Human Physiology

Curated preclinical study track (not a medical degree, no licensure claim). Original explanations and practice only, following the reviewed course handout.

The fabric in motion

- The control frame first, then the great systems (excitation, circulation, respiration, kidney), then gut and hormones.
- Every claim is an equation you can evaluate - output, alveolar gas, **clearance**, Henderson-Hasselbalch.

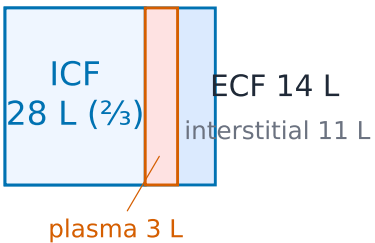
Homeostasis: three tanks, one grammar

1. **Tanks** 42 L = ICF 28 (2/3) + ECF 14 (1/3: plasma 3 + interstitial 11); water distributes by osmolality.
2. **Loop** Sensor → integrator → effector around a set point: every later system is an instance.
3. **Failure** Loops fail at sensor, effector or set point - a shifted set point is held perfectly (SIADH pattern).

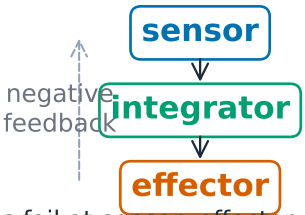
42 L in three tanks; the loop every system speaks.

the three tanks

total body water 42 L



the control grammar



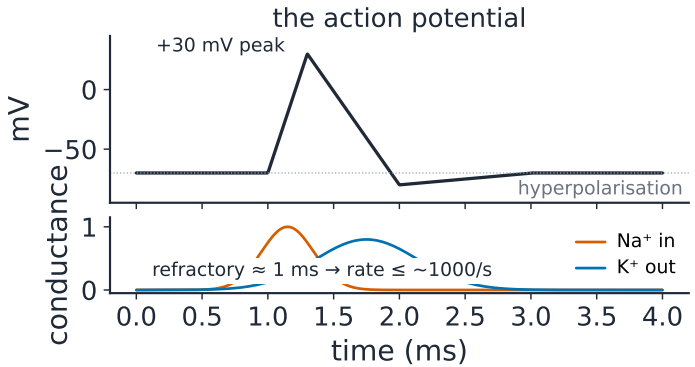
loops fail at sensor, effector, or set point

> 42 L in three tanks; the loop every system speaks.

Excitable cells: one sentence of electricity

1. **Spike** Rest -70 mV (K^+); Na^+ upstroke ($+30$, positive feedback); K^+ repolarisation; brief hyperpolarisation.
2. **Limits** Refractory $\sim$1 ms caps firing $\sim$1000/s; myelin $\rightarrow$ **saltatory conduction** up to $\sim$100 m/s.
3. **Muscle** Spike $\rightarrow$ Ca^{2+} $\rightarrow$ sarcomere: twitch 100 ms vs refractory 2 ms, so $\sim$50/s fuses into **tetanus** - never in the heart.

The action potential

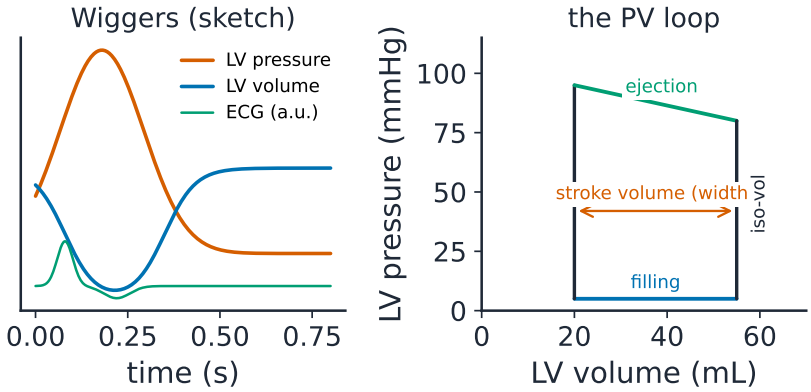


One sodium upstroke, one potassium repolarisation, one refractory gap.

Cardiovascular: the three equations

1. **Output** CO = HR × SV: 70 × 70 = 4.9 L/min; MAP = CO × SVR; MAP ≈ DBP + (SBP−DBP)/3 ≈ 93 mmHg.
2. **Loop** PV loop: width = **stroke volume**, area = work; preload widens (Starling), contractility tilts, afterload narrows.
3. **Shock** Haemorrhage: CO 5→3 with SVR up by two-thirds holds pressure at baseline while organ flow has fallen 40% - trust perfusion, not the cuff.

Cardiovascular physiology - the PV loop

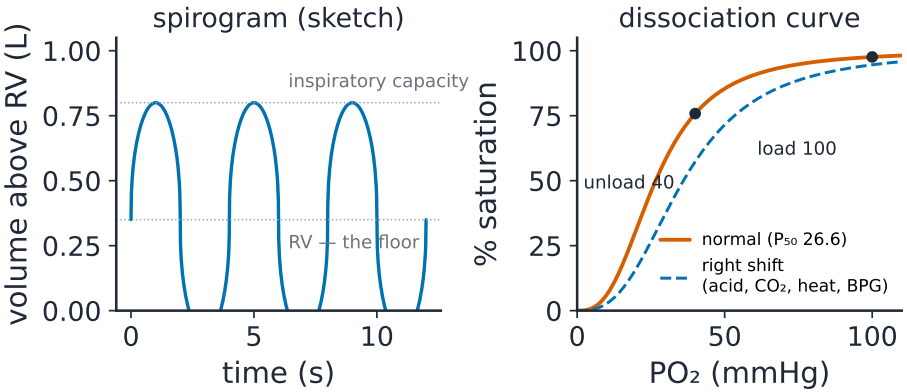


Wiggers sketch beside the pressure-volume loop (width = SV).

Respiratory physiology: one equation, one curve

1. **Equation** Alveolar $PO_2 = 150 - (CO_2 \div 0.8)$ $\rightarrow$ 100 mmHg at CO_2 40; A-a gradient normal 5–15.
2. **Sorting** Shunt and V/Q mismatch WIDEN the A-a gradient; hypoventilation and altitude keep it normal.
3. **Curve** P50 26.6 mmHg; loads 100 $\rightarrow$ 97%, unloads 40 $\rightarrow$ ~75%; right shift with acid, CO_2, heat, BPG; saturation is not content.

Respiratory physiology - spirogram and curve



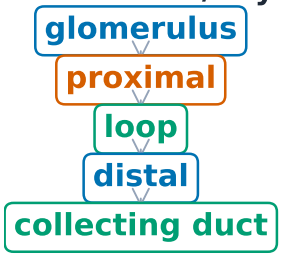
Spirogram sketch; dissociation curve with its right shift.

Renal: the chemists arithmetic

1. **Filtration** GFR 125 mL/min $\rightarrow$ 180 L/day, >99% back: proximal 65% Na^+, loop 25%, distal taps under **aldosterone** and **ADH**.
2. **Clearance** $C = UV/P$: creatinine approximates GFR; PAH (one-pass) = renal plasma flow.
3. **Acid-base** $pH = 6.1 + \log(HCO_3 \div (0.03 \cdot PCO_2))$; Winter: expected $PCO_2 = 1.5 \times HCO_3 + 8$ — mismatch = second disorder.

Renal physiology - transport map

180 L/day in → ~1.5 L out (>99% back)



filter 125 mL/min

65% Na^+ back

25% Na^+ back

aldosterone: $Na^+ \leftrightarrow K^+/H^+$

ADH: water channels

The transport map with percentages and the two hormonal taps.

Gastrointestinal: nine litres, four stations

1. **Ledger** 9 L/day in (drink 2, food 1, secretions 6): jejunum the workhorse, ileum signs for B12 and bile salts, colon polishes ~1.3 L.
2. **Control Enteric nervous system** (the local plexus) under vagus and gastrin/secretin/CCK.
3. **Failure** Ileal resection: B12 out (years of stores) AND bile salts lost (days to weeks) - one segment, two clocks.

Absorption by segment with the nine-litre ledger.

9 L in → ~0.15 L out

stomach > **duod/jejunum** > **ileum** > **colon** >

chyme + acid

workhorse: sugars, peptides, iron, folate

B12 + bile salts (signed for here)

water (~1.3 L), microbiota

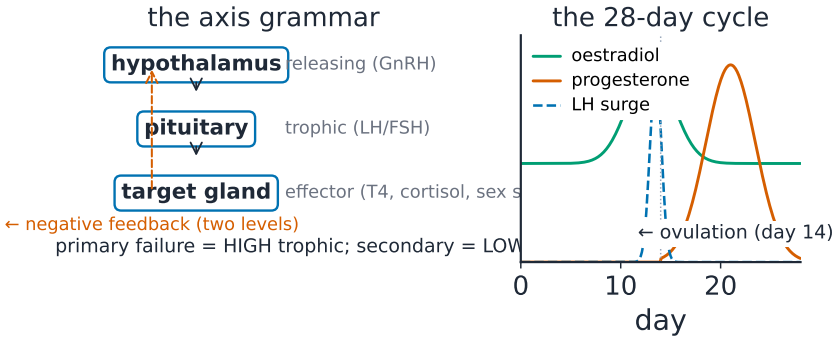
ileal failure = B12 deficiency AND bile-salt diarrhoea

Absorption by segment with the nine-litre ledger.

Endocrine: one grammar, every axis

1. **Axis** Releasing $\rightarrow$ trophic $\rightarrow$ effector $\rightarrow$ feedback at both higher levels; 28-day rhythm in reproduction.
2. **Labs** Primary failure = HIGH trophic; secondary = LOW both - one pattern pair retires a dozen syndromes.
3. **Cycle** Ovulation = oestradiol flipping to POSITIVE feedback once per cycle: the LH surge; unopposed oestrogen names the risk.

The axis grammar beside the 28-day cycle sketch.



The axis grammar beside the 28-day cycle sketch.

Check yourself

- **Cardiac output** at HR 70, SV 70 mL? (~5 L/min.)
- Alveolar PO_2 at CO_2 40, R 0.8? (~100 mmHg.)
- Winter for HCO_3 12? (PCO_2 26 $\pm$ 2.)
- Free T4 low, TSH high? (Primary thyroid failure.)