Materials
For this paper you must have:
- Ruler
- Pencil, Rubber, Protractor and Compass
- Scientific calculator, which you are expected to use when appropriate

Instructions
- Answer all questions
- Answer questions in the space provided
- All working must be shown
- Do all rough work in this book. Cross out any rough work you don't want to be marked

Information
- The marks for the questions are shown in brackets

www.examqa.com
Sexual reproduction in humans involves the joining together of an egg cell and a sperm cell.

The sex of an embryo is decided by the chromosomes they inherit from their mother and father.

(a) Where in the cell are the chromosomes?

Tick one box.

Cell membrane

Cytoplasm

Nucleus

Ribosomes

(b) Draw one line from each type of cell to the number of chromosomes in the cell.

<table>
<thead>
<tr>
<th>Type of cell</th>
<th>Number of chromosomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sperm cell</td>
<td>26</td>
</tr>
<tr>
<td>Embryo cell</td>
<td>52</td>
</tr>
</tbody>
</table>
(c) A man and a woman decide to have a child.

Complete the genetic diagram in the figure below.

<table>
<thead>
<tr>
<th>Parent</th>
<th>X</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>X</td>
<td>XX</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td></td>
</tr>
</tbody>
</table>

(d) On the figure above, circle a male child.

(e) What is the chance of the man and woman having a boy?

Tick one box.

1 in 2

1 in 3

1 in 4

1 in 8

(Total 7 marks)
A person’s characteristics can be due to:

- environmental causes
- genetic causes
- both environmental and genetic causes.

(a) Complete Table 1.

Put a tick to show what each characteristic is due to.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Environmental causes</th>
<th>Genetic causes</th>
<th>Both environmental and genetic causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eye colour</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A scar</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(b) Draw one line from each key term to the correct definition.

<table>
<thead>
<tr>
<th>Key term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genotype</td>
<td>The genus of an organism</td>
</tr>
<tr>
<td>Phenotype</td>
<td>The mutation of genes</td>
</tr>
<tr>
<td></td>
<td>The physical characteristic of an organism</td>
</tr>
</tbody>
</table>
(c) Farmers use selective breeding to control the characteristics in cows.

**Table 2** shows the stages of selective breeding in cows.

Complete **Table 2** to show the correct order of the stages.

The first stage has been numbered for you.

**Table 2**

<table>
<thead>
<tr>
<th>Stage in selective breeding</th>
<th>Order of stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cows are bred over many generations</td>
<td></td>
</tr>
<tr>
<td>Parents are bred together</td>
<td></td>
</tr>
<tr>
<td>Cows with the desired characteristics are chosen</td>
<td>1</td>
</tr>
<tr>
<td>Calves with the most desired characteristics are bred together</td>
<td></td>
</tr>
</tbody>
</table>

(d) Farmers selectively breed cows for many different reasons.

Suggest **two** characteristics that cows may be bred for.

Do **not** suggest coat colour.

1. ___________________________________________________________________
   ___________________________________________________________________

2. ___________________________________________________________________
   ___________________________________________________________________

(e) Selective breeding can lead to problems.

Suggest how problems caused by selective breeding in cows can have negative financial effects for the farmer.

_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________

(Total 11 marks)
In humans, hair colour is an inherited characteristic.
Red hair is caused by a recessive allele.

(a) When does a recessive allele control the development of a characteristic?

Tick (✔) one box.

- When the allele is present on only one of the chromosomes.
- When the dominant allele is not present.
- When the allele is inherited from the female parent.

(b) Figure 1 shows the inheritance of hair colour in one family.

(i) Brown hair is caused by a dominant allele, B.
Red hair is caused by the recessive allele, b.
What combination of alleles does person 1 have?

Tick (✔) one box.

- BB
- Bb
- bb
(ii) Person 3 married a woman with brown hair.

Figure 2 shows how hair colour could be inherited by their children.

![Figure 2]

Complete Figure 2 to show the combination of alleles that the children would inherit. One has been done for you.

(2)

(iii) What is the probability that one of the children would have red hair?

Tick (✔) one box.

- 1 in 2
- 1 in 3
- 1 in 4

(1)

(Total 5 marks)
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 glabo*.

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. _________________________________________________________________
   ___________________________________________________________________

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

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

___________________________________________________________________
___________________________________________________________________

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

Give two features of the domain Archaea.

1. _________________________________________________________________
   ___________________________________________________________________

2. _________________________________________________________________
   ___________________________________________________________________

(Total 5 marks)
(a) Which of the following is the **best** definition of a species?

Tick (✓) one box.

- Organisms with many features in common
- Organisms that live in the same habitat and eat the same food
- Organisms that reproduce together to form fertile offspring

(b) **Figure 1** is a photograph of the Grand Canyon.

The layers of rock contain fossils.

> Figure 1

© Sumikophoto/iStock/Thinkstock

Scientists found five fossils of different species of animal, P, Q, R, S and T, at the positions shown in **Figure 1**.

(i) What is the evidence in **Figure 1** that animals P and Q were alive at the same time?

__________________________________________________________________________
__________________________________________________________________________

(1)
(ii) Was animal **R** alive at an earlier time or at a later time than animals **P** and **Q**?

Give the reason for your answer.

________________________________________________________________________

________________________________________________________________________

(iii) Which **two** of the following would be evidence that animal **T** may have evolved from animal **S**?

Tick (✓) **two** boxes.

- The fossils of animals **S** and **T** have many features in common, but **T** is more complex than **S**. [ ]

- The fossils of animals **S** and **T** are the same size. [ ]

- The fossils of animals **S** and **T** have the same skin colour. [ ]

- The fossil of animal **S** was found in a deeper layer of rock than the fossil of animal **T**. [ ]

- The fossil of animal **T** is more similar to the fossil of animal **R** than to the fossil of animal **S**. [ ]

(2)
Figure 2 shows two species of ground squirrel, W and X.

Squirrel W lives on the high ground to the south of the Grand Canyon.

Squirrel X lives on the high ground to the north of the Grand Canyon.

The land to the north of the Grand Canyon is about 300 metres higher than the land on the south side. The north side also has lower winter temperatures and has more rain and snow than the south side.

(i) The two species of squirrel are very similar.

Describe one way, which you can see in Figure 2, in which squirrel X is different from squirrel W.

______________________________________________________________
______________________________________________________________

(1)
(ii) The Grand Canyon was formed about 6 million years ago.

Explain how the two different species of squirrel could have developed from a common ancestor.

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(iii) Squirrels W and X are separate species, but they are still very similar.

Suggest why the two species have not become more different over time.

______________________________________________________________
______________________________________________________________
______________________________________________________________
______________________________________________________________

(6)

(2)

(Total 14 marks)
Bacteria can cause disease.

**Figure 1** shows some features of a *Salmonella* bacterium.

![Salmonella bacterium diagram]

1 μm

(a) **Draw one** line from each feature of the *Salmonella* bacterium to the function.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell membrane</td>
<td>Controls the movement of substances into and out of the cell</td>
</tr>
<tr>
<td>Plasmid DNA</td>
<td>Carries genetic information</td>
</tr>
<tr>
<td></td>
<td>Provides support and protection</td>
</tr>
<tr>
<td></td>
<td>The site of protein synthesis</td>
</tr>
</tbody>
</table>

(2)
(b) How is *Salmonella* spread between people?

Tick **one** box.

- Animal bites
- Contaminated food
- Sneezing
- Sexual contact

(c) Give **two** ways you could stop *Salmonella* from spreading.

1. _________________________________________________________________
   ___________________________________________________________________

2. _________________________________________________________________
   ___________________________________________________________________
Harmful bacteria can also be useful.

Scientists are doing research to find out if *Salmonella* can be used in a vaccine to treat cancer.

The *Salmonella* vaccine can be injected into the blood or swallowed in a tablet.

One benefit of injecting the vaccine is that it gets to the cancer quickly in the blood.

What is another benefit?

Tick **one** box.

- All cancers can be treated by the injection
- It will not cause sickness and diarrhoea side effects
- The injection is not painful to the patient
- The injection introduces cancer cells into the body

(1)
(e) The *Salmonella* bacterium used in the vaccine is genetically modified using part of a virus.

Look at **Figure 2**.

**Figure 2**

Bacteria reproduce quickly in part __________________________

DNA with the desired gene is removed from the virus in part __________________

The chosen gene is inserted into the plasmid in part ______________________

(3)

(Total 9 marks)
Humans can use different methods to produce animals and plants with desired characteristics.

The figure below shows some different breeds of horse.

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

Suggest what you could do to show this.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(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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___________________________________________________________________
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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)

8

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 \((1 \text{ picogram} = 10^{-12} \text{ grams})\).

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

Cell B _____________ picograms

Cell C _____________ picograms

Cell E _____________ picograms

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

_______________________________ picograms

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

Name this type of cell division.

_______________________________

(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?

______________________________________________________________

______________________________________________________________

______________________________________________________________

______________________________________________________________

(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).

______________________________________________________________

______________________________________________________________
(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.

________________________________________________________________________

________________________________________________________________________

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

________________________________________________________________________

________________________________________________________________________

(Total 10 marks)

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

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

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

(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.

(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*.

(Total 8 marks)
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 __________________________________________________

(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 = ___________________
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.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________