REAL-LIFE BIOLOGY

Multicellular Organisms

Teacher guide

For the National 5 Biology workbook



C. Blewis

Blewis LEARNING

Using the workbooks

The National 5 Biology workbook for **Multicellular Organisms** has seven topics. Every topic has learning pages, a practical the learner plans and evaluates, a brain break and an exam-style check-up.

PRACTICALS

Learners plan each investigation (variables, prediction, kit, risk, method), take repeat readings, work out averages, draw graphs with their own scales, and write conclusions and evaluations.

PRACTICAL SAFETY

Every practical has a Stay safe table and a teacher note with hazards, adapted versions and common problems. The Stay safe tables and these notes are a starting point, not a complete risk assessment: the teacher or school must risk assess every practical for their own learners, room and kit before use, following their employer's policies and national guidance (in Scotland, SSERC). Always check learners' care plans and medical information. Activities with flames or microbes are teacher demonstrations, with example results provided.

NO LAB, NO KIT, OR A LEARNER ABSENT

Each practical includes example results so learners can still complete the results, graph, conclusion and evaluation.

EVIDENCE

The practicals develop the skills needed for the assignment and for questions on experimental work in the exam; the learn pages and check-ups build knowledge and problem solving. The skills tracker at the back of each workbook can be signed off as you go. Always check the latest course documents and your centre's arrangements.

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TEACHER NOTES

Practical 1: Stages of mitosis in a root tip

Time	One 50-minute lesson. Pupils need about 25 minutes at the microscope.
Kit per pair	Light microscope with × 400, a prepared and stained root-tip slide (garlic, onion or broad bean), tally chart. Projected photographs of a root tip work as a full alternative.
Prep	Use commercially prepared slides. Do not have pupils prepare root squashes with acid and stain at this level. Check every microscope focuses at × 400 near the tip region.
Expected results	Roughly 75 to 85% of cells not dividing; of the dividing cells, the first stage (chromosomes condensing) is the most common.
Level	N5 identifies variables, takes counts from several fields, processes them into percentages and evaluates reliability.

Safety and inclusion

- Glass slides: carry flat, report breakages. Never use a mirror with direct sunlight.
- Pupils who find microscopes hard can count from a printed or projected image; the skills assessed are the same.
- Risk assess this practical for your own learners, room and kit, following your employer's policies and SSERC guidance.

Common problems

- **Counting the wrong region:** dividing cells are only near the very tip.
- **Unclear stages:** show labelled photos of each stage first.
- **Percentage of the wrong total:** decide whether the question asks about all cells or dividing cells only.

No lab, no time, or a learner absent?

The sample results let learners complete the totals, percentage, bar chart, conclusion and evaluation.

Assessment link

Practises assignment skills: raw data in a table, processed data (totals and percentages), a bar chart, a conclusion linked to the aim and evaluation of reliability.

Answers: Topic 1

Topic 1: Producing new cells (N5)

1 The stages of mitosis

1 (1) Chromosomes become visible as two chromatids; (2) chromosomes line up at the equator; (3) spindle fibres pull the chromatids to opposite poles; (4) a nuclear membrane forms round each group, making two nuclei; (5) the cytoplasm divides, giving two cells.

2 They attach to the chromosomes and pull the chromatids apart to opposite poles of the cell.

3 Each chromosome is copied exactly before division, and one chromatid of every chromosome goes to each new nucleus, so both get a full, identical set.

2 Why mitosis matters

1 78, because mitosis keeps the diploid chromosome number the same as the parent cell.

2 Growth (more cells as it gets bigger) and repair (replacing damaged cells, e.g. bark or leaves eaten by insects).

3 2 hours = 6 divisions, so $2^6 = 64$ cells.

4 Mitosis keeps the chromosome number the same (diploid); it is gamete production that halves it.

3 Stem cells and organisation

1 Unspecialised; can divide to make more stem cells (self-renew); can differentiate into specialised cells. Any two.

2 e.g. bone marrow transplant for blood disorders, skin grafts for burns, research or drug testing.

3 Cell, tissue, organ, system.

Practical 1: Stages of mitosis

Dependent: number of cells at each stage. Independent: the stage of mitosis. Controlled: same slide and region of the root tip, same magnification, same rules for deciding the stage.

Prediction, e.g. chromosomes becoming visible, because it is the longest stage.

Equipment: microscope, prepared slide, pencil and tally chart, microscope lamp (if the microscope needs one). Not needed: thermometer, stopwatch.

Hazards, e.g. broken glass (report it, do not handle); microscope lamp gets hot (do not touch the bulb); using sunlight with a mirror (never point at the Sun, it can damage eyes).

Method key points: focus on low power then × 400 near the very tip; use a fixed description of each stage; count every cell in each field; count at least five fields; % = number at a stage ÷ total × 100.

Totals: not dividing 209, chromosomes visible 27, lined up 12, separating 7, two nuclei forming 7; total 262 cells. Dividing = 53 ÷ 262 × 100 = 20.2%.

Bar chart: four bars (27, 12, 7, 7), labelled axes with the stage and number of cells. Conclusion: chromosomes becoming visible lasts longest, because most dividing cells were at that stage.

9a One field could be unusual; more fields give a better average and show whether results are consistent. 9b Stages blend into each other; agree clear descriptions or photos of each stage before counting, or have one person check all the counts.

Check-up

1 B (1)

2 Chromosomes become visible as two chromatids (1); they line up at the equator and spindle fibres attach (1); chromatids are pulled to opposite poles and a nucleus forms at each pole (1).

3 So every new cell has the full set of genetic information (1).

4(a) Unspecialised cell (1) that can divide/self-renew and differentiate into specialised cells (1). (b) e.g. skin grafts, research, drug testing (1).

5 System (1).

TEACHER NOTES

Practical 2: Reaction time and hand

Time	One 50-minute lesson including processing. Each pair needs about 10 minutes for the drops.
Kit per pair	30 cm ruler, table and chair. The conversion table on the page avoids the physics calculation.
Prep	Demonstrate the starting position: catcher's thumb and finger level with 0 cm, not touching the ruler; the dropper gives no warning.
Expected results	Catch distances of 10 to 25 cm (0.14 to 0.23 s). Many learners show little difference between hands; this is a good evaluation point.
Level	N5 identifies variables, calculates means, converts data using a table, presents a bar chart and evaluates fairness.

Safety and inclusion

- Low risk. Keep rulers vertical and away from faces; clear the table.
- Be sensitive to learners with motor coordination difficulties or hand injuries: they can drop the ruler, record or use the sample data.
- Risk assess this practical for your own learners and room, following your employer's policies and SSERC guidance.

Common problems

- **Calling the ruler catch a reflex:** it is a voluntary, learned response involving the brain.
- **Anticipating the drop:** vary the waiting time before each drop.
- **Mean in the wrong units:** find the mean distance first, then use the table.

No lab, no time, or a learner absent?

The sample results let learners calculate means, convert them and complete the bar chart, conclusion and evaluation.

Assessment link

Practises assignment skills: raw data with units, a mean, a data conversion, a bar chart, a conclusion and evaluation of fairness and reliability.

Answers: Topic 2

Topic 2: Control and communication (N5)

1 The nervous system

1 Brain and spinal cord.

2 Cerebrum: deciding where to pass, remembering tactics (conscious thought, memory). Cerebellum: keeping balance and coordinating a kick. Medulla: raising breathing and heart rate during a sprint.

3 Medulla.

2 Neurons and reflexes

1 Receptor, sensory neuron, inter neuron, motor neuron, effector.

2 The impulse goes through the spinal cord (or a short pathway) without the brain having to think and decide, so fewer steps and no delay for conscious thought.

3 The impulse makes the end of one neuron release chemicals, which diffuse across the gap and start an impulse in the next neuron.

4 e.g. blinking, pulling a hand away from heat, coughing, the pupil narrowing in bright light. Any two.

3 Hormones and blood glucose

1 Only target tissue cells have receptors with a shape complementary to the hormone, so it can only bind to and act on those cells.

2 The pancreas detects the rise and releases insulin; insulin makes the liver convert glucose into glycogen, so blood glucose falls back to normal.

3 Glucagon; it makes the liver convert glycogen into glucose, which raises blood glucose.

Practical 2: Reaction time and hand

Independent: hand used (writing hand or other hand). Dependent: catch distance (cm), changed to reaction time (s). Controlled: same person catching, same ruler, same starting position (thumb and finger level with 0), same posture, no warning before the drop, same number of tries.

Prediction, e.g. the writing hand will be faster because it is used more and is better coordinated.

Equipment: 30 cm ruler, partner, chair and table, pencil. Not needed: stopwatch (the ruler measures the time), thermometer.

Hazards, e.g. ruler falling on feet or glassware; poking an eye with the ruler (hold it vertically, not near the face).

Headings: Hand, Try 1 (cm), Try 2 (cm), Try 3 (cm), Mean (cm).

Sample results: right hand mean = (18 + 15 + 16) ÷ 3 = 16.3 cm, about 0.18 s; left hand mean = (23 + 21 + 25) ÷ 3 = 23.0 cm, about 0.22 s (reading between 20 and 25 cm on the table).

Bar chart: two labelled bars with reaction time (s) on the y-axis. Conclusion: Kai's writing (right) hand had a shorter reaction time, about 0.18 s against 0.22 s.

9a One try may be unusual (lucky guess or distraction); a mean reduces the effect of one odd result. 9b e.g. more tries, test several people, give a practice try first with each hand, same partner and drop height, so differences are due to the hand only. 9c The response is voluntary: the impulse goes to the brain, which decides to close the hand; a reflex is automatic and does not involve conscious thought.

Check-up

1 B (1)

2(a) Receptor in the skin detects the stimulus and sends an impulse along a sensory neuron (1) to an inter neuron in the spinal cord / CNS (1), then along a motor neuron to the effector (leg muscle), which contracts (1). (b) It is rapid and automatic, so it protects the foot from damage (1).

3 Pancreas (1)

4 When blood glucose falls, glucagon is released by the pancreas (1); it makes the liver convert glycogen into glucose, raising blood glucose (1).

5 Liver cells have receptors complementary to glucagon; muscle cells do not (1).

TEACHER NOTES

Practical 3: Pollen tube growth in sucrose

Time	One 50-minute lesson: set up in 15 minutes, leave 30 minutes (teach learn page 3 meanwhile), count in 10 minutes. Some pollen needs longer; set up at the start of a double.
Kit per group	Microscope, fifteen cavity slides (three per concentration), droppers, sucrose solutions 0, 5, 10, 15 and 20%, fresh flowers with ripe anthers (sweet pea, lily, tulip or busy lizzie work well).
Prep	Make up sucrose solutions in advance. Test that your flowers germinate within 30 minutes; a trace of boric acid is sometimes added in published methods, but is not needed for this lesson.
Expected results	A peak germination at about 10 to 15% sucrose, low in water and at high concentrations.
Level	N5 plans variables, repeats, processes counts into percentages, draws a line graph and evaluates.

Safety and inclusion

- Check for hay fever and pollen allergies; affected learners record and count from photographs.
- Glass slides: report breakages. Microscope lamps get warm.
- Risk assess this practical for your own learners, room and kit, following your employer's policies and SSERC guidance.

Common problems

- **No germination:** anthers not ripe, or too little time; use the sample results.
- **Counting the same grain twice:** scan the slide in strips.
- **Mean not changed to a percentage:** divide by 50 and multiply by 100.

No lab, no time, or a learner absent?

The sample results let learners find means and percentages, draw the line graph and write the conclusion and evaluation.

Assessment link

Practises assignment skills: raw data, processed data (means and percentages), a line graph with labelled axes and units, and a conclusion linked to the aim.

Answers: Topic 3

Topic 3: Reproduction (N5)

1 Diploid and haploid cells

1 22.

2 Sperm: testes; has a tail to swim to the egg (or many mitochondria). Egg: ovaries; large food store in the cytoplasm for the embryo.

3 So that when two gametes fuse at fertilisation, the zygote has the diploid number again; otherwise the chromosome number would double every generation.

2 Gametes in flowering plants

1 Anther. 2 Ovary (inside the ovules). 3 7.

4 Similar: both are haploid (or both fuse at fertilisation). Different: plant male gametes are inside pollen grains and travel down a pollen tube, while sperm swim; or the female gamete is inside an ovule.

3 Fertilisation

1 The first cell of a new organism, formed when two gamete nuclei fuse.

2 Each gamete is haploid with one set of chromosomes; fusing gives two sets.

3 Each kit gets a different mix of chromosomes from each parent, because each sperm and egg carries a different combination of genetic information.

Practical 3: Pollen tube growth

Independent: sucrose concentration (%). Dependent: percentage of grains with a pollen tube. Controlled: type of flower, time (30 minutes), temperature, volume of solution, number of grains counted.

Prediction, e.g. more grains will grow a tube as the sucrose concentration rises, up to a point.

Equipment: microscope, cavity slides, dropper, sucrose solutions, timer. Not needed: balance, thermometer (unless monitoring the room).

Hazards, e.g. pollen allergy (as given); broken glass slides (report, do not handle); microscope lamp hot.

Method key points: a drop of each solution on a cavity slide; dust pollen from a ripe anther on to the drop; leave 30 minutes in the same place; count 50 grains on each slide; a grain counts if its tube is longer than the grain is wide; three slides per concentration.

Headings: Sucrose concentration (%), Slide 1, Slide 2, Slide 3, Mean percentage with a tube (%).

Means: 5, 19, 32, 26, 12 grains, so 10%, 38%, 64%, 52%, 24%. Line graph: concentration on the x-axis (0 to 20%), percentage on the y-axis, points joined or a smooth curve.

Conclusion: germination increases as sucrose rises to 10% (64%) and then falls at higher concentrations; 10% gave the most pollen tubes.

9a To reduce the effect of an unusual slide and show whether results are consistent. 9b Sucrose provides the energy (food) for the pollen tube to grow; with no sugar there is little energy, and water may enter the grains by osmosis.

Check-up

1 C (1) 2 B (1)

3 A pollen tube grows to the ovule / the male gamete travels down a pollen tube (1); its nucleus fuses with the nucleus of the female gamete in the ovule (1).

4(a) 32 (1). (b) It is made by the fusion of two haploid gametes, each with 32 chromosomes (1).

5 e.g. tail to swim to the egg; many mitochondria to release energy for swimming (1).

TEACHER NOTES

Practical 4: Modelling a monohybrid cross with beads

Time	One 50-minute lesson. 40 draws take a pair about 10 minutes; collecting class totals is the key step.
Kit per pair	Two opaque bags or cups, each with 50 dark and 50 light beads of the same size (counters, dried beans or paper slips also work), a tray, a tally chart.
Prep	Put the class totals table on the board and add each group's results.
Expected results	Individual groups vary widely; class totals approach 1 : 2 : 1 and 3 : 1.
Level	N5 uses a model, records tallies, combines data, calculates a ratio and evaluates sample size and the model.

Safety and inclusion

- Low risk. Beads can be a slip and choking hazard: work over trays; use larger counters for any learner who mouths objects.
- Learners with fine motor difficulties can be the recorder.
- Risk assess this activity for your own learners and room, following your employer's policies and SSERC guidance.

Common problems

- **Not putting beads back:** this changes the odds as the bag empties.
- **Writing bB:** always write the dominant allele first, Bb.
- **Ratio not simplified:** divide both numbers by the smaller one.

No lab, no time, or a learner absent?

The sample results let learners total the data, find the ratio, draw the bar chart and evaluate.

Assessment link

Practises assignment skills: recording and combining data, processing into a ratio, presenting in a bar chart and evaluating sample size.

Answers: Topic 4

Topic 4: Variation and inheritance (N5)

1 Discrete and continuous variation

1 Discrete: eye colour in fruit flies, ear-lobe type. Continuous: mass of eggs, length of leaves.

2 A histogram (or line graph of grouped data), because mass is continuous variation with a range of values, not separate groups.

3 A characteristic controlled by many genes.

2 The language of genetics

1 Gene: a section of DNA that codes for a protein. Allele: a different form of a gene. Genotype: the alleles an organism has. Phenotype: the characteristic that shows (the appearance). Dominant: an allele that shows whenever it is present. Recessive: an allele that only shows when there is no dominant allele (two recessive alleles). Homozygous: two identical alleles. Heterozygous: two different alleles.

2 B is dominant, so it shows even though the b allele is also present.

3 Monohybrid crosses

1 Gametes T and t from each parent; offspring TT, Tt, Tt, tt; 3 tall : 1 dwarf.

2 31 : 9 (about 3.4 : 1), since 62 ÷ 18 = 3.44. Fertilisation is random, so the real numbers vary from the prediction, especially with small numbers.

3 Bb (a BB parent could not give white offspring).

Practical 4: Bead model of a Bb × Bb cross

Record: the genotype of each pair (BB, Bb or bb) as a tally. Keep the same: 50 of each bead in each bag, take one bead from each bag, take without looking, mix before each draw. The bead goes back so the bag always has a 50 : 50 chance, like a parent always making equal numbers of B and b gametes.

Prediction: about 10 BB, 20 Bb and 10 bb out of 40.

Equipment: two bags of beads, tally chart, partner. Not needed: balance, stopwatch.

Hazards, e.g. beads on the floor (as given); small beads near the mouth (do not put them in your mouth).

Sample totals: BB 31, Bb 59, bb 30, total 120. Black = 90, white = 30, ratio 90 : 30 = 3 : 1. Bar chart: three bars labelled BB, Bb, bb.

Conclusion: the combined results were very close to 1 : 2 : 1 (and 3 : 1); single groups varied more.

9a Yes: with more offspring the effect of chance evens out, so the results get closer to the predicted ratio. 9b e.g. real gametes are not beads; organisms do not make exactly equal numbers of offspring; real crosses produce far fewer offspring; some offspring may not survive.

Check-up

1 B (1)

2(a) HH (1). (b) Gametes H and h from the bull, h from the cow (1); offspring Hh and hh (1); 50% with horns (1). (c) Fertilisation is random (1).

3 The characteristic that shows / its appearance (1).

TEACHER NOTES

Practical 5: Wind and transpiration with a potometer

Time	One 50-minute lesson with the potometers set up beforehand. Each reading takes 5 minutes plus 5 minutes settling.
Kit per group	Bubble potometer (or a simple capillary tube and rubber tubing), leafy shoot (laurel, privet or willow), petroleum jelly, fan with guard, metre stick, stopwatch.
Prep	Cut shoots under water with a sharp blade (teacher only) and fit them under water. Seal joints with petroleum jelly. Check each potometer for leaks before the lesson.
Expected results	Rate falls as the fan moves away. Readings drift if the room warms up, so record the temperature.
Level	N5 identifies variables, repeats, calculates means and rates, draws a line graph and evaluates the method.

Safety and inclusion

- Use a PAT-tested fan and check the plug and cable before use; dry hands; switch off at the socket before moving the fan; or use a battery or USB fan. Keep fans and cables away from water; use a fan with a blade guard. Only the teacher uses blades.
- Glass capillaries can break: handle and clamp with care.
- Risk assess this practical for your own learners, room and kit, following your employer's policies and SSERC guidance.

Common problems

- **Air leaks:** the bubble stops or jumps; reseal or remount under water.
- **Not waiting to settle:** results are inconsistent.
- **Rate not calculated:** divide the mean distance by the time.

No lab, no time, or a learner absent?

The sample results let learners calculate means and rates, draw the graph and complete the conclusion and evaluation.

Assessment link

Practises assignment skills: raw data with units, means and rates, a line graph with a curve of best fit, and evaluation of controlled variables.

Answers: Topic 5

Topic 5: Transport systems: plants (N5)

1 Plant organs and the leaf

1 Upper epidermis: protective, transparent layer that lets light through (often with a waxy layer). Palisade mesophyll: most photosynthesis, packed with chloroplasts. Spongy mesophyll: some photosynthesis; air spaces for gas exchange. Guard cells and stomata: control gas exchange and water loss. Vein: carries water in (xylem) and sugar out (phloem).

2 They get the most light there, and lots of chloroplasts absorb light for photosynthesis.

2 Water and transpiration

1 Soil → root hair cells (osmosis) → xylem in the root, stem and leaf vein → mesophyll cells → evaporates into air spaces → diffuses out of the stomata.

2 Lignin strengthens the walls so the vessels do not collapse and can support the plant.

3 e.g. high temperature makes water evaporate faster; wind carries water vapour away from the leaves; so the seedlings lost water faster than the roots could take it up.

4 Transpiration slows down (less water vapour can escape).

3 Sugar transport in phloem

Table: xylem dead, phloem living; xylem water and minerals, phloem sugar; xylem upwards, phloem up and down; xylem lignin and hollow, phloem sieve plates and companion cells.

1 Companion cells. 2 Sugar made in the leaves is carried down to the tubers in the phloem, where it is turned into starch. 3 Every cell needs water from the xylem, and sugar made in every part of the leaf must be carried away in the phloem.

Practical 5: Wind and transpiration

Independent: distance from the fan (cm). Dependent: rate of water uptake (distance the bubble moves per minute). Controlled: same shoot, same temperature, same light, same humidity, same fan setting, same time for each reading.

Prediction, e.g. the closer the fan, the faster the rate, because faster-moving air removes water vapour from around the leaves.

Equipment: leafy shoot in a potometer, fan, metre stick, stopwatch, ruler (scale on the potometer). Not needed: balance, microscope.

Hazards, e.g. fan and water (as given); glass capillary tube breaking (handle with care, teacher sets up); fan blades (keep the guard on, do not touch).

Method key points: cut the shoot under water and fit it under water so no air enters; seal joints; let a bubble into the capillary; leave 5 minutes at each distance to settle; measure the distance moved in 5 minutes; reset the bubble with the reservoir; three runs at each distance.

Headings: Distance from fan (cm), Run 1, Run 2, Run 3 (mm), Mean (mm), Rate (mm/min). Means 45, 32, 22, 17 mm; rates 9.0, 6.4, 4.4, 3.4 mm/min.

Line graph: distance from fan on the x-axis, rate on the y-axis, a smooth curve falling with distance. Conclusion: the closer the fan (higher wind speed), the faster the rate of water uptake and transpiration.

9a Almost all the water taken up is lost by transpiration, so the uptake rate is a fair way to compare (a small amount is used in photosynthesis or kept in cells). 9b So the plant could adjust to the new conditions and the reading was steady.

Check-up

1 B (1)

2 Any two (1 each): xylem is dead, phloem living; xylem carries water, phloem sugar; xylem has lignin, phloem has sieve plates and companion cells; xylem moves upwards, phloem up and down.

3 33 ÷ 6 = 5.5 mm/min (1)

4 Higher humidity means more water vapour in the air outside the leaf (1), so water vapour diffuses out more slowly and transpiration decreases (1).

5 Guard cells (1) 6 Anchor the plant, or absorb water and minerals (1)

TEACHER NOTES

Practical 6: Pulse recovery after exercise

Time	One 50-minute lesson for one or two runs per pair. Three full runs need the 10-minute rests, so groups can pool data or use the sample results.
Kit per pair	A low, stable step (a gym bench or step about 20 to 30 cm), stopwatch, a metronome or music for a steady beat. A pulse oximeter or fitness tracker is a useful check.
Prep	Teach finding the pulse at the wrist (radial) or side of the neck (carotid, gently). Clear the space.
Expected results	Resting 60 to 90 beats/min, rising to 110 to 150 after exercise and recovering over 3 to 6 minutes.
Level	N5 plans variables, repeats, processes into means and rates, draws a line graph and evaluates.

Safety and inclusion

- Check care plans: asthma, heart conditions, recent illness or injury. Participation is voluntary; any learner can be the timer or recorder and use the sample data.
- Low step, clear floor, sensible footwear. No competition between learners; be sensitive about fitness and body image.
- Risk assess this practical for your own learners and room, following your employer's policies and SSERC guidance.

Common problems

- **Counting with the thumb:** the thumb has its own pulse; use two fingers.
- **Late first reading:** start counting immediately after the exercise stops.
- **Forgetting to multiply by 4.**

No lab, no time, or a learner absent?

The sample results let learners calculate means and rates, draw the graph and complete the conclusion and evaluation.

Assessment link

Practises assignment skills: raw data, processed data, a line graph with a reference line, a conclusion and evaluation of the method.

Answers: Topic 6

Topic 6: Transport systems: animals (N5)

1 What blood is made of

1 Haemoglobin.

2 Any two: haemoglobin binds oxygen; biconcave shape gives a large surface area for oxygen to diffuse in; no nucleus leaves more room for haemoglobin.

3 More red blood cells (more haemoglobin) can carry more oxygen to her muscles for respiration.

4 It engulfs the bacterium and digests it (phagocytosis).

2 The heart

1 Pulmonary artery.

2 The left ventricle pumps blood all round the body, which needs a higher pressure; the right ventricle only pumps blood to the lungs nearby.

3 They stop blood flowing backwards.

4 The heart muscle no longer gets enough oxygen (and glucose) for respiration, so part of the muscle stops working or dies.

3 Arteries, veins and capillaries

1 Artery: thick muscular, elastic wall; narrow channel; no valves; carries blood at high pressure. Vein: thinner wall; wide channel; valves; low pressure, valves stop backflow. Capillary: wall one cell thick; very narrow (one red cell wide); no valves; exchange of materials with cells.

2 So substances such as oxygen and glucose only have a short distance to diffuse between the blood and the cells.

3 Blood in veins is at low pressure and could flow backwards; valves stop this. In arteries the high pressure from the heart keeps blood moving forward.

Practical 6: Pulse recovery

Independent: time after exercise (min).
Dependent: pulse rate (beats per minute).
Controlled: same person, same step height, same rate and time of stepping (2 minutes), same position for counting, same counting time (15 s).

Prediction, e.g. pulse rate will be highest straight after exercise and fall back towards the resting rate within a few minutes.

Equipment: low step, stopwatch, partner, trainers. Not needed: thermometer, balance.

Hazards, e.g. exercise (as given); tripping on the step (low, stable step, clear space, trainers); feeling pressured (no competition; anyone can sit out and use the sample data).

Method key points: sit for 5 minutes; count beats at the wrist or neck for 15 s; step up and down at a steady beat for 2 minutes; count for 15 s at once and at the start of each minute after; × 4 for beats per minute; rest 10 minutes; three runs.

Mean pulse (beats/min): rest 73, 0 min 132, 1 min 112, 2 min 92, 3 min 81, 4 min 75. Graph: time on the x-axis, pulse on the y-axis, a curve falling towards the resting line.

Conclusion: pulse rate rose to about 132 beats/min and fell back almost to the resting rate (73) within 4 minutes.

9a So her pulse was back to resting before the next run; otherwise the starting point would be higher and the runs would not be a fair comparison. 9b Any counting error is multiplied by 4 (missing one beat gives an error of 4 beats/min).

Check-up

1 D (1) 2 They make antibodies (1).

3 Vena cava → right atrium → right ventricle → pulmonary artery (1); lungs → pulmonary vein → left atrium (1); left ventricle → aorta (1).

4 18 × 4 = 72 beats per minute (1).

5 To withstand (and maintain) the high pressure of blood pumped from the heart (1).

6 Walls one cell thick, or a large network so every cell is close (1).

TEACHER NOTES

Practical 7: Agar cubes and surface area

Time	One 50-minute lesson. The 3 cm cubes take over 20 minutes, so start them first, or use 0.5, 1 and 2 cm cubes.
Kit per group	Agar cubes of 1, 2 and 3 cm containing phenolphthalein and a little dilute sodium hydroxide (pink), 0.1 mol/l hydrochloric acid, 250 cm^3 beakers, measuring cylinder, forceps, stopwatch, white tile, eye protection.
Prep	Make the agar the day before and cut the cubes (teacher only, with a sharp knife on a board). Keep the cubes covered so they do not dry out.
Expected results	Times rise steeply with cube size: a few minutes for 1 cm cubes and around 20 minutes or more for 3 cm cubes.
Level	N5 plans variables, repeats, calculates means and surface area : volume ratios, presents a chart and evaluates.

Safety and inclusion

- Eye protection throughout. Use dilute (0.1 mol/l) acid; the indicator solution is made up by the teacher.
- Blades for cutting agar: teacher only.
- Risk assess this practical for your own learners, room and kit, following your employer's policies and SSERC guidance.

Common problems

- **Cubes not the same size:** measure with a ruler and trim.
- **Judging the end point:** use a white tile and agree "no pink visible".
- **Surface area slip:** a cube has six faces: 6 × side × side.

No lab, no time, or a learner absent?

The sample results let learners calculate means and ratios, draw the chart and complete the conclusion and evaluation.

Assessment link

Practises assignment skills: raw data with units, processed data (means and ratios), a bar chart, and a conclusion linked to the underlying biology.

Answers: Topic 7

Topic 7: Absorption of materials (N5)

1 What cells need

1 Any two of glucose, amino acids (also water, minerals, vitamins). 2 Carbon dioxide.

3 The blood carries absorbed materials away quickly, so the concentration in the blood stays low and a steep concentration gradient is kept for diffusion.

4 It is small, so it has a large surface area compared with its volume, and every part is close to the outside; diffusion through its surface is enough.

2 The alveoli

1 Oxygen diffuses from the air in the alveolus into the blood; carbon dioxide diffuses from the blood into the alveolus.

2 Any two explained: large surface area (many alveoli) so more gas can diffuse at once; walls one cell thick so the diffusion distance is short; good blood supply keeps a steep concentration gradient; moist lining lets gases dissolve.

3 Fewer, larger sacs have a smaller total surface area, so less oxygen diffuses into the blood.

3 The villi

1 Glucose: capillaries. Amino acids: capillaries. Fatty acids: lacteal. Glycerol: lacteal.

2 They give a much larger surface area for absorption, with thin walls and a good blood supply.

3 Any two: large surface area, thin walls (one cell thick), good blood supply (capillary network).

Practical 7: Agar cubes and surface area

Independent: size of cube (side length, cm). Dependent: time for the cube to turn completely colourless (s). Controlled: concentration and volume of acid, temperature, same agar and indicator, cubes fully covered.

Prediction, e.g. the bigger the cube, the longer it takes, because acid has further to diffuse and the surface area is small compared with the volume.

Equipment: agar cubes, beakers, measuring cylinder, stopwatch, eye protection, forceps. Not needed: thermometer (unless checking temperature), microscope.

Hazards, e.g. acid (as given); cutting agar with a knife or scalpel (teacher cuts the cubes, or use a cutter with care).

Method key points: measure cubes with a ruler; add 100 cm^3 of acid to a beaker; drop the cube in with forceps and start timing; stop when no pink is left; three cubes of each size; same acid temperature.

Means: 1 cm 187 s, 2 cm 650 s, 3 cm 1400 s. Surface area 6, 24, 54 cm^2; volume 1, 8, 27 cm^3; surface area : volume 6 : 1, 3 : 1, 2 : 1.

Conclusion: the smaller the cube, the larger its surface area : volume ratio and the faster the acid diffused through it.

9a The colour fades gradually and the middle is hard to see; view against a white tile, use the same observer, or cut cubes in half at set times to check. 9b Folding into villi gives a very large surface area compared with the volume of the gut, so digested food is absorbed quickly.

Check-up

1 C (1) 2 C (1)

3 Any three: many villi give a large surface area (1); wall one cell thick gives a short distance for diffusion (1); a dense capillary network carries glucose away / keeps a steep gradient (1); glucose passes into the capillaries (1).

4 e.g. glucose, amino acids, fatty acids, glycerol: any two (1).

5 The concentration of carbon dioxide is higher in the blood than in the air in the alveolus (1).

About the author

C. Blewis has taught for 17 years, including 10 years in Additional Support Needs (ASN) provision, teaching sciences, maths, PE and more.

In many schools, especially smaller and specialist settings, teachers are often asked to teach outside their own subject. These books are written for them, and for the young people they teach: clear, practical and ready to use from the first lesson.