Each numbered question has equal value.

Please read each question carefully.
1. In what phase of meiosis do chromosomes do most of their crossing over?
   a. prophase I
   b. metaphase I
   c. metaphase II
   d. telophase I
   e. b or c

2. At what stage of the cell cycle are chromosomes condensed enough to be photographed for a "chromosome squash" karyotype?
   a. prophase
   b. metaphase
   c. anaphase
   d. telophase I
   e. b or c

3. Give three examples of haploid cells.

4. Meiosis can be thought of as two successive mitoses with the important difference that in meiosis
   a. there are two synthesis phases
   b. chromosomes do not line up together
   c. centromeres divide only once
   d. a spindle does not form
   e. a and c are correct

5. A suppressor tRNA counteracts the effects of a mutation by
   a. reversing the mutation
   b. frameshifting
   c. inserting an amino acid at a stop codon
   d. b and c
   e. none of the above

6. At what phase of meiosis do sister chromatids separate?
   a. anaphase II
   b. metaphase II
   c. metaphase I
   d. interphase
   e. anaphase I

7. Ignoring crossing over, how many different kinds of human zygotes are possible from one pair of individuals?
8. Farmers typically buy hybrid seed to grow commercial crops. These hybrids are produced by crossing parental lines true-breeding for eight or more loci (many of which are not simple Mendelian dominant/recessive pairs). E.g.,

AABBCDDEEFFGGHH male x aabbccddeeffgghh female

Show the genotype of the resulting octahybrid F\textsubscript{1} plants.

9. How might the F\textsubscript{1} hybrids above perhaps be phenotypically different than the original male parent?
   a. polyploidy
   b. co-dominance
   c. quantitative trait loci
   d. c and b
   e. none of the above

10. If a farmer saves some of the seed from the F\textsubscript{1} plants above for next season, assuming independent assortment of all loci, what proportion of the new crop (F\textsubscript{2}) would be identical to the original true-breeding lines? (Use exponential form for your answer.)

11. Suppose a laboratory population of fruit flies has five different alleles at a locus for wing shape, each codominant with all others. What is the maximum number of different wing phenotypes that a given pair of parent flies could have among their offspring?

12. The autosomal genes \textit{cinnabar} and \textit{brown} in \textit{Drosophila} encode proteins required for eye pigments. When the recessive allele of the sex-linked \textit{white} gene is homozygous or hemizygous, however, neither pigment is actually visible in the fly's eye. What is this relationship among different gene called?
13. Centromere replication takes place at the beginning of what phase of the cell cycle?
   a. telophase  
   b. anaphase  
   c. metaphase 
   d. prophase  
   e. interphase

14. A woman who is not colorblind has a colorblind husband. They have a colorblind son. What are the chances their daughter will be colorblind?

15. A white-eyed female fly is mated with a red-eyed male fly. What kind of offspring are expected and in what ratios?

16. The process of making mRNA from a DNA template is
   a. transformation  
   b. transcription  
   c. transportation 
   d. translation  
   e. translocation

17. In a test cross of a dihybrid plant, AaBb, to a plant homozygous recessive at both loci, the following numbers of offspring with the indicated phenotypes were observed:

<table>
<thead>
<tr>
<th>Phenotype</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>AB</td>
<td>16</td>
</tr>
<tr>
<td>aB</td>
<td>84</td>
</tr>
<tr>
<td>Ab</td>
<td>84</td>
</tr>
<tr>
<td>ab</td>
<td>16</td>
</tr>
</tbody>
</table>

   Circle any/all phenotypes that are recombinants.

18. In the above, what were the genotypes of the four types of offspring listed?

19. In the above, what were the most likely genotypes of the parents of the dihybrid plant, assuming they were from true-breeding lines?
20. How many centimorgans apart are the two linked genes A and B in the above question?

21. What is the most likely order of arrangement of the genes A, B, C and D from the following data?

<table>
<thead>
<tr>
<th>cross</th>
<th>% recombination</th>
</tr>
</thead>
<tbody>
<tr>
<td>A - B</td>
<td>10</td>
</tr>
<tr>
<td>D - B</td>
<td>50</td>
</tr>
<tr>
<td>D - C</td>
<td>30</td>
</tr>
<tr>
<td>C - A</td>
<td>30</td>
</tr>
<tr>
<td>B - C</td>
<td>20</td>
</tr>
</tbody>
</table>

22. A woman whose paternal uncle was colorblind marries a man who is colorblind and bears a son. The woman herself is not colorblind, nor is anyone else in the immediate family. Show the pedigree of all members of this family. You may assign gender to any unknown individuals as needed.

23. What is the probability her son (above) will be colorblind?

24. In trying to determine whether DNA or protein was the genetic material, Hershey and Chase made use of which of the following facts?

   a. Protein contains phosphorus, but DNA does not.
   b. Protein does not contain sulfur, but DNA does.
   c. DNA contains greater amounts of $^{15}$N.
   d. Protein contains greater amounts of phosphorus than does DNA.
   e. none of the above.
25. RNA polymerase
   a. elongates a nucleotide chain by extending the 5' end of a chain.
   b. uses DNA as a template.
   c. requires a primer.
   d. a and b only.
   e. a, b and c.

26. Cleopatra was reportedly the product of a marriage between her father and his sister. What is the degree of relatedness between little Cleo's parents? (I.e., how much of their genomes do they share by common descent?)

27. Why is close-relative marriage generally considered a bad idea?

28. When Griffith injected heat-killed R-type Streptococcus cells into mice, he observed
   a. transformation
   b. live R cells
   c. sick mice
   d. b and c only
   e. none of the above

29. The A-site on the ribosome
   a. reads the codon
   b. binds the mRNA
   c. catalyzes amino acyl-tRNA synthesis
   d. holds a new amino acid
   e. holds the growing protein

30. A restriction enzyme
   a. connects DNA molecules
   b. is a clone
   c. plays a role in replication
   d. cuts double-stranded DNA
   e. a and c

31. In an analysis of the nucleotide composition of DNA to see which bases are equivalent in concentration, which of the following will always be true?
   a. A = G
   d. A + C = G + T
b. \( G + C = A + T \)  
e. c and d  
c. purines = pyrimidines

32. Which of the following can be the result of non-dysjunction during meiosis?

a. Down's syndrome  
 b. balanced translocation  
c. aneuploidy  
 d. cytoplasmic inheritance  
 e. a and c

33-35. Use all the words from the following list to label the following diagram in the appropriate places:

<table>
<thead>
<tr>
<th>coding strand</th>
<th>anticodon</th>
<th>template</th>
<th>amino acid</th>
</tr>
</thead>
<tbody>
<tr>
<td>codons</td>
<td>mRNA</td>
<td>tRNA</td>
<td>ribosome</td>
</tr>
<tr>
<td>rRNA</td>
<td>P-site</td>
<td>30S</td>
<td>methionine</td>
</tr>
</tbody>
</table>

36. What happens when bacteriophages are grown with radioactive phosphorus?

a. Their DNA becomes radioactive.  
b. Their proteins become radioactive.  
c. Their DNA is found to be of intermediate density in gradient centrifugation.  
d. They transfer their radioactivity to \( E. coli \) proteins during infection.  
e. a and d are true.

37. Which of the following most often causes frameshift mutations?
38. Write the sequence of an RNA strand complementary to the following sequence, and label the ends:

5' - C T G A G A C C T G C A - 3'

39. Given the parents aaBBcc x AaBbCC, and assuming simple dominance and independent assortment, what proportion of the progeny will be expected to phenotypically resemble the first parent?

a. 1/4  
b. 1/8  
c. 3/4  
da. 0  
e. 1

40. An ORF

a. always begins with a UAA codon  
b. reads the same on both strands  
c. binds RNA polymerase  
d. increases transcription  
e. none of the above

41. Translate the following mRNA sequence in all three reading frames:

5' - G G G G G C A A U U C C G A G - 3'

frame 1

frame 2

frame 3

42. You are conducting an experiment using artificial RNA as a substrate for translation in a cell-free system. Your template is poly-C with a weak doping of A. What amino acids would you find incorporated into the resulting product?
43. A lysogenic bacteriophage
   a. enters the nucleus  
   b. kills the cell  
   c. is integrated into the chromosome  
   d. has a membrane coat  
   e. a and c

44. Treatment of bacterial infections with antibiotics
   a. kills sensitive viruses  
   b. stimulates immunity  
   c. is useless  
   d. prevents re-infection  
   e. none of the above

45. What enzyme closes the gaps between DNA fragments during replication and is also used in genetic engineering to perform the same function on cloned fragments?
   a. DNA ligase  
   b. DNA polymerase  
   c. RNA polymerase  
   d. primase  
   e. restriction enzyme

46. When bacterial DNA adjacent to a prophage is occasionally packaged into phage heads, which of the following results?
   a. lysogeny  
   b. generalized transduction  
   c. transformation  
   d. specialized transduction  
   e. increased mutation rate

47. Which of the following is characteristic of a plasmid? Circle all that apply
   a. double stranded  
   b. circular  
   c. selectable gene  
   d. integrates into genome

48. Why is it no surprise that the first mutant fruit fly was found in a male fly?

49. How has genetic engineering affected the relationship between hemophilia and AIDS?
50. How do mammalian cells deal with the problem of balancing the dosage of X chromosomes genes between the two sexes?

51. Which of the following applies to Huntington's chorea?
   a. extra CAG codons
   b. Lake Maricaibo, Venezuela
   c. dementia
   d. dominant mutation
   e. all of the above

52. A cell contains a pair of homologs, one with a large inversion, the other without. What is the consequence of crossing-over when it occurs with this inverted region?
   a. dicentric chromosome
   b. aneuploidy
   c. acentric chromosome
   d. a and c
   e. none of the above

53. Which of the following is a binding site for a protein that is encoded by a regulatory gene?
   a. operon
   b. operator
   c. promoter
   d. repressor
   e. substrate

54. Which of the following is characteristic of a plasmid? Circle all that apply
   a. single stranded
   b. circular
   c. selectable gene
   d. integrates into genome

55. An operon that encodes proteins to be used in synthesis of an amino acid will likely
   a. contain introns
   b. be repressible by the amino acid
   c. be inducible by the amino acid
   d. always be turned ON
   e. none of the above