2025 Bi H2 Q2

Section: DNA and the Genome

Topic: Mutations

Question Summary:

The MSTN gene codes for myostatin, a protein that inhibits muscle growth. Two cattle breeds show different base sequences. You must identify the mutation, explain why it has a major effect on protein structure, explain the effect on muscle mass, and compare pregnancy length and birth mass for beef versus dairy breeds.

Worked Solution:

Part of the MSTN gene is shown:

Breed A: ... C C C A C G G A G T G T G A G T A G ...
Breed B: ... C C C A C G G A G T T G A G T A G ...

Notice the difference:
- In breed A the sequence contains "... T G T G ..."
- In breed B that part reads "... T T G ..."

So one base has been removed in breed B. This is a deletion.

(a)(i) Type of mutation
A single base has been deleted, so this is a gene deletion mutation.
Because it is a one base deletion inside a coding sequence, it causes a frame shift.

(a)(ii) Why a major effect on protein structure
Codons are read in groups of three bases.
Deleting one base shifts the reading frame.
This changes every codon after the deletion point.
Therefore all amino acids after that point are altered, giving a very different polypeptide.
A different amino acid sequence usually folds differently, so the protein structure is greatly changed.

(b) Why breed B has increased muscle mass
Myostatin normally inhibits muscle growth.
The mutation makes myostatin non functional or greatly reduced.
With no effective myostatin, inhibition is removed.
Muscle tissue can grow more, so muscle mass increases.

(c) Compare beef and dairy cattle
From the table:
Beef breeds (Aberdeen Angus 285 days, Hereford 284 days) have pregnancies around 284 to 285 days.
Dairy breeds (Ayrshire 280, Holstein 277, Jersey 275) have shorter pregnancies, about 275 to 280 days.
So beef cattle have longer pregnancies than dairy cattle.

Birth mass:
Beef breeds are about 34.6 to 35.3 kg.
Dairy breeds are about 36.9 to 38.2 kg.
So dairy cattle have higher birth mass than beef cattle.

Final Answers:

(a)(i) Deletion (one base deletion causing a frame shift).
(a)(ii) Deletion shifts the reading frame, changing all codons and amino acids after the mutation, so the protein structure is greatly altered.
(b) Myostatin is ineffective, so it no longer inhibits muscle growth and muscle mass increases.
(c) Beef cattle have longer pregnancies and lower birth mass than dairy cattle (dairy cattle shorter pregnancies and higher birth mass).

Revision Tips:

- One base insertions or deletions in a coding region cause frame shift mutations.
- Frame shifts change every codon after the mutation, usually giving a non functional protein.
- Myostatin is an inhibitor of muscle growth; losing it increases muscle mass.
- When comparing groups, state both trends clearly (beef vs dairy for pregnancy length and birth mass).