MA99 EDUCATION

Cells to systems: Summary 02

NSW BIOLOGY 11-12 SYLLABUS 2025 FOR HSC 2028 AND LATER

1. Key ideas

- **Cells in groups.** Unicellular: one cell does everything (Chlamydomonas). Colonial: similar cells, each able to live alone (Gonium pectorale, about 16 cells). Multicellular: specialised cells that depend on each other. Volvox carteri (about 2,000 somatic cells and up to 16 gonidia, two types) is on the boundary and usually classed as multicellular.
- **SA:V limits size.** For a cube SA:V = 6 ÷ L. Volume grows faster than surface, so big cells and big organisms need flattening, folding and transport systems.
- **Hierarchy.** Organelle, cell, tissue, organ, system, organism. Each level is built from the one below.
- **Plants are autotrophs that also respire.** They need CO_2, water and light for photosynthesis, O_2 for respiration, and nitrate, phosphate, magnesium and potassium ions.
- **Limiting factors.** The rate of photosynthesis is set by the factor in shortest supply (Blackman, 1905): light, CO_2 or temperature.
- **Xylem pulls, phloem pushes.** Xylem: dead, lignified tubes, water and ions up, by cohesion tension (Dixon and Joly, 1894). Phloem: living sieve tubes, sucrose from source to sink, by pressure flow (Münch, 1930).
- **Transpiration** speeds up with light, heat and wind and slows in humid air: every factor acts on the gradient or the stomata.
- **Animals are heterotrophs.** Digestive, respiratory, circulatory and excretory systems supply every cell and remove its wastes.
- **Digestion has three kinds.** Mechanical (muscle), physical (dissolving, bile emulsifies fat), chemical (enzymes hydrolyse). Absorption is mostly in the small intestine; the large intestine absorbs water before elimination.
- **Blood changes in every organ.** Every organ uses O_2 and adds CO_2; the lungs are the only organ that adds O_2.
- **The nephron filters, reabsorbs and secretes.** About 180 L filtered a day, about 99 per cent reabsorbed. Dialysis copies filtration by diffusion, with a pressure difference to remove water.
- **Homeostasis runs on negative feedback:** stimulus, receptor, control centre, effector, response, and the response reduces the stimulus.
- **The hypothalamus controls the pituitary:** releasing hormones to the anterior lobe, nerves to the posterior lobe (ADH, oxytocin).
- **Diabetes breaks the glucose loop** and with it water balance, pH and, over years, the kidneys, eyes, nerves and heart.

> If you remember one number, make it 180 L filtered and 1.5 L of urine: that is why reabsorption matters.

2. Numbers to know

WHAT	VALUE	SOURCE
Gonium pectorale	About 16 cells, undifferentiated	Hamaji et al., 2013; Hanschen et al., 2016
Volvox carteri	About 2,000 somatic cells (1,400 to 3,000); up to 16 gonidia	Nozaki et al., 2018
Centurion, Eucalyptus regnans	100.5 m tall, measured in 2018	Discover Tasmania, 2018
Tallest known tree in 2004, coast redwood	112.7 m; predicted limit 122 to 130 m	Koch et al., Nature, 2004

WHAT	VALUE	SOURCE
Surface of the whole gut lining	About 32 m^2; large intestine about 2 m^2	Helander and Fändriks, 2014
Alveoli in an adult lung	Mean 480 million (274 to 790 million)	Ochs et al., 2004
Alveolar surface; barrier thickness	143 m^2; 0.62 µm	Gehr, Bachofen and Weibel, 1978
Nephrons per kidney	About 900,000 to 1 million (200,000 to over 2.5 million)	Bertram et al., 2011
Glomerular filtration rate	About 125 mL a minute, so about 180 L a day	StatPearls, Physiology, Glomerular Filtration Rate
Dialysis in Australia, 2024	About 16,000 people (53% of kidney replacement therapy)	AIHW, 2026
Haemodialysis schedule	3 days a week, 4 to 5 hours each	healthdirect, 2024
Diabetes in Australia, 2022 to 2024	1 in 15 adults (6.5%, about 1.3 million); First Nations adults 3.2 times as likely	AIHW, 2026
Diabetes thresholds	Fasting 7.0 mmol/L or more; 2 hours after 75 g glucose 11.1 or more	WHO criteria
Glucose in urine	Above about 10 mmol/L in blood	Textbook renal threshold
Hypoglycaemia	Below 4 mmol/L	healthdirect, 2024
Body temperature	Normal 36.5 to 37 °C; fever 38; hypothermia below 35; life threatening 32 or lower; heatstroke above 40	healthdirect, 2024 to 2026
EPO at simulated altitude	16.0 to 22.5 mU/mL at 3,000 m; 16.7 to 28.0 at 4,000 m	Eckardt et al., 1989
Stress test	Salivary cortisol 2 to 4 times baseline	Kirschbaum et al., 1993

3. How to answer the question

SA:V of a cube. SA = $6L^2$; V = L^3; SA:V = SA ÷ V. Check: 6 ÷ L.

Percentage of an agar cube reached. Core side = L minus 2 × depth. Reached = L^3 minus $core^3$. Percentage = reached ÷ L^3 × 100. Example: L = 2 cm, depth 0.3 cm gives 65.7 per cent.

Potometer rate. Volume = πr^2 × distance moved. Rate = volume ÷ time. Example: r = 0.5 mm, 36 mm in 5 min gives 28.3 mm^3 and 5.65 mm^3 per minute.

Rate from a time. Rate = 1 ÷ time (for example, time for 5 of 10 leaf discs to float).

Percentage change. (new minus old) ÷ old × 100. Example: EPO 16.7 to 28.0 is 67.7 per cent.

Percentage reabsorbed. (filtered minus urine) ÷ filtered × 100. Example: (180 minus 1.5) ÷ 180 × 100 = 99.2 per cent.

Variables in a design. Independent (what you change), dependent (what you measure), controlled (what you keep the same), plus three repeats and a mean.

4. Comparisons at a glance

	XYLEM	PHLOEM
Carries	Water, mineral ions	Sucrose, amino acids
Direction	Up	Source to sink, up or down
Cells	Dead, hollow, lignified, no end walls	Living sieve tubes, sieve plates, companion cells
Theory	Cohesion tension	Pressure flow (translocation)

	ARTERY	CAPILLARY	VEIN
Wall	Thick muscle, elastic	One cell thick	Thin
Pressure	High, pulsing	Falling	Low
Feature	Elastic recoil	Exchange	Valves

	KIDNEY	HAEMODIALYSIS
Removes urea	Filtration	Diffusion into urea free dialysate
Keeps glucose	Active reabsorption	Glucose already in dialysate
Timing and control	Continuous; ADH	About 12 to 15 hours a week; fixed settings
Hormones	Makes EPO	None

	TYPE 1 DIABETES	TYPE 2 DIABETES
Cause	Beta cells destroyed: little or no insulin	Cells resistant to insulin; secretion falls later
Insulin in a glucose test	Low	Present, often delayed and high
Treatment	Insulin for life	Diet, exercise, tablets; sometimes insulin

5. Loops and pathways

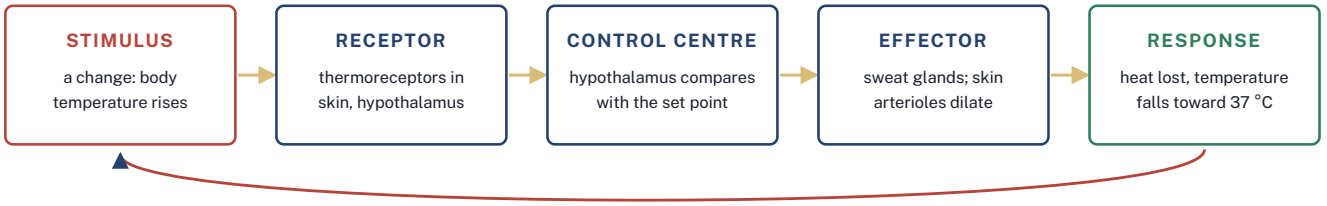
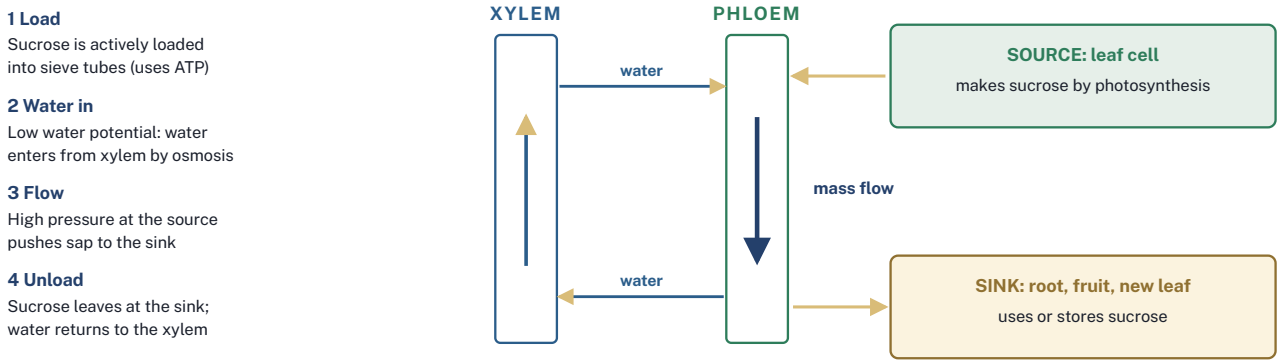


Figure 1 · Every negative feedback loop has the same five parts. Source: NESA glossary definitions; healthdirect, Fever, 2026.

LOOP	RECEPTOR	CONTROL CENTRE	EFFECTOR	RESPONSE
Glucose high	Beta cells	Pancreas	Liver, muscle, fat (insulin)	Glucose taken up and stored
Glucose low	Alpha cells	Pancreas	Liver (glucagon)	Glycogen broken down
Too hot	Thermoreceptors	Hypothalamus	Sweat glands, skin arterioles	Sweating, vasodilation
Too cold	Thermoreceptors	Hypothalamus	Skeletal muscle, skin arterioles	Shivering, vasoconstriction
CO_2 high, pH low	Chemoreceptors	Respiratory centre, medulla	Diaphragm, intercostals	Faster, deeper breathing
O_2 low	Kidney cells	Kidney cells (EPO)	Bone marrow	More red blood cells

Stress response. Fast: hypothalamus, sympathetic nerves, adrenal medulla, adrenaline. Slow: hypothalamus, CRH, anterior pituitary, ACTH, adrenal cortex, cortisol, which feeds back to turn CRH and ACTH down.



Translocation (pressure flow): the sap moves from high pressure at a source to low pressure at a sink, so it can go up or down.

Figure 2 · Translocation by pressure flow, from source to sink. Source: MA99 Education, after Münch's pressure flow hypothesis (1930).

6. Common errors

WHAT STUDENTS WRITE	WHAT EARNS THE MARK
Volvox is a colony	Gonium is colonial; Volvox has a germ and soma division of labour
Plants respire at night	Plants respire all the time; in light photosynthesis hides it
Roots push water up trees	Transpiration pulls a cohesive water column
Phloem moves sugar down	Phloem moves sugar from source to sink, up or down
The gut is a tennis court	About 32 m^2, half a badminton court (2014)
Removing faeces is excretion	It is egestion; excretion removes cell wastes such as urea and CO_2
Veins carry deoxygenated blood	Veins carry blood to the heart; pulmonary veins carry oxygenated blood
Dialysis is an artificial kidney	Diffusion and pressure only, intermittent, no active reabsorption, no EPO
Type 2 means no insulin	Insulin is present; cells respond poorly
A loop: "too high, back to normal"	Name receptor, control centre and effector, both directions

7. Checklist

- ☐ Calculate SA:V for a 3 cm cube and explain why the answer limits cell size.
- ☐ Name the independent, dependent and three controlled variables for the agar cube experiment.
- ☐ Draw and label a limiting factor graph for light intensity at two CO_2 levels.
- ☐ Explain translocation in four steps, with the aphid stylet evidence.
- ☐ Explain the cohesion tension theory in three steps and calculate a potometer rate.
- ☐ Relate stomata, spongy mesophyll and root hair cells to their functions.
- ☐ Discuss the optimal range and critical tolerance limits for body temperature.
- ☐ Describe mechanical, physical and chemical digestion, absorption and elimination.
- ☐ Account for the change in blood across the lungs, liver, small and large intestines, kidneys and muscles.
- ☐ Explain filtration, selective reabsorption and secretion, and compare haemodialysis with a kidney.
- ☐ Draw negative feedback loops for glucose, temperature, pH and EPO.
- ☐ Discuss the hypothalamus and pituitary, insulin, glucagon, adrenaline and cortisol.
- ☐ Analyse the impact of diabetes on homeostasis with one Australian statistic.

About this resource

MA99 EDUCATION

Scope

NSW Biology, Year 11. Written to the NSW Biology 11-12 Syllabus 2025, Cells to systems, for students sitting the HSC in 2028 and later years. Written to the new syllabus, taught in Year 11 from 2027. Real organisms, studies and data are named with their source; any data not from a named source is labelled hypothetical.

Permitted use

Print it, annotate it and keep it on any device you own, for your own study.

Not permitted

Sharing, posting, selling or redistributing it, in whole or in part. Each copy is licensed to one student.

Copyright MA99 Education.
ma99education.com.au