



Good luck!

**1. (2.00 pts)**

c) Karla and Bob's 4th child, unfortunately, has the disease. They somehow still want another child. What is the probability that their 5th child has Hemophilia? (2 point)

**2. (2.00 pts)**

**More Genetic Counseling**

Assume disease H is recessive and autosomally inherited. Assume disease B is also recessive and autosomally inherited. A woman, Kate, heterozygous for both H and B wants to have a child with Peter, who is recessive for both diseases.

a) What is the probability of the pair having a son with disease B but not H? (2 points)

**3. (3.00 pts)**

b) Researchers find out that disease H and B are located on the same chromosome, 20 map units apart from each other. If you know Kate's mother had disease H only and her father had disease B only, what is the probability that Kate and Peter have a child with both diseases? What is the probability that they have a child with only one disease? (3 points) (TB) (NOTE: please write the answer in simplified fractions, in the order asked.

4. (3.00 pts)

c) Now assume that both traits are actually X-linked. Everything else from the previous question applies. What is the probability of the pair having a child who has both diseases? No disease at all? (3 points) (TB)(NOTE: please write the answer in simplified fractions, in the order asked.)



5. (1.00 pts) Karyotype



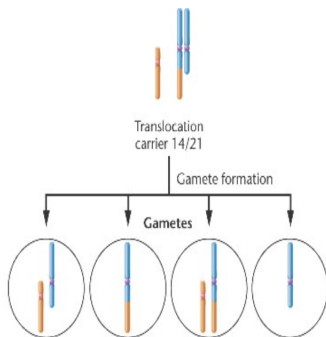
a) Is this person male or female? (1 point)

6. (2.00 pts) b) What two diseases does this person have? (2 points) (use non numbered name, order alphabetical, do not type syndrome)



7. (4.00 pts)

This is a Robertsonian translocation, which occurs in the five acrocentric chromosome pairs (13, 14, 15, 21, and 22). The chromosomes break at their centromeres and the long arms fuse to form a single, large chromosome with a single centromere. Chromosome 21 is labeled in orange, while chromosome 14 is labeled in blue.



Describe what phenotype/ disease arises (or none) from crossing each of the 4 gametes with a normal gamete. (4 points)

type one of four choices EXACTLY: none trisomy monosomy lethal

1st gamete:

2nd gamete:



8. (4.00 pts) 3rd gamete:

4th gamete:

trisomy

lethal

9. (3.00 pts) Assume you have a normal germ cell that can undergo both mitosis and meiosis. What is the ploidy (n, 2n, 4n) during each of these stages? (3 points)

Start of mitosis:

Immediately after mitosis:

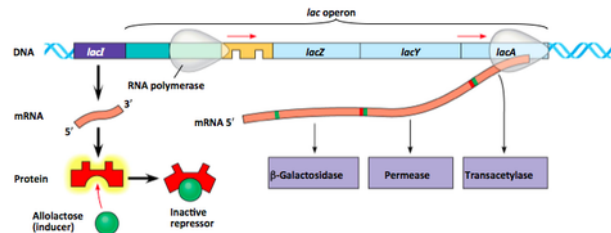
Immediately after meiosis I:

2n

2n

n

### 10. (4.00 pts) Bacterial Genomes



The *E. coli* Greg is studying has a defective lac operon, specifically the gene which encodes for lactose permease. The bacteria is transformed with a plasmid with the lac operon. Which of the following plasmids would allow for the bacteria to metabolize lactose normally? (Select all that apply)

(Mark **ALL** correct answers)

- ☐ A) Lac O<sup>+</sup>/Lac Z<sup>+</sup>/Lac Y<sup>-</sup>/Lac A<sup>+</sup>, normal repressor
- ☐ B) Lac O<sup>c</sup>/Lac Z<sup>+</sup>/Lac Y<sup>+</sup>/Lac A<sup>-</sup>, super repressor
- ☐ C) Lac O<sup>c</sup>/Lac Z<sup>-</sup>/Lac Y<sup>+</sup>/Lac A<sup>-</sup>, normal repressor
- ☒ D) Lac O<sup>+</sup>/Lac Z<sup>+</sup>/Lac Y<sup>+</sup>/Lac A<sup>-</sup>, normal repressor
- ☒ E) Lac O<sup>+</sup>/Lac Z<sup>+</sup>/Lac Y<sup>+</sup>/Lac A<sup>+</sup>, normal repressor

11. (4.00 pts) Greg is studying *E. coli*, specifically the operons. But first, he looks at the whole DNA sequence.

a) If the genome is composed of 26% A, what is the % composition for T and G? (4 points)

Enter your first 2 answers as integers without % sign in the order specified.

26

24

12. (3.00 pts) b) Using the same genome, what is the probability of a given codon in a random sequence of DNA being a stop codon? (stop codons are UAA, UAG, UGA) (3 points)

Enter your answer for b as a percentage rounded to the first decimal place (do not type the character '%').

5.0

13. (3.00 pts) This time the bacteria has a defective Lac O<sup>c</sup>, meaning the operator is constitutively active. A plasmid with a copy of a normal operator is introduced to the bacteria.

What will happen to the expression of lactose?

Glucose	Lactose	Expression (high/low)
high	high	

low	high	
low	low	

low

high

high

14. (10.00 pts)

Greg finds five mutant bacteria in his culture. For each strain of bacteria, he transforms the bacteria with plasmids containing the lac operons of the other 4 bacteria. He grows each transformed bacteria in a lactose-only medium. + indicates ability to grow, - indicates no growth. Each bacteria has a different mutation. **M1 is LacZ-**.

	M1	M2	M3	M4	M5	M6
M1	-	-	+	-	+	+
M2		-	+	-	+	+
M3			+	+	+	+
M4				-	-	-
M5					-	+
M6						+

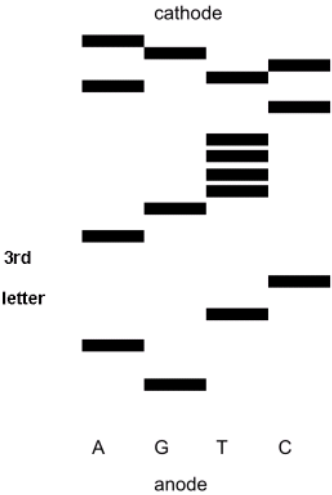
- a) Super repressor mutation
- b) Lac Oc
- c) Promoter mutation
- d) nonfunctional repressor
- e) Lac Y- mutation

Indicate using letters the type of mutation for each mutant from M2 to M5 **IN THAT ORDER**. Please separate your answer using commas and spaces (ex. a, b, c, d, e)

c, b, a, e, d

15. (6.00 pts)

		Second Letter			
		U	C	A	G
1st letter	U	UUU   Phe UUC   UUA   Leu UUG	UCU   Ser UCC   UCA   UCG	UAU   Tyr UAC   UAA   Stop UAG   Stop	UGU   Cys UGC   UGA   Stop UGG   Trp
	C	CUU   CUC   Leu CUA   CUG	CCU   Pro CCC   CCA   CCG	CAU   His CAC   CAA   Gln CAG	CGU   CGC   Arg CGA   CGG
	A	AUU   AUC   Ile AUA   AUG   Met	ACU   Thr ACC   ACA   ACG	AAU   Asn AAC   AAA   Lys AAG	AGU   Ser AGC   AGA   Arg AGG
	G	GUU   GUC   Val GUA   GUG	GCU   Ala GCC   GCA   GCG	GAU   Asp GAC   GAA   Glu GAG	GGU   GGC   Gly GGA   GGG



a) Amy needs to sequence a DNA sample using Sanger Sequencing (refer to diagram in top right). Suppose the primer she used was 5'-GATC-3'. What was the DNA sequence of the template? Answer 5' to 3' LETTERS ONLY all caps

TCGATGAAACTGATCGA

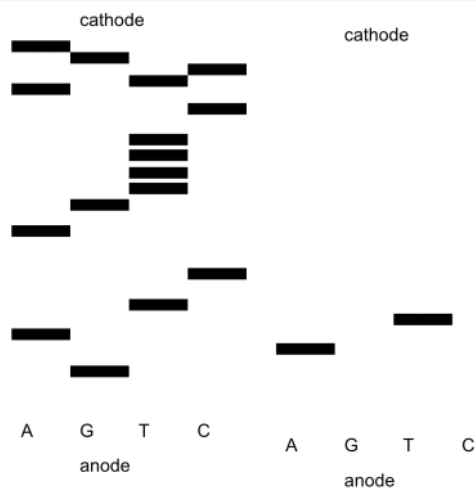
16. (3.00 pts) b) Translate the DNA to amino acid sequence. Write the 3 letter codes for the first 3 amino acids below.

ASP

GLN

PHE

17. (4.00 pts)



c) The experiment is run a second time, but this time it seems that some dNTPs/ddNTPs are missing. Select all that **must** have been missing.

(Mark **ALL** correct answers)

- ☐ A) dATP
- ☒ B) dCTP
- ☐ C) dGTP
- ☐ D) ddTTP
- ☐ E) ddCTP
- ☒ F) ddGTP

18. (3.00 pts)

d) Amy needs to make a primer for a different sequence she wants to amplify for PCR. This is the sequence: 5' CATCCCGATACTTA...ACGATCGATCAGTT 3' Write the sequence for the **forward** then **reverse** primers, from 5' to 3'. DO NOT add 5' or 3' - only type the letters in all caps.

CATCCCGATACTTA

AACTGATCGATCGT

19. (6.00 pts)

### Polygenic Inheritance

Suppose that the hair color of cats is controlled by 5 genes. 1 gene, A, is X linked, while the other 4, B, C, D, and E, are autosomal. When a cat is dominant for any of these 5 genes, it increases the darkness of their hair by 1 unit. A cat can have hair color "darkness" from 0 to 5 units.

Alice crosses a cat with genotype *XAXaBbCCddEe* with another cat, genotype *XAYbbccdde*. What fraction of cats will have hair color darkness of 3 units? 2 units? 5 units? Type your answer in that order into the 3 boxes. If fractions, please simplify.

7/16

5/16

0

**20. (3.00 pts)**

Alice later finds out that the genes D and E are on the same chromosome. She crosses another pair of cats, this time with genotypes  $XAXaBbCcDdEe$  with  $XAYbbCcdd ee$ . The darker cat had parents  $XAXABBCCDDEE$  and  $XaYbbccdd ee$ . If these 2 cats have many, many cats, and the resulting % of cats with hair color 0, 1, 2, 3, 4, and 5 is approximately 2%, 9%, 26%, 29%, 25%, and 10% respectively, what is the recombination frequency of genes D and E? (3 points) Type your answer as a percentage (without the percent sign) to the nearest INTEGER.

**Trihybrid fun!**

Suppose 3 genes for eye color, body color, and wings are on the same autosomal chromosome. A wild type fruit fly is crossed with a recessive fruit fly.

type	Eye color	Body	Wings	Number of progeny
1	wild type	yellow	wild type	2
2	wild type	yellow	vestigial	18
3	wild type	wild type	wild type	50
4	white	yellow	wild type	430
5	wild type	wild type	vestigial	434
6	white	wild type	wild type	21
7	white	yellow	vestigial	43
8	white	wild type	vestigial	1

**21. (6.00 pts)** a) Calculate recombination frequencies for each pair of genes: (6 points)

EYE COLOR -- BODY

BODY -- WINGS

EYEC OLOR -- WINGS

write as percentages (without % sign) to the nearest INTEGER.

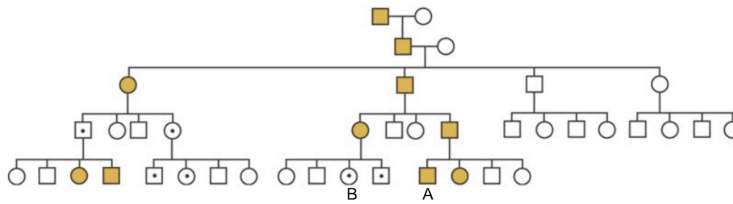
**22. (3.00 pts)** Select the wildtype fly's alleles on each chromosome separated by a / (note the order) WT = wildtype

- ☐ A) WT (body) WT (eye) WT (wings) / yellow (body) white (eye) vestigial (wings)
- ☐ B) WT (eye) yellow (body) vestigial (wings) / WT (eye) WT (body) vestigial (wings)
- ☐ C) white (eye) yellow (body) WT (wings) / WT (eye) WT (body) vestigial (wings)
- ☒ D) yellow (body) white (eye) WT (wings) / WT (body) WT (eye) vestigial (wings)

**23. (3.00 pts)** There seems to be less double crossovers than expected. Calculate the interference ( $1 - \text{observed number of double crossovers} / \text{expected number of double crossovers}$ )

Enter your answer as a decimal rounded to 2 DECIMAL PLACES.

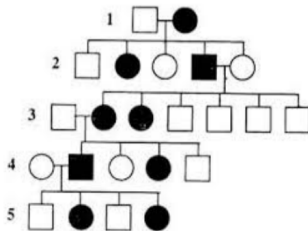
**24. (2.00 pts)** Pedigrees!



What inheritance pattern does this mostly likely suggest? (2 points)

- ☐ A) X-linked recessive
- ☒ B) maternal imprinting
- ☐ C) X-linked dominant
- ☐ D) Autosomal dominant
- ☐ E) Autosomal recessive

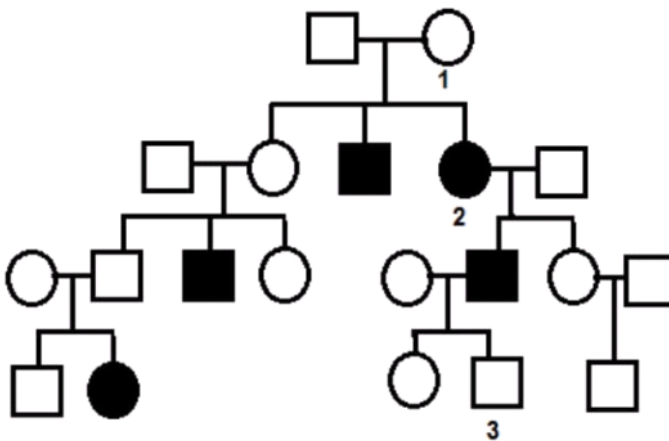
25. (2.00 pts)



What inheritance pattern does this most likely suggest? (2 points)

- ☐ A) Autosomal recessive
- ☐ B) Autosomal dominant
- ☒ C) X-linked dominant
- ☐ D) Mitochondrial
- ☐ E) X-linked recessive

26. (2.00 pts)



b) What is the probability that individual 3 is a carrier of the disease? (2 points) Answer in simplified fraction.

**27. (2.00 pts)** Which of the following combinations would be impossible?

- ☐ A) Mother: A, Father: B, Child: O
- ☐ B) Mother A, Father B, Child: AB
- ☒ C) Mother A, Father AB, Child O
- ☐ D) Mother A, Father B, Child B
- ☐ E) A and C
- ☐ F) All possible

**28. (2.00 pts)** If a woman knows her blood type is BO and is Rh-, and her child's blood type is O Rh- , what cannot be her husband's blood type? (select all that apply)

(Mark **ALL** correct answers)

- ☐ A) A Rh+
- ☐ B) B Rh-
- ☒ C) AB Rh-
- ☐ D) O Rh+
- ☐ E) O Rh-

**29. (2.00 pts)**

A woman wants to breed a manx cat named Vladimir. A manx cat has an autosomally inherited gene M that controls tail length. Short tail length (M) is dominant to long tail length(m), but the homozygous dominant genotype is not viable. If Vladimir's parents are both heterozygous for M, what is the likelihood that Vladimir has a short tail?

- ☐ A) 1/2
- ☒ B) 2/3
- ☐ C) 1/4
- ☐ D) 3/4

**30. (2.00 pts)** What type of genetic phenomenon does CFTR represent?

- ☒ A) Pleiotropy
- ☐ B) Epistasis
- ☐ C) Polygenic Inheritance
- ☐ D) Codominance

**31. (2.00 pts)** Which of the following statements about cyclin is NOT true?

(Mark **ALL** correct answers)

- ☒ A) Cyclin dependent kinase (Cdk) activity is the highest during M phase
- ☒ B) Cyclin levels remain constant throughout the cell cycle
- ☐ C) Cdk levels remain constant throughout the cell cycle
- ☐ D) Interfering with Cdk levels could lead to cell death



**32. (2.00 pts)** Which of the following would be most likely in the form of heterochromatin? (select all that apply)

(Mark **ALL** correct answers)

- ☒ A) Barr body
- ☐ B) Housekeeping gene
- ☒ C) CpG island
- ☒ D) Centromere

**33. (2.00 pts)**

Transposable elements are segments of DNA that can move within the genome. Which of the following is NOT a potential reason why so much of the human genome consists of these elements?

(Mark **ALL** correct answers)

- ☐ A) Transposable elements can introduce potentially beneficial mutations
- ☐ B) Transposable elements can insert exons into to new locations, potentially allowing for new function
- ☐ C) Transposable elements are selfish genes that proliferate like parasites
- ☒ D) Transposable elements can cause deleterious mutations associated with many diseases

**34. (2.00 pts)**

Chickens use the ZW sex determination system. Males are the homogametic sex (ZZ), while females are the heterogametic sex (ZW). Suppose a chickens have a gene on the Z chromosome that determines their comb color (C), with dominant color red and recessive color as white. If a heterozygous, red combed male is mated with a red combed female, what is the distribution of comb color in their offspring?

(Mark **ALL** correct answers)

- ☐ A) Female: 100% red; Male: 100% white
- ☐ B) Female: 50% red; Male: 50% red
- ☐ C) Female: 100% white; Male: 100% red
- ☒ D) Female: 50% red; Male: 100% red
- ☐ E) Female: 50% red; Male: 100% white

**35. (2.00 pts)**

You find a bacteria that lives in the middle of a hydrothermal vent. You sequence the bacteria, but forget to label it! Which of the following sequences is mostly likely part of its DNA?

- ☐ A) 5'-ATATCGATATATTATCCG-3'
- ☒ B) 5'-CGACGCCTCGCGCAC-3'
- ☐ C) 5'-AAATAATAATATCATATA-3'
- ☐ D) 5'-AATTTTGGCATAATATA-3'

**36. (2.00 pts)** If the genetic code consisted of four bases per codon rather than three, the maximum number of unique amino acids that could be encoded would be

- ☐ A) 16
- ☐ B) 64
- ☐ C) 128
- ☒ D) 256
- ☐ E) 512

**37. (2.00 pts)** In humans, the Barr body is an

- ☐ A) active X chromosome in females
- ☐ B) active X chromosome in males
- ☐ C) inactive Y chromosome in males
- ☐ D) inactive Y chromosome in females
- ☒ E) inactive X chromosome in females

**38. (2.00 pts)** An RNA-dependent RNA polymerase is likely to be present in the virion of a

- ☐ A) DNA virus that multiplies in the cytoplasm
- ☐ B) DNA virus that multiplies in the nucleus
- ☒ C) minus-strand RNA virus
- ☐ D) plus-strand RNA virus
- ☐ E) transforming virus

**39. (2.00 pts)** In *E. coli*, the inability of the *lac* repressor to bind an inducer would result in

- ☒ A) no substantial synthesis of beta-galactosidase
- ☐ B) constitutive synthesis of beta-galactosidase
- ☐ C) inducible synthesis of beta-galactosidase
- ☐ D) synthesis of inactive beta-galactosidase
- ☐ E) synthesis of beta-galactosidase only in the absence of lactose

**40. (2.00 pts)**

Genes *a*, *b*, and *c* are widely spaced in the bacterial genome. Transducing phage from an  $a^+ b^+ c^+$  bacterium were used to infect a culture of  $a^- b^- c^-$  cells, and  $b^+$  transductants were selected. Which of the following best describes the predicted genotypes of these transductants?

- ☒ A) Mostly  $a^- b^+ c^-$
- ☐ B) Mostly  $a^- b^+ c^+$
- ☐ C) Mostly  $a^+ b^+ c^+$
- ☐ D) Mostly  $a^+ b^+ c^-$
- ☐ E) Two of the above in equal frequency

**41. (2.00 pts)** If a cell has one chromosome in excess of the normal number of chromosomes present in the nucleus, it is referred to as

- ☒ A) aneuploid
- ☐ B) polyploid
- ☐ C) tetraploid
- ☐ D) haploid
- ☐ E) allotetraploid

**42. (2.00 pts)** Which of the following statements about retrotransposons is correct?

- ☒ A) They transpose via an RNA intermediate
- ☐ B) They contain genes for ribosomal proteins
- ☐ C) They possess a gene for RNA-dependent RNA polymerase
- ☐ D) They possess genes that encode proteins that integrate RNA into chromosomes
- ☐ E) They are found only in bacteria

**43. (2.00 pts)** When bacteria produce mammalian proteins, cDNA is used rather than genomic DNA. Which of the following is the best explanation?

- ☐ A) It is easier to clone cDNA than genomic DNA of comparable size.
- ☐ B) It is easier to clone RNA than DNA.
- ☐ C) It is not possible to clone the entire coding region of the gene.
- ☒ D) Most eukaryotic genes have introns that cannot be removed in bacteria.
- ☐ E) Most eukaryotic gene promoters do not function in bacteria.

**44. (2.00 pts)** A mutation deleting an upstream activating sequence for a single gene would be expected to be

- ☐ A) polar
- ☐ B) *trans*-dominant
- ☒ C) *cis*-dominant
- ☐ D) silent
- ☐ E) reversible

**45. (2.00 pts)** Particular RNAs that are important for development are located in distinct regions of the *Drosophila* embryo. This is most directly demonstrated by using

- ☐ A) western blotting
- ☐ B) northern blotting
- ☒ C) *in situ* hybridization
- ☐ D) *in vitro* translation
- ☐ E) electroporation

**46. (2.00 pts)** Which of the following events can induce a transient arrest in the translation of a secretory protein?

- ☐ A) Binding of a polysome to an ER receptor
- ☒ B) Binding of SRP to an N-terminal signal sequence
- ☐ C) Binding of snRNPs to the large ribosomal subunit
- ☐ D) Presence of a stop-transfer sequence in the polypeptide
- ☐ E) Cleavage of the signal sequence by signal peptidase

**47. (2.00 pts)**

A microarray is a large collection of specific DNA oligonucleotides spotted in a defined pattern on a microscope slide. What is the most useful experiment that can be done with such a tool?

- ☐ A) Predicting the presence of specific metabolites in a cell
- ☐ B) Comparing newly synthesized nuclear RNA with cytoplasmic RNA to locate introns
- ☒ C) Comparing RNA produced under two different physiological conditions to understand patterns of gene expression
- ☐ D) Comparing proteins produced under two different physiological conditions to understand their function
- ☐ E) Evaluating the linkage relationships of genes

**48. (2.00 pts)** In vertebrate genes, transcription regulatory regions that contain CpG islands are inactivated by which CpG modification?

- ☒ A) Methylation
- ☐ B) Myristylation
- ☐ C) Phosphorylation
- ☐ D) Acetylation
- ☐ E) Ubiquitination

**49. (2.00 pts)**

In a study of arginine biosynthesis in yeast, four mutant haploids requiring arginine (Arg<sup>-</sup>) were isolated. The Arg<sup>-</sup> haploids were fused in pairwise combinations to form diploids, whose requirement for arginine was tested. The results of the tests were that all diploid combinations yielded arginine prototrophs. How many different Arg genes are represented among the four mutants?

- ☐ A) One
- ☐ B) Two
- ☐ C) Three
- ☒ D) Four
- ☐ E) Five

**50. (2.00 pts)**

A set of genes from *Bacillus subtilis* that encode the proteins required for sporulation have conserved DNA sequences -35 and -10 nucleotides before the site of transcript initiation, although the sequence at -35 is different from that seen in most other genes from that species. Which of the following best explains this difference?

- ☒ A) A novel sigma factor is required for transcription initiation at these genes.
- ☐ B) The -35 sequence is the binding site for a repressor of transcription.
- ☐ C) The replication of these genes requires a specifically modified DNA polymerase.
- ☐ D) Translation of the mRNAs transcribed from these genes requires specific ribosomes that recognize a modified Shine-Dalgarno sequence.
- ☐ E) Transcription of these genes is induced by cAMP.

**51. (2.00 pts)** Which of the following best describes the hyperchromicity of DNA?

- ☐ A) The shift in UV absorbance to longer wavelengths upon denaturation
- ☐ B) The shift in UV absorbance to shorter wavelengths upon hydrolysis
- ☐ C) The shift in UV absorbance to longer wavelengths upon annealing (forming double strands)
- ☐ D) The increase in absorbance at 260 nm upon annealing
- ☒ E) The increase in absorbance at 260 nm upon denaturation

**52. (2.00 pts)** The synthesis of mRNAs that encode the proteins of eukaryotic ribosomes occurs in the

- ☐ A) cytoplasm
- ☐ B) nuclear envelope
- ☐ C) nucleolus
- ☒ D) euchromatin
- ☐ E) heterochromatin

**53. (2.00 pts)**



The uppermost figure above shows the locations of four genes on the genetic map of an organism; the lower figure shows the locations of the same four genes on a physical map derived from the nucleotide sequence of the DNA of that organism. The maps are not identical because

- ☐ A) there is no relationship between the position of genes in a genetic map and their positions on the DNA
- ☒ B) recombination frequencies per kb of DNA are not uniform throughout a chromosome
- ☐ C) the farther apart two genes are, the more likely they are to recombine
- ☐ D) the closer two genes are, the more likely they are to recombine
- ☐ E) some genes contain introns

**54. (2.00 pts)** The karyotype of a triploid plant contains 72 chromosomes. How many chromosomes would the karyotype of a diploid plant of the same species contain?

- ☐ A) 24
- ☒ B) 48
- ☐ C) 49
- ☐ D) 71
- ☐ E) 96

**55. (2.00 pts)** The DNA from the bacteriophage  $\phi$ X174 has a base composition of 25% A, 33% T, 24% G, and 18% C. Which of the following best explains this observation?

- ☐ A) In viral genomes, the base pairing does not follow the standard Watson-Crick rules, and allows G-A and C-T base pairs.
- ☐ B) In viral genomes, the base pairing does not follow the standard Watson-Crick rules, and allows G-T and C-A base pairs.
- ☐ C) Viral genomes are linear and tolerate base-pair mismatches.
- ☐ D) Nucleic acids from viruses are tightly complexed with nucleic acid-binding proteins and so cannot base-pair with one another.
- ☒ E) The genome of bacteriophage  $\phi$ X174 is single-stranded.

**56. (2.00 pts)** The GAL4 protein activates transcription from the GAL1 promoter in yeast. To bind to DNA, the protein utilizes a

- ☐ A) heme group
- ☐ B) transcriptional-activating domain
- ☒ C) zinc-finger domain

- ☐ D) transmembrane segment
- ☐ E) signal peptide

**57. (2.00 pts)** Active transposable elements have which of the following features?

- I. Repeated sequences at the ends of the transposable element
- II. Different numbers and chromosomal positions in different species of a single genus
- III. The ability to alter the phenotype of an organism

- ☐ A) I only
- ☐ B) II only
- ☐ C) I and II only
- ☐ D) I and III only
- ☒ E) I, II, and III

**58. (2.00 pts)**

Consider the average in vivo turnover rates for proteins, DNA, and mRNA. Which of the following orders best describes the turnover rate from fastest (shortest average lifetime) to slowest (longest average lifetime)?

- ☐ A) mRNA > DNA > proteins
- ☒ B) mRNA > proteins > DNA
- ☐ C) proteins > mRNA > DNA
- ☐ D) proteins > DNA > mRNA
- ☐ E) DNA > mRNA > proteins

**59. (2.00 pts)** Which of the following gene products are least likely to be encoded by an oncogene?

- ☐ A) GTP-binding proteins
- ☐ B) DNA-binding proteins
- ☐ C) Transmembrane proteins
- ☒ D) Capsid proteins
- ☐ E) Tyrosine kinases

**60. (2.00 pts)**

When the nucleus of a frog red blood cell, which does not replicate DNA, is transplanted into an enucleated frog egg, the egg goes through several cell divisions. Which of the following is the best interpretation for this phenomenon?

- ☐ A) Isolated red-blood-cell nuclei synthesize DNA.
- ☐ B) The nucleus plays no role in cell division.
- ☐ C) An enucleated frog egg can divide.
- ☐ D) Genes do not function during early cleavage.
- ☒ E) The cytoplasm controls nuclear DNA synthesis.

**61. (2.00 pts)** The nuclear-synthesized poly-A sequence at the 3' end of eukaryotic messenger RNA is

- ☐ A) attached at random sequences within the 3' non-translated region of a pre-mRNA
- ☐ B) found also as a common feature in rRNA and tRNA

- ☐ C) transcribed from poly-T sequences in template DNA
- ☐ D) transcribed by RNA polymerase II
- ☒ E) added after 3' end cleavage of the pre-mRNA transcript

**62. (2.00 pts)** A silent mutation in a gene results in

- ☐ A) no change in the nucleotide sequence of the mRNA encoded by the gene
- ☒ B) no change in the amino acid sequence of the protein encoded by the gene
- ☐ C) no expression of the protein encoded by the gene
- ☐ D) an amino acid substitution that has a significant effect on the functional activity of the protein encoded by the gene
- ☐ E) a shift of the translational reading frame

**63. (2.00 pts)**

Which of the following most accurately explains the cause for the abnormal numbers of chromosomes during human reproduction that can result in Down syndrome, Turner's syndrome, or Klinefelter's syndrome?

- ☒ A) The occurrence of nondisjunction of homologous chromosomes during meiosis
- ☐ B) The duplicative production of extra chromosomes during DNA replication
- ☐ C) The abnormal pairing of nonhomologous chromosomes during prophase of meiosis I
- ☐ D) The selective loss of particular chromosomes from the sex cells after formation of the mature gamete
- ☐ E) The fusion of two sperm with one egg to provide an extra set of paternal chromosomes

**64. (2.00 pts)** The enzyme reverse transcriptase is useful in the generation of cDNA libraries for which of the following reasons?

- ☐ A) It is sensitive to high temperatures and so can be readily "killed" by heat treatment when the reaction is completed.
- ☐ B) It does not require a primer to initiate polymerization as do most DNA polymerases.
- ☐ C) It is insensitive to high temperatures and so can survive the many cycles of heating required to perform the polymerase chain reaction.
- ☒ D) It is an RNA-dependent DNA polymerase.
- ☐ E) It lacks the proofreading function of most DNA polymerases and so is able to utilize mRNA from mutated genes as a template.

**65. (2.00 pts)** Gene rearrangements play a role in which of the following processes?

- ☐ A) Adaptation to carbon source by bacteria
- ☒ B) Surface antigen changes in trypanosomes
- ☐ C) Sex determination in nematodes
- ☐ D) Host range modification in bacteriophage T4
- ☐ E) Segmentation during arthropod development

**66. (2.00 pts)**

A mutant of *E. coli* with a heat-sensitive DNA ligase (25 degrees C permissive, 37 degrees C nonpermissive) has been used to show that DNA synthesis is discontinuous. Examination of DNA replication in the presence of [<sup>3</sup>H]-thymidine in the mutant would demonstrate which of the following?

- ☐ A) The accumulation of short segments of unlabeled DNA at 25 degrees C and at 37 degrees C
- ☐ B) The accumulation of short segments of unlabeled DNA at 25 degrees C but not at 37 degrees C
- ☒ C) The accumulation of short segments of unlabeled DNA at 37 degrees C but not at 25 degrees C
- ☐ D) The accumulation of short segments of radioactive DNA at 25 degrees C but not at 37 degrees C

- ☐ E) The incorporation of short fragments of radioactive DNA into longer ones at 25 degrees C and at 37 degrees C

**67. (2.00 pts)** All of the following statements are true about damage by ultraviolet light to DNA in living cells EXCEPT:

- ☐ A) The damage blocks normal DNA replication
- ☐ B) The most damaging wavelength is about 260 nm
- ☐ C) Covalent bonds are formed that join neighboring pyrimidines
- ☒ D) Neighboring phosphodiester bonds are cleaved
- ☐ E) Most cells can synthesize proteins capable of repairing UV damage

**68. (2.00 pts)** A dicentric chromosome is unstable because

- ☐ A) it cannot resynthesize its telomeres during replication
- ☐ B) it pairs with nonhomologous chromosomes in meiosis
- ☐ C) it pairs with nonhomologous chromosomes in mitosis
- ☒ D) it is often simultaneously drawn to opposing spindle poles in mitosis
- ☐ E) many of its genes are silenced

**69. (2.00 pts)** Which of the following statements about repetitive DNA is NOT true?

- ☐ A) Repetitive DNA is associated with the centromeres and telomeres in higher eukaryotes.
- ☒ B) Repetitive DNA is restricted to nontranscribed regions of the genome.
- ☐ C) Repetitive DNA sequences are often found in tandem clusters throughout the genome.
- ☐ D) Repetitive DNA was first detected because of its rapid reassociation kinetics.
- ☐ E) Transposable elements can contribute to the repetitive DNA fraction.

**70. (2.00 pts)** Which of the following is NOT characteristic of a eukaryotic enhancer element?

- ☐ A) Its activity is independent of its orientation (i.e., the sequence can be inverted without effect).
- ☒ B) Its activity is dependent on its distance from the start site of transcription.
- ☐ C) It may be found as far as 1 to 2 kilobases from the promoter.
- ☐ D) It may be positioned at the 5' end or the 3' end of the gene.
- ☐ E) It increases the level of transcription of genes under its control.

**71. (2.00 pts)** Mitosis and meiosis accomplish segregation of the replicated DNA to two or more daughter cells. Which of the following is characteristic of both mitosis and meiosis?

- ☐ A) Chromosomes attach to spindle fibers composed of actin.
- ☐ B) The resulting cells are diploid (2n).
- ☐ C) The resulting cells are haploid (1n).
- ☒ D) Spindle fibers attach to chromosomes at their kinetochores.
- ☐ E) Chiasmata form between chromosome arms.

**72. (2.00 pts)** The increase in the number of nucleoli during oocyte development in the frog *Xenopus laevis* is the result of



- ☐ A) accelerated cell division
- ☐ B) rapid chromosome replication
- ☐ C) rapid synthesis of transfer RNA
- ☒ D) amplification of the ribosomal RNA genes
- ☐ E) accumulation of yolk protein

**73. (2.00 pts)** In meiosis, an inversion in one member of a pair of homologous chromosomes will most likely lead to which of the following?

- ☐ A) Nondisjunction of the affected chromosome
- ☒ B) Chromosomes with duplications and deficiencies
- ☐ C) Increased recombination frequency in the inverted region
- ☐ D) Mispairing of the affected chromosome with a nonhomologous chromosome
- ☐ E) Cellular arrest in meiotic prophase

**74. (2.00 pts)** One important mechanism for maintaining sequence identity among the many copies of a gene within a tandem array is

- ☐ A) unequal crossing-over
- ☒ B) gene conversion
- ☐ C) retrotransposition
- ☐ D) deletion
- ☐ E) inversion

**75. (2.00 pts)** Which of the following mRNA molecules would form the most stable stem-loop structure?

- ☐ A) 5'...GGCUU.....UUCGG.....3'
- ☒ B) 5'...GGCUU.....AAGCC.....3'
- ☐ C) 5'...GGCUU.....GGCUU.....3'
- ☐ D) 5'...GGCUU.....CCGAA.....3'
- ☐ E) 5'...AAGCC.....AAGCC.....3'

**76. (2.00 pts)** Which of the following conditions is likely to interfere with the transfer of genetic material by conjugation in bacteria?

- ☐ A) Pretreatment of the recipient cells with DNase
- ☐ B) Pretreatment of the recipient cells by application of strong shearing forces
- ☐ C) Treatment of the recipient cells with cycloheximide
- ☒ D) Treatment of the mating cell pairs by application of strong shearing forces
- ☐ E) Treatment of the mating cell pairs with RNase

**77. (2.00 pts)** The primary action of steroid hormones is at the level of

- ☐ A) RNA export from the nucleus
- ☒ B) transcription
- ☐ C) pre-mRNA splicing
- ☐ D) mRNA degradation
- ☐ E) gene rearrangement

**78. (2.00 pts)** In an operon regulated only by attenuation, a mutation causing oversynthesis of the gene products is most likely to be in the part of the DNA corresponding to the

- ☐ A) operator
- ☐ B) 3' terminal sequence of the RNA
- ☒ C) 5' terminal sequence of the RNA
- ☐ D) introns of the RNA
- ☐ E) coding sequence for the *trans* activator

**79. (2.00 pts)** The processes that lead to the synthesis of the functional light chain of an antibody molecule include

- ☐ A) DNA rearrangement but no RNA splicing
- ☒ B) DNA rearrangement but no gene duplication
- ☐ C) DNA rearrangement but no protein processing
- ☐ D) RNA splicing but no DNA rearrangement
- ☐ E) gene duplication but no protein processing

**80. (2.00 pts)** A second mutation in the same gene restores the wild-type phenotype. This phenomenon is referred to as

- ☐ A) intergenic complementation
- ☐ B) gene conversion
- ☐ C) synthetic enhancement
- ☒ D) intragenic suppression
- ☐ E) epistasis

**81. (2.00 pts)** The exchange of material between nonhomologous chromosomes is

- ☐ A) transition
- ☐ B) transversion
- ☒ C) translocation
- ☐ D) tautomerization
- ☐ E) reversion

**82. (2.00 pts)** The change from a mutant allele to a wild-type allele is

- ☐ A) Transition
- ☐ B) Transversion
- ☐ C) Translocation
- ☐ D) Tautomerization
- ☒ E) Reversion

**83. (2.00 pts)** Which of the following produces oligonucleotides that contain damaged bases?

- ☐ A) Photoreactivation

- ☒ B) Excision repair
- ☐ C) Recombination repair
- ☐ D) SOS repair
- ☐ E) Mismatch repair

**84. (2.00 pts)** Which of the following acts only on pyrimidine dimers?

- ☒ A) Photoreactivation
- ☐ B) Excision repair
- ☐ C) Recombination repair
- ☐ D) SOS repair
- ☐ E) Mismatch repair

**85. (2.00 pts)** Which of the following uses methyl groups to distinguish parental and daughter strands?

- ☐ A) Photoreactivation
- ☐ B) Excision repair
- ☐ C) Recombination repair
- ☐ D) SOS repair
- ☒ E) Mismatch repair

**86. (2.00 pts)** Which of the following is often mutagenic?

- ☐ A) Photoreactivation
- ☐ B) Excision repair
- ☐ C) Recombination repair
- ☒ D) SOS repair
- ☐ E) Mismatch repair

**87. (2.00 pts)** Which of the following involves exchange of sister strands?

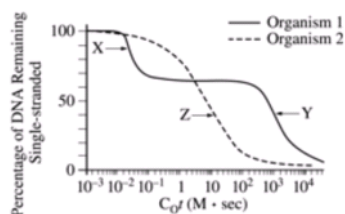
- ☐ A) Photoreactivation
- ☐ B) Excision repair
- ☒ C) Recombination repair
- ☐ D) SOS repair
- ☐ E) Mismatch repair

**88. (2.00 pts)** Which of the following possesses genes that may be integrated into the genome of an infected eukaryotic cell?

- ☐ A) *E. coli*
- ☐ B) Yeast
- ☐ C) Bacteriophage T4
- ☐ D) Bacteriophage lambda
- ☒ E) Adenovirus

89. (2.00 pts)

The figure below is a graph of the reannealing (reforming of double-stranded molecules) of total genomic DNA from two different organisms. DNA was extracted from each organism, sheared to a uniform size, and then denatured by heating. An identical amount of each preparation of sheared, single-stranded DNA was allowed to reanneal under identical conditions of pH, buffer, ionic strength, and temperature. The reannealing curves shown were obtained by plotting the percentage of DNA remaining single-stranded *versus* the product of the total DNA concentration ( $C_0$ ), in moles of nucleotide per liter, times the renaturation time ( $t$ ), in seconds.

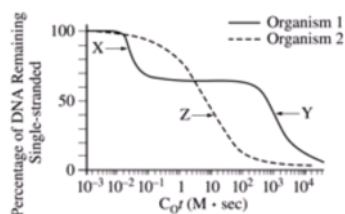


In the samples of sheared DNA, which of the following is true about the sequence complexity of the populations indicated by X, Y, and Z in the figure?

- ☒ A) Y is more complex than either X or Z.
- ☐ B) X is more complex than either Y or Z.
- ☐ C) X and Y are of equivalent complexity and more complex than Z.
- ☐ D) X and Y are of equivalent complexity and less complex than Z.
- ☐ E) X, Y, and Z are of equivalent complexity.

90. (2.00 pts)

The figure below is a graph of the reannealing (reforming of double-stranded molecules) of total genomic DNA from two different organisms. DNA was extracted from each organism, sheared to a uniform size, and then denatured by heating. An identical amount of each preparation of sheared, single-stranded DNA was allowed to reanneal under identical conditions of pH, buffer, ionic strength, and temperature. The reannealing curves shown were obtained by plotting the percentage of DNA remaining single-stranded *versus* the product of the total DNA concentration ( $C_0$ ), in moles of nucleotide per liter, times the renaturation time ( $t$ ), in seconds.



Proteins are most likely encoded by which of the populations of DNA fragments indicated by X, Y, and Z in the figure?

- ☐ A) X only
- ☐ B) Y only
- ☐ C) X and Y
- ☐ D) X and Z
- ☒ E) Y and Z

91. (2.00 pts)

In *Drosophila melanogaster*, cinnabar eye (*cn*) and vestigial wing (*vg*) are simple recessive traits. A female, heterozygous for both genes, was crossed with a male with cinnabar eyes and vestigial wings. The offspring resulting from this cross are listed in the table below.

Class	Phenotype	Number
I	Wild type	445
II	Cinnabar eye, wild-type wing	51
III	Wild-type eye, vestigial wing	49
IV	Cinnabar eye, vestigial wing	455

Recombinant phenotypes include which of the following classes?

- ☐ A) IV only
- ☐ B) I and IV only
- ☒ C) II and III only
- ☐ D) I, II, and III only
- ☐ E) II, III, and IV only

92. (2.00 pts)

In *Drosophila melanogaster*, cinnabar eye (*cn*) and vestigial wing (*vg*) are simple recessive traits. A female, heterozygous for both genes, was crossed with a male with cinnabar eyes and vestigial wings. The offspring resulting from this cross are listed in the table below.

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From the data shown, the distance between the *cn* and *vg* genes is approximately

- ☐ A) 500 map units
- ☐ B) 100 map units
- ☐ C) 50 map units
- ☒ D) 10 map units
- ☐ E) 5 map units

93. (2.00 pts)

In *Drosophila melanogaster*, cinnabar eye (*cn*) and vestigial wing (*vg*) are simple recessive traits. A female, heterozygous for both genes, was crossed with a male with cinnabar eyes and vestigial wings. The offspring resulting from this cross are listed in the table below.

Class	Phenotype	Number
I	Wild type	445
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IV	Cinnabar eye, vestigial wing	455

If crossing-over were to occur in the male parent, the anticipated effect on phenotypic numbers would be

- ☐ A) a decrease in class I
- ☐ B) a decrease in class II
- ☐ C) a decrease in class III
- ☐ D) a decrease in class IV
- ☒ E) no significant difference

94. (2.00 pts)

In *Drosophila melanogaster*, cinnabar eye (*cn*) and vestigial wing (*vg*) are simple recessive traits. A female, heterozygous for both genes, was crossed with a male with cinnabar eyes and vestigial wings. The offspring resulting from this cross are listed in the table below.

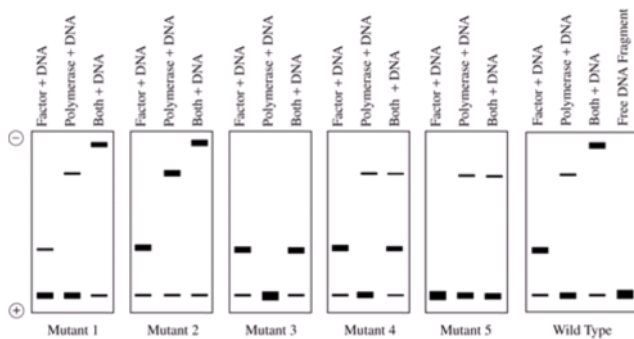
Class	Phenotype	Number
I	Wild type	445
II	Cinnabar eye, wild-type wing	51
III	Wild-type eye, vestigial wing	49
IV	Cinnabar eye, vestigial wing	455

If *cn* and *vg* were unlinked, what percent of the offspring would be expected to have either cinnabar eyes or vestigial wings or both?

- ☐ A) 100%
- ☒ B) 75%
- ☐ C) 50%
- ☐ D) 25%
- ☐ E) 6%

95. (2.00 pts)

Five *E. coli* strains have been identified, each of which has a different mutation that disrupts the normal regulation of a particular operon. For each mutant strain, the mutation has been mapped to the promoter or the operator region; however, the exact sequence changes are not known for these mutations. It is known that the normal promoter/operator consists of a single binding site for a positively acting transcription factor located just upstream of the promoter itself. Short DNA fragments containing the promoter and the operator were subcloned from each of the five mutant strains and from the wild type, purified, and radiolabeled. These fragments were then incubated under conditions of DNA excess with either purified regulatory factor or RNA polymerase or with both polymerase and regulatory factor. The resulting protein-DNA complexes were separated by electrophoresis, and the radioactive DNA fragments were detected by exposure to x-ray film, giving the results shown below. Electrophoresis is from top to bottom; the largest complexes run slowest.

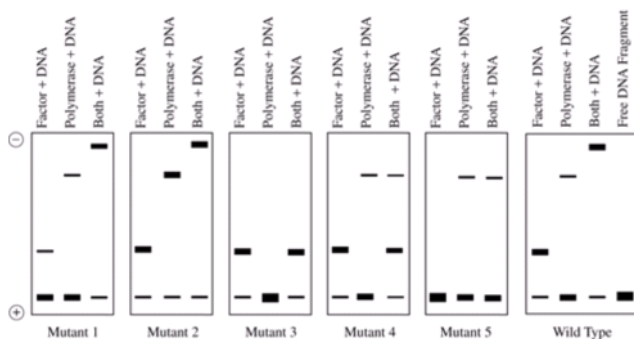


One of the mutations increases the affinity of the polymerase for the promoter. Transcription of the operon is not stimulated by the regulatory factor in this mutant. Which mutant is most likely to show this effect?

- ☐ A) Mutant 1
- ☒ B) Mutant 2
- ☐ C) Mutant 3
- ☐ D) Mutant 4
- ☐ E) Mutant 5

#### 96. (2.00 pts)

Five *E. coli* strains have been identified, each of which has a different mutation that disrupts the normal regulation of a particular operon. For each mutant strain, the mutation has been mapped to the promoter or the operator region; however, the exact sequence changes are not known for these mutations. It is known that the normal promoter/operator consists of a single binding site for a positively acting transcription factor located just upstream of the promoter itself. Short DNA fragments containing the promoter and the operator were subcloned from each of the five mutant strains and from the wild type, purified, and radiolabeled. These fragments were then incubated under conditions of DNA excess with either purified regulatory factor or RNA polymerase or with both polymerase and regulatory factor. The resulting protein-DNA complexes were separated by electrophoresis, and the radioactive DNA fragments were detected by exposure to x-ray film, giving the results shown below. Electrophoresis is from top to bottom; the largest complexes run slowest.



One of the mutations maps to the operator. Transcription of the operon is not stimulated by the regulatory factor in this mutant. Which mutant is most likely to show this effect?

- ☐ A) Mutant 1
- ☐ B) Mutant 2
- ☐ C) Mutant 3
- ☐ D) Mutant 4
- ☒ E) Mutant 5

#### 97. (2.00 pts)

☐ A) Mutant 1

☐ B) Mutant 2

☐ C) Mutant 3

☒ D) Mutant 4

☐ E) Mutant 5

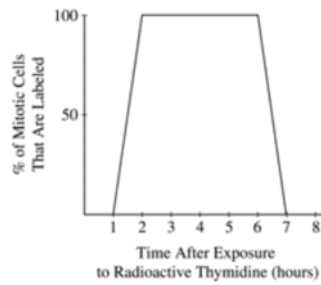
Time After Exposure (hours)	% of Mitotic Cells Labeled
1	0
2	100
3	100
4	100
5	100
6	100
7	0

- ☐ A) cells must repair thymidine-induced DNA damage before entering G2
- ☐ B) the cells get out of synchrony as they proceed through the cell cycle
- ☐ C) the period of thymidine labeling is 5 minutes
- ☒ D) G2 lasts 1 hr
- ☐ E) M phase lasts 1 hr

99. (2.00 pts)



The stages of the cell cycle for a cultured mammalian cell line require the following periods of time:  $G_1 = 8$  hr,  $S = 5$  hr,  $G_2 = 1$  hr,  $M = 1$  hr. An asynchronous culture of these cells is exposed to radioactive thymidine for five minutes and then allowed to continue to grow in nonradioactive medium. The figure below shows the percent of mitotic cells that are radioactively labeled as a function of time after exposure to the radioactive thymidine.

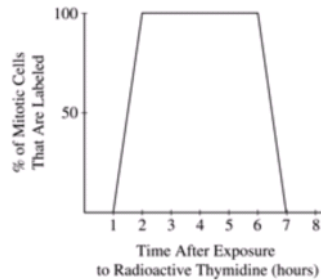


What percent of labeled cells are in M phase at 2 hours after exposure to labeled thymidine?

- ☐ A) 100
- ☐ B) 33
- ☒ C) 20
- ☐ D) 6
- ☐ E) 0

#### 100. (2.00 pts)

The stages of the cell cycle for a cultured mammalian cell line require the following periods of time:  $G_1 = 8$  hr,  $S = 5$  hr,  $G_2 = 1$  hr,  $M = 1$  hr. An asynchronous culture of these cells is exposed to radioactive thymidine for five minutes and then allowed to continue to grow in nonradioactive medium. The figure below shows the percent of mitotic cells that are radioactively labeled as a function of time after exposure to the radioactive thymidine.

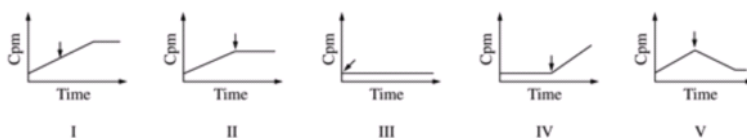


If the length of  $G_2$  were increased by one hour, which of the following statements would be true regarding the slope of the line from the point of the first appearance of labeled mitotic cells to the first point at which all the mitotic cells were labeled?

- ☐ A) It would increase.
- ☐ B) It would decrease.
- ☒ C) It would stay the same.
- ☐ D) It would switch from a positive to a negative slope.
- ☐ E) No conclusion regarding the slope of the line can be drawn.

#### 101. (2.00 pts)

The graphs below represent various curves obtained in different *in vitro* bacterial translation experiments. The peptide product was assayed as acid-precipitable counts per minute (cpm) that resulted from incorporation of a mixture of radiolabeled amino acids. The arrows represent the times at which various substances were added to the systems.

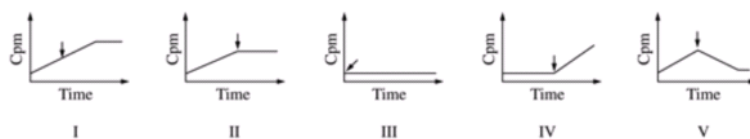


The addition of an antibiotic at the start of the assay results in the curve shown in graph III, while addition at a later time yields the curve shown in graph I. This antibiotic most likely blocks

- ☐ A) elongation only
- ☒ B) initiation only
- ☐ C) termination only
- ☐ D) both initiation and elongation
- ☐ E) both elongation and termination

102. (2.00 pts)

The graphs below represent various curves obtained in different *in vitro* bacterial translation experiments. The peptide product was assayed as acid-precipitable counts per minute (cpm) that resulted from incorporation of a mixture of radiolabeled amino acids. The arrows represent the times at which various substances were added to the systems.

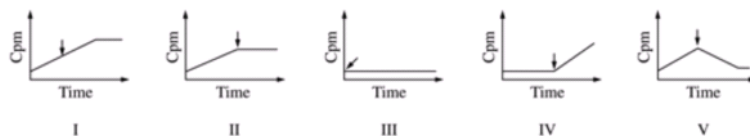


Addition of *fmet*-tRNA<sub>f</sub> to a system lacking only this component is most likely to give the curve shown in graph

- ☐ A) I
- ☐ B) II
- ☐ C) III
- ☒ D) IV
- ☐ E) V

103. (2.00 pts)

The graphs below represent various curves obtained in different *in vitro* bacterial translation experiments. The peptide product was assayed as acid-precipitable counts per minute (cpm) that resulted from incorporation of a mixture of radiolabeled amino acids. The arrows represent the times at which various substances were added to the systems.

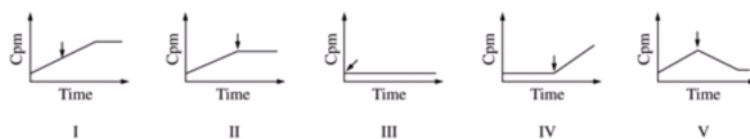


Addition of a peptide that binds irreversibly to the A site of the ribosome will most likely give which of the following graphs?

- ☐ A) II only
- ☐ B) III only
- ☐ C) IV only
- ☐ D) I and V only
- ☒ E) II and III only

104. (2.00 pts)

The graphs below represent various curves obtained in different *in vitro* bacterial translation experiments. The peptide product was assayed as acid-precipitable counts per minute (cpm) that resulted from incorporation of a mixture of radiolabeled amino acids. The arrows represent the times at which various substances were added to the systems.



Addition of which of the following would most likely give the curve seen in graph V?

- ☐ A) Ribonuclease
- ☒ B) Exopeptidase
- ☐ C) Deoxyribonuclease
- ☐ D) Chloramphenicol
- ☐ E) Cycloheximide

105. (2.00 pts)

The effects of a newly discovered human virus on host cell metabolism were studied by infecting HeLa cells with the virus at a multiplicity of infection of 10 virus particles per cell. Before infection (0 hour) and at various times after infection (6, 12, 18, and 24 hours), samples from the cultures were labeled with  $^{35}\text{S}$ -methionine for 30 minutes. At the end of each 30-minute labeling, cell extracts were prepared and analyzed by SDS-polyacrylamide gel electrophoresis. The gels were dried and exposed to x-ray film to detect radioactive proteins. The results of this experiment are shown in Figure 1. The numbers to the right of the figure show the positions of molecular weight standards.

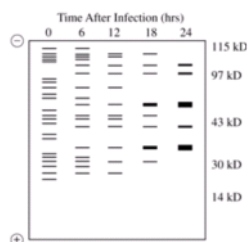


Figure 1

In a second set of experiments, mRNA-free cytosolic extracts were prepared from the cells at 0 hours and at 24 hours after infection and used for *in vitro* translation assays. In addition to  $^{35}\text{S}$ -methionine, either actin mRNA or the intact viral genome was added to each reaction. The products were examined by gel electrophoresis and autoradiography, and the results are shown in Figure 2. Also shown in Figure 2 are the results of a similar *in vitro* translation reaction carried out using the viral template and the 24-hour extract with the addition of microsomes. Note that in the presence of microsomes, the band labeled *X* disappears and a new band, *Y*, appears. Bands *X* and *Y* were excised from the gel and digested with trypsin, and the tryptic peptides obtained were compared by gel electrophoresis. Most of the peptides obtained from the two proteins were identical, but each protein gave rise to one unique peptide.

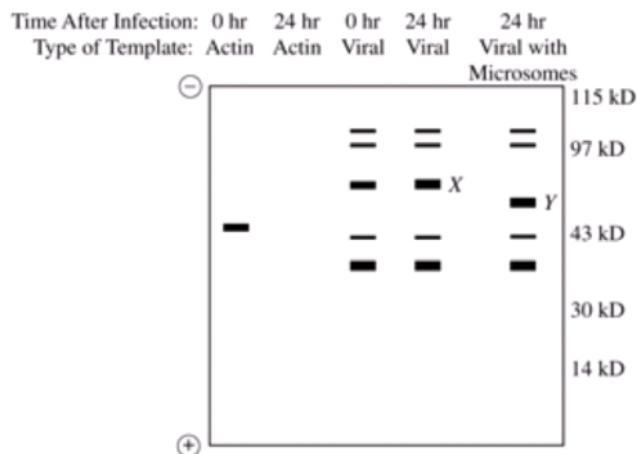


Figure 2

The bands in Figure 1 represent which of the following?

- ☐ A) Total viral and cellular proteins present in cells at the time the extracts were prepared
- ☐ B) Total viral proteins present in cells at the time the extracts were prepared
- ☐ C) Only viral proteins that were synthesized during the 30-minute labeling period
- ☐ D) Only cellular proteins that were synthesized during the 30-minute labeling period
- ☒ E) Both viral and cellular proteins that were synthesized during the 30-minute labeling periods

106. (2.00 pts)

The effects of a newly discovered human virus on host cell metabolism were studied by infecting HeLa cells with the virus at a multiplicity of infection of 10 virus particles per cell. Before infection (0 hour) and at various times after infection (6, 12, 18, and 24 hours), samples from the cultures were labeled with <sup>35</sup>S-methionine for 30 minutes. At the end of each 30-minute labeling, cell extracts were prepared and analyzed by SDS-polyacrylamide gel electrophoresis. The gels were dried and exposed to x-ray film to detect radioactive proteins. The results of this experiment are shown in Figure 1. The numbers to the right of the figure show the positions of molecular weight standards.

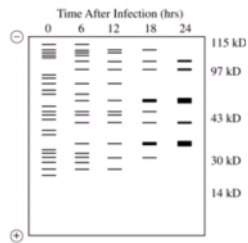


Figure 1

In a second set of experiments, mRNA-free cytosolic extracts were prepared from the cells at 0 hours and at 24 hours after infection and used for *in vitro* translation assays. In addition to <sup>35</sup>S-methionine, either actin mRNA or the intact viral genome was added to each reaction. The products were examined by gel electrophoresis and autoradiography, and the results are shown in Figure 2. Also shown in Figure 2 are the results of a similar *in vitro* translation reaction carried out using the viral template and the 24-hour extract with the addition of microsomes. Note that in the presence of microsomes, the band labeled X disappears and a new band, Y, appears. Bands X and Y were excised from the gel and digested with trypsin, and the tryptic peptides obtained were compared by gel electrophoresis. Most of the peptides obtained from the two proteins were identical, but each protein gave rise to one unique peptide.

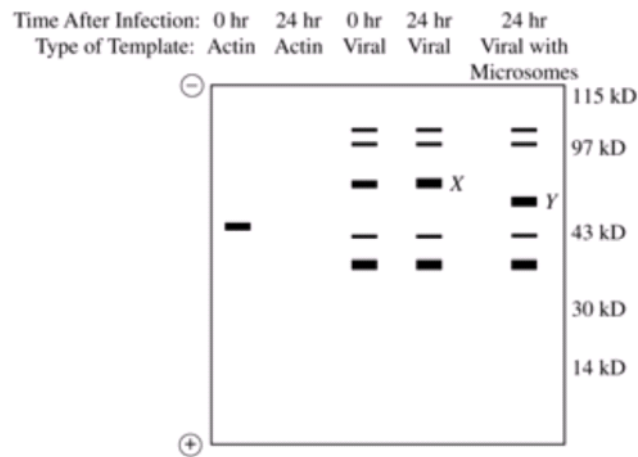


Figure 2

According to the data in Figure 2, the genome of the virus is

- ☒ A) plus-strand RNA
- ☐ B) plus-strand DNA
- ☐ C) double-stranded RNA
- ☐ D) double-stranded DNA
- ☐ E) minus-strand RNA

107. (2.00 pts)

The effects of a newly discovered human virus on host cell metabolism were studied by infecting HeLa cells with the virus at a multiplicity of infection of 10 virus particles per cell. Before infection (0 hour) and at various times after infection (6, 12, 18, and 24 hours), samples from the cultures were labeled with  $^{35}\text{S}$ -methionine for 30 minutes. At the end of each 30-minute labeling, cell extracts were prepared and analyzed by SDS-polyacrylamide gel electrophoresis. The gels were dried and exposed to x-ray film to detect radioactive proteins. The results of this experiment are shown in Figure 1. The numbers to the right of the figure show the positions of molecular weight standards.

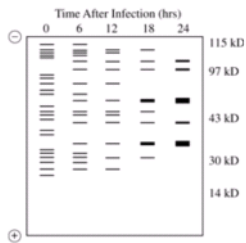


Figure 1

In a second set of experiments, mRNA-free cytosolic extracts were prepared from the cells at 0 hours and at 24 hours after infection and used for *in vitro* translation assays. In addition to  $^{35}\text{S}$ -methionine, either actin mRNA or the intact viral genome was added to each reaction. The products were examined by gel electrophoresis and autoradiography, and the results are shown in Figure 2. Also shown in Figure 2 are the results of a similar *in vitro* translation reaction carried out using the viral template and the 24-hour extract with the addition of microsomes. Note that in the presence of microsomes, the band labeled *X* disappears and a new band, *Y*, appears. Bands *X* and *Y* were excised from the gel and digested with trypsin, and the tryptic peptides obtained were compared by gel electrophoresis. Most of the peptides obtained from the two proteins were identical, but each protein gave rise to one unique peptide.

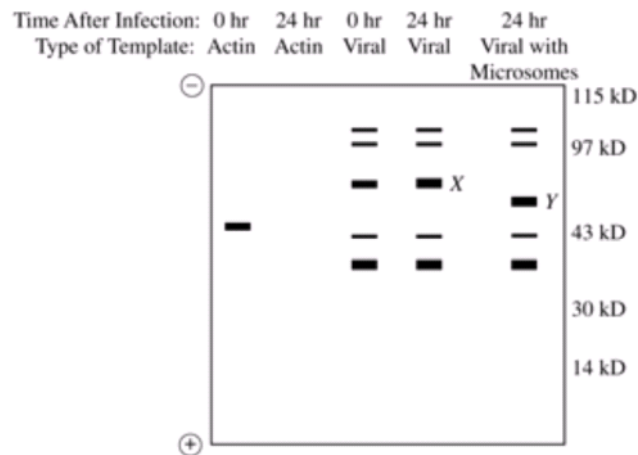


Figure 2

The most likely explanation for the data in Figures 1 and 2 is that the virus shuts off

- ☐ A) host-cell DNA synthesis
- ☐ B) transcription of cellular but not viral mRNAs
- ☒ C) translation of cellular but not viral mRNAs
- ☐ D) transcription of viral and cellular mRNAs
- ☐ E) translation of viral and cellular mRNAs

108. (2.00 pts)

The effects of a newly discovered human virus on host cell metabolism were studied by infecting HeLa cells with the virus at a multiplicity of infection of 10 virus particles per cell. Before infection (0 hour) and at various times after infection (6, 12, 18, and 24 hours), samples from the cultures were labeled with <sup>35</sup>S-methionine for 30 minutes. At the end of each 30-minute labeling, cell extracts were prepared and analyzed by SDS-polyacrylamide gel electrophoresis. The gels were dried and exposed to x-ray film to detect radioactive proteins. The results of this experiment are shown in Figure 1. The numbers to the right of the figure show the positions of molecular weight standards.

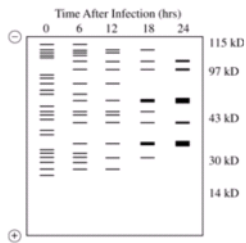


Figure 1

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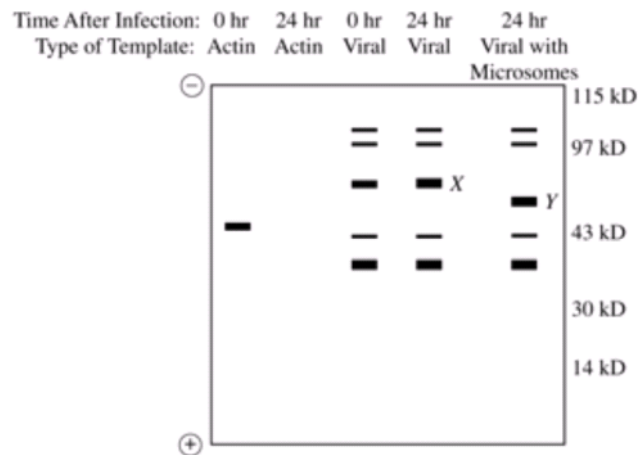


Figure 2

The most likely explanation for the appearance of the protein Y in Figure 2 is which of the following?

- ☐ A) Protein Y is translated from the same mRNA as protein X, but in a different reading frame.
- ☐ B) Protein Y is translated in the same reading frame as protein X, but uses a different AUG initiation codon.
- ☐ C) Protein X and Y are encoded by differentially spliced mRNAs.
- ☐ D) Protein X is a proteolytic product of protein Y.
- ☒ E) Protein Y is a proteolytic product of protein X.

109. (2.00 pts)

The effects of a newly discovered human virus on host cell metabolism were studied by infecting HeLa cells with the virus at a multiplicity of infection of 10 virus particles per cell. Before infection (0 hour) and at various times after infection (6, 12, 18, and 24 hours), samples from the cultures were labeled with <sup>35</sup>S-methionine for 30 minutes. At the end of each 30-minute labeling, cell extracts were prepared and analyzed by SDS-polyacrylamide gel electrophoresis. The gels were dried and exposed to x-ray film to detect radioactive proteins. The results of this experiment are shown in Figure 1. The numbers to the right of the figure show the positions of molecular weight standards.

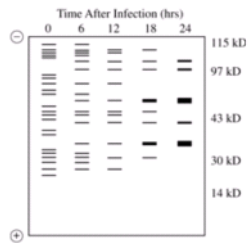


Figure 1

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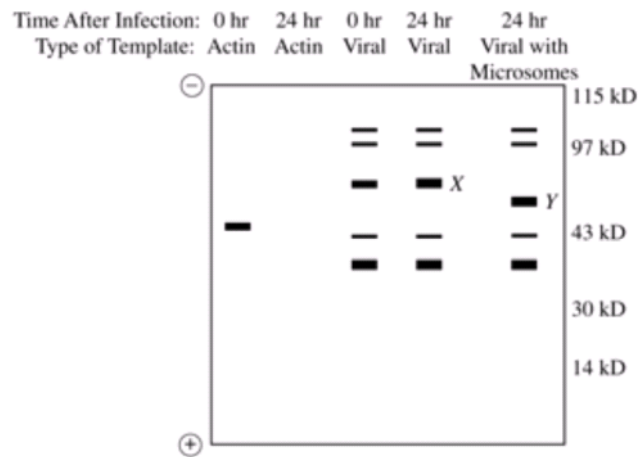


Figure 2

According to the information in Figure 2, protein Y most likely represents which of the following viral proteins?

- ☐ A) RNA polymerase
- ☐ B) DNA polymerase
- ☐ C) Capsid protein
- ☐ D) Protease
- ☒ E) Envelope protein

110. (2.00 pts)

The antibiotic fluconazole is used against pathogenic fungi. After long-term treatment, resistant organisms can arise. One yeast strain was resistant to  $10\text{ }\mu\text{g}\cdot\text{mL}^{-1}$  fluconazole, whereas the growth of the wild type was prevented by  $5\text{ }\mu\text{g}\cdot\text{mL}^{-1}$ . The kinetics of the enzyme that is the target of fluconazole, lanosterol 14-demethylase (14-DM), were determined in the wild type and the resistant yeast, and the curves shown in Figures 1a and 1b were obtained. In order to determine whether resistance was caused by a mutation in 14-DM, the sequences of the genes from the wild type and the resistant strain were determined. Figure 2 shows a comparison of the part of these sequences where differences were found.

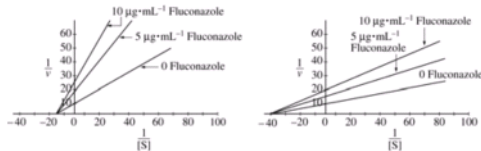


Figure 1a. WILD-TYPE STRAIN

Figure 1b. RESISTANT STRAIN

Wild Type

```
300
Codon: ...UUU UUA AAG GCA CAC AAC GAG UUA UGG UUU ... 330
51
Protein: ... phe leu lys ala his asn glu leu trp phe ... 60
```

Resistant Strain

```
300
Codon: ...UUU AUU AAA GGC ACA CAA CGA GUU UGG UUU ... 330
51
Protein: ... phe ile lys gly thr gln arg val trp phe ... 60
```

Figure 2 PARTIAL CODING SEQUENCES AND DEDUCED AMINO ACIDS FROM THE 14-DM GENES OF RESISTANT AND WILD-TYPE YEAST

Which of the following kinds of mutation is found in the gene for the resistant enzyme shown in Figure 2?

- ☐ A) Missense
- ☐ B) Nonsense
- ☒ C) Frameshift
- ☐ D) Silent
- ☐ E) Null

111. (2.00 pts)

The antibiotic fluconazole is used against pathogenic fungi. After long-term treatment, resistant organisms can arise. One yeast strain was resistant to  $10\text{ }\mu\text{g}\cdot\text{mL}^{-1}$  fluconazole, whereas the growth of the wild type was prevented by  $5\text{ }\mu\text{g}\cdot\text{mL}^{-1}$ . The kinetics of the enzyme that is the target of fluconazole, lanosterol 14-demethylase (14-DM), were determined in the wild type and the resistant yeast, and the curves shown in Figures 1a and 1b were obtained. In order to determine whether resistance was caused by a mutation in 14-DM, the sequences of the genes from the wild type and the resistant strain were determined. Figure 2 shows a comparison of the part of these sequences where differences were found.

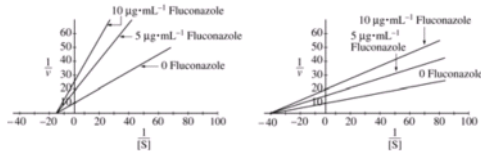


Figure 1a. WILD-TYPE STRAIN

Figure 1b. RESISTANT STRAIN

Wild Type

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300
Codon: ...UUU UUA AAG GCA CAC AAC GAG UUA UGG UUU ... 330
51
Protein: ... phe leu lys ala his asn glu leu trp phe ... 60
```

Resistant Strain

```
300
Codon: ...UUU AUU AAA GGC ACA CAA CGA GUU UGG UUU ... 330
51
Protein: ... phe ile lys gly thr gln arg val trp phe ... 60
```

Figure 2 PARTIAL CODING SEQUENCES AND DEDUCED AMINO ACIDS FROM THE 14-DM GENES OF RESISTANT AND WILD-TYPE YEAST

A diploid was made by mating the resistant yeast and the wild type. Of 20 diploids picked, all were resistant to 10 mcg/mL of fluconazole. This is most likely due to which of the following?

- ☐ A) Gene conversion
- ☒ B) Dominance of the mutation
- ☐ C) Suppression of the mutation
- ☐ D) Complementation
- ☐ E) Mitotic crossing-over

Congrats! You made it to the end :)



