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OUTSTANDING SCHOLARSHIP EXEMPLAR

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

QUALIFY FOR THE FUTURE WORLD
KIA NOHO TAKATŪ KI TŌ ĀMUA AO!

Scholarship 2015
Biology

9.30 a.m. Tuesday 10 November 2015
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.

Write your answers in this booklet.

Start your answer to each question on a new page. Carefully number each question.

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.

PLANNING

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Evolutionary & Ecological Factors.

- Gause's principle
- Outcompeted -> interspecific competition, niche overlap, resources
- Change in environment -> unable to adapt
  - -> lack of genetic diversity? - selection pressures.
  - ice ages, fires, flooding, temperature changes
- Moa extinction -> flightless -> dominant herbivore (little competition)
  - -> competition with turkey

Increase in rate of extinction.

- Effects of humans - destroying habitats, introducing predators or competition, hunting, technology, changing the world so fast that animals no longer have sufficient time to adapt.

Transfer of Moa DNA.

- cloning -> take nucleus from Moa place in egg of a host species female insert egg

-> Costly
-> low success rates
-> Old age of DNA
-> New species would lack genetic diversity.
-> Males & females required for a self-sustaining population
-> New competition
-> Not exposed to current day diseases
-> reduced habitat.

ecological effects

possible divergence
speciation

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Presence

rare variant -> result of mutation -> still produces functioning protein occurred in Denisovans

Mutation developed after H.S left Africa

Distribution

Denisovans found in east-central Asia after migration of H. Sapiens out of Africa. H.S populations already established around the world including in Asia.
interbreeding between Denisovans and H.S. -> rare allele EPAS1 gene passed on.
Provides selective advantage so selected for. - Describe
Allele frequency in gene pool increases so 87% have allele in Tibetan population.
Some interbreeding with Chinese - not selected for in lowland China so much lower frequency
Denisovans interbred with Oceania but no selective advantage for allele so allele not selected for - may have been lost from popⁿ.
No interbreeding with Europe or Africa so no rare EPAS1

PLANNING

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Distribution and diversity.
- Adaptive radiation → formation of many new species as new niches become available. - divergent evolution
- Different niches → different selection pressures → natural selection
  - beak → diet difference
  - colour → behavioural RIM promote speciation - courtship rituals, song
  - great phenotypic diversity. - disruptive selection
- Allopatric speciation → different islands, → geographically isolated
- Sympatric speciation → niche differentiation but in same geographic location.
- Reduce intraspecific competition for resources
- formation of new islands → new niches → new species

Most birds only found on one island.

Great genetic diversity

founders effect → arrival of pop^n to Hawaiian Islands
→ allele frequencies not indicative of original pop^n.

Genetic drift → initial small pop^n random loss or fixation of alleles.

Mutations allow for diversity

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Question One: Moa a goer?

There are a range of evolutionary and ecological factors which can contribute to declining population numbers that may result in the extinction of species. The first is competition. If there is considerable niche overlap between two species the species will adapt to new niches or one will out compete the other (Gause's competitive exclusion principal). If a species is less well adapted to its environment than another species that it shares this environment with it will be out competed and if it fails to adapt to a new niche may eventually become extinct. This happens when there are not sufficient resources in an area to support the populations living there. A change in environment can also lead to a decline in population numbers. If a species has a lack of genetic diversity and their environment changes they may not have an adaptation present within their population which is suited to or favoured in the new environment. If the species is unable to adapt to the new environment then their population numbers will decline which could ultimately lead to the extinction of their species. Examples of environment changes could include coming into or out of an ice age, fires, flooding, introduction of a new predator or new competition or removal of a species primary food source. Any of these would result in new selection pressures for the species, which if they cannot adapt to will result in the decline of population numbers and may ultimately result in extinction. Small population size, lack of genetic diversity or inbreeding too can also ultimately result in extinction. These increase the chances of lethal alleles coming together which could prevent or limit the reproductive success of the species. An example of species extinction due to a population decline is the Moa. With the

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arrival of humans in New Zealand came increased competition and predation for the Moa (the presence of humans caused a change in their environment). The arrival of humans would likely have been followed by the destruction of a large amount of the Moa's habitat as forests, shrublands and grasslands were ~~[illegible]~~ cleared away to make room for settlements, farms, etc. This would have significantly reduced the Moa's food supply which may have lead to their extinction. The arrival of humans could also have meant the introduction of new predators. As moa are flightless it may have been difficult for them to escape or avoid predators (having been the dominant herbivore) and they may not have been able to adapt to these changing selection pressures causing them to die out. Human technology has also drastically improved including hunting technology. Humans may be changing the ~~[illegible]~~ environment too drastically for some species to have sufficient time to adapt and therefore these species may become extinct. These technological advances may account for the very large increase in the rate of extinction in modern times as species do not have sufficient time for natural selection to work resulting in the extinction of species. Other factors may also be causes such as the spread of disease across much larger distances as a result of increased contact globally (ie. importing or exporting animals, increased international travel, etc.) which may facilitate the spread of disease exposing more of the species populations.
In order to restore a moa population humans could

manipulate the transfer of Moa DNA using cloning techniques. The nucleus or DNA of a moa species (ie. the Mantell's moa) could be inserted into a host egg of a living species of similar stature (ie. large domestic turkey). The egg would then be placed back inside the host to be nurtured and developed and the birth of the animal would result in the de-extinction of that species. However cloning does have many biological implications. Firstly it would be very costly and require a large amount of equipment and expertise. This makes it impractical. It also has very low success rates. This too proves costly as well as wasteful. The DNA being used is extremely old which decreases the chance of success. The new species would be likely to lack genetic variation and so could find it difficult to adapt to a new environment. An inability or difficulty to adapt may mean that the moa species will die out once again, not longer after having been brought back to life. Both males and females would be required for a self-sustaining population which means cloning would have to be successful more than once as well as viable fertile offspring being able to be produced.
If moa were brought back to life they would have new competition, be less adapted to modern day environment and may have ~~[illegible]~~ different food sources available to them compared to what they originally had. ~~[illegible]~~ Any new competition for them would already be adapted to this environment so would have an advantage over the moa which may allow them to outcompete the moa resulting in their extinction again.

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The different food sources may not be suited to the moas needs and it may have sufficient nutrients or plants that it's able to consume and so may die out once more. The different selection pressures of modern times however could result in changes to the moa phenotype as it adapts to fill a different niche to before or becomes better suited to the environment. The successful reintroduction of the moa could disrupt food webs. It may reduce the food supplies for other herbivores (as it was once the dominant herbivore) but could also provide a new food source for carnivores and scavengers. I feel that the restoration of a moa population is unlikely to be successful and the time and money could be better spent on keeping current endangered species alive. In addition moa have not been exposed to modern day diseases and so may not be able to fight them or recover from them which may result in them dying out. They would also be coming back to a significantly reduced habitat which may cause them to adapt to a slightly different niche or too result in their extinction again. 4

IV J

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EOJ ✓ EC ✓ (MCJ2) ✓ MSJ ✓ IEJ1 ✓

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Question Two: Human Dispersal

Any variation in genes (alleles) occurs through mutation. The rare variant of the EPAS1 gene exists as a result of mutation which caused a change in the amino acid sequence of the protein changing its function but still resulted in a functioning protein. It is most likely that this mutation occurred in Denisovans and was then passed on to groups of Homo Sapiens through interbreeding. The mutation must have developed after humans left Africa as it is not present in any ~~the~~ modern humans outside East Asia, including in other high altitude areas where it would be favourable or selected for. Denisovans lived in east-central Asia and co-existed with (lived alongside) modern humans. Interbreeding occurred between Denisovans and populations of modern humans living in Oceania and Asia. As a result of this interbreeding the rare variant of the EPAS1 gene was passed on at some point to the Tibetan and Han Chinese populations. This variant provided a selective advantage for those living at higher altitudes as it does not result in the overproduction of haemoglobin at high altitudes and so was selected for in those living at a high altitude. It is advantageous as it does not cause the blood to thicken in higher altitudes and so the problems associated with this (ie. heart attacks, strokes, hypertension, difficulty in conceiving, low birth weight and increased mortality). All of these could result in a decrease in the reproductive fitness or success of individuals within the population and so any gene variant which reduces the risk of or prevents entirely these problems would be selected for in

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higher altitudes. These problems are not issues at lower altitudes as the blood does not thicken due to EPAS1. As it is selected for at higher altitudes the individuals with this gene variant are more likely to survive and reproduce, increasing the frequency of their alleles in the population. This natural selection can account for the high percentage (87%) of the Tibetan population who have the rare variant of EPAS1. The ~~old~~ rare variant would not have the same benefits to the Han Chinese who live in lowland China and so the frequency of the variant in their population is much lower (only 9%) but is still greater than the rest of the world. The presence of the gene suggests interbreeding between Han Chinese and either Denisovans and/or Tibetans. The frequency of 9% may be due to chance or genetic drift or the allele for the rare variant may be linked to another gene that is selected for which increased its frequency to 9%. Denisovans also interbreed with modern humans living in Oceania and so the ~~m~~ rare variant could have been passed on. However as it provides no selective advantage to those living in Oceania at sea level, the allele would not have been selected for and so may have been lost due to chance or genetic drift (or may not even have been passed on). Denisovans did not interbreed with European or African modern humans and so these populations do not possess the rare variant of the EPAS1 gene.

PMJ ✓ LLJ ✓ LT ✓ LA ✓ LJ
PSJ1 ✓ LOJ ✓ LH ✓ LE ✓ 4D

PSJ LT LH LLJ LOJ LE

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Question Three: Hawaiian Honeycreepers

The large number of honeycreeper species that have existed is an example of adaptive radiation. As new niches became available and were exploited groups of honeycreepers adapted and diverged eventually becoming separate species. Different niches have different selection pressures which will favour different phenotypes. Natural selection means that those individuals best suited to that niche will survive and reproduce, increasing the frequency of their alleles in the population. For example the differences in the size and shape of the beak amongst honeycreepers is likely due to a difference in diet. Different shaped beaks would be better suited to different food sources (ie. nectar, fruit, seeds, etc.) and so divergence would occur as different beak shapes are selected for in different niches. Changes in body colour also resulted amongst honeycreepers. This may have been due to selection pressures on body colour (ie. camouflage for protection) a result of the 'founder effect' (ie. alleles for ~~the~~ different body colours may have been lost or fixed in different populations which eventually became different species) or as a result of linked genes in which the gene for body colour ~~was~~ is linked to a different gene (ie. beak size) which is being selected for or against. Any of these would have resulted in an increase in the frequency of that particular allele colour. This may have provided a behavioural reproductive isolating mechanism, which meant that birds of different body colour did not mate together (as not recognised as same species) and so promoted divergence until speciation occurred. Both allopatric and sympatric

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speciation occurred in the establishment of the diverse range of honeycreeper species. Allopatric speciation occurred when species were located on different islands ~~and~~ and so were geographically isolated when speciation occurred (ie. the Maui Creeper and Kauai Creeper being found on different islands). Sympatric speciation occurred when the species were not geographically isolated during speciation but another Reproductive isolating mechanism was in place (ie. ecological, behavioural, temporal, etc). Niche differentiation or the exploitation of new and different niches resulted in decreased intraspecific competition as the number of individuals trying to access the same resources would be reduced. This would increase the ~~[illegible]~~ reproductive fitness of the birds as they would be more likely to survive and reproduce. The formation of new islands resulted in new niches being formed. This allowed honeycreepers to exploit these new niches and adapt to them promoting divergence and hence speciation. When the initial group of birds (common ancestor of rose-finches and Hawaiian honeycreepers) colonised the Hawaiian islands they would have been subject to the founders effect. The initial gene pool for the birds on the Hawaiin islands is unlikely to be indicative of the original bird population — some alleles may have been fixed, not present at all or in higher or lower frequencies. This would have resulted in different allele frequencies in the gene

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pool and the more different selection pressures the birds were exposed to the more different their gene pool would become compared to the original population. Being a small population they also would have been subject to genetic drift (the random loss or fixation of alleles) which may have been a factor in their ~~[illegible]~~ divergence from both their common ancestor and divergence between populations in the Hawaiian islands. Any favourable mutations that occurred would have increased the diversity of honeycreepers as it would have enabled the exploitation of a new niche, promoted divergence and ultimately enabled speciation to occur. Most birds are only found on one island which would prevent or limit interbreeding and thus gene flow making it a reproductive isolating mechanism that prevents hybridisation and ~~[illegible]~~ promotes divergence and hence speciation. As most of them are only found on one island this also suggests that they have specialised niches which are not available for them to access on other islands explaining why they are only found on one island. Other birds such as the Apapane are found on all four islands suggesting that it is either able to adapt to different environments on all four islands or more likely that similar niches are available on all four. It also suggests that gene flow is

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occurring between the Apapane populations on the different islands to prevent speciation and divergence.

DNJ ✓
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DSJ ✓
DMJ ✓
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