FOR OFFICIAL USE

National Qualifications 2025

Mark

X807/77/01

Biology
Section 1 — Answer grid and Section 2

TUESDAY, 27 MAY
9:00 AM – 12:00 NOON

X8077701

Fill in these boxes and read what is printed below.

Full name of centre

Town

Forename(s)

Surname

Number of seat

Date of birth
Day Month Year

Scottish candidate number

Total marks — 100

SECTION 1 — 20 marks
Attempt ALL questions.
Instructions for the completion of Section 1 are given on *page 02*.

SECTION 2 — 80 marks
Attempt ALL questions.
A supplementary sheet for question 1 is enclosed inside the front cover of this question paper.
Question 12 contains a choice.
Write your answers clearly in the spaces provided in this booklet. Additional space for answers and rough work is provided at the end of this booklet. If you use this space you must clearly identify the question number you are attempting. Any rough work must be written in this booklet. Score through your rough work when you have written your final copy.
Use **blue** or **black** ink.
Before leaving the examination room you must give this booklet to the Invigilator; if you do not, you may lose all the marks for this paper.

SQA

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MARKS | DO NOT WRITE IN THIS MARGIN

SECTION 2 — 80 marks

Attempt ALL questions

Question 12 contains a choice

1. **Read through the supplementary sheet for question 1 before attempting this question.**

(a) Only the male, orange-clawed fiddler crab has an enlarged claw.

(i) State the term used to describe the physical differences between the male and the female. 1

(ii) Explain how these differences arise through male-male rivalry. 1

(b) Refer to **Figure 1A** and **Figure 1B**.

Compare the morphology of the dactyl in a regenerated claw to that of an original crab claw. 1

(c) Refer to **Figure 2A** and **Figure 2B**.

Fiddler crabs are unable to visually distinguish between original and regenerated claws; during the signalling stages of aggressive contests, individuals with regenerated claws are equally successful.

(i) State one conclusion that can be drawn from **Figure 2A** regarding claw size. 1

1. (c) (continued)

(ii) **Figure 2B** shows an increase in claw muscle mass as claw size increases for both original and regenerated claws.

Describe how this trend differs between the original and regenerated claws. 1

(iii) It can be concluded that the regenerated claw in this species is a **dishonest** signal to rival males.

Explain how the data support this conclusion. 1

(d) Refer to **Figure 3A** and **Figure 3B**.

A study concluded that investing in high quality signals, which act as effective weapons during combat, is metabolically costly.

(i) Explain why the data in **Figure 3A** and **Figure 3B** support this conclusion. 2

(ii) Suggest why it may be advantageous for males that lose their claw during combat to regenerate a physically weaker claw. 1

[Turn over

2. An assay is an investigative procedure used in the laboratory.

Students carried out a colorimetric assay to determine the concentration of a protein in a solution using a colorimeter. Initially, the colorimeter was used to gather data about known concentrations of the protein in solution.

The results are shown in the table.

	Absorbance reading at 540 nm		
Concentration of protein ($mol\,L^{-1}$)	1	2	3
0.2	0.11	0.10	0.09
0.4	0.19	0.21	0.21
0.5	0.24	0.23	0.25
0.8	0.40	0.41	0.42
1.0	0.57	0.56	0.58

(a) State the type of dilution series used during the investigation. 1

_____

(b) Before each value was obtained, the students used a blank as part of their experimental method.

Explain the purpose of a blank when using a colorimeter. 1

_____

_____

(c) As part of the evaluation of their results, the students should consider the precision of the data.

Indicate whether the data are precise or not precise by ticking (✓) one box.

Justify your selection. 1

Precise ☐ Not precise ☐

Justification _____

_____

MARKS | DO NOT WRITE IN THIS MARGIN

2. (continued)

(d) Describe how the students could use the data they have gathered to determine the protein concentration of an unknown solution. 2

(e) Colorimeters can also be set to measure percentage transmission.

When a colorimeter is used to record the percentage transmission of a suspension of cells, what property of the suspension is being measured? 1

[Turn over

3. The weever fish is common in coastal waters around the United Kingdom.

This fish buries itself in the sand, leaving its dorsal fin sticking up out of the sand. When a person treads on the fish, the spines on the fin inject a venom into their foot, causing severe pain. The venom contains proteins and other molecules and is thought to have evolved as an anti-predator defence.

(a) A traditional treatment for the sting of a weever fish is to place the foot into hot water to reduce the pain. One theory is that this denatures proteins in the venom.

Explain how increasing temperature affects protein structure. **2**

(b) The venom of the weever fish contains a hydrophilic signalling molecule, 5-HT that binds to specific receptors.

Describe how an extracellular hydrophilic signalling molecule can trigger an intracellular response. **3**

3. (continued)

(c) It was discovered that for a mammal, a lethal dose of the weever fish venom protein is 1.8 μg per gram of mammal body mass.

Calculate the number of milligrams of venom protein needed to kill a mammal with a body mass of 35 kg. 1

Space for calculation

_____ mg

[Turn over

4. Cytidine triphosphate synthetase (CTPS) is an enzyme required for the synthesis of the nucleotide cytidine triphosphate (CTP). CTP is an important precursor for RNA and DNA synthesis. CTPS is inhibited by its product CTP.

In humans, there are two different forms of the CTPS enzyme, coded for by two different genes, *CTPS1* and *CTPS2*. These genes are expressed differently in different tissues.

(a) (i) State the term that describes the entire set of proteins expressed by a genome. 1

(ii) Suggest one factor that might determine which CTPS gene is expressed. 1

(b) Both *CTPS1* and *CTPS2* are expressed in normal lymphocytes.

(i) The expression of the *CTPS1* gene is low in resting lymphocytes but significantly increases when the lymphocyte is selected on exposure to a pathogen.

Explain why the nucleotide CTP must be produced in high quantities in lymphocytes exposed to pathogens. 1

(ii) Inhibiting the CTPS1 form of the enzyme is a focus for researchers investigating autoimmune conditions where lymphocytes are selected by the body's own cells.

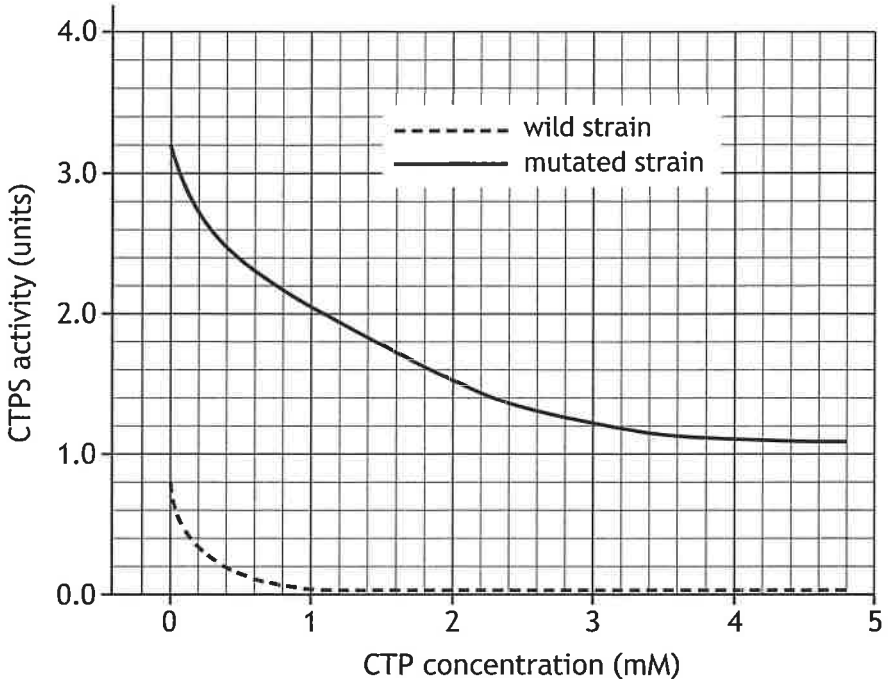
CTPS1 has been found to be less sensitive to feedback inhibition by CTP than CTPS2. This is thought to be due to a single amino acid substitution in a CTP binding site on the enzyme.

Suggest why developing a specific inhibitor to interact with this CTP binding site on CTPS1 could be effective in treating autoimmune disease. 1

4. (continued)

(c) The gene for CTPS also occurs in bacteria, which are used to manufacture nucleotides for research purposes and certain medical treatments.

The figure shows the effect of CTP concentration on the activity of CTPS for a wild and a mutated strain of a bacterium.



(i) Describe the effect of increasing CTP concentration on CTPS activity in the wild strain of the bacterium. **1**

(ii) Use the data at a single CTP concentration to justify whether the mutation shown is likely to be an advantage or a disadvantage in the commercial production of CTP. **2**

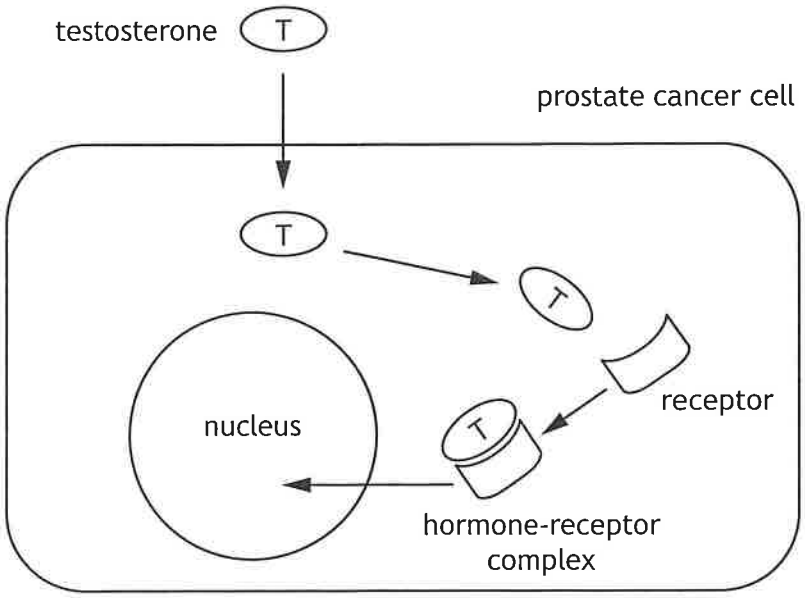
[Turn over

MARKS | DO NOT WRITE IN THIS MARGIN

5. Describe the control of protein activity by the reversible binding of phosphate. 5

6. Testosterone is a steroid hormone that promotes the growth of both normal and cancerous cells, including those of the prostate gland in males.

Once testosterone has diffused into the cell it binds with its receptor in the cytosol, forming a hormone-receptor complex. This hormone-receptor complex can then stimulate the expression of specific genes, including the gene coding for the protein NKX3.1 that plays a major role in prostate cancer cell development.



(a) Describe how a hormone-receptor complex can affect gene expression. **2**

(b) Flavonoids are compounds that are widely found in fruit and vegetables. Research has investigated their use in the treatment of prostate cancer. One flavonoid, QRS, has been found to inhibit the expression of the testosterone receptor gene in prostate cancer cells.

Suggest a mechanism by which the flavonoid QRS may prevent prostate cancer cell growth. **2**

6. (continued)

(c) Testosterone has multiple roles in the body.

Explain how different cell types show a tissue-specific response to testosterone. 1

_____

_____

(d) Other than testosterone, name one steroid hormone. 1

_____

7. Milkweeds are plants that get their name from the white sap they produce when damaged. This sap contains toxic chemicals called *cardenolides*. Cardenolides can cause cardiac arrest in vertebrates if consumed in sufficient quantity.

(a) Cardenolides cause cardiac arrest by binding to and blocking the activity of the sodium-potassium pump in heart muscle cells.

(i) The sodium-potassium pump uses energy from the hydrolysis of ATP to transport ions against a steep concentration gradient.

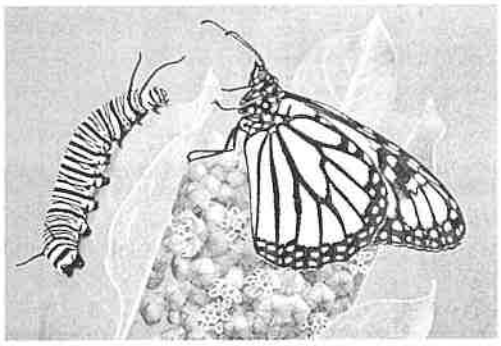
Describe the role of conformational change in altering the affinity of the sodium-potassium pump for sodium and potassium ions. **2**

(ii) Predict what effect cardenolides would have on the concentration of sodium and potassium ions inside the heart muscle cells. **1**

[Turn over

7. (continued)

(b) Monarch butterflies lay their eggs on milkweed plants and their caterpillars feed on the plants but are unaffected by the cardenolides. Instead they absorb the cardenolides and store them in their skin.



(i) The sodium-potassium pump of monarch butterflies and their caterpillars has been altered by a mutation and is less affected by cardenolides than that of most vertebrates.

State the term used to describe the process by which two or more species adapt over time in response to selection pressures imposed by each other. 1

_____

(ii) The black-headed grosbeak is a bird that occupies the same habitat as the monarch butterfly and has evolved the same mutations in its sodium-potassium pump as the monarch butterfly itself.

Predict the benefit to the black-headed grosbeak of these mutations. 1

_____

_____

8. Since their domestication, dogs have lived and worked alongside humans. Given the close co-operation between these two species, it is important to understand dogs' learning and behaviour.

(a) Anthropomorphism is common when people describe the behaviours of their pets.

Explain why anthropomorphism must be avoided in scientific studies of animal behaviour. 1

(b) Dogs exhibit a behaviour called *head-tilt* in which they move their head to one side (**Figure 1**). A recent study investigated whether head-tilting was related to dogs processing verbal stimuli.

Figure 1

Prior to taking part in this study, the dogs' owners gave informed consent.

What is meant by the term informed consent? 1

[Turn over

8. (continued)

A few dogs can rapidly learn the names of objects such as toys; these dogs are referred to as *gifted word learner* (*GWL*) dogs. This study compared the head-tilting behaviour of GWL and non-GWL dogs when they were listening to humans asking them to fetch familiar toys.

40 dogs (7 GWL and 33 non-GWL dogs) were given three months of training with the toys to be used in subsequent tests. The dogs were trained by their owners, all of whom received the same training protocol and weekly sessions with a dog trainer.

During the tests:

- the owner asked the dog to fetch one of the toys the dog had been familiarised with by saying the name of the toy
- the dogs were sitting or standing in front of the owner; the toys were in an adjacent room
- upon hearing the owner's request, the dogs entered this room and chose a toy. The same toys were used throughout the study
- the dogs were tested monthly; each test consisted of 12 trials per dog
- for every trial, the display or absence of head-tilt was noted from when the owner started to speak to when the dog left to fetch a toy.

(c) (i) During tests it was the dogs' owners who spoke the names of the toys.

Indicate whether this can be considered a positive or a negative aspect of the experimental design.

Justify your choice. 1

Aspect _____

Justification _____

_____

(ii) During each trial, the position of the owner relative to the dog when they spoke was recorded.

Explain why it was important to take account of the position of the owner when speaking. 1

_____

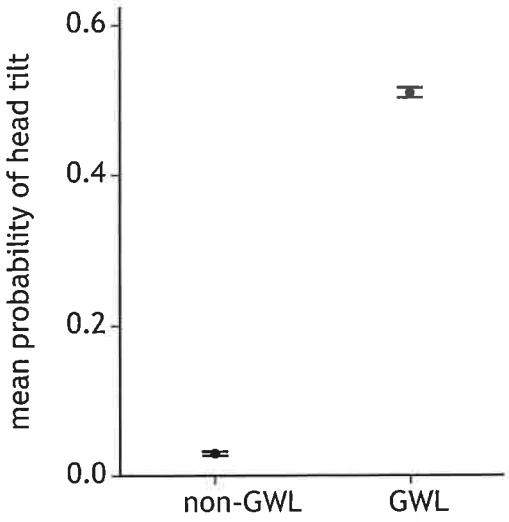
_____

8. (continued)

MARKS | DO NOT WRITE IN THIS MARGIN

(d) Data from this study are shown in **Figure 2.**

Figure 2



It was concluded that the GWL dogs tilted their heads significantly more than non-GWL dogs in response to a verbal request.

(i) Explain why the data support the conclusion that the sample size was large enough for this conclusion to be valid. **1**

(ii) Explain how the procedures used can exclude the possibility that the familiarity of the stimulus was enough to elicit head-tilting in GWL dogs. **1**

(e) *Lateralisation* of brain function is the tendency for some processes to be asymmetric (specialised to either the right or the left side of the brain).

It was suggested that dogs displaying a consistent preference to head-tilt to one side would suggest asymmetric processing of the verbal stimuli.

Briefly describe how the study could be extended to test this hypothesis. **2**

9. The European beaver (*Castor fiber*) is a large semi-aquatic mammal. Beavers are herbivores and are most active at dawn and dusk. They fell trees and divide them into smaller branches to build dams and create pools of deep, still water. Within these pools, they construct lodges made of sticks and branches, in which they live. Beavers are thought to have become extinct in Scotland because of hunting by humans.

The Scottish Beaver Trial in 2009 oversaw the planned reintroduction and monitoring of a small population of beavers into Knapdale forest in mid-Argyll, Scotland. Sixteen beavers were transported from Norway and released into freshwater lochs. Over the next five years, the beavers were monitored and their impact on the forest ecosystem assessed.

(a) Fieldwork can present a variety of hazards, so must be risk-assessed.

(i) State what is meant by the term 'risk' in the context of risk-assessment. **1**

(ii) Suggest one control measure that would be appropriate when carrying out the fieldwork in this trial. **1**

9. (continued)

(b) Several methods were used to monitor and gather data about the movements and behaviours of the beavers in this trial.

(i) Uniquely colour-coded ear tags and GPS trackers fitted to the animals are two methods that were used.

Choose one of these methods of monitoring and suggest why it would have been useful for gathering data for this trial. 1

Method _____

Reason _____

_____

(ii) Scientists and volunteers undertook direct visual observation of the beavers.

The beavers were seen regularly, and they seemed to be relatively unconcerned by the presence of observers. Later in the trial, camera traps were placed close to areas such as lodges and dams.

Suggest one reason why camera traps would be an improvement for gathering data. 1

_____

_____

(c) Various sampling strategies were used to monitor the impact of the beavers on other species.

Name the sampling strategy being used if samples are taken at regular intervals along the banks of a waterway. 1

_____

9. (continued)

(d) In 2017, a second project was set up to reinforce the Knapdale beaver population with beavers from a population in Tayside, which had been unofficially released. The Tayside beavers were from a population that is thought to have originated in a region of Germany.

Inbreeding (matings between closely-related individuals) is a potential issue in small populations as it affects genetic diversity. One measure of genetic diversity is *heterozygosity*, which indicates the proportion of genes having two different alleles.

The table contains data about the heterozygosity of the Knapdale population before and after reinforcement with the Tayside beavers.

	Heterozygosity
Before reinforcement	0.05
After reinforcement	0.18

Suggest how the change in heterozygosity following reinforcement is important for the long-term future of the beaver population in Knapdale. 2

10. Most evolutionary changes in humans occur as a result of small changes in the frequencies of many alleles that together influence the phenotype being selected for. However, new allele patterns can sometimes emerge when strong selection pressure increases a single allele's frequency in a population from low to high over a relatively short period of time; these changes are termed a *selective sweep*.

In humans, the milk sugar lactose is digested by the enzyme lactase. This enzyme is produced by intestinal cells and is encoded by the lactase (*LCT*) gene.

Most mammals cannot utilise lactose after infancy as the expression of *LCT* stops after weaning. However, some human populations have a high proportion of adults able to digest lactose. This ability to utilise lactose, *lactase persistence*, is inherited, and individuals who cannot digest lactose during adulthood are described as being lactase non-persistent. Lactase persistence is thought to be the result of a selective sweep.

(a) Lactase persistence appears to correlate with dairy farming providing fresh milk for consumption by adults, which happened in several cultures over the last 10 000 years.

Suggest how selection could have brought about a selective sweep at the *LCT* gene. **2**

(b) Scientists studying selective sweep can use genome sequence data to detect possible examples. This is being helped by large databases of ancient DNA (aDNA) sequences, which are rapidly becoming available.

Explain how aDNA databases could be used to identify a selective sweep. **1**

[Turn over

MARKS | DO NOT WRITE IN THIS MARGIN

10. (continued)

(c) Describe how the Hardy-Weinberg principle can be used to determine whether evolution is happening within a population. 3

11. Kestrels (*Falco tinnunculus*) are small falcons found throughout the UK. They are birds of prey that feed mainly on small mammals and form exclusive long-lasting pair bonds.

A normal clutch size of 5–6 eggs is produced in late April to early May with about 2 days between each egg being laid. The female starts to incubate the eggs after the third egg is laid. The heat provided by incubation ensures that the eggs can develop and hatch. After about a month of incubation all the chicks hatch.

After hatching, growth of the chicks is entirely supported by the hunting activity of the male. If all the chicks survive, he may need to provide seven times his normal catch.

(a) Name the mating system employed by kestrels. **1**

_____

(b) Describe the activities of kestrels that make up the parental investment of each of the two sexes. **2**

_____

_____

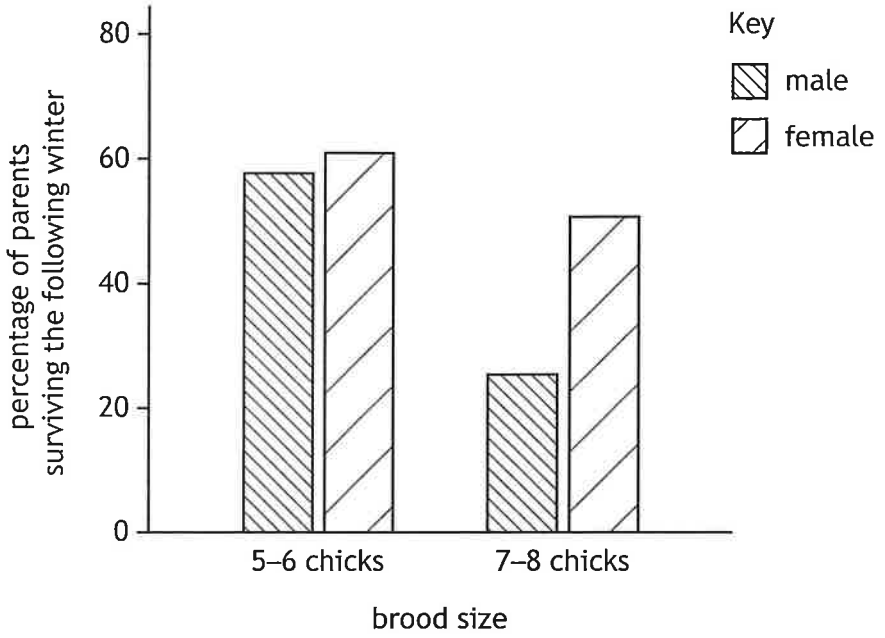
_____

[Turn over

11. (continued)

(c) In a study of kestrels, the normal brood size of 5–6 chicks was increased in some nests to 7–8 chicks. To evaluate the consequences of raising a larger number of chicks, the percentage of male and female parents that survived the following winter was measured.

Some results from this study are shown in the graph.



(i) Use the information to show that normal brood sizes, although smaller than the maximum number of chicks that can be raised, maximise total lifetime reproductive output. 2

(ii) Predict one consequence of brood enlargement that might affect the survival of chicks. 1

MARKS | DO NOT WRITE IN THIS MARGIN

12. Answer **either A or B.** Write your answer in the space below and on *page 30.*

A Discuss meiosis under the following headings:

(i) meiosis I — 7

(ii) meiosis II. — 2

OR

B Discuss parasites under the following headings:

(i) life cycle of *Plasmodium* — 6

(ii) modification of hosts by parasites to increase transmission. — 3

[Turn over

National Qualifications 2025

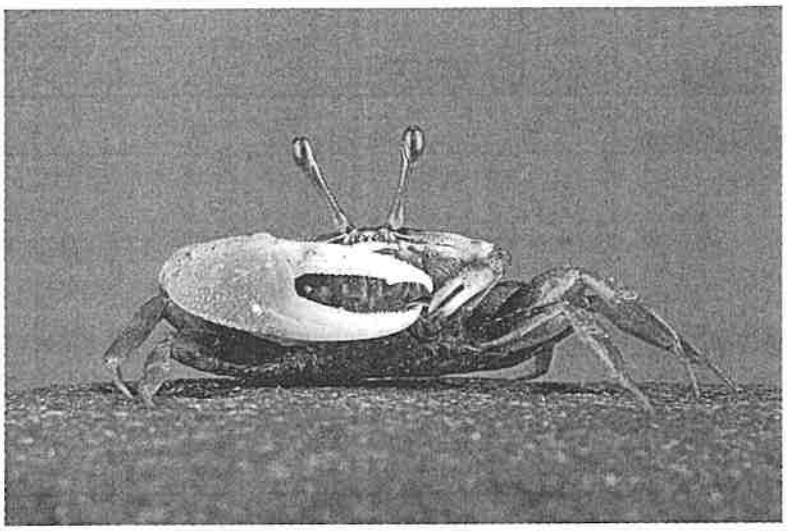
X807/77/11

Biology
Supplementary sheet

TUESDAY, 27 MAY
9:00 AM – 12:00 NOON

Supplementary sheet for question 1

1. The orange-clawed fiddler crab, *Gelasimus vomeris*, is a species of crustacean that can be found living on mudflats in north-eastern Australia.



Male fiddler crabs possess a greatly enlarged claw that is used as a signal during prefight assessment of rival males, and as a weapon during physical contests, such as establishing territories. Larger-clawed individuals are generally more successful in such contests than smaller-clawed individuals.

If male fiddler crabs lose their enlarged claw during fights or attacks from predators, they can regenerate a replacement claw. Regenerated claws do not differ in overall length compared to original claws. They do, however, differ in morphology (shape and structure).

Figure 1A and **Figure 1B** show the morphology of an enlarged claw and how two features of the morphology relate to claw strength for both original and regenerated claws.

Figure 1A

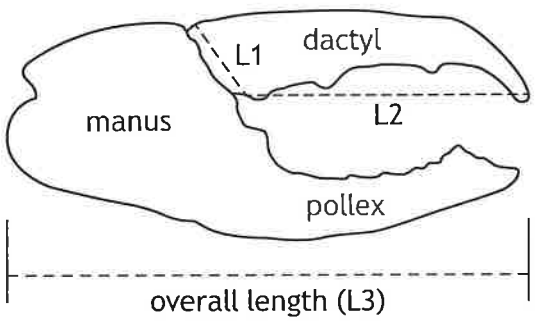
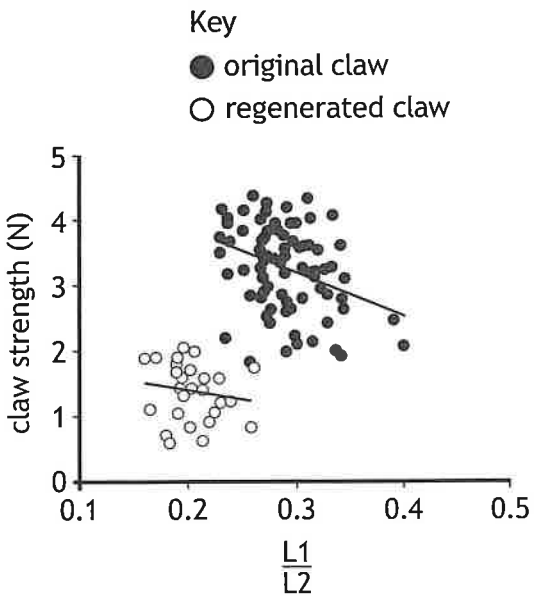


Figure 1B



1. (continued)

Claw size is the primary signal of male dominance. Signals of potential strength can change an opponent's behaviour as both competitors can assess the likelihood of combat success should the dispute escalate to physical contact. Smaller-clawed males will often retreat before entering into physical contact with larger-clawed males.

An investigation was carried out to determine how the morphological changes in the shape of regenerated claws affected their muscle mass and strength compared to original claws.

The results are shown in **Figure 2A** and **Figure 2B**.

Figure 2A

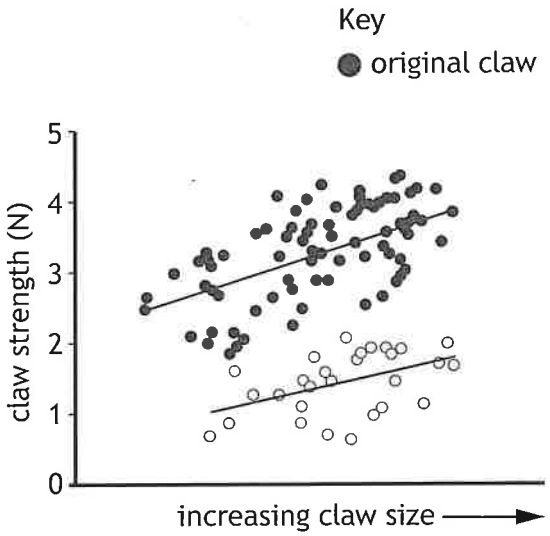
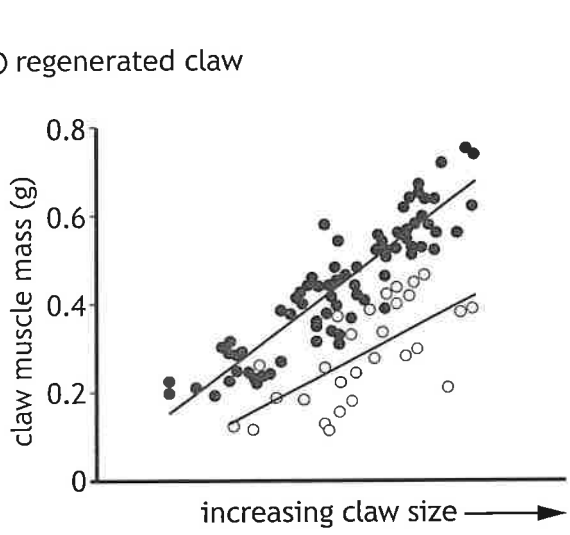


Figure 2B



A second investigation compared the metabolic costs of claw muscle tissue for males with either an original or a regenerated claw.

The results are shown in **Figure 3A** and **Figure 3B**.

Figure 3A

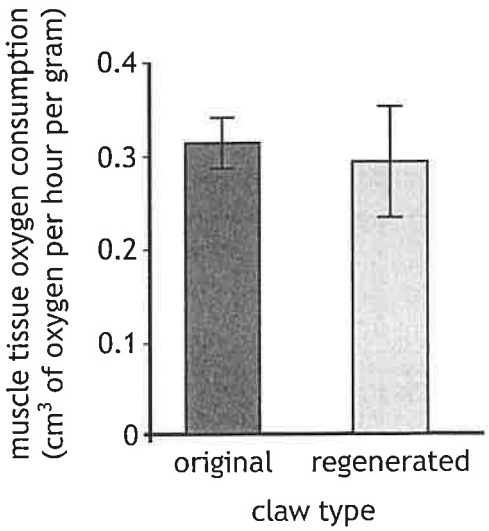
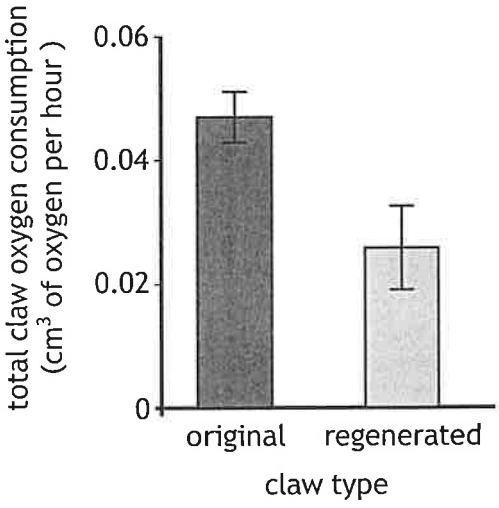


Figure 3B



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