Physical laws

The flow rate of a liquid through a pipe is directly proportional to the difference between the pressures at the two ends of the pipe, and inversely prop to the pipe's resistance

- flow only stops when levels are equal and pressure gradient no longer exist
- pressure gradient (ΔP) driving blood flow through the systemic circut equals the mean arterial pressure (average pressure in the aorta througnout the cardiac cycle

- resistence = $\frac{8L\eta}{\pi r^4}$ (L= length, η= viscosity of the fluid, r= tube internal radius)
- vasoconstriction anywhere in a network of blood vessels increases resistance → vasodialation decreases the resistance
- total peripheral resistance (TPR): combined resistances of all the blood vessels within the circut
- cardiac output = mean arterial pressure / TPR

Arteries

- conduct blood away from the heart to body's tissue
- act as pressure reserviors to ensure smooth, continual blood flow → possible b/c they have a low compliance

Measuring blood pressure

1) physician increases cuff pressure until it is greater than systolic arterial pressure (max pressure heart exerts while beating) → causes the brachial artery to collapse → stops blood flow
2) physician opens a valve to slowly let air out of the cuff → when cuff pressure drops to slightly below systolic arterial pressure, the artery opens w/ each heartbeat to let blood in → creates Korotkoff sounds (audible vibrations)
3) physician notes cuff pressure when Korotkoff sounds appear → recorded as systolic arerial pressure
4) when cuff pressure falls below diastolic arterial pressure (pressure in arteries inbetween beats), blood flow returns to smooth pattern + Korotkoff sounds disappear

5) Physician notes cuff pressure as the diastolic arterial pressure

→ blood pressure = $\frac{\text{systolic}}{\text{diastolic}}$, average = $^{110}/_{70}$ mm Hg

→ pulse pressure = SP − DP , average = 40 mm Hg

→ MAP = $\frac{SP + (2 \times DP)}{3}$ average = $\frac{110 + (2 \times 70)}{3}$ = 83.3 mm Hg

- not the average of SP and DP b/c in a single cardiac cycle, aortic pressure is close to its minimum pressure for about 2x its at its max

Arterioles

- a passageway for blood to enter capillaries
- provide the greatest resistance to blood flow + resistance can be regulated to control blood flow to individual capillary beds + regulate MAP

Intrinsic Control of blood flow distribution to organs

- individual organs or tissues regulate their own blood flow based on their needs through local control
- organ blood flow = ΔP / organ resistance

↳ accomplished through relaxation or contraction of smooth muscles in arterioles

→ Responses of vascular smooth muscle in response to...

- changes in metabolic activity: causes change in extracellular fluid concentration (oxygen, carbon dioxide, etc.)
  - metabolic activity ↑ causes vasodialation (smooth muscle relaxes + radius of arterioles ↑, resistance ↓) and vice versa
  - <u>active hyperemia</u>: increase in metabolic activity followed by an increase in blood flow
- changes in blood flow
  - if blood flow was blocked, oxygen levels would ↓ and CO_2 ↑, this would cause vasodialation + a reduction in vascular resistance → increase blood flow

    → <u>reactive hyperemia</u>: this increase in blood flow in response to a previous reduction in blood flow
- Stretch of arteriolar smooth muscle
  - myogenic response: a change in vascular resistance that occurs in response to stretch of blood vessles
- Regulation by locally secreted chemical messengers

- nitric acid : released continually by endothelial cells to act on smooth muscle to promote vasodilation
- prostacyclin : an eicosanoid that causes vasodilation to prevent blood clots

Extrinsic Control of arteriole radius and MAP

- Flow rule: $F = \Delta P / R = CO = MAP / TPR \implies MAP = CO \times TPR = SV \times HR \times TPR$
- Sympathetic control: high concentrations of epinephrine promote vasoconstriction, ↑TPR and ↑MAP
- Hormonal Control
  - vasopressin (ADH): limits urine output + promotes vasoconstriction + ↑MAP
  - Angiotensin II : protein that promotes vasoconstriction + ↑MAP + ↑TPR

Capillaries + Venules

Capillaries: smallest blood vessels + consist of a single layer of endothelial cells w/ a basement membrane

↳ capillary beds : networks of capillaries that facilitate exchange of substances between blood + tissue

- continuous capillaries: tight junctions make intercellular clefts (spaces between cells) narrow to limit some movement. Highly permeable to watersoluble substances
- Fenestrated capillaries: large pores that allow rapid diffusion of small water-soluble substances
- discontinuous capillaries : serve as a transition from fenestrated capillaries to sinusoids (blood filled spaces)

- Local control of blood flow
- shunts: allow blood to flow from arterioles to venules, bypassing capillaries

- microcirculation : arterioles, capillaries + venules → can only be seen w/ a microscope