Grade 12 Biology Model Paper 2

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)** collenchyma, whose living cells are thickened with cellulose at the corners

b. **(i)** short-day plants

c. **(iii)** 18 atm

d. **(iii)** The rate is held back by whichever factor is in shortest supply: carbon dioxide in bright light, light in dim light.

e. **(iii)** rhizome

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

Question 2 — 4 marks

a. A **lenticel** is a small raised pore in the bark, where the cork cambium makes loose, rounded cells with air spaces between them (complementary cells) instead of cork, so that gases can be exchanged through the bark. **[1]**

Marking scheme

- A pore in the bark of loose complementary cells with air spaces, through which gases are exchanged.

b. The cambium works with the seasons. In spring (or when the rains start) it is very active and makes many **wide, thin-walled vessels**: pale **spring wood**. Later in the year it slows and makes **narrow, thick-walled** cells: dense, dark **autumn wood**. One band of each is the wood of **one year**, an annual ring. **[1]**

Marking scheme

- Wide, thin-walled vessels in spring (pale spring wood) and narrow, thick-walled cells later in the year (dark autumn wood): one pair a year.

c.

- The tree is about **62 years** old: one annual ring is added each year. **[2]**
- Choose the dark central wood, the **heartwood**: before its living cells died they filled it with tannins, resins and gums (and tyloses blocked its vessels), which keep out termites and rot, so it is harder and more **durable**. The pale **sapwood** still carries water and stores food, and rots in a few years.

Marking scheme

- About 62 years (one ring a year).
- Heartwood, because it is filled with tannins, resins and gums that resist termites and rot.

Question 3 — 4 marks

a. i. **Grafting** (the twig is the scion, the seedling the stock). **[2]**

ii. **Air layering** (gootee).

Marking scheme

- Grafting.
- Air layering (gootee).

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b. The tubers are pieces of the parent, so every new plant gets whatever the parent carries. **Viruses** in an infected plant pass into its tubers, so they are carried into each new crop, and they **build up over generations**: more plants are infected each year, and the yield falls. **[2]**

He should plant **disease-free seed tubers**, for example from virus-free plants multiplied by tissue culture, and not keep his own tubers from infected plants.

Marking scheme

- Viruses are carried from infected plants into their tubers and build up crop after crop, so the yield falls.
- Plant disease-free (virus-free, for example tissue-cultured) seed tubers.

Question 4 — 4 marks

a. The two strands of the DNA separate, and each serves as a **template** for a new strand. So each of the two daughter molecules has **one old strand and one new strand**: half of the parent molecule is kept (conserved) in each. **[1]**

Marking scheme

- Each daughter DNA molecule has one parental (old) strand and one newly made strand.

b. In double-stranded DNA, A pairs with T and G with C, so A = T and G = C (Chargaff's rule). **[2]**

- Thymine = adenine = **30%**.
- G + C = 100 − (30 + 30) = 40%, so guanine = cytosine = **20%** each.

Marking scheme

- Thymine 30% (A = T).
- Guanine 20% and cytosine 20% (G = C, sharing the remaining 40%).

c. **Half** of them. After the first division every molecule is hybrid (one ^{15}N strand, one ^{14}N strand). In the second, each hybrid gives one hybrid and one wholly light molecule: of 4 molecules, 2 are hybrid and 2 light. **[1]**

Marking scheme

- Half (2 hybrid and 2 light of every 4), because each old heavy strand stays in one molecule.

OR

a. **Sex-linked inheritance** is the inheritance of characters whose genes are on a **sex chromosome** (usually the X), so that they are passed on, and appear, differently in males and females. **[1]**

Marking scheme

- Inheritance of characters whose genes lie on the sex chromosomes (X), so they appear differently in the two sexes.

b. White-eyed female X^rX^r × red-eyed male X^RY. **[2]**

	X^r (egg)	X^r (egg)
X^R (sperm)	X^RX^r, red-eyed female	X^RX^r, red-eyed female
Y (sperm)	X^rY, white-eyed male	X^rY, white-eyed male

All the daughters are red-eyed (carriers) and **all the sons white-eyed**.

Marking scheme

- Parents $X^rX^r \times X^RY$ and the checkerboard.
- All daughters red-eyed (X^RX^r), all sons white-eyed (X^rY).

c. A son gets his **X chromosome from his mother** and only the Y, which has no allele for eye color, from his father. His mother's X chromosomes both carry X^r, so every son is white-eyed. (This crisscross inheritance, from mother to son, is the mark of an X-linked gene.) **[1]**

Marking scheme

- A son's only X comes from his mother (the father gives the Y, with no eye-color allele), so he shows the mother's allele.

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Question 5 — 4 marks

a. **Restriction enzymes** ("molecular scissors") are enzymes that cut DNA at particular short base sequences, their recognition sites. **[1]**

Marking scheme

- Enzymes that cut DNA at specific base sequences (recognition sites).

b. The same enzyme cuts both at the same sequence and leaves the **same sticky ends**, whose bases pair with each other, so the human gene fits into the opened plasmid and **DNA ligase** can seal the joins. **[1]**

Marking scheme

- Both get matching (complementary) sticky ends, so the gene joins the plasmid and ligase seals it.

c. **[2]**

1. It is **human insulin**, made from the human gene, so it is identical to the patient's own and less likely to cause allergic or immune reactions than cattle or pig insulin, whose amino acids differ slightly.
2. Bacteria multiply quickly in fermenters, so it can be made in **large amounts**, cheaply and of steady quality, without depending on the pancreases of slaughtered animals (which some people also object to on religious grounds).

Marking scheme

- Identical to human insulin, so fewer allergic or immune reactions.
- Made in large amounts, cheaply and reliably, without slaughtered animals.

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

Question 6 — 8 marks

a. *Gibberella fujikuroi* (the fungus of the bakanae disease of rice). **[1]**

Marking scheme

- *Gibberella fujikuroi*.

b. **[3]**

1. **Stem elongation:** they make the internodes grow longer, and can make genetically dwarf plants grow to normal height.
2. **Bolting:** in rosette plants such as cabbage they make the short stem grow suddenly long and flower.
3. **Breaking dormancy and germination:** they break the dormancy of seeds and buds; in a germinating cereal grain they make the aleurone layer produce α-amylase, which digests the stored starch.

(Also: they make seedless fruits (parthenocarpy) and enlarge grapes.)

Marking scheme

- A first effect explained: stem (internode) elongation, or curing genetic dwarfism.
- A second: bolting of rosette plants.
- A third: breaking seed or bud dormancy (α-amylase in germinating grain), or parthenocarpy and larger fruits.

c. **No.** The gibberellin only made their internodes grow longer; it did not change their genes, which are still those of a dwarf (tt). **[2]**

Their seeds carry the dwarf alleles, so the plants grown from them will be **dwarf**, unless they too are sprayed.

Marking scheme

- No: gibberellin changes the plant's growth, not its genes (still dwarf, tt).
- Plants from their seeds will be dwarf.

d. Ripe fruits give off **ethylene**, a plant hormone that is a **gas** and makes fruits ripen. In a closed room the ethylene from the ripe bananas does not escape: it builds up in the air round the green ones and makes them ripen too (and they then give off ethylene themselves). **[2]**

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Marking scheme

- Ripe fruits release ethylene, a gaseous hormone that brings on ripening.
- In a closed room the gas builds up and reaches the green bananas, so they ripen.

OR

a. The **thylakoid membranes** (of the grana). **[1]**

Marking scheme

- The thylakoid membranes (grana).

b. **[3]**

1. Light absorbed by **photosystem II** excites electrons in its reaction center (P680), which pass to an electron acceptor. They are replaced by electrons from **water**, which is split (**photolysis**): $2\,H_2O \longrightarrow 4\,H^+ + 4\,e^- + O_2$, and the **oxygen** is given off.
2. The excited electrons pass along an **electron transport chain** (plastoquinone, cytochromes, plastocyanin) to photosystem I; the energy they lose is used to make **ATP** from ADP and phosphate.
3. Light absorbed by **photosystem I** (P700) excites the electrons again, and they are passed through ferredoxin to **NADP**, which with the hydrogen ions forms **NADPH**. The electrons do not come back to PSII, so the flow is non-cyclic.

Marking scheme

- PSII is excited by light and its electrons are replaced from water, which is split, giving off oxygen.
- The electrons pass down an electron transport chain to PSI, and ATP is made.
- PSI re-excites the electrons, which reduce NADP to NADPH (one-way, non-cyclic flow).

c. For one glucose: 12 NADPH need 24 electrons. Each water molecule gives 2 electrons, so **12 water molecules** are split, giving 6 oxygen molecules. **[2]**

For 3 glucose: $3 \times 12 =$ **36 molecules of water** split, and $3 \times 6 =$ **18 molecules of oxygen** given off.

Marking scheme

- 12 water split per glucose (24 electrons for 12 NADPH), so 36 for 3 glucose.
- 6 oxygen per glucose, so 18 for 3 glucose.

d. In maize, carbon dioxide is first fixed in the mesophyll by **PEP carboxylase**, which takes up carbon dioxide strongly even when little is left in the leaf and never binds oxygen. The four-carbon acid made is carried into the **bundle sheath**, where carbon dioxide is released at a high concentration round RuBisCO. **[2]**

In wheat, RuBisCO takes carbon dioxide straight from the air spaces. In hot, bright weather the stomata partly close, carbon dioxide in the leaf falls and oxygen rises, so RuBisCO binds oxygen and wastes fixed carbon by **photorespiration**. Maize has almost none, so it fixes more carbon and grows faster.

Marking scheme

- Maize fixes carbon dioxide with PEP carboxylase and concentrates it in the bundle sheath round RuBisCO.
- So it has almost no photorespiration, which in hot, bright weather wastes much of wheat's fixed carbon.

Question 7 — 8 marks

a. **Law of independent assortment:** when two pairs of contrasting characters are inherited together, the alleles of each pair separate into the gametes **independently** of those of the other pair. **[2]**

So an F_1 plant (RrYy) makes four kinds of gametes in equal numbers: **RY, Ry, rY and ry** (25% each).

Marking scheme

- The alleles of one pair separate into the gametes independently of those of another pair.
- Gametes RY, Ry, rY and ry, in equal numbers.

b. RrYy × rryy. Gametes: RY, Ry, rY, ry from the F_1; ry only from the wrinkled, green plant. **[3]**

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	RY	Ry	rY	ry
ry	RrYy, round yellow	Rryy, round green	rrYy, wrinkled yellow	rryy, wrinkled green

Offspring: **round yellow : round green : wrinkled yellow : wrinkled green = 1 : 1 : 1 : 1**. (This is a test cross: the four classes show the F_1's four kinds of gametes directly.)

Marking scheme

- Gametes of the two parents (RY, Ry, rY, ry and ry).
- Genotypes RrYy, Rryy, rrYy, rryy with their phenotypes.
- Ratio 1 : 1 : 1 : 1.

c. The dihybrid F_2 ratio is 9 : 3 : 3 : 1, 16 parts. One part of 496 is $496 \div 16 = 31$, so the expected numbers are: **[3]**

	Round yellow	Round green	Wrinkled yellow	Wrinkled green
Expected (9 : 3 : 3 : 1)	279	93	93	31
Bishal's	278	95	89	34

They are very close, so **they agree with 9 : 3 : 3 : 1** (and each pair alone is about 3 : 1: round 373, wrinkled 123).

So the genes for seed shape and seed color **assort independently**: they behave as if they lie on different chromosomes, each pair separating without regard to the other.

Marking scheme

- Expected numbers from 9 : 3 : 3 : 1 ($496 \div 16 = 31$: 279, 93, 93, 31).
- Bishal's numbers are close to them, so they fit the ratio.
- The two genes assort independently (not linked).

Zoology, Group A Multiple choice (Zoology) 6 marks

Question 8 6 × 1 = 6

a. **(i)** *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus*

b. **(ii)** The cells are joined end to end by intercalated discs, through which the impulse passes quickly from cell to cell.

c. **(iii)** the ampulla of the fallopian tube

d. **(iii)** as bicarbonate ions, formed in the red cells by carbonic anhydrase

e. **(ii)** glucagon, from the alpha cells of the islets

f. **(ii)** the cerebellum

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

Question 9 4 marks

a. **Chondrocytes** (which sit in spaces called lacunae in the matrix). **[1]**

Marking scheme

- Chondrocytes.

b. **[2]**

- **Vinegar** (an acid) dissolved the **calcium salts** (calcium phosphate) of the matrix, leaving the collagen: so the salts make bone **hard and rigid**.
- **Heating** burned away the organic part, the **collagen fibers (ossein)**, leaving the salts: so the collagen makes bone **tough and slightly springy**, keeping it from being brittle.

Marking scheme

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- Vinegar dissolved the calcium salts, which make bone hard (the collagen left is flexible).
- Heating destroyed the collagen (ossein), which keeps bone from being brittle (the salts left crumble).

c. A **ligament**, which joins bone to bone at a joint. **[1]**

Marking scheme

- Ligament.

Question 10 — 4 marks

a. The heavy **yolk** in the vegetal half pushes the spindles of the third division towards the animal pole, so the furrow forms **above the equator**: four small micromeres above, four large, yolky megameres below (cleavage is unequal). **[1]**

Marking scheme

- The yolk in the vegetal half pushes the third (latitudinal) furrow above the equator, so the lower cells (megameres) are larger.

b.
- Each cleavage doubles the cells: $2^5 = 32$ **cells**, the stage called the **morula** (a ball like a mulberry). **[2]**
- It is **no larger** than the zygote: the cells don't grow between divisions, so each division makes them smaller while the embryo's size stays the same.

Marking scheme

- 32 cells: the morula.
- No larger than the zygote, since the cells do not grow between cleavages.

c. From the **yolk stored inside its cells** during oogenesis. Everything the embryo uses until the tadpole can feed comes from that store, so the egg must be large, packed with yolk. **[1]**

Marking scheme

- From the yolk stored in the egg's cells, which must last until the tadpole feeds, so the egg is large.

Question 11 — 4 marks

a. **Salivary amylase** (ptyalin). **[1]**

Marking scheme

- Salivary amylase (ptyalin).

b.
- **Tube A: no blue-black color** (iodine stays brown): the amylase has digested the starch to maltose. **[2]**
- **Tubes B and C: blue-black**: starch is still there. Boiling **denatured** the enzyme in B, and in C the **acid** made the pH too low for salivary amylase, which works best near neutral.

Marking scheme

- Tube A stays brown (no starch left), because amylase digested the starch.
- Tubes B and C turn blue-black: the enzyme was destroyed by boiling (B) or stopped by the acid (C).

c. In the stomach the food is mixed with **hydrochloric acid**, and the **low pH** stops salivary amylase working; the stomach's own juice has no enzyme that digests starch. Starch digestion starts again in the small intestine, with pancreatic amylase. **[1]**

Marking scheme

- The stomach's acid stops salivary amylase, and gastric juice has no amylase of its own.

OR

a. **Myopia** (short-sightedness, near-sightedness). **[1]**

Marking scheme

- Myopia (short-sightedness).

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b. His eyeball is too long, so light from a **distant** object comes to a focus **in front of the retina** and is spread out again by the time it reaches it. A **concave (diverging) lens** spreads the rays out a little before they enter the eye, so they focus on the retina. **[2]**

Marking scheme

- Light from a distant object focuses in front of the retina in the too-long eyeball.
- Corrected with a concave (diverging) lens.

c. **No.** She has **presbyopia**: with age her lens has lost its elasticity and can't round up for near objects, while distant vision stays good. Dawa's near vision is good and his distant vision poor, from a too-long eyeball. Her defect is corrected with convex reading glasses, his with concave lenses. **[1]**

Marking scheme

- No: hers is presbyopia (a stiff lens that can't focus near objects), the opposite of Dawa's myopia.

Question 12 — 4 marks

a. It usually causes **no symptoms for years**, so people don't know they have it, while it strains the heart and damages the arteries, until it leads to a heart attack, stroke or kidney failure. **[1]**

Marking scheme

- It gives no symptoms for years while damaging the heart and arteries, leading to heart attack, stroke or kidney disease.

b. Only **152/96 mmHg**: both its systolic (152) and diastolic (96) pressures are above 140/90. 118/76 is normal, and 135/85 is below the limit. **[1]**

Marking scheme

- 152/96 mmHg, above 140/90.

c. Any two, for example: **[2]**

1. **Eat less salt** (less in pickles, achar, chips and instant noodles): too much salt makes the body hold more water in the blood, which raises the pressure.
2. **Exercise regularly** (a brisk walk most days): it strengthens the heart, keeps the arteries supple and helps keep a healthy weight.
3. **Stop smoking and drink little or no alcohol**: tobacco narrows and damages the arteries.
4. **Keep a healthy weight and manage stress**: extra weight and long stress both raise the pressure.

Marking scheme

- One change with how it helps (for example, less salt: less water held in the blood).
- A second change with how it helps (exercise, no smoking or alcohol, healthy weight, less stress).

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

Question 13 — 8 marks

a. **Composite fish culture** (polyculture) is rearing several species of fish together in one pond, chosen so that they feed on different foods at different levels of the pond. **[1]**

Marking scheme

- Rearing several fish species together in a pond, each using a different food or level.

b. Each species takes a different food, at a different level of the pond: **[3]**

1. **Surface: silver carp** strain **phytoplankton** (algae) and **bighead carp** take **zooplankton**.
2. **Middle and weeds: rohu** feeds in mid-water, and **grass carp** eat **water weeds** and the grass the farmer throws in (their droppings even fertilize the water for the plankton).
3. **Bottom: mrigal** eat the rotting matter (**detritus**) on the bottom, and **common carp** root in the mud for worms and insect larvae.

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So there is little competition between them, and no food is left unused.

Marking scheme

- Surface feeders: silver carp (phytoplankton) and bighead (zooplankton).
- Rohu in mid-water, and grass carp on weeds and grass.
- Bottom: mrigal (detritus) and common carp (worms and larvae in the mud), so all levels and foods are used without competition.

c. Of 5,000 fingerlings: **[2]**

- silver carp 30%: **1,500**; rohu 20%: **1,000**;
- common carp 15%: **750**; mrigal 15%: **750**;
- bighead carp 10%: **500**; grass carp 10%: **500**.

(Check: $1{,}500 + 1{,}000 + 750 + 750 + 500 + 500 = 5{,}000$.)

Marking scheme

- Silver carp 1,500, rohu 1,000, common carp 750.
- Mrigal 750, bighead 500, grass carp 500.

d. **Smaller.** All 5,000 fish feed on the same food, **phytoplankton**, so they **compete** for it and grow less, while the zooplankton, weeds, detritus and the worms of the mud are left **unused**. In Aastha's pond each food feeds its own species, so the same pond produces more fish in all. **[2]**

Marking scheme

- Smaller: all the fish compete for one food (phytoplankton) and grow less.
- The pond's other foods (zooplankton, weeds, detritus, bottom animals) go unused.

Question 14 — 8 marks

a. 1. A sudden rise in LH in the middle of the cycle (the **LH surge**) makes the mature Graafian follicle burst and release the egg: **ovulation**. **[2]**
2. LH then turns the empty follicle into the **corpus luteum**, and keeps it secreting **progesterone** (with some estrogen) through the luteal phase.

Marking scheme

- The LH surge brings on ovulation (the Graafian follicle bursts and releases the egg).
- LH turns the empty follicle into the corpus luteum and keeps it secreting progesterone.

b. **[2]**

- 32-day cycle: $32 - 14 =$ about **day 18**.
- 28-day cycle: $28 - 14 =$ about **day 14**.

(The luteal phase stays about 14 days; it is the follicular phase that is longer in a longer cycle.)

Marking scheme

- About day 18 of the 32-day cycle ($32 - 14$).
- About day 14 of a 28-day cycle.

c. **[4]**

- Through the luteal phase the **corpus luteum's progesterone** (and estrogen) keep the thickened, blood-rich **endometrium** ready for an embryo.
- If the egg is not fertilized, the corpus luteum **degenerates** after about 14 days (into the corpus albicans), and **progesterone falls**.
- Without progesterone the endometrium can't be kept: its blood vessels close, the lining breaks down and is shed with blood, **menstruation**, and a new cycle begins.
- If she is pregnant, the embryo's outer cells (later the placenta) make **hCG**, which keeps the corpus luteum alive and secreting progesterone, so the endometrium is kept and there is no menstruation (later the placenta makes the progesterone itself).

Marking scheme

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- The corpus luteum's progesterone keeps the endometrium thick and ready.
- Without fertilization the corpus luteum degenerates and progesterone falls.
- The endometrium then breaks down and is shed: menstruation.
- In pregnancy, hCG from the embryo (placenta) keeps the corpus luteum making progesterone, so the lining stays.

OR

a. This is **ultrafiltration**: **[2]**

1. The **efferent arteriole** is narrower than the afferent, so the blood in the glomerulus is under **high pressure**, which pushes water and small dissolved substances out through the capillary endothelium, the basement membrane and the slits between the podocytes of Bowman's capsule.
2. The **filtrate** collects in the capsule: plasma without its proteins (water, glucose, amino acids, salts, urea, uric acid, creatinine). Blood cells and proteins are too large to pass.

Marking scheme

- High blood pressure in the glomerulus (efferent arteriole narrower than afferent) forces fluid through the filtering membrane into Bowman's capsule.
- The filtrate is plasma without proteins or cells: water, glucose, salts, urea and other small molecules.

b. Net filtration pressure = glomerular blood pressure − (osmotic pressure of the blood + capsular pressure) **[2]**

$$= 58 - (30 + 16) = 58 - 46 = \mathbf{12\ mmHg}$$

Marking scheme

- NFP = glomerular hydrostatic pressure − (blood colloid osmotic pressure + capsular pressure).
- $58 - (30 + 16) = 12$ mmHg.

c. **[4]**

- Glucose is small, so it passes into the filtrate in proportion to its level in the blood. In a healthy person **all of it is taken back** (actively) by the cells of the **proximal convoluted tubule**, so none reaches the urine.
- The PCT's carriers can take back only so much glucose a minute. With Sangam's very high blood glucose, more is filtered than they can reabsorb, so the **extra is left in the filtrate** and passes into the urine.
- Glucose left in the tubule holds water with it by **osmosis**, so less water is reabsorbed and he passes **large amounts of urine**.
- Losing so much water, his body fluids become concentrated and he feels **thirsty**, drinking to replace the water lost.

Marking scheme

- Normally all the filtered glucose is reabsorbed actively in the PCT.
- At Sangam's high blood glucose, more is filtered than the PCT can reabsorb, so the rest passes into the urine.
- The glucose left in the tubule holds water by osmosis, so more urine is passed.
- The water lost makes him thirsty.

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