Digestion of proteins & fat in GIT

Dr- Iman Aolymat

imank@hu.edu.jo

Proteins in diet

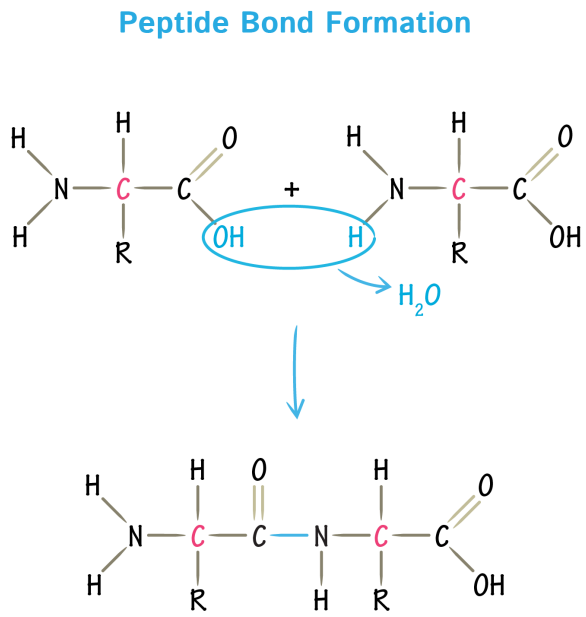
- High protein food are meat, fish, egg and milk.
- Proteins are also available in wheat, soybeans, oats and various types of pulses.

- **Proteins present in common foodstuffs are:**
- 1. Wheat: Glutenin and gliadin, which constitute gluten
- 2. Milk: Casein, lactalbumin, albumin and myosin
- 3. Egg: Albumin and vitellin
- 4. Meat: Collagen, albumin and myosin.

Dietary proteins are formed by long chains of amino acids, bound together by peptide linkages.

Formation of Proteins
Multiple amino acids bound by peptide linkages.
H+& OH− removal→ H2O & dipeptide

Hydrolysis. proteolytic enzymes return
H+& OH− from H2O to protein molecules to split them into amino acids.



Digestion of Proteins

- No protein digestion in the mouth
- No proteolytic enzymes in saliva

Digestion of Proteins

- Digestion of proteins to AA occurs in 3 locations –

1. **Stomach** - pepsin

✓ Active pH 2-3, inactive pH > 5,

✓ Digests collagen, important for meat digestion

✓ 10-20 % of protein digestion

✓ Products: proteoses, peptones, & polypeptides

Digestion of Proteins

- Digestion of proteins to AA occurs in 3 locations –

2. Upper Small intestine (D & J) - pancreatic secretion

✓ Most protein digestion

✓ trypsin, chymotrypsin →small polypeptides/ Carboxypolypeptidase → amino acids/ & elastase → digests meat elastin fibers)

✓ Trypsin and chymotrypsin are called **endopeptidases**→break the **interior** bonds of protein molecules

✓ Only small % of proteins are digested to their constituent amino acids by pancreatic juices. Most remain as dipeptides & tripeptides.

Digestion of Proteins

- Digestion of proteins to AA occurs in 3 locations –

3. Enterocytes lining SI Villi-by succus entericus

✓ Brush border –peptidases (aminopolypeptidase & dipeptidases→ split larger polypeptides into tripeptides, dipeptides & amino acids → easily transported through the microvillar membrane to enterocyte.

✓ Cytoplasm of enterocytes- dipeptidases & tripeptides digested to amino acids→ pass to other side of enterocyte →blood.

>99% of final protein digestive products are absorbed in form of amino acids

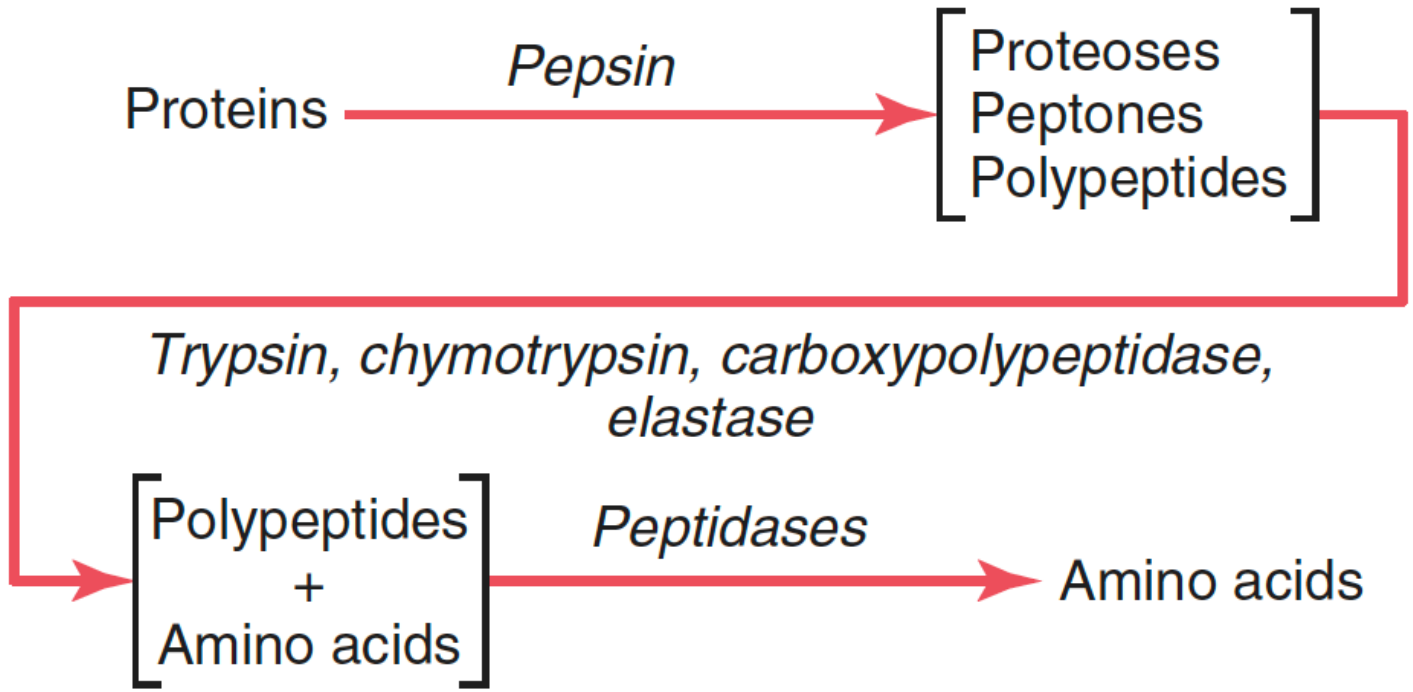


Figure 66-2. Digestion of proteins.

TABLE 46.1: Digestion of proteins

Area	Juice	Enzyme	Substrate	End product
Mouth	Saliva	No proteolytic enzyme	Polysaccharides – cooked starch	Disaccharides – dextrin and maltose
Stomach	Gastric juice	Pepsin	Proteins	Proteoses, peptones, large polypeptides
Small intestine	Pancreatic juice	Trypsin	Proteoses Peptones	Dipeptides Tripeptides Polypeptides
		Chymotrypsin		
		Carboxypeptidases A and B	Dipeptides Tripeptides Polypeptides	Amino acids
	Succus entericus	Dipeptidases	Dipeptides	Amino acids
		Tripeptidases	Tripeptides	
		Amino peptidases	Large polypeptides	

Digestion of fats

Lipids in diet

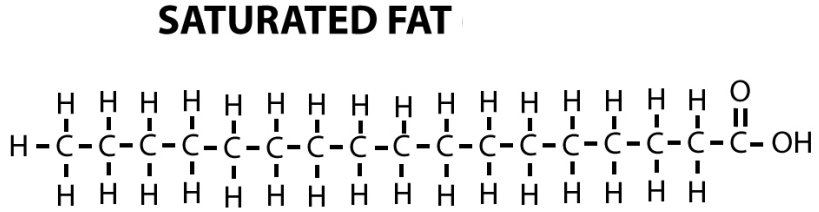
- Lipids are mostly consumed in the form of neutral fats= TG
- TG are made up of glycerol nucleus and free fatty acids
- Triglycerides form the major constituent in foods of animal origin and much less in foods of plant origin.
- Usual diet also contains small quantities of cholesterol and cholesterol esters.

- Dietary fats are classified into two types:

1. Saturated fats
2. Unsaturated fats.

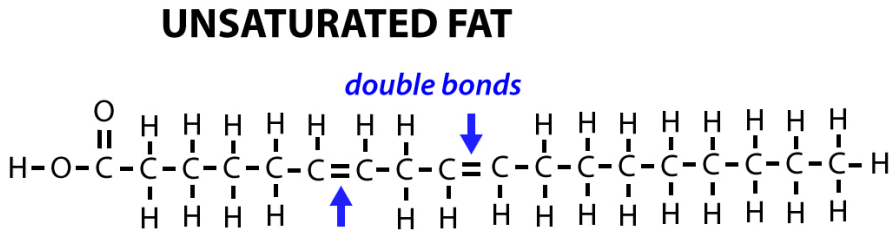
Saturated fats

- Contain TG formed from only saturated fatty acids.
- Saturated fatty acids are fatty acids having maximum amount of hydrogen ions **without** any double bonds between carbon atoms.



Unsaturated fats

- Fats containing unsaturated fatty acids.
- Unsaturated fatty acids are fatty acids formed by dehydrogenation of saturated fatty acids.
- Unsaturated fats are classified into three types:

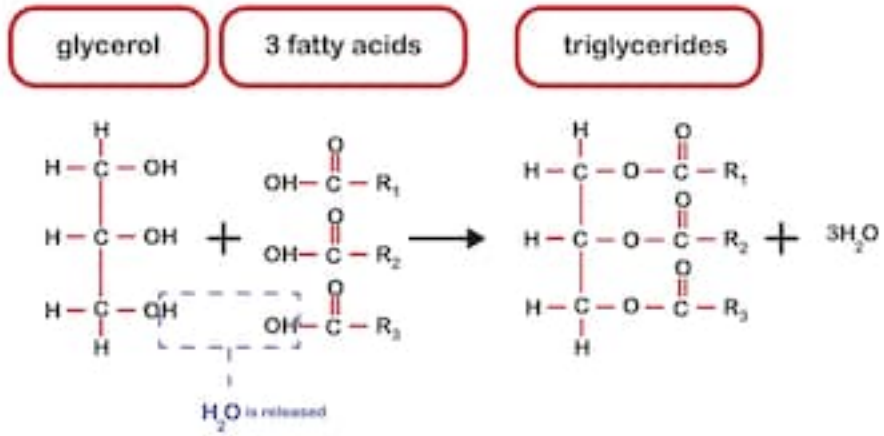


1. Monounsaturated fats (1 double bond between C atoms)
2. Polyunsaturated fats (>1 double bond between C atoms, essential FA, Omega-3 &6, too much omega 6 is hazardous, 3 : 1 ratio of omega-6 to omega-3 FA is recommended)
3. Trans fats (containing trans (across or opposite side) double bonds between C atoms.

Type of fat	Functions
Saturated fats	Increase blood cholesterol and thereby increase the risk of atherosclerosis and coronary heart diseases
Monounsaturated fats	Decrease blood cholesterol and thereby decrease the risk of coronary heart diseases
Polyunsaturated fats	*Decrease* Blood cholesterol and triglycerides and thereby reduces blood pressure Risk of coronary heart diseases Risk of obesity Platelet aggregation and prevents excess blood clotting Inflammation throughout body *Increase* Disease-countering actions in the body
Trans fats	Increase low density lipoproteins and thereby increase the risk of atherosclerosis and coronary heart diseases

Formation of TG
Diet mainly consists of TG = 3 fatty acid + glycerol
During condensation, 3 H2O molecules removed.

Hydrolysis :reverse process: fat-digesting enzymes return 3 H2O molecules to TG splitting fatty acid from the glycerol



Digestion of fats

- Major fat in diet: TG (animal food >plant food)
- Minor fat in diet :phospholipids, cholesterol (sterol/ no fatty acid) & cholesterol esters
- **Mouth- No digestion only secretion of lingual lipase**
- **Stomach**

✓ TG are digested by lingual lipase (secreted by saliva) < 10 %

✓ Gastric lipase or tributyrase (weak enzyme) digests tributyrin (butter fat) into FA and glycerols.

- **SI**- Almost all lipids are digested in the SI. bile salts & pancreatic lipase
- 1 minute digestion of all TG

Digestion of Fats

- First step → breaking fat globules into very small sizes→ water-soluble digestive enzymes (mainly pancreatic lipase) can act only on the globule surfaces.

- This process is called **emulsification** of fat, and it begins by **agitation in the stomach** to mix the fat with the products of stomach digestion.

- Most of the emulsification occurs in the duodenum under the influence of bile - large quantity of bile salts as well as the phospholipid lecithin.

- Bile salts & lecithin – water & fat soluble – **detergent action**

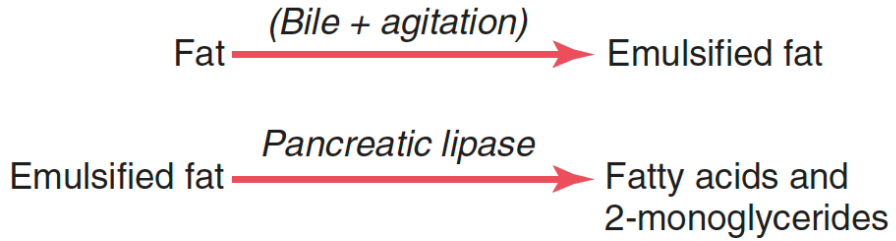
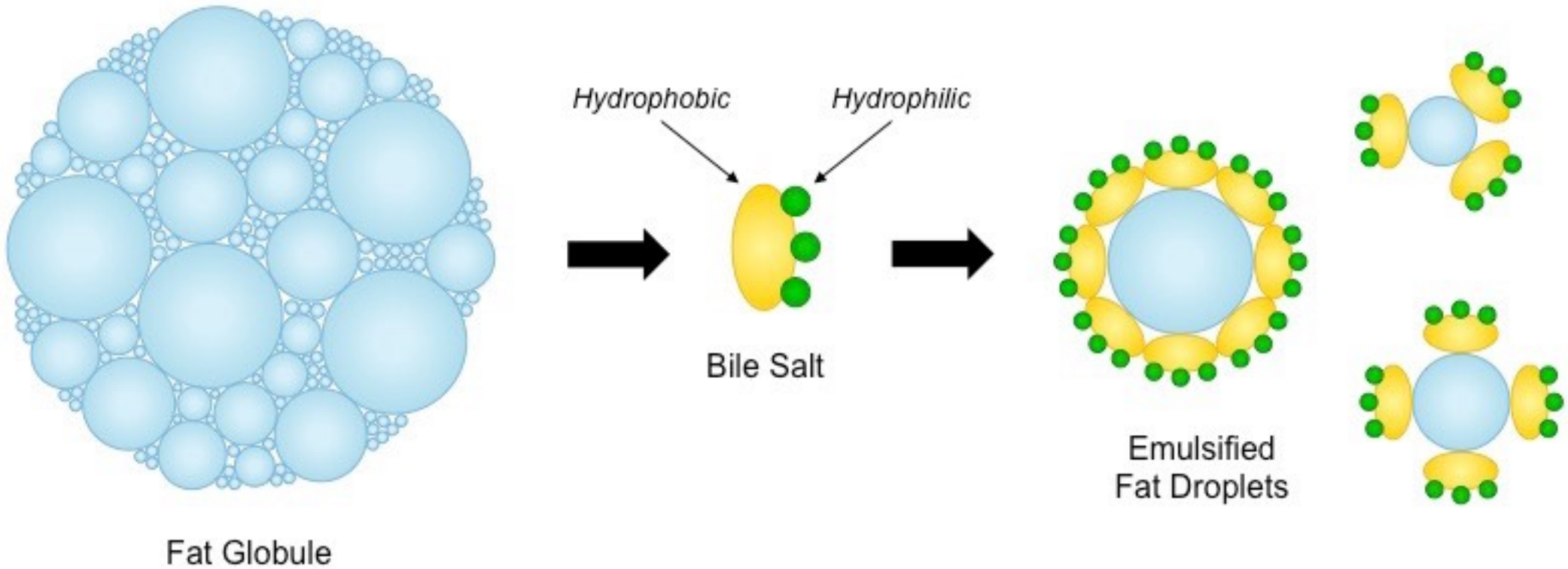
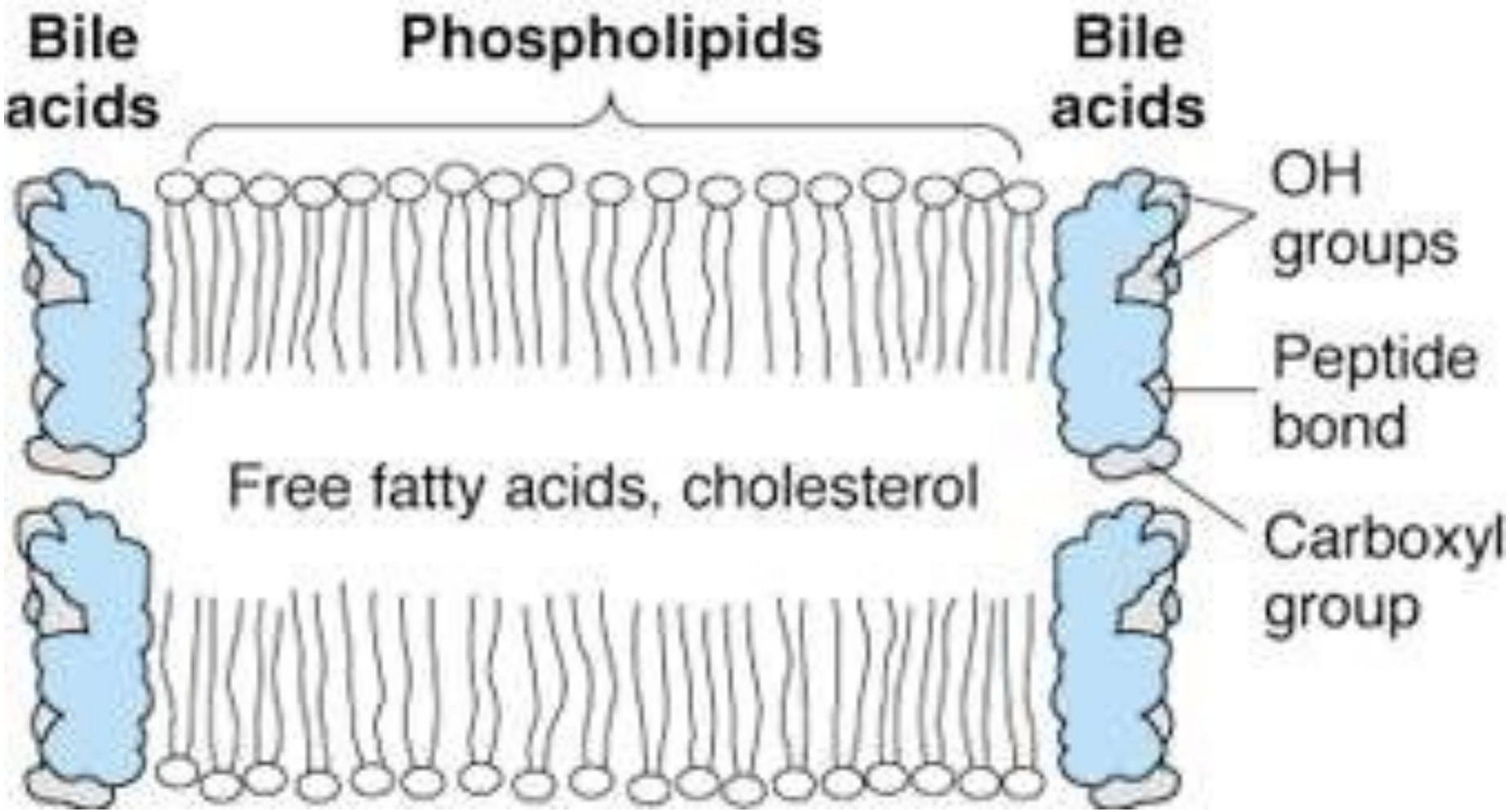


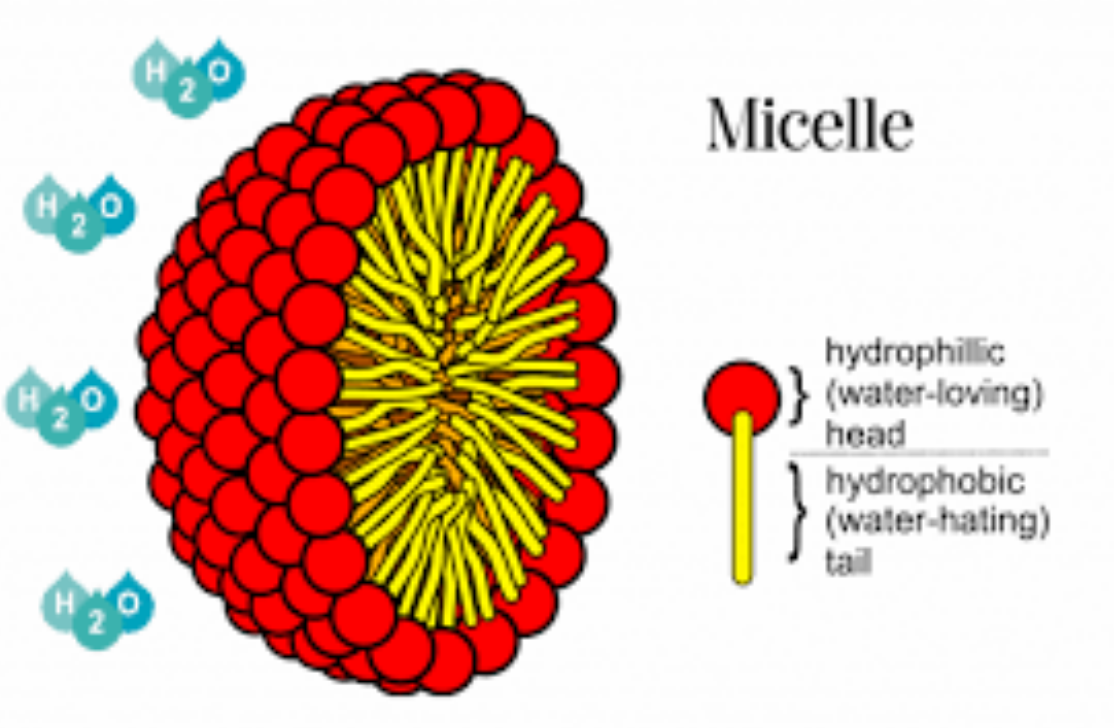
Figure 66-4. Digestion of fats.


Hydrophobic
Hydrophilic
Bile Salt
Fat Globule
Emulsified
Fat Droplets


Bile acids
Phospholipids
Bile acids
OH groups
Peptide bond
Carboxyl group
Free fatty acids, cholesterol

Digestion of Fats

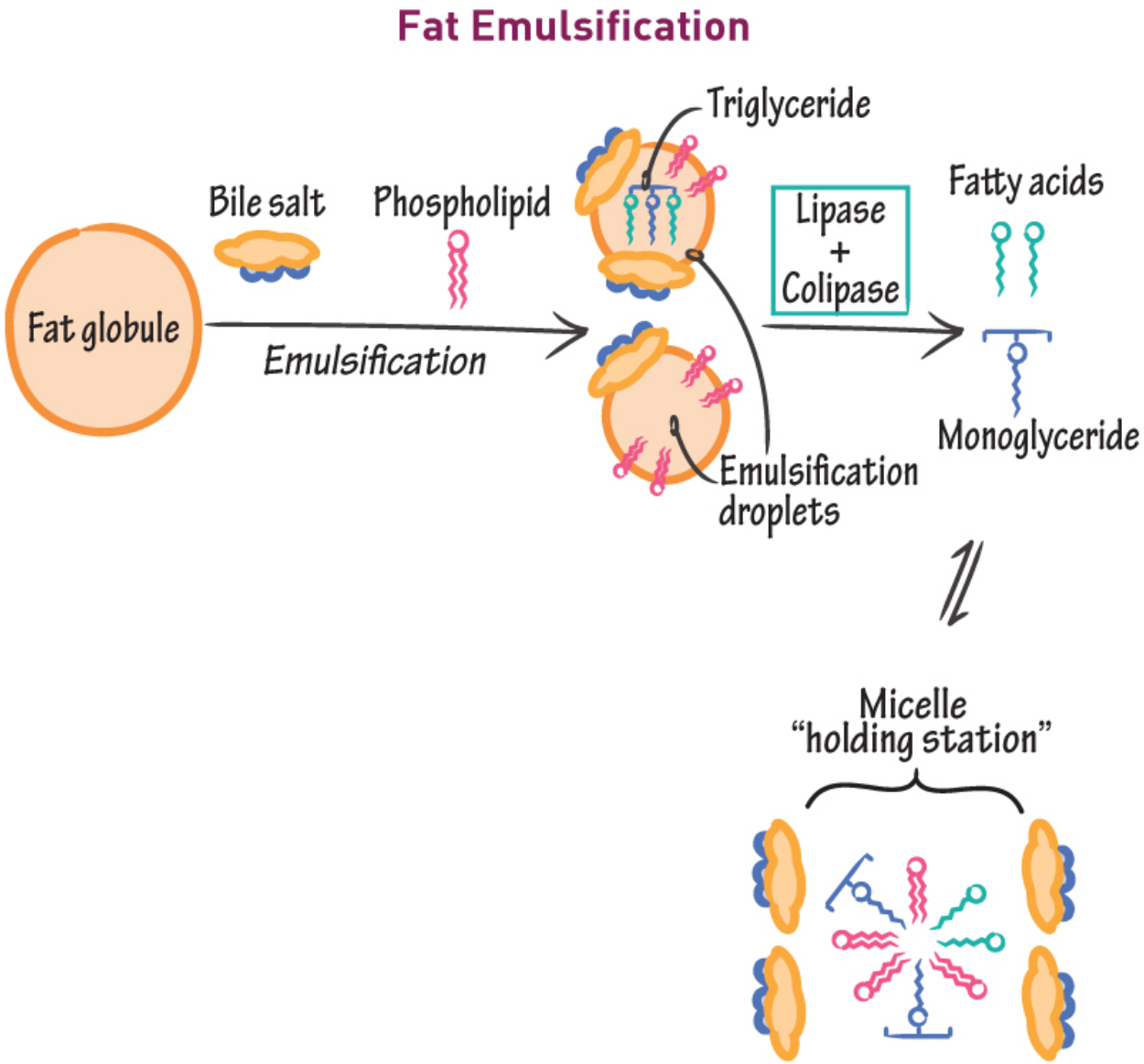
- The enterocytes of SI contain enteric lipase
- Most of the triglycerides of the diet are split by pancreatic lipase into free fatty acids and 2- monoglycerides-Both can diffuse into enterocyte.
- Bile salts, when in high enough concentration in water, have the propensity to form micelles, which are small spherical, cylindrical globules



- Micelles-3-6 nmin diameter
- Composed of 20-40 molecules of bile salt- Inside fats – outside surface water soluble

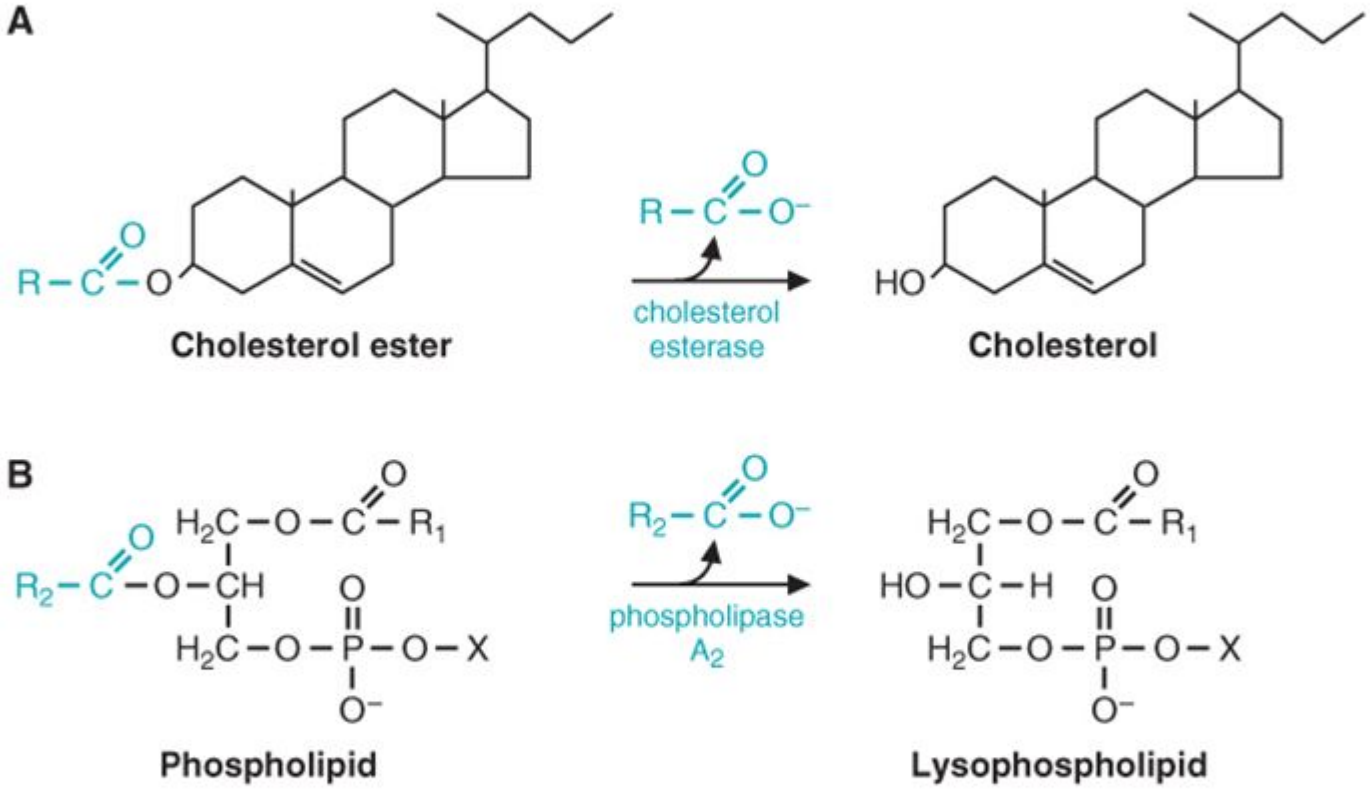
Bile Salts Form Micelles That Accelerate Fat Digestion and absorption.

Micelles carry monoglycerides and fatty acids (relatively insoluble) to brush borders of intestinal epithelial cells→ absorbed into blood



Digestion of Fats

- Bile salts released back into the chyme & again reused
- **Cholesterol ester hydrolase** hydrolyzes cholesterol ester
- **Phospholipase A_2** hydrolyzes the phospholipid



Digestion of Fats

- The bile salt micelles play the same role in “ferrying” **free cholesterol**
- **phospholipid** play role in “ferrying” monoglycerides and free fatty acids
- No cholesterol is absorbed without this function of the **micelles**

FA, cholesterol and monoglycerides are the final products of lipid digestion

TABLE 47.2: Digestion of lipids

Area	Juice	Enzyme	Substrate	End product
Mouth	Saliva	Lingual lipase	Triglycerides	Fatty acid 1, 2-diacylglycerol
Stomach	Gastric juice	Gastric lipase (weak lipase)	Triglycerides	Fatty acids Glycerol
Small intestine	Pancreatic juice	Pancreatic lipase	Triglycerides	Monoglycerides Fatty acid
		Cholesterol ester hydrolase	Cholesterol ester	Free cholesterol Fatty acid
		Phospholipase A	Phospholipids	Lysophospholipids
		Phospholipase B	Lysophospholipids	Phosphoryl choline Free fatty acids
		Colipase	Facilitates action of pancreatic lipase	–
		Bile-salt-activated lipase	Phospholipids	Lysophospholipids
			Cholesterol esters	Cholesterol and fatty acids
	Succus entericus	Intestinal lipase	Triglycerides	Fatty acids Glycerol (weak action)


The End