CC5:UNIT III: Nutrients

LIPIDS/ FATS (Part-2)

(Function & deficiency of lipids)

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Introduction:

In continuation with the first part, let us learn about the functions, deficiency and excess of lipids in this unit. In earlier unit, you learnt about the definition of lipids, followed by classification. You also leant about how lipids are digested and absorbed in the body through various transport systems. In this unit, let us learn the following aspects.

Fats are concentrated source of energy providing 9 Kcal/g, and are made up of fatty acids in different proportions. Dietary fats are derived from two sources viz. the invisible fat present in plant and animal foods; and the visible or added fats and oils. Fats serve as a vehicle for fat-soluble vitamins like vitamins A, D, E and K and carotenes. They are essential to promote absorption of fat soluble vitamins. They are sources of essential polyunsaturated fatty acids. It is necessary to have adequate and good quality fat in the diet with sufficient polyunsaturated fatty acids in proper proportions.

Diet should include adequate amounts of fat particularly for infants and children. Fats are concentrated source of energy. The energy needs per kg body weight of infants and children is nearly twice those of adults. Adults need to be cautioned to restrict intake of saturated fat (butter, ghee and hydrogenated fats) and cholesterol (red meat, eggs, organ meat). Excess of these substances could lead to obesity, diabetes, cardiovascular disease and cancer.

This episode deals with the following important sub headings.

- ✓ Functions of lipids
- ✓ Choice of Different fats for maintaining good health

- ✓ Deficiency caused by lipids
- ✓ Abnormalities caused by excess consumption of fats

1. Functions of lipids

Lipids are transported in blood by lipoproteins; surrounded by hydrophilic molecules. Chylomicrons transport triglycerides, cholesterol, phospholipids and fat-soluble vitamins from the small intestine to body cells. Lipids are the constituents of cell membrane structure and regulate the membrane permeability. Lipids are also constituents of internal membranes of the nucleus, endoplasmic reticulum and membrane bound organelles. Lipids regulate the flow of materials into and out of the cells, which are involved in growth. Lipids protect the internal organs serving as insulating materials. Subcutaneous fat acts as insulating material for body, which prevents heat loss. They also acts as protector which surrounds certain vital organs, such as kidney and heart. Fat imparts palatability to the diet. Fats slows stomach emptying time, thus giving a feeling of fullness. This delay of onset of hunger is called 'satiety value' of fats. The calories in fat spare the proteins from being oxidized for energy.

1.1. Energy stores / fat reserve:

Lipids are the concentrated fuel reserve of the body. Fat is the primary form in which energy is stored in the body. Essential Fatty acids (EFAs) are found in skin phospholipids and within adipocytes (fat cells) in adipose tissue serving as energy stores. Fat is stored to the extent of 90% largely in the form of globules of Triglycerides (TGs).

1.2. Bactericidal activity:

The EFAs are involved in the bactericidal activity against common pathogens like staphylococci, streptococci and pneumococci. They are known to be very much involved in the membrane composition of immuno competent cells such as T cells and B cells. The homologous of these fatty acids are known to have bactericidal effect. They have the ability to disrupt cell wall membranes by their detergent effect.

1.3 Modulation of membrane structure and functions

Lipids are integral components of cell membranes. They play significant role in membrane fluidity and lipid protein interactions. Lipid protein interactions alter

activity of membrane-related transport systems, ion channels, membrane bound enzymes and cellular receptors for hormones and neurotransmitters.

1.4. Growth and development

The EFAs play a role in fetal growth and early human development. There are significant associations between dietary intakes of arachidonic acid (AA) and docosahexaenoic acid (DHA) with birth weight, head circumference and placental weight. The fetus depends completely on the maternal source of linoleic acid (LA), alpha-linolenic acid (ALA), AA and DHA. Infant obtains these PUFAs through breast milk.

1.5. Role of dietary fatty acids in preventing CHD

Dietary fatty acids modify the concentrations of plasma triglycerides and lipoprotein cholesterol fractions. This modification affects coronary heart disease (CHD) risk significantly. Diet consumed rich in Lauric, myristic and palmitic acids increase serum Low-density lipoprotein (LDL) and total cholesterol. Increase in these fats, reduce insulin sensitivity and enhance thrombogenicity and increase CHD risk. Therefore, Saturated Fatty acids (SFA) intake should not exceed 8-10% of total energy. Trans Fatty Acids (TFA) is similar to SFA in increasing LDL cholesterol. In addition to increasing, they lower the protective effects of High-density lipoprotein (HDL) cholesterol **(Table 1)**.

High intake of specific fatty acids- LA, ALA, EPA and DHA lowers the risk of CHD and CHD events. The Long Chain (LC) n-3 PUFA provided from fish and other seafood's lower serum TGs. Further, PUFAs influence peripheral glucose utilization, insulin action, decrease adiposity. Therefore, they are called as anti atherogenic. The lipid lowering and other physiological effects of individual members of the PUFAs vary widely. As compared to LA, ALA is more beneficial. It helps in prevention of inflammation and accumulation of fatty material in blood vessels (atherosclerosis) and clotting of blood (thrombosis). The long chain n-3 PUFA of fish oils have greater antiatherogenic, antithrombotic and anti-inflammatory effects than ALA of plant foods.

The intake of PUFA should be 8-10% of energy intake. The remaining 8-10% of fat calories can be derived from mono-unsaturated fatty acids (MUFA). Excessive use of highly unsaturated fats should be avoided. Further, to get a good proportion of

all the classes of fatty acids, it is advisable to consume more than one type of vegetable oils.

1.6. Health of Skin:

The major fatty acid of the epidermis is AA. It constitutes about nine percent apart from linoleic and other homologous. LA serves in the epidermis regulating barrier function. It maintains the integrity of the skin and fragility of mitochondrial membranes. All the skin functions and maintenance of membrane stability are done mostly by n-6 fatty acids.

1.7. Non-glyceride components and their nutritional and health promoting effects

The non-glyceride components of fats from animal foods contain cholesterol and fat soluble vitamins (A, E, D). The components from Plant foods and vegetable oils contain, in addition to fat soluble vitamins (E, D, K and carotenoids), plant sterols and a wide range of other chemical compounds. Plant sterols and some of the unique non-glyceride components (oryzanols and sesame lignans) lower serum LDL cholesterol. Vitamin E, carotenoids, sesame lignans and oryzanols have antioxidant effects. Non-glyceride components in combination with antioxidant have beneficial role in reducing excess cholesterol in body. Therefore, natural antioxidants present in these plant sterols and vegetable oils have positive benefits to reduce dyslipidemia and other disorders **(Table 2)**.

2. Choice of Different fats for maintaining good health

In view of the above functional roles of different types of fat, an ideal quality fat is required for maintaining good health.

An ideal quality fat for good health is the one, which maintains a balance. It gives a ratio of PUFA/SFA of 0.8-1.0, and LA/ALA of 5-10 in the total diet. The appropriate balance of these fatty acids is necessary to maintain with cereal-based diets. Hence, the choice of cooking fat should be as follows:

- Use of more than one source of fat/oil has advantage of providing a variety of minor components in the diet **(Table 3)**.
- Regular consumption of oils and foods rich in ALA (Eg: Rapeseed, Mustard, Soyabean).
- Eating fish provides long chain n-3 PUFA.

- Part of visible fat and/or invisible fat from animal foods may be substituted by whole nuts and legumes. These foods have good proportion of ALA
- The plant oils in addition contain certain useful substances such as lignans (sesame oil), sterols, tocopherols (vitamin E) oryzanole (rice bran oil), and carotenoids. All of these reduce cholesterol and reduce oxidant damage due to ageing, inflammation which occur in chronic diseases.

- ***Vanaspati:*** Vanaspati is prepared by hydrogenation of vegetable oils. During hydrogenation, the liquid oils become solid. The MUFA and PUFA are converted into SFAs and isomers called TFAs. Vanaspati is used as a substitute for ghee in cooking. It is used in the preparation of bakery products, sweets and snack foods. High intake of SFAs and TFAs may increase the risk of heart disease. Therefore, it is essential to limit the intake of vanaspati. The intake of TFAs should not exceed 1% of energy intake.

- **To increase n-3 PUFAs :** Consume foods which have high contents of ALA and / LCn-3 PUFAs. Individuals/populations who do not consume fish should achieve higher intake of ALA

- **To minimize TFAs:** Avoid foods prepared in partially hydrogenated vegetable oils (PHVO-processed, premix, ready to eat and fast foods). Consume low fat milk and dairy foods

- **To limit SFAs:** Consume low fat milk and dairy foods. Moderate consumption of beef, mutton.

- **To increase MUFAs & PUFAs:** Consume whole nuts but total energy and fat calories should be within the recommended limits

3. Deficiency:

Deficiency of lipids is rare in man. Deficiency is seen in patients who are only on Total Parenteral Nutrition (TPN) for long periods without fat emulsions. EFAs deficiency can occur in fat malabsorption and in protein calorie malnutrition where there is a deficiency of fat calories.

In 1929, two American nutritionists Burr and Burr, put young rats on a fat-free diet. They continued to grow normally upto 8 weeks. However, growth then slowed down and stopped altogether by 2 weeks. A squamous dermatitis developed and was most marked over the tail. Therefore, it was proved that lipids are important for proper growth and development

Essentiality of LA was reported by Hansen and colleagues in 1963. Infants were fed on milk formulas that had lower than recommended levels of LA for 3months. The amounts of LA varied from 0.1%-7.3% of total calorie needs. Infants who were fed with lowest amount of linoleic acid developed dry, thick, flaking skin and suffered from retarded growth. The clinical symptoms disappeared when large amount of LA was provided.

Deficiency related to retina was observed in child receiving TPN devoid of n-3 fatty acid for 5 months. Child developed blurred vision when the feeding formulas given were low in ω-3 fatty acid.

Deficiency of EFA may cause permanent learning defects and alterations in synaptic functions in the brain.

EFAs are required for the maintenance of normal human skin. Non-availability of EFAs to skin causes a disease called as Phrynoderma or toad skin. This disease is characterised by horny popular eruptions on the limbs, back and buttocks. Phrynoderma can be cured by EFA along with vitamin A and B complex group.

Deficiency of EFA can increase the risk for CHD. AA which is derived from LA is the precursor of prostaglandins. These are converted to prostacyline which help in vasodilation. In LA deficiency, there are more chances for the thrombus formation. Therefore, there are chances of getting CHD.

EFA deficiency adversely affects:

- Reproduction and lactation
- Integrity of the cell membranes and cells
- Regular functioning of certain enzyme systems
- Transportation of cholesterol
- Water balance
- Growth and development
- Production of energy by oxidation of fatty acids

EFA deficiency responds successfully to the application to the skin of lipids containing a high proportion of LA.

4. Excess

Fats/ lipids (triglycerides, cholesterol and phospholipids) are transported in blood in combination with proteins in the form of lipoproteins **(Figure 1)**. The low density lipoproteins transport cholesterol from liver to various tissues. Tarns Fatty Acids increase CHD risk factors and CHD events.

4.1. Lipids, Lipoproteins, and Cardiovascular Disease Risk

High blood LDL will deposit cholesterol in the inner walls of the arteries that feed the heart and brain. It can form plaque (thick, hard deposit) that can narrow the arteries and make them less flexible. This condition is known as atherosclerosis (**Figure 2)**. If a clot forms and blocks a narrowed artery, heart attack or stroke can result. Atherosclerotic plaques can rupture and stimulate clot formation in blood vessels to completely block blood flow. In the heart, this causes heart attacks (also called myocardial infarctions, or MIs). In the brain, this causes strokes (also called cerebral vascular accidents, or CVAs). The existence of such a link has come to be known as the lipid hypothesis **(Figure 3)**. This maintains that dietary lipid intake can alter blood lipid levels, which in turn initiate atherosclerosis.

4.2. Cholesterol

Cholesterol is a major component of atherogenic fatty plaque. The levels of cholesterol in body is dependent on LDL and HDL concentrations. High blood levels of LDL cholesterol result in accumulation of lipids in the cells. HDL scavenges excess cholesterol from the tissues to the liver for degradation. Maintaining low serum levels of LDL and high levels of HDL supports wellness, the concept of “good” and “bad” cholesterol. The “good” form is the cholesterol associated with HDL. The “bad” form is the cholesterol transported as LDL. Cholesterol and especially cholesteryl ester are major components of fatty plaque.

4.3. Saturated and Unsaturated Fatty Acids

The effect of dietary fats containing primarily SFAs, MUFAs, PUFAs is as extensive as that related to consumption of cholesterol itself (**Table 4)**. SFAs are

hypercholesterolemic, and PUFAs are hypocholesterolemic. Furthermore, MUFAs are neutral, neither increasing nor lowering serum cholesterol. Diets rich in MUFA is as effective as PUFA-rich diets in lowering LDL cholesterol and triacylglycerols without significant change in HDL.

Consumption of the following lipids shows hypercholesterolemic effect which increases the risk of cardiovascular disease (CVD)

i. total fat
ii. saturated fatty acids
iii. cholesterol
iv. trans fat

4.4. Trans Fatty Acids

Major sources of TFAs in the diet are chemically hydrogenated margarine, shortening, commercial frying fats, high-fat baked goods, and salty snacks containing these fats. It is observed that TFAs have a negative effect on human health. Higher intakes of TFAs are associated with increased risk for CHD, cancer and other chronic diseases (including type 2 diabetes and allergies). It is recommended that dietary consumption of hydrogenated and SFAs should be reduced.

5. Conclusion:

Fats or oils are lipids and occur naturally in food. Fats are concentrated source of energy providing 9 Kcal/g. Dietary fats are derived from invisible and visible fat sources. Fats serve as a vehicle for fat-soluble vitamins and promote their absorption. The functions of lipids include generation of cellular energy; bactericidal activity; growth and development, preventing CHD, to maintain healthy skin and acts as insulator, protector for certain vital organs. To perform the functional roles, an ideal quality of different types of fats has to be consumed in the diet. Deficiency of lipid causes phrynoderma, dry, thick, flaking skin, retarded growth, abnormalities in vision, permanent learning defects and alterations in synaptic functions in the brain. Excess consumption of food rich in cholesterol, trans fats, saturated fats increases the risk for coronary heart disease, obesity, diabetes and cancer.

Table 1: Unsaturated Fats vs. Trans Fats

	Unsaturated Fats	**Trans Fats**
Cell Membranes	Essential for healthy function	Interfere with healthy function
Hormones	Enhance hormone production	Interfere with hormone production
Inflammation	Suppress	Encourage
Heart Disease	Lower Lp(a). Raise “good” cholesterol	Raise Lp(a). Lower “good "cholesterol
Omega-3	Put in tissues and conserve	Reduce levels in tissues
Diabetes	Help insulin receptors	Inhibit insulin receptors
Immune System	Enhance	Depress
Prostaglandins	Encourage production and balance	Depress production; cause imbalances

Table 2: Non-glyceride components in dietary fats and oils

Non glyceride components	**Oil**	**Biological and health function**
Plant sterols, Vitamin A , D, K	All vegetable oils, Ghee/butter	Hypocholesterolemic, Vitamin
Tocopherols	All vegetable oils	Vitamin, Antioxidant
Tocotrienols	Palm oil, Rice bran oil	Vitamin, Antioxidant
Carotenes	Red Palm oil	Provitamin, Antioxidant
Oryzanols	Rice bran oil	Hypocholesterolemic, Antioxidant
Sesamin	Sesame	Hypocholesterolemic, Anti-inflammatory
Sesamolin, Sesamol	Sesame	Antioxidant

Table 3: Recommendations for Type of Visible Fat

1	Use correct combination / blend of 2 or more vegetable oils (1:1)
	Oil containing LA + oil containing both LA and ALA *
	Groundnut / Sesame[a] / Rice bran[b] / Cottonseed + Mustard/ Rapeseed **
	Groundnut /Sesame[a] / Ricebran[b] / Cottonseed + Canola
	Groundnut / Sesame[a] / Ricebran[b] / Cottonseed + Soyabean
	Palmolein[c] + Soyabean
	Safflower / Sunflower + Palm oil/Palmolein[c] + Mustard/ Rapeseed**
	Oil containing high LA + oil containing moderate or low LA ***
	Sunflower / Safflower + Palmolein[c] / Palm oil[c] / Olive
	Safflower / Sunflower + Groundnut / Sesame[a] / Ricebran[b] / cottonseed
2	Re Limit use of butter/ghee[d]
3	Avoid use of PHVO as medium for cooking / frying
4	Replacements for PHVO
	Frying : oils which have higher thermal stability -- palm oil[c] / palmolein[c], sesame[a], ricebran[b], cottonseed -- single / blends (home /commercial)
	Bakery fat, shortening, Mithai / Indian sweets etc -- Food applications which require solid fats : coconut oil/ palm kernel oil/ palm oil / palmolein/ palm stearin and / their solid fractions and / their blends

All vegetable oils contain tocopherols and plant sterols
[a]sesame lignans, [b]oryzanols+tocotrienols, [c]tocotrienols, [d]vitamin A & D
* Approximately 30-40% PUFAs with >3 %ALA
** Combinations with rapeseed/ mustard reduce erucic acid levels.
*** approximately 40-50 % LA and <0 .5 % ALA, recommended only when intake of ALA from other foods/unconventional foods is increased and or adequate amount of fish is consumed

Source: ***Nutrient Requirements and Recommended Dietary Allowances for Indians, Indian Council of Medical Research, National Institute of Nutrition, 2010***

Table 4: Effect of different types of fats on Cholesterol levels

Type of fat	Main Source	Effect on cholesterol levels
Monounsaturated	Oilve oil, canola oil, peanut oil, cashews, almonds, peanuts, and most other nuts, avacados	Lowers LDL, raises HDL
Polyunsaturated	Corn, soyabean, safflower, and cottonseed oils, fish	Lowers LDL, raises HDL
Saturated	Whole milk, butter, cheese and ice-cream, red meat, chocolate, coconuts, coconut milk and coconut oil	Raises both LDL and HDL
Trans	Most margarines, vegetable shortening; partially hydrogenated vegetable oil; deep fried chips, many fast foods, most commercial baked goods	Raises LDL

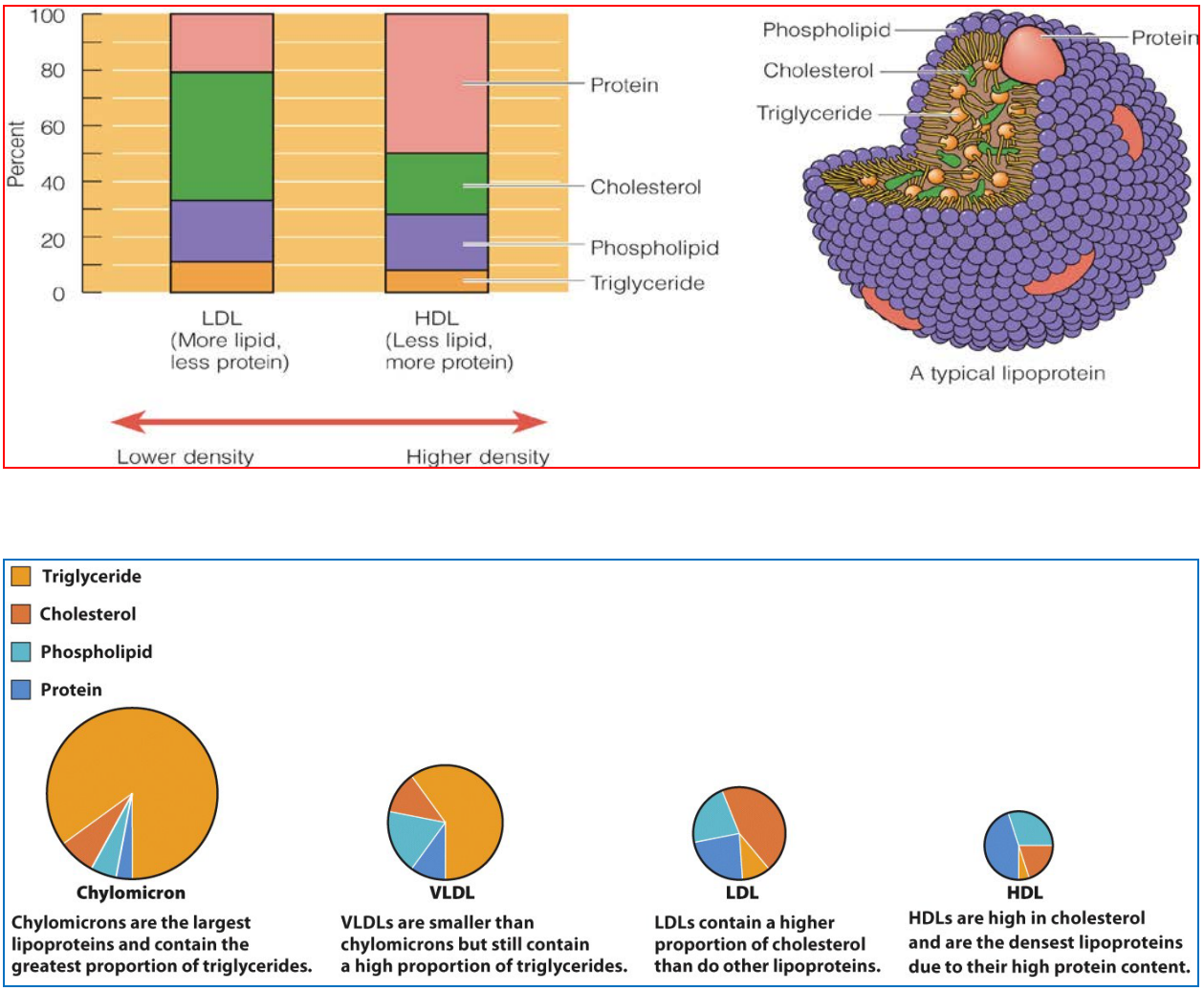

Figure 1: Lipoproteins

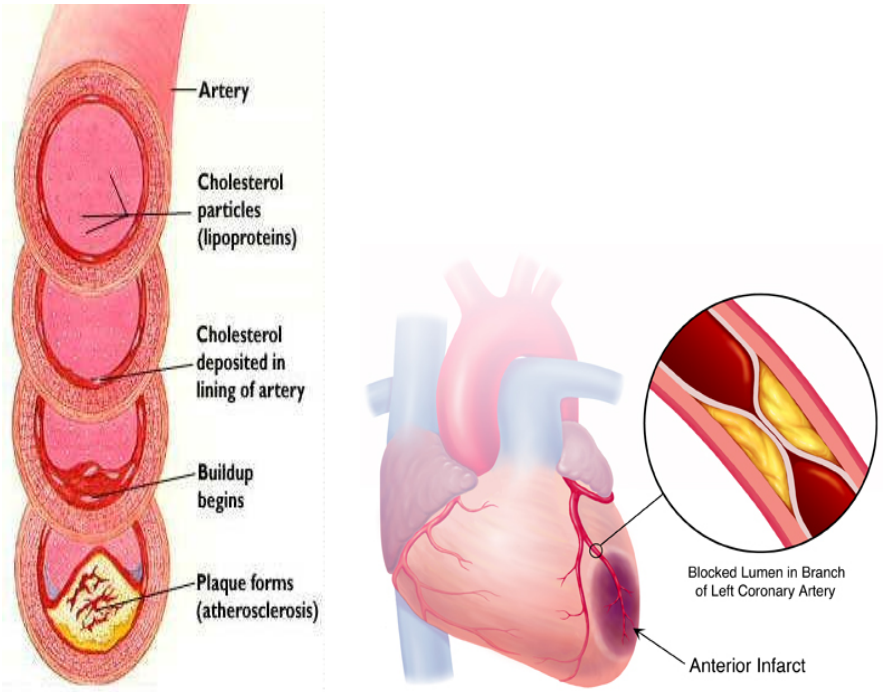

Figure 2: Formation of Plaque (Atherosclerosis)

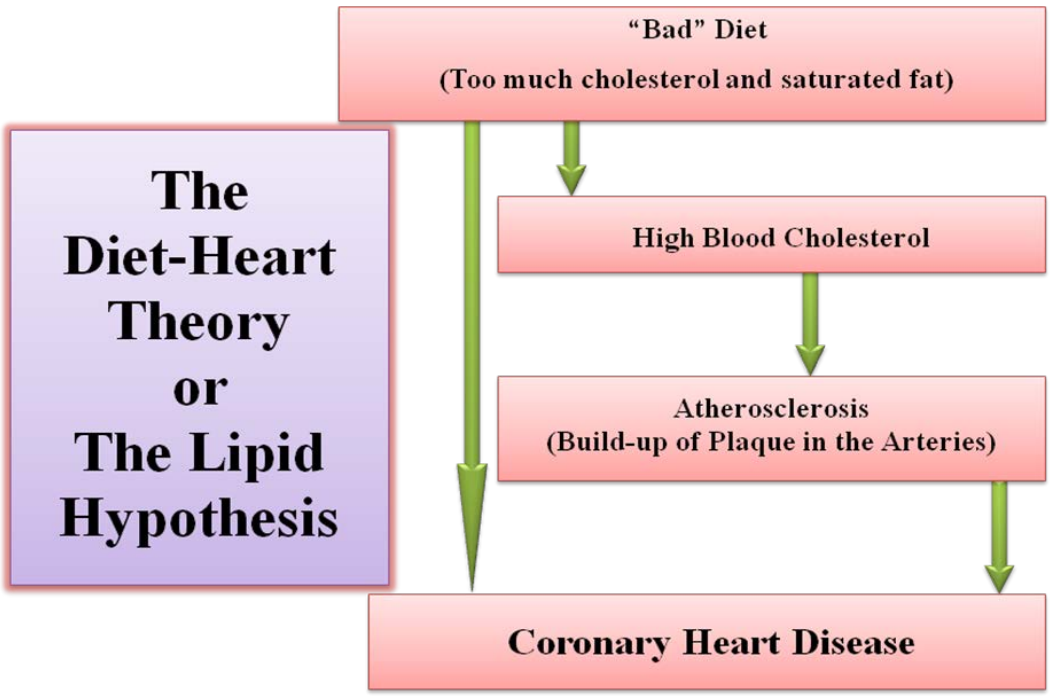

Figure 3: Lipid Hypothesis