INNOVA JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
in preparation for General Certificate of Education Advanced Level
Higher 1

CANDIDATE NAME	**MARK SCHEME**		
CLASS		INDEX NUMBER	

BIOLOGY

8875/02

Paper 2 Core Paper

23 August 2016

2 hours

Additional Materials: Answer Paper
Cover Page

READ THESE INSTRUCTIONS FIRST

Write your name and class on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions.

Section B
Answer **one** question.

At the end of the examination, fasten all your work securely together.

The number of marks is given in the brackets [ ] at the end of each question or part question.

For Examiner's Use	
Section A	
1	/14
2	/11
3	/8
4	/7
Section B	
5 / 6	/20
Total	/60

This document consists of **11** printed pages and **1** blank page.

For Examiner's Use

Section A
Answer **all** questions.

1 Fig. 1.1 shows an animal cell undergoing mitosis.

Fig. 1.1

(a) **(i)** With reference to Fig. 1.1, identify a cell structure that is present only in an animal cell.

centrioles; [1]

(ii) Describe the structure and function of the structure identified in **a(i)**.

1. [str] occurs in a pair

located right angles to each other;

2. made of microtubules

consisting of 9 sets of triplets arranged in a ring;

3. [fx] organise spindle fibres

to align chr at equator during metaphase OR
help to separate sister chromatids during anaphase OR

interxt to elongate the cell;

4. migrate to oppo poles of the cell to form MTOC / mark poles of the cell; [3]

(b) Explain the behaviour of the nuclear envelope in the early stage of mitosis.

1. during prophase of mitosis

nuclear envelope disintegrates / fragments;

2. allows the binding of spindle fibres to centromere

so as to align pairs of sister chromatids to the metaphase plate; [2]

(c) With reference to Fig. 1.1,

(i) state the number of chromosomes observed at metaphase stage.

6; [1]

(ii) state the number of chromosomes observed at anaphase stage.

12; [1]

(d) In an experiment, a protease was added to the mitotic stage immediately before the stage shown in Fig. 1.1.

Suggest the effect of protease on the events shown in Fig. 1.1.

1. kinetochore prot / spindle fibres degraded

prevent the attachment of spindle fibres to the chromatid / prevent separation of sister chromatids during anaphase;

2. digest / breakdown cohesin before chr are properly aligned at metaphase plate;

3. leading to pairs of sister chromatids remaining at the metaphase plate in a single row;

4. leading to non-disjunction thus polyploidy / aneuploidy;

5. leading to cells not passing spindle checkpoint thus triggering apoptosis; [2]

Fig. 1.2 shows the same animal cell in a later stage of mitosis.

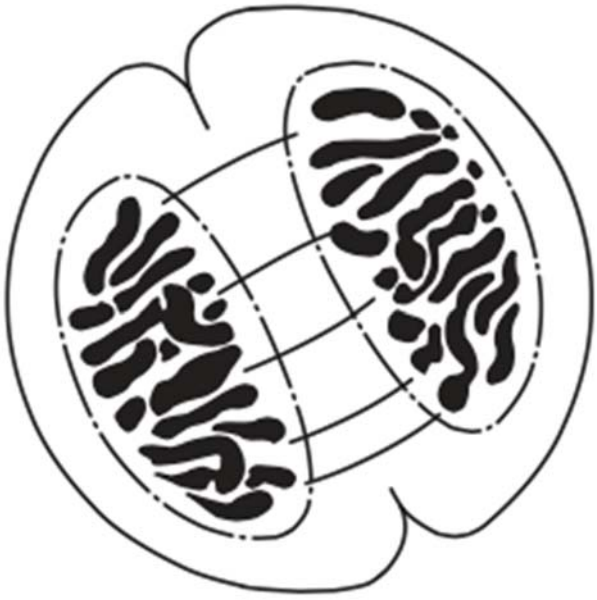

Fig. 1.2

(e) Explain the property of the membrane that allows it to form the cleavage furrow.

1. fluidity

allow membrane to invaginate to form cleavage furrow (w the aid of contractile ring of microfilaments);

2. phospholipid molecules capable of lateral movement

as they are held by weak hydrophobic interactions; [2]

(f) State **two** changes in the composition of the membrane if the temperature surrounding the cell is increased.

1. ↑ cholesterol in memb;

2. ↑ degree of saturation in FA of phospholipid;

3. ↑ length of FA in phospholipid;

4. mem prot may denature / △ in 3D config; [2]

[Total: 14]

2 Polymerase chain reaction (PCR) is a molecular technique used to amplify target DNA. It comprises of a three-stage process involving cycles of repeated heating and cooling.

Fig. 2.1 is a graph showing the process.

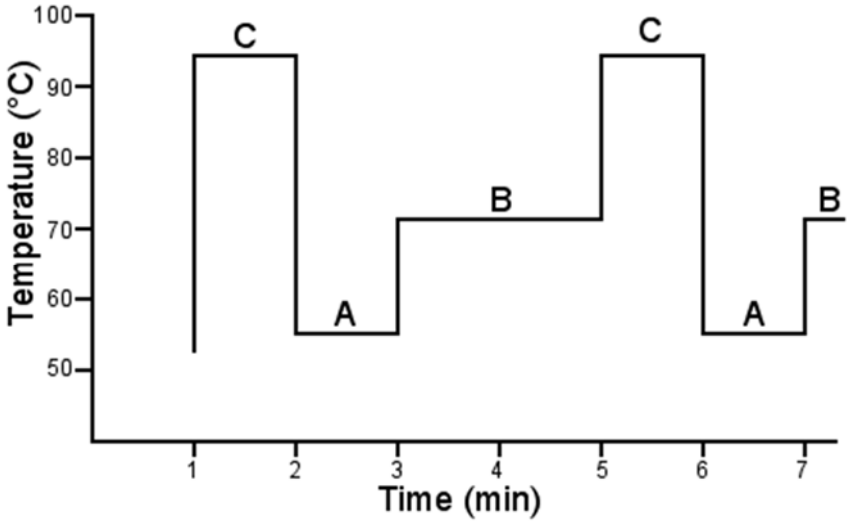

Fig. 2.1

For Examiner's Use

(a) With reference to Fig. 2.1,

(i) describe the process occurring in stage **B**.

1. elongation stage

at 70°C;

2. Taq pol adds free deoxyribonucleotides at 3' OH end of primers

with target seq acting as template;

3. in 5' → 3' direction

forming phosphodiester bonds btw nucleotides; [3]

(ii) describe the process occurring in stage **C**.

1. denaturation stage

at 95°C;

2. ↑ heat ➡ ↑ KE ➡ break H bonds btw comp bp

separation of dsDNA → ssDNA; [2]

(b) Stage **A** is the annealing phase of PCR.

Describe **two** differences between this phase for DNA replication in eukaryotes and in stage **A** of PCR.

1. DNA replication - requires use of RNA primase to synthesise primers

PCR - primers are provided / chemically synthesised;

2. PCR - primers in PCR are specific / comp to regions flanking the DNA of interest

DNA replication - primers are synthesised to bind at various regions in the DNA; [2]

In PCR, the design of the primer is important in the successful amplification of the target sequence.

Fig. 2.2 shows the efficacy of different primers (**D**, **E** and **F**) binding to the same target sequence against its melting temperature. The same concentration of primers was used in the experiment. A higher amount of fluorescence observed indicates the presence of higher amounts of bound primer.

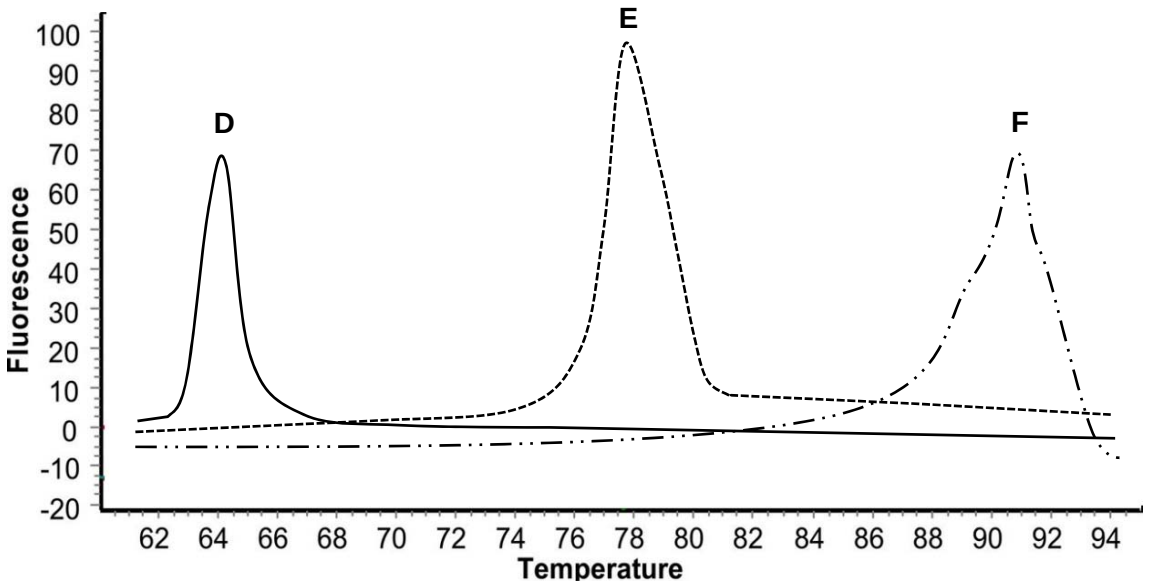

Fig. 2.2

(c) With reference to Fig. 2.1 and Fig. 2.2,

(i) explain why primers **D** and **E** have different melting temperatures;

1. primer E higher melting pt than primer D

[QV] 78°C to 63°C;

2. primer E is longer than primer D

more energy required to break the bonds btw primer & target DNA; [2]

(ii) suggest and explain which is the optimal primer to be used for this PCR.

1. primer E

highest affinity to bind target seq;

2. melting temperature is below denaturation temp allowing it to dissociate from target seq (c.f. to primer F);

melting temperature is above elongation temp allowing it to extend primer (c.f. to primer D); [2]

[Total: 11]

3 Sickle cell anaemia is caused by a mutation in the gene coding for haemoglobin. This mutation results in a loss of the restriction site *Dde*I, as shown in Fig. 3.1.

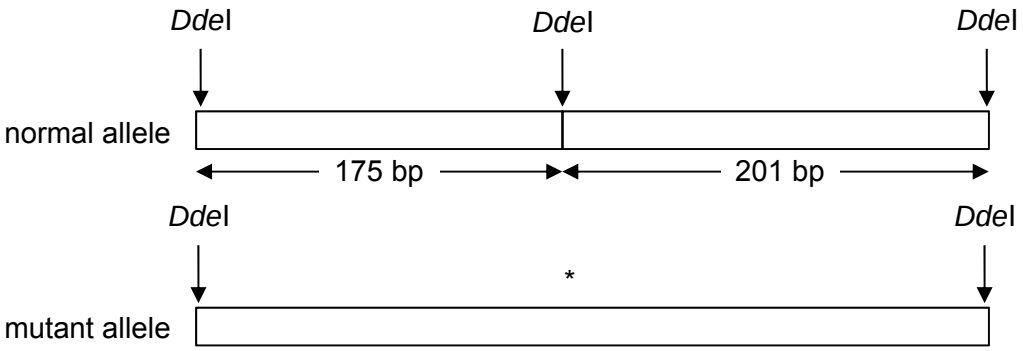

Fig. 3.1

DNA samples were obtained from children of a family. After subjecting the samples to restriction digestion using the enzyme *Dde*I, the resultant fragments were analysed using gel electrophoresis.

Fig. 3.2 shows the inheritance of sickle cell anaemia in the family and the results obtained from the gel electrophoresis.

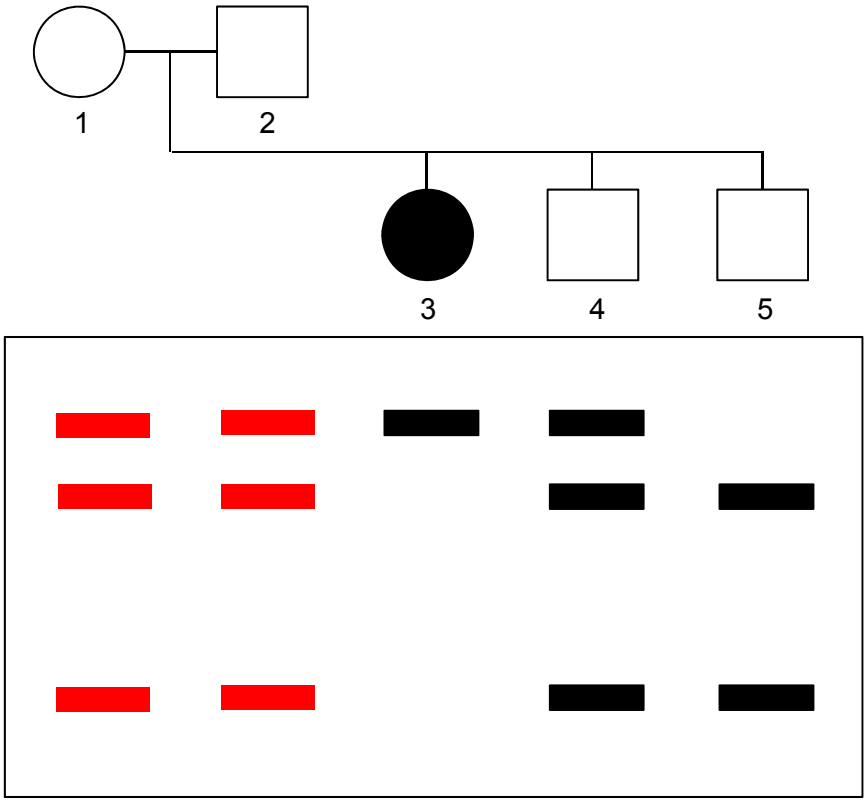

Fig. 3.2

(a) State the mode of inheritance of sickle cell anaemia.

autosomal recessive;

[1]

(b) Using the symbols **A** and **a**, determine the genotypes of individuals **3**, **4** and **5**.

3 ***aa***

4 ***Aa***

5 ***AA; (award 1m if all correct)*** [1]

(c) The same procedure was performed on the DNA samples obtained from the parents.

In the outline of the gel shown in Fig. 3.2, sketch the DNA banding pattern obtained for individuals **1** and **2**. [2]

(d) With reference to the information given, outline how the following procedures are used in detection of sickle cell anaemia:

(i) restriction digestion;

1. restriction digestion of mutant and normal alleles using DdeI

produces fragments of diff lengths ➡ allow identification of alleles;

2. mutant allele – 376bp

normal allele – 175 & 201bp; [2]

(ii) gel electrophoresis.

1. gel electrophoresis separates restriction fragments based on molecular size;

allows identification of genotype of individual;

2. e.g. homozygous dominant – 2 bands (175 and 201 bp), heterozygous – 3 bands (175, 201, 376 bp)

homozygous recessive – 1 band (376 bp); [2]

[Total: 8]

4 Iron deficiency is the most common nutritional deficiency in the world. Use of genetic engineering to increase the iron content of the crops can be achieved by the introduction of genes coding for iron-binding proteins.

FvC5sdp is an iron-binding protein expressed in fungus. Five plants (D-1, D-2, D-3, D-4 and D-5) expressing the gene coding for FvC5sdp were created. The total iron content of the fruits from wild type control (WT) and the transgenic lines were measured. The results are shown in Fig. 4.1.

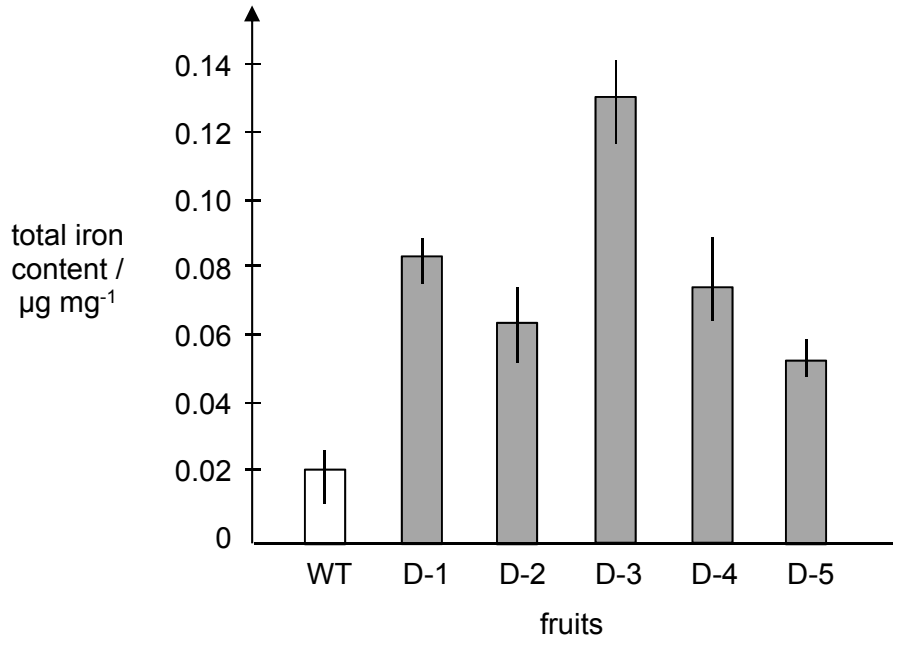

Fig. 4.1

(a) With reference to Fig. 4.1, account for the effect of introducing the gene coding for FvC5sdp into the plants.

1. ↑ iron content in all genetically modified plants

[QV] 0.08, 0.06, 0.12, 0.07, 0.05 µg mg^{-1} in all D-1 to D-5 respectively vs 0.02 µg mg^{-1} in WT;

2. FvC5sdp is an iron-binding protein

allows increased uptake of iron by GM plants; [2]

(b) Genetically modifying plants to increase iron content improves the quality of such crop plants.

Describe another example of a genetically modified crop plant with improved quality.

1. Golden Rice produced by introducing psy gene (from daffodil) and crt1 gene (from soil bacterium)

which codes for phytoene synthase and phytoene desaturase respectively;

2. allows for biosynthesis of β-carotene in rice grain

which is the precursor to vit A; [2]

(c) Discuss the ethical and social implications of genetically modifying crop plants.

1. threat to human safety

e.g. transfer of antibiotic resistant genes to gut bacteria;

2. threat to environmental safety

e.g. herbicide-resistant plants ➡ ↑ liberal use of herbicides ➡ pollution / insect-resistant plants ➡ development of insecticide-resistance in pests;

3. threat to ecological balance

gene flow to wild-type species ➡ establishment of invasive 'superweeds';

4. risk assessment

inconclusive studies of long term impacts / no legislation on GM labelling; [3]

(max 3m, any 3 pts)

[Total: 7]

Section B

Answer **one** question.

Write your answers on the separate answer paper provided.
Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.
Your answers must be in continuous prose, where appropriate.
Your answers must be set out in section **(a)**, **(b)** etc., as indicated in the question.

5 **(a)** Describe the structure of an amino acid and how a peptide bond is formed with another amino acid. [6]

[structure]

1. ***made up of a central α-carbon atom bonded to a hydrogen atom, carboxyl group, amine group and a variable R group (student may use labels on diagrams to highlight these groups with accompanying prose);***
2. ***properties of R group: polar, non-polar, charged (+ve and –ve);***

[peptide bond formation]

3. ***H and OH from amine groups and carboxyl groups of two adjacent aa;***
4. ***undergo condensation with removal of 1 H_2O molecule (student may use labelled diagram to show this process with the accompanying prose) to form peptide bond btwn aa;***
5. ***catalysed by peptidyl transferase in ribosome;***
6. ***labelled diagram;***

(b) Explain how the structure of haemoglobin is adapted to its function. [6]

Structure	***Function***
1. presence of iron (Fe^{2+}) - containing prosthetic group ➧ haem	***1. allow reversible binding to 1 oxygen molecule;***
2. 4 subunits (tetramer) each containing 1 haem group;	***2. allow 4 oxygen molecules to be bound to haem groups;***
3. folding of polypeptide chains into a globular haemoglobin keeps hydrophobic amino acids in the interior of the protein;	***3. allow it to be soluble in the cytoplasm of red blood cells;***
4. αβ-dimer associated with each other via hydrogen and ionic bonds;	***4. allows for cooperative binding of oxygen;***
5. exists in two states which are the T (tense) state in deoxyhaemoglobin and R (relaxed) state in oxyhaemoglobin.	***5. ⧋ in structure from T to R state where binding of one oxygen molecule in one subunit, exposes oxygen binding sites in other subunits that increases binding affinity of the subunits;***
6. haemoglobin's close packing makes it compact;	***6. more molecules of haemoglobin can be dissolved per volume of***

	blood;
7. Packing of the haemoglobin results in 25% of the total protein volume existing as small cavities;	***7. allows the globular haemoglobin subunits to be flexible in its conformation, therefore Hb can undergo conformation change which is needed for cooperative binding;***

(c) Catalase is an enzyme found in potatoes. It catalyses the breakdown of hydrogen peroxide to oxygen and water.

Describe how you would investigate the effect of substrate concentration on the rate of reaction. [8]

1. ***labelled diagram of set-up;***
2. ***placing of potatoes in hydrogen peroxide solution and collecting oxygen released using a gas syringe;***
3. ***prepare 5 concentrations of H_2O_2 (e.g. 1%, 2%, 3%, 4%, 5%) and standardise volume (e.g. 2 ml);***
4. ***control temp using a water bath (e.g. 30℃) to ensure that rate of enz rxn is not affected by changes in temp;***
5. ***control pH (~ pH 7) using pH buffer to ensure that rate of enz rxn is not affected by changes in pH;***
6. ***standardise size of potato discs (e.g. 0.2 cm width, 1 cm diameter);***
7. ***standardise reaction time using stopwatch***
8. ***graph showing expected results;***
9. ***hydrogen peroxide corrosive – require use of gloves;***

6 (a) Outline the main features of photophosphorylation. [6]

1. ***photon of light absorbed by pigments in light harvesting complex ➡ en transferred to chl a in PS II in the reaction centre via inductive resonance;***
2. ***photoactivation of chl a ➡ e^- brought to higher en lvl;***
3. ***e^- accepted by primary e^- acceptor ➡ pass down a series of e- carriers in ETC to PS I;***
4. ***en released from e^- transfer used to pump H+ from stroma to thylakoid space;***
5. ***accumulation of H^+ in thylakoid space ➡ generate proton gradient ➡ proton motive force;***
6. ***H^+ diffuses from thylakoid space to stroma through ATP synthase ➡ phosphorylation of ADP to ATP ➡ ATP synthesis via chemiosmosis;***
7. ***photolysis of water to replace e- deficit in PSII;***
8. ***ref to cyclic photophosphorylation;***

(b) Explain how the structure of chloroplasts is adapted to its function. [6]

1. ***contain photosynthetic pigments in thylakoid memb***
   for absorption of light for light-dependent reactions to occur;
2. ***photosystems, e^- carriers and ATP synthase embedded in thylakoid memb***
   allow light-dependent reactions / photophosphorylation to occur;
3. ***thylakoid discs bound by thylakoid membrane***
   impermeability of memb to ions ➡ allow protons to accumulate in thylakoid lumen for chemiosmosis;
4. ***memb permeable to carbon dioxide***
   allow carbon dioxide to enter for carbon fixation of Calvin cycle;
5. ***stroma contains photosynthetic enz***
   allow reactions of Calvin cycle to take place;
6. ***stroma contains circular DNA and 70S ribosomes***
   allow synthesis of proteins for use in chloroplast (e.g. RNA pol, photosynthetic enz, thylakoid prot);

(c) Describe how Calvin cycle differs from the Krebs cycle. [8]

	Calvin cycle	***Krebs cycle***
1. site of reaction	***stroma of chloroplast***	***matrix of mitochondria;***
2. nature of the process	***anabolic (produces carbo)***	***catabolic (break down carbo);***
3. involvement of CO_2	***absorbed in carbon fixation stage***	***released during oxidative decarboxylation***
4. coenzyme	***NADP produced / reduced NADP used***	***NAD used / reduced NAD produced and FAD used / reduced FAD produced;***
5. ATP	***is used up during carbon reduction and regeneration of RuBP***	***is produced during substrate level phosphorylation of succinyl CoA to succinate;***
6. occurs in	***plants***	***plants and animals;***
7. involvement of O_2	***does not need O_2***	***does not occur in the absence of O_2***
8. process	***occurs during photosynthesis***	***occurs during aerobic respiration;***
9. starting material	***5C RuBP***	***4C oxaloacetate;***

[Total: 20]