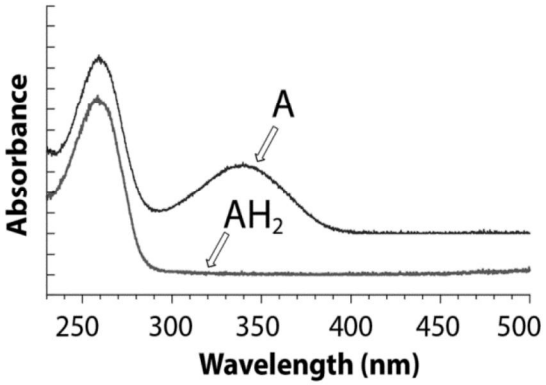
(Summer 2013) READ EACH QUESTION CAREFULLY.

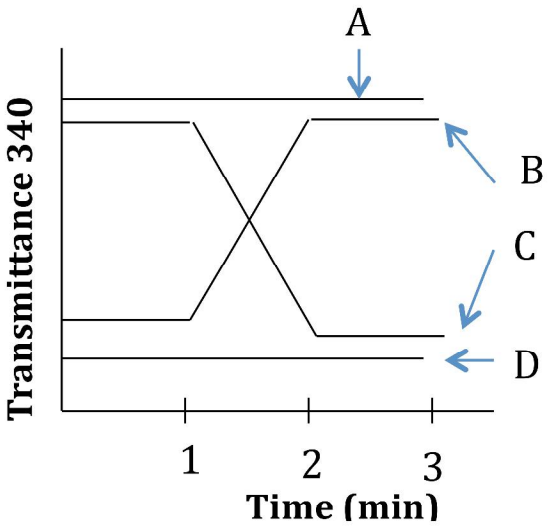
1. You are studying salivary amylase activity similar to part I of the enzyme lab. You have excess substrate present for each measurement. You use an enzyme concentration of 100 ng/ml and determine the amount of activity to be 0.25 O.D. units/min/ng of enzyme. Note the UNITS. You then test the activity of a 200 ng/ml enzyme solution (twice as concentrated as the 100 ng/ml). What is the activity of this 200 ng/ml solution?

A) about 0.25 O.D. units/min/ng of enzyme
B) about 0.50 O.D. units/min/ng of enzyme
C) about 0.75 O.D. units/min/ng of enzyme
D) about 1.0 O.D. units/min/ng of enzyme
E) about 2.5 O.D. units/min/ng of enzyme

2. Photosynthesis can be analyzed by measuring the reduction of reagent A instead of the reduction of DCPIP as performed in Lab: $2H^+ + 2e^- + A \rightarrow AH_2$. An absorption spectrum of reagents A and AH_2 is shown below left, and the wavelength 340 nm was chosen for quantification. The experimental design is similar to the one we used in lab (chloroplast isolation, buffers, etc). Assume that no other molecules absorb light in the 340 nm range. Select the line A-D on the graph below right that best represents the following condition:

1 min treatment in the dark, followed by 1 min light exposure, followed by 1 min light + DCMU.

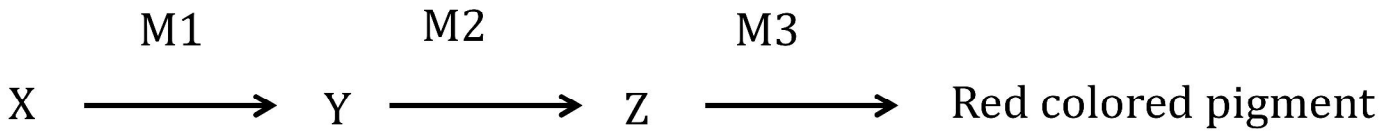




3. Which of the following most likely limits the product size of the non-unit length of DNA molecules in a typical PCR reaction that started with a large linear chromosomal DNA template molecule?

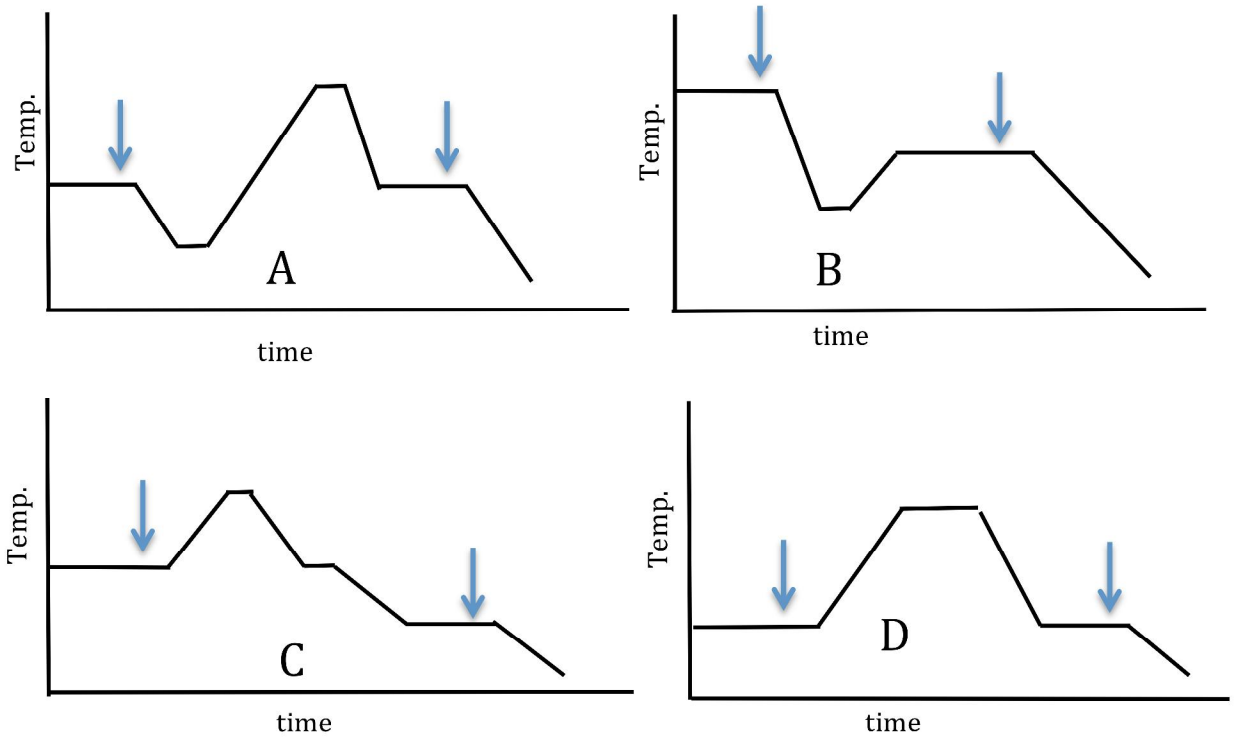
A) Annealing position of primers
B) GC content of the template
C) Total number of primers
D) Extension time
E) Annealing temperature

4. A species of fungus produces a red colored pigment. The pathway is shown below. Three mutants are indicated as M1, M2 and M3 and they are listed in the pathway that corresponds to their defect. The mutants are single mutants; all other genetic loci, other than the mutation, are wild type. All mutant alleles are recessive to wild type alleles. Which of the following matings would result in the production of red colored fungi?



A) Mating type alpha M1 with mating type A M1
B) Mating type alpha M1 with mating type alpha M2
C) Mating type alpha M1 with mating type alpha M3
D) Mating type alpha M1 with mating type A M3
E) Both B and C

5. Which of the following graphs, A - D, most accurately represents the correct temperature sequence for series of cycles of PCR? The arrows indicate the interval between all required steps for one cycle (it just keeps repeating each cycle).



6. Which ONE of the following is FALSE regarding prokaryotes?
A) Some Archaea have introns in their DNA
B) Eubacteria are more likely to live in "extreme" environments than Archaea
C) *All* prokaryotes possess a cell membrane
D) Some prokaryotes use pilli for mating and other cell-to-cell interactions
E) Most prokaryotes have a single circular chromosome usually attached to the cell membrane and suspended within the cytoplasm

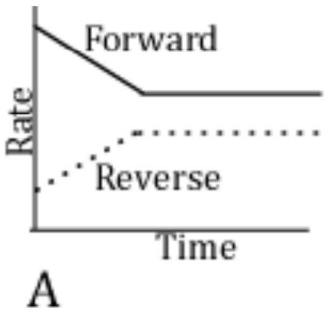
7. Which of the following statements concerning the light reactions of oxygenic photosynthesis is FALSE?

A) The splitting of water provides a source of electrons and protons.
B) Chlorophyll *b* is involved in light absorption and energy transfer.
C) Molecular oxygen is released as a product of the non-cyclic light reactions.
D) Electrons are transferred from photosystem II to photosystem I via the electron transport chain.
E) A proton gradient is used to reduce $NADP^+$ to NADPH.

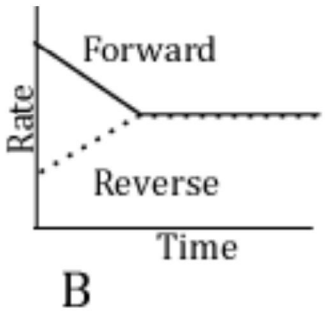
8. A sample of 560 μL of pure water at 25˚C would weigh about _____ .

A) 560 μg
B) 560 mg
C) 5.6×10^{-3} grams
D) Both A and C
E) Both B and C

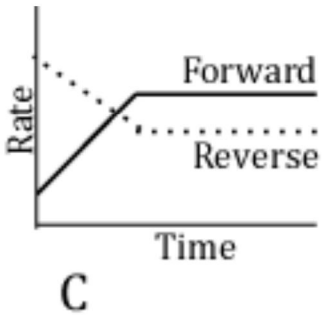
9. (3 pts) Under initial starting conditions, a reaction A --> B is an exergonic reaction. The reaction is allowed to go to equilibrium. Both forward and reverse rates can be measured during the time course required to reach equilibrium. The forward rate of the reaction (solid line) and the reverse rate of the reaction (dashed line) are plotted against time. Which graph best represents the expected results?



A



B



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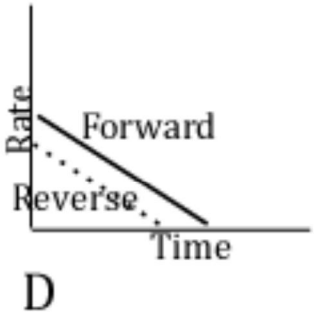
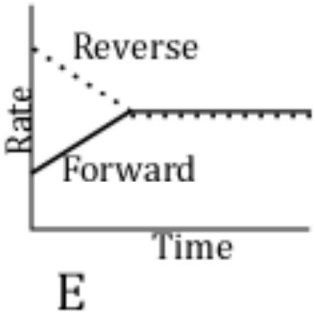


D



E

10. During the photosynthesis lab you measured the rate of reduction of DCPIP under two conditions, both light and light plus methylamine. One could however have measured ATP production and O_2 production. How would the rate of ATP production and the rate of oxygen production vary in the two conditions: light *vs* light + methylamine.

A) in the light only experiment, the rate of ATP production and O_2 production would both be larger compared to light + methylamine.
B) in the light only experiment, the rate of ATP production and O_2 production would both be smaller compared to light + methylamine.
C) in the light only experiment, the rate of ATP production would be smaller and O_2 production would be larger compared to light + methylamine.
D) in the light only experiment, the rate of ATP production would be larger and O_2 production would be smaller compared to light + methylamine.

11. This question refers to microscopy *in general*, not necessarily to the student microscopes you used. Which ONE of the following statements does NOT derive directly from the equation for resolution, which is: $d=0.612\ \lambda / \eta \sin \alpha$, where:

d ...= .. the distance of resolution
λ ...= .. the wavelength of the light photons or other particles used for imaging
η ...= .. the index of refraction of the medium between the cover slip & the front objective lens.

A) We can improve resolution by switching from red light to blue light
B) We can improve resolution by using electrons instead of photons; electrons have wavelengths about 1000x shorter than visible light photons
C) We can improve resolution by placing oil between the cover slip and objective lens
D) Anything that *increases* the numerical aperture ($\eta \sin \alpha$) of an objective will, in theory, improve resolution
E) None. All of the above statements are TRUE regarding microscopy and resolution.

12. (3 pts) An 8 base pair sequence is shown below. What is the chance that I can take a random 8 base pair sequence from a huge genome and it will match? You know that the % of A in the genome is 30%.

Sequence = 5' – ACTGCAGT – 3'
3' – TGACGTCA – 5'

A) $(1/4)^8$
B) (0.3) X (0.2) X (0.3) X (0.2) X (0.2) X (0.3) X (0.2) X (0.3)
C) (0.3) X (0.4) X (0.3) X (0.4) X (0.4) X (0.3) X (0.4) X (0.3)
D) $(3/4)^8$
E) $(1/2)^8$

Work area:

13. Imagine that you wish to use a spectrophotometer (at a constant wavelength!) to construct a standard curve with which you can then determine the dye concentration of an unknown sample of that dye. Using solutions of known dye concentration, you obtain the *Absorbance*/Molar Concentration data in the table below (which you might want to graph). Using this data, what is the dye concentration of an unknown solution whose *Transmittance* is 10%?

Answer: _____

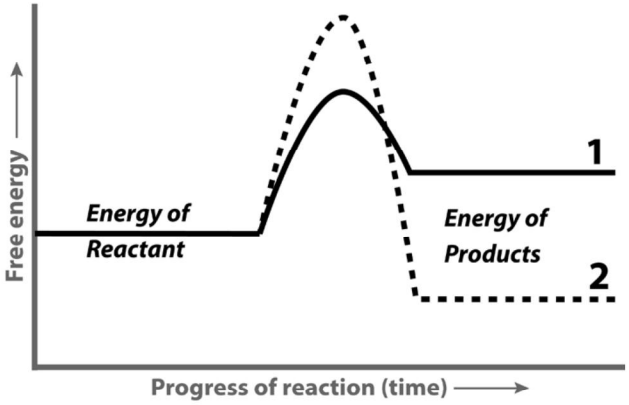
Abs (OD)	Conc (M)
0.0	0.00
0.5	0.25
1.0	0.50
1.5	0.75
2.0	1.00

A) 0.01 M
B) 0.1 M
C) 0.5 M
D) 1.0 M
E) None of the above

14. Which ONE of the following, if any, is NOT a defined medium? A medium consisting of (per liter):

A. 50 mM sodium chloride + 50 mM sodium phosphate + 1 mM glucose
B. 5 mM NaCl + 0.5 mM $FeCl_2$ + 10 mL yeast extract
C. 50 mM NaCl + 1mL of 100 mM sodium phosphate + 5 mM glycerol
D. 50 mM NaCl + 5 mM KCl + 1 mM $NaPO_4$ + 0.1 mM HCl + 1 mM glucose
E. All of the above are defined media.

For Q15-16. In the energy diagram seen here, two reactions, labeled 1 and 2, are plotted with free energy increasing upwards and reaction progress (time) proceeding to the right. Select the correct answer for each question.



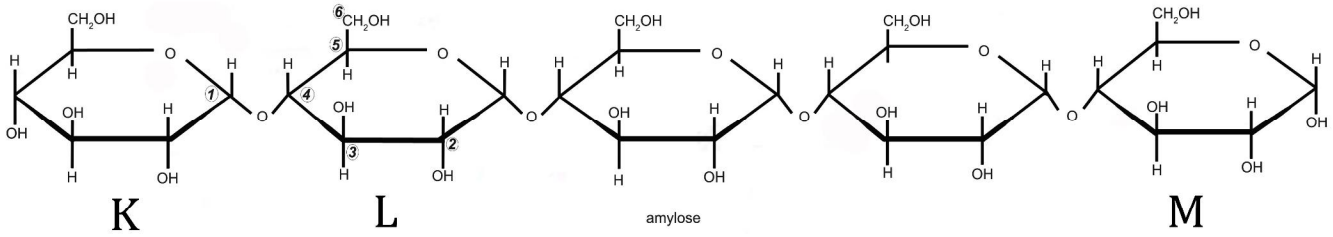
15. Which reaction has the largest energy of activation?

A) Reaction 1
B) Reaction 2
C) They have the same energy of activation.
D) You cannot tell from the graphs.

16. Which reaction is catalyzed by an enzyme?

A) Reaction 1
B) Reaction 2
C) They both use enzymes.
D) Neither use enzymes.
E) You cannot tell from the graphs.

17. A oligomer that is 6 glucose units is shown below. The carbons are numbered in the second glucose from the left. This numbering system applies to all of the glucose units. Three glucose units are labeled; K, L and M. In the enzyme lab you added DNS and then heated the sample to drive the reaction of DNS and the reducing unit. Imagine you do a similar procedure but the hexamer is present as shown below. Select the best answer with respect to the glucose unit and the carbon number that would be reacting.



A Only glucose K would react, Carbon # 1
B) Only glucose K would react, Carbon # 6
C) Any glucose would react, Carbon #1
D) Only glucose M would react, Carbon # 1
E) Only glucose M would react, Carbon # 6

18. (3 pts) On a distant planet, extraterrestrial biologists have discovered a new type of life that uses genetic material that is exactly the same as DNA, but replicates in the 3'-> 5' direction. Select the FALSE statement regarding the consequence of this change in directionality. If all of the statements are true then select E. Draw out the reaction or use your hands to help you answer this.

A) Both a leading and lagging strand would occur during replication.
B) dNTPs would be necessary for synthesis.
C) DNA polymerase would not be necessary as the DNA would self-assemble.
D) Proofreading would still occur during replication.
E) All of above events would be expected to occur.

Work area:

19. (3 pts) The Henderson-Hasselbalch equation is pH = pKa + log ([A-]/[AH]). Methylamine has a pKa of about 10.6. What is the approximate ratio of unprotonated to protonated forms at a pH of 8.6?

A) Ratio of unprotonated to protonated is (100/1).
B) Ratio of unprotonated to protonated is (10/1).).
C) Ratio of unprotonated to protonated is (1/1).
D) Ratio of unprotonated to protonated is (1/10).
E) Ratio of unprotonated to protonated is (1/100).

Work area:

20. (1 pt) Which of the following (genera) belong in the Domain Eubacteria?

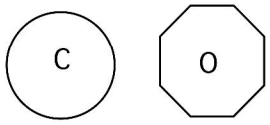
A) *Homo*
B) *Paramecium*
C) Yeast
D) All of the above (A-C)
E) *Anabaena*

21. Doubling the enzyme concentration will ___ the Vmax and ___ the Km.

A) double; double
B) double, halve
C) double; not change
D) halve; double
E) None of the above—need more information.

22. You need to set critical illumination for the light microscope. One of the first steps is to position the condenser correctly. To do this, you close down the field diaphragm, and then position the condenser so that the light is in sharp focus. At this time the light should appear as _____ (either C or O). A later step requires you to adjust the aperture diaphragm to see the specimen most clearly. Opening the aperture diaphragm would result in _____. Select the correct answer from choices A-D.

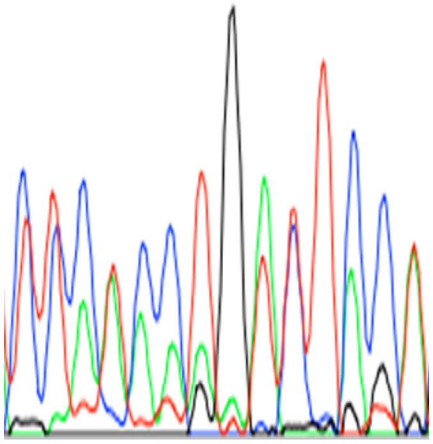
A) appears as C, an increase in contrast
B) appears as C, a decrease in contrast
C) appears as O, an increase in contrast
D) appears as O, a decrease in contrast



23. A short section of a chromatogram is shown below. Select the most likely explanation for this data?

A) Both 16s rRNA and rpoB DNA loci being replicated due to the addition of only the forward primer for 16s rRNA.
B) Only the 16s rRNA locus due to the addition of both forward and reverse primer for 16s rRNA.
C) Only the 16s rRNA locus due to the addtion of both forward and reverse primer for rpoB.
D) All of the above.
E) Both A and B.

(Note this is an actual chromatogram!)



24. Oligonucleotide primers included in the polymerase chain reaction mixture do all of the following EXCEPT:

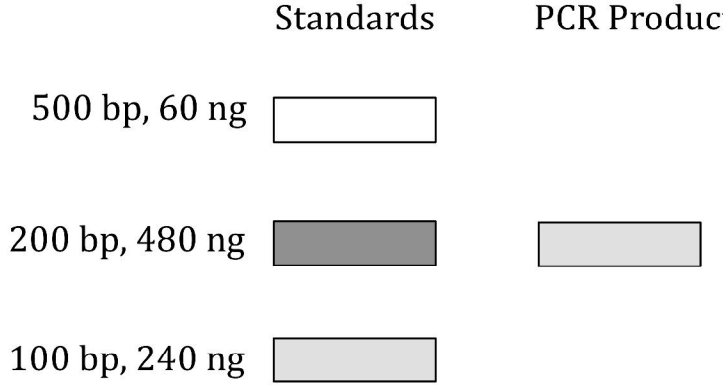
A) hybridize to single-stranded DNA.
B) provide for specificity in amplification.
C) allow DNA polymerase to synthesize a new DNA strand.
D) serve as template DNA.

25. You are given a short portion of a protein sequence and are asked to find out if there are diseases associated with the gene. Which online database or databank would you FIRST use to begin your investigation?

A) PubMed
B) Entrez
C) OMIM
D) ExPasy
E) BLAST

26. (3 pts) 5 μl of PCR product (double stranded DNA) was run out on the gel shown below, along with the standards. What is the approximate concentration of DNA in the PCR product? The average molecular weight for a nucleotide is 300 grams/mole.

A) 1.6×10^{-6} Moles/liter
B) 4.0×10^{-7} Moles/liter
C) 8.0×10^{-7} Moles/liter
D) 1.2×10^{-8} Moles/liter
E) None of the above.



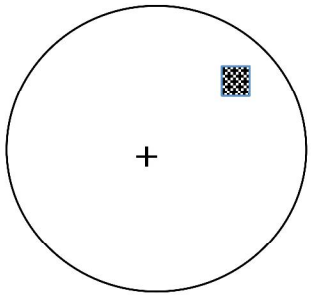
Work area:

27. You identify a mutant male fly whose wing stripes are green. You cross this mutant to a female from a true-breeding wild-type (brown stripes) flies, and find that half of the F1 progeny are green-striped and the other half are brown striped. Males and females show the traits equally. Select the correct genotype of your original mutant male fly.

A) $bs//bs^+$
B) $BS//BS^+$
C) $gs//gs^+$
D) $GS//GS^+$
E) $X^{bs}//Y$

28. The following image is seen in the field of view of a microscope. The center of the field of view is indicated with a +. In which direction would you move the stage to center the square image in the field of view as indicated by the +.

A) move the stage to the right and down.
B) move the stage to the right and up.
C) move the stage to the left and down.
D) move the stage to the left and up.



29. You are studying several very, very closely related species. You decide to sequence DNA in an attempt to build a cladistic tree. Select the type of genetic locus that would best allow you to determine the closest genetic relationships.

A) a gene that encodes rRNA since all species should have the gene and many differences (mutations) can be tolerated
B) a gene that encodes for a protein and look for isoforms (alternative splicing products) in the various species
C) a gene that encodes for a protein that is highly conserved
D) a gene that encodes for a protein that is NOT highly conserved

30. Of the listed processes, which <u>regenerate</u> CO2 in plants?

A) Linear electron transport chain
B) Calvin cycle
C) Glycolysis
D) Krebs Cycle
E) Both C and D

31. Which of the following sequence of events <u>would work</u> for the blank tube in the enzyme lab?

A) amylase – starch – DNS – heat
B) amylase – starch – heat – DNS
C) DNS – amylase – starch – heat
D) starch - amylase – DNS –– heat
E) either C or D would work

32. You are trying to amplify a particular genetic locus using PCR. You observe two bands, one at 1,500 bp and the other at 1,800 bp. The most likely explanation for this is that:

A) the individual is homozygous at this locus but due to alternative splicing two products are produced.
B) the individual is heterozygous at this locus.
C) the scientist accidentally used a paired primer set (Forward and Reverse) when they should have only used a forward or a reverse primer, not both.
D) the scientist accidentally used only one primer (Forward or Reverse, but not both together).
E) the scientist used the wrong ratio of ddNTPs to dNTPs resulting in the shorter fragment.

33. (4) Three mutant phenotypes in flies are broken bristles, elongated antennae, and quiet flight. You mate a female fly with normal bristles, normal antennae and normal flight with a male with broken bristles, elongated antennae and quiet flight. Both are from true-breeding populations. All F1 flies have normal bristles, elongated antennae and normal flight. You let the flies breed for many generations. You never see a difference in the number of males and females for these three traits.

After two months and many generations you randomly select a male and female fly. The male has broken bristles, normal antennae and quiet flight. The female has normal bristles, elongated antennae and normal flight. You get the following data.

Phenotype	#
Normal bristles, normal antennae, normal flight	5
Normal bristles, normal antennae, quiet flight	20
Normal bristles, elongated antennae, normal flight	5
Normal bristles, elongated antennae, quiet flight	20
Broken bristles, normal antennae, normal flight	20
Broken bristles, normal antennae, quiet flight	5
Broken bristles, elongated antennae, normal flight	20
Broken bristles, elongated antennae, quiet flight	5

Select the genotype of the **female** fly used to generate the offspring data in the table (final cross). Correct genotype notation must be used.

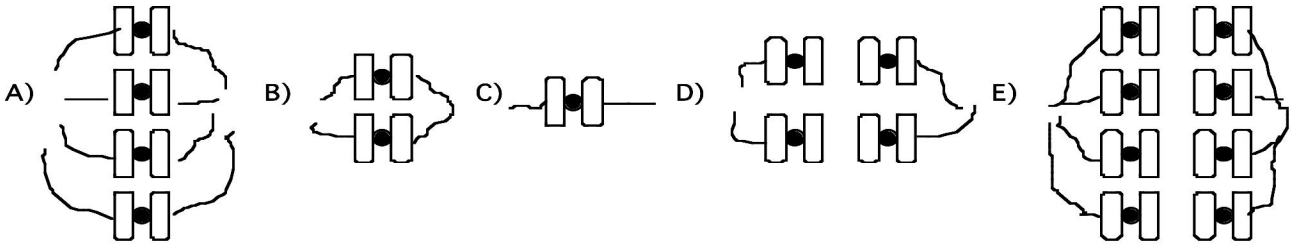
	Genotype of the female fly in the last cross
A)	$EA^+//EA$; $bb//bb^+$; $qf^+//qf$
B)	$EA^+bb//EA\ bb^+$; qf/qf
C)	$bb^+\ qf//bb\ qf^+$; $EA^+//EA$
D)	$bb\ qf^+//bb\ ^+qf$; $ea^+//ea$
E)	$bb^+qf^+//bb\ qf$; $ea^+//ea$

Work area:

34. Genome = $1x10^9$ bp; %A = 25%. What is the minimum length of the primer sequence in order for it to appear only once in the genome? Base your answer upon the statistical analysis of the problem. Remember $(1/4)^5 = 1 \times 10^{-3}$

A) 10 nucleotides
B) 15 nucleotides
C) 20 nucleotides
D) 15 base pairs
E) 20 base pairs

35. Which figure corresponds to metaphase I of meiosis of an animal cell with 1N = 4?



36. For the animal above you know that there are 4,000 genes in a gamete. How many genes are present in a 2N cell at G1? at G2? Note: the question is asking how many genes, not how many alleles!

A) 4,000 genes at G1, 4,000 genes at G2
B) 4,000 genes at G1, 8,000 genes at G2
C) 8,000 genes at G1, 8,000 genes at G2
D) 8,000 genes at G1, 16,000 genes at G2

37. (3 pts) A mutant allele affects development of organ systems in cats. Heterozygous individuals have three kidneys (instead of two). Homozygous mutant embryos fail to develop and are not born. If two heterozygous cats mate and produce kittens, what proportion of the playful kittens will have the normal number of two kidneys?

A) 75%
B) 66%
C) 50%
D) 33%
E) 25%

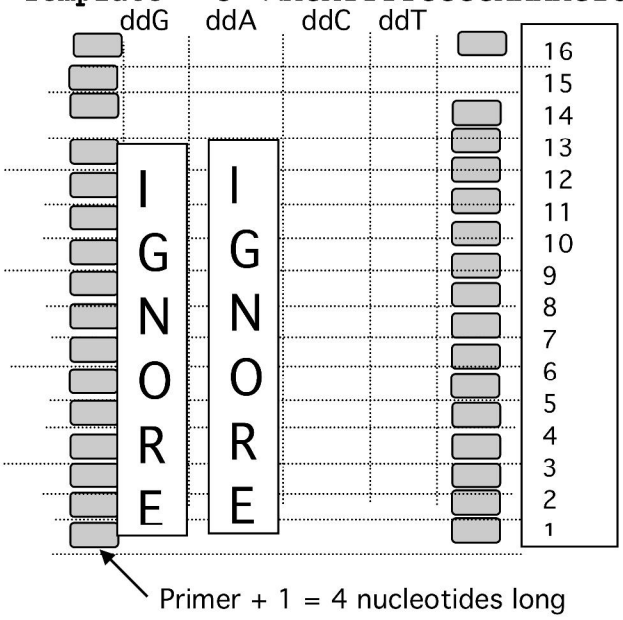
Work area

38. Instead of using DCPIP in the Hill reaction, an alternative electron acceptor was used. However, the oxidized form, P, is found to be a clear solution while the reduced form, PH_2, changes into a dark blue. As a result, when making the blank for this reaction, it should contain:

A) Compound P, Phosphate buffer, Chloroplasts
B) Compound PH_2, Phosphate buffer, Chloroplasts
C) Compound P, Sucrose-Phosphate buffer, Chloroplasts
D) Compound PH_2, Sucrose-Phosphate buffer, Chloroplasts

Q39-40: A DNA template that is 19 nucleotides long is shown below. A group of four students sets up the sequencing reactions. They have the appropriate radioactive primer, dNTPs, ddNTPs, enzymes, etc. so that the sequencing reaction should work. In the ddCTP tube there are 1,000,000 template molecules and the ratio of ddCTP to dCTP is such that 10% is ddCTP & 90% is dCTP. In the ddTTP tube there are 1,000,000 template molecules and the ratio of ddTTP to dTTP is such that 50% is ddTTP & 50% is dTTP. In order to visualize a band on a gel, you need at least **50,000** molecules. The migration of marker DNA is shown (every size is visible).

Template = 5'-AAGATTTTGGGGAAAAGTC**- 3', Radioactive primer = 3'-CAG- 5'**



Note: 10%ddCTP/90% dCTP Note: 50% ddTTP/ 50% dTTP

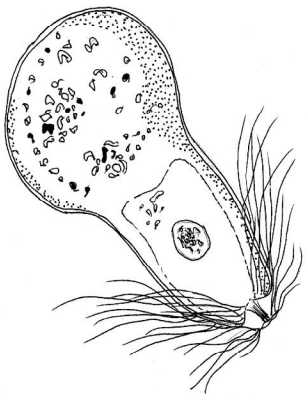
39. Select the choice that correctly describes the visible bands for the ddC tube.
   A) 5th and 6th positions only
   B) 5th, 6th, 7th, 8th positions only
   C) 5th, 6th, 7th, 8th and 14th positions only
   D) 5th, 6th, 7th, 8th ,14th and 16th positions only
   E) No bands would be visible.

40. Select the choice that correctly describes the visible bands for the ddT tube.
   A) 1st, 2nd, 3rd and 4th positions only
   B) 1st, 2nd, 3rd, 4th and 13th positions only
   C) 1st, 2nd, 3rd, 4th,13th and 16th positions only
   D) 9th, 10th, 11th and 12th positions only
   E) 9th, 10th, 11th, 12th and 16th positions only

41. Which of the following chemical solution(s) could be <u>safely</u> disposed of in the laboratory <u>sink?</u>
   A) the blanks used in the enzyme lab
   B) the blank used in the Hill reaction
   C) 4% starch solution (pH 7)
   D) Both B & C
   E) A, B and C.

42. Identify the organism shown to the right.

A) *Anabaena and* is photosynthetic, but no chloroplasts.
B) *Euglena and* is photosynthetic and contains chloroplasts.
C) *Streblomastix* and is non-photosynthetic.
D) *Trichonympha* and is non-photosynthetic.
E) *Nitella* and is photosynthetic and contains chloroplasts.



43. (3 pts) Two groups of scientists (1 & 2) are studying the same species of birds. Unlike humans, in birds, females are ZW (heterogametic) and males are ZZ (homogametic). Normally these birds have blue colored feathers. Each group independently finds mutants with gray colored feathers and generate true-breeding populations that have only this mutation. Each group knows the mutation maps to a Z chromosome and the mutant allele is recessive to blue feathers. They want to determine if the two mutations are alleles at the same locus. They mate true breeding gray females (group 1) with true breeding gray males (group 2). The scientists determine the two gray mutations represent different genetic loci. Select the data that supports their conclusion. Hint: You might want to write out genotypes to help yourself answer this question.

A. All offspring have blue feathers.
B. All of the females have gray feathers and all of the males have blue feathers.
C. 50 % of the females and males have blue feathers, the other 50 % have gray feathers.
D. 50% of the females have gray feathers, the other 50% have blue feathers. All the males have blue feathers.
E. All the females have gray feathers. 50% of the males have gray feathers, the other 50% have blue feathers.

WORK SPACE:

EXAM CONTINUES

Q44-46: Three genetically linked genes are A, B and C (mutations are dominant). An individual heterozygous for all 3 loci was crossed with another individual homozygous for all three wild type traits (wild type is recessive). The following phenotypes and numbers are seen. Use this data to answer questions 44-46.

ABC	10
$A^+B^+C^+$	10
ABC^+	100
A^+B^+C	100
A^+BC	690
AB^+C^+	690
AB^+C	200
A^+BC^+	200

44. Which of the following represents the alleles of one of the parental chromosomes?

A) A^+B^+C
B) AB^+C
C) ABC^+
D) A^+BC
E) None of the above

45. Which trait maps between the other two (i.e. is in the middle)?

A) A
B) B
C) C

46. Approximately how far apart are the A and B loci?

A) 2 map units
B) 5 map units
C) 10 map units
D) 20 map units
E) 50 map units

END OF EXAM