

1

In the 18th century a binomial system of grouping similar organisms was developed.

Before the binomial system was developed the common briar rose had the following names:

- *Rosa sylvestris inodora seu canina*
- *Rosa sylvestris alba cum rubore folio glabro.*

In the binomial system, the same rose is called *Rosa canina*.

- (a) One advantage of the binomial system is that the name is shorter than the names used before this system.

Suggest **two other** advantages of the binomial system.

1. \_\_\_\_\_  
\_\_\_\_\_

2. \_\_\_\_\_  
\_\_\_\_\_

(2)

- (b) Classification systems have changed in the last 50 years.

Give **one** reason why we now have more information to classify organisms.

\_\_\_\_\_  
\_\_\_\_\_

(1)

- (c) 'Archaea' is one of the groups in the three-domain system of classification.

Give **two** features of the domain Archaea.

1. \_\_\_\_\_  
\_\_\_\_\_

2. \_\_\_\_\_  
\_\_\_\_\_

(2)

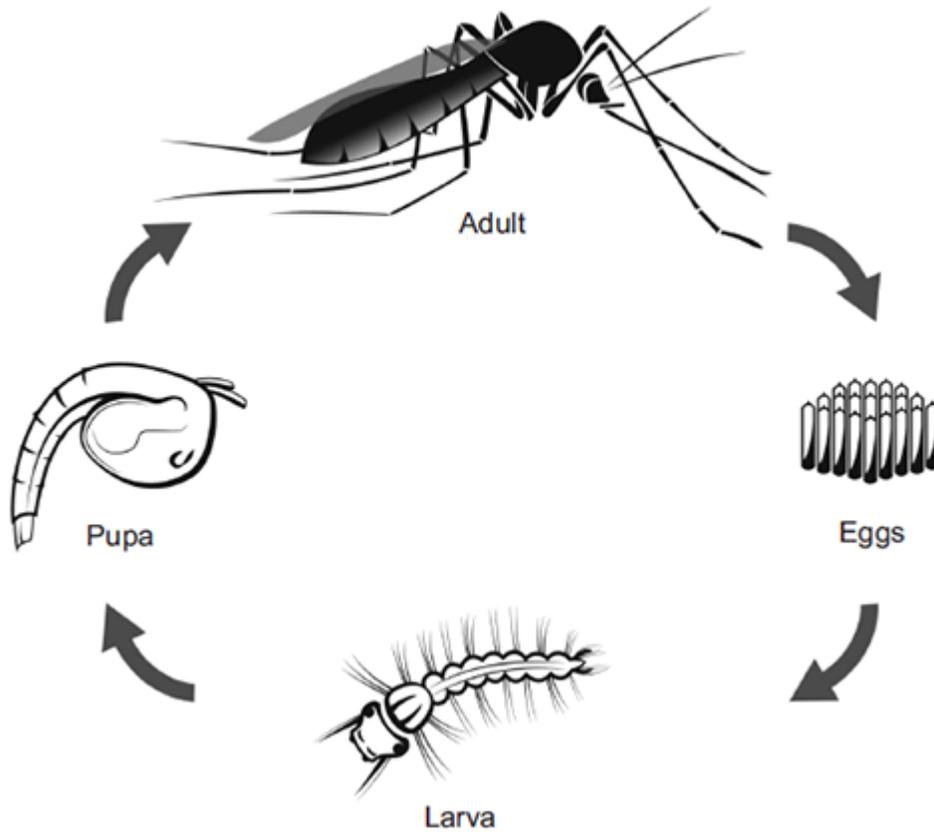
(Total 5 marks)

2

Malaria is a disease caused by a microorganism carried by mosquitoes.

The microorganism is transferred to humans when adult female mosquitoes feed on human blood.

The figure below shows the life cycle of a mosquito.



© watcharapon/iStock

The World Health Organisation estimates that  $3 \times 10^8$  people are infected with malaria every year.

Scientists estimate that malaria kills  $2 \times 10^6$  people every year.

The people who are infected with malaria but do not die, may be seriously ill and need health care for the rest of their lives.

(a) Based on the estimated figures, what percentage of people infected with malaria die from the disease?

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(2)

- (b) An internet article states:
- 1 Mosquito larvae are at the start of the food chain for some fish.
  - 2 Adult mosquitoes provide food for bats and birds.
  - 3 Mosquitoes are also important in plant reproduction because they feed from flowers of crop plants.

(i) The first sentence in the article is **not** correct.

Explain why.

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(2)

(ii) A company plans to produce genetically modified (GM) adult male mosquitoes. The GM mosquitoes will carry a gene from bacteria. The gene causes the death of offspring before they become adults.

Male mosquitoes do **not** feed on blood.  
Scientists are considering releasing millions of adult male GM mosquitoes into the wild.

Do you think scientists should release millions of male GM mosquitoes into the wild?

In your answer you should give advantages and disadvantages of releasing GM mosquitoes into the wild.

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(4)

(iii) Describe the process for creating a GM mosquito.

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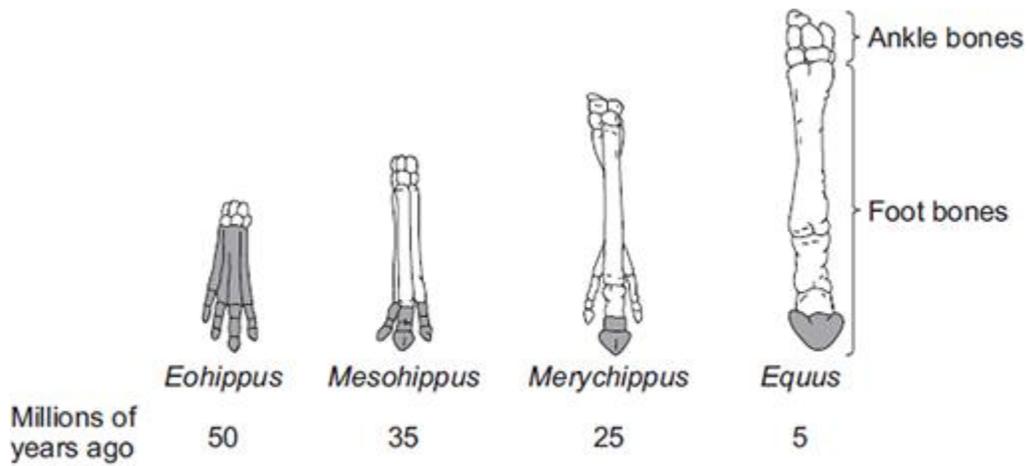
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(3)

(Total 11 marks)

3

The diagram below shows changes in the foot bones of four ancestors of modern horses over the past 50 million years.



**Key:** The shaded bones are the bones which touched the ground.

(a) Describe **two** changes to the bones in the feet of horses that have taken place over the past 50 million years.

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(2)

(b) *Eohippus* lived in swampy areas with soft mud.

Since this time the ground in the habitat has become drier and harder.

All of the horse ancestors were preyed upon by other animals.

(i) Explain **one** advantage to *Eohippus* of the arrangement of bones in its feet.

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(2)

(ii) The changes in the arrangement of the foot bones of horses support Darwin's theory of evolution by natural selection.

Explain how the arrangement of the foot bones of *Eohippus* could have evolved into the arrangement of the foot bones of *Equus*.

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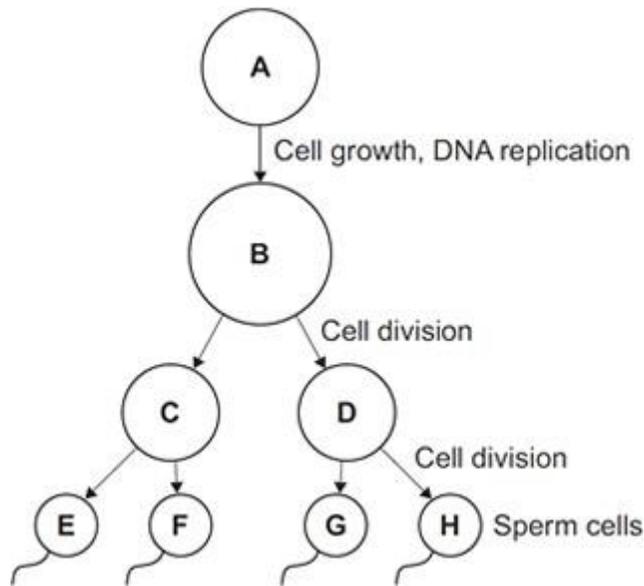
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(4)

(Total 8 marks)

4

The diagram below shows the production of human sperm cells.



(a) Name the organ where the processes shown in the diagram above take place.

\_\_\_\_\_

(1)

(b) (i) Not every cell in the diagram above contains the same amount of DNA.

Cell A contains 6.6 picograms of DNA (1 picogram =  $10^{-12}$  grams).

How much DNA is there in each of the following cells?

Cell B \_\_\_\_\_picograms

Cell C \_\_\_\_\_picograms

Cell E \_\_\_\_\_picograms

(2)

(ii) How much DNA would there be in a fertilised egg cell?

\_\_\_\_\_picograms

(1)

(iii) A fertilised egg cell divides many times to form an embryo.

Name this type of cell division.

\_\_\_\_\_

(1)

(c) After a baby is born, stem cells may be collected from the umbilical cord. These can be frozen and stored for possible use in the future.

(i) What are stem cells?

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(2)

(ii) Suggest why it is ethically more acceptable to take stem cells from an umbilical cord instead of using stem cells from a 4-day-old embryo produced by In Vitro Fertilisation (IVF).

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(1)

(iii) Stem cells taken from a child's umbilical cord could be used to treat a condition later in that child's life.

Give **one** advantage of using the child's own umbilical cord stem cells instead of using stem cells donated from another person.

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(1)

(iv) Why would it **not** be possible to treat a genetic disorder in a child using his own umbilical cord stem cells?

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(1)

(Total 10 marks)

5

Humans can use different methods to produce animals and plants with desired characteristics.

The figure below shows some different breeds of horse.



© GlobalP/iStock/Thinkstock

(a) All breeds of horse are of the same species.

Suggest what you could do to show this.

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(2)

(b) Horse racing is an ancient sport.

Selective breeding has been used for centuries to produce racehorses.

Describe the steps involved in selective breeding to produce a racehorse.

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(3)

(c) Another way of producing organisms with desired characteristics is genetic engineering.

Bt cotton is a variety of cotton that has been genetically engineered to produce a poison.

The poison kills several different species of insect that feed on cotton plants.

The poison is naturally produced by a soil bacterium called *Bacillus thuringiensis*.

Describe how cotton plants can be genetically engineered to produce the Bt poison.

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(3)

(d) Describe the advantages and disadvantages of growing Bt cotton.

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(4)

(Total 12 marks)

6

Huntington's disease is an inherited disorder that affects the nervous system.

It is caused by a dominant allele.

A man is heterozygous for Huntington's disease.

His partner is healthy and does not have the allele that causes Huntington's disease.

(a) What are the genotypes of the man and the woman?

Use:

- **H** for the allele that causes Huntington's disease
- **h** for the healthy allele.

Man's genotype \_\_\_\_\_

Woman's genotype \_\_\_\_\_

(1)

(b) The couple want to have a child.

Use a Punnett square to determine the probability of the child having Huntington's disease.

Circle the genotypes of any children that will have Huntington's disease.

Probability of child having Huntington's disease = \_\_\_\_\_

(4)

(c) The couple visit a genetic counsellor, who gives them the following options.

1. Adopt a child.
2. Gamete donation – uses sperm from another man to fertilise the woman's eggs by in vitro fertilisation (IVF).
3. Conceive naturally.
4. Use pre-implantation genetic diagnosis (PGD).
  - Many embryos are produced by IVF using gametes from the man and woman.
  - Embryos are tested for Huntington's disease and a healthy embryo is implanted into the woman's uterus.
  - The risk of implanting an embryo with the allele for Huntington's disease is 0.2%.
  - Costs the NHS about £11 000.
5. Conceive naturally and use prenatal diagnosis (PND) once the woman becomes pregnant.
  - A sample of the placenta is taken at 10 weeks of pregnancy or a sample of fluid is taken from around the developing baby at 16 weeks of pregnancy.
  - The sample is tested for the Huntington's allele.
  - A 0.5–1.0% risk of miscarriage.
  - About 1% of samples collected are unsuitable for testing.
  - Costs the NHS about £600.

The couple decide they want to have a healthy baby that is their own biological offspring.

Evaluate the options.

Suggest which option would be best for the couple.

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**(6)**  
**(Total 11 marks)**

## Mark schemes

- 1** (a) same name to everyone 1
- (genus) part gives information on ancestry 1
- (b) any **one** from:
- DNA / RNA analysis
  - improvements to (electron) microscopes
  - improved understanding of biochemical processes
  - evidence of internal structures being more developed 1
- (c) primitive bacteria / prokaryotes 1
- (often) from extreme environments / extremophiles 1
- [5]**
- 2** (a) 0.67(%) 2
- allow 0.6 or 0.7*
- allow 1 mark for evidence of  $(2 \times 10^6) \div (3 \times 10^8)$*
- or**
- allow 1 mark for 0.0067 or 0.6*
- (b) (i) idea that food chains start with plants / producers 1
- allow food chains do not start with animals or larvae are consumers*
- idea that these make food (for other organisms in the chain)
- allow idea that plants / producers photosynthesise or plants / producers get energy from the sun*
- allow mosquito larvae do not make food / photosynthesise or mosquito larvae do not get energy from the sun* 1

- (ii) any **four** from:
- reasoned argument for **or** against release  
*must refer to at least one advantage and one disadvantage.*  
*max 3 marks for either only advantages **or** only disadvantages*

advantages:

- fewer mosquitos biting **or** spreading malaria
- fewer people get / die from malaria  
*allow people won't get / die from malaria*
- lower medical costs (for those infected **or** for treatment) **or** less healthcare needed
- better economically for developing / tropical countries.

disadvantages:

- fewer crops reproduce  
*allow fewer crops pollinated*
- poorer crop yield
- possible starvation (of people)
- high cost of GM production / mosquito release
- less food for bats / birds **or** bats / birds die  
*allow disruption to food chain / ecosystem **or** reduction of biodiversity*
- gene could 'escape' into other wildlife / species  
*ignore into plants*

4

- (iii) any **three** from:

- gene from bacteria cut out  
*allow allele for gene*
- ref to enzymes (anywhere in process)  
*allow at any point in process, ie in cutting or in splicing*
- (gene) transferred to chromosome of mosquito  
*allow DNA for chromosome*
- at an early stage of development  
*allow egg / embryo*

3

[11]

- 3** (a) any **two** from:

- larger / longer / thicker  
*allow examples eg fewer toes **or** bones fused*
- fewer (bones in total)  
*allow smaller surface area touching the ground*
- fewer bones touching the ground

2

- (b) (i) large(r) surface / area in contact with the ground  
**or**  
 low / less pressure on ground 1
- (so) less likely to sink into mud / ground  
**or**  
 (so) could run fast(er)  
*allow easy / easier to escape predators* 1
- (ii) variation (in size / number / arrangement of bones)  
*allow mutation(s) (in size / number / arrangement of bones)* 1
- (and) those with large(r) / few(er) bones more suited to running **or** run faster (on  
 harder / drier ground) 1
- these survive **and** breed  
*allow ref to offspring for breed* 1
- (so) genes / DNA (for larger / fewer bones) passed on  
*allow alleles passed on* 1

[8]

- 4** (a) testis / testes  
*allow testicle(s)* 1
- (b) (i) **B = 13.2**  
**C = 6.6**  
**E = 3.3**  
*all 3 correct = 2 marks*  
*2 or 1 correct = 1 mark*  
*If no marks awarded allow ecf for C **and** E based on answer to B*  
*ie C = ½ B and E = ½ C for one mark* 2
- (ii) 6.6  
*allow twice answer for cell E in part bi* 1
- (iii) mitosis  
*correct spelling only* 1

- (c) (i) any **two** from:
- cells that are able to divide
  - undifferentiated cells / not specialised
  - can become other types of cells / tissues **or** become specialised/differentiated
- allow pluripotent* 2
- (ii) 4-day embryo is a (potential) human life
- or**
- destroying/damaging (potential) human life
- allow cord would have been discarded anyway*
- ignore reference to miscarriage*
- allow cannot give consent* 1
- (iii) perfect tissue match **or** hard to find suitable donors
- allow same/matching antigens*
- allow no danger of rejection*
- allow no need to take immunosuppressant drugs (for life)*
- ignore genetically identical **or** same DNA* 1
- (iv) stem cells have same faulty gene / allele / DNA / chromosomes
- allow genetically identical*
- ignore cells have the same genetic disorder* 1

**[10]**

- 5** (a) cross / breed / mate different breeds of horse 1
- if the offspring are fertile then the two breeds are of the same species 1
- (b) select the fastest male and female to cross / mate 1
- allow any relevant characteristic, eg stamina*
- select the fastest offspring and breed them 1
- repeat over several generations to produce faster horses 1
- (c) gene for the Bt poison is cut from the bacterial DNA / plasmid / chromosome 1
- ignore characteristic*
- accept *Bacillus thuringiensis**
- using enzymes(s) 1

and transferred to cotton plant cells / DNA / chromosome  
do **not** allow to cotton plant plasmid

1

(d) any **four** from:

*must have both advantages and disadvantages for full marks*

advantages

- increased yield as less eaten by insects
  - fewer pesticides need to be used
  - (so) producer can make more money
- this point may only be gained if linked to one of the points above*

Disadvantages:

- gene (for poison) could be passed on to wild plants
- may kill useful insects  
*allow named insect eg bees*
- ecosystem / food chain could be affected
- gene pool of cotton plants could be reduced  
*allow less variation in cotton plant population*

max. 4

[12]

6

(a) Man's genotype **Hh**

*both needed for the mark*

Woman's genotype **hh**

1

(b) gametes correctly derived from parents genotypes in 05.1

1

offspring genotypes correctly derived from gametes

1

all Hh circled

<b>Man's gametes</b>		<b>Woman's gametes</b>	
		h	h
	H	Hh	Hh
	h	hh	hh

1

(Probability =) any **one** from:

- 50%
- $\frac{1}{2}$
- 2 / 4
- 0.5
- 1 in 2
- 2 in 4
- 1:1
- 2:2

1

**(c) Level 3 (5–6 marks):**

A detailed and coherent evaluation is provided which considers a range of relevant points and comes to a conclusion consistent with the reasoning.

**Level 2 (3–4 marks):**

An attempt is made to relate relevant points and come to a conclusion. The logic may be inconsistent at times but builds towards a coherent argument.

**Level 1 (1–2 marks):**

Discrete relevant points made. The logic may be unclear and the conclusion, if present, may not be consistent with the reasoning.

**0 marks:**

No relevant content

**Indicative content**

- adoption / gamete donation unsuitable as offspring not biologically theirs
- natural conception too risky / only 50% chance of healthy offspring
- natural conception would cause worry whether baby would be healthy or not
- (therefore) choice is between PGD and PND

**pros of PGD**

- baby would be theirs
- results obtained at an early stage
- high chance baby produced would be healthy
- parents would have confidence of having a healthy baby from start of pregnancy
- lower risk of miscarriage compared to PND
- frozen embryos can be used to have another healthy child
- PGD occurs before pregnancy / implantation
- PGD does not involve abortion so less trauma / less pain / ethical comparison
- spare healthy embryos may be used for research / medical treatment

**cons of PGD**

- slight / 0.2% chance of misdiagnosed embryo
- expensive procedure
- cost to NHS of non-essential procedure
- (unhealthy) embryos might be destroyed
- large number of embryos produced so healthy embryos may be destroyed
- ethical issues of using embryos for research
- some people are opposed to IVF due to their religious beliefs

**pros of PND**

- natural conception less invasive for mother
- psychological benefit of producing child naturally
- 99% / high chance that result of test will be conclusive

**cons of PND**

- sampling technique invasive to mother
- risk of miscarriage
- risk of infection
- long wait before test can be carried out
- 50% chance baby will have allele for Huntington's disease
- parents will have a difficult decision to make if baby is unheathly
- baby may be aborted
- ethical / religious issues of abortion
- a justified conclusion

6

[11]