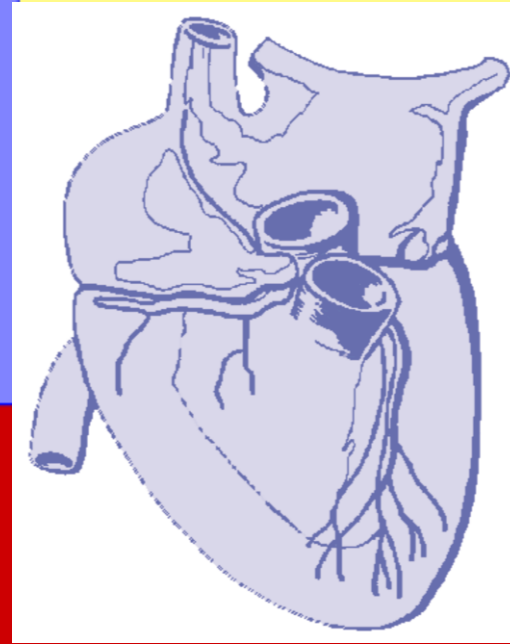


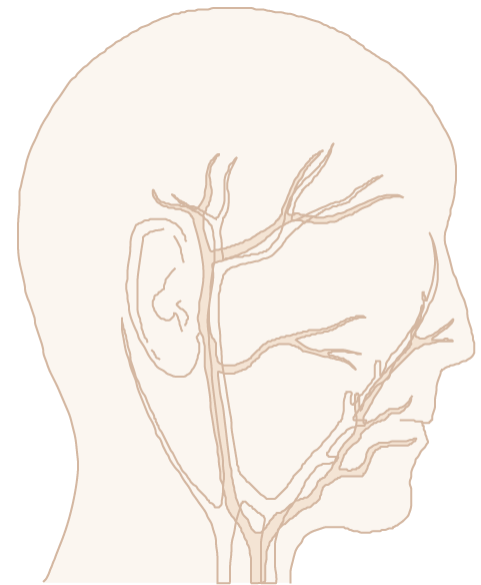


CARDIOVASCULAR CONTROL DURING EXERCISE

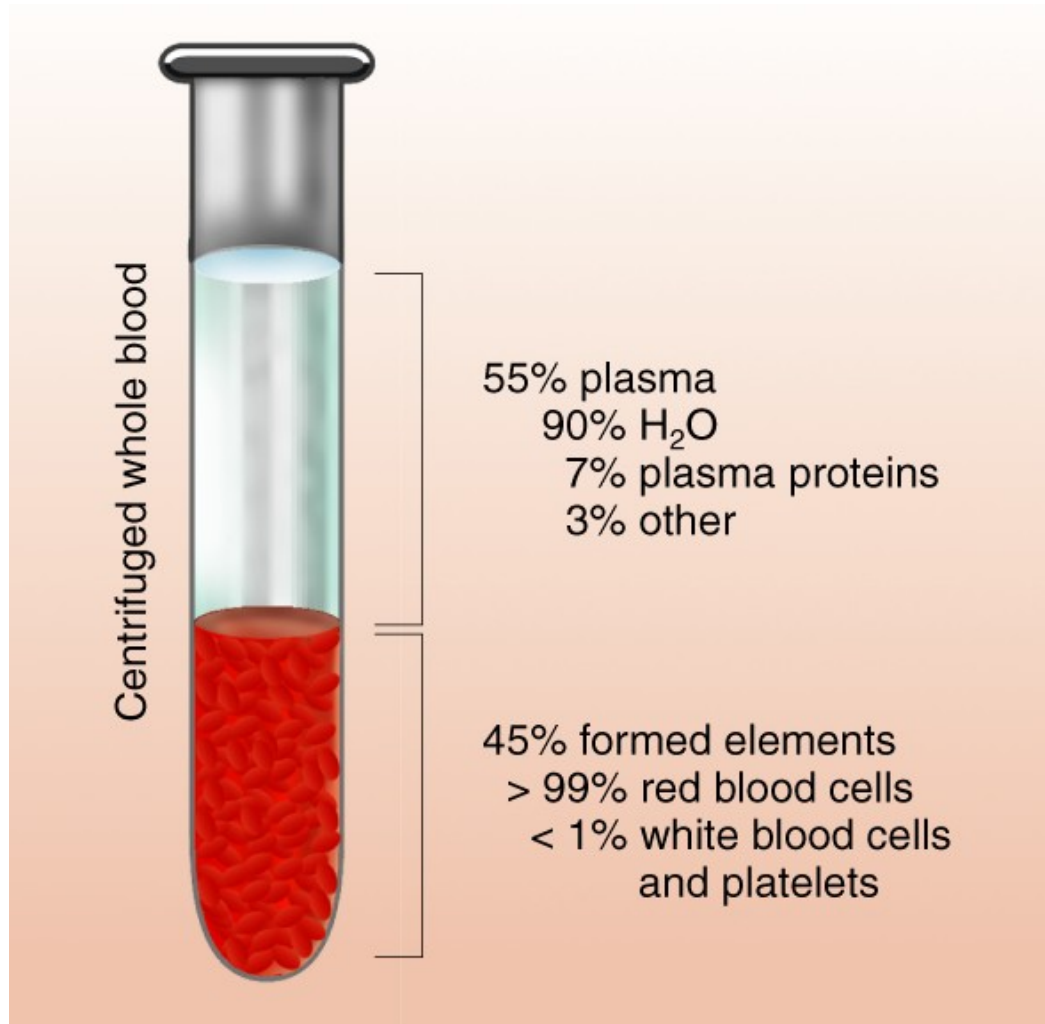


Functions of the Blood

- ◆ Transports gas, nutrients, and wastes
- ◆ Regulates temperature
- ◆ Buffers and balances acid base



COMPOSITION OF TOTAL BLOOD VOLUME



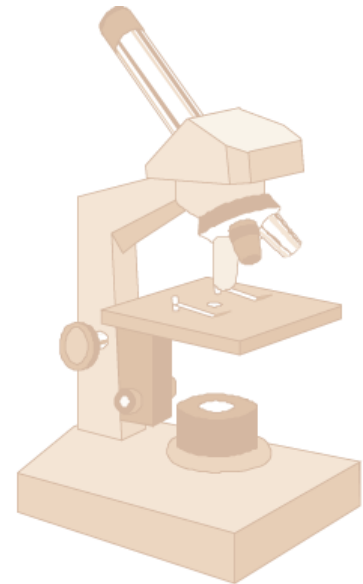
Blood Formed Elements and Hematocrit

Blood formed elements

- ◆ White blood cells—protect body from disease organisms
- ◆ Blood platelets—cell fragments that help blood coagulation
- ◆ Red blood cells—carry oxygen to tissues with the help of hemoglobin

Hematocrit

- ◆ Ratio of formed elements to the total blood volume
- ◆ Hematocrit— $\text{Formed elements} / \text{total blood volume}$



Blood Viscosity

- ◆ Thickness of the blood
- ◆ The more viscous, the more resistant to flow
- ◆ Higher hematocrits result in higher blood viscosity

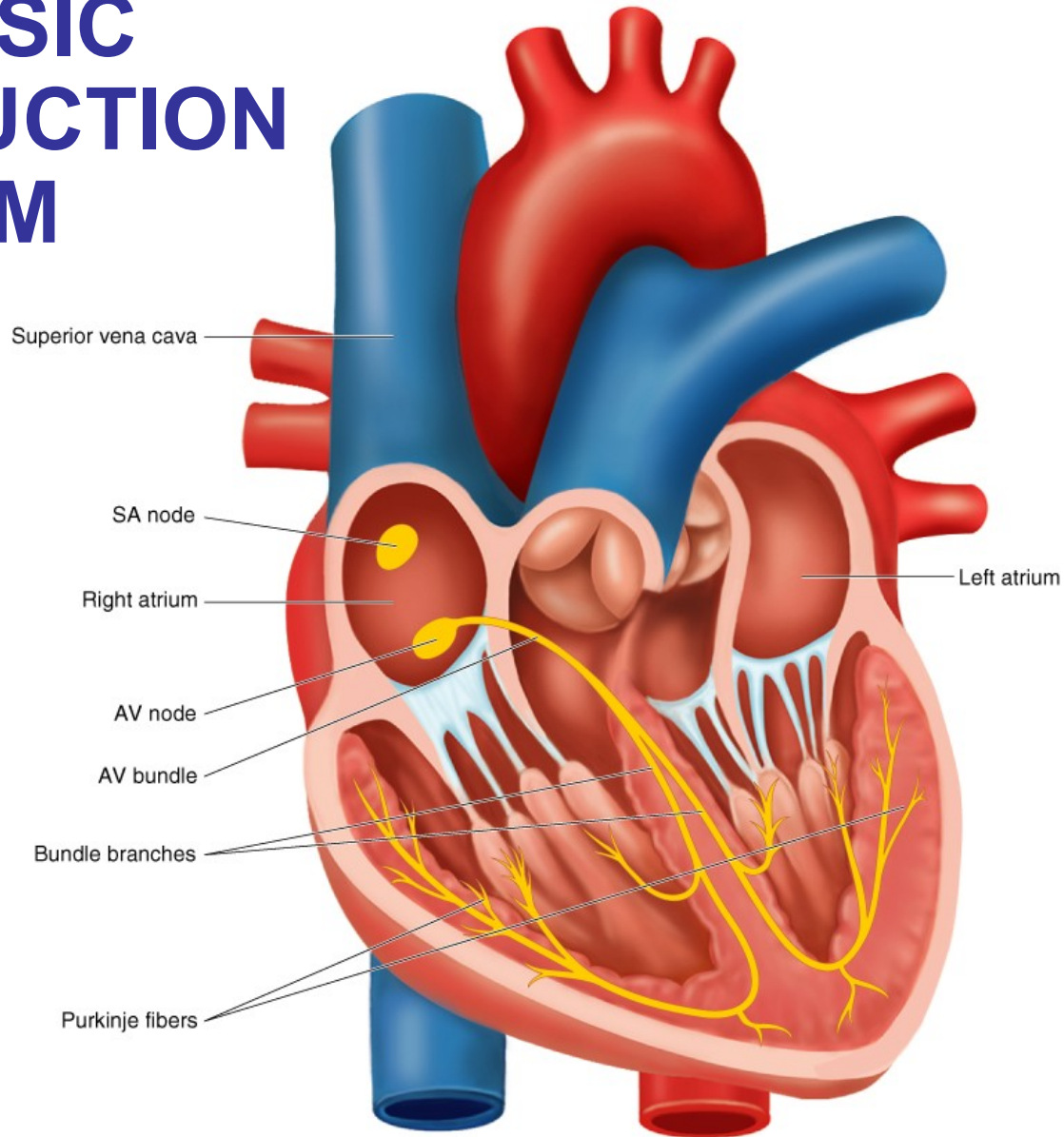


Key Points

Blood

- ◆ Blood and lymph transport materials to and from body tissues.
- ◆ Blood is about 55% to 60% plasma and 40% to 45% formed elements (white and red blood cells and blood platelets).
- ◆ Oxygen travels through the body by binding to hemoglobin in red blood cells.
- ◆ An increase in blood viscosity results in resistance to flow.

INTRINSIC CONDUCTION SYSTEM



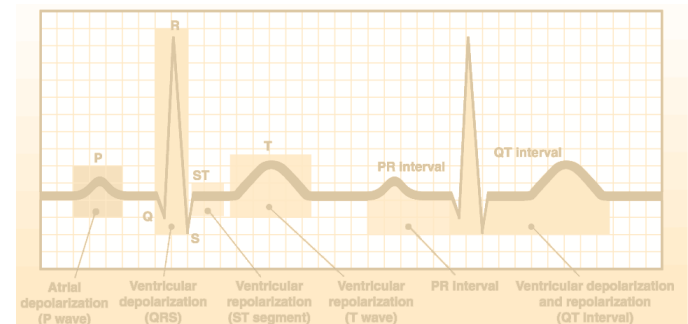
Cardiac Conduction System

- ◆ 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

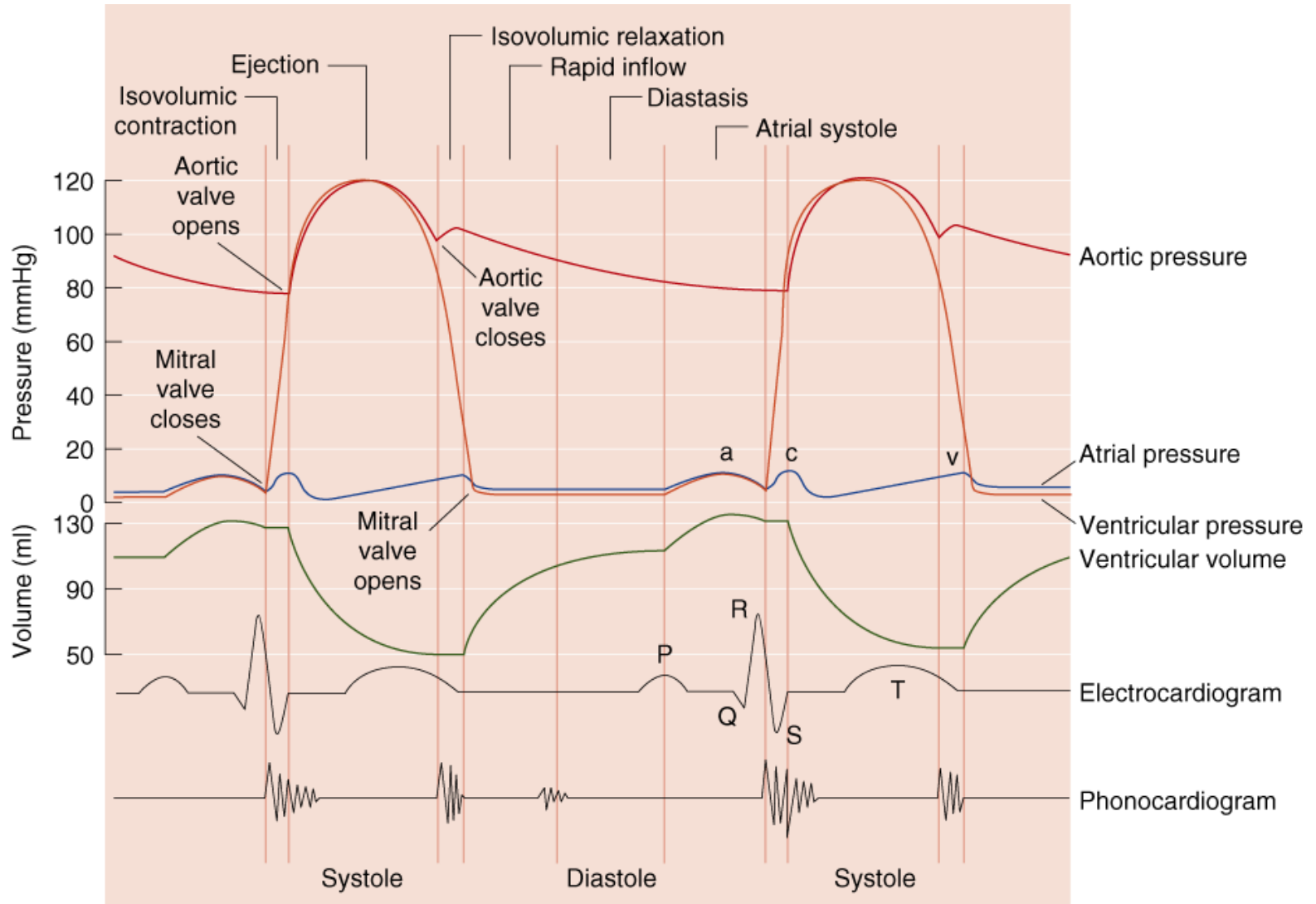


Cardiac Cycle

- ◆ 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



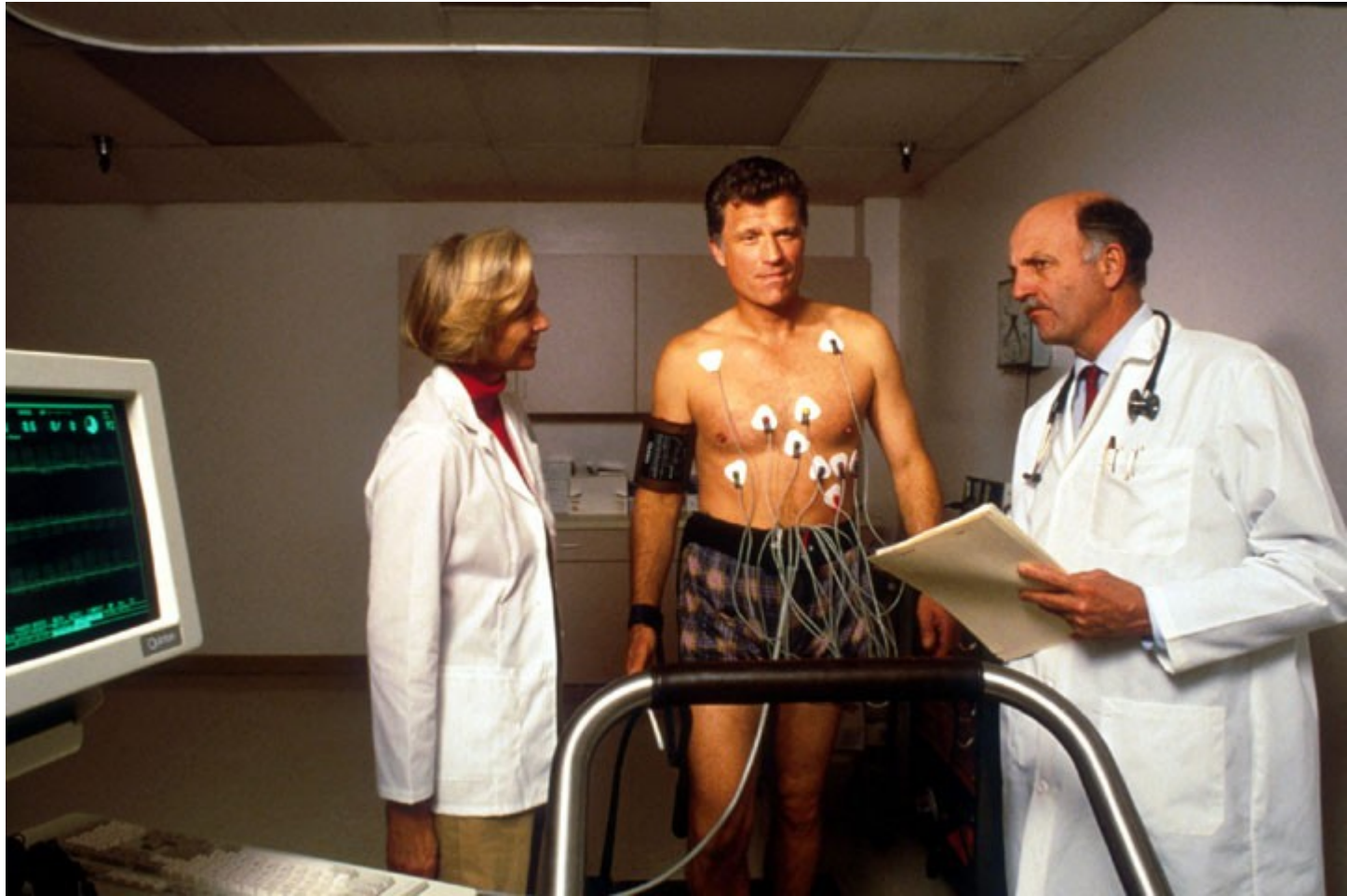
WIGGERS DIAGRAM—CARDIAC CYCLE

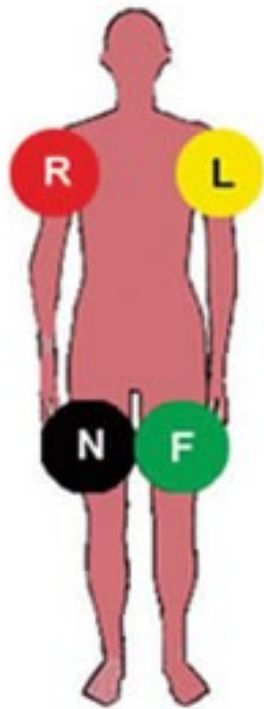


Electrocardiogram (ECG)

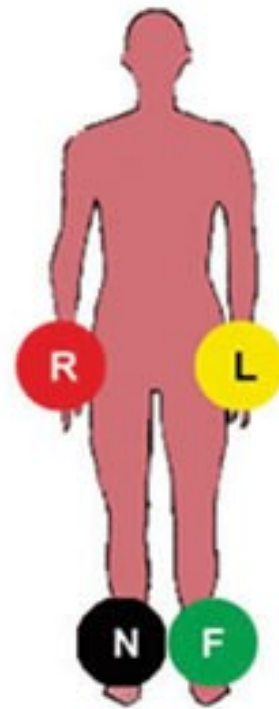
- ◆ Printout shows the heart's electrical activity and can be used to monitor cardiac changes
- ◆ The P wave—atrial depolarization
- ◆ The QRS complex—ventricular depolarization and atrial repolarization
- ◆ The T wave—ventricular repolarization

TAKING AN EXERCISE ECG

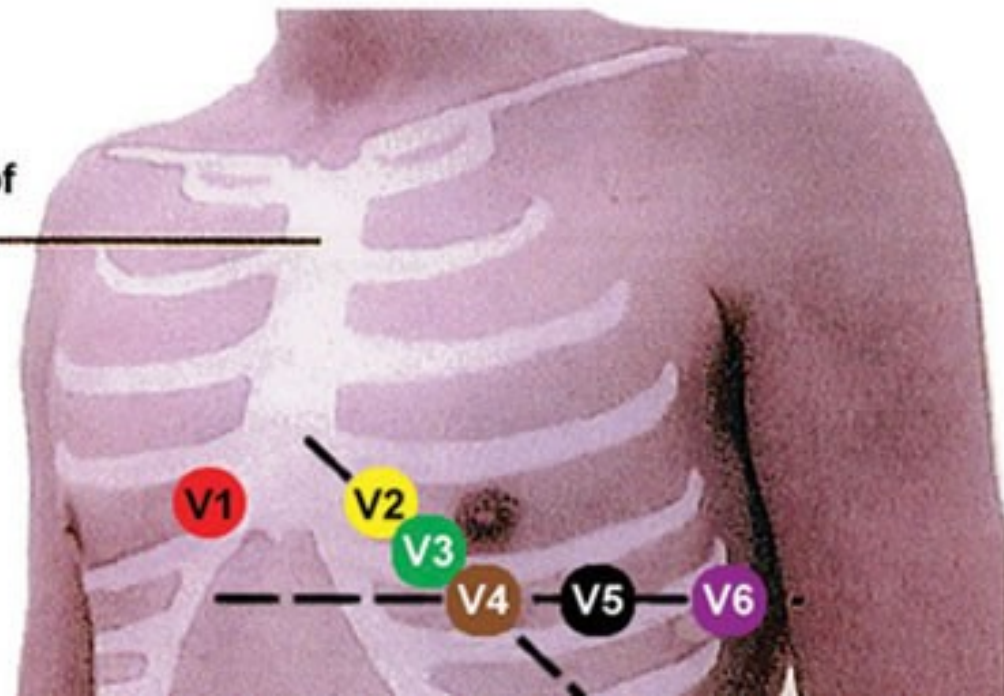


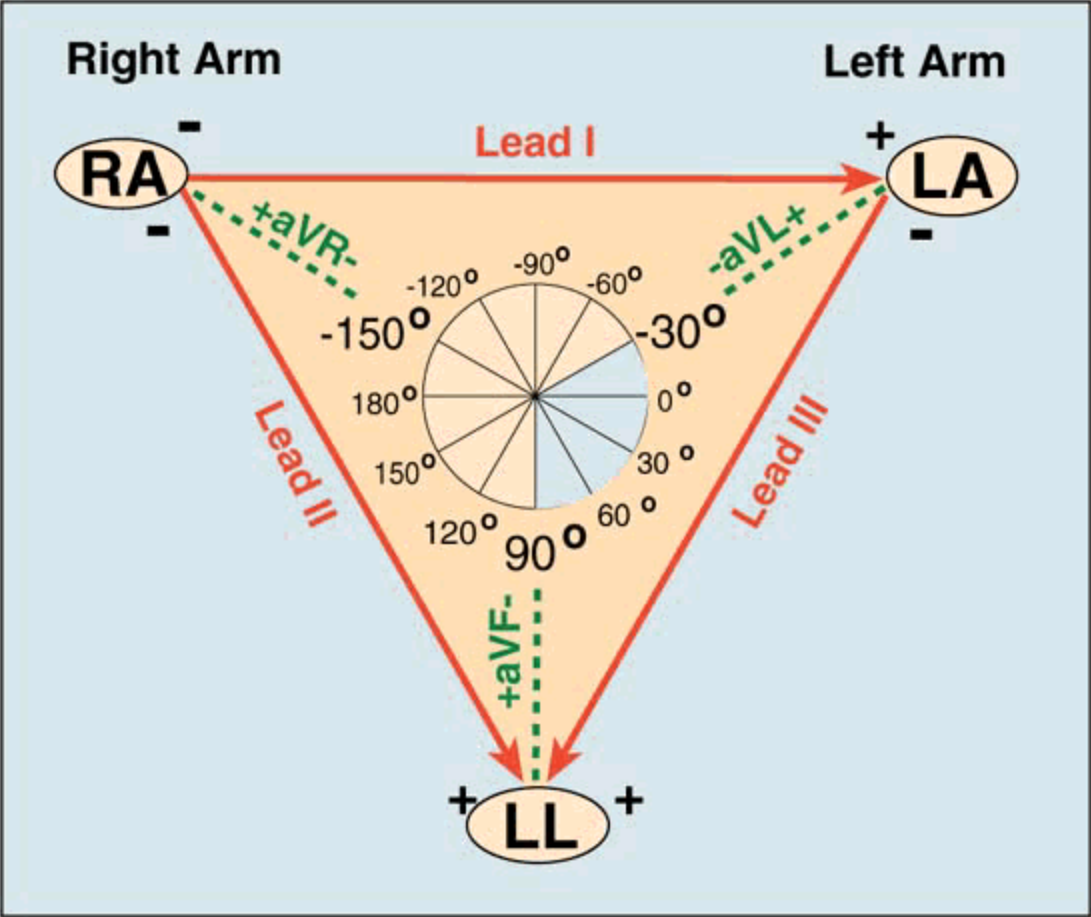


OR



Angle of
Louis





Each of the 12 leads represents a particular orientation in space, as indicated below (RA = right arm; LA = left arm, LF = left foot):

Bipolar limb leads (frontal plane):

- Lead I: RA (-) to LA (+) (Right Left, or lateral)
- Lead II: RA (-) to LF (+) (Superior Inferior)
- Lead III: LA (-) to LF (+) (Superior Inferior)

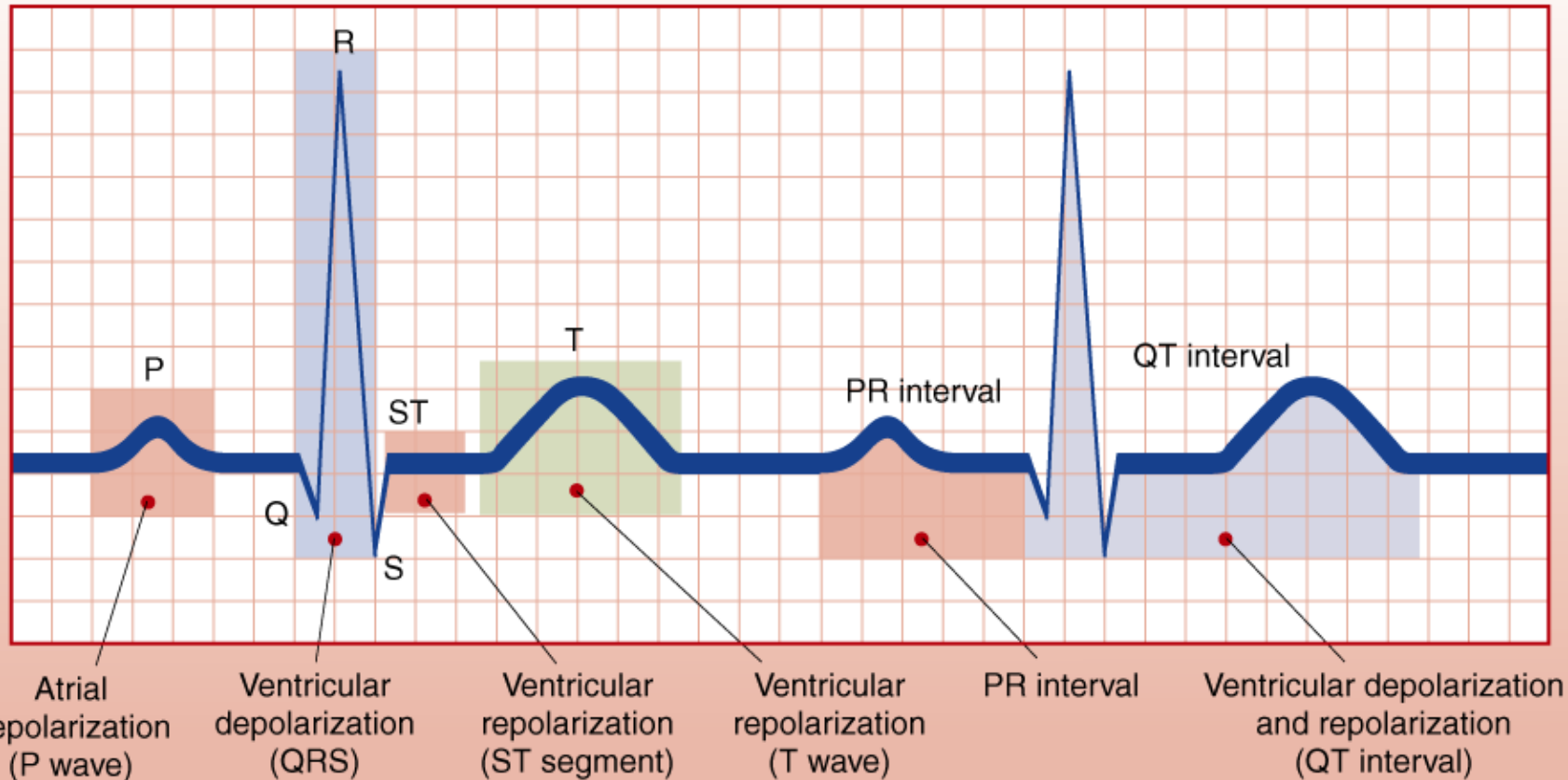
Augmented unipolar limb leads (frontal plane):

- Lead aVR: RA (+) to [LA & LF] (-) (Rightward)
- Lead aVL: LA (+) to [RA & LF] (-) (Leftward)
- Lead aVF: LF (+) to [RA & LA] (-) (Inferior)

Unipolar (+) chest leads (horizontal plane):

- Leads V1, V2, V3: (Posterior Anterior)
- Leads V4, V5, V6: (Right Left, or lateral)

PHASES OF A RESTING ECG



b

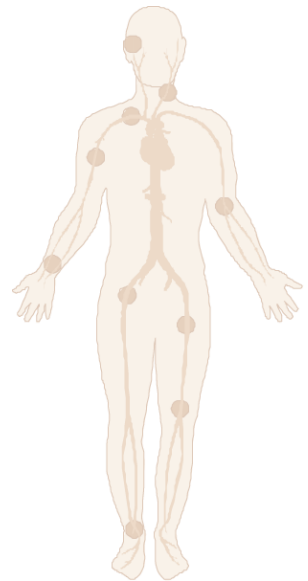
Key Points

Structure and Function of the Cardiovascular System

- ◆ The pacemaker of the heart is the SA node; it establishes heart rate and coordinates conduction.
- ◆ The autonomic nervous system or the endocrine system can alter heart rate and contraction strength.
- ◆ An ECG records the heart's electrical function and can be used to detect cardiac disorders.

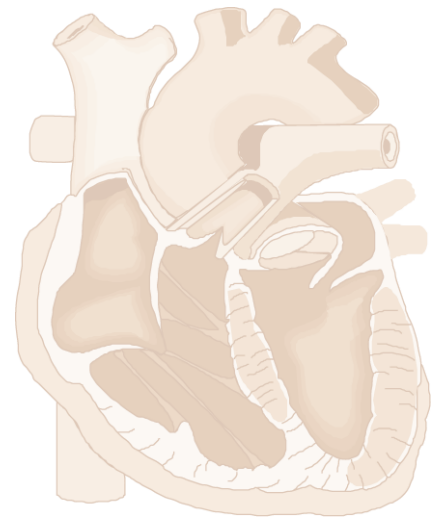
Vascular System

- ◆ Arteries
- ◆ Arterioles
- ◆ Capillaries
- ◆ Venules
- ◆ Veins

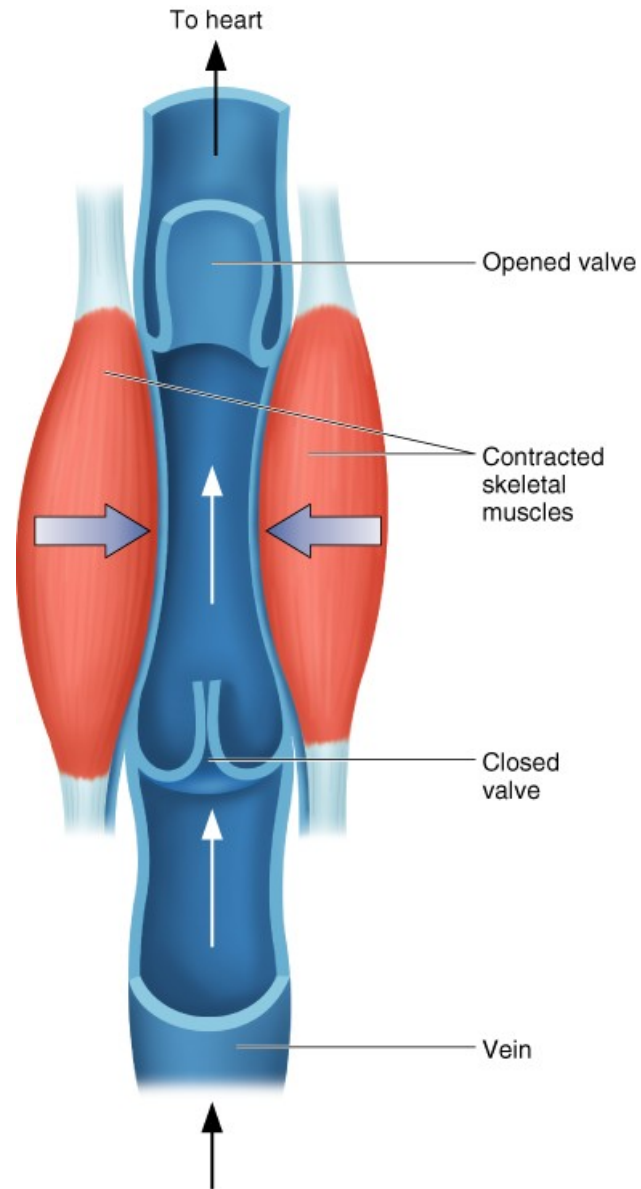


Did You Know...?

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.



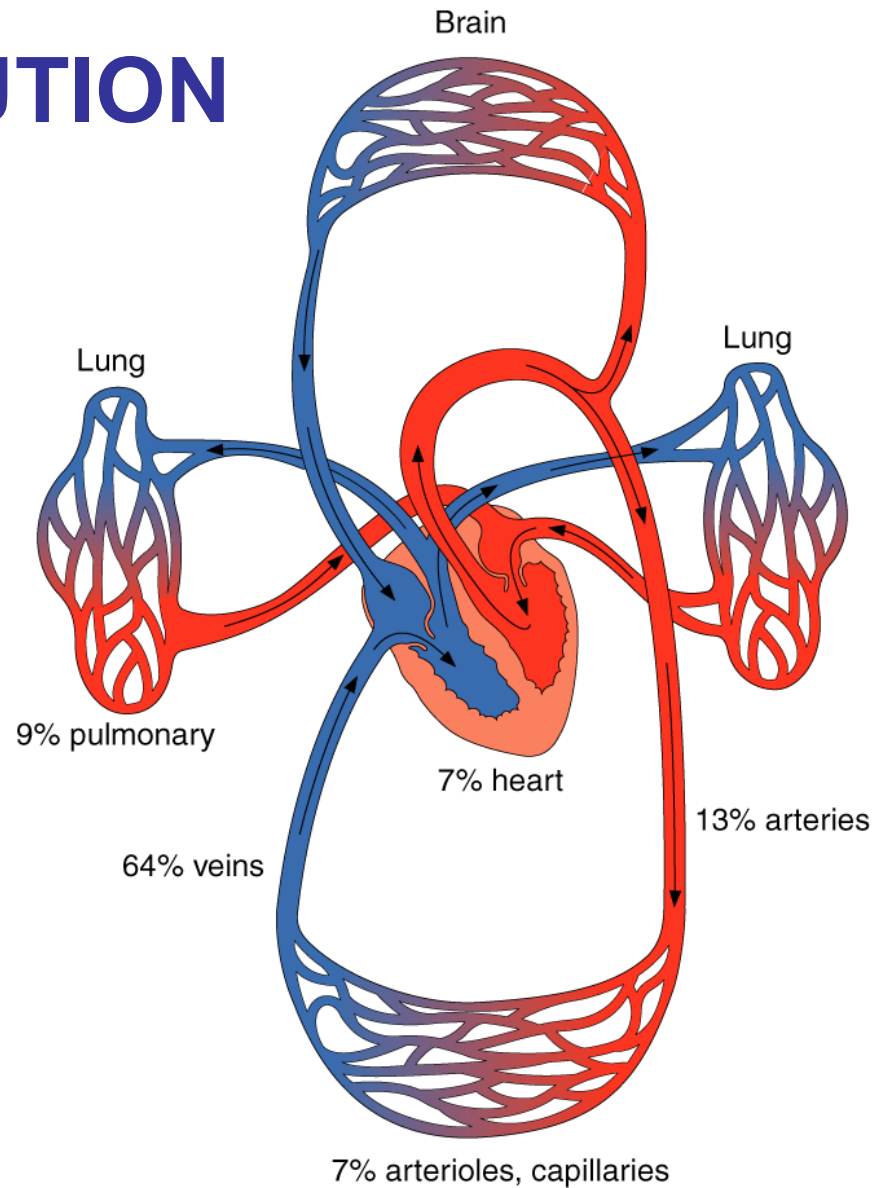
MUSCLE PUMP



Blood Distribution

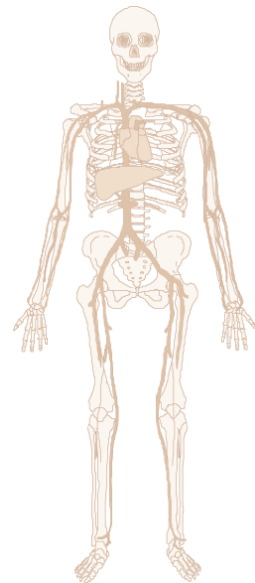
- ◆ Matched to overall metabolic demands
- ◆ Autoregulation—arterioles within organs or tissues dilate or constrict in response to the local chemical environment
- ◆ Extrinsic neural control—sympathetic nerves within walls of vessels are stimulated causing vessels to constrict
- ◆ Determined by the balance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

BLOOD DISTRIBUTION AT REST

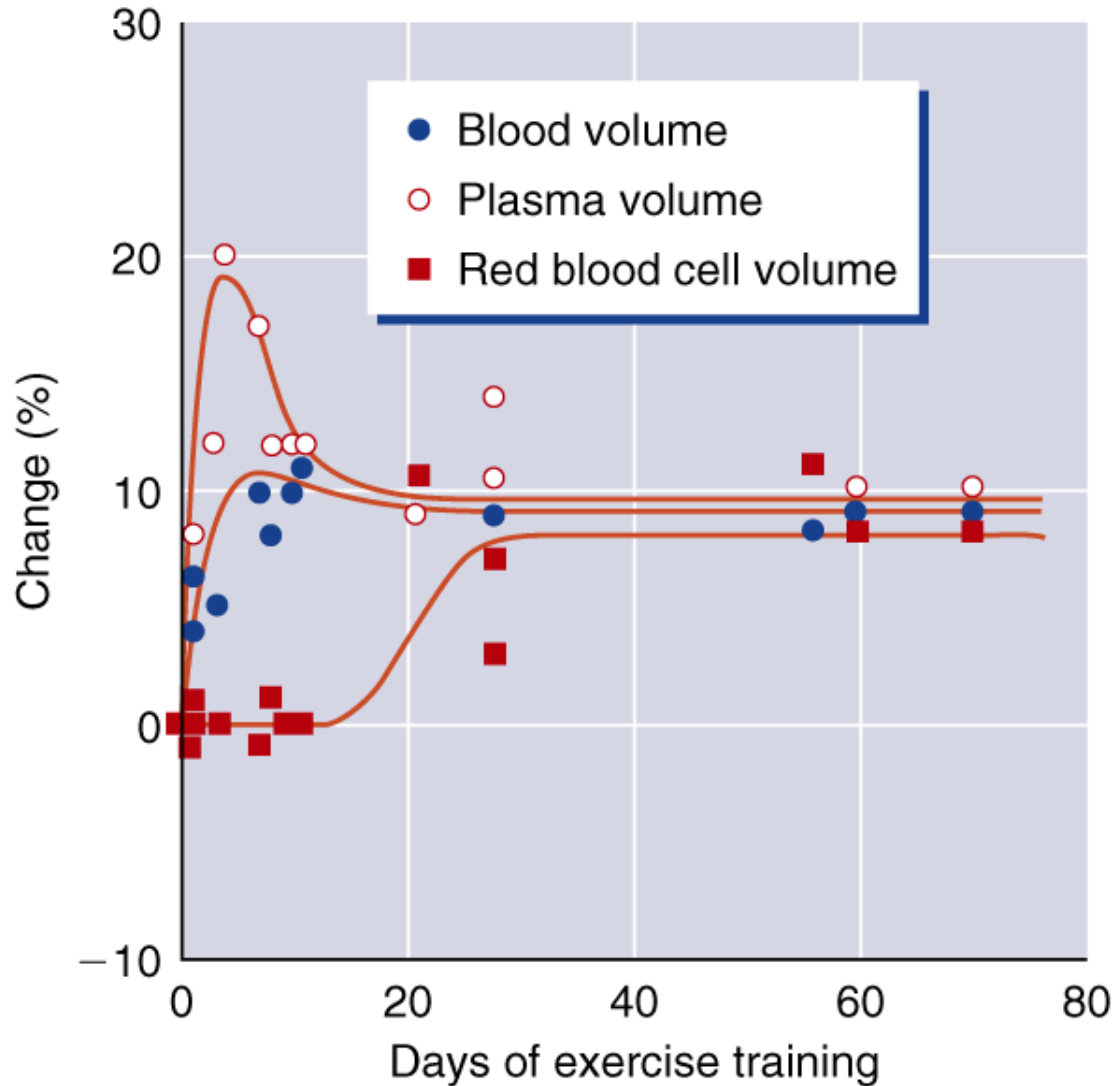


Blood Flow Increases With Training

- ◆ Increased capillarization of trained muscles (higher capillary-to-fiber ratio)
- ◆ Greater opening of existing capillaries in trained muscles
- ◆ More effective blood redistribution—blood goes where it is needed
- ◆ Increased blood volume



BLOOD VOLUME AND TRAINING

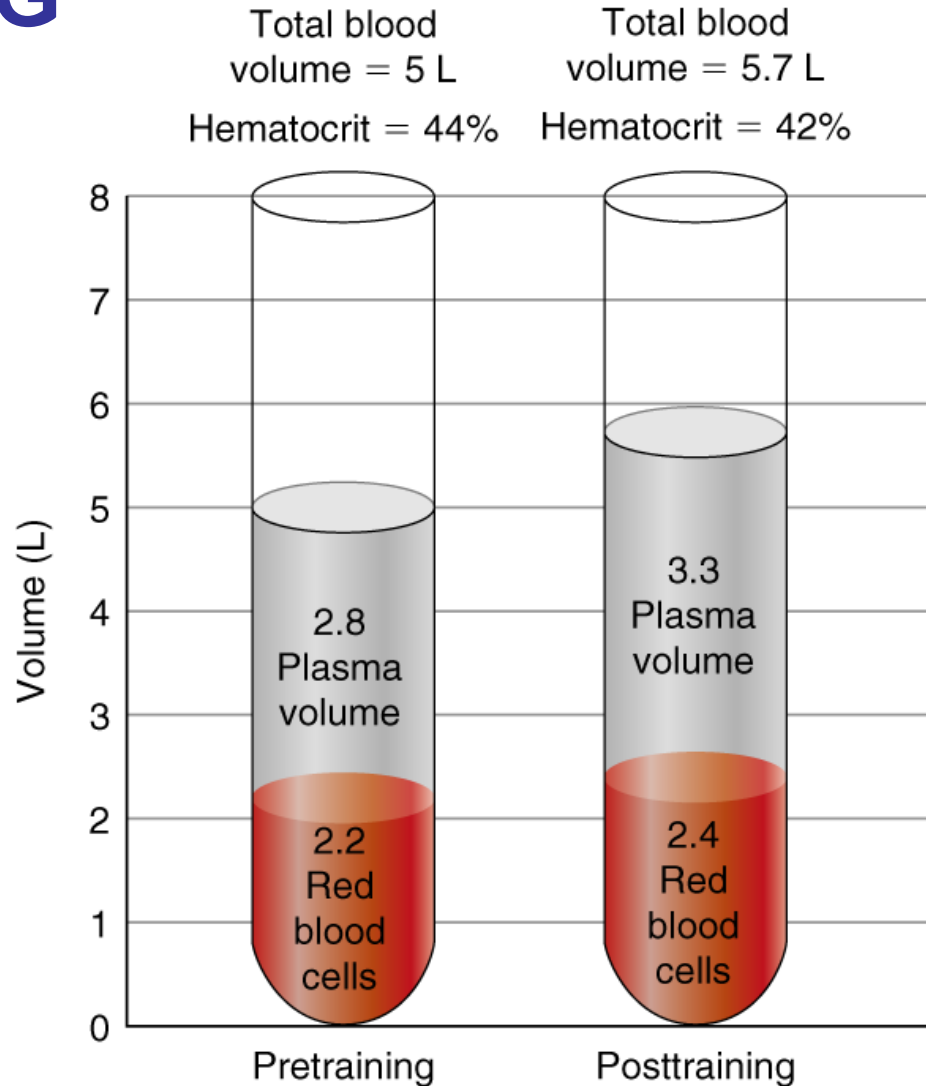


Key Points

Blood Volume and Training

- ◆ Endurance training, especially intense training, increases blood volume.
- ◆ Blood volume increases due primarily to an increase in plasma volume (increases in ADH, aldosterone, and plasma proteins cause more fluid to be retained in the blood).
- ◆ Red blood cell volume increases, but increase in plasma volume is higher; thus, hematocrit decreases.
- ◆ Blood viscosity decreases, thus improving circulation and enhancing oxygen delivery.
- ◆ Changes in plasma volume are highly correlated with changes in SV and $\dot{V}O_2$ max.

BLOOD AND PLASMA VOLUME AND TRAINING



Cardiovascular Adaptations to Training

- ◆ Left ventricle size and wall thickness increase
- ◆ Resting, submaximal, and maximal stroke volume increases
- ◆ Maximal heart rate stays the same or decreases
- ◆ Cardiac output is better distributed to active muscles and maximal cardiac output increases
- ◆ Blood volume increases, as does red cell volume, but to a lesser extent
- ◆ Resting blood pressure does not change or decreases slightly, while blood pressure during submaximal exercise decreases

