New Zealand Scholarship
Biology

Time allowed: Three hours
Total marks: 24

Answer ALL questions from the Question Booklet.

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.

NOTE: This exemplar is adapted from the 2011 Scholarship examinations.
You have three hours to complete this examination.

Planning page
Planning page
Colony Collapse Disorder (CCD) is most likely brought about by multiple factors that result in the decline in the health of the adult bees and the subsequent collapse of the colony during mainly the winter months. One factor which may contribute is the substitute food of high fructose corn syrup (HFCS) that the bees are fed during winter. The bees have evolved to pollinate plants and use the nectar as a food source meaning their metabolism is suited to nectar. The HFCS substitute may not provide essential nutrients to the bees and consequently make them more susceptible to disease e.g. IAPV as they have a less effective immune system.

Another factor may be that insecticides such as neonicotinoids, applied to crops, accumulate in the nectar (and pollen) and is taken back to the hive to make honey. This is supported by the scientists' findings of insecticides in bees and beeswax. The insecticides are designed to kill pest insects by attacking the nervous system. If ingested by bees it may have the same effect, directly killing them and contributing to CCD. It may also have a less direct effect on killing bees by weakening their natural defence against pathogens and parasites.

This theory is supported by the evidence from hives that have experienced CCD; the adult bees are usually the only ones that die. This can be explained by the fact that only adult bees...
which eat honey (while immature bees do not) have accumulated insecticides within them which has led to their death or increased susceptibility to disease.

Colony of bees may be susceptible to parasites and pathogens, as a collective, due to the close proximity in which they live. Therefore, introduced pathogens and parasites can spread throughout a colony quickly. The Nosema ceranae fungus may further increase the chances of the bees not being able to survive the winter. If infected, bees may become malnourished as they cannot process food properly. This could result in decreased health of the bees which can result in death from the harsh conditions of the cold winter. Along with the varroa mite, the fungus is able to allow the bees to be more easily infected, contributing to CCD. Varroa mites can also carry IAPV, which is a lethal pathogen. The factors described above may compound to result in a colony of bees that could no longer survive an infection from IAPV. The result would be many adult bees becoming paralysed and dying when outside the hive. It is likely that IAPV (along with the other health hindering factors) is a large contributor to CCD because, with CCD dead bees are not found in the hive which coincides with the result of infection from IAPV when bees die outside the hive.

Information from the evidence provided is selected and organised to continue a coherent answer.
These factors most likely all act to result in CCD. The fact that CCD has resulted in huge losses of colonies could be explained by the fact that there are only few genetic lines of honey bees in the USA. This would mean there is not very much genetic variation within the honey bee population (ie all honey bees are relatively genetically similar). This would mean they would all be similarly susceptible to the factors that cause CCD.

Honey bees are the main pollinators of commercial crops in the world. The loss of mass number of colonies can therefore have a significant impact on both the managed and natural ecosystems.

In the managed ecosystem there is a high dependence on a bee colony due to the fact that most bee colonies we used to pollinate only one type of crop. If a certain colony collapses from CCD, the crop that depends on it for pollination may have a hindered production. Large losses of colonies may result in many crops such as nut, fruit, berry and vegetable not being pollinated. Therefore, the crops will die out (unless a new pollinator is found).

In nature, CCD may result in an imbalance in the ecosystem. Plants that depend on bees for pollination may become less successful as they could no longer reproduce successfully. Other natural
Relevant biological concepts not fully developed.

The script is at Scholarship level because the biological evidence is selected, organised and applied to biological concepts. It presents a well written discussion. This script is not at Outstanding Scholarship because it lacks depth, especially in the second part of the question.

Red underlining in the answers indicates evidence for the grades awarded.

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4 Js and 6 ds = 6
Question 2

Originally, there would have been a large ancestral, unspecialised population of butterflies with genetic variation present. Intraspecific competition would have occurred for resources such as food. When the environment started to change and different niches became available, small populations diverged and occupied these different niches to reduce competition. Each species only lays eggs on one variety of plant, and caterpillars only feed on this plant. This is an example of a prezygotic reproductive isolating barrier, "niche differences". When it is time to mate and lay eggs, only butterflies of the same species will be in contact and reproduce to produce offspring of the same species. Because different niches had different selection pressures, the different populations had different phenotypes and characteristics, so different alleles were favoured. This caused gene pools to diverge from each other, and because the populations were separated by prezygotic barriers such as temporal differences (mating at different times) or the inability to recognise different courtship rituals, the accumulation of genetic differences of gene pools caused speciation to occur. This was only possible because of the genetic variation present in the original population. As reproductive isolation occurred without any geographical barriers present, it is an example of sympatric speciation.
The eight different coloured phenotypes within the Amazon butterflies species shows mimicry. Batesian and Mullerian mimicry are two interspecific relationships. Batesian mimicry is when an edible species copies the phenotype of an inedible or dangerous species to protect itself from predators. Mullerian mimicry is when different species that are all inedible or dangerous exhibit the same phenotype and physical characteristics. Because the Amazon rainforest has so many species of predatory insectivorous birds (over 350), it is very advantageous for butterflies to demonstrate mimicry. The small number of only eight phenotypes means that many species exhibit the same phenotype and the birds will not prey on butterflies that they have learnt has an inedible phenotype. Mimicry may be the reason for some species displaying the same phenotypes and shows convergent evolution as distantly related species have the same phenotype, eg Pteronymia primula and Ithomia amicilla both have the “Euromeda” phenotype. However the phylogenetic tree of the butterflies shows divergent evolution because different species have evolved from a common ancestor. The large number of species of Ithomiine butterflies would have risen from the large number of vacant niches in the Amazon forest, and different populations being able to occupy those niches.
This answer is at Scholarship level because the biological evidence in the question has been considered and reasoned judgements have been made. The answer is coherent and well written, using biological terms appropriately. It is not at Outstanding Scholarship level because there is a lack of breadth and depth, so it is not sufficiently comprehensive. In addition, it does not draw on material beyond that provided.
The scientific evidence suggests that the two species, Homo neanderthalensis and Homo sapiens, diverged out of a common ancestral population of Homo heidelbergensis. Thus, it is likely that the H. heidelbergensis population must have split, with one dispersing towards the north into Europe and adapting to the different environment (different selection pressures - cooler climate, harsh ice-age conditions) to become H. neanderthalensis and the other evolving into H. sapiens within Africa.

After the separation from a common ancestor, H. neanderthalensis were exposed to cold conditions and adapted phenotypic characteristics that were a survival benefit for the species and gave the individuals a reproductive advantage, i.e., natural selection actively worked on the phenotypes (based on genotype) to select for individuals that had short and stocky body sizes, as these individuals were able to retain more heat, as they had a lower surface area to volume ratio, exposed in cold conditions. Larger body sizes were selected for as they allowed regulation of greater oxygen to the lungs in shorter time lengths in the cold conditions to maintain blood flow and respiratory responses.

The Neanderthals also evolved socially by living in groups of 8-25 individuals which allowed them to take care of each other, have division of tasks, give more protection to infants (ie, several females...
caring for the infants in the group), thus posing a greater survival advantage for the group. The fact that the females moved between different groups was a highly advantageous mechanism as it allowed for greater genetic variation within the Neanderthal groups, as alleles from different groups could be mixed through inter-breeding between groups. As a result, this provided a greater survival advantage as this meant that each group had greater variation of alleles in the gene pool.

The Neanderthals also evolved within Western Europe to hunt large herbivores, catching prey which meant meat made up most of their diet through complex cooperative hunting methods. The concept of cutting up meat using stone tools also indicates cultural evolution within Homo neanderthalensis.

Meanwhile, Homo sapiens evolved from H. heidelbergensis within Africa. They then dispersed into Europe and out-competed the residing Neanderthal populations. However, H. sapiens did breed with the Neanderthals, which is why the non-African H. sapiens populations share 4% of their DNA in common with the Neanderthals. The fact that the non-African H. sapiens populations share this DNA in common with H. neanderthalensis but not the African H. sapiens populations indicates that H. sapiens evolved within Africa.
Even though *H. neanderthalensis* had successful adaptations that allowed them to survive for up to 400,000 years, the species still faced extinction as a result of being outcompeted by *H. sapiens* populations.

*H. sapiens* did survive possibly as a result of a mutation(s) that resulted in alleles that allowed for greater neurological development which would have encouraged increased logic and reasoning, communication (wernicke's and brea's areas), expanding of cerebrum etc. As a result of increased logic *H. sapiens* could have had a greater survival advantage as they were able to imagine and plan ahead for successful hunting something the Neanderthals could not do. This mutation must have occurred after the divergence of the ancestral *H. neanderthalensis* population, such that it was only contained within the *H. sapiens* population and due to no gene flow, was not introduced in the Neanderthal population. As a result of their brain development *H. sapiens* were able to develop more sophisticated tools.

*H. sapiens* were able to outcompete *H. neanderthalensis* and were better adapted for surviving in the warming climate which led to them surviving and *H. neanderthalensis* becoming extinct.

Red underlining in the answers indicates evidence for the grades awarded.

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3 Js and 5 ds = 5
Overall this booklet is at Scholarship level. Throughout the three questions the candidate displays sufficient breadth of knowledge to make well-reasoned responses in a wide range of biological contexts. Answers are well written and contain relevant information, although they lack the depth and insight required for Outstanding Scholarship.
New Zealand Scholarship Biology

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Planning page
Planning page
Colony collapse disorder is likely to be caused by a combination of a number of factors. The fungus *Nosema ceranae*, by infecting the intestinal tract of bees, reduces their ability to process food. The honey that the mature bees eat, now full of insecticides including the new nervous system-attacking neonicotinoids, is unable to be broken down properly. This means that the neurotoxins will have a much greater impact on the bee's nervous system. Further, the fungus infection weakens the bee's immune system making it more susceptible to other infections as well as the neurotoxins in the insecticides. On top of this, the *Varroa* varroa mite, by feeding on the blood of bees, weakens their immune system further and thus their ability to cope with neurotoxins and viruses such as *IAPV* which the varroa mite acts as a vector for so the virus is spread quickly through the bee colonies. *IAPV* breaks down the ribosomes in bees, so preventing protein synthesis. This, combined with a weakened nervous system (due to the neonicotinoids, in the honey eaten by the mature bees), must be the final cause of the death of the mature bees as they become paralysed and die outside the hive, thus causing the lack of dead bees inside the hive. It must therefore be the insecticides putting the final nail in the colonies' coffin, so to speak, as CCD is a recent phenomenon as are the neonicotinoids. Also, only mature bees die first and they are the only ones...
This page shows perception and insight as the biological material, and knowledge from beyond is used in a fluent discussion.

Eating the honey, immature bees simply die after they are neglected by the dead mature bees.

These factors causing CCD are spread around the country rapidly because beekeepers carry their hives all over the country to pollinate commercial crops, so it is very easy for a colony infected by any or all of IAPV, Varroa, or Nosema from eg the southern USA to come into contact with a colony from eg the northern USA which then becomes infected.

All of the bees in the USA come from only 4 genetic lines, so if one or more of these lines carries a genetic defect that makes them more susceptible to one or more of the factors causing CCD, a large proportion of the population will be affected simply because of the similarity in the genetic makeup.

If bees are only able to pollinate one type of crop and are then fed only one type of substitute food (HFCS) in winter, they may not be getting a balanced diet which has a wide range of nutrients that would allow them to fight the factors causing CCD more effectively. Therefore, they may be more susceptible to CCD than "wild" bee populations that feed on a variety of nectars.

CCD could have a significant effect on both managed and natural ecosystems. Many managed
The analysis draws from material beyond that provided, leading to a fully integrated answer.

Ecosystems could almost completely collapse as honey bees are the main pollinators of most commercial crops. This would lead to reduced crop production — fruit, vegetables, nuts — so reduced food for humans (and any other animals that feed on the crops e.g. insects). Farmers may have to investigate use of native bee pollinators, or even other insects or birds as pollinators, to keep crop production viable. The number of seeds produced for future years would also decrease if pollination could not occur. Natural ecosystems could also suffer if 'wild' bee populations are affected by CCD too. If CCD does spread to 'wild' populations, 'wild' plants will not be pollinated and so the number of seeds will decrease, so plant numbers (of plants pollinated by bees) will decrease. Bird or wind pollinated plants may benefit due to reduced competition. Animals that rely on fruit or nuts produced by bee pollinated plants will have reduced food sources and some may starve. Birds and other pollinators relying on nectar from partially bee pollinated plants may suffer due to reduced plant numbers.

Therefore, there are many different factors combining to cause CCD in honey bees and the collapse of many hives of bees will have significant ecological impacts on natural and managed ecosystems.
Red underlining in the answers indicates evidence for the grades awarded.

CF2 CIJ
CV3 CTJ
CV1 CGJ
(NA1) CDJ
(NA2) MAJ1
5 Js and 5 ds = 7

This answer is at Outstanding Scholarship level. It uses independent thought to integrate evidence from the resource material provided, and beyond, to provide an in-depth response and make informed judgement. It is a fully integrated, coherent discussion.
The Amazon rainforest has a large number of different plant species. This results in many different ecological niches in the rainforest which butterflies could occupy. Gause's principle states that no two species may co-exist in the same ecological niche for a long period of time without one outcompeting the other. As all butterflies share a similar niche (adults feed on nectar, caterpillars feed on leaves) they would be in direct competition with their own species and also have interspecific competition for space and food. The diagram shows that species with the same phenotype are not necessarily very genetically similar e.g. Episcada sulphurea and Scala zibia both have the 'eurimediterranean' phenotype but diverged from each other a long time ago. This shows that the small number of color patterns in the butterflies is the result of mimicry as opposed to recent divergence.

Batesian mimicry is where a species visually mimics a dangerous or toxic species so as to avoid predation as the predators think that they too are toxic. As there are many species of insectivorous birds in the Amazon rainforest, this mimicry would have been beneficial to the species that were non-toxic and so the allele frequency for the phenotype similar to those of the toxic species would be selected for.

Mullerian mimicry is where a group of toxic species share similar phenotypes and so the
predators know that if an individual has an orange and black 'mothone' phenotype then they should not prey on it. Butterflies with a phenotype different to the 'mothone' would be recognized as non-toxic so would be preyed on and not survive.

The presence of mimicry is a form of convergent evolution where species of different origin develop similar characteristics (eg the color patterns) as a result of similar selection pressures (which are the birds). The predatory birds act as selecting agents as they remove phenotypes which they did not recognize as toxic. However, before this convergent evolution of phenotypes occurred, there was a lot of divergent evolution. This is a result of the biodiverse ecosystem that is the Amazon rainforest. The original unspecialized, genetically diverse, ancestral species would have dispersed into the available niches which are different as there are different species of predators and different plant food species. In the various habitats, there would be different selection pressures such as food availability and competition for space for reproduction that resulted in different adaptations being selected for or against eg color patterns. Dispersal into these niches would have been favored as a result of intraspecific competition for resources between individuals of the ancestral population. Over time, genetic differences
Would accumulate as there is limited gene flow between populations due to habitat or ecological differences, and also through beneficial mutations so that eventually the species became so different they would be unable to successfully interbreed because of some genetic isolation mechanism. Gametes unable to fertilize. Thus speciation would have occurred. This speciation is an example of sympatric speciation as there is no geographical barrier between the differing populations but rather other pre-zygotic isolating mechanisms. As the different species became more adapted to their respective habitats within an area, sympatric speciation would have continued to occur as the butterflies became specific as to what plant they laid their eggs on (ecological niche differences, reducing interspecific competition). This would have meant that there would have been reduced gene flow between populations so promoting speciation. During the caterpillar phase, species in the same habitat do not have much interaction as they live on their respective plants. However, as adults the butterflies drink nectar from a range of flowers common to other butterfly species in that habitat. Thus, they would be in interspecific competition with each other during this phase. However, the majority of growth occurs during the caterpillar phase and this would unlikely lead to any significant selection pressures for food as there.

A fluent and coherent discussion.
is no interspecific competition between the caterpillars as they don't interact. However, as the caterpillars of a species are on one species of plant, there would be increased intraspecific competition between them.

Thus, as a result of the divergence into species due to the abundance of different niches, there are many different species. However, due to the benefits of mimicry to the survival of the butterfly species, convergent evolution resulted in only a small number of colour pattern phenotypes.

A succinct, accurate summary addressing the question enhances convincing communication.

Red underlining in the answers indicates evidence for the grades awarded.
ED  EM,2
EC  EM,3
ET  EP
EN
EA
ER
EE
7Js + 3ds = 8

This answer is at Outstanding Scholarship level as it is a comprehensive discussion with both breadth and depth, showing sophisticated linking of biological concepts. The evidence is supported by evidence from the resource material and beyond. The discussion is fluent and coherent, and all material presented is relevant.
Homo heidelbergensis evolved in Africa. While most of the species remained in Africa, a small population dispersed into Europe. The much colder climate of Europe acted as a selection pressure on the population and short, stocky bodies were selected for — the population evolved into the species we call Homo neanderthalensis. They evolved their distinctive features which allowed them to survive successfully in the cold, Ice age climate present at that time in Europe. Their short, stocky stature provided minimal surface area to volume ratio reducing heat loss from the skin, large upper warmed and moisturized the cold air before it entered the lungs. By living in caves, H. neanderthalensis sheltered from the cold and wind. By living in small groups in large territories they had adequate resources such as food to access and provide for all. Females moving between groups provided gene flow, maintaining genetic diversity, and reducing the chances of genetic defects becoming prevalent due to inbreeding. Hunting large herbivores such as mammoths provided large amounts of meat with relatively little energy expenditure. Eating a mostly meat diet provided high levels of protein which provided the necessary heat and energy to survive.

H. heidelbergensis that remained in Africa evolved very differently and became the species we call Homo sapiens. The last harsh climate
Selected tall slender bodies which maximised surface area to volume ratio facilitating heat loss from the surface of the body. So individuals didn't overheat. Eventually, populations of H. sapiens migrated from Africa into Europe and dispersed into the areas where H. neanderthalensis lived. H. sapiens and H. neanderthalensis co-existed at some point and interbred - this is shown by the fact that H. sapiens not from Africa share 4% of their DNA in common with H. neanderthalensis. There is no sharing of DNA from H. neanderthalensis with H. sapiens in Africa.

It is likely that H. sapiens and H. neanderthalensis occupied the same or very similar niches once H. sapiens dispersed into Europe. Two species occupying the same niche cannot co-exist for long without one outcompeting the other (Gause's Principle). In this situation, H. sapiens outcompeted H. neanderthalensis who became extinct. H. neanderthalensis were specialists, adapted to cold climates and the resources found there. When the world warmed at the end of the ice age, they were unable to adapt and found survival difficult. With the arrival of H. sapiens, competition for the large herbivores increased. H. sapiens had a wider diet than H. neanderthalensis so were less affected by the competition. As the number of large herbivores decreased, it is likely that many
The small groups of *H. neanderthalensis* made them very easy to wipe out, as they were unable to form large groups that would have been able to defend themselves more effectively. Even if large groups did form, the reduced ability to communicate and so plan effectively would have made defence less successful. *H. sapiens* on the other hand, had no such survival difficulties. Their varied diet allowed them to survive on any food at hand. Their logic, memory, and communication allowed them to make sensible changes to the way they lived in order to survive more effectively in a wide range of different and changing environments. They could use knowledge of similar situations and past events to plan ahead and communicate these plans efficiently. This meant that their rate of cultural evolution was fast, allowing them to adapt rapidly to changes in their environment. They no longer had to wait many generations for biological evolution to create adaptive features to suit the environment; they were now beginning to create the environment to suit themselves. *H. sapiens* survived to exist today, while *H. neanderthalensis* became extinct.

Candidate analyses the information provided, and draws on their own knowledge to make an informed judgement.
Red underlining in the answers indicates evidence for the grades awarded.

HP   HS_{j}^{1}
RO   HS_{j}^{2}
HI_{j}^{1}
RF_{j}
RC_{j}
RB_{j}

6 Js + 2 ds = 7

This answer (Question 3) is at the Outstanding Scholarship level because it is a comprehensive discussion showing both depth and breadth of biological knowledge. It is a fully integrated, fluent, and clear answer.

Overall this booklet is at Outstanding Scholarship level because the answers have depth and breadth of knowledge drawn from the resource material provided and beyond. Answers are fully integrated, fluent and coherent, displaying convincing communication.