Medical Biophysics – Exam Summary

1. Blood Flow, Pressure & Circulation

Circulation basics

- **Arteries** → carry blood **away** from heart.
- **Veins** → carry blood **towards** heart.
- **Pulmonary circulation** → heart ↔ lungs.
- **Systemic circulation** → heart ↔ body.
- Blood flows **from high → low pressure**.
- Heart valves open/close according to **pressure differences** and prevent backflow.

Blood pathway:

Vena cava → RA → tricuspid valve → RV → pulmonary valve → pulmonary artery → lungs → pulmonary veins → LA → mitral valve → LV → aortic valve → aorta

Pressure

- **Systolic BP** = maximum arterial pressure during ventricular contraction.
- **Diastolic BP** = minimum pressure during relaxation.
- **Pulse pressure = systolic − diastolic pressure.**

Pressure progressively falls through the circulation, with an important pressure drop across the **arterioles**, which regulate peripheral resistance and distribution of flow.

Hydrostatic pressure

$$P = \rho g h$$

Pressure increases with:

- ↑ fluid density ρ
- ↑ gravitational acceleration g
- ↑ depth/height h

Clinical application: IV bags must be placed above the patient to generate hydrostatic pressure.

Flow

$$Q = \frac{\Delta P}{R}$$

Therefore:

- ↑ pressure difference → ↑ flow
- ↑ resistance → ↓ flow.

Continuity equation

$$A_1 v_1 = A_2 v_2$$

Therefore:

↓ cross-sectional area → ↑ velocity

and

↑ cross-sectional area → ↓ velocity

This explains the very slow flow through the enormous total cross-sectional area of the capillary bed.

Poiseuille's law

$$Q = \frac{\Delta P \pi r^4}{8 \eta L}$$

Flow:

- ↑ with **pressure difference**
- ↑ dramatically with **radius⁴**
- ↓ with ↑ **viscosity**
- ↓ with ↑ **vessel length**

Most important: vessel **radius has the greatest effect**.

Small ↓ radius → very large ↓ blood flow.

Laminar vs turbulent flow

Laminar

- Smooth
- Fluid travels in parallel layers
- Normally occurs in blood vessels

Turbulent

- Chaotic mixing
- Favoured by:
    - ↑ velocity

- ↑ vessel diameter
- ↓ viscosity
- obstruction/irregularity

Reynolds number:

$$Re = \frac{\rho v L}{\eta}$$

↑ Reynolds number → greater likelihood of turbulent flow.

Bernoulli principle

↑ fluid velocity → ↓ pressure

Therefore, when fluid passes through a narrowing:

↓ area → ↑ velocity → ↓ lateral pressure

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2. Diffusion, Osmosis & Tonicity

Cell membrane

Plasma membrane consists primarily of:

- Phospholipid bilayer
- Embedded proteins

It is **selectively permeable**.

Diffusion

Movement of particles:

High concentration → low concentration

Driven by random thermal motion.

↑ temperature → ↑ molecular motion → ↑ diffusion.

Fick's law

$$J = DA\frac{C_1 - C_2}{\Delta x}$$