BIOLOGICAL FRAMEWORKS FOR ENGINEERS

Session #26 [m: Vascular System]

General Objectives:

- ✓ The cardiovascular system delivers nutrients and O_2 to cells while removing their waste
- ✓ Feedback control is central to the function of the cardiovascular system
- ✓ Hemodynamics governs the flow of blood to the body and its ability to exchange nutrients, gases, and waste

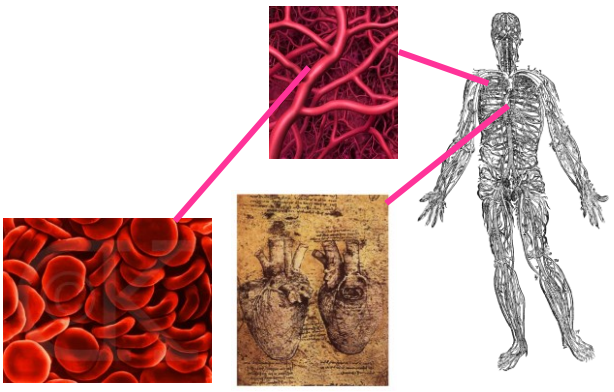
Central Framework:

- ✓ The vascular system is a dynamic flow system with feedback control enabling the body systemically to maintain the viability and metabolic activity of individual tissues and cells

Session Outline:

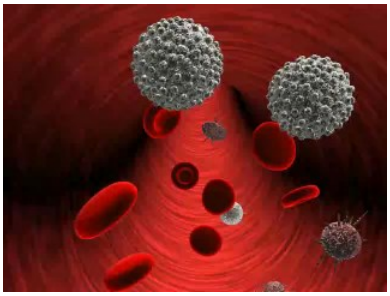
Basic Physiology of the Cardiovascular System

System Parts



Function

Blood

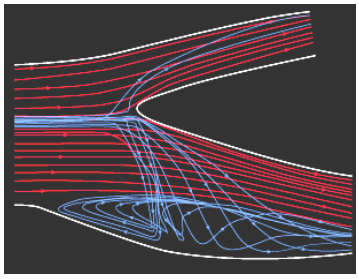


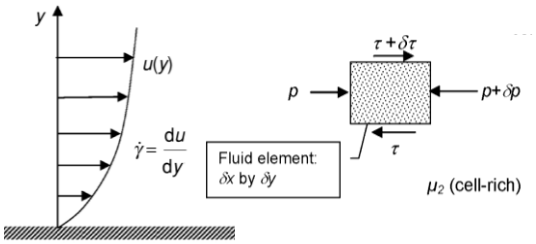
Composition

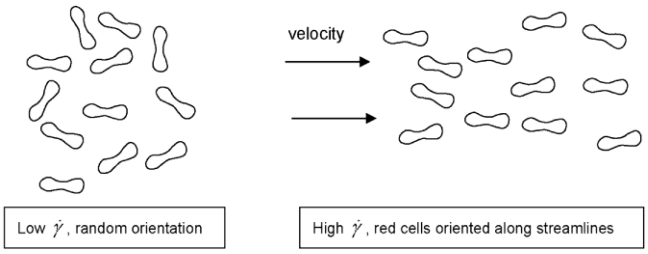
Plasma

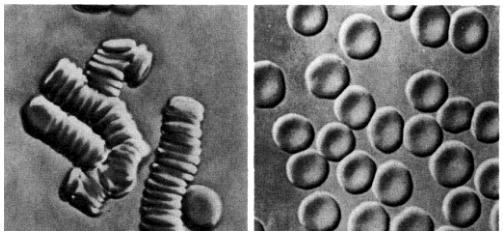
Cells

Hemodynamics



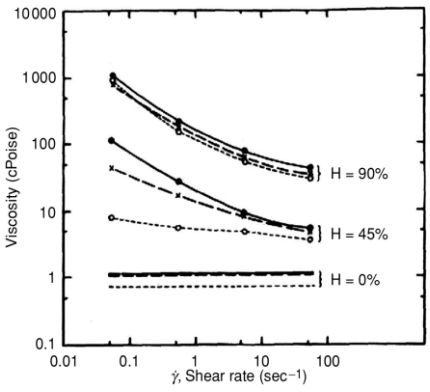






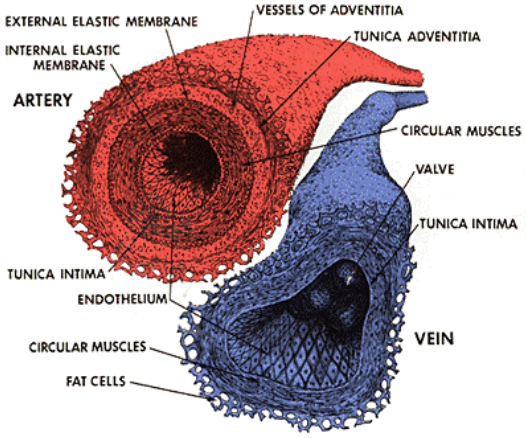
Characteristic	Low shear rate	High shear rate
Rouleaux behavior	Rouleaux formation enhanced; effective viscosity μ_{eff} is increased	Rouleaux break up; effective viscosity μ_{eff} is decreased
Individual red cell orientation	Red cells are randomly oriented; μ_{eff} is increased	Red cells are aligned with streamlines; μ_{eff} is decreased

Viscosity



Plot of effective viscosity versus shear rate for blood of differing hematocrits (H). Note the Newtonian behavior of the fluid at zero hematocrit, and the logarithmic vertical scale. •, whole blood; ×, defibrinated blood (i.e., blood from which the clotting protein fibrinogen has been removed); ○, washed cells in Ringer's solution. The points are determined from a fifth-order polynomial curve fit to experimental data. From Chien *et al.* J App Physiol, **21** (1966), 81-87.

Vascular Anatomy



Arteries

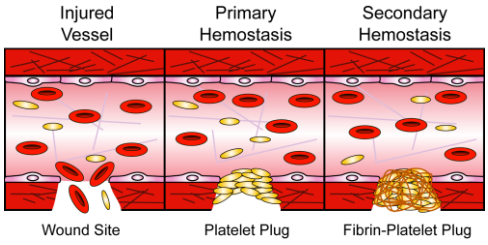
Arterioles

Capillaries

Venules

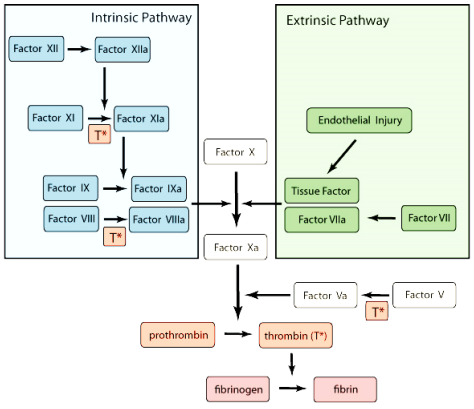
Veins

Coagulation



Hemostasis

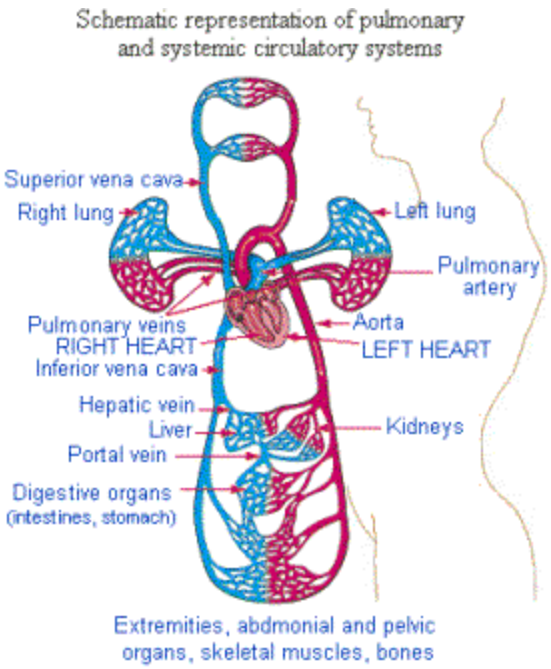
Thrombosis



Coagulation Cascade

Cardiovasculature

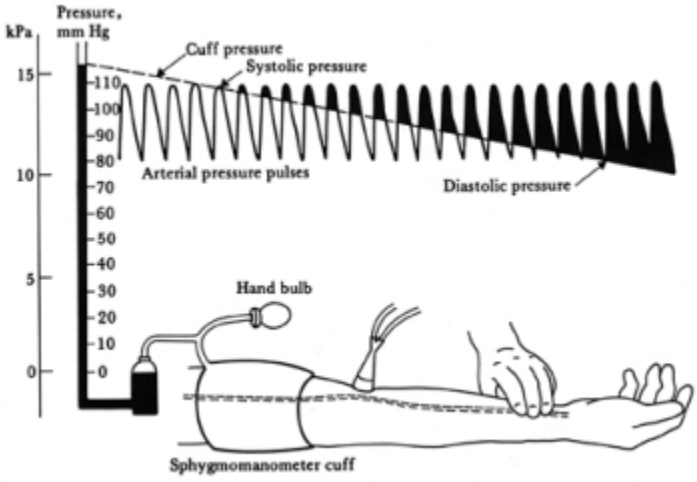
Pulmonary vs. systemic circulations



What are the primary functions of the cardiovascular system?

How are these functions regulated?

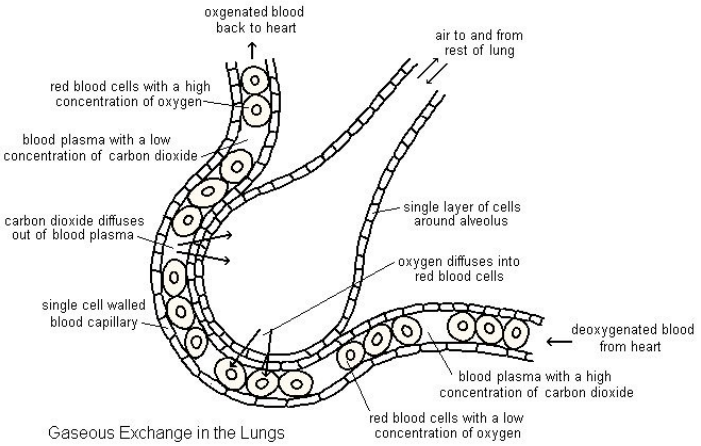
Sphygmomanometer



Pulmonary cycle

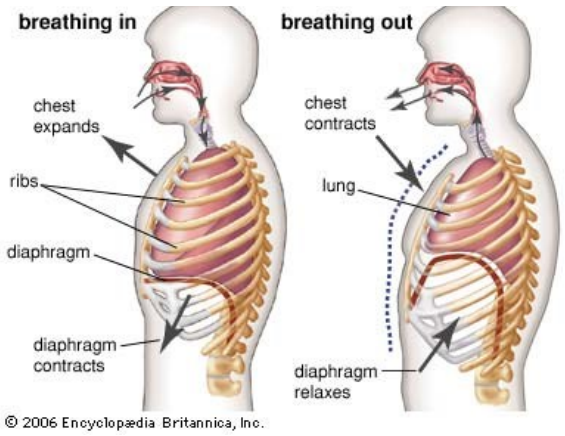
Airways

Alveoli



Gaseous Exchange in the Lungs

Respiration vs. Ventilation



Properties of the Vascular Network