Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Friday 06 June 2025

Morning (Time: 1 hour 45 minutes)

Paper reference **WBI15/01**

Biology

International Advanced Level
UNIT 5: Respiration, Internal Environment, Coordination and Gene Technology

You must have:
Scientific article (enclosed), scientific calculator, ruler, HB pencil

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided – *there may be more space than you need.*

Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- In questions labelled with an **asterisk (*)**, marks will be awarded for your ability to structure your answer logically, showing how the points that you make are related or follow on from each other where appropriate.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

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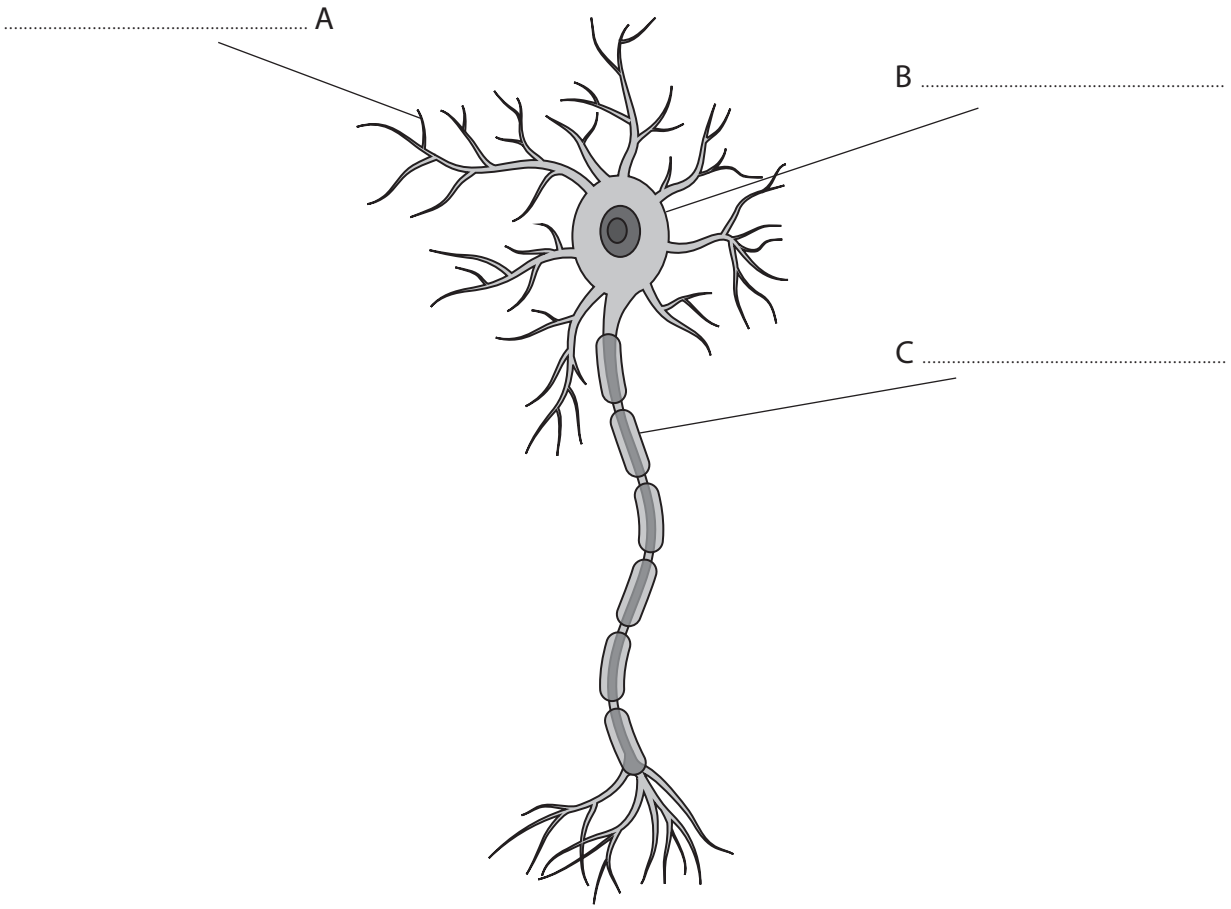
Answer ALL questions.

Write your answers in the spaces provided.

Some questions must be answered with a cross in a box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 The nervous system is involved in coordination in animals.

The diagram shows a motor neurone.



(a) Complete the diagram by naming the parts labelled A to C.

(2)

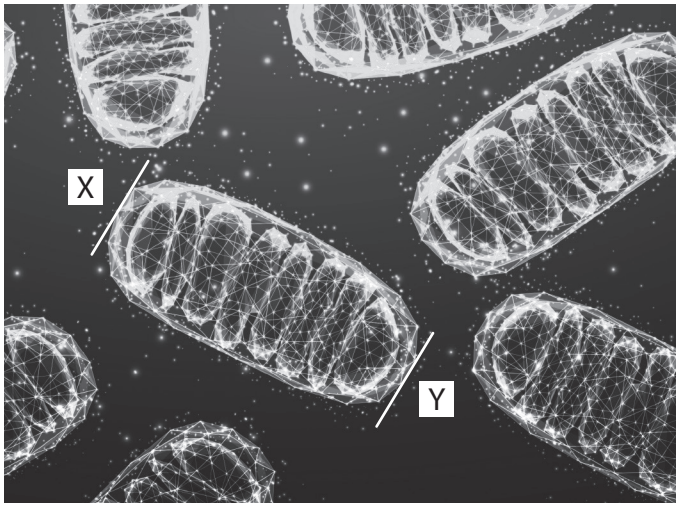
(b) Describe how a nerve impulse is conducted across the synapse between neurones.

(3)

(Total for Question 1 = 5 marks)

2 Some stages of aerobic respiration take place inside mitochondria.

The photograph shows some mitochondria.



(Source: © Inkoly / Shutterstock)

(a) (i) Name a structure formed by the folding of the inner mitochondrial membrane.

(1)

.....

(ii) Which is a role of the inner mitochondrial membrane?

(1)

- ☒ **A** to convert glucose to pyruvate
- ☒ **B** to phosphorylate ADP
- ☒ **C** to produce glucose from carbon dioxide
- ☒ **D** to trap light

(iii) The actual length of the mitochondrion between X and Y in the photograph is 2.7 μm.

Calculate the magnification of this mitochondrion.

Give your answer in standard form.

(2)

Answer .....

(b) Describe how **reduced** NAD is involved in the synthesis of ATP inside a mitochondrion.

(3)

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(c) (i) Which is the role of oxygen molecules in mitochondria?

(1)

- ☒ **A** to accept electrons
- ☒ **B** to donate electrons
- ☒ **C** to donate hydrogen ions
- ☒ **D** to form carbon dioxide

(ii) Which part of a mitochondrion contains the electron transport chain (ETC)?

(1)

- ☒ **A** inner mitochondrial membrane
- ☒ **B** mitochondrial matrix
- ☒ **C** outer mitochondrial membrane
- ☒ **D** ribosome

(Total for Question 2 = 9 marks)

3 A number of drugs can affect the nervous system of mammals.

(a) Which describes the effect lidocaine has on the membranes of neurones?

(1)

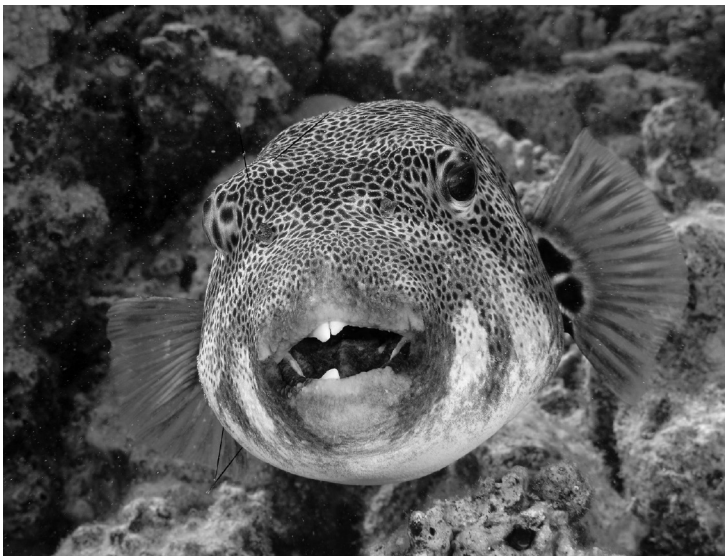
- ☒ **A** it closes sodium ion channels
- ☒ **B** it increases the number of action potentials
- ☒ **C** it opens potassium ion channels
- ☒ **D** it opens sodium ion channels

(b) Which describes the effect of MDMA (ecstasy) on neurones?

(1)

- ☒ **A** it damages the myelin sheath of neurones
- ☒ **B** it decreases the release of neurotransmitters
- ☒ **C** it decreases the speed of action potential transmission in neurones
- ☒ **D** it increases the release of neurotransmitters

(c) The photograph shows a puffer fish.



(Source: © ImageBROKER on Offset / Shutterstock)

Tetrodotoxin (TTX) is a toxin found in puffer fish.

This toxin works by binding to ion channels in neurones.

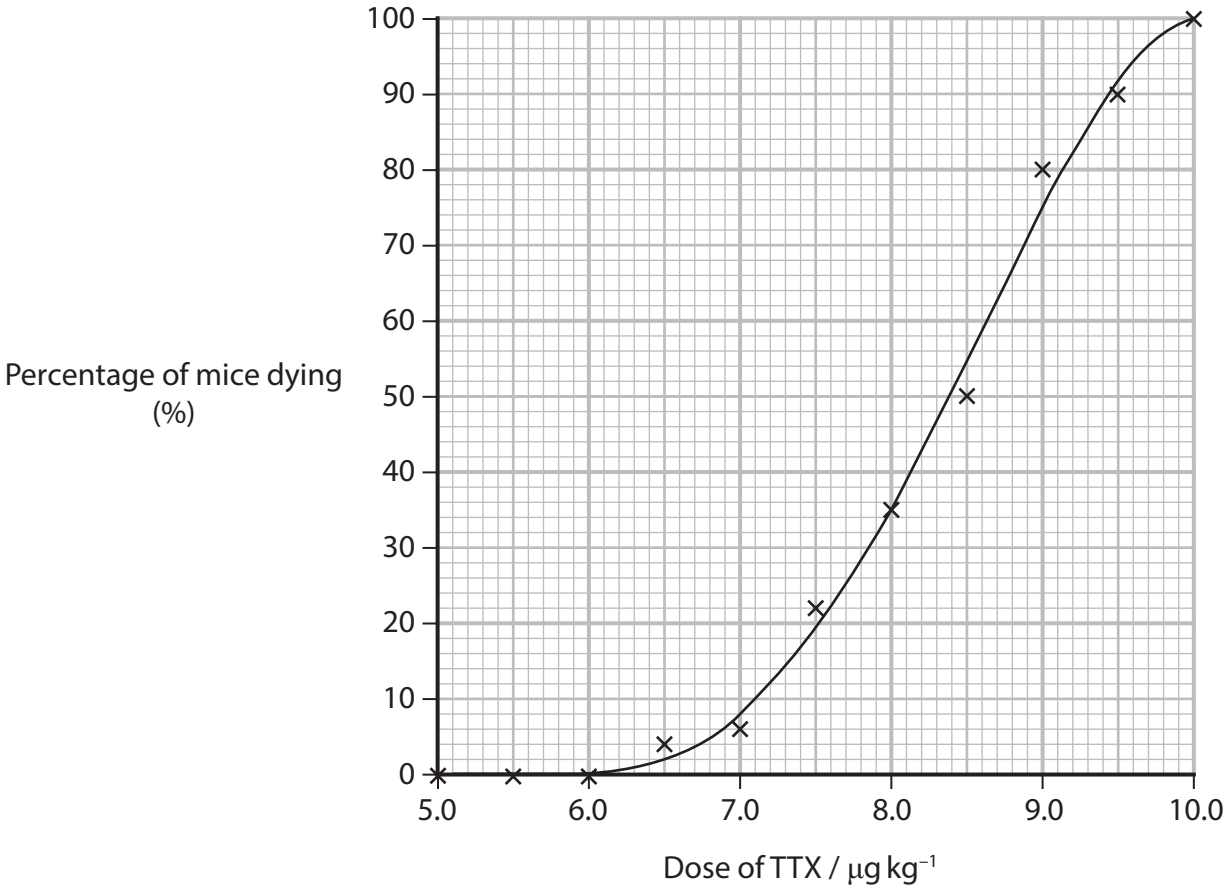
Suggest how TTX could inhibit the nervous control of breathing.

(3)

(d) The toxicity of TTX in mice was investigated.

Groups of mice were given different doses of TTX. The percentage of mice dying at each dose was recorded.

The graph shows the results of this investigation and a line of best fit.



(i) The LD_{50} obtained from this graph is 8.4 μg kg^{-1}.

Give the meaning of LD_{50} = 8.4 μg kg^{-1}.

Use the information in the graph to support your answer.

(1)

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(ii) Comment on the toxicity of TTX in mice.

(3)

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(Total for Question 3 = 9 marks)

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4 (a) Parkinson's disease arises from decreased dopamine production in the brain.

Explain why L-Dopa, **given orally in tablet form**, reduces the symptoms of Parkinson's disease.

(4)

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(b) The medulla oblongata is part of the nervous system.

Which is a function of the medulla oblongata?

(1)

- ☒ **A** control of the cardiac response
- ☒ **B** long-term memory
- ☒ **C** release of ADH
- ☒ **D** voluntary movement

*(c) Ageing affects different organ systems.

Three systems affected by ageing are the:

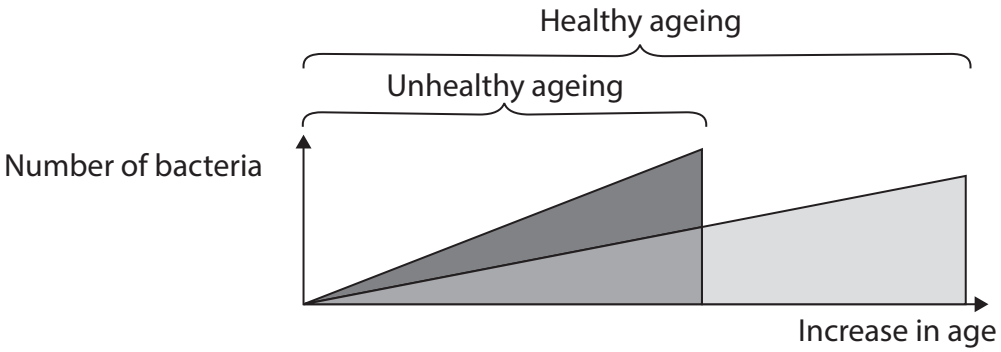
- cardiovascular system
- breathing and gas exchange system
- brain and nervous system.

Ageing is affected by:

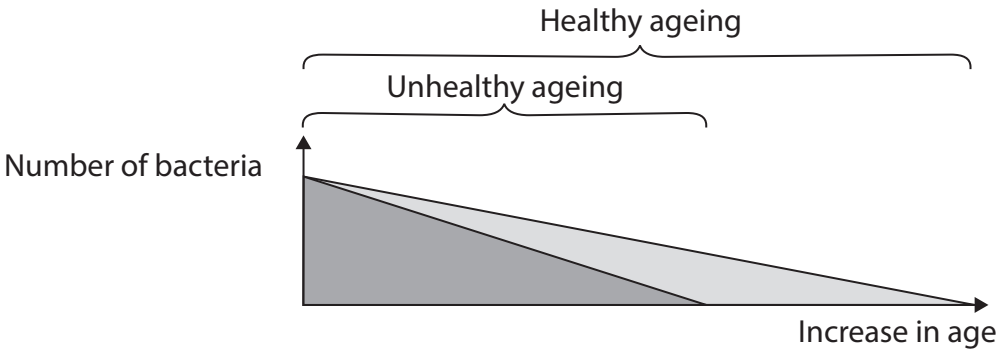
- types of bacteria living on the skin and in the gut
- inflammation in different parts of the body
- lifestyle.

The graphs show the changes in the types of bacteria and inflammation during healthy and unhealthy ageing.

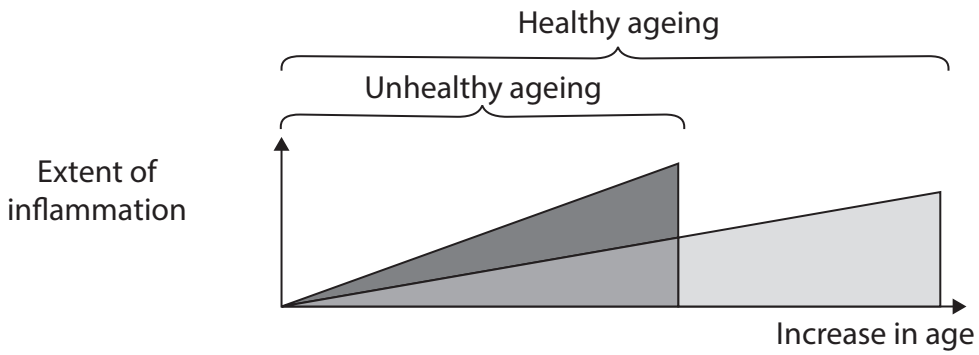
Graph 1 Changes in pathogenic bacteria



Graph 2 Changes in protective bacteria



Graph 3 Changes in inflammation



Discuss the role of bacteria, inflammation and lifestyle in ageing.

Use the information in the graphs and your own knowledge to support your answer.

(6)

(Total for Question 4 = 11 marks)

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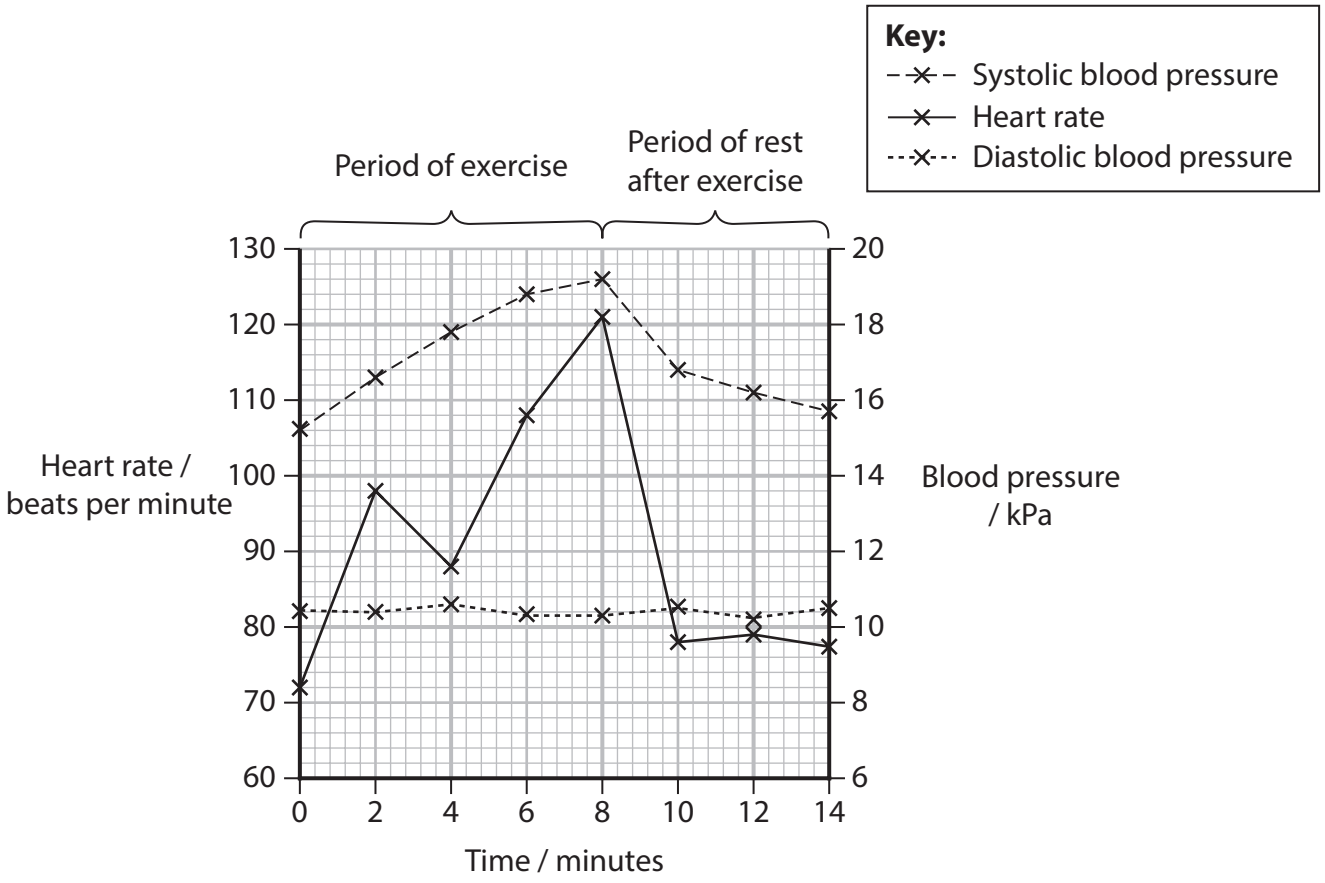
5 Exercise affects heart rate and blood pressure.

(a) The effect of exercise on heart rate and blood pressure of a group of people was investigated.

The mean heart rate and blood pressure were recorded:

- at the start of exercise
- every 2 minutes during the exercise
- every 2 minutes after the exercise.

The graph shows the results.



(i) Describe **three** conclusions from this investigation.

(3)

(ii) Describe how the systole and diastole parts of the cardiac cycle are controlled during the exercise.

(4)

(b) At rest, a heart pumps 5 dm^3 $minute^{-1}$ of blood and has a heart rate of 72 beats $minute^{-1}$.

Calculate the stroke volume.

Use the equation:

cardiac output = heart rate × stroke volume

Give your answer in cm^3 and to **two** significant figures.

(2)

Answer ..... cm^3

(Total for Question 5 = 9 marks)

6 Specialised molecules play a role in the coordination of the response of plants to light.

(a) Which molecule detects light during germination of seeds?

(1)

- ☒ **A** chlorophyll
- ☒ **B** phytochrome
- ☒ **C** retinal
- ☒ **D** rhodopsin

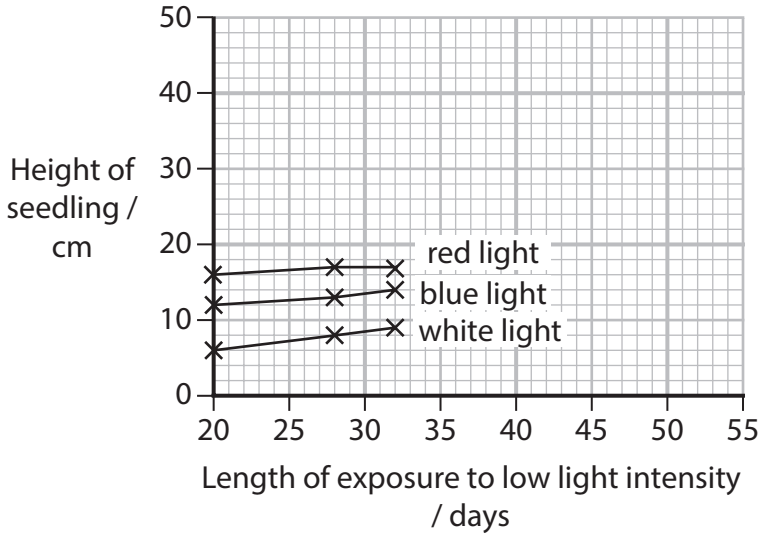
(b) The effect of red, blue and white light at low and high light intensities on the growth of peanut seedlings was investigated.

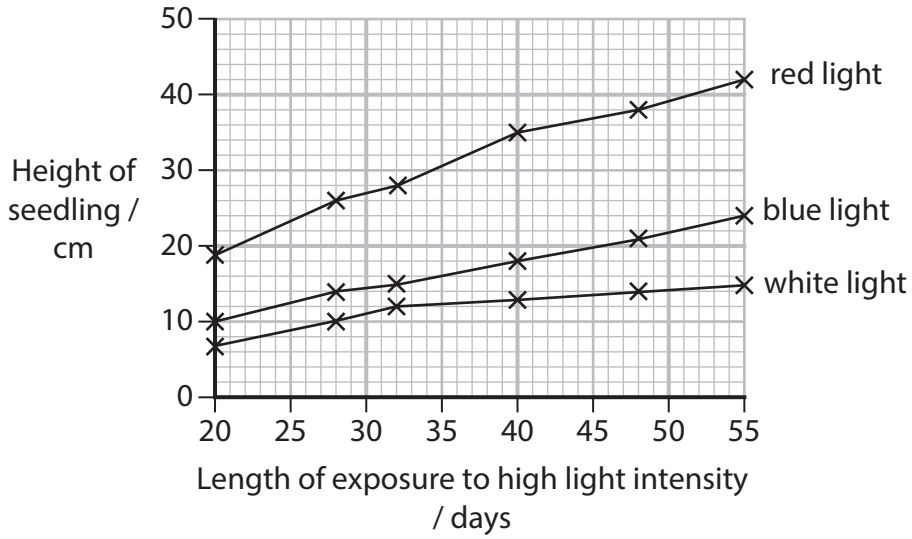
The photograph shows a peanut seedling.

(Source: © Ramdeva Ram / Shutterstock)

The graphs show the results of this investigation.

The plants in low light intensities died after 32 days.





Determine the effect of light on the growth of the seedlings in this investigation.

(4)

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(c) Auxin stimulates:

- the release of hydrogen ions that disrupt cellulose microfibrils
- the uptake of potassium ions by cells.

Explain how auxin causes cells to increase in size.

(4)

(d) The effect of different concentrations of gibberellin on seed germination of the ashoka tree was investigated.

The photograph shows the leaves and flowers of an ashoka tree that grows in parts of Asia.

(Source: © Roberto Pascual Gomez / Shutterstock)

Samples containing 200 seeds were each treated with different concentrations of gibberellin.

The table shows the results of this investigation.

Gibberellin concentration / ppm	Number of seeds germinating
0	26
100	92
200	114
300	66
400	46

(i) Calculate the percentage change in germination between 200 ppm and 400 ppm gibberellin concentration.

(2)

Give your answer as a whole number.

Answer .....%

(ii) Explain how gibberellins affect germination in this investigation.

(2)

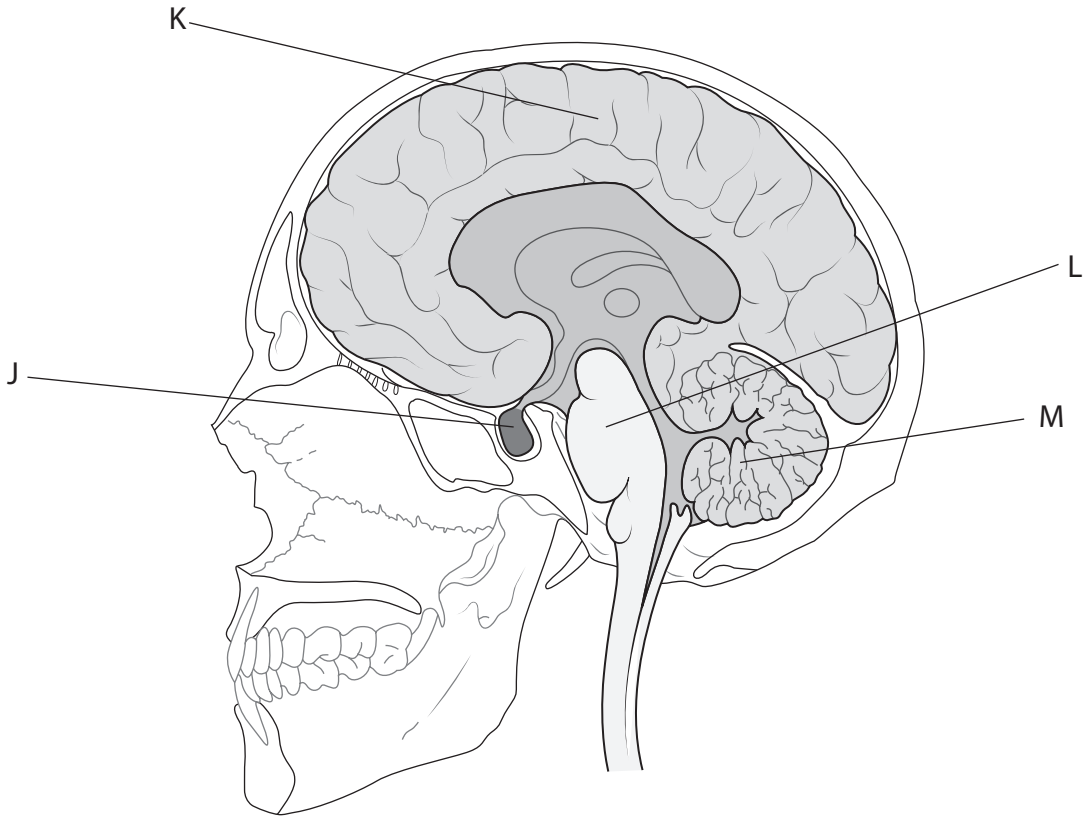
(Total for Question 6 = 13 marks)

7 Hormones are chemicals that coordinate different functions in the body.

Growth hormone (GH) is one of the many hormones produced by the brain.

(a) Growth hormone is produced in the pituitary gland.

The diagram shows a cross section through the brain.



(i) Which **label** identifies the pituitary gland?

(1)

☒ **A** J

☒ **B** K

☒ **C** L

☒ **D** M

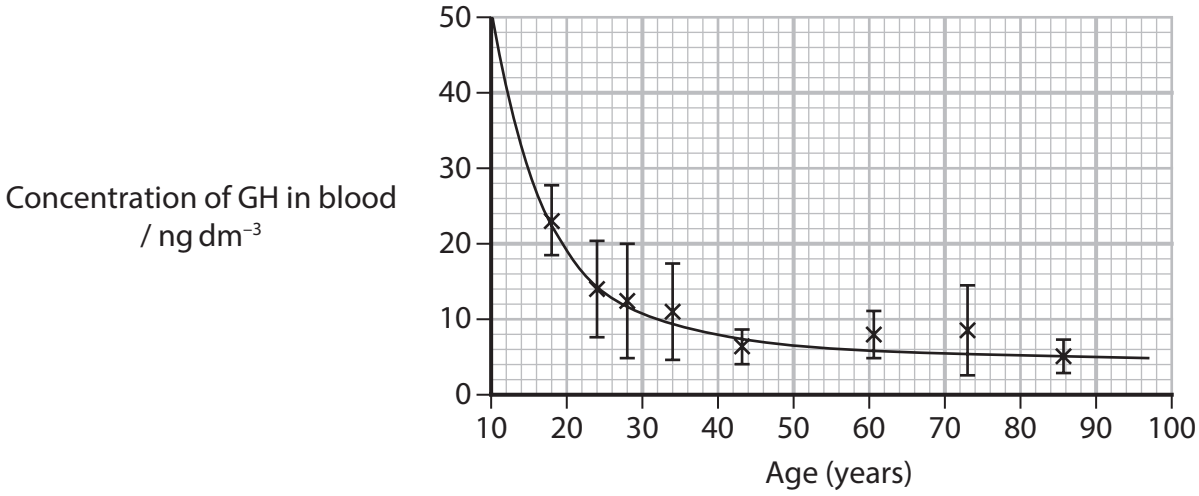
(ii) Growth hormone is a peptide hormone that stimulates the synthesis of protein in muscle.

Explain how GH stimulates the synthesis of protein in muscle.

(3)

(b) The concentration of GH in the blood changes during the life of a person.

The graph shows the changes in the concentration of GH in the blood of males of different ages.



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Comment on the changes in the concentration of GH in the blood of males.

Use the data in the graph to support your answer.

(3)

(c) Growth hormone stimulates the development of the gland that secretes the fight or flight hormone.

Which hormone is the fight or flight hormone?

(1)

- ☒ **A** adrenaline
- ☒ **B** amylopectin
- ☒ **C** cholesterol
- ☒ **D** statin

(d) Synthetic GH can be produced from genetically modified mouse cells.

(i) Describe how mouse cells can be genetically modified to synthesise human GH.

(4)

(ii) Suggest **one advantage** and **one disadvantage** of using genetically modified mouse cells rather than E. coli bacteria to produce human GH.

(2)

(Total for Question 7 = 14 marks)

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8 The scientific document you have studied is adapted from the articles *Risk of heart failure may increase with age due to Y chromosome loss* and *Essence of man: Y size doesn't matter* in the New Scientist.

Use the information from the scientific document and your own knowledge to answer the following questions.

(a) (i) Name the type of microscope that would be used to produce the image before paragraph 1.

(1)

.....

(ii) Calculate the ratio of the length of the X chromosome to the Y chromosome in this image.

Give your answer to **one** decimal place.

(2)

Answer ..... : 1

(b) Suggest why the loss of the Y chromosome may lead to higher rates of heart disease in men than women (paragraphs 4 and 5).

(2)

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(c) Describe the roles of nucleic acids and enzymes used in CRISPR gene editing to remove some of the Y chromosome genes (paragraph 5).

(2)

(d) Describe how the cardiovascular health of participants in the UK Biobank study could be assessed (paragraph 6).

(3)

(e) Explain how an antibody could block the effects of an inflammatory signalling molecule (ISM) (paragraphs 7 and 8).

(2)

(f) Explain how environmental factors such as temperature could determine the sex of an animal (paragraph 14).

(2)

(g) Calculate the percentage of genes that have been lost from the original Y chromosome (paragraph 15).

(1)

Answer ..... %

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(h) Explain how epigenetic changes could ensure that the 'gene output' from the X chromosomes in females is the same as in males (paragraph 19).

(2)

(i) Explain why elderly men who have lost their Y chromosome have a higher risk of cancer (paragraphs 2, 3 and 20).

(3)

(Total for Question 8 = 20 marks)

TOTAL FOR PAPER = 90 MARKS

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Pearson Edexcel International Advanced Level

Friday 06 June 2025

Morning (Time: 1 hour 45 minutes)

Paper reference **WBI15/01**

Biology

International Advanced Level

UNIT 5: Respiration, Internal Environment, Coordination and Gene Technology

Scientific document for use with Question 8

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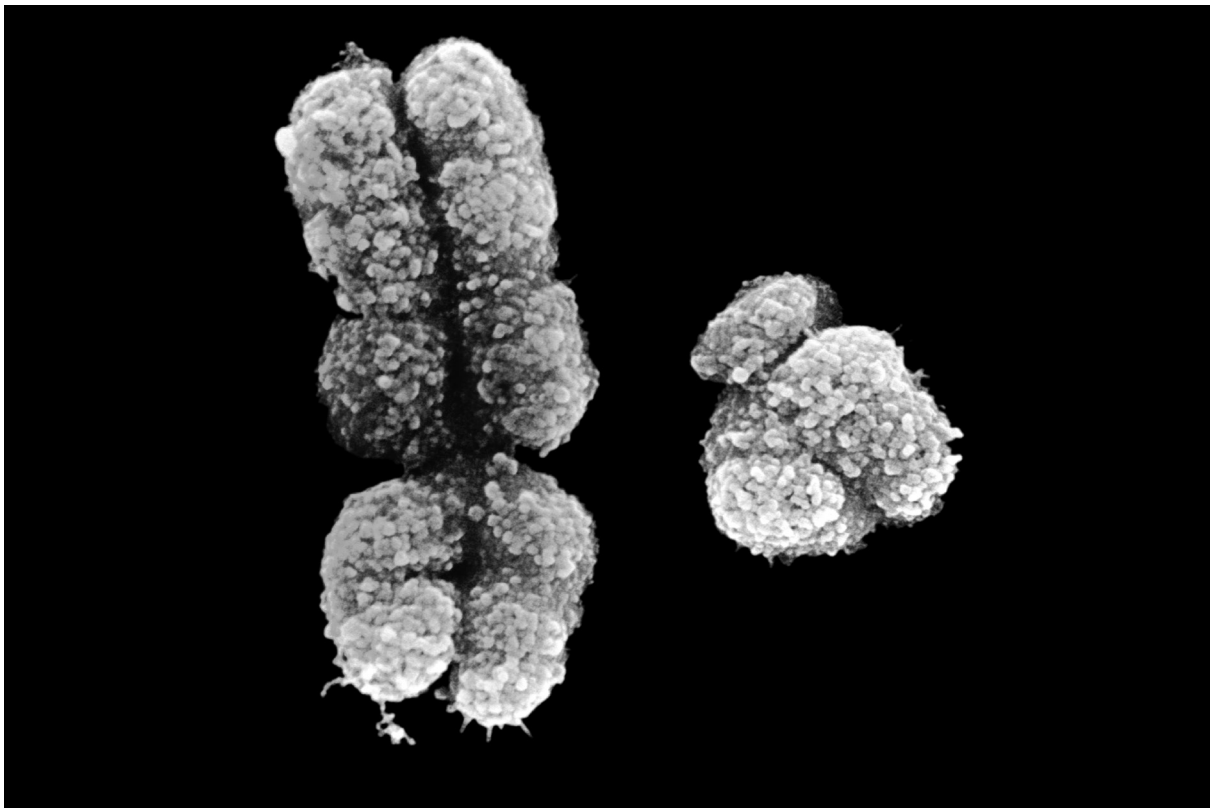
Scientific document for use with Question 8

Article 1

Risk of heart failure may increase with age due to Y chromosome loss

The Y chromosome, involved in sex determination, mysteriously disappears from some men's immune cells as they get older – and that could be fatal



(Source: © Biophoto Associates / Science Photo Library))

The Y chromosome (right) is smaller than the X chromosome (left)

1. The immune cells of many older men lose their Y chromosomes, and this may contribute to men having a higher rate of heart disease than women.

   Health risks from Y chromosome loss have long been suspected, but evidence from animals and people now adds more support to the idea – and may suggest a treatment for the damage caused to the heart.

2. It was discovered several decades ago that in some people born with XY chromosomes, a proportion of the immune cells have no Y chromosome, a phenomenon that becomes more common with increasing age. For instance, 40 per cent of 70-year-old men have no Y in at least some of the immune cells found in their blood.

3. The reasons for this are unclear, but it could be because the Y chromosome is small and carries relatively few genes apart from those involved in sex determination and sperm production, so the stem cells that produce immune cells can survive if they happen to lose their Y when replicating their DNA. If they lose any other chromosomes, however, the cells would be more likely to die.

4. Loss of this Y chromosome in immune cells correlates with higher rates of health problems, including heart disease, cancer and Alzheimer's disease. But it was unclear whether Y loss causes these conditions or if faulty DNA replication is behind both Y loss and the health issues, says Lars Forsberg at Uppsala University in Sweden.

5. To find out, Forsberg and his colleagues used the CRISPR gene-editing technique to remove the Y chromosome from about two-thirds of the immune cells of male mice to mimic the phenomenon. These mice developed heart problems once they got to about 1 year of age, precipitated by their heart muscle becoming scarred. "We show causality," says Forsberg. "We can see that losing the Y chromosome in the blood causes disease in the heart."

6. The researchers also looked at how Y chromosome loss affected men in a large ongoing medical study called UK Biobank, which tracks participants' health over time. They found that the more immune cells without a Y that the men had at the time of their enrolment, the higher their risk of dying from any type of heart disease over the following 12 years. For instance, men who had lost the Y chromosome in more than 40 per cent of their immune cells had a 31 per cent higher risk of dying from any circulatory disease during the study period. Scarring of heart muscle can contribute to some common types of heart disease, such as heart failure, says Forsberg.

7. Further work on the mice uncovered clues about how immune cells cause heart scarring. When the animals were dissected, immune cells lacking a Y chromosome were found to have infiltrated heart muscle, triggering the release of an inflammatory signalling molecule called transforming growth factor beta.

8. Treating the mice with an antibody that blocks this growth factor reduced the harmful effects of the loss of the Y chromosome – although it is too soon to conclude the same approach would benefit men who are losing their Y chromosomes, says Forsberg. He is co-founder of a biotech firm called Cray Innovation that is developing a blood test to tell people if they have loss of the Y chromosome in their immune cells.

9. "This is the best evidence I have seen for a direct effect of Y chromosome loss on a physiological process," says John Perry at the University of Cambridge.

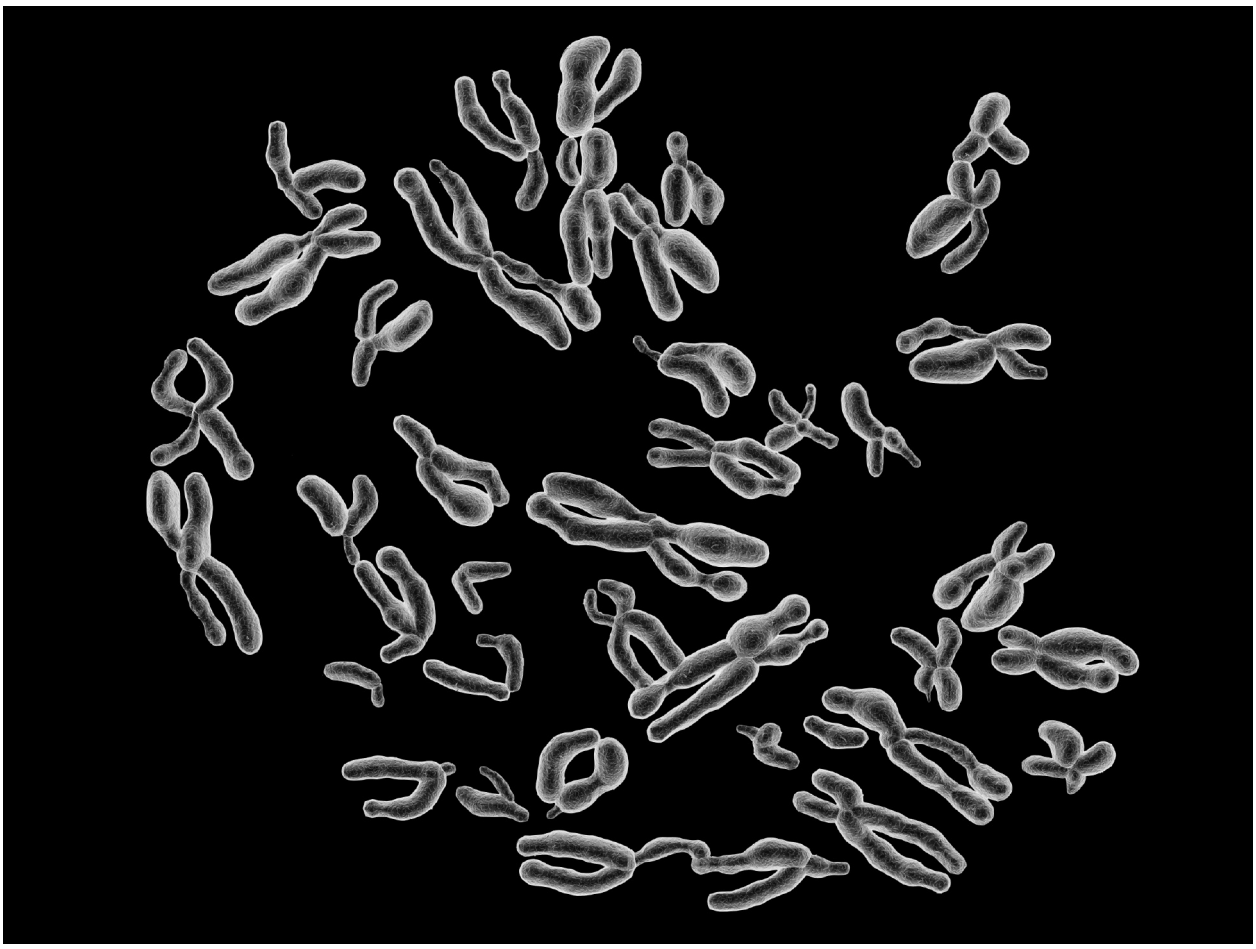
   In 2019, Perry and his colleagues published work suggesting that a propensity for Y chromosome loss is caused by many genetic variants that raise the likelihood of DNA errors during cell division, which could be why loss of the Y chromosome is linked with cancer.

10. Forsberg's team next plans to investigate whether people born with XYY chromosomes experience different effects if they lose one of their Y chromosomes.

Article 2

Essence of man: Y size doesn't matter

The Y chromosome, which makes men male, has been shrinking for 180 million years. But there's more to this rotting husk than anyone suspected



(Source: © Alfred Pasieka / Getty)

11. There's nothing very macho about the Y chromosome. Even though it's what makes men male, the human Y, like its counterparts in almost all mammals, is tiny compared with its partner, the X chromosome. It's lost hundreds of genes – and if the Y continues to lose them, it could someday wink out of existence entirely.

12. Claims of its impending demise are starting to look premature, however. Far from being a rotting husk, the modern Y, tiny though it is, is turning out to be a highly evolved and surprisingly important part of men's wider genetic endowment, responsible for far more than just maleness.

13. It is easy to see why some biologists thought the Y was destined for oblivion: it is all on its own. There are two copies of all other chromosomes, which are basically containers for holding genes. Each copy acts as a backup for the other. The pairs line up and swap bits when organisms reproduce. Some offspring get landed with chromosomes full of damaged genes and are eliminated by natural selection, whereas others inherit undamaged copies and survive to reproduce.

14. Way back in the evolutionary past, there was no Y, just a regular pair of chromosomes. Sex was determined by environmental factors such as temperature. But then a gene

on a single chromosome mutated in a way that made any individual that inherited it male. At first this proto-Y could still swap genes with its partner, the proto-X chromosome. About 180 million years ago – in the line of mammals that branched away from the platypus and echidna – a section of it containing the gene variant for maleness got flipped back to front. This section no longer lined up properly with the corresponding part of the proto-X, so damaged genes in this section could no longer be swapped for good ones.

Beyond repair

15. Further inversions put more and more of the Y beyond repair. The X was fine because females inherit two copies that can swap parts. The Y, however, started to lose bits because men have just one copy. The human version now has just 78 genes, far less than its original 600 or so. At this rate of decay the Y ought to disappear altogether within 5 million years, as famously predicted a few years ago by Jenny Graves at La Trobe University in Melbourne, Australia.

16. But there is growing reason to believe that what's left of the Y is here to stay. For one thing, even though it has lost almost all of its original set of genes, it has gained others: we now know that 61 of the human Y's 78 genes were not present before the first inversion took place. Almost all the new genes play a role in sperm production, making the Y a perfect home for them. There are often several copies of these genes, too, so there are backups.

17. An even stronger reason to think the Y chromosome has a bright future comes from the discovery, by Daniel Bellott at the Whitehead Institute in Boston, that its decay seems to have ground to a halt. His team compared the Y chromosomes of eight mammals – human, chimp, rhesus macaque, marmoset, mouse, rat, bull and opossum – to trace its evolutionary history. They found bursts of gene loss directly after inversions happen, followed by long periods of stability. In fact, not a single gene has been lost from the oldest part of the human Y in the past 44 million years.

18. The remaining genes may simply be too essential to lose. A team led by Henrik Kaessmann at the University of Lausanne, Switzerland, surveyed the Y chromosomes of 15 different mammal species and one bird. They found that a chromosome linked with maleness evolved three distinct times – once in birds, once in the ancestor of the platypus and echidna, and a third time in the ancestor of all other mammals. The ancestors of the three Ys each started with different kinds of genes, but to Kaessmann's surprise, all ended up with a stable set of the same sorts of genes, which is what Bellott's team also found. "You play this evolutionary game with different sets of genes, and you get the same kinds of genes retained in each case," he says. "It's always the regulatory genes that remain."

19. Why? When a gene is lost from the Y, males are left with one copy of the gene, on their single X chromosome. That means less of the protein the gene codes for gets made – roughly half the usual dosage. Evolution can fix this in males by ramping up production from the single X, but then their female descendants get a double dose from their two Xs. To keep gene output the same in the two sexes despite this difference, females have evolved to inactivate one of their two copies of most genes on the X. Perhaps the amount of protein produced by the regulatory genes retained on the Y had to be so precisely calibrated that organisms couldn't survive the awkward intermediate stage when this workaround did not yet function perfectly, suggests James Turner at the MRC National Institute for Medical Research in London. Regulatory genes are particularly vital because they control many other genes.

20. So important are the Y genes, in fact, that even during a man's lifetime, losing the Y in some tissues takes a toll. Chromosomes can be lost when cells divide, and men who lose the Y chromosome in their bone marrow – which happens in about 8 per cent of elderly men – have a higher risk of cancer and die an average of 5.5 years younger than other men.

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Sources:

Article 1: Clare Wilson | New Scientist

Science DOI: 10.1126/science.abn3100

Article 2 : Bob Holmes | New Scientist