1. **Essay: The Digestive and Absorption Processes of Macronutrients**

Whenever we eat, the foods we ingest in our bodies undergo different processes in order to put resourceful nutrients to work and eliminate unnecessary waste products. In regards to utilizing nutrients from foods for the body, processes such as digestion and absorption are involved. Digestion is when foods are broken down into components, and absorption is when these products of digestion are moved through the small intestine walls and overall into circulation of the body. These processes correlate to everything we eat, which includes macronutrients. Macronutrients, in particular, are the nutrients in which a living organism needs in huge amounts for effective growth and development. The three main macronutrients consist of: lipids, carbohydrates, and proteins.

Lipids are one group of macronutrients. Lipids are a diverse class of molecules in which are insoluble in water, meaning that they do not dissolve in the presence of water. Fats, in particular, are one type of lipid. There are three different kinds of lipids found in foods: **triglycerides**, **phospholipids**, and **sterols**. In essence, the role of fat in our body is to provide energy and energy storage for later usage. The digestion and absorption of fats are not done easily as fats are insoluble, but these processes do happen primarily in the small intestine. The process of digestion for fats first starts off in the mouth, as salivary glands produce an enzyme called “lingual lipase”. This particular enzyme digests some triglycerides that can be found within the fats being ingested. As the food is swallowed, it moves along into the stomach. The intact food is then mixed and broken down into particles/fat droplets. The stomach also
releases gastric lipase, which aids in digesting some more triglycerides. At this point, however, a lot of
digestion has not taken place. The gallbladder releases bile into the small intestine, and chyme (containing
fat molecules) also passes slowly into the small intestine. The bile from the gallbladder helps to emulsify
the fat, alongside pancreatic enzymes that derive from the pancreas. These pancreatic enzymes help to
break triglycerides into monoglycerides and fatty acids. Then, the spherical micelles found in the small
intestine help to transport free fatty acids to the mucosal cells for absorption processes. Within these
mucosal cells, a small amount of protein is involved, and is added to the lipids - and this overall creates
chylomicrons, which are lipoproteins produced by the cells that line the small intestine. Chylomicrons are
considered to be the transport system that help remove fats and overall travel through the lymphatic
system, along with being transported into the bloodstream. In order to get through these systems and cells,
the triglycerides in the chylomicrons are once again broken down into two fatty acids and a monoglyceride
with the help of lipoprotein lipase. Once entering the cell membrane, the broken down fatty acids and
monoglyceride reform a triglyceride structure again. This is where the triglyceride can be utilized for the
body, either for immediate energy use, to make lipid-containing compounds, and/or for storage in the
muscle and liver cells. The remaining fats can also be stored as “adipose tissue” (fat cells) within the
body. As for elimination of waste products that involve fats, the undigested lipids move along to the large
intestine. The intestinal bacteria in the large intestine helps to break down the undigested lipids into waste
products (feces).

Carbohydrates are another group of macronutrients that are mainly derived from plant foods (e.g.
fruits, vegetables, and grains). In essence, carbohydrates can be classified as simple and complex. Within
these two categories, there are many different types of carbohydrates involved. These various
carbohydrates are digested and absorbed within the body through various steps. Carbohydrate digestion
starts from the mouth and salivary amylase is produced from saliva. The salivary amylase starts off the
process by breaking down the starch (glucose molecules) into maltose, a disaccharide. Once the food is ingested, the produced maltose goes to the stomach. The acidic content of the stomach causes the maltose to become non-functioning and shapeless. Although the content might go to the stomach, carbohydrates do not get digested via the stomach. Like lipid digestion, carbohydrate digestion also occurs mainly in the small intestine. The pancreas also helps by secreting pancreatic amylase into the small intestine, in order to break down starch found in the carbohydrates. As chyme enters the small intestine, the pancreatic amylase hydrolyzes starch into maltose effectively (unlike the stomach). The small intestine also helps to break down disaccharides into monosaccharides through certain enzymes. Then, these converted monosaccharides are all absorbed by the small intestine and overall enter the bloodstream. Through the bloodstream, these monosaccharides transfer over to the liver. The liver is where all the monosaccharides are then converted to glucose, and this glucose is spread out to different cells of the body for energy purposes. The remaining glucose, converted to glycogen, is then stored in the liver. Overall, the remaining (undigested) carbohydrates transport over to the large intestine. As we humans do not contain the bodily enzymes to digest fiber, the large intestine helps in breaking down some fiber structures. The large intestine contains intestinal bacteria that helps to break down the undigested carbohydrates, overall excreting it out of the body as feces.

Proteins are the third type of macronutrients, and they are large and complex molecules that are made up of amino acids. Proteins are the primary source of nitrogen within our diets, and the digestion and absorption of proteins includes extensive steps as well as the other two macronutrients. The digestion of protein starts off in the mouth, where the proteins found in the food are broken down by salivary glands in saliva and chewing. This breakdown of food is then moved along to the stomach, where protein digestion essentially begins. The hydrochloric acid found in the stomach helps break down protein structure, also activating pepsin. Pepsin also helps to deconstruct proteins into single amino acids and smaller
polypeptides. The chyme overall moves along to the small intestine, where digestion continues, and pancreatic proteases help to digest the polypeptides into even smaller particles. The liver overall effectively digests the proteins, as the cells found in the wall of the small intestine complete breaking down polypeptides into single amino acids. The single amino acids then are transferred over to the liver, monitoring their metabolism and overall sending them out throughout the cells in the body as needed. The remaining dietary protein is eliminated by the help of the large intestine and its intestinal bacteria that helps to break down remaining proteins into feces.

2. Flowcharts of Digestion and Absorption processes of Macronutrients

*The flowcharts of the macronutrients are found below in this order:

- Lipids (Fats) flowchart
- Carbohydrates flowchart
- Proteins flowchart
Digestion of Lipids

Mouth
- Salivary glands create lingual lipase
- Digestion of triglycerides

Stomach
- Most fat is still intact at stomach
- Breaks down food into droplets

Liver
- Produces bile

Pancreas
- Pancreatic enzymes created here, in order to digest lipids

Gallbladder
- Bile is stored here, then released into the small intestine
- Bile emulsifies the fat droplets
- Chyme moves slowly from stomach to small intestine also

Small Intestine
- Where most of the fat digestion occurs
- Bile breaks down fats in smaller matter
- Pancreatic enzymes break triglycerides into a monoglyceride + 2 fatty acids
- Micelles are formed, transporting free fatty acids to intestinal mucosal cells for absorption

Intestinal Mucosal Cells
- Triglycerides are reformed
- Chylomicrons (lipoprotein = a small amount of protein and lipids) are formed

Chylomicrons
- Removes absorbed fats from small intestine
- Breaks down triglycerides again to pass through cell membranes

Large Intestine
- Intestinal bacteria helps to breakdown remaining, undigested lipids into feces

Rectum, Anal Canal, Anus
- Feces is excreted, eliminated out of body

Lipids are sent to different cells of the body, such as: muscle and liver cells.
- Travels through bloodstream, Travels into lymphatic system
- Remaining fats are stored in the body (primarily adipose tissue). Body’s storage for energy use, etc.
Carbohydrates

Mouth
Chewing = Saliva = Salivary amylase
Salivary amylase breaks down starch (shorter polysaccharides + maltose)

Stomach
Salivary amylase is denatured by acids in stomach
No digestion taken place.

Pancreas
*Pancreas creates pancreatic amylase
*Secretes it into the small intestine

Small Intestine
- Primarily where digestion of carbohydrates occurs
- Pancreatic amylase deconstructs remaining starch into maltose
- Disaccharides convert to monosaccharides
- All monosaccharides absorbed and enters into the bloodstream

Liver
- Monosaccharides (from bloodstream) converted to glucose
- Glucose transported to cells of body to provide energy
- Remaining glucose (converts to glycogen) is stored here

Large Intestine
- Undigested carbohydrates
- Intestinal bacteria breaks them down
- Remaining fiber = excreted out of the body as feces
Proteins

Mouth
- Chewing and saliva = Breakdown of proteins in food

Stomach
- Proteins denatured by hydrochloric acid
- Pepsin = Single amino acids and smaller polypeptides

Pancreas
- Pancreatic proteases are created, sent to the small intestine

Small Intestine
- Pancreatic proteases digests polypeptides
- Polypeptides become smaller particles
- Cells of small intestine walls fully break down all polypeptides into single amino acids

Large Intestine
- Large intestine bacteria helps to breakdown undigested proteins
- Eventually excreted out of body as feces

Liver
- Amino acids from small intestine
- Liver "monitors" the absorbed amino acids
- Sents out amino acids to cells of body where its needed