosal plexus (plexus of meissner) part of the autonomic nerve supply to the blood vessels and muscularis of the gut.
Muscularis: The outer layer of muscle that surrounds the submucosa. In the mouth, pharynx, and superior part of the esophagus has skeletal muscle, everywhere else, smooth muscle. Smooth muscle in two layers: inner layer circular, outer layer longitudinal.
Serosa: Outer layer of the GI track, a serous membrane composed of connective tissue that is connected to the peritoneum.

4. What are the major functions of the peritoneum (i.e., visceral peritoneum)? What do the parts of the visceral peritoneum support (i.e, mesentery, mesocolon, falciform ligament, lessor omentum, and greater omentum)?
Functions of the peritoneum:
A. Supports the organs it attaches to, keeps them in place, reduces friction.
B. Serves as a conduit for nerves, lymph and blood vessels.
Mesentery: Surrounds the small intestine, attaches to the posterior wall of the abdomen.
Mesocolon: Surrounds the large intestine, attaches to the posterior wall of the abdomen.
Falciform ligament: Holds the liver to the anterior abdominal wall and diaphragm.
Lesser omentum: Two folds: stomach & duodenum, suspend them from the liver.
Greater omentum: Largest fold, drapes over the front of the transverse colon and small intestine. Contains large amounts of fat and many lymph nodes to protect the peritoneum from infection.

5. What do the mucous cells, parietal, and chief cells in the stomach release and what is the function of these secretions?
Mucous cells: mucus w/ basic secretions. Keep the stomach lining basic so the stomach acids and enzymes won't digest the stomach lining.
Parietal cells: hydrochloric acid, pH 1.6-2.4, helps in the digestion of the food and activates the enzymes. Also secrete intrinsic factor which helps the small intestine absorb vitamin B-12.
Chief cells: digestive enzymes (in inactive form = zymogens). The enzymes become active when they hit the acidic environment of the stomach.

6. What hormone causes the gastric juices to be released?
Gastrin: secreted by G-cells when the stomach is stretched.

7. What is chyme and what hormone causes it to be released from the stomach.
The semi-fluid paste that is your food as it passes through the digestive track. Gastrin (again from the G-cells) also triggers the release of the chyme through the pyloric sphincter into the small intestine.

8. How is the stomach protected from the acid and digestive enzymes it produces? What is a zymogen and what activates zymogens in the stomach and in the pancreas?
Zymogen: Inactive enzyme precursor.
Stomach zymogens are activated by the highly acidic contents of the stomach.
The pancreatic zymogens are activated in the small intestine when they bond with other enzymes or their substrates.

9. What is secreted by the pancreas and the gall bladder and what are the functions of these secretions? What hormones are involved in the release of materials from the pancreas and gall bladder.
Pancreas:

Secretion – Inactive	Primary function	Primary Hormone
Bicarbonate	Neutralizes acids	Secretin Hormone
Trypsinogen - Trypsin	Breaks down proteins	CCK – cholecystokinin
Chymotrypsinogen - chymotrypsin	Breaks down peptide bonds	CCK - cholecystokinin

There are a few other digestive enzymes also released by the pancreas. The hormone gastrin also plays a minor role in regulating the pancreas' release of digestive enzymes.
Gall bladder:
The gall bladder stores the bile produced by the liver and releases it when signaled by the hormone cholecystokinin (CCK) or by parasympathetic nerve signals (vegas nerve).
Bile: increases the effectiveness of enzymes and emulsifies fats.

10. What are the major functions of the parts of the digestive system (e.g., stomach, small intestine, or large intestine).
Stomach: Stores food and starts digestion.
Small intestine: Major site of food absorption, some digestion.
Large intestine: Forms feces, absorbs water, minerals and vitamins, and minor digestion mostly by bacteria.

11. To what form must proteins, carbohydrates, and lipids be digested before they can be absorbed in the gut? How and where are proteins, carbohydrates, and lipids absorbed into the body? What would happen if the body absorbed full sized polysaccharides or proteins?
Proteins: must be broken down into amino acids to be digested, absorbed in the small intestine, moved into the body by cotransport with H^+ ions or Na^+.
Carbohydrates: must be broken down to monosaccharides to be absorbed, active transport or facilitated diffusion. Some by cotransport w/ Na^+.
Lipids: Broken down to glycerol and fatty acids, move into the body as chylomicron (a protein coated ball of fats, phospholipids and cholesterol which the lacteals care from the intestine to the blood.

12. How is gut surface area increased for absorption in the small intestine.
Plicae circulares: Circular folds on the gut wall.
Villi: finger like projections on the plicae.
Microvilli: Smaller finger like projections on the villi.

13. What are the parts of the small intestine? - Duodenum, jejunum, and ileum
Duodenum: First 25 cm
Jejuneum: Middle 2/5 (2.5m)
Ileum: Final 3/5 (3.5m)

14. What are the parts of the large intestine? What do the different parts do?
Cecum: Pouch off the start of the large intestine, may aid in digestion of fats.
Colon: Reabsorbs salts and water, lots of bacteria and protozoa that aid in digestion and make some vitamins (B & K), absorbs some vitamins and minerals.
Rectum: Stores feces.

15. List 7 things that the liver does.
A. Site of transdeamination (removal of amine groups from amino acids)
B. makes urea from amine groups removed from amino acids
C. Inter-converts amino acids (converts from one amino acid to another), can convert 10, can't convert other 10.
D. Makes blood proteins
E. Stores sugar as glycogen
F. Makes lipids from proteins and carbohydrates.
G. Makes carbohydrates from lipids and proteins.
H. Inter-converts forms of lipids
I. Breaks down toxic chemicals (many drugs)
J. Stores vitamins A, D, B-12 and iron
K. Picks up dead red blood cells and makes bile from them.
L. Helps destroy foreign cells by phagocytosis

16. What are the necessary diet components?
Carbohydrates: energy, liver can convert proteins or fats if needed
Lipids: Liver can make all forms except **Linoleic acid**.
Proteins: 10 amino acids are essential, liver can make all others from them.
Vitamins: Fat soluble: A, D, E, K (sunlight required for production of D), water soluble: C & B. You can overdose on fat soluble vitamins.

17. How many amino acids are essential? What does this mean?
There are 10 amino acids that the body cannot produce (or cannot produce in sufficient quantity) and thus it is essential that you consume these amino acids for the body to function.

18. What is the essential fatty acid?
Linoleic acid.

19. What are minerals and what are vitamins?
Minerals: Inorganic elements (Ca, P, K, S, Na, Cl, Mg)
Vitamins: Complex organics necessary for life

20. Which vitamins are fat soluble and which are not fat soluble? What is the significance this?
Fat soluble vitamins: A, D, E & K.
Water soluble vitamins: C & B complex.
Fat soluble vitamins are carried by lipids, can cross the cell membrane easily, are stored in the liver and fatty tissue and reside in the body much longer, therefore it is easier to overdose on them if you take in too many over a period of time.
Water soluble vitamins are carried by water, are not stored in the body but are washed out in the urine, we need a continuous supply of them.

21. What are free radicals and how are they formed. What are antioxidants and what compounds act as antioxidants?
Free radicals are electrically charged ions. Since they are charged they are highly reactive and can damage molecules and cell structures by taking electrons from them. Some are natural, others are due to our habits (smoking, etc.).
Antioxidants are vitamins and minerals that can give up electrons to free radicals or bond to free radicals preventing them from damaging more permanent parts of the body.
Common antioxidants: Vitamins A, C, & E, bioflavins from green leafy vegetables, Selenium, and the hormone melatonin.

22. What is dietary fiber and how does it benefit the body?
Dietary fiber consists of indigestible plant substances such as cellulose, lignin, and pectin found in fruits, grains and vegetables.
Insoluble fibers move through the gut largely unchanged and help the movement of materials through the gut (keep you regular…)
Soluble fiber is soluble in water and has the consistency of gelatin and tends to slow the movement of food through the gut.
High fiber diets have been shown to reduce the risks of: obesity, diabetes, arteriosclerosis, gallstones, hemorrhoids, diverticulitis, appendicitis, colon cancer, and reduce blood cholesterol levels.

23. What is the glucostatic theory of hunger and what is the lipostatic theory of hunger?
Glucostatic: Low blood glucose stops the inhibition of the hunger center by the satiety center making a person feel hungry.
Lipostatic: Suggests that fatty acids are released from stored fats in proportion to the fat levels in the body, higher fat levels in the blood trigger the satiety center making a person feel full.

24. Discuss three factors that affect the desire to eat.
A. Increased body temperature reduces hunger
B. Distention of the gut reduces hunger
C. The hormone **cholecystokinin** inhibits hunger and is released when triglycerides enter the small intestine.
D. Psychological factors may override other factors (comfort food).

25. Contrast the absorptive state and the postabsorptive state. When do they start and how long do they last? What hormones trigger them and what is the main energy source for the body during each.
Absorptive state: Eat -> 4 hours, triggered by insulin (also gastrin, secretin, and CCK), Glucose is high in the blood, so glucose is main energy source.
Postabsorptive state: starts about 4 hours after meal, triggered by glucagons (also hGH, epinephrine and sympathetic nerves), blood glucose levels have dropped, so glycogenolysis (glycogen → glucose) and gluconeogenesis (amino acids → glucose) increasingly becomes the source of energy for the body.

26. Define the basal metabolic rate and explain how it is measured.
BMR is the rate at which heat is produced when you are at rest after fasting, or the energy you are using at rest (couch potato)
Metabolic rates are measured using a spirometer that measures the oxygen the body uses (reported in $Kcal/m^2/day$).

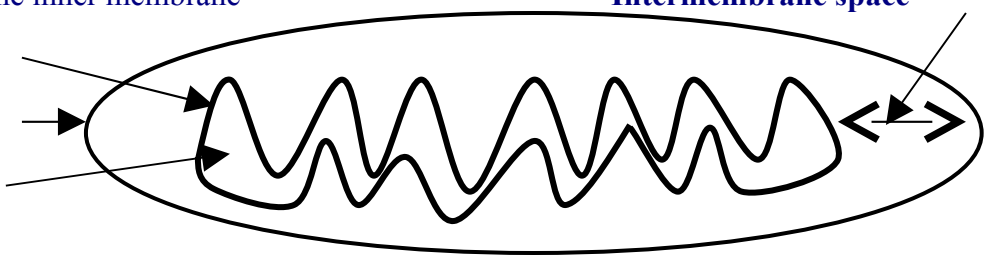
27. Name 6 factors that increase a person's metabolic rate.
A. Exercise (10-15x)
B. Thyroid hormones, hGH & testosterone levels
C. Sympathetic nerves increase metabolic rate (fight or flight response)
D. Epinephrine & norepinephrine (fight or flight)
E. Higher body temperature (fevers) increase metabolic rate.
F. Ingestion of food requires energy, thus increases metabolic rate
G. Metabolic rate decreases with age.
H. Men have a higher BMR then women.
I. MR is lower when sleeping
J. Malnutrition lowers your metabolic rate.
K. Location (tropical climate lowers your metabolic rate).
L. Pregnancy increases your metabolic rate

28. Explain how your body responds if you are too hot or too cold.
Too Hot:
A. Sweating, evaporation = cooling
B. Increases blood flow to skin and extremities, more cooling
C. Reduces metabolic rate, reduced heat generation
Too Cold:
A. Reduced blood flow to extremities and skin, keep core warm
B. Increase metabolism to utilize the heat from the reactions (60%)
C. Shivering to increase reactions (muscle contractions) and the heat they generate.

29. Why does life require energy?

30. Be able to draw and label the parts of the mitochondria.

Cristae = folds in the inner membrane



31. What are coenzymes? What are the two coenzymes used in respiration?
Coenzymes: Molecules that act as electron carriers between redox reactions (i.e., electrons that carry H^+ ions).
$FAD/FADH_2$ – Flavin adenine dinucleotide
$NAD/NADH_2$ – Nicotinamide adenine dinucleotide

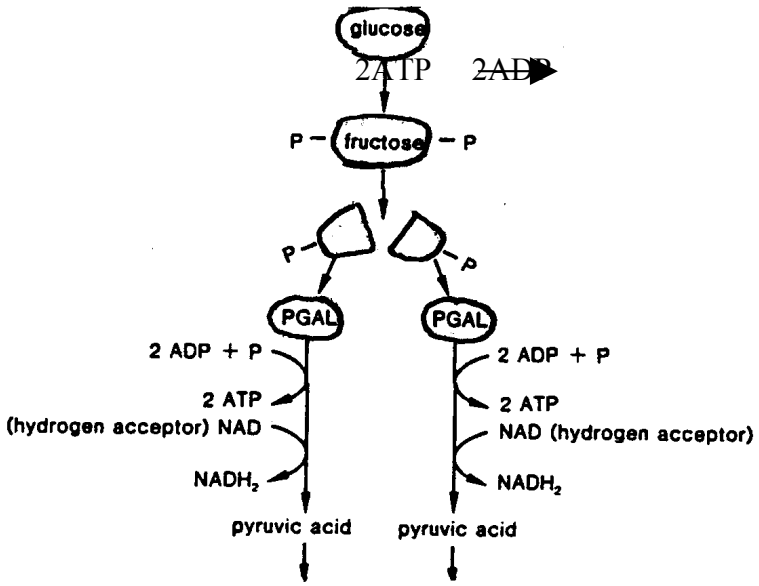
32. Define and be able to contrast oxidation or reduction.
Oxidation: The removal of electrons (e^-) from a molecule, more positive charge.
Reduction: The addition of electrons (e^-) to a molecule, more negative charge.
OIL-RIG: Oxidation involves loss, Reduction involves gain.

33. Where does glycolysis occur? Where does pyruvic acid oxidation and Krebs cycle occur?
Glycolysis occurs in the cytoplasm outside the mitochondria.
Pyruvic acid oxidation and **Krebs cycle** occur in the matrix fluid of the mitochondria.

34. Explain how glucose goes through glycolysis? How is energy used and produced in this process? Why does $NADH_2$ produced in glycolysis produce less energy in the electron transport chain than $NADH_2$ produced in pyruvic acid oxidation or the Krebs cycle?

Less energy is produced by the $NADH_2$ produced in glycolysis because some of that energy is lost in the transport of the $NADH_2$ from the cell cytoplasm to the electron transport system (assuming the glycerol phosphate shuttle is used). This transport mechanism converts each $NADH_2$ into $FADH_2$.

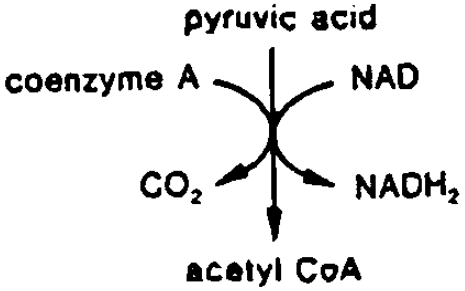
How glucose goes through glycolysis:



A. Glucose (6C) is converted into a similar 6 carbon sugar (Fructose) and phosphorylated using Phosphate groups (PO_4) from two ATP molecules, forming a fructose molecule with two phosphate groups (fructose 1,6 biphosphate) -(two ATP are used in this process)
B. The fructose molecule is then split into two PGAL (glyceraldehydes 3 phosphate) molecules.
C. Each of these PGAL molecules are oxidized resulting in the following:
- 2 ADP + P -> 2 ATP
- NAD -> $NADH_2$
- Pyruvic acid

Totals for this chain of reactions:
- 2 ATP used, 4 produced = +2 ATP
- 2 NAD -> 2 $NADH_2$
- 2 Pyruvic Acids produced

35. Explain what happens in pyruvic acid oxidation and the Krebs cycle. How is energy used and produced in this process? How much ATP is produced directly and how much is produced by different compound in the electron transport chain. Be able to show where the carbons are ending up in these cycles.



Step 2 (Acetyl-CoA Formation):
Here coenzyme A removes a carbon and 2 oxygens from the pyruvic acid in a reaction that also reduces NAD to $NADH_2$.

For the two pyruvic acid molecules produced in the original glycolysis step of the process the total molecules produced in this step are:
- 2NAD → $2NADH_2$ molecules – sent to the electron transport chain
- $2CO_2$ molecules – by product
- 2 Acetyl-CoA molecules – sent to the krebs cycle.

36. Be able to explain the total ATP produced in aerobic respiration. Which compound produce ATP and how much do they produce?

Step	Products	Produced at ETC	Total ATP Produced
Glycolysis	**4 ATP – 2 ATP used = 2 ATP**		**2**
	2 $NADH_2$ (sent to electron transport chain)	**4 ATP (assuming glycerol phosphate shuttle)**	**4**
Acetyl-CoA production	**2 $NADH_2$** **2 CO_2**	**6 ATP (3 per $NADH_2$)**	**6**
Krebs Cycle	**2 ATP** **4 CO_2**		**2**
	6 $NADH_2$	**18 ATP (3 per)**	**18**
	2 $FADH_2$	**4 ATP (2 per)**	**4**
Total			**36**

Each $NADH_2$ produces 3 ATP molecules, each $FADH_2$ produces 2 ATP molecules

37. Explain how the electron transport system and chemiosmosis produce ATP from $FADH_2$ and $NADH_2$. Be able to explain why $NADH_2$ produces more energy than $FADH_2$.
See below.

38. Where and how is oxygen used in respiration?
Oxygen is used in the Acetyl-CoA production step in the formation of the CO_2 to remove 2 carbon atoms. Oxygen is also used in the krebs cycle in the formation of the CO_2, to remove 4 carbon atoms. Finally oxygen is used in the electron transport chain.

39. How is lactic acid produced in anaerobic respiration? Why must the hydrogens on $NADH_2$ be remove?
The lactic acid is produced from pyurvic acid when the H^+ ions on the $NADH_2$ molecules are removed so that the NAD may be reused in additional glycolysis reactions.

40. Where do glycerol and fatty acids from triglycerides enter the Krebs cycle? What is beta oxidation?
The triglycerides is broken down (lipolysis), the glycerol (glyceraldehydes 3-phosphate) and enter into the glycolysis process. The three fatty acids undergo beta oxidation which takes two carbons off of the chain at a time and loads them onto coenzyme-A forming acetyl Co-A which then enters the kreb's cycle. Some of the acetyl Co-A molecules can be sent to the liver to undergo ketogenesis instead of being sent into the kreb's cycle.

41. What is ketogenesis? What ketones are formed in the liver? What is ketosis
Ketogenesis: The formation of ketones from acetyl Co-A molecules in the liver.
Ketosis: High levels of ketones in the blood which cause blood pH to drop (**ketoacidosis**).
The liver produces the ketone **acetoacetic acid** which it then converts into the ketones **hydroxybutyric acid** and **acetone.**

42. What is transdeamination and where does it occur? Where do amino acids enter the Krebs cycle (in general)?
Transdeamination is the removal of the amine groups from amino acids that is performed in the liver. In general most amino acids enter the krebs cycle at the Acetyl coenzyme A step (top).

Final Exam review question 37

$NADH_2$

1. $NADH_2$ drops its 2 electrons and 2 H^+ (hydrogen) ions at the $FMNH_2$ protein. The 2 H^+ are moved to the intermembrane space and the electrons travel on down the electron transport chain.
2. At electron carry Q the 2 electrons use their negative charge to grab 2 H^+ ions from water in the matrix leaving 2 OH^- (hydroxyl) ions behind. The 2H+ are moved to the intermembrane space and the electrons continue to travel down the electron transport chain.
3. At electron carry Cyt b the 2 electrons use their negative charge to grab 2 H^+ ions from water in the matrix leaving 2 OH^- (hydroxyl) ions behind. The 2H+ are moved to the intermembrane space and the electrons continue to travel down the electron transport chain.
4. At the end of the electron transport chain (i.e. Cyt a_3) the electrons are loaded on to an oxygen molecule (O_2) giving it a net charge of negative two. This causes the oxygen molecule to grab 2 H^+ ions form water in the matrix leaving 2 OH^- (hydroxyl) ions behind.

   Note, this process actually occurs when 4 H^+ ions are loaded on to an oxygen molecule.

5. Now we have 6 H^+ ions in the intermembrane space and 6 OH^- in the matrix.
6. The H^+ ions are moved two at a time form the intermembrane space to the matrix fluid through membrane bound ATP-ase. For every 2 H^+ ions moved through membrane bound ATP-ase, 1 ATP is formed.
7. $NADH_2$ moves 6 H^+ to the intermembrane space, so it can create 3 ATP.

$FADH_2$

1. $FADH_2$ drops its 2 electrons and 2 H^+ (hydrogen) ions at the Q protein. The 2 H^+ are moved to the intermembrane space and the electrons travel on down the electron transport chain.
2. At electron carry Cyt b the 2 electrons use their negative charge to grab 2 H^+ ions from water in the matrix leaving 2 OH^- (hydroxyl) ions behind. The 2H+ are moved to the intermembrane space and the electrons continue to travel down the electron transport chain.
3. At the end of the electron transport chain (i.e. Cyt a_3) the electrons are loaded on to an oxygen molecule (O_2) giving it a net charge of negative two. This causes the oxygen molecule to grab 2 H^+ ions from water in the matrix leaving 2 OH^- (hydroxyl) ions behind.

   Note, this process actually occurs when 4 H^+ ions are loaded on to an oxygen molecule.

4. Now we have 4 H^+ ions in the intermembrane space and 4 OH^- in the matrix.
5. The H^+ ions are moved two at a time from the intermembrane space to the matrix fluid through membrane bound ATP-ase. For every 2 H^+ ions moved through membrane bound ATP-ase, 1 ATP is formed.
6. $FADH_2$ moves 4 H^+ to the intermembrane space, so it can create 2 ATP.

-$FADH_2$ produces less energy in the electron transport chain than $NADH_2$ because it starts farther down the electron transport chain and so only moves 4 H^+ to the intermembrane space as compared to 6 H^+ moved to the intermembrane space by $NADH_2$.