

Model Answers: Medium

1a

a) The zebrafish gene is attached to Protein **Q** because...

- It acts as a marker gene to show that the pig gene has been taken up / expressed; [1 mark]
- Only cells/embryos that contain the gene will fluoresce / give off blue light; [1 mark]

[Total: 2 marks]

Marker genes are used to verify that the gene has been taken up by the cells and the protein is being expressed. Remember, it is the **protein that fluoresces** blue and **not the gene**. This can sometimes act as a way of selecting cells that express the protein.

1b

b) A promoter...

- Is the region of a gene to which RNA polymerase/transcription factors bind to initiate / start transcription; [1 mark]

A goat promoter specific to the milk gland is used because...

Any **two** of the following:

- Protein **Q** is present in milk **OR** Protein **Q** is extracted from milk; [1 mark]
- The gene is only expressed in milk glands / udder **OR** the gene is not expressed elsewhere; [1 mark]
- It means that there is no need to kill goats (to obtain Protein **Q**); [1 mark]

[Total: 3 marks]

It is a much easier process to produce and harvest a sufficient amount of protein that can be given to pigs as milk or as an injection rather than trying to add the gene straight into the pig's germline. Gene expression is hard to control within the pig's body and it could be harmful if the protein is overexpressed in certain areas of the body. That is why the protein is ideally expressed in milk as it does not enter the bloodstream of the host animal and can be harvested and given to pigs in a controlled amount. Pig's milk is hard to harvest and therefore a different, more lactating animal has been chosen.

1c

c) Very few live births result from embryos that are implanted because...

- Mutations may arise **OR** the nucleus/chromosomes/DNA may be damaged **OR** genes are disrupted; [1 mark]
- Which may interfere with the proteins that are produced / gene expression / translation; [1 mark]

OR

- Embryo/antigens produced due to genetic modification are foreign; [1 mark]
- Which causes the embryo to be rejected/attacked by their immune system; [1 mark]

[Total: 2 marks]

1d

d) Farmers could use genetic fingerprinting to find unrelated pigs by...

- Selecting mating partners with dissimilar DNA fingerprints; [1 mark]

[Total: 1 mark]

When the parents of animals are too closely related there is a lack of genetic variation in the offspring. This could result in an increased likelihood of inheriting a rare genetic disease or could make the offspring more vulnerable to infectious diseases as they don't inherit protection from either parent.

2a

a) The gene could be isolated in the following ways:

- Using reverse transcriptase to create cDNA from mRNA (of the sodium-pump protein); [1 mark]
- Using restriction endonucleases/restriction enzyme to cut the gene at a specific base sequence/recognition site from *Arabidopsis*/salt-tolerant species; [1 mark]
- Using a gene machine to produce the desired fragment/gene from a known DNA sequence **OR** make artificial DNA using DNA polymerase; [1 mark]

[Total: 3 marks]

Whilst the salt tolerance gene has originated and could be extracted using **restriction enzymes** to cut the gene from the *Arabidopsis* DNA, it is also possible to produce the required DNA sequence using alternative methods. This could be done using bioinformatics databases to **sequence the gene** required and then create copies of the sequence from nucleotide bases. Another method is to work backwards, **isolate the mRNA** from the protein first then use the **reverse transcriptase enzyme** to produce a **cDNA** strand using

the **mRNA as a template**. Then building up the single-stranded cDNA into the double-stranded fragment required using **DNA polymerase**.

2b

b) The transgenic tomato plant is able to produce the sodium pump because:

Any **two** of the following:

- The genetic code is universal **OR** every organism uses the same combinations of nucleotide bases to create amino acids; [1 mark]
- Transcription and translation mechanisms are also universal; [1 mark]
- So the transferred DNA can be used to synthesize proteins in the recipient organism; [1 mark]

[Total: 2 marks]

2c

c) The cells with the sodium pump gene could be selected by...

- Exposing the cells to a high salt environment; [1 mark]
- So that only the tolerant cells survive; [1 mark]
- Use a marker gene/gene probe/marker probe; [1 mark]
- (The marker gene/probe) would show the presence of the required gene through fluorescence / radioactivity / complementary base pairing; [1 mark]

[Total: 4 marks]

In order to identify the cells which have taken up the required gene, we need to find a way to distinguish between them and those which have not taken the gene up. The best way to do this in this scenario is to use a label or marker which could be observed. It would also be possible to identify them by testing their salt tolerance, however, this method is likely to be less definitive because salt-tolerance is likely to be on a scale and cells may not immediately die when they are exposed to salt.

2d

d) The tomato plant cells in Fig. 1 are totipotent because...

- The cells are grown into complete new plants **OR** the cells give rise to whole new plants; [1 mark]
- This means that they must be able to differentiate into different tissues/other specialised cell types; [1 mark]

[Total: 2 marks]

Totipotency is demonstrated by the ability of these plant cells to differentiate to become any of the cells required to produce a whole plant.

3a

a) By including the Ocean pout promoter gene...

- Scientists ensure the growth hormone is continually expressed in the salmon all year round (instead of only in the spring and summer); [1 mark]
- Meaning the GM salmon will grow more rapidly than non-GM salmon; [1 mark]
- So that producers have more product (sufficiently large fish) to sell in a shorter timeframe, which increases their yield; [1 mark]

[Total: 3 marks]

It is key that you thoroughly read the passage above in order to gain full marks here. The passage states that Ocean pout are **cold-water fish** and they thrive in near-freezing waters, suggesting that they are able to **grow in size** in these conditions (meaning growth hormone is being produced continually).

Furthermore, Fig. 1 shows that the GM salmon is significantly **larger in size** compared to the non-GM salmon.

3b

b) The GM salmon was made sterile...

Any **one** of the following:

- To ensure they could not breed with the wild population; [1 mark]
- To maintain/protect the genetic diversity within the wild population of salmon; [1 mark]

[Total: 1 mark]

There are strict regulations and protocols surrounding the use of GMOs. Many precautions are taken to try and ensure that wild populations are minimally affected.

3c

c) The ethical implications of using GMOs in food production:

Any **two** of the following:

- There is a lack of long-term research on the effects on human health; [1 mark]
- Without appropriate labelling, the consumer cannot make an informed decision / has a lack of choice about the consumption of GM foods; [1 mark]
- It may reduce biodiversity for future generations; [1 mark]

AND

The social implications of growing GMOs for food:

Any **four** of the following:

- GM crops may become weeds or invade the natural habitats bordering the farmland; [1 mark]
- Resistance to the introduced genes may arise in the wild population of insects (e.g. for Bt toxin); [1 mark]
- Harm to non-targeted species (e.g. Bt cotton and the Monarch butterfly); [1 mark]
- Cost to farmers required to purchase new seed needs every year; [1 mark]
- Ability to provide enriched foods to those suffering from deficiencies (eg. Golden Rice); [1 mark]
- Reduced impact on the environment / less beneficial insects being harmed due to reduction in pesticide use; [1 mark]
- Reduction in biodiversity could affect food webs; [1 mark]
- The herbicides that are used on the GM crops could leave toxic residues; [1 mark]
- The gene for herbicide resistance in crops (e.g. soybeans) could transfer to weeds leading to the evolution of superweeds; [1 mark]

Without a named example the maximum number of marks that can be gained is five.

[Total: 6 marks]

It is clearly stated in your syllabus that you should be able to discuss the social and ethical implications of using GMOs in food production. Make sure to learn a few real-life **examples** to back up the different points of discussion!