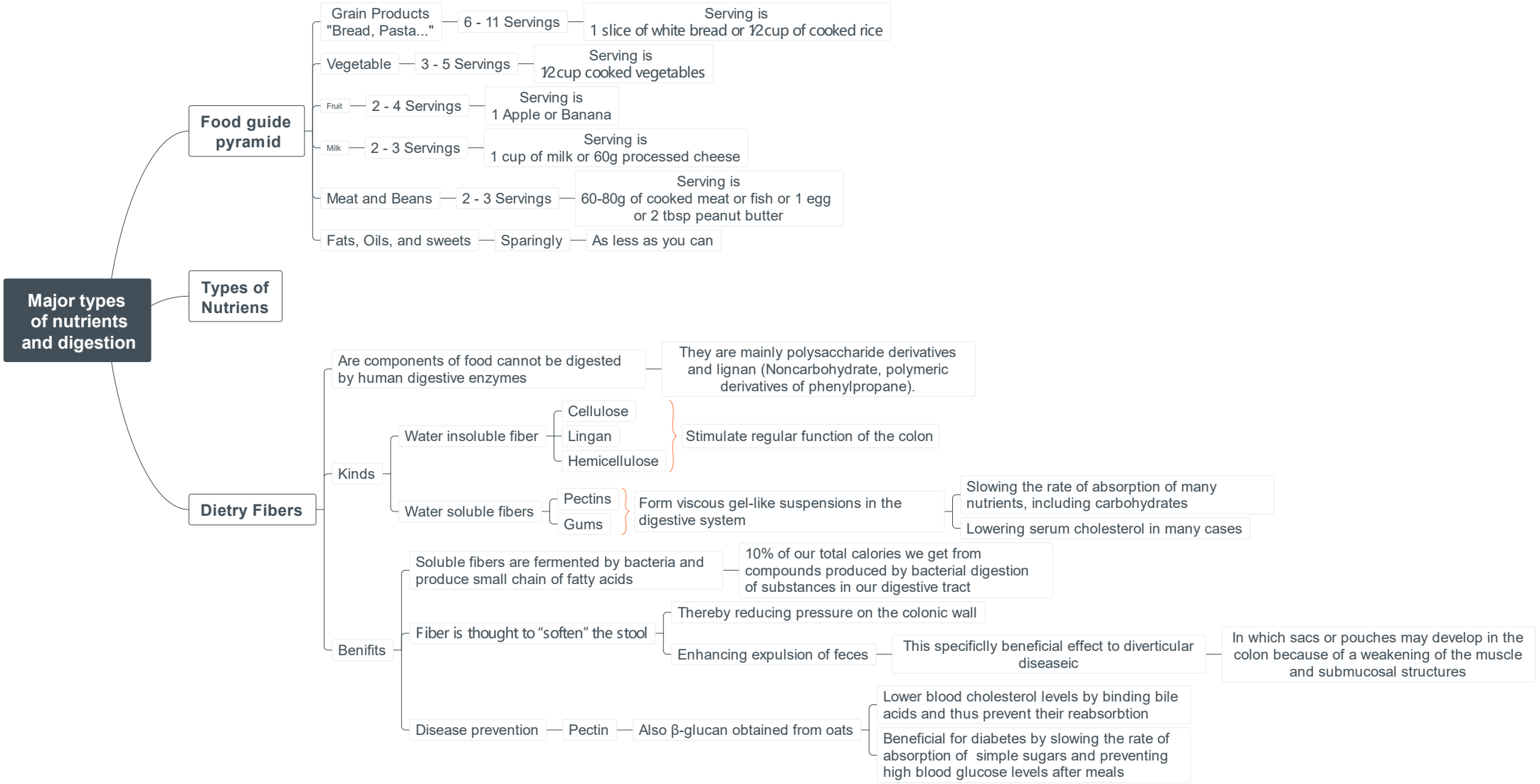
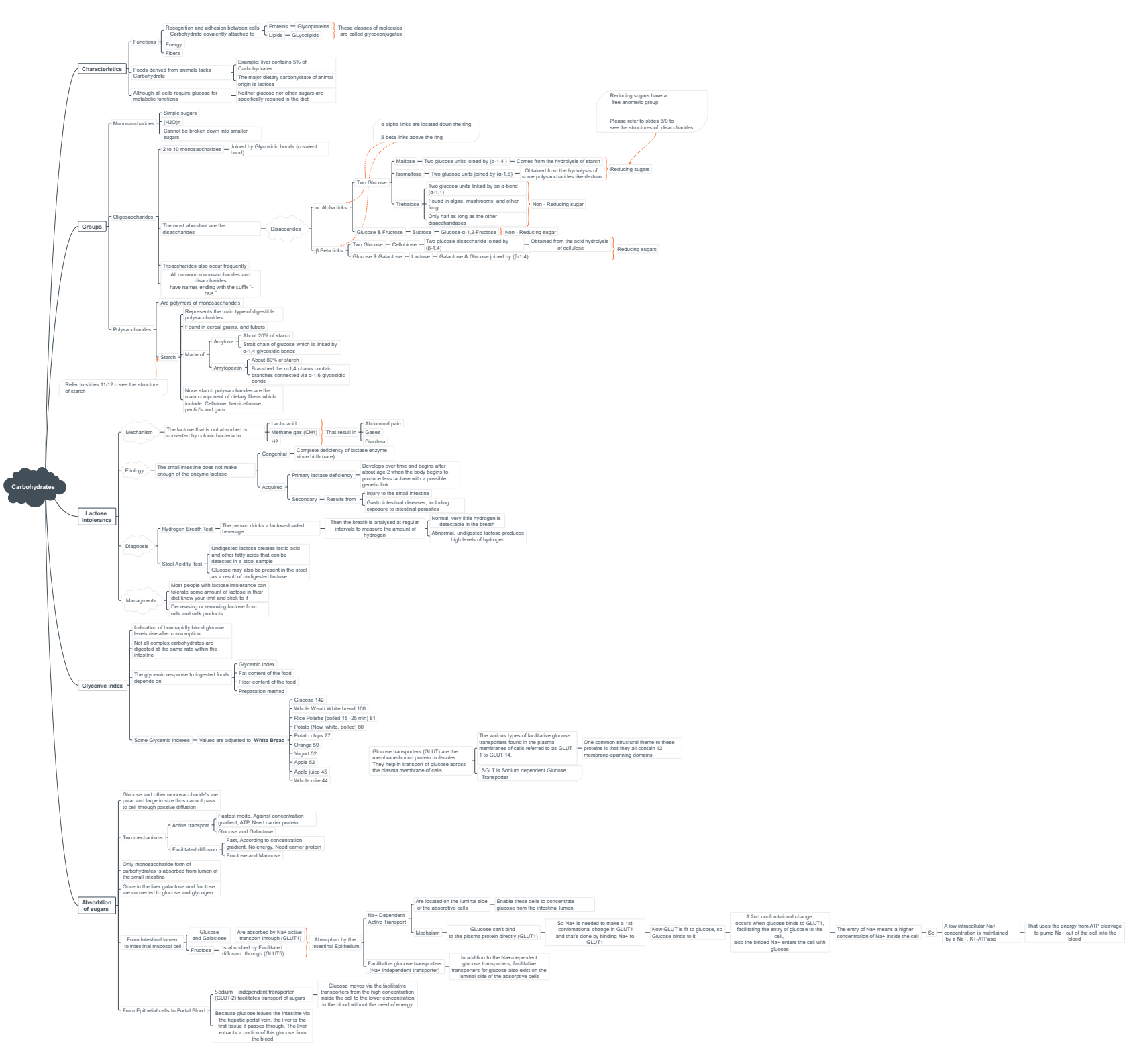
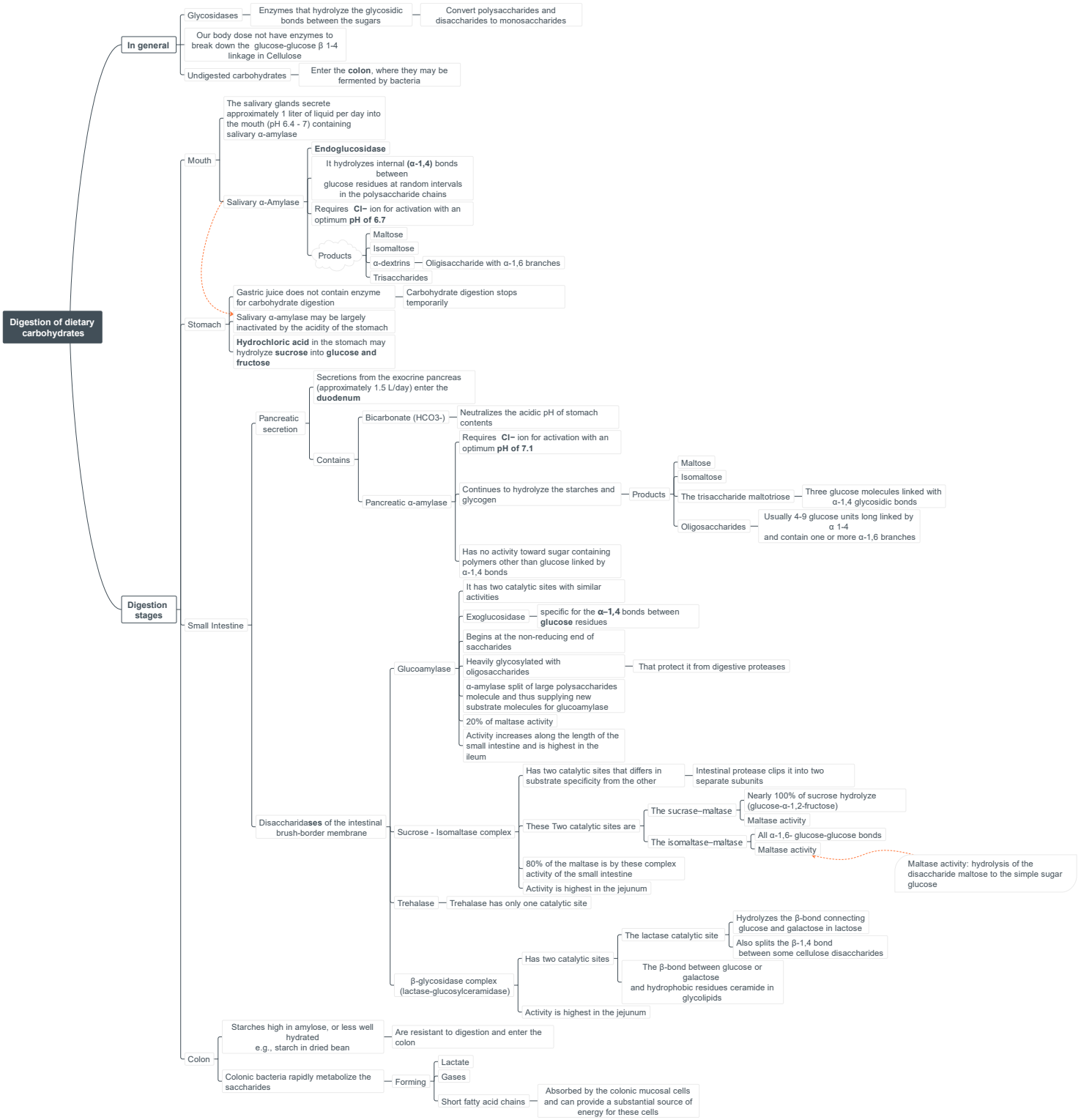

Major types of nutrients and digestion
Food guide pyramid
Grain Products "Bread, Pasta..."
6 - 11 Servings
Serving is 1 slice of white bread or 1⁄2cup of cooked rice
Vegetable
3 - 5 Servings
Serving is 1⁄2cup cooked vegetables
Fruit
2 - 4 Servings
Serving is 1 Apple or Banana
Milk
2 - 3 Servings
Serving is 1 cup of milk or 60g processed cheese
Meat and Beans
2 - 3 Servings
Serving is 60-80g of cooked meat or fish or 1 egg or 2 tbsp peanut butter
Fats, Oils, and sweets
Sparingly
As less as you can
Types of Nutriens
Dietry Fibers
Are components of food cannot be digested by human digestive enzymes
They are mainly polysaccharide derivatives and lignan (Noncarbohydrate, polymeric derivatives of phenylpropane).
Kinds
Water insoluble fiber
Cellulose
Lingan
Hemicellulose
Stimulate regular function of the colon
Water soluble fibers
Pectins
Gums
Form viscous gel-like suspensions in the digestive system
Slowing the rate of absorption of many nutrients, including carbohydrates
Lowering serum cholesterol in many cases
Benifits
Soluble fibers are fermented by bacteria and produce small chain of fatty acids
10% of our total calories we get from compounds produced by bacterial digestion of substances in our digestive tract
Fiber is thought to “soften” the stool
Thereby reducing pressure on the colonic wall
Enhancing expulsion of feces
This specificlly beneficial effect to diverticular diseaseic
In which sacs or pouches may develop in the colon because of a weakening of the muscle and submucosal structures
Disease prevention
Pectin
Also β-glucan obtained from oats
Lower blood cholesterol levels by binding bile acids and thus prevent their reabsorbtion
Beneficial for diabetes by slowing the rate of absorption of simple sugars and preventing high blood glucose levels after meals

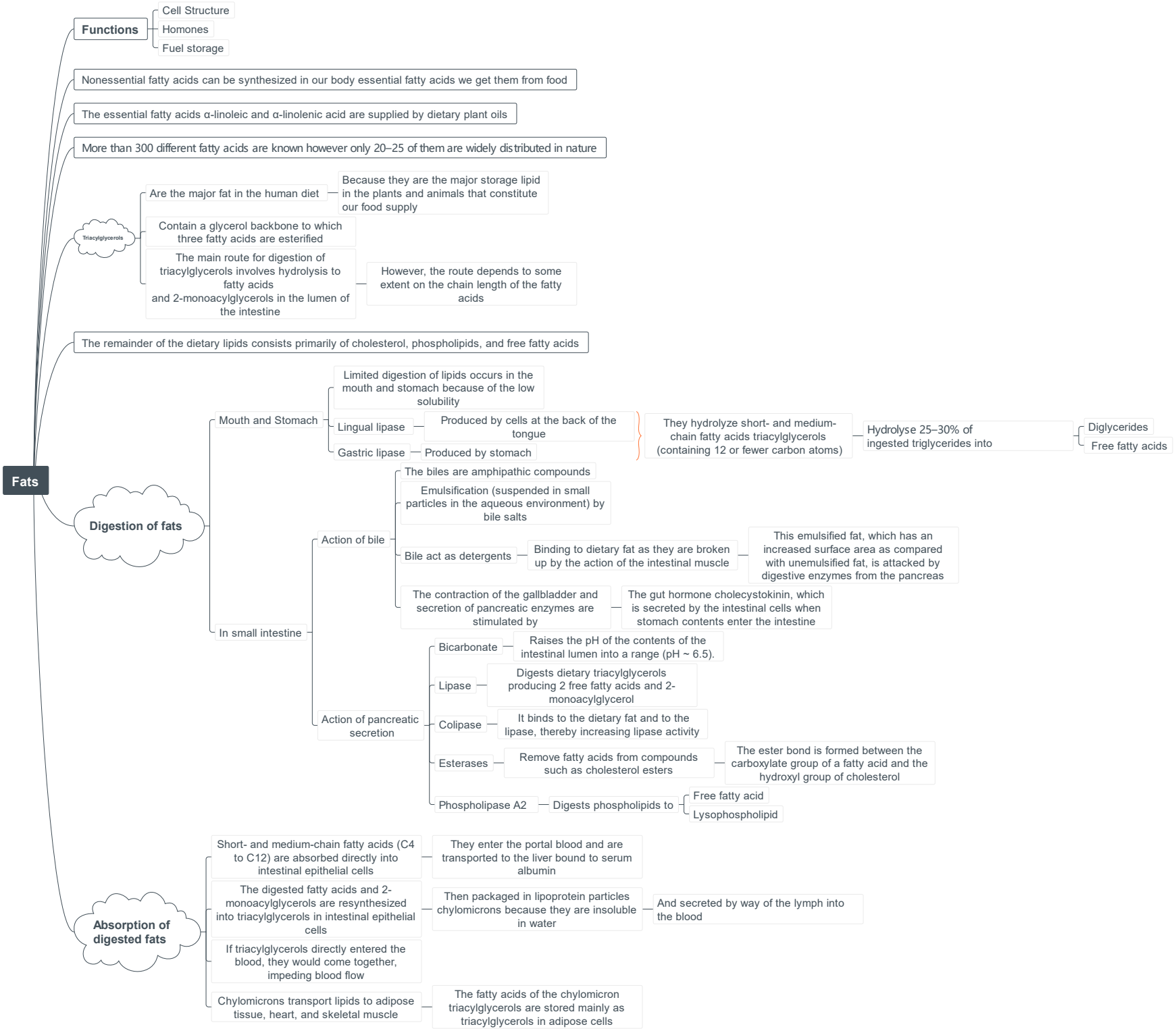
Proteins

- **General Characterstics (لل قرؤه م)**
  - Functions
    - Cytoskeleton
    - Movement — Actin and Myosin
    - Transport (Hb)
    - Immune protection (Antibodies)
    - Receptors
    - Enzymes
  - High quality protein contain all essential amino acids (proteins from animals origin) — While low quality protein don't contain all essential aa and are plants origin
  - Amino acids are the building blocks of proteins
  - The sequence of amino acids in a protein is determined by the genetic code
  - Four levels of protein structure are commonly defined: Primary structure, Secondary structure, Tertiary structure, and Quaternary structure
  - There are 20 different amino acids 8 essential and 12 nonessential amino acids that form human proteins
- **Conditionally essential amino acids**
  - Children and pregnant women have a high rate of protein synthesis to support growth — And require more of arginine and histidine than their body synthesise
  - Tyrosine — Tyrosine is synthesized from phenylalanine (by hydroxylation of phenylalanine) (Refer to slide 50) — And it is required in the diet
    - If phenylalanine intake is inadequate — The congenital disease phenylketonuria
    - Or if an individual is congenitally deficient in an enzyme required to convert phenylalanine to tyrosine
- **Zymogens**
  - Inactive enzymes precursors are called zymogens or proenzymes
    - It only acquire full activity upon specific proteolytic cleavage of one or several of their peptide bonds
    - Zymogen activation by specific proteolysis is an irreversible process
    - Important to switch on processes at the appropriate time and place
  - The synthesis of zymogens as inactive precursors prevents them from cleaving proteins prematurely at their sites of synthesis or secretion
  - Zymogen Activation
    - Pancreas Zymogens
      - Trypsinogen — Active form is — Trypsin } This process activator is — Enteropeptidase (Brush border enzyme)
      - Chymotrypsinogen — Active form is — Chymotrypsin
      - Procaboxypeptidase — Active form is — Caboxypeptidase
      - Proelastase — Active form is — Elastase
      - } This 3 processes activator is — Trypsin — So you need the first proccess to intiate the 2nd three
    - Stomach Zymogens — Pespsinogen — Active form is — Pepsin } This process activator is — H+ (pH drop)
    - Activation of Chymotrypsinogen
      - Chymotrypsinogen is a 245-Amino acid cross-linked by five disulfide bonds
      - 1. Chymotrypsinogen is converted to an enzymatically active form called π-chymotrypsin — When trypsin cleaves the peptide bond joining Arginine 15 and Isoleucine 16 "Refer to slide 54"
      - 2. The enzymatically active π-chymotrypsin acts upon other π-chymotrypsin molecules — Removing two dipeptides
        - Serine14 - Arginine15
        - Threonine147- Asparagine148
      - 3. The end product of this processing pathway is the mature protease α-chymotrypsin, in which the three peptide chains
        - A (residues 1 through 13)
        - B (residues 16 through 146)
        - C (residues 149 through 245)
        - } Remain together because they are linked by two disulfide bonds, one from A to B, and one from B to C
- **Digestion of proteins**
  - In the stomach
    - Pepsinogen
      - Is activated to its active form pepsin by acidic gastric juice (pH 1.0 to 2.5) — That alters the conformation of so that it can cleave itself, producing the active pepsin
      - Acts as an endopeptidase, cleaving peptide bonds at various points within the protein chain
    - Acidity
      - Causes dietary proteins denaturation — This serves to inactivate the proteins and partially unfolds them such that they are better substrates for proteases
      - Smaller peptides and some free amino acids are produced
  - By Pancreas
    - Bicarbonate — Causes raises the pH such that the pancreatic proteases can be active
    - Trypsinogen — Is cleaved to form trypsin by enteropeptidase (a protease) secreted by the brush-border cells of the small intestine
    - Trypsin
      - Is most specific that cleaves endopeptidases peptide bonds between lysine or arginine (cleaves peptide bonds of basic amino acids (+ve)
      - Catalyzes conversion of
        - Chymotrypsinogen to chymotrypsin — That favors residues that contain hydrophobic or acidic amino acids
        - Proelastase to elastase — That cleaves elastin and proteins with small side chains (alanine, glycine, or serine).
        - Procarboxypeptidases to carboxypeptidases
          - Carboxypeptidase A — Preferentially releases hydrophobic amino acids
          - Carboxypeptidase B — B releases basic amino acids (arginine and lysine)
          - These exopeptidases remove amino acids from the carboxyl ends of peptide chains
  - Intestinal Cells
    - Aminopeptidases
      - lCcated on the brush border
      - Cleave one amino acid at a time from the amino end of peptides
    - Amino acids are absorbed from the intestinal lumen through Na+- dependent transport systems and through **facilitated diffusion**

Sequences of amino acids in a peptide are read from the amino terminal end to the carboxy-terminal end


Carbohydrates
Characteristics
Functions
Recognition and adhesion between cells
Carbohydrate covalently attached to
Proteins — Glycoproteins
Lipids — GLycolipids
These classes of molecules are called glycoconjugates
Energy
Fibers
Foods derived from animals lacks Carbohydrate
Example: liver contains 5% of Carbohydrates
The major dietary carbohydrate of animal origin is lactose
Although all cells require glucose for metabolic functions
Neither glucose nor other sugars are specifically required in the diet
Groups
Monosaccharides
Simple sugars
(H2O)n
Cannot be broken down into smaller sugars
Oligosaccharides
2 to 10 monosaccharides
Joined by Glycosidic bonds (covalent bond)
The most abundant are the disaccharides
Disaccarides
α Alpha links
α alpha links are located down the ring
β beta links above the ring
Two Glucose
Maltose — Two glucose units joined by (α-1,4) — Comes from the hydrolysis of starch
Isomaltose — Two glucose units joined by (α-1,6) — Obtained from the hydrolysis of some polysaccharides like dextran
Reducing sugars
Reducing sugars have a free anomeric group
Please refer to slides 8/9 to see the structures of disaccharides
Trehalose
Two glucose units linked by an α-bond (α-1,1)
Found in algae, mushrooms, and other fungi
Only half as long as the other disaccharides
Non - Reducing sugar
Glucose & Fructose — Sucrose — Glucose-α-1,2-Fructose — Non - Reducing sugar
β Beta links
Two Glucose — Cellobiose — Two glucose disaccharide joined by (β-1,4) — Obtained from the acid hydrolysis of cellulose — Reducing sugars
Glucose & Galactose — Lactose — Galactose & Glucose joined by (β-1,4)
Trisaccharides also occur frequently
All common monosaccharides and disaccharides have names ending with the suffix "-ose."
Polysaccharides
Are polymers of monosaccharide's
Starch
Represents the main type of digestible polysaccharides
Found in cereal grains, and tubers
Made of
Amylose
About 20% of starch
Strait chain of glucose which is linked by α-1,4 glycosidic bonds
Amylopectin
About 80% of starch
Branched the α-1,4 chains contain branches connected via α-1,6 glycosidic bonds
None starch polysaccharides are the main component of dietary fibers which include: Cellulose, hemicellulose, pectin's and gum
Refer to slides 11/12 o see the structure of starch
Lactose Intolerance
Mechanism
The lactose that is not absorbed is converted by colonic bacteria to
Lactic acid
Methane gas (CH4)
H2
That result in
Abdominal pain
Gases
Diarrhea
Etiology
The small intestine does not make enough of the enzyme lactase
Congenital — Complete deficiency of lactase enzyme since birth (rare)
Acquired
Primary lactase deficiency — Develops over time and begins after about age 2 when the body begins to produce less lactase with a possible genetic link
Secondary — Results from
Injury to the small intestine
Gastrointestinal diseases, including exposure to intestinal parasites
Diagnosis
Hydrogen Breath Test — The person drinks a lactose-loaded beverage — Then the breath is analysed at regular intervals to measure the amount of hydrogen
Normal, very little hydrogen is detectable in the breath
Abnormal, undigested lactose produces high levels of hydrogen
Stool Acidity Test
Undigested lactose creates lactic acid and other fatty acids that can be detected in a stool sample
Glucose may also be present in the stool as a result of undigested lactose
Managments
Most people with lactose intolerance can tolerate some amount of lactose in their diet know your limit and stick to it
Decreasing or removing lactose from milk and milk products
Glycemic index
Indication of how rapidly blood glucose levels rise after consumption
Not all complex carbohydrates are digested at the same rate within the intestine
The glycemic response to ingested foods depends on
Glycemic Index
Fat content of the food
Fiber content of the food
Preparation method
Some Glycemic indexes — Values are adjusted to White Bread
Glucose 142
Whole Weat/ White bread 100
Rice Polishe (boiled 15 -25 min) 81
Potato (New, white, boiled) 80
Potato chips 77
Orange 59
Yogurt 52
Apple 52
Apple juice 45
Whole mile 44
Glucose transporters (GLUT) are the membrane-bound protein molecules. They help in transport of glucose across the plasma membrane of cells
The various types of facilitative glucose transporters found in the plasma membranes of cells referred to as GLUT 1 to GLUT 14.
One common structural theme to these proteins is that they all contain 12 membrane-spanning domains
SGLT is Sodium dependent Glucose Transporter
Absorbtion of sugars
Glucose and other monosaccharide's are polar and large in size thus cannot pass to cell through passive diffusion
Two mechanisms
Active transport
Fastest mode, Against concentration gradient, ATP, Need carrier protein
Glucose and Galactose
Facilitated diffusion
Fast, According to concentration gradient, No energy, Need carrier protein
Fructose and Mannose
Only monosaccharide form of carbohydrates is absorbed from lumen of the small intestine
Once in the liver galactose and fructose are converted to glucose and glycogen
From Intestinal lumen to intestinal mucosal cell
Glucose and Galactose — Are absorbed by Na+ active transport through (GLUT1)
Fructose — Is absorbed by Facilitated diffusion through (GLUT5)
Absorption by the Intestinal Epithelium
Na+ Dependent Active Transport
Are located on the luminal side of the absorptive cells — Enable these cells to concentrate glucose from the intestinal lumen
Mechaism — GLucose can't bind to the plasma protein directly (GLUT1) — So Na+ is needed to make a 1st confomational change in GLUT1 and that's done by binding Na+ to GLUT1 — Now GLUT is fit to glucose, so Glucose binds to it — A 2nd confomtaional change occurs when glucose binds to GLUT1, facilitating the entry of glucose to the cell, also the binded Na+ enters the cell with glucose — The entry of Na+ means a higher concentration of Na+ inside the cell — So — A low intracellular Na+ concentration is maintained by a Na+, K+-ATPase — That uses the energy from ATP cleavage to pump Na+ out of the cell into the blood
Facilitative glucose transporters (Na+ independent transporter)
In addition to the Na+-dependent glucose transporters, facilitative transporters for glucose also exist on the luminal side of the absorptive cells
From Epithelial cells to Portal Blood
Sodium – independent transporter (GLUT-2) facilitates transport of sugars — Glucose moves via the facilitative transporters from the high concentration inside the cell to the lower concentration in the blood without the need of energy
Because glucose leaves the intestine via the hepatic portal vein, the liver is the first tissue it passes through. The liver extracts a portion of this glucose from the blood


Digestion of dietary carbohydrates
In general
Glycosidases
Enzymes that hydrolyze the glycosidic bonds between the sugars
Convert polysaccharides and disaccharides to monosaccharides
Our body dose not have enzymes to break down the glucose-glucose β 1-4 linkage in Cellulose
Undigested carbohydrates
Enter the colon, where they may be fermented by bacteria
Digestion stages
Mouth
The salivary glands secrete approximately 1 liter of liquid per day into the mouth (pH 6.4 - 7) containing salivary α-amylase
Salivary α-Amylase
Endoglucosidase
It hydrolyzes internal (α-1,4) bonds between glucose residues at random intervals in the polysaccharide chains
Requires Cl− ion for activation with an optimum pH of 6.7
Products
Maltose
Isomaltose
α-dextrins
Oligisaccharide with α-1,6 branches
Trisaccharides
Stomach
Gastric juice does not contain enzyme for carbohydrate digestion
Carbohydrate digestion stops temporarily
Salivary α-amylase may be largely inactivated by the acidity of the stomach
Hydrochloric acid in the stomach may hydrolyze sucrose into glucose and fructose
Small Intestine
Pancreatic secretion
Secretions from the exocrine pancreas (approximately 1.5 L/day) enter the duodenum
Contains
Bicarbonate (HCO3-)
Neutralizes the acidic pH of stomach contents
Pancreatic α-amylase
Requires Cl− ion for activation with an optimum pH of 7.1
Continues to hydrolyze the starches and glycogen
Products
Maltose
Isomaltose
The trisaccharide maltotriose
Three glucose molecules linked with α-1,4 glycosidic bonds
Oligosaccharides
Usually 4-9 glucose units long linked by α 1-4 and contain one or more α-1,6 branches
Has no activity toward sugar containing polymers other than glucose linked by α-1,4 bonds
Disaccharidases of the intestinal brush-border membrane
Glucoamylase
It has two catalytic sites with similar activities
Exoglucosidase
specific for the α–1,4 bonds between glucose residues
Begins at the non-reducing end of saccharides
Heavily glycosylated with oligosaccharides
That protect it from digestive proteases
α-amylase split of large polysaccharides molecule and thus supplying new substrate molecules for glucoamylase
20% of maltase activity
Activity increases along the length of the small intestine and is highest in the ileum
Sucrose - Isomaltase complex
Has two catalytic sites that differs in substrate specificity from the other
Intestinal protease clips it into two separate subunits
These Two catalytic sites are
The sucrase–maltase
Nearly 100% of sucrose hydrolyze (glucose-α-1,2-fructose)
Maltase activity
The isomaltase–maltase
All α-1,6- glucose-glucose bonds
Maltase activity
Maltase activity: hydrolysis of the disaccharide maltose to the simple sugar glucose
80% of the maltase is by these complex activity of the small intestine
Activity is highest in the jejunum
Trehalase
Trehalase has only one catalytic site
β-glycosidase complex (lactase-glucosylceramidase)
Has two catalytic sites
The lactase catalytic site
Hydrolyzes the β-bond connecting glucose and galactose in lactose
Also splits the β-1,4 bond between some cellulose disaccharides
The β-bond between glucose or galactose and hydrophobic residues ceramide in glycolipids
Activity is highest in the jejunum
Colon
Starches high in amylose, or less well hydrated e.g., starch in dried bean
Are resistant to digestion and enter the colon
Colonic bacteria rapidly metabolize the saccharides
Forming
Lactate
Gases
Short fatty acid chains
Absorbed by the colonic mucosal cells and can provide a substantial source of energy for these cells


Fats
Functions
Cell Structure
Homones
Fuel storage
Nonessential fatty acids can be synthesized in our body essential fatty acids we get them from food
The essential fatty acids α-linoleic and α-linolenic acid are supplied by dietary plant oils
More than 300 different fatty acids are known however only 20–25 of them are widely distributed in nature
Triacylglycerols
Are the major fat in the human diet
Because they are the major storage lipid in the plants and animals that constitute our food supply
Contain a glycerol backbone to which three fatty acids are esterified
The main route for digestion of triacylglycerols involves hydrolysis to fatty acids and 2-monoacylglycerols in the lumen of the intestine
However, the route depends to some extent on the chain length of the fatty acids
The remainder of the dietary lipids consists primarily of cholesterol, phospholipids, and free fatty acids
Digestion of fats
Mouth and Stomach
Limited digestion of lipids occurs in the mouth and stomach because of the low solubility
Lingual lipase
Produced by cells at the back of the tongue
Gastric lipase
Produced by stomach
They hydrolyze short- and medium-chain fatty acids triacylglycerols (containing 12 or fewer carbon atoms)
Hydrolyse 25–30% of ingested triglycerides into
Diglycerides
Free fatty acids
In small intestine
Action of bile
The biles are amphipathic compounds
Emulsification (suspended in small particles in the aqueous environment) by bile salts
Bile act as detergents
Binding to dietary fat as they are broken up by the action of the intestinal muscle
This emulsified fat, which has an increased surface area as compared with unemulsified fat, is attacked by digestive enzymes from the pancreas
The contraction of the gallbladder and secretion of pancreatic enzymes are stimulated by
The gut hormone cholecystokinin, which is secreted by the intestinal cells when stomach contents enter the intestine
Action of pancreatic secretion
Bicarbonate
Raises the pH of the contents of the intestinal lumen into a range (pH ~ 6.5).
Lipase
Digests dietary triacylglycerols producing 2 free fatty acids and 2-monoacylglycerol
Colipase
It binds to the dietary fat and to the lipase, thereby increasing lipase activity
Esterases
Remove fatty acids from compounds such as cholesterol esters
The ester bond is formed between the carboxylate group of a fatty acid and the hydroxyl group of cholesterol
Phospholipase A2
Digests phospholipids to
Free fatty acid
Lysophospholipid
Absorption of digested fats
Short- and medium-chain fatty acids (C4 to C12) are absorbed directly into intestinal epithelial cells
They enter the portal blood and are transported to the liver bound to serum albumin
The digested fatty acids and 2-monoacylglycerols are resynthesized into triacylglycerols in intestinal epithelial cells
Then packaged in lipoprotein particles chylomicrons because they are insoluble in water
And secreted by way of the lymph into the blood
If triacylglycerols directly entered the blood, they would come together, impeding blood flow
Chylomicrons transport lipids to adipose tissue, heart, and skeletal muscle
The fatty acids of the chylomicron triacylglycerols are stored mainly as triacylglycerols in adipose cells