*This version of the test is Code 111. If you wrote a different version/code, you'll need to mark the correct answers on the version of the test that you wrote, then compare your Scantron answers to the order of answers on your version.

Circle the best single letter choice for each of the following questions before transferring your answers to your Scantron sheet. Note, for "multiple-multiple" style questions, more than one option may be correct (e.g. 1, 2 & 3 only). Part marks may be available for choosing some of the correct answers but choosing any incorrect answer earns a grade of "0". If you are unsure on these questions, play it safe.

*Correct answers are highlighted in yellow. Answers that received part marks are highlighted in purple.

*The grading of Questions 2, 22, and 24 were adjusted, please see the comments for these questions.

1. The translation of RNA to proteins occurs in a nearly universal manner in cells. Ribosomes "read" 3 nucleotide bases from an RNA molecule and the sequence of these 3 bases corresponds to a specific amino acid of a protein.

   How does this observation relate to evolutionary theory?

   A. It confirms that life has stopped evolving.
   B. It undermines the importance of variation in evolution by natural selection.
   C. It demonstrates that certain traits have evolved to function optimally.
   D. It is evidence that all life on earth has descended from a common ancestor.

2. George-Louise Leclerc (i.e. le Compte de Buffon) was a French naturalist. In his studies, he noticed what we now recognize as 'vestigial structures" in some organisms. What problem was created by the observation and recognition of vestigial structures in understanding the diversity of life when he was alive?

*An answer of B or C received 1 mark.

C is the correct answer, but B is also essentially correct, that the existence of vestigial structures indicates that organisms are not perfectly "designed", so perhaps were not created by a divine being

   A. Vestigial structures implied that individuals differed in their reproductive success.
   B. Vestigial structures implied that life on Earth was not created by a divine being.
   C. Vestigial structures implied that ancestors were (in some degree) different from their descendants.
   D. Vestigial structures implied that the Earth has experienced profound changes during its history causing some species to go extinct.

3. Which of the following statements correctly describes an aspect of evolutionary theory?

   A. Evolution progresses toward a goal.
   B. Individuals evolve when they develop new traits as their environment changes.
   C. Evolution results in organisms that are perfectly adapted to their environment.
   D. Evolution by natural selection does not occur unless there is variation in the population.

4. Why is Lamarck's theory of acquired characteristics NOT possible?

A. Individuals cannot pass on physical changes acquired over a lifetime to the next generation.
B. Fossils of animals with intermediate evolutionary stages have not been found.
C. It would take too much time for this mechanism to result in evolutionary change.
D. Individuals cannot acquire new characteristics over their lifetime.

B. Fossils of this sort have been found.

C. Knowing that the Earth is billions of years old, there is time for slow evolutionary change to occur. Furthermore, Lamarck's theory would actually result in relatively fast evolution.

D. An individual can acquire new characteristics over a lifetime, like building muscle mass or developing moles (but these acquired traits are not passed on to off-spring).

5. Which of the following observations was made by Charles Darwin in support of his theory of natural selection?

1. Most organisms produce more offspring than the number that survive to adulthood.
2. Populations do not increase in size indefinitely.
3. Food and other resources are limited for most populations.
4. There is variation in many characteristics among individuals in a population.

Darwin observed that 2 and 3 were true of populations of animals and plants, not only of people as he read about in Thomas Malthus' book

A. 1 and 3 0.5 marks
B. 2 and 4 0.5 marks
C. 1, 2, and 3 0.75 marks
D. 4 only 0.25 marks
E. All of 1, 2, 3, and 4 are correct

6. Pinyon pines (*Pinus edulis*) are small trees in the American Southwest that are able to survive droughts (long periods of dry weather) due to their water-use efficiency. Which of the following characteristics of pinyon pines would result in the evolution of increased water-use efficiency under severe drought conditions by natural selection?

1. Pinyon pines vary in their ability to use water efficiently.
2. When water is scarce, pinyon pine seedlings intensely compete for water.
3. Pinyon pines have different alleles of a gene, glycerate dehydrogenase, that affects their water-use efficiency.
4. Individual pinyon pines respond to water shortages by growing thicker leaves to prevent water from escaping.

option 4 is a physiological response to water shortage resulting in thicker leaves, and the thicker leaves is not a trait that will be inherited in the off-spring

A. 1 and 3 0.67 marks
B. 2 and 4
C. 1, 2, and 3
D. 4 only
E. All of 1, 2, 3, and 4 are correct

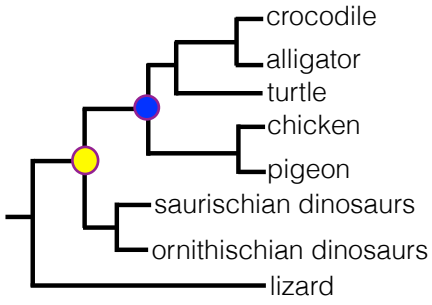
7. You capture 100 ladybugs and note that all of them have red bodies. As an experiment, you use non-toxic nail polish to colour 50 of these ladybugs green. The green-painted ladybugs are better camouflaged against grass and leaves, and are less likely to be eaten by birds. The green ladybugs thus survive longer than red ladybugs, giving them time to lay more eggs. However, when the next generation of ladybugs hatch, all of the off-spring are red, not green.

   Which of the requirements of natural selection was NOT met in your experiment?

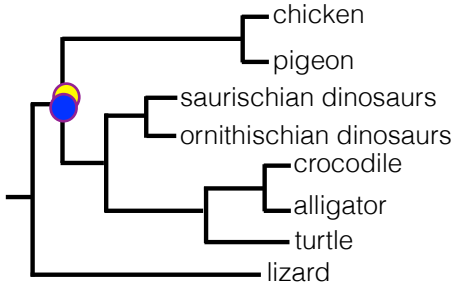
   A. Heritability of the trait
   B. Variation in the trait among individuals
   C. Differences in reproductive success due to the trait
   D. Selection acting on individuals

8. Which evolutionary tree below correctly shows that birds are more closely related to dinosaurs than they are to crocodiles?

A.



B.



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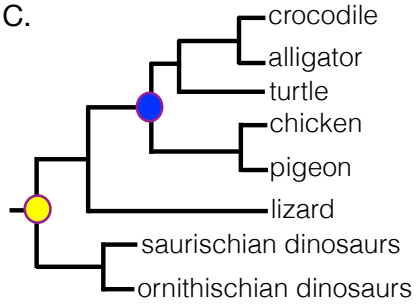


D.

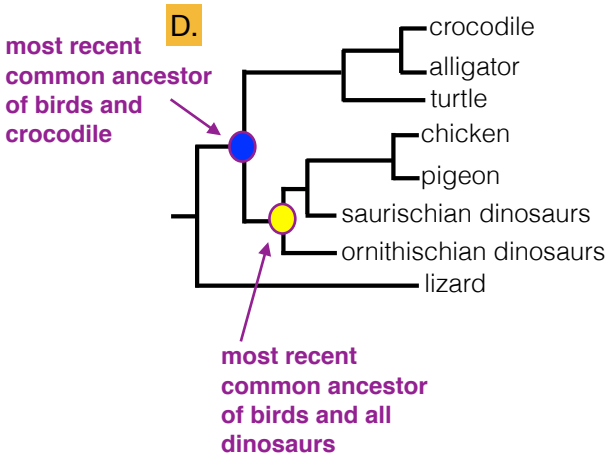
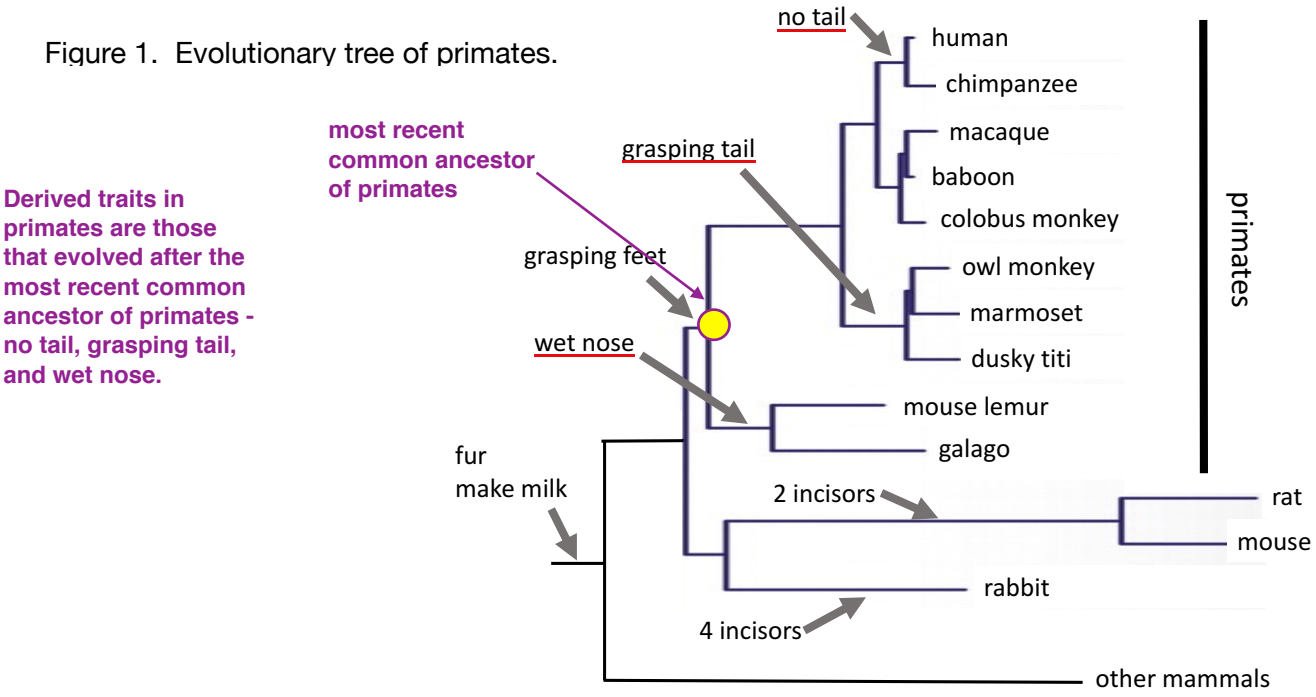


Figure 1. Evolutionary tree of primates.



9. Based on the evolutionary tree of primates above in Figure 1, which of the following traits is derived in primates?

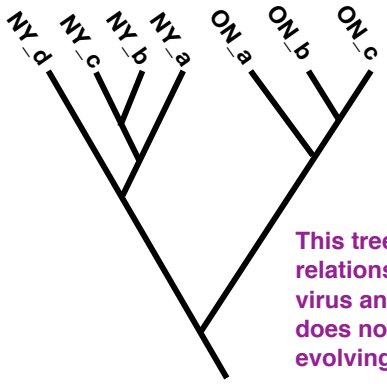
1. no tail
2. grasping feet
3. wet nose
4. 2 incisors (cutting teeth)

A. 1 and 3
B. 2 and 4
C. 1, 2, and 3
D. 4 only
E. All of 1, 2, 3, and 4 are correct

10. The spread of West Nile Virus (WNV) to new geographic areas can be monitored by building evolutionary trees based on nucleic acid sequences of the virus. West Nile Viruses were sampled from 4 locations in New York (NY_a, NY_b, NY_c, NY_d) and 3 locations in Ontario (ON_a, ON_b, ON_c) to determine the direction of their geographic spread.

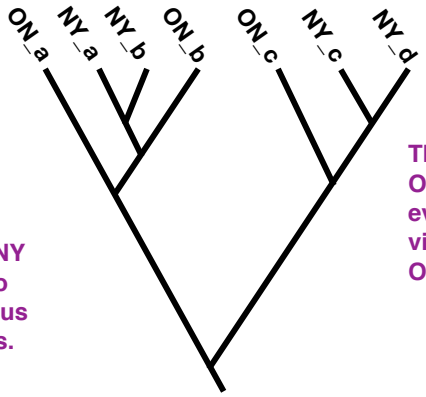
Which of the following trees supports the hypothesis of WNV spreading from New York to Ontario most convincingly (i.e. WNV in Ontario evolved from WNV that was in New York)?

A.



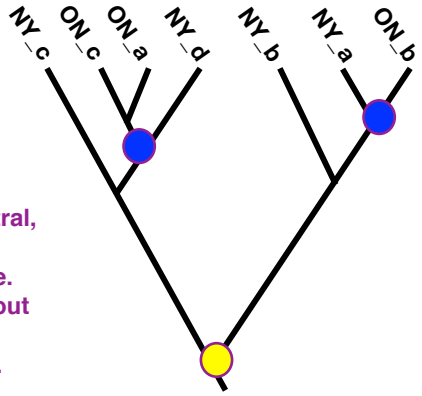
This tree shows equal relationship between the NY virus and Ontario virus, so does not show Ontario virus evolving from the NY virus.

B.



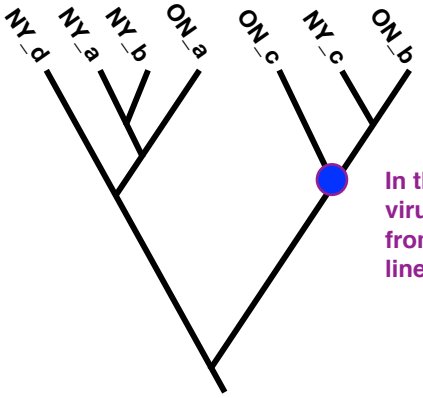
This tree shows Ontario virus as evolving first, then NY virus evolving from Ontario virus

C.



New York viruses ancestral, with Ontario viruses evolving from NY lineage. Another way to think about it - Ontario viruses are derived from NY viruses.

D.



In this clade, NY virus has evolved from Ontario lineage

11. Which of the following statements describes a difference between Bacteria and Archaea correctly?

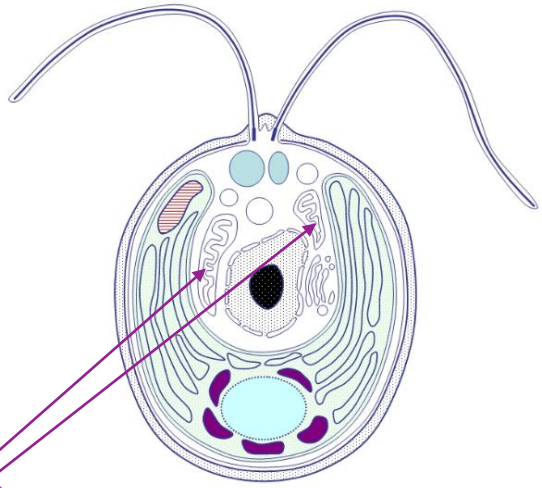
1. Nearly all Bacteria and Archaea have circular DNA chromosomes

1. Bacteria have circular DNA chromosomes, Archaea have linear DNA chromosomes.
2. Only bacteria have cell membranes made of lipid monolayers containing isoprene chains. 2. Archaea are known to have this structure of cell membranes, not Bacteria
3. Bacteria are distinctly different in shape from Archaea.
4. Many bacteria are known to cause disease in humans, but not Archaea.

C. Many Bacteria and Archaea are of similar shape and size, and this is not a good way to distinguish them

A. 1 and 3
B. 2 and 4
C. 1, 2, and 3
D. 4 only
E. All of 1, 2, 3, and 4 are correct

12. The diagram at right shows a single cell. Which of the following observations and conclusions about this cell is correct?



A. The cell has membrane-bound organelles, therefore it must be a eukaryotic cell.
B. The cell lacks a nucleoid region, therefore it must be a bacterial or archaeal cell.
C. The cell has flagella, therefore it must be a eukaryotic cell.
D. The cell lacks mitochondria, therefore it must be a bacterial or archaeal cell.

B. Bacteria and Archaea have nucleoid regions, they don't lack them

C. Bacteria and Archaea also have flagella, so this is not a trait that only eukaryotes have

D. mitochondria are here

13. Which of the following statements accurately describes multicellular organisms?

1. Multicellular organisms all develop from a single cell (eg. a fertilized egg) then this cell replicates make more cells, and eventually different tissues

1. They have a unicellular stage.
2. The DNA in each cell type is different.
3. Their cells rely on energy produced by mitochondria.
4. Multicellularity evolved only once resulting in plants, fungi, and animals.

2. Most cells in a multicellular organism have the same DNA, regardless of the cell type

3. Multicellular organisms are almost exclusively eukaryotes, so have mitochondria

4. Multicellularity evolved many times in the evolutionary history of life, to give rise to plants, to give rise to multicellular fungi many times, to give rise to animals, to give rise to brown algae, and also giving rise to other multicellular lineages.

A. 1 and 3
B. 2 and 4
C. 1, 2, and 3
D. 4 only
E. All of 1, 2, 3, and 4 are correct

14. Which of the following organisms has circular chromosomes in their cells?

1 and 2 are eukaryotes. These organisms have linear chromosomes in their nuclei, but also have circular chromosomes in their mitochondria.

1. *Suncus etruscus,* the smallest known mammal.
2. *Plasmodium vivax,* the protist that causes malaria.
3. *Prochlorococcus*, the group of bacteria that are the most abundant photosynthetic organism on Earth.
4. *Morbillivirus*, the group of viruses which causes diseases sucha s the measles.

3. Bacterial have circular DNA chromosomes as their primary genetic information

4. Viruses are not cells. And most viruses, such as Morbilliviruses, have linear genomes.

A. 1 and 3 0.67 marks
B. 2 and 4
C. 1, 2, and 3
D. 4 only
E. All of 1, 2, 3, and 4 are correct

15. Which of the following statements regarding unicellular organisms is correct?

A. They do not evolve.
B. They can be eukaryotic.
C. They are mostly disease-causing microorganisms.
D. Protists are exclusively unicellular organisms.
E. Egg and sperm are unicellular organisms.

A. All life has and continues to evolve

C. Most unicellular organisms do not cause disease

D. Brown algae, kelp, slime molds are examples of multicellular protists

E. Egg and sperm are not independent organisms, they are the reproductive cells of animals and technically a type of tissue of multicellular organisms

16. Which of the following observations describing evidence for the endosymbiotic origin of mitochondria is correct?

1. Mitochondria have circular DNA, like Bacteria do

1. Mitochondria have linear DNA chromosomes similar to protists.
2. Mitochondria divide and replicate similarly to prokaryotes.
3. Proteins for the electron transport chain are free (not attached) in the mitochondria.
4. The DNA in mitochondria has genes homologous to Bacteria.

3. Proteins for electron transport chain are attached to membranes inside the mitochondria, similarly to proteins attached to the plasma membrane of Bacteria

A. 1 and 3
B. 2 and 4
C. 1, 2, and 3
D. 4 only 0.5 marks
E. All of 1, 2, 3, and 4 are correct

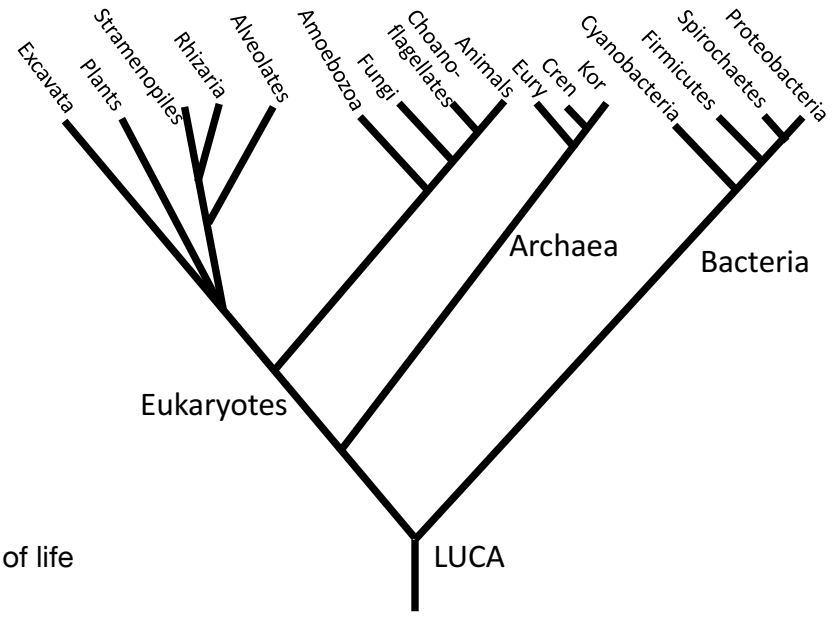


Figure 2. Evolutionary tree of life

17. Using the evolutionary tree of life (Figure 2) above as a guide and your knowledge of cellular life, which of the following statements about the evolution of life on Earth is true?

A. Eukaryotes are more closely related to Bacteria than to Archaea.
B. Golgi bodies are an ancestral trait of Eukaryotes.
C. Bacteria are more closely related to Archaea than to Eukaryotes.
D. Lipid cell membranes are a derived trait in Archaea.
E. Bacteria have more recently evolved than Eukaryotes.

A. Eukaryotes are more closely related to Archaea than to Bacteria

C. Bacteria are equally related to Archaea and Eukaryotes

D. All organisms have lipid cell membranes, so this is likely an ancestral trait of all life

E. As a group, the bacterial lineage evolved before Eukaryotes. And, all organisms continue to evolve.

18. Why are viruses not considered "life"?

A. Viruses are not made of cells.
B. Viruses do not have genomes.
C. Viruses are parasites.
D. Viruses do not use enzymes and proteins.
E. Viruses do not evolve.

B. Viruses DO have genomes, often dsDNA, but also other kinds

D. Viruses DO use enzymes and proteins, however they may not be able to make their own

E. Viruses DO evolve, like all forms of life do

C. Just because viruses are parasites is not a reason why they are not considered "life". Other lifeforms are parasites, eg. bacteria, insects, and depend on other organisms to survive, so being a parasite is not a criteria that defines life or not.

19. Which of the following statements about the chemical structure of DNA is correct?

1. The backbone of a DNA strand is comprised of repeating covalent bonds between phosphate and a base. 1. Backbone of DNA are repeating covalent bonds between phosphate and a sugar
2. Pyrimidines are equally common as purines in a DNA double helix.
3. The 5' end of a DNA strand ends in an OH group. 3. 5' end of a DNA strand ends in an PO4 group, 3' end is OH
4. Hydrogen bonds are broken when two DNA strands are separated.

A. 1 and 3
B. 2 and 4
C. 1, 2, and 3
D. 4 only 0.5 marks
E. All of 1, 2, 3, and 4 are correct

20. Bread wheat is a globally important crop, accounting for 20% of the calories consumed by people. The genome of the bread wheat plant consists of 7 different chromosomes, and its leaf cells are hexaploid (6n).

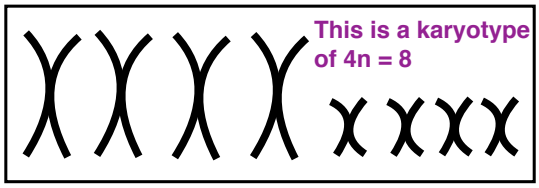
How many DNA double helices are in the nucleus of a leaf cell of the bread wheat plant (assume the leaf cell is in G1 phase so the DNA is not replicated)?

A. 14
B. 21
C. 42
D. 84
E. 168

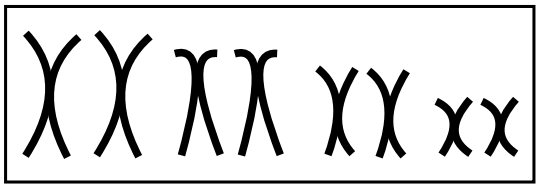
6n is 6 sets of 7 different chromosomes, so 6 x 7 = 42 chromosomes total
Each chromosome is one DNA double helix, when the DNA is not replicated.

21. Which of the following diagrams shows the karyotype of an organism that has 2N = 8 chromosomes? 2N means 2 sets of chromosomes, and in total there is 8 chromosomes
So, each set consists of 4 different chromosomes, and there are 2 of each different chromosome.

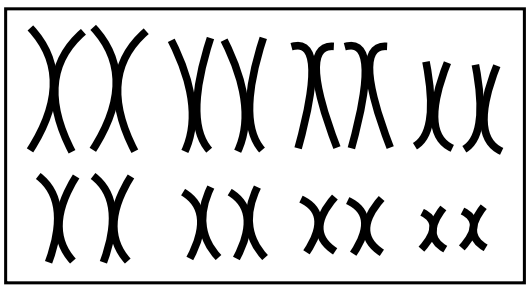
A.



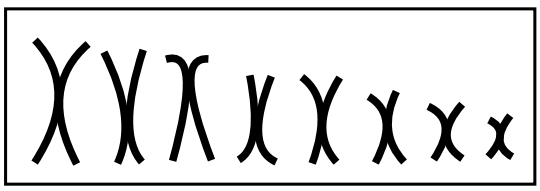
B.



C.



D.



*This question was unclear, and the answers reflected this. As a result, any answer was given 1 mark.

22. In his article on learning, Leamnson refers to understanding as a process of turning information into knowledge.

Which of the following strategies would Leamnson likely support in order to increase understanding of content in this course?

1. Explain course content to non-science colleagues
2. Create your own questions on course content
3. Discuss course content in small groups of other students in the course
4. Recall course content in relatively short time blocks over successive days

The intent of the question was to ask which study methods work to turn information into knowledge and to ultimately understand. Option 4 which describes recalling course content which helps in gaining information, but not the process of turning that information into knowledge and understanding.

A. 1 and 3 1 mark
B. 2 and 4 1 mark
C. 1, 2, and 3
D. 4 only 1 mark
E. All of 1, 2, 3, and 4 are correct 1 mark

23. The chili pepper *Capsicum baccatum* is a tetraploid (4N) organism with 20 picograms (pg) of DNA in each of its cells during G1 phase (i.e. a growth phase and the DNA has not replicated). What is the C-value for this organism?

A. 5 pg
B. 10 pg
C. 20 pg
D. 40 pg
E. 80 pg

C-value is the amount of DNA for a haploid (1) set of chromosomes. Tetraploid has 4 sets of chromosomes in each nuclei. So if there is 20 pg for 4 sets of chromosomes, 1 set would be 20 / 4 = 5 pg of DNA

24. Which of the following statements about alleles is correct?

*This proved to be a difficult question for everyone, so it was essentially removed from the test, everyone earning 1 mark.

A. For diploid organisms, there are only 2 alleles per gene 1 mark
B. Each allele is responsible for a different trait in an individual 1 mark
C. Alleles are different versions of homozygous genes 1 mark
D. Alleles are different versions of homologous genes

*Alleles are an important concept to understand that we will be discussing further and a solid understanding is essential. Take in the feedback posted below fo this question, and expect to find questions on alleles on future tests.

25. The human genome has low gene density, especially compared to the genome of the bacterium *Escherichia coli*. What does it mean for the human genome to have lower gene density than the *Escherichia coli* genome?

A. For the same length of DNA, there are fewer junk sequences in the human genome.
B. For the same length of DNA, there are fewer genes in the human genome.
C. For the same length of gene, there are fewer codons in the human genome.
D. For the same length of gene, there are fewer introns in the human genome.

Feedback for question 24:

A. For a group or population of diploid organisms, there can be more than 2 alleles that exist, but any individual can have a maximum of 2 alleles.

B. Different alleles may not result in a different trait if the DNA sequence for each allele does not result in a significant change in the protein. Also, a trait or phenotype is due to the combination of alleles in an individual, and can be due to many genes, not just the alleles of one particular gene.