HL Paper 3

Define *gene pool*.

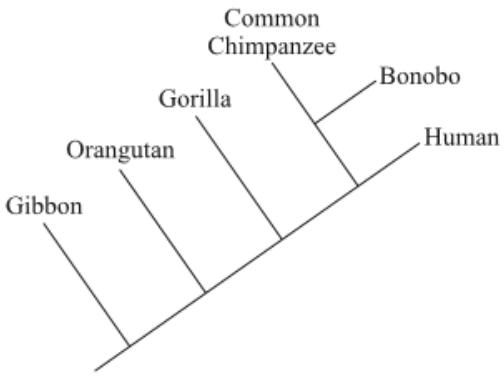
Markscheme

all of the genes/alleles in an interbreeding <u>population</u>

Examiners report

Most candidates had difficulty providing a complete definition for gene pool.

The diagram below is a cladogram.



a. State a function of each of the following parts of the human brain. [2]

(i) Cerebellum

(ii) Hypothalamus

b (i) Identify the **two** most closely related organisms. [1]

b (ii) Identify the species to which the Bonobo is most distantly related. [1]

c. Describe **one** type of barrier that may exist between gene pools. [3]

Markscheme

a. (i) (coordinates) unconscious motor functions/balance and movement

(ii) (maintains) homeostasis/thermoregulation/appetite/thirst / coordinates endocrine systems / secretes hormones/regulating factors

b (i) (common) chimpanzee and bonobo

b (ii) gibbon

c. named barrier;

description of its action;

results in terms of gene pools;

e.g.:

behavioural barrier;

different populations mate at different times of year thus preventing interbreeding;

allele frequencies become different in the two gene pools/separates gene pools / sympatric speciation;

Examiners report

a. The vast majority of candidates provided correct answers.

b (i) This part presented a cladogram of larger primates and the two subparts were interpreted correctly by the vast majority of candidates.

b (ii) This part presented a cladogram of larger primates and the two subparts were interpreted correctly by the vast majority of candidates.

c. This part required candidates to name a barrier that may exist between gene pools and describe its action and the results in terms of gene pools. Mixed results were obtained here, although many candidates gained all the marks. Some candidates confused between types of barrier and types of evolution (e.g. geographic vs allopatric), were vague about its action and could not relate to gene pools.

Cystic fibrosis (CF) is caused by a mutation of a human gene which codes for a chloride channel. The frequency of the CF allele is much higher in Europe than expected for an allele that causes a harmful condition. It has been suggested that individuals who are heterozygous for this allele may be protected against an infectious disease such as cholera or typhoid. This could cause both the CF allele and the normal allele of the chloride channel gene to persist in the population.

a. State the name given to the situation where two alleles of a gene persist indefinitely in a population. [1]

b. CF is a recessive condition that affects approximately 1 in 2500 births in Australia. Calculate the percentage of heterozygous individuals in the population. Show your calculation. [2]

c. Using CF as an example, distinguish between *allele frequency* and *gene pool*. [2]

Markscheme

a. balanced polymorphism

b. $2pq = (2)(0.98)(0.02) = 0.039$;

3.9%;

*Award **[1]** for working and **[1]** for correct answer.*

c. gene pool is all of the genetic information/genes/alleles present (in an interbreeding population);

allele frequency is the proportion of one allele of one/CF gene in a population;

Examiners report

a. The majority could name balanced polymorphism properly. Most knew that they had to apply the Hardy-Weinberg equation to find the percentage of heterozygotes in the population, but many had difficulties in determining the value of p and/or 2pq. Many found it hard to distinguish between allele frequency and gene pool using appropriate terminology. The conditions of application for the Hardy-Weinberg law were well known by the majority of candidates.

b. The majority could name balanced polymorphism properly. Most knew that they had to apply the Hardy-Weinberg equation to find the percentage of heterozygotes in the population, but many had difficulties in determining the value of p and/or 2pq. Many found it hard to distinguish between allele frequency and gene pool using appropriate terminology. The conditions of application for the Hardy-Weinberg law were well known by the majority of candidates.

c. The majority could name balanced polymorphism properly. Most knew that they had to apply the Hardy-Weinberg equation to find the percentage of heterozygotes in the population, but many had difficulties in determining the value of p and/or 2pq. Many found it hard to distinguish between allele frequency and gene pool using appropriate terminology. The conditions of application for the Hardy-Weinberg law were well known by the majority of candidates.

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b. Outline the endosymbiotic theory. [2]

c (ii)Define *gene pool*. [1]

Markscheme

b. a. mitochondria/chloroplasts were once (independent) prokaryotes;

b. taken in by (larger) heterotrophic/host cell (through endocytosis);

c. new living arrangement mutually beneficial / depend on each other to exist as single organism;

c (ii) all the alleles/genes of a population (at a particular time)

Examiners report

b. While many candidates were able to get 1 mark, and some 2, few wrote clearly or accurately about the endosymbiotic theory. The question was not asking for evidence of the theory which is what some candidates wrote about.

c (ii) The definition of gene pool in (ii) was answered better than in previous years.

Populations of threespine sticklebacks (*Gasterosteus sp*.), a fish living in small freshwater lakes in British Columbia, Canada, are derived from the marine threespine stickleback (*Gasterosteus aculeatus*). In order to investigate the process of speciation in these populations, three small lakes were studied. Each lake contained two varieties of stickleback: a large, bottom-dwelling variety that fed on invertebrates near the shore and a small, plankton-eating variety that lived in the open water. The probability of breeding between pairs of individuals was measured under laboratory conditions in the following breeding combinations:

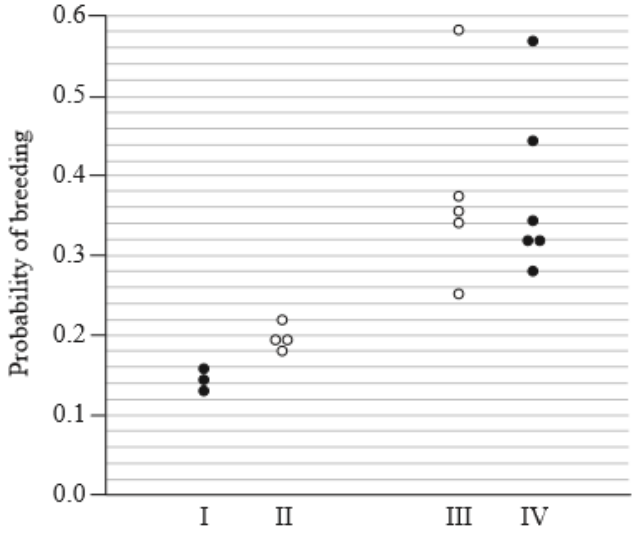
I different varieties (small × large) from the same lake

II different varieties from different lakes

III same variety (small × small) and (large × large) from different lakes

IV same variety from the same lake.

The data are summarized below.



[Source: HD Rundle, *et al*., (2000), *Science*, **287**, pages 306–308]

a. Identify the highest and lowest probabilities of breeding for individuals of the same variety from different lakes. [1]

Highest probability:

Lowest probability:

b. Identify the breeding combination that results in the lowest probability of breeding. [1]

c. Analyse the probability of breeding between individuals from the same lake. [2]

d. Scientists concluded that speciation is taking place in these populations. Discuss the evidence for speciation provided by the data. [3]

Markscheme

a. *Highest probability*: 0.58 (*Allow answers from 0.57–0.59*)

Lowest probability: 0.25 (*Allow answers from 0.24–0.26*)

Both required for the mark.

b. different varieties from same lake / I

c. individuals are more likely to breed if they are the same variety / individuals of different varieties have a low probability of breeding;

the probability of breeding between individuals of the same variety shows a large range of values / narrow range if of different variety;

the probability of breeding between any two individuals is always less than 0.6/correct numerical value;

d. data provides (strong) evidence for reproductive isolation between the varieties in each lake;

different sizes/feeding habits/habitat (shore versus open water) seem to contribute (strongly) to low breeding probability;

this could lead to speciation/formation of separate species in each lake;

same varieties from different lakes do not show strong reproductive isolation / geographical isolation is a weak factor in speciation / no evidence of allopatric speciation;

sympatric speciation seems to be taking place because different varieties from the same lake have a low probability of breeding;

Examiners report

a. Almost every candidate was able to find the probabilities required from the graph.

b. Almost all obtained one mark for correctly indicating that the lowest probability of breeding was between different varieties from the same lake.

c. Many were able to get one mark for indicating that individuals were more likely to breed if they were from the same variety but few received a second mark for looking at the variation in range of values.

d. This was the most discriminating section of this data analysis question with only the abler candidates discussing the evidence for reproductive isolation indicated by the data and for looking at what type of speciation this might be. Few used the terms allopatric or sympatric speciation.

Outline how isolation of a gene pool can lead to evolution.

Markscheme

a. initially isolated populations may have been genetically different/different allele frequencies;

b. different mutations in two gene pools;

c. different parts of population subject to different selective pressures / *OWTTE*;

d. over time leads to changes in allele/gene frequencies;

e. may lead to reproductive isolation;

Examiners report

Although this was a popular option, candidates did not do very well on it.

Candidates struggled to outline how isolation of a gene pool can lead to evolution. Very vague responses were seen with seldom any reference to different selective pressures on the isolated populations.

Discuss evolution by gradualism and punctuated equilibrium.

Markscheme

a. both describe the pace/speed/rate of evolution;

b. gradualism suggests that evolution occurs over a long time;

c. gradualism changes are slow/steady over time;

d. gradualism would occur when there is little change in the environment;

e. punctuated equilibrium implies long periods with no change;

f. punctuated equilibrium implies short periods with great change;

g. punctuated equilibrium occurs when there are great changes in the environment;

h. example; *(eg: in times of volcanic activity/meteorite impact/great climate change / OWTTE)*

i. generally accepted that both ideas take place in evolution

Examiners report

There was a very wide range of answers on gradualism and punctuated equilibrium. Most showed good general understanding, but gave answers that were too incomplete, especially about the required indications of time, as well as magnitude of change.

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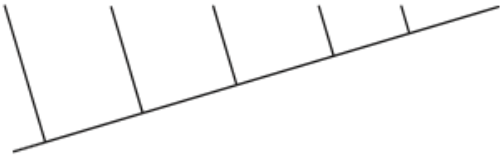
a. The table shows certain characteristics present (+) or absent (–) in six organisms. [3]

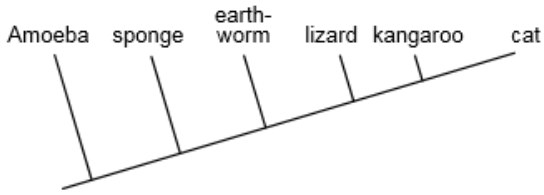
	Segmented	Jaws	Hair	Placenta	Multicellular	Limbs
Amoeba	–	–	–	–	–	–
Cat	+	+	+	+	+	+
Earthworm	+	–	–	–	+	–
Kangaroo	+	+	+	–	+	+
Lizard	+	+	–	–	+	+
Sponge	–	–	–	–	+	–

Using the data, label the cladogram with the names of the organisms.



c. A species is often defined as a group of similar individuals that interbreed in nature and produce fertile offspring. Discuss some problems with the use of this definition. [2]

Markscheme

a. 

*Award **[1]** for the correct position of any two organisms.*
*Award **[1 max]** if the correct order is reversed horizontally (ie from cat on the left to Amoeba on the right).*

c. a. not all organisms can be defined in this way / does not take into account hybrids/ microorganisms/plants;

b. (even if able to interbreed) may have differences in DNA/protein;

c. does not apply to bacteria/other organisms that reproduce asexually;

d. in sympatric/allopatric isolation members of the same species do not interbreed;

e. (in some species) significant differences in morphology can occur within the same species eg: sexual dimorphism/metamorphosis/ring species;

Accept any other correct answer.

Examiners report

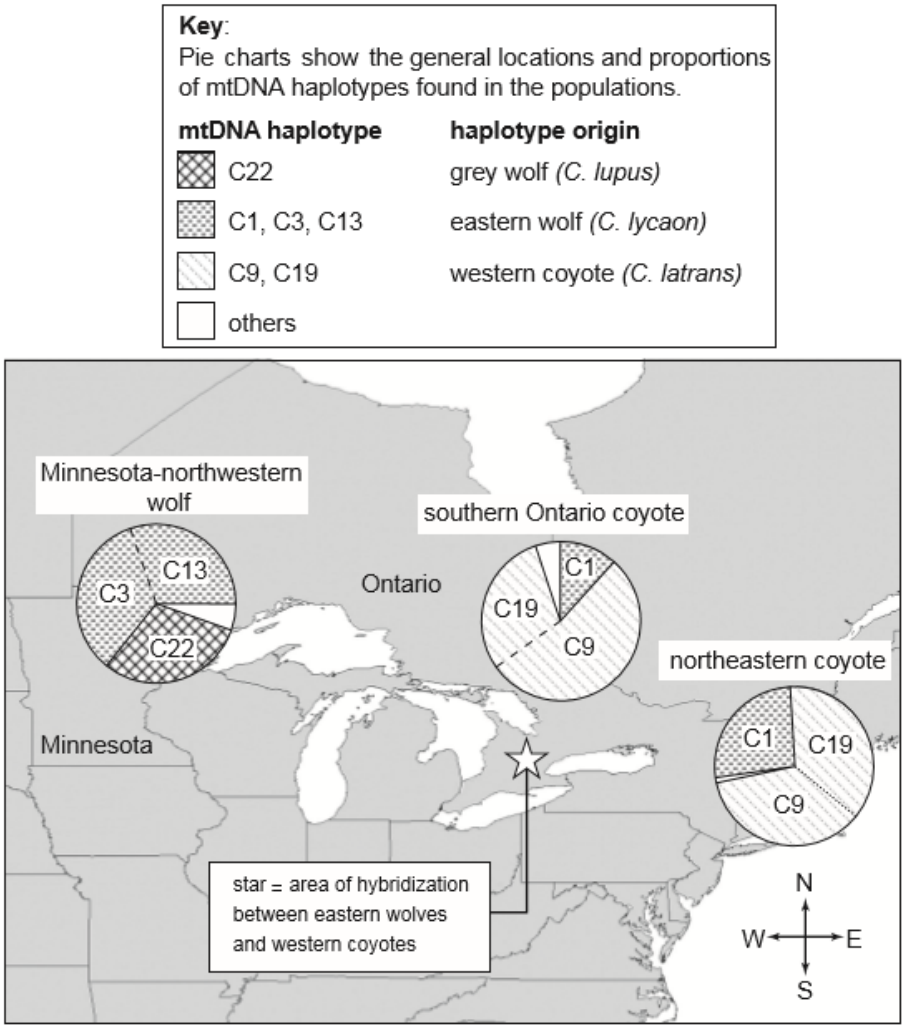
a. The majority of candidates could label the cladogram correctly, although a certain number did it backwards.

c. Many candidates presented a good discussion about the use of species definition, but many others could not express their ideas clearly enough or only had a vague idea.

There are many closely related *Canis* species in North America including the grey wolf (*C. lupus*), eastern wolf (*C. lycaon*) and western coyote (*C. latrans*). Hybridization can occur between members of these species.

For example, during the last 100 years, hybridization has occurred between western coyotes (*C. latrans*) and eastern wolves (*C. lycaon*) in the area of Ontario shown by a star in the map shown below.

Genetic evidence for hybridization is based on identification of haplotypes (combinations of linked alleles in clusters of similar genes) that exist in mitochondrial DNA (mtDNA) of *Canis* populations. The populations in this study were the Minnesota-northwestern wolf, southern Ontario coyote and northeastern coyote. Assume that all animals in each *Canis* population have the same mtDNA haplotypes.



[Source: T. Wheeldon *et al.* (2010) *Biology Letters*, **6** (2), pages 246–247. Colonization history and ancestry of northeastern coyotes. By permission of the Royal Society.]

a. Outline the genetic evidence that *Canis* populations have hybridized. [2]

b. Compare the genetic data for southern Ontario coyotes and northeastern coyotes. [2]

c. State with a reason whether the genetic evidence shows that the western coyote and the grey wolf have overlapping ranges. [1]

d. The northeastern coyote has more wolf-like skull features than the southern Ontario coyote. Suggest a reason for this difference. [1]

e. Discuss briefly whether there is genetic evidence to show a common ancestor for the Minnesota-northwestern wolf, the southern Ontario coyote and the northeastern coyote. [2]

Markscheme

a. a. (all three) *Canis* populations show a mixture of haplotypes from two (or more) origins;

b. Minnesota-northwestern wolves have a mixture of haplotypes from grey wolf/*C. lupus* and eastern wolf/*C. lycaon*;

c. southern Ontario coyote has mixture of haplotypes from western coyote/*C. latrans* and eastern wolf;

d. northeastern coyote has mixture of haplotypes from western coyote/*C. latrans* and eastern wolf;

b. a. both contain haplotypes C1, C9 and C19;

b. C19 haplotype in greater proportion in northeastern coyotes / vice versa;

c. C9 haplotype in greater proportion in southern Ontario coyotes / vice versa;

d. C1 in smaller proportion in southern Ontario than northeastern coyotes / vice versa;

e. southern Ontario coyotes / northeastern coyotes have more haplotypes from coyotes than wolves;

f. fewer haplotypes from other sources in northeastern coyotes / vice versa;

c. no overlapping ranges since no haplotypes/C9, C19 from western coyotes present with haplotype/C22 from grey wolf in any of the hybrids.

d. northeastern coyote has greater proportion of C1/ haplotype from (eastern) wolf (than southern Ontario coyote)

e. a. all three show evidence that the eastern wolf was their ancestor/all have haplotypes from the eastern wolf;

b. southern Ontario and northeastern coyotes have different eastern wolf haplotypes from the Minnesota northwestern wolf / southern Ontario and northeastern coyotes have C1 while the Minnesota northwestern wolf has C3 and C13;

Examiners report

a. There were some comments on the G2 forms regarding the graphs for this question being difficult to analyze or confusing. The names of the wolves and coyotes did sometimes lead to confusion. One problem was that many candidates misread the diagram and thought it showed proportions of areas instead of proportions of haplotypes. Despite this, Question D1 often scored fairly well.

Most candidates were able to get 1 mark for either seeing that all Canis populations showed a mixture of haplotypes from 2 or more origins or for giving an example to support this. Only the better candidates were able to get 2 marks.

b. There were some comments on the G2 forms regarding the graphs for this question being difficult to analyze or confusing. The names of the wolves and coyotes did sometimes lead to confusion. One problem was that many candidates misread the diagram and thought it showed proportions of areas instead of proportions of haplotypes. Despite this, Question D1 often scored fairly well.

Most candidates again were able to get at least 1 mark, often for stating that both species had the same 3 haplotypes. Many were also able to get a second mark for telling how they differed in the proportion of these haplotypes.

c. There were some comments on the G2 forms regarding the graphs for this question being difficult to analyze or confusing. The names of the wolves and coyotes did sometimes lead to confusion. One problem was that many candidates misread the diagram and thought it showed proportions of areas instead of proportions of haplotypes. Despite this, Question D1 often scored fairly well.

Only better candidates were able to see there was no overlap in ranges and use the data to explain why.

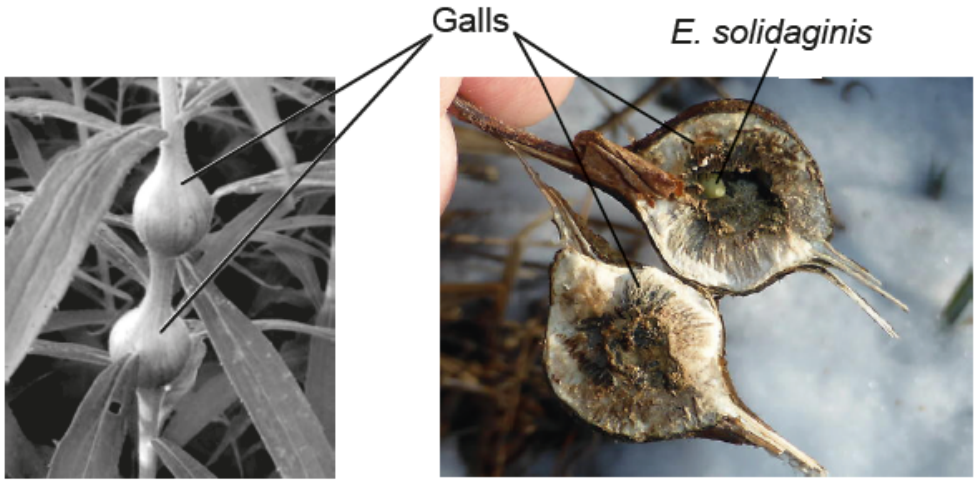
d. There were some comments on the G2 forms regarding the graphs for this question being difficult to analyze or confusing. The names of the wolves and coyotes did sometimes lead to confusion. One problem was that many candidates misread the diagram and thought it showed proportions of areas instead of proportions of haplotypes. Despite this, Question D1 often scored fairly well.

This was often answered well with many able to get a mark for suggesting that more of the C1 haplotype gave more wolf-like features to the northeastern coyote.

e. There were some comments on the G2 forms regarding the graphs for this question being difficult to analyze or confusing. The names of the wolves and coyotes did sometimes lead to confusion. One problem was that many candidates misread the diagram and thought it showed proportions of areas instead of proportions of haplotypes. Despite this, Question D1 often scored fairly well.

Many obtained 1 mark for seeing that the eastern wolf was a common ancestor but few were able to get a second mark.

The larval stage of the fly *Eurosta solidaginis* develops in the plant *Solidago altissima*. The larva secretes a chemical which causes plant tissue to grow around it forming a swelling called a gall. The gall provides the developing insect with protection from predators.



[Source: https://nhgardensolutions.files.wordpress.com]

[Source: Masumi Palhof]

The *E. solidaginis* fly is preyed upon by the parasitic wasp *Eurytoma gigantea*. The graph shows the relationship between gall diameter and the percentage of flies that avoid predation by *E. gigantea*.

a. In order to form galls, the insects choose a location where cell division occurs at a high rate. State the term for a region of rapid cell division within a plant. [1]

b. Describe the relationship between gall diameter and percentage survival of *E. solidaginis*. [2]

c. Explain the concept of directional selection with respect to this example. [2]

Markscheme

a. «apical» meristem/shoot apex

b. a. percentage survival is higher with larger diameter galls

OR

positive relationship

b. variation/outlier at the lower diameters *OWTTE*

c. little variation in survival percentage at highest diameters *OWTTE*

c. a. directional selection is when an extreme phenotype/characteristic is favoured *OWTTE*

b. flies that form small galls will be selectively predated *OWTTE – accept vice versa*

c. over time, flies that produce small galls will become rarer
OR
mean gall size will increase

Examiners report

a. [N/A]
b. [N/A]
c. [N/A]