Grade 12 Biology Model Paper 3

ANSWER KEY

Full marks 75 · 3 hours

Give the marks for the points in the marking scheme; an answer in other words that says the same is right.

A practice paper by Science Playground, made to CDC's Specification Grid 2078, Grade 12 Biology (Bio. 202); not an official CDC or NEB paper.

Botany, Group A Multiple choice (Botany) — 5 marks

Question 1 — 5 × 1 = 5

a. **(ii)** the intercalary meristem at the bases of the internodes and leaves

b. **(iv)** abscisic acid

c. **(ii)** 30

d. **(ii)** What the plant measures is an unbroken dark period, and a flash of light breaks it.

e. **(ii)** the micropyle

Botany, Group B Short answers (Botany), each on one content area — 16 marks

Question 2 — 4 marks

a. **Bulliform cells** (motor cells) are large, thin-walled, empty-looking cells in groups in the **upper epidermis of grass (monocot) leaves**; when they lose water the leaf rolls up, cutting water loss. **[1]**

Marking scheme

- Large, thin-walled cells of the upper epidermis of monocot leaves that make the leaf roll up when they lose water.

b. The lower surface is in **shade** and cooler, so less water evaporates from stomata there than from the sunlit upper surface: the leaf takes in carbon dioxide while **losing less water** by transpiration. **[1]**

Marking scheme

- The shaded, cooler lower surface loses less water through its stomata than the sunlit upper one.

c.

- **P is a dicot leaf** (dorsiventral): its mesophyll is divided into **palisade** above and **spongy** tissue below, and its stomata are mostly on the lower surface. **[2]**
- **Q is a monocot leaf** (isobilateral): its mesophyll is **all one kind**, it has stomata on **both** surfaces, and it has **bulliform cells**.

Marking scheme

- P, dicot (dorsiventral): palisade and spongy mesophyll / stomata mostly below.
- Q, monocot (isobilateral): undifferentiated mesophyll / stomata on both surfaces / bulliform cells.

Question 3 — 4 marks

a. **Pollination** is the transfer of pollen grains from the anther to the stigma of a flower. **[2]**

Devices that favor cross-pollination (any two): **dichogamy** (anthers and stigma ripen at different times: protandry or protogyny), **self-incompatibility** (a plant's own pollen can't fertilize it), **herkogamy** (a barrier of form between anthers and stigma), **unisexual flowers** or separate male and female plants.

Marking scheme

- Pollination: the transfer of pollen from the anther to the stigma.
- Any two devices: dichogamy, self-incompatibility, herkogamy, unisexual flowers or separate sexes.

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b. Maize is wind-pollinated, and its pollen can fall on its own silks. Maize has separate male flowers (the tassel) and female flowers (the silks of the cob), so removing the female rows' tassels leaves them **no pollen of their own**, so every silk is pollinated by the **male parent's** pollen blown from the next rows, and every seed on those cobs is a **hybrid**. The male rows keep their tassels to supply that pollen. **[2]**

A plant whose tassel was missed would shed its own pollen on itself and its neighbors, so some seeds would come from pollen of the same plant (**geitonogamy**, genetically self-pollination) or of other female-row plants, **not hybrid**, and the seed lot would be mixed and would give a weaker, uneven crop.

Marking scheme

- Without their own tassels the female plants can only be pollinated by the male parent, so all their seeds are hybrid; the male rows keep theirs to supply the pollen.
- Missed plants would self-pollinate, so some seeds would not be hybrid and the seed would be mixed.

Question 4 — 4 marks

a. The DNA is read in codons of three bases, each meaning one amino acid. A change of one base can change a codon to one that means a **different amino acid** (a missense mutation); the protein's chain then has that amino acid in place of the right one, which can change its shape and how it works. **[1]**

Marking scheme

- A changed base changes the codon, so a different amino acid is put in the protein, which can change its shape and working.

b. **[2]**

- It is a **point mutation by substitution** (A replaced by T, a transversion), and a **missense** mutation: only one amino acid, the sixth, changes.
- A deletion of one base is a **frameshift mutation**: every codon after it is read in the wrong frame, so the amino acids from that point on are all changed (and a stop codon usually comes early). The protein would be far more damaged.

Marking scheme

- Substitution (missense, transversion): one amino acid changed.
- A one-base deletion shifts the reading frame, changing every amino acid after it (frameshift).

c. Carriers, with **one copy**, are usually healthy and are **partly protected from malaria**, which was common in the Terai. So in malarial areas carriers survived and had children more often than others, and the allele stayed common. **[1]**

Marking scheme

- Carriers are partly protected from malaria, common in the Terai, so the allele was kept in the population.

OR

a. Most amino acids are coded by **more than one codon** (for example CAT and CAC, in DNA, both mean histidine): there are 64 codons for only 20 amino acids. **[1]**

Marking scheme

- An amino acid can be coded by more than one codon.

b. mRNA bases pair with the template: A → U, T → A, G → C, C → G. **[2]**

- mRNA: **AUG CCU AAG** (its first codon, AUG, is the start codon).
- The tRNA's anticodon pairs with AUG: **UAC**.

Marking scheme

- mRNA AUG CCU AAG.
- Anticodon UAC.

c. There are four bases. Pairs of bases give only $4 \times 4 = \mathbf{16}$ different words, too few for **20 amino acids**; triplets give $4 \times 4 \times 4 = \mathbf{64}$, enough for every amino acid and the stop signals. **[1]**

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Marking scheme

- Two bases give only 16 codes for 20 amino acids; three give 64, which are enough.

Question 5 — 4 marks

a. A **biofertilizer** is a preparation of **living microorganisms** (bacteria, cyanobacteria or fungi) that adds nutrients to the soil or makes them available to plants, for example by fixing nitrogen. **[1]**

Marking scheme

- Living microorganisms that supply nutrients to the soil or plants (such as by fixing nitrogen).

b. **Azolla**, a small water fern that floats on the field: the cyanobacterium **Anabaena** living in its leaves **fixes nitrogen** from the air, and when the Azolla dies and rots the nitrogen goes into the soil for the rice. (Free-living blue-green algae work the same way.) **[1]**

Marking scheme

- Azolla (with Anabaena) or blue-green algae, which fix atmospheric nitrogen for the rice.

c. 1. **It harms only the target pests**: the Bt toxin kills caterpillars that eat the sprayed leaves, but not bees and other pollinators, the insects that eat the pests, birds, animals or people. **[2]**
2. **It leaves no harmful residue**: it breaks down quickly in the field, so the cabbage carries no poison to the people who eat it, and the soil and water aren't polluted (and pests become resistant to it more slowly than to a chemical used week after week).

Marking scheme

- Bt acts only on the target pests and spares useful insects, animals and people.
- It breaks down and leaves no poisonous residue on the food or in soil and water.

Botany, Group C Long answers (Botany), each on one content area — 16 marks

Question 6 — 8 marks

a. **Transpiration** is the loss of water as **vapor** from the aerial parts of a plant, mostly through the stomata of the leaves. **[1]**

Marking scheme

- The loss of water as vapor from the aerial parts of a plant (mostly through the stomata).

b. 1. A stoma is a pore between two **kidney-shaped guard cells**, each with a **thick inner wall** next to the pore and a **thin outer wall**. **[3]**
2. When water enters the guard cells by **osmosis**, their turgor rises: the thin outer walls stretch and bulge outward more than the thick inner walls, so the guard cells bow apart and the **pore opens**.
3. When the guard cells lose water, they become **flaccid**, straighten and come together, and the **pore closes**. Stomata usually open in light and when carbon dioxide in the leaf is low, and close at night or when the plant is short of water.

Marking scheme

- The guard cells are kidney-shaped with thick inner and thin outer walls.
- When they become turgid (water enters by osmosis) the thin outer walls stretch, they bow apart and the pore opens.
- When they lose water and become flaccid, the pore closes (open in light, closed at night or in drought).

c. Leaf C (lower surface covered) lost as little as leaf A (both covered), while leaf B (upper surface covered, lower open) lost about as much as uncovered leaf D. So almost all the water was lost through the **lower surface**: this plant's stomata are mostly on the **lower epidermis**, as in a dicot leaf. **[2]**

Marking scheme

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- Covering the lower surface stopped water loss (A and C), covering the upper one hardly changed it (B like D).
- So the stomata are mostly on the lower surface.

d. **No.** Transpiration does good and harm, but the plant can't do without it. **[2]**

- **Necessary:** the stomata must be open to let carbon dioxide in for photosynthesis, and water vapor escapes through the same pores; transpiration also pulls water and minerals up the xylem and cools the leaf.
- **Evil:** the plant loses far more water than it uses, and in hot or dry weather this can make it wilt and even die, and slow its growth.

Marking scheme

- Necessary: open stomata for carbon dioxide inevitably lose water; transpiration also lifts water and minerals and cools the leaves.
- Evil: the large loss of water can make the plant wilt or die in dry, hot weather.

OR

a. **Vernalization** is the bringing on of flowering by a period of **low temperature** (cold treatment), given to moist seeds or young plants. **[1]**

Marking scheme

- Promotion of flowering by a period of cold treatment of moist seeds or young plants.

b. **[3]**

1. **Epigeal germination:** the **hypocotyl** grows long, often as a hook, and pulls the **cotyledons above the ground**, where they often turn green; for example castor, cotton, papaya, bean.
2. **Hypogeal germination:** the **epicotyl** grows long and pushes the plumule up, while the **cotyledons stay below the ground**; for example pea, gram, maize and the other cereals.
3. **Vivipary:** the seed germinates **while still on the parent plant**, inside the fruit, as in mangroves such as *Rhizophora*; the seedling falls into the mud only later.

Marking scheme

- Epigeal: the hypocotyl lengthens and the cotyledons come above the ground (castor, bean, cotton).
- Hypogeal: the epicotyl lengthens and the cotyledons stay underground (pea, gram, maize).
- Vivipary: germination while the seed is still on the parent plant (mangroves).

c. i. **Seismonasty** (seismonastic movement): a nastic movement in response to touch or shock, caused by a quick loss of turgor in the pulvinus; its direction doesn't depend on where it is touched. **[2]**

ii. **Thigmotropism** (haptotropism): a growth movement towards the touched side, the tendril growing faster on the side away from the support.

Marking scheme

- *Mimosa*: seismonastic (nastic, turgor) movement.
- Tendril: thigmotropism (haptotropism, a growth movement).

d. Winter wheat **needs a period of cold** before it can flower. Sown in spring, it never had the winter's cold, so it stayed vegetative and flowered late or not at all. **[2]**

He could have **vernalized** the seed: soaked it so it was moist and kept it near freezing (a few degrees above 0 °C) for some weeks before sowing in spring. The chilled seed then flowers in the same season, like a spring variety. (Dry seed can't be vernalized.)

Marking scheme

- Winter wheat needs a cold period to flower, which spring-sown wheat doesn't get.
- Vernalize the seed: chill the moist seed for some weeks before sowing.

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Question 7 — 8 marks

a. [2]

1. In **prophase I of meiosis** (pachytene), homologous chromosomes pair closely, each made of two chromatids. Two **non-sister chromatids** break at the same point and rejoin each other's pieces; the places where they cross are seen as **chiasmata**. So genes are **exchanged** between the homologous chromosomes.
2. It makes **new combinations** of linked genes (recombinants) in the gametes, adding to variation, which is the raw material for evolution and for breeders, and its frequency is used to **map genes** on chromosomes.

Marking scheme

- In prophase I, non-sister chromatids of paired homologous chromosomes break and exchange segments (chiasmata).
- It gives new combinations of linked genes (variation; used for gene maps).

b. [3]

- **Parental** types (the parents' combinations): colored full 480 and colorless shrunken 470, the large classes.
- **Recombinant** types (new combinations): colored shrunken 26 and colorless full 24, the small classes.
- Recombination frequency $= \frac{26+24}{1000} \times 100 = \frac{50}{1000} \times 100 = \mathbf{5\%}$, so the genes are about **5 map units** (5 centimorgans) apart.

Marking scheme

- Parental: colored full and colorless shrunken (480 and 470).
- Recombinant: colored shrunken and colorless full (26 and 24).
- Recombination frequency $50/1{,}000 \times 100 = 5\%$, so about 5 map units apart.

c. [3]

- The genes are in the order **A – B – C**: A and C are farthest apart (16), and $12 + 4 = 16$, so B lies between them, 12 map units from A and 4 from C.
- The farther apart two linked genes are, the more often a crossover falls **between them**, so the more recombinant gametes they give. The recombination frequency therefore measures the **distance** between genes ($1\% = 1$ map unit), and distances add up along the chromosome.

Marking scheme

- Order A – B – C, with B in the middle.
- Reason: A–B (12) + B–C (4) = A–C (16).
- The recombination frequency rises with distance, because a crossover falls between distant genes more often ($1\% = 1$ map unit).

Zoology, Group A Multiple choice (Zoology) — 6 marks

Question 8 — 6 × 1 = 6

a. **(i)** Ranikhet (Newcastle) disease

b. **(ii)** Like other connective tissues it has cells scattered in a matrix, here the fluid plasma, and it develops from mesoderm.

c. **(ii)** oxytocin

d. **(i)** the sympathetic nerves

e. **(ii)** He still ejaculates semen, but it contains no sperms.

f. **(ii)** Bile is no longer stored and released in large amounts after a meal, so big amounts of fat are not well emulsified for lipase.

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Zoology, Group B Short answers (Zoology), each on one content area 16 marks

Question 9 4 marks

a. **Nodes of Ranvier**. **[1]**

Marking scheme

- Nodes of Ranvier.

b. They are **neuroglia** (glial cells), the supporting cells of nervous tissue. Any two functions: **[2]**

1. They **support** the neurons and hold them in place, as connective tissue does elsewhere.
2. They form the **myelin sheath** round axons (oligodendrocytes in the brain and spinal cord, Schwann cells in the nerves).
3. They supply the neurons with food and keep the fluid round them right, and some (microglia) **engulf** germs and debris.

Marking scheme

- Neuroglia, with one function explained (support, forming myelin, nourishing the neurons, or defense).
- A second function explained.

c. They are **multipolar neurons**: many dendrites and one axon (like the motor neurons of the spinal cord). **[1]**

Marking scheme

- Multipolar neurons (many dendrites, one axon).

Question 10 4 marks

a. In gastrulation the cells of the blastula move inward through the blastopore and are arranged into the **three germ layers**, ectoderm, mesoderm and endoderm, each in the place where it will build its organs; the archenteron (the future gut) forms, and the body's main axes are set. **[1]**

Marking scheme

- It forms the three germ layers in their places (and the archenteron), from which all the organs develop.

b.

- Brain and spinal cord: **ectoderm** (the neural plate rolls up into the neural tube). **[2]**
- Lining of the gut: **endoderm**.
- Notochord and muscles: **mesoderm**.

Marking scheme

- Brain and spinal cord from the ectoderm.
- Gut lining from the endoderm, notochord and muscles from the mesoderm.

c. The dorsal lip is an **organizer**: it doesn't just form tissue itself, it **makes the cells round it** (which would otherwise have formed belly tissue) build a nervous system and a body axis. It directs the development of its neighbors (induction). **[1]**

Marking scheme

- The dorsal lip is an organizer: it induces the neighboring cells to form a body axis.

Question 11 4 marks

a. **Malleus, incus and stapes** (hammer, anvil and stirrup). **[1]**

Marking scheme

- Malleus, incus, stapes.

b. As the plane descends, the air pressure in the cabin **rises**, but the air in the middle ear stays at the lower pressure of the height: the higher pressure outside pushes the **eardrum inward**, so it can't vibrate freely, and she hears less. **[2]**

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Swallowing **opens the Eustachian tube**, which joins the middle ear to the throat, so air flows into the middle ear and the **pressure on both sides of the eardrum is equal** again: it pops back and vibrates normally.

Marking scheme

- The outside pressure rose while the middle ear's stayed low, pushing the eardrum in, so it vibrates poorly.
- Swallowing opens the Eustachian tube, equalizing the pressure on both sides of the eardrum.

c. Rotation is sensed by the **cristae** in the ampullae of the **semicircular canals**: the endolymph lags as the head turns and bends the jelly **cupula** over the hair cells. When she stops suddenly, the endolymph **goes on moving** for a moment and bends the cupula the other way, so the hair cells signal a turning that isn't happening. **[1]**

Marking scheme

- The endolymph in the semicircular canals keeps moving after she stops, bending the cupula, so the cristae signal rotation.

OR

a. Blood group **O** (O negative, in the Rh system too): its red cells carry neither antigen A nor antigen B. **[1]**

Marking scheme

- Group O (O negative).

b.

- **Donor X: group B.** Clumping with anti-B shows antigen B on the red cells; no clumping with anti-A shows no antigen A. **[2]**
- **Donor Y: group O.** No clumping with either serum: the red cells carry neither antigen.

Marking scheme

- X is group B (antigen B only).
- Y is group O (neither antigen).

c. The mother has no anti-Rh antibodies until she is **sensitized**, which happens mostly when the first baby's blood mixes with hers at **birth**. The antibodies made then attack the red cells of her **next** Rh-positive baby (erythroblastosis fetalis); an anti-D injection after each birth prevents it. **[1]**

Marking scheme

- The mother is sensitized (makes anti-Rh antibodies) only by the first baby's blood at birth, so they harm only the next Rh-positive baby.

Question 12 — 4 marks

a. Population, unchecked, grows in a **geometric series** (1, 2, 4, 8, 16…: doubling each period), while food grows only in an **arithmetic series** (1, 2, 3, 4, 5…). So people would outgrow their food, until famine, disease and war (positive checks), or later marriage and fewer children (preventive checks), held them back. **[1]**

Marking scheme

- Population grows geometrically, food arithmetically, so population outgrows food unless checked.

b.

- At 2.66% a year: $70 \div 2.66 \approx$ **26 years**. **[1]**
- At 0.96% a year: $70 \div 0.96 \approx$ **72–73 years**.

Marking scheme

- About 26 years at 2.66% and about 72–73 years at 0.96%.

c. **Not as he expected.** **[2]**

- Food production has grown far faster than an arithmetic series, with new crop varieties, fertilizers and irrigation, so the world feeds many more people than in his day (though hunger remains where people are poor).

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- More importantly, as countries pass through the **demographic transition**, death rates fall first, and then **birth rates fall too**, through schooling (especially of girls), towns, contraception and fewer children dying. Population growth then slows by **choice**, the preventive check, as in Nepal, where growth fell from about 2.66% to 0.96% a year; in some countries the population now shrinks.

Marking scheme

- Not as predicted: food production rose much faster than arithmetically (new varieties, fertilizers, irrigation).
- Birth rates fall in the later stages of the demographic transition (education, contraception), so growth slows by choice, as in Nepal.

Zoology, Group C Long answers (Zoology), each on one content area 16 marks

Question 13 8 marks

a. The **BOD** is the amount of dissolved **oxygen** that microbes would use in breaking down the **organic matter** in the water: a measure of how much organic pollution it carries. **[1]**

Marking scheme

- The amount of dissolved oxygen microbes would use to break down the water's organic matter.

b. **[3]**

1. The settled sewage from primary treatment flows into an **aeration tank**, where **air is blown through it**, so that aerobic microbes have plenty of oxygen.
2. The microbes, mostly **aerobic bacteria**, with protozoa that eat them, grow in clumps (**flocs**) and break down the **dissolved and fine organic matter** to carbon dioxide, water and more microbes.
3. The mixture then flows to a **secondary clarifier**, where the flocs **settle** as activated sludge, and the cleaner water flows on; **part of the sludge is returned** to the aeration tank, so it always has plenty of active microbes.

Marking scheme

- Air is blown through the sewage in an aeration tank.
- Aerobic bacteria (with protozoa) in flocs break down the dissolved organic matter.
- The flocs settle in a secondary clarifier, and part of the sludge is returned to the aeration tank.

c. **[2]**

- After primary treatment: 30% of $300 = 90$ mg/L removed, leaving $300 - 90 =$ **210 mg per liter**.
- After secondary treatment: 90% of $210 = 189$ mg/L removed, leaving $210 - 189 =$ **21 mg per liter** (only 7% of the raw sewage's BOD).

Marking scheme

- After primary treatment: 210 mg per liter.
- After secondary treatment: 21 mg per liter.

d. **[2]**

- The bacteria in the stream break down the sewage's organic matter using the stream's **dissolved oxygen**; sewage of such a high BOD uses so much that little is left, and the **fish suffocate**. Without oxygen, **anaerobic** bacteria take over, making black, foul-smelling products (such as hydrogen sulfide).
- In the **dry season** the stream carries far **less water** to dilute the same sewage, so its oxygen runs out fastest then (as in the Bagmati in Kathmandu).

Marking scheme

- Microbes breaking down the sewage use up the dissolved oxygen, so the fish suffocate and anaerobic decay turns the water black and smelly.
- In the dry season there is less water to dilute the sewage, so the oxygen runs out more.

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Question 14 — 8 marks

a. [2]

- The **anterior pituitary's hormones control other endocrine glands**: TSH the thyroid, ACTH the adrenal cortex, FSH and LH the gonads (and growth hormone and prolactin act widely), so it seems to direct the whole endocrine system.
- The **hypothalamus** controls it: its neurosecretory cells release **releasing and inhibiting hormones**, which travel down the blood vessels of the **pituitary stalk** (the hypophyseal portal system) to the anterior lobe and switch its hormones on or off. So the master gland itself takes orders from the brain.

Marking scheme

- Its hormones (TSH, ACTH, FSH, LH and others) control other endocrine glands.
- The hypothalamus sends releasing and inhibiting hormones through the portal vessels of the stalk to the anterior lobe.

b. [2]

- **Patient X: diabetes mellitus**, glucose in the urine from too little insulin (or insulin not working).
- **Patient Y: diabetes insipidus**, from a lack of **ADH** (vasopressin), which the damaged posterior pituitary no longer releases.

Marking scheme

- X: diabetes mellitus (lack of insulin).
- Y: diabetes insipidus (lack of ADH).

c. [4]

- **Patient X:** without enough insulin, the cells take up little glucose and the **blood glucose rises** very high.
- So much glucose is filtered that the kidney tubules can't take it all back; the glucose left in the filtrate **holds water by osmosis**, and a large volume of sweet urine is passed.
- **Patient Y:** normally **ADH** makes the walls of the distal tubules and **collecting ducts** let water through, so water is taken back from the filtrate into the salty medulla and the urine is concentrated.
- Without ADH the collecting ducts stay **waterproof**, the water stays in the filtrate, and huge volumes of dilute, tasteless urine are passed. In both, the lost water makes the patient thirsty.

Marking scheme

- X: lack of insulin raises the blood glucose.
- X: glucose left in the filtrate holds water by osmosis, so much sweet urine is passed.
- Y: ADH normally lets the collecting ducts reabsorb water, concentrating the urine.
- Y: without ADH the ducts stay waterproof, so large volumes of dilute urine are passed.

OR

a. [2]

1. The **sodium–potassium pump** in the membrane uses ATP to push **3 Na^+ out** for every **2 K^+ in**, so there is much more Na^+ outside and more K^+ inside.
2. At rest the membrane lets **K^+ leak out** far more easily than Na^+ leaks in, and the large negative ions (proteins) inside can't leave. So more positive charge is outside: the inside is about **−70 mV**, and the membrane is **polarized**.

Marking scheme

- The sodium–potassium pump moves 3 Na^+ out for 2 K^+ in, so Na^+ is high outside and K^+ high inside.
- The membrane leaks K^+ out more than Na^+ in, and negative proteins stay inside, so the inside is negative (about −70 mV).

b. [2]

- In the absolute refractory period no second impulse can start, so at most one impulse every 2 ms: 1,000 ms ÷ 2 ms = **500 impulses a second** (in practice a few hundred).
- By the **all-or-none law** every impulse is the same size; a stronger stimulus makes the fiber fire **more impulses a second** (and excites more fibers).

Marking scheme

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- At most $1{,}000 \div 2 = 500$ impulses a second.
- A stronger stimulus raises the frequency of impulses (all-or-none: their size stays the same).

c. [4]

- Normally, acetylcholine released into the synaptic cleft binds to its receptors and is **split at once by acetylcholinesterase**, so each signal is short and clear.
- With the enzyme blocked, acetylcholine is not removed: it **piles up** in the cleft and goes on stimulating the receptors, at every cholinergic synapse.
- So the nerves to the glands and muscles are signaled without stopping: the victim **sweats and drools**, has small pupils and a slow heart, and the muscles **twitch**.
- The muscles, kept stimulated, soon stop responding and grow **weak**; when the breathing muscles fail, the person can't breathe and may die without treatment in hospital.

Marking scheme

- Acetylcholine is normally broken down at once by acetylcholinesterase.
- Blocked, acetylcholine piles up and keeps stimulating the receptors.
- Glands and muscles are overstimulated: sweating, drooling, small pupils, slow heart, twitching.
- The muscles, including the breathing muscles, become weak, so breathing can fail.

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