ENGINEERING PRINCIPLES AND CONCEPTS ON THE ROLE OF EDIBLE FAT IN THE BODY

By Kaku Kyiamah Ph.D.

Mobile: - +233(0)208138025/(0)243152053
Email: - feanza1995@yahoo.ca

The controversy over edible fat

The controversy is also underpinned by certain difficulties which can best by explained by a quotation from "The Chemical Constitution of Natural Fats"

> ***'In spite of the vast amount of careful experimental work which has been carried out, our knowledge of the development and utilization of fats in vivo is still in many respects scanty, and very often uncertain. The problems are extremely very difficult to study experimentally; artificially designed tests, such as specific diets to animals, require careful interpretation in order to avoid erroneous conclusions; and the isolation of intermediate metabolic products has rarely, if ever, been attained in connection with the synthesis of fats in the living organism.'***

Current science and the controversy

Recent extensive and almost miraculous achievements in science and technology have enabled scientists to:

- Identify the process of production and utilization of fatty acids and fats in the body.
- The role of fatty acids and fat in the body.
- The isolation of intermediate metabolic products and progenies of fatty acids and their effect in the body.

Edible Fat Vital to Good Health

The Burrs, a husband and wife team, showed in 1930 that edible fats are important and critical to health.

The Burrs proved that the complete absence of fat in the diet caused many different kinds of life threatening diseases and ailments, which vitamins had no answer.

THE SATURATED FAT/CHOLESTEROL HYPOTHESIS

The **saturated fat/cholesterol hypothesis** generated a controversy over the role of fat and fatty acids in the body. The controversy induced a number of prominent scientists and medical personnel to organize TINCS – The International Network of Cholesterol Sceptics.

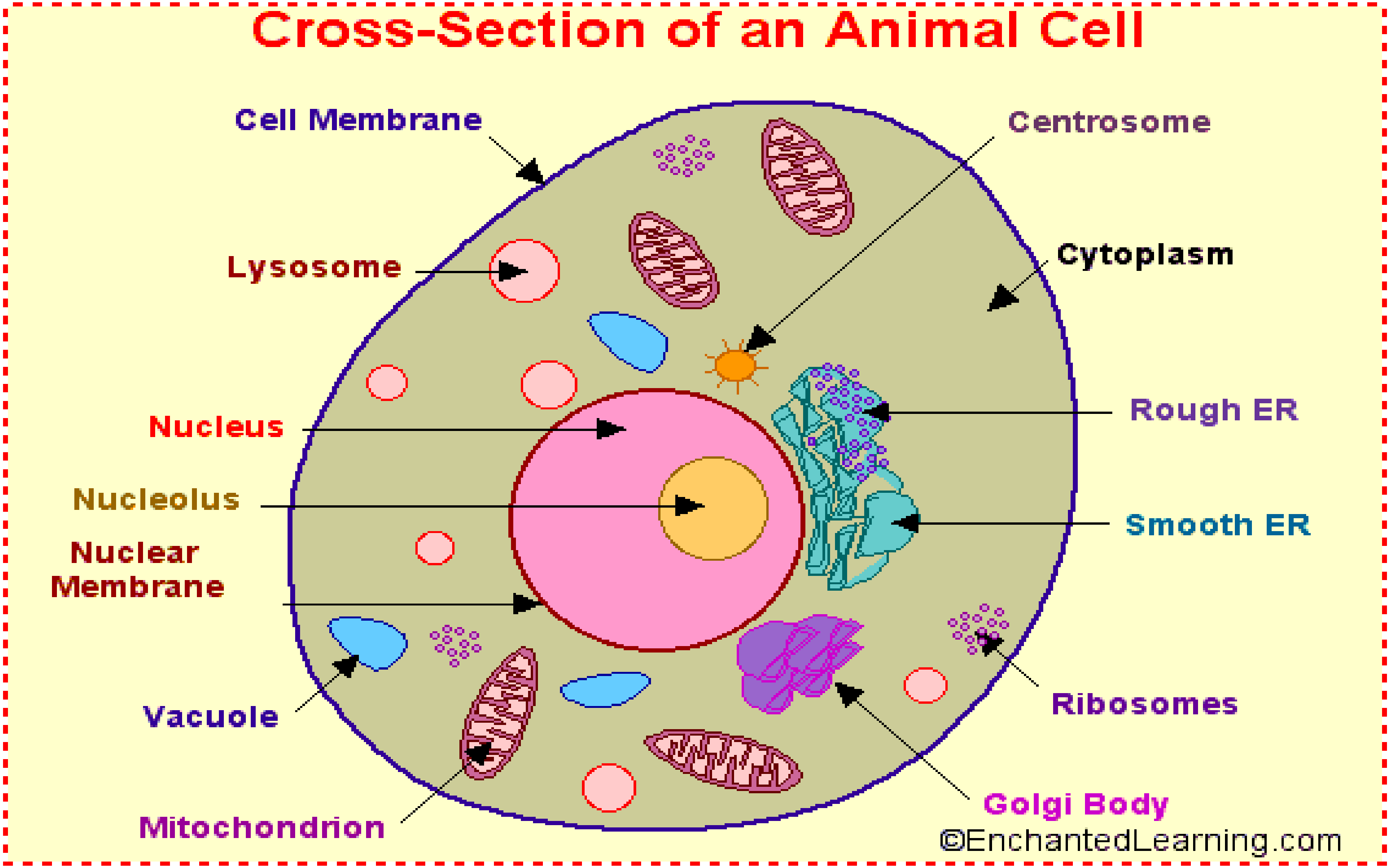
The members of TINCS have written extensively on how the saturated fat/cholesterol hypothesis is unscientific and illogical.

After the 2nd World War, the financial interest of the North Americans on the usage of rape seed oil for lubrication was threatened by the petroleum industry; and the British interests in edible tropical saturated fats were also threatened by the fight for independence by the people of the Indian sub-continent and Africa, especially West Africa. Hence, using **Saturated Fat/Cholesterol Hypothesis,** edible tropical saturated fats were also roped in for condemnation by the Five-I Countries[23].

(Show Senator McGovern's Report)


CBS 5:45:00 JUL 26 77

THE CELL


Cross-Section of an Animal Cell
Cell Membrane
Centrosome
Lysosome
Cytoplasm
Nucleus
Rough ER
Nucleolus
Smooth ER
Nuclear Membrane
Vacuole
Ribosomes
Mitochondrion
Golgi Body
©EnchantedLearning.com

IN VIVO PRODUCTION OF FAT

- All mammals can produce sequentially ten fatty acids from acetic acid in vivo.
- The ten fatty acids are as follows:
  - two short chain saturated fatty acids –i.e., butyric and caproic acids;
  - three medium chain saturated fatty acids –i.e., caprylic, capric and lauric acids;
  - three long chain saturated fatty acids –i.e., myristic, palmitic and stearic acids
  - two long chain mono unsaturated fatty acids –i.e., palmitoleic and oleic acids.
- No other fatty acids can be produced by the cell.

SMCS FATTY ACIDS

- In view of the fact that acetic acid goes through sequential production of the short and medium chain saturated fatty acids, until the two preferred fatty acids are produced, we can safely conclude that any ingested saturated fatty acid with less than 16 carbons would join the process of producing the two preferred fatty acids, i.e., palmitic and oleic acids.
- The SMCS fatty acids cannot be found in any part of the body of mammals after 36 hours.

See diagram on usage of fatty acids by pigs.

DIAGRAM ON USAGE OF FATTY ACIDS BY PIGS

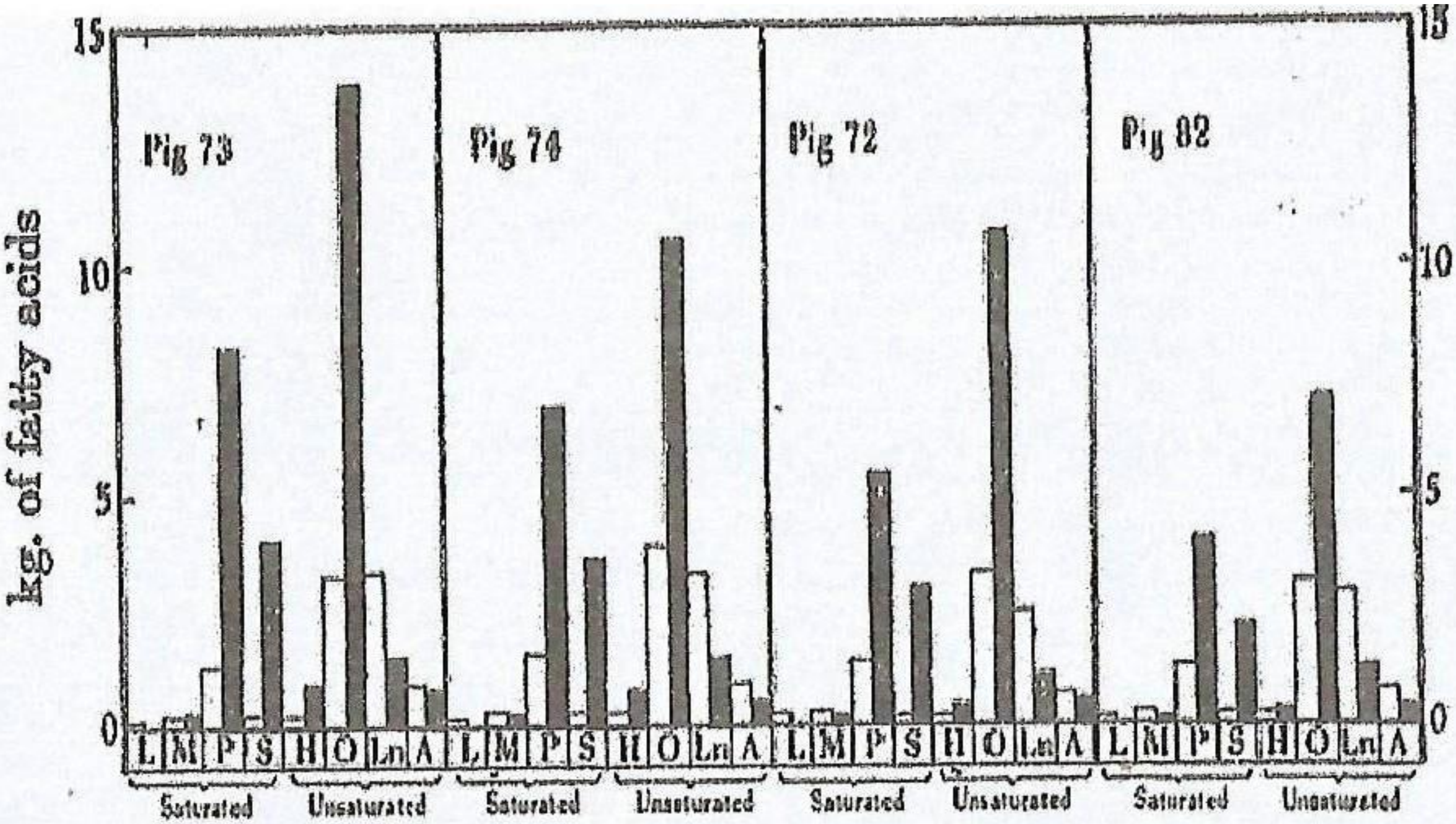


FIG. 1 Ingestion and deposition of fatty acids by pigs. Fatty acids: ingested, *white*; deposited in tissues, *black*. *L*, lauric (and lower saturated) acids; *M*, myristic acid; *P*, palmitic acid; *S*, stearic acid; *H*, hexadecenoic acid; *O*, oleic acid; *Ln*, linoleic acid; *A*, unsaturated C_{20-22} acids

TABLE 1: - DEPOT FATS OF DIFFERENT TYPES OF MAMMALS

% weight	RODENTS		HERBIVORA					
	Rat	Rabbit	Horse	Pig	Deer	Sheep	Camel	K'aroo
SATURATED								
Butyric								
Caproic								
Caprylic								
Capric								
Lauric								
Myristic	7	6	5	1	4	3	6	5
Palmitic	24	31	26	28	25	25	29	26
Stearic	5	5	5	12	35	28	27	14
Arachidic								
Behenic								
Lignoceric								
MONO UNSATURATED								
Palmitoleic	6	6	7	3	3	1	3	3
Oleic	49	30	34	48	25	37	26	46
Sum : the 3 Fatty Acids	78	66	65	88	85	90	82	86
POLY UNSATURATED								
Linoleic etc.	5	16	5	6	5	5	2	3
Unsat. C_{20-22}	1	1	2	2		1	3	3
SOURCE: - Page 131 of The Chemical Constitution of Natural Fats; by T. P. Hilditch. and P.N. Williams								

TABLE 2: - DEPOT FATS OF DIFFERENT TYPES OF MAMMALS

	HERBIVORA			**OMNIVORA**		**CARNIVORA**		
% weight	Hippo	Giant Panda	E'phant	Sacred Bamboo	Human	Cat	Lion	Tiger
SATURATED								
Butyric								
Caproic								
Caprylic								
Capric								
Lauric								
Myristic	2	5	6	3	6	4	5	1
Palmitic	27	26	44	19	25	29	29	22
Stearic	22	7	7	6	6	17	18	25
Arachidic								
Behenic								
Lignoceric								
MONO UNSATURATED								
Palmitoleic	2	4	5	4	7	4	2	7
Oleic	45	45	27	54	45	41	40	39
Sum : the 3 Fatty Acids	94	78	78	79	76	87	87	86
POLY UNSATURATED								
Linoleic etc.	4	12	6	13	8	2		4
Unsat. C_{20-22}	1		3	1	2		3	

SOURCE: - Page 131 of The Chemical Constitution of Natural Fats; by T. P. Hilditch. and P.N. Williams

TABLE 3: -FATTY ACID LEVELS OF MILK OF MAMMALS

% Molar	Indian Cow	Indian Sheep	Indian Goat	Indian Camel	Indian Buffalo	Turkish Buffalo	European Human
SATURATED							
Acetic							
Butyric	10.6	13.5	15.4	10.1	11.5	12.6	1.1
Caproic	3.7	0.4	1.1	0.7	-	3.3	0.1
Caprylic	1.6	0.5	1.4	2.2	0.1	0.8	0.7
Capric	2.8	1	1.5	1.8	0.5	1.7	3.4
Lauric	2.9	2,5	2	3.4	1.9	3.5	7.8
Myristic	14.3	13.3	9.8	7.8	5.3	12.5	9.6
Palmitic	28.4	31.5	31.9	22.5	25.1	26.3	23.4
Stearic	6.8	10.1	12.9	16.3	19	11.5	6.3
Arachidic	0.7		0.1	1	1.1	1.1	0.9
MONO UNSATURATED							
Palmitoleic	1.5	2	3	6.5	2.9	3.5	3.3
Oleic	23.1	23	16.8	23.1	32	21	33.3
Total Fatty Acids	96.4	95.3	95.9	95.4	99.4	97.8	89.9
POLY UNSATURATED							
Linoleic	3.1	0.4	1.2	0.2	1	1.3	7.2
Linolenic							0.4
Euricic							
C_{20-22}	0.5	0.8	3.3		0.6	0.9	2.2
SOURCE: - The Industrial Chemistry of the Fats and Waxes by T. P. Hilditch D.Sc (Lond.) F.R.I.C, F.R.S.							

Lubrication of the Contents of the Cell

Two quotations from a biochemistry text book give an idea about specification of the fat inside the cell:

- *"The diffusion coefficient in a lipid is about 2μm^2* **/***sec. Thus, a phospholipid molecule diffuses an average distance of 2μm in 1 sec. This rate means that a lipid molecule travels from one end of a bacterium to the other in a second. The magnitude of the observed diffusion coefficient indicates that the viscosity of the membrane is about 100 times that of water, rather like that of olive oil."* [1 page 336]
- *"The released un-esterified cholesterol can then be used for membrane biosynthesis.* ***It can be re-esterified for storage inside the cell.*** *Re-esterified cholesterol contains mainly oleate and palmitoleate, which are mono unsaturated fatty acids."* [1 page 729]

Characteristics of Fatty Acids for the BL of FA

Purity[1]: Only saturated fatty acids can be identified as having no blemish, hence pure.

Ordered Rigid State[1, 26, 27]: The long chain saturated fatty acids are rigid. Unsaturated fatty acids are not rigid at the body temperature.

Insulation[40, 41, 42]: - The hydrophobic hydrocarbon tails of all fatty acids have insulating properties and would be able to prevent (a) the diffusion of ions; (b) leakage of electrical signals or (c) the drop of voltage across the bilayer. However, long chain saturated fatty acids have markedly lower dielectric constants than unsaturated fatty acids; hence long chain saturated fatty acids would ensure higher impedance. See Figure 3.

Reaction with Oxygen or Water: [1, 42] The long chain polyunsaturated fatty acids are unstable and can be easily attacked by water, and do react easily oxygen [3].

Impermeable to Water and other Molecules [42]: Polyunsaturated fatty acids (both cis and trans) have holes and are susceptible to the ingress of water molecules and microorganisms.

Self-Sealing[1, 27]**:** All fatty acids are self-sealing; but only saturated fatty acids can seal tightly together.

The six factors are fully satisfied by the three long chain saturated myristic, palmitic and stearic acids.

Figure 3: Spectra of dielectric constant at 75 °C.

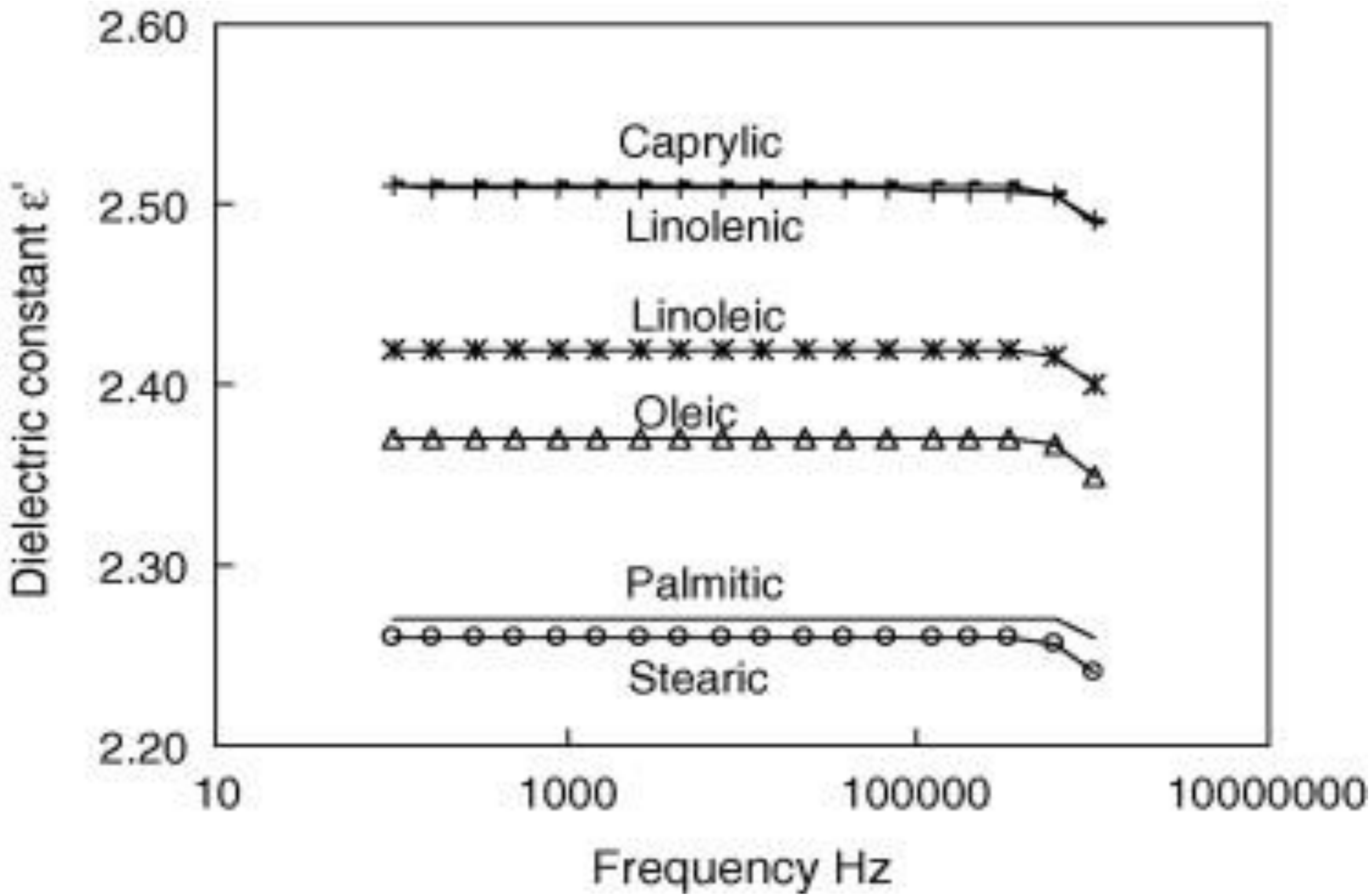


Figure 1: - Space-Filling Structures of Saturated, Mono-Unsaturated and Poly-Unsaturated Fatty Acids

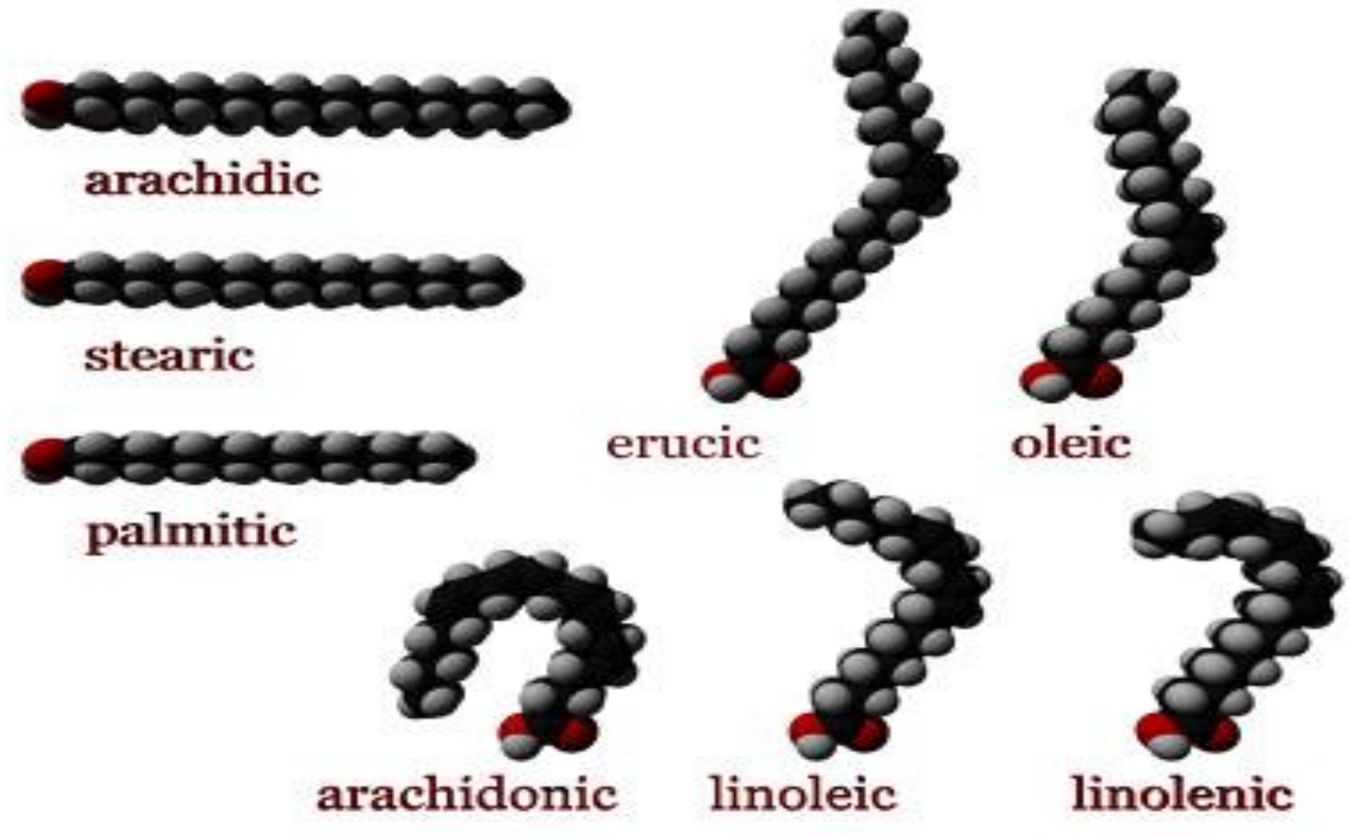
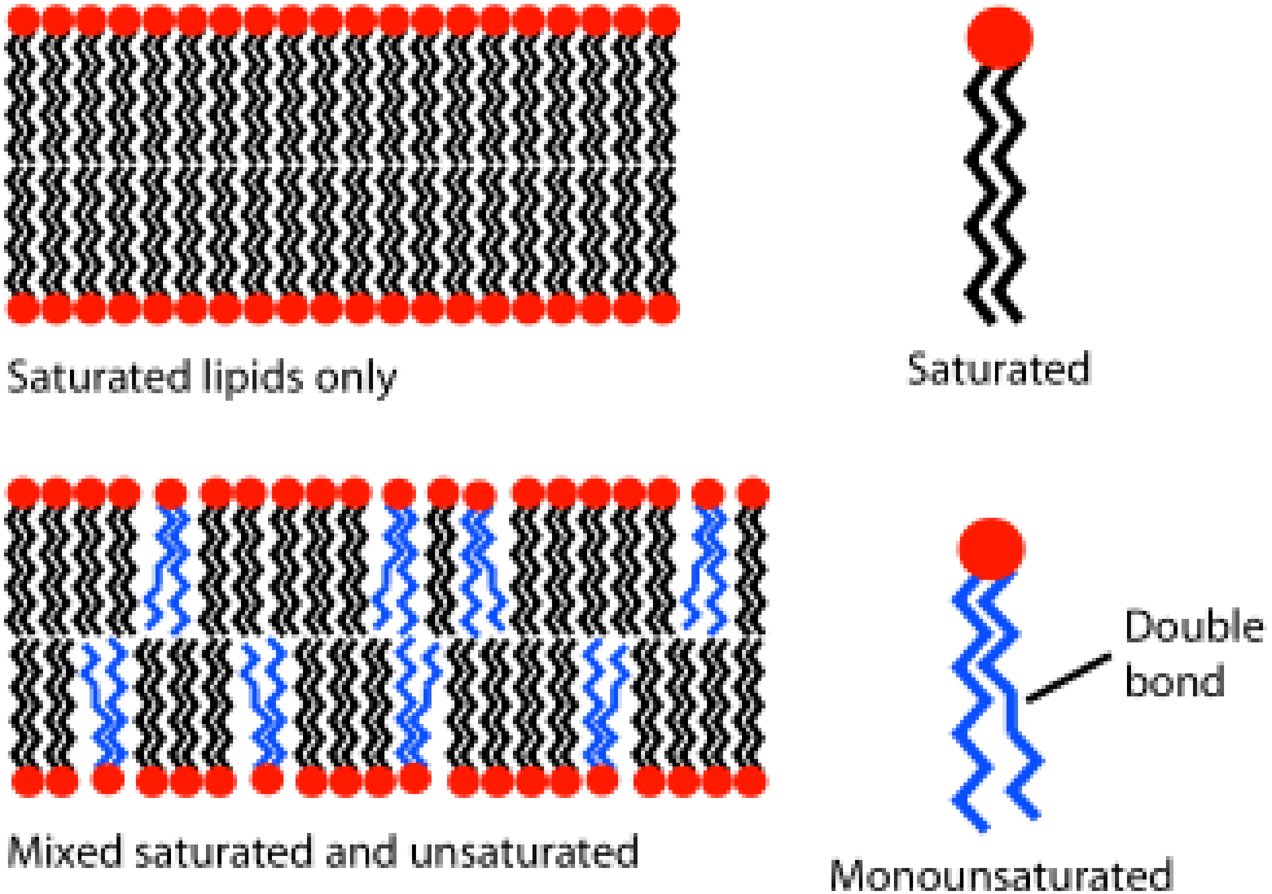


Figure 2 : - The unsaturated double bonds make it more difficult to pack the chains together. The saturated straight chains make the bilayer pack tightly and rigid at the body temperature.



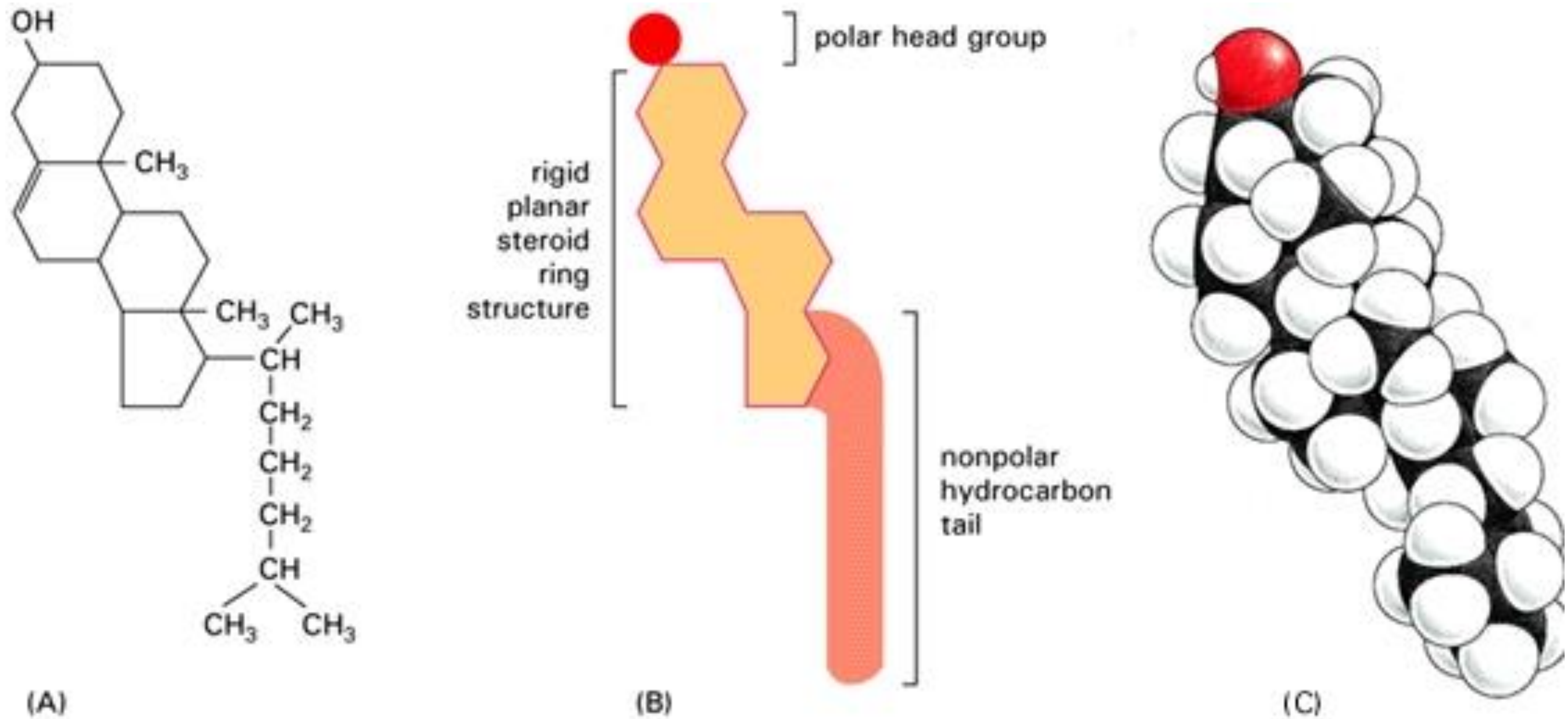
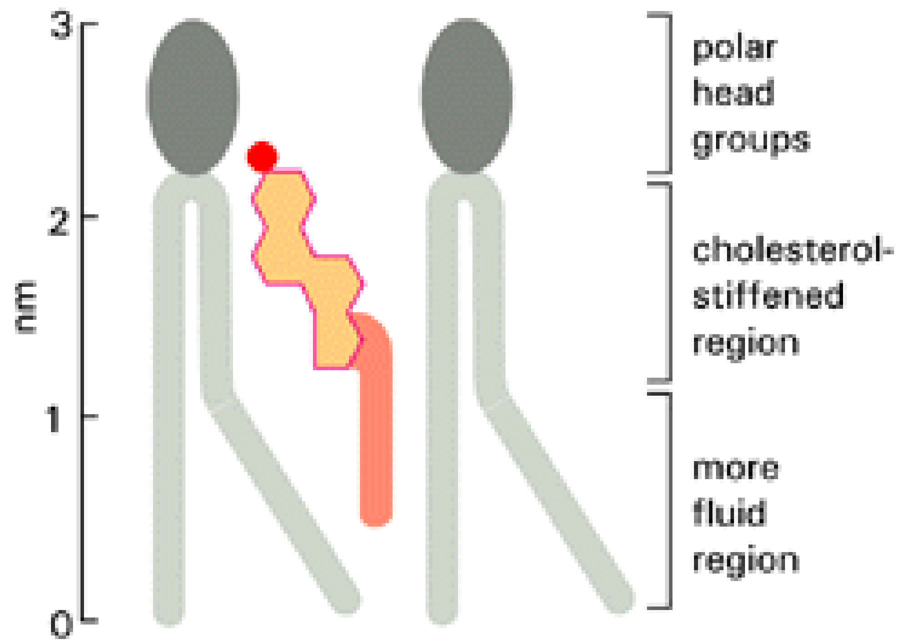


FIG. 3: - Structure of CHOLESTEROL

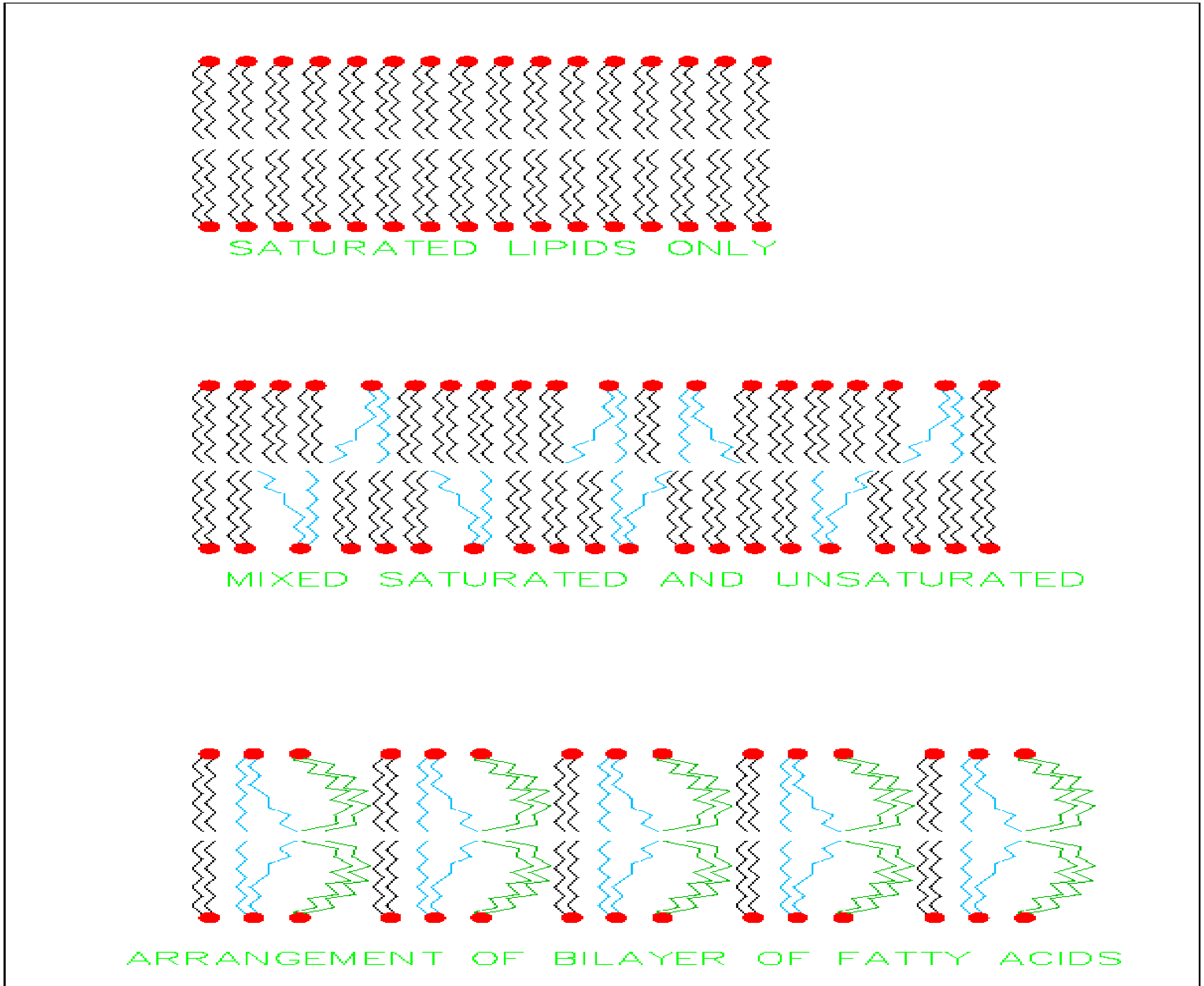
Cholesterol is represented by a formula in (A), by a schematic drawing in (B), and as a space-filling model in (C).

Fig 4: - Cholesterol in a lipid bilayer.

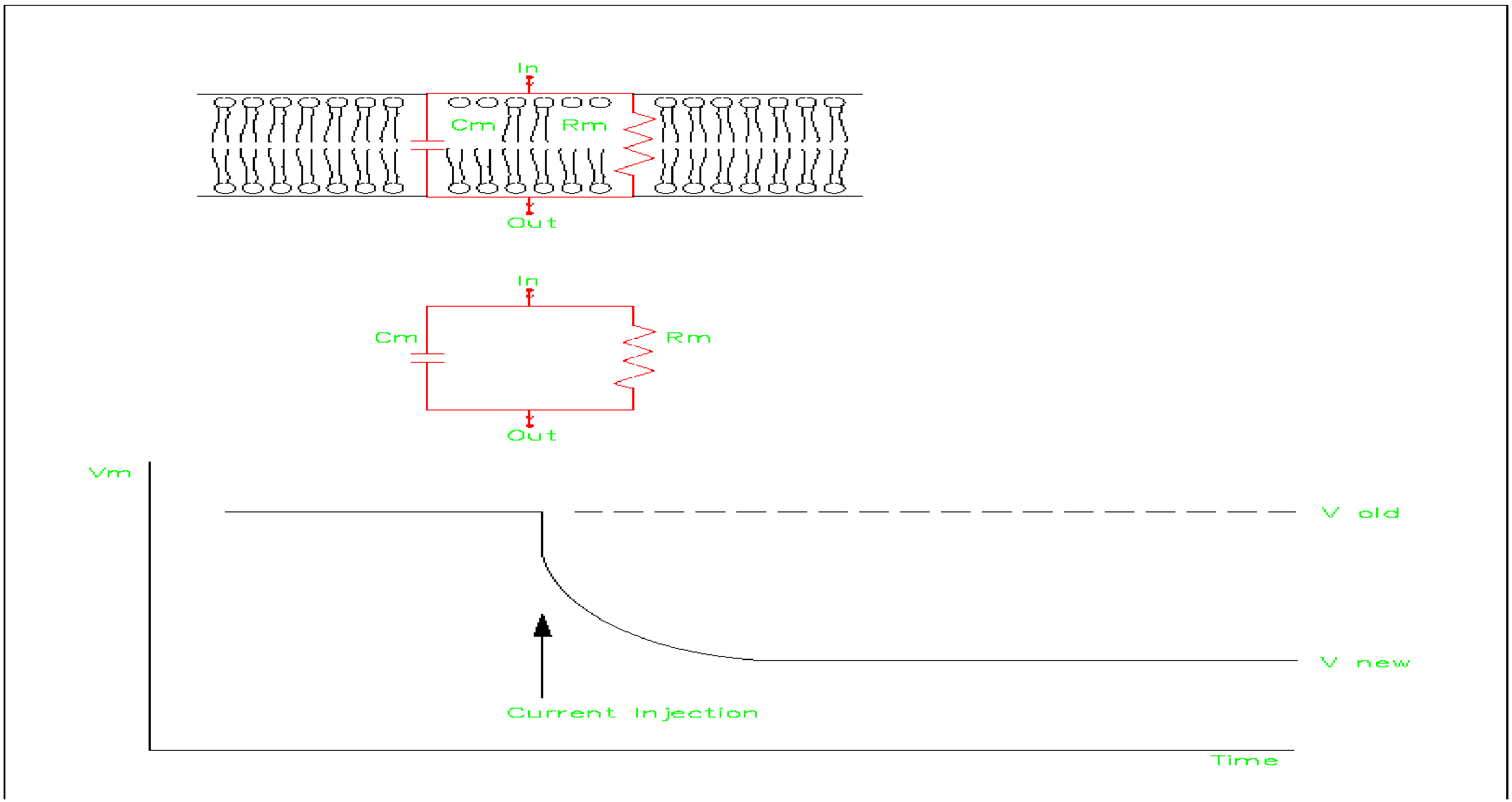


Schematic drawing of a cholesterol molecule
interacting with two mono-unsaturated fatty acid molecules

three different fatty acids in the bilayer



SIGNAL DECAY IN THE BILAYER



THE EFFECT OF FATTY ACIDS AND FAT IN THE BODY

Fatty acids have three unique effects in the body. Hence, they can be placed into three groups. Each group of fatty acids is metabolised differently by the cell. Tables 4, 5, 6 provide information on the composition of fatty acids in different 'edible' fats.

Group 1 Fatty Acids

They Consist of three short and three medium chain fatty acids, which are used for the production of Group 2 fatty acids. Ingestion of any of the six short and medium chain saturated fatty acids; i.e., acetic, butyric, caproic, caprylic, capric and lauric acids would be absorbed and fully converted by the cells to form five long chain fatty acids. These short and medium chain saturated fatty acids disappear completely from the body, after ingestion, within 36 hours and none is excreted.

Group 2 Fatty Acids

Group 2 Fatty Acids **c**onsist of the five long chain fatty acids, i.e. saturated myristic, palmitic and stearic acids and mono-unsaturated palmitoleic and oleic acids which the cell can produce in vivo.

Group 3 Fatty Acids

Group 3 Fatty Acids: Consist of fatty acids which the body cannot produce naturally. The body normally excretes fatty acids which the body cannot produce in vivo. However, fatty acids such as long chain polyunsaturated, omega-3 and omega-6 fatty acids and mono unsaturated euricic acid, which have characteristics similar to oleic acid, are normally assembled with glycerol in the adipose cells as fat. The fat stored in the adipose cells provide glycerol during periods of starvation. The ingestion of high levels fatty acids which the body cannot produce in vivo causes the adipose tissue to increase in size resulting in obesity.

Ruminants and polyunsaturated fatty acids

Ruminants do not eat fat; but if a ruminant ingests polyunsaturated fatty acids beyond a certain low level it gets affected by acidosis which can be fatal.

Long chain polyunsaturated fatty acids patched up with cholesterol found in the blood plasma are known as low density lipoprotein cholesterol (LDL-C), the bad cholesterol, and I quote: -

- ***“Low density lipoprotein is the major carrier of cholesterol in blood. It contains a core of 1,500 ester cholesterol molecules; the most fatty acyl chain is polyunstaurated fatty acid.”***

High levels of LDL-C in the blood plasma tend to harm the cell in at least three ways.

1. They produce progenies of long chain poly unsaturated omega-3 and omega-6 fatty acids. The progenies are (a) very long chain polyunsaturated fatty acids, (b) prostaglandins or eicosanoids and (c) free radicals-radiations.
2. The presence of cholesterol in the bilayer of fatty acids and prostaglandins or eicosanoids reduces the impermeability of the bilayer of fatty acid and the plasma membrane.
3. The presence of cholesterol impairs the impedance of the bilayer of fatty acids.

TABLE 1: - DEPOT FATS OF DIFFERENT TYPES OF MAMMALS

% weight	RODENTS		HERBIVORA					
	Rat	Rabbit	Horse	Pig	Deer	Sheep	Camel	K'aroo
SATURATED								
Butyric								
Caproic								
Caprylic								
Capric								
Lauric								
Myristic	7	6	5	1	4	3	6	5
Palmitic	24	31	26	28	25	25	29	26
Stearic	5	5	5	12	35	28	27	14
Arachidic								
Behenic								
Lignoceric								
MONO UNSATURATED								
Palmitoleic	6	6	7	3	3	1	3	3
Oleic	49	30	34	48	25	37	26	46
Sum : the 3 Fatty Acids	78	66	65	88	85	90	82	86
POLY UNSATURATED								
Linoleic etc.	5	16	5	6	5	5	2	3
Unsat. C_{20-22}	1	1	2	2		1	3	3
SOURCE: - Page 131 of The Chemical Constitution of Natural Fats; by T. P. Hilditch. and P.N. Williams								

TABLE 2: - DEPOT FATS OF DIFFERENT TYPES OF MAMMALS

% weight	HERBIVORA			OMNIVORA		CARNIVORA		
	Hippo	Giant Panda	E'phant	Sacred Bamboo	Human	Cat	Lion	Tiger
SATURATED								
Butyric								
Caproic								
Caprylic								
Capric								
Lauric								
Myristic	2	5	6	3	6	4	5	1
Palmitic	27	26	44	19	25	29	29	22
Stearic	22	7	7	6	6	17	18	25
Arachidic								
Behenic								
Lignoceric								
MONO UNSATURATED								
Palmitoleic	2	4	5	4	7	4	2	7
Oleic	45	45	27	54	45	41	40	39
Sum : the 3 Fatty Acids	94	78	78	79	76	87	87	86
POLY UNSATURATED								
Linoleic etc.	4	12	6	13	8	2		4
Unsat. C_{20-22}	1		3	1	2		3	
SOURCE: - Page 131 of The Chemical Constitution of Natural Fats; by T. P. Hilditch. and P.N. Williams								

TABLE 3: -FATTY ACID LEVELS OF MILK OF MAMMALS

% Molar	Indian Cow	Indian Sheep	Indian Goat	Indian Camel	Indian Buffalo	Turkish Buffalo	European Human
SATURATED							
Acetic							
Butyric	10.6	13.5	15.4	10.1	11.5	12.6	1.1
Caproic	3.7	0.4	1.1	0.7	-	3.3	0.1
Caprylic	1.6	0.5	1.4	2.2	0.1	0.8	0.7
Capric	2.8	1	1.5	1.8	0.5	1.7	3.4
Lauric	2.9	2,5	2	3.4	1.9	3.5	7.8
Myristic	14.3	13.3	9.8	7.8	5.3	12.5	9.6
Palmitic	28.4	31.5	31.9	22.5	25.1	26.3	23.4
Stearic	6.8	10.1	12.9	16.3	19	11.5	6.3
Arachidic	0.7		0.1	1	1.1	1.1	0.9
MONO UNSATURATED							
Palmitoleic	1.5	2	3	6.5	2.9	3.5	3.3
Oleic	23.1	23	16.8	23.1	32	21	33.3
Total Fatty Acids	96.4	95.3	95.9	95.4	99.4	97.8	89.9
POLY UNSATURATED							
Linoleic	3.1	0.4	1.2	0.2	1	1.3	7.2
Linolenic							0.4
Euricic							
C_{20-22}	0.5	0.8	3.3		0.6	0.9	2.2
SOURCE: - The Industrial Chemistry of the Fats and Waxes by T. P. Hilditch D.Sc (Lond.) F.R.I.C, F.R.S.							

FOODS ASSOCIATED WITH GROUP 1 FATTY ACIDS

Food items with high levels of group 1 fatty acids normally have no or very little of the group 3 fatty acids. The food items include:

- Organic butter, organic mammalian milk, coconut oil, palm kennel oil, organic eggs and fermented foods e.g. fermented grains (ahey, nmgbeda, pito, beer, fermented corn dough, fermented cocoa, leaven bread, etc.), fermented fruits (vinegar, wine, etc.), fermented tubers, leaves and tree parts (gari, konkonte, tea, palm wine, bitters, etc.) fermented fish and meat (kobi, momoni, etc.), yoghurt and chee

FOODS ASSOCIATED WITH GROUP 2 FATTY ACIDS

Food items with high levels of group 2 fatty acids normally have low levels of group 3 fatty acids. Sources of such food items include:

- Organic butter, organic fresh milk, palm oil, shea butter, cocoa butter, olive oil, organic animal fat, fruits, edible leaves.

FOODS ASSOCIATED WITH GROUP 3 FATTY ACIDS

Food items with high levels of group 3 fatty acids have more than 30% of polyunsaturated fatty acids and less than 40% of levels group 2 fatty acids and practically no Group 1 fatty acids. Such food items include:

- Soybean oil, corn oil, cotton seed oil, algalin, sunflower oil, safflower oil, canola oil (rape seed oil), flax seed oil, ground nut oil, palm olein, margarine, shortening, ground nuts, unfermented seed grains, and food item prepared with unfermented grains and unsaturated vegetable oils or fish oil.

THE WHO ON FAT

A former Director-General of the WHO stated in the World Health Report 2002 on 'Reducing Risks, Promoting Healthy Life' that:

- *"The rapidly growing epidemic of non-communicable diseases, already responsible for some 60% of world deaths, is clearly related to changes in global dietary patterns and increased consumption of industrially processed fatty, salty and sugary foods."*

MY QUERY ON WORLD HEALTH REPORT 2002

In Ghana, the major change in our diet may be summarised as follows:

- Salt is important in the diet of most mammals, since it provides the minerals and ions for the transmission of signals. Sea salt has been an important part of our diet for many centuries e.g. ‘wo ato nkyene’ as some Ghanaians have to be reminded after they have visited a coastal town to trade. Humans can naturally decide on the suitable level of salt in their diet.

MY QUERY ON WORLD HEALTH REPORT 2002 (cont.)

Good quality natural sugars are needed for the production of energy in the body. The the change to industrially processed grain-based sugar or sweeteners should be of serious concern. They introduce group 3 fatty acids into the diet.

Fatty acids i.e. fats are vital for good health. On the advice of the international community, group 3 fatty acids have become the basis for the fat in the diet. This is the only drastic and dramatic change in the type of fat in our diet. We have changed from our traditional tropical saturated oils to processed unsaturated vegetable oils and unfermented grains.

THE WHO ON FAT

Global Strategy on Diet, Physical Activity and Health – Diet

"For diet, recommendations for populations and individuals should include the following:

- *achieve energy balance and a healthy weight*
- ***limit energy intake from total fats and shift fat consumption away from saturated fats to unsaturated fats and towards the elimination of trans-fatty acids***
- *increase consumption of fruits and vegetables, and legumes, whole grains and nuts*
- *limit the intake of free sugars*
- *limit salt (sodium) consumption from all sources and ensure that salt is iodized*

These recommendations need to be considered when preparing national policies and dietary guidelines, taking into account the local situation."

Unfortunately, the WHO recommendation has a scientifically flawed clause which serves as the major underlying reason for the epidemic of non-communicable diseases. The scientifically flawed clause is: -

> **“LIMIT ENERGY INTAKE FROM TOTAL FATS AND SHIFT FAT CONSUMPTION AWAY FROM SATURATED FATS TO UNSATURATED FATS AND TOWARDS THE ELIMINATION OF TRANS-FATTY ACIDS”**

MY QUERY ON WHO STRATEGY

This scientifically flawed clause raises many very disturbing questions, which include: -

- How can energy intake be limited from total fats; since the main component of fat fatty acids cannot contribute to energy intake? The other component of fat, glycerol contributes to energy intake only during the starvation period.
- Why limit fat consumption, since fatty acids are vital for all living things?
- Why shift fat consumption away from saturated fats, which contain the preferred fatty acids for the cell?
- Why shift fat consumption to unsaturated fats, which normally have high levels of poly unsaturated fatty acids, the cause of oxidative stress and many other health concerns?
- How can one eliminate trans-fatty acids by shifting to unsaturated fats, which are the main source of trans-fatty acids?

BENEFITS

The adoption of types 1 and 2 fats for food and other purposes would benefit Ghana and the inhabitants in many ways e.g. : -

- Savings in foreign exchange by the reduction in the importation of trans fatty acid loaded “edible fats” such as refined bleached and deodorised unsaturated vegetable fats, margarines and shortening;
- Increased production of tropical saturated fats, such as indigenous palm oil, shea butter, palm kernel oil, coconut oil, thus creating many new jobs;
- Reduction in the lifestyle diseases such as heart diseases, diabetes, asthma, whites, peptic ulcers, prostrate enlargements, cancers, skin diseases, chest diseases, skin diseases, strengthen muscles and cartilages, reduce the occurrence of cramps and heart attacks, etc
- Reduction in infertility problems among women and men;
- Reduction in abnormal births such as autistic children;
- Increase in the healthy growth of babies and children;
- Savings in foreign exchange by the reduction in the importation of special drugs.