THE HUMAN HEART

Shanthi Mendis

Getting to the heart of things

What exactly is the thing called 'Heart'? It just happens to be the most hard working organ in the body. Not much bigger than a clenched fist.

It is a hollow structure which is divided into four separate compartments by a wall (Figure 1). Each of the two upper compartments is called an atrium and lower compartments are called ventricles. The wall (septum) completely separates the right atrium from left atrium and the right ventricle from the left ventricle so that the blood is not permitted to pass between these. The atrium is connected to the ventricle on the same side by a valve.

The wall of the heart consists of three layers: the outer layer (the pericardium) the middle layer (the myocardium) on the inner layer (the endocardium).

The middle layer (the myocardium) is the muscle layer of the heart and therefore is responsible for the work of the heart. The muscle is of a special type called cardiac muscle which is not under control of the will, as in skeletal muscle of the arms and legs for example, but rather works involuntarily. The myocardium varies in thickness according to the work demand of the different parts of the

heart. The right atrium and the left atrium have little work to do and therefore the walls of the atria are thin. The right ventricle has more work in that as it must drive the blood to the lungs and therefore has a thicker wall than the atria. The left ventricle must pump blood through out the entire body and has to do the most amount of work. Therefore, it has a wall which is three times thicker than that of the right ventricle.

The endocardium is the lining of the heart. It lines the entire cavity of the heart and folds upon itself at the junction of atria and ventricles to form values.

The heart must have values to keep the blood flowing in one direction. The values open only in one direction allowing the blood to flow in that direction and close between strokes of the heart so that the blood does not flow backwards.

These valves are located in four areas between each atrium and ventricle and at the outlets from each ventricle (Figure 1).

Work of the Heart

The heart beat is initiated in the right atrium. There is a small bundle of nerve tissue called sino-atrial node. This node is known as the normal pacemaker of the heart, from it an electric wave is given off which spreads through out the muscle tissue of the atria causing them to contract thus forcing the blood into the ventricles.

The electrical impulse then spreads in a network of nerve fibres located throughout the muscle walls of the ventricle causing the ventricles to contract.

The rate of the heart contractions is approximately 72 times per minute in the normal adult but may go as high as 120 in the new-born and the young. The heart beat increases during exercise and emotional states. The heart pumps about ½ a litre of blood a minute to all parts of the body. That is about 700 litres of blood a day or full 3 million barrels in a 70 year life span. That is a lot of hard work! The heart has to cope up with this tremendous load of work in order to pump blood that carry nutritional elements to all tissues of the body. The most important of these is oxygen but blood also carries salt, sugar food stuffs and many other chemical to the cells of the body.

Blood supply to the heart

The heart like any other organs must also have a blood supply if it is to function efficiently. It receives this blood supply from the coronary arteries, which are branches of the aorta just after it leaves the heart (Figure 2).

Unfortunately, the blood supply via the coronary arteries to the heart is not very efficient. In most of the other organs of the body there is a collateral blood supply, which means that if blood vessel (artery) of a particular area becomes diseased then there is another blood vessel

nearby, connected to it by small channels or collateral vessels, which will take over the blood supply to the area. This feature, however is not true in the wall of the heart because there is very poor collateral circulations.

This explains the large number of people who die each year of heart disease because if the blood supply to a portion of the heart is cut off then there is no alternate blood supply to compensate.

Disease of the coronary arteries

Any obstruction in the two small arteries - coronary arteries- that supply nourishment to the heart is critical, then the whole pumping system of the heart is liable to breakdown or failure. There are many types of coronary artery disease but the most common type is disease due to Atherosclerosis.

In Atherosclerosis, a mass of fat (produced by fats such as cholesterol normally circulating in the blood) finds its way into the vessel wall and hardens it (Figure 3). Scar tissue or fibrous tissue later grows around the fat deposits (Atheroma) and Calcium deposition also can occur in the Atheroma. Then the Atheroma becomes harder. This Atheroma may stay small or become larger so that it might eventually block the entire coronary artery. Under any circumstance however, Atheroma slow down the blood flow in the blood vessel. When the blood flow is slowed down a blood clot may form on the Ahteroma. This blood clot is then called a "Thrombus". When it occurs in a coronary artery, it is called "coronary thrombosis".

What is a heart attack

Any partial or complete blocking of the coronary arteries is of serious consequence because the heart has a very poor collateral blood supply. The heart muscle requires a considerable amount of oxygen and if one of the coronary arteries is partially or completely blocked, it leaves very little reserve capacity when more oxygen is needed for heart muscle as for instance, when running after eating a large meal or during exercise. When there is insufficient blood supply to heart muscle, chest pain (Angina pectoris) may develop. This type of chest pain usually lasts a few minutes and is related to exertion, over-eating and emotional upset. If the blood supply is insufficient to maintain life in heart muscle then that portion of the heart muscle will die and this is known as a "heart attack" (Myocardial infraction).

During a heart attack a severe crushing sensation is felt in the centre of the chest and sometimes the pain is also felt on the shoulder, left arm and neck and ocassionally in the right arm and upper abdomen. Some people feel, very little pain with only a sensation of fullness on the chest. In the early stages of a heart attack, there may be some nausea, vomitting and sweating. It is not easy to arrive at the right diagnosis as these symptoms can occur in other diseases.

Many people die suddenly of heart attacks and do not reach medical care. Despite advances in treatment 10% of those who survive die in the 1st year and 5% yearly thereafter.

FACTORS THAT PROMOTE HEART ATTACKS

A heart attack is not an inevitable consequence of ageing or affluence. Coronary atherosclerosis (fibrous fatty change in arteries as described earlier) is a process that starts in childhood. Heart diseases becomes apparent only when the underlying arterial disease is advanced.

Several factors are known to interact and result in atherosclerosis. These factors identified as risk factors for atherosclerosis may be non-controllable or controllable.

Non-controllable factors

These factors are beyond the control of an individual. They are:

(1) Age

(2) Sex and

(3) family history of heart diseases.

The risk of atherosclerosis increases with age. The risk is greater for men and menopausal females than for pre menopausal females. The risk is also greater in people when there is a family history of heart disease (atherosclerosis) in early age.

Controllable factors

These can be controlled at least partly. They are:

(1) smoking

(2) high blood pressure

(3) high blood lipid

(4) diet

(5) exercise

(6) stress and personality

(7) High blood sugar (Diabetes - Mellitus)

(8) Overweight (obesity)

Smoking - the totally preventable risk factor

The evidence that cigarette smoking is a very important, totally preventable risk factor in coronary heart disease is now very strong. It is supported by large scale studies. The most striking aspect seems to be that there is a special relationship to suddent death: those who smoke more than 20 cigarettes per day have five times greater risk of sudden death at a young age than non-smokers of dying from coronary heart disease. In those who stop smoking the risk of developing heart diseases declines to the level of a non-smoker within one year.

The mechanism by which tobacco smoking influences coronary heart diseases is not yet clear. Nicotine, carbon-dioxide and other toxic compounds in cigarette smoke may be responsible for the effect on coronary heart disease.

Control of cigarette smoking

Smoking habits and smoking trends vary from country to country. In most European countries, the number of males smoking is falling. In Sri Lanka on the other hand, there seems to be an alarming increase

in smoking during the last decade. A trend, which can be attributed to the powerful advertising influence of tobacco companies. An effective anti-smoking campaign needs to be launched to arrest this rising trend in smoking in Sri Lanka. The public must be told about the severe health risks of smoking and it should receive more prominence at all levels of education. Doctors, teachers and other members of the caring profession should be encouraged to set a good example by not smoking. Children should be well informed about the unpleasant consequences of smoking and this will prevent them from starting the smoking habit. Children can also favourably influence their parents' smoking habits. Opposition to smoking control programmes by those in agriculture and tobacco industry represents dominance of monstery consideration over those of health. While the production of tobacco in a country contributes to the economy of that country, but it does so usually at the expense of reduced food production and the consumption of fuel to provide heat for curing tobacco. Smoking also generates extra demands for medical care. Again, such medical care given and paid for, is a real cost to society and cannot be offset by increased tobacco taxes. Smoking is not something that affects only the smoker. It incurs costs that affect his family, other tax payers and society at large.

High blood pressure

High blood pressure is one of the most frequent circulatory disorders. It is most commonly seen between the ages of 40 and 60 years and the tendency towards the developing high blood pressure may be hereditary. High blood pressure arises primarily because of increased resistance of blood flow which in turn is caused by narrowing of the lumean of the arteries. The heart tries to overcome this resistance by pumping more forcefully. Under the increasing strain, the heart becomes enlarged and when it reaches the limit of its capabilities, it may begin to fail.

It is well established that elevated blood pressure carries in an increased risk of coronary heart diseases proportionate to the height of the blood pressure.

High blood pressure can cause headache, giddiness, shortness of breath and many other symptoms. However, it is important to realize that high blood pressure may not give rise to any symptoms in its early stages. Therefore, it is important to get one's blood pressure checked by a doctor at least once in six months specially after the age of 40 years.

High serum lipids/diet and coronary heart disease

The type of diet has an important role in the development and progression of Atherosclerosis. Alterations in blood lipids and development of atherosclerosis are in fact the end results of dietary

habits over decades. Improper diet can result in increased levels of lipids in blood or trigger and underlying genetic tendency of atherosclerosis. The important dietary factors are:

(a) cholesterol

(b) fat

(c) fatty acids

(d) fibre

(e) proteins

(f) total calories, carbohydrates and refined sugar

(a) Cholesterol

Cholesterol is a lipidic compound found in all human cells. It performs several important functions in the body. However, under certain conditions, cholesterol is prone to accumulate in the walls of arteries as lipid plaques and produce atherosclerosis.

There is confusion in the minds of people over the terms 'dietary cholesterol" and 'blood cholesterol'. Cholesterol in blood is derived from two sources - namely, the diet and indigenous synthesis (synthesis in the body). Only about 1/5th of the ingested cholesterol is absorbed. However, if dietary intake of cholesterol is markedly increased the absorption is also increased within limits. Dietary cholesterol also inhibits the indigenous synthesis of cholesterol. Cholesterol is excreted into the bile as cholesterol and bile acids. These are eliminated through

The effect of dietary cholesterol on blood cholesterol levels is also influenced by the nutrient composition of diet. Knowing the baseline level of dietary cholesterol from which observations are made is also important. Because of these variations there has been a confusion as to which dietary cholesterol will influence the level of blood cholesterol. The widely expected view today is this. There seems to be a threshold amount of dietary cholesterol below which small increments do not affect blood cholesterol. The threshold is probably between 100 - 200 mg/day. Also, if one consumes excessive increments of dietary cholesterol, one reaches a "ceiling" above which there is no additional change in plasma cholesterol. This is probably between 500-600 mg/cholesterol/day.

The food items that are rich in cholesterol are:

Egg yolk, meat and dairy fat.

Dietary cholesterol is of minor importance as compared to total calories and fat in increasing blood cholesterol level. Blood cholesteral is an important risk factor of coronary heart disease. Persons with high level of cholesterol in blood have greater chance of suffering from heart attack than those with lower levels.

Cholesterol is transported in blood as lipid protein complexes called lipoproteins. Lipoproteins have been named according to their density, each having a distinct physiological role. The low density lipoprotein (LDL) carries cholesterol from the liver to cells of the organs

of the body including blood vessels and heart. Therefore, increase in LDL cholesterol increases the of atherosclerosis. The high density lipoproteins (HDL) helps to mobilize the cholesterol depots from the tissues. In other words HDL acts as a scavenger and prevents the accumulation of cholesterol in blood vessels and heart. Increase in HDL cholesterol therefore is associated with a decrease in the risk of coronary heart disease. In recent years, therefore, it is emphasized that in addition to total cholesterol in blood, its distribution in LDL and HDL is also important in predicting the risk of coronary heart disease in an individual or a population.

(b) Fat

The amount of fat and kind of fat in the diet affects the levels of lipids in blood and therefore has an effect on atherosclerosis and coronary heart disease.

Fats may be divided into two major classes. Saturated fatty acids contain all the hydrogen atoms that are possible for them to carry.

In unsaturated fatty acids some of the positions where hydrogen atoms might normally be attached are unfilled and double bonds are formed instead between carbon atoms.

(c) Fatty Acids

Saturated fatty acids

All animal fats (butter, ghee, meat, fat etc) are highly saturated

except for those which occur in fish. Coconut oil and hydrogenated vegetable oils are also rich in saturated fatty acids (Table 1).

Unsaturated fatty acids

Mono-unsaturated fatty acids carry one double bond and poly-unsaturated fatty acids carry more than one double bond.

The diet must supply a certain amount of poly-unsaturated fatty acids particularly Linoleic and Arachidonic acids. These fatty acids are essential nutrients because the body cannot synthesize them in sufficient quantity to meet its need. Therefore, they are known as essential fatty acids (EFA).

Effects of dietary fat on blood cholesterol

High fat diets particularly saturated fats increase the level of blood cholesteral Poly-unsaturated fatty acids increasing excretion of cholesterol and bile acids in faeces and reduce blood cholesterol. Reduction in blood cholesteral can therefore be achieved by reducing saturated fat or by increasing poly-unsaturated fat or by both.

Essential fatty acids such as linoleic acid (Omega - 6 - fatty acid) are required for normal transport and oxidation of cholesterol. Deficiency of essential fatty acids can cause an increase in plasma cholesterol.

Recently, it has also been observed that poly-unsaturated fatty acids present in fish and fish oils (Omega - 3 - fatty acid) lower the blood lipids.

Effect of dietary fat on thrombosis (Blood clot formation)

In addition to its effect on blood lipids dietary fat has an effect on blood platelets and coagulation system (promote platelet aggregration) and also activate the coagulation system. Both these processes favour thrombus formation.

In platelets and blood vessels the Omega - 6 - poly-unsaturated fatty acids are converted to an important class of biological regulators known as prostaglandins. The prostaglandins play a crucial role in thrombosis. The types of prostaglandins formed from Omega - 6 - polyunsaturated fatty acids are anti-thrombotic Omega - 3 - poly-unsaturated fatty acids present in fish have a more pronounced anti-thrombotic effect.

Therefore, it can be seen that a proper balance of different fatty acids is important in maintaining blood lipid levels and thrombotic tendency. Thus, it is important to be conscious of the quantity as well as quality of fat consumed.

(d) Fibre in diet

High fibre foods have a cholesterol lowering effect. The action of fibre in lowering blood cholesterol is mostly caused by binding of bile acids and increasing their faecal loss. Dietary fibre

found in unprocessed cereals, legumes, vegetables and fruits contribute bulk to the diet and therefore helps in keeping calorie intake low.

(e) Proteins in diet

Vegetable proteins have a blood cholesterol lowering effect. Therefore, those who have high blood cholesterol levels are likely to benefit from a vegetation diet.

(f) Total calories

Carbohydrates and refined sugar - Energy intake should match energy expenditure. Refined flour and sucrose increase blood lipid levels and therefore will indirectly promote atherosclerosis.

Overcoming Heart attacks

On the basis of firmly established scientific information, it can be concluded that diet is of Key importance on the aetiology of atherosclerosis. Regardless of the degree to which non-controllable risk factors contribute to an increased blood lipid levels dietary modifications will always result in improvement.

Dietary Guide lines

1. Decrease intake of total fat and saturated fat.

   Increase intake of poly-unsaturated fatty acids.

2. Total dietary fat should contribute 30% of the energy (about 60 g. of fat).

What to eat/What not to eat

1. Reduce intake of butter, ghee, whole milk, cheese and animal fat. Avoid lard.

2. Eat less and lean meat. Instead of meat have non-meat meals with proteins from mixed vegetable sources (cereals, pulses) or choose more fish or poultry (avoid pork, bacon, ham and sausages). Reduce intake of saturated vegetable oils like coconut oil and palm oil and with replacement by poly-unsaturated vegetable oils such as soya-bean oil, gingelly oil and corn oil (see Table 1). Avoid hard margarines and use poly-unsaturated margarines.

3. Reduce intake of cholesterol to less than 300 mg/day.	1. Restrict egg yolk, meat, dairy fat (avoid liver, kidney, shell-fish).
4. Ensure a satisfactory intake of essential fatty acid.	2. Eat more green leafy vegetables. Desirable amounts of omega - 3 fatty acids can be obtained by eating fish once or twice a week.
5. Energy intake should balance energy expenditure.	3. Restrict cake, pastries, pudding, ice-cream and confectionery. Watch you body weight. Do not over-eat.
6. Increase consumption of complex carbohydrates and fibre	Take whole grain products un-polished, rice, kurakkan, chapati, bread, macaroni, noodles pulses (beans, peas, etc.). Fruits, nuts, vegetables, yams as potato, manioc, sweet potato and bread fruit, peanuts and winged bean seeds. Honey, yams, jelly, juggery in moderate amounts. Restrict refined sugar.

Five rules for prevention of heart attacks

1. Do not smoke

2. Take regular exercise

3. Get your blood pressure checked regularly

4. Do not be hostile to others

5. Promote healthy eating habits

Figure 1 SECTION OF HEART

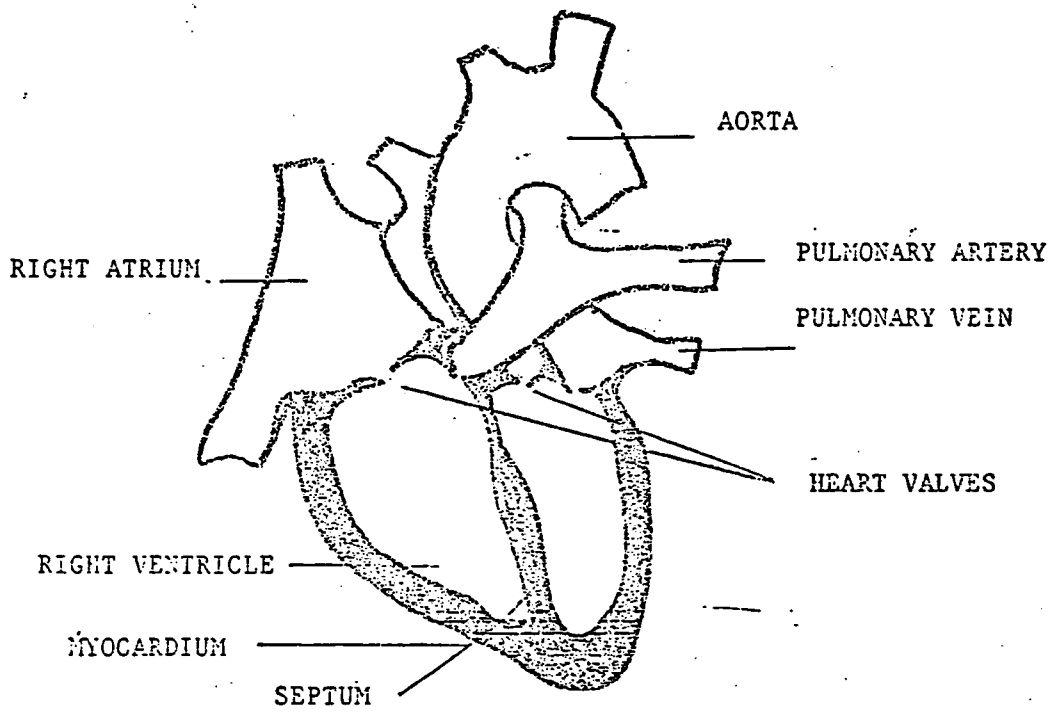

Figure 3 THROMBUS AND ATHEROSCLEROSIS IN CORONARY VESSELS

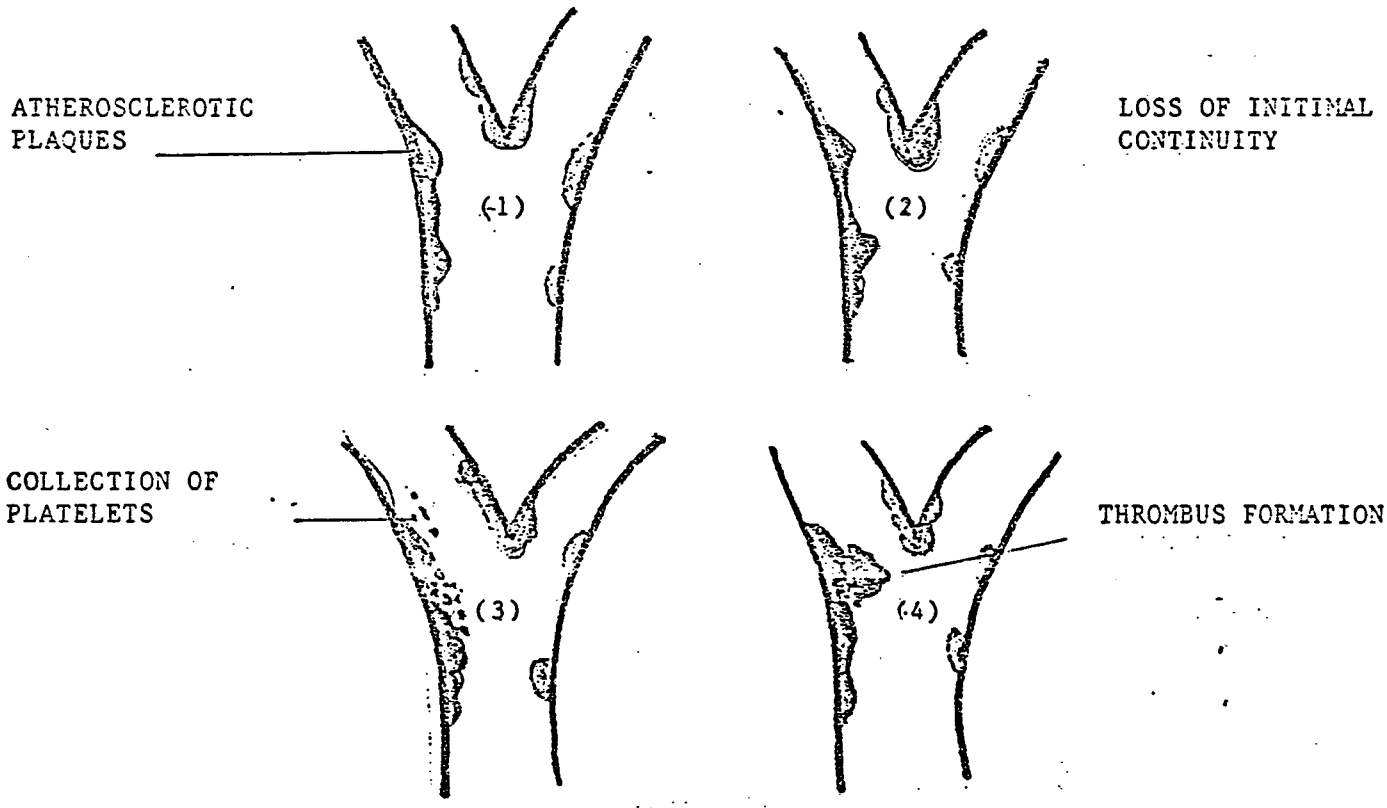

FIGURE 2

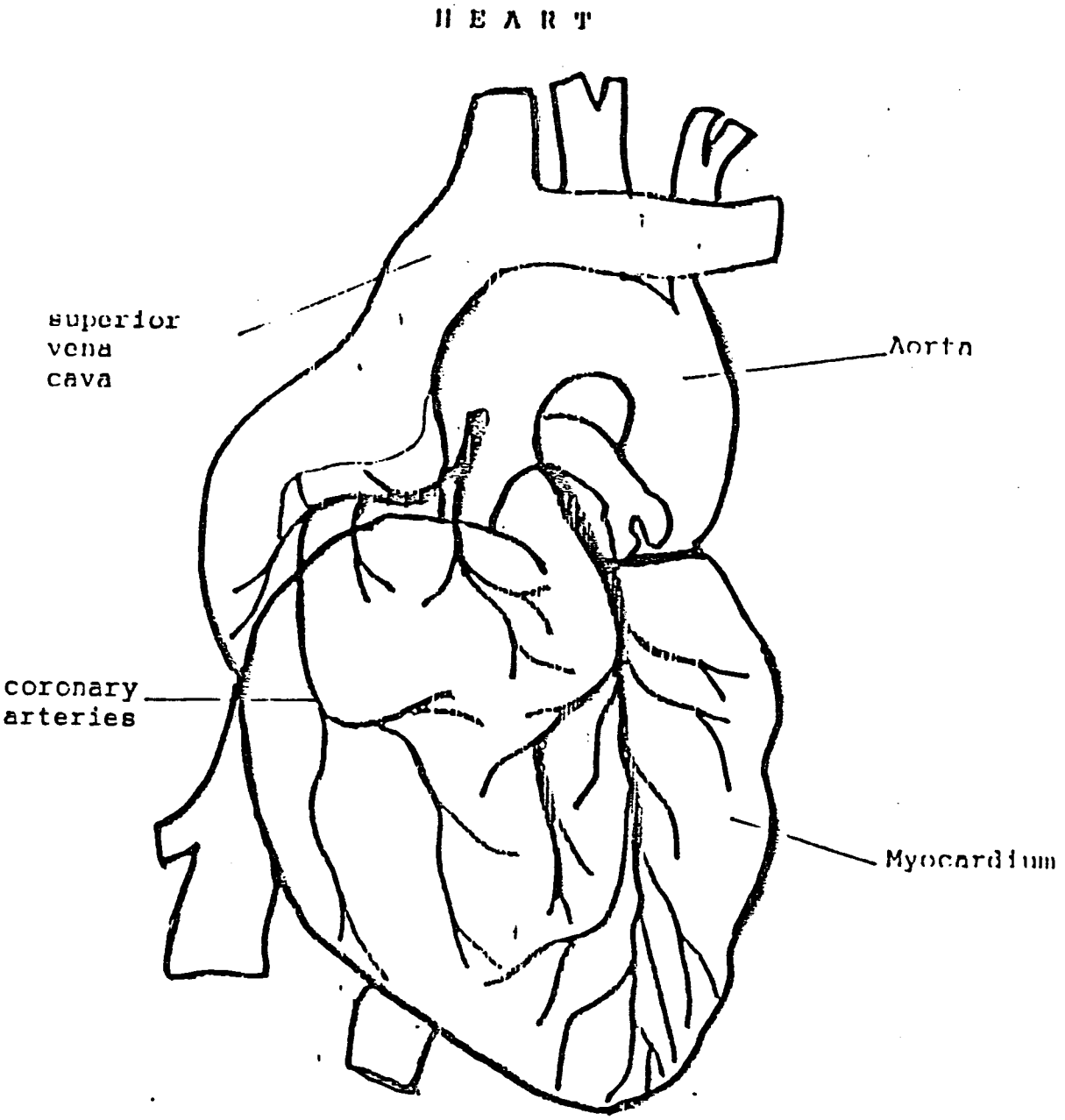
HEART
superior
vena
cava
Aorta
coronary
arteries
Myocardium

Table 1

PLANTS AND ANIMAL FATS

Fatty acid	Composition (% wt)	
	Saturated fatty acids	Poly-unsaturated fatty acids
Coconut	88	02
Palm	48	09
Corn	13	60 (rich in Omega - 6 FA)
Soya	15	58 (rich in Omega - 6 FA)
Gingelly	12	51 (rich in Omega - 6 FA)
Pea nut	19	30
Sunflower	10	56
Safflower	09	73
Winged bean	31	30
Olive	11	04
Beef	43	02
Chicken	30	26
Pork	38	11
Fish (depends on type)	18	40