General physiology
Cardiovascular system

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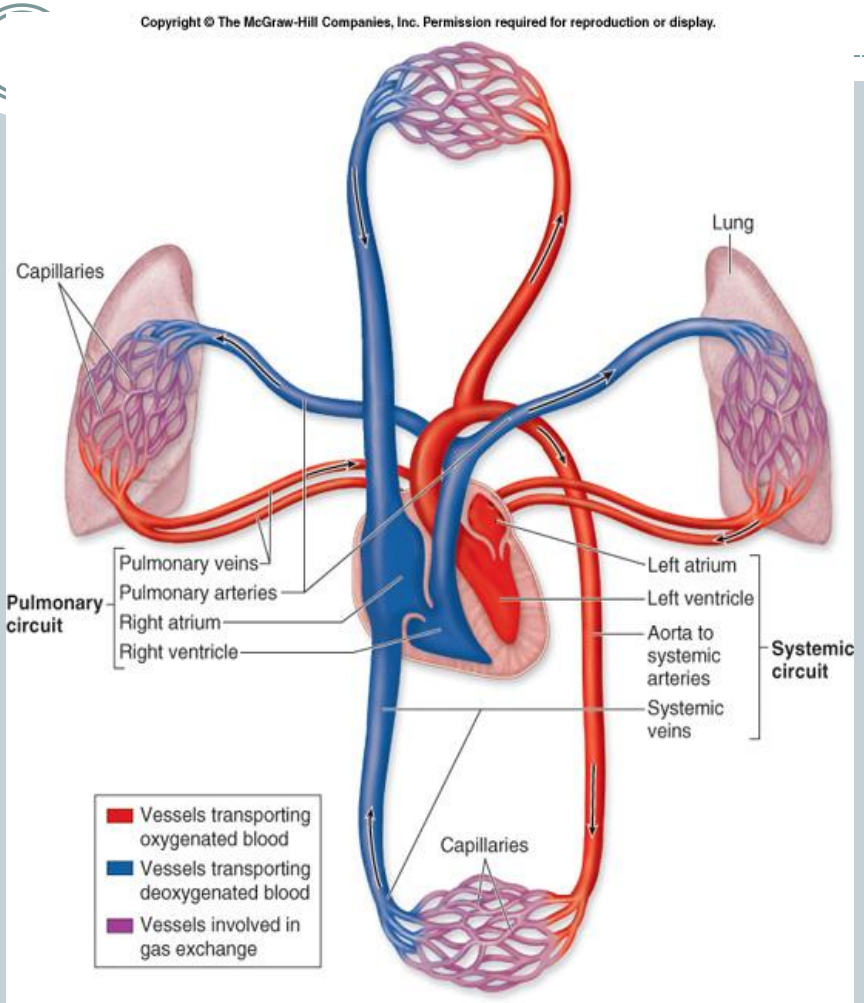
Cardiovascular system

The cardiovascular system consists of the heart and two vascular systems.

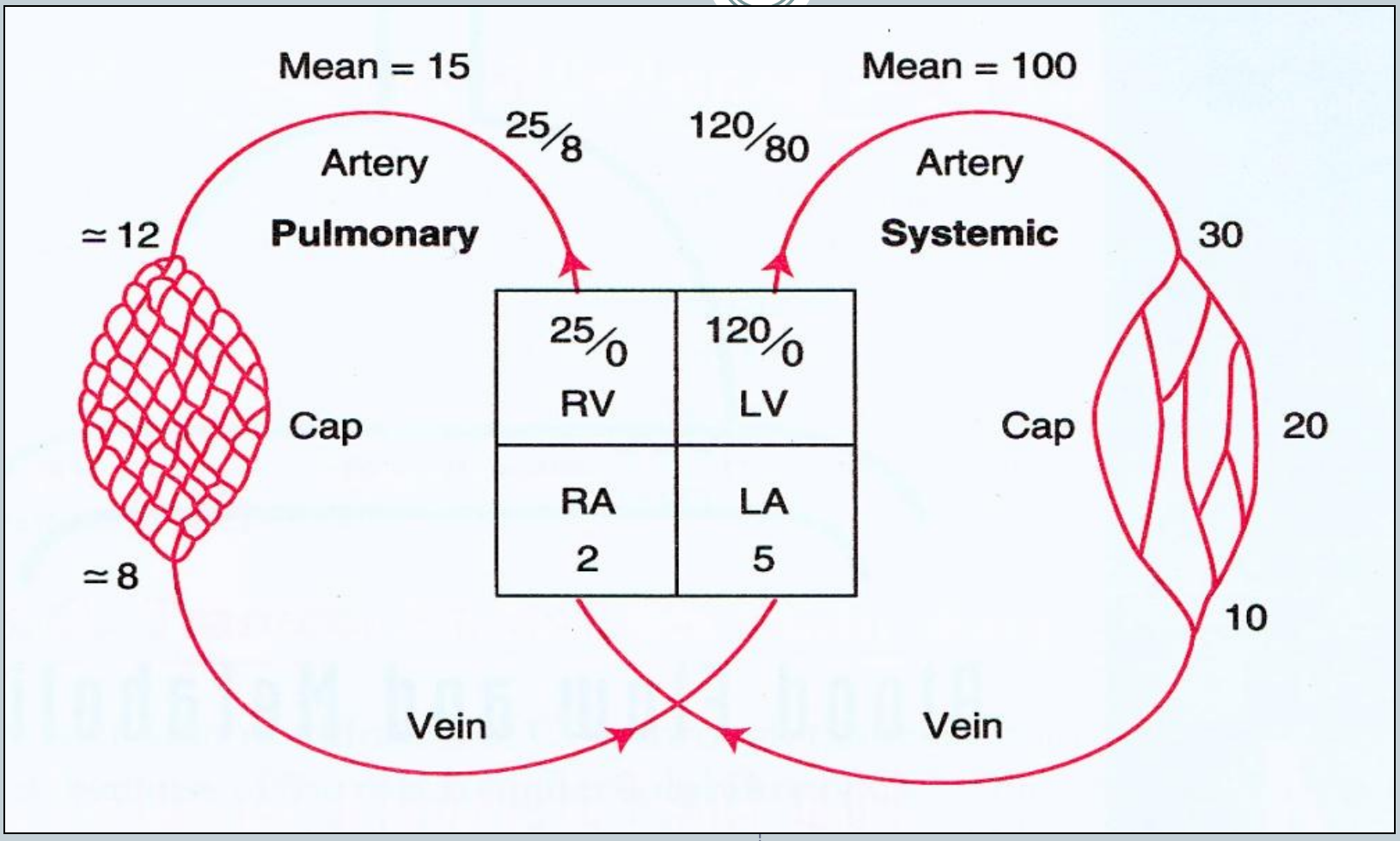
The heart consists of two pumps, pumps blood through two vascular systems:

the low pressure pulmonary circulation in which gas exchange occurs

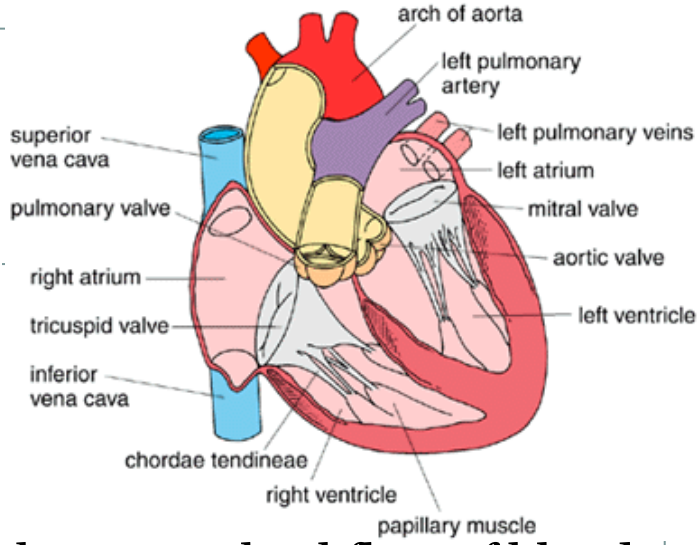
the systemic circulation, which delivers blood to organs,.



Two vascular systems



Special structures of the heart



1-Valves are outgrowths from the endocardium which prevent backflow of blood. Heart valves ensure unidirectional blood flow through the heart

- **Atrioventricular (AV)** valves lie between the atria and the ventricles
- AV valves prevent backflow into the atria when ventricles contractSemilunar
- **Aortic semilunar** valve lies between the left ventricle and the aorta
- **Pulmonary semilunar** valve lies between the right ventricle and pulmonary trunk

Valves contain three components.

a. Endothelium covers the valve.

b. **chordae tendineae** attach the flaps of the AV valves to the heart wall at the apex of the heart..

C. papillary muscles

Heart Valves

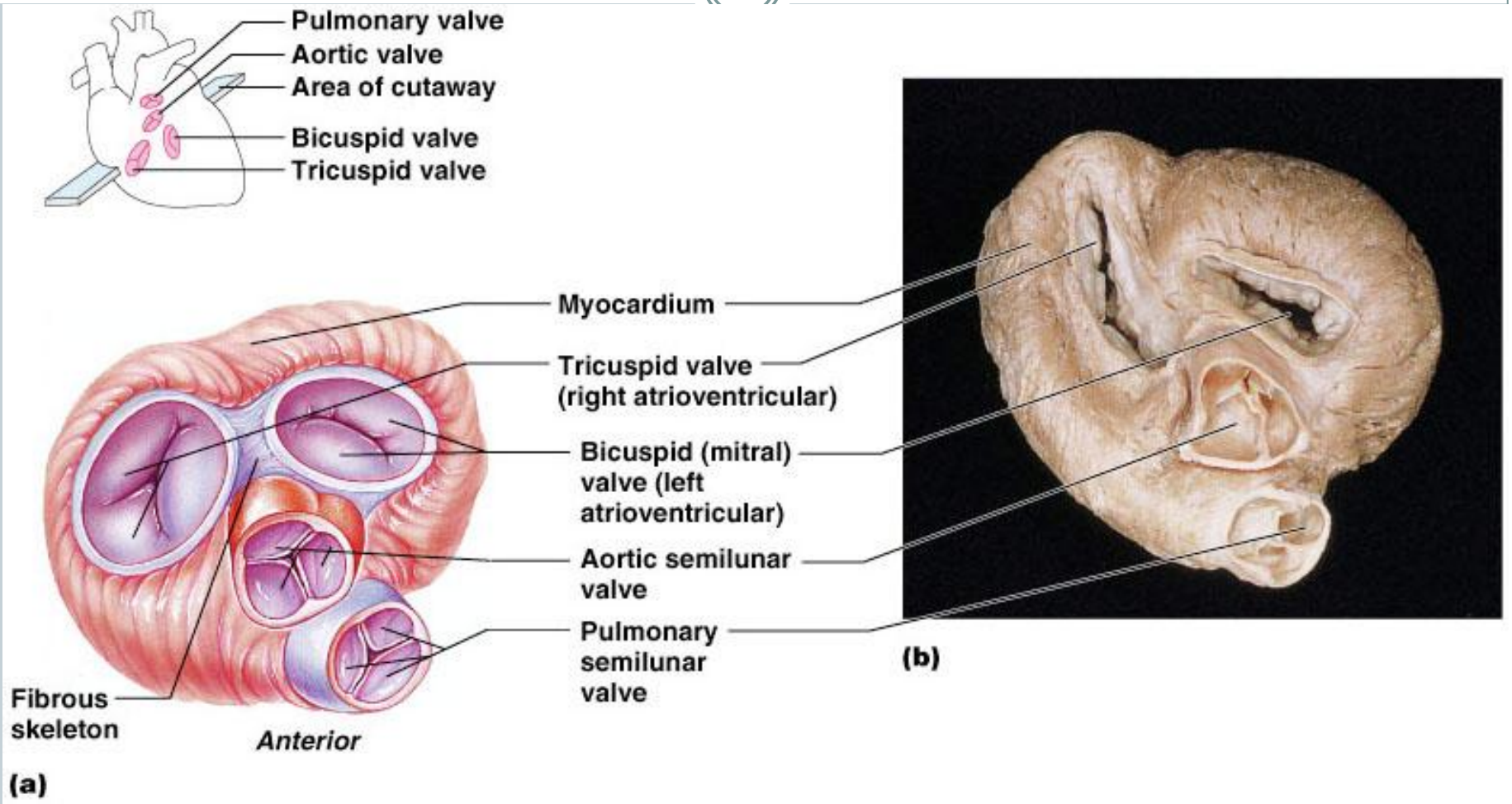


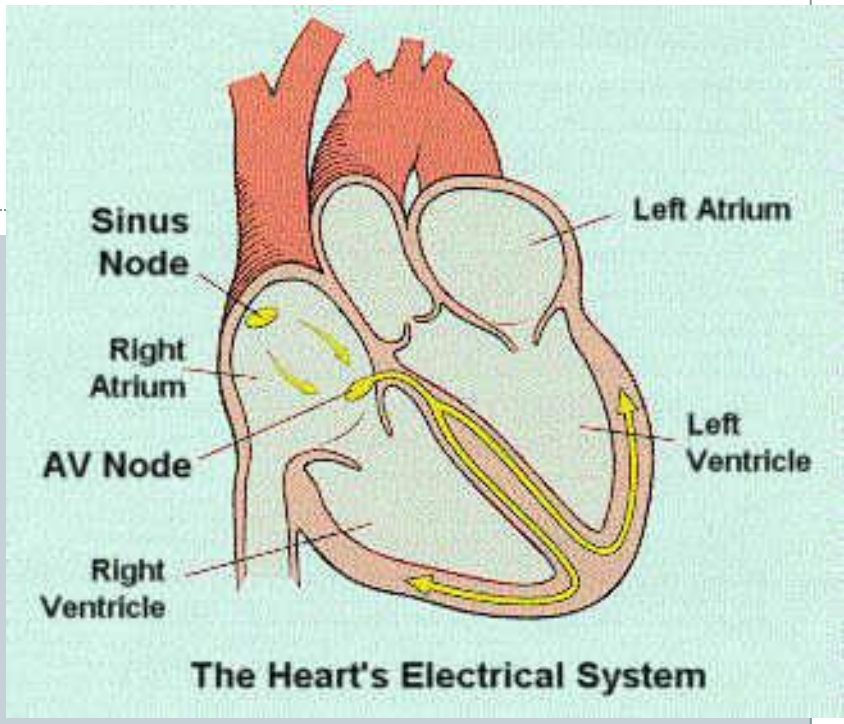
Figure 18.8a, b

Heart sounds

Four sounds are created during each heart beat, and two of these sounds are clearly audible. These sounds are typically described as "lub-dup.
The first sound, *lub, is louder and longer is the AV valves closing. This occurs at the beginning of systole as the ventricular pressure increases above the atria pressure, causing the AV valves to close as blood begins returning to the atria.*
The *dup sound is caused by the semilunar valves closing at the beginning of ventricular diastole.*
The two other sounds, which are less audible, are due to the blood turbulence during ventricular filling and atrial systole. Heart murmurs include clicking, rushing, or gurgling sounds. Although not always due to a problem,
heart murmurs generally indicate a valve disorder. If the valve is stenotic, meaning it has a narrowed opening, a click may be audible when the valve should be fully opened. In contrast, if a swishing sound is heard when the valve should be closed, it may indicate that blood is able to backfl ow through the valve.

2- The conducting system

The heart contains specialized cardiac musclefibers that can self-generate an action potential, and are therefore called autorhythmic fibers. These cells do not require extrinsic neural input, and they can continue to generate an action potential even when the heart is removed from the body



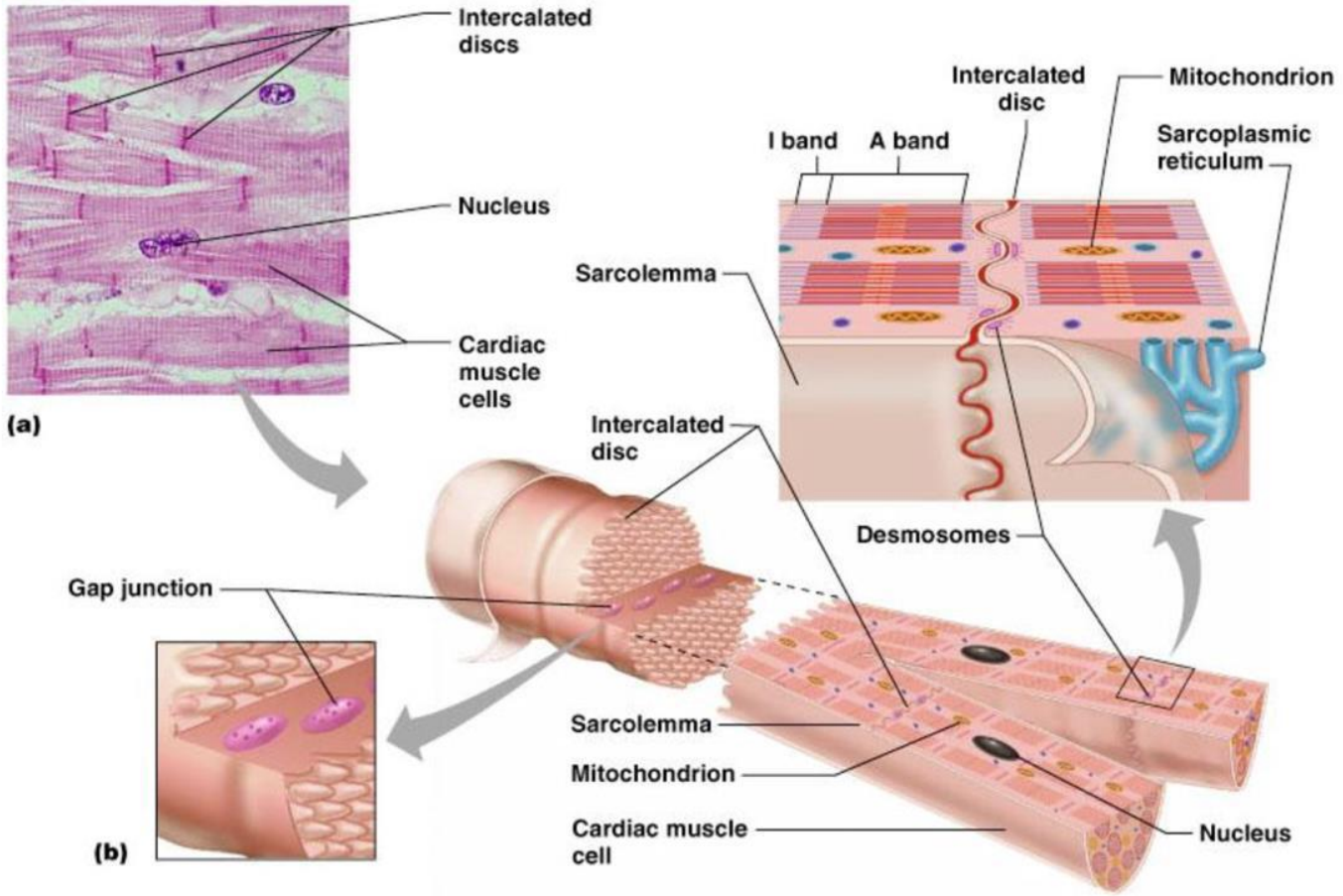
1- SA nodeThe heart normally has a self-firing unit, located in the right atrium, called the *sinoatrial node* or sinus node (*pacemaker cells*),

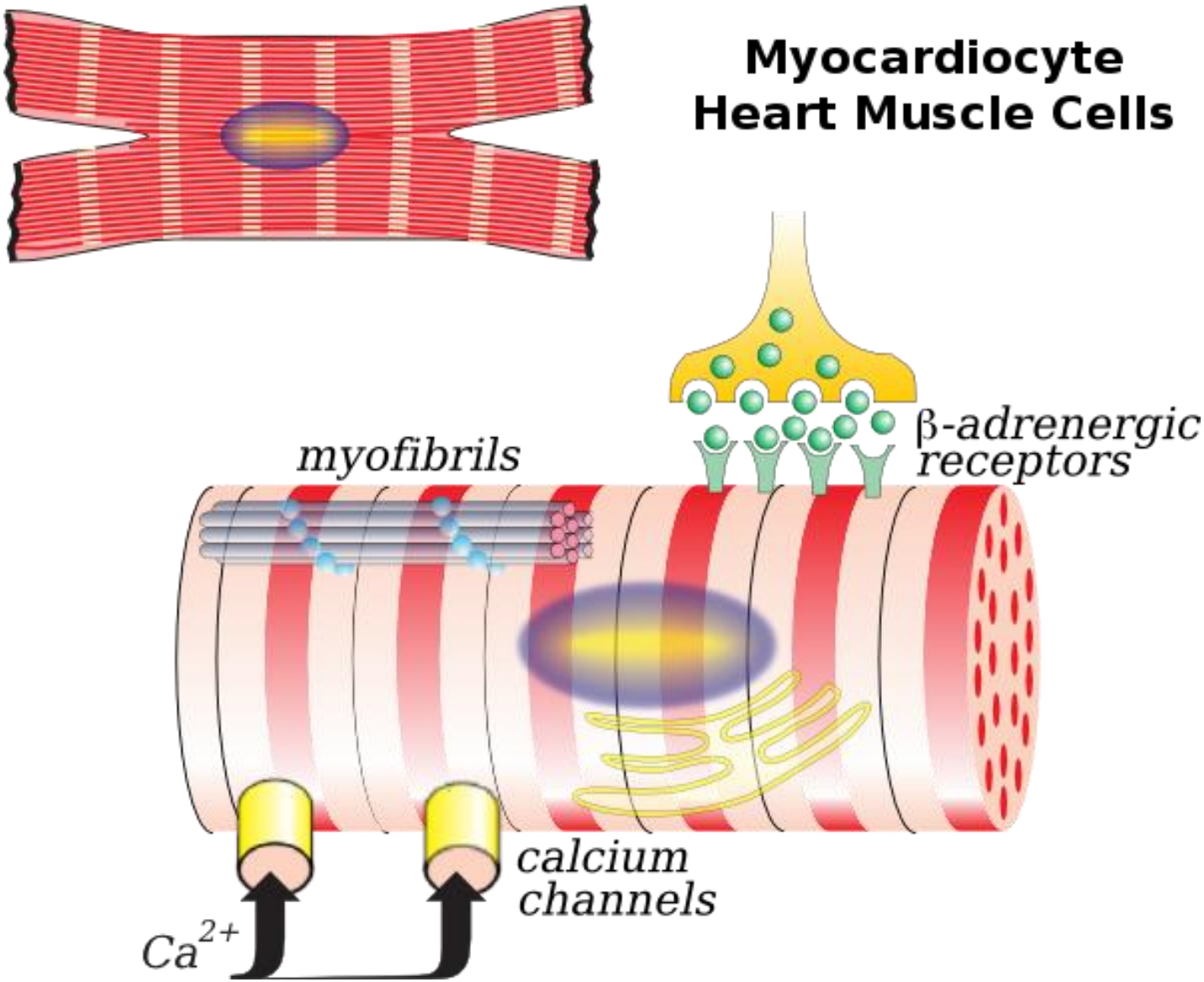
2-The electric signal from the sinus node activates the atrial walls to contraction, and then reaches the main conduction system at the level of the *atrioventricular node* (AV node).

3-From the *bundle of His*, the signal is transmitted down a rapid conduction pathway

4- These bundle branches divide into a network of conducting *Purkinje fibres* just below the endocardial surface. Purkinje fibres are large diameter cells without T-tubulesbundle of his

Molecular structure of the myocardium



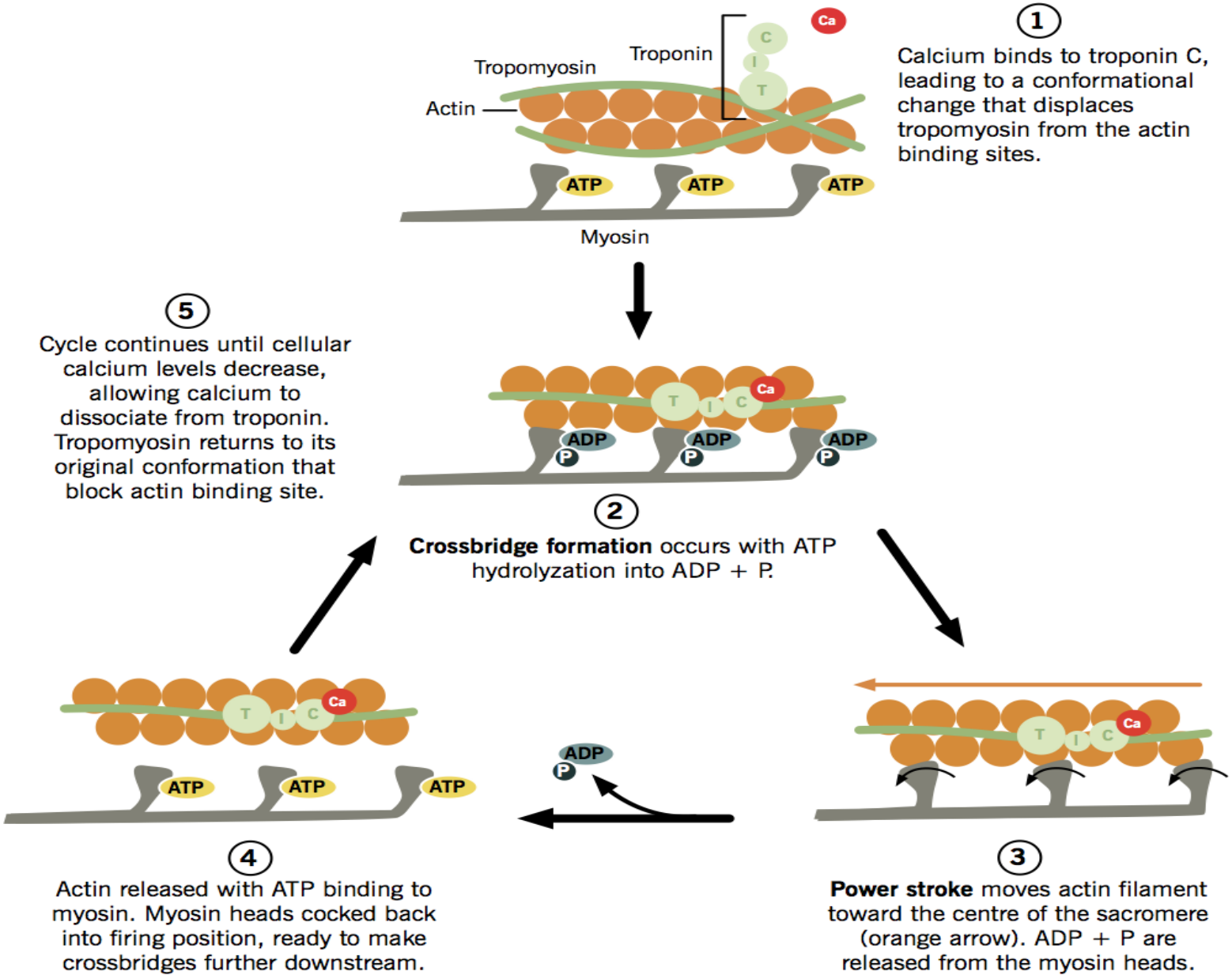

Myocardiocyte
Heart Muscle Cells
β-adrenergic
receptors
myofibrils
calcium
channels
Ca^{2+}

Ionic basis of cardiac muscle contraction

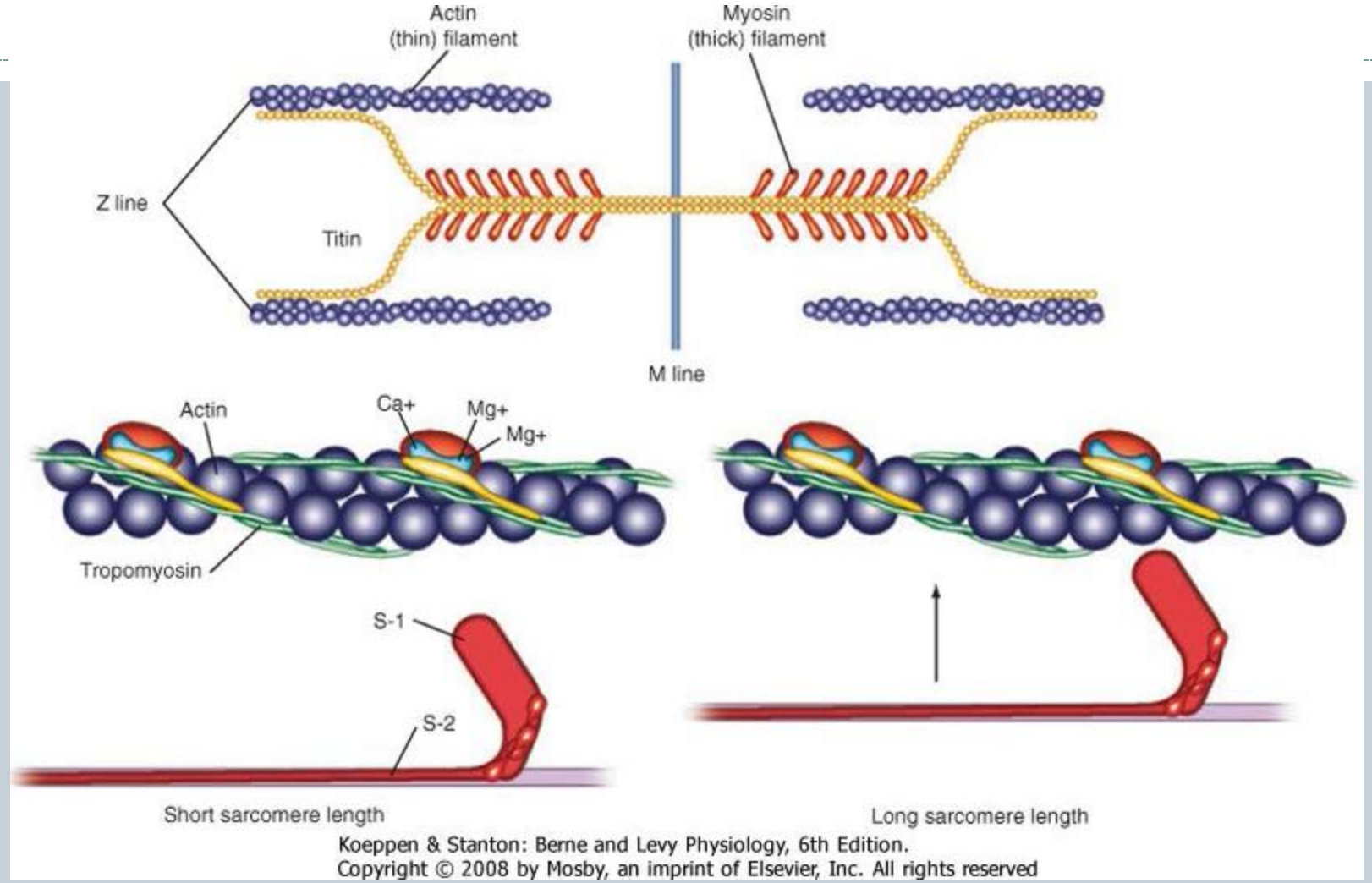
- The mechanism of contraction of cardiac muscle fibers is similar to that in skeletal muscle fibers. As intracellular Ca 2+ concentrations increase, Ca 2+ binds to troponin, causing the tropomyosin to move and thus uncovering the myosin binding sites on the actin fi laments. Myosin then binds to actin, and the actin is pulled across the myosin filament. Drugs that alter the movement of calcium into the cardiac muscle fibers can affect the strength of heart contraction.

Cardiomyocyte contractile cycle

Grigoriy Ikonnikov and Eric Wong

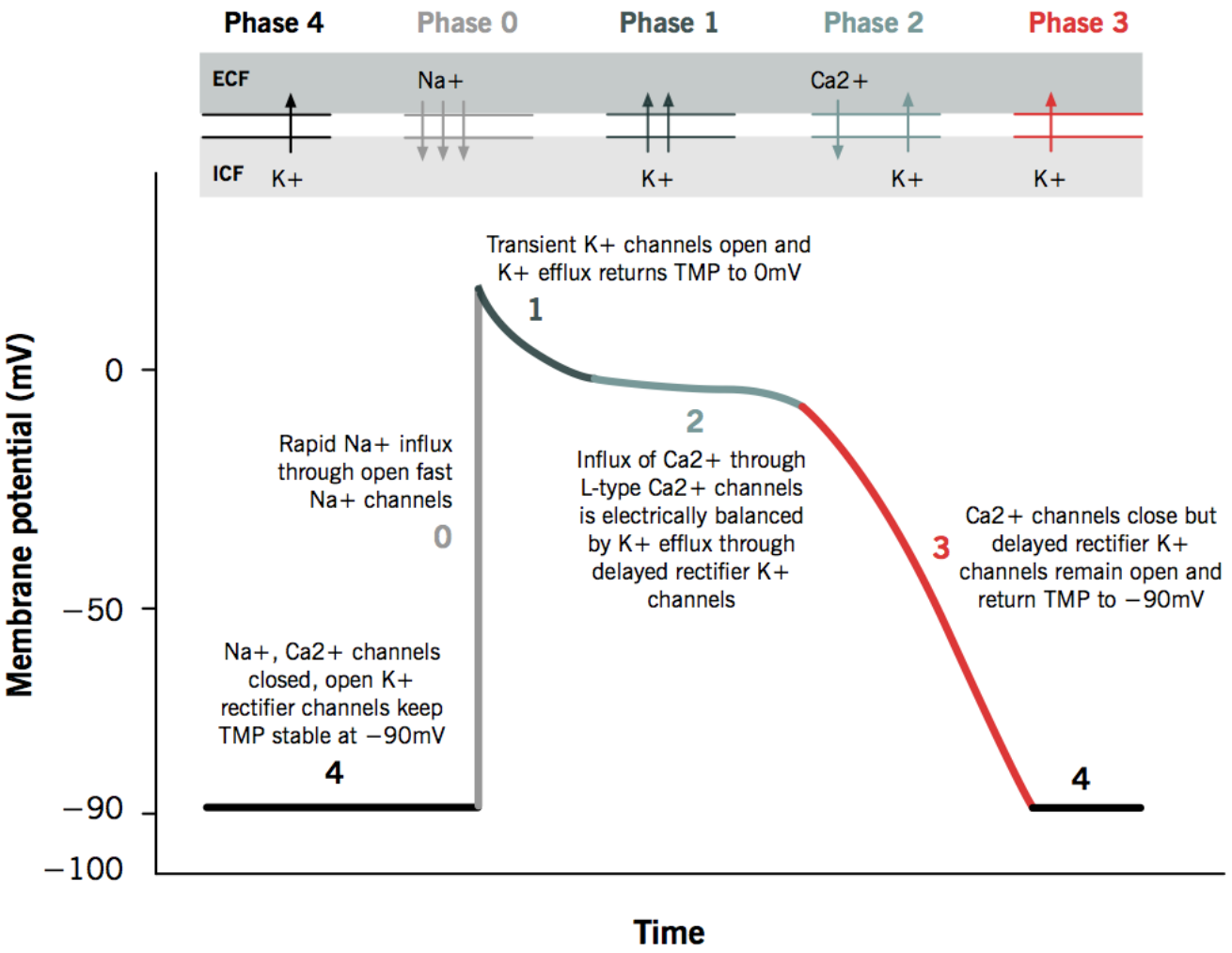


Molecular basis of cardiomyocyte contraction



Action potential of cardiac muscles

Grigoriy Ikonnikov and Eric Wong



Circulatory system

A- Arteries:-

There are types of arteries:

1. Elastic or conducting arteries, Largest in diameter , Have high pressure fluctuations ,Provide pressure reservoir

2. Muscular or medium arteries *distribution vessels. Smooth muscle allows vessels to regulate blood supply by constricting or dilating*

3. Arterioles Transport blood from small arteries to capillaries *resistance vessels;,* Control the amount of resistance. Greatest drop in pressure occurs in arterioles which regulate blood flow through tissues

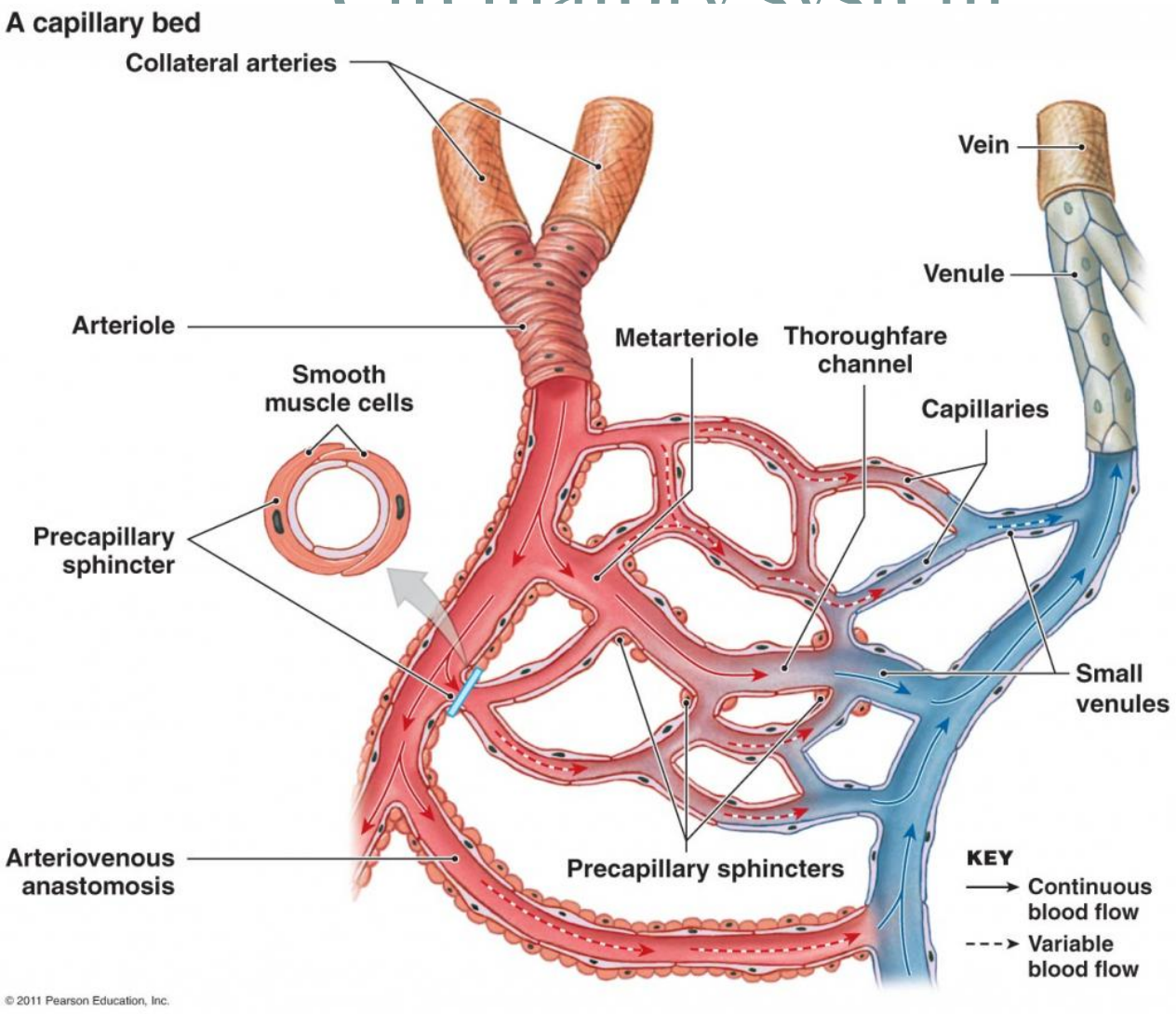
B- Capillary Beds Capillaries form networks called capillary beds, the capillaries are *exchange vessels*

C- venules and veins are *capacitance vessels. The venous system can be expanded to contain more than 75% of the total blood volume. The veins function as capacitance vessels, and* ***become very distended.***

Severe exercise and loss of blood cause an increase in venous tone, which for a period actually can increase the circulating blood volume. During hard work the muscular venous pump provides up to 1/3 of the energy required for blood circulation (the peripheral venous heart).

The venous system also plays an important role by its graded venous return to the heart.

Circulatory system



Blood pressure (**BP**) Is the pressure exerted by circulating blood upon the walls of blood vessels.
Pressure of arterial blood is regulated by blood volume, TPR, and cardiac rate(Heart rate)
MAP=CO ´ TPR
CO= HR x SV
3 most important variables are HR, SV, and TPR.
Increase in each of these will result in an increase in BP.

Regulation of blood Pressure

Long-Term

There are 5 mechanisms by which blood pressure is regulated over the long term:

1. Renin-Angiotensin-Aldosterone Mechanism

This mechanism detects a fall in blood pressure and initiates a series of events that help to bring blood pressure back to normal..

2. Antidiuretic Hormone (ADH or Vasopressin) Mechanism

ADH is released by the posterior pituitary when osmoreceptors in hypothalamus detect an increase in plasma osmolality

Dehydration or excess salt intake:

Produces sensation of thirst

Stimulates water reabsorption from urine in kidneys, elevating blood volume

. Atrial Natriuretic Peptide Mechanism

Produced by the atria of the heart in response to increased blood pressure

Stretch of atria stimulates production of ANP.

Antagonistic to aldosterone and angiotensin II.

Promotes sodium and water excretion in the urine by the kidney.

Promotes vasodilation

4. Fluid Shift Mechanism: Administration of hypertonic fluids e.g. mannitolor hypertonic saline solution

Administration of plasma proteins such as albumin

5. Epinephrine/Norepinephrine Mechanism

Are produced by cells in the adrenal medulla in response to

- **Short-Term**
- **Baroreceptor Reflexes**
  - Baroreceptors are sensory receptors that detect changes in blood pressure
  - Baroreceptors are located in the carotid sinus, aortic arch, and other arteries
  - Changes in peripheral resistance, heart rate, and stroke volume occur in response to changes in blood pressure
- **Chemoreceptor Reflexes**
- Chemoreceptors are sensory receptors sensitive to oxygen, carbon dioxide, and pH levels of blood

Cardiac output(CO) The amount of blood pumped by the heart ventricles per minute, is a measure of how much work heart is doing). CO is equal to stroke volume (SV), the amount of blood pumped by the ventricle per single heart beat multiplied by the heart rate

CO = SV × HR (mL/min) (mL/beat) (beats/min)

SV = EDV – ESV