Key Terms: sinoatrial (SA) node, atrioventricular (AV) node, electrocardiogram (ECG), blood pressure, systolic pressure, diastolic pressure, sphygmomanometer, cardiac output, and stroke volume.

The heart muscles contract and relax rhythmically, and are controlled by the autonomic nervous system. There are specialized muscle tissue within the heart called the **sinoatrial (SA) node**; also known as the pacemaker; that is responsible for stimulating the rate of contraction and relaxation of the heart. The SA node is located in the wall of the Right Atrium. The impulse generated stimulates a downward contraction of both atria, forcing blood into the ventricles. The signal continues and stimulates a secondary node, called the **atrioventricular (AV) node**.

![Heart Diagram](image)

Figure 12.14: The SA node sends out an electrical stimulus that causes the atria to contract.

**Sinoatrial (SA) node**: the modified heart cells in the right atrium that that spontaneously generate the rhythmic signals that cause the atria to contract.

**Atrioventricular (AV) node**: the modified heart cells near the junction of the atria and ventricles that cause the ventricles to contract.
The AV node sends the signal along a fibre called the **Bundle of His**, at the superior portion of the septum. The signal continuous to run along the septum along a set of fibres called the **Purkinje Fibres**. The Purkinje fibres stimulate the contraction of the ventricles from the apex of the heart upwards towards the AV valves.

**The Heartbeat**

The normal heart sound is a double beat, described as a “**lub – Dub**”. The sound is created by two different sets of valves closing at different times.

The ‘lub’ sound is created when the AV values close as the ventricles contract after the blood is forced into the Aorta and Pulmonary arteries.

The ‘dub’ sound is created when the semilunar valves close as blood tries to return to the ventricles during relaxation, the filling phase.

A **‘heart murmur’** is a variation in a normal heart beat. The blood does not flow smoothly in the heart caused by a stenosis. A stenosis is the narrowing in the opening of the heart valves or arteries. A murmur can also be caused in the valves do not close tightly and blood backflows into the atria.
The Electrocardiogram (ECG)

**Electrocardiogram (ECG):** a record of the electrical impulses generated by the beating heart.

The impulse of the heart creates small voltage, of only a few milli-Volts which can be measured using electrodes. The impulses create an electrocardiogram or graph of the change in voltage. This graph can indicate changes in a healthy heart.

**P Wave:** occurs when the SA node stimulate the atrium contraction.

**QRS Wave:** or complex, occurs when the AV node stimulates the contraction of the ventricle.

**T Wave:** occurs when the ventricle relaxes.

![Figure 12.15: An ECG is produced by placing electrodes on the skin of the chest. The electrodes record voltage changes produced by nerve signals that control the heartbeat. From the information on an ECG, doctors can determine whether a person’s heart is generating signals with a normal frequency, strength, and duration.](image-url)
Blood Pressure

As blood passes through the vessels, it exerts a pressure on the walls, forcing the diameter to increase. Blood pressure changes as the phases of heart contraction and relaxation occur. When the ventricles contract, **Systole phase**, large volumes of blood enter the pulmonary arteries and aorta, exerting the highest pressure on the vessels, called **Systolic pressure**.

When the ventricles relax, **Diastole phase**, the pressure in the vessels decreases, the lowest pressure before the ventricle contracts, called **Diastole pressure**.

**Blood pressure**: the force that blood exerts against the walls of blood vessels.

**Systolic pressure**: the pressure generated in the circulatory system when the ventricles contract and push blood from the heart.

**Diastolic pressure**: the pressure generated in the circulatory system when the ventricles fill with blood.

![Figure 12.16](https://example.com/figure1216.png)

**Figure 12.16**: (A) Small muscles surrounding the veins contract and relax to squeeze blood along the veins. (B) One-way valves inside the veins prevent blood from flowing backward due to the pull of gravity.
**Measuring Blood Pressure**

**Sphygmomanometer**: a medical device used to measure blood pressure.

Sphygmomanometer (blood pressure cuff) is used by doctors to determine a person’s blood pressure.

When blood pressure is measured, it is measured as millimeters of mercury, mmHg. (1 mmHg = 0.133 kPa) The systolic pressure reading is presented over the diastolic pressure. The average blood pressure is **120/80 mmHg**.

During exercise, the blood pressure adjusts. The Ventricles must work harder, pumping greater volumes of blood per unit time, leading to a change in the arteries.

Hypertension occurs when your blood pressure stays high even when you are resting, causing the heart to work harder, which will eventually weaken the arteries, risk of heart attack, stroke, and kidney failure. This can be cause by genetics, activity, stress, body temperature, diet, and medications.

Learning Check

Questions 13 – 18
**Cardiac Output and Stroke Volume**

The amount of blood pumped by the heart is known as the cardiac output and is measured in mL/min. Cardiac output is an indicator of the level of oxygen delivered to the body.

Heart rate and stroke volume contribute to the cardiac output. The heart rate is the beats per minute, and the stroke volume is the volume of blood pumped per beat.

\[
\text{Cardiac output} = \text{heart rate} \times \text{stroke volume}
\]

The average stroke volume is 70 mL. The resting heart rate is 70 beats per minute.

\[
\text{Cardiac output} = 70 \text{ mL} \times 70 \text{ bs/min}
\]

\[
= 4900 \text{ mL/min}
\]

The average human has about 5 L. Therefore with a cardiac output of 4900 mL/min. indicates that the entire blood flows through the heart in one minute.

Exercise will increase the cardiac output of an individual.

**Cardiac Output**: the volume of blood pumped out by the heart in mL/min.

**Stroke volume**: the volume of blood pumped out of the heart with each heartbeat.
Cardiovascular Fitness

A good indicator of cardiovascular fitness is the length of time it takes the heart to recover its resting heart rate after strenuous exercise. The more fit the heart is, the shorter the time it takes to return to the resting heart rate.

<table>
<thead>
<tr>
<th>Individual</th>
<th>Resting Heart Rate (beats/min)</th>
<th>Stroke Volume (mL/beat)</th>
<th>Cardiac Output (mL/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>70</td>
<td>70</td>
<td>4900</td>
</tr>
<tr>
<td>B</td>
<td>98</td>
<td>50</td>
<td>4900</td>
</tr>
<tr>
<td>C</td>
<td>35</td>
<td>140</td>
<td>4900</td>
</tr>
</tbody>
</table>

Table 12.3: Comparison of Cardiovascular Fitness and Heart Efficiency in Three Individuals

Review Questions

Questions 1 – 14