



INE | INSTITUTE OF
NUTRITIONAL
ENDOCRINOLOGY

Macronutrients: Fat Structure and Function

Dr. Ritamarie Loscalzo

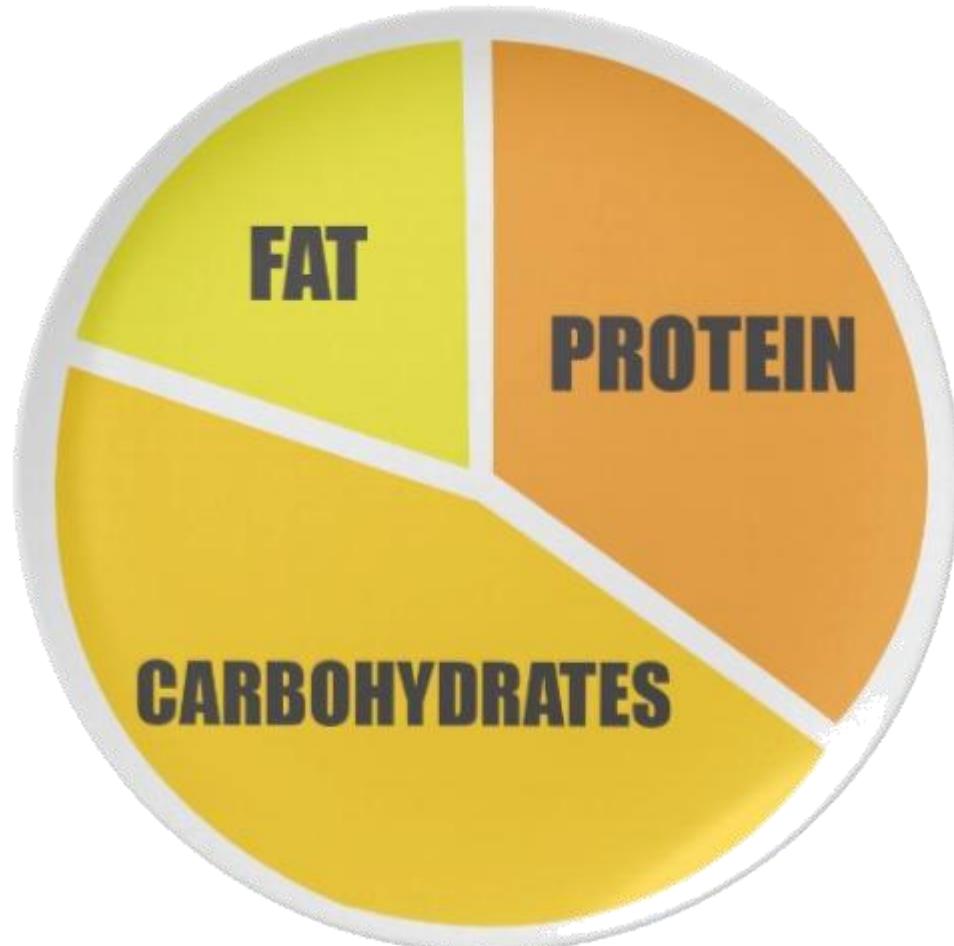


Medical Disclaimer: The information in this presentation is not intended to replace a one-on-one relationship with a qualified health care professional, and is not intended as medical advice. It is intended as a sharing of knowledge and information from the research and experience of Dr. Ritamarie Loscalzo, drritamarie.com, and the experts who have contributed. We encourage you to make your own health care decisions based upon your research and in partnership with a qualified health care professional.



Primary Macronutrients

- ✓ Water
- ✓ Fat
- ✓ Protein
- ✓ Carbohydrate



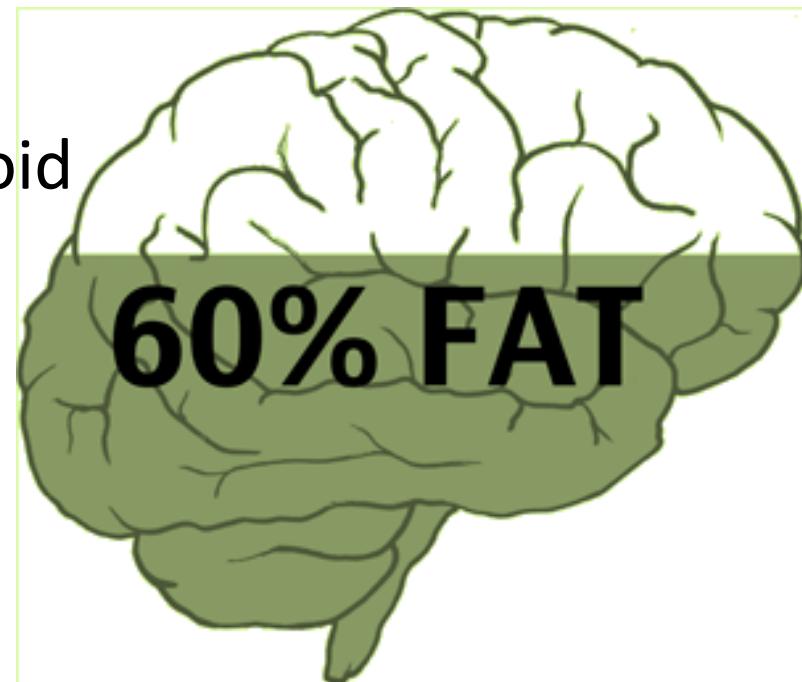
What You'll Learn:

- ✓ The importance of fat in the body
- ✓ Categories of fats
- ✓ Chemical structure of fats
- ✓ Omega classification of polyunsaturated fats
- ✓ Omega fats naming conventions
- ✓ Essential fats vs nonessential fats
- ✓ Refining and processing of fats



Importance of Fats in the Body

- ✓ More than $\frac{1}{2}$ dry weight of brain is fat and 25% of the body's cholesterol is in the brain
- ✓ Cholesterol is precursor of steroid hormones -- adrenal, sex, regulation of blood pressure
- ✓ Cell membranes are mostly fat
- ✓ Myelin sheaths are fat
- ✓ Hair and skin need fat
- ✓ Immune system and inflammation
- ✓ Improves absorption of fat-soluble vitamins



Importance of Fats in the Body

One cup of fresh avocado (150 grams) added to a salad of romaine lettuce, spinach, and carrots **increased absorption of carotenoids from this salad between 200-400%.**



Categories of Dietary Fats

Saturated Fats

- ✓ Meat
- ✓ Dairy
- ✓ Butter
- ✓ Cheese
- ✓ Ghee
- ✓ Eggs
- ✓ Coconut
- ✓ Palm

Monounsaturated Fats

- ✓ Olives
- ✓ Macadamia nuts
- ✓ Cashews
- ✓ Hazel nuts
- ✓ Avocado
- ✓ Sesame seeds
- ✓ Pecans
- ✓ Almonds

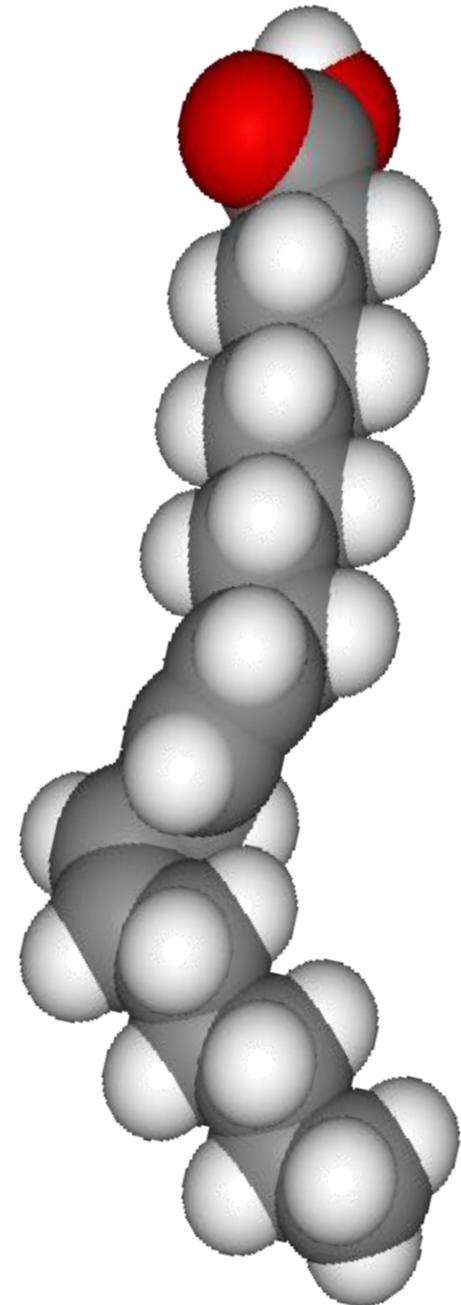
Polyunsaturated Fats

- ✓ Nuts
- ✓ Seeds
- ✓ Grains
- ✓ Vegetables
- ✓ Legumes
- ✓ Fish

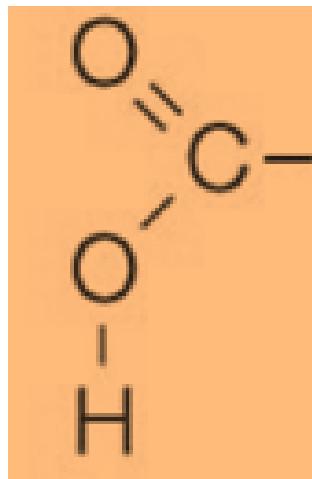
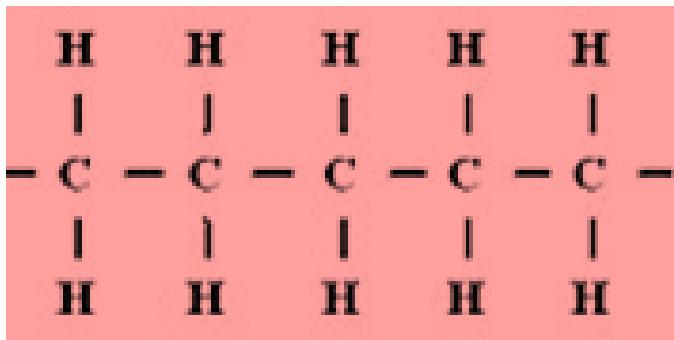


Fatty Acids

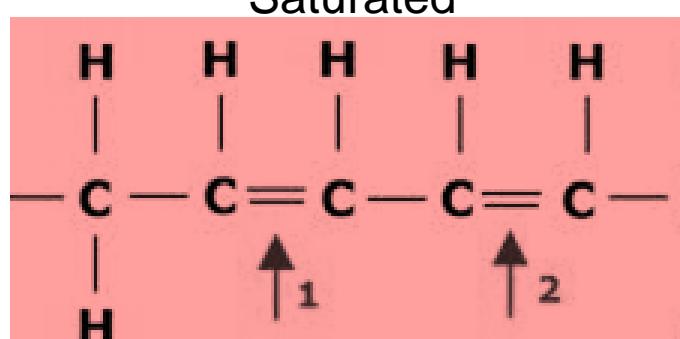
- ✓ Building blocks of fats
- ✓ Carboxylic acid with long carbon chain
- ✓ They differ by length of carbon tail, degree of saturation and position of double bond(s)
- ✓ Most fatty acids have 12 – 20 carbons
- ✓ Most have even number of carbons
- ✓ Linoleic acid - 18:2 (n-6) – 18 carbon fat, 2 double bonds, first double bond at 6th carbon from the methyl end (Omega-6)



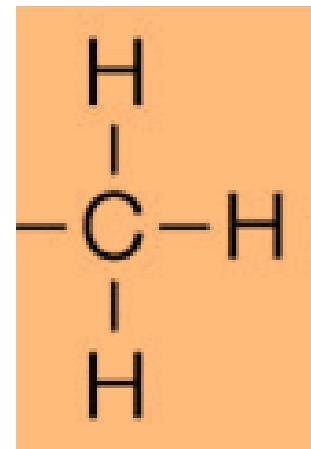
Structure of Fats



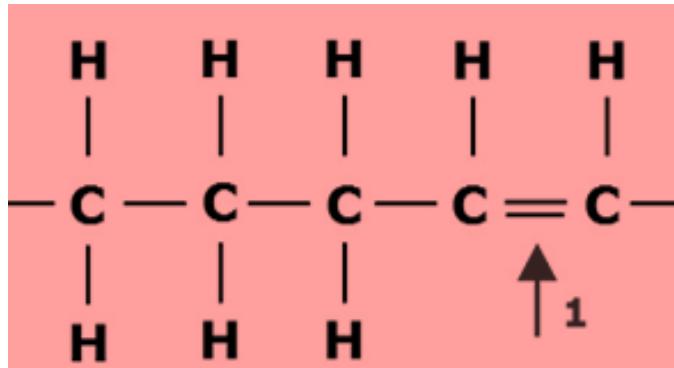
Carboxyl Group



Polyunsaturated



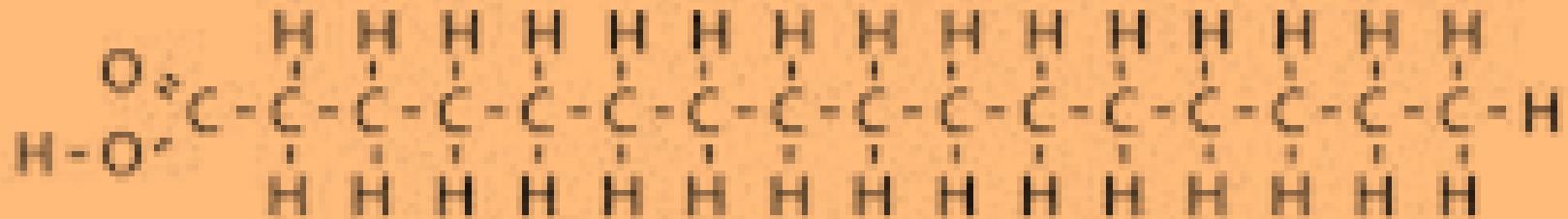
Methyl Group



Monounsaturated



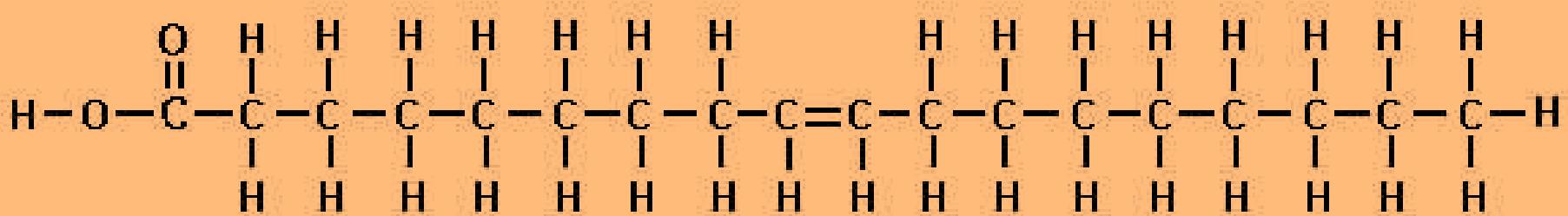
Saturated Fats



- ✓ **Butyric acid (C4)**
- ✓ Caproic acid (C6)
- ✓ **Caprylic acid (C8)**
- ✓ Capric acid (C10)
- ✓ **Lauric acid (C12)**
- ✓ **Myristic acid (C14)**
- ✓ Pentadecylic acid (C15)
- ✓ Palmitic acid (C16)
- ✓ Margaric acid (C17)
- ✓ Stearic acid (C18)
- ✓ Arachidic acid (C20)
- ✓ Behenic acid (C22)
- ✓ Lignoceric acid (C24)
- ✓ Cerotic acid (C26)



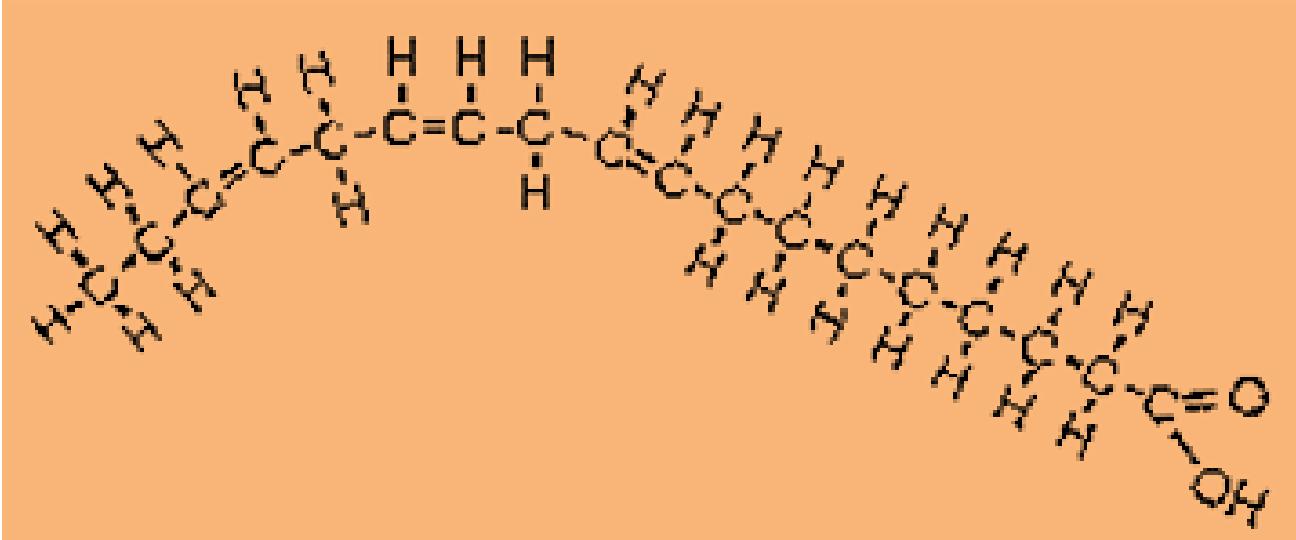
Monounsaturated Fats



- ✓ Myristoleic acid (14:1)
- ✓ Pentadecenoic (15:1)
- ✓ Palmitoleic acid (16:1)
- ✓ Heptadecenoic (17:1)
- ✓ Oleic acid (18:1)
- ✓ Eicosenoic acid (20:1)
- ✓ Erucic acid (22:1)
- ✓ Nervonic acid (24:1)



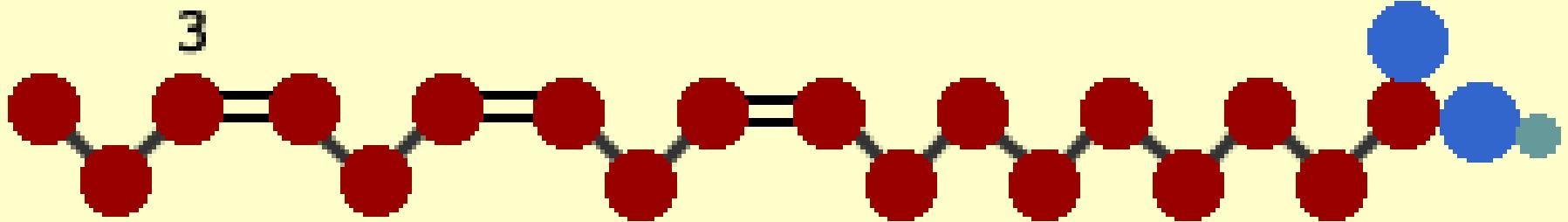
Polyunsaturated Fats



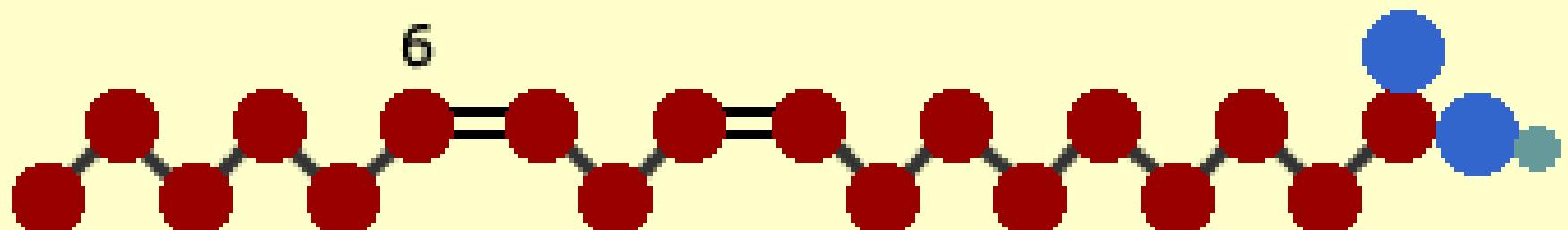
- ✓ Hexadecatrienoic acid
- ✓ Linoleic acid (LA)
- ✓ Alpha-linolenic acid (ALA)
- ✓ Gamma Linoleic Acid (GLA)
- ✓ Stearidonic acid (SDA)
- ✓ Eicosatrienoic acid (ETE)
- ✓ Eicosatetraenoic acid (ETA)
- ✓ Eicosapentaenoic acid (EPA)
- ✓ Arachidonic acid (AA)
- ✓ Heneicosapentaenoic acid (HPA)
- ✓ Docosadienoic acid
- ✓ Docosapentaenoic acid (DPA)
- ✓ Docosahexaenoic acid (DHA)
- ✓ Tetracosapentaenoic acid
- ✓ Tetracosahexaenoic acid



Omega Classification



Alpha-Linolenic acid (omega 3)



Linoleic acid (omega 6)



Omega Classification of Unsaturated Fats

Omega-3

- ✓ Alpha-linolenic acid (ALA)
- ✓ Eicosapentaenoic acid (EPA)
- ✓ Docosahexaenoic acid (DHA)

Omega-6

- ✓ Linoleic acid (LA)
- ✓ Gamma-linolenic acid (GLA)
- ✓ Dihomo-gamma-linolenic acid (DGLA)
- ✓ Arachidonic Acid (AA)

Omega-9

- ✓ Oleic
- ✓ Nervonic



Omega-3 Fatty Acids

- ✓ Hexadecatrienoic acid (HTA) 16:3 (n-3)
- ✓ Alpha-linolenic acid (ALA) 18:3 (n-3)
- ✓ Stearidonic acid (SDA) 18:4 (n-3)
- ✓ Eicosatrienoic acid (ETE) 20:3 (n-3)
- ✓ Eicosatetraenoic acid (ETA) 20:4 (n-3)
- ✓ Eicosapentaenoic acid (EPA) 20:5 (n-3)
- ✓ Heneicosapentaenoic acid (HPA) 21:5 (n-3)
- ✓ Docosapentaenoic acid (DPA) 22:5 (n-3)
- ✓ Docosahexaenoic acid (DHA) 22:6 (n-3)



Omega-6 Fatty Acids

- ✓ Linoleic acid (LA) (18:2 n-6)
- ✓ Gamma-linolenic acid (GLA) (18:3 n-6)
- ✓ Eicosadienoic acid (20:2 n-6)
- ✓ Dihomo-gamma-linolenic acid (DGLA) (20:3 n-6)
- ✓ Arachidonic acid (AA) (20:4 n-6)
- ✓ Docosadienoic acid (22:2 n-6)
- ✓ Docosatetraenoic acid (22:4 n-6)
- ✓ Tetracosatetraenoic acid (24:4 n-6)
- ✓ Tetracosapentaenoic acid (24:5 n-6)



Fatty Acid Composition of Common Fats

	Saturated	Monounsaturated	Polyunsaturated	Cholesterol	Vitamin E
	g/100g	g/100g	g/100g	mg/100g	mg/100g
Animal fats					
Lard	40.8	43.8	9.6	93	0.00
Duck fat ^[12]	33.2	49.3	12.9	100	2.70
Butter	54.0	19.8	2.6	230	2.00
Vegetable fats					
Coconut oil	85.2	6.6	1.7	0	.66
Palm kernel oil	81.5	11.4	1.6	0	3.80
Palm oil	45.3	41.6	8.3	0	33.12
Cottonseed oil	25.5	21.3	48.1	0	42.77
Wheat germ oil	18.8	15.9	60.7	0	136.65
Soybean oil	14.5	23.2	56.5	0	16.29
Olive oil	14.0	69.7	11.2	0	5.10
Corn oil	12.7	24.7	57.8	0	17.24
Sunflower oil	11.9	20.2	63.0	0	49.00
Safflower oil	10.2	12.6	72.1	0	40.68
Hemp oil	10	15	75	0	12.34
Canola/Rapeseed oil	5.3	64.3	24.8	0	22.21



Results of Imbalances in Omega-3 and Omega-6 Fats

- ✓ Inflammation and chronic pain
- ✓ Heart disease
- ✓ Clotting disorders
- ✓ Hormonal imbalances
- ✓ Depression and anxiety
- ✓ Autoimmune disease
- ✓ Asthma
- ✓ Rashes
- ✓ Dry, flaky skin and dandruff



0241 Bloodspot Fatty Acid Profile

Methodology: Capillary Gas Chromatography/Mass Spectrometry

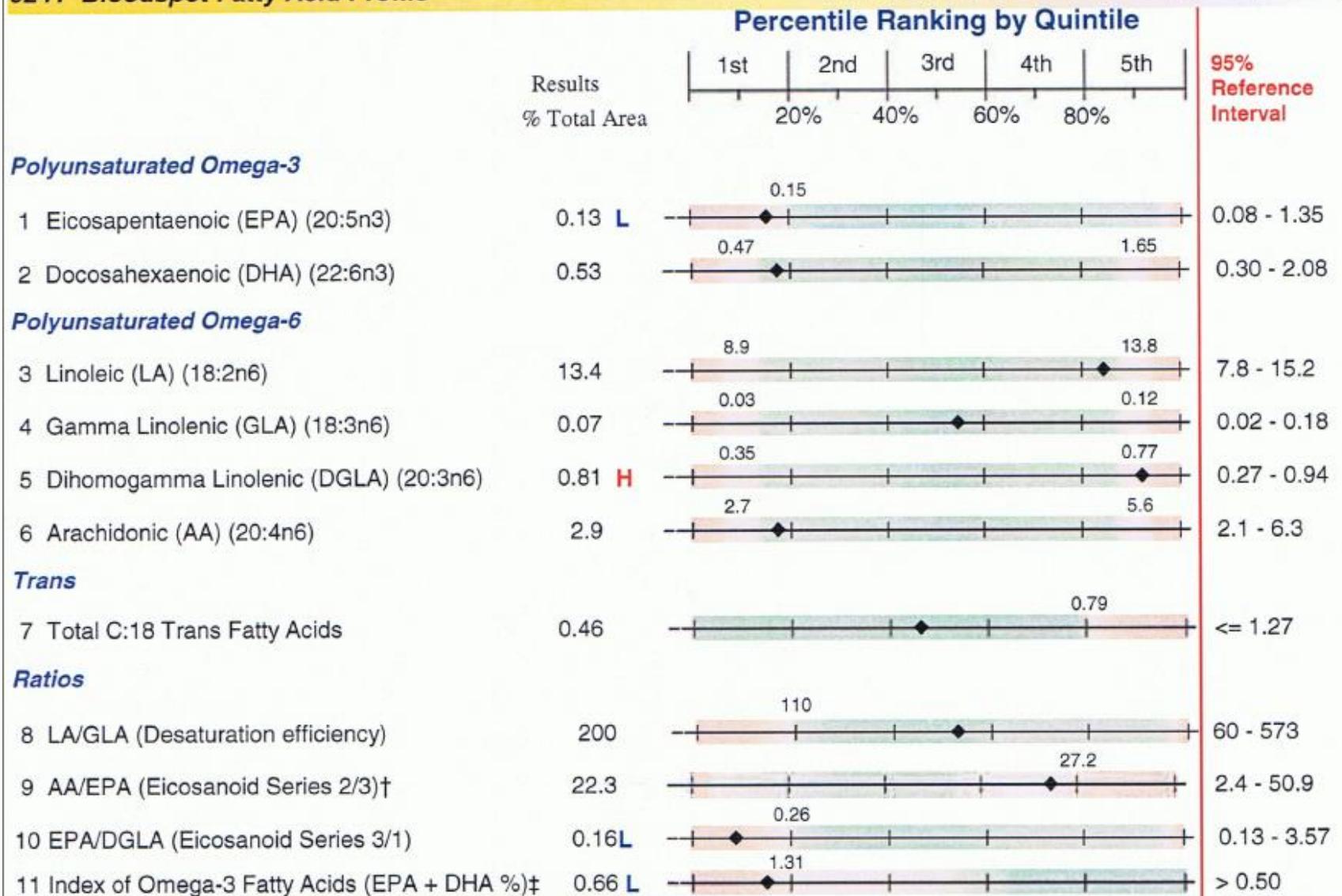
Percentile Ranking by Quintile

†Sears, B. *Toxic Fat: When Good Fat Turns Bad*. 1st ed. Nashville, TN: Thomas Nelson; 2008.‡Harris, WS. Omega - 3 fatty acids and cardiovascular disease: A case for omega-3 index as a new risk factor. *Pharmacological Research* 2007; 55:217-223.

60 YO Female - Depression Celiac

0241 Bloodspot Fatty Acid Profile

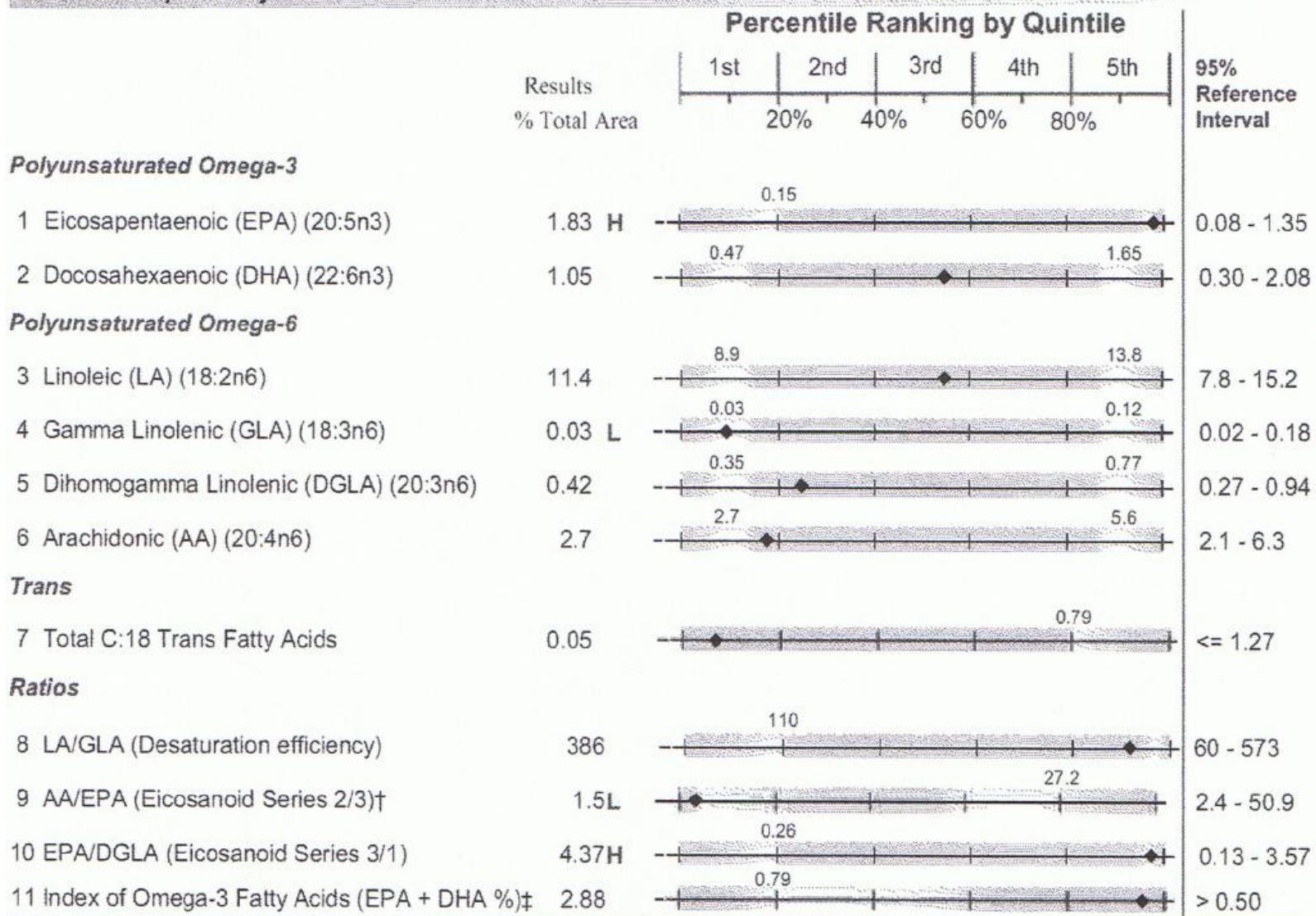
Methodology: Capillary Gas Chromatography/Mass Spectrometry



60 YO Female - 4 Months Later

0241 Bloodspot Fatty Acid Profile

Methodology: Capillary Gas Chromatography/Mass Spectrometry



Omega 3 Fatty Acids

Analyte

(cold water fish, flax, walnut)

Reference Range

α -Linolenic (ALA) 18:3 n3	0.14	≥ 0.09 wt %
Eicosapentaenoic (EPA) 20:5 n3	0.86	≥ 0.16 wt %
Docosapentaenoic (DPA) 22:5 n3	2.53	≥ 1.14 wt %
Docosahexaenoic (DHA) 22:6 n3	7.3	≥ 2.1 wt %
% Omega 3s	10.9	≥ 3.8



Omega 6 Fatty Acids

Analyte

(vegetable oil, grains, most meats, dairy)

Reference Range

Linoleic (LA) 18:2 n6	9.6	10.5-16.9 wt %
γ-Linolenic (GLA) 18:3 n6	0.09	0.03-0.13 wt %
Dihomo-γ-linolenic (DGLA) 20:3 n6	1.10	>= 1.19 wt %
Arachidonic (AA) 20:4 n6	22	15-21 wt %
Docosatetraenoic (DTA) 22:4 n6	3.24	1.50-4.20 wt %
Eicosadienoic 20:2 n6	0.18	<= 0.26 wt %
% Omega 6s	36.4	30.5-39.7



Omega 9 Fatty Acids

Analyte

Reference Range

(olive oil)

Oleic 18:1 n9	11	10-13 wt %
Nervonic 24:1 n9	3.2	2.1-3.5 wt %
% Omega 9s	14.2	13.3-16.6



Monounsaturated Fats

Omega 7 Fats

Reference Range

Palmitoleic 16:1 n7	 0.24	<= 0.64 wt %
Vaccenic 18:1 n7	 0.65	<= 1.13 wt %

Trans Fat

Elaidic 18:1 n9t	 0.27	<= 0.59 wt %
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Saturated Fatty Acids

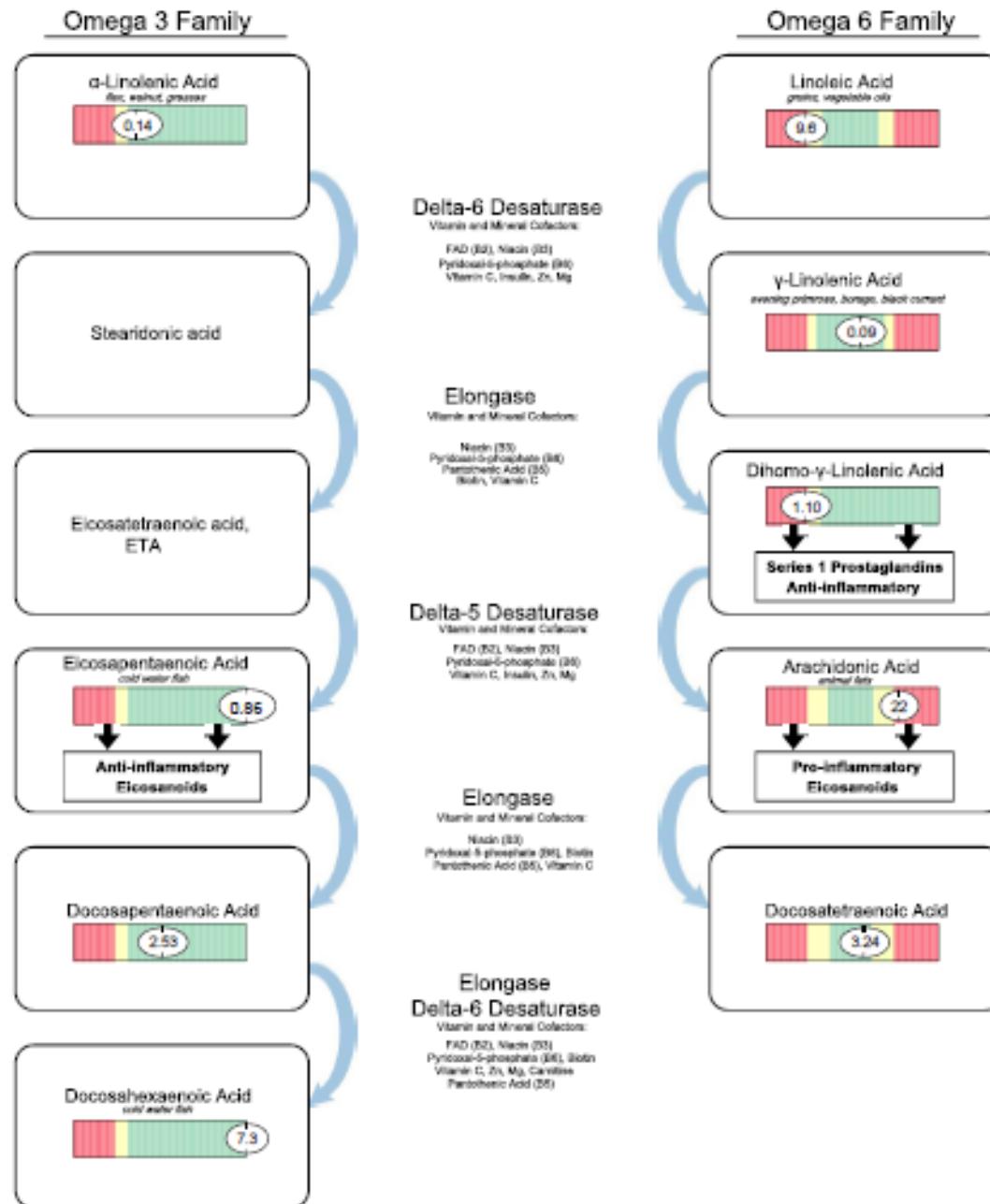
Analyte

(meat, dairy, coconuts, palm oils)

Reference Range

Palmitic C16:0	17	18-23 wt %
Stearic C18:0	16	14-17 wt %
Arachidic C20:0	0.23	0.22-0.35 wt %
Behenic C22:0	0.98	0.92-1.68 wt %
Tricosanoic C23:0	0.22	0.12-0.18 wt %
Lignoceric C24:0	2.9	2.1-3.8 wt %
Pentadecanoic C15:0	0.11	0.07-0.15 wt %
Margaric C17:0	0.27	0.22-0.37 wt %
% Saturated Fats	37.4	39.8-43.6



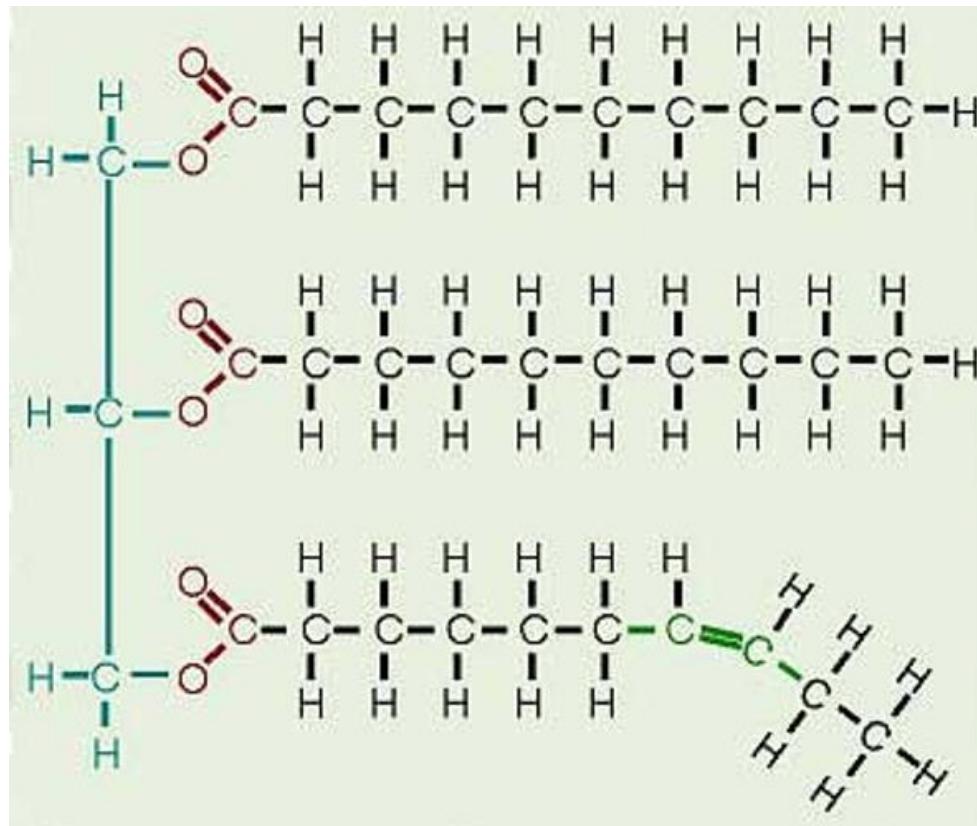


This test was developed and its performance characteristics determined by Genova Diagnostics, Inc. It has not been cleared or approved by the U.S. Food and Drug Administration.



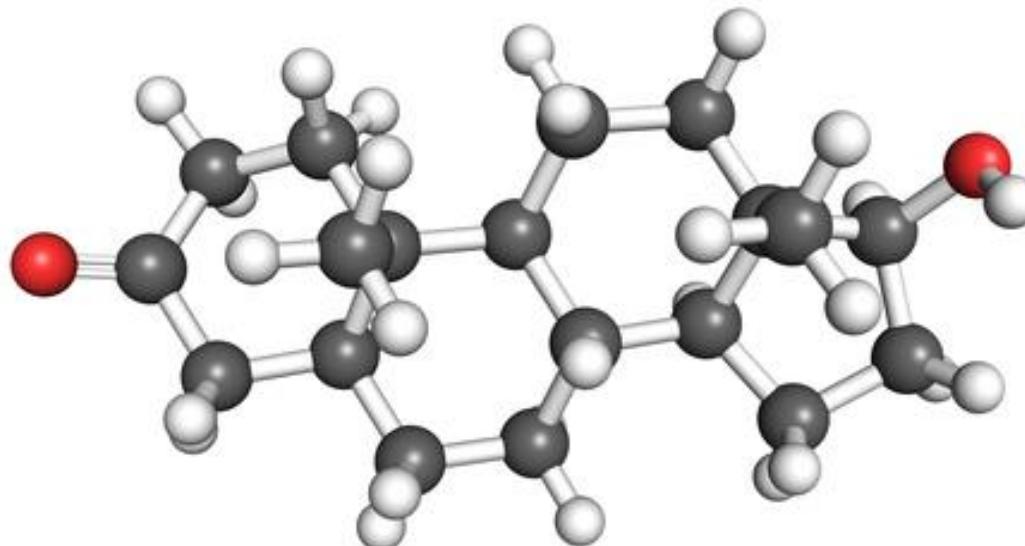
Triglycerides

- ✓ Concentrated form of stored energy
- ✓ 95% of dietary fat
- ✓ Liquid or solid depending on fatty acids

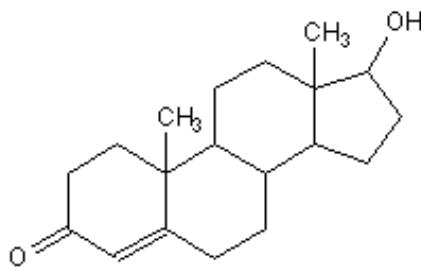


Steroids

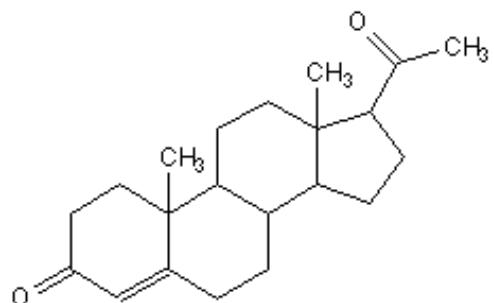
- ✓ Four rings of carbon atoms, three six-membered and one five
- ✓ Many hormones, alkaloids, and vitamins
- ✓ Corticosteroids are hormones produced in the adrenal cortex



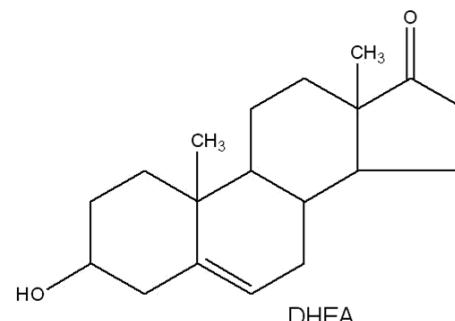
Steroids



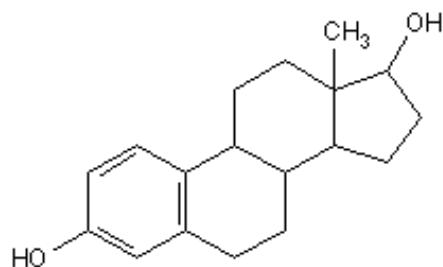
Testosterone



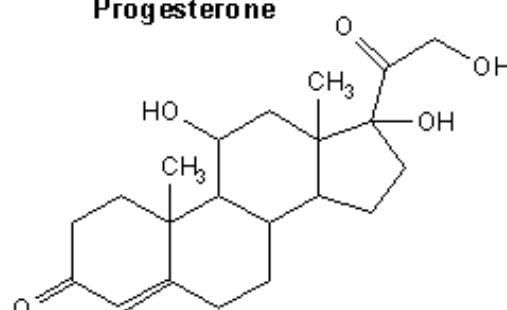
Progesterone



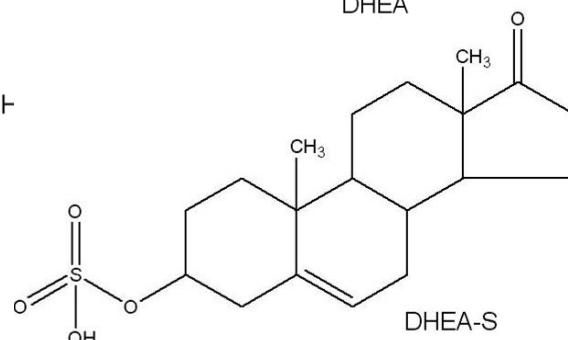
DHEA



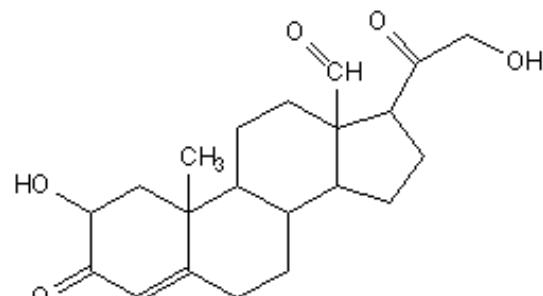
Estradiol



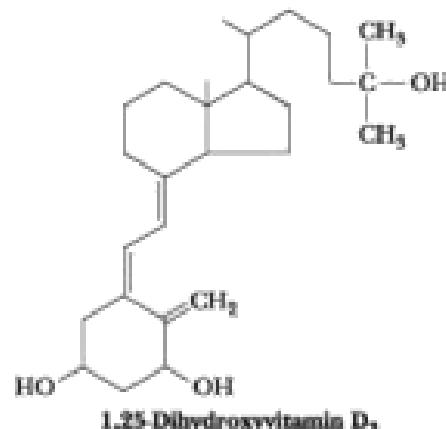
Cortisol



DHEA-S



Aldosterone

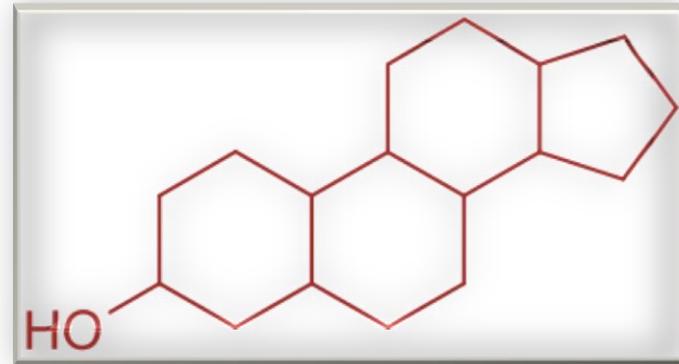


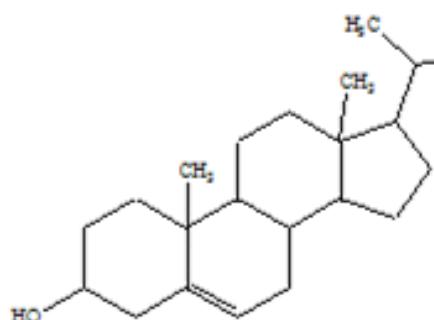
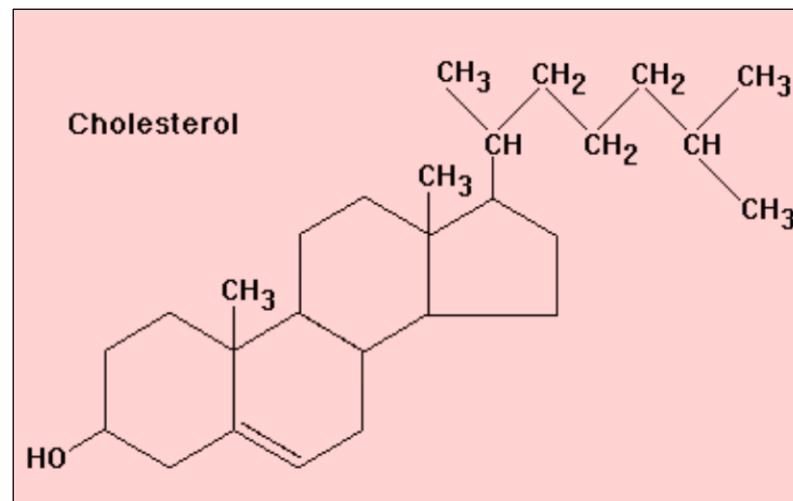
1,25-Dihydroxyvitamin D₃



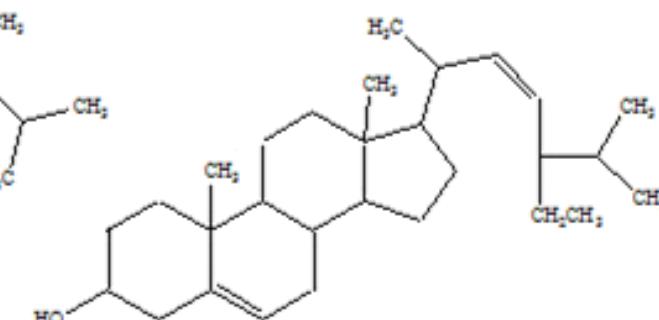
Sterols

- ✓ Subgroup of the steroids known as steroid alcohols
- ✓ Plant sterols are called phytosterols
- ✓ Animal sterols are called zoosterols
- ✓ Cholesterol is the most well known animal sterol
 - Vital to animal cell membrane structure and function
 - Precursor to fat-soluble vitamins and steroid hormones
 - Precursor to bile acids
- ✓ Ergosterol found in fungi cell membrane: role similar to cholesterol in animal cells
- ✓ Phytosterols block cholesterol absorption sites in the human intestine, thus helping to reduce cholesterol in humans

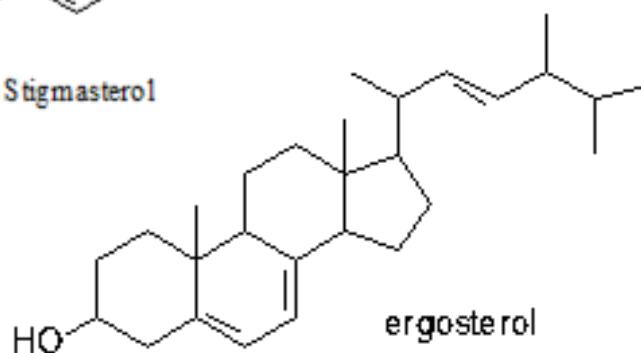




Sitosterol

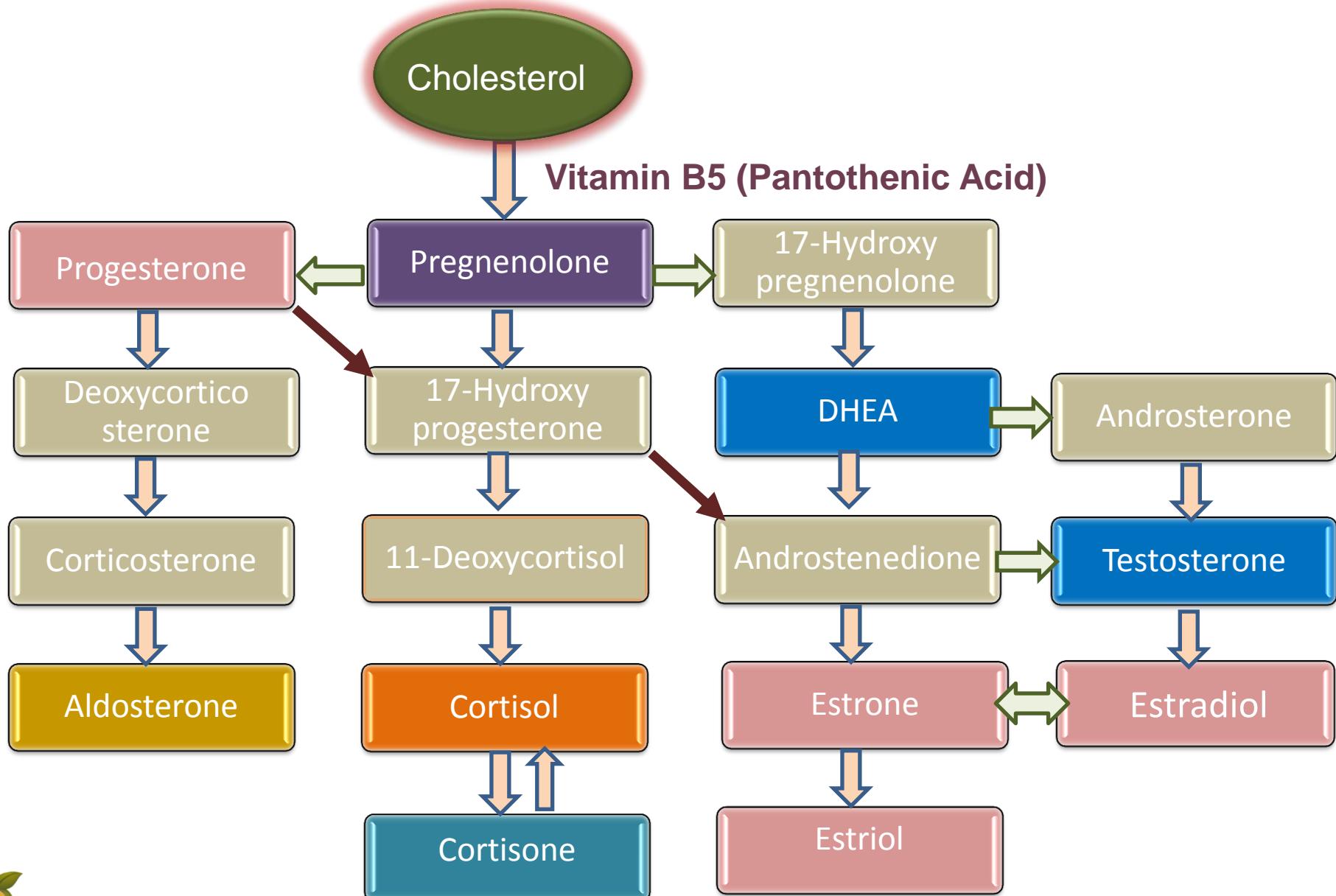


Stigmasterol



ergosterol





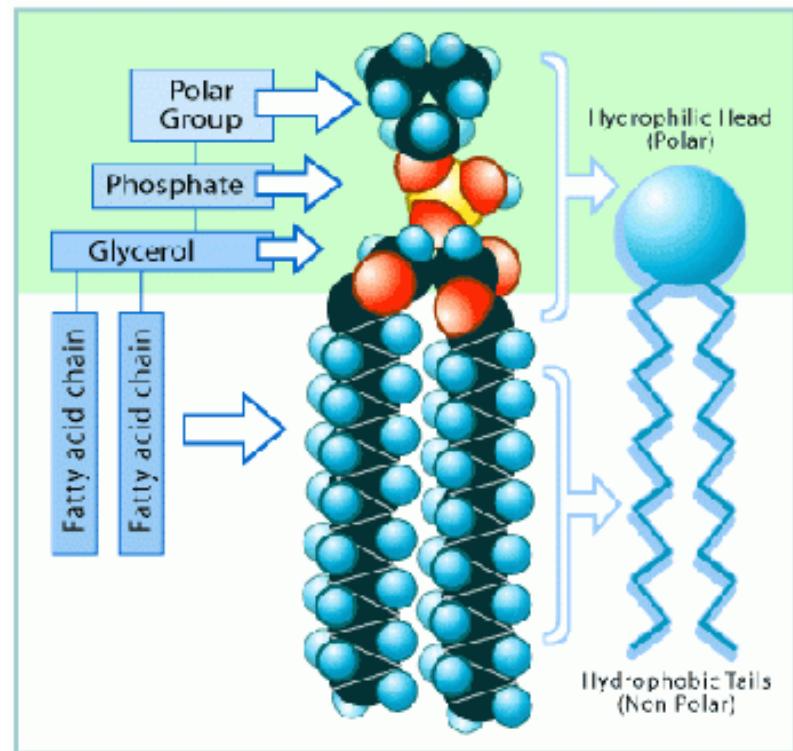
Phospholipids

✓ Spingophosphatides
(including inositol derivatives):

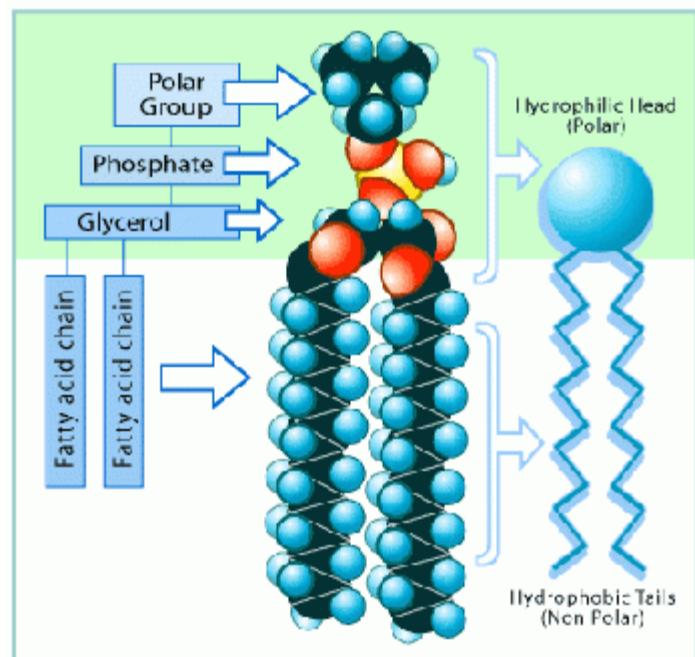
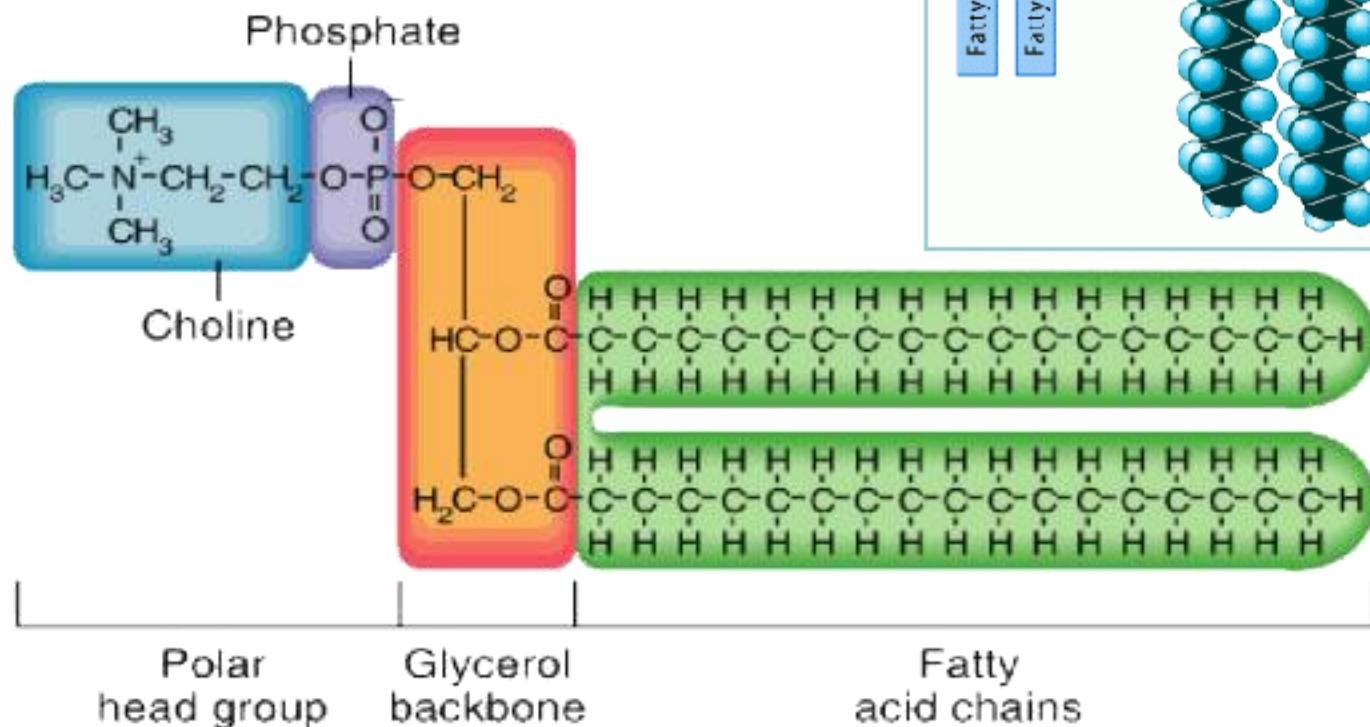
backbone of sphingosine
(myelin sheaths)

✓ Glycerophosphatides:
backbone of glycerol

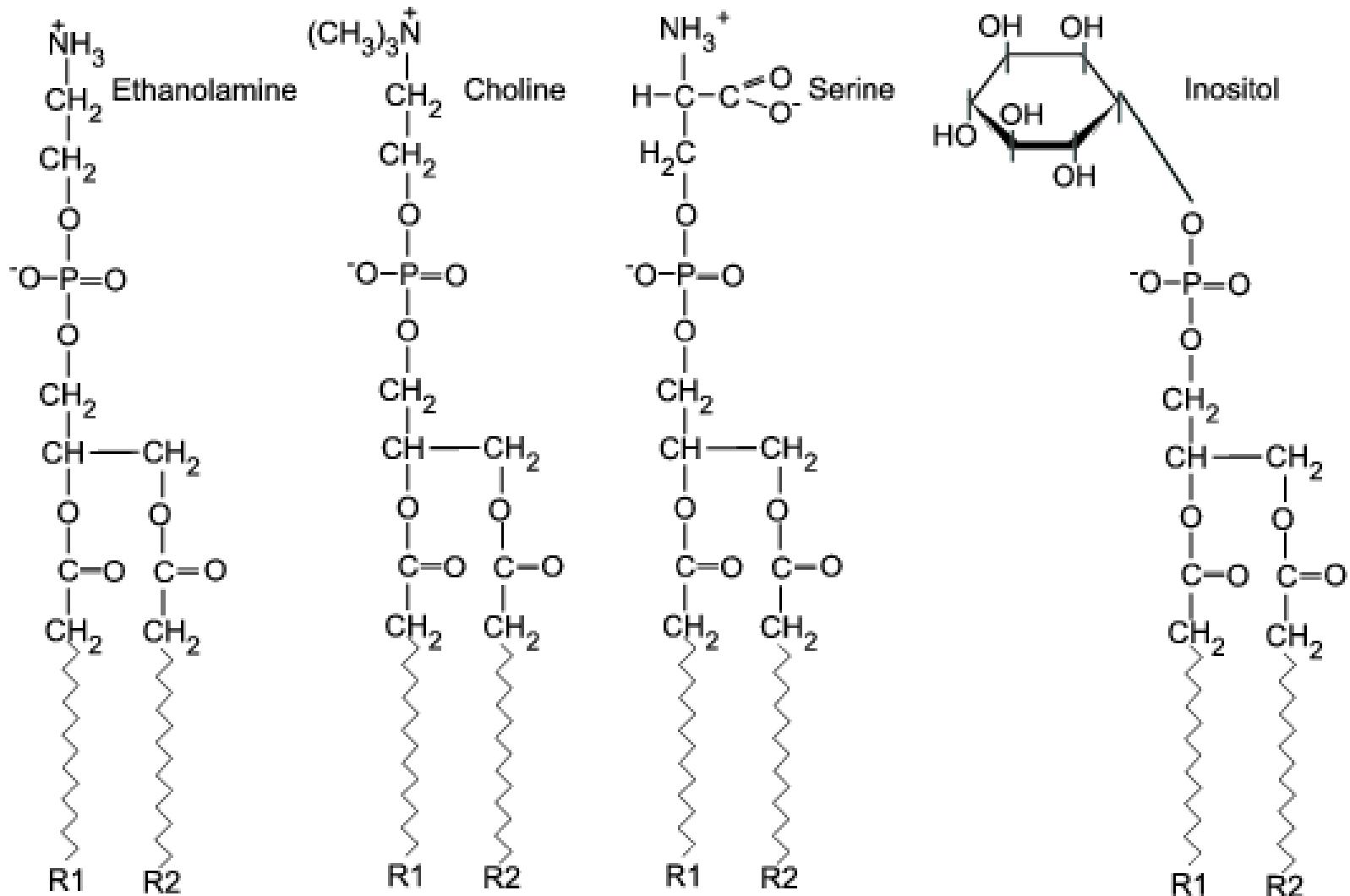
- lecithin: phosphatidylcholine,
phosphatidylethanolamine, and
phosphatidylinositol



Phosphatidylcholine

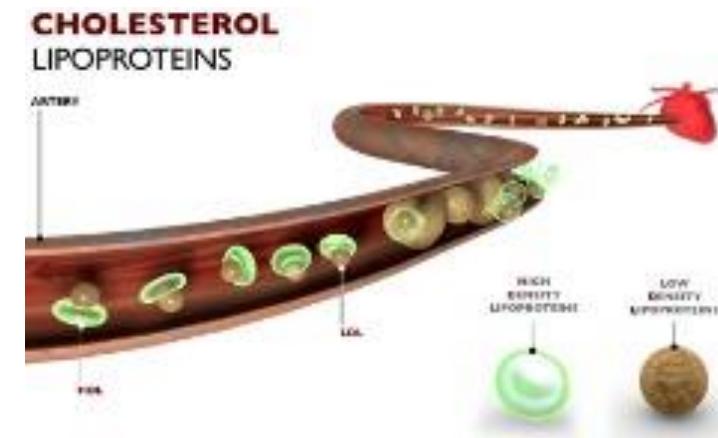


Phospholipid Molecules



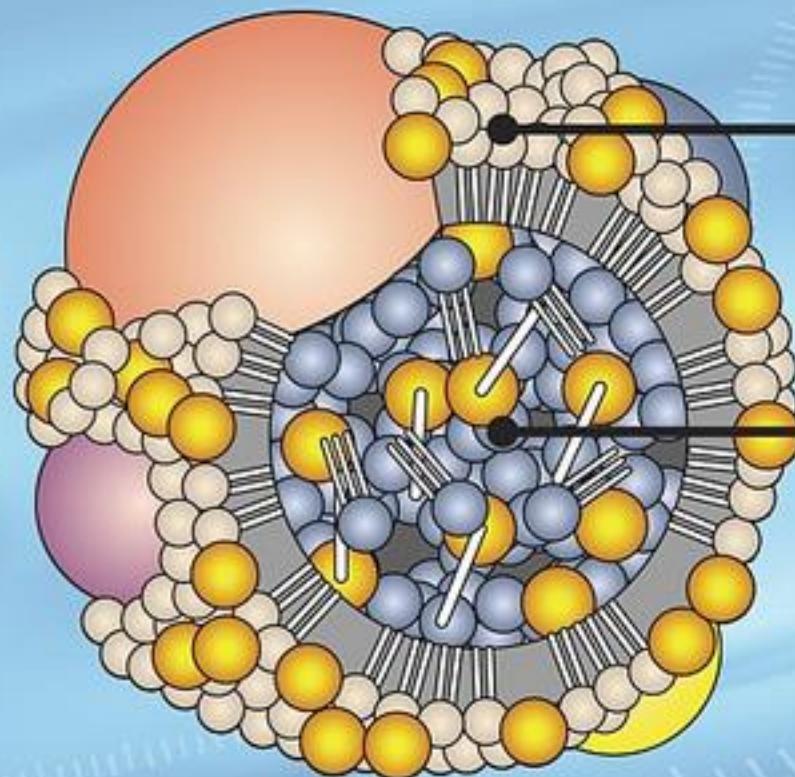
Lipoproteins

- ✓ Lipids bound to proteins to allow transport through the bloodstream
- ✓ The proteins emulsify the lipid molecules
- ✓ Many enzymes, transporters, structural proteins, antigens, adhesins, and toxins are lipoproteins
- ✓ Examples
 - High Density Lipoproteins (HDL)
 - Low Density Lipoproteins (LDL)
 - Very Low Density Lipoproteins (VLDL)





GENERAL STRUCTURE OF A LIPOPROTEIN



Polar surface envelope

Apolipoprotein



Free cholesterol



Phospholipid



Neutral lipid core

Cholesteryl ester



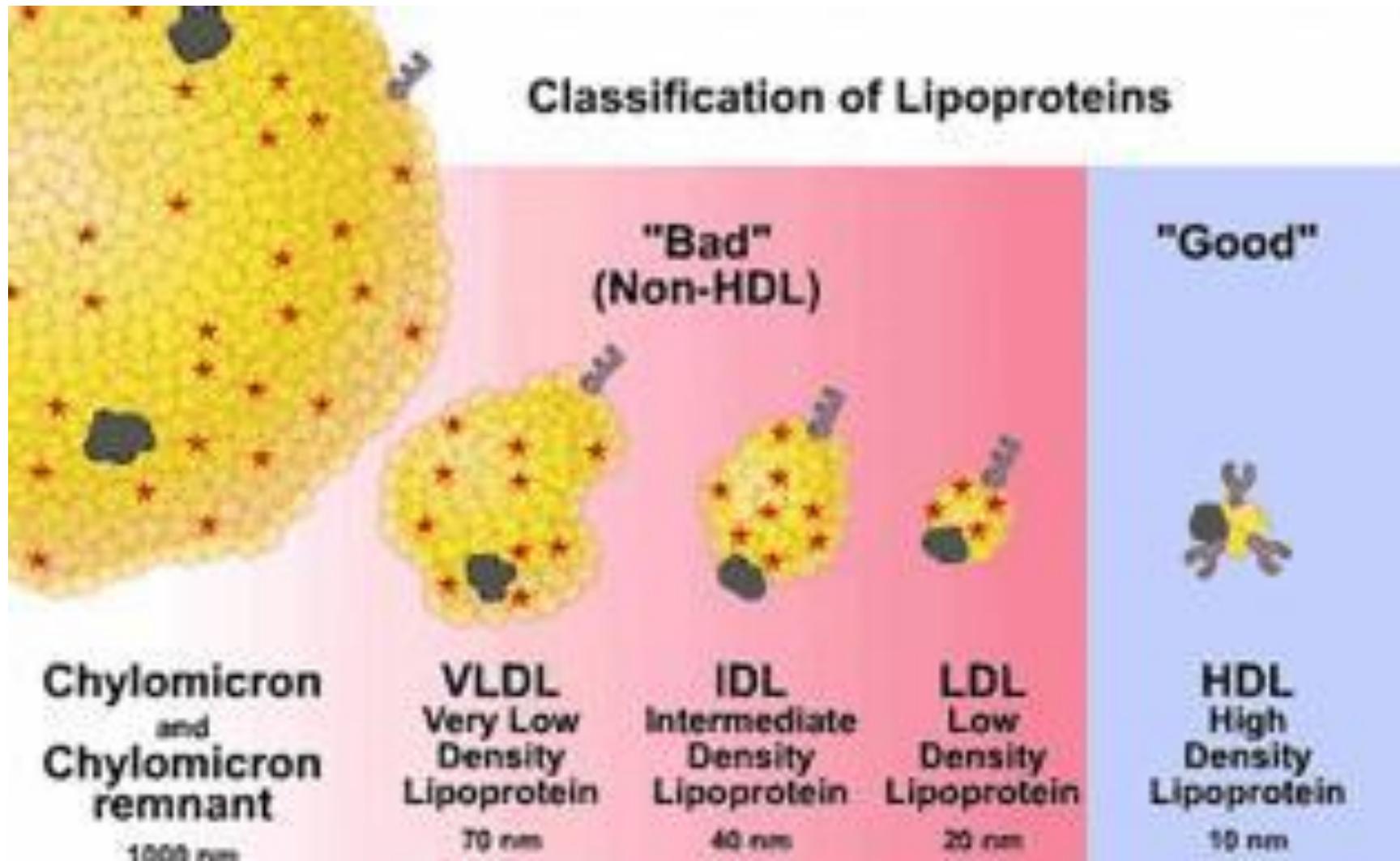
Triglyceride



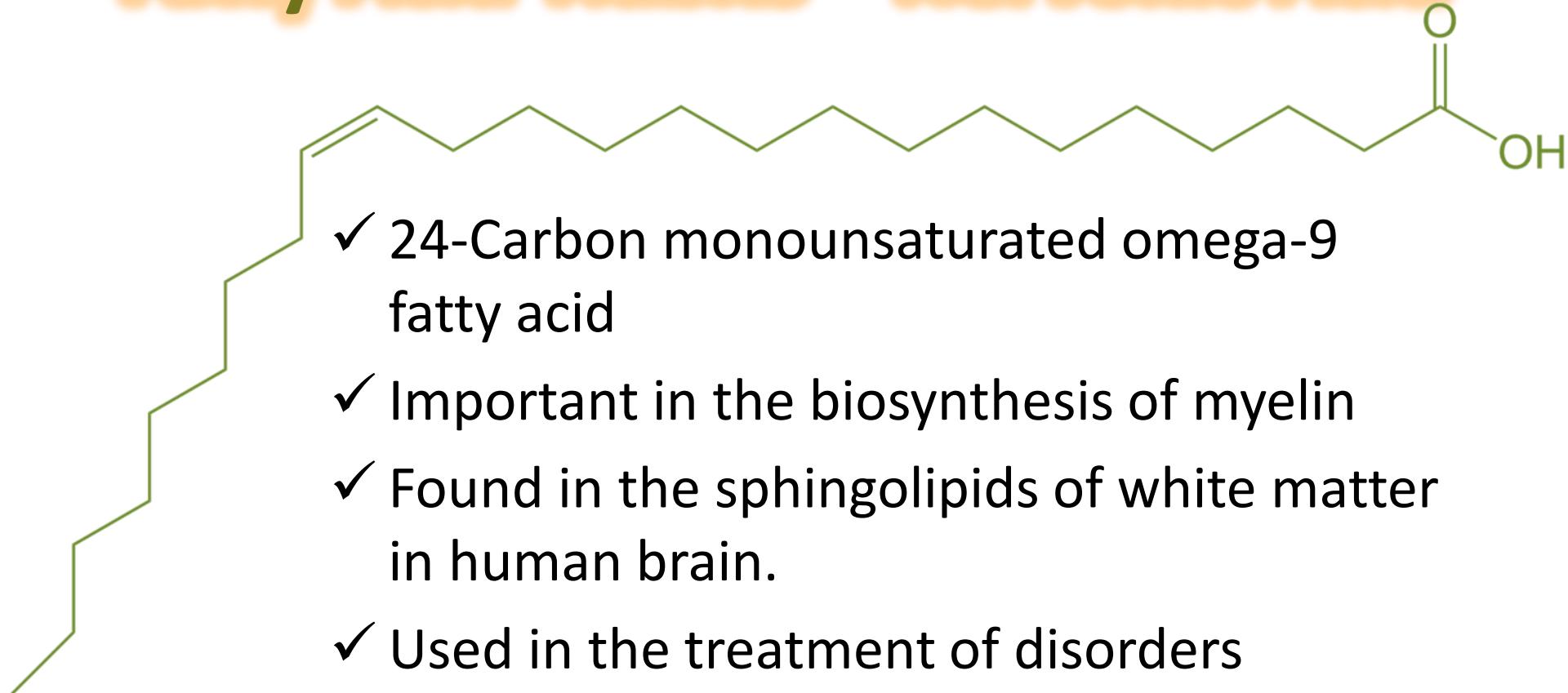
Source: International Chair on Cardiometabolic Risk
www.cardiometabolic-risk.org



Classification of Lipoproteins



Fatty Acid Tidbits – Nervonic Acid



Nervonic Acid Sources

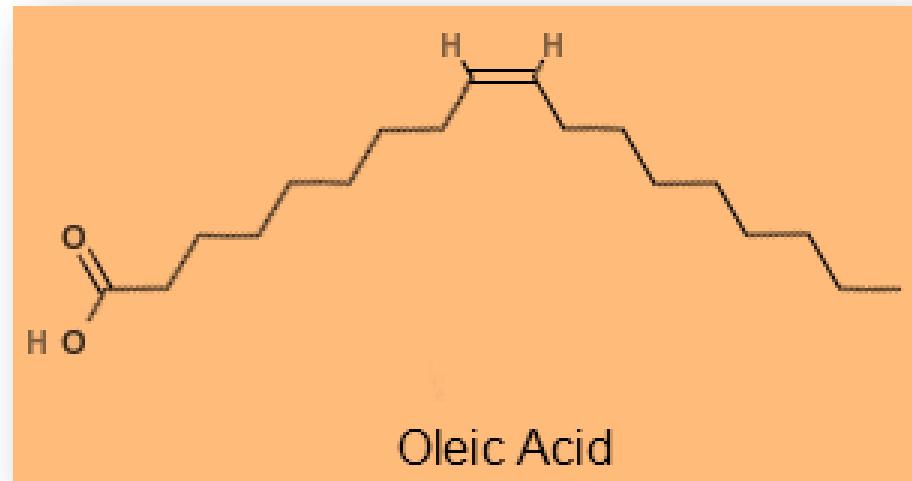
- ✓ **King salmon:** 140 mg/100g
- ✓ **Yellow mustard seed:** 83 mg/100g
- ✓ **Flax seed:** 64 mg/100g
- ✓ **Sockeye salmon:** 40 mg/100g
- ✓ **Sesame seed:** 35 mg/100g
- ✓ **Macadamia nuts:** 18 mg/100g



Oleic Acid

- ✓ The most abundant fatty acid in human adipose tissue
- ✓ **Food Sources:**

- 55-83% of olive oil
- 59-75% of pecan oil
- 61% of canola oil
- 36-67% of peanut oil
- 60% of macadamia oil
- 37-56% of chicken and turkey fat
- 44-47% of lard
- 20-85% of high oleic sunflower oil
- 15-20% of grape seed oil, sea buckthorn oil, and sesame oil
- 14% of poppyseed oil



References

- ✓ Unlu NZ, Bohn T, Clinton SK et al. *Carotenoid Absorption from Salad and Salsa by Humans Is Enhanced by the Addition of Avocado or Avocado Oil.* J. Nutr., Mar 2005; 135: 431 - 436. 2005.
- ✓ *Advanced Nutrition and Human Metabolism*, Chapter 6
- ✓ <http://www.metametrix.com/test-menu/profiles/fatty-acids/fatty-acids-bloodspot>
- ✓ <http://www.gdx.net/product/fatty-acids-profile-erythrocytes-nutritional-test-blood>
- ✓ http://en.wikipedia.org/wiki/Fatty_acid
- ✓ <http://www.cyberlipid.org/fa/acid0002.htm>
- ✓ <http://www.prosperorganics.com/category/natural-remedies/page/2/>

