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For Supervisor's use only

TOP SCHOLAR

NZQA

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

Scholarship 2009
Biology

9.30 am Friday 27 November 2009
Time allowed: Three hours
Total marks: 24

ANSWER BOOKLET

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should answer ALL the questions from 93101Q in this Answer Booklet.

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Start your answer to each question on a NEW page. Number each question carefully.

Check that this booklet has pages 2–26 in the correct order. Pages 2-4 are blank and are to be used for planning. Pages 5–26 are lined pages for writing your answers.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

Question number

1. When the lesser short-tailed bat first arrived in New Zealand (NZ), it was adapted to life in densely forested regions. They developed the tendancy to feed off the ground after introduction to NZ because of the local absence of ground-dwelling mammals (and thus little competition for insects) (~~except possibly the kiore~~). As NZ had few insectivorous, nocturnal mammals, the lesser short-tailed bat was able to access this niche and those that were more efficient insect catchers were able to survive and reproduce better as they were better nourished. Therefore, the structural adaptation of having wings that can fold to act as legs, became selected for as less energy was required to move short distances (as opposed to flying), natural selection acted by increasing the frequency of the allele(s) that allowed for feeding off of ground-dwelling insects, a invertebrates, pollen, fruits and nectars and "scurrying" across the ground. This process is directional selection, favouring those who can best access the ground food and move efficiently.
Furthermore, there were very few predators around in NZ until the recent introductions from humans, (the only predator then being the morepork which can feeds on both flying and non-flying bats) so there was little disadvantage from accessing food resources on the ground as predation rates would have been about the same either way.

Lesser short-tailed bats are still found in the relatively dense red beech forests of present day NZ and the fact that they are the main pollenators of the ground-dwelling wood rose plant suggests that it has been integrated into the NZ ecosystem.

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Question number

Gause's competitive exclusion principle states that no two species with similar ecological niches can co-exist in the same place for an indefinite amount of time. Any competition between the lesser short-tailed bat and the long-tailed bat has obviously been overcome as they have co-existed sympatrically for one million years. According to Fig 1(b), most lesser short-tailed bats are found in the vicinity of the red beech forest with virtually none being found on the forest's edge. While the long-tailed bat is found mostly on the forest's edge and is scarce in the red beech forest (where the forest is more dense and less suited to flying). This suggests that by feeding in different parts of the forest they are avoiding competition, which would be selected for as those who compete least would be able to feed best. Similarly, the emergence of long-tailed bats is, on average, an hour earlier than that of the lesser short-tailed bat. This allows the two species to avoid feeding on (some of) the same foods at the same time and wasting energy by competing.

Because the lesser short-tailed bat had already evolved a diet which included plant foods (fruits, pollen, nectar etc); not just insects, it was able to avoid the very strong competition that would have occured if it was completely insectivorous as the long-tailed bat is.

Question number

The fact that the lesser short-tailed bat is still able to catch flying insects means that it may start competing with long-tailed bats

The introduction of mice to NZ may mean that the lesser short-tailed bat will have to find an alternative for some of its food sources (fruits, invertebrates etc) and may begin competing more fiercely with the long-tailed bats than before mice arrived. This would lead to more niche divergence between the two bat species, which will then decrease the level (inter-specific) of competition. This may be in the form of periods of activity overlapping even less by the lesser short-tailed bat emerging later.

The ability of the lesser short-tailed bat to resist the relative cold of NZ also allows it to be more active during winter months and at colder times in the night than the long-tailed bat (which is more dependent on the warmth provided by non-winter months and is most active upto two hours after sunset - and is most active upto two hours after sunset - fig. 2). This means that even less competition occurs between the species.

The tendancy for long-tailed bats to be active earlier than lesser short-tailed bats is caused by their higher roosts //

Question number

2. The lactase persistence allele is dominant, so is expressed in all individuals who have at least one of these alleles. Also, it is known to be on an autosome (chromosome 2) (non-sex determining chromosome) so is found in the same frequency in males and females. It must have mutated in a germ cell, otherwise it would not have been inherited.

The lactase persistence allele must have mutated in a germ cell, otherwise it would not have been inherited. A possible senario:

	P	p
P	Pp	pp
p	Pp	pp

1:1 ration persistence : non-persistence

where P is the dominant mutation and p is the normal allele (non-persistence)

Any heterozygote would have about half of their offspring able to digest lactose for life, if they reproduced with a normal partner.

The mutation that allowed for lactase persistence was possibly in the gene that controls when the lactase gene is switched off and so would have caused it to no longer be able to down-regulate the production of no longer be able to down-regulate the production of lactase. This may have been a point-base substitution, but is more likely to be an addition or deletetion mutation, as a base substitution may have no effect on the polypeptide produced (because of the degeneracy of the genetic code) while additions/deletion mutations cause many amino acids in the peptide to change, as well as its length, so it is less able to regulate gene expression of the lactase gene.

PTO.

Question number

The cultural evolution of Homo sapiens lead to the use of animals as a food and energy source (about 10,000 years ago). Orginally, sheep, goats and cattle would have been farmed for their meat but when it was discovered that the milk was edible, the milking of animals became an easy way of gaining nutrition without the risks of hunting (about 8,000 years ago). Some of the nutrients in milk would have been available to non-persistent lactase humans (i.e. water, calcium, protein etc.) but those with the lactase persistence allele would have been able to access extra energy from the lactose (and also avoid painful stomach cramps from the gases produced by lactose fermentation). Therefore, the lactase persistence allele would have provided more ways in which energy can be accessed, so those with the mutation would survive longer and/or reproduce more often (and care for young more effectively etc.). Natural selection acted on the lactase persistence allele and it became selected for. However, this selection only occured in Europe and parts of Africa where the allele was already present (otherwise there would be no allele for natural selection to act on) and only in regions cattle, goats or sheep were milked and the milk was fed to humans (over the age of four). In other regions the mutation would have been silent (not advantageous or disadvantageous) if it did exist there at all.

Question number

The lactase persistence allele ~~may have~~ mutated in the ~~humans~~ Homo sapiens that ~~migrated out of Africa~~ lived in Europe ~~and may have mutated in Europe~~. This is the cause of the high frequencies in White Americans, non-indeginous Australians and New Zealanders, ~~all~~ all of which originated from Europe. There is also a high frequency of lactase persistence in Russia, which may have been acheived through copious gene flow between Russia and Europe. The medium frequency of lactase persistence in South American's, Mexicans, and Indians may be explained by the invasions and colonisations of Europeans ~~which~~ (the Conquistadors and the English) who may have also interbreed with the local population, introducing the gene and the concept of milking. The frequency is only moderate as only a short time has passed since the invasions, so the allele frequency has not been acted on by natural selection for long. The ~~two~~ founder effect may have also played a part in the ~~in~~frequency of ~~the~~ allele in these populations.

The ~~two~~ founder effect may have also played a part in the ~~in~~frequency of ~~the~~ allele in these populations.

The low frequency of the lactase persistence allele in ~~Southern~~ southern Africans is explained by the allele not having mutated in those who migrated / lived in southern Africa and little gene flow occured between them and populations with high frequencies of lactase persistence. North American blacks also rarely have the allele because of the recent slave trade that caused their forced migrations from Africa (and therefore no / few ~~to~~ mutant alleles).

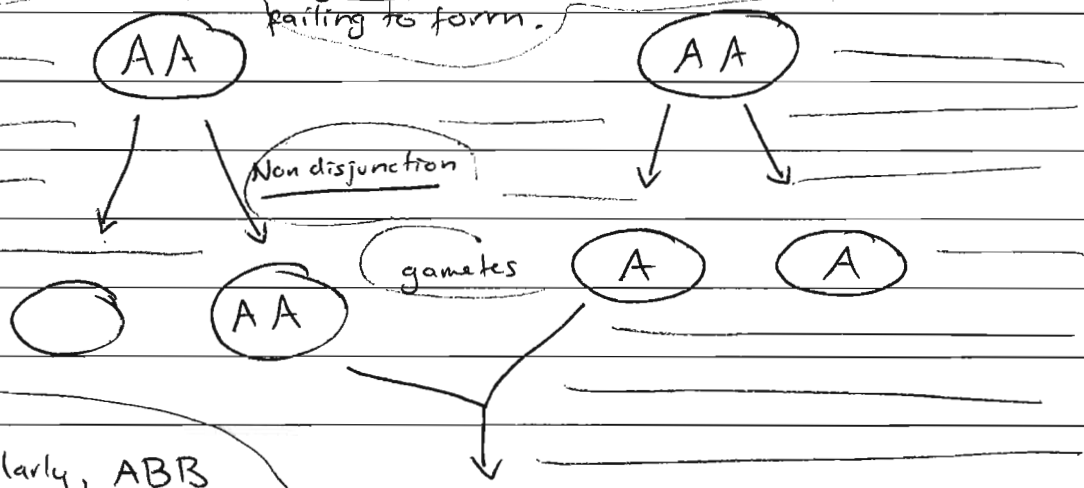
PTO.

Question number

Similarly, ~~little~~ gene flow would have occured in those who inhabited Asia and those with the lactase persistence allele, so the ~~frequency is~~ low. Furthermore, milking was uncommon until recently in Africa and Asia so little selection occured. Indigenous Australians are descended from these Asian populations so have a low frequency of lactase persistence.

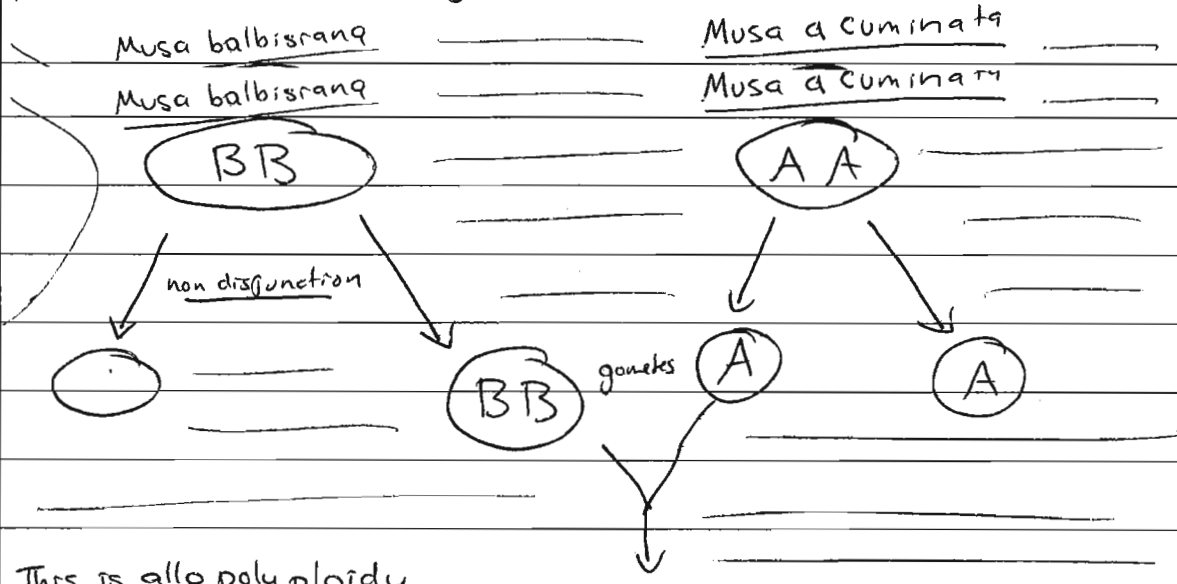
Question number

3. Non-disjunction during meiosis (failure of chromosomes to seperated during gamete production) is responsible for the AAA genome and the ABB genome. If one Musa acuminata was to produce a gamete that was diploid (AA) by non-disjunction, this gamete could be fertilised by a normal gamete (A) to produce the AAA genome. This is called autopolyploidy and is caused by the spindle fibres failing to form.



Similarly, ABB could be produced by a normal A gamete fertilising a BB gamete from Musa balbisiana produced in the same way:

AAA new species

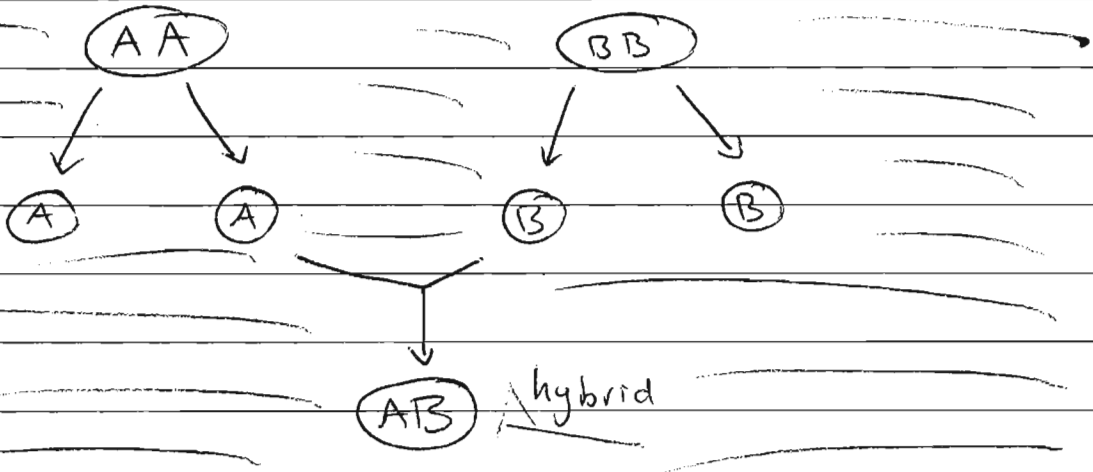


This is allopolyploidy (different species).

ABB new species.

Question number

The AB genome would have originated from the cross-species pollination between M. acuminata and M. balbisiana.



For these genomes to arise, there must firstly have been an "error" in producing the spindle fibres in meiosis causing both sets of chromosomes to end up in one gamete. Also, the new plants are not able to reproduce sexually anymore (as the chromosomes cannot pair up for meiosis), so these new species can only reproduce asexually. Furthermore, they must have been only marginally affected by the effects of hybrid disadvantage (in AB and ABB) or they would have been out-competed by normal bananas easily and no longer exist.

The Gros Michel, Grande Naine and Cavendish cultivars are a result of genetic variation between the "species". This variation may have been introduced by different plants of origin, for instance the Cavendish bananas may have been produced by plants that belonged to a different subspecies of M. acuminata than the plants that produced Gros Michel and Grande Naine.

Question number

This would mean that each cultivar would be genetically different (like humans are genetically different) and unable to interbreed (because of the inability of the chromosomes to pair up, causing infertility) so the genetic differences between the cultivars was maintained as no interbreeding occured.

Another possibility is that one AAA cultivar had a major mutation in a cell that asexually reproduced (deletion or addition) that caused the new cultivar to be identified as different to the original cultivar and hence given different names.

If a typical school laboratory investigation was to take place on the effects of ethylene concentration on the ripening rate of bananas there are some factors that must be considered. For instance, whether or not ethylene is used up when the bananas are ripening or if the ethylene reacts (e.g. with atmospheric Br_2, H_2 or Cl_2) to form a different substance which does not ripen the fruit. This is because if ethylene is used up, it's concentration will drop over time and the test will not be valid as the concentration cannot be allowed to change over time. The bananas used should be of the same cultivar so as to reduce the error provided by genetic variation as much as possible as a cultivar that reproduces asexually will be the most genetically uniform as each other They should also be at the same stage of ripening, as ethylene may have because

Question number

different effects on ~~the ripening~~ rate of bananas at different stages of ripening. (Colour of fruit may be an ~~unreliable~~ indicator.) ^Furthermore, the temperature of each trail should be kept constant because almost all biological reaction rates are effected by ~~the~~ temperature. ~~A good way to may make an investigatio. make reliable to begin~~ If some bananas were ripened at higher temperatures than others, they would ripen faster and error would be introduced.

By ripening several bananas ~~bananas~~ at once and then averaging the time for each banana to ripen to a given stage, ~~the~~ the ~~error~~ random error of the experiment can be reduced and the reliability improved. Normally, the larger the sample size, the better the results. ~~However~~

The experiment should ideally take place in a "fume cupboard" (which are a relatively common ~~in~~ chemistry classroom item) so as to prevent ethylene leaking out and other gases or pests getting in. //

out and other gases or pests getting in. //