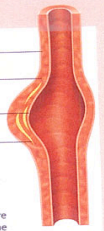
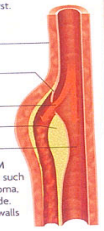
ANEURYSM

ABNORMAL SWELLING OF A WEAKENED ARTERIAL WALL MAKES THE WALL BULGE OUT LIKE A BALLOON.

This defect in an arterial wall may be due to disease or injury, or it can be congenital. Although aneurysms may occur in arteries anywhere in the body, they most often affect the main artery from the heart, the aorta. Most aortic aneurysms occur in the abdominal section below the kidneys, rather than in the chest, and this type of aneurysm tends to run in families. Small aortic aneurysms are usually symptomless, although large ones may cause localized pain. Aneurysms may be treated by surgery, the aim of which is to repair the artery before the aneurysm dissects, or ruptures (see right). Berry aneurysms occur in the small arteries at the base of the brain. There may be one or several of them, and they are thought to be present from birth. If a berry aneurysm ruptures, it causes a subarachnoid hemorrhage (see p.94) and results in an intensely painful headache.



COMMON ANEURYSM
If the muscle fibers of the tunica media layer of the artery wall are weak or deficient, the high pressure of the blood can cause the weak area to bulge or burst.



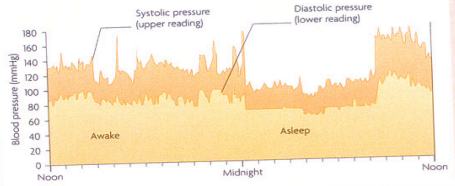
DISSECTING ANEURYSM
A split in the artery lining, such as near a plaque of atheroma, allows blood to seep inside. The artery swells and its walls thin and may burst.

HYPERTENSION

PERSISTENT, HIGHER-THAN-NORMAL BLOOD PRESSURE CAN DAMAGE INTERNAL ORGANS IF UNTREATED.

Normally, blood is under pressure as the heart forces it around the circulation. In hypertension, this pressure is above normal limits. There are no symptoms at first, but despite this, over time it increases the risk of many serious disorders, such as stroke, heart disease, and kidney failure. There is no obvious cause for hypertension; however, lifestyle and genetic factors may contribute, as do being overweight, drinking excessive amounts of alcohol, smoking, and having a high-salt diet. Hypertension is most common in middle-aged and elderly people. A stressful lifestyle may aggravate the condition. Hypertension cannot be cured, but it can be controlled. A change of diet and lifestyle may be all that is necessary, but more severe cases may be treated with antihypertensive drugs.

BLOOD PRESSURE GRAPH
Normal blood pressure varies according to activity levels. This graph shows that during sleep, both the systolic and diastolic pressures (see pp.120–21) are much lower.



ARRHYTHMIA

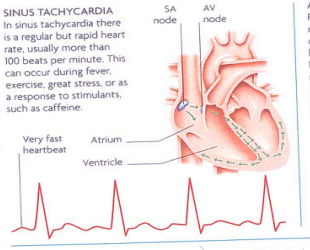
AN ABNORMAL HEART RATE OR RHYTHM IS CAUSED BY A DISTURBANCE IN THE ELECTRICAL SYSTEM THAT CONTROLS THE WAY HEART MUSCLE CONTRACTS.

An arrhythmia is a heart rate that is unusually slow or fast, or erratic. A normal heartbeat is initiated by specialized cells in the natural "pacemaker," the sinoatrial (SA) node, at the top of the right atrium. They send electrical signals resembling nerve impulses out through the atrial muscle tissue, stimulating it to contract. These signals are relayed by the atrioventricular (AV) node along nervelike fibers through the septum (central dividing wall) and into the thick muscle tissue of the ventricle walls. A fault in the system can lead to the arrhythmias described here.

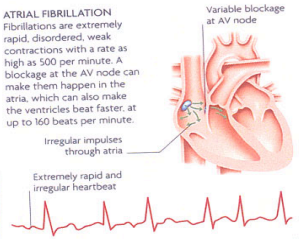
TREATMENTS

Often, heart arrhythmias can be treated with drugs. Another solution is to implant an artificial pacemaker into the chest wall. The pacemaker is connected to the heart by wires and takes over the role of supplying electrical signals to the heart muscle. In some cases, cardioversion (sometimes known as defibrillation) is also possible using an implant. A cardiac defibrillator (ICD), about the size of a pager, can be implanted just below the collarbone. It monitors heart rate and can detect life-threatening arrhythmias. The ICD reacts by shocking the heart with a jolt of electricity, which restores its normal rhythm.

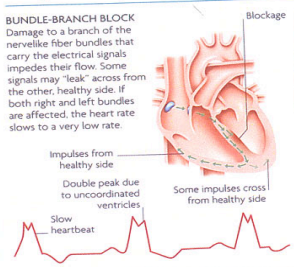
SINUS TACHYCARDIA
In sinus tachycardia there is a regular but rapid heart rate, usually more than 100 beats per minute. This can occur during fever, exercise, great stress, or as a response to stimulants, such as caffeine.



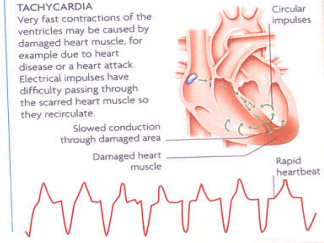
ATRIAL FIBRILLATION
Fibrillations are extremely rapid, disordered, weak contractions with a rate as high as 500 per minute. A blockage at the AV node can make them happen in the atria, which can also make the ventricles beat faster, at up to 160 beats per minute.



BUNDLE-BRANCH BLOCK
Damage to a branch of the nervelike fiber bundles that carry the electrical signals impedes their flow. Some signals may "leak" across from the other, healthy side. If both right and left bundles are affected, the heart rate slows to a very low rate.



VENTRICULAR TACHYCARDIA
Very fast contractions of the ventricles may be caused by damaged heart muscle, for example due to heart disease or a heart attack. Electrical impulses have difficulty passing through the scarred heart muscle so they recirculate.

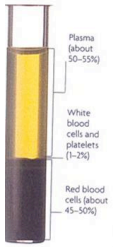


BLOOD AND BLOOD VESSELS

BLOOD IS A COLLECTION OF SPECIALIZED CELLS SUSPENDED IN A STRAW-COLORED LIQUID CALLED PLASMA. BLOOD DELIVERS OXYGEN AND NUTRIENTS TO BODY CELLS, COLLECTS WASTE, DISTRIBUTES HORMONES, SPREADS HEAT AROUND THE BODY TO CONTROL TEMPERATURE, AND PLAYS A PART IN FIGHTING INFECTION AND HEALING INJURIES.

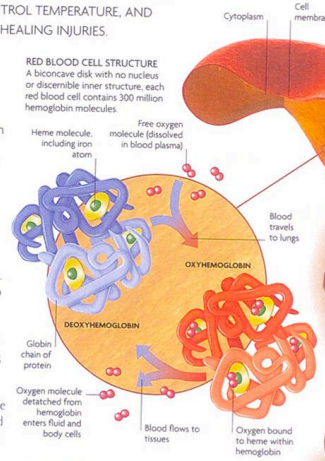
WHAT IS BLOOD?

Blood forms about one-twelfth of the body weight of an adult, amounting to about 11 pints (5 liters) in volume. Roughly 50–55 percent of blood is plasma, the liquid-only portion in which cellular components are distributed. Plasma is 90 percent water containing dissolved substances such as glucose (blood sugar), hormones, enzymes, and also waste products such as urea and lactic acid. Plasma also contains proteins such as albumins, fibrinogen (important in clotting), and globular proteins or globulins. Alpha and beta globulins help transport lipids, which are fatty substances such as cholesterol. Gamma globulins are mostly the disease-fighting substances that are known as antibodies. The remaining 45–50 percent of blood is made up of three types of specialized cells. Red cells or erythrocytes carry oxygen; various white cells, known as leucocytes, are part of the defense system; and cellular fragments (platelets or thrombocytes) are involved in the process of clotting.



PARTS OF BLOOD
Blood is made up of a liquid portion (plasma), red blood cells, and a small band of platelets and white blood cells.

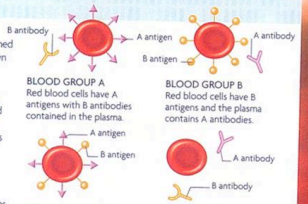
RED BLOOD CELL STRUCTURE
A biconcave disk with no nucleus or discernible inner structure, each red blood cell contains 300 million hemoglobin molecules.



ROLE OF HEMOGLOBIN
Hemoglobin is composed of heme, an iron-rich pigment, and globin, ribbonlike protein chains. Oxygen in the lungs latches onto heme to make oxyhemoglobin. In this conjoined form, oxygen travels through the bloodstream to all parts of the body.

BLOOD GROUPS

Every individual falls into one of four blood groups, which are determined by markers on red blood cells known as antigens (agglutinogens). Both of the antigens, A and B, may be present (AB), neither A nor B (O), or just one of them (A or B), and blood groups are named correspondingly. Plasma contains different antibodies (isohemagglutinins). For example, a person with blood group A has plasma containing B antibodies. If mixed with type B blood (with A antibodies in its plasma), A antibodies clump (or agglutinate) with A antigens. Therefore blood types must be matched for blood transfusions.



BLOOD GROUP A
Red blood cells have A antigens with B antibodies contained in the plasma.

BLOOD GROUP B
Red blood cells have B antigens and the plasma contains A antibodies.

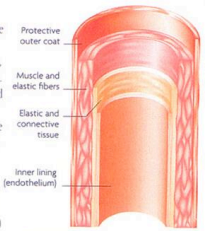
BLOOD GROUP AB
Red blood cells have A and B antigens, with neither A nor B in plasma.

BLOOD GROUP O
This lacks A and B antigens, but the plasma contains both A and B antibodies.

BLOOD MAKE-UP
In $^{1}/_{4,000}$ in³ (1mm³) of blood float approximately 5 million red cells, 10,000 white cells, and 300,000 platelets. Infection can double the white cell count within hours. In capillaries, the cells may have to move in single file.

ARTERIES

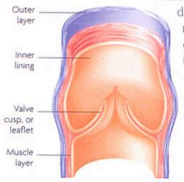
Arteries carry blood away from the heart toward organs and tissues. Apart from the pulmonary arteries, all arteries carry oxygenated blood. Their thick walls and muscular and elastic layers can withstand the high pressure that occurs when the heart contracts. An artery narrows when the heart relaxes, helping push blood onward. The largest artery is the aorta, with a diameter of 1in (25mm); it conveys blood from the heart at up to 16in (40cm) per second. Most other arteries have a diameter of $^{1}/_{8}$–$^{1}/_{4}$ in (4–7mm) and walls $^{1}/_{25}$ in (1mm) thick.



ARTERY SECTION
Four distinct layers are found in an artery, with the blood-carrying space, called the lumen, in the center.

VEINS

A vein is more flexible than an artery and its walls are considerably thinner. The blood inside a vein is under relatively low pressure and, as a result, it flows slowly and smoothly. Many larger veins, particularly the long veins in the legs, contain valves that are formed from pouchlike pockets of single-cell lining tissue (endothelium). These prevent blood from flowing back down the legs, a job helped by muscles around the veins that contract during movement. The two main veins returning blood from the upper and lower parts of the body are called the superior and inferior venae cavae.

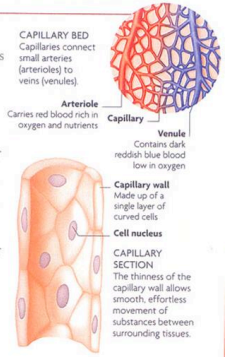


VEIN SECTION
The muscle layer of a vein is thin and enclosed by two layers; the innermost layer of some veins has valves at regular intervals.

CAPILLARIES

The smallest and most numerous of the blood vessels, capillaries convey blood between arteries and veins. A typical capillary is $^{1}/_{25}$ in (1mm) or less in length, about $^{1}/_{2,500}$ in (0.01mm) in diameter, and only slightly wider than a red blood cell, which is $^{1}/_{3,500}$ in (0.007mm) across. Many capillaries enter tissue to form a capillary bed–the area where oxygen and other nutrients are released, and where waste matter passes into the blood. At any moment, only 5 percent of the body's blood is traveling in capillaries, with 20 percent in arteries, and 75 percent in veins.

CAPILLARY BED
Capillaries connect small arteries (arterioles) to veins (venules).



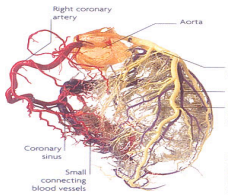
CAPILLARY SECTION
The thinness of the capillary wall allows smooth, effortless movement of substances between surrounding tissues.

HEART STRUCTURE

THE HEART IS A POWERFUL ORGAN ABOUT THE SIZE OF A CLENCHED FIST, LOCATED JUST TO THE LEFT OF CENTER BETWEEN THE LUNGS, IT OPERATES AS TWO COORDINATED PUMPS THAT SEND BLOOD AROUND THE BODY.

THE HEART'S BLOOD SUPPLY

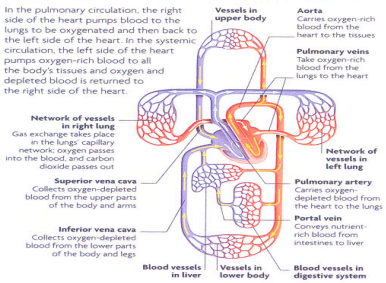
The muscular wall, or myocardium, of the heart is constantly active and needs a generous supply of oxygen and energy from blood. To provide this, the heart muscle has its own network of blood vessels known as the coronary arteries. These two arteries—the right and the left—branch from the main artery, the aorta, just after it leaves the heart, divide over the heart's surface, and send smaller blood vessels into the heart muscle. The pattern of the coronary veins, which collect wastes from the muscle tissue, is similar. Most of the blood in these veins is collected by the coronary sinus, a large vein at the back of the heart that empties into the right atrium.

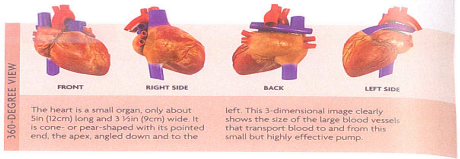


CORONARY VESSELS
There are many connecting vessels between the coronary arteries. If an artery becomes blocked, these can provide an alternative route for the blood flow.

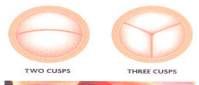
DOUBLE CIRCULATION

In the pulmonary circulation, the right side of the heart pumps blood to the lungs to be oxygenated and then back to the left side of the heart. In the systemic circulation, the left side of the heart pumps oxygen-rich blood to all the body's tissues and oxygen and depleted blood is returned to the right side of the heart.



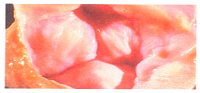


The heart is a small organ, only about 5in (12cm) long and 3.5in (9cm) wide. It is cone- or pear-shaped with its pointed end, the apex, angled down and to the left. This 3-dimensional image clearly shows the size of the large blood vessels that transport blood to and from this small but highly effective pump.

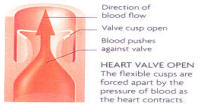


HEART VALVES

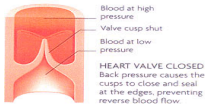
The heart has four valves to control blood flow. Each has a similar structure, although they differ in certain details. The two atrioventricular valves lie between the atria and ventricles. The mitral valve on the left has two cusps (leaflets) while its right counterpart, the tricuspid valve, has three. The two semilunar valves are at the exits from the ventricles: the pulmonary valve between the right ventricle and the pulmonary artery, and the aortic valve between the left ventricle and the aorta.



PULMONARY SEMILUNAR VALVE
This valve lies between the right ventricle of the heart and the pulmonary artery. It opens as the right ventricle contracts and forces blood out of the heart toward the lungs.



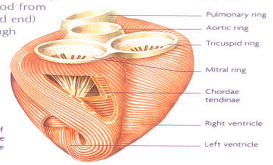
HEART VALVE OPEN
The flexible cusps are forced apart by the pressure of blood as the heart contracts.



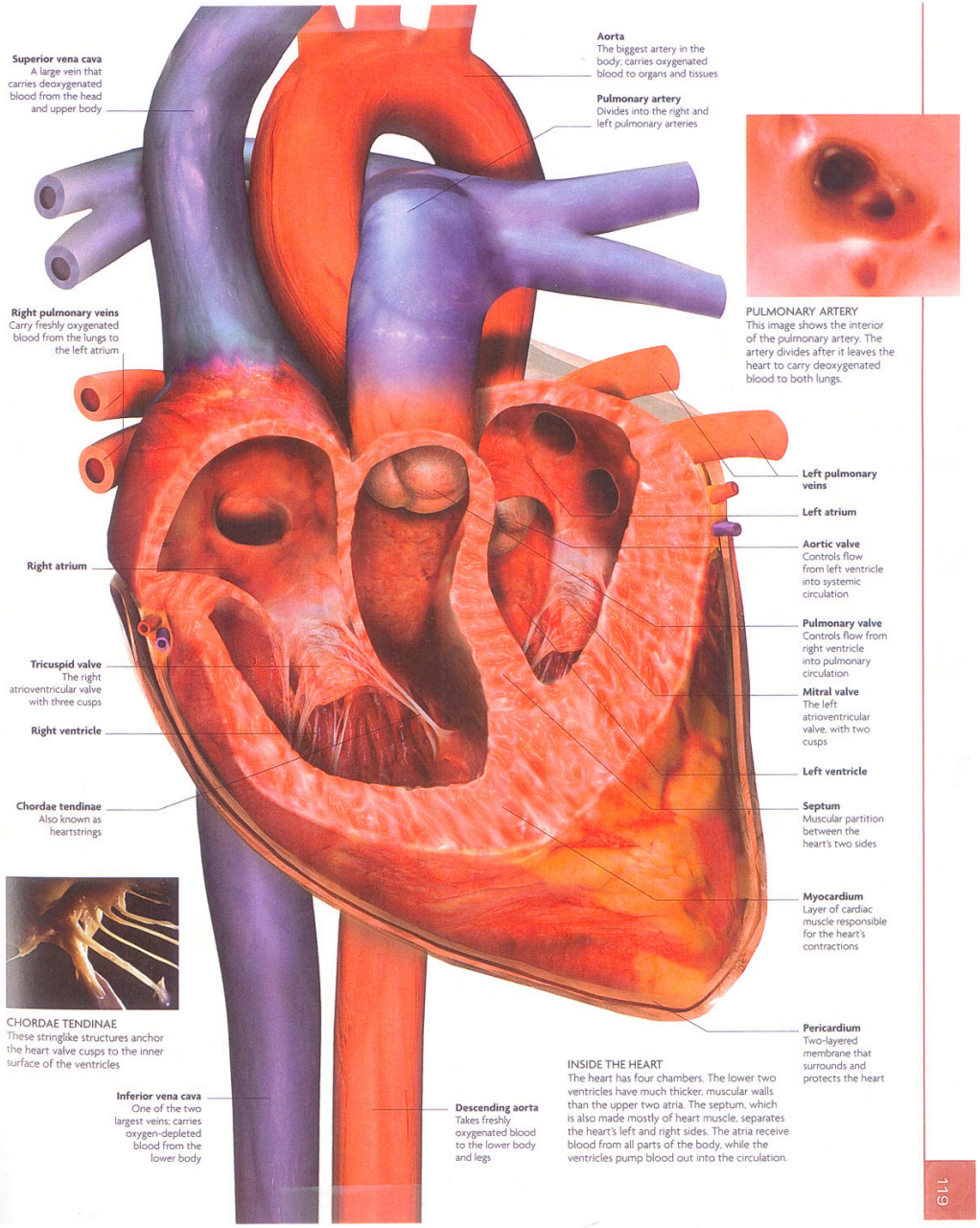
HEART VALVE CLOSED
Back pressure causes the cusps to close and seal at the edges, preventing reverse blood flow.

CARDIAC SKELETON

A set of four fibrous, cufflike rings known as the cardiac skeleton is built into the upper heart. The rings provide rigid points of attachment for the four heart valves and for the various sections of heart muscle. The wraparound arrangement of the muscle fibers in ventricle walls and the timing of their contractions enable the ventricles to squirt blood from the apex (lower pointed end) upward, and out through the pulmonary and aortic valves, rather than squeezing blood down so that it pools into the apex region.



FIBROUS FRAMEWORK
The rigidity of the four rings of fibrous tissue in the heart—the cardiac skeleton—prevents the valves from deforming.



PULMONARY ARTERY
This image shows the interior of the pulmonary artery. The artery divides after it leaves the heart to carry deoxygenated blood to both lungs.

CHORDAE TENDINAE
These stringlike structures anchor the heart valve cusps to the inner surface of the ventricles

INSIDE THE HEART
The heart has four chambers. The lower two ventricles have much thicker, muscular walls than the upper two atria. The septum, which is also made mostly of heart muscle, separates the heart's left and right sides. The atria receive blood from all parts of the body, while the ventricles pump blood out into the circulation.

HOW THE HEART BEATS

THE HEART IS A DYNAMIC, UNTIRING, PRECISELY ADJUSTABLE DOUBLE-PUMP THAT FORCES BLOOD AROUND THE BODY'S IMMENSE NETWORK OF BLOOD VESSELS—PERHAPS MORE THAN THREE BILLION TIMES DURING A LIFETIME.

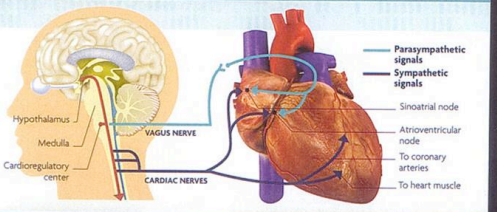
The heart's power comes from its two lower chambers (ventricles), which have thick muscular walls that contract to squeeze blood out into the arteries. The upper chambers (atria) have thinner walls and function partly as passive reservoirs for blood oozing in from the main veins. Each heartbeat has two main phases: in the first phase (diastole), the heart relaxes and refills with blood; during the second stage (systole), it contracts, forcing the blood out. The whole cycle takes, on average, less than a second. During vigorous activity or stress, both the beating rate and the volume of blood pumped out of the heart increase greatly.

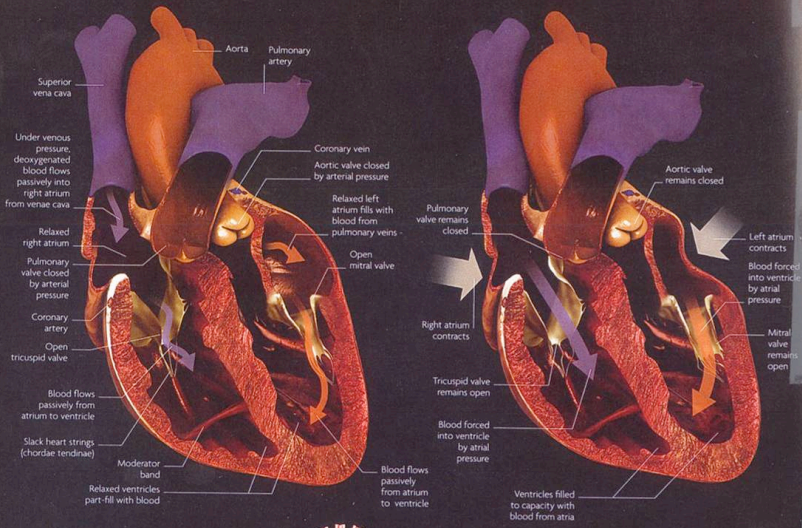
CONDUCTING FIBERS
The heart's conducting fibers are specialized long, thin cardiac muscle cells known as conducting myofibers or Purkinje fibers. These cells convey electrical impulses through the heart.

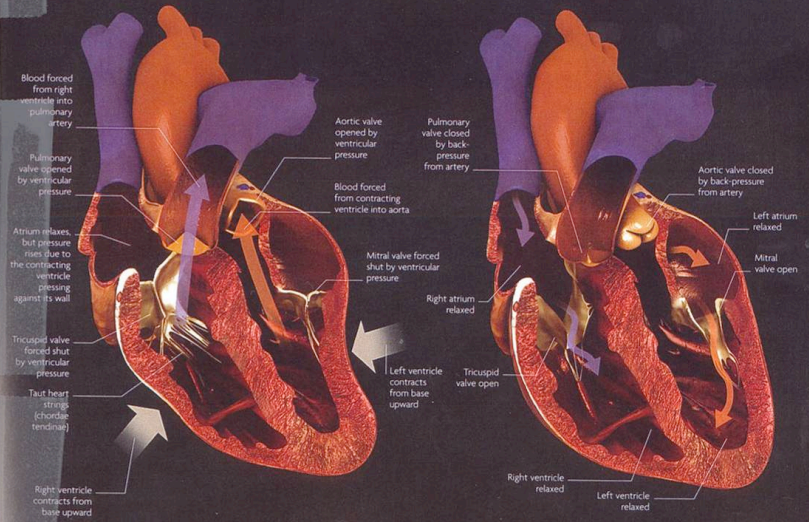
CONTROL OF THE HEART RATE

Without control, the heart would beat at its natural, intrinsic rate of about 100 times per minute. However, a region known as the cardioregulatory center in the medulla of the brainstem sends electrical impulses along nerves (especially the cranial vagus nerve) to set an average resting rate of about 70 beats per minute. During activity or stress, the sympathetic cardiac nerve signals, controlled by the hypothalamus, convey overriding signals to speed up the heart rate. The rate is also influenced by hormones such as adrenaline.

THE BRAIN'S INFLUENCE
The heart controls its own rhythm, but its rate is controlled by the central nervous system.

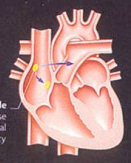






1 RELAXATION (LATE DIASTOLE)

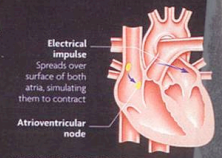
During this phase of the heartbeat sequence, the muscular walls of the heart relax. The atrial chambers balloon slightly as they fill with blood coming in under low pressure from the main veins. Deoxygenated blood from the body enters the right atrium, while oxygenated blood from the lungs enters the left atrium. Some of the blood in the atria flows down into the ventricles. By the end of this phase, the ventricles are filled to about 80 percent of capacity.



PACEMAKER (SINOATRIAL NODE)
The sinoatrial node is inactive during most of diastole. As systole approaches, it begins to send out a wave of electrical impulses which will coordinate the heartbeat.

2 CONTRACTION OF THE ATRIA (ATRIAL SYSTOLE)

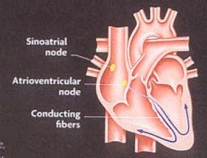
The heart's natural pacemaker, known as the sinoatrial node, is located in the upper part of the right atrium. It "fires" electrical impulses, much like those generated by nerves, which set off the contraction phase. Some impulses spread through the atrial walls and stimulate their cardiac muscle to contract. This squeezes blood inside the atria through the atrioventricular (tricuspid and mitral) valves into the ventricles, whose walls remain relaxed.



ELECTRICAL IMPULSES SPREAD
Impulses traveling through atrial muscles make them contract within 0.1 seconds. Some signals pass faster along conducting fibers to the atrioventricular node.

3 CONTRACTION OF THE VENTRICLES (VENTRICULAR SYSTOLE)

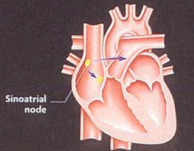
During this most active and powerful stage of the heartbeat, the thick cardiac muscle in the ventricle walls contracts, stimulated by electrical impulses relayed by the atrioventricular node. This causes a rise in ventricular pressure, which opens the aortic and pulmonary valves at the exits of the ventricles. Blood is forced out into the main arteries, making the atrioventricular valves snap shut.



ATRIOVENTRICULAR SIGNALS FIRE
The atrioventricular node "fast-tracks" impulses along conducting fibers within the septum (dividing wall) to the lower ventricles and up through ventricle muscle.

4 RELAXATION (EARLY DIASTOLE)

The walls of the ventricles begin to relax, causing ventricular pressure to reduce. The pressure of the recently ejected blood in the main arteries is now high, so both the aortic and pulmonary valves close. This prevents back-flow into the ventricles. As ventricular pressure on the atrioventricular valves relaxes, the valves open. This reduces pressure in the atria, allowing blood to enter once again from the main veins.



ELECTRICAL IMPULSES FADE
Impulses spread through the ventricular walls back toward the atria within 0.2 seconds of leaving the sinoatrial node, which then fires again to continue the cycle.

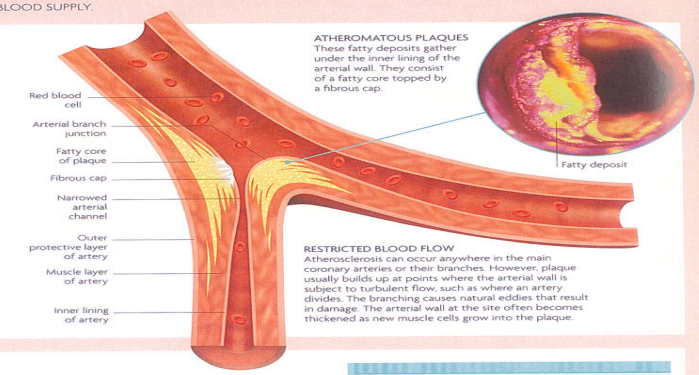
CORONARY ARTERY DISEASE

THE CARDIAC MUSCLE, OR MYOCARDIUM, OF THE HEART WALL DEPENDS ON A CONSTANT FLOW OF BLOOD SUPPLIED BY THE CORONARY ARTERIES. IF THIS SUPPLY IS RESTRICTED, THEN OXYGEN AND NUTRIENTS CANNOT REACH THE MUSCLE AND THE RESULT COULD BE A FORM OF CORONARY ARTERY DISEASE (CAD). THE EXTENT OF THE SYMPTOMS OF CAD DEPENDS ON THE LOCATION, SEVERITY, AND SPEED OF ONSET OF THE RESTRICTED BLOOD SUPPLY.

ATHEROSCLEROSIS

ATHEROSCLEROSIS IS CAUSED BY THE NARROWING AND STIFFENING OF THE ARTERIES DUE TO FATTY DEPOSITS, KNOWN AS ATHEROMA, ACCUMULATING IN THEIR WALLS.

The process that leads to atherosclerosis begins with abnormally high levels of excess fats and cholesterol in the blood. These substances infiltrate the lining of arteries at sites of microscopic damage, forming deposits known as atheroma. This can happen in any of the body's arteries, including those supplying the brain with blood, when the result may be a stroke. The atheromatous deposits gradually form raised patches known as plaques. These consist of fatty cores within the arterial wall, covered by fibrous caps. The plaques narrow the space, or lumen, within the artery and this restricts the overall flow of blood to tissues beyond the site. It also causes turbulence that disrupts the smooth flow of blood and the eddies over the plaque surface make it more likely that blood will clot. The major risk factors for atherosclerosis include smoking, a diet high in saturated fats, lack of exercise, and excess weight.



ATHEROMATOUS PLAQUES
These fatty deposits gather under the inner lining of the arterial wall. They consist of a fatty core topped by a fibrous cap.

RESTRICTED BLOOD FLOW
Atherosclerosis can occur anywhere in the main coronary arteries or their branches. However, plaque usually builds up at points where the arterial wall is subject to turbulent flow, such as where an artery divides. The branching causes natural eddies that result in damage. The arterial wall at the site often becomes thickened as new muscle cells grow into the plaque.

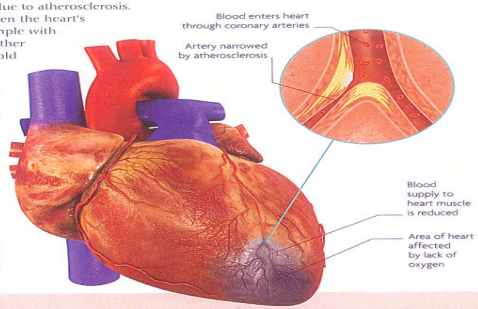
ANGINA

ANGINA, CHEST PAINS THAT COME ON WITH EXERTION AND ARE RELIEVED BY REST, IS A SIGN THAT THE HEART MUSCLE IS NOT RECEIVING AN ADEQUATE SUPPLY OF BLOOD.

Angina is caused by a temporarily inadequate supply of blood to the heart muscle, usually because of arterial narrowing due to atherosclerosis. The pain most often occurs when the heart's workload is increased, for example with exercise, and fades with rest. Other triggers for angina are stress, cold weather, or a large meal. An angina attack typically begins with a heavy, constricting pain behind the breastbone. This can spread into the throat and jaw, and down into the arms, especially the left one. The pain usually subsides within 10–15 minutes. People with angina often take medication that relieves the pain by causing the coronary arteries to widen (dilate).

DAMAGED HEART MUSCLE
During angina, areas of heart muscle downstream from a narrowed artery suffer from lack of oxygen. After the attack, the muscle recovers.

WHY ANGINA OCCURS
Atherosclerosis of a coronary artery causes narrowing in the vessel and a reduction in blood flow. During exertion the heart beats faster and the muscle's demand for oxygen increases. However, extra blood cannot pass through the narrowed artery and the muscle "cramps."



ANGIOGRAPHY

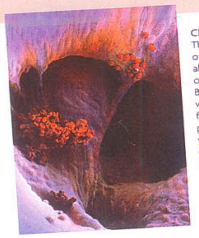
The diagnostic procedure known as angiography shows the outline of blood vessels on a specialized X-ray image (called an angiogram). A fine catheter (hollow tube) is passed into an artery, usually in the leg, and then threaded up toward the heart via the aorta. A contrast medium, or radiopaque dye, is injected into the catheter and X-ray images are viewed on a monitor. These show the dye flowing through the coronary artery network and reveal any narrowing or blockage.

X-RAY IMAGE
The pattern of coronary arteries is similar in most hearts. This coronary angiogram reveals a narrowing that restricts blood flow to a region of cardiac muscle.

HEART ATTACK

A HEART ATTACK OCCURS WHEN AN AREA OF CARDIAC MUSCLE IS DEPRIVED OF BLOOD, AND THEREFORE OXYGEN, DUE TO A BLOCKAGE IN AN ARTERY.

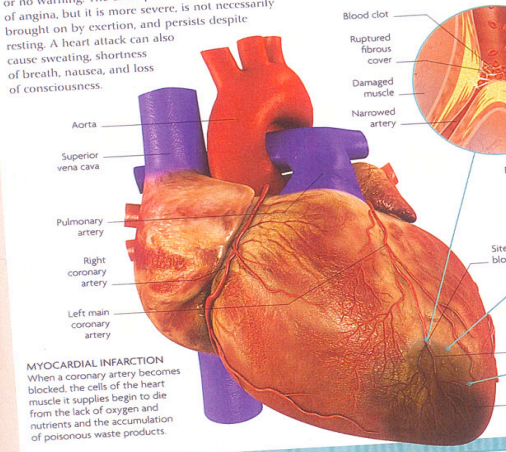
A heart attack (myocardial infarction) is the result of coronary artery disease due to atherosclerosis, and the subsequent formation of a blood clot, or thrombus. Once formed, the clot can completely block blood flow to an area of heart muscle, starving it of blood and eventually causing tissue death. If possible, the blood flow must be restored to the damaged cells as quickly as possible. A heart attack usually occurs suddenly, with little or no warning. The chest pain may resemble that of angina, but it is more severe, is not necessarily brought on by exertion, and persists despite resting. A heart attack can also cause sweating, shortness of breath, nausea, and loss of consciousness.



CLOTTED ARTERY
The healthy lining of a blood vessel allows blood to slip over it smoothly. Blood tends to clot where this smooth flow is disturbed by projections from the vessel wall, seen, for example, on the left of this image.

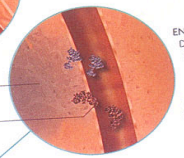
THROMBOLYTICS

The key to heart attack treatment is speed. The sooner the arterial blockage can be removed, the sooner blood flow is restored to the damaged area and it may be able to recover. Thrombolytic drugs are often introduced directly into the bloodstream after a heart attack. These help dissolve the clot that is blocking the coronary artery by increasing levels of a substance called plasminogen in the blood. Plasminogen breaks down the strands of fibrin that bind the clot together and the clot dissolves. Antiplatelet drugs are usually given for some time the heart attack because they thin the blood and prevent further clot formation.

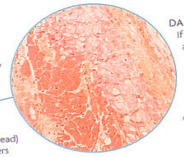


MYOCARDIAL INFARCTION
When a coronary artery becomes blocked, the cells of the heart muscle it supplies begin to die from the lack of oxygen and nutrients and the accumulation of poisonous waste products.

CORONARY THROMBOSIS
An area of plaque may become roughened, perhaps because its fibrous covering tears. Blood cells, especially platelets, begin to stick to the area and trigger the formation of a thrombus (clot).



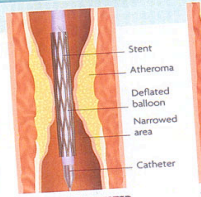
ENZYME RELEASE
Degenerating muscle fibers in the affected area release a number of enzymes into the circulation. Measuring these enzymes through a blood test indicates the extent of the heart muscle damage.



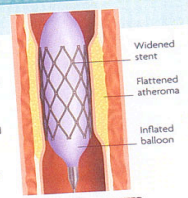
DAMAGED HEART MUSCLE
If cells are deprived of oxygen and nutrients, they quickly degenerate. If the blood supply is not restored quickly, the tissue eventually dies, a process known as necrosis. At this stage, the damage to the cells is irreversible.

ANGIOPLASTY

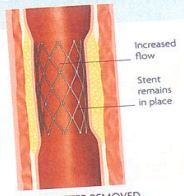
This procedure is used to widen a section of coronary artery that has been narrowed or blocked by atheroma. It is often carried out to treat severe angina or after a heart attack. Angioplasty may be part of the same procedure as angiography, which visualizes the coronary arteries on an X-ray (see opposite page). Under local anesthetic, a fine catheter (hollow tube) is inserted into the femoral artery in the groin (or sometimes the arm), and passed up the aorta and into the coronary artery network. When the affected site is reached, a tiny balloon at the end of the catheter is inflated to widen the narrowed area. An expandable stainless steel mesh stent is often left permanently in place after withdrawal of the balloon catheter. This prevents the artery from narrowing again.



1 CATHETER INSERTED
The catheter is equipped with a small inflatable balloon near its end and, in this case, a metal mesh self-expanding tube called a stent.



2 BALLOON INFLATED
When the balloon is positioned within the narrowed area, it is inflated with gas or liquid to stretch the artery and widen the stent.



3 CATHETER REMOVED
The balloon is deflated and withdrawn, leaving the stent in place in its expanded form. In a few weeks, a thin layer of cells grows over the stent.

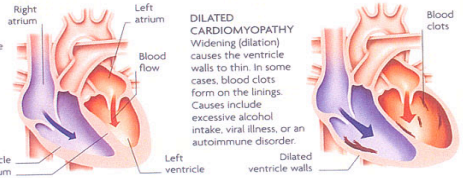
HEART MUSCLE DISORDERS

THE HEART IS COMPOSED MOSTLY OF SPECIALIZED MUSCLE, KNOWN AS THE CARDIAC MUSCLE, OR MYOCARDIUM. SOME HEART DISORDERS ARE CAUSED BY PROBLEMS WITH THIS MUSCLE OR WITH THE SACLIKE PERICARDIUM SURROUNDING THE HEART. LONG-STANDING OR SEVERE HEART MUSCLE PROBLEMS CAN LEAD TO HEART FAILURE, WHEN THE HEART'S PUMPING POWER IS REDUCED.

HEART MUSCLE DISEASE

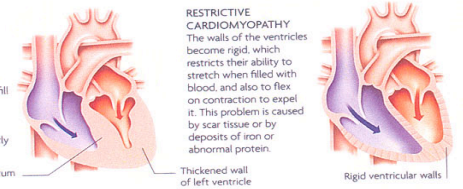
INFLAMMATION OF THE HEART MUSCLE IS KNOWN AS MYOCARDITIS; NONINFLAMMATORY HEART MUSCLE DISEASE IS CALLED CARDIOMYOPATHY.

Many cases of myocarditis are due to infection, often with a virus such as coxsackie. The problem may go unnoticed, but, if severe, can lead to chest pain and long-term heart failure. Other causes of myocarditis include rheumatic fever, exposure to radiation or certain drugs or chemicals, or an autoimmune condition such as systemic lupus erythematosus (see p.168). Cardiomyopathy is noninflammatory heart muscle disease in which the muscle becomes weakened, damaged, and stretched. This condition takes several forms with various causes, as illustrated below.



NORMAL HEART
The muscular walls of a normal heart, especially the ventricles, are substantial. They are also flexible and bend as they contract and squeeze out blood. The pumping rate and volume adjust to cope with the body's demands for oxygenated blood.

DILATED CARDIOMYOPATHY
Widening (dilation) causes the ventricle walls to thin. In some cases, blood clots form on the linings. Causes include excessive alcohol intake, viral illness, or an autoimmune disorder.



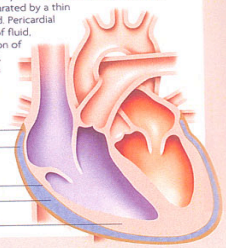
HYPERTROPHIC CARDIOMYOPATHY
This condition causes the heart muscle to thicken, especially in the left ventricle and septum, so that the heart cannot fill with blood properly. It is usually an inherited problem and a cause of sudden death in apparently healthy young people.

RESTRICTIVE CARDIOMYOPATHY
The walls of the ventricles become rigid, which restricts their ability to stretch when filled with blood, and also to flex on contraction to expel it. This problem is caused by scar tissue or by deposits of iron or abnormal protein.

PERICARDITIS

INFLAMMATION OF THE PERICARDIUM—THE TWO-LAYERED MEMBRANOUS SAC THAT SURROUNDS THE HEART—IS OFTEN DUE TO A VIRAL INFECTION OR A HEART ATTACK.

The most common cause of pericarditis is a viral infection that inflames the pericardium. Other causes include bacterial pneumonia, tuberculosis, the spread of a cancerous tumour to the pericardium, an autoimmune disorder such as rheumatoid arthritis, kidney failure, a heart attack, or a penetrating wound to the area. Any inflamed pericardium cannot lubricate the heart's beating motions normally, so it rubs and scrapes. Symptoms include pain in the centre of the chest, which is relieved by leaning forward but worsened by a deep breath, breathlessness, or fever.

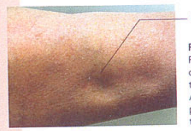


PERICARDIAL EFFUSION
The outer (fibrous) layer of the pericardium is tough and elastic. The inner (serous) membrane forms a double layer around the heart, separated by a thin film of lubricating fluid. Pericardial effusion is an excess of fluid, caused by inflammation of the serous membrane, and can interfere with the heart's pumping.

HEART FAILURE

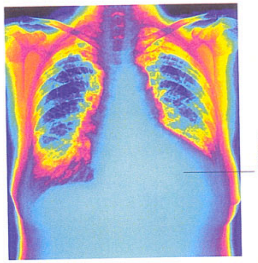
THE HEART'S INABILITY TO PUMP BLOOD EFFECTIVELY TO THE LUNGS AND BODY TISSUES CAN BE ACUTE (COMING ON SUDDENLY) OR CHRONIC (DEVELOPING OVER TIME).

Acute heart failure develops as a result of trauma to the heart, such as a heart attack or valve damage. Heart failure of the left side of the heart causes rapid accumulation of fluid in the lungs. This results in wheezing and breathlessness, sweaty pale skin, and a cough that brings up blood-stained sputum. Acute heart failure usually occurs in both sides of the heart.



FLUID RETENTION
Fluid accumulation due to chronic heart failure makes the tissues swollen and soggy. An indentation caused by pressing tends to stay after the pressure is removed.

Chronic heart failure is a long-term problem with many causes. These include coronary artery disease, persistent high blood pressure, cardiomyopathy, a heart valve or rhythm disorder, or chronic obstructive pulmonary disease (see pp.142–43). In left-sided chronic heart failure, the heart's left ventricle fails to pump blood out to the body as fast as it enters from the lungs. As a result, blood backs up in the pulmonary veins and lungs, causing congestion. The pressure in the lungs causes fluid to collect there (a condition known as pulmonary edema) and oxygen is absorbed less efficiently, producing symptoms such as breathlessness, coughing, and fatigue. In right-sided chronic heart failure, the right ventricle cannot pump blood out to the lungs as fast as it comes in from body tissues. Blood backs up in the main veins, again causing congestion. Increased venous pressure forces fluid out of the capillaries into the tissues with noticeable swelling (edema) in the ankles and lower back. Other symptoms include breathlessness, fatigue, and nausea.



ENLARGED HEART
In heart failure, the heart becomes grossly enlarged over time as it struggles to pump blood through the body's circulation.

STRUCTURAL DISORDERS

STRUCTURAL HEART DISORDERS CAN AFFECT PEOPLE OF ANY AGE; CONGENITAL HEART DEFECTS ARE PRESENT AT BIRTH, WHILE VALVE DISORDERS GENERALLY ARISE LATER IN LIFE. MEDICAL ADVANCES ALLOW MANY DEFECTS IN THE HEART TO BE EFFECTIVELY TREATED WITH SURGICAL TECHNIQUES. SIMILARLY, DISEASED VALVES CAN BE SURGICALLY WIDENED OR REPLACED.

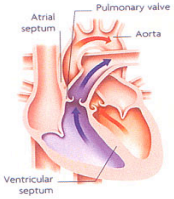
CONGENITAL HEART DEFECTS

HEART DEFECTS PRESENT FROM BIRTH (CONGENITAL) MAY BE DUE TO A FAULT IN DEVELOPMENT DURING EARLY EMBRYO DEVELOPMENT.

Some types of congenital heart defect (CHD) run in families, suggesting there is a genetic influence, although usually there is no obvious cause. However, in some cases there is a link with the mother catching an infection such as rubella during pregnancy or being exposed to certain drugs including alcohol. Symptoms of CHD include breathlessness (which can affect feeding) and slow weight gain. Ultrasound scans can help diagnose some types of CHD so that appropriate treatment can be prepared.

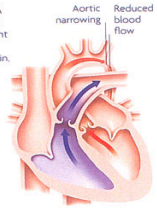
HEART DEVELOPMENT

In the embryo, the heart develops as a section of blood vessel that thickens its walls and begins to twist and loop, creating atrial and ventricular chambers. Complex connections of arteries and veins begin to take shape. Many congenital heart defects arise from a problem during this initial stage of development. Here, deoxygenated blood is blue; red is oxygenated blood.



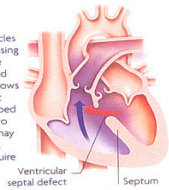
COARCTATION OF AORTA

A short section of the aorta is narrowed, usually at a point where the main arteries branch off for the head, brain, arms, and upper body. This results in restricted blood flow to the lower body and legs. The heart works harder to compensate, so blood pressure in the upper body is elevated. A sufferer is usually pale and finds it difficult to breathe or eat. Urgent corrective surgery may be needed.



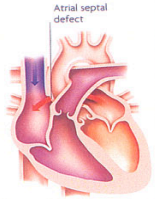
VENTRICULAR SEPTAL DEFECT

This is a hole in the wall between the two ventricles (ventricular septum), causing the blood to mix (purple color). Oxygenated blood from the left ventricle flows through the hole so that too much blood is pumped by the right ventricle into the lungs. A small hole may close as the child grows, but a larger one will require surgical repair.



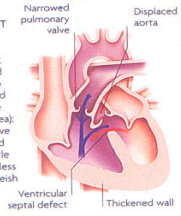
ATRIAL SEPTAL DEFECT

This is an abnormal opening in the wall (atrial septum) between the two upper chambers (atria). As a result, blood shunts from the high-pressure left side of the heart into the right side (purple area). The blood flow to the lungs increases in consequence and less is pumped around the body. Both atrial and ventricular septal defects are common in children with Down Syndrome.



TETRALOGY OF FALLOT

A combination of four structural defects: a ventricular septal defect; an aorta that is displaced towards the right side so that deoxygenated blood can flow into it from the right ventricle (purple area); narrowed pulmonary valve (pulmonary stenosis); and a thickened right ventricle wall. A sufferer is breathless and has a distinctive blueish skin color (cyanosis).



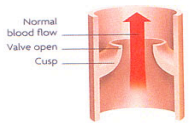
VALVE DISORDERS

THERE ARE SEVERAL CONDITIONS THAT CAN AFFECT THE EFFICIENT FUNCTIONING OF ANY OF THE HEART'S FOUR VALVES.

There are two main types of valve disorder. In stenosis, the valve outlet is too narrow and restricts blood flow. It may be congenital or due to an infection such as rheumatic fever. Stenosis is also part of the aging process. In incompetence, the valve does not close fully, allowing backflow of blood. This problem can occur as a result of a heart attack or an infection of the valve.

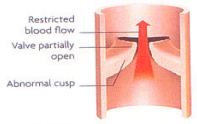
MITRAL VALVE

This image of a healthy human heart valve shows the heart strings (chordae tendinae) and cusps. The mitral valve lies between the left atrium and the left ventricle.



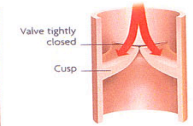
NORMAL VALVE OPEN

As a heart chamber contracts, the high pressure pushes against the cusps of the valve, forcing it open and allowing blood to flow past.



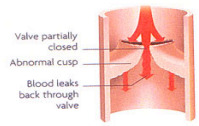
STENOSIS

The valve tissue is stiffened and cannot open fully. Blood passing through it is restricted so the heart beats harder to maintain flow.



NORMAL VALVE CLOSED

The pressure on the other side of the valve increases and the valve cusps snap shut so that blood cannot flow backward.



INCOMPETENCE

The valve cusps do not close properly and allow blood to leak backward. As a result, the heart has to work harder to circulate blood.

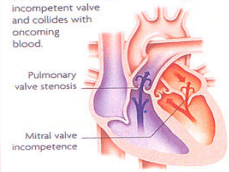
HEART MURMURS

UNUSUAL HEART SOUNDS PRODUCED BY TURBULENT BLOOD FLOW MAY BE DUE TO A HEART VALVE DEFECT.

The "lub-dub" sound of the heartbeat is made by healthy valves snapping shut. Some types of unusual sounds are known as "murmurs" and may indicate an abnormality. However, many murmurs, particularly in children, do not indicate valve abnormalities.

ABNORMAL FLOW

Murmurs can be produced by turbulent flow as blood rushes around the cusps of a stenosed valve or leaks back through an incompetent valve and collides with oncoming blood.



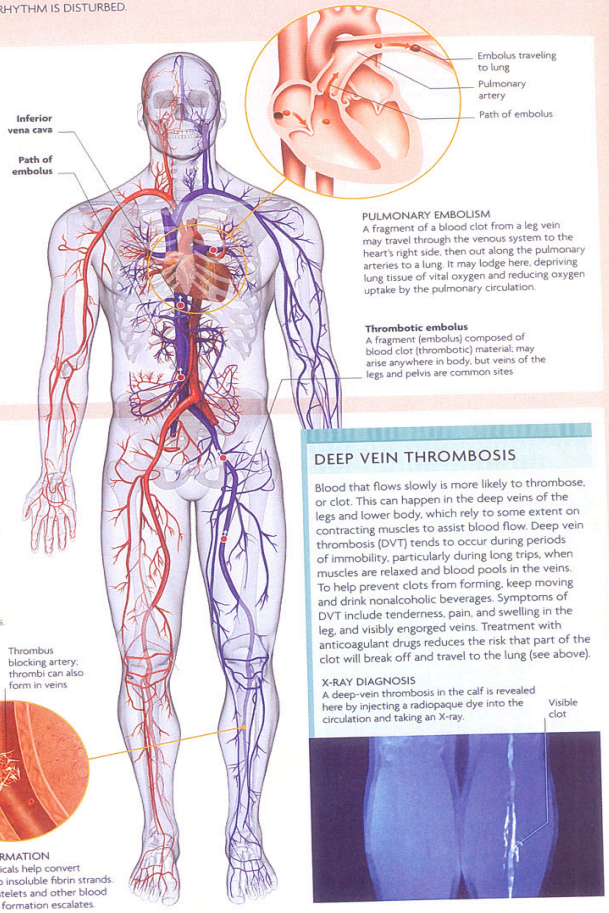
CIRCULATORY AND HEART-RATE DISORDERS

A CONSTANT AND ADEQUATE BLOOD SUPPLY IS ESSENTIAL FOR HEALTHY TISSUES. SHOULD A BLOCKAGE OCCUR IN A BLOOD VESSEL, THE TISSUES BEYOND IT MAY BE STARVED OF OXYGEN, CAUSING TISSUE DAMAGE OR, IN MORE SEVERE CASES, TISSUE DEATH. THE HEART MAY ALSO BE AFFECTED IF THE ELECTRICAL SYSTEM THAT MAINTAINS HEART RATE AND RHYTHM IS DISTURBED.

EMBOLISM

AN EMBOLUS—A FRAGMENT OF MATERIAL THAT BREAKS AWAY FROM ITS ORIGINAL SITE—CAN CAUSE THE PARTIAL OR TOTAL BLOCKAGE OF A BLOOD VESSEL.

Most emboli are fragments of a blood clot (thrombus), or even a whole clot, that has detached from its original site and traveled in the bloodstream to lodge in a blood vessel. An embolus may also be made of fatty material from an atheromatous plaque (see p.122) in an arterial wall, crystals of cholesterol, fatty bone marrow that has entered the circulation following a bone fracture, or an air bubble or amniotic fluid. In a pulmonary embolism, a clot originating elsewhere in the body travels to the lungs in veins. Clots that form in the heart or arteries can block circulation anywhere in the body. An embolus is most likely to block a blood vessel where it narrows or branches, depriving tissues beyond it of vital oxygen. Symptoms depend on the site affected; for example, an embolus blocking an artery supplying the brain may lead to a stroke. If the embolus is a fragment of a clot, it can be treated with thrombolytic, or "clot-busting," drugs.



PULMONARY EMBOLISM
A fragment of a blood clot from a leg vein may travel through the venous system to the heart's right side, then out along the pulmonary arteries to a lung. It may lodge here, depriving lung tissue of vital oxygen and reducing oxygen uptake by the pulmonary circulation.

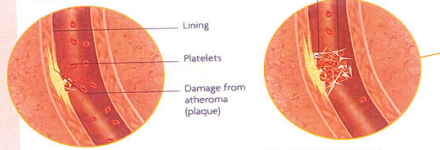
Thrombotic embolus
A fragment (embolus) composed of blood clot (thrombotic) material; may arise anywhere in body, but veins of the legs and pelvis are common sites

THROMBOSIS

THE PARTIAL OR TOTAL BLOCKAGE OF AN ARTERY, VEIN, OR EVEN THE HEART CAN OCCUR WHEN A BLOOD CLOT (THROMBUS) FORMS DUE TO A CIRCULATORY PROBLEM.

Thrombosis is most likely to occur where the normal smooth flow of blood is disrupted and either slows down or becomes turbulent. This disruption may be caused by plaques of fatty atheromatous tissue in the walls of an artery or by inflammation of the blood vessel. The clot eventually narrows or blocks the passage for blood so that tissues downstream are deprived of oxygen and nutrients. The effects depend on the site of the thrombosis.

THROMBUS FORMATION
Thrombosis can occur in arteries and veins, but commonly happens at a site of atherosclerosis in an artery wall, which disrupts normal blood flow.



1 INTERNAL DAMAGE
When an artery lining is damaged by plaque, platelets in the area clump together, stick to the wall and release chemicals that begin the clotting or coagulating process.

2 CLOT FORMATION
The chemicals help convert fibrinogen into insoluble fibrin strands. These trap platelets and other blood cells, and clot formation escalates.

DEEP VEIN THROMBOSIS

Blood that flows slowly is more likely to thrombose, or clot. This can happen in the deep veins of the legs and lower body, which rely to some extent on contracting muscles to assist blood flow. Deep vein thrombosis (DVT) tends to occur during periods of immobility, particularly during long trips, when muscles are relaxed and blood pools in the veins. To help prevent clots from forming, keep moving and drink nonalcoholic beverages. Symptoms of DVT include tenderness, pain, and swelling in the leg, and visibly engorged veins. Treatment with anticoagulant drugs reduces the risk that part of the clot will break off and travel to the lung (see above).

X-RAY DIAGNOSIS
A deep-vein thrombosis in the calf is revealed here by injecting a radiopaque dye into the circulation and taking an X-ray.