Bioengineering 3202 Notes
Lecture #6, March 22, 2006
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- Frog heart has only one ventricle
    - Humans can have a defect in the ventricular wall which allows blood to flow freely from one ventricle to the other, however normal mammalian hearts always have 4 chambers.
- Slight digression on Hemodynamics: 2 Factors control blood flow in the vessels:
    - Resistance (inverse correlation with diameter)
    - Pressure
    - We can write this as a form of Ohm's Law
        - $I = \frac{V}{R}$; $Q_{Flow} = \frac{P_{ressure}}{R_{esistance}}$; Resistance is proportional to $\frac{1}{d^4}$; where d is diameter
    - So when thinking about blood flow, always think about the pressure that drives the flow and the resistance, which determines the flow that will results from that pressure

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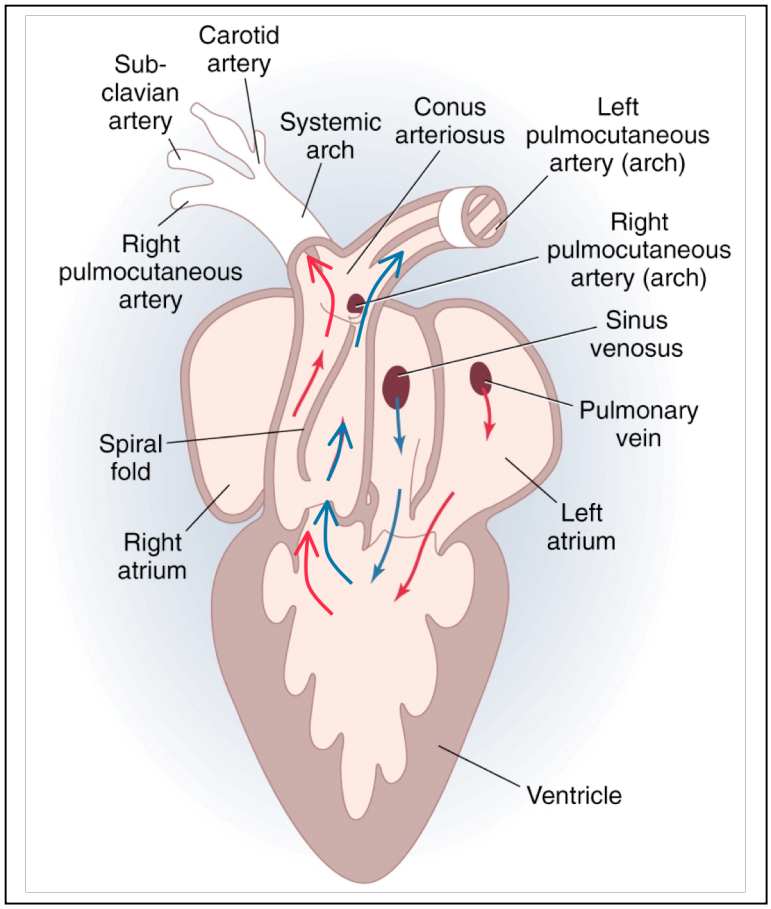
- Back to the Frog Heart:



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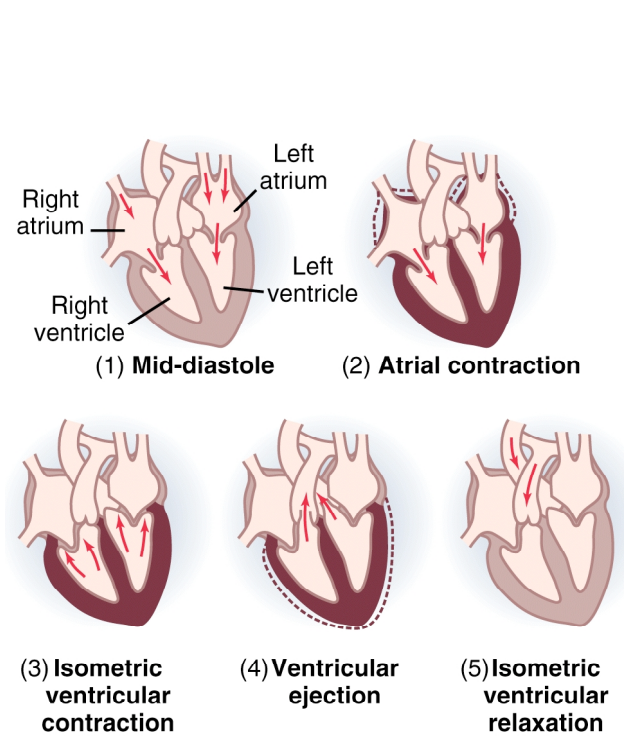
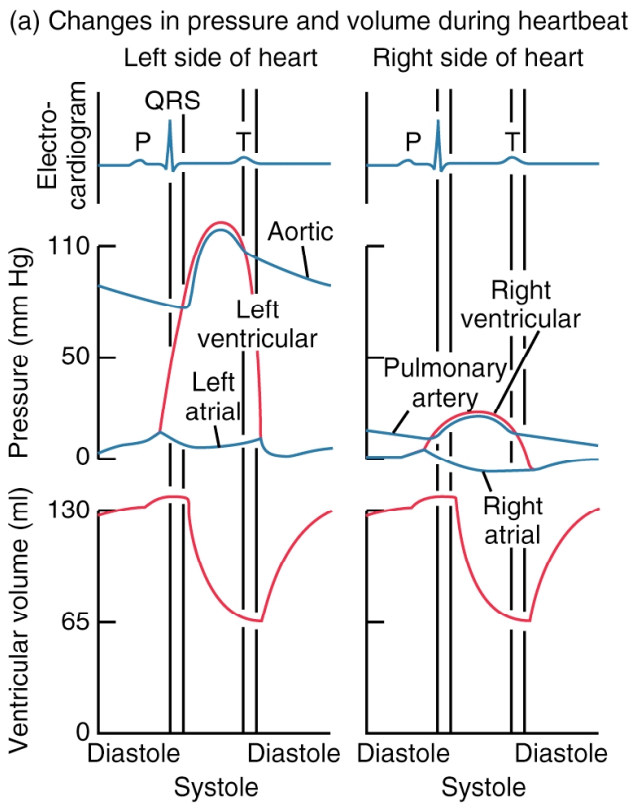
    - From the figure above, we can see the two atria, both delivering blood to the common ventricle. The arrows indicate flow of oxygenated (red) and deoxygenated (blue) blood.
    - Non-oxygenated blood and oxygenated blood tends to stay separated (doesn't mix completely). In this way, blood from the right atrium tends to travel up the side of the common outflow tract to the pulmonary artery.

Oxygenated blood from the left atrium tends to flow up the left side of the common outflow and then go to the system circulation.

- Breathing also affects blood flow by causing an increase/decrease in thoracic pressure, which, in turn, alters the way the blood flow divides between the pulmonary and systemic circulations
- Blood flows the 'path of least resistance', or the one with the lowest downstream pressure
    - When the frog inhales, more blood flows into the lungs (which is mostly non-oxygenated)
    - When the frog exhales, more blood flows into the systemic system (which is mostly oxygenated)
- Note: Blood in chambers does not oxygenate the surrounding heart muscle (same as in humans); however, oxygenation of the heart muscle occurs via the coronary arteries

- Wigger's Diagram of the Heart Cycle





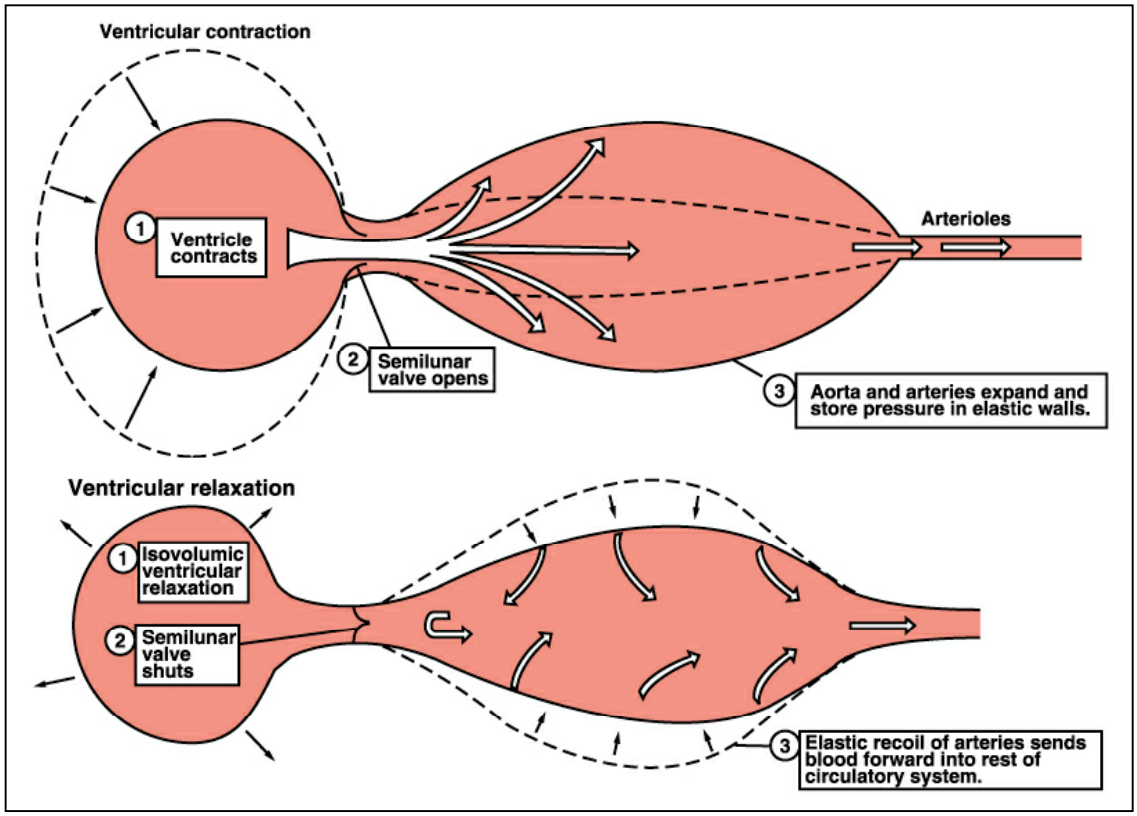
Panel on the left shows the various phases of the heart cycle. The figure on the right shows the associated pressures and volumes as functions of time over the heart cycle.

- Heart Cycle:
  - Before contraction, atrium and ventricles are at the same pressure and AV valve is open; pressure slightly increases in both atrium and ventricle because they are filling with blood. At the end of this filling phase, the atria contract and there is a slight increase in pressure
  - During ventricular contraction, the AV valve closes as soon as LV pressure exceeds that of the LA. First phase of ventricular contraction

occurs with both valves closed; only when LV pressure exceeds aortic pressure does the aortic valve open and blood flow into the system circulation.

- When comparing the left side of the heart to the right side, the volume for both is the same; however, the left side has greater pressure in both the atrium and ventricle

- Mechanism of aortic smoothing of blood pressure (Mechanical RC Circuit)



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  - Vessels have compliance (elastic recoil) which can be related to the electrical equivalent of capacitance
  - Comparison to hose- when a valve opens and then shuts, the pressure creates a bulge which travels down the length of the vessel

- This same expansion of the aorta and great vessels allows them to absorb the large pulse of blood from the contracting ventricle and then shrink elastically back to the original volume and thus smooth out the pulsatile pressure of the heart.