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1) During what stage of the cell cycle would you expect to have the lowest amount of cellular growth and synthesis taking place?
2) How many chromosomes are present in a human somatic cell during the G2 phase?
3) Which of the following steps is irreversible in the cell cycle? (Circle all of the following)
   I. Transition from prophase to metaphase
   II. Sister chromatid separation
   III. DNA replication
4) What is genetic drift?

5) A few years ago, an international consortium was formed to uncover the locations of genetic variation in the human genome. In particular, the consortium worked to identify single nucleotide polymorphisms (SNPs) within the human population.

   a) Is the genomic variation between individuals randomly distributed across the genome or does such variation occur at common sites?

   b) What is a haplotype?

   c) Why is an understanding of genomic variation useful for studying human health?

6) There are several subspecies of the mouse, *Mus Musculus*, living throughout the world. You decide to study their spread from an ancestral population using sequences from mitochondria and Y chromosomes.

   Why are mitochondria and Y chromosomes often used for this purpose?

7) What is polymorphism? Give an example.

8) Is polymorphism the same as a mutation? Explain.

9) John studies plum tree genetics. He had a pure-breeding mutant strain of plum trees that has two unusual characteristics; the mutant tree produces figs instead of plums and there are huge spikes growing out of the branches. John crossed the mutant with a pure-breeding wild-type plum tree. The F1 progeny produce figs, but have no spikes.

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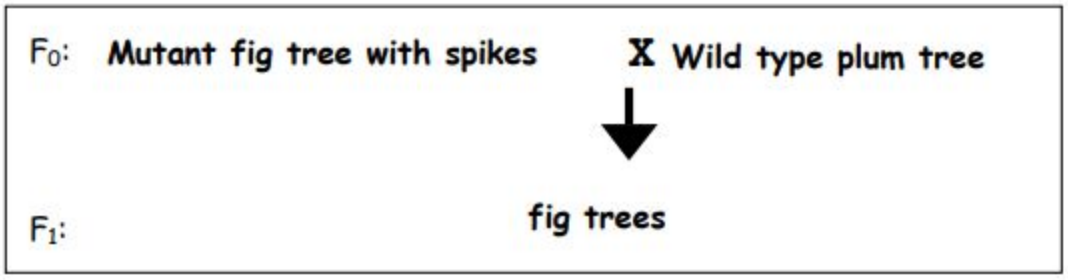
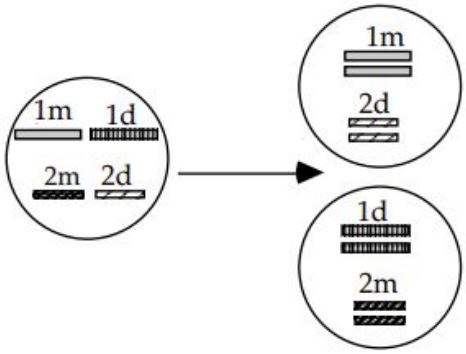


a) For each pair, circle the dominant phenotype.
Plums Figs Spikes No spikes

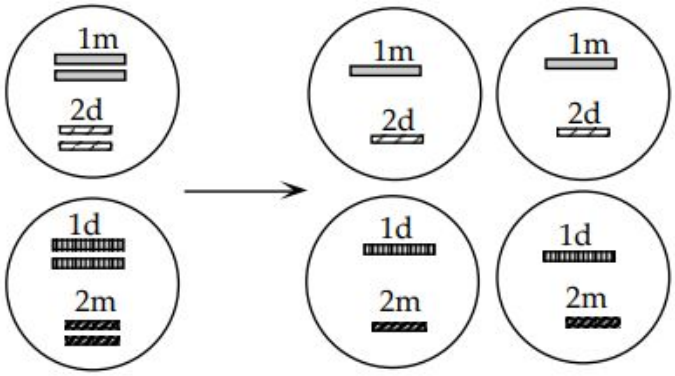
b) John performed a backcross of an F1 individual with an F0 individual from the mutant strain. If there are 32 progeny trees from this cross how many trees have each of the following phenotypes?
Figs, spikes _____
Figs, no spikes _____
Plums, spikes _____
Plums, no spikes _____

10) The following diagrams show a diploid cell with 2 chromosomes, 1 and 2. The chromosome derived from the mother is denoted "m", and the chromosome derived from the father is denoted "d".

a) The picture below shows the end of: _____



b) The picture below shows the end of: _____



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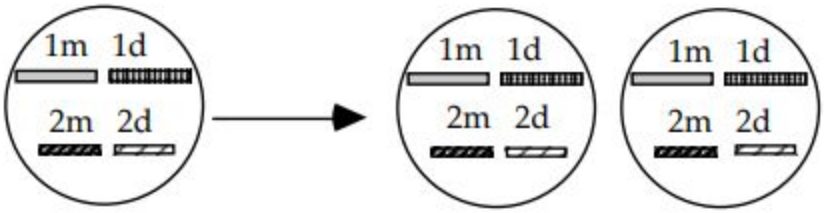
c) The picture below shows the end of: _____



11) Assume mRNA is being transcribed starting from the far left side of the following double stranded DNA template.

5'GTGCTAGCGGGAATGAGCTGGGATACTAGTAGGGCT3'
3'CACGATCGCCCTTACTCGACCCTATGATCATCCCGA5'

a) What are the first five nucleotides of the mRNA sequence? _____
b) What are the first 5 amino acids encoded? _____

c) The following sequences show (in bold) different mutations affecting the above DNA sequence. Assume none affect the expression of the mRNA synthesis. Fill out the chart underneath based on the following:

Correct DNA strand:
5'GTGCTAGCGGGAATGAGCTGGGATACTAGTAGGGCT3'
3'CACGATCGCCCTTACTCGACCCTATGATCATCCCGA 5'

A.
5'GTGCT**G**AGCGGGAATGAGCTGGGATACTAGTAGGGCT3'
3'CACGA**C**TCGCCCTTACTCGACCCTATGATCATCCCGA5'

B.
5'GTGCTAGCGGGAATGAGCTG**C**GGATACTAGTAGGGCT3'
3'CACGATCGCCCTTACTCGAC**G**CCTATGATCATCCCGA5'

C.
5'GTGCTAGCGGGAATGAGCTG**A**GATACTAGTAGGGCT3'
3'CACGATCGCCCTTACTCGAC**T**CTATGATCATCCCGA5'

D.
5'GTGCTAGCGGGAATGAGCTGGGA**A**ACTAGTAGGGCT3'
3'CACGATCGCCCTTACTCGACCCTT**T**GATCATCCCGA5'

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E.
5'GTGCTAGCGGGAATGAGCTGGGA**C**ACTAGTAGGGCT 3'
3'CACGATCGCCCTTACTCGACCCT**G**TGATCATCCCGA 5'

F.
5'GTGCTAGCGGGAATGAGCTGG**C**ATACTAGTAGGGCT3'
3'CACGATCGCCCTTACTCGACC**G**TATGATCATCCCGA5'

Sequence	Type of mutation	Effect on protein
A		
B		
C		
D		
E		
F		

12) According to Chargaff's rule, if the DNA content of a cell was composed of 15% A, then C would make up _____% , G would make up _____%, and T would make up_____ % of the cell's DNA.

13) What is Chargaff's rule?

14) You know in yeast that mitosis takes one hour. You decide to further study the cell cycle in yeast cells using radioactive dTTP. Cells grown in radioactive dTTP incorporate this radioactive nucleotide into their DNA.

You label a population of asynchronously growing yeast cells by adding radioactive dTTP to the medium for one minute. You then replace this medium with medium containing unlabelled dTTP and continue growing the cells. At one hour time points following the replacement you count the number of radioactively labeled cells in mitosis. Your data is shown below.

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a) Cells are in which phase of the cell cycle when incorporating radioactive dTTP into their DNA? (Circle one.)
G0 phase G1 phase G2 phase M phase S phase Lunar phase
b) Estimate the length of the G2 phase from the graph. (Circle one.)

Can't be determined 0 hrs ~2-3 hrs ~6-7 hrs ~9-10 ~11-12 hrs ~13-14 hrs ~20 hrs ~22

c) Estimate the length of the S phase from the graph. (Circle one.)

Can't be determined 0 hrs ~2-3 hrs ~6-7 hrs ~9-10 ~11-12 hrs ~13-14 hrs ~20 hrs ~22 hrs

d) Estimate the duration of the cell cycle. (Circle one)
Can't be determined 0 hrs ~2-3 hrs ~6-7 hrs ~9-10 ~11-12 hrs ~13-14 hrs ~20 hrs ~22

e) Estimate the length of the G1 phase from the graph. (Circle one.)
Can't be determined 0 hrs ~2-3 hrs ~6-7 hrs ~9-10 ~11-12 hrs ~13-14 hrs ~20 hrs ~22

15) Shown below is a schematic of the production of a heavy chain polypeptide for an antibody. At the top is the chromosomal arrangement found in an immature B cell, at the bottom is shown the heavy chain polypeptide.

i) Label the process indicated by each arrow. Choose the one best option for each from:

protein processing	RNA ligation
transcription	RNA splicing
translation	DNA rearrangement
transduction	DNA ligation

16) What is the "The Transforming Principle"?

17) What is an auxotrophic mutation?

18) In _____, part of chromosome 21 breaks off during cell division and attaches to another chromosome, typically chromosome ____. While the total number of chromosomes in the cells remain ____, the presence of an extra part of chromosome 21 causes the characteristics of _____ syndrome.

19) _____ occurs when nondisjunction of chromosome 21 takes place in one – but not all – of the initial cell divisions after fertilization.When this occurs, there is a mixture of two types of cells, some containing _____ chromosomes and others containing _____. This type accounts for about _____ of all cases.

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20) Which base can undergo deamination and thereby course mutations?

21) In pea plants, the allele that encodes tall plants (H) dominates the allele that encodes short plants (h). How large a fraction of the progeny will be tall in a monohybrid cross between two plants that are both heterozygous with regards to height?

22) Besides DNA from a biological sample and primers, which ingredients are needed for PCR?

23) What is the basic purpose of PCR?

24) Why is a thermal cycler used in PCR?

25) Who invented PCR?

26) The frequency of two alleles in a gene pool is 0.19 (A) and 0.81(a). Assume that the population is in Hardy-Weinberg equilibrium.
   a) Calculate the percentage of heterozygous individuals in the population.

   b) Calculate the percentage of homozygous recessives in the population.

27) An allele W, for white wool, is dominant over allele w, for black wool. In a sample of 900 sheep, 891 are white and 9 are black. Calculate the allelic frequencies within this population, assuming that the population is in H-W equilibrium.

   p = _____ q = _____

28) In a population that is in Hardy-Weinberg equilibrium, the frequency of the recessive homozygote genotype of a certain trait is 0.09. Calculate the percentage of individuals homozygous for the dominant allele.

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29) In humans, the Rh factor genetic information is inherited from our parents, but it is inherited independently of the ABO blood type alleles. In humans, Rh+ individuals have the Rh antigen on their red blood cells, while Rh– individuals do not. There are two different alleles for the Rh factor known as Rh+ and rh.

    Assume that a dominant gene Rh produces the Rh+ phenotype, and that the recessive rh allele produces the Rh– phenotype. In a population that is in Hardy-Weinberg equilibrium, if 160 out of 200 individuals are Rh+, calculate the frequencies of both alleles.

30) In the gametogenesis picture, they refer to imprints as “methylation markers”. Methylation allows imprinting by promoting the _____ of chromatin at the gene. In other words, it promotes the formation of _____

31) When you turn fifteen, your arm begins to undergo uncontrolled bone growth. Read and answer the questions that follow using the codon chart below when needed.

Second Base

First Base	U	C	A	G	*Third Base*
U	Phe	Ser	Tyr	Cys	U
	Phe	Ser	Tyr	Cys	C
	Leu	Ser	Stop	Stop	A
	Leu	Ser	Stop	Trp	G
C	Leu	Pro	His	Arg	U
	Leu	Pro	His	Arg	C
	Leu	Pro	Gln	Arg	A
	Leu	Pro	Gln	Arg	G
A	Ile	Thr	Asn	Ser	U
	Ile	Thr	Asn	Ser	C
	Ile	Thr	Lys	Arg	A
	Met	Thr	Lys	Arg	G
G	Val	Ala	Asp	Gly	U
	Val	Ala	Asp	Gly	C
	Val	Ala	Glu	Gly	A
	Val	Ala	Glu	Gly	G

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a. After consulting your doctor, you learn that your rare disease is caused by a Pro250Arg event in the FGFR3 gene. What is the meaning of “Pro250Arg”?

b. What kind of DNA mutation caused this event? Be specific about the mutation’s position within the codon and the nitrogenous bases involved. Use the chart above to help you.

c. You wonder if your little brother has the mutation too, so you run his DNA fragments on a gel against yours. Both are cut with the same restriction enzymes. On your answer sheet’s gel block diagram, which shows a fragment containing the locus of the mutated site, draw the corresponding fragment location for your brother if he does have the mutation and if he doesn’t have the mutation. A quick sketch.

d. Briefly explain whether or not the gel electrophoresis experiment is enough to determine if your brother has the mutation or not. If not, what should you do next to determine if he does?

e. The full name of FGFR3 is fibroblast growth factor receptor 3. Do you think FGFR3 is under the control of a tissue-specific enhancer? Briefly explain why or why not.

32) In less than one sentence each,briefly describe the four levels of protein structure:

33) Glycine is unique among the amino acids for lacking which biochemical property?

34) By examining a number of somatic-cell hybrid lines for enzyme activities and their human chromosome constitution, scientists can determine

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A. on which human chromosome the gene for a particular enzyme is located
B. the number of genes for enzymes in the human genome
C. the number of chromosomes in the human genome
D. the number of human chromosomes in each cell
E. Scientists cannot determine any of these things

35) Which of the following describes a type of polymorphism that occurs within the gene that causes Huntington's disease? (May have multiple answers, circle all of the following that answers the question)

A. RFLPs, "restriction fragment length polymorphisms"
B. ESTs, "expressed sequence tags"
C. STRPs, "short tandem repeat polymorphisms"
D. STSs, "sequence tagged sites"
E. None of the above

36) Which of the following type(s) of polymorphism are commonly detected by using the polymerase chain reaction (PCR) and specific oligonucleotide primers? (May have multiple answers, circle all of the following that answers the question)

A. RFLPs, "restriction fragment length polymorphisms"
B. ESTs, "expressed sequence tags"
C. STRPs, "short tandem repeat polymorphisms"
D. STSs, "sequence tagged sites"

37) Which term describes centromeres uncoupling, sister chromatids separating, and the two new chromosomes moving to opposite poles of the cell?

38) A mutation results in a cell that no longer produces a normal protein kinase for the M phase checkpoint. Which of the following would likely be the immediate result of this mutation?

39) Where do the catabolic products of fatty acid breakdown enter into the citric acid cycle?

40) If the DNA content of a diploid cell in the G1 phase of the cell cycle is y, then the DNA content of the same cell at metaphase of meiosis I would be:

41) a) How many different combinations of maternal and paternal chromosomes can be packaged in gametes made by an organism with a diploid number of 8?
b) How about a diploid with 12?

42) How many unique gametes could be produced through independent assortment by an individual with the genotype TtBbDDEeFF?

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43) Mendel's second law of independent assortment has its basis in which of the following events of meiosis I?

44) Given the parents AABBCc × AabbCc, assume simple dominance and independent assortment. What proportion of the progeny will be expected to phenotypically resemble the first parent?

45) Skin color in a certain species of fish is inherited via a single gene with four different alleles. How many different types of gametes would be possible in this system?

46) Gene Scooby controls the sharpness of spines in a type of cactus. Cactuses with the dominant allele, S, have sharp spines, whereas homozygous recessive ss cactuses have dull spines. At the same time, a second gene, Noodes, determines whether cactuses have spines. Homozygous recessive nn cactuses have no spines at all.

   a) This is an example of: _____
   b) You performed a cross between a true-breeding sharp-spined cactus and a spineless cactus to produce different gametes. What is the maximum number of different gametes can you produce? Be specific:
      _____
   c) You then allowed doubly heterozygous SsNn cactuses to self-pollinate, the F2 would segregate to what ratio? _____

47) What is pleiotropy?
_____

48) Take in this scenario:

   a) Gene Takis and gene Marshmallow affect the ability for human bones to turn into Twizzlers. What type of inheritance is this?
      _____
   b) After much research you realize that the ability for bones to turn into Twizzlers is only affected by Gene Takis. After conducting many trials, you see that Gene Takis affects the lungs, the pancreas, the digestive system, and other organs, resulting in symptoms ranging from breathing difficulties to recurrent infections. You would describe this as a _____ inheritance.
   c) You found out that your once two trustworthy assistants, Alice and Bob, faked all the findings. After firing them both you realize that Gene Takis when present prevents any human bones from developing. This is an example of: _____ Why? _____
   d) After verifying the pathway of Gene Takis you present your research to the World Epidemic Incorporation Rare Diseases Organization (WEIRDO). They do not accept your work. So you go on to compare different genes to Gene Takis

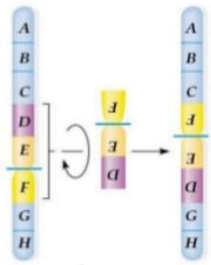
and its pathway. Give an example of two genes in the human body that follow the Gene Takis' pathway: _____

49) Heliomania is a Mendelian disorder in the human population. Two normal parents have two children with Heliomana. The probability of their next child being normal is: _____

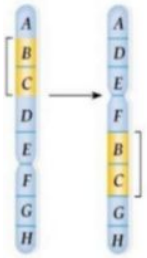
50) What is the mechanism for the production of genetic recombinants? (Hint: Two Answers)

_____

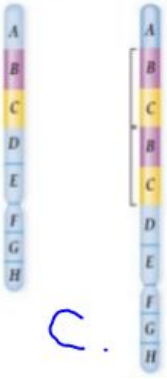
51) Describe the following chromosomal changes (specific!!!!):



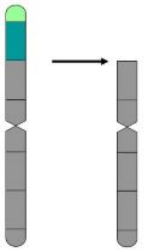
a.



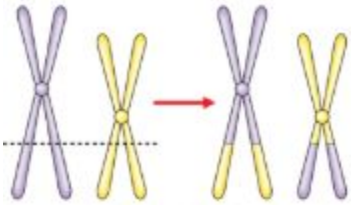
b.



c.

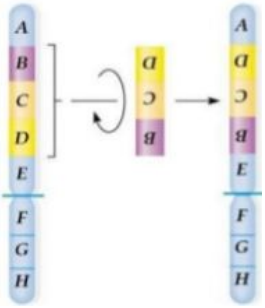


d .

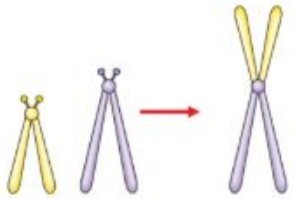


e.

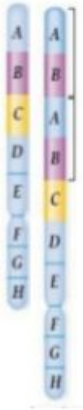
f.



g.



h.



i.

a) _____
b) _____
c) _____
d) _____
e) _____
f) _____
g) _____
h) _____
i) _____

52)

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Robertsonian translocations appear in _____ chromosomes. This includes chromosomes _____. An example of a disease caused by robertsonian translocations _____.

53) Define “transition mutations” and “transversion mutations.” Give one example of each:

54) Write the letter(s) of all statements that apply to that type of mutation. (Hint: Each statement may be used more than once and each type of mutation may have more than one correct statement.)

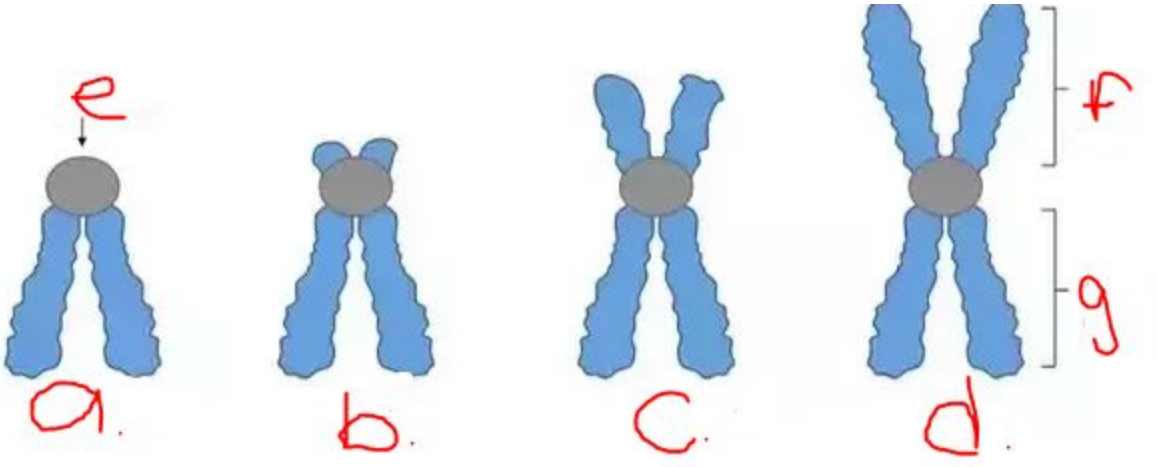
a) A mutation that changes UUU to UUG 2
b) A mutation that gives methionine instead of leucine
c) Created by the addition of a nucleotide to a coding region
d) A stop codon is read as an amino acid
e) A chemically similar amino acid is replaced by the mutation
f) A mutation that changes CCU to ACU
g) Deleting a nucleotide in a coding region gives this type of mutation h) Mutation does not alter the peptide
i) A mutation changing UAU to UAG
j) Premature termination codon is responsible for this mutation
k) A chemically different amino acid is replaced by the mutation

Missense mutation: _____
Silent mutation: _____
Frameshift mutation: _____
Nonsense mutation: _____
Synonymous mutation: _____
Suppressor mutation: _____

55) What is the difference between discrete and continuous traits?

56) What is dosage compensation?

57)



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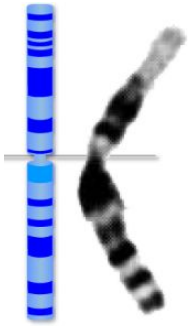
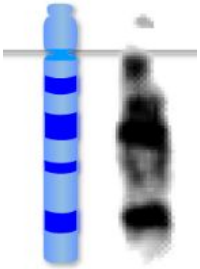
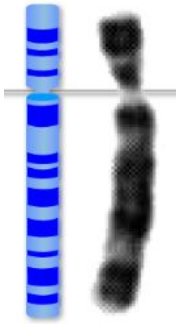
a.) _____
b.) _____
c.) _____
d.) _____
e.) _____
f.) _____
g.) _____

58) Label the type of chromosome:







_____ _____ _____

59) In proteins the amine group is labeled as the: _____
60) In proteins the unbound carboxyl group is labeled as: _____
61) When a protein is translated from messenger RNA, it is created from _____ to _____.
62) Label yes or no on whether the following situations interfere with the replication process of DNA:

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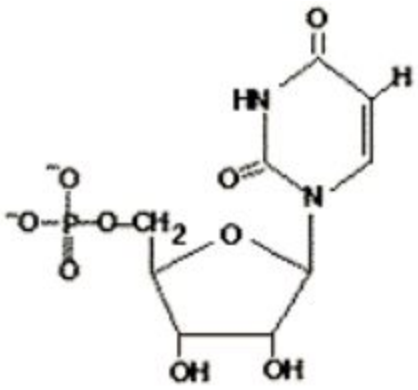
	Affects leading strand	Affects lagging strand
i) the presence of dideoxy-thymidine:	_____	_____
ii) absence of functional ligase:	_____	_____
iii) defective spliceosome machinery:	_____	_____
iv) absence of functional telomerase:	_____	_____

63) Does the molecular below come from RNA or DNA? Justify your answer.



64) List five differences between eukaryotic transcription and prokaryotic transcription:

65) List five differences between eukaryotic translation and prokaryotic translation:

66) List two differences between eukaryotic DNA replication and prokaryotic DNA replication: (EXTRA POINTS IF YOU LIST MORE THAN TWO)

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67) Imagine you are young scientist that was in a food court. You were not off work, no not indeed! You brought your work to the food court as you collected samples of DNA from your monster friends: the potatoes.

You are attempting to figure out the first genetic map of those organism, gain scientific glory, and avoid returning to your busboy position in Prof. Morgan's laboratory. You are analyzing the relationship between four potato melanogaster factors (genes): A, B, and D. You began your experiment by crossing females from one pure-breeding line with males from a different pure-breeding line. The F1 female progeny were then crossed with testcross males. Your inspection of 1000 F2 progeny yielded the following phenotypes:

AbD	333
aBd	322
ABD	115
abd	130
ABd	44
abD	51
Abd	2
aBD	3
Total	1000

a) Based on the table above, what are the parental types?
b) What is the map order? Explain your reasoning.

c) Using all of the relevant data, calculate each of the three two-factor recombination frequencies. Show your work below and on the table above. Express all frequencies as percentages.

d) What is the frequency of double recombination? Show your work.

e) What frequency of double recombination would you calculate if the data contained no evidence of interference? Show your work.

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68) You are studying an inversion heterozygote.

The order of genes along one homolog is centromere – A – B – D – E – F
The order of genes along the other homolog is centromere – A – E – D – B – F

a) Assuming that the first homolog is the normal chromosome, draw an arrow(s) at that breakpoint(s) that gave rise to the abnormal chromosome:

b) The homologs undergo recombination between genes B and D. Draw a clear sketch depicting the chromosomes of this inversion heterozygote as they align at pachytene. In your sketch, only include the chromatids undergoing recombination.

c) Draw a clear sketch of the recombinant products from such as cross-over event.

d) Will the recombinant chromatids segregate normally during cell division? Explain.

69) Genes A, B, and R are linked to one another. A genetic map of the locations of these genes is shown below:

a) You cross a pure-breeding A R strain with a pure-breeding a r strain, and then testcross the F1 progeny. What percentage of the testcross progeny do you expect to be phenotypically A r?

b) You cross a pure-breeding A R B strain with a pure-breeding a r b strain and then testcross the F1 progeny. What percentage of the testcross progeny do you expect to be phenotypically A R B?

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70) At which phase(s) is it preferable to obtain chromosomes to prepare a karyotype?

71) A wild-type fruit fly (heterozygous for gray body color and normal wings) is mated with a black fly with vestigial wings. The offspring have the following phenotypic distribution: wild type, 778; black-vestigial, 785; black-normal, 158; gray-vestigial, 162. What is the recombination frequency between these genes for body color and wing size?

72) In another cross, a wild-type fruit fly (heterozygous for gray body color and red eyes) is mated with a black fruit fly with purple eyes. The offspring are as follows: wild type, 721; black-purple, 751; gray-purple, 49; black-red, 45. What is the recombination frequency between these genes for body color and eye color?

Using information from problem 86, what fruit flies (genotypes and phenotypes) would you mate to determine the sequence of the body-color, wing-size, and eye-color genes on the chromosome?

73) Determine the sequence of genes along a chromosome based on the following recombination frequencies:
A—B, 8 map units
A—C, 28 map units
A—D, 25 map units
B —C, 20 map units
B—D, 33 map units

74)

a) The following scientists made significant contributions to our understanding of the structure and function of DNA. Breifly explain their procedures and discovery:

Avery, McCarty, and MacLeod:

Griffith:

Hershey and Chase:

Meselson and Stahl:

Watson and Crick:

Erwin Chargaff:

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b) Place the scientists' names in the correct chronological order, starting with the first scientist(s) to make a contribution:

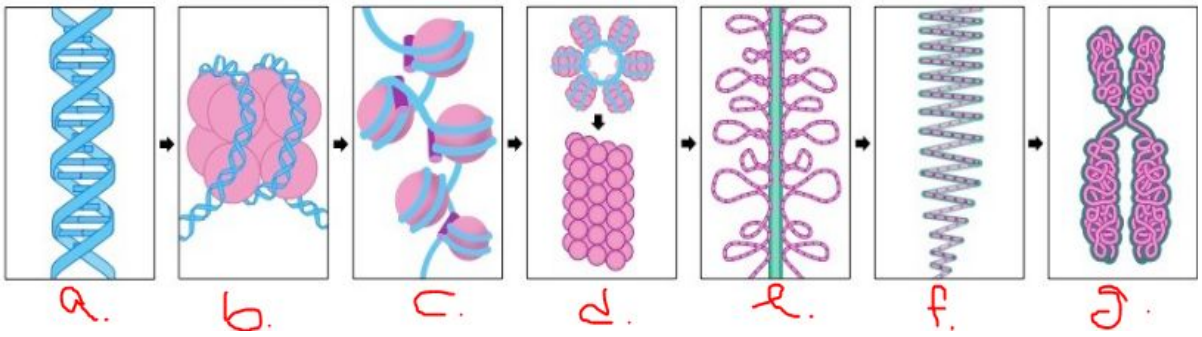
_____

75) When trying to determine whether DNA or protein is the genetic material, Hershey and Chase made use of which fact?

76) The enzyme telomerase solves the problem of replication at the ends of linear chromosomes by which method?

77) What is a telomere? What is its function?

78) Label the following based on the corresponding DNA structure:



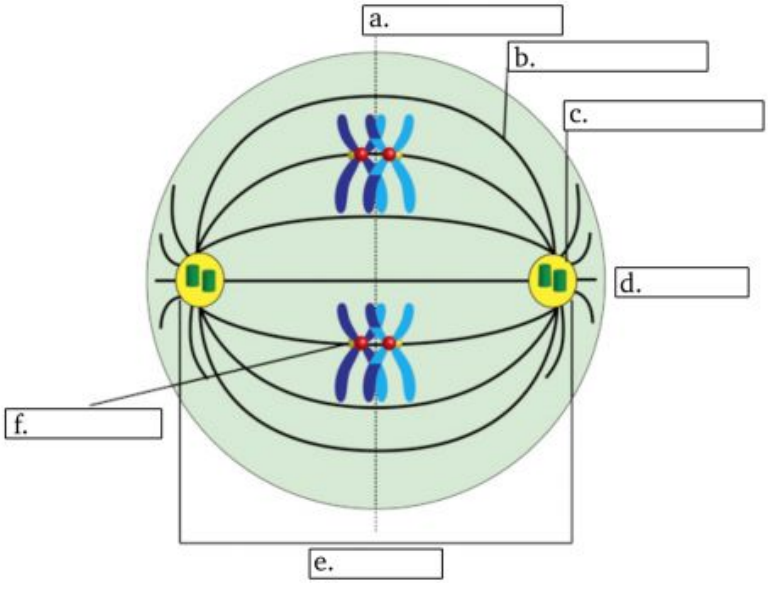
a.) _____ b.) _____ c.) _____ d.) _____

e.) _____ f.) _____

g.) _____

79)

a) Label the following spindle apparatus:



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b) If a normal diploid cell has 16 chromosomes, then
a. There are 16 homologous pairs of chromosomes per diploid cell.
b. There are 16 chromatids per diploid cell between S phase and the first division of meiosis.
c. There are 8 chromosomes per cell after meiosis 1.
d. Sperm cells made from this diploid cell would have 16 chromosomes.

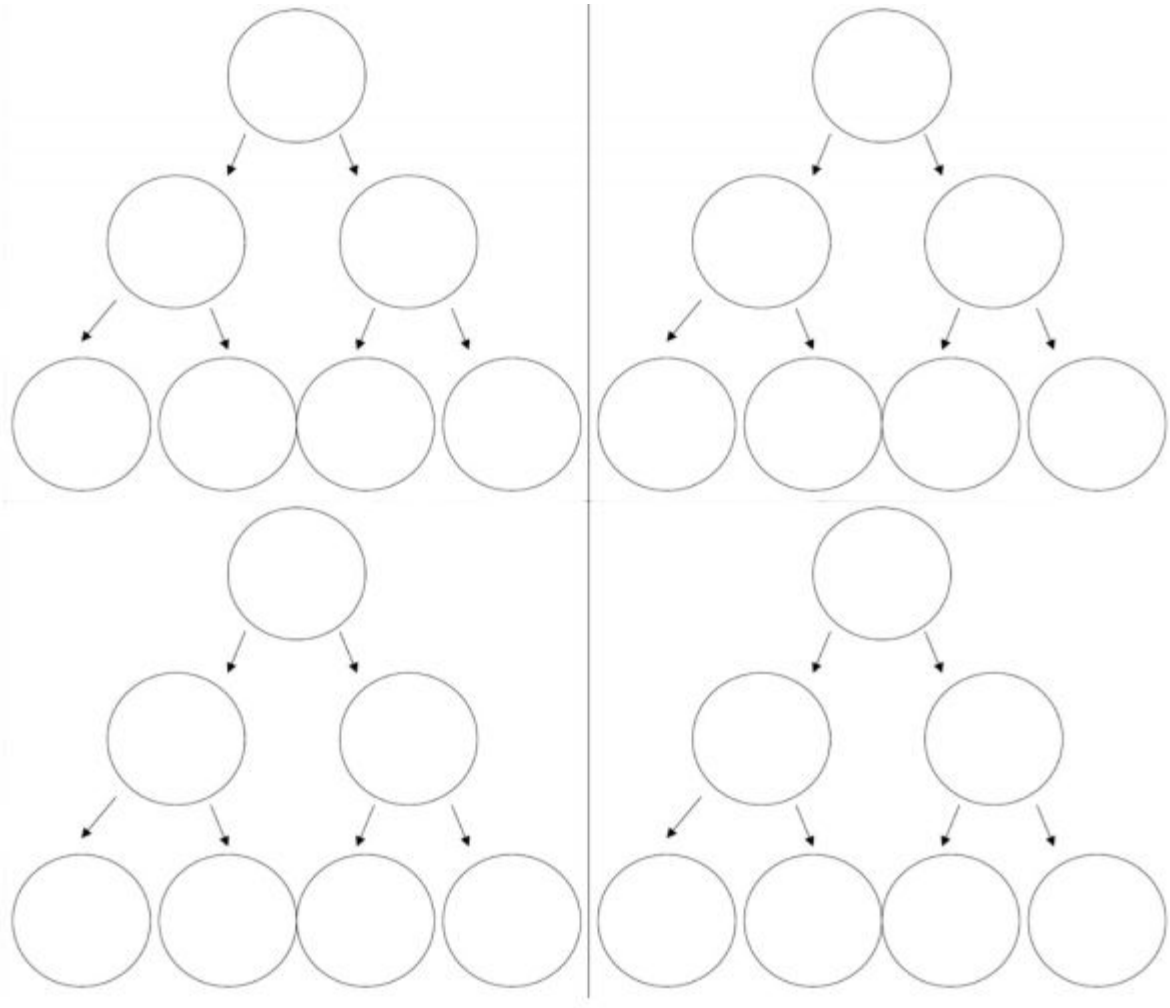
80)

a) After you run your PCR, you find the amplification yield to be 100,000x after 25 cycles. What then is the average yield of one template per cycle? Show your work.

b) What is the percent yield of the reaction? Show your work.

c) Suggest a reason why the actual yield would be less than the theoretical yield.

81) Klinefelter syndrome is a chromosomal condition in boys and men that can affect physical and intellectual development. Individuals with this syndrome present with a trisomy 23, XXY. Present 2 possible meiosis charts for both the mother and the father that could explain how this trisomy could come about. Clearly indicate which gametes participate in fertilization.



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82) You meet a person with mosaic Down's syndrome. What causes this biologically? How do the symptoms differ from regular Down's syndrome?

83)

a) One assumption of the Hardy - Weinberg Equilibrium is no gene flow. What is gene flow? How does this differ from genetic drift?

b) What are the other four assumptions of Hardy-Weinberg Equilibrium?

84)

a) RFLP analysis can be used to distinguish between alleles based on differences in which of the following?

b) Which of the following procedures would produce RFLPs?

A) incubating a mixture of single-stranded DNA from two closely related species
B) incubating DNA nucleotides with DNA polymerase
C) incubating DNA with restriction enzymes
D) incubating RNA with DNA nucleotides and reverse transcriptase
E) incubating DNA fragments with ″sticky ends″ with ligase