# 2018 Stem Cells STQ MS

**2018 / H2 / EJC PRELIM / P2 Q3**

**1** Bone marrow contains stem cells that divide by mitosis to form blood cells. The fate of a stem cell was tracked and it was recorded that during the observed duration the stem cell divided asymmetrically each time.

Fig. 3.1 shows changes in the mass of DNA in a human stem cell from bone marrow during three cell cycles.

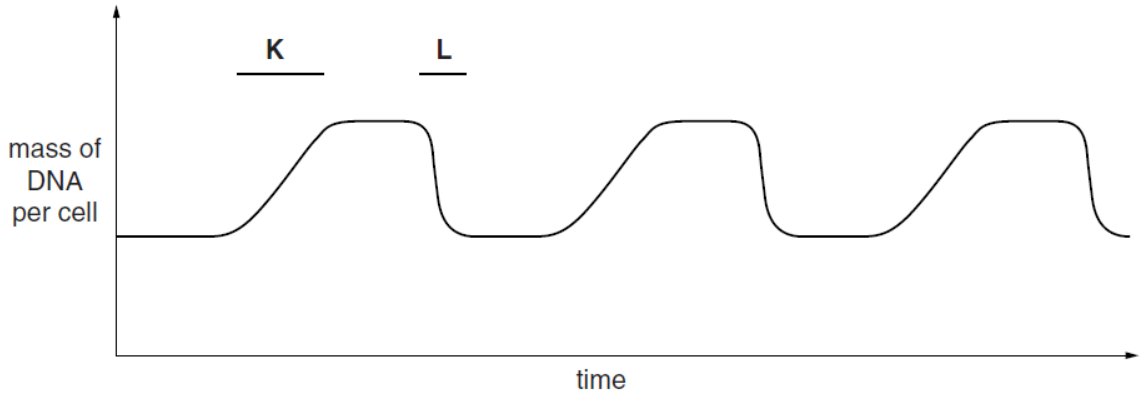


**Fig. 3.1**

**(a)** With reference to the information provided above,

**(i)** Describe what happens to bring about the changes in the mass of DNA per cell at time period **K** and at time period **L**.

**K**

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……

**L** ……

……...[2]

1. **K: DNA replication/ synthesis during S phase of interphase;**
2. **L : cytoplasmic division during cytokinesis;**

**(ii)** State one function of these stem cells undergoing the above type of cell division.

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……...[1]

1. **To replace blood cells that die due to injury/ wear and tear/ disease;**

**(iii)** The process of meiosis is significant to natural selection in evolution.

Explain this significance.

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……..[2]

1. **Meiosis gives rise to genetically different haploid gametes;**
2. **During Prophase I of meiosis, crossing over between chromatids of homologous chromosomes would give rise to different combinations of alleles**

   **OR**

   **During Metaphase I and Anaphase I, independent assortment and separation of homologous chromosomes would give rise to different combinations of maternal and paternal chromosomes;**

3. **Resulting in genetic variation in diploid organisms leading to different phenotypes/ variation in phenotypes;**

4. **those with advantageous phenotypes are selected for, resulting in change in allele frequency in the population over time;**

   **(1 and 2 + 3 / 4 OR 1+ 3 and 4)**

A bone marrow cell was extracted and observed under the electron micrograph shown in Fig. 3.2. The student focused on an organelle which he described as having “an envelope surrounding genetic material containing both darker and lighter stained patches, distinct from the site where ribosomal subunits were assembled”.

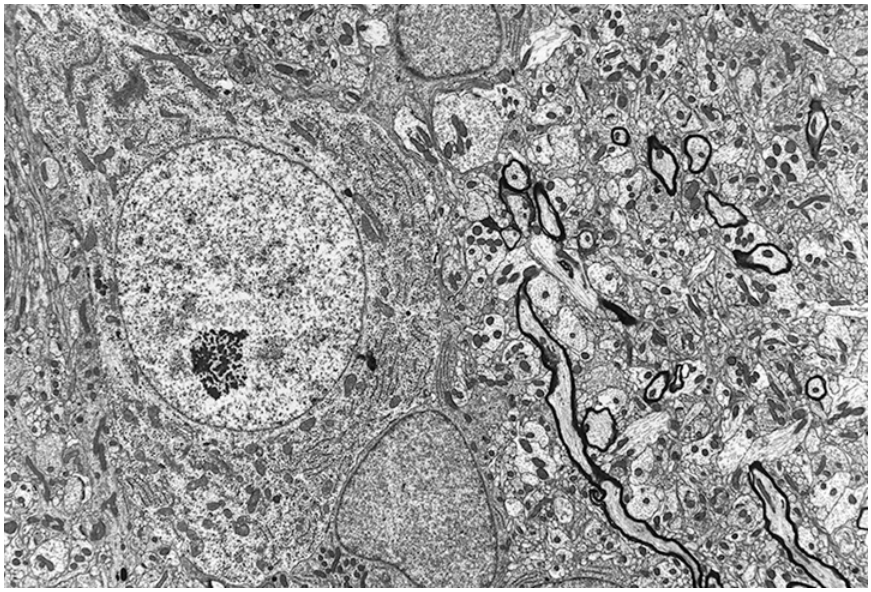

**Fig. 3.2**

**(b)** Explain the significance of the "darker and lighter stained patches" that the student referred to, in a cell undergoing differentiation.

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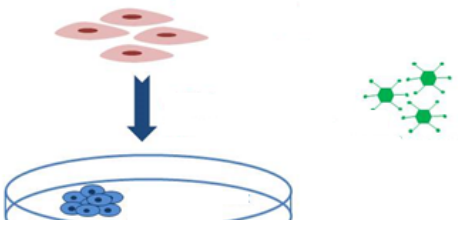
……[3]

**1. The darker stained patches are heterochromatin while the lighter stained patches are euchromatin;**
**2. The genes that are found within heterochromatin are transcriptionally inactive/not expressed while the genes found in euchromatin are transcriptionally active/are expressed;**
**3. Thus producing specific proteins that allow the differentiated cell to perform specific functions;**

The use of embryonic stem cells (ESCs) for stem cell therapy and research is controversial and considered by many people as unethical. Scientists have circumvented this issue through the use of induced pluripotent stem cells (iPSCs) as an alternative to ESCs.

Fig. 3.3 summarises the procedure for obtaining iPSCs and its use.



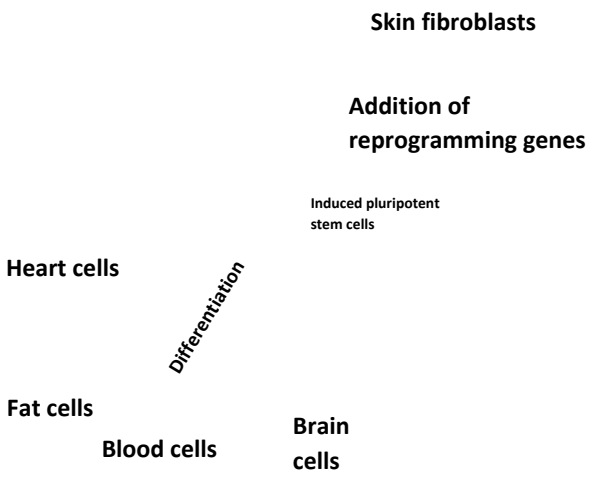



**Fig. 3.3**

**(c)** Explain why the use of iPSCs is preferred over ESCs.

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.....[2]

1. **Since iPSCs can be derived directly from adult tissues/specialised somatic cell/ skin cells, it does not destroy any human embryos unlike ESCs;**
2. **iPSCs from adult/specialised somatic cell/ skin cell can be easily obtained without risk to the donor, whereas obtaining the embryo to isolate ESCs is more invasive;**
   **(R: easy vs difficult because no elaboration)**
3. **In contrast to ES cells extracted from human embryos, iPSCs derived from a patient's own cells would open the possibility of generating patient-specific cells, which will not be rejected by the immune system upon transplantation; (A: idea of iPSCs obtained from self vs embryos not from self thus contain antigens that will be rejected by immune system);**
4. **Sources of obtaining iPSCs is more easily accessible compared to the source of obtaining ESCs/ obtaining the embryo;**
   **(any one, answer must make comparison with ESCs)**

[Total: 10]

**2018 / H2 / NJC PRELIM / P2 Q7**

**2** **(a)** Define and state an example of a multipotent stem cell.

1. **Differentiate into cell types of a tissue / organ;**
2. **Haematopoietic stem cell;**

[2]

**(b)** **(i)** One unique feature of stem cells is their ability to differentiate into different

cell types, where some genes are silenced and some genes are expressed.

Explain how stem cells achieve this.

1. **DNA methylation occurs on the CG islands of DNA;**
2. **Recruits Histone Deacetylases;**
3. **Histone deacetylation on lysine residues of histone tails;**
4. **Increases the positive charge of histone tails and increases electrostatic forces of attraction between histone tails and DNA;**
5. **Decrease gene expression / silencing of certain genes resulting in differentiation;**

[Opposite way of expressing idea will be awarded equivalent marks] [4]

**(ii)** During the process of differentiation, specific proteins are produced.

Account for the roles of **three** types of RNA in producing these proteins.

1. **mRNA – carries genetic information from DNA in the form of a series of codon to specify the amino acid sequences of proteins;**
2. **tRNA – serves as an adaptor molecule in protein synthesis; carries the correct amino acid to the ribosome and its anti-codon base-pairs with its complementary mRNA codon;**
3. **rRNA – component of ribosome, plays structural and catalytic role in ribosomes;**

[3]

**(c)** A recent advancement in stem cell gene therapy is the use of CRISPR/Cas9 system to edit genes. This stem cell gene therapy can help to cure genetic diseases by removing the undesired gene and adding the corrected version in the stem cells.

The CRISPR/Cas9 system works by delivering a Cas9 nuclease complexed with a single-stranded RNA (artificial guide) into a cell.

Fig. 7.1 and Fig. 7.2 explain how gene editing is achieved using CRISPR/Cas9 system.

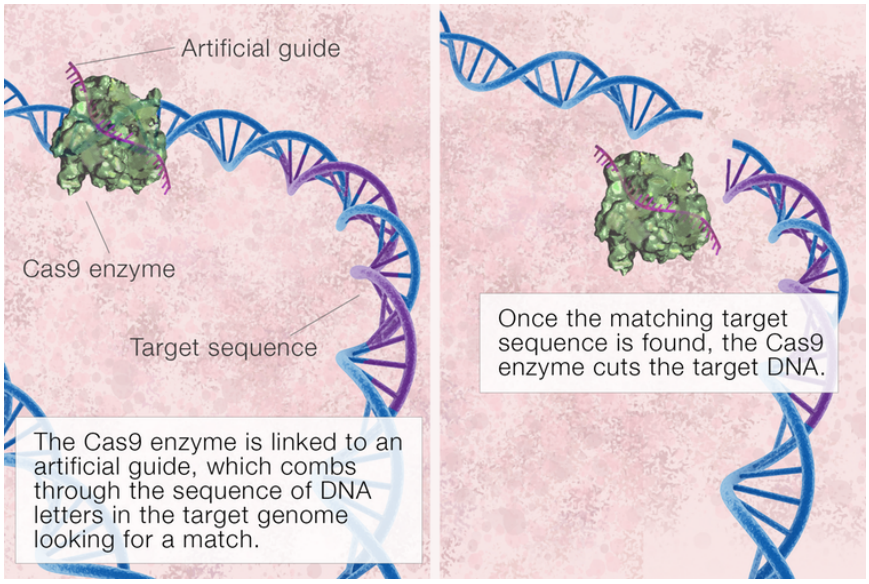


**Fig. 7.1**

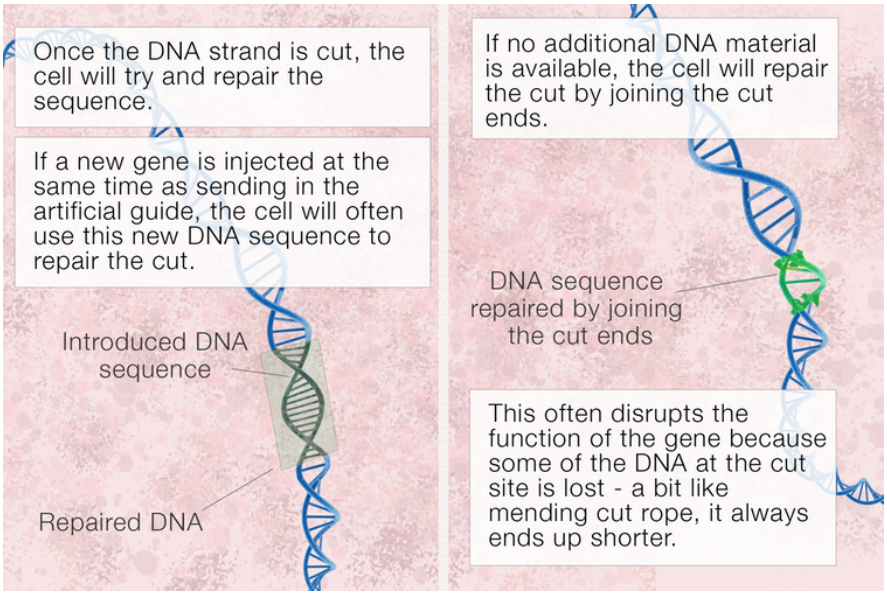


**Fig. 7.2**

**(i)** With reference to Fig. 7.1 and Fig. 7.2, explain why CRISPR/Cas9 is believed to have potential applications for treating **many** genetic diseases in humans.

1. **Different genetic diseases are caused by different genes;**
2. **Use of artificial guide allows Casp9 enzyme to find the right gene based on complementary base-pairing of the guide to the target gene to edit the gene;**

[2]

**(ii)** Despite the potential of CRISPR/Cas9 in treating many genetic diseases, some scientists are worried about the use of such technology in humans.

Suggest **one** possible consideration.

1. **Possible off-target mutations (unintended mutations) in the genome. Mutations are deleterious;**
2. **Cost of germline editing technology is very high to the extent that only families from rich countries could afford it;**
3. **Genome editing in human embryos could have unpredictable effects to the future generation;**
4. **Technology could be used for non-therapeutic modifications, leading to loss of human diversity and eugenics;**
5. **AVP**

[1]

[Total: 12]