# Transport

B3.2 · SL

# A pump cannot replace local exchange surfaces

## Follow the conducting pathway and the exchange step

Common content: capillaries, arteries and veins; pulse and coronary evidence; absorbed nutrients; xylem water transport and dicot tissue plans.

All numerical examples are invented teaching data.

# Branching and narrow lumens solve different problems

## Distinguish one vessel from the whole capillary bed

Many branches provide a large collective surface area. A narrow lumen brings red cells close to a one-cell-layer endothelial wall.

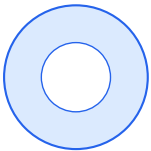
A large combined cross-sectional area lowers average velocity at the same total flow. Thin walls shorten diffusion distance.

Fenestrations in some capillaries aid rapid selected exchange, rather than permitting unrestricted loss of blood cells.

# Use combined area when predicting average velocity

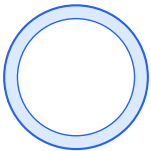
1. **Relation.** Volume flow per time = average velocity × total cross-sectional area.
2. **Controlled change.** At unchanged flow, five times total area gives one-fifth velocity; eight times gives one-eighth.
3. **Limit.** Adequate gradients, permeability and perfusion are still required. One narrow capillary is not the whole parallel network.

# Identify structures without assuming oxygen content



**Artery**

Muscle + elastic wall
Relatively thick



**Vein**

Flexible thin wall
Many have valves



**Capillary**

Thin endothelium
Narrow lumen

> Direction defines artery and vein; compare wall and lumen in equivalent vessel sizes.

# Connect wall structure to pressure and return

| Feature | Functional explanation |
| --- | --- |
| Arterial muscle/elastic tissue | Withstands pressure; stretch and recoil sustain pressure between ejections |
| Venous compliance | Permits compression by surrounding muscles |
| Valves in many veins | Limit reverse flow under changing pressure; do not actively pump |
| Identification | Combine wall/lumen ratio, tissue structure and preparation limits |

# Wall-to-lumen ratio supports an identification

1. **Matched model vessels.** A: wall 0.30 mm, lumen diameter 1.20 mm. B: wall 0.10 mm, lumen 2.00 mm.
2. **Ratios.** A: $0.30/1.20 = 0.25$. B: $0.10/2.00 = 0.05$. A is more consistent with a thicker-walled artery.
3. **Caution.** Section angle, collapse and vessel size matter. Pulmonary arteries are relatively oxygen-poor; pulmonary veins oxygenated.

# Convert interval counts and keep repeats distinct

1. **Three 15-second counts.** 18, 19 and 18 beats give 72, 76 and 72 beats/minute; mean about 73.3.
2. **Counting error.** One missed beat changes the estimate by four beats/minute for 15 seconds, but one for a full minute.
3. **Sampling.** Use approved voluntary resting radial measurements or supplied data. Standardize posture, rest and timing. One person measured three times is not three people.

# Pulse is a pressure wave, not a packet of blood

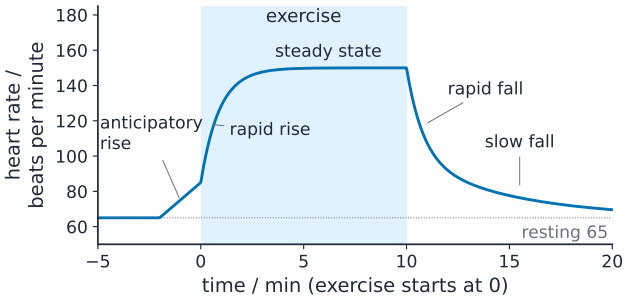
## Rate does not provide every circulation quantity

A pulse reflects a travelling pressure wave associated with ventricular ejection.

Pulse count alone does not give stroke volume, cardiac output or blood pressure. Compare sensor and manual methods where appropriate.

Use fingertips lightly at the wrist under an approved protocol and record variation.

# Heart rate around a run




A rapid fall, then a slow fall to rest

# Coronary blood supplies the contracting muscle

## Trace obstruction to impaired ATP supply and contraction

The thick myocardium cannot rely on blood inside chambers supplying it by diffusion alone. Coronary vessels provide its own supply.

Atherosclerotic plaque can narrow arteries; plaque disruption can trigger an obstructing thrombus.

Reduced oxygen delivery limits aerobic ATP production and contraction. Prolonged severe ischaemia can kill muscle.

# Interpret risks before claiming a cause

1. **Invented cohort.** 30 outcomes/600 exposed versus 12/600 comparison participants over ten years.
2. **Compare.** Risks 5% and 2%; difference three percentage points; risk ratio 2.5.
3. **Evaluate.** Age, smoking, activity, measurement and follow-up can confound comparison. Even a strong correlation does not by itself prove causation.

# Keep chemical breakdown, crossing and bulk movement separate

| Process | Example and limit |
| --- | --- |
| **Digestion** | Enzymes produce absorbable products; bile assists emulsification but is not an enzyme |
| **Absorption** | Sugars/amino acids enter blood; much packaged dietary lipid initially enters intestinal lymph |
| Transport | Blood or lymph distributes absorbed material |
| Food tests | Controlled component detection is not evidence that a food causes a health outcome |

# Trace the origin and transmission of the pull

1. **Evaporation.** Water leaves moist mesophyll walls; curved interfaces in wall pores generate tension.
2. **Transmission.** Water is drawn from xylem toward walls. Cohesion helps maintain a continuous column; adhesion supports wall contact.
3. **Pathway.** Water-potential differences drive flow through soil, plant and atmosphere. Xylem sap may be under negative pressure; it is not an ATP-powered water pump.

# Explain the vessel adaptation rather than listing it

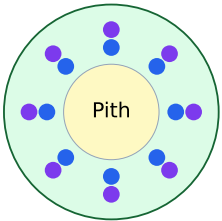
| **Xylem feature** | **Functional consequence** |
|---|---|
| Dead, hollow elements | Lack of contents leaves a low-resistance lumen |
| Open/perforated ends | Permit longitudinal flow |
| Lignified walls | Resist collapse under tension |
| Pits | Permit lateral exchange through appropriate wall regions |

# Negative pressure is still a pressure comparison

1. **Same height and solute conditions.** Root xylem $-0.2$ MPa; leaf xylem $-0.8$ MPa.
2. **Compare.** The leaf pressure is lower by 0.6 MPa, favouring movement toward it.
3. **Limits.** Whole-plant movement also depends on height, solute contributions, resistance and pathway continuity. Cavitation can disrupt conducting columns.

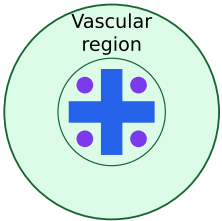
# Locate transport tissues before drawing individual cells

**Young dicot stem**




Epidermis outside; cortex within

**Young dicot root**




Epidermis outside; cortex within

Blue: xylem  Purple: phloem

Stem bundles form a peripheral ring; root vascular tissues occupy a central region in this representative model.

# Annotate a plan with the main tissue functions

| Region | Location and function |
| --- | --- |
| Stem bundle | Xylem toward centre, phloem outward; water support and organic-solute transport |
| Root vascular cylinder | Often star-shaped xylem, phloem between arms |
| Cortex/epidermis | Surrounding tissues; storage/support and outer interface |
| Plan drawing | Tissue regions and relative positions, not every nucleus or sieve pore |

# Calibrate a measurement in the same units

1. **Invented image.** Stem image 12 mm across; specimen 0.60 mm.
2. **Magnification.** $12/0.60 = 20$. A 3.0 mm cortex region in the image is $3.0/20 = 0.15$ mm in the specimen.
3. **Drawing.** Use clear tissue boundaries, labels and relative positions. Match the actual section because species, age and secondary growth alter patterns.

# Attempt the complete handout questions before checking

## Start with units, direction and the comparison model

Wall/lumen pairs 0.24/0.96 and 0.08/1.60 mm: calculate ratios and justify identification.

Counts 23, 24, 25 in 20-second intervals: calculate rates and mean; explain sampling limits.

Coronary cohort: 24/400 versus 8/400. Calculate risks, difference and ratio; evaluate causation.

# Check the main quantitative comparisons

1. **Vessels and pulse.** Ratios 0.25 and 0.05; thicker relative wall supports arterial identification. Rates 69, 72, 75; mean 72 beats/minute.
2. **Cohort.** 6% versus 2%; difference four percentage points; risk ratio three. Check confounding and measurement/follow-up.
3. **Plant image.** $18/0.90 = 20\times$; image region $4/20 = 0.20$ mm. Pressure $-0.9$ versus $-0.3$ MPa differs by 0.6 MPa.

# Check yourself

## Name direction, pathway, pressure and evidence

Distinguish individual vessels from collective capillary area; sample repeats from independent participants; components from causal health outcomes.

In plants trace the force-generating process and the conducting tissue. Use the actual tissue section.