BIOZONE

Textbook Lite | Activities | Study Guide

NCEA LEVEL 3 BIOLOGY

INTERNALS

FREE SAMPLE for classroom trial

This sample packet may be photocopied and trialled in the classroom.

Achievement Standard 3.1

Maintaining a stable internal environment

Key terms

Common terms
effectors
homeostasis
hormones
hypothalamus
negative feedback
nerves
positive feedback
receptors

Thermoregulation
hyperthermia
hypothermia
thermoregulation

Blood glucose regulation
blood glucose
diabetes mellitus
glucagon
insulin

Fluid and electrolyte balance
acid-base balance
ADH
electrolyte
kidney
osmoregulation

Blood pressure regulation
adrenal cortex
blood pressure
kidney
renin-angiotensin system

Regulation of respiratory gases
breathing rate
chemoreceptors
heart rate

Homeostatic mechanisms help the body maintain a constant internal environment, even when external conditions are changing. Homeostasis makes it possible to carry out essential life processes.

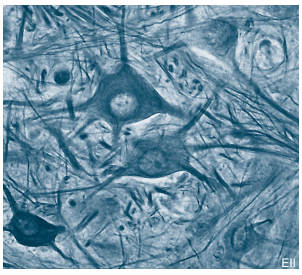
Achievement criteria and explanatory notes

Achievement criteria for achieved, merit, and excellence

☐ A Demonstrate understanding of how an animal maintains a stable internal environment: Use biological ideas to describe a control system by which an animal maintains a stable internal environment. Use annotated diagrams or models to support your description.

☐ M Demonstrate in-depth understanding of how an animal maintains a stable internal environment: Use biological ideas to explain how or why an animal maintains a stable internal environment. Include reference to how a specific disruption results in responses that reestablish homeostasis.

☐ E Demonstrate comprehensive understanding of how an animal maintains a stable internal environment: Link biological ideas about maintaining a stable internal environment in an animal. Include at least one of:
- The significance of the control system in terms of adaptive advantage.
- The processes underpinning the mechanism (e.g. metabolic pathways).
- An example of how environmental influences result in system breakdown.



Principles of homeostasis

Homeostatic systems involve the following biological principles

Activity number

Several mechanisms are common to homeostatic systems. An understanding of these will help you describe and explain your chosen examples.

☐ 1 Negative feedback mechanisms have a stabilising effect and are self correcting. **32 33**

☐ 2 Positive feedback mechanisms amplify a response to achieve a specific outcome. **34**

☐ 3 Nervous and hormonal controls are both involved in homeostatic systems. **32 35-37**

Explanatory notes: Control systems

You must choose at least one homeostatic system

Activity number

4 For the system you choose, describe the role of the system, its components, and the mechanisms involved in regulation. Homeostatic systems include:

☐ a Body temperature (thermoregulation). **39-44**

☐ b Blood glucose. **46-49**

☐ c Osmotic (fluid and electrolyte) balance. **51-55 57**

☐ d Blood pressure **56-57**

☐ e Level and balance of respiratory gases in tissues. **62**

☐ 5 For the homeostatic system of your choice, describe the effects of disruption to normal regulation by internal or external influences. These may include extreme environmental conditions, exertion, infection, drugs or toxins, or internal failures such as genetic conditions or metabolic disorders. **43 49 55 59-66**

24 Interpreting the Results of a Fair Test

Key Idea: A fair test is when only one variable is changed and all other variables are kept constant. Conclusions based on results are more likely to be valid when the test is fair.

The experiment below describes a fair test for analysing the effect of urea on duckweed growth. Use this activity to test your knowledge about how to analyse and interpret results.

The aim

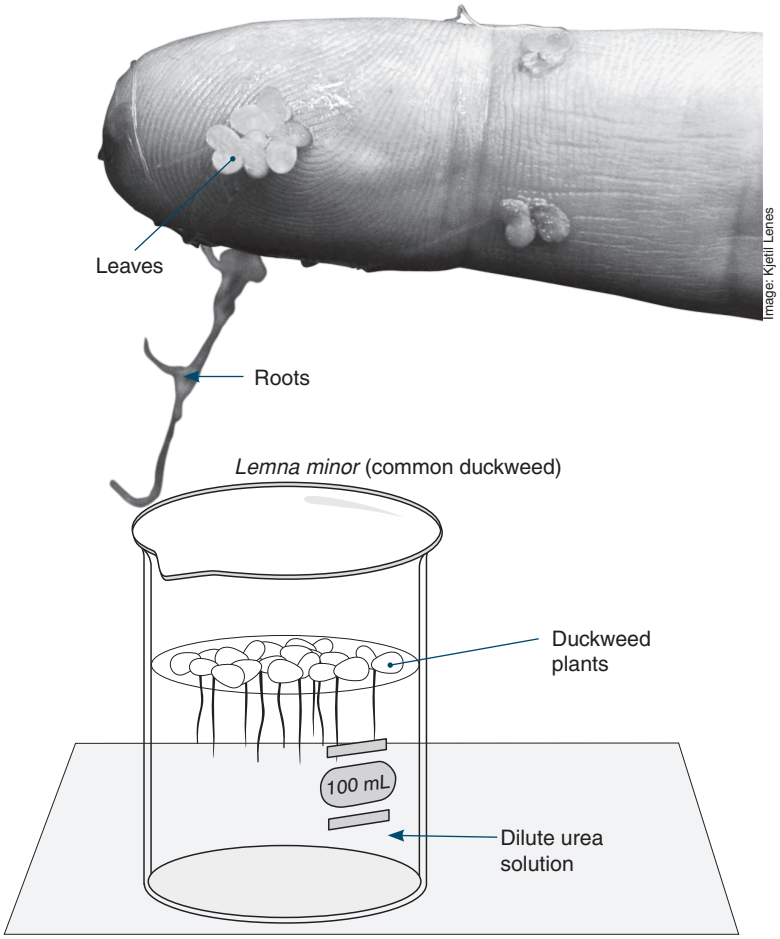
To investigate the effect of urea concentration on the growth of duckweed (*Lemna minor*).

Background

Duckweed is a small plant commonly found floating in the water of drains and pond edges. There are many species of duckweed. The most common species in New Zealand is *Lemna minor*. It is a small (1-3 mm), free-floating plant with 2-4 leaves held flat against the water's surface and a single root. *Lemna minor* grows very rapidly. In ideal conditions doubling time is as little as three days.

Experimental method

Solutions of urea were made up to concentrations of 3 x 10^{-2}, 3 x 10^{-3}, 3 x 10^{-4}, and 3 x 10^{-5} mol L^{-1}. For each urea concentration, 80 mL of the appropriate solution was pipetted into three separate beakers. Ten duckweed plants, each with one leaf, were placed in each beaker. The beakers were arranged randomly and placed together in direct sunlight. The number of plants in each beaker was counted and recorded eight times over the next three weeks.



Day 1

No. of leaves			
3 x 10^{-2}	3 x 10^{-3}	3 x 10^{-4}	3 x 10^{-5}

Ten plants, each with one leaf, in each beaker

Day 5

	No. of leaves			
	3 x 10^{-2}	3 x 10^{-3}	3 x 10^{-4}	3 x 10^{-5}
1	10	20	17	19
2	8	18	13	15
3	10	15	17	17

Day 8

	No. of leaves			
	3 x 10^{-2}	3 x 10^{-3}	3 x 10^{-4}	3 x 10^{-5}
1	8	28	24	24
2	8	23	17	17
3	10	20	22	20

Day 9

	No. of leaves			
	3 x 10^{-2}	3 x 10^{-3}	3 x 10^{-4}	3 x 10^{-5}
1	10	21	25	21
2	10	24	18	20
3	12	31	25	28

Day 12

	No. of leaves			
	3 x 10^{-2}	3 x 10^{-3}	3 x 10^{-4}	3 x 10^{-5}
1	10	20	37	22
2	8	28	19	23
3	10	34	29	31

Day 15

	No. of leaves			
	3 x 10^{-2}	3 x 10^{-3}	3 x 10^{-4}	3 x 10^{-5}
1	10	23	28	22
2	7	23	21	23
3	7	32	28	31

Day 18

	No. of leaves			
	3 x 10^{-2}	3 x 10^{-3}	3 x 10^{-4}	3 x 10^{-5}
1	7	36	30	34
2	7	27	22	26
3	8	25	29	22

Day 21

	No. of leaves			
	3 x 10^{-2}	3 x 10^{-3}	3 x 10^{-4}	3 x 10^{-5}
1	6	38	30	34
2	7	26	21	29
3	6	25	31	25

Data provided by F. Hicks

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1. Use the raw data on the previous page to complete the table below:

	Mean number of leaves							
Concentration of urea	Day 1	Day 5	Day 8	Day 9	Day 12	Day 15	Day 18	Day 21
3×10^{-2} mol L^{-1}								
3×10^{-3} mol L^{-1}								
3×10^{-4} mol L^{-1}								
3×10^{-5} mol L^{-1}								

2. Plot the average number of leaves per day for each concentration on the grid below:

3. (a) Describe the results of the investigation: _____

_____

(b) How could you test if the results are significant? _____

_____

4. Write a brief discussion for the investigation. Include discussion on the biological relevance of the investigation and an evaluation of the reliability of the results:

_____

_____

_____

_____

_____

_____

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39 Thermoregulation in Humans

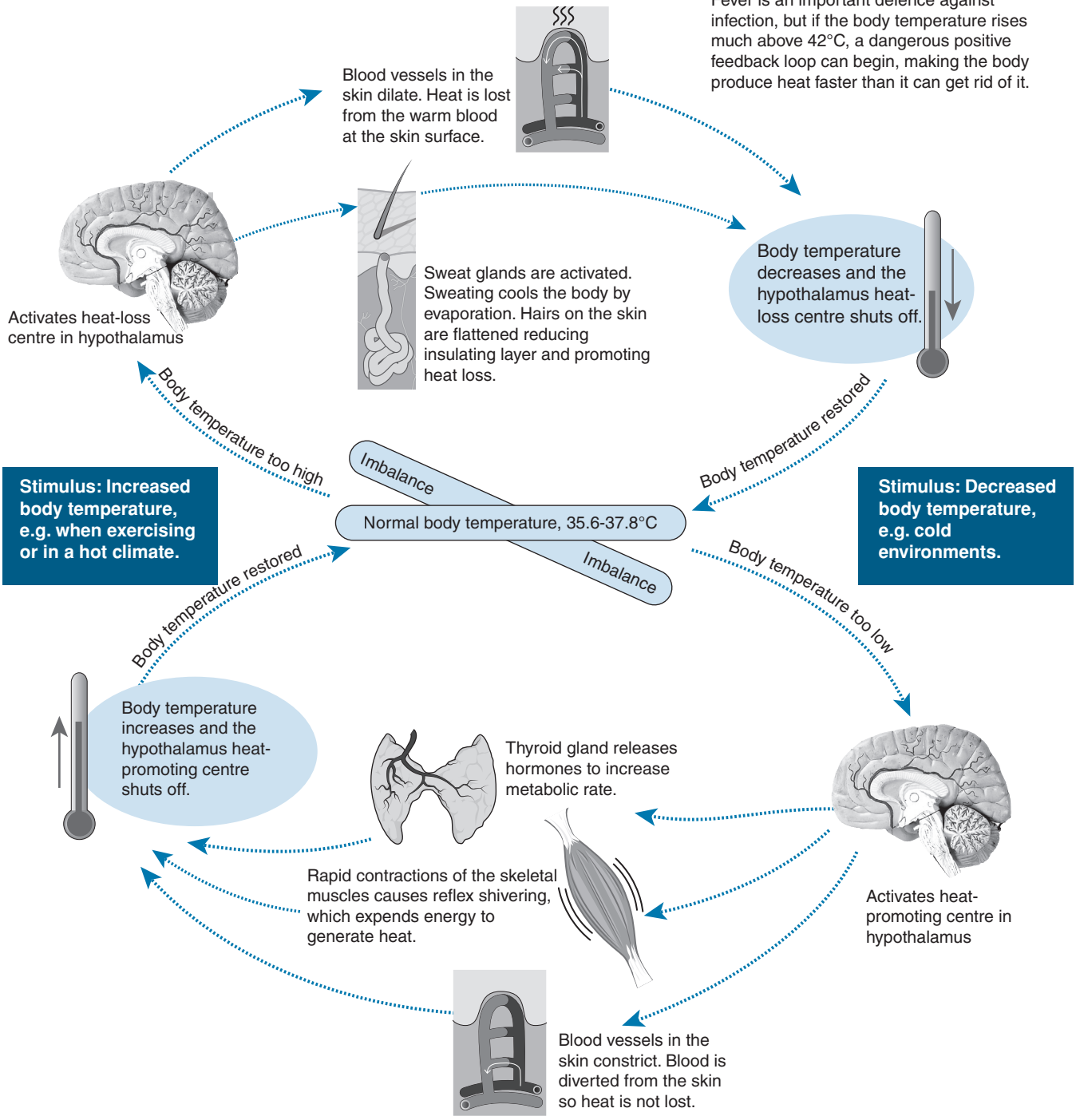
Key Idea: In humans, the temperature regulation centre is in the hypothalamus. Thermoregulation relies on negative feedback mechanisms and involves several body systems.

In humans and other mammals, the temperature regulation centre of the body is in the hypothalamus. The hypothalamus responds directly to changes in core temperature and to nerve impulses from receptors in the skin. It then coordinates appropriate nervous and hormonal responses to counteract any deviations from its 'set point' temperature of 36.7°C. Like a thermostat, the hypothalamus detects a return to normal temperature and the corrective mechanisms are switched off (negative feedback regulation).

The hypothalamus regulates temperature

- The hypothalamus acts as a thermostat. It detects changes in core body temperature and also receives information about temperature change from thermoreceptors in the skin. It then coordinates the nervous and hormonal responses to counteract the changes and restore normal body temperature (below).
- When normal temperature is restored, the corrective mechanisms are switched off. This is an example of a negative feedback regulation.
- Infection can reset the set-point of the hypothalamus to a higher temperature. Homeostatic mechanisms then act to raise the body temperature to the new set point, resulting a fever (right). This speeds up the body's immune response to infection.

Fever is an important defence against infection, but if the body temperature rises much above 42°C, a dangerous positive feedback loop can begin, making the body produce heat faster than it can get rid of it.



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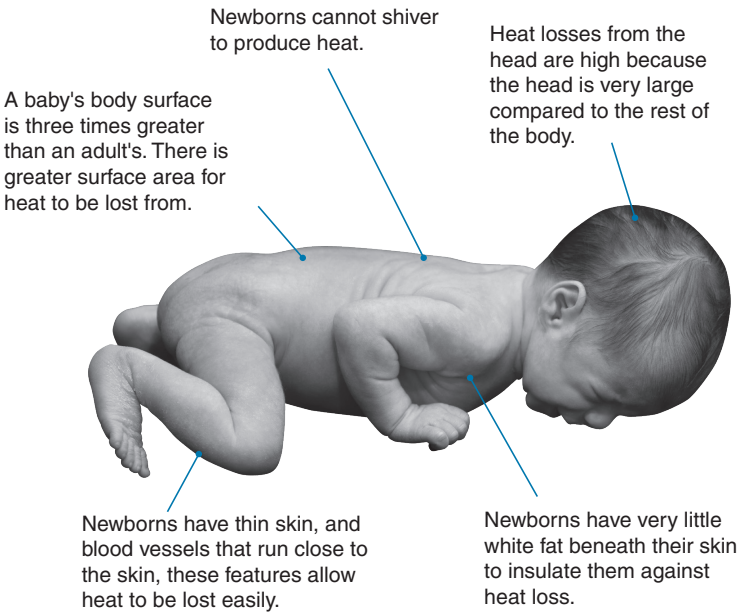
Thermoregulation in newborns

- Newborn babies cannot fully thermoregulate until six months of age. They can become too cold or too hot very quickly.
- Newborns minimise heat loss by reducing the blood supply to the periphery (skin, hands, and feet). This helps to maintain the core body temperature. Increased brown fat activity and general metabolic activity generates heat. Newborns are often dressed in a hat to reduce heat loss from the head, and tightly wrapped to trap heat next to their bodies.
- Newborns lower their temperature by increasing peripheral blood flow. This allows heat to be lost, cooling the core temperature. Newborns can also reduce their body temperature by sweating, although their sweat glands are not fully functional until four weeks after birth.



1. (a) Where is the temperature regulation centre in humans located? _____

   (b) How does it carry out this role? _____

   _____

2. Describe the role of the following in maintaining a constant body temperature in humans:

   (a) The skin: _____

   _____

   (b) The muscles: _____

   _____

   (c) The thyroid gland: _____

   _____

3. How is negative feedback involved in keeping body temperature within narrow limits? _____

   _____

   _____

   _____

4. (a) Why does infection result in an elevated core body temperature? _____

   _____

   (b) What is the purpose of this? _____

   _____

   (c) Explain why a prolonged fever can be fatal: _____

   _____

5. (a) What features of a newborn cause it to lose heat quickly? _____

   _____

   (b) What mechanisms do newborns have to control body temperature? _____

   _____

   _____

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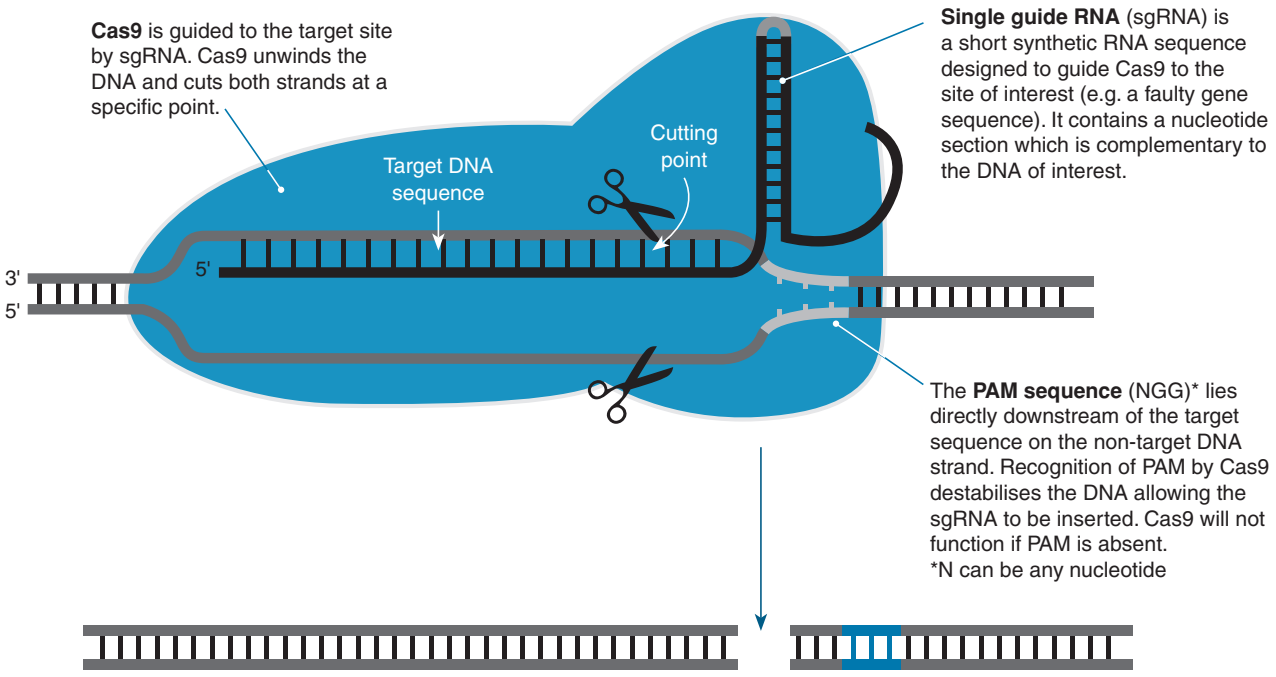
80 New Tools: Gene Editing with CRISPR

Key Idea: CRISPR is a complex comprising Cas9 endonuclease and sgRNA. The CRISPR complex cuts DNA at very specific sequences and can be used to edit genes.

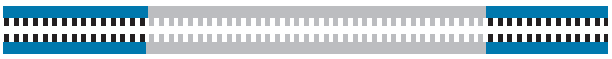
CRISPR-Cas9 (shortened to CRISPR and pronounced crisper) is an endonuclease complex occurring naturally in bacteria, which use it to edit the DNA of invading viruses. CRISPR is able to target specific stretches of DNA and edit it at very precise locations. Two key components are required for CRISPR to work: an RNA guide that locates and binds to the target piece of DNA and the Cas9 endonuclease that unwinds and cuts the DNA. The technology has potential applications in correcting mutations responsible for disease, switching faulty genes off, adding new genes to an organism, or studying the effect of specific genes. It represents a major advance because it allows more precise and efficient gene editing at much lower cost than ever before.



The cut DNA can be repaired using one of the following methods:

Gene knock in "gene editing"

A new DNA sequence is inserted into the DNA break. For example, a faulty gene sequence can be replaced with the correct sequence to restore normal gene function.



Gene knock out "gene silencing"

As the cell's normal repair process mends the broken DNA, errors occur resulting in the insertion or deletion of nucleotide bases. The resulting frame-shift mutation changes the way the nucleotide sequence is read, either disabling gene function or producing a STOP signal. This technique can be used to silence a faulty gene.

1. What are the roles of the following in CRISPR gene editing:

   (a) Cas9: _____

   (b) sgRNA: _____

2. Outline two ways CRISPR can be used to edit genes: _____

   _____

   _____

   _____

3. What benefits are offered by CRISPR technology? _____

   _____

   _____

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93 Engineering for Insect Resistance

Key Idea: Up to one fifth of the world's crops are lost due to insects each year. Losses can be reduced through the use of genetic engineering to introduce the Bt gene into crop plants.

A key goal in horticulture is the reduction of insect crop damage. Normally this is done using sprays. However this requires a lot of effort and leaves potentially harmful chemical residues on the food and in the environment. Using genetic engineering to produce crop plants with their own in-built insect deterrents can result in greater crop yields and reduced chemical use.

Bt toxin

Bacillus thuringiensis is a soil living bacterium. It also occurs naturally in the gut of caterpillars and on leaf surfaces. The bacteria form spores that are associated with crystalline proteins called δ-endotoxins. These are lethal to lepidopteran (butterfly and moth) larvae but do not affect other insects such as beetles or bees (or any other animal). For this reason the Bt toxin has been used as a targeted insecticide since the 1960s.

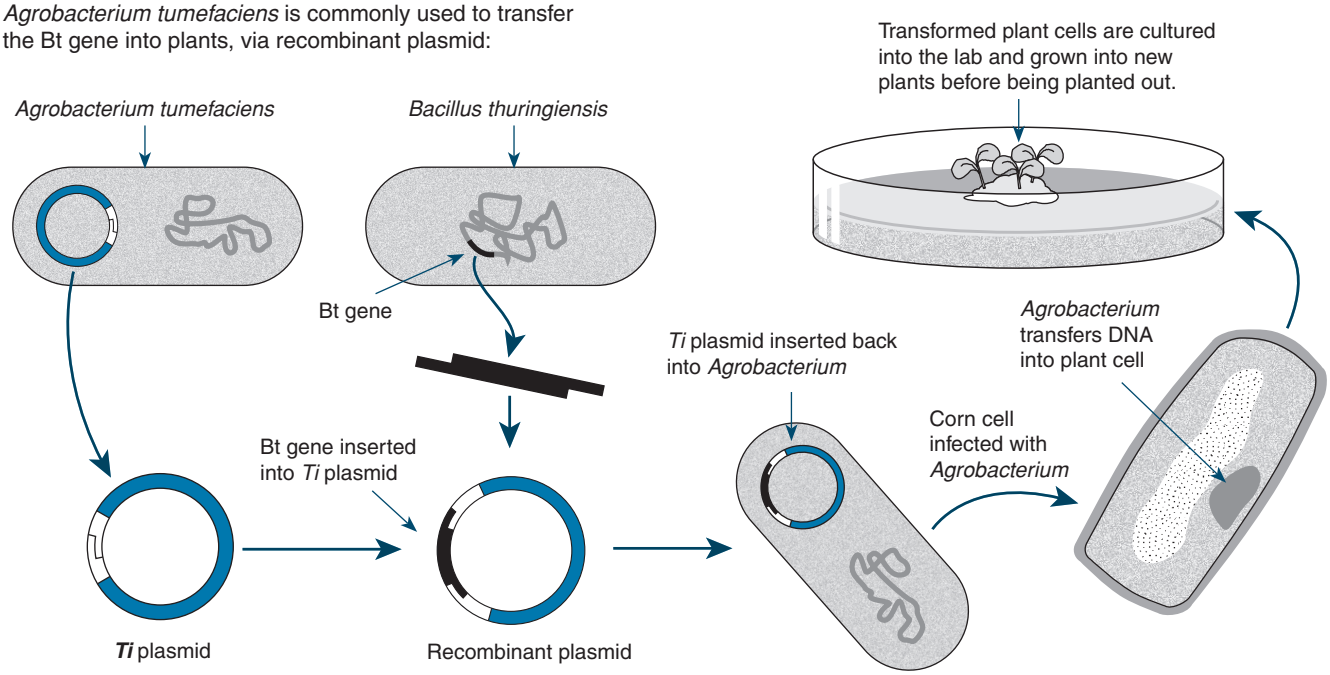
In 1996 the seed company Monsanto released its first versions of Bt corn. This corn had been genetically modified to contain the gene that produces the Bt protein. The target insect pest for Bt corn is the larval stage of the European corn borer, which causes hundreds of millions of dollars worth of damage to crops annually.

USDA

The effects of the Bt toxin on insect deterrence. The plant on the right has been treated with Bt toxin before being exposed to caterpillars. The plant on the left had not been treated with Bt toxin.

Producing a Bt plant

Genetic engineering has been used to produce cotton, corn, and potato varieties that produce the Bt toxin. The bacterium *Agrobacterium tumefaciens* is commonly used to transfer the Bt gene into plants, via recombinant plasmid:



1. Name the bacteria that produces Bt toxin: _____

2. Why is Bt toxin a useful insecticide? _____

_____

3. What is the primary target of the Bt toxin in Bt corn? _____

_____

4. Explain how Bt corn is produced using *Agrobacterium tumefaciens*: _____

_____

_____

_____

_____

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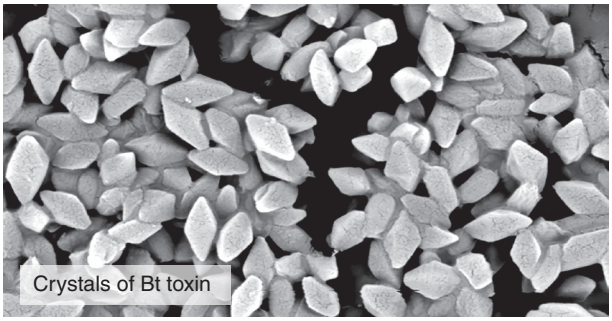
What's killing the monarchs? It's not the corn

Bt corn was developed by the company Monsanto and sales began in 1996. There are many different types of Bt corn, each one engineered to produce the toxin in slightly different ways. One of the first produced was Bt 176.

By 1999 monarch butterfly populations in the American Midwest began declining. During that year, Cornell University published a paper showing that the Bt toxin could be dispersed to other plants by the corn's pollen. Pollen landing on milkweed near corn crops could potentially kill the monarch caterpillars that fed exclusively on the milkweed. This resulted in a backlash against Bt corn by environmental activists. However, in 2001 a study was released that argued the toxin in pollen was not causing monarch decline. The toxicity in pollen was due mainly to the Bt 176 variety which was used in less than 2% of the corn grown and was in the process of being phased out. Other Bt corn varieties did not develop enough toxin, or their pollen density was too low to affect monarch caterpillars.

It now appears that there is a related but quite different reason for the Monarch butterfly decline. In 1996, Monsanto also began selling "Roundup Ready" corn, engineered to withstand glyphosate herbicide. Corn crops could be sprayed with herbicide and while the weeds die the corn would keep on growing, allowing less targeted spraying applications. As a result milkweed, which often grew in or near corn crops, was also killed, leaving no food for monarch caterpillars.

So... What's killing the monarchs?



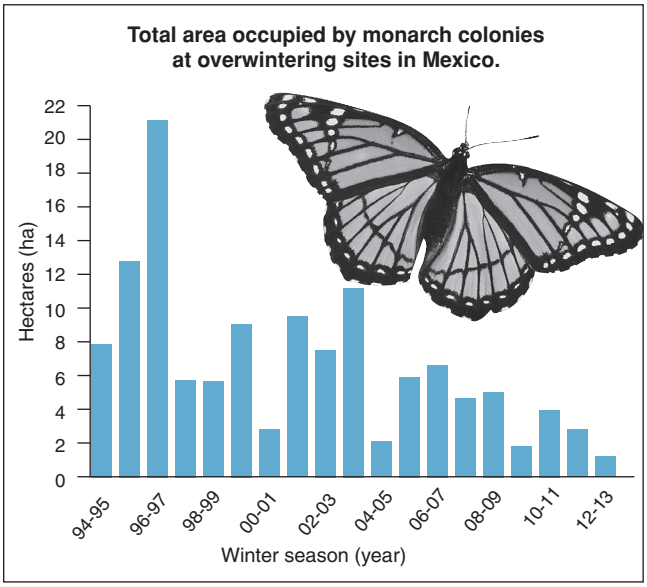
Crystals of Bt toxin

David R. Tribble

Scott McDougall

Above: North American populations of monarchs migrate to overwintering sites in Mexico and California.

Right: Monarch caterpillars feed exclusively on milkweed.



5. As a group, discuss the ethical issues surrounding GM corn and monarch declines. Who is to blame for the decline of monarchs and what can be done to help the population recover? Summarize the main points of your discussion below:

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BIOZONE International
32 Somerset Street, Frankton, Hamilton 3204, New Zealand
PHONE 07 856 8104
FAX 07 856 9243
EMAIL sales@biozone.co.nz

www.BIOZONE.com/nz