HL Paper 2

a. The probability of extinction of a species increases if the population is small with low genetic variation. [2]

State **two** processes that cause population size to decrease.

b. Explain how meiosis promotes variation. [3]

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a. List **two** causes of variation within a gene pool. [2]

b. Describe how variation contributes to evolution by natural selection. [3]

c. Outline what is required for speciation to occur. [3]

The biological insights of Mendel and Darwin in the 19th century remain important to this day.

a. Discuss the role of genes and chromosomes in determining individual and shared character features of the members of a species. [7]

b. Outline the process of speciation. [4]

c. Describe, using **one** example, how homologous structures provide evidence for evolution. [4]

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a. Outline the processes that occur during the first division of meiosis. [6]

b. Prior to cell division, chromosomes replicate. Explain the process of DNA replication in prokaryotes. [8]

c. Outline outcomes of the human genome project. [4]

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a. Draw a labelled diagram of a mature sperm. [5]

b. Outline the formation of chiasmata during crossing over. [5]

c. Explain how an error in meiosis can lead to Down syndrome. [8]

In the red squirrel (*Tamiasciurus hudsonicus*), the allele for grey fur colour (G) is dominant to the allele for red fur colour (g) and the allele for a fluffy tail (F) is dominant to hairless tail (f).

a. The genes described above form a linkage group. Define *linkage group*. [1]

b. A cross is made between squirrels of the following genotypes. [2]

$$\frac{G\ F}{g\ f} \times \frac{g\ f}{g\ f}$$

Using a similar format, identify the genotypes of offspring which are recombinants.

c. Explain how the recombinants are formed during meiosis. [3]

d. Explain the role of transfer RNA (tRNA) in the process of translation. [2]

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a. Cells go through a repeating cycle of events in growth regions such as plant root tips and animal embryos. Outline this cell cycle. [4]

b. Draw a labelled diagram of the formation of a chiasma by crossing over. [3]

c. Explain the control of gene expression in eukaryotes. [8]

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a. Describe the causes of Down syndrome. [5]

b. Describe how human skin colour is determined genetically. [5]

c. Explain the causes of sickle-cell anemia. [8]

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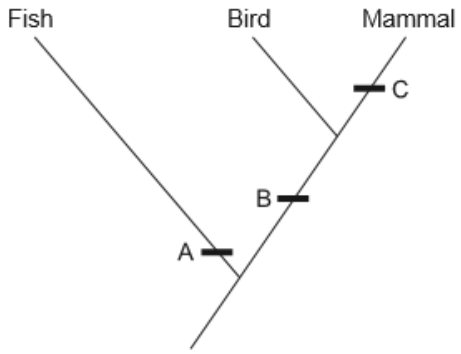
a. Describe the process of crossing over. [2]

b. Explain the reason for linked genes **not** following the pattern of inheritance discovered by Mendel. [2]

a. The image shows part of a cladogram. [3]



Using the cladogram, identify one diagnostic feature that characterizes the given groups of vertebrates at A, B and C.

A: .....
B: .....
C: .....

b. Starting from the concept of gene pool, explain briefly how populations of early vertebrates could have evolved into different groups. [3]

c. Mitochondria are thought to have evolved from prokaryotic cells. Describe **two** adaptations of the mitochondria, each related to its function. [2]

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a. Outline how reproductive isolation can occur in an animal population. [3]

b. Describe the different cell types in the seminiferous tubules that are involved in the process of spermatogenesis. [4]

c. Explain the roles of specific hormones in the menstrual cycle, including positive and negative feedback mechanisms. [8]

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b. Explain, using a **named** example, how polygenic inheritance gives rise to continuous variation. [2]

c. Describe the inheritance of colour blindness in humans. [3]

In some maize plants the seed is enclosed in a green sheath called a tunica. The allele (T) for this is dominant to the allele (t) for normal, unenclosed seeds. The endosperm of the seed can be starchy (allele E) or sugary (allele e). The genes for these two characteristics are linked. The table below shows the outcome of crosses between a plant heterozygous for both characteristics and one that is homozygous recessive for both characteristics.

Phenotype	Number
Tunica present, starchy	326
Unenclosed seeds, starchy	111
Tunica present, sugary	118
Unenclosed seeds, sugary	295

a (i) State the genotype of the heterozygous parent using the correct notation. [1]

a (ii) Identify which individuals are recombinants in this cross. [1]

a (iii) Explain what has occurred to cause these results. [2]

b. Maize belongs to the group of plants known as angiospermophyta. Distinguish between angiospermophytes and bryophytes. [2]

In the pea plant (*Pisum sativum*), the allele for tall plants is A and the allele for short plants is a. The allele for green plants is B and the allele for yellow plants is b.

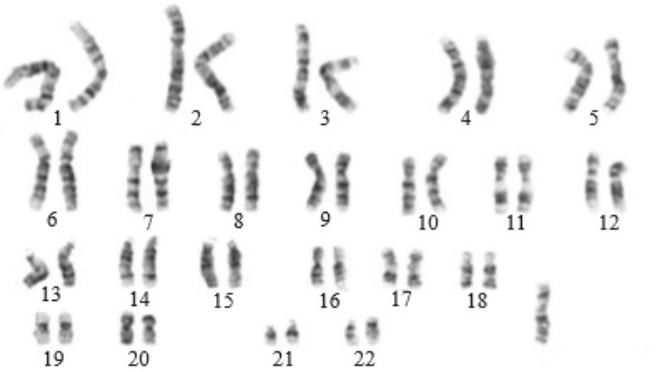
a. Determine the phenotype of Aabb. [1]

b. Compare the information that could be deduced when the genotypes are presented as AaBb or [2]

$$\frac{A\ B}{a\ b}.$$

c. Deduce **one** possible recombinant offspring of individual $\frac{A\ B}{a\ b}$ after a test cross. [1]

The image shows the karyotype of a person who developed as a female.



[Source: http://en.wikipedia.org/wiki/File:45,X.jpg]

a (i) In a strain of soybeans, high oil content (H) in seeds is dominant to low oil content (h) and four seeds in a pod (F) is dominant to two seeds in a pod (f). A farmer crosses two soybean plants, both with high oil content and four seeds in a pod. The offspring have a phenotypic ratio of 9 : 3 : 3 : 1. [1]

Identify the genotypes of the soybean plants with high oil content and four seeds in a pod that were used in the cross.

a (ii) In a strain of soybeans, high oil content (H) in seeds is dominant to low oil content (h) and four seeds in a pod (F) is dominant to two seeds in a pod (f). A farmer crosses two soybean plants, both with high oil content and four seeds in a pod. The offspring have a phenotypic ratio of 9 : 3 : 3 : 1. [2]

Determine the genotypes of the gametes and offspring using a Punnett grid.

a (iii) In a strain of soybeans, high oil content (H) in seeds is dominant to low oil content (h) and four seeds in a pod (F) is dominant to two seeds in a pod (f). A farmer crosses two soybean plants, both with high oil content and four seeds in a pod. The offspring have a phenotypic ratio of 9 : 3 : 3 : 1. [2]

Identify the phenotypes of each part of the phenotypic ratio.

Ratio	Phenotypes
9	
3	
3	
1	

b (i) Deduce the reason for the person developing as a female. [1]

b (ii) Determine, with a reason, whether this karyotype shows that non-disjunction has occurred. [1]

The diagram shows a human karyotype.

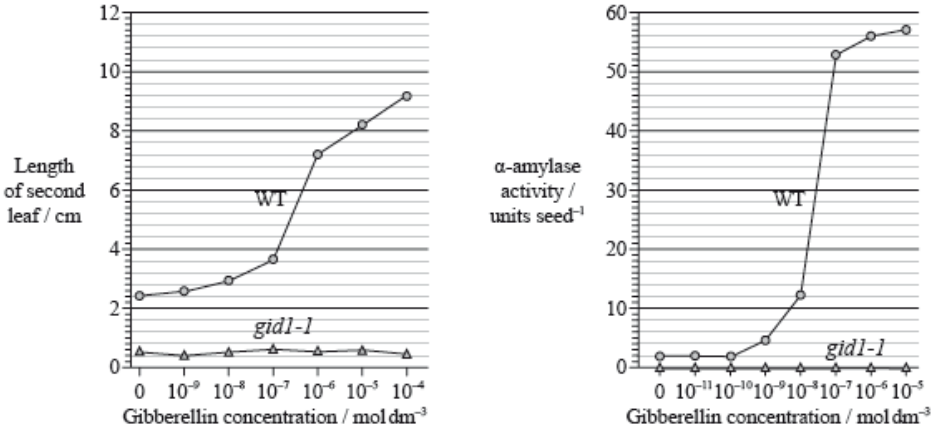
[Source: http://en.wikipedia.org/wiki/File:NHGRI_human_male_karyotype.png, courtesy of the National Human Genome Research Institute.]

a. Analyse this karyotype. [2]

b. Outline the inheritance of hemophilia in humans. [2]

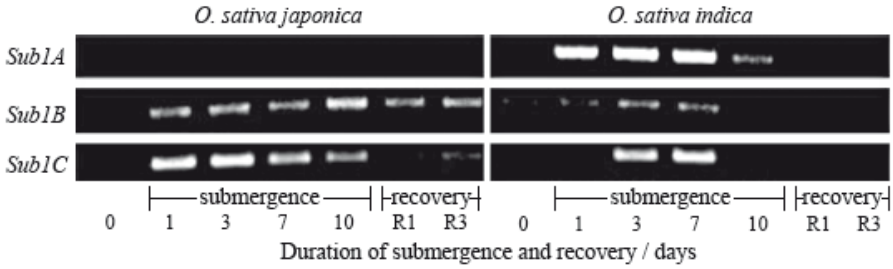
c. Using an example, describe polygenic inheritance. [3]

Gibberellin promotes both seed germination and plant growth. Researchers hypothesize that the gene *GID1* in rice (*Oryza sativa*) codes for the production of a cell receptor for gibberellin. The mutant variety *gid1-1* for that gene leads to rice plants with a severe dwarf phenotype and infertile flowers when homozygous recessive. It is suspected that homozygous recessive *gid1-1* plants fail to degrade the protein SLR1 which, when present, inhibits the action of gibberellin. The graphs show the action of gibberellin on the leaves and α-amylase activity of wild-type rice plants (WT) and their *gid1-1* mutants.



[Source: adapted from M. Ueguchi-Tanaka et al. (2005) 'Gibberellin-insensitive dwarf1 encodes a soluble receptor for gibberellin'. Nature, 437, pp. 693—698. Adapted by permission from Macmillan Publishers Ltd (c) 2005.]

Most rice varieties are intolerant to sustained submergence under water and will usually die within a week. Researchers have hypothesized that the capacity to survive when submerged is related to the presence of three genes very close to each other on rice chromosome number 9; these genes were named *Sub1A*, *Sub1B* and *Sub1C*. The photograph below of part of a gel shows relative amounts of messenger RNA produced from these three genes by the submergence-intolerant variety, *O. sativa japonica*, and by the submergence-tolerant variety, *O. sativa indica*, at different times of a submergence period, followed by a recovery period out of water.

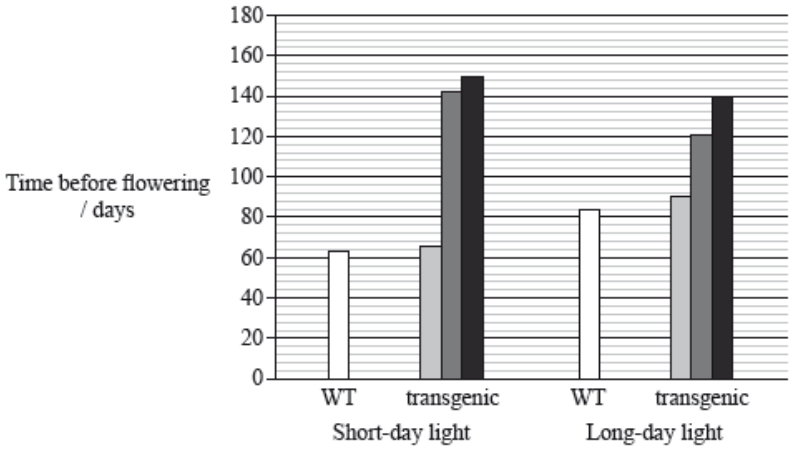


[Source: Adapted from "Sub1A is an ethylene-response-factor-like gene that confers submergence tolerance to rice" (2006) Kenong Xu, Xia Xu, Takeshi Fukao, Patrick Canlas, Reycel Maghirang-Rodriguez et al. Nature, 442, pp. 705—708. Adapted by permission from Macmillan Publishers Ltd (c) 2006.]

The *OsGI* gene causes long-day flowering and the effect of its overexpression has been observed in a transgenic variety of rice. Some wild-type rice (WT) and transgenic plants were exposed to long days (14 hours of light per day) and others to short days (9 hours of light per day).

The shades of grey represent the genotypes of the transgenic plants, where:

- –/– do not have the overexpressed *OsGI* gene
- +/– are heterozygous for the overexpressed *OsGI* gene
- +/+ are homozygous for the overexpressed *OsGI* gene.



[Source: adapted from R. Hayama, S. Yokoi, S. Tamaki, M. Yano and K. Shimamoto (2003) 'Adaptation of photoperiodic control pathways produces short-day flowering in rice.' Nature, 422, pp. 719—722. Adapted by permission from Macmillan Publishers Ltd (c) 2003.]

a(i). State which variety of rice fails to respond to gibberellin treatment. [1]

a(ii). The activity of α-amylase was tested at successive concentrations of gibberellin. Determine the increment in gibberellin concentration that produces the greatest change in α-amylase activity in wild-type rice plants (WT). [1]

b. Discuss the consequence of crossing *gid1-1* heterozygous rice plants amongst themselves for food production. [3]

c(i). Determine which gene produced the most mRNA on the first day of the submergence period for variety *O. sativa japonica*. [1]

c(ii). Outline the difference in mRNA production for the three genes during the submergence period for variety *O. sativa indica*. [2]

d. Using only this data, deduce which gene confers submersion resistance to rice plants. [2]

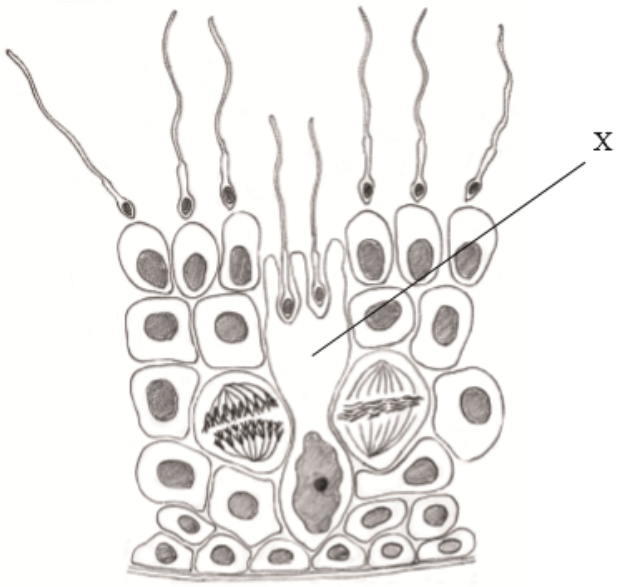
e(i). State the overall effect of overexpression of the *OsGI* gene in plants treated with short-day light. [1]

e(ii). Compare the results between the plants treated with short-day light and the plants treated with long-day light. [2]

e(iii). State, giving **one** reason taken from the data opposite, if unmodified rice is a short-day plant **or** a long-day plant. [1]

g. Evaluate, using all the data, how modified varieties of rice could be used to overcome food shortages in some countries. [2]

The diagram below shows a small portion of the tissue in a transverse section of a testis.



a. Outline the process of *in vitro* fertilization (IVF). [3]

b (i). Identify the cell labelled X. [1]

b (ii). Outline the function of this cell. [1]

c. Explain how meiosis results in genetic variation in gametes. [2]

The diagram below shows the structure of lactase

[Source: Kindly provided by RL Miesfeld, The University of Arizona, Tucson, AZ USA]

a (i). A study of 600 adolescents in Sweden showed that milk consumption has a positive effect on height which shows continuous variation. [1]

However, milk contains lactose which some people can digest but some cannot.

State the pattern of inheritance that contributes to continuous variation.

a (ii) Explain the production of lactose-free milk. [3]

b (i) Identify the protein structures indicated by I and II. [1]

I: .....
II: .....

b (ii) Describe how structure I is held together. [2]

b (iii) This protein is described as a globular protein. Distinguish between globular and fibrous proteins. [2]