

The cardiovascular system

In the human body blood is pumped by the heart through blood vessels that range in diameter from about 1 cm down to less than a thousandth of that (0.01 mm or 10 μm). The blood transports *nutrients* and oxygen to body tissues and carries away carbon dioxide and other by-products of the body's *metabolism*. The blood, the heart and the associated blood vessels are collectively known as the cardiovascular system.

The circulatory system

The circulatory system includes the cardiovascular system (the blood system) and the lymphatic system – a system of ducts and *nodes* containing lymph fluid. The nodes are small roughly kidney-shaped swellings, typically about 5 mm in diameter, where a number of lymph ducts meet. *Lymph fluid* is comparatively clear and does not contain red blood cells. It circulates more slowly than blood. The lymphatic system removes excess fluid from body tissues and has an important role in the body's defence against disease.

Blood vessels

The blood vessels that carry blood away from the heart are called *arteries*; they have thick walls and can withstand the relatively high pressure (about a sixth of atmospheric pressure). The vessels that carry blood back to the heart have relatively thin walls. The smallest blood vessels (the *capillaries*) are so small that red blood cells can just about squeeze through them.

Cardiovascular Diseases (CVD)

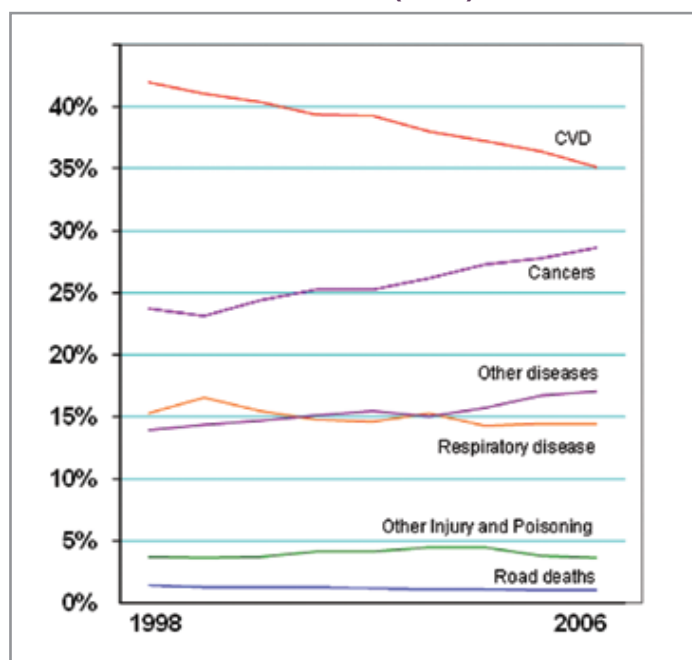


Fig. 1 Causes of death in Ireland 1998 - 2006

The principal forms of *CVD* are:

- Ischaemic Heart Disease ('heart attack') causing 20% of all deaths
- Cerebrovascular Disease ('stroke') causing 8% of all deaths
- Hypertensive Disease (high *blood pressure*) causing 1% of all deaths

Other forms of CVD account for almost 10% of all deaths. These include rheumatic heart disease, congenital heart disease and peripheral artery disease.

Between 1998 and 2006 the percentage of all deaths in Ireland due to CVD fell from 42% to 35% (CSO data). It is still the major cause of death. Research in the UK indicates that this decline is due mainly to **lifestyle changes** (especially reduction in smoking) and to improved treatment.

Worldwide in 2005 about 30% of all deaths were due to CVD – that's 17.5 million deaths – considerably more than any other cause of death including cancer, AIDS, TB, malaria, (7.6 M, 1.7 M, 1.6 M, 1 M respectively). Annually between 2 and 5 million children die due to malnutrition while in the West an estimated 2.5 M people die of CVD due to over-eating.

Causes of CVD

The major causes of cardiovascular disease are

- tobacco smoke
- insufficient physical activity
- unhealthy diet.

In contrast to many other causes of death, the risk of CDV can be greatly reduced by lifestyle changes. Although the incidence of CVD in Ireland is falling it is still above the average for the OECD countries and more than twice that of France.

Overestimating some risks

Popular media often exaggerate relatively insignificant factors such as food colouring, pesticides and microwaves for which there is little or no evidence of risk when used within normal limits. People become over concerned about minor risks over which they have little control and neglect undisputed risks that are thousands of times greater but which require **personal decisions** and lifestyle changes.

Comparative risks for men and women

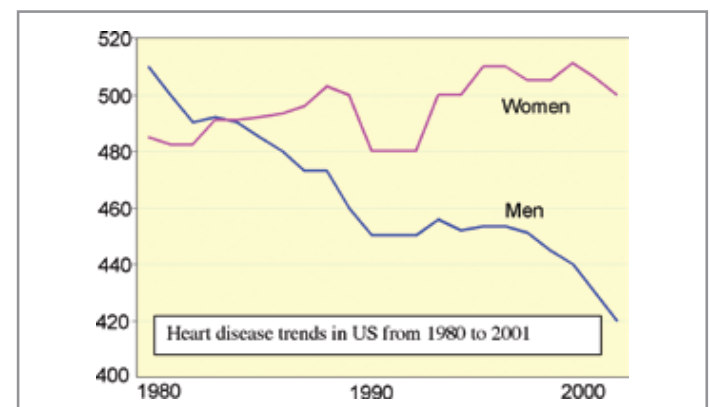


Fig. 2 Deaths due to heart disease in US, per 100,000 per annum

In Ireland the overall risk of CVD is about the same for men and women (35%); men have slightly higher risk of heart attack than women but lower risk of stroke and other CVDs. In the US during the past thirty years the incidence of CVD in men has declined significantly; over the same period the incidence in women has declined little and may indeed have increased.

Incidence of CDV varies considerably from country to country even in Europe. For instance, in Latvia CVD mortality is more than 12 times that of Switzerland. The lowest CVD mortality rates are in Portugal, Spain, France and Italy.

Smoking

People sharing accommodation with smokers increase their risk of heart attack by 25% – 30%; the smokers more than double their own risk of heart attack and stroke. Smokers become addicted to *nicotine* and so find it very difficult to quit. The vast majority admit to having being addicted by the time they left school. Without nicotine they suffer withdrawal symptoms that only nicotine will relieve; this gives the illusion that smoking calms them down.

Teenagers' insecurities and their need to belong contribute to their becoming addicted. However there are many benefits to quitting: it gives a sense of personal control of your life; it greatly reduces your risk of heart attack and stroke; it shows a sense of social responsibility; increases your ability to enjoy sports and other active pursuits; and it saves you about €3000 a year.

Smoking is a major cause of *atherosclerosis*; this is a build up of fatty material in the arteries, which restricts the flow of blood and therefore puts more strain on the heart. When this happens in the heart's own blood vessels it causes severe pain (*angina pectoris*); if the coronary arteries become completely blocked the risk of heart attack increases greatly.

Obesity and excess weight People who are overweight are more likely to have elevated levels of *cholesterol* in their blood and often high blood pressure. They are also more likely to have a blood clot. The fact that they have to carry extra weight inhibits their ability to engage in sport and aerobic exercise. The lack of activity generally means that they 'burn' less carbohydrate than they consume and so they put on more weight.

Activity People who are active can enjoy life more. They are less likely to be obese or to suffer breathlessness. Aerobic exercise reduces blood pressure and the risk of atherosclerosis, although the mechanism is unclear. Regular exercise improves the efficiency of the heart and reduces the risk of other diseases such as osteoporosis and diabetes.

Diet

A balanced diet includes carbohydrate, protein, fat, vitamins, mineral salts and fibre in the correct proportions. In the West the average diet is unbalanced, having too much carbohydrate, protein and saturated fat not enough fibre. A healthier diet would have less animal fat and more fruit and vegetables.

Treatment

Despite the fact that many risk factors are controllable by adopting a healthier lifestyle many people ignore medical advice.



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The core technologies at the Waterford site are inhalation (inhalers) and solid dose products (tablets and capsules). The Waterford site includes an extensive Research & Development capability and is the Teva Centre of Excellence for respiratory products.

To learn more about research by Teva see www.teva.ie

There are several classes of drugs for the treatment of CVD. These include:

- beta blockers (especially to manage *cardiac arrhythmias*)
- statins (to lower cholesterol levels)

Other treatments include:

- implanting a cardioverter-defibrillator (ICD)
- the insertion of a *stent* (to widen restricted sections of arteries)
- a *cardiac bypass* (adding blood vessels to 'bypass' restricted sections)

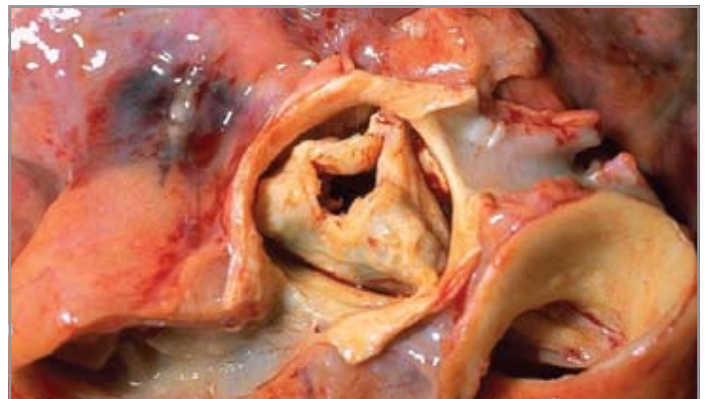


Fig. 3 *Arterial Stenosis* - narrowing or blocking of the artery

Syllabus Reference

Leaving Certificate Biology

- The circulatory system: description of the structures and organisation of tissues in the closed circulatory system in humans, strong muscular heart and vessels (arteries, veins, capillaries, venules, arterioles).
- Role of muscle tissues and valves. Two-circuit circulatory system.
- Cardiac supply through the cardiac artery and vein.
- Knowledge of the effect of smoking, diet and exercise on the circulatory system.

Learning Outcomes

On completing this section the student should be familiar with:

- The basic functions of the circulatory system
- The major types of cardiovascular disease
- Why cardiovascular disease is the major cause of death in Ireland and in the Western World
- The different contributing factors that increase the risk of cardiovascular disease
- The lifestyle changes that can be made to reduce the risk of cardiovascular disease.

General Learning Points

- The circulatory system is an organ system that moves nutrients, gases and wastes to and from the cells, fights disease and helps maintain homeostasis.
- The circulatory system is composed of the cardiovascular system and the lymphatic system.
- Cardiovascular disease can be any number of diseases that affect the heart; the three main types include: Ischemic Heart Disease, Cerebrovascular Disease and Hypertensive Disease.
- In the last few years, as people have adopted healthier lifestyles, the incidence of cardiovascular diseases has fallen.
- The major factors that increase your risk of cardiovascular disease include: smoking, obesity, inactivity and poor diet.
- The risk of cardiovascular disease can be reduced by making healthier decisions such as quitting smoking, controlling fat intake and taking regular exercise.
- In severe cases where medical intervention is needed, certain drugs can be used to treat CVD. They include beta blockers, statins and aspirin (anti-platelet medication that reduces clot formation).

Student Activities

Measure your Heart Rate

Find your pulse by turning the palm of your hand towards the ceiling and placing the index and middle fingers of your opposite hand over your wrist (radial pulse). Press down in the groove between your tendons and you should feel a throbbing, this is your pulse.

If you cannot find your pulse there try placing your fingers on your neck just underneath your jaw-line (carotid pulse).

Count the number of beats that you can feel in one minute.

Your pulse is the rhythmic expansion of your arteries as the blood is forced through by the contractions of the heart.

Heart rate is an approximate measure of how hard your heart is working, depending on your fitness level. Normal heart rates can range between 60 and 90 bpm (beats per minute); an athlete can have a resting heart rate lower than 60 bpm.

True/False Questions

- | | |
|---|-----|
| a) Arteries carry blood from the heart to the arterioles. | T F |
| b) About two thirds of all deaths in Ireland are due to CVD. | T F |
| c) About two thirds of CVD deaths are due to heart attack. | T F |
| d) Lymph contains red corpuscles and white blood cells. | T F |
| e) Most of the cholesterol in our bodies comes from cholesterol-rich foods that we eat. | T F |
| f) All hearts age at the same rate. | T F |
| g) Both blood and lymph travel through the circulatory system. | T F |
| h) Lymph fluid is formed from interstitial fluid. | T F |
| i) Aspirin may be prescribed to patients with a high risk of CVD. | T F |

Check your answers to these questions on www.sta.ie

Examination Questions

Leaving Certificate Biology, 2003 Ordinary Level

11.(a)

- Draw a large labelled diagram of a vertical section through the mammalian heart. Include the attached parts of the major blood vessels in your diagram and label the following:
bicuspid valve, left ventricle, right atrium, septum, aorta, pulmonary artery.
 - Why is there more muscle in the wall of the left ventricle than in the wall of the right ventricle?
- (b) Answer the following sections in relation to red blood cells.
- Give one location in which they are made.
 - Describe their shape.

- (iii) Name a metal associated with them.
- (iv) State one function.
- (v) State one difference (other than colour) between a red blood cell and a white blood cell.
- (c) Describe an experiment to investigate the effect of activity on the human heart rate.

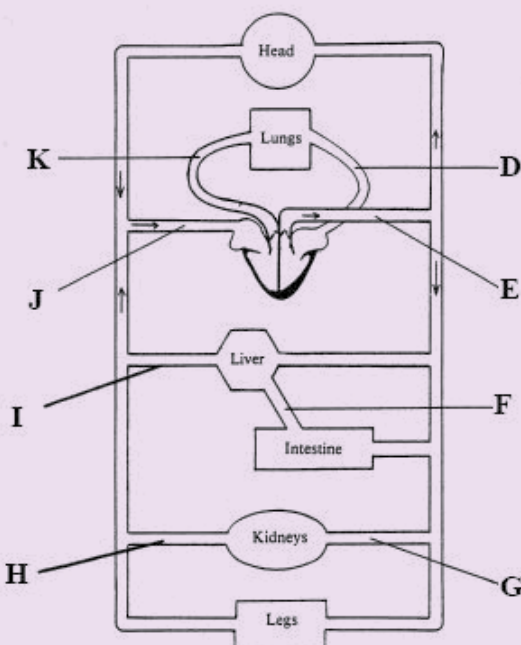
Leaving Certificate Biology, 2003 Higher Level

- (i) Contrast the structure of arteries and veins in transverse section by use of labelled diagrams.
- (ii) Give reasons for any two differences in the structure of arteries and veins.

Leaving Certificate Biology, 2001 Ordinary Level

The diagram shows the blood circulatory system of a mammal.

- a) State which letter represents each of the following parts.
(i) aorta, (ii) hepatic portal vein, (iii) pulmonary vein, (iv) renal artery, (v) vena cava.
- b) State what changes occur in the blood as it passes through
(i) the lungs, (ii) the kidney.
- c) Draw simple labelled diagrams to show a transverse section through,
(i) an artery (ii) a vein.
- d) Veins have valves and arteries do not. Suggest one reason for this.
- e) Describe an experiment to show the effect of exercise on heart rate.



For further examples of past questions check www.sta.ie

Did You Know?

- The valves of the heart were discovered around the 4th century BC. After death, blood collects in the veins so arteries appear empty. Ancient anatomists assumed that they were filled with air and were used for the transportation of air.
- Your heart beats about 100,000 times in a day and approximately 35 million times in a year. During an average human lifetime the heart will beat more than 2.5 billion times.
- Even at rest, the muscle of the heart works twice as hard as the leg muscles of a runner.
- There are approximately 5.6 litres of blood circulating around your body. Blood completes a circuit about three times every minute. In one day your blood travels 19,000 km – that's over twice the distance from Ireland to Perth.
- Every day 48,000 people around the world die of cardiovascular disease. About 25 people die of CVD in Ireland every day.
- Three years after a person quits smoking their chance of having a heart attack is the same as that of someone who has never smoked before.

Biographical Notes

Ibn al Nafis

In 1242 the Arabian physician Ibn al Nafis became the first person to accurately describe the process of blood circulation. He is now considered the 'father of circulatory physiology'.

With the publication of William Harvey's book, *An Anatomical Exercise on the Motion of the Heart and Blood in Animals*, in 1628, the circulation of the blood became more widely known and accepted.

Dr. Daniel Hale Williams (1858-1931)

Daniel Hale Williams, an African American medical pioneer, was the first person to successfully carry out heart surgery. He repaired a torn pericardium (the sac that surrounds the heart) and saved the life of a patient who otherwise would have died.

Dr. Christiaan Barnard (1922-2001)

Christiaan Barnard was a South African surgeon famous for performing the first successful human heart transplant. His patient was suffering from an incurable heart disease. The donor heart functioned in the patient's body and thus the procedure was a milestone in life-extending surgery.

Revise The Terms

Can you recall the meaning of the following terms? Reviewing the terminology is a powerful aid for recall and retention.

angina pectoris, arterial stenosis, artery, atherosclerosis, blood pressure, capillary, cardiac arrhythmia, cardiac bypass, cholesterol, CVD, lymph fluid, metabolism, nicotine, node, nutrient, stent.

Check the Glossary of Terms for this lesson at www.sta.ie