‘A’ level Biology
Y11 into Y12 Gap task

Name: ....

The gap task is split into 5 sections, firstly, to enable you to better understand the demands of the ‘A’ level Biology course and secondly, to allow your teachers to better understand your needs. The 5 sections are as follows:

1. Independent study – retrieval practice
2. Literacy
3. Numeracy
4. Practical skills
5. Wider reading

Each section will be based on a topic that you will be studying in the first few weeks of the ‘A’ level Biology course and will begin to build on the knowledge you have acquired from your GCSE studies.

You should complete all tasks during the summer break and bring your completed paper to your first biology lesson in September.

Independent study – retrieval practice

Past students have cited the increased expectation of independent study as one of the biggest demands of studying A level Biology. Roughly speaking, each hour of lesson should be supported by another hour of independent study. This means over a 2-week timetable, you should be doing 12 hours of independent study **on top of** any homework you are set per subject!

It can be difficult to know what exactly to do for independent study. Simply reading or copying your notes / textbook will not improve how well you can retrieve key information. Instead, make your study strategies generative i.e. retrieving the information from memory with **no cues**. You can then check what you have retrieved using your notes / textbook and make corrections. This is known as retrieval practice. Doing this regularly (30 minutes a day) is hugely powerful in developing strong memory of the key information needed for the subject.

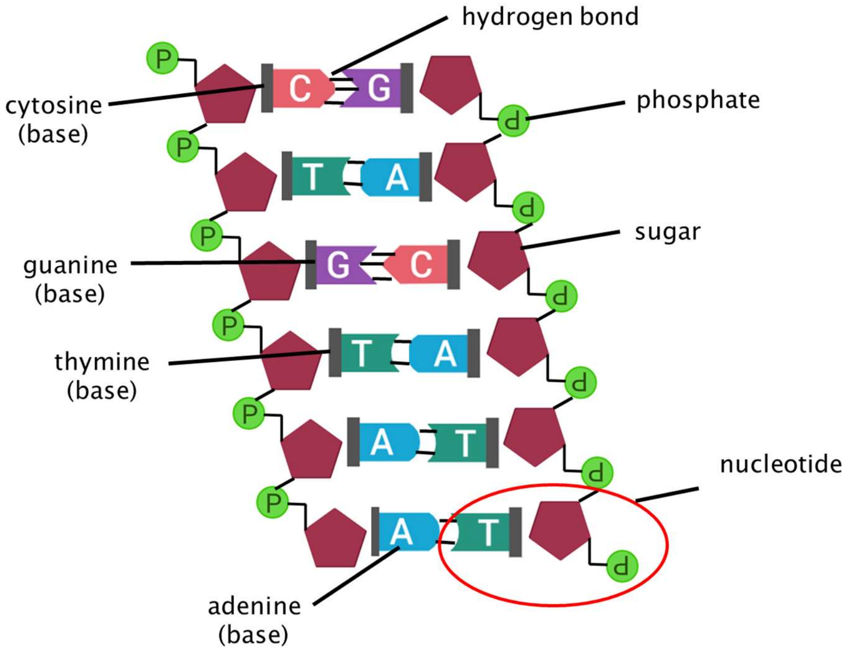
Retrieval practice can take many forms but here I would like you to try out 2 examples:

Task 1

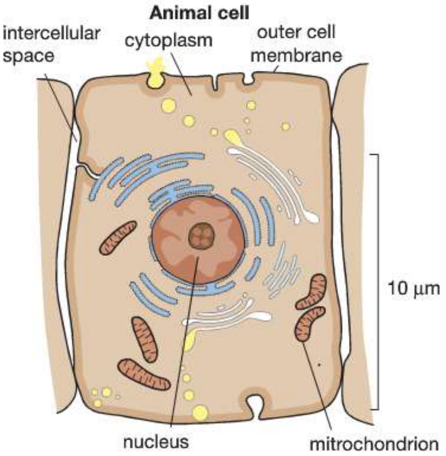
Below (and on the next page) are labelled diagrams of animal, plant and bacterial cells and the structure of DNA. There is also a table showing the functions of the cell organelles.

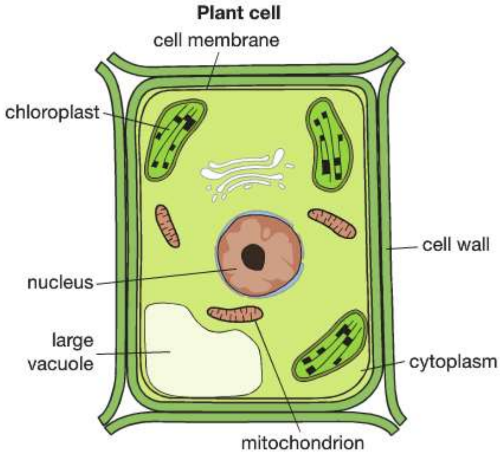
Practice "self-quizzing" of the labels / functions of the cells and DNA by redrawing from memory (it doesn't need to be a work of art!) and checking your drawing against the diagrams. Repeat this every week until you make no mistakes.

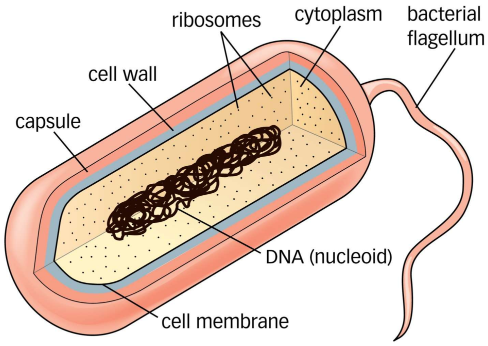
Structure of DNA



Cells & organelles







Nucleus	Contains the genetic information (genome) for the cell.
Mitochondria	Site of aerobic respiration where energy in the form of ATP is released,
Cytoplasm	Site of chemical reactions and contains a protein network to allow the movement of substances within the cell.
Cell membrane	Regulates the transport of substances into and out of the cell.
Ribosome	Site of protein synthesis (translation).
Cell wall	Strengthens the cell, preventing it from bursting and maintaining its shape.
Chloroplast	Contains chlorophyll to absorb light energy and site of photosynthesis producing glucose.
Large vacuole	Contains water and dissolved substances and maintains the cell's shape.
Capsule	Protects the cell.
Flagellum	Allows movement.
Nucleoid	Loop of bacterial DNA not contained within a nucleus.

Literacy

The ‘A’ level Biology course requires you to write extended responses to exam questions. Not only do these responses need to have a good level of spelling, punctuation and grammar, they also need to utilise specialist scientific vocabulary. Additionally, the exam questions will often use an unfamiliar context that might have new vocabulary for you to decode.

A good technique to use is to use the etymology or morphology of a word to help you understand what it means e.g.

	biology
bios	-logia
Greek meaning life	Latin meaning study

From this we deduce that the word “biology” means “the study of life”. But we can also now deduce the meaning of other words containing “bios” and “logia”.

Task 2

Research and write down the etymology of the following terms you will have learnt at GCSE (a simple Google search works well):

a) membrane

b) chloroplast

c) glucose

d) enzyme

e) mitochondria

f) chromosome

g) mitosis

h) lipid

i) carbohydrate

j) organelle

Numeracy

10% of the written exam questions will require you to use level 2 mathematical skills. These include selecting and using appropriate statistical tests, rearranging equations and converting units. Getting your own scientific calculator is a must as you will need to know how to perform various calculations on it and each model is slightly different.

Task 3

Answer the following questions (**with appropriate units**).

a) Convert the following:

i. 42 kg to grams

____

____

ii. 5 m^3 to cubic centimetres

____

____

iii. 2000 cm^2 to square metres

____

____

b) An adult human's kidneys process approximately 1200 cm^3 of blood every minute

i. What is the volume in cubic decimetres?

____

____

ii. How much blood is processed by the kidneys every second? Give your answer in mm^3.

____

____

c) Round the following numbers:

i. 0.0719 gs^{-1} to 3 decimal places

____

ii. 8.045 dm^3 to 2 significant figures

____

d) Complete the following table:

Ordinary number	84100			0.000022
Standard form		5.412×10^4	7.46×10^9	

e) Convert the following units to metres and write them in standard form:

i. 1 mm

____

ii. 1 nm (nanometre)

____

iii. 1 μm (micrometre)

____

iv. 1 cm

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v. 27 mm

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vi. 5647 mm

----

vii. 399 cm

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viii. 29000000 μm

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f) Calculate the surface area **and** volume of the following shapes. Show your working:

i. A cube with side length of 5 mm

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ii. A cuboid with height of 4 mm, width of 3 mm and depth of 1.5 mm

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iii. A cylinder with a diameter of 2 cm and length of 12 cm

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g) The body temperatures of 6 people are shown below:

36.7 ºC, 37.2 ºC, 36.5 ºC, 36.2 ºC, 36.9 ºC and 36.5 ºC

i. What is the range of temperatures?

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ii. What is the mode?

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iii. What is the median?

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iv. What is the mean?

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h) Complete the following table by calculating the percentage increase in plant height.

Plant	Height at week 2 (cm)	Height at week 5 (cm)	Percentage increase (%)
1	7.6	11.4	
2	6.7	10.7	
3	8.5	11.9	

Practical skills

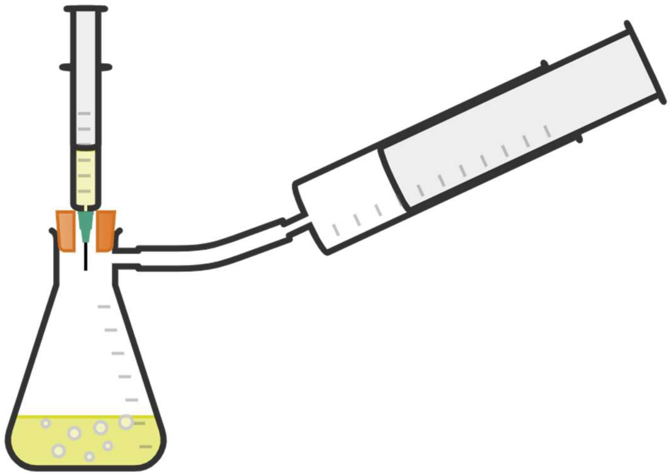
As part of your A level Biology studies, you will complete several practical investigations. These are not formally assessed but do combine to form a portfolio known as the Practical Endorsement. At the end of your course you will receive a pass or a fail in this which will go alongside your grade from the exams.

Task 4

Read the method for a practical investigation into enzyme activity. Answer the How Science Works questions about the investigation.

Method

1. Clamp the gas syringe securely, angled slightly downward.
2. Add 10 ml of 5 % hydrogen peroxide to a conical flask.
3. Put the bung securely in the flask and connect to the gas syringe.
4. Draw 2 ml of 5% yeast solution and 3 ml of air into a 10ml syringe.
5. Connect the 10ml syringe to the flask using the second bung hole.
6. Dispense the yeast solution into the conical flask and start timing.
7. Record the volume of gas in the gas syringe every 10s, record in the results table.
8. Repeat twice more for this concentration using the same conical flask.
9. Repeat steps 2 to 8 with 10, 15 and 20 % hydrogen peroxide.



a) What is the independent variable in this investigation?

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b) What is the dependent variable?

____

____

c) Suggest a variable that would need to be controlled.

____

____

d) One student suggested that a set of 3 repeats should be completed with 10 ml of water instead of hydrogen peroxide. Why is this a good suggestion?

____

____

____

e) Identify a limitation with the experiment and suggest an alteration that would improve it.

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Wider reading

You are now studying only 3 subjects and (hopefully!) this is because you really enjoy them! Biology is a wide reaching subject and you will find that your teachers have passions for particular aspects of it. These passions start by discovering information away from the course itself through wider reading.

Task 5

Read the attached article on anti-predator defences ('The secrets of staying alive') and complete the following tasks:

a) Summarise the article in your own words (no more than half an A4 page).
b) Produce a glossary of any biological / scientific terms used (don't forget to include some etymology – see task 3).

Task 6

Familiarise yourself with the recommended reading and watching lists below.

Reading around your 'A' level subjects will help you develop a more comprehensive understanding of particular topics and their real-life contexts. Try to develop a habit of reading books, articles, or news articles, and listening to podcasts or watching TV programmes related to biology. If you discover other interesting sources of information, please share them with the rest of us!

Websites

https://phys.org/biology-news/

https://www.quantamagazine.org/biology/

https://www.newscientist.com/

http://www.bbc.co.uk/news/science_and_environment

Books

The Serengeti Rules by Sean B. Carroll

What is Life? By Paul Nurse

The Song of the Cell by Siddhartha Mukherjee

The Body by Bill Bryson

Mutants: On the Form, Varieties and Errors of the Human Body by Armand Marie Leroi

The Ancestor's Tale by Richard Dawkins

Genome: The Autobiography of a Species in 23 Chapters by Matt Ridley

Power, Sex and Suicide: Mitochondria and the Meaning of Life by Nick Lane

Epigenetics: The Ultimate Mystery of Inheritance by Richard C Francis

The Symbiotic Planet by Lynn Margulis

Microbes and Man by John Postgate

Podcasts / Radio

Ingenious - https://www.bbc.co.uk/programmes/m000h0fy

A 5 part series with each 15 minute episode exploring a single gene, including the ginger gene and the breast cancer gene.

BBC Inside Science - https://www.bbc.co.uk/programmes/b036f7w2

A weekly show exploring whatever science is in the news.

Big Biology - https://www.bigbiology.org/

Big Biology is a podcast that tells the stories of scientists tackling some of the biggest unanswered questions in biology.

Films

Contagion

"Healthcare professionals, government officials and everyday people find themselves in the midst of a pandemic as the CDC works to find a cure."

Gattaca

"A genetically inferior man assumes the identity of a superior one in order to pursue his lifelong dream of space travel."

This film explores the issues around genetic engineering and genetic selection.

Creation

"Torn between faith and science, and suffering hallucinations, English naturalist Charles Darwin struggles to complete 'On the Origin of Species' and maintain his relationship with his wife."

The Immortal Life of Henrietta Lacks

"An African-American woman becomes an unwitting pioneer for medical breakthroughs when her cells are used to create the first immortal human cell line in the early 1950s."

TV

There are many David Attenborough documentaries on BBC iPlayer that are fantastic, here is a selection of the most recent:

Planet Earth II - https://www.bbc.co.uk/programmes/p02544td

Blue Planet II - https://www.bbc.co.uk/programmes/p04tjbtx

Dynasties - https://www.bbc.co.uk/programmes/p06mvmmr

Aside from Attenborough, there are some other great shows with biology at their heart:

Secret Universe: The Hidden Life of The Cell - https://www.dailymotion.com/video/xzh0kb

The Serengeti Rules documentary - The Serengeti Rules (2019) | Full Documentary

The secrets of Anti-predator defence mechanisms

Ants spraying formic acid is an example of chemical anti-predator defence

Rebecca Verspoor

Survival in the wild is a struggle. Animal behaviourist Rebecca Verspoor discusses how this has driven the evolution of a huge diversity of species over millions of years

EXAM LINKS

AQA Populations in ecosystems; Genetic diversity and adaptation; Transport across cell membranes
OCR A The types of plant responses; Classification and evolution; Populations and sustainability
OCR B Cells and chemicals for life; Genetics in the twenty-first century
Pearson Edexcel A Genes and health; Biodiversity and natural resources
Pearson Edexcel B Natural selection; Origins of genetic variation; Ecosystems
WJEC Eduqas Variation and evolution

Predation is the killing and consumption of one animal by another. It is not a single event, but a sequence. Predation starts with the detection of the prey by a potential predator, recognition that the prey is suitable, overcoming the prey and finally eating the prey item. Prey may use a variety of anti-predator defences at any part of the predation sequence.

Predation and defence mechanisms

Many species have evolved defences that act at several stages along the predation sequence. However, anti-predator defences are costly to maintain and can impact the **fitness** of an individual. For the prey, defences that affect the predatory sequence at the earliest point possible are especially valuable, because they reduce the opportunity for injury or energy loss from attempting to escape or fight the predator. As these defences are used early in the sequence and most frequently, they should be relatively low cost compared with later-acting defences, which are used less often.

Selection of these diverse defences often results in a remarkable diversity of adaptations and extreme traits that appear over generations. For example, natural selection might improve the visual

staying alive

abilities of predators, enabling them to increase prey detection. To survive, prey need counteradaptation. Natural selection therefore favours enhanced camouflage and occupation of different niches, making it more difficult for predators to find them.

In the context of predator–prey interactions, this means that prey animals with effective anti-predator defences are more likely to survive and pass on their genes to the next generation. Over time, these traits become more common within the population.

Types of anti-predator defence

Anti-predator defences fall into three categories: physical, chemical and behavioural. Physical defences involve structural features of the animal's body that deter predators, or make it harder for them to succeed in an attack. They include features such as thorns or spikes (as seen in the masked spiny lizard) and a hard shell. These features make it harder for a predator to attack their prey. If they do manage to capture one, the features make it harder to consume the prey – by the need for more handling – and increase the risk of injury for the predator.

When an animal cannot out-fight its predator, it may use a more widespread form of defence – chemicals. These are often undetectable by the predator until it is too late. Chemical defences include noxious, smelly, indigestible, toxic or venomous substances that repel, deter, harm, distract or prevent detection by predators. These can be released away from the prey (such as being sprayed, as in various ant species), cover the prey's body, or be injected directly into a predator.

Behavioural defences are actions or strategies that enable a prey animal to elude danger. These can include running away, alarm calls, herding or **defensive thanatosis**, such as in the Pacific tree frog.

Insect defences

Insects exhibit some of the most diverse and effective anti-predator defences. Their short generation time, rapid reproductive rates and large population sizes offer huge potential for novel evolutionary adaptations to emerge.

Mimicry and camouflage are common and effective strategies. Mimicry involves resembling other objects or organisms – often a more dangerous or inedible species. Research shows that predators are likely to avoid the harmless mimic following a previous unpleasant experience with more dangerous prey. Batesian and Müllerian are two types of mimicry (see Box 1).

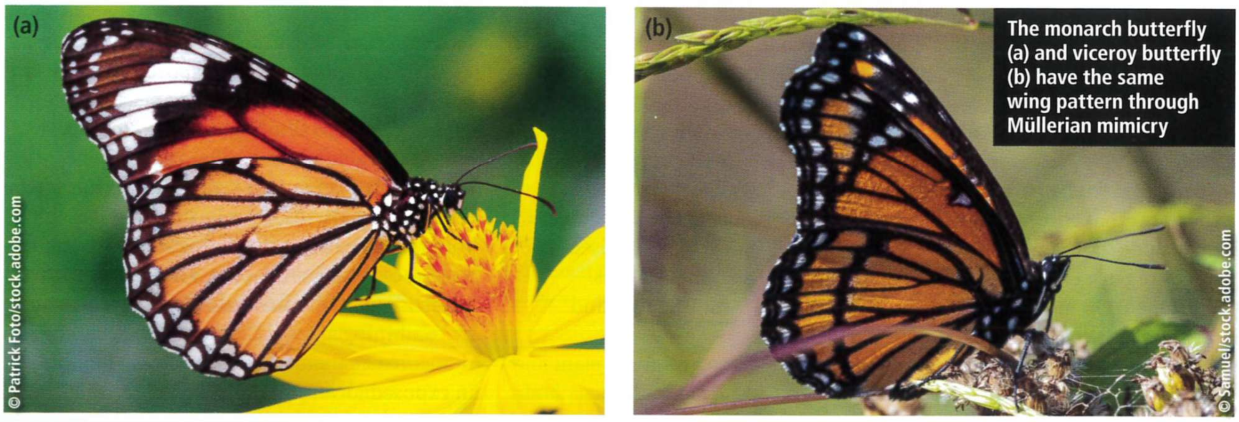
Box 1 Batesian and Müllerian mimicry

In Batesian mimicry, harmless edible insects copy the warning signals of harmful species. In Müllerian mimicry, many inedible species have evolved a similar warning signal, reinforcing the avoidance behaviour in predators.

An example of Batesian mimicry is found in the edible hornet moth, which resembles a venomous hornet. The similarity to a hornet makes it unappealing to predators.

The two butterflies shown are examples of Müllerian mimicry, whereby both the viceroy butterfly and monarch butterfly have evolved the same warning signal that deters predators. The benefit of this strategy is that predators only need one unpleasant encounter with one member of the set of mimics (in this case a viceroy or monarch butterfly) to avoid all similar colourations, irrespective of whether or not it belongs to the same species as the first encounter.

This leads to selection of a common phenotype or 'mimicry ring', which reduces the cost of learning by predators. Müllerian mimics do not usually exhibit sexual dimorphism, because the mimetic advantage of increased frequency in these species outweighs any sexually selected advantage of non-mimetic patterns.



The monarch butterfly (a) and viceroy butterfly (b) have the same wing pattern through Müllerian mimicry

Box 2 Multi-layered defence in a nematode

The nematode *Heterorhabditis bacteriophora* is a host to symbiotic bacteria, *Photorhabdus luminescens*. The worm infects soil-dwelling hosts, kills them and then reproduces inside the hosts for around 2 weeks. Rather than decaying, the infected host remains turgid and potentially vulnerable to being eaten by a predator, but the host is not consumed at this stage.

Instead, the bacteria cause a number of changes in the host that deter predation, including aposematism, a foul-smelling odour and **bioluminescence**. Research has shown that these defences are maintained to act at different points of the predation sequence, but also to target different predators that are likely to encounter the infected host.

Birds rely on the red warning colour (aposematism) to avoid the host, whereas nocturnal rodent predators avoid the host due to the bioluminescence. Beetles and ants avoid the infected host based on the nasty smell it gives off. The result is successful reproduction of the nematode.

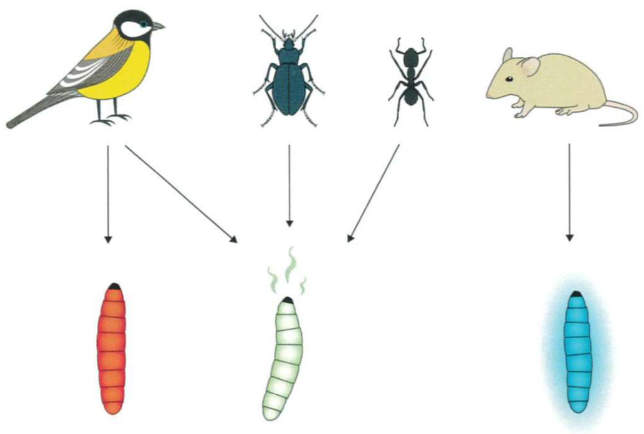


Figure 2.1 The different defences of the nematode *Heterorhabditis bacteriophora*, including warning colouration, chemical defence, bioluminescence and a foul-smelling odour. These target a range of predators with different visual and olfactory systems

TERMS EXPLAINED

Bioluminescence The production and emission of light by a living organism.

Defensive thanatosis Feigning death to avoid predation. Most predators only catch live prey and so will leave 'dead' prey alone.

Fitness An organism's ability to survive and reproduce in its environment, and pass on its genes to the next generation.

Gene knock-out A genetic engineering technique in which a specific gene is purposefully inactivated or removed from an organism's genome. This is often done to study the gene's function or the impact of its absence on the organism's overall functioning.

Camouflage and crypsis (avoiding detection) can involve colouration that matches the background, disruptive patterns that break up the organism's outline, or physical adaptations that mimic elements of the habitat, such as leaves or twigs. A classic example of camouflage is in the melanic and light forms of the peppered moth.

Chemical defences are another common mechanism. Some insects, such as certain species of beetle and many caterpillars, can make their own toxins and then release them when threatened. Other species, including aphids, obtain their toxins (alkaloids) from plant hosts, and store them in their bodies.

Insects that feed on alkaloid-containing plants have evolved various mechanisms that allow them to cope with the consequences of these toxins. These include sequestration, where insects store alkaloids in specialised tissues or organs, enzymatic detoxification through enzymes such as cytochrome P450 monooxygenases and glutathione *S*-transferases, and behavioural adaptations, such as selective feeding.

A classic example of this is the interaction between the milkweed plant and monarch butterflies. Monarch butterflies feed exclusively on milkweed plants, which contain cardenolides – noxious compounds. They can tolerate this food source because of a peculiarity in a crucial protein in their bodies, a sodium pump, which the cardenolide toxins usually interfere with.

Researchers have known for some time that there are mutations in at least one of the genes that carry instructions for making sodium pumps, which make it harder for the cardenolides to bind. They have recently identified the specific genes through producing **gene knock-out** fruit flies. Not only did this resistance to the toxin open up a whole new source of food, but it also allowed the butterflies to repel predators by storing the toxins in their bodies.

Sequestering or producing chemicals also leads to another anti-predator strategy, common in insects – aposematic colouration. This is the combination of bright, conspicuous colours (reds, yellow or orange), in combination with a chemical defence. This strategy helps to advertise the unpalatability of prey to predators, protecting individuals with these signals.

These visual cues are extremely effective because they are easily learned and remembered by predators. Common examples of these in nature include bees, wasps and ladybirds, which all have distinctive and memorable patterns, backed up by a chemical defence in the form of a painful sting (some bees and wasps) or poisonous secretion (ladybirds).

As in Müllerian mimicry, aposematic insects benefit from the predator's prior negative experiences with similarly coloured toxic prey, even if it is a different species, thus reducing the likelihood of being attacked. Selection has acted on these signals, resulting in similar warning patterns and colours appearing in nature across a range of different taxa. Some insects take this advertisement of unpalatability a step further by combining aposematism with behaviours that enhance their visibility, such as remaining in exposed locations or displaying specific movements that highlight their warning colours.


A masked spiny lizard with defensive spines

© prin79/stock.adobe.com

Many insects also demonstrate collective or group behaviours as a defence mechanism, although these behaviours are typically associated with mammals and birds. Many social insects, such as many bees, ants and termites, exhibit sophisticated group defence tactics, such as co-ordinated attacks on predators and the construction of protective nests.

Protective nests are made out of tough materials that are hard to penetrate, as well as having concealed entrances that are often guarded by individuals of the colony. These behaviours can reduce an individual's risk of predation through the dilution effect, whereby the chance of any individual being predated is reduced in a larger group.

A multi-layered defence system

Prey rarely rely on just a single type of defence, but instead use multiple strategies. There are several advantages to using a multi-layered defence system, including redundancy. If one defence mechanism fails, there is still a back-up that can help to protect the prey. For example, if a predator detects a camouflaged insect, the insect may still be able to escape using flight. A multi-layered defence can also provide protection against a range of different predators. Using multiple defences can therefore provide better protection against a bigger range of threats (see Box 2).

In summary, prey organisms can employ a diverse and complex array of anti-predator defences. Mimicry and camouflage allow them to avoid detection and deceive predators, while collective behaviours provide safety in numbers. Chemical defences deter or harm predators directly, and aposematism signals these chemical defences through bright warning colours. Together, these strategies form a multi-layered defence system that enhances the survival of prey in a world full of predatory threats.

RESOURCES

A blog post on *Heterorhabditis bacteriophora* and its defences (Box 2): **https://tinyurl.com/multi-layered-defence**

How squid outsmart their predators (TED talk): **https://tinyurl.com/squid-defence**

PRACTICE EXAM QUESTIONS

1. Compare and contrast Batesian mimicry and Müllerian mimicry. [4 marks]
2. Pouyannian mimicry is a form of mimicry found in plants.
   In one example, the flower of the bee orchid, *Ophrys speculum*, has a shape and colouration similar to that of a female *Dasyscolia ciliata* bee. Glands in the orchid's flower secrete a chemical that is indistinguishable from the bee's pheromones.
   Suggest the selective advantage of the bee orchid's mimicry. [3 marks]

BiologicalSciencesReview*Extras*

Go online for the answers at www.hachettelearning.com/bioreviewextras

KEY POINTS

- Predation is a step-by-step process, and evolution followed by natural selection has provided prey with ways to defend themselves at each stage.
- Defences can be physical, chemical, or behavioural, with insects providing some great examples of these.
- Many animals have a mix of defences that protect them against different predators.

Dr Rebecca Verspoor is a lecturer in the School of Biosciences at the University of Liverpool. Her research interests are anti-predator defences and the evolution of warning signals.