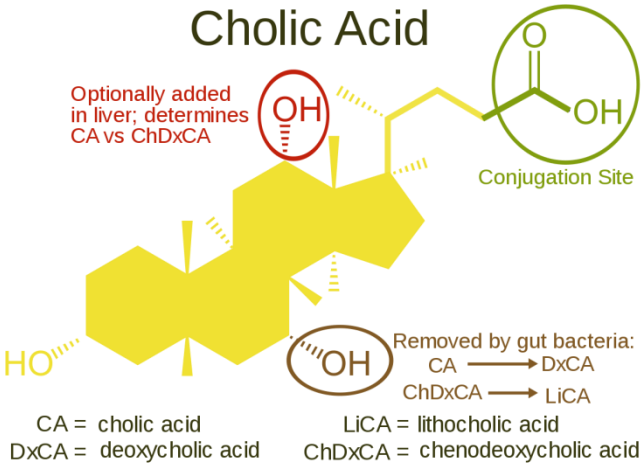
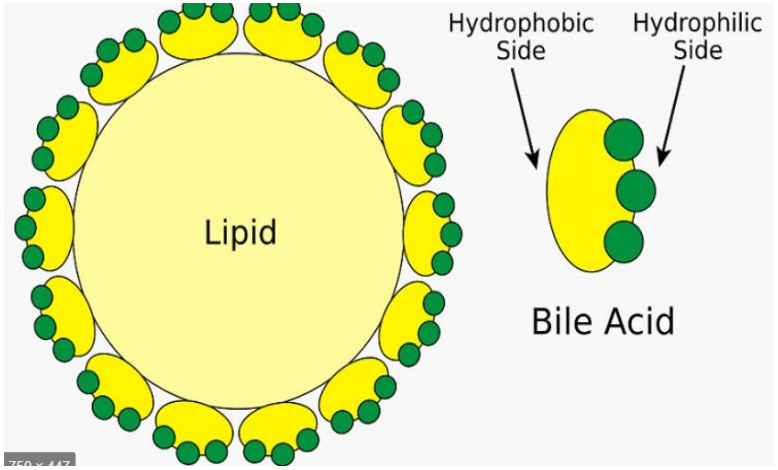
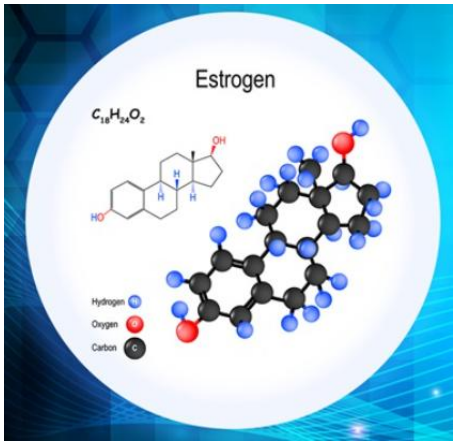
Functional Lipids



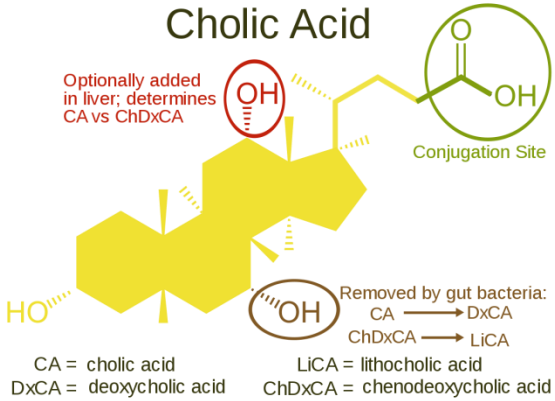


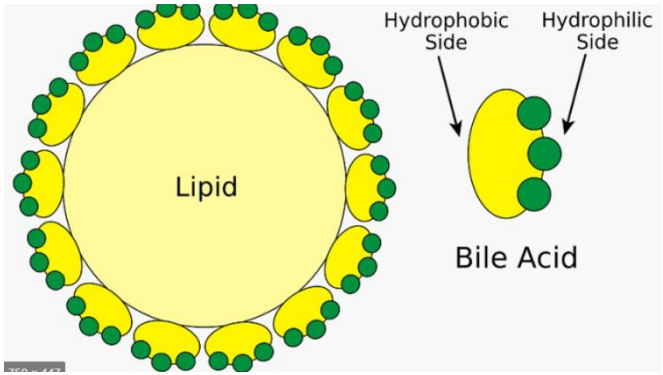


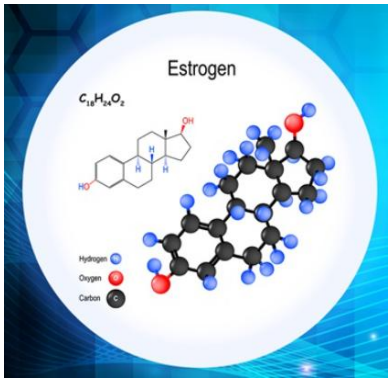
Functional Lipids

Lipids as Hormones, Signals, Cofactors and Pigments

- Hormones (sex hormones e.g. Estrogen , testosteron)
- Enzyme cofactors (coenzyme A)
- Electron carriers (coenzyme Q, plastpquinone)
- Light-absorbing pigments (carotenoids)
- Emulsifying agents (bile salts)
- Intracellular messengers (phosphatidyl inositol)







Functional Lipids as Signals

Phosphatidylinositols and Sphingosine Derivatives Act as Intracellular Signals

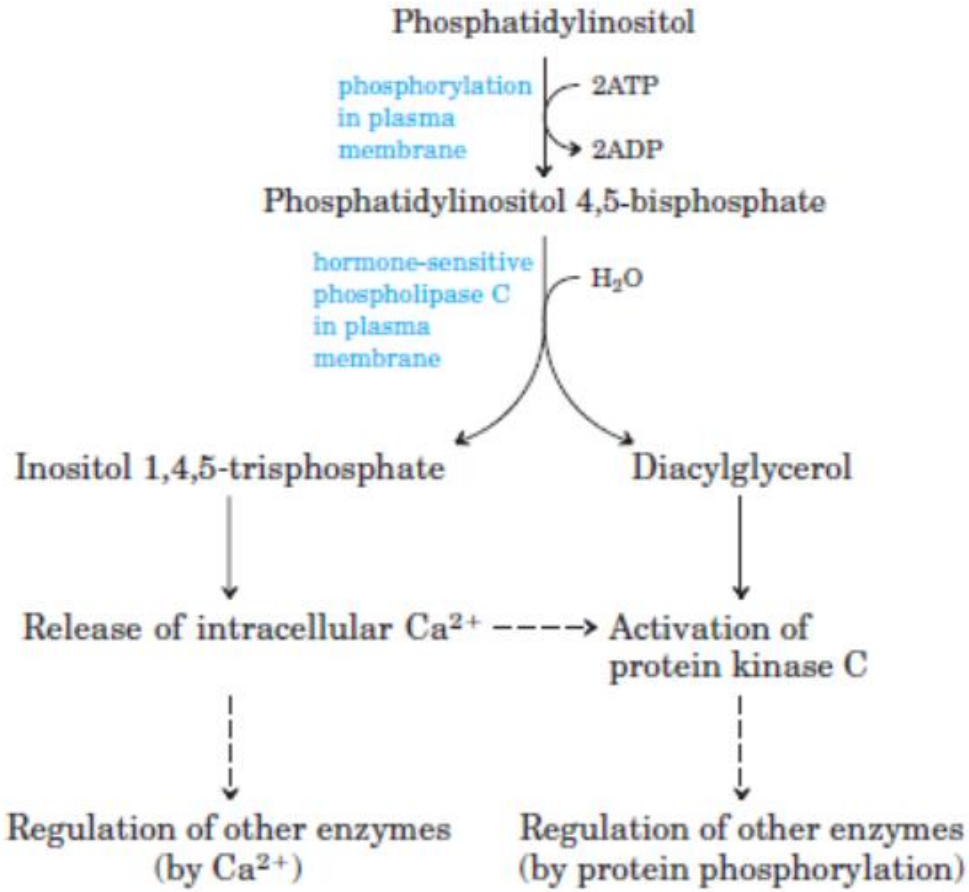


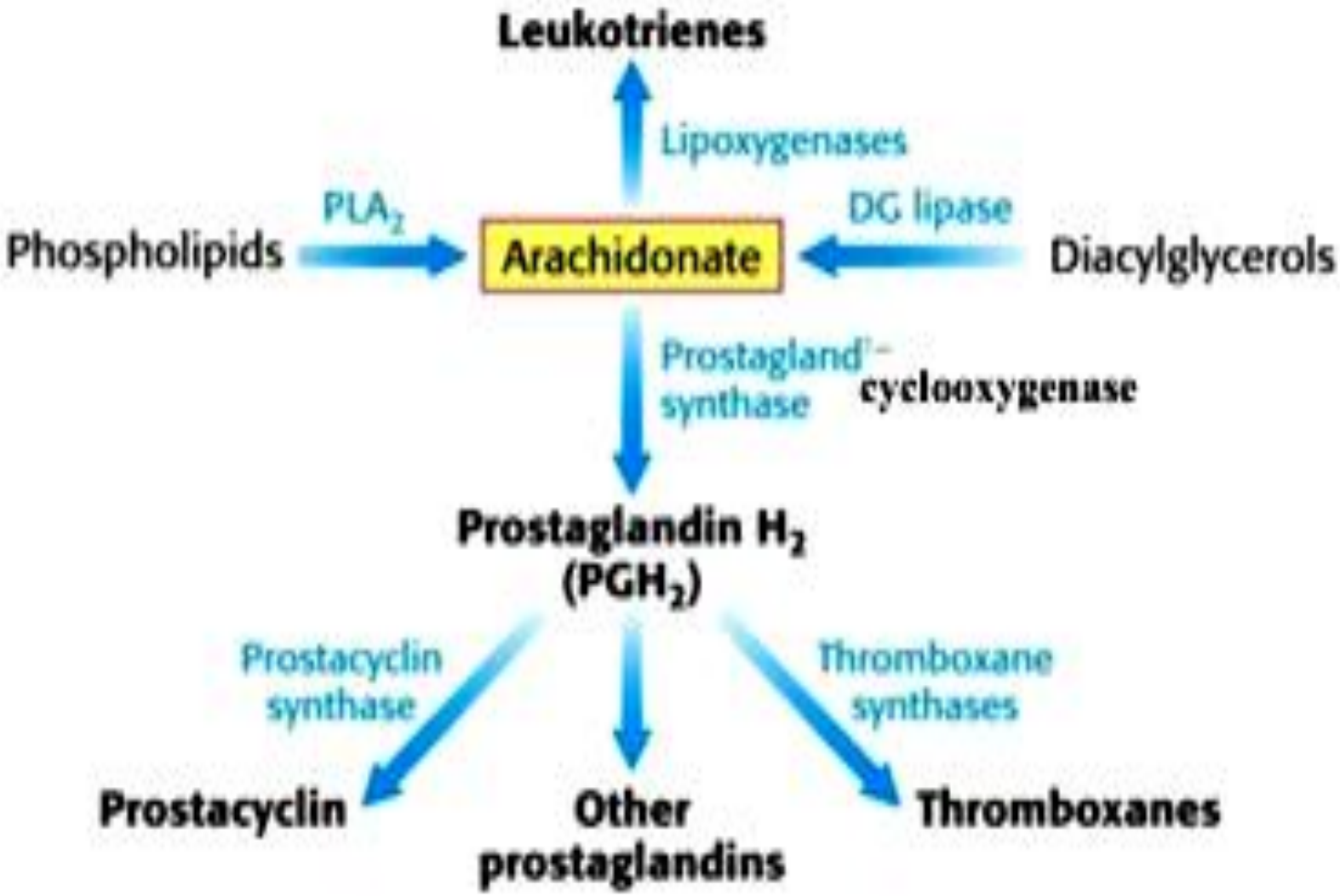
FIGURE 10–17 Phosphatidylinositols in cellular regulation. Phosphatidylinositol 4,5-bisphosphate in the plasma membrane is hydrolyzed by a specific phospholipase C in response to hormonal signals. Both products of hydrolysis act as intracellular messengers.

Membrane sphingolipids also can serve as sources of intracellular messengers. Both ceramide and sphingomyelin are potent regulators of protein kinases, and ceramide or its derivatives are known to be involved in the regulation of cell division, differentiation, migration, and programmed cell death.

Functional Lipid: Eicosanoids Carry Messages to Nearby Cells

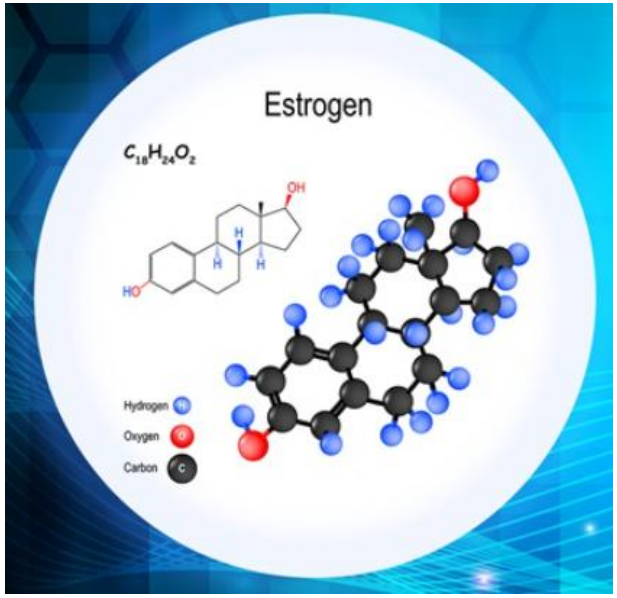
- **Eicosanoids are paracrine hormones**, substances that act only on cells near the point of hormone synthesis.
- All **eicosanoids are derived from arachidonic acid** (20:4(5,8,11,14)) (Fig. 10–18), the 20-carbon polyunsaturated fatty acid.
- There are three classes of eicosanoids: **prostaglandins**, **thromboxanes**, and **leukotrienes.**

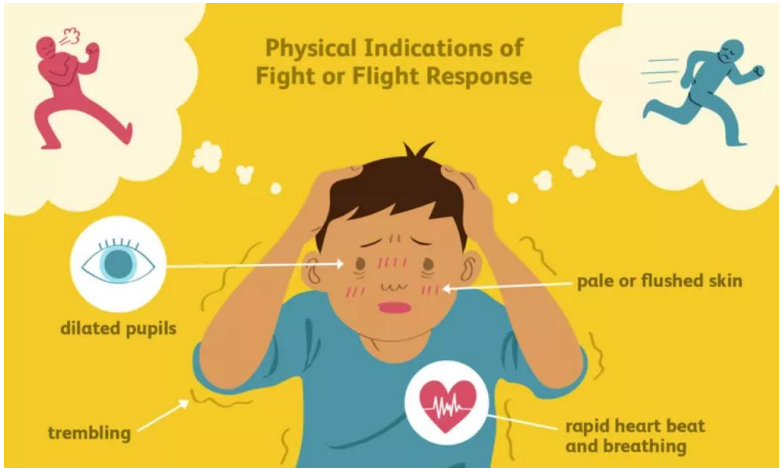
Eicosanoid


Leukotrienes
Lipoxygenases
PLA2
DG lipase
Phospholipids
Arachidonate
Diacylglycerols
Prostaglandin-synthase
cyclooxygenase
Prostaglandin H2 (PGH2)
Prostacyclin synthase
Thromboxane synthases
Prostacyclin
Other prostaglandins
Thromboxanes

Functional Lipid: Steroid Hormones Carry Messages between Tissues

- **Steroids are oxidized derivatives of sterols**; they have the sterol nucleus but lack the alkyl chain attached to ring D of cholesterol, and they are more polar than cholesterol.
- The major groups of steroid hormones are the **male and female sex hormones** and the hormones produced by the adrenal cortex, **cortisol and aldosterone**.

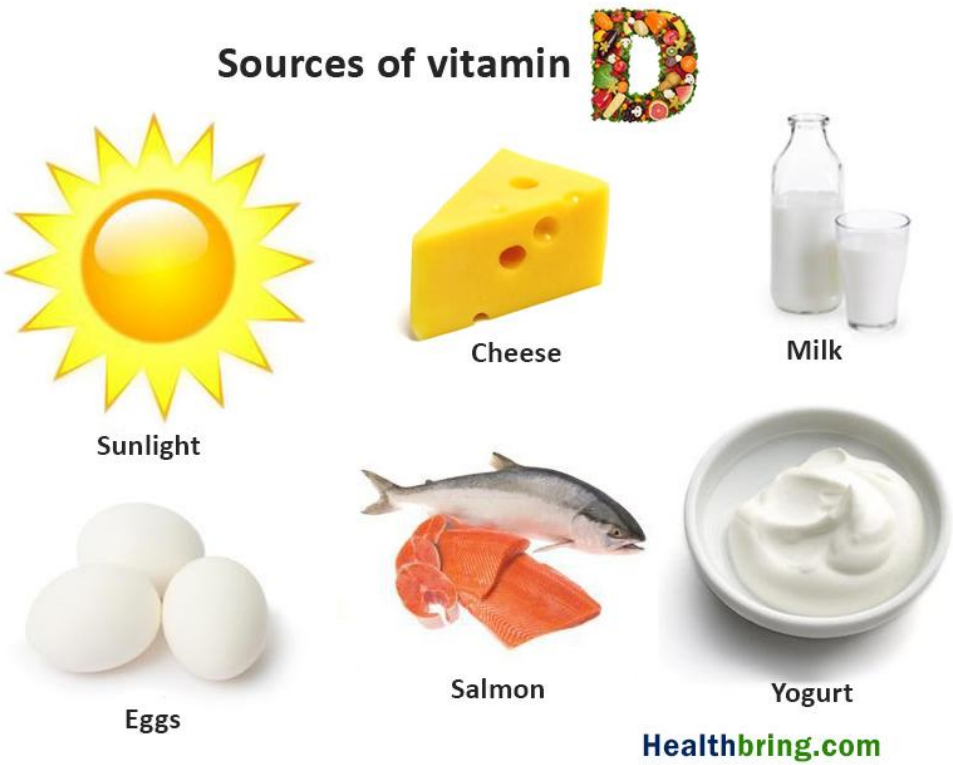




Functional Lipid: Vitamins D is Hormone Precursor

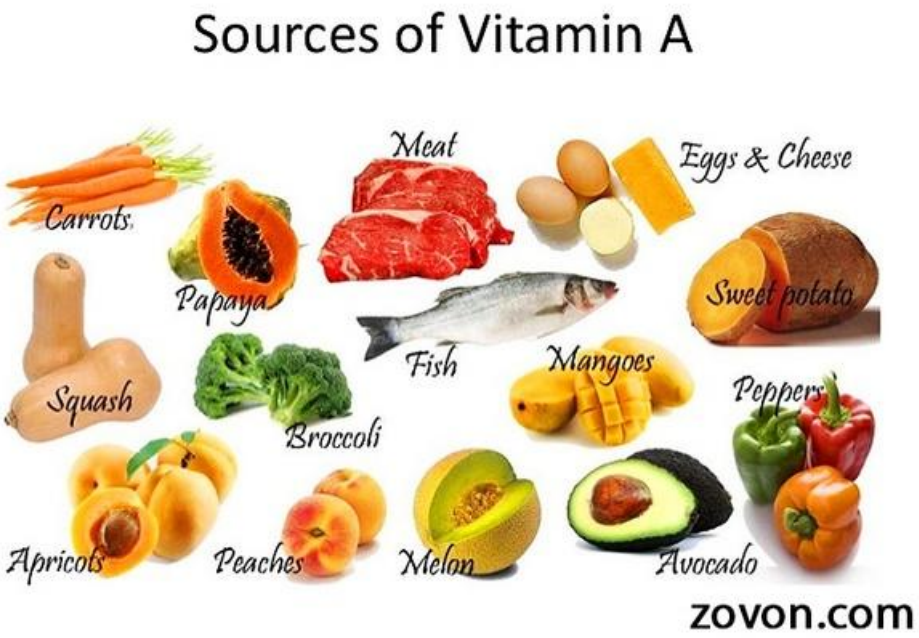
- **Vitamin D3, also called cholecalciferol, is normally** formed in the skin from 7-dehydrocholesterol in a photochemical reaction driven by the UV component of sunlight.

- **It regulates calcium uptake in the intestine and calcium levels in kidney and bone**



Functional Lipid: Vitamins A is Hormone Precursor

- **Vitamin A (retinol) in its various forms functions** as a hormone and as the **visual pigment of the vertebrate eye**.
- Acting through receptor proteins in the cell nucleus, the vitamin A derivative retinoic acid **regulates gene expression in the development of epithelial tissue, including skin**.



Functional Lipids: Vitamins E, K and Lipid Quinones are Oxidation-Reduction Cofactors

- **Vitamin E (tocopherols)** functions in the protection of membrane lipids from oxidative damage.
- **Vitamin K (phylloquinone)** is essential in the blood-clotting process.
- **Ubiquinones and plastoquinones**, also isoprenoid derivatives, function as electron carriers in mitochondria and chloroplasts, respectively.

Lipid Digestion & Absorption

Lipid Digestion

Stomach - lingual lipase and gastric lipase attack triacylglycerols and hydrolyse a limited number of FA.

Small Intestine - acid chyme (stomach contents) stimulates mucosa cells to release hormone (choleocystokinin) which stimulates gall bladder and pancreas to release bile and digestive enzymes respectively (bile acids help emulsify fat droplets thus increasing their surface area).

Other mucosa cells release secretin which causes pancreas to release bicarbonate rich fluid to neutralise chyme.

Enzymic digestion of lipids in small intestine

Triacylglycerol —(Pancreatic lipase)→ fatty acid + fatty acid + **2-monoacylglycerol**

i.e. two fatty acids from carbons 1 and 3 are removed leaving 1 fatty acid attached to carbon 2 of the glycerol.

Cholesteryl ester —(Cholesteryl ester hydrolase)→ Cholesterol + fatty acid

Cholesterol with fatty acid attached by ester linkage

Phospholipids —(Phospholipase A2)→ lysophospholipid + fatty acid

lysophospholipid —(lysophospholipase)→ Glycerolphosphoryl base + fatty acid

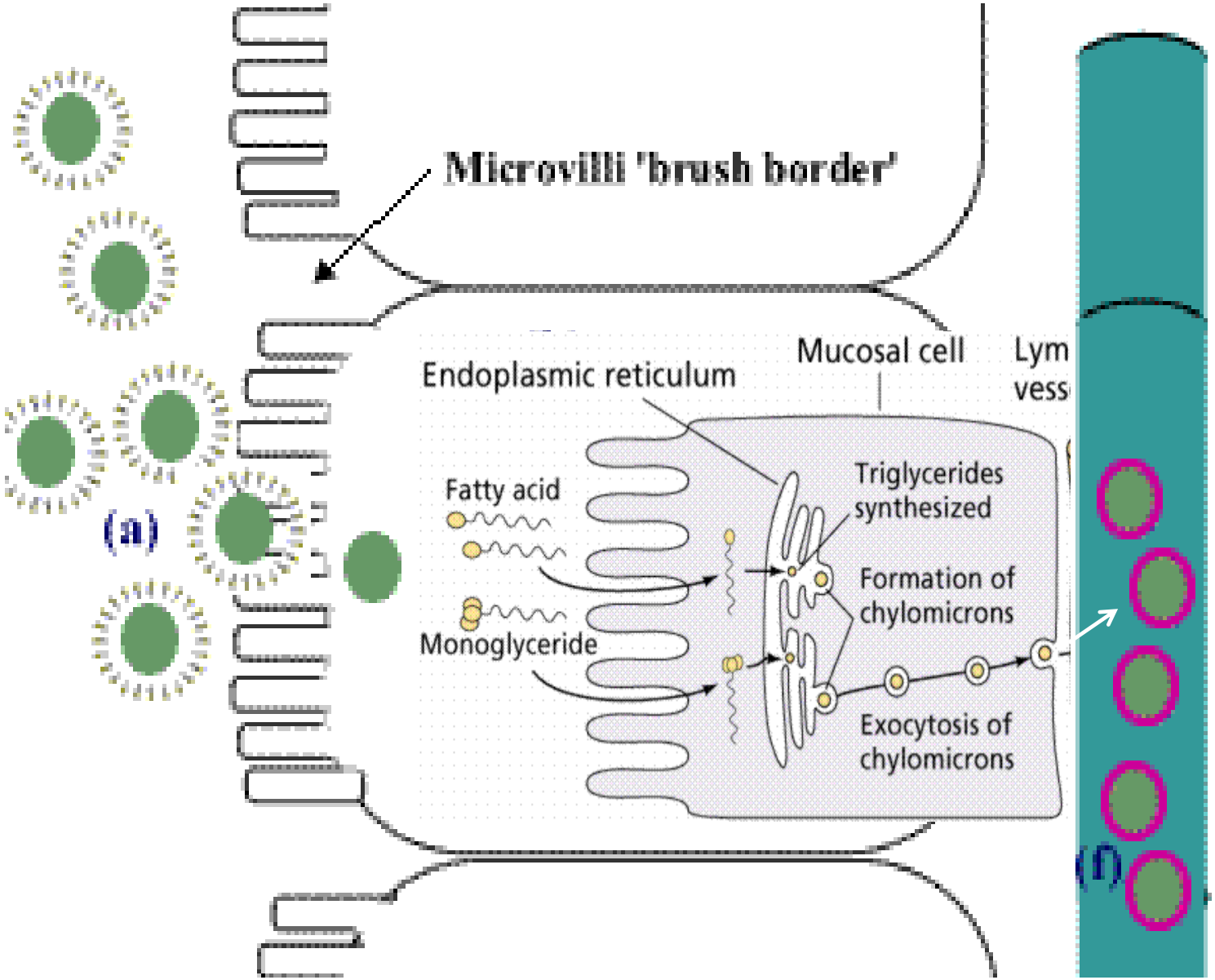
Lipid Absorption

- **Enzymic digestion generates more polar products that form mixed micelles of free fatty acids, 2-monoacylglycerol, cholesterol & bile salts which are absorbed by intestinal membrane.**

- **Adsorbed fatty acids and 2-monoacylglycerol are recombined to form triacylglycerol.**

- **Triacylglycerol + cholesterol + phospholipid + proteins form a lipoprotein complex called a chylomicron which transports the lipids in the circulation.**

Absorption of Lipids



Lipid Oxidation

What is rancidity and why is it a problem?

- **The process which causes a substance to become rancid, that is, having an unpleasant smell or taste.**

OR

- **The hydrolysis and/or autoxidation of fats into short-chain aldehydes and ketones which are objectionable in taste and odor.**

- **A. Foods that are high in lipids and might become rancid include potato chips, peanut butter, crackers, and others.**

- **B. Light, oxygen, trace elements such as iron and zinc, salt, water, bacteria, and molds are factors that speed up the oxidation process.**

RANCIDITY

- The condition reached in certain foods as the lipid material (fat) undergoes oxidation reactions producing aldehydes, hydroxyl acids, keta acids, and other compounds which are responsible for the odor and off-flavor producing stale foods
- Foods high in lipids
  - potato chips
  - peanut butter
  - crackers
- Factors causing rancidity
  - light
  - oxygen
  - trace elements (i.e.—iron, zinc)
  - salt
  - water
  - bacteria
  - mold

(Courtesy, Agricultural Research Service)

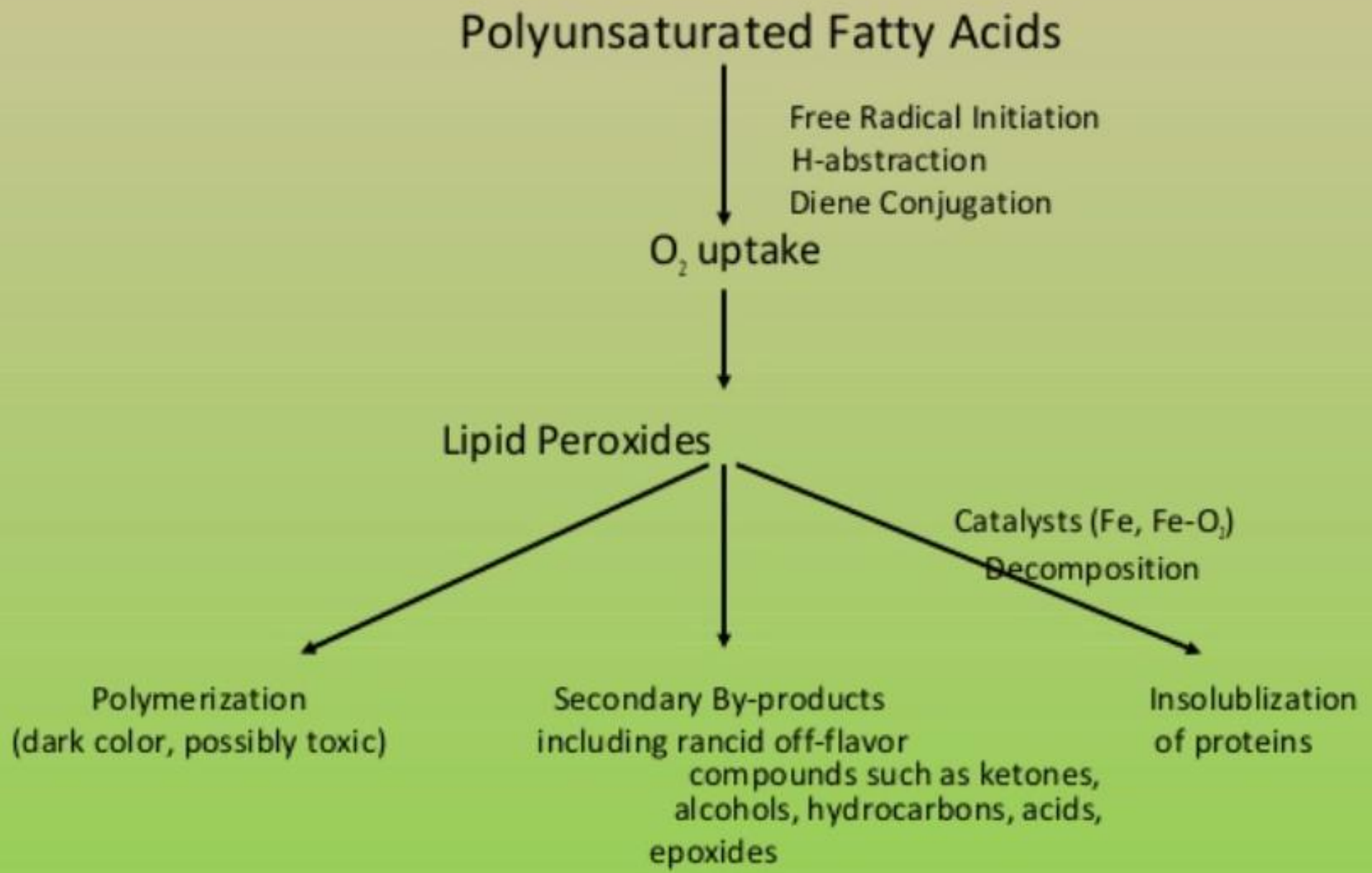
Lipid Oxidation

- What is Lipid Oxidation?

Ans: Fats, when in contact with air with o2 producing products with undesirable characteristics.

- The overall mechanism of lipid oxidation consists of three phases:
  - (1) initiation, the formation of free radicals;
  - (2) propagation, the free-radical chain reactions; and
  - (3) termination, the formation of nonradical products.

Autoxidation



Factors affecting the development of lipid oxidation in foods

- Fatty acid compositions
- Oxygen, free radicals
- Prooxidants
- Antioxidants and additives
- Processing conditions of meat
  - Irradiation
  - Cooking
  - Grinding, cutting, mixing, restructuring etc.
  - Packaging
- Storage: time and conditions