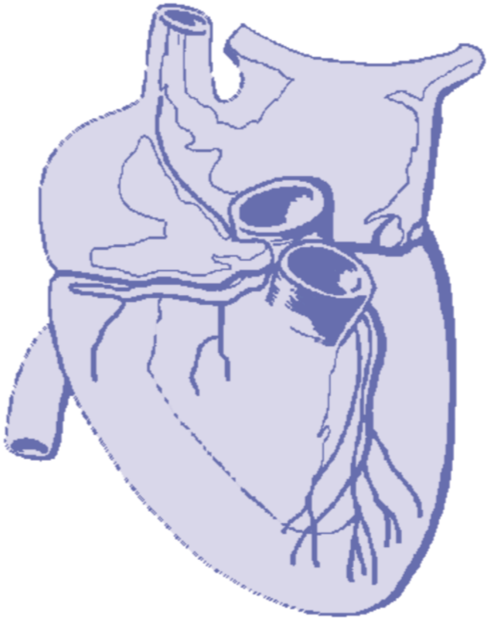
CHAPTER 7

CARDIOVASCULAR CONTROL DURING EXERCISE



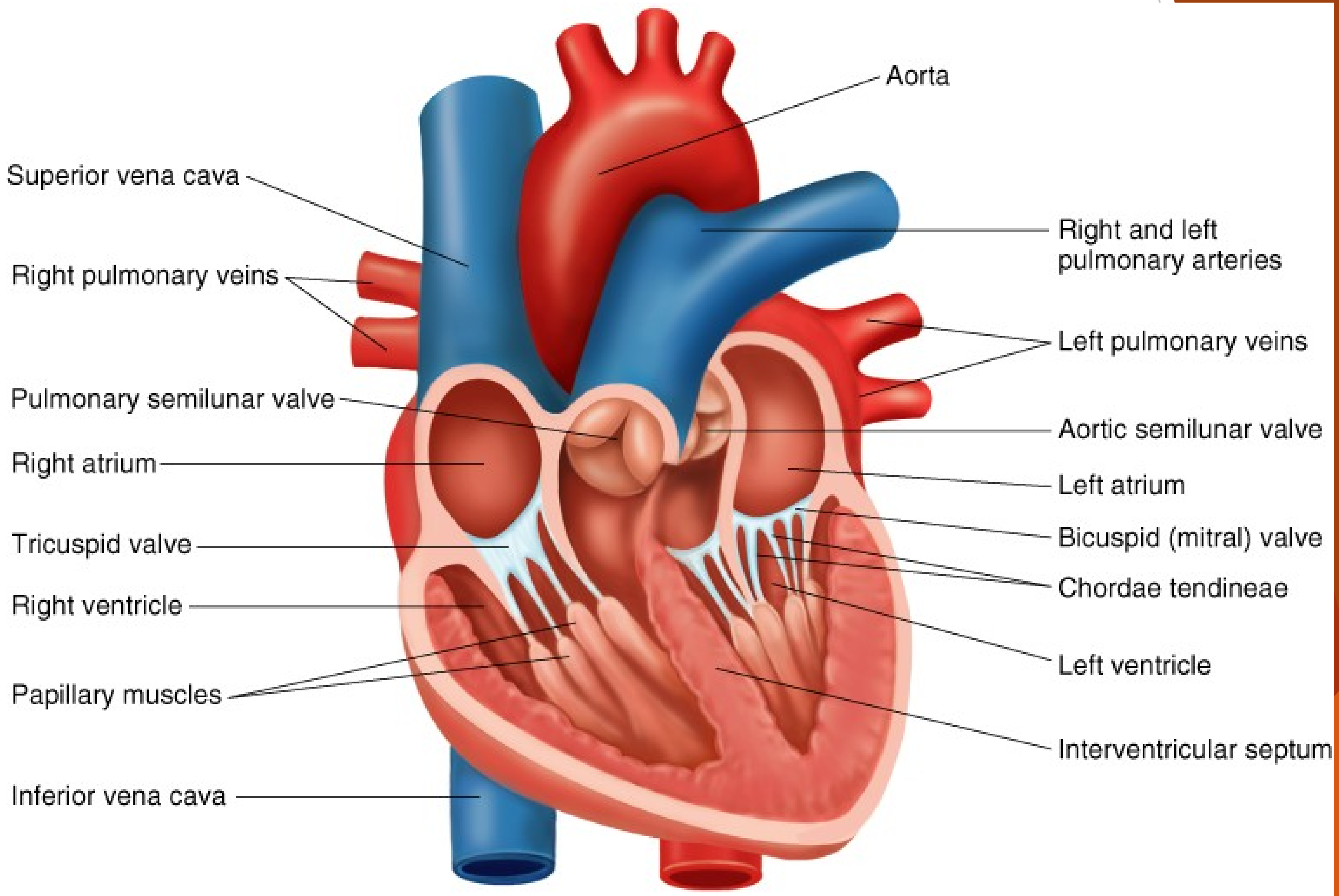
Major Cardiovascular Functions

- Delivery (e.g., oxygen and nutrients)
- Removal (e.g., carbon dioxide and waste products)
- Transportation (e.g., hormones)
- Maintenance (e.g., body temperature, pH)
- Prevention (e.g., infection—immune function)

Cardiovascular System

- A pump (the heart)
- A system of channels (the blood vessels)
- A fluid medium (blood)

HEART

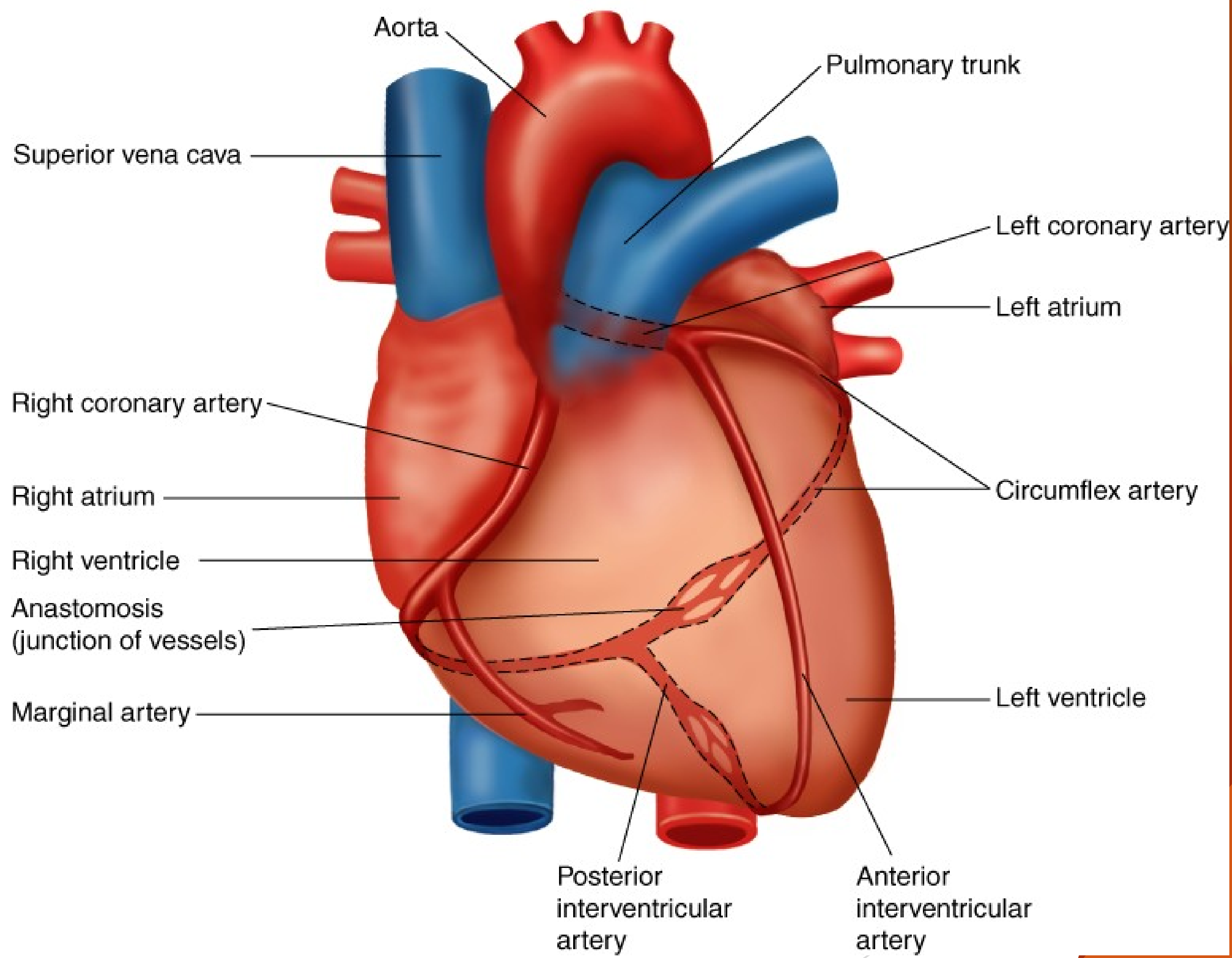


Aorta
Superior vena cava
Right and left
pulmonary arteries
Right pulmonary veins
Left pulmonary veins
Pulmonary semilunar valve
Aortic semilunar valve
Right atrium
Left atrium
Tricuspid valve
Bicuspid (mitral) valve
Chordae tendineae
Right ventricle
Left ventricle
Papillary muscles
Interventricular septum
Inferior vena cava

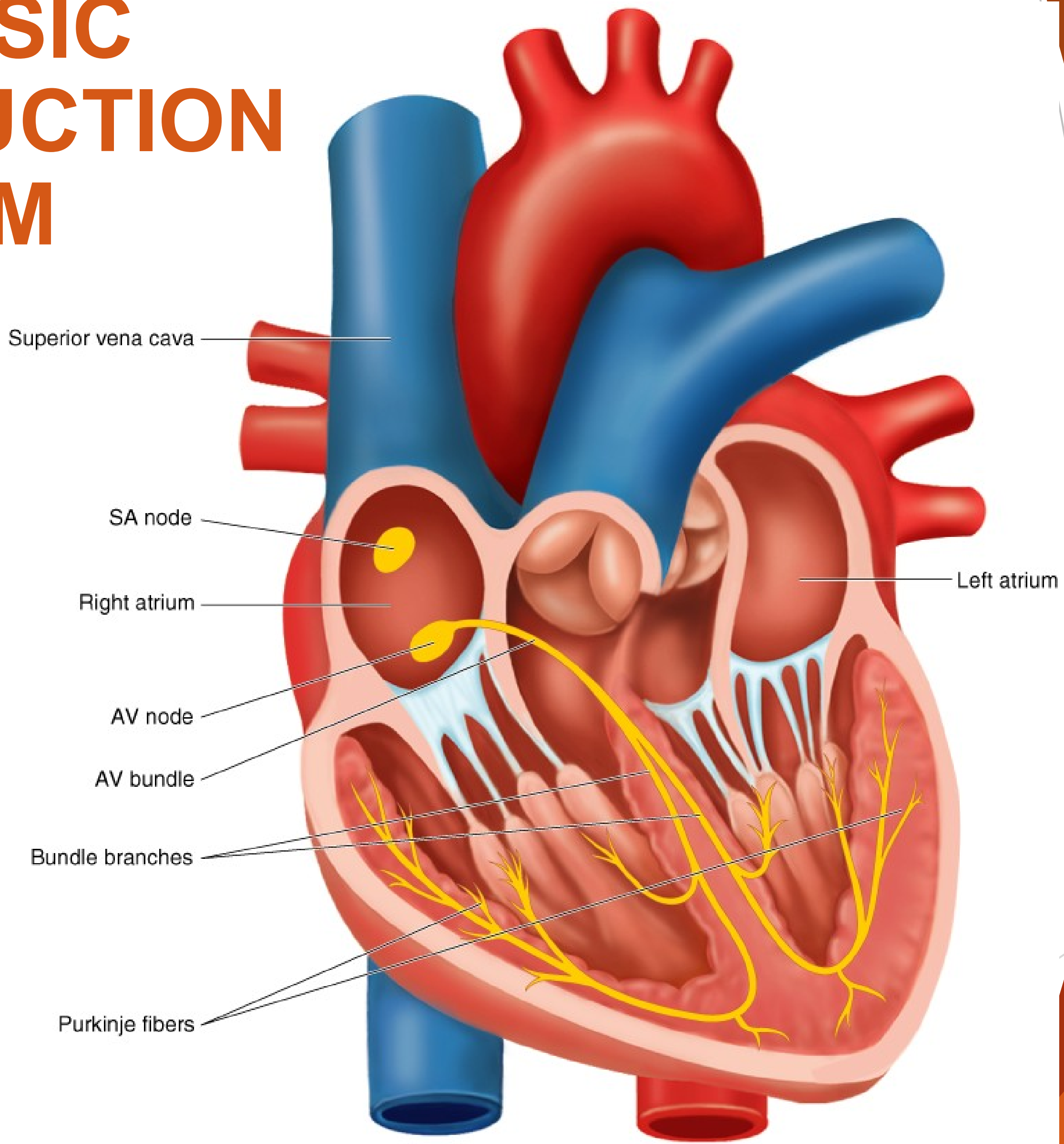
Myocardium—Cardiac Muscle

- Thickness varies directly with stress placed on chamber walls.
- Left ventricle is the most powerful of chambers and thus, the largest.
- With vigorous exercise, the left ventricle size increases.

CORONARY CIRCULATION



INTRINSIC CONDUCTION SYSTEM



Cardiac Conduction System

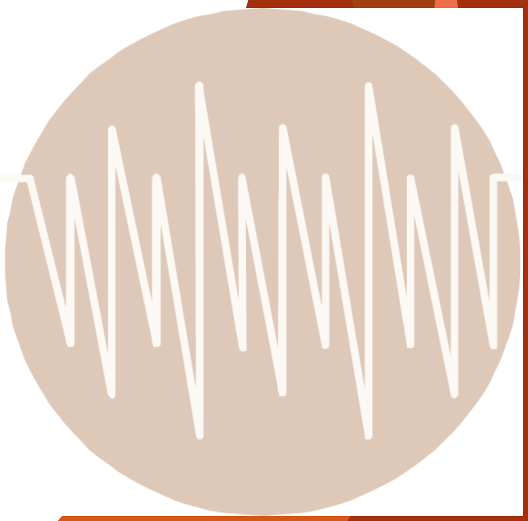
- Sinoatrial (SA) node—pacemaker (60–80 beats/min intrinsic heart rate)
- Atrioventricular (AV) node—built-in delay of 0.13 s
- AV bundle (bundle of His)
- Purkinje fibers—6 times faster transmission

Extrinsic Control of the Heart

- Parasympathetic nervous system acts through the vagus nerve to decrease heart rate and force of contraction (predominates at rest—vagal tone).
- Sympathetic nervous system is stimulated by stress to increase heart rate and force of contraction.
- Epinephrine and norepinephrine—released due to sympathetic stimulation—increase heart rate.

Did You Know…?

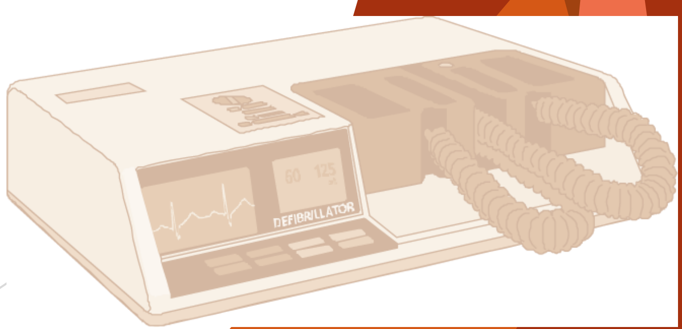
Resting heart rates in adults tend to be between 60 and 85 beats/min. However, extended endurance training can lower resting heart rate to 35 beats/min or less. This lower heart rate is thought to be due to decreased intrinsic heart rate and increased parasympathetic stimulation.



Main Cardiac Arrhythmias

Bradycardia—resting heart rate below 60 beats/min

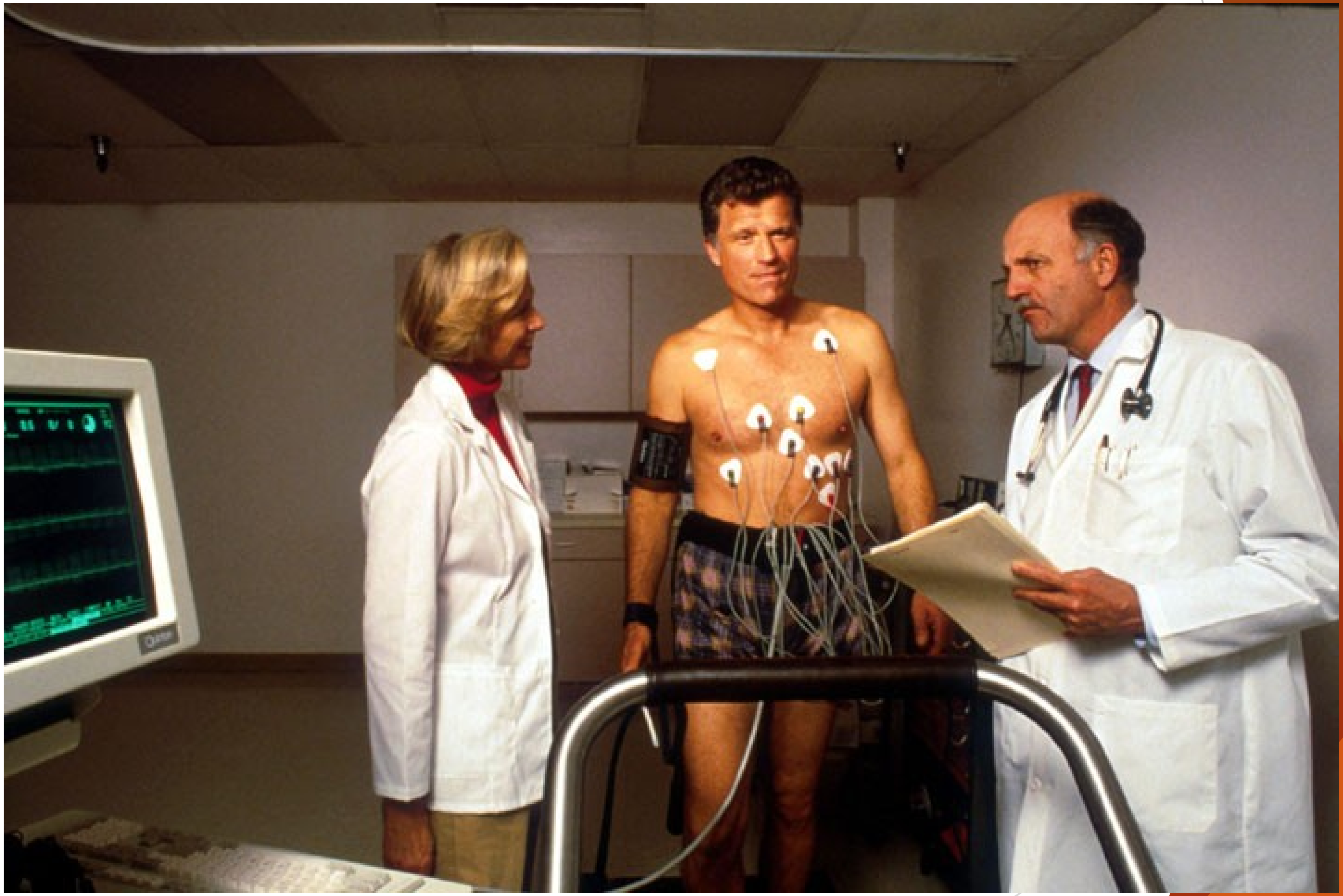
Tachycardia—resting heart rate above 100 beats/min



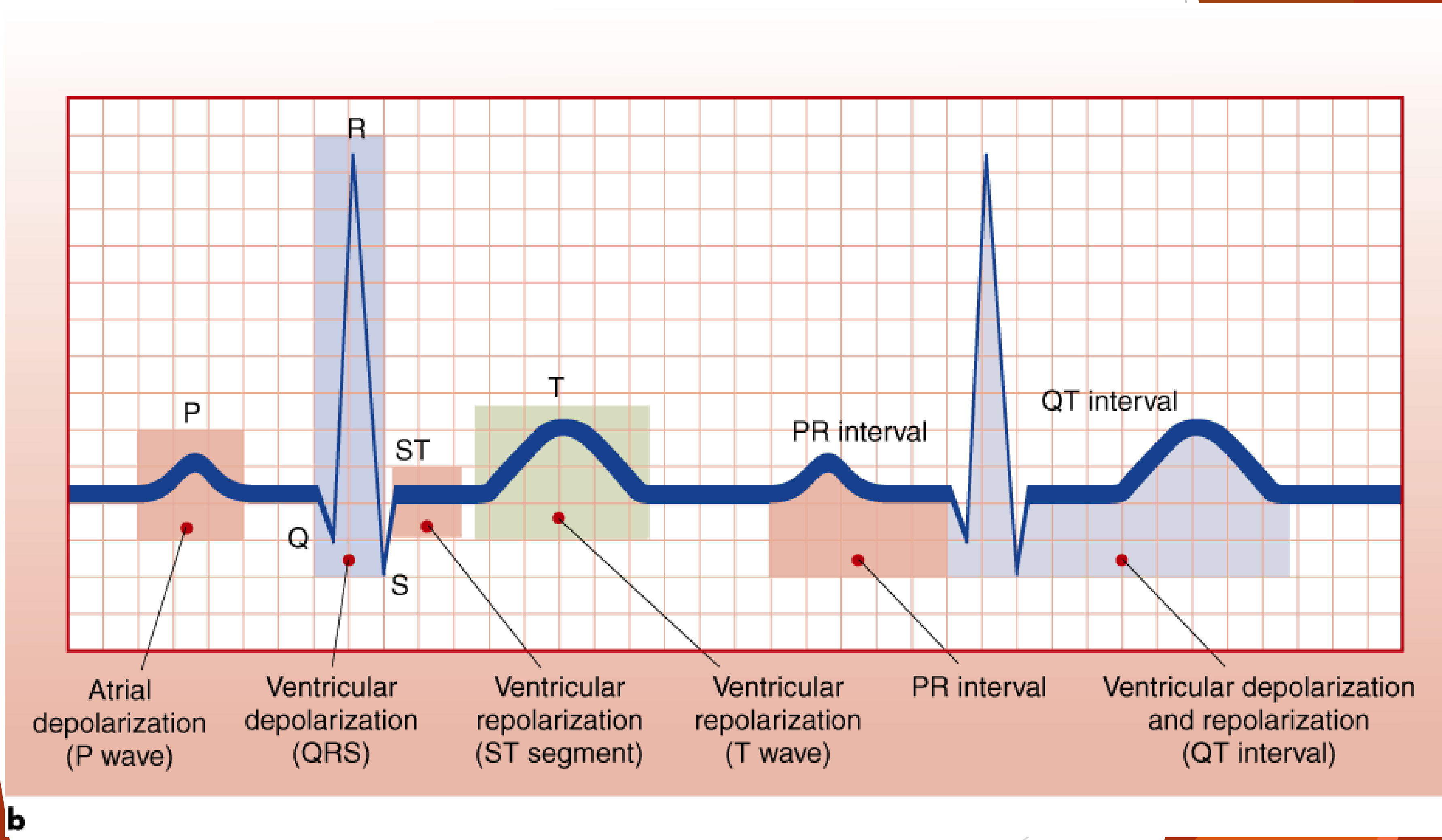
Electrocardiogram (ECG)

- Printout shows the heart's electrical activity and can be used to monitor cardiac changes
- The P wave—atrial depolarization
- The QRS complex—ventricular depolarization and atrial repolarization
- The T wave—ventricular repolarization

TAKING AN EXERCISE ECG

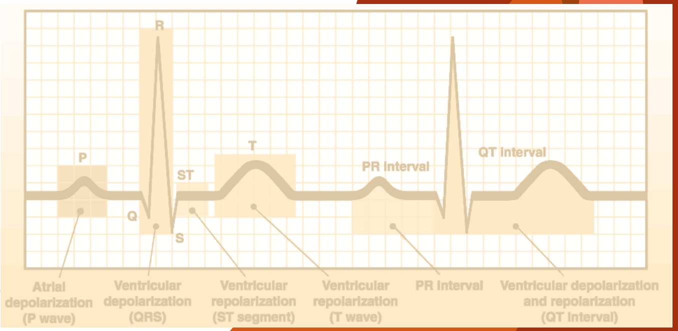


PHASES OF A RESTING ECG

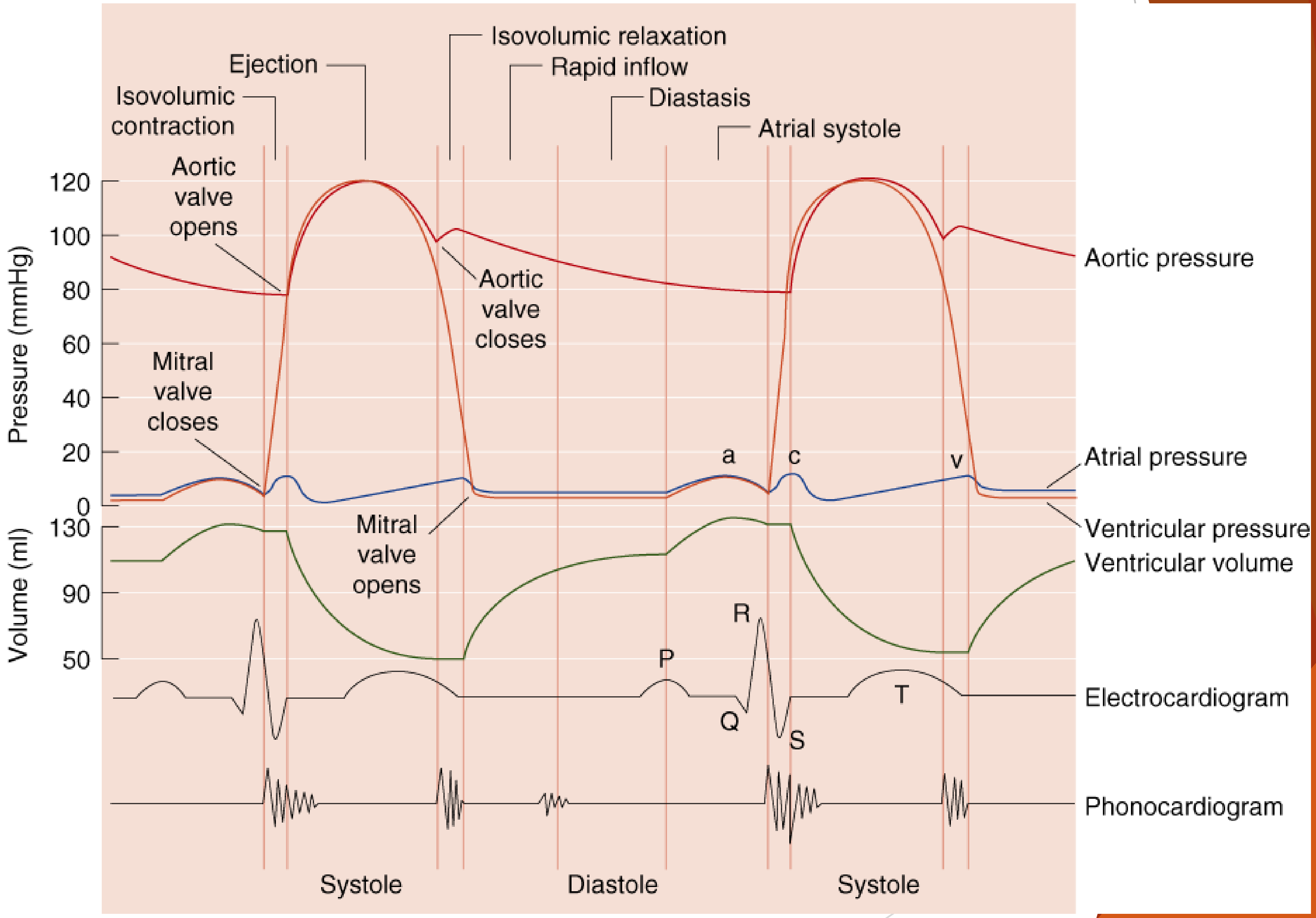


Cardiac Cycle

- Events that occur between two consecutive heartbeats (systole to systole)
- Diastole—relaxation phase during which the chambers fill with blood (T wave to QRS)—62% of cycle duration
- Systole—contraction phase during which the chambers expel blood (QRS to T wave)—38% of cycle duration



WIGGERS DIAGRAM



Stroke Volume and Cardiac Output

Stroke Volume (SV)

- Volume of blood pumped per contraction
- End-diastolic volume (EDV)—volume of blood in ventricle before contraction
- End-systolic volume (ESV)—volume of blood in ventricle after contraction
- $SV = EDV – ESV$

Cardiac Output ($\dot{Q}$)

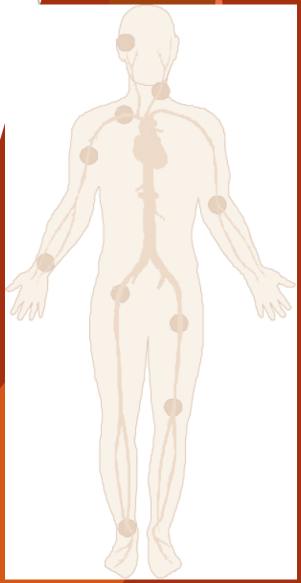
- Total volume of blood pumped by the ventricle per minute
- $Q = HR \times SV$

Ejection Fraction (EF)

- Proportion of blood pumped out of the left ventricle each beat
- EF = SV/EDV
- Averages 60% at rest

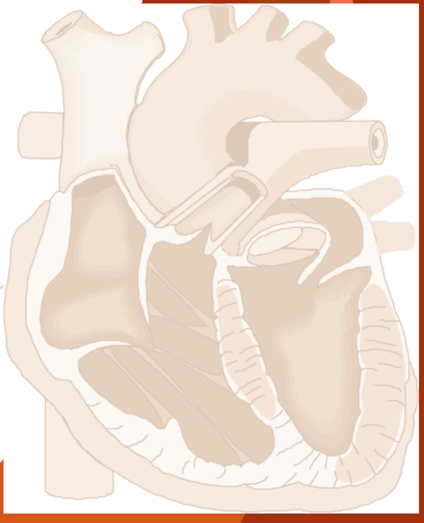
Vascular System

- Arteries
- Arterioles
- Capillaries
- Venules
- Veins

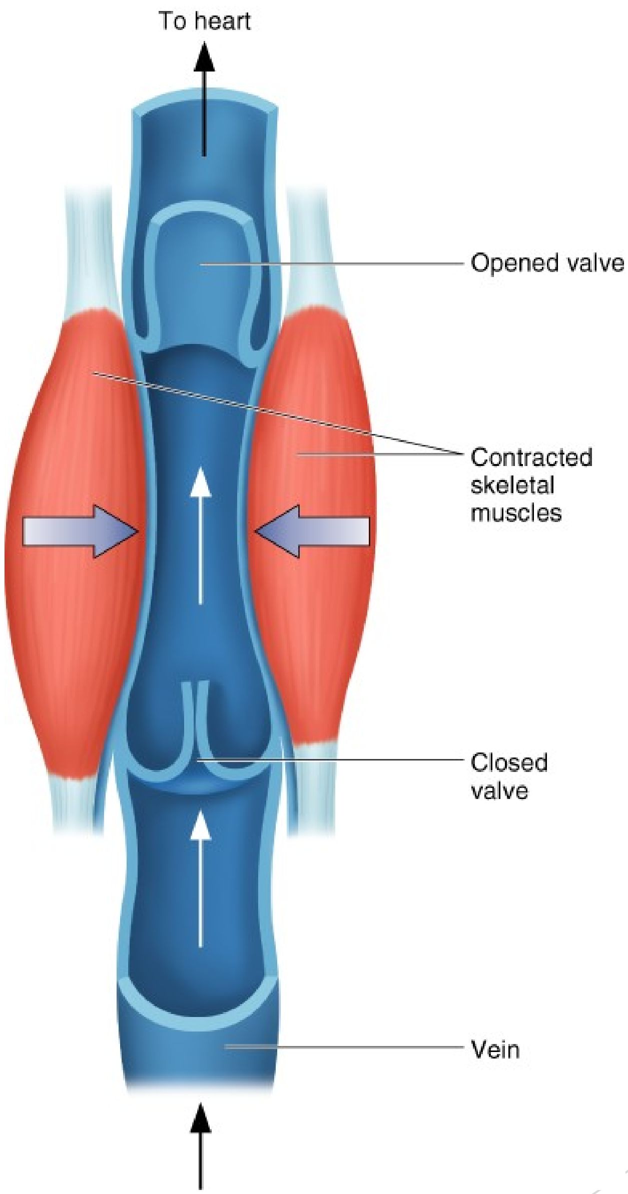


Did You Know…?

Arteries always carry blood away from the heart; veins always carry blood back to the heart with the help of breathing, the muscle pump, and valves. Pulmonary "veins" carry oxygenated blood from the lungs to the heart and pulmonary "arteries" carry blood with lower oxygen levels to the lungs for oxygenation.



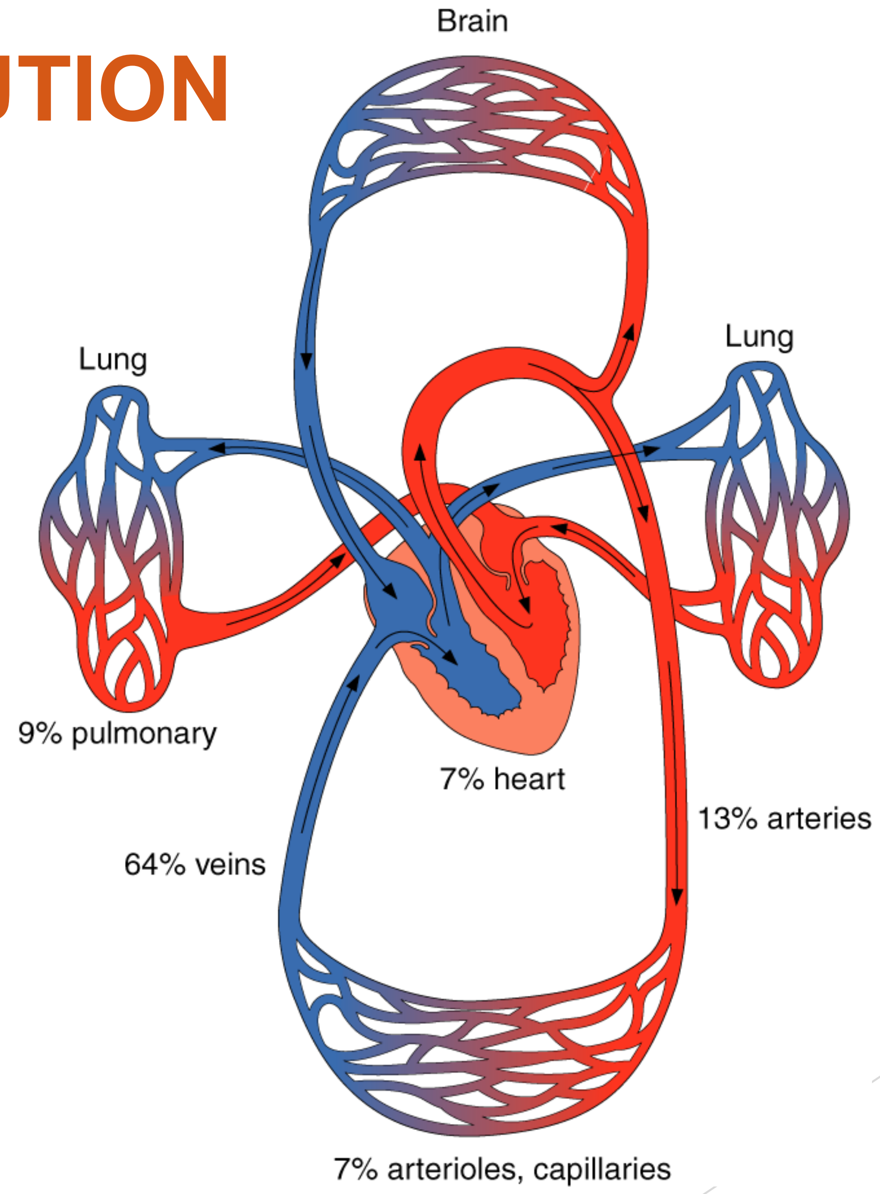
MUSCLE PUMP


To heart
Opened valve
Contracted
skeletal
muscles
Closed
valve
Vein

Blood Distribution

- Matched to overall metabolic demands
- Autoregulation—arterioles within organs or tissues dilate or constrict in response to the local chemical environment
- Extrinsic neural control—sympathetic nerves within walls of vessels are stimulated causing vessels to constrict
- Determined by the balance between mean arterial pressure and total peripheral resistance

BLOOD DISTRIBUTION AT REST



Blood Pressure

- Systolic blood pressure (SBP) is the highest pressure and diastolic blood pressure (DBP) is the lowest pressure
- Blood vessel constriction increases blood pressure; dilation reduces blood pressure

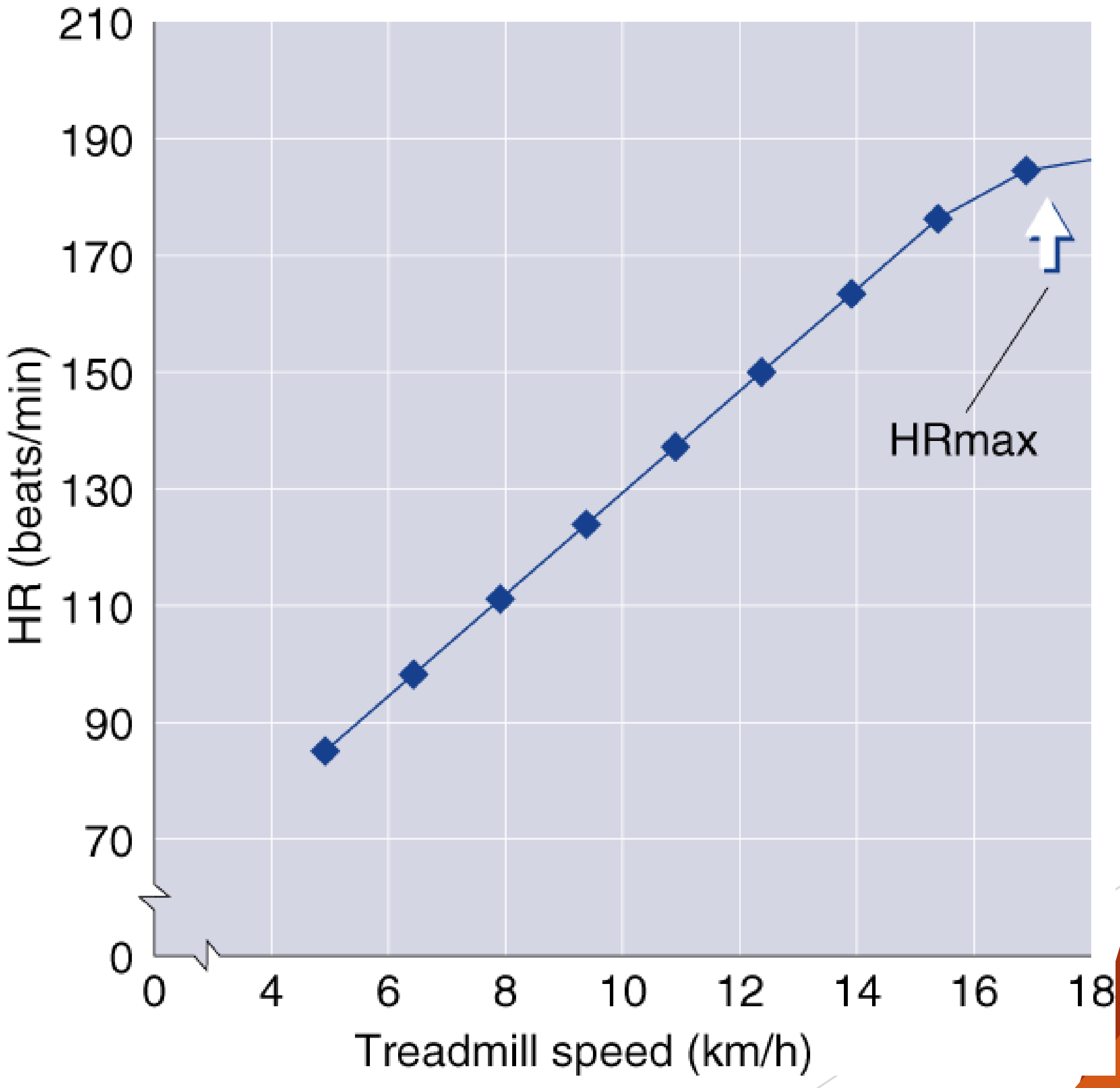
Cardiovascular Response to Acute Exercise

- Heart rate (HR) increases as exercise intensity increases up to maximal heart rate.
- Stroke volume (SV) increases up to 40% to 60% VO_2max in untrained individuals and up to maximal levels in trained individuals.
- Increases in HR and SV during exercise cause cardiac output (Q) to increase.
- Blood flow and blood pressure change.

Maximum Heart Rate

- The highest heart rate value one can achieve in an all-out effort to the point of exhaustion
- Remains constant day to day and changes slightly from year to year
- Can be *estimated*: HRmax = 220 – age in years or
  HRmax = 208 – (0.7 × age)

HEART RATE AND INTENSITY



Heart rate detection

- Auscultation at the heart apex
- ECG record (R–R distance)
- Pulse palpation
- Photometric, piezoelectric or electric devices

Heart rate (HR) changes

- Average rest HR is 72 bpm
- The HR is higher in children
- The HR is higher during exercise, stress or fever
- During exercise the HR increases as much as twice
- After exercise the HR drops back to rest state within 3 minutes
- In trained individuals the rest HR reoccurs faster

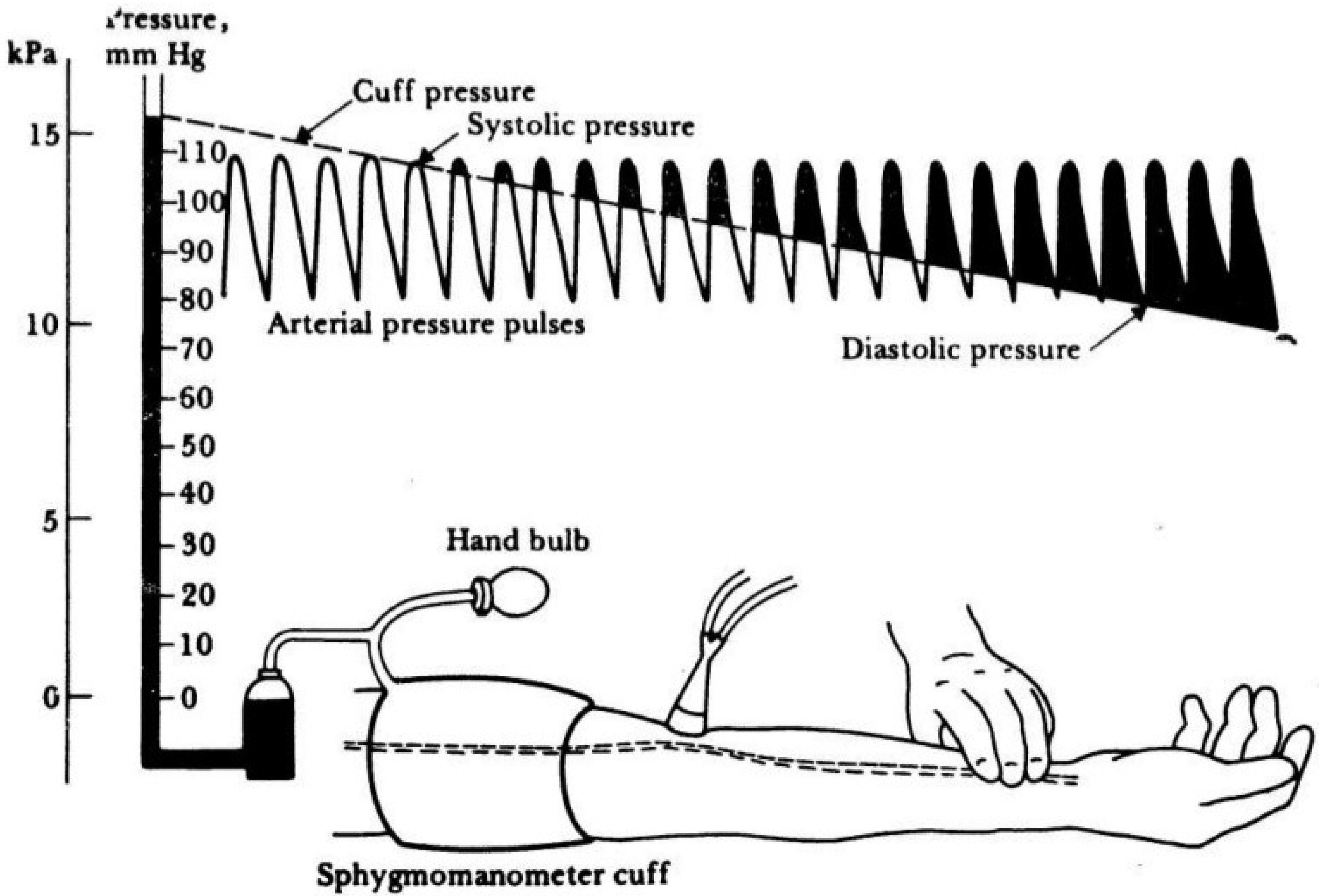
HR during exercise

- Initial increase of HR (mental preparation)
- Work state HR (followed by steady-state HR – corresponds to the load intensity)
- Subsequent HR (after the load, decrease to rest HR)

Pulse

- During systolic ejection a flexible wall of aorta expands.
- During diastole the wall of aorta contracts and empowers the bloodstream.
- The expansion and contraction of the arterial walls transmit throughout the body (from centre to peripheries).
- This wave-like transmission is called a pulse. It could be palpated close to body surface.

Indirect Blood Pressure Measurement - Sphygmomanometer



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