



GCE A LEVEL

1400U40 –1

FRIDAY, 14 JUNE 2024 – MORNING

BIOLOGY – A2 UNIT 4

**VARIATION, INHERITANCE AND
OPTIONS**

**2 hours plus your additional time
allowance**

Surname: _____

First name(s): _____

Centre Number: _____

Candidate Number: 2 _____

For Examiner's use only			
	Question	Maximum Mark	Mark Awarded
Section A	1.	11	
	2.	15	
	3.	13	
	4.	10	
	5.	12	
	6.	9	
Section B	Option	20	
	Total	90	

ADDITIONAL MATERIALS

In addition to this paper, you will require a calculator and a ruler.

ITEMS INCLUDED WITH QUESTION PAPER

A separate Diagram Booklet.

The Diagram Booklet **MUST be handed in to the invigilators and sent for marking.**

(Turn over)

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball–point pen or your usual method.

Write your name, centre number and candidate number in the spaces on the front cover.

Write your answers in the spaces provided. If you run out of space, use the additional page(s) at the back of this booklet, taking care to number the question(s) correctly.

(Turn over)

INFORMATION FOR CANDIDATES

This paper is in 2 sections, A and B.

Section A: 70 marks. Answer ALL questions. You are advised to spend about 1 hour 35 minutes on this section.

Section B: 20 marks; Options. Answer ONE OPTION ONLY. You are advised to spend 25 minutes on this section.

The number of marks is given in brackets at the end of each question or part–question.

The assessment of the quality of extended response (QER) will take place in question 6. The quality of written communication will affect the awarding of marks.

(Turn over)

SECTION A

Answer ALL questions.

- 1. Refer to IMAGE 1.1 in the separate Diagram Booklet. The male reproductive system consists of a number of sex organs that play a role in the process of human reproduction. These organs are located on the outside of the body and within the pelvis as shown in IMAGE 1.1**

continued on the next page . . .

(Turn over)

Question 1 continued

- 1. (a) Using the numbers in IMAGE 1.1, identify the following structures and briefly describe ONE function for each structure in TABLE 1.1 in separate Diagram Booklet.**

[5 marks]

continued on the next page . . .

(Turn over)

Question 1 continued

1. (b) Compare the function of the urethra in males and females.

[2 marks]

continued on the next page . . .

(Turn over)

Question 1 continued

1. (c) Refer to IMAGE 1.2 in the separate Diagram Booklet.

(i) Name the cells A, B, C and D in IMAGE 1.2

Cells	Name
A	_____
B	_____
C	_____
D	_____

[2 marks]

continued on the next page . . .

(Turn over)

Question 1 (c) continued

1. (c) (ii) High numbers of spermatozoa must be constantly produced to ensure fertility.

Use your knowledge of CELL DIVISION to explain why it is important that all type I spermatogonia do not become type II spermatogonia.

10

[2 marks]

(Total for Question 1 = 11 marks)

(Turn over)

- 2. Refer to IMAGE 2.1 in the separate Diagram Booklet. Germination involves the rapid onset of biochemical activity and growth of a seedling until the plant can carry out photosynthesis and become independent of the food stores contained in the cotyledons. IMAGE 2.1 shows some stages of a germinating pea plant over a 15–day period.**

continued on the next page . . .

(Turn over)

Question 2 continued

2. (a) (i) The germinating pea seed labelled P in IMAGE 2.1 was cut open. This is shown in IMAGE 2.2 in the separate Diagram Booklet.

**ADD LABELS TO LINES A,
B AND C to identify the
COTYLEDON, PLUMULE
AND RADICLE on IMAGE 2.2**

[2 marks]

continued on the next page . . .

(Turn over)

Question 2 (a) continued

2. (a) (ii) State TWO reasons why it is important that the radicle emerges prior to the plumule.

[2 marks]

continued on the next page . . .

(Turn over)

[3 marks]

continued on the next page . . .

(Turn over)

Question 2 continued

- 2. (c) Refer to IMAGE 2.3 in the separate Diagram Booklet. Gibberellin is required for maize kernel (seed) germination. It is blocked by another plant hormone, abscisic acid (ABA) whilst the kernel is maturing on the cob. Mutant kernels which cannot produce ABA germinate whilst still on the cob. This is shown in IMAGE 2.3**

continued on the next page . . .

(Turn over)

[3 marks]

continued on the next page . . .

(Turn over)

Question 2 continued

- 2. (d) Refer to TABLE 2.4 in the separate Diagram Booklet. Field trials were carried out to investigate the effect of increasing soil temperature on the average number of wheat plants that grow. The results are shown in TABLE 2.4**
- In each field, the wheat grains were planted at a depth of 4 cm at a rate of 100 kg per hectare and the temperature was measured in each field at a depth of 5 cm.**

continued on the next page . . .

(Turn over)

Question 2 (d) continued

2. (d) (i) One simple conclusion from this data is that higher soil temperatures reduce the number of mature wheat plants per square metre. State FOUR other factors that could affect the growth and so your confidence in this conclusion.

I. _____

II. _____

(Turn over)

Question 2 (d) (i) continued

III. _____

IV. _____

[2 marks]

2. (d) (ii) Assuming that this was a valid conclusion, state why the results of this research are of serious significance to worldwide wheat production.

3. An artificial gene coding for human growth hormone (HGH), was synthesised in a laboratory.

The synthesised gene was used to genetically modify E. COLI bacteria, which then produced HGH.

The synthesised HGH was identical to natural HGH in size and biological activity.

continued on the next page . . .

Question 3 continued

3. (a) The human genome project determined the base pairs that make up human DNA.

Explain how the results from the human genome project have allowed the synthesis of the artificial gene to become possible.

[1 mark]

continued on the next page . . .

(Turn over)

[3 marks]

continued on the next page . . .

(Turn over)

Question 3 continued

3. (c) Refer to IMAGE 3.1 in the separate Diagram Booklet. The plasmid used to genetically modify the E. COLI is shown in IMAGE 3.1 It also shows the positions of TWO antibiotic resistance genes and the site of insertion of the HGH gene.

Name the TWO types of enzymes needed for the successful insertion of the human growth hormone gene and state their function in the process.

(Turn over)

[2 marks]

continued on the next page . . .

(Turn over)

Question 3 continued

- 3. (d) Refer to IMAGE 3.2 in the separate Diagram Booklet. To test that the plasmid has transferred successfully, the bacteria were grown on separate agar plates containing the two antibiotics. The bacteria were initially grown on agar containing tetracycline and the colonies were then transferred, using a replica pad, to agar containing ampicillin as shown in IMAGE 3.2**

continued on the next page . . .

(Turn over)

Question 3 (d) continued

3. (d) (i) Explain the need for PLATE A in the process.

[1 mark]

(ii) Explain the results shown on PLATE B.

(Turn over)

[3 marks]

continued on the next page . . .

(Turn over)

Question 3 (d) continued

3. (d) (iii) Suggest ONE vital property of the cells on PLATE C which would need to be confirmed prior to their use in the production of HGH.

[1 mark]

continued on the next page . . .

(Turn over)

Question 3 continued

- 3. (e) Each E. COLI cell transformed with this recombinant plasmid produced 2.9×10^6 molecules of HGH. If there are 1×10^8 bacteria in the culture vessel, calculate the number of HGH molecules being produced by the cells. GIVE YOUR ANSWER IN STANDARD FORM.**

Answer space continues on the next page

(Turn over)

Question 3 (e) continued

Number of HGH molecules = _____

[2 marks]

(Total for Question 3 = 13 marks)

(Turn over)

4. Refer to the IMAGE 4.1 in the separate Diagram Booklet. Bones can be preserved as fossils so research into evolutionary patterns and processes can include extinct vertebrates.

IMAGE 4.1 shows how the leg bones of the modern horse have evolved from a horse-like mammal over the last 38 million years.

(a) Explain how the information in IMAGE 4.1 supports Darwin's theory of evolution.

(Turn over)

[3 marks]

continued on the next page . . .

(Turn over)

Question 4 continued

- 4. (b) Refer to IMAGES 4.2 and 4.3 in the separate Diagram Booklet. Ancient horses had many coat colours. One type of gene controlling depth of colour in horses is the dun allele (D). For example the bay horse in IMAGE 4.2 is homozygous for the d allele but a horse is a dun if it has at least one D allele (IMAGE 4.3).**

continued on the next page . . .

(Turn over)

Question 4 (b) continued

- 4. (b) (i) In a sample of 900 wild horses, 891 were dun and 9 were bay. Calculate the frequencies of the three genotypes within this population, assuming that the population is in Hardy–Weinberg equilibrium.**

continued on the next page . . .

(Turn over)

Question 4 (b) (i) continued

$$p + q = 1$$

$$p^2 + 2pq + q^2 = 1$$

where

**p = frequency of the
dominant allele (D)**

**q = frequency of the
recessive allele (d)**

Answer space continues on the next page

(Turn over)

Question 4 (b) (i) continued

Frequency of dd = _____

Frequency of DD = _____

Frequency of Dd = _____

[3 marks]

continued on the next page . . .

(Turn over)

Question 4 (b) continued

4. (b) (ii) The population in (b) (i) consisted of randomly mating horses in semi-desert conditions.

Use all the information given to give TWO reasons why this population may not be in Hardy-Weinberg equilibrium.

(Turn over)

[2 marks]

continued on the next page . . .

(Turn over)

Question 4 continued

- 4. (c) Refer to IMAGES 4.4A and 4.4B in the separate Diagram Booklet. IMAGES 4.4A and 4.4B show photographs of a mule and a hinny.**

Mules are considered more patient, hardy and long-lived than horses and are described as less obstinate and more intelligent than donkeys.

They can carry heavy loads for long distances so are an ideal pack-animal.

continued on the next page . . .

(Turn over)

Question 4 (c) continued

A mule is a hybrid resulting from crossing a male donkey (E. ASINUS) with a female horse (E. CABALLUS).

- (i) Explain why a breeder would need to use a donkey and a horse EACH TIME they wished to produce a mule.**

[1 mark]

continued on the next page . . .

(Turn over)

Question 4 (c) continued

4. (c) (ii) The opposite cross (a hinny) can also be carried out, but it is done very rarely. The mother is the much smaller donkey compared with the larger horse mother in a mule cross. Explain why the mule cross is more suitable for a load-bearing pack animal.

[1 mark]

(Total for Question 4 = 10 marks)

(Turn over)

5. **There are many sex–linked genetic diseases in humans which cause changes in phenotype.**

X–linked inheritance means that the gene is located on the X chromosome.

X–linked severe combined immunodeficiency (X–SCID) is a recessive immunodeficiency disorder in which the body produces very few lymphocytes.

continued on the next page . . .

(Turn over)

Question 5 continued

5. (a) (i) I. Use the symbols X^D for unaffected by X-SCID and X^d for affected by X-SCID to draw a genetic diagram to show how parents who are both unaffected can produce a son with X-SCID.

Refer to the incomplete information for Question 5 (a) (i) I in the separate Diagram Booklet. Complete the information to help you with your genetic diagram.

continued on the next page . . . (Turn over)

Question 5 (i) continued

Space for genetic diagram

[2 marks]

continued on the next page . . .

(Turn over)

Question 5 (a) (i) continued

5. (a) (i) II. COMPLETE THE TABLE on the next page linking the FOUR different genotypes from your genetic diagram with their correct phenotype.

Space for working

(Turn over)

Question 5 (a) (i) II continued

Offspring genotype	Offspring phenotype
<hr/> <hr/>	<hr/> <hr/>
<hr/> <hr/>	<hr/> <hr/>
<hr/> <hr/>	<hr/> <hr/>
<hr/> <hr/>	<hr/> <hr/>

[2 marks]**continued on the next page . . .****(Turn over)**

Question 5 (a) continued

5. (a) (ii) The estimated UK incidence of X – SCID is 1 in 48 933 The population of Wales in 2018 was 3 139 000

Calculate the number of cases of X – SCID that would have been expected in Wales in 2018.

GIVE YOUR ANSWER TO AN APPROPRIATE NUMBER OF SIGNIFICANT FIGURES.

Answer space continues on the next page

(Turn over)

Question 5 (a) (ii) continued

Number of cases = _____

[2 marks]

continued on the next page . . .

(Turn over)

Question 5 continued

Refer to IMAGE 5.1 in the separate Diagram Booklet. There are other mechanisms, such as epigenetic changes, which can alter the phenotype of organisms. One example is DNA methylation, where a methylated promoter region decreases the expression of a gene and demethylation increases the expression of a gene.

This is shown in IMAGE 5.1

Epigenetic control mechanisms can be seen in coat colour in mice which is influenced by the nutrition of the pregnant female.

continued on the next page . . . (Turn over)

Question 5 continued

When the pregnant females are fed compounds such as BPA (used in plastic production) with their normal diet, this can cause more yellow offspring to be born. When the pregnant females' normal diets are supplemented with high folic acid, more brown offspring are born. This is summarised in IMAGE 5.2 in the separate Diagram Booklet.

continued on the next page . . .

(Turn over)

Question 5 continued

When mice were fed the two different diets, the following results were obtained, with ranges in coat colour as shown in IMAGE 5.3 in the separate Diagram Booklet. The number of each type of coat colour is shown in GRAPH 5.4, also in the separate Diagram Booklet.

continued on the next page . . .

(Turn over)

Question 5 continued

5. (b) (i) Using IMAGES 5.1, 5.2, 5.3 and GRAPH 5.4, explain the effect of the TWO different supplements on gene expression and coat colour in mice.

(Turn over)

[4 marks]

continued on the next page . . .

(Turn over)

Question 5 (b) continued

5. (b) (ii) Use all of the information to suggest how the results of this study might influence the use of BPA in the production of food containers and packaging.

(Turn over)

[2 marks]

(Total for Question 5 = 12 marks)

(Turn over)

6. Mutations in the DNA of an organism may have a profound effect on the phenotype. There are two main types of mutations; gene and chromosome.

Explain what is meant by the term mutation and describe some factors which increase the rate of mutations.

Describe the different types of gene and chromosome mutations and, using suitable examples, explain the different effects that gene and chromosome mutations may have on the phenotype.

[9 QER marks]

(Total for Question 6 = 9 marks)

TOTAL FOR SECTION A = 70 MARKS

(Turn over)

SECTION B: OPTIONAL TOPICS

Option A: IMMUNOLOGY AND DISEASE

Option B: HUMAN MUSCULOSKELETAL ANATOMY

Option C: NEUROBIOLOGY AND BEHAVIOUR

Answer the question on ONE TOPIC ONLY.

Place a tick (✓) in ONE of the boxes above, to show which topic you are answering.

YOU ARE ADVISED TO SPEND ABOUT 25 MINUTES ON THIS SECTION.

(Turn over)

OPTION A: IMMUNOLOGY AND DISEASE

7. Tuberculosis (TB) is the leading cause of death by an infectious disease worldwide.

(a) (i) State why tuberculosis is called an infectious disease.

[1 mark]

continued on the next page . . .

(Turn over)

Question 7 (a) continued

7. (a) (ii) To prevent the spread of TB, the BCG vaccination was introduced in 1953 for children aged 10–14 years old. Define the term vaccine.

[1 mark]

continued on the next page . . .

(Turn over)

Question 7 (a) continued

- 7. (a) (iii) Refer to IMAGE 7.1 in the separate Diagram Booklet. The BCG vaccination is no longer part of childhood immunisations. It is only offered to those who are at higher risk of TB; for example, children under 5 who live in an area of the UK with a high rate of TB, as in some areas of London. IMAGE 7.1 shows the population density of different areas of London.**

continued on the next page . . .

(Turn over)

[2 marks]

continued on the next page . . .

(Turn over)

Question 7 continued

- 7. (b) Refer to GRAPH 7.2 in the separate Diagram Booklet. GRAPH 7.2 shows the concentration of antibodies released by the body following a BCG vaccination and then after exposure to the live infectious micro-organism, MYCOBACTERIUM TUBERCULOSIS.**

continued on the next page . . .

(Turn over)

Question 7 (b) continued

The BCG vaccine initiates an active immune response which leads to the production of antibodies by the patient.

- 7. (b) (i) Describe and explain the shape of the part of GRAPH 7.2 which shows the primary immune response.**

(Turn over)

[4 marks]

7. (b) (ii) With reference to GRAPH 7.2, explain how vaccination prevents development of TB when exposed to M. TUBERCULOSIS.

(Turn over)

Question 7 continued

- 7. (c) Refer to GRAPH 7.3 in the separate Diagram Booklet. Since the 1940s, antibiotics have been used to treat TB. GRAPH 7.3 shows the change in the numbers of diagnosed TB cases in England and Wales from 1940 to 2015**

continued on the next page . . .

(Turn over)

Question 7 (c) continued

7. (c) (i) Calculate the percentage decrease in TB INCIDENCE between 1940 and 2015

Percentage decrease in incidence of

TB = _____%

[2 marks]

continued on the next page . . .

(Turn over)

Question 7 (c) continued

MYCOBACTERIUM TUBERCULOSIS can develop into a dormant state, referred to as latent TB. Whilst dormant, **M. TUBERCULOSIS** is resistant to antibiotics. Patients with TB receive a combination of antibiotics to kill active bacteria rapidly and to try to prevent latent TB.

Refer to **IMAGE 7.4** in the separate **Diagram Booklet**. Two new treatments have been proposed to target dormant **M. TUBERCULOSIS** to prevent TB recurring in a patient.

continued on the next page . . .

(Turn over)

Question 7 (c) continued

TREATMENT 1

Use of DRUG A to activate the dormant bacteria as well as treating with high doses of antibiotics to kill all activated bacteria.

TREATMENT 2

Use of DRUG B that will inhibit the activation of any dormant bacteria while the drug is present.

These treatments have been trialled in mice as shown in IMAGE 7.4

continued on the next page . . .

(Turn over)

Question 7 (c) continued

7. (c) (ii) Complete TABLE 7.5 in the separate Diagram Booklet by stating ONE advantage and ONE disadvantage for each of the treatments.

[4 marks]

(d) The methods of treating TB can also be used to treat malarial infections. Explain why these methods are less effective when they are used in the treatment of malarial infections.

(Turn over)

[2 marks]

(Total for Question 7 = 20 marks)

(Turn over)

OPTION B: HUMAN**MUSCULOSKELETAL ANATOMY**

8. The human musculoskeletal system is comprised of a number of different tissues, including muscle, cartilage and bone.

Refer to IMAGE 8.1 in the separate Diagram Booklet. IMAGE 8.1 shows the structure and appearance of a sarcomere in relaxed, striated muscle. It also shows transverse sections of the actin and myosin filaments in the sarcomere.

(Turn over)

Question 8 continued

8. (a) (i) COMPLETE THE APPEARANCE of transverse SECTION 3 shown on IMAGE 8.1

[1 mark]

(ii) During contraction of the muscle, the sarcomere shortens. Describe and explain what happens to the H zone and A band.

(Turn over)

Question 8 (a) continued

- 8. (a) (iii) When the sarcomere is contracted, its length is $1.5 \mu\text{m}$ long. Use IMAGE 8.1 to calculate the percentage decrease in length when the sarcomere contracts.**

Percentage decrease in length

of sarcomere = _____

[2 marks]

continued on the next page . . .

(Turn over)

Question 8 (a) continued

8. (a) (iv) Describe how the structure of actin allows cross bridges to form during contraction of the muscle and explain why cross bridges are unable to form in a resting muscle.

(Turn over)

[2 marks]

8. (b) Cartilage is connective tissue found in the skeleton. There are several forms of cartilage.

(i) Explain how the structure of hyaline cartilage relates to its function in the skeleton.

(Turn over)

[2 marks]

continued on the next page . . .

(Turn over)

Question 8 (b) continued

8. (b) (ii) Refer to IMAGE 8.2 in the separate Diagram Booklet. IMAGE 8.2 shows a normal knee joint and a joint affected by rheumatoid arthritis.

Describe what is meant by rheumatoid arthritis and name TWO types of tissues affected by rheumatoid arthritis as shown in IMAGE 8.2

(Turn over)

[2 marks]

continued on the next page . . .

(Turn over)

Question 8 continued

8. (c) Refer to IMAGE 8.3 in the separate Diagram Booklet.

Osteoporosis is a form of brittle bone disease in humans.

It is caused by the loss of calcium from the bones leading to decreased bone density.

IMAGE 8.3 shows a cross section of bone from a healthy patient, and one from a patient suffering from osteoporosis.

continued on the next page . . .

(Turn over)

Question 8 (c) continued

8. (c) (i) Using IMAGE 8.3 and your own knowledge, describe the effect of osteoporosis on the composition of the bones.

[2 marks]

continued on the next page . . .

(Turn over)

Question 8 (c) continued

Refer to TABLE 8.4 in the separate Diagram Booklet. Amniotic fluid contains a form of stem cell that can differentiate into osteoblasts. Research has been carried out to assess the effectiveness of stem cells in treating osteogenesis imperfecta (OI) in mice. Three groups of mice were tested. The treatment received by each group is shown in TABLE 8.4

The results of the research are shown in GRAPHS 8.5 and 8.6 in the separate Diagram Booklet.

continued on the next page . . .

(Turn over)

Question 8 (c) continued

8. (c) (ii) Summarise the effect of stem cell treatment in the experimental group C in comparison to the healthy mice (A) and the control group (B) shown in GRAPHS 8.5 AND 8.6

(Turn over)

[3 marks]

continued on the next page . . .

(Turn over)

Question 8 (c) continued

8. (c) (iii) The use of human stem cells is being considered for clinical trials in humans to treat osteoporosis. Using all of the information provided, suggest how stem cell treatment could improve the condition of bones in osteoporosis patients.

(Turn over)

[2 marks]

(Total for Question 8 = 20 marks)

(Turn over)

OPTION C: NEUROBIOLOGY AND BEHAVIOUR

- 9. Prairie dogs (CYNOMYS LUDOVICIANUS) are rodents, native to the grasslands of North America, which live in large colonies. Members of a family group interact through a variety of social behaviours such as kissing and grooming one another. IMAGE 9.1 in the separate Diagram Booklet, shows prairie dogs sharing a greeting kiss.**

continued on the next page . . .

(Turn over)

Question 9 continued

9. (a) Prairie dogs are said to demonstrate social behaviour.

(i) Define the term social behaviour.

[1 mark]

continued on the next page . . .

(Turn over)

Question 9 (a) continued

- 9. (a) (ii) Prairie dogs communicate with other members of the colony by making different sounding barks. When an intruder approaches, the first prairie dog gives a sharp bark, bobs up and down, barks again, and then plunges into a burrow. Other lookouts further away repeat this behaviour alerting other members of the colony along the route taken by the intruder.**

continued on the next page . . .

(Turn over)

Question 9 (a) (ii) continued

The social behaviour of ‘barking and bobbing’ is an example of a fixed action pattern. Explain how such a fixed action pattern is generated and why it may be advantageous to the animals within the social group.

(Turn over)

[2 marks]

continued on the next page . . .

(Turn over)

[2 marks]

continued on the next page . . .

(Turn over)

Question 9 continued

- 9. (b) Social behaviour involves a large number of learnt responses.**

Researchers investigated the behaviour of prairie dogs in colonies in Colorado. They were trying to find out if prairie dogs became habituated to the arrival of a human in their territory.

continued on the next page . . .

(Turn over)

Question 9 (b) continued

9. (b) (i) Define the term habituation and explain why it is an advantage to the prairie dogs.

[2 marks]

continued on the next page . . .

(Turn over)

Question 9 (b) continued

The researchers selected two colonies of prairie dogs:

Colony A **From a rural area, out of town, and not used to human presence.**

Colony B **From an urban area, close to city parks, where the prairie dogs would occasionally encounter humans.**

continued on the next page . . .

(Turn over)

Question 9 (b) continued

Humans slowly approached each colony 100 times over 200 days. They recorded the concealment distance – this is the distance from the lookout animal to the human when the prairie dogs went down into the burrows. The researchers expected that the prairie dogs would become habituated to the presence of humans.

Refer to GRAPH 9.2 in the separate Diagram Booklet.

The results are shown in GRAPH 9.2

continued on the next page . . .

(Turn over)

Question 9 (b) continued

- 9. (b) (ii) Using GRAPH 9.2, calculate the percentage increase in concealment distance for the rural prairie dogs over the 200 days.**

Percentage increase in concealment

distance = _____

[2 marks]

continued on the next page . . .

(Turn over)

[3 marks]

- 9. (c) Refer to IMAGES 9.3 and 9.4 in the separate Diagram Booklet. IMAGES 9.3 and 9.4 show fMRI scans of two patients taken whilst carrying out language skill tasks.**

continued on the next page . . .

(Turn over)

Question 9 (c) continued

9. (c) (i) State why an fMRI scan was the most suitable form of brain scan to show where the patients were processing language.

[1 mark]

continued on the next page . . .

(Turn over)

Question 9 (c) continued

9. (c) (ii) Suggest the area of the brain where the stroke took place and explain what has happened in the brain of the stroke patient in IMAGE 9.4 to account for the fMRI scan result.

(Turn over)

Question 9 (c) continued

- 9. (c) (iii) The patient in IMAGE 9.4 regained all aspects of language. Refer to IMAGE 9.5 in the separate Diagram Booklet. IMAGE 9.5 shows an fMRI scan from a patient who had a stroke as a mature adult.**

continued on the next page . . .

(Turn over)

Question 9 (c) (iii) continued

Using IMAGE 9.5 and your own knowledge, explain why it would be more difficult for this patient to fully regain all aspects of language.

(Turn over)

[3 marks]

(Total for Question 9 = 20 marks)

TOTAL FOR SECTION B = 20 MARKS

END OF PAPER

TOTAL FOR PAPER = 90 MARKS

(Turn over)



GCE A LEVEL

1400U40-1

FRIDAY, 14 JUNE 2024 – MORNING

BIOLOGY – A2 UNIT 4

VARIATION, INHERITANCE AND OPTIONS

The Diagram Booklet MUST be handed in to the invigilators and sent for marking.

Diagram Booklet

Surname: _____

First name(s): _____

Centre number: _____

Candidate Number: 2 _____

IMAGE 1.1

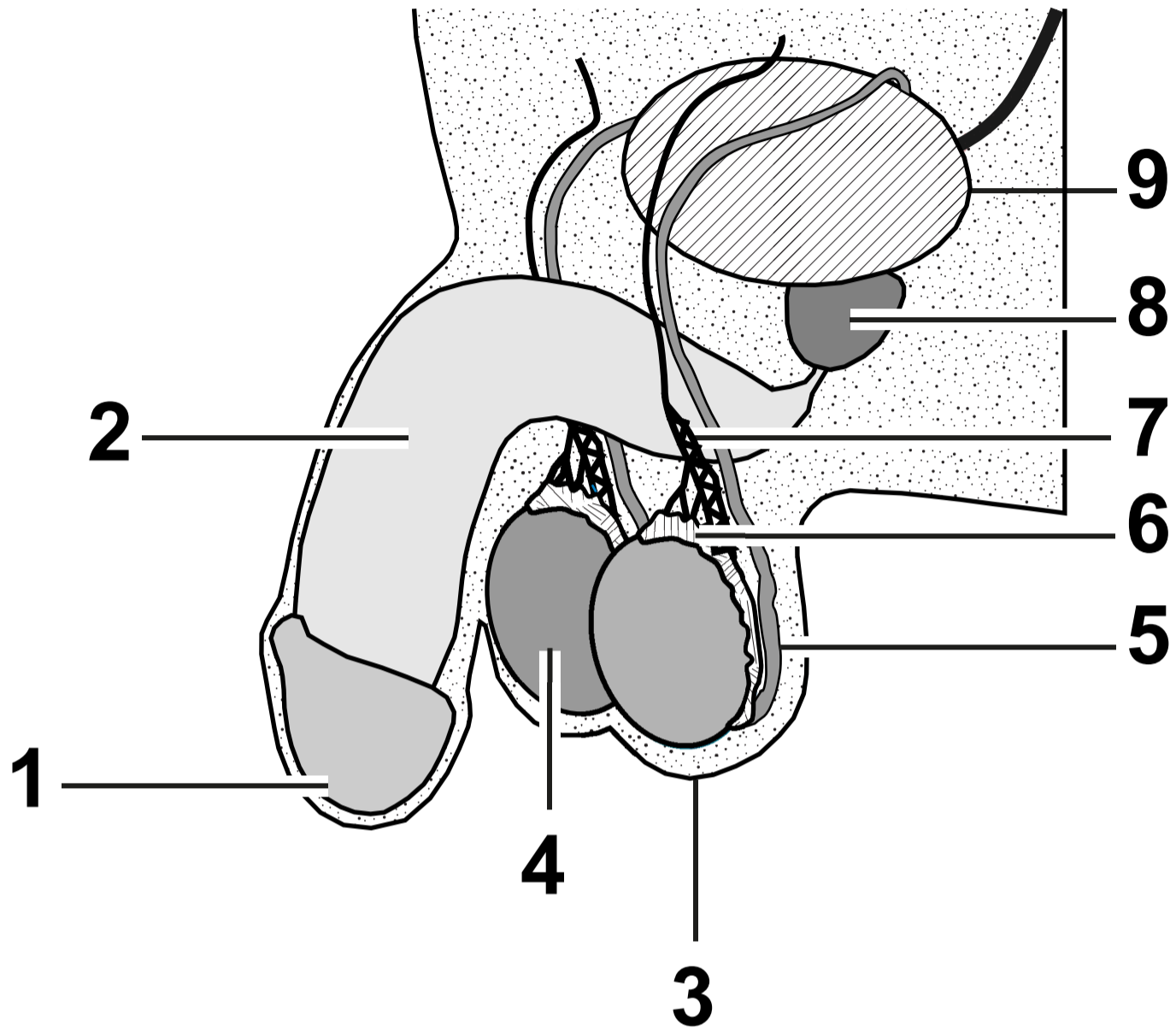


TABLE 1.1

Structure	Number from IMAGE 1.1	Function
vas deferens	<hr/>	<hr/> <hr/>
scrotum	<hr/>	<hr/> <hr/>
testes	<hr/>	<hr/> <hr/>
epididymis	<hr/>	<hr/> <hr/>
prostate gland	<hr/>	<hr/> <hr/>

IMAGE 1.2

**TYPE I
SPERMATOGONIA**

re - enter cell cycle

**TYPE II
SPERMATOGONIA**

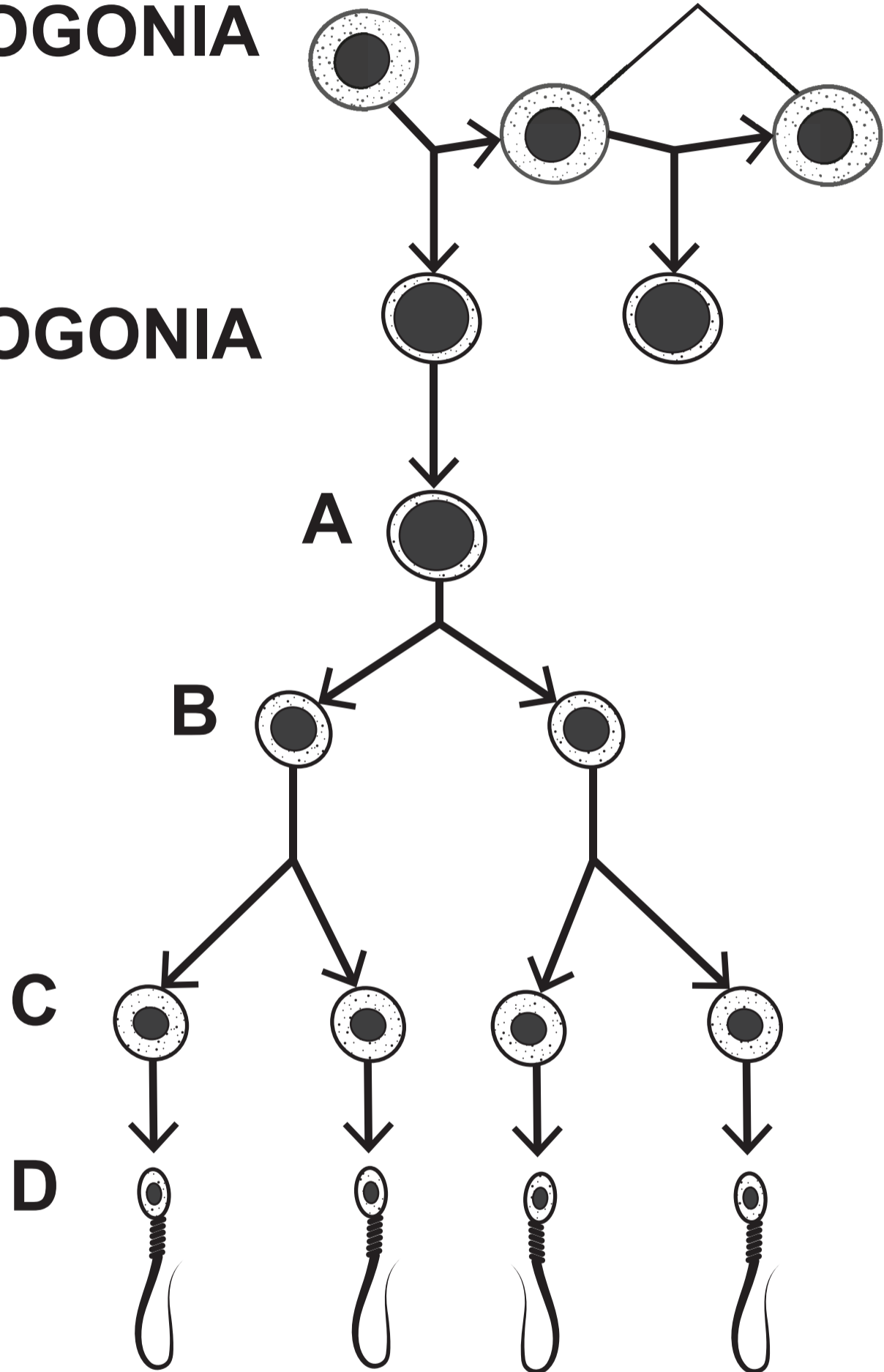
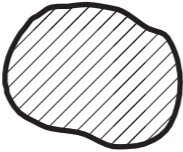
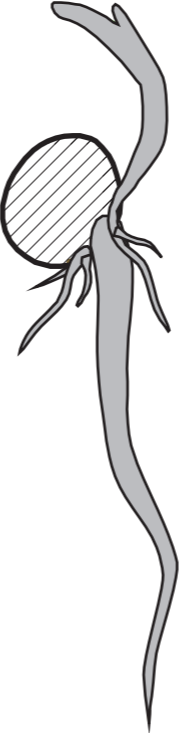
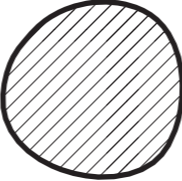


IMAGE 2.1

Day 1



P



Day 15

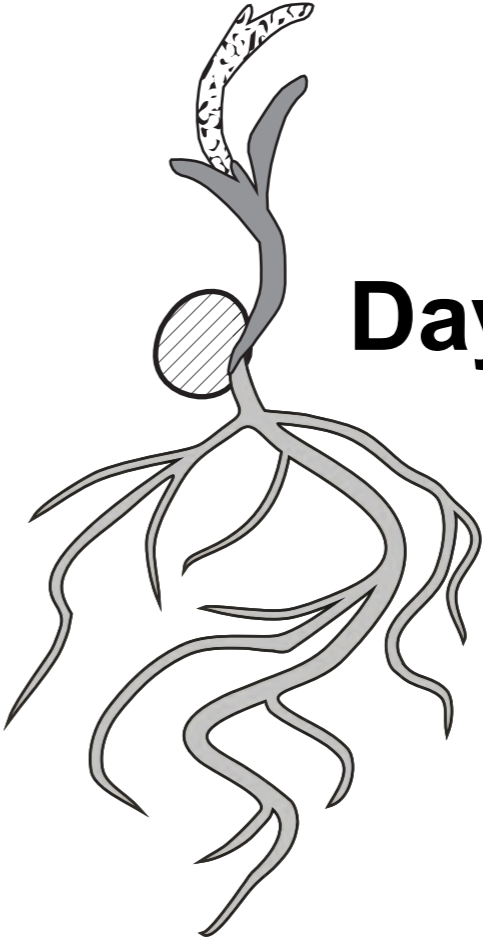


IMAGE 2.2

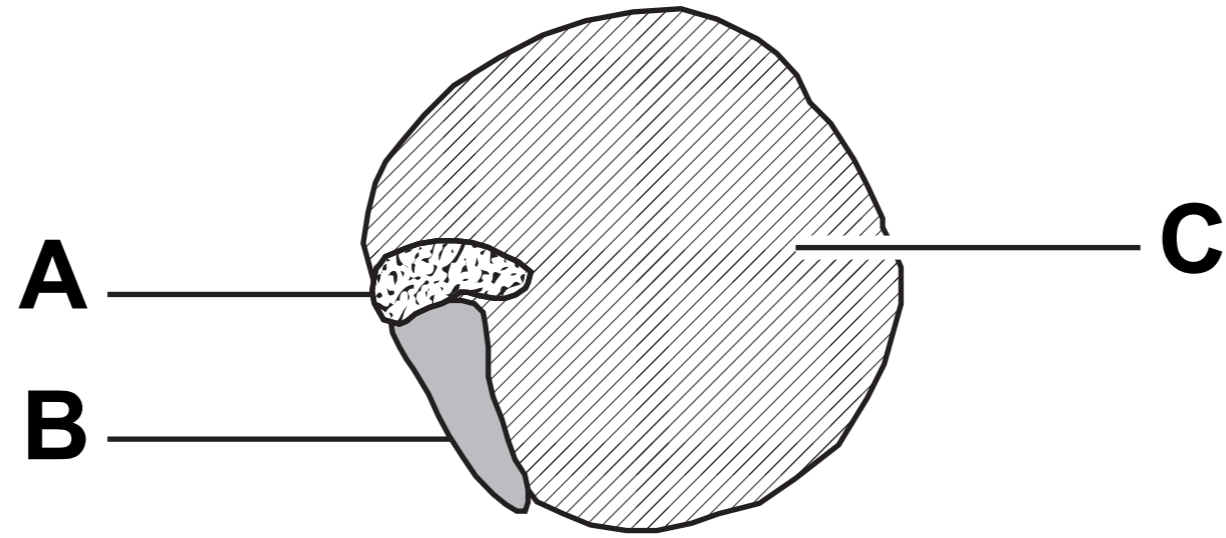


IMAGE 2.3



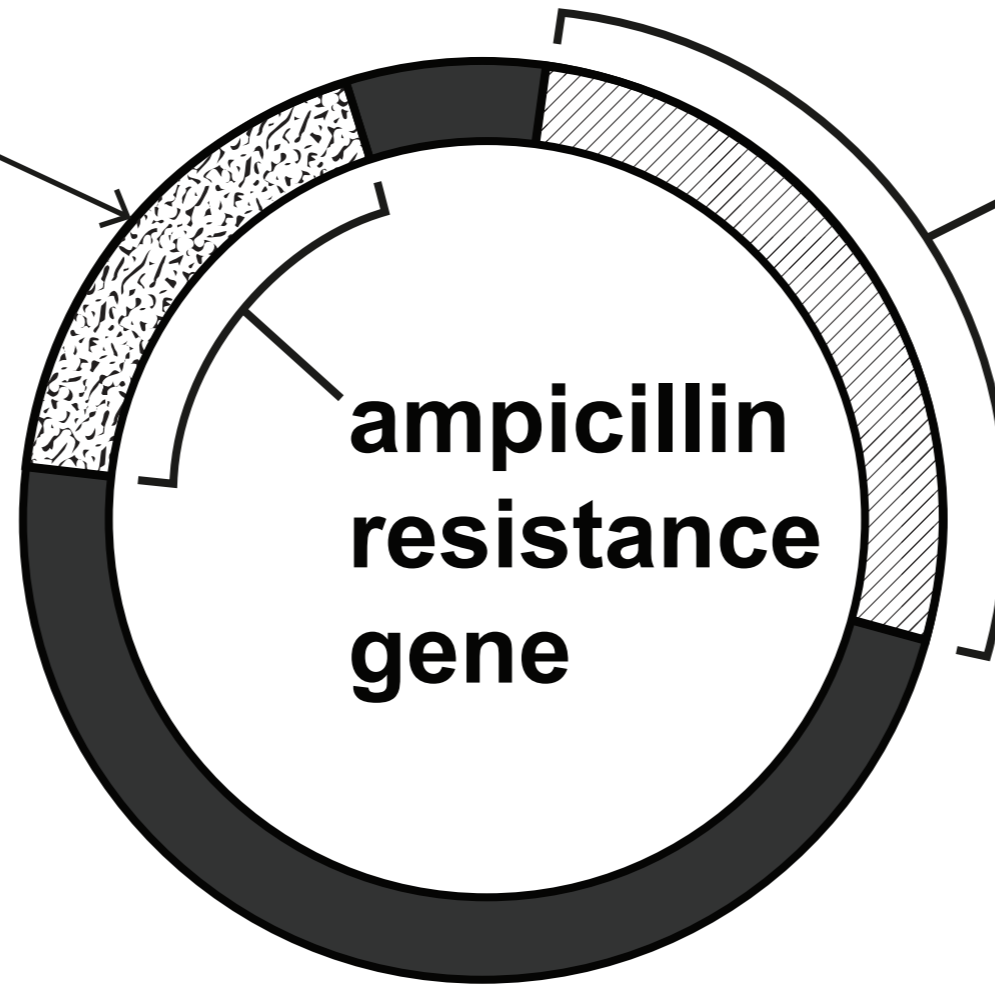
TABLE 2.4

Mean maximum soil temperature (°C)	Number of mature wheat plants per m²
20•2	315•3
33•2	256•7
42•2	89•8

IMAGE 3.1

site of insertion of
HGH gene

tetracycline
resistance
gene



ampicillin
resistance
gene

IMAGE 3.2

replica pad – cells stick to sterile velvet surface

1. press replica pad to pick up cells

2. press replica pad to deposit cells

3. identify the missing colonies

4. transfer the identified colonies to another plate – PLATE C

PLATE A
master
(tetracycline)
plate

PLATE B
replica
(ampicillin)
plate

grid pattern of colonies
makes identification easier

missing colonies

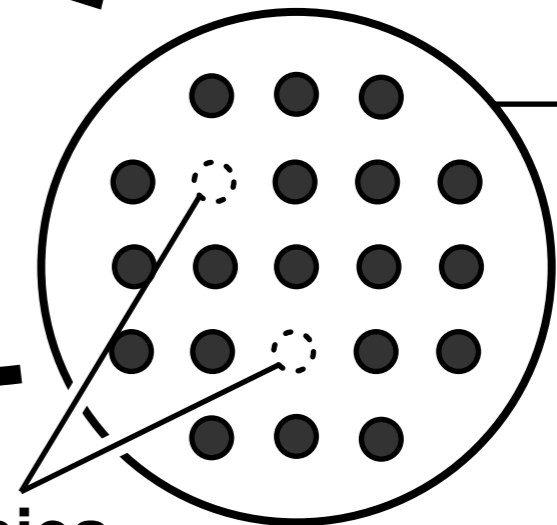
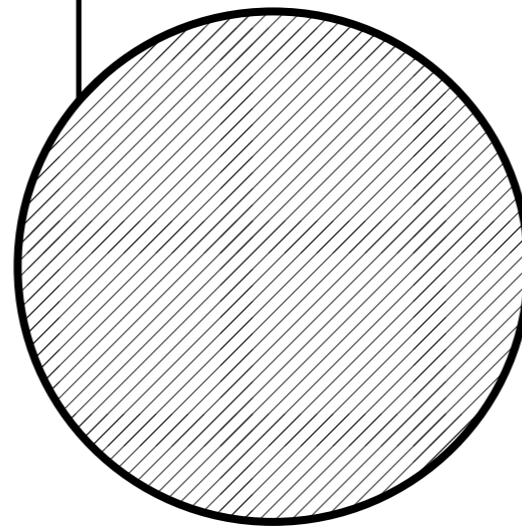
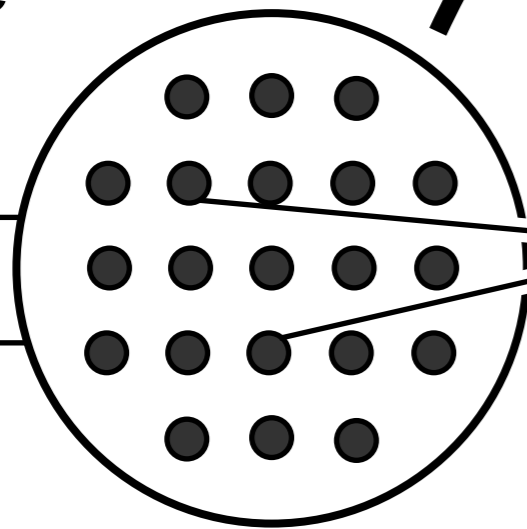


IMAGE 4.1

MYA = Million Years ago

**Equus
Recent**



**Merychippus
Middle Miocene
11 MYA**



**Mesohippus
Late Eocene
38 MYA**

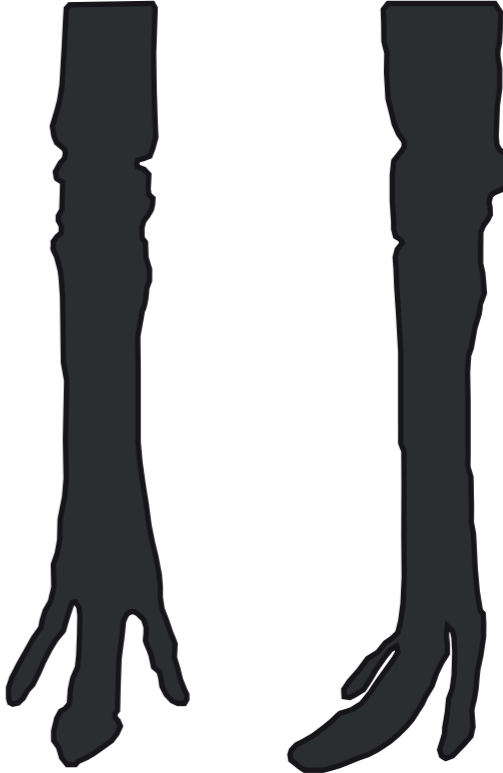


IMAGE 4.2 and IMAGE 4.3

IMAGE 4.2 Bay (dd)



IMAGE 4.3 Dun (DD or Dd)



IMAGE 4.4A and IMAGE 4.4B

IMAGE 4.4A – Mule



IMAGE 4.4B – Hinny



Question 5 (a) (i) I.

Incomplete information

Parental phenotype **unaffected male** × **unaffected female**

Parental genotypes

Gametes

IMAGE 5.1

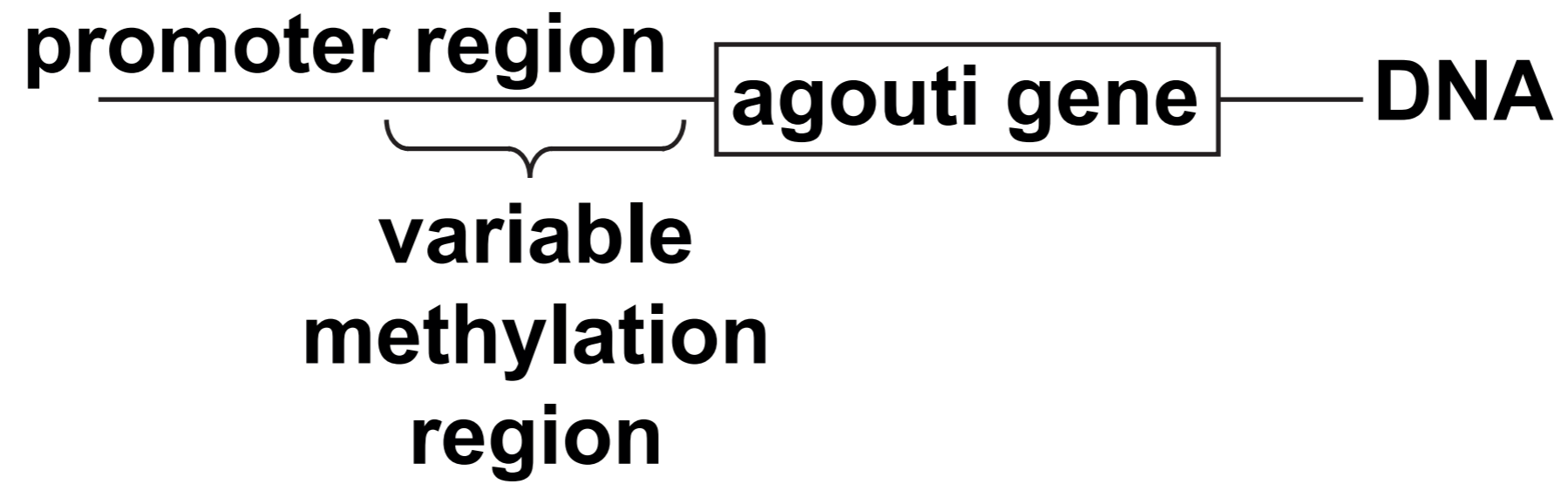
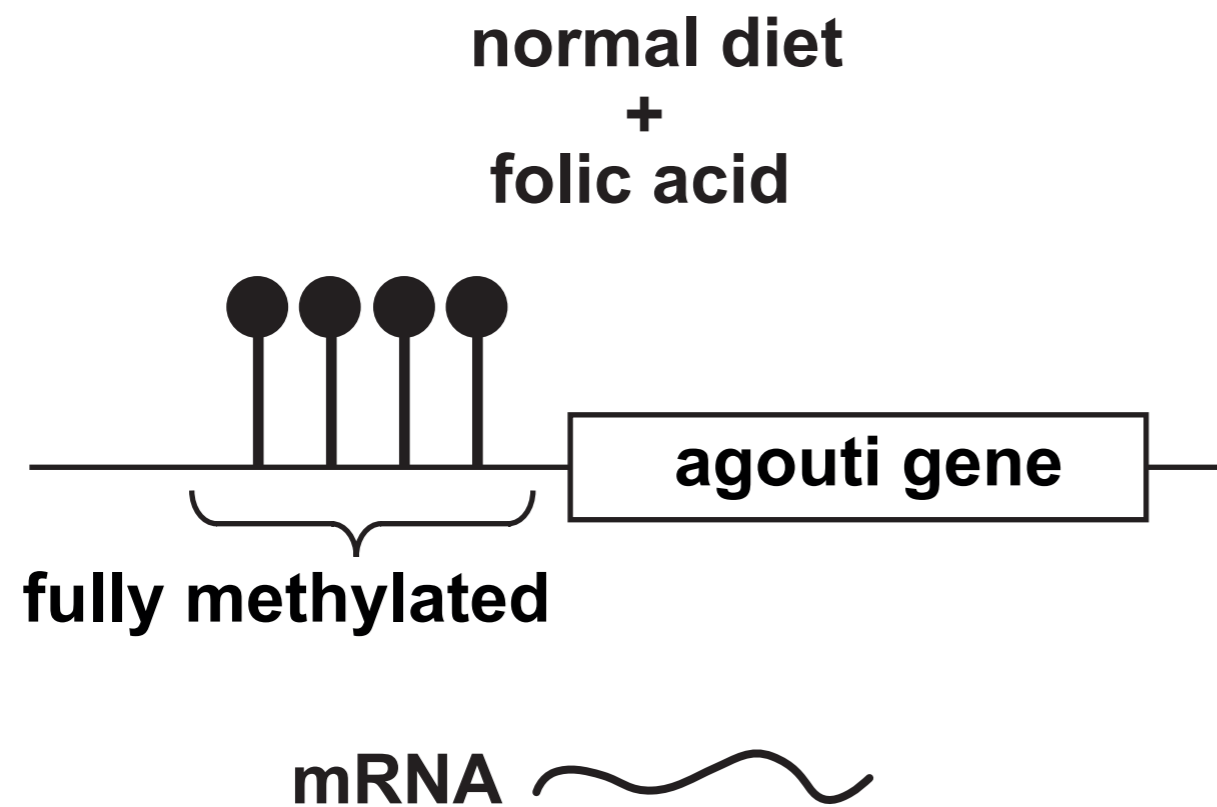
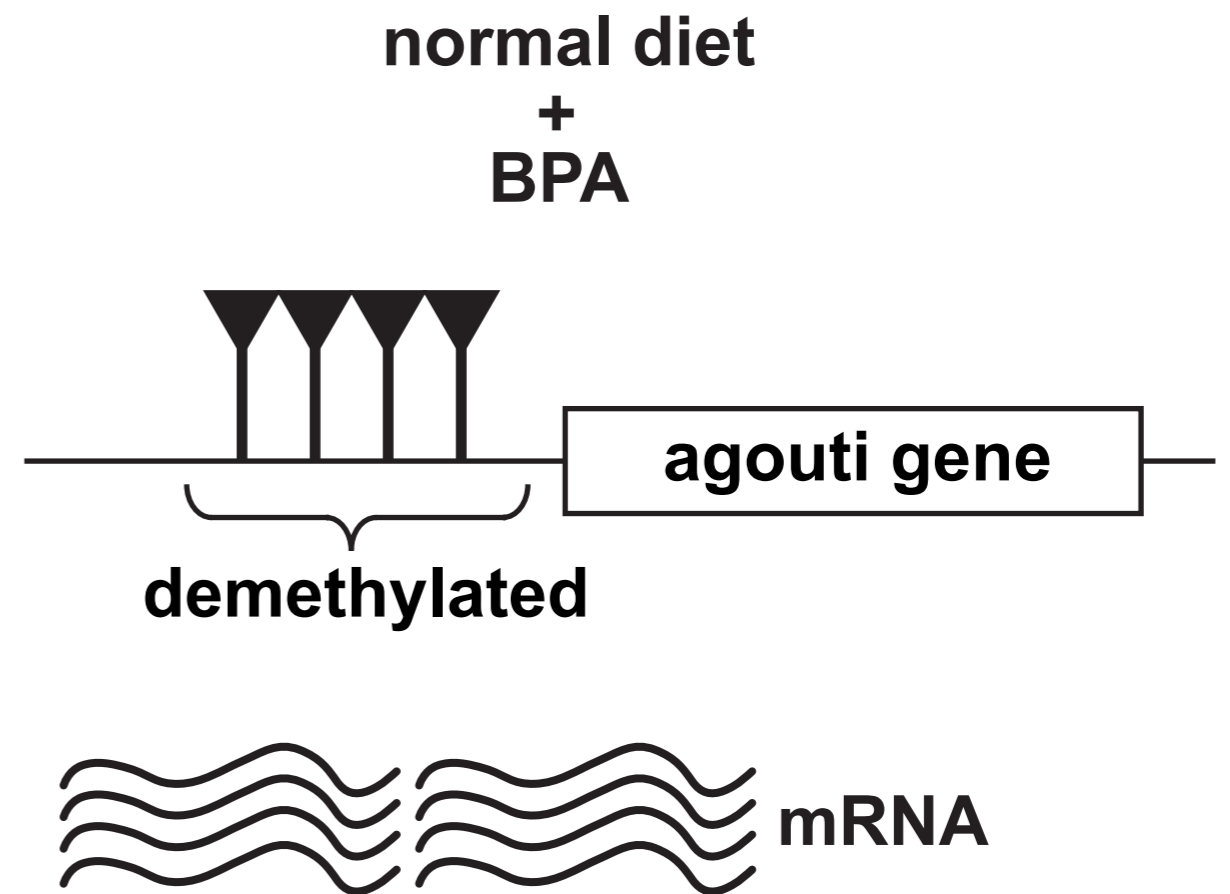


IMAGE 5.2



agouti mRNA briefly made during development.
agouti gene silenced for the remainder
of the mouse 's life.

healthy mouse with brown fur.



agouti gene is continually active, producing
mRNA across the mouse 's lifespan.

mouse with yellow fur;
develops obesity and diabetes during
adulthood.

IMAGE 5.3

Coat colour

Key:

b = brown

hb = heavily mottled

m = mottled

sm = slightly mottled

y = yellow

b

hm

m

sm

y



GRAPH 5.4

Key:

 normal diet + folic acid

 normal diet + BPA

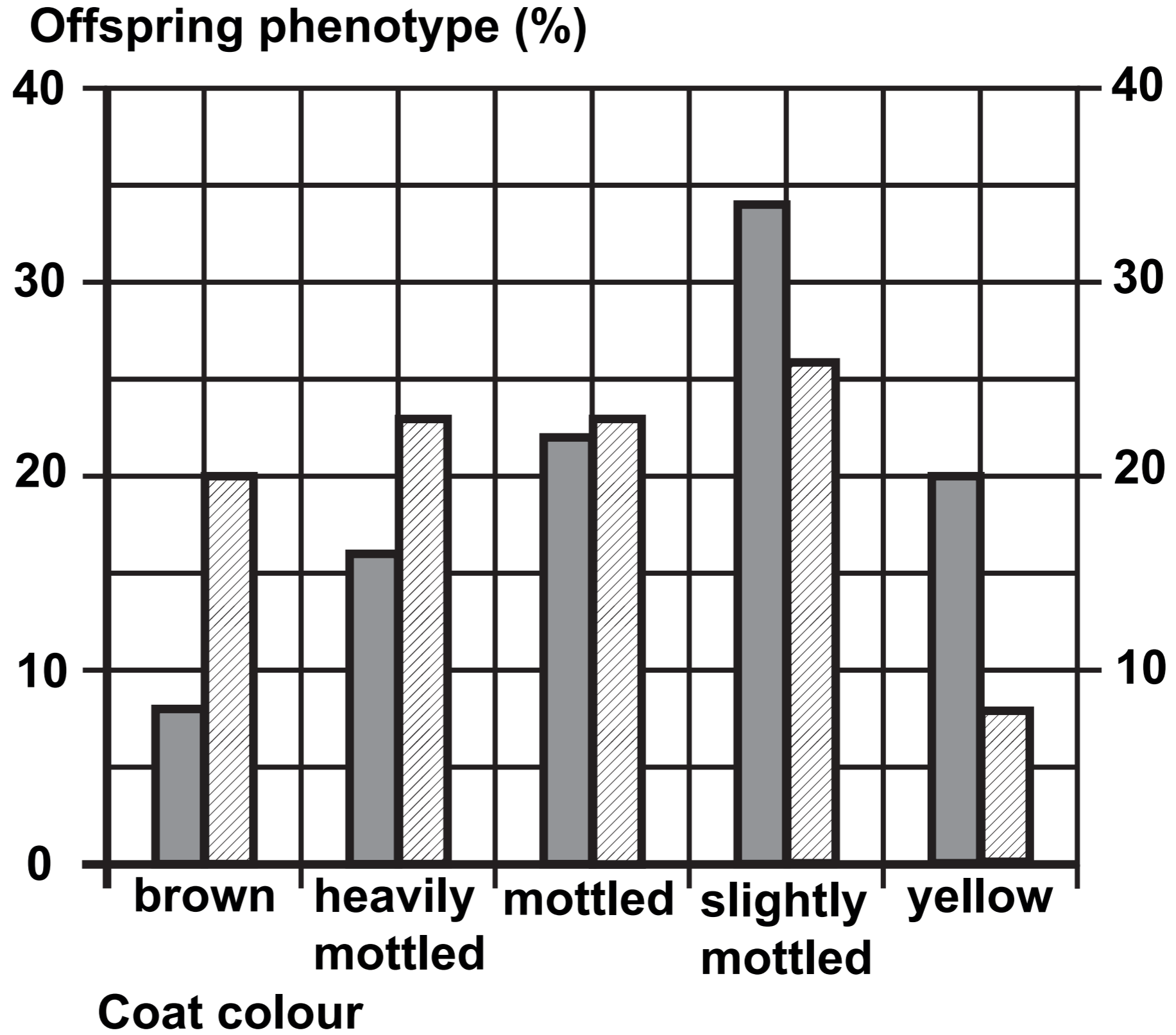
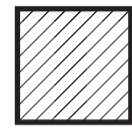


IMAGE 7.1

**Population density
(people per sq km)**



10 000 or over



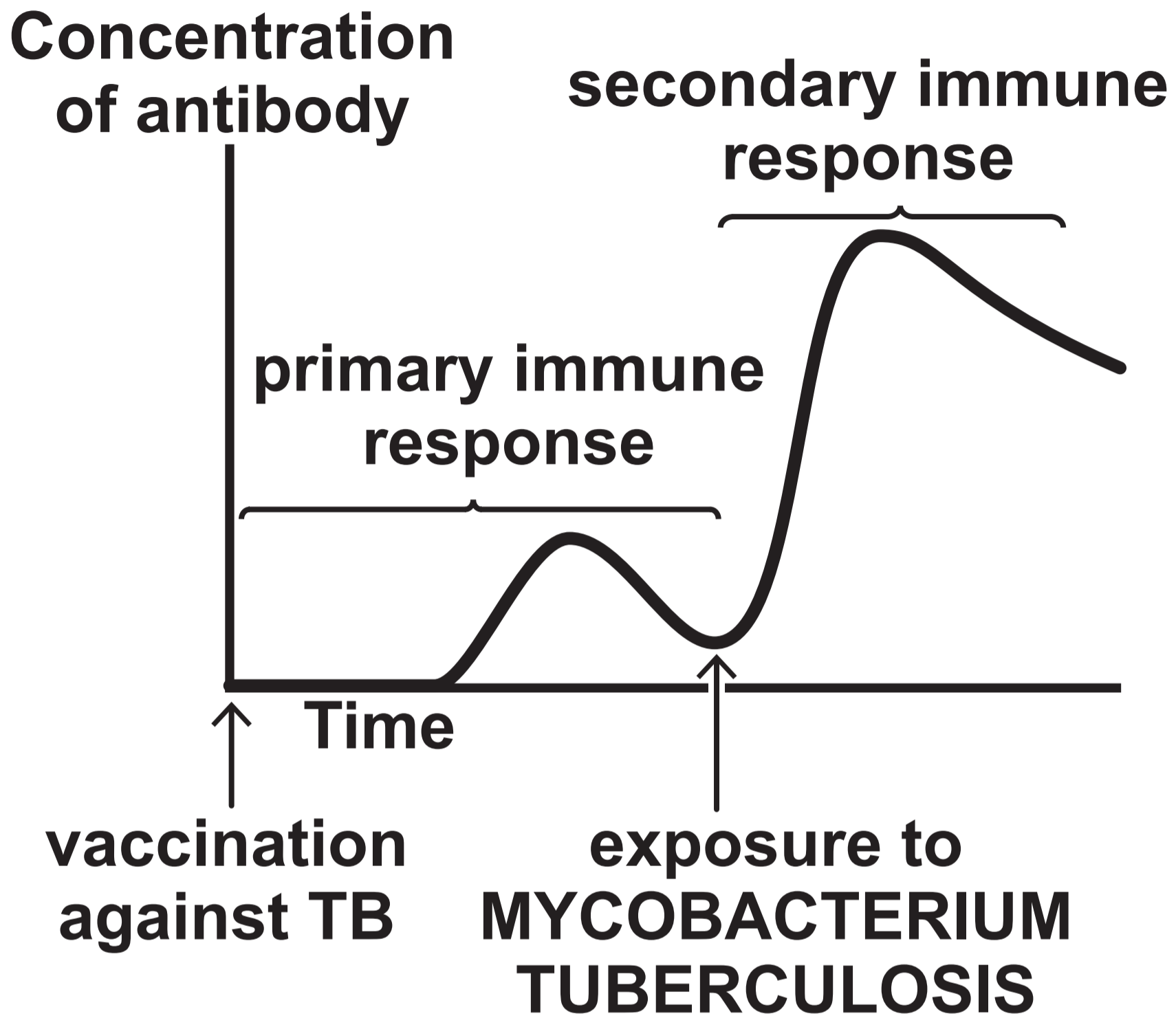
5 000 – 9 999



4 999 or under



GRAPH 7.2



GRAPH 7.3

Number of cases of TB per 100 000 people

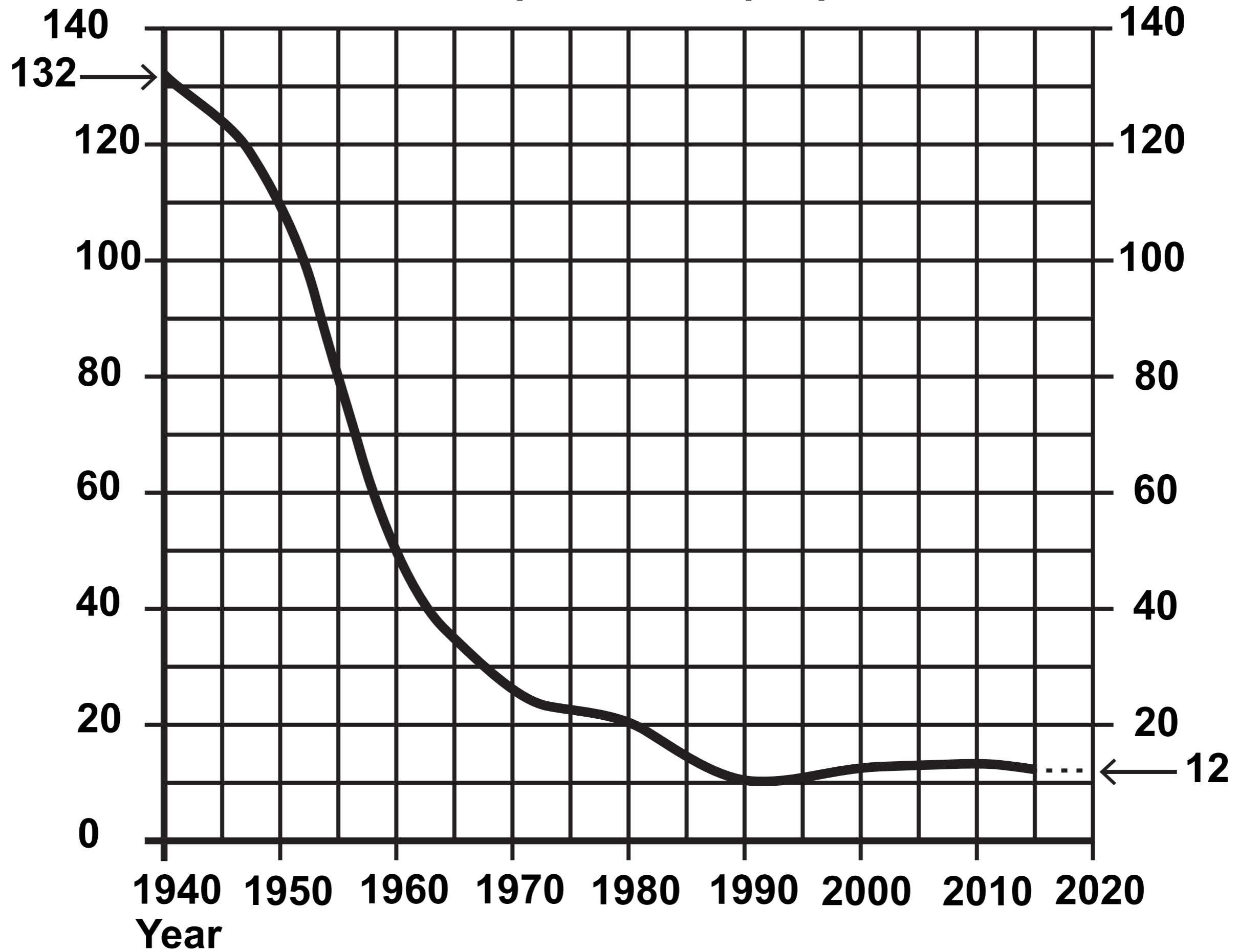


IMAGE 7.4

Mice with dormant M. TUBERCULOSIS



**TREATMENT 1
use of DRUG A
and antibiotics**

**TREATMENT 2
use of DRUG B
alone**



**three months after
treatment stopped**

no M. TUBERCULOSIS

**dormant M. TUBERCULOSIS
still present**

TABLE 7.5

Treatment	Advantage	Disadvantage
DRUG A and antibiotics	<hr/> <hr/> <hr/>	<hr/> <hr/> <hr/>
DRUG B alone	<hr/> <hr/> <hr/>	<hr/> <hr/> <hr/>

IMAGE 8.1

Transverse sections across sarcomere

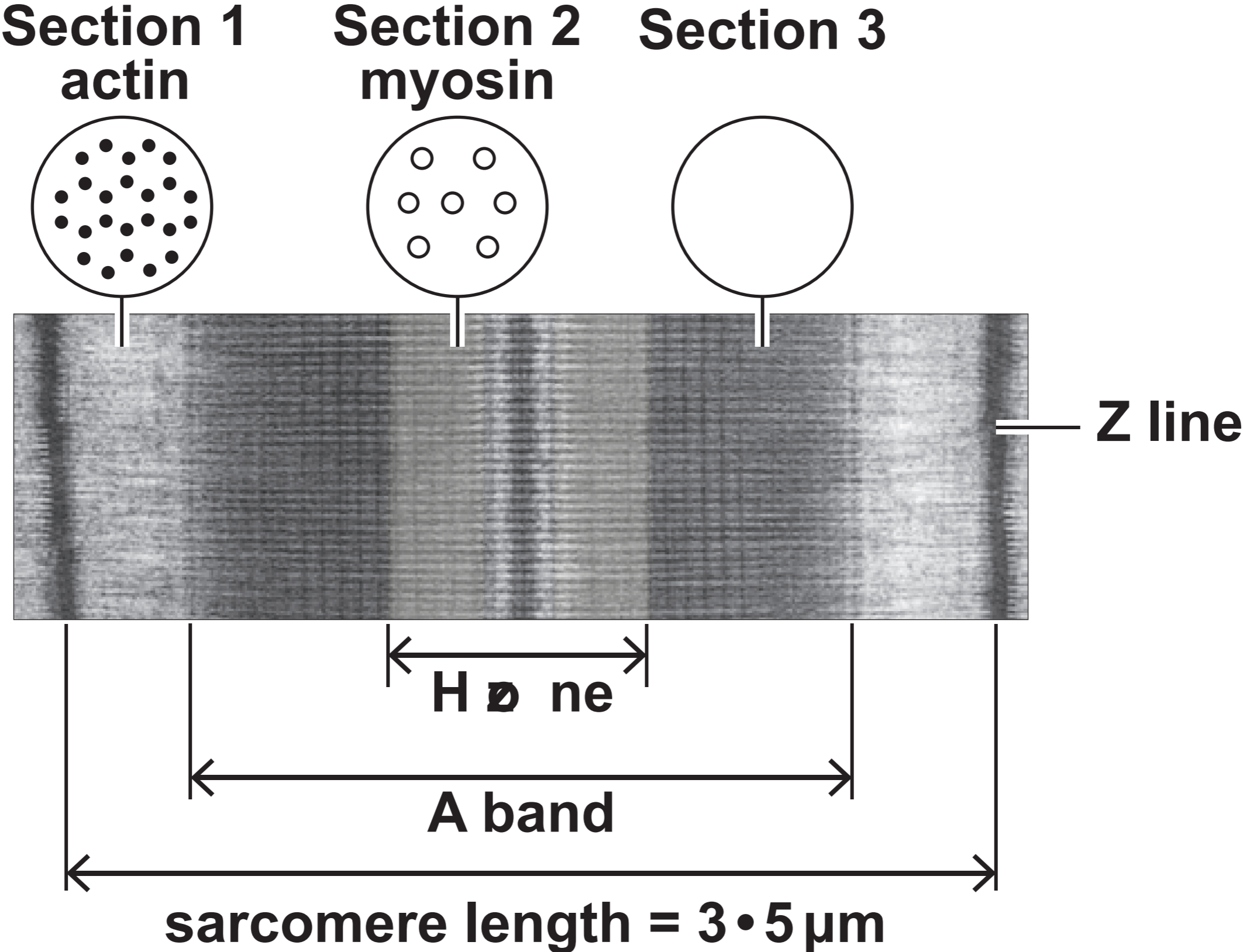


IMAGE 8.2

normal knee joint

**knee joint with
rheumatoid arthritis**

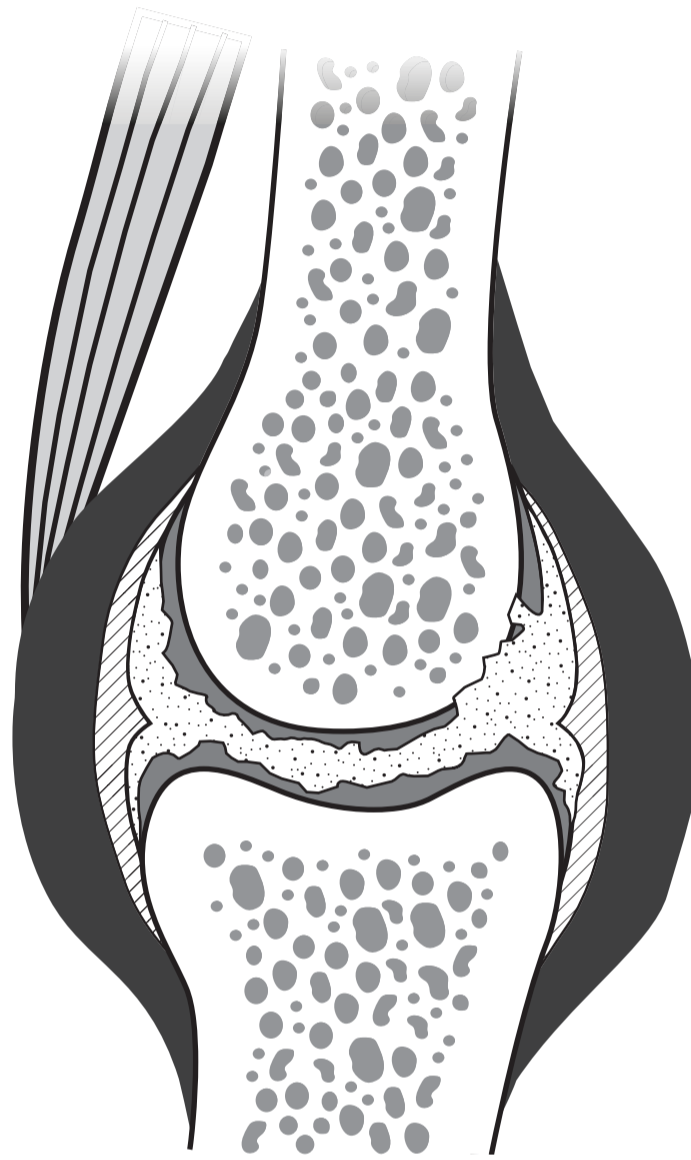
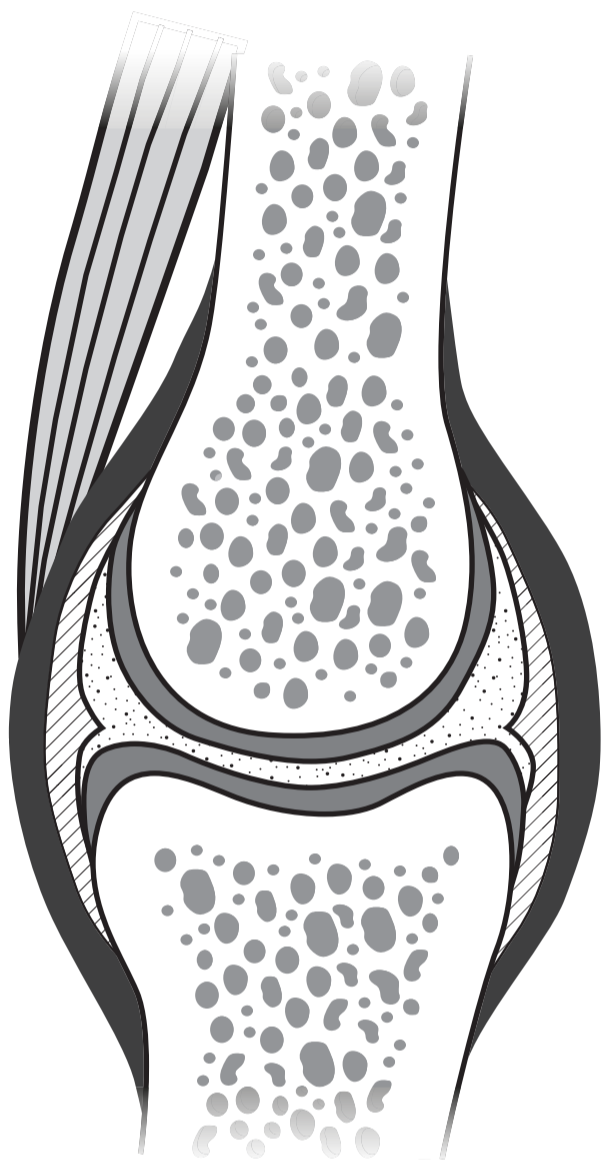
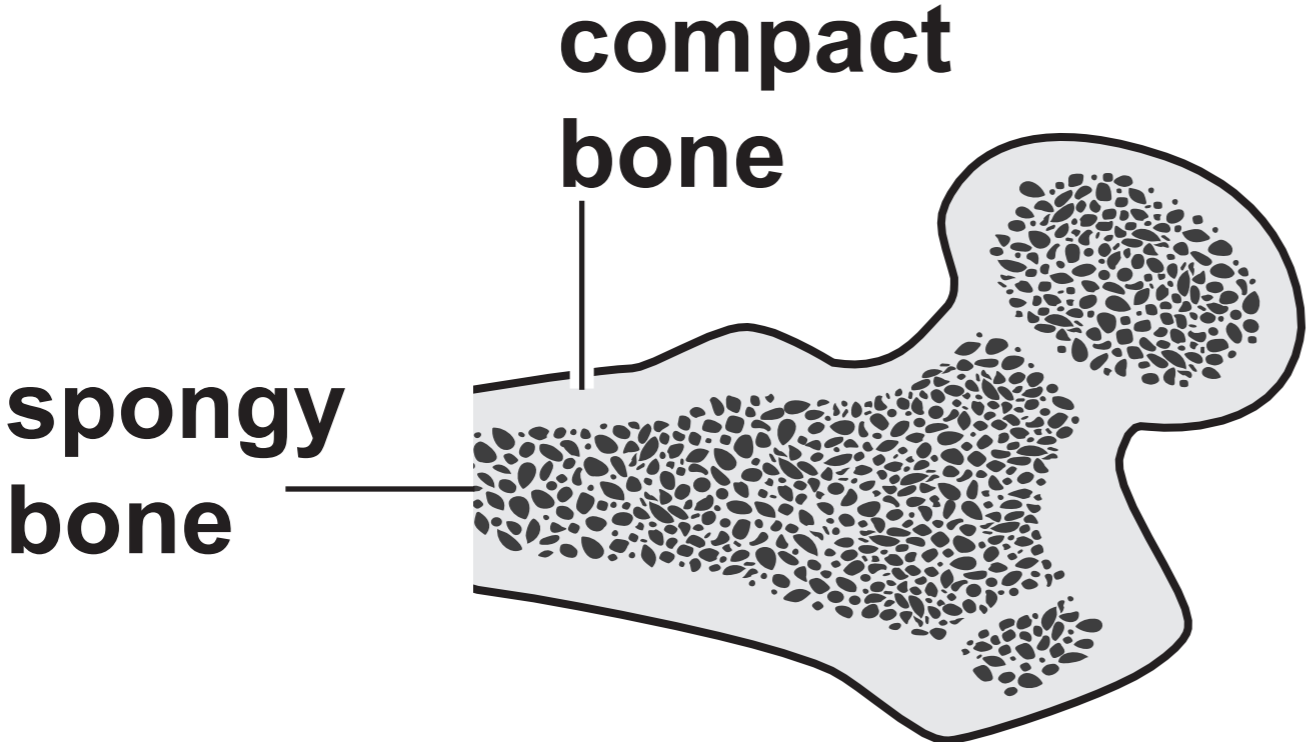


IMAGE 8.3

NORMAL BONE



BONE WITH OSTEOPOROSIS

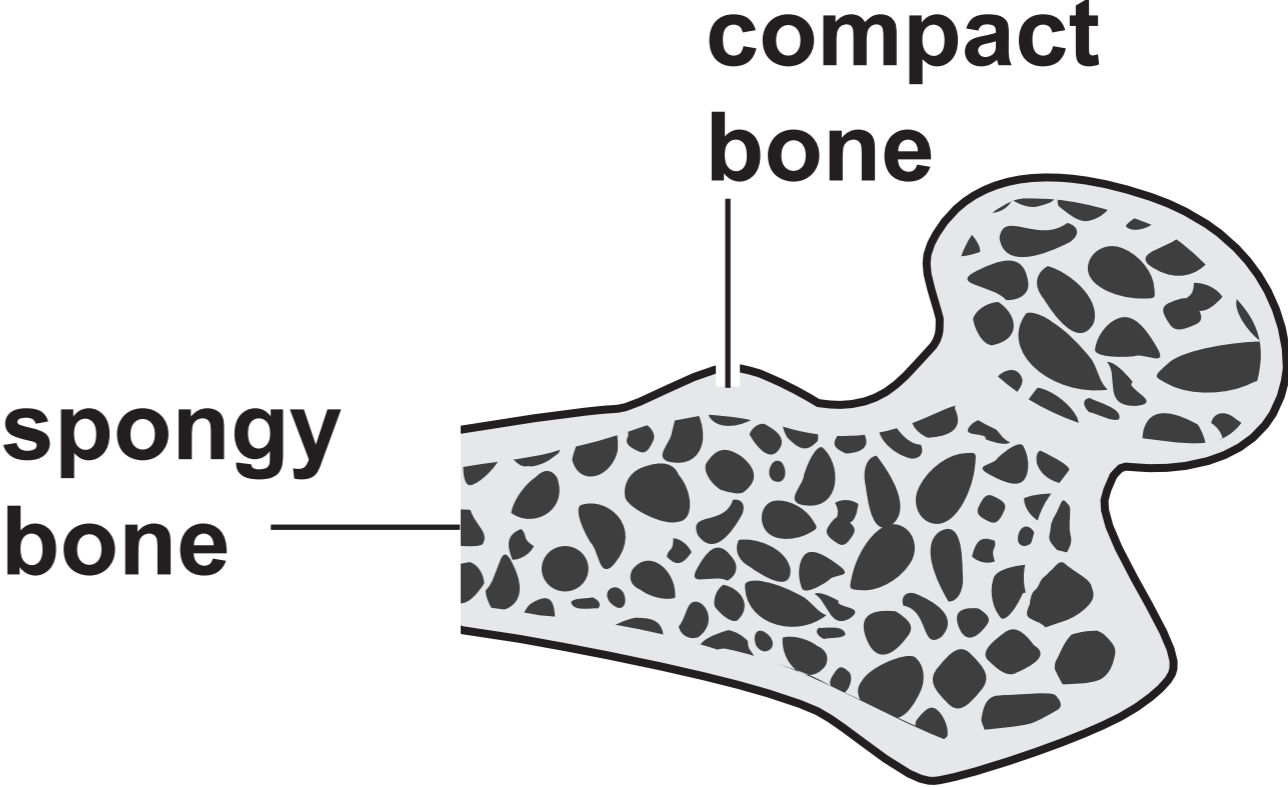


TABLE 8.4

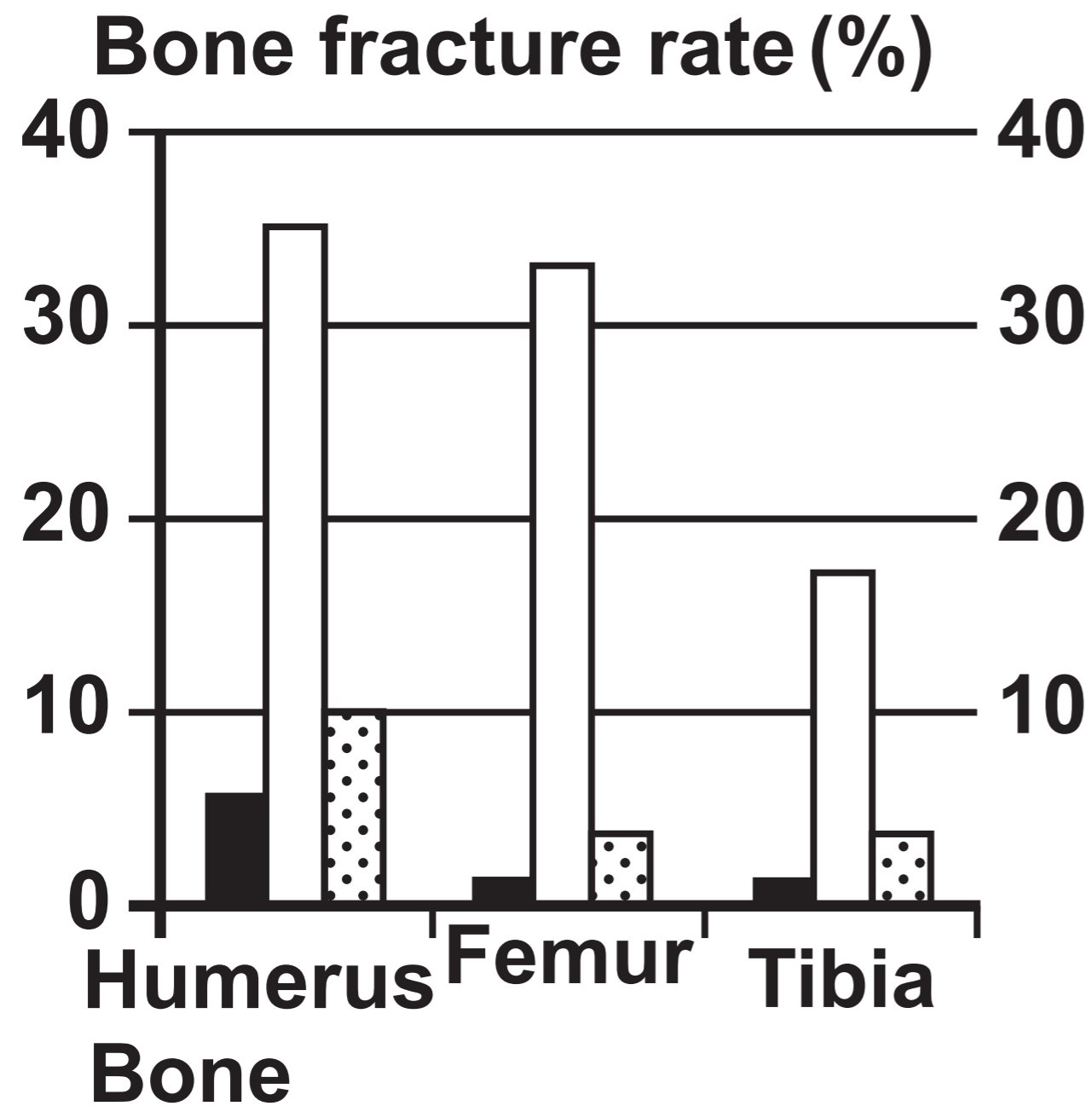
Group of mice	Osteogenesis imperfecta (OI) present	Received amniotic stem cells at birth
A – healthy mice	No	No
B – control group	Yes	No
C – experimental group	Yes	Yes

GRAPH 8.5 and GRAPH 8.6

Key:

- Group A
- Group B
- ▣ Group C

GRAPH 8.5



GRAPH 8.6

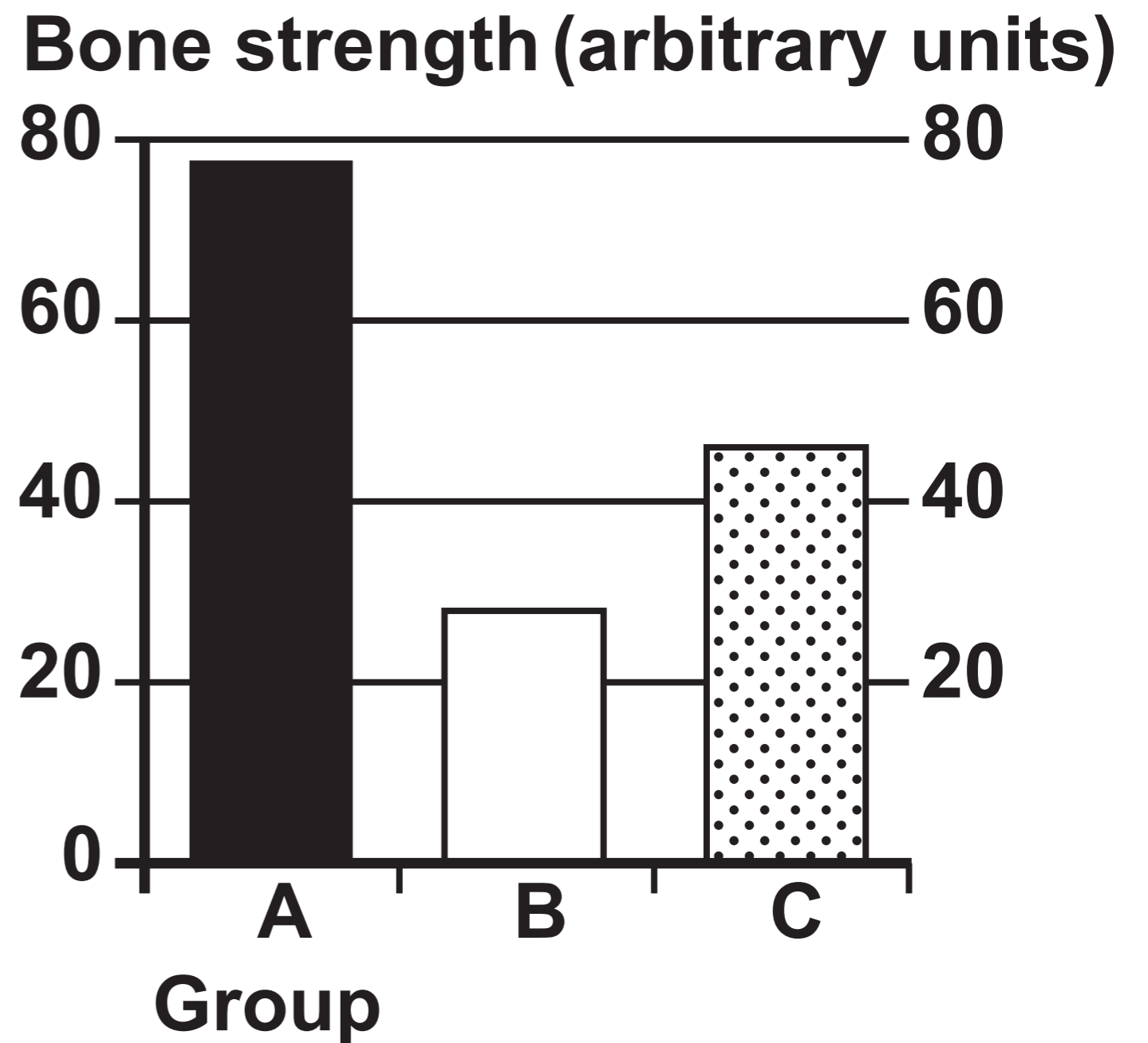


IMAGE 9.1



GRAPH 9.2

Key:

- - - - colony A - rural

———— colony B - urban

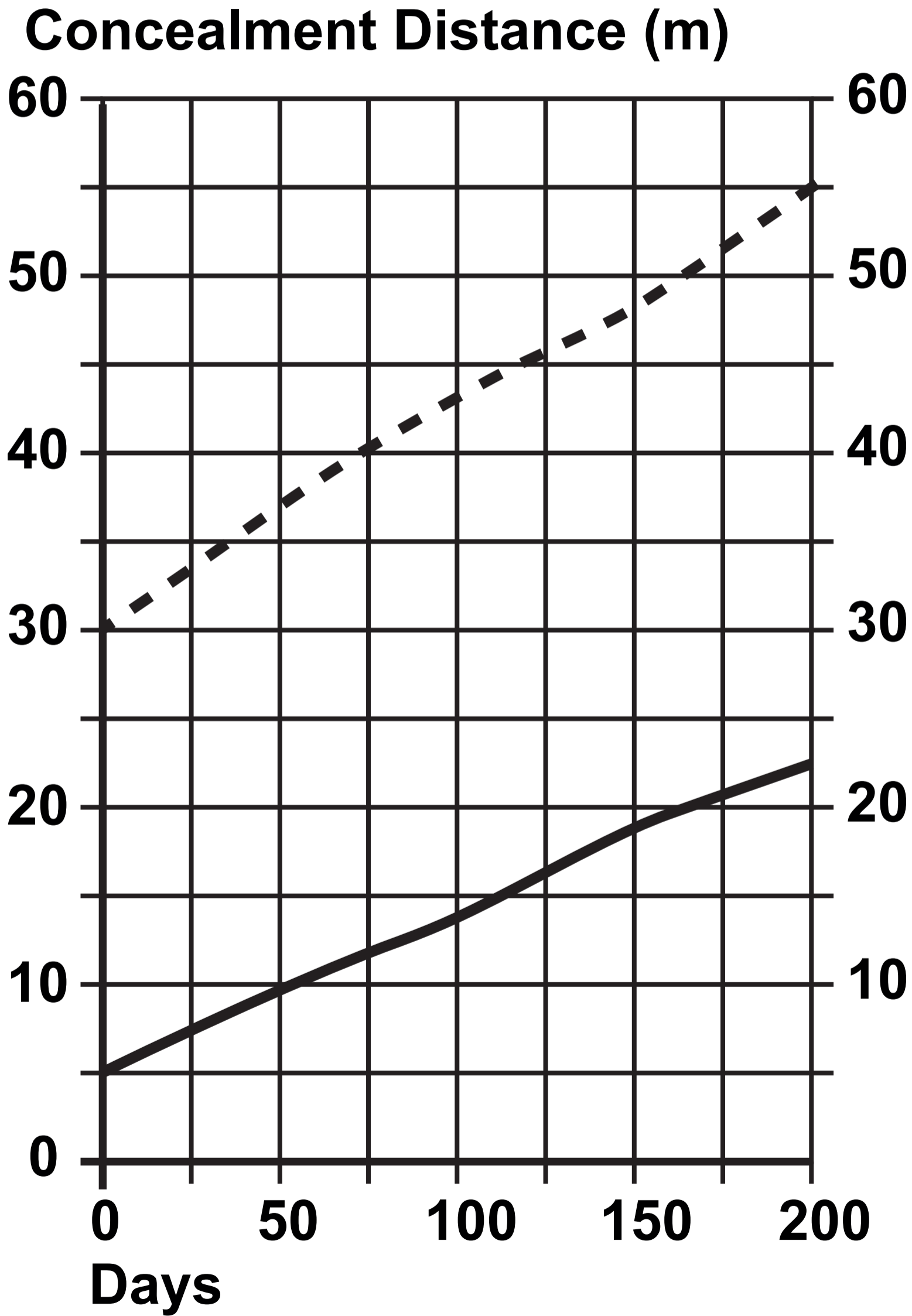


IMAGE 9.3 and IMAGE 9.4

IMAGE 9.3

fMRI taken from a healthy adult patient

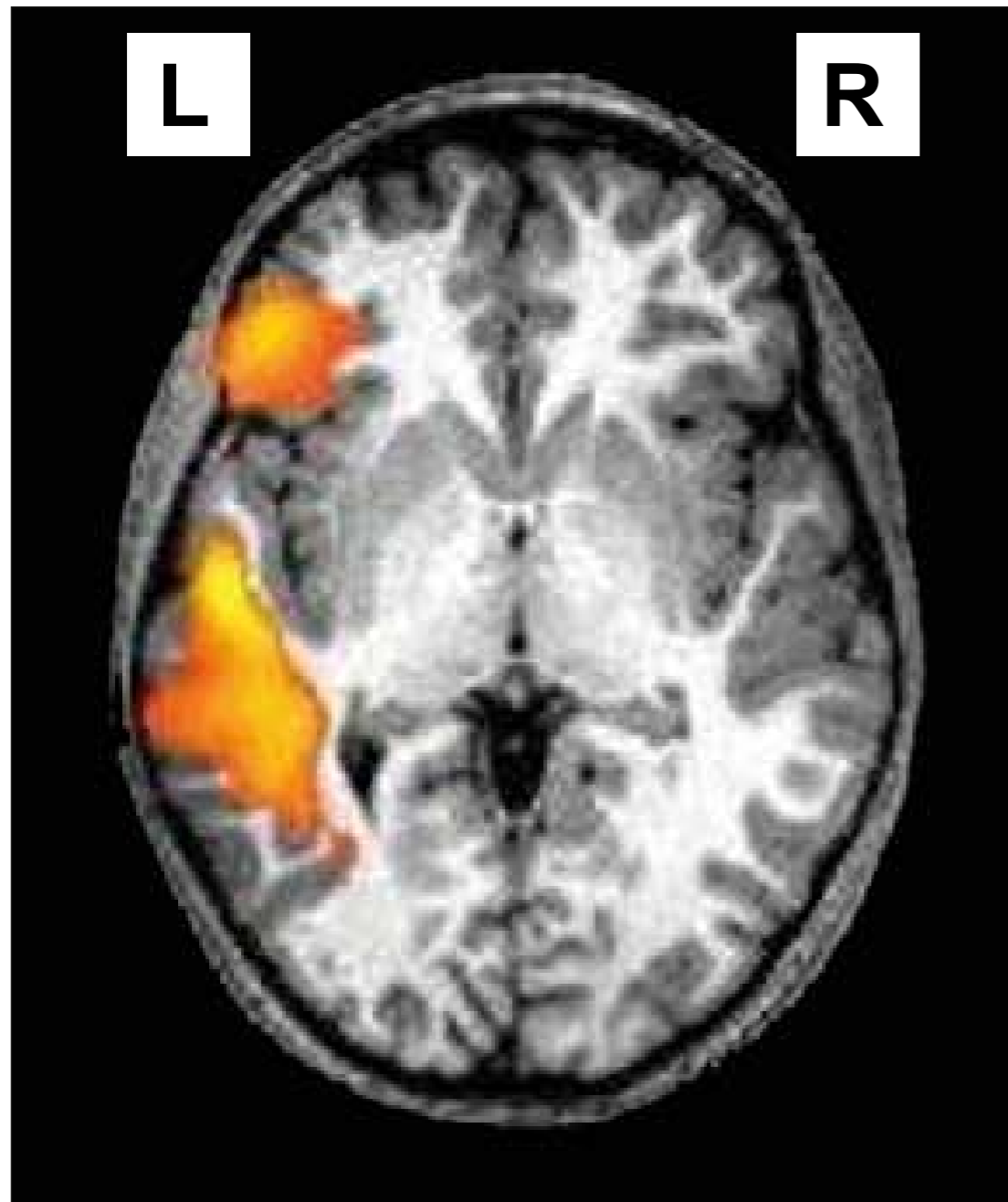


IMAGE 9.4

fMRI taken from an adult patient who had a stroke shortly after birth

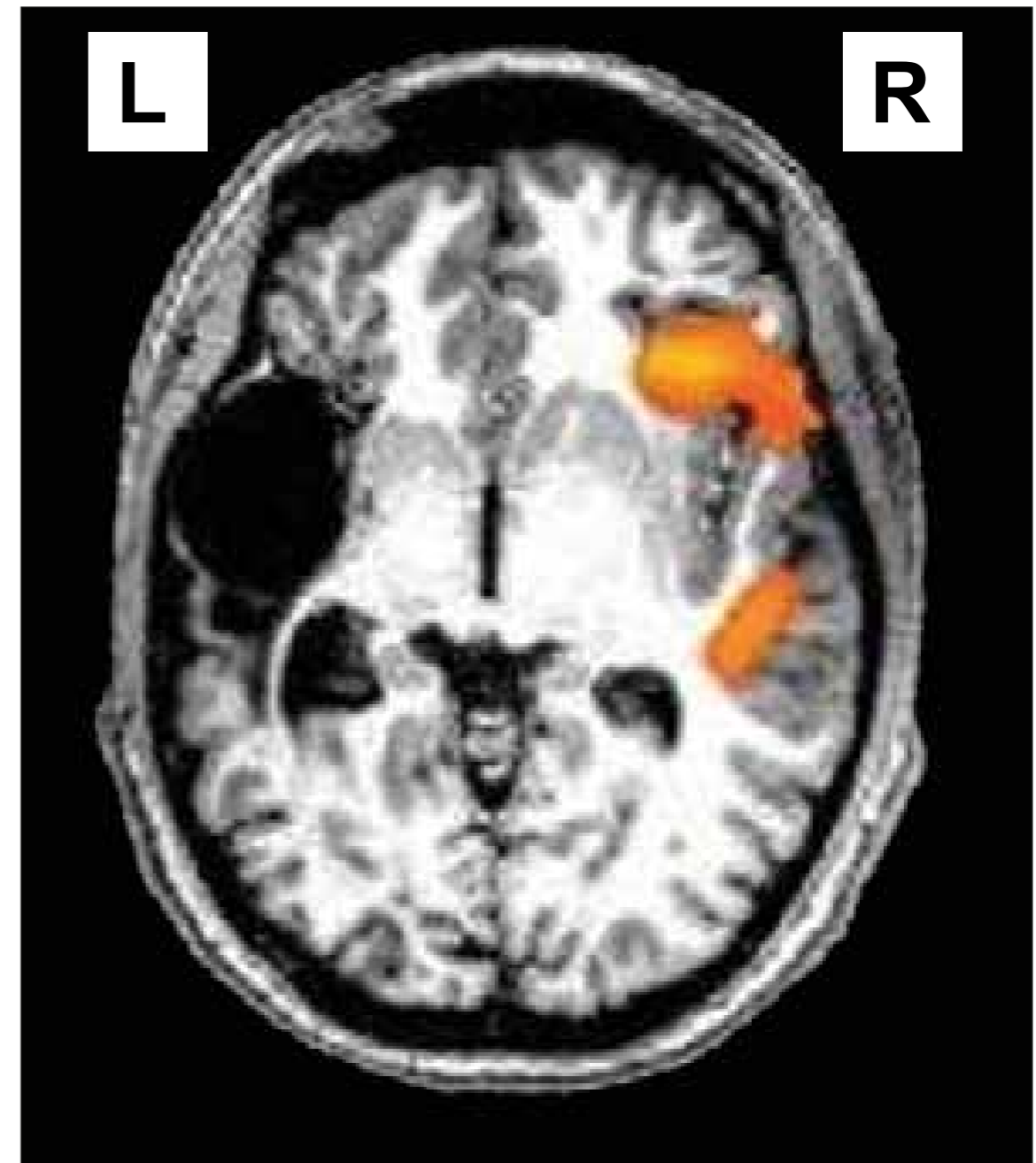


IMAGE 9.5

