Instructions (shown before students start the test)

- The rules for this event have been adapted for our virtual tournament and follow the **2020-2021 Regional Rules**.
- For fill-in-the-blank questions, the capitalization of the answers (e.g, **A**nswer vs. **a**nswer) will **NOT** be considered (i.e, both answers will be accepted). However, incorrect spelling and unnecessary spaces before/after the answers will lead to an incorrect answer. Keep this in mind!
- For multiple-choice questions with multiple answers, it's ALL or NOTHING - *there's no partial credit!*
- The maximum number of obtainable points on this exam is **116**.
- Leaving the test window is **NOT** acceptable - time outside the browser *will* be monitored by Scilympiad!!
- If you have any questions or concerns regarding this exam, feel free to contact me through the following email once the testing window has concluded: shrayenpatel@utexas.edu
- Exam Author: Shrayen Patel, *The University of Texas at Austin, B.S. Biology '24*
- Per Texas Science Olympiad rules, you must have printed notes for this event. If you are communicating with your partner through a voice or video call, please start it before you begin the test itself.

Significant time spent outside of the browser window is grounds for a penalty or disqualification per TSO policies.

Introduction (shown after students start the test)

Use the following scenario for the next 3 questions (1-3):

In giants, peach skin (R) is dominant to red skin (r).

1. (1.00 pts)
If a true-breeding peach-skinned giant is crossed with a true-breeding red-skinned giant, what percentage of the offspring will be peach-skinned and what percentage of the offspring will be red-skinned? The offspring here are considered the F1 generation for this sequence of questions.

- ○ A) 100% peach, 0% red
- ○ B) 75% peach, 25% red
- ○ C) 50% peach, 50% red
- ○ D) 25% peach, 75% red
- ○ E) 0% peach, 100% red

2. (1.00 pts)
If two F1 individuals are crossed with one another, what percentage of the offspring will be peach-skinned and what percentage of the offspring will be red-skinned? The offspring here are considered the F2 generation for this sequence of questions.

- ○ A) 100% peach, 0% red
- ○ B) 75% peach, 25% red
- ○ C) 50% peach, 50% red
- ○ D) 25% peach, 75% red
- ○ E) 0% peach, 100% red

3. (3.00 pts)

If two F2 individuals are crossed with one another, what percentage of the offspring will be peach-skinned and what percentage of the offspring will be red-skinned? The offspring here are considered the F3 generation for this sequence of questions.

(Mark **ALL** correct answers)

- [ ] A) 100% peach, 0% red
- [ ] B) 75% peach, 25% red
- [ ] C) 50% peach, 50% red
- [ ] D) 25% peach, 75% red
- [ ] E) 0% peach, 100% red

Use the following scenario for the next 5 questions (4-8):

In wizards, a purple coat (P) is dominant to a blue coat (p). Being fast (F) is dominant to being slow (f) as well.

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4. (1.00 pts)

If a true-breeding purple-coated + fast minion is crossed with a true-breeding blue-coated + slow minion, what percentage of the offspring will be blue-coated and what percentage of the offspring will be fast? The offspring here are considered the F1 generation for this sequence of questions.

- ○ A) 100% blue-coated, 100% fast
- ○ B) 50% blue-coated, 0% fast
- ○ C) 100% blue-coated, 0% fast
- ○ D) 0% blue-coated, 100% fast
- ○ E) 0% blue-coated, 50% fast
- ○ F) 50% blue-coated, 50% fast

---

5. (2.00 pts)

If two F1 individuals are crossed with one another, what percentage of the offspring will be purple-coated + slow and what percentage of the offspring will be blue-coated + fast? The offspring here are considered the F2 generation for this sequence of questions

- ○ A) 56.25% purple-coated + slow, 62.5% blue-coated + fast
- ○ B) 31.25% purple-coated + slow, 18.75% blue-coated + fast
- ○ C) 12.5% purple-coated + slow, 43.75% blue-coated + fast
- ○ D) 18.75% purple-coated + slow, 18.75% blue-coated + fast
- ○ E) 37.5% purple-coated + slow, 37.5% blue-coated + fast
- ○ F) 18.75% purple-coated + slow, 37.5% blue-coated + fast

---

6. (1.00 pts)

If a testcross performed with a purple-coated + slow wizard results in a progeny class of 50% purple-coated + slow wizards, 50% blue-coated + slow wizards, 0% purple-coated + fast wizards, and 0% blue-coated + fast wizards, what must be the genotype of the purple-coated + slow wizard used in the testcross?

- ○ A) PPFf
- ○ B) PpFf
- ○ C) ppFf
- ○ D) PPff
- ○ E) Ppff
- ○ F) ppff

---

7. (2.00 pts)

If a testcross performed with a purple-coated + fast wizard results in a progeny class of 25% purple-coated + slow wizards, 25% blue-coated + slow wizards, 25% purple-coated + fast wizards, and 25% blue-coated + fast wizards, what must be the genotype of the purple-coated + fast wizard used in the testcross?

- ○ A) PPFf
- ○ B) PpFf
- ○ C) ppFf

○ D) PPFF

○ E) PpFF

○ F) ppFF

---

8. (3.00 pts)

If two F2 individuals are crossed with one another, what percentage of the offspring will be purple-coated + fast and what percentage of the offspring will be blue-coated + fast? The offspring here are considered the F3 generation for this sequence of questions.

(Mark **ALL** correct answers)

☐ A) 37.5% purple-coated + fast, 12.5% blue-coated + fast

☐ B) 25% purple-coated + fast, 25% blue-coated + fast

☐ C) 50% purple-coated + fast, 0% blue-coated + fast

☐ D) 37.5% purple-coated + fast, 37.5% blue-coated + fast

☐ E) 0% purple-coated + fast, 0% blue-coated + fast

☐ F) 0% purple-coated + fast, 75% blue-coated + fast

Use the following scenario for the next 3 questions (9-11):

Let's say that in miners, one dominant trait is required for a troop to dig. In this case, both an AaBB individual and an Aabb individual would dig.

---

9. (1.00 pts)

If an AaBb individual were mated with an AaBb individual, what would the resulting phenotypic ratio of dig : non-dig be in the offspring? The offspring here are considered the F2 generation for this sequence of questions.

○ A) 15:1

○ B) 13:3

○ C) 12:3:1

○ D) 9:7

○ E) 9:4:3

○ F) 9:3:3:1

---

10. (1.00 pts)   The phenotypic ratio given from the above problem is representative of what specific epistatic pattern?

---

11. (2.00 pts)

Now let's say that over time, non-digging miners aren't evolutionarily favored and, although the genotype for non-digging miners is still in the genetic pool at this time, zygotes coding for non-digging miners aren't viable and die before birth. If an AaBb individual was mated with another AaBb individual, what would be the percentage of homozygous miners in the resulting progeny? **Round to the nearest integer & exclude the % sign in your answer.**

Use the following scenario for the next 3 questions (12-14):

Let's say that in dragons, two dominant traits are required for a troop to exhale fire. In this case, an AaBB individual would exhale fire, but an Aabb individual would not.

---

12. (2.00 pts)

If an AaBb individual were mated with an AaBb individual, what would the resulting phenotypic ratio of fire-exhaling : non-fire exhaling be in the offspring? The offspring here are considered the F2 generation for this sequence of questions.

○ A) 15:1

○ B) 13:3

○ C) 12:3:1

○ D) 9:7

○ E) 9:4:3

○ F) 9:3:3:1

---

13. (2.00 pts) The phenotypic ratio given from the above problem is representative of what specific epistatic pattern?

[text box]

---

14. (2.00 pts)

Now let's say that over time, non-fire exhaling dragons aren't evolutionarily favored and, although the genotype for non-fire exhaling dragons is still in the genetic pool at this time, zygotes coding for non-fire exhaling dragons aren't viable and die before birth. If an AaBb individual was mated with another AaBb individual, what would be the percentage of homozygous dragons in the resulting progeny? **Round to the nearest integer & exclude the % sign in your answer.**

[text box]

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15. (1.00 pts)

Schizophrenia is a disease with a multifactorial pattern of inheritance - for this reason, individuals with mutations in genes coding for neuregulin, proline dehydrogenase, and other proteins experience varying levels of intensity of the disease.

○ True   ○ False

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16. (1.00 pts)   Height and skin color are BOTH multifactorial traits.

○ True   ○ False

---

17. (1.00 pts)   In eukaryotes, but not prokaryotes, transcription begins with the binding of transcription factors to the promoter site on DNA strands.

○ True   ○ False

---

18. (1.00 pts)   In prokaryotes, ribosomes can begin translating a partial mRNA strand as it's still being transcribed from DNA.

○ True   ○ False

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19. (2.00 pts)   Eukaryotic promoters contain a _____ box whereas prokaryotic promoters contain a _____ box. **(enter only *one* word in each blank, in the correct order)**

[text box]   [text box]

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20. (1.00 pts)   In eukaryotes, a promoter alone has a relatively high affinity for RNA polymerase to bind.

○ True   ○ False

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21. (1.00 pts)   In prokaryotic promoters, two vital sequences are usually located at the ___ and ___ positions relative to the transcription start sequence.

(Mark **ALL** correct answers)

☐ A) -50

☐ B) -45

☐ C) -35

☐ D) -20

☐ E) -15

☐ F) -10

22. (1.00 pts) DNA bendability is important for the proper binding of transcription factors.

○ True   ○ False

Use the following scenario for the next 3 questions (23-25):

Let's say that in goblins, skin color is sex-linked on the X chromosome, with green skin (X^G) dominant to red skin (X^g).

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23. (1.00 pts) If an $X^G X^g$ female is crossed with an $X^G Y$ male, what percentage of the female offspring will have green skin?

○ A) 0%

○ B) 25%

○ C) 50%

○ D) 75%

○ E) 100%

○ F) Not possible to determine based on given info!

---

24. (1.00 pts)

If an $X^G X^g$ female is crossed with an $X^g Y$ male, what percentage of the male offspring will have green skin? The offspring here are considered the F1 generation for this sequence of questions.

○ A) 0%

○ B) 25%

○ C) 50%

○ D) 75%

○ E) 100%

○ F) Not possible to determine based on given info!

---

25. (3.00 pts) If two opposite-gender F1 offspring are crossed with one another, the resulting F2 offspring could consist of?

(Mark **ALL** correct answers)

☐ A) Males that are 100% red-skinned

☐ B) Males that are 50% red-skinned

☐ C) Males that are 0% red-skinned

☐ D) Females that are 100% red-skinned

☐ E) Females that are 50% red-skinned

☐ F) Females that are 0% red-skinned

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26. (2.00 pts) A man has been diagnosed with a disorder that's been genetically proven to be Y-linked. Which of his grandparents CAN be the source of this disorder?

(Mark **ALL** correct answers)

☐ A) Maternal Father

☐ B) Paternal Father

☐ C) Maternal Mother

☐ D) Paternal Mother

Use the following scenario for the next 4 questions (27-30):

Let's say pumpkins have two alleles, one coding for yellow spots (Y^Y) and one coding for pink spots (Y^P).

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27. (1.00 pts)

If a true-breeding yellow-spotted pumpkin was crossed with a true-breeding pink-spotted pumpkin in a co-dominant manner, what percentage of the progeny class would be yellow-spotted? **Round to the nearest integer & exclude the % sign in your answer.**

[ ]

28. (1.00 pts)

Continuing from the previous question, if a yellow-spotted pumpkin is crossed with a pink and yellow-spotted pumpkin, what percentage of the progeny class would be yellow-spotted? **Round to the nearest integer & exclude the % sign in your answer.**

[ ]

29. (1.00 pts)

If a true-breeding yellow-spotted pumpkin was crossed with a true-breeding pink-spotted pumpkin in an incomplete dominant manner, what percentage of the progeny class would be orange-spotted? **Round to the nearest integer & exclude the % sign in your answer.**

[ ]

30. (1.00 pts)

Continuing from the previous question, if an orange-spotted pumpkin is crossed with another orange-spotted pumpkin, what percentage of the progeny class would be yellow-spotted? **Round to the nearest integer & exclude the % sign in your answer.**

[ ]

Use the following scenario for the next 2 questions (31-32):

Matt has type O blood and Victor has type A blood.

31. (3.00 pts) Which of the following are possibilities for the blood types of Matt's parents?

(Mark **ALL** correct answers)

☐ A) Mother - A, Father - B

☐ B) Mother - AB, Father - B

☐ C) Mother - O, Father - AB

☐ D) Mother - A, Father - AB

☐ E) Mother - O, Father - B

☐ F) Mother - A, Father - A

32. (1.00 pts) Victor marries a girl with type B blood. Theoretically, his children could have type AB blood.

○ True   ○ False

33. (1.00 pts)

A sample of DNA found at a crime scene contains 26% adenine. What percent of the sample is cytosine? **Round to the nearest integer & exclude the % sign in your answer.**

[ ]

34. (3.00 pts) Which of the following replication enzymes are correctly paired with their respective functions?

(Mark **ALL** correct answers)

☐ A) Topoisomerase - adds torsional strain on DNA during unwinding

☐ B) Helicase - unzips double helix at replication fork

☐ C) DNA Polymerase I - main replication enzyme that adds nucleotides to the new DNA strand

☐ D) DNA Polymerase III - removes RNA primers

☐ E) DNA Polymerase II - repairs errors in replication

☐ F) Ligase - creates new gaps between Okazaki fragments

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35. (1.00 pts) Both DNA transcription & translation have 3 steps - initiation, elongation, and termination.

○ True ○ False

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36. (1.00 pts) rRNA is what carries the anticodon and amino acid to the ribosomal subunit during translation.

○ True ○ False

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37. (1.00 pts) The presence of alpha-helices or beta-pleated sheets indicate a tertiary structure protein.

○ True ○ False

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38. (2.00 pts) Euchromatin DNA has ____ expression and is ____ compacted, whereas heterochromatin DNA has ____ expression and is ____ compacted.

○ A) Low, tightly; high, loosely

○ B) High, tightly; low, tightly

○ C) High, loosely; low, loosely

○ D) Low, loosely; high, tightly

○ E) High, loosely; low, tightly

○ F) High, tightly; low, loosely

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39. (3.00 pts) Which of the following are true regarding meiosis?

(Mark **ALL** correct answers)

☐ A) In telophase I, homologous chromosomes still exist

☐ B) In metaphase II, homologous chromosomes no longer exist

☐ C) Meiosis II takes significantly longer to finish than Meiosis I

☐ D) At the end of Meiosis II, 6 daughter cells are produced

☐ E) In anaphase II, homologous chromosomes no longer exist

☐ F) In anaphase II, sister chromatids are lined up at the center of the cell

---

40. (1.00 pts) The secondary oocyte produced from meiosis I cannot pass metaphase II of meiosis until _____ occurs.

[   ]

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41. (3.00 pts) Which of the following portions of the below diagram representing a chromosome are correctly identified?
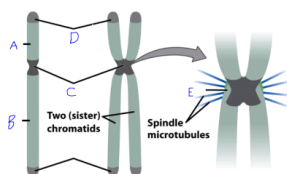
(Mark **ALL** correct answers)

☐ A) A - Q arm

☐ B) B - P arm

☐ C) B - Q arm

☐ D) C - Kinetochore

☐ E) D - Telomere

☐ F) E - Kinetochore

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42. (1.00 pts) When looking at a karyotype, Y chromosomes are shorter than X chromosomes.

○ True ○ False

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43. (2.00 pts) Which of the following are chromosomal abnormalities?

(Mark **ALL** correct answers)
☐ A) Deletions
☐ B) Duplications
☐ C) Inversions
☐ D) Substitutions
☐ E) Translocations

---

44. (3.00 pts) Which of the following are correctly matched with the chromosome on which their abnormality occurs?

(Mark **ALL** correct answers)
☐ A) Down syndrome - 21
☐ B) Edward's syndrome - 13
☐ C) Patau syndrome - 18
☐ D) Cri du chat syndrome - 5
☐ E) Wolf-Hirschhorn syndrome - 6
☐ F) Jacobsen syndrome - 11

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45. (1.00 pts) What pattern of inheritance is displayed by the below pedigree?
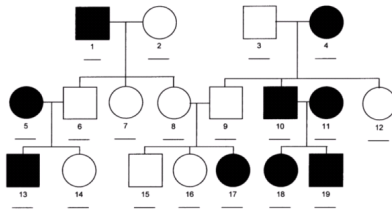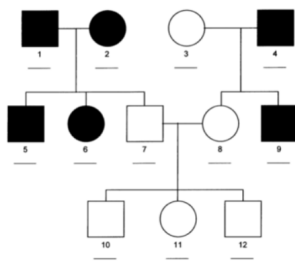

○ A) Autosomal dominant
○ B) Autosomal recessive
○ C) X-linked dominant
○ D) X-linked recessive
○ E) Y-linked
○ F) Mitochondrial

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46. (1.00 pts) Briefly explain how you came to your conclusion for the previous answer.

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47. (1.00 pts) What pattern of inheritance is displayed by the below pedigree?

- A) Autosomal dominant
- B) Autosomal recessive
- C) X-linked dominant
- D) X-linked recessive
- E) Y-linked
- F) Mitochondrial

48. (1.00 pts) Briefly explain how you came to your conclusion for the previous answer.

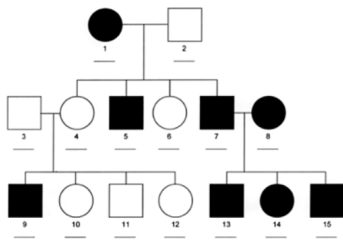**49. (1.00 pts)** What pattern of inheritance is displayed by the below pedigree?

- A) Autosomal dominant
- B) Autosomal recessive
- C) X-linked dominant
- D) X-linked recessive
- E) Y-linked
- F) Mitochondrial

50. (1.00 pts) Briefly explain how you came to your conclusion for the previous answer.
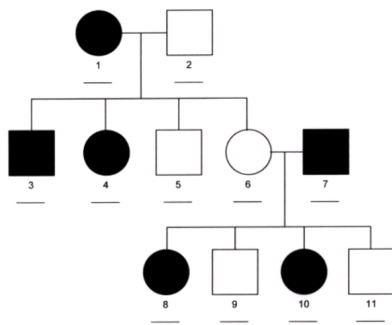
51. (1.00 pts) What pattern of inheritance is displayed by the below pedigree?

- ○ A) Autosomal dominant
- ○ B) Autosomal recessive
- ○ C) X-linked dominant
- ○ D) X-linked recessive
- ○ E) Y-linked
- ○ F) Mitochondrial

52. (1.00 pts)   Briefly explain how you came to your conclusion for the previous answer.
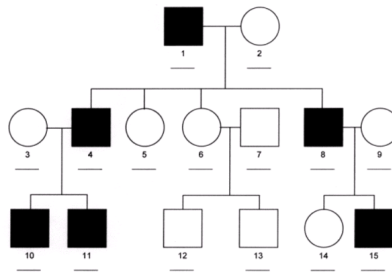
53. (1.00 pts)   What pattern of inheritance is displayed by the below pedigree?

- ○ A) Autosomal dominant
- ○ B) Autosomal recessive
- ○ C) X-linked dominant
- ○ D) X-linked recessive
- ○ E) Y-linked
- ○ F) Mitochondrial

54. (1.00 pts)   Briefly explain how you came to your conclusion for the previous answer.
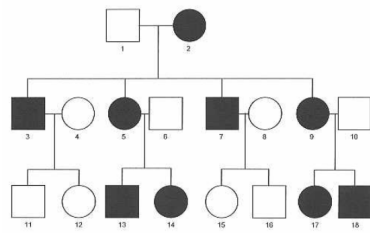
55. (1.00 pts)   What pattern of inheritance is displayed by the below pedigree?

- ○ A) Autosomal dominant
- ○ B) Autosomal recessive
- ○ C) X-linked dominant
- ○ D) X-linked recessive
- ○ E) Y-linked
- ○ F) Mitochondrial

56. (1.00 pts) Briefly explain how you came to your conclusion for the previous answer.

57. (1.00 pts) The genetic code is?

- ○ A) Universal
- ○ B) Degenerate
- ○ C) Neither of the above
- ○ D) Both of the above

58. (1.00 pts) Coding regions of DNA are called _____ whereas noncoding regions of DNA are called _____. **(enter only ONE word in each blank, in the correct order)**

59. (1.00 pts) A _____ consists of a nitrogenous base and a 5-carbon sugar such as ribose.

60. (2.00 pts) Briefly describe when and how sex-specific imprinting occurs.

61. (1.00 pts) A neomorphic allele is one that has an increased level of protein expression.

- ○ True   ○ False

62. (1.00 pts) Which of the following are TRUE regarding a frameshift mutation?

- ○ A) A frameshift mutation can be a deletion
- ○ B) A frameshift mutation can result in a longer protein
- ○ C) A frameshift mutation can alter the chain of amino acids produced by a coding sequence

○ D) A & C only

○ E) B & C only

○ F) A, B, & C

---

63. (1.00 pts) A _____ mutation results in a stop codon where a normal amino acid should have been.

[   ]

Use the following scenario for the next 4 questions (64-67):

Let's say in pekkas, black armor (B) is dominant to blue armor (b), horns (H) are dominant to tails (h), and speed (G) is dominant to stealth (g).

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64. (2.00 pts)
A true-breeding black-armored + horned + speedy pekka is crossed with a true-breeding blue-armored + tailed + stealthy pekka. Two resulting offspring (F1) are mated with one another to produce an F2 progeny class that results in 8 different phenotypes. If there are 640 individuals in the F2 generation, how many would you expect to be black-armored + tailed + stealthy?

○ A) 640

○ B) 320

○ C) 270

○ D) 160

○ E) 90

○ F) 30

---

65. (2.00 pts) Continuing from the previous question, how many individuals would you expect to have the genotype bbHhGg, bbHHGg, Bbhhgg, or BBhhGG?

○ A) 640

○ B) 320

○ C) 270

○ D) 160

○ E) 90

○ F) 30

---

66. (4.00 pts)
Now, from the F2 generation, let's say a blue-armored + horned + speedy pekka is crossed with a black-armored + horned + stealthy pekka. Considering all possibilities, what percentage of the offspring (F3) will be black-armored + horned + stealthy pekkas?

(Mark **ALL** correct answers)

☐ A) 18.75%

☐ B) 25%

☐ C) 32.5%

☐ D) 37.5%

☐ E) 43.75%

☐ F) 50%

---

67. (3.00 pts) In order for the answer to the previous question to be 25%, which two of the following genotypes must be included in the cross between the two F2 individuals?

(Mark **ALL** correct answers)

☐ A) bbHhGg

☐ B) bbHHGG

☐ C) bbHhGG

☐ D) BbHhgg

☐ E) BbHHgg

☐ F) BBHhGg

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68. (1.00 pts) The genome size of both mitochondria and chloroplasts is relatively uniform across different species.

○ True ○ False

---

69. (1.00 pts) In base excision repair, DNA _____ cleaves an altered nitrogenous base from the sugar of its nucleotide.

[   ]

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70. (1.00 pts) Base excision repair is particularly important in the removal of uracil from DNA.

○ True ○ False

---

71. (1.00 pts) In nucleotide excision repair, an enzyme complex containing which of the following proteins patrols DNA for irrelgularities?

○ A) UvrA
○ B) UvrB
○ C) UvrC
○ D) A & B
○ E) A & C
○ F) B & C

---

72. (1.00 pts) Continuing from the previous question, next, an enzyme complex containing which of the following proteins cuts the damaged DNA strand?

○ A) UvrA
○ B) UvrB
○ C) UvrC
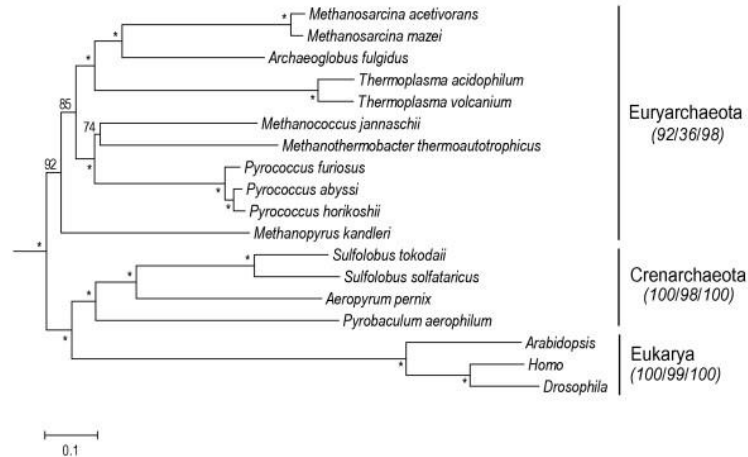○ D) A & B
○ E) A & C
○ F) B & C

Use the following diagram for the next 2 questions (73-74):
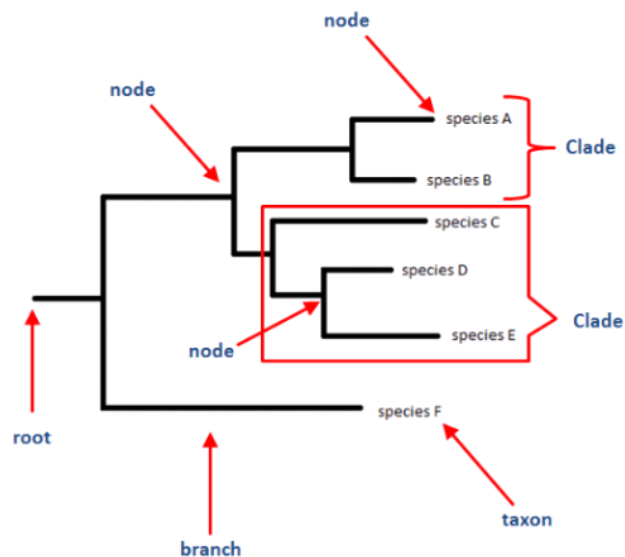
73. (1.00 pts)   If species A and B form a monophyletic group, then species B and D form a _____ group.

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[                    ]
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74. (1.00 pts)   If species A and B form a monophyletic group, then species B, D, and F form a _____ group.

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[                    ]
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Use the following diagram for the next 2 questions (75-76):

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75. (1.00 pts)   *Pyrococcus abyssi* is more closely related to *Methanosarcina mazei* than *Pyrobaculum aerophilum* is to *Sulfolobus tokodaii*.

○ True   ○ False

---

76. (1.00 pts)   *Pyrococcus furiosus* and *Methanococcus jannaschii* share a common ancestor.

○ True   ○ False

---

77. (1.00 pts)   During the gel electrophoresis portion of RFLP analysis, smaller DNA bands move faster through the gel than larger DNA bands.

○ True   ○ False

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78. (1.00 pts)   Restriction Fragment Length Polymporphism (RFLP) analysis is more cost-effective than Polymerase Chain Reaction (PCR) testing.

○ True   ○ False

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79. (1.00 pts)   In Sanger sequencing, each DNA fragment produced is distinguishable according to its terminal 3' base.

○ True   ○ False

---

80. (1.00 pts)   During Sanger sequencing, ddCTP is added to the template DNA at a higher concentration than dCTP.

○ True   ○ False

---

81. (1.00 pts)   The two priming oligonucleotides always dictate the nature of the final PCR product.

○ True   ○ False

82. (1.00 pts)   Simple sequence repeats (SSRs) cannot be genotyped by examining PCR product sizes on gels.

○ True   ○ False

Congratulations, you've completed the 2021 UT Austin Regional Designer Genes C test! Best of luck in your other events, and I hope you enjoyed taking this test today! If you have any feedback about any of the exams at this tournament, please let us know through this form: https://tinyurl.com/utreg21feedback (https://tinyurl.com/utreg21feedback)

- Shrayen Patel (UT '24)

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