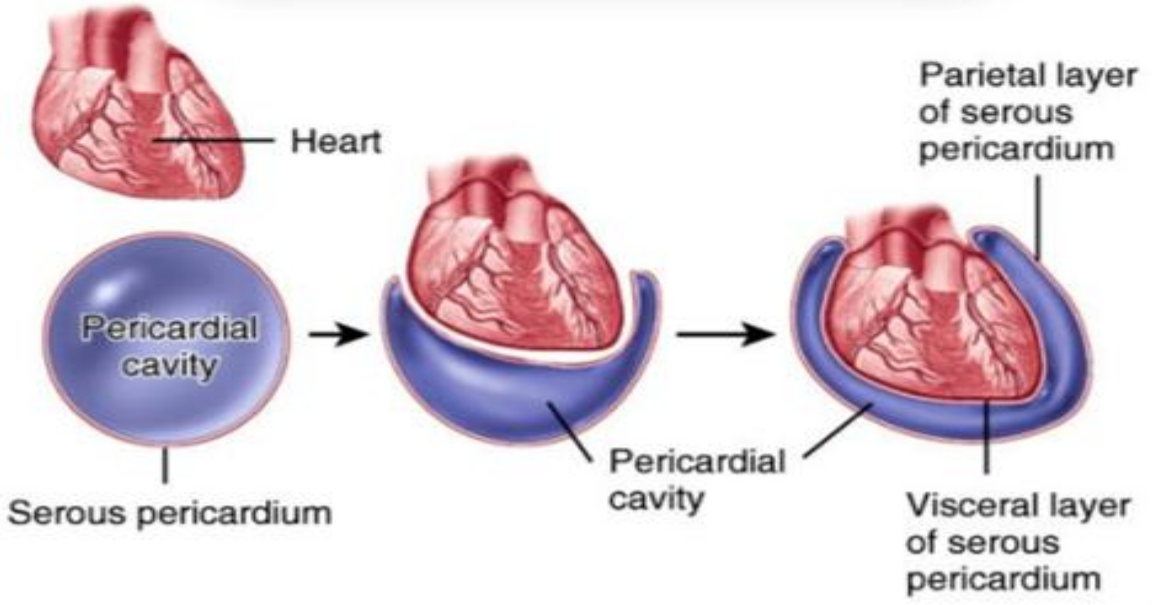
Pericardium

- **OUTER FIBROUS PERICARDIUM**
  - A tough, inelastic, dense irregular connective tissue
  - Attaches to diaphragm and fused to connective tissues of blood vessels entering and leaving the heart
  - Prevents overstretching of heart, provides protection, anchors the heart to mediastinum
- **SEROUS PERICARDIUM** (double layered membrane enclosing a serous fluid filled cavity, each layer is made of mesothelium and its supporting loose areolar CT. Mesothelium is a simple squamous epithelial layer)

1. **Outer serious pericardium (parietal pericardium)** – fused to the inner fibrous pericardium
2. **Inner visceral pericardium (visceral pericardium = epicardium)** – fused to the surface of the heart

Pericardium



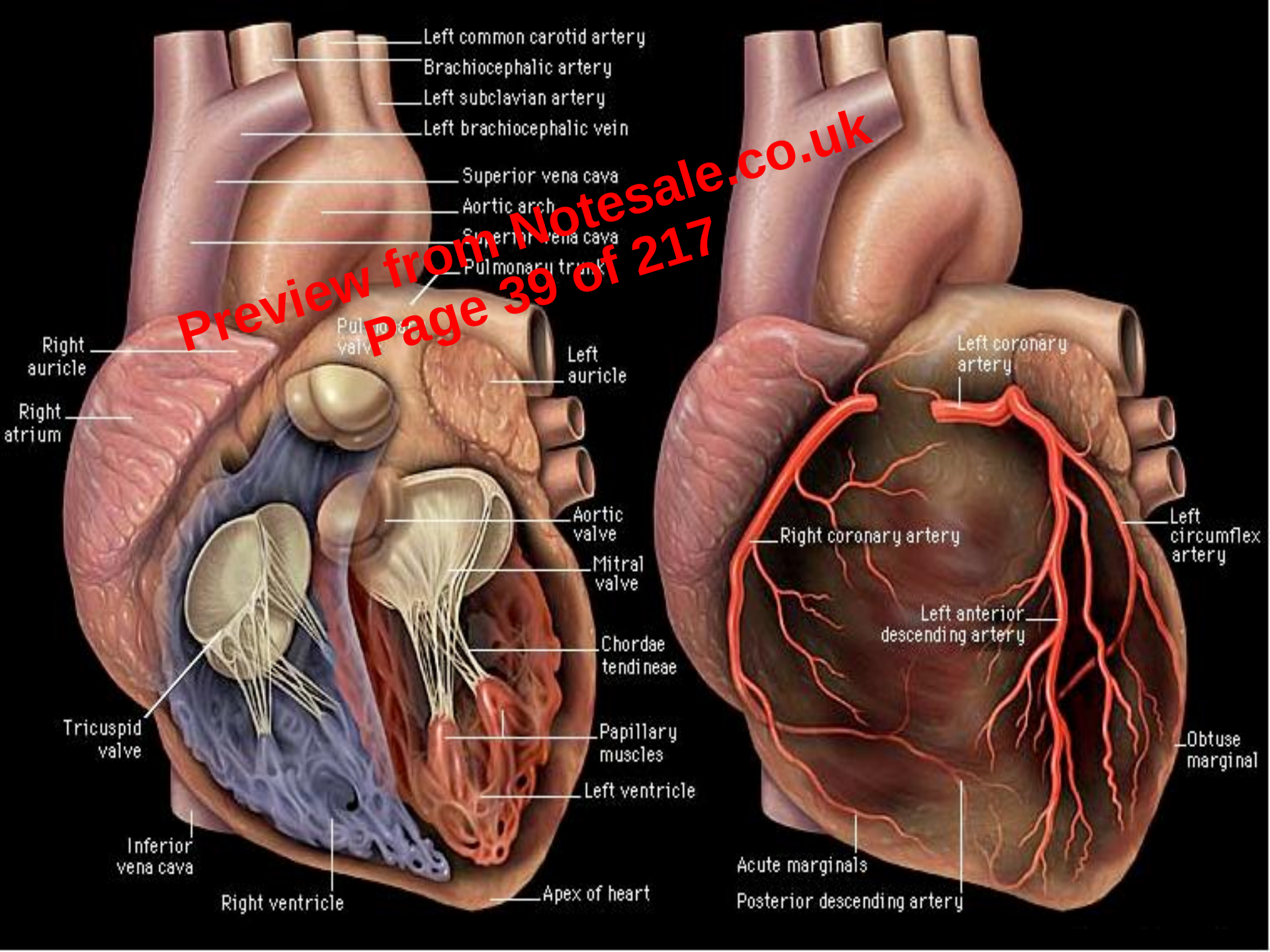
RIGHT ATRIUM

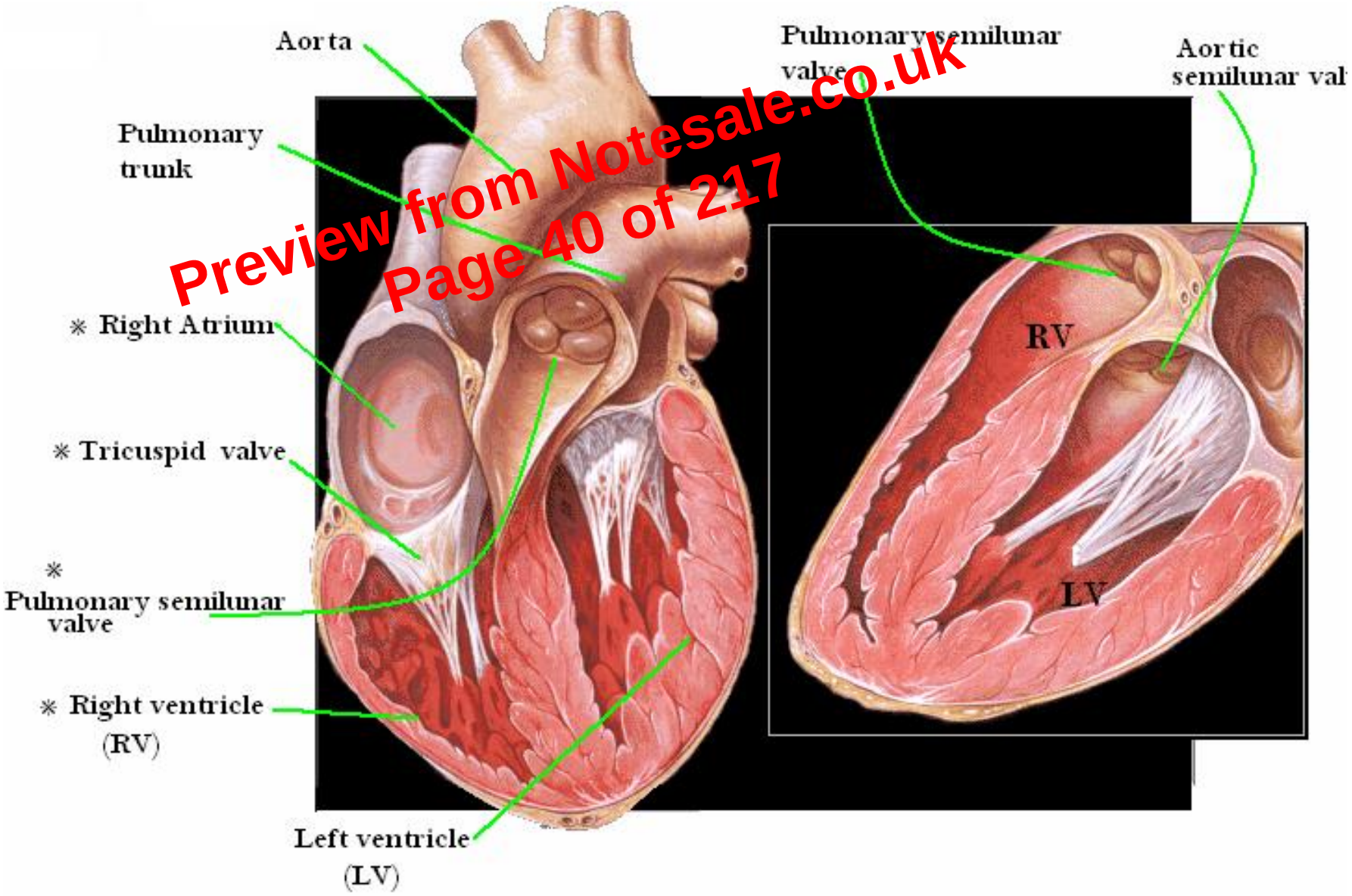
- It receives blood from 3 places
  1. **Superior vena cava** (drains blood from body regions above below the heart)
  2. **Inferior vena cava** (drains blood from body regions below the heart)
  3. **Coronary sinus** (drains blood from the heart venous system)
- Blood passes from R/Atrium ⟶ R/Ventricle through **tricuspid valve (right atrio-ventricular valve)**.

Tricuspid valve – 3 cusps of dense connective tissue.

- "***RAT on the Right***" (Right atrio-ventricular, Tricuspid)

- The **septum** separating the right and left atria has an oval depression called the **fossa ovalis** - the remnant of the **foramen ovale**





LEFT ATRIUM

~ 2- 3mm thickness

- Receives blood from **pulmonary veins** (returning from the lungs)

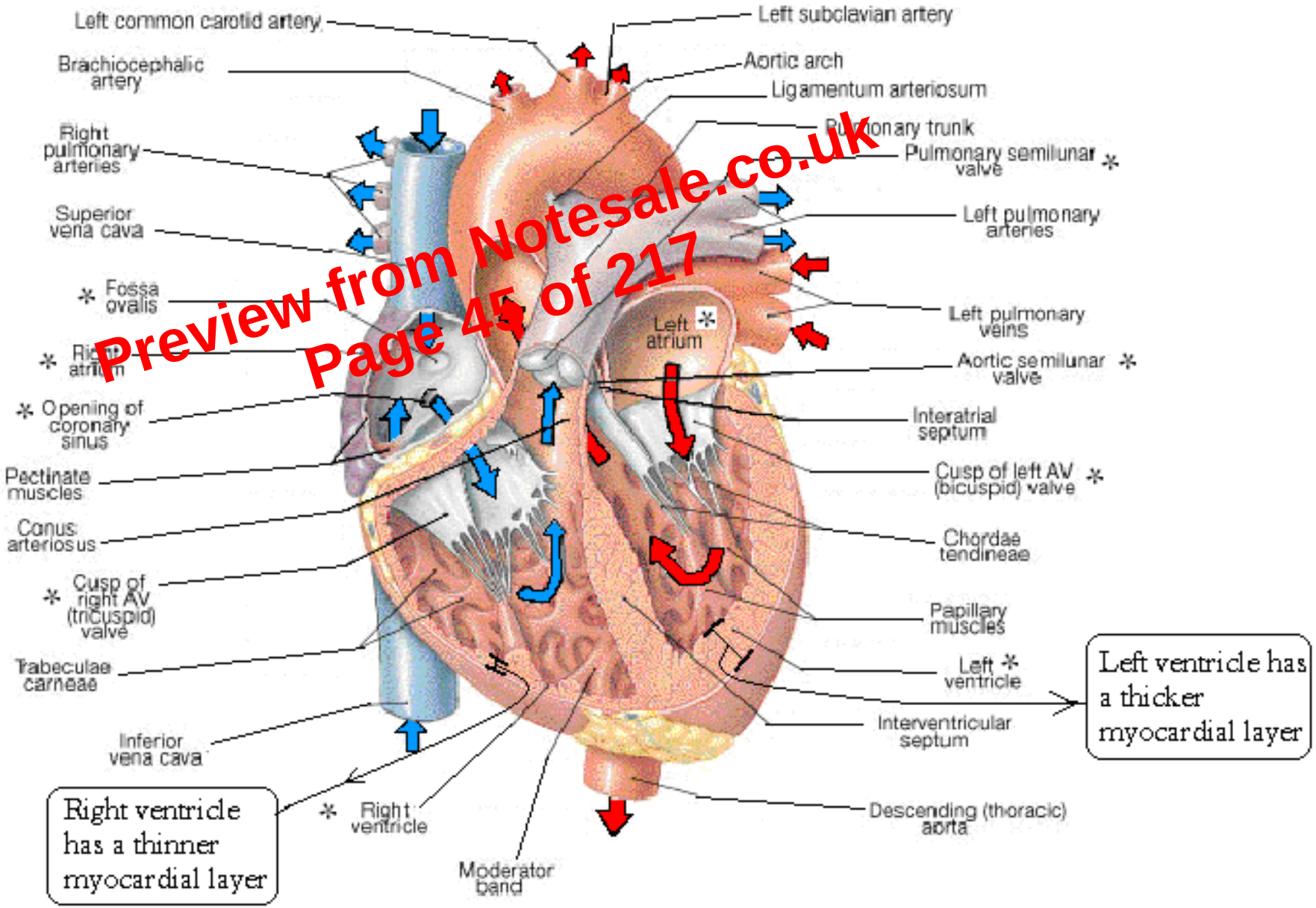
*__Pectinate muscles__ in auricles,

*Anterior wall is smooth

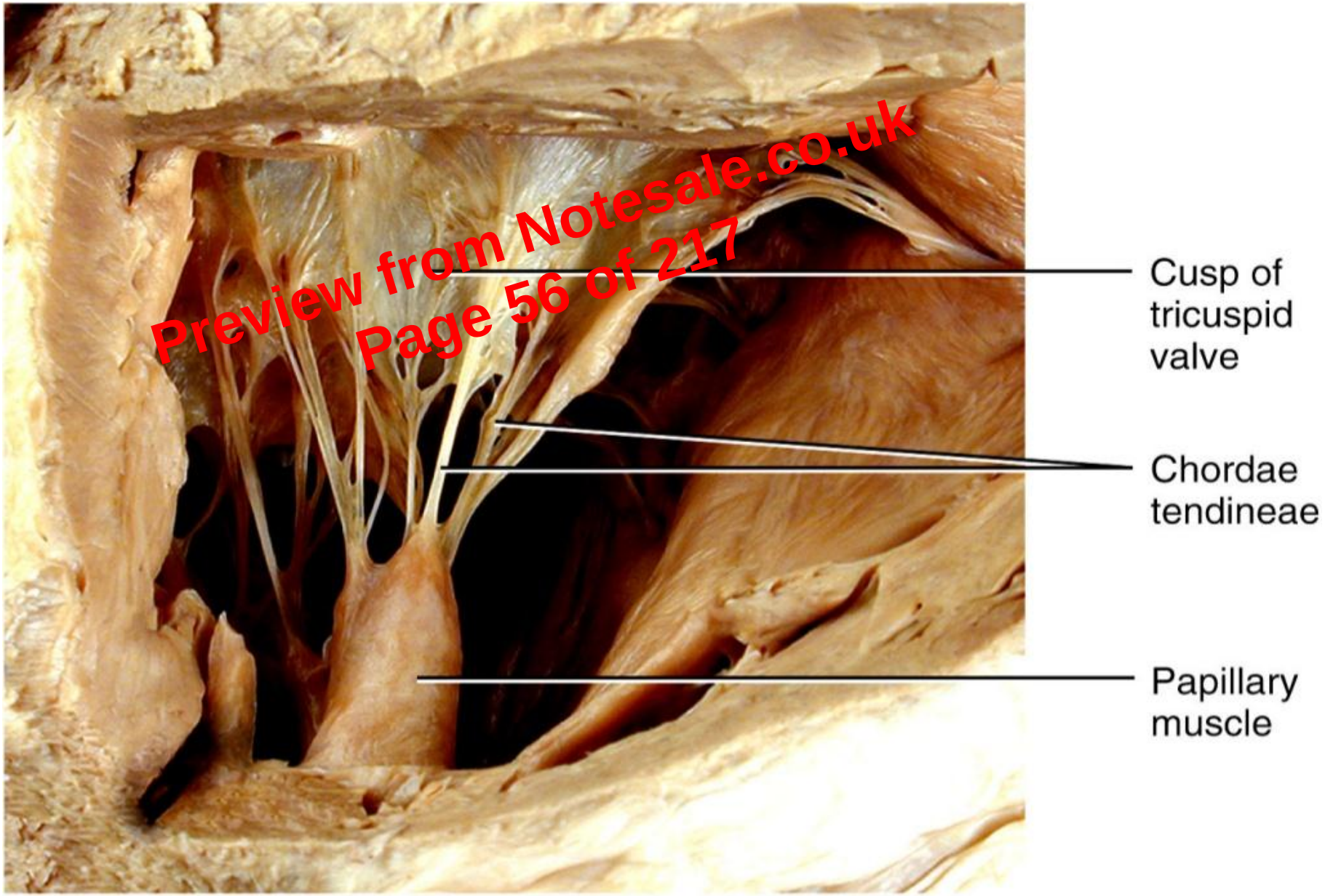
- Blood passes from **L/ Atrium** ⟶ **L/ Ventricle** through **bicuspid (mitral) valve** (left atrioventricular valves).
- Bicuspid valve: 2 cusps, *"LAMB on the left"*

;**L**eft **A**trio-ventricular **M**itral or **B**icuspid

Bishop mitre

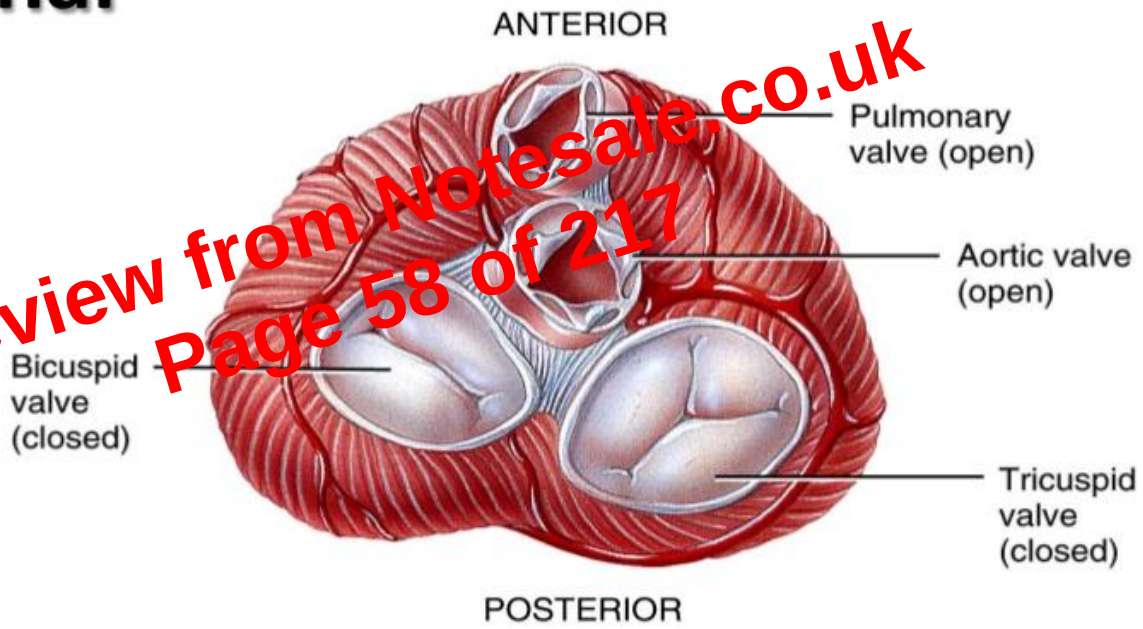


(a) Frontal section, anterior view



(c) Tricuspid valve open

Semilunar Valves



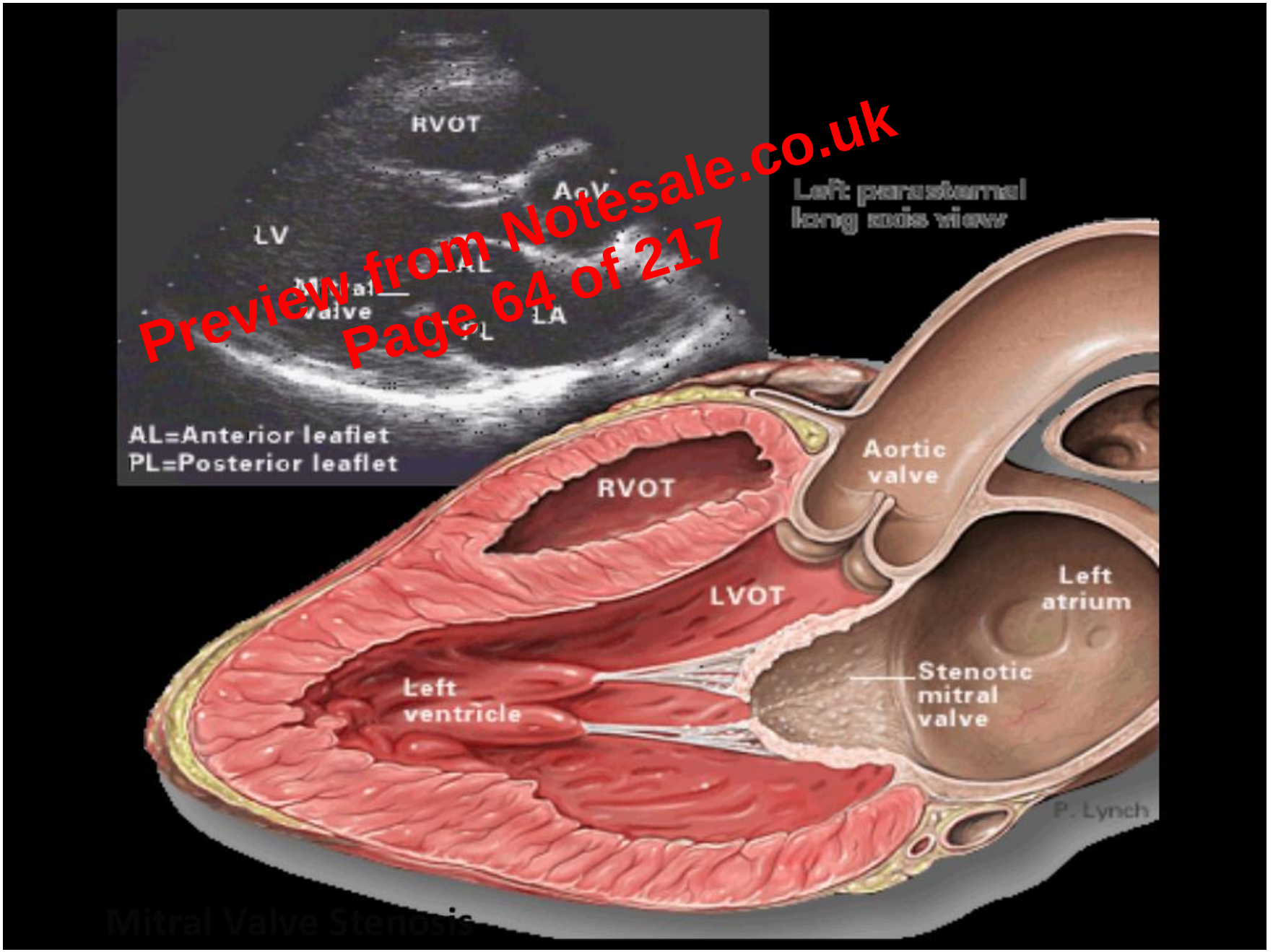
(e) Superior view with atria removed: pulmonary and aortic valves open, bicuspid and tricuspid valves closed.

SL valves OPEN during ventricular contraction
- allow blood flow into pulmonary trunk & aorta

SL valves CLOSE during ventricular relaxation
- blood fills cusps & valves close
- prevents blood from flowing backwards into ventricles

Clinical – heart valve disorders

- **Stenosis** – narrowing of heart valves, restricting the flow of blood through them.
- **Insufficiency (incompetence)** – valve fails to close completely e.g. mitral insufficiency due to mitral valve prolapse (MVP)
- **Mitral valve prolapse (MVP)** – one or both cusps of valve protrudes into left atrium during ventricular contraction. ~ 30% population. Most common valvular disorder.
- **Rheumatic fever** – streptococcal throat infection causing acute system inflammation. Strep bacteria provokes immune response (antibodies produced). But antibodies attach and inflame connective tissues in joints, heart valves and other organs. *damage mitral and aortic valves



Mitral Valve Stenosis

SYSTEMIC & PULMONARY CIRCULATION

- Two circuits in series (i.e. output from one circulation feeds onto the other circulation – cycle repeating itself)

SYSTEMIC CIRCULATION

- **Left side of heart** is the pump for the systemic circulation
- It pumps **oxygenated** blood to the vessels of the body (systemic circulation)

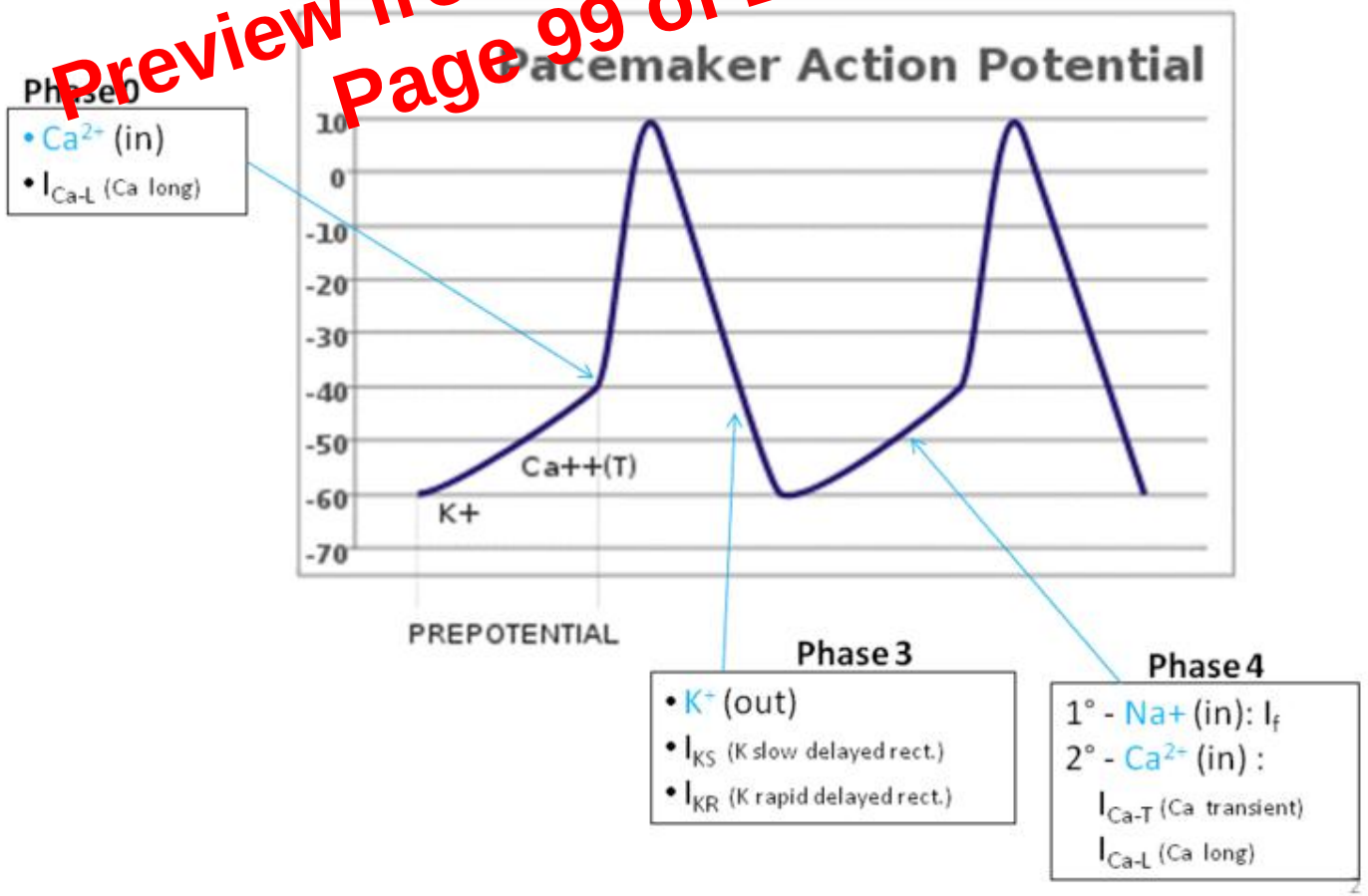
PULMONARY CIRCULATION

- **Right side of heart** is the pump for pulmonary circulation
- It pumps **deoxygenated blood** to the lungs for oxygenation

PROPERTIES OF HEART MUSCLE

- The heart pumps blood through the PULMONARY & SYSTEMIC circulations by a continuing cycle of contraction and relaxation (SYSTOLE & DIASTOLE)
- In order for muscle to contract, it must first be electrically activated.
- The heart is not activated all at one instant - but by a wave of excitation that spreads through the myocardium in a coordinated manner.
- It stimulates each area at the appropriate time
- So that at systole (contraction) blood is effectively propelled forward into the circulation.
- If the normal pattern of spread of electrical activation is upset then the heart will not be an effective pump

Action potential from an sinoatrial node



CONDUCTION AND PACEMAKER OF THE HEART

TWO FUNCTIONS OF THE CONDUCTION SYSTEM;

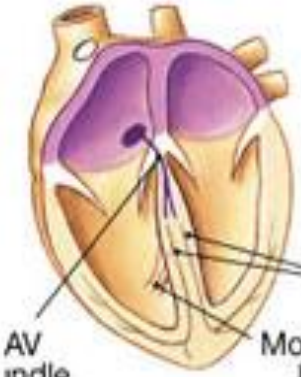
1. **PACE-MAKER** - sets the rhythm of the entire heart
   - fastest AP firing rate ~ 100 times per minute
   NB: AV node ~75 AP per minute, purkinje fibers ~ 40 AP per minute
2. Forms **CONDUCTION SYSTEM** – route for conduction of action potentials throughout the heart muscle.
   - They have **little or no contractile proteins**.
   - It includes; sinoatrial node, atrioventricular node, AV bundle (Bundle of His), Bundle branches and purkinje fibers.

STEP 1:
SA node activity and atrial activation begin.

Time = 0

STEP 2:
Stimulus spreads across the atrial surfaces and reaches the AV node.

Elapsed time = 50 msec

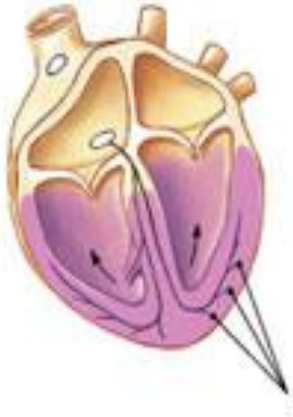


STEP 3:
There is a 100-msec delay at the AV node. Atrial contraction begins.

Elapsed time = 150 msec

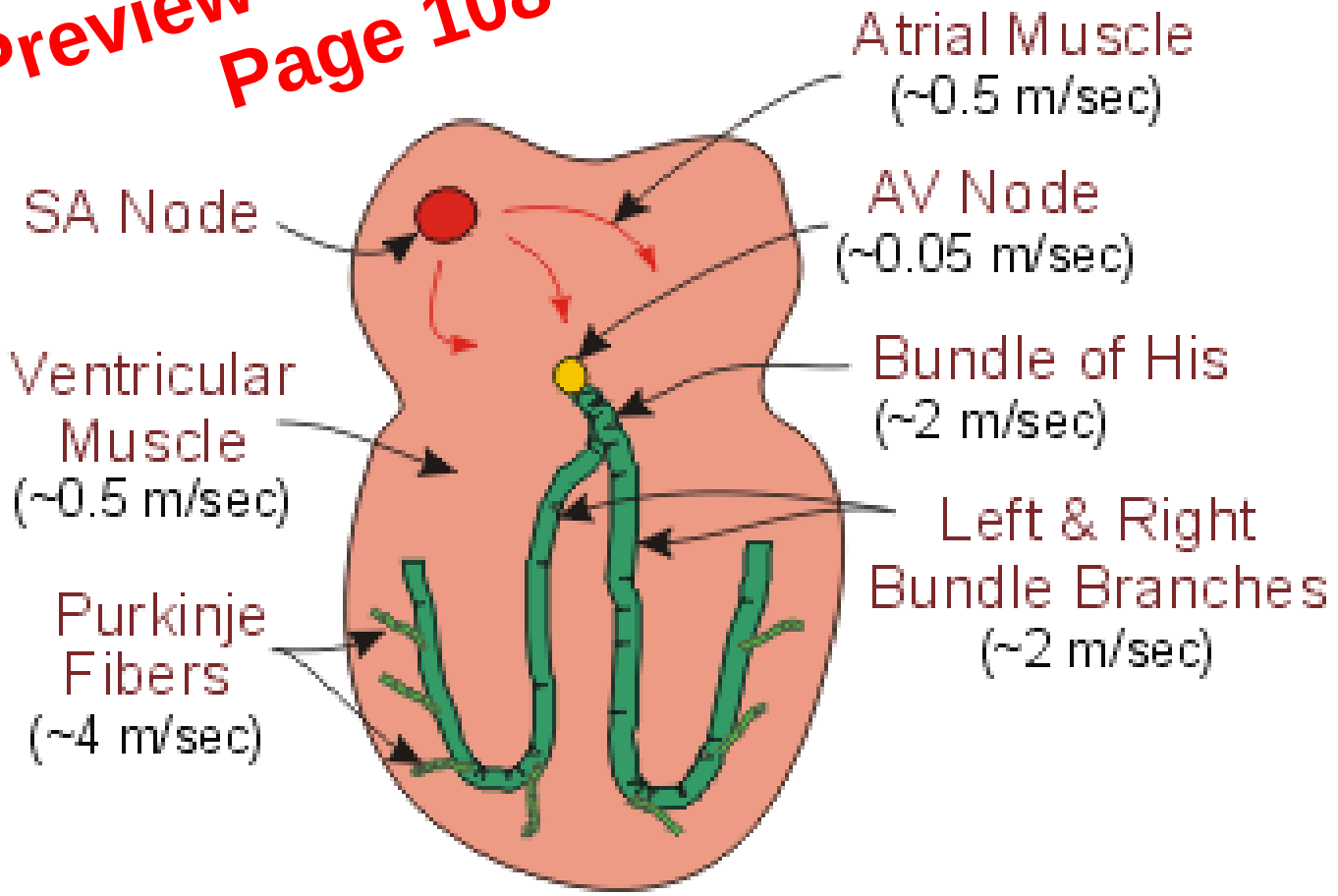
STEP 4:
The impulse travels along the interventricular septum within the AV bundle and the bundle branches to the Purkinje fibers and, via the moderator band, to the papillary muscles of the right ventricle.

Elapsed time = 175 msec



STEP 5:
The impulse is distributed by Purkinje fibers and relayed throughout the ventricular myocardium. Atrial contraction is completed, and ventricular contraction begins.

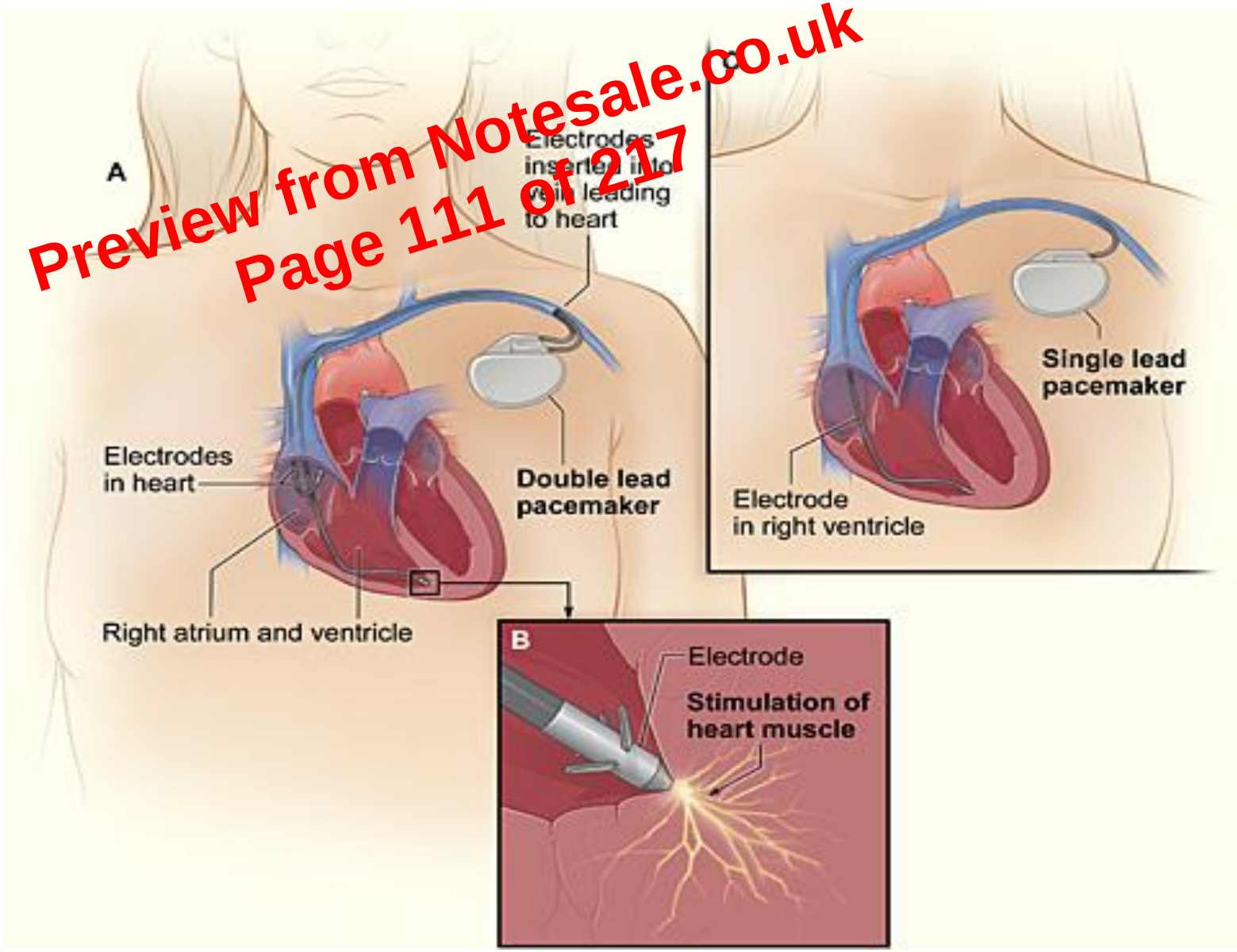
Elapsed time = 225 msec



Clinical – artificial pacemaker

- SA node (~100 – 75 AP/ min) damaged/ diseased, slower AV node (~65 -40 AP/ min) become the pacemaker.
- Both nodes damaged other conduction pathway (AV bundle, right or left branch, purkinje fibers) can become pace maker (~35 -20 AP/ min). Firing rate too slow to maintain normal blood flow to the brain.
- **Artificial pacemaker** – (battery and impulse generator) a device that sends out electrical currents to heart muscle to contract. Implant beneath skin just inferior to clavicle. Pace-maker with one (or 2) lead wires are threaded through superior vena cava and passed into chambers of heart.

Clinical – artificial pacemaker

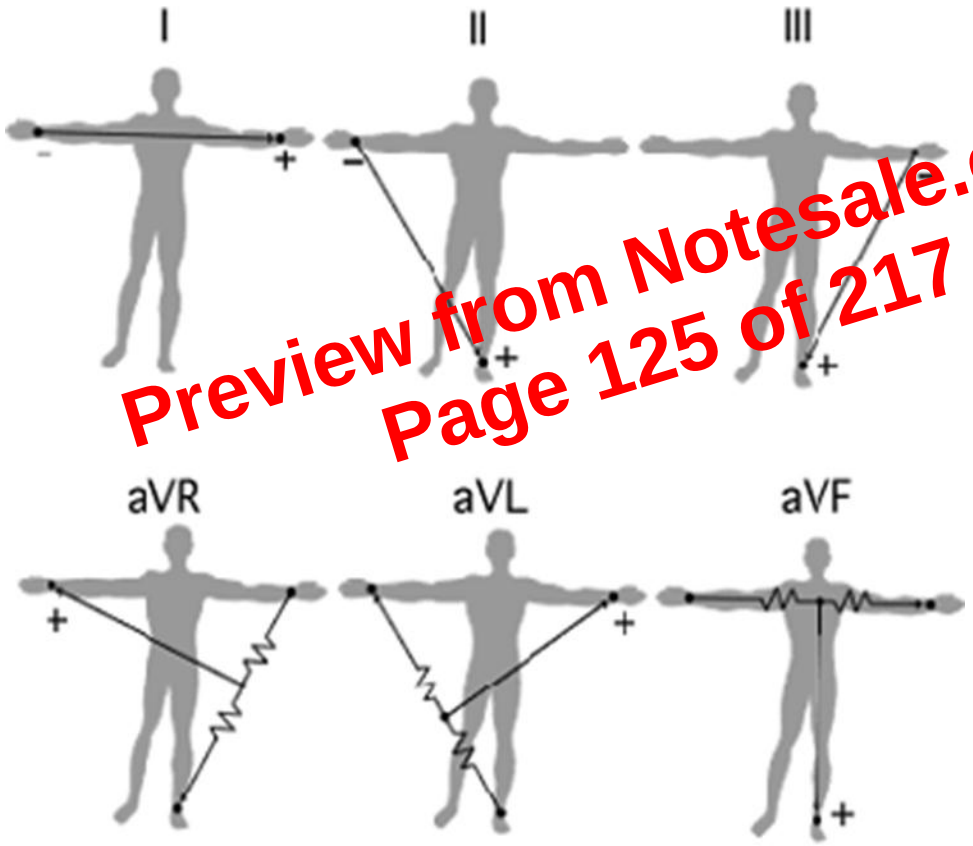


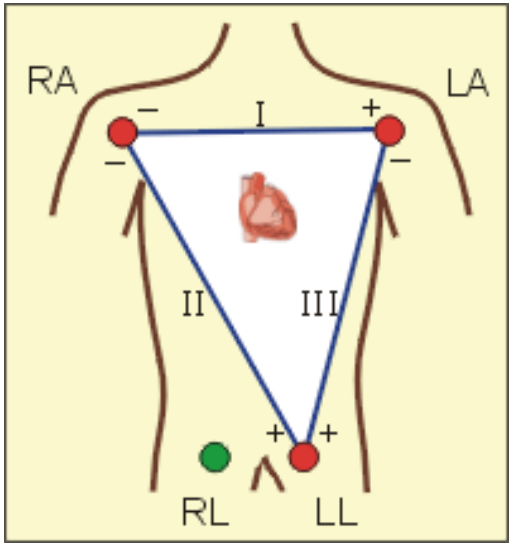
Action potential and contraction of heart contractile fibers

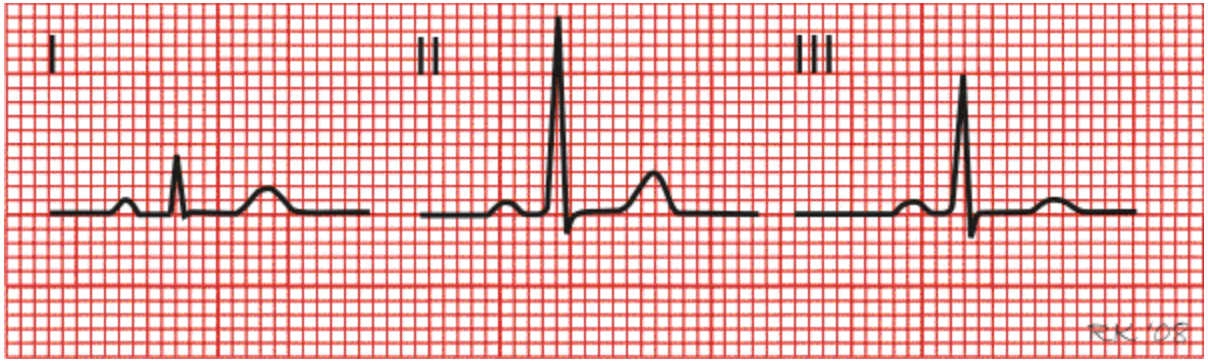
3. Repolarization

- Towards end of plateau, more voltage gated K+ channels opens and creates a dominant K+ outward current. This brings about the repolarization phase.

- Simultaneously Ca^{2+} channels in sarcolemma and sarcoplasmic reticulum are also closing and contributes to repolarization and both brings membrane potential to -90mV.







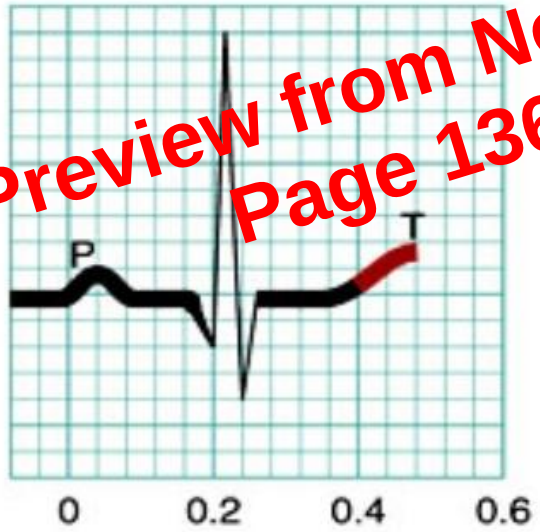
ELECTROCARDIOGRAM

- Each limb and chest electrode shows different electrical activity because of its different position relative to the heart

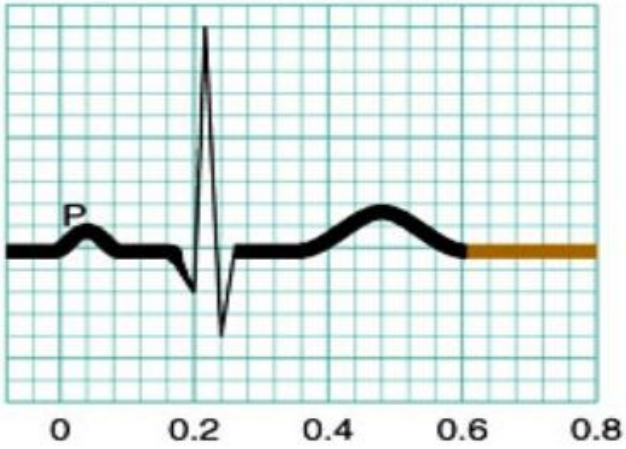
Uses: By comparing these recordings with one another and with normal records we can show:

1. Abnormality in conduction system
2. Heart enlargement
3. Certain regions of the heart damaged
4. Causes of chest pain

5 Repolarization of ventricular contractile fibers produces T wave



6 Ventricular diastole (relaxation)

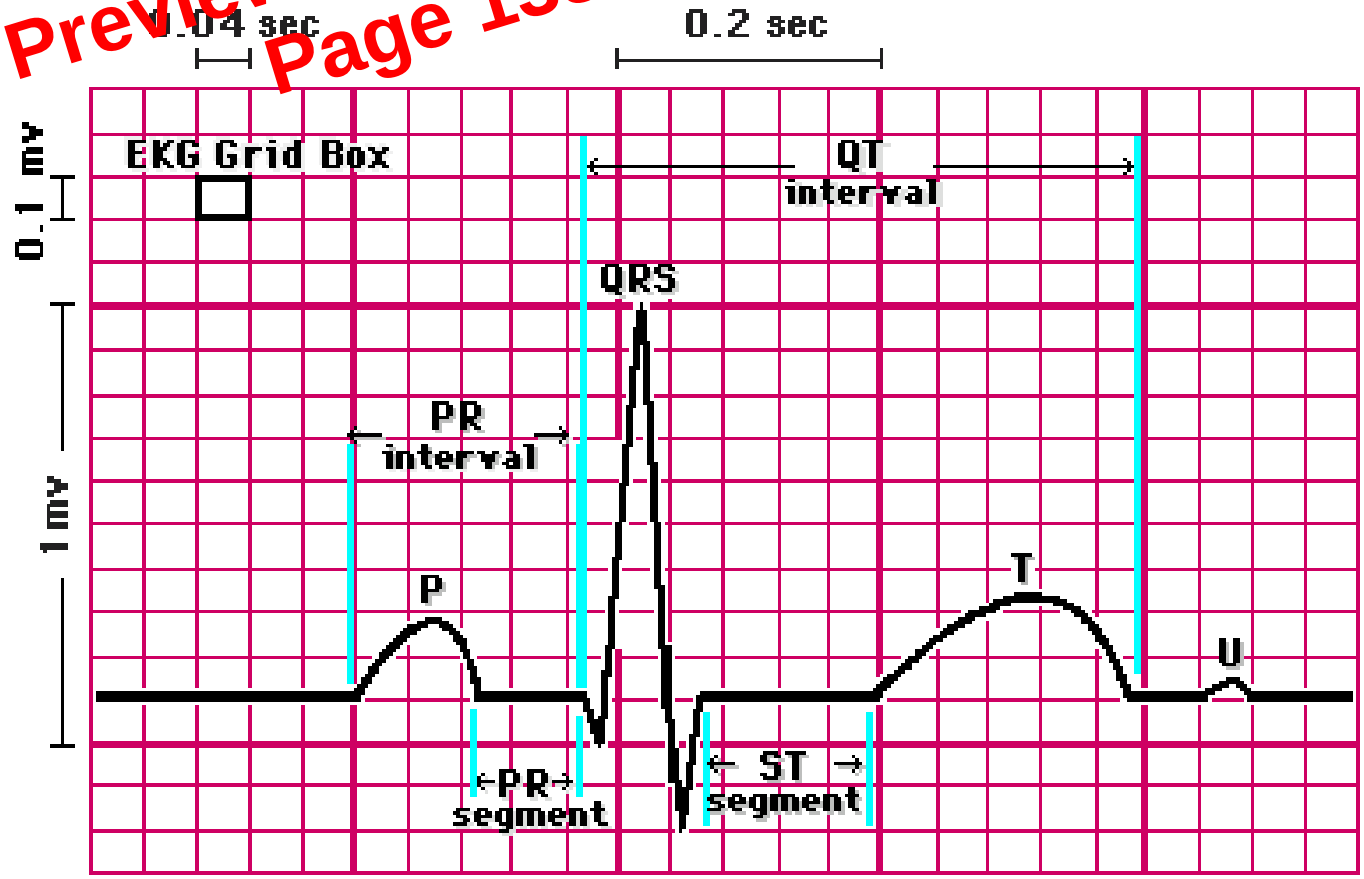


Examples of Abnormalities in ECG waves

- Larger P wave – enlarged atria
- Enlarge Q wave – myocardial infarction
- Enlarged R wave – enlarged ventricles
- Flatter T wave – insufficient Oxygen in heart muscle
- Elevated T wave - hyperkalemia

ELECTROCARDIOGRAM

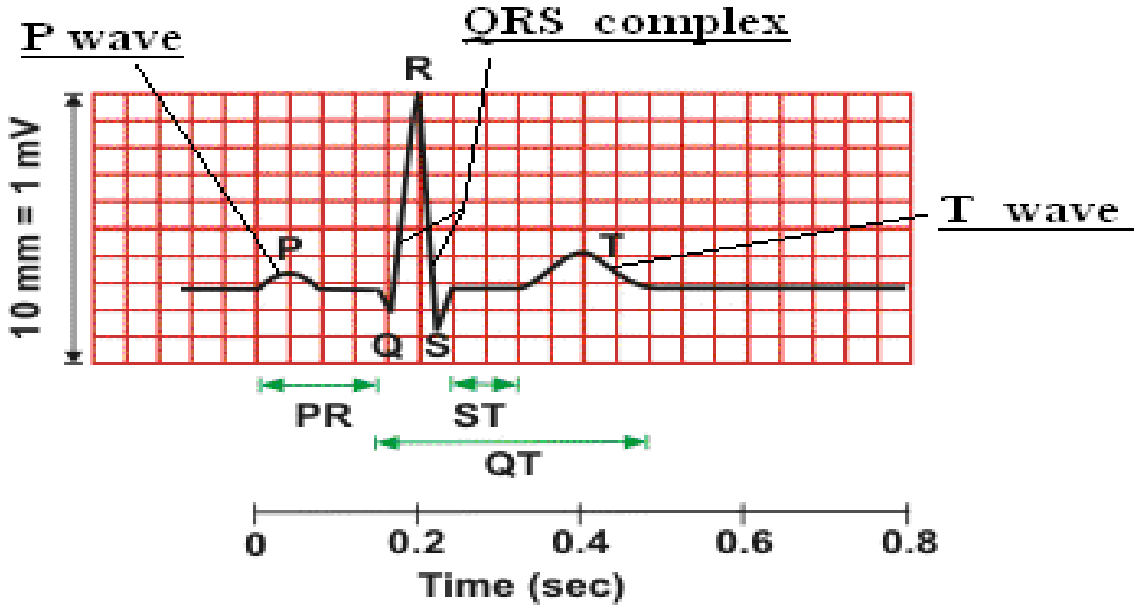
- Time spans between waves – intervals or segments



ELECTROCARDIOGRAM

- The cardiac cycle is also an **electrical event** associated with a heart beat
- This electrical activity can be detected at the surface and shown by an **electrocardiogram,(ECG), tracings.**

NB: Electrical activity can be recorded at a distant from the heart because the body tissues act as conductors.



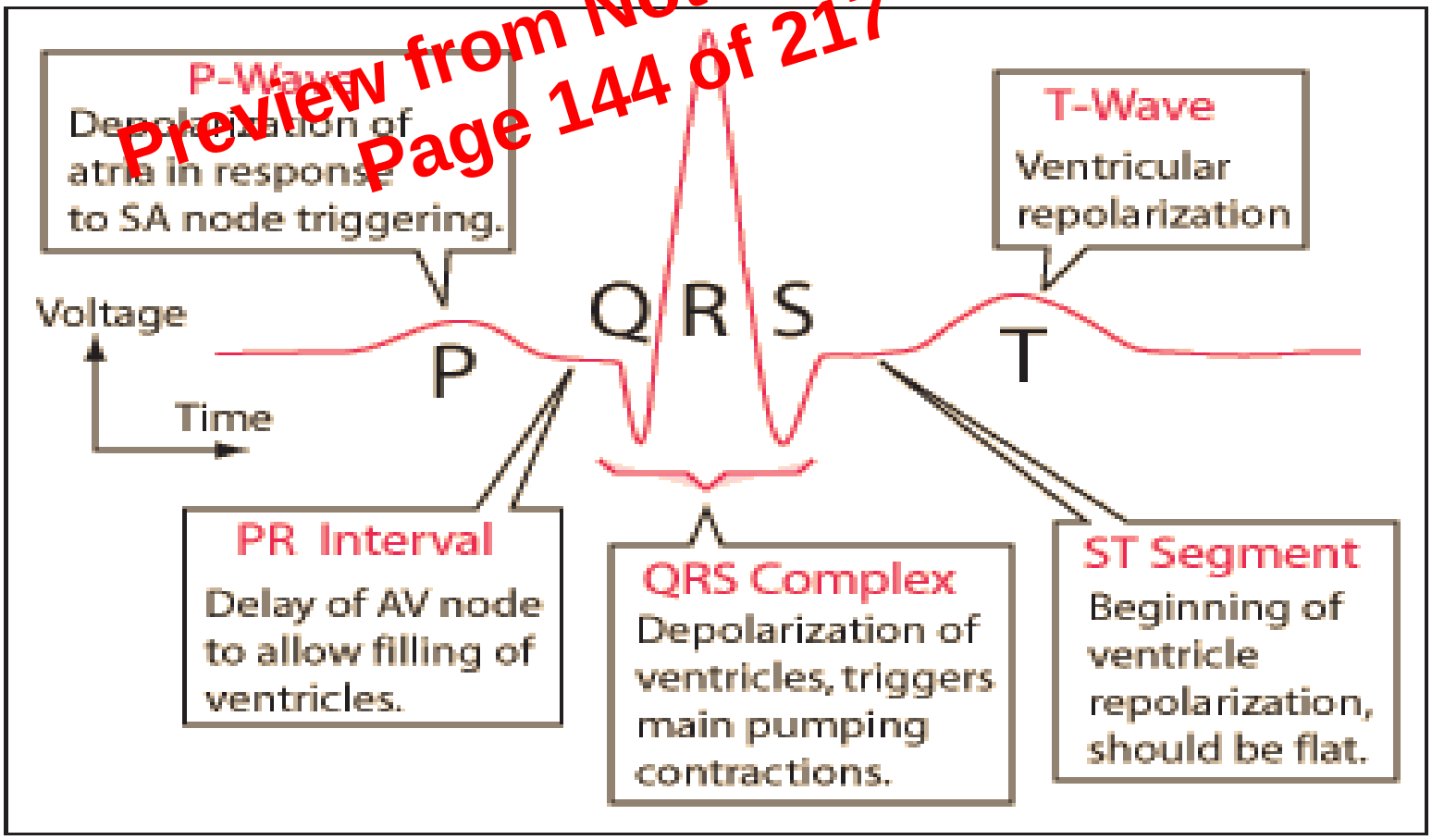
P wave (0.08 - 0.10 s)

QRS (0.06 - 0.10 s)

P-R interval (0.12 - 0.20 s)

Q-T_C interval (≤ 0.44 s)*

ECG DEFLECTIONS

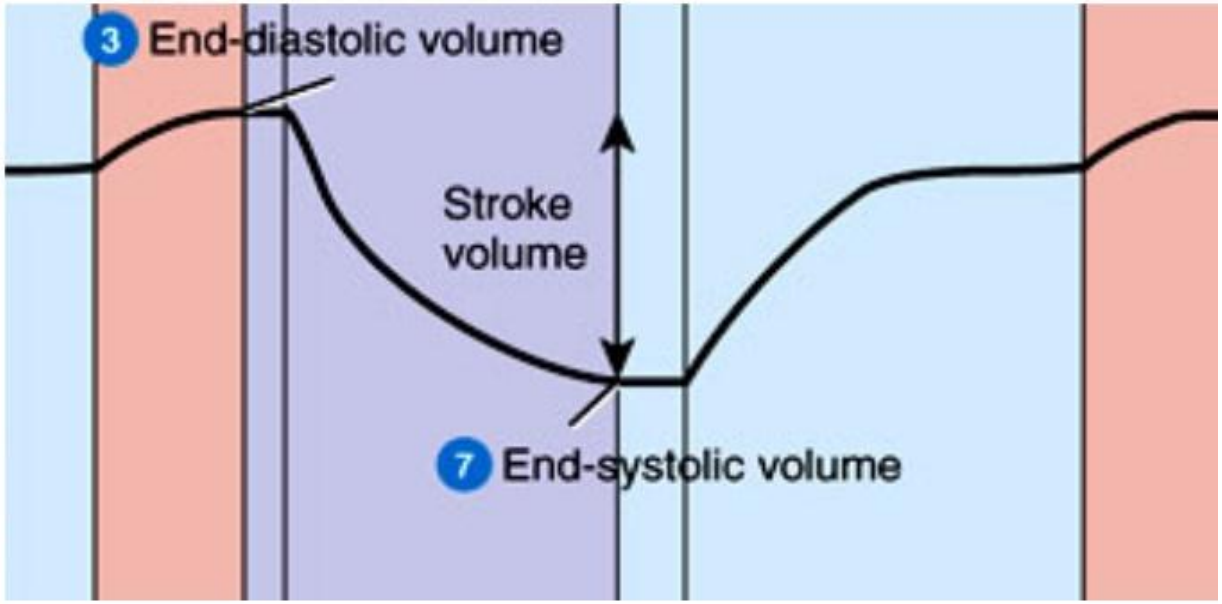


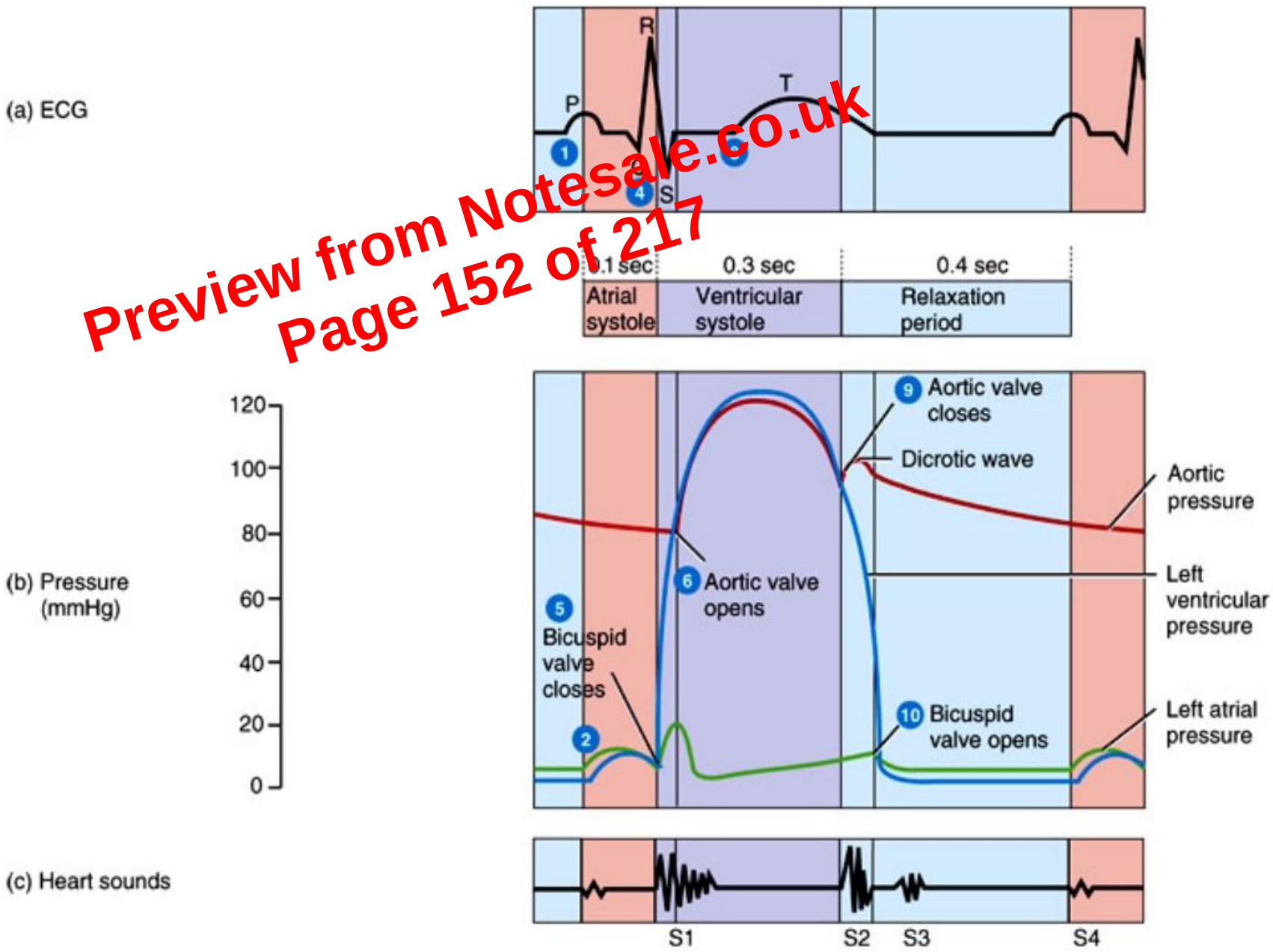
Blood Volumes

End Diastolic Volume (EDV)
= 130 ml

End Systolic Volume (ESV)
= 60 ml

Stroke Volume (SV)
= 70 ml





HEART SOUNDS

- PRODUCED by **blood turbulence** created as **valves closes**
- 4 types of heart sounds (S1, S2, S3 and S4)
- NORMAL HEART SOUNDS: - S1 and S2

i.e. 1) **S1 – "LUBB"** sound

- louder and longer
- produced by **blood turbulence** from **closure of AV valves** after ventricular systole.

2) **S2 – "DUBB"** sound

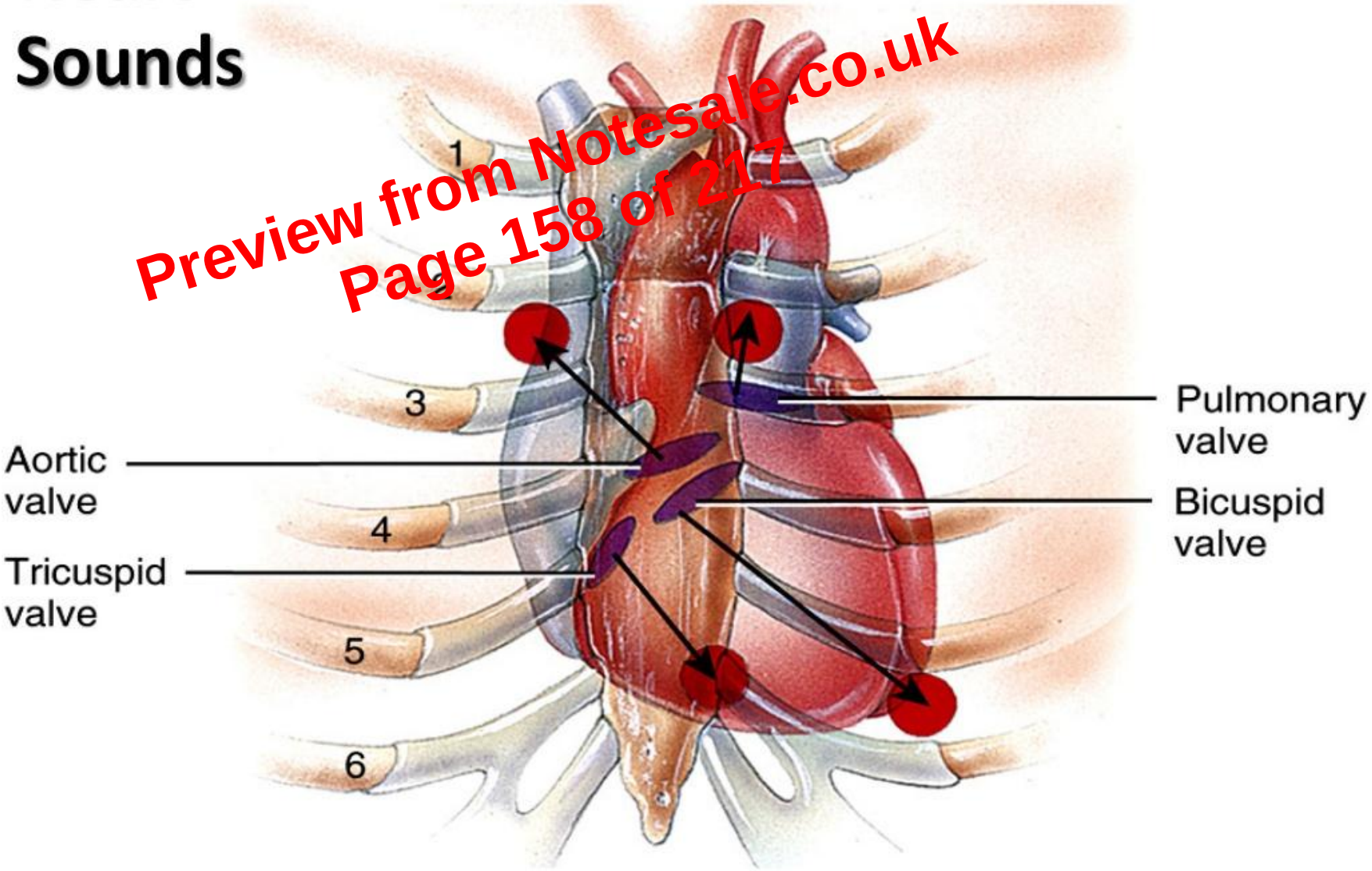
- caused by **blood turbulence** from **closure of semilunar valves** at beginning of ventricle diastole

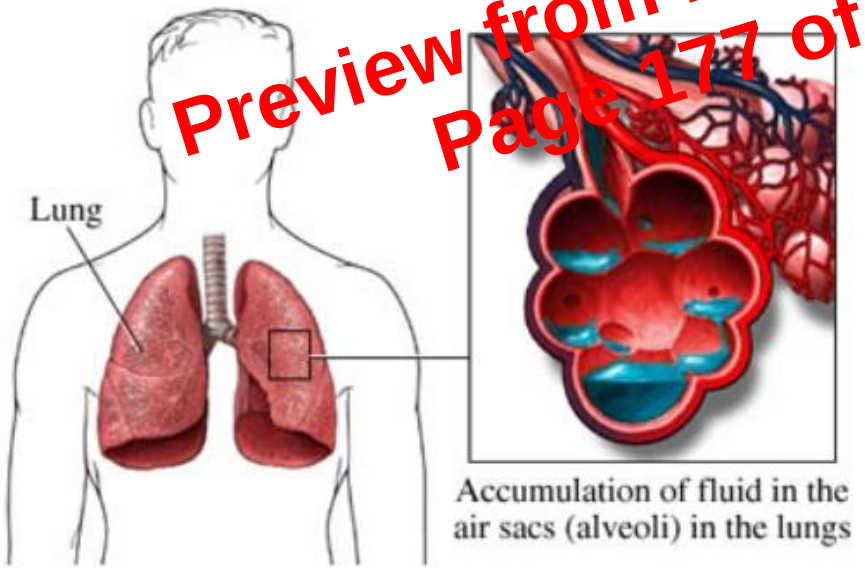
- HEART SOUNDS NOT USUALLY HEARD

(and if heard it can be abnormal)- S3, S4

1) **S3** - caused by **rapid ventricular filling**
2) **S4** – caused by **atrial contraction**

Heart Sounds





Accumulation of fluid in the air sacs (alveoli) in the lungs

Edema (swelling) of the ankles and feet

REGULATION OF HEART RATE

SIGNIFICANCE OF A CHANGING HEART RATE

- It is important in short-term control of cardiac output and blood pressure.

BRIEF OVERVIEW OF BLOOD VESSELS

- Blood vessels form a closed system of tubes that carry blood away from the heart → transport it to tissues of the body then return → it to the heart.

ARTERIES – carry **blood** from heart **to tissues**

ARTERIOLES – small arteries that **connect to capillaries**

CAPILLARIES – are the **site of substance exchange** between blood and body tissues

VENULES – **connect** capillaries to larger veins

VEINS – convey blood from the tissues back to the heart

VASA VASORUM – are **small blood vessels** that **supply blood** to the **cells of arteries and veins**.

ARTERIES

CHARACTERISTIC;

Blood are under **high pressure**. Blood volume contained in arteries are called **stressed volume**

FUNCTIONAL PROPERTIES of arteries;

1) **ELASTICITY** – due to **elastic tissue** in **tunica intima** and **tunica media**

SIGNIFICANCE: Allows arteries to **accept blood under great pressure** from the contraction of ventricles and to send it on through the systemic circulation.

2) **CONTRACTILITY** – due to the **smooth muscle** in **tunica media**.

SIGNIFICANCE: Allows arteries to **increase or decrease lumen size** and to **limit bleeding** from wounds.

FUNCTION:

- **Carries oxygenated blood** away from the heart to the **tissues**.

VEINS