IB Biology HL - Prediction Exams
May 2025 - Paper 2

Paper 2

8 questions | 150 mins | 80 marks

Section A: answer all questions; Section B: only answer two questions

Filters | Go to Question

Question Type: All | Difficulty: Easy | Medium | Hard

Section A

Question 1

Hard

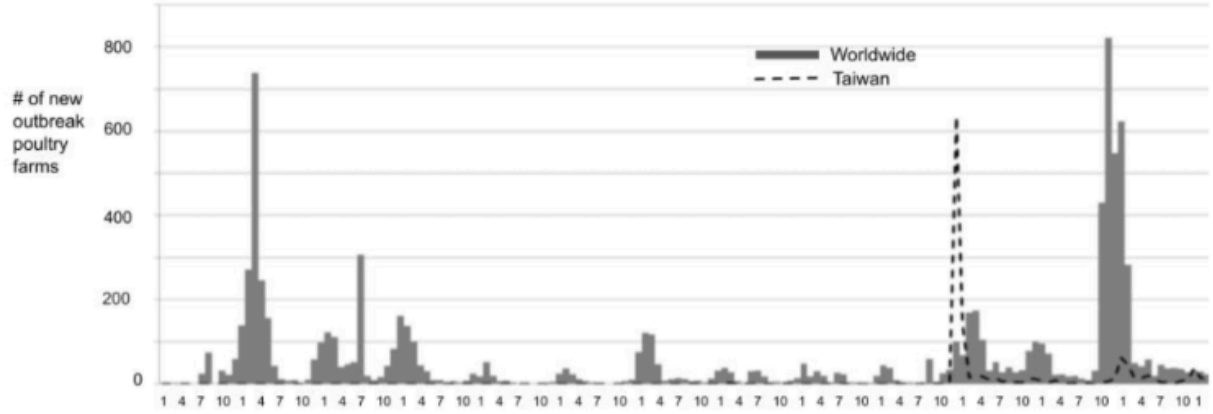
[Maximum mark: 15]

Avian influenza (AI), or bird 'flu, is caused by the influenza A virus, primarily affecting birds but occasionally infecting mammals, including humans. AI strains are classified as low pathogenic (LPAI) or high pathogenic (HPAI) based on disease severity in domestic chickens, though this classification does not always reflect effects in other species. A strain is considered HPAI if it causes $\geq 75\%$ mortality in infected chickens.

Both LPAI and HPAI occur worldwide, with outbreaks most common in Asia and fewer cases in Africa, North America, and Europe. AI outbreaks can have economic impacts on the poultry industry, potentially cause human pandemics, and threaten ecosystems.

Figure 1 shows monthly HPAI outbreaks in domestic poultry farms globally and in Taiwan from 2005 to 2017.

Figure 1. Numbers of new outbreaks in domestic poultry farms affected by the HPAI virus worldwide and in Taiwan from 2005 to 2017 by month.



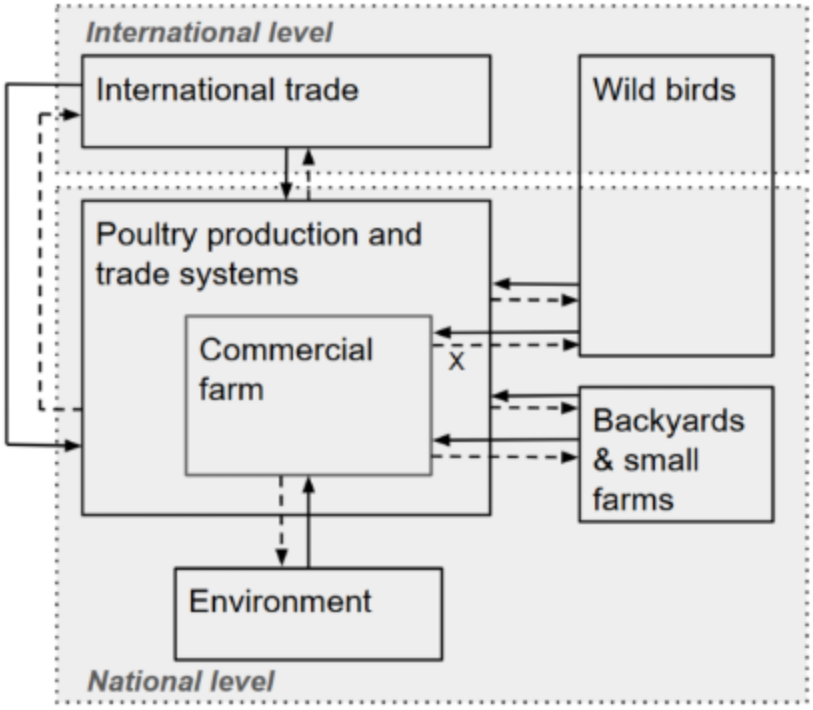
[Source Adapted from: Liang WS, He YC, Wu HD, Li YT, Shih TH, et al. (2020, August 13) *Ecological factors associated with persistent circulation of multiple highly pathogenic avian influenza viruses among poultry farms in Taiwan during 2015-17.* Retrieved December 23, 2024, from https://doi.org/10.1371/journal.pone.0236581. CC-BY 4.0]

(a) Using **Figure 1**, estimate the number of new outbreaks in poultry farms in Taiwan in month one of 2015. [1]

(b) (i) Describe the annual pattern observed in the worldwide data for the number of new poultry outbreaks, based on **Figure 1**. [1]

(ii) Suggest one reason for this observed trend, as shown in **Figure 1**. [1]

Figure 2 illustrates AI spread between compartments, with solid arrows for confirmed pathways and dashed arrows for suspected ones. "Poultry production and trade systems" are key concerns, with major transmission routes shown.



[Source Adapted from: Hautefeuille C, Dauphin G, Peyre M (2020, March 20). *Knowledge and remaining gaps on the role of animal and human movements in the poultry production and trade networks in the global spread of avian influenza viruses – A scoping review.* Retrieved December 23, 2024 from https://doi.org/10.1371/journal.pone.0230567. Copyright under CC BY 4.0]

(c) Identify one international source through which avian influenza (AI) entered the national poultry industry, based on the transmission pathways shown in **Figure 2**. [1]

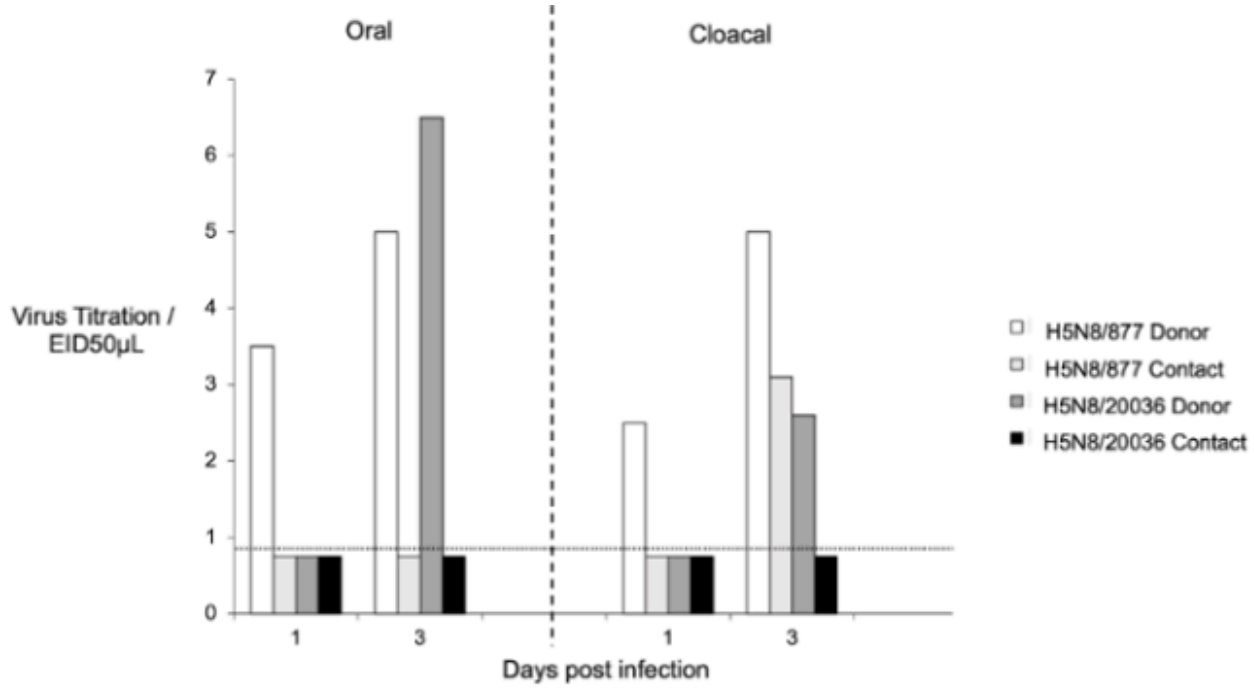
(d) The letter X in **Figure 2** shows the suspected transmission pathway from commercial farms to wild birds. Suggest one possible mechanism for this pathway. [1]

Since 2006, the World Organization for Animal Health has mandated the reporting of all LPAI H5 and H7 detections due to their potential to evolve into highly pathogenic strains.

The H5N1 avian influenza virus, first identified in 1996 in chickens, spread across Asia, Europe, Africa, and the Middle East, causing significant economic losses. While human transmission is rare, its high lethality and mutation potential make H5N1 a pandemic threat.

More recently, H5N8 has emerged, causing high poultry mortality and rapid spread among birds.

Viral shedding, the release of virus particles from infected birds, facilitates AI spread. In a study, chickens inoculated with H5N8/20036 or H5N8/877 (donors) were placed with uninfected chickens (contacts), and viral shedding was measured via oral (mouth) and cloacal (end of digestive tract) swabs at 1 and 3 days post-infection (DPI) using an EID assay. Figure 3 presents the results, with the dotted line indicating the lower detection limit.



[Source Adapted from: Moatasim Y, Aboulhoda BE, Gomaa M, El Taweel A, Kutkat O, et al. (2024, October 29). *Genetic and pathogenic potential of highly pathogenic avian influenza H5N8 viruses from live bird markets in Egypt in avian and mammalian models.* Retrieved December 23, 2024 from https://doi.org/10.1371/journal.pone.0312134. Copyright under CC BY 4.0]

(e) Deduce, with reason, whether the results from the research, shown in Figure 3, indicate that chickens should be housed in open areas to reduce H5N8 transmission. [1]

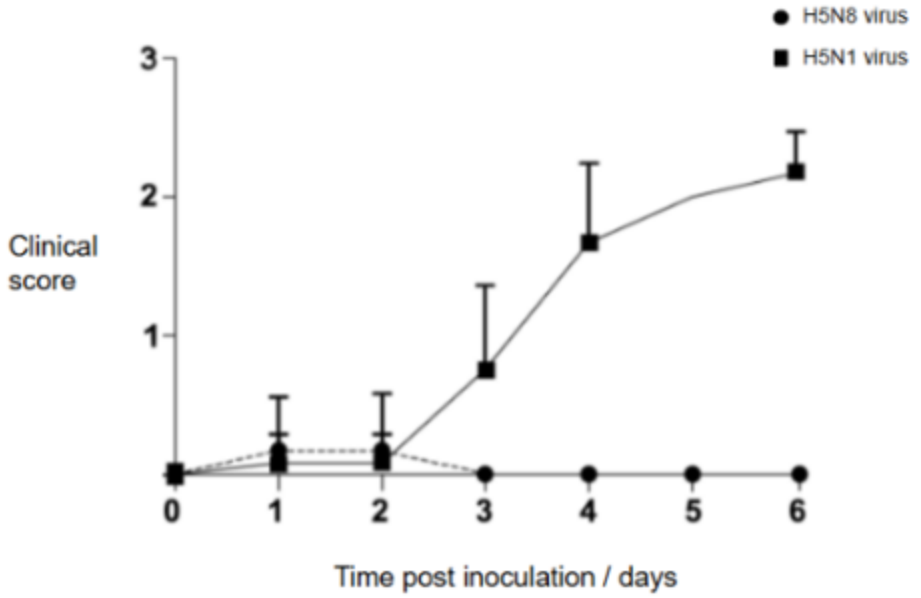
Like other flu viruses, HPAI H5N8 has mutation potential, raising concerns it could evolve to infect humans, similar to H5N1.

The virulence of the HPAI H5N8 virus was compared to that of the HPAI H5N1 virus in ferrets, a common model for influenza research due to their susceptibility to both human and avian influenza and their similar respiratory symptoms.

In the study, ferrets were inoculated with either HPAI H5N8 or HPAI H5N1, and clinical signs were scored daily:

- **0**: Alert and playful
- **1**: Alert and playful only when stimulated
- **2**: Alert but not playful when stimulated
- **3**: Neither alert nor playful when stimulated

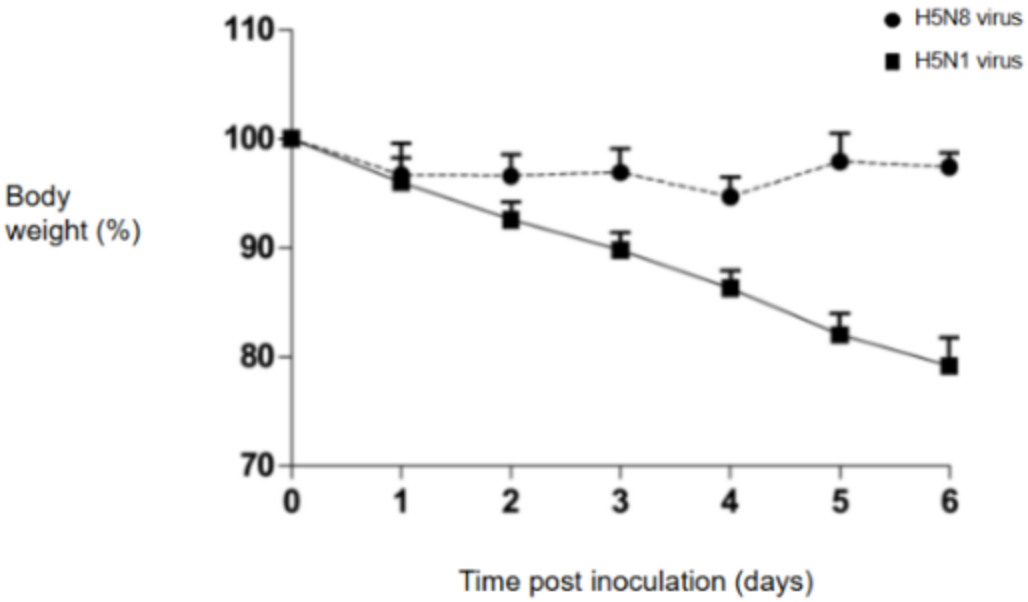
Figure 4 presents the results, with error bars indicating standard deviation.



[Source: Adapted from: Richard M, Herfst S, van den Brand JMA, Lexmond P, Bestebroer TM, et al. (2015, June 19) *Low Virulence and Lack of Airborne Transmission of the Dutch Highly Pathogenic Avian Influenza Virus H5N8 in Ferrets*. Retrieved December 23, 2024 from https://doi.org/10.1371/journal.pone.0129827. Copyright under CC BY 4.0]

(f) Compare the clinical scores of HPAI H5N8 and HPAI H5N1 inoculated ferrets over the six-day period, shown in **Figure 4**. [1]

Body weight was measured over the course of the study and calculated as a percentage change. The results are shown in **Figure 5**; error bars represent the standard deviation.

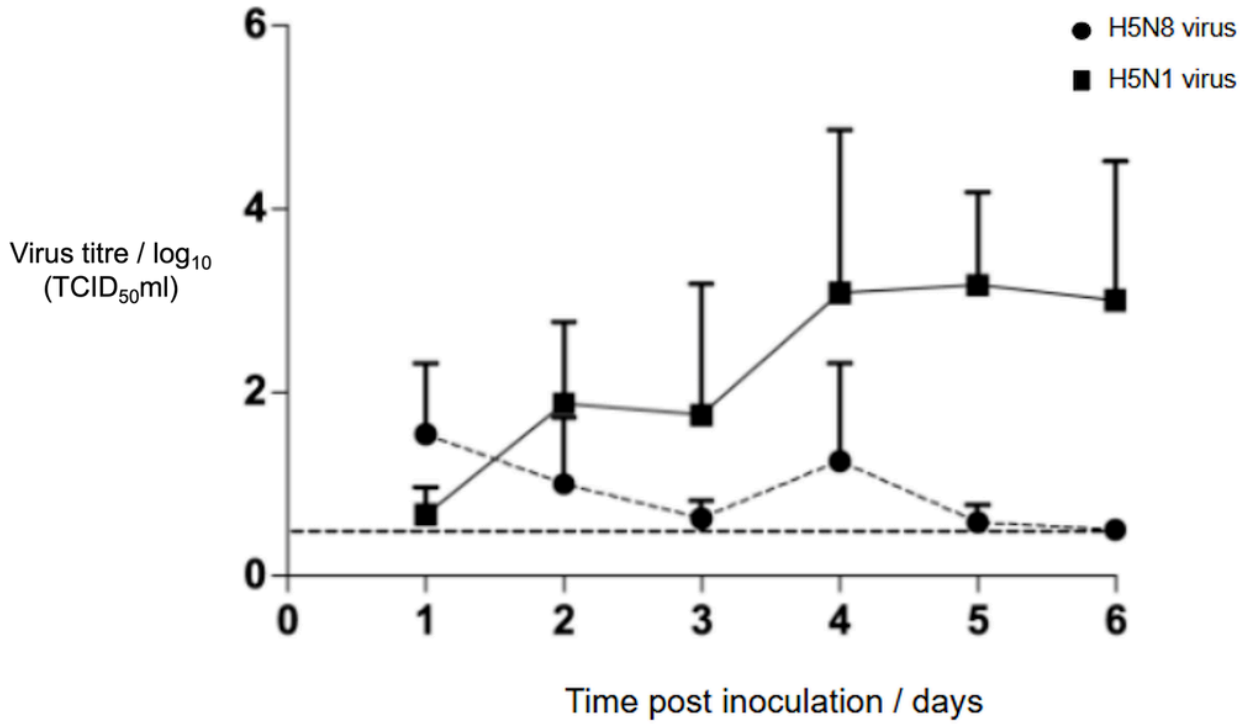


[Source: Adapted from: Richard M, Herfst S, van den Brand JMA, Lexmond P, Bestebroer TM, et al. (2015, June 19) *Low Virulence and Lack of Airborne Transmission of the Dutch Highly Pathogenic Avian Influenza Virus H5N8 in Ferrets*. Retrieved December 23, 2024 from https://doi.org/10.1371/journal.pone.0129827. Copyright under CC BY 4.0]

(g) Calculate the maximum weight loss (%) for ferrets infected with HPAI H5N8 and HPAI H5N1, using **Figure 5**. [2]

A virus titre measures the concentration of infectious virus particles in a sample, reflecting viral load. In this study, scientists collected throat swabs from ferrets and inoculated cell cultures to assess viral infection and host response.

Figure 6 presents virus titres in cell cultures from ferrets infected with H5N8 or H5N1. Dashed lines indicate the lower detection limit and error bars represent standard deviation.

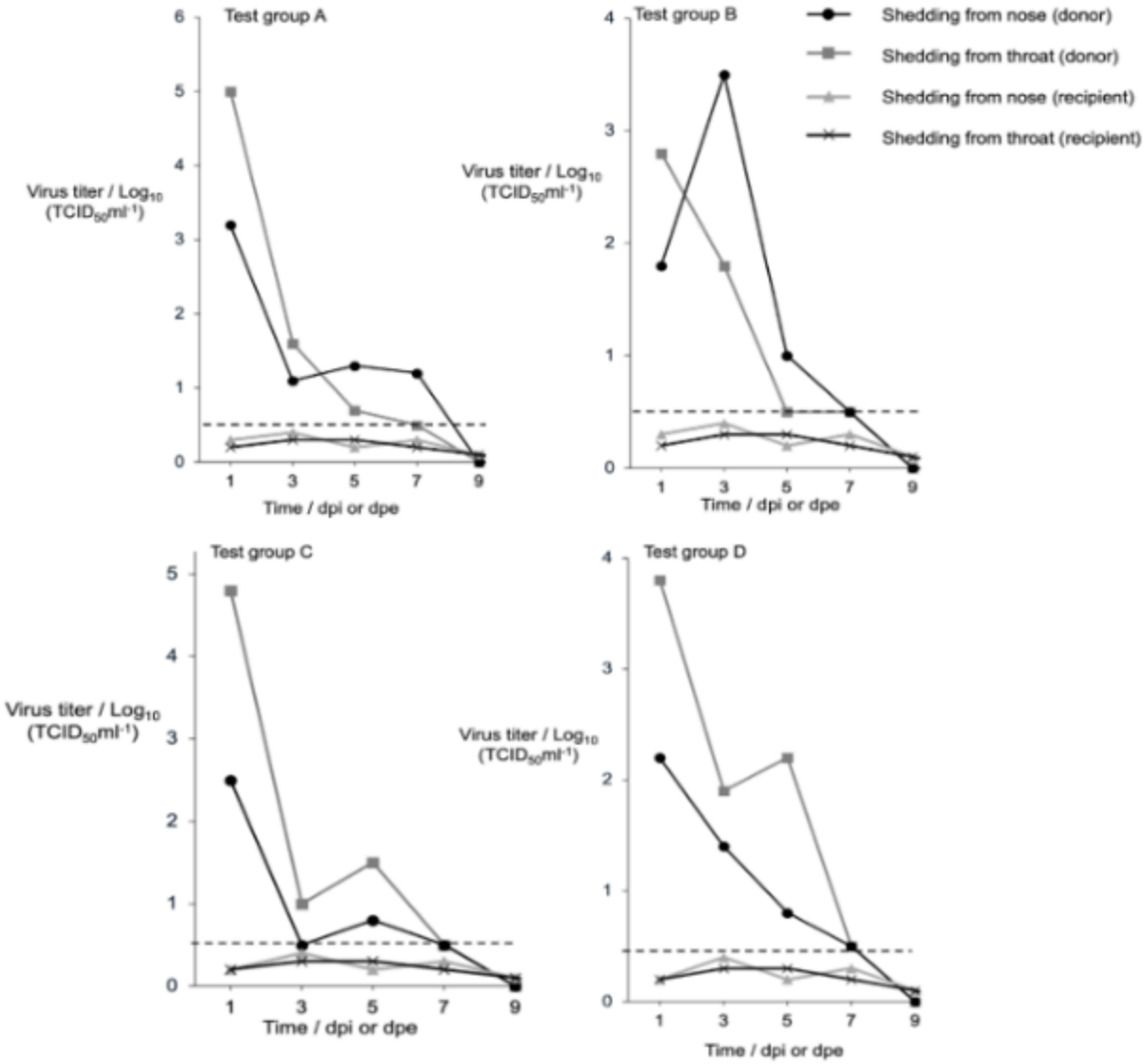


[Source: Adapted from: Richard M, Herfst S, van den Brand JMA, Lexmond P, Bestebroer TM, et al. (2015, June 19) *Low Virulence and Lack of Airborne Transmission of the Dutch Highly Pathogenic Avian Influenza Virus H5N8 in Ferrets*. Retrieved December 23, 2024 from https://doi.org/10.1371/journal.pone.0129827. Copyright under CC BY 4.0]

(h) Explain the relationship between clinical scores (**Figure 4**) and virus titre (**Figure 6**) in ferrets infected with HPAI H5N8 and HPAI H5N1. [2]

Each donor ferret was placed in a transmission cage after inoculation. After 24 hours, a naïve recipient ferret was introduced into the same environment, positioned opposite the donor. Each pair was housed in a separate cage allowing airflow but no direct contact.

Swabs from the nose and throat were taken from donor ferrets up to 9 days post-inoculation (dpi), while samples from recipient ferrets were collected at up to 9 days post-exposure (dpe) for virus titration. The results are shown in **Figure 7**; dashed lines represent the lower limit of detection.



[Source: Adapted from: Richard M, Herfst S, van den Brand JMA, Lexmond P, Bestebroer TM, et al. (2015, June 19) *Low Virulence and Lack of Airborne Transmission of the Dutch Highly Pathogenic Avian Influenza Virus H5N8 in Ferrets*. Retrieved December 23, 2024 from https://doi.org/10.1371/journal.pone.0129827. Copyright under CC BY 4.0]

(i) Describe the patterns of viral shedding in nasal and throat swabs from donor and recipient ferrets in all four test groups, as shown in Figure 7. [2]

(j) Discuss how the data presented in these studies can be utilised to inform vaccination measures for workers in the poultry industry. [2]

Video Solutions 11

Newton AI

Question 2

Medium

[Maximum mark: 8]

Haem is the non-protein, iron-binding component found in haemoglobin. Haem and chlorophyll are similar in structure but chlorophyll contains a magnesium ion instead of iron. The biochemical pathways that make haem and chlorophyll involve enzymes that are highly conserved across many distantly related species. The diagram shows an amino acid sequence alignment for part of one such enzyme, delta-aminolevulinate dehydratase. Each amino acid is represented by a single-letter code.

[Source: Alignment created with and adapted from Cobalt with Refseq and Genbank sequences from National Center for Biotechnology Information (NCBI)[Internet]. *Bethesda (MD): National Library of Medicine (US), National Center for Biotechnology Information; [1988] – [cited 2024]*. Available from: https://www.ncbi.nlm.nih.gov/]

(a) The diagram suggests that certain metabolic pathways are conserved across diverse organisms. Discuss how these conserved pathways provide evidence for LUCA. [2]

(b) Suggest two environmental conditions found in hydrothermal vents that may have facilitated the evolution of early metabolic pathways. [2]

(c) Explain how genomic analysis can be used to estimate the time period in which the last universal common ancestor (LUCA) existed. [2]

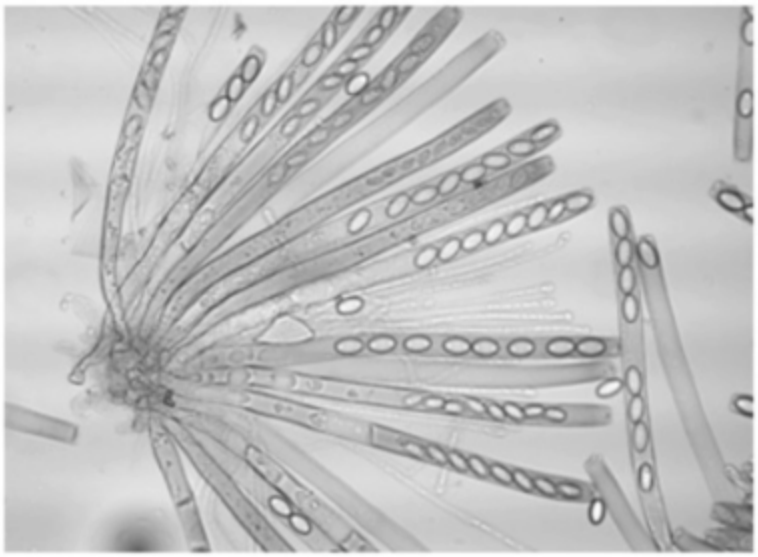
(d) Scientists discovered a bacterial enzyme with a significantly different amino acid sequence from its human counterpart but nearly identical function. Suggest possible reasons why this function is conserved despite sequence divergence. [2]

Question 3

Hard

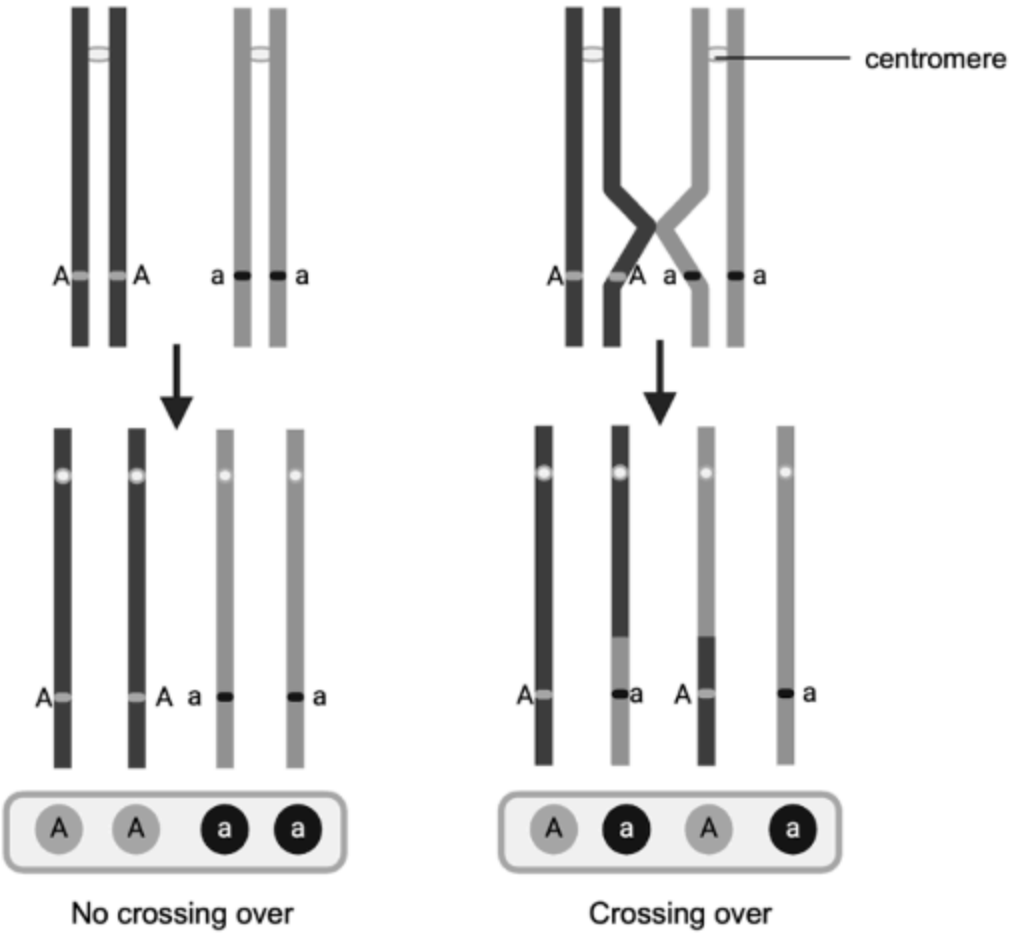
[Maximum mark: 10]

An ordered tetrad is a group of four haploid fungal spores contained within an ascus (a sac). These spores are arranged in a straight line, reflecting the exact order in which they were produced during meiosis.



[Source *File: Peziza nivalis (Port-neuf, Québec) 4.jpg.* (2022, April 8). Wikimedia Commons. Retrieved 03:33, January 15, 2025 from https://commons.wikimedia.org/w/index.php?title=File: Peziza_nivalis_(Port-neuf,_Qu%C3%A9bec)_4.jpg&oldid=647612529.]

The diagram below illustrates the process of crossing over and its effects on the arrangement of alleles within an ascus of a fungus. Scientists use biochemical markers of specific sequences or chromosomes to visualise the differences between spores.



[© Revision Village 2024. Created with BioRender.com]

(a) Explain how the arrangement of spores in the ascus without crossing over reflects the segregation of alleles during meiosis. [1]

(b) Describe how the recombination event alters the spore arrangement by contrasting the diagrams. [1]

(c) In a study of meiosis in a fungal species, the following percentages of tetrad types were observed: 65% no crossing over, and 35% crossing over. Predict how these percentages would change if the gene locus was closer to the centromere. [1]

(d) Describe a method to determine the relative positions of three genes on a chromosome using this type of analysis and only testing one gene at a time. [2]

(e) Describe the key events in meiosis I and meiosis II that lead to the spore arrangements shown in the diagram. [3]

(f) Explain how a mutation affecting the recombination machinery in fungi might alter the ratio of the ”crossing over” to ”no crossing over” patterns in asci **AND** predict the consequences for genetic diversity. [2]

Mark Scheme

Video Solutions 6

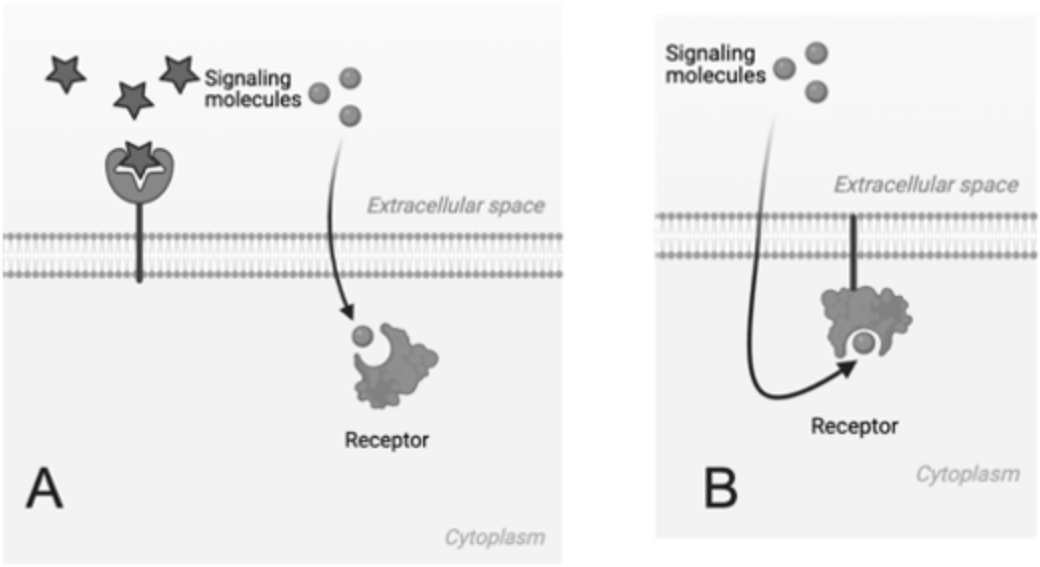
Newton AI

Question 4

Hard

[Maximum mark: 6]

The diagram below shows two different types of receptor proteins binding their ligands.



[Adapted from *"Intracellular Receptors"*, by BioRender.com (2025). Retrieved from https://app.biorender.com/biorender-templates]

(a) Deduce the probable properties of the amino acids in the ligand-binding site of the extracellular and intracellular receptors. [2]

Engineered receptors with transmembrane anchors, like the one shown in diagram B, are commonly used in research and therapeutic applications.

(b) Predict how the presence of a transmembrane anchor might affect the normal activity and localisation of an intracellular receptor. [2]

(c) Compare the signalling speed of integral membrane and intracellular receptors AND suggest a reason for the difference. [2]

Revisit | Complete

Mark Scheme

Video Solutions 3

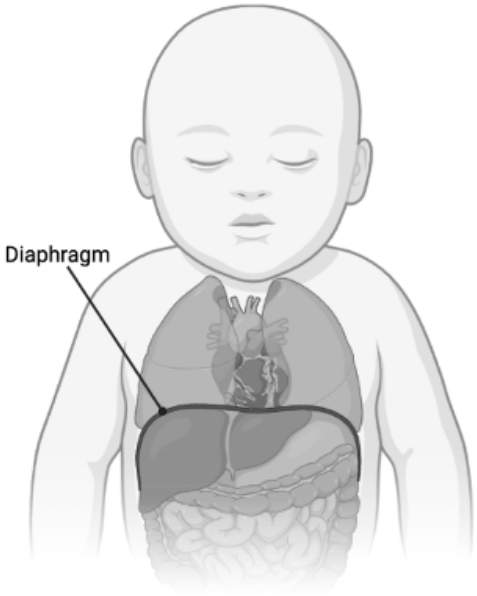
Newton AI

Question 5

Hard

[Maximum mark: 9]

Premature infants are often treated with caffeine to prevent episodes of apnea, a condition characterised by a temporary cessation of breathing. Although the exact mechanism of action is not fully understood, scientists have observed that treatment with caffeine leads to increased intracellular calcium levels in the muscle cells of the diaphragm.



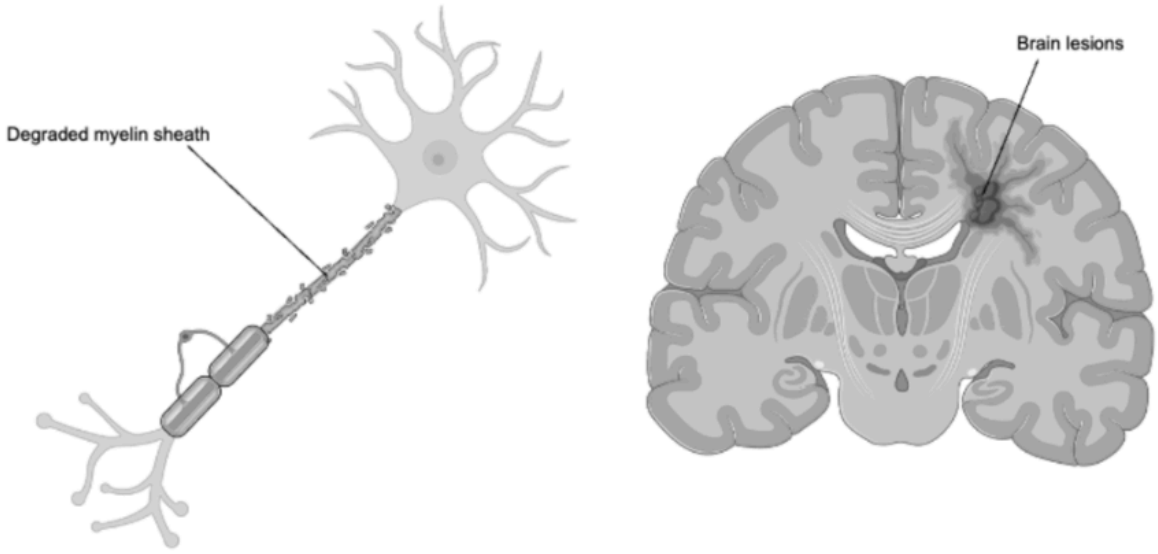
[Source: *File: Premature infant CPAP.jpg.* (2020, October 9). Wikimedia Commons. Retrieved 04:32, January 16, 2025 from https://commons.wikimedia.org/w/index.php?title=File:Premature_infant_CPAP.jpg&oldid=484646381.]

[Adapted from *"Newborn baby organs"*, by BioRender.com (2025). Retrieved from https://app.biorender.com/biorender-templates]

(a) State the organelle that is the most probable source of calcium. [1]

(b) Suggest a possible mechanism for the treatment's success. [1]

Multiple Sclerosis can also cause apnea. MS attacks the myelin sheath around neurons and leaves behind lesions in the brain.



[© Revision Village 2025. Created in https://BioRender.com]

(c) Describe how MS could result in apnea. [3]

Multiple sclerosis can also result in impaired ability to sense heat or cold, which can lead to accidental burns or frostbite when handling hot or cold objects.

(d) Explain the process by which high temperatures detected in the fingers trigger an action potential in an undamaged sensory neuron. [4]

Newton AI

Section B

Question 6

Hard

[Maximum mark: 16]

(a) Nutritional versatility is a key part of archaea's ability to colonise extreme environments. Describe the different sources of energy that archaea use for ATP production. [4]

(b) Discuss the effectiveness of Rubisco's active site in facilitating carbon fixation. [4]

(c) Explain how fatty acids can spontaneously form vesicles, and why this was important for the development of primitive cells (protocells). [7]

Revisit | Complete

Mark Scheme

Video Solutions 3

Newton AI

Question 7

Medium

[Maximum mark: 16]

(a) Explain four properties of water that make it important in supporting life on Earth. [4]

(b) Describe the recent methods used to reclassify plant groups, such as the figwort family (*Scrophulariaceae*), based on cladistic evidence. [4]

(c) Explain how the structure of synovial joints is adapted for movement and why this influences the range of motion. [7]

Revisit | Complete

Mark Scheme

Video Solutions 3

Newton AI

Question 8

Medium

[Maximum mark: 16]

(a) Outline how overpopulation is an important part of natural selection. [3]

(b) Discuss why sympatric speciation is less common than allopatric speciation [5]

(c) Explain how gonadotropin-releasing hormone (GnRH) and steroid sex hormones control the developmental changes during puberty. [7]

Revisit | Complete

Mark Scheme

Video Solutions 3

Newton AI

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