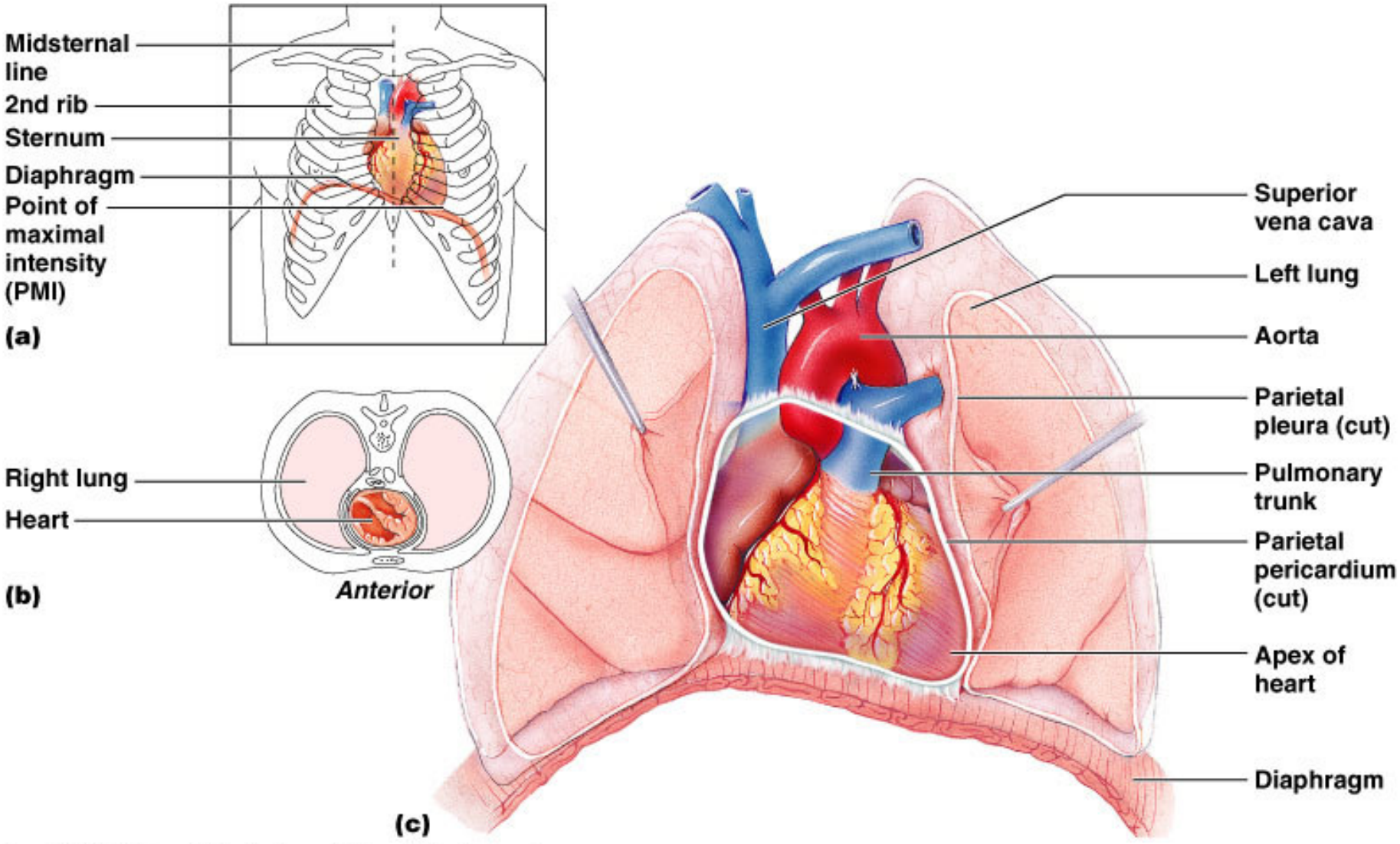
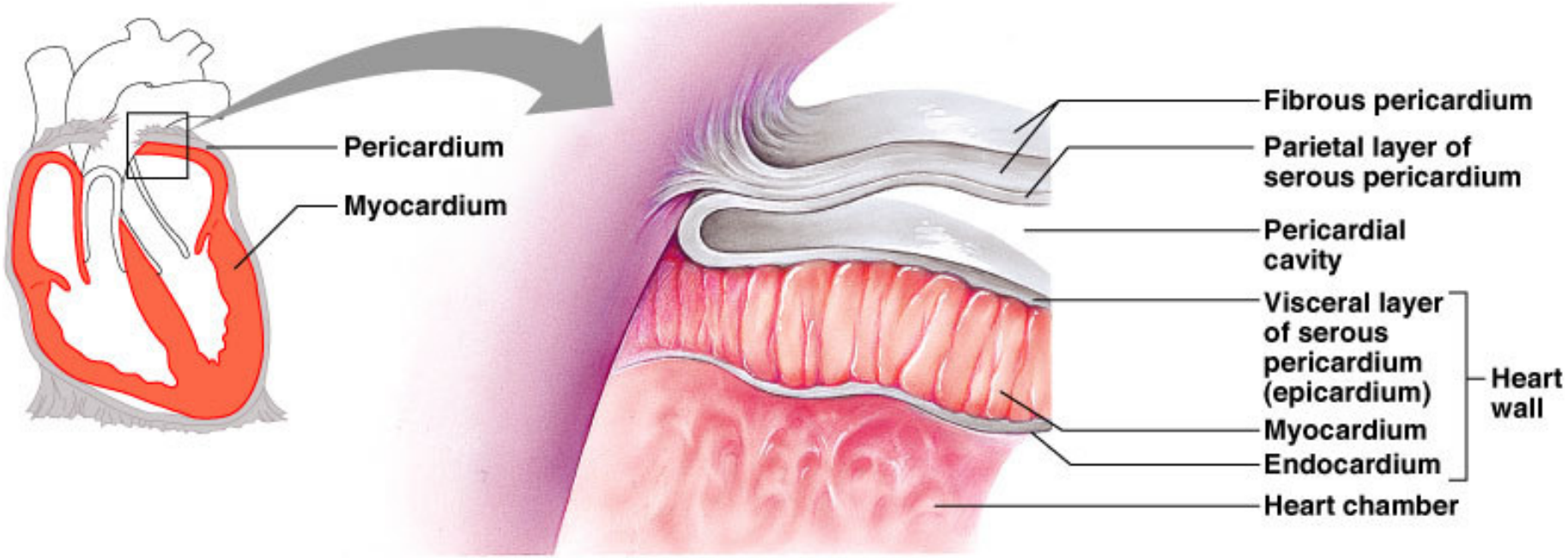
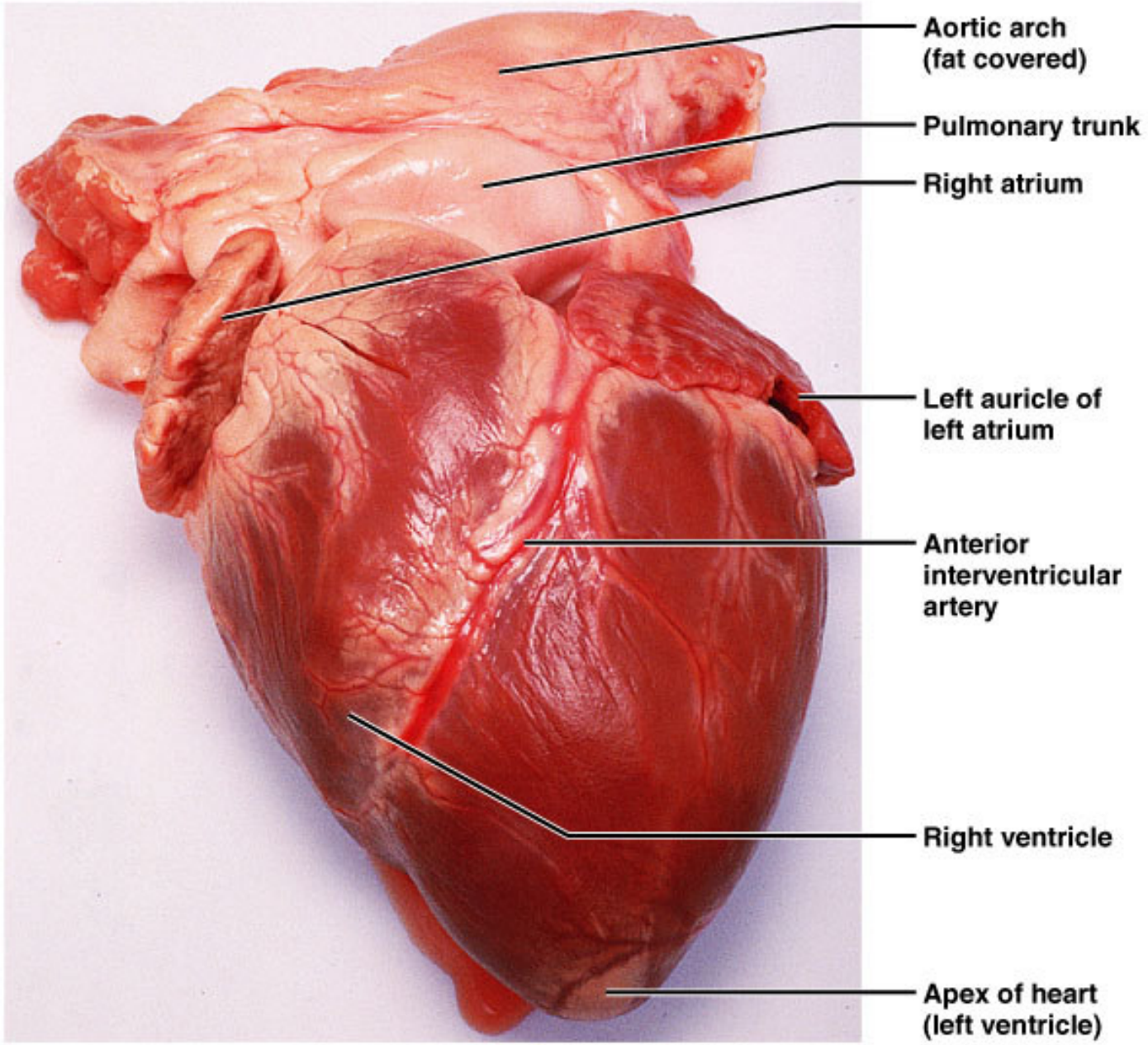
Heart


Midsternal line
2nd rib
Sternum
Diaphragm
Point of maximal intensity (PMI)
(a)
Right lung
Heart
(b)
Anterior
(c)
Superior vena cava
Left lung
Aorta
Parietal pleura (cut)
Pulmonary trunk
Parietal pericardium (cut)
Apex of heart
Diaphragm

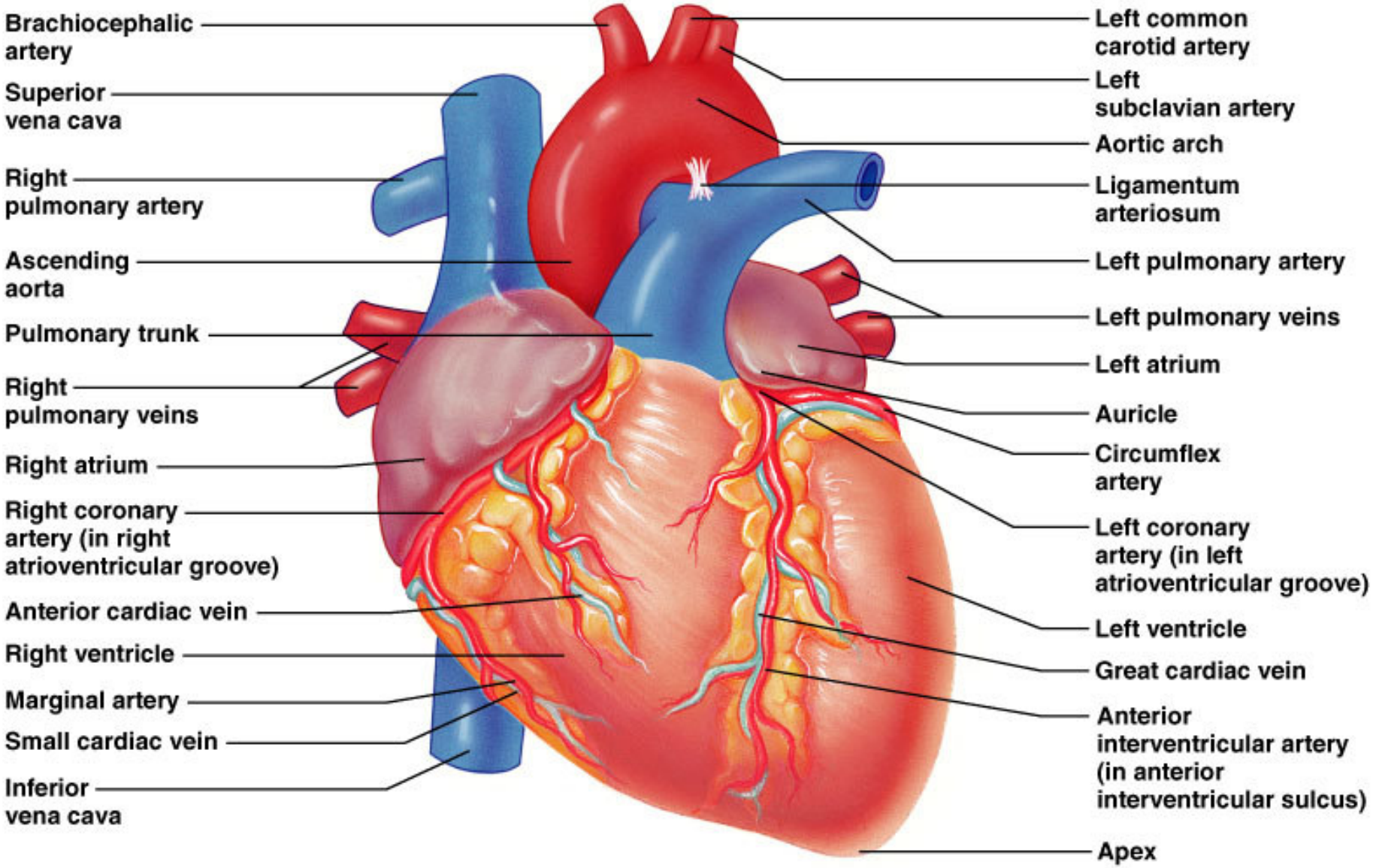
Heart


Pericardium
Myocardium
Fibrous pericardium
Parietal layer of serous pericardium
Pericardial cavity
Visceral layer of serous pericardium (epicardium)
Myocardium
Endocardium
Heart wall
Heart chamber

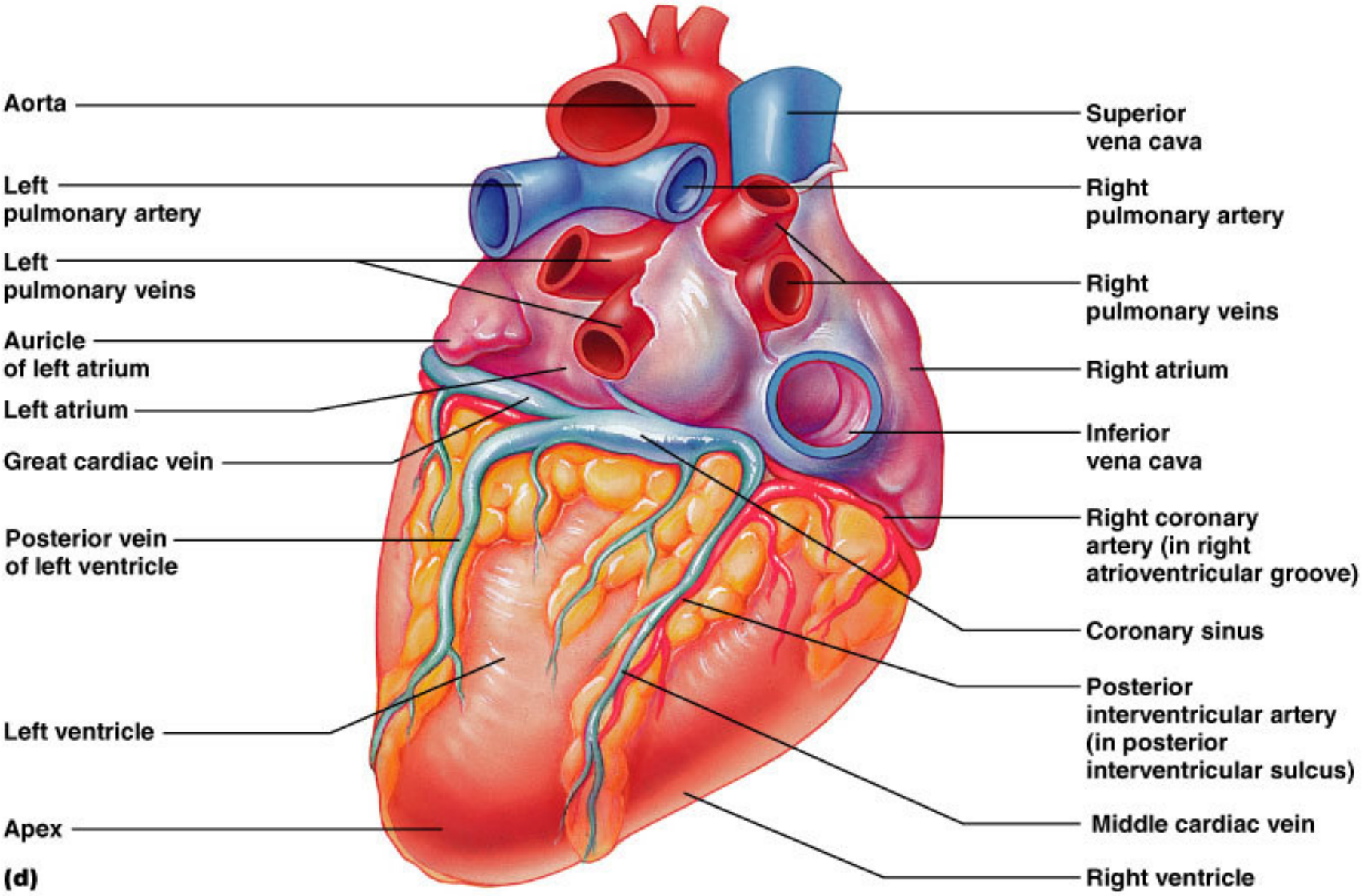

Aortic arch
(fat covered)
Pulmonary trunk
Right atrium
Left auricle of
left atrium
Anterior
interventricular
artery
Right ventricle
Apex of heart
(left ventricle)

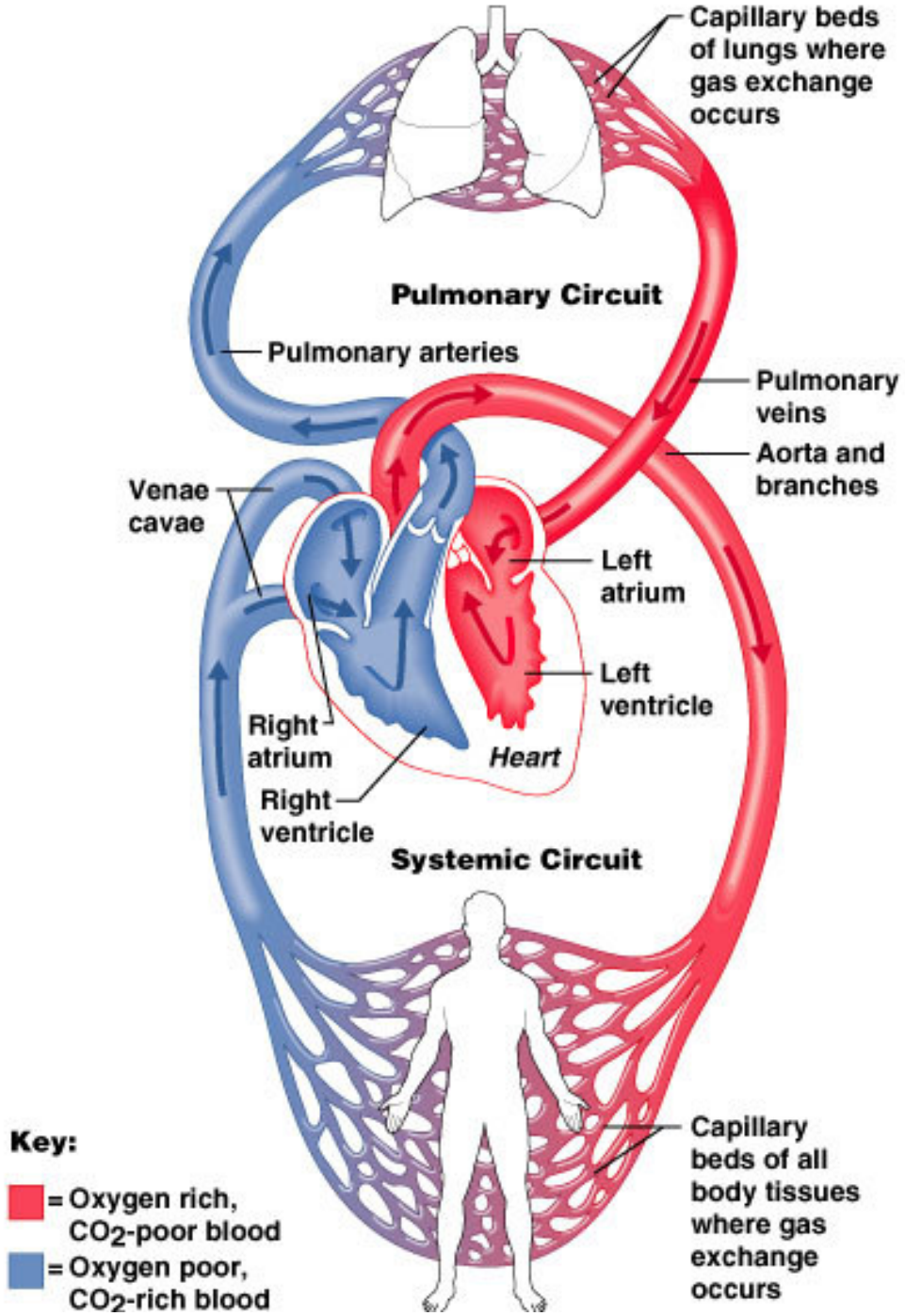
(a)

Heart

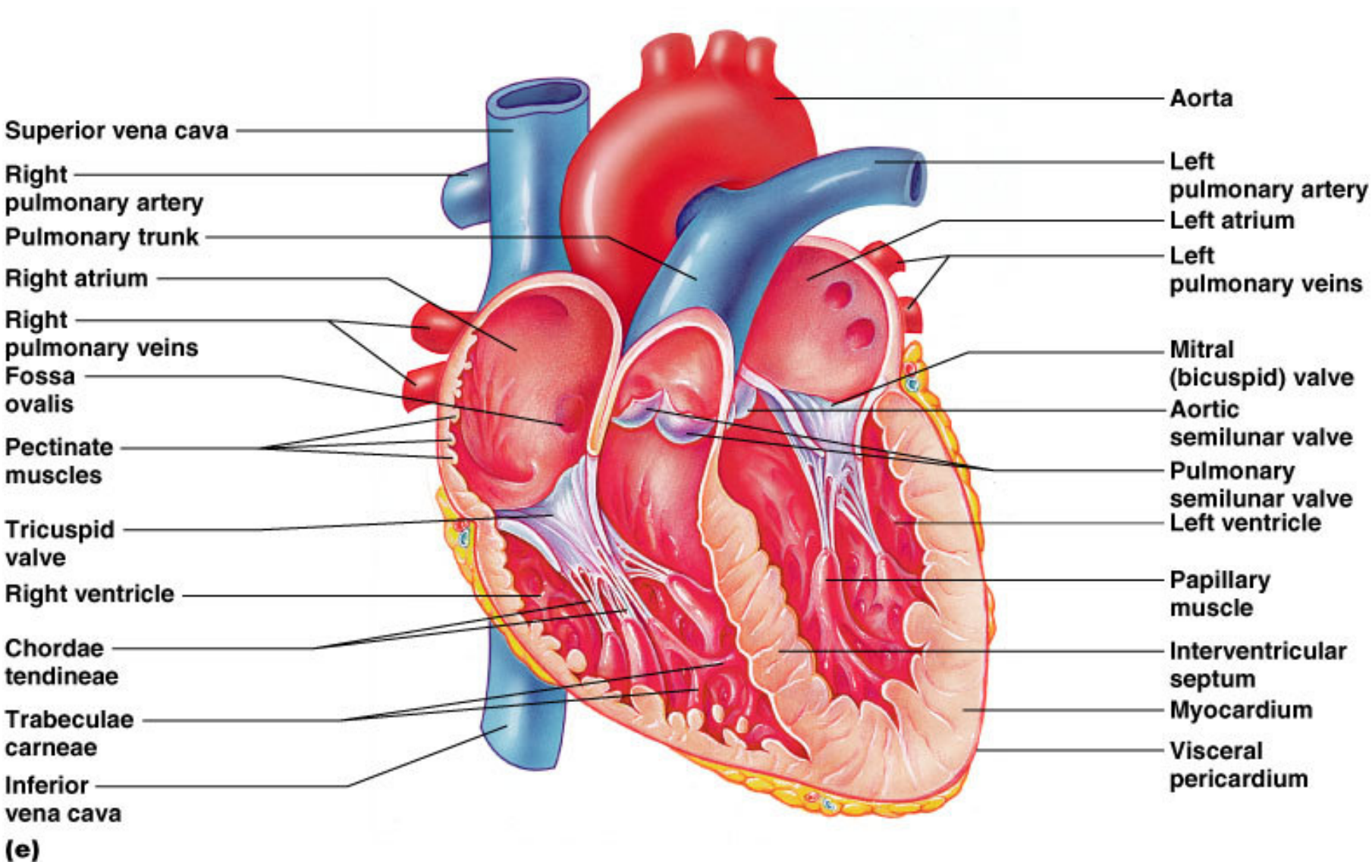

Brachiocephalic artery
Superior vena cava
Right pulmonary artery
Ascending aorta
Pulmonary trunk
Right pulmonary veins
Right atrium
Right coronary artery (in right atrioventricular groove)
Anterior cardiac vein
Right ventricle
Marginal artery
Small cardiac vein
Inferior vena cava
Left common carotid artery
Left subclavian artery
Aortic arch
Ligamentum arteriosum
Left pulmonary artery
Left pulmonary veins
Left atrium
Auricle
Circumflex artery
Left coronary artery (in left atrioventricular groove)
Left ventricle
Great cardiac vein
Anterior interventricular artery (in anterior interventricular sulcus)
Apex
(b)

Heart

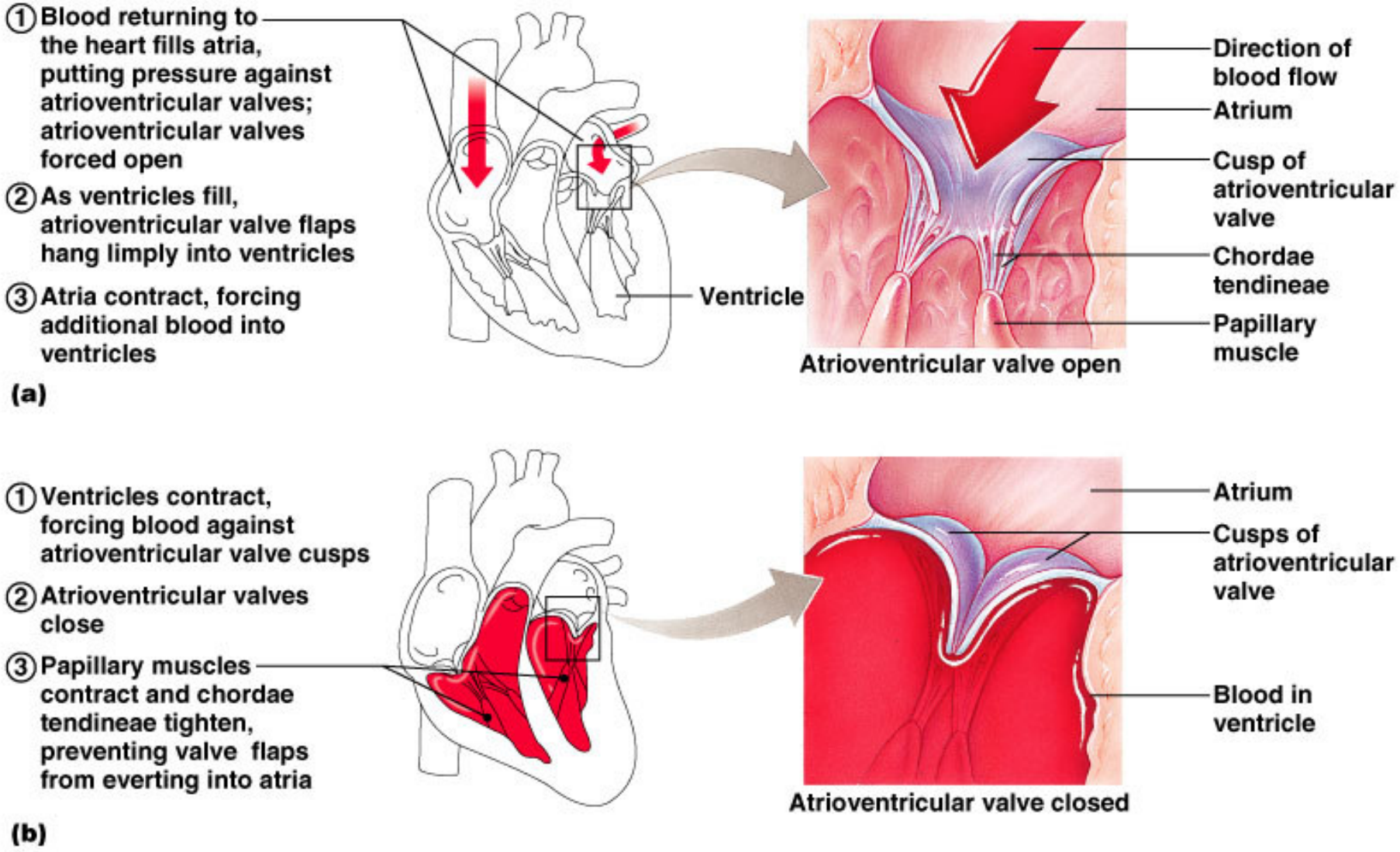

Aorta
Left pulmonary artery
Left pulmonary veins
Auricle of left atrium
Left atrium
Great cardiac vein
Posterior vein of left ventricle
Left ventricle
Apex
(d)
Superior vena cava
Right pulmonary artery
Right pulmonary veins
Right atrium
Inferior vena cava
Right coronary artery (in right atrioventricular groove)
Coronary sinus
Posterior interventricular artery (in posterior interventricular sulcus)
Middle cardiac vein
Right ventricle


Capillary beds of lungs where gas exchange occurs
Pulmonary Circuit
Pulmonary arteries
Pulmonary veins
Aorta and branches
Venae cavae
Left atrium
Left ventricle
Right atrium
Heart
Right ventricle
Systemic Circuit
Capillary beds of all body tissues where gas exchange occurs
Key:
= Oxygen rich, CO_2-poor blood
= Oxygen poor, CO_2-rich blood

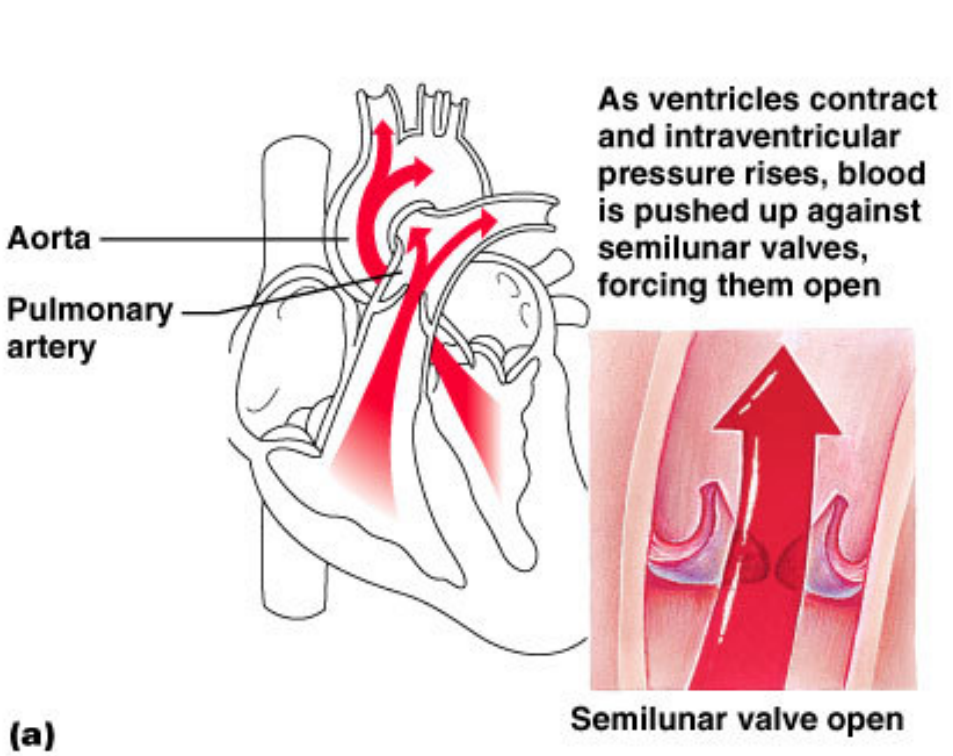
Heart

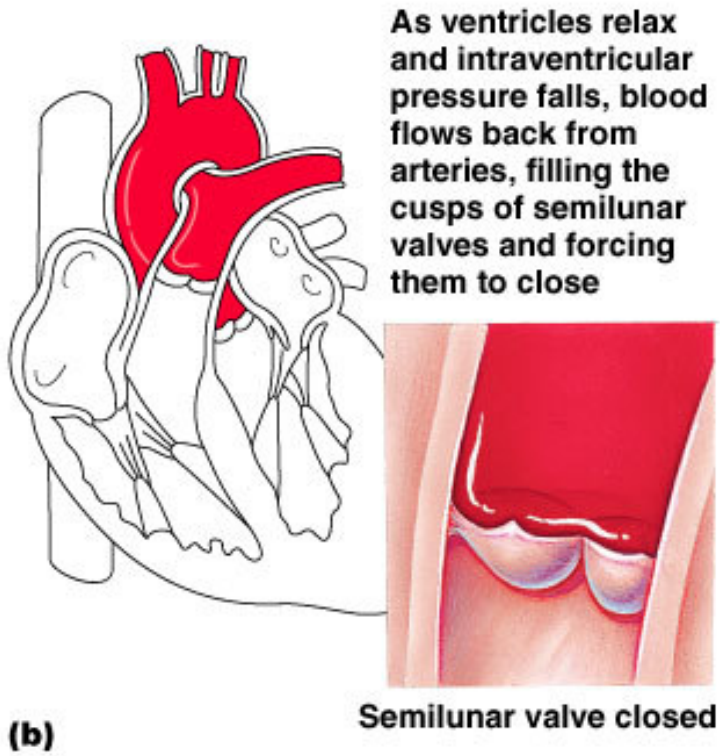

Superior vena cava
Right pulmonary artery
Pulmonary trunk
Right atrium
Right pulmonary veins
Fossa ovalis
Pectinate muscles
Tricuspid valve
Right ventricle
Chordae tendineae
Trabeculae carneae
Inferior vena cava
(e)
Aorta
Left pulmonary artery
Left atrium
Left pulmonary veins
Mitral (bicuspid) valve
Aortic semilunar valve
Pulmonary semilunar valve
Left ventricle
Papillary muscle
Interventricular septum
Myocardium
Visceral pericardium

Heart


① Blood returning to the heart fills atria, putting pressure against atrioventricular valves; atrioventricular valves forced open
② As ventricles fill, atrioventricular valve flaps hang limply into ventricles
③ Atria contract, forcing additional blood into ventricles
(a)
Ventricle
Direction of blood flow
Atrium
Cusp of atrioventricular valve
Chordae tendineae
Papillary muscle
Atrioventricular valve open
① Ventricles contract, forcing blood against atrioventricular valve cusps
② Atrioventricular valves close
③ Papillary muscles contract and chordae tendineae tighten, preventing valve flaps from everting into atria
(b)
Atrium
Cusps of atrioventricular valve
Blood in ventricle
Atrioventricular valve closed

Heart

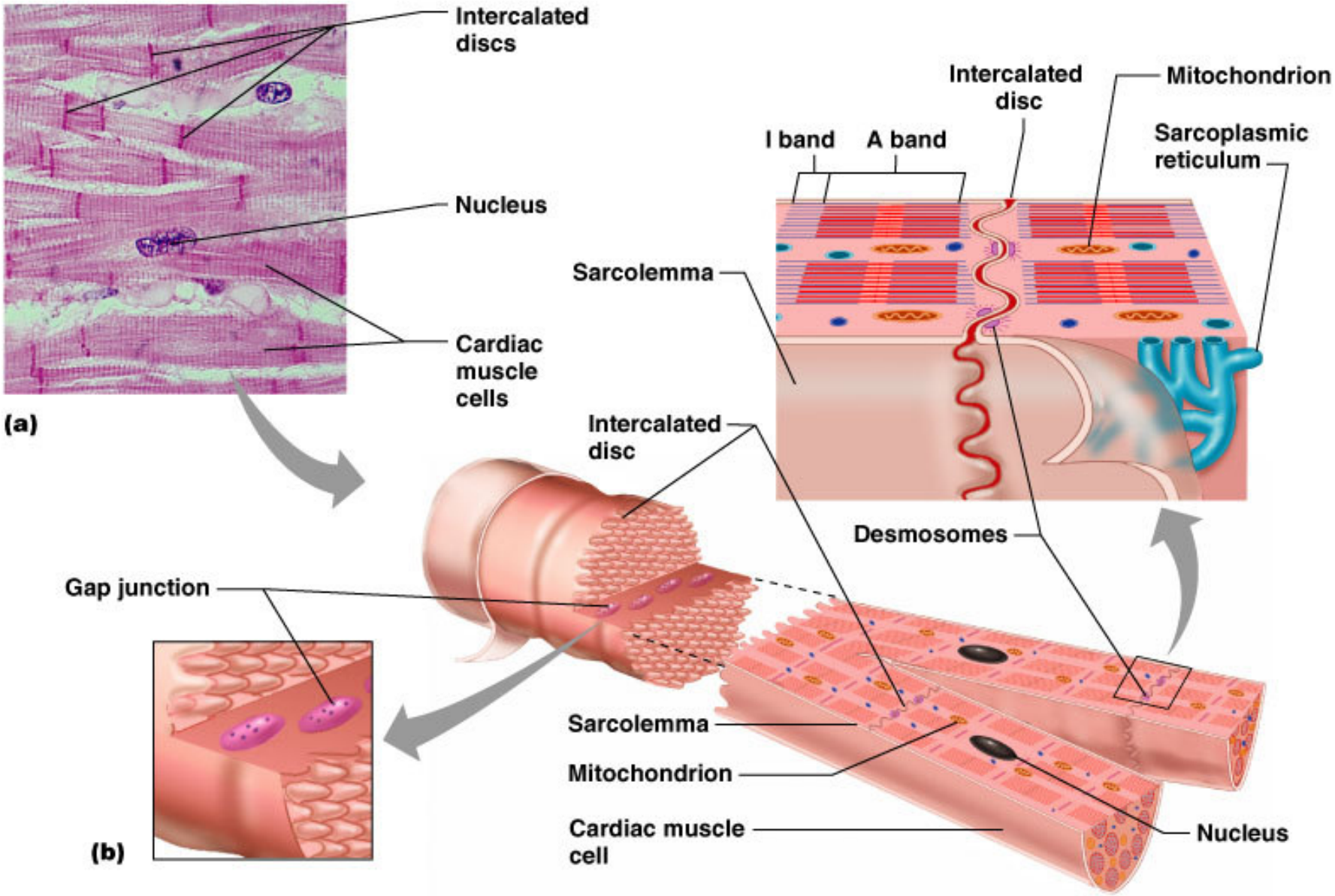

Aorta
Pulmonary artery
As ventricles contract and intraventricular pressure rises, blood is pushed up against semilunar valves, forcing them open
Semilunar valve open
(a)


As ventricles relax and intraventricular pressure falls, blood flows back from arteries, filling the cusps of semilunar valves and forcing them to close
Semilunar valve closed
(b)

Properties of Cardiac Muscle Fibers

- **Microscopic Anatomy**
  - **Branched**
  - **Centrally located nucleus**
  - **Actin and myosin arranged into sarcomeres**
  - **Sarcoplasmic reticulum and T tubules not well organized**
  - **Cells joined by intercalated discs, heart functions as a syncytium**

Properties of Cardiac Muscle Fibers

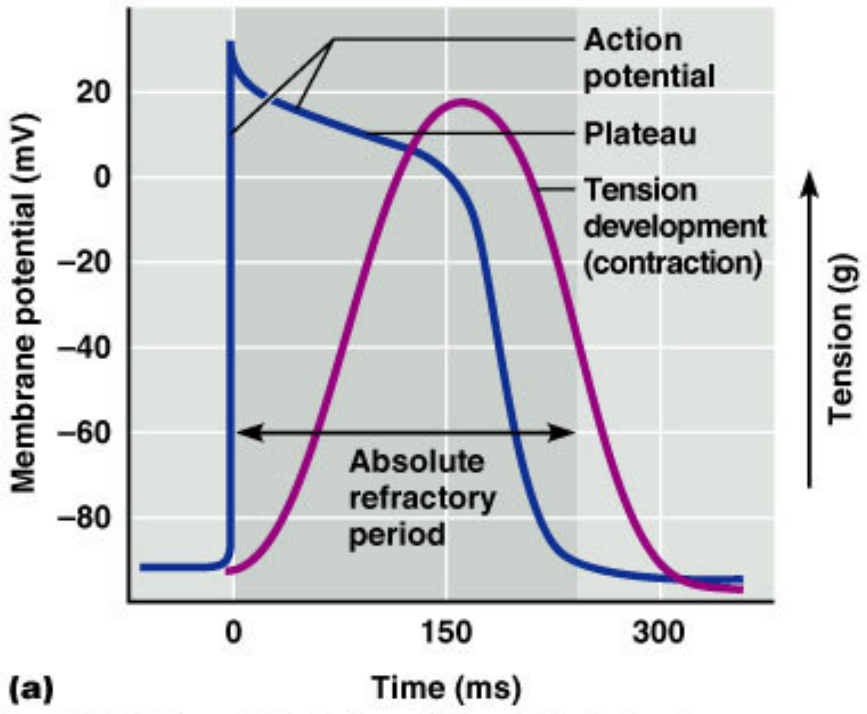


Properties of Cardiac Muscle Fibers

- **Mechanisms and Events of Contraction**
  - **Means of Stimulation**
    - **Some self exciteable (automaticity or autorhythmicity)**
  - **Organ vs Motor Unit Contraction**
    - **Skeletal muscle each motor unit contracts independently**
    - **Entire heart either contracts or not**

Properties of Cardiac Muscle Fibers

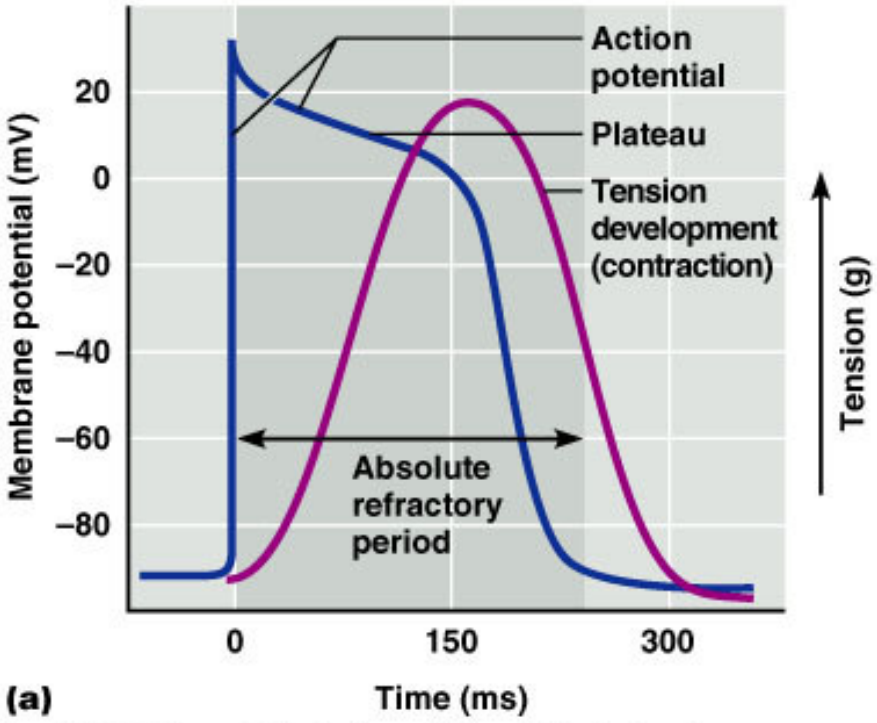
- **Length of Absolute Refractory Period**
  - **Much longer than skeletal muscle**
  - **Prevents tetany**

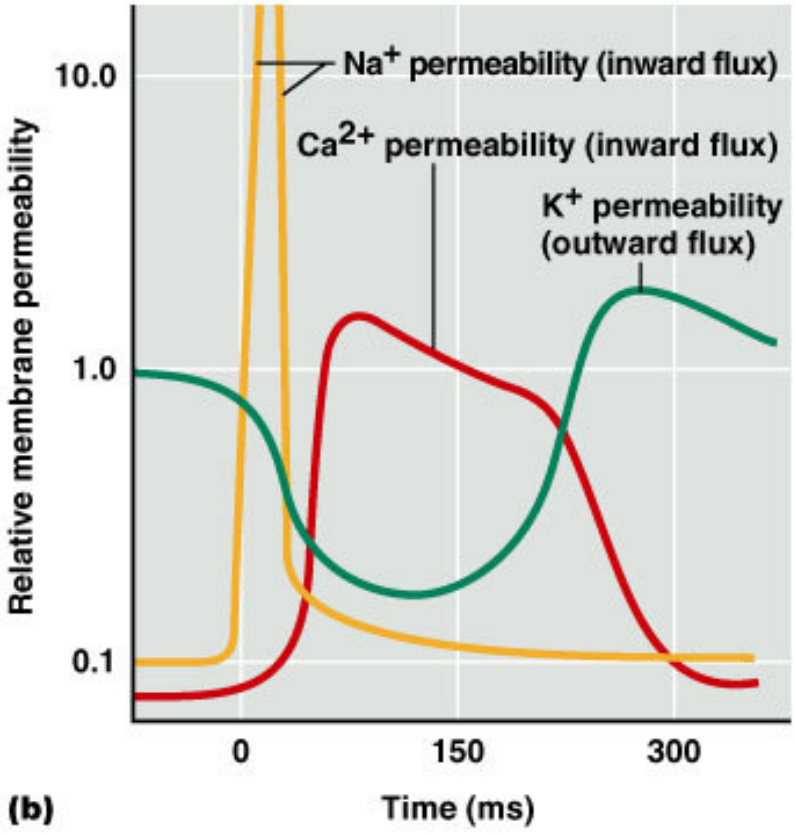


Properties of Cardiac Muscle Fibers

- **Events in the Contraction of Cardiac Muscle**
  - **Voltage-regulated Fast Na^+ Channels open, initiating an action potential**
  - **Depolarization travels down T tubules resulting in the release of Ca^{2+}**
    - **20 – 30% of Ca^{2+} needed for contraction comes from outside the cell; this acts as the stimulus to release Ca^{2+} from the sarcoplasmic reticulum**
    - **For Ca^{2+} to enter the cell depolarization of cell membrane via Na^+ channels opening, opens slow Ca^{2+} channels**
      - » **Ca^{2+} enters the cell causing Ca^{2+} channels to open in the sarcplasmic reticulum, releasing Ca^{2+}**

Properties of Cardiac Muscle Fibers



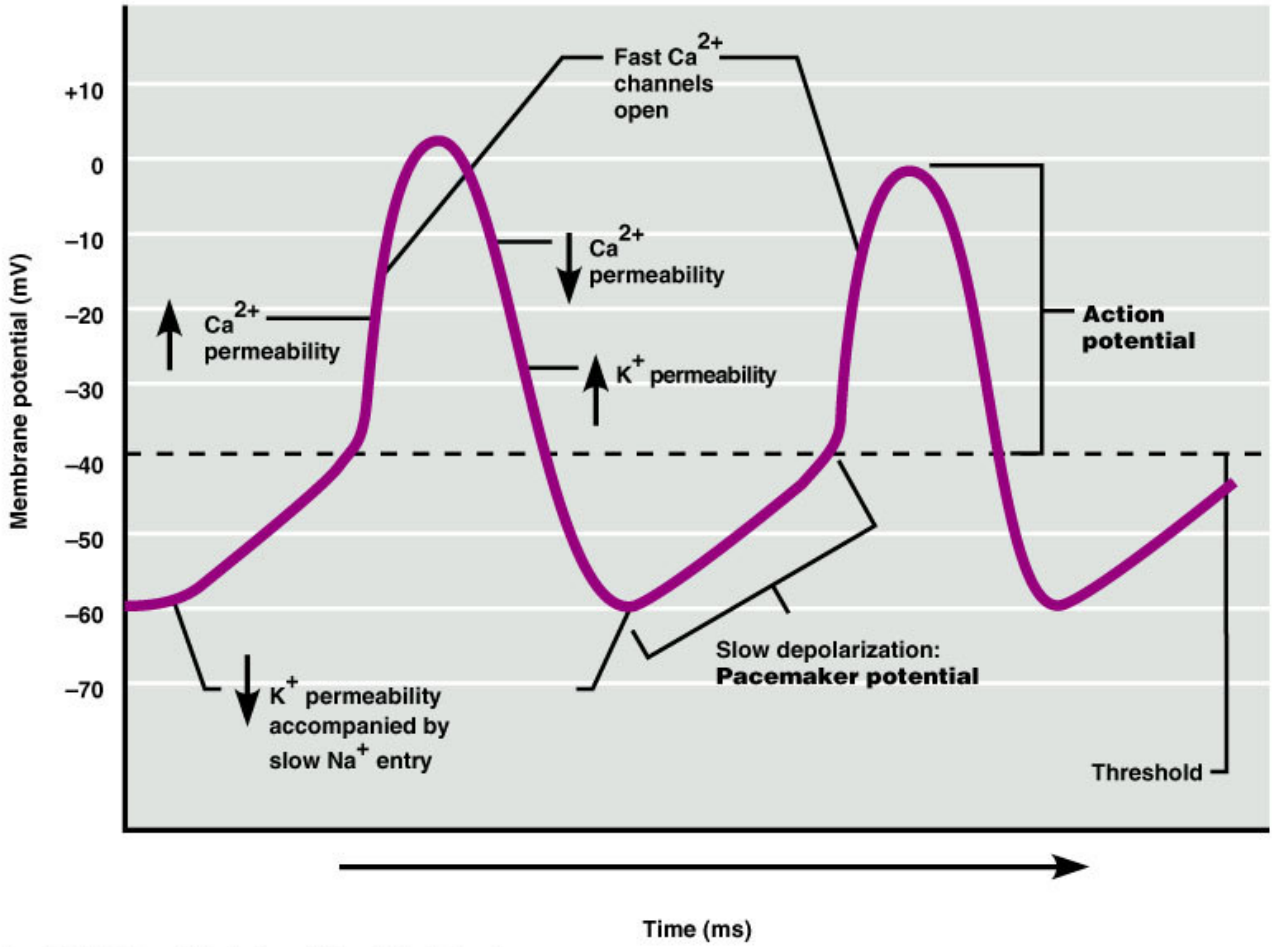


Properties of Cardiac Muscle Fibers

- **Energy Requirements**
  - **Possess a large number of mitochondria (needs large amounts of oxygen)**
  - **Cannot function anaerobically for very long, unlike skeletal muscle**
  - **Utilizes multiple fuels – even lactic acid generated by skeletal muscle contraction**

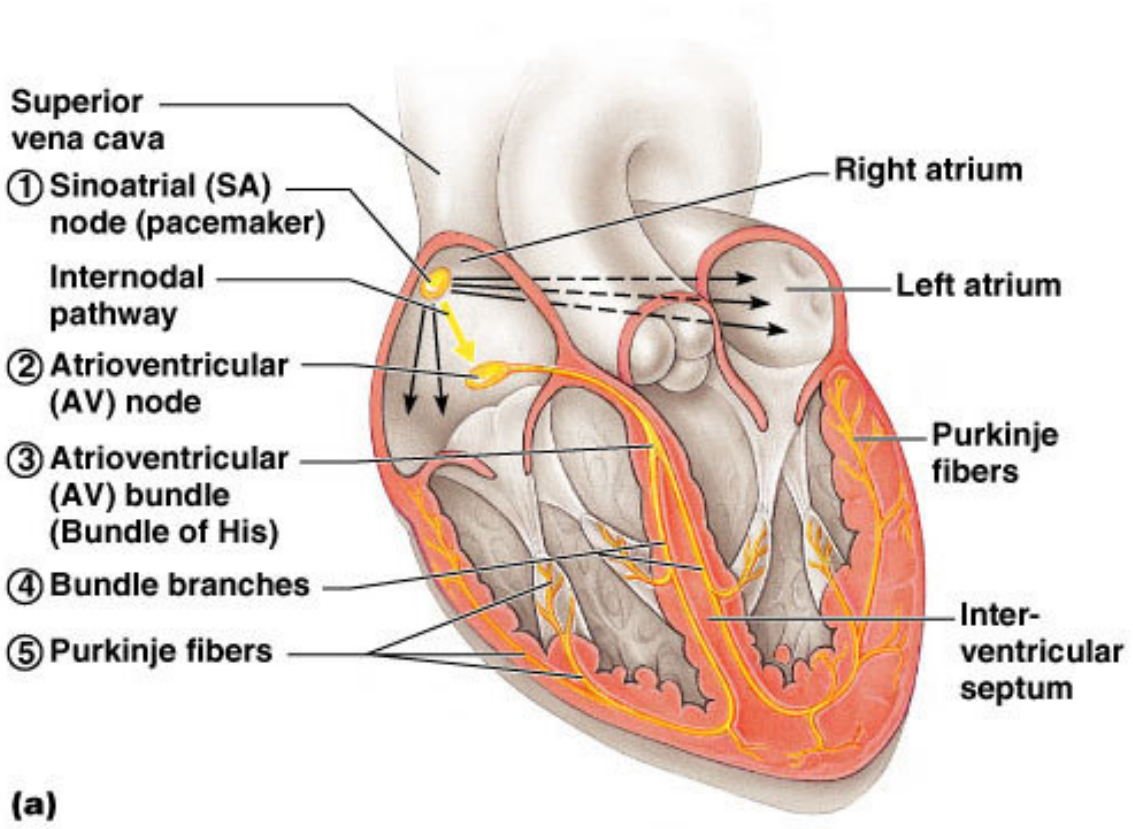
Heart Physiology

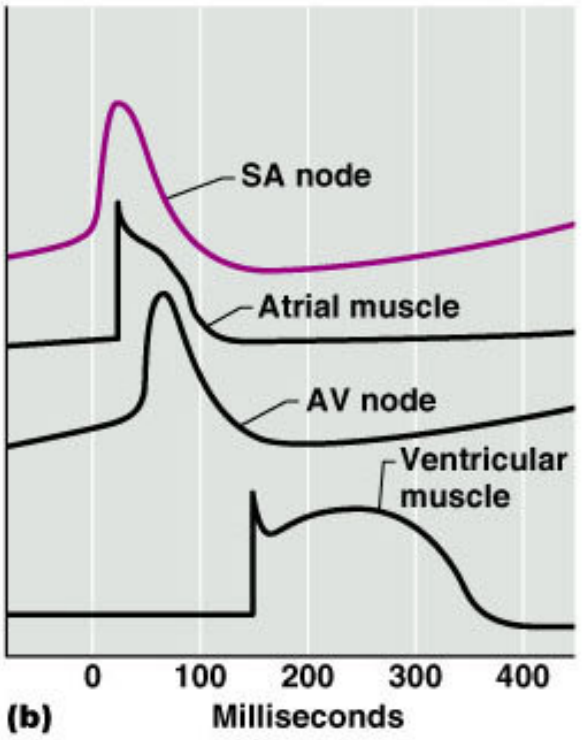
- **Electrical Events**
  - **Autorhythmicity of Cells – important to understand, some cardiac drugs work at this level**



Heart Physiology

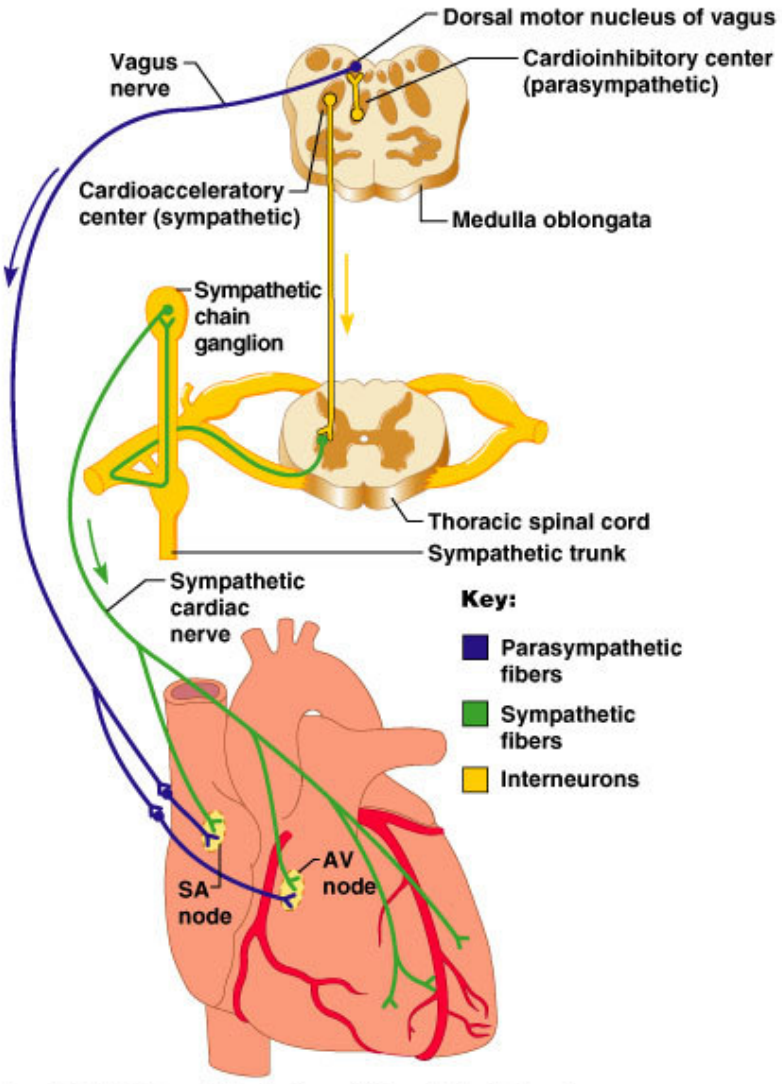
- **Sequence of Excitation**





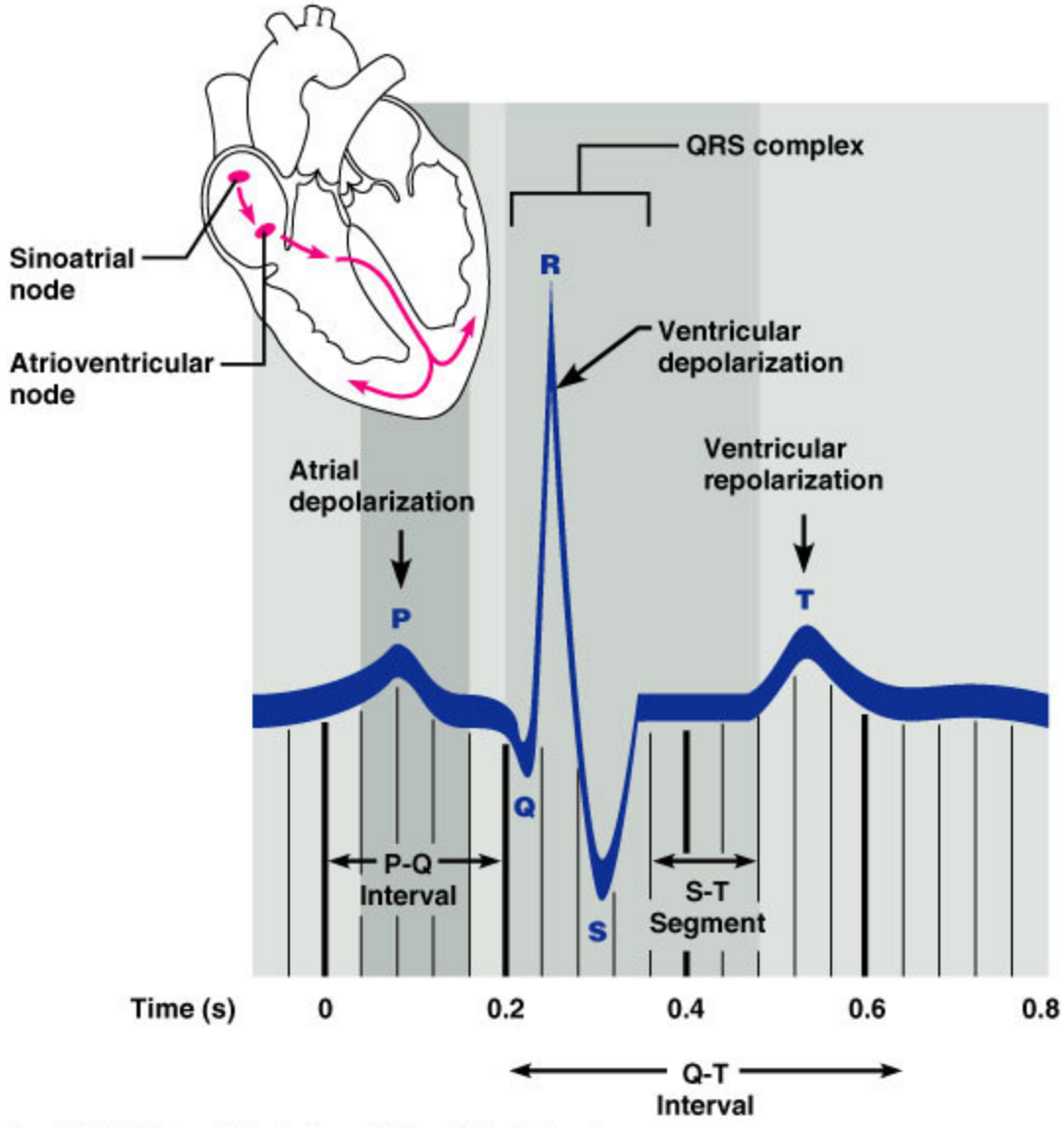
Heart Physiology

- **Modifying the Basic Rhythm: Extrinsic Innervation of the Heart**

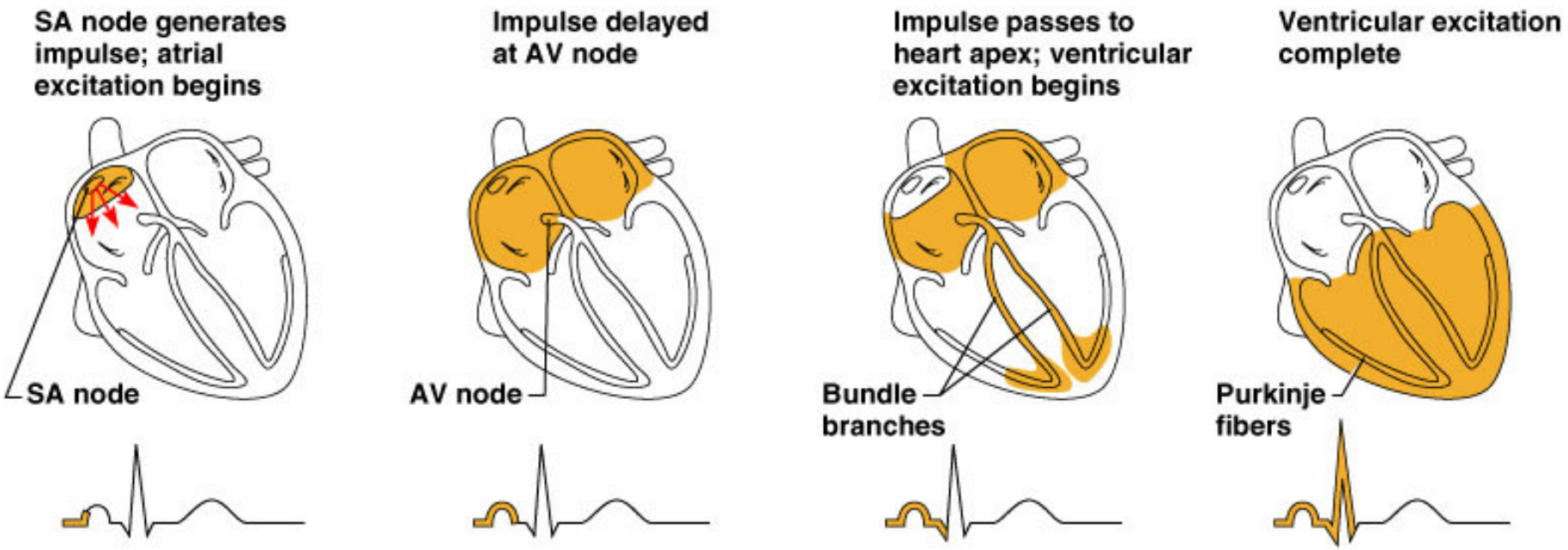


Heart Physiology

- **Electrocardiography**

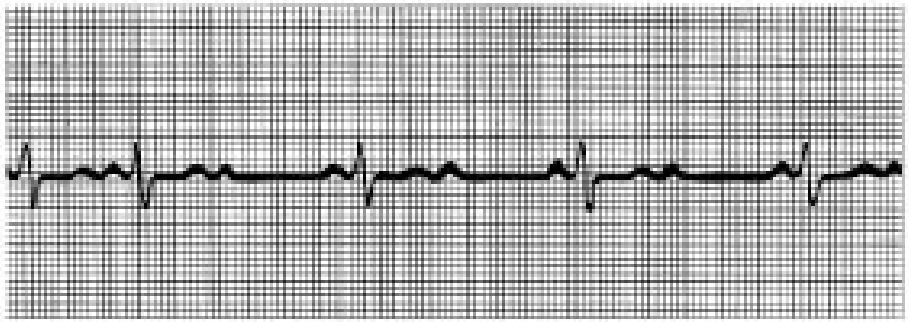


Heart Physiology

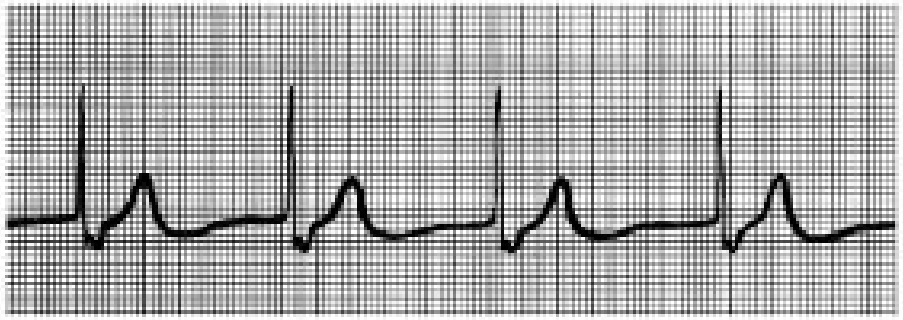


Heart Physiology

(a)



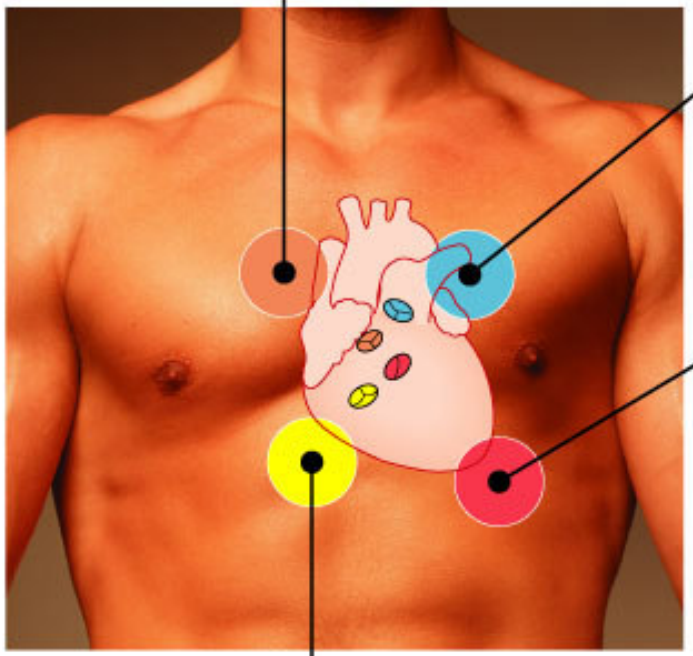
(c)



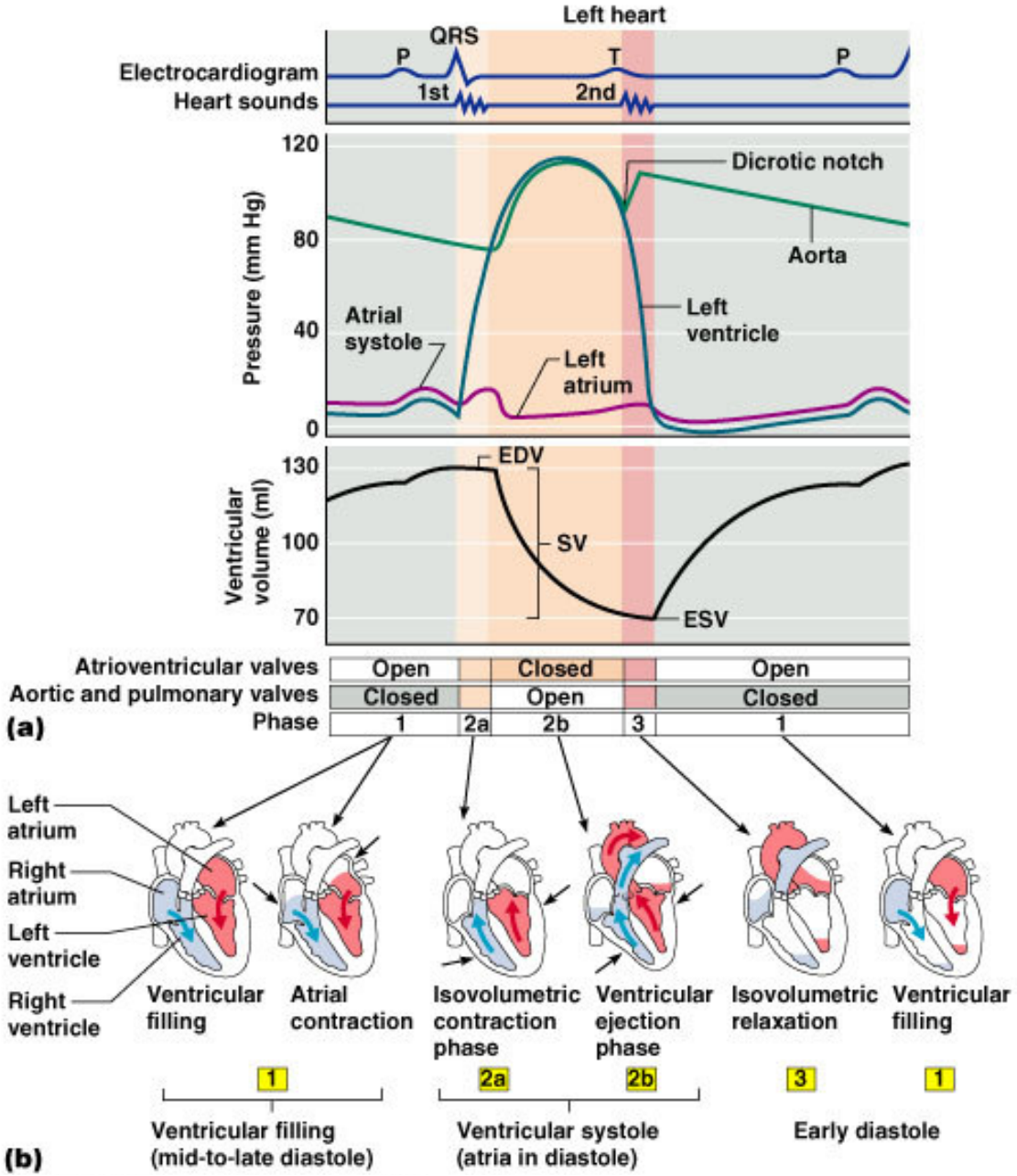
(b)

(d)

Heart Sounds



Mechanical Events: The Cardiac Cycle



Cardiac Output

- **Cardiac output is equal to the stroke volume times the heart rate**
    - **Stroke volume is the volume of blood pumped by either the right or left ventricle during one ventricular contraction – it equals the end-diastolic volume minus the end-systolic volume**

SV = EDV – ESV

70 = 125 – 55

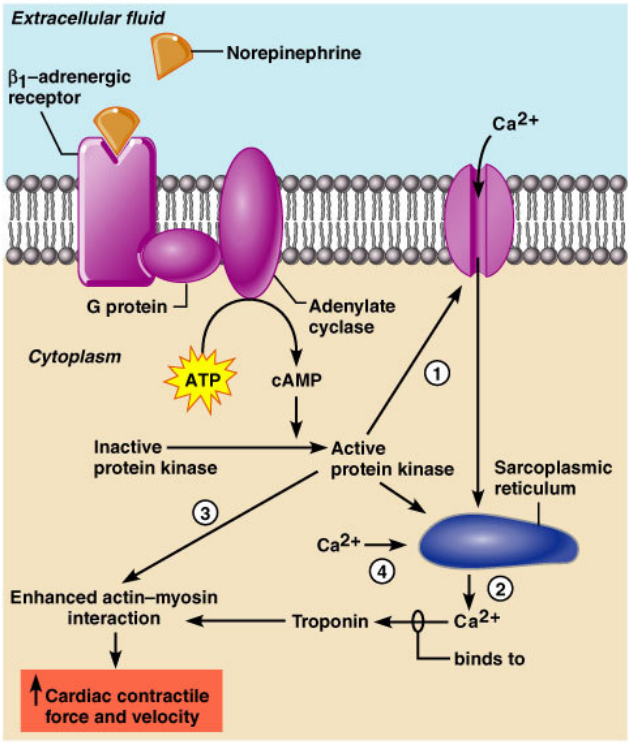
CO = SV x HR

5250 = 70 ml/b x 75 b/m *(bpm)

CO = 5.25L/min

Cardiac Output

- **Regulation of Stroke Volume**
  - **Preload: Degree of Stretch of Heart Muscle (Frank-Starling Law of the Heart) – greatest factor influencing stretch is venous return**
  - **Contractility – strength of contraction**
    - **Increased Ca^{2+} the result of sympathetic nervous system**



Cardiac Output

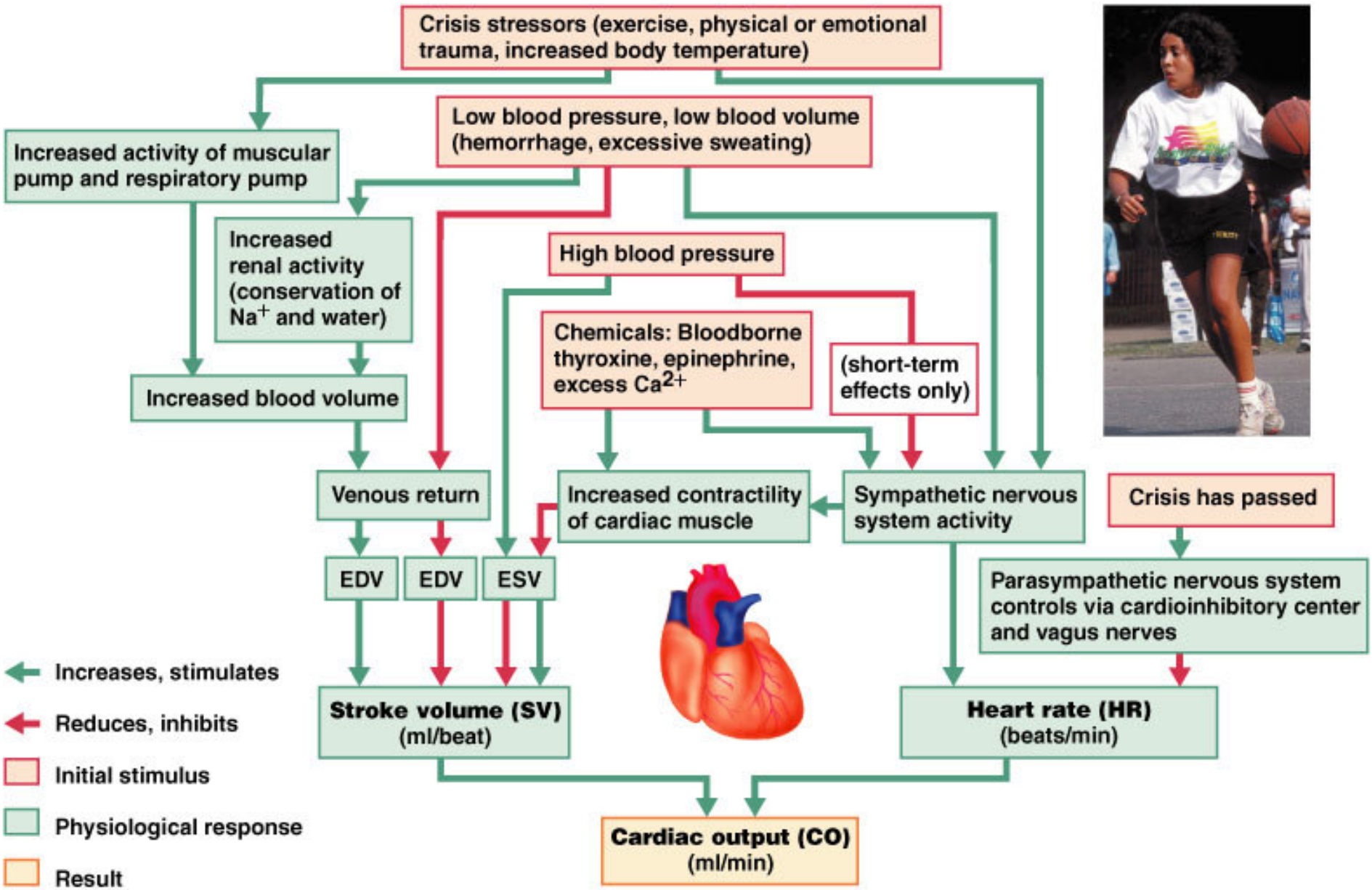
- Other chemicals can affect contractility
  - » Positive inotropic agents – glucagon, epinephrine, thyroxine, digitals
  - » Negative iontropic agents – acidosis, rising K^+ levels, calcium channel blockers

- **Afterload: Back Pressure Exerted by Arterial Blood**

– **Regulation of Heart Rate**

- **Autonomic Nervous System**
- **Chemical Regulation**
  - – Hormones
    - » Epinephrine
    - » Thyroxine
  - – Ions

Cardiac Output



Cardiac Output

- **Other Factors**
  - **Age**
    - » **Infants faster**
  - **Gender**
    - » **Women faster (Why?)**
  - **Exercise/Body Temperature**

Read Homeostatic Imbalances on your own along with "A Closer Look" on pages 704-705 – If you have questions ASK !!!!