Choose the BEST answer. Two points each. Equations and other possibly useful materials
(Genetic Code; Chi-square table) can be found on the last page of the exam.

1. Which of the following is an example of a discontinuous/qualitative character/trait?
   a. red vs. white flower color in peas
   b. number of bristles on a fruit fly’s head
   c. tail length in monitor lizards
   d. number of ommatidia in a fly’s eye
   e. more than one of the above

2. Genes include regions known as _____________ that are excised and discarded during gene
   expression. The intervening, retained regions are known as _____________.
   a. introns; exons
   b. exons; operons
   c. operons; introns
   d. loci; alleles
   b. exons; introns

3. The only two factors involved in the expression of phenotype are genes and environment.
   a. true
   b. false
   c. this is easy!

4. The curve shown at the right represents the distribution of a particular physical trait, with the x axis indicating
   the number of individuals in the population and the y axis indicating the state of the trait itself. Of the choices given below,
   how many genes are most likely involved in the expression of this trait?
   a. one
   b. two
   c. three
   d. ten
   e. cannot determine from the information provided

5. A wild type female zebra carries an X-linked trait encoding pink stripes. If she mates with a wild-type, black-striped male, what is the likelihood that offspring will have pink stripes?
   a. 25%
   b. 50%
   c. 75%
   d. 100%

6. If the baby zebra above is male, what is the likelihood that it will have pink stripes?
   a. 10%
   b. 25%
   c. 50%
   d. 75%
   e. 100%

Choose the BEST and MOST SPECIFIC answer from the following five choices for #7 - 11. Any answer
may be used once, more than once, or not at all. You decide.

7. In mitotic division, these remain genetically identical to one another.
   a. homologous chromosomes
   b. sister chromatids
   c. dyad
   d. tetrad
   e. more than one of the above

8. A cell containing a _____________ has—if only briefly—four copies of its genome.

9. These have the same gene loci, but not necessarily the same alleles at each locus.

10. During leptonema, these are undergoing synapsis.

11. Chromosomes in this configuration are always identifiable as being joined by the
    synaptonemal complex.

12. How many individual molecules of DNA are found in the nucleus of a normal human ovum?
    a. one
    b. 23
    c. 46
    d. 92
    e. none

13. How many copies of the nuclear genome are found in the head of a normal human sperm?
    a. one
    b. 23
    c. 46
    d. 92
    e. none
14. The mitochondrial genome is maternally inherited because
   a. sperm contain no mitochondria
   b. the region of sperm containing mitochondria does not fuse with the ovum
   c. mitochondria in the ovum displace sperm mitochondria after a few cell divisions
   d. the zygote sequesters sperm mitochondria in vacuoles and digests them
   e. shortly after fertilization, the male mitochondria sneak off to watch the big game

15. Mendel studied seven different discontinuous traits in the garden pea (Pisum sativum). The fact that all seven traits obeyed his Law of Independent Assortment suggests that
   a. the ploidy of a garden pea gamete is 7.
   b. the ploidy of a garden pea somatic cell is 7.
   c. all seven traits are governed by genes on the same homologous pair of chromosomes.
   d. all seven traits are governed by genes located on separate chromosomes.
   e. the peas were very frightened of Mendel, and wanted to please him.

16. Sarah and Aaron are both carriers of Tay Sachs Disease, an autosomal recessive disorder. Which of the following would you use to determine the probability that if they have ten children, then five will be carriers and five will express the disorder?
   a. Chi Square Test
   b. Sum Rule
   c. Product Rule
   d. Binomial Theorem
   e. reciprocal cross

17. Considering the previous question and using the correct algorithm, calculate the probability that if Aaron and Sarah have five children, one will express Tay Sachs, and four will not.
   a. 0
   b. 0.18
   c. 0.25
   d. 0.40
   e. 3.25

18. Which of the following is TRUE of mtDNA, but NOT TRUE of nucDNA in mammals?
   a. it can code for enzymes involved in the electron transport chain
   b. both strands (sense and antisense) of the double helix are transcribed
   c. it is transcribed by an RNA polymerase encoded by genes in the nucleus
   d. it is inherited, either completely or in part, from the maternal parent
   e. All of the above are true of BOTH mtDNA and nucDNA

19. If you were to estimate the actual average tail length of all members of the House Mouse (Mus musculus) species by measuring and averaging the tail length of 30 individual mice, the number you would so calculate is known as the _______________. This is an estimate of the ideal—though incalculable—quantity of the actual, total population known as the _________.
   a. mean; average
   b. average; mean
   c. parameter; statistic
   d. statistic; parameter
   e. range; variance

20. If we assume that genes A, B, C, D, and E are located on separate chromosomes, how many unique gametes could be produced by an individual with the genotype AaBbCCDdEE?
   a. 4
   b. 8
   c. 16
   d. 32
   e. 64

21. A bacterial colony that can grow and proliferate on medium containing water, inorganic salts, and an organic energy source is said to be
   a. auxotrophic
   b. prototrophic
   c. mutant
   d. pathogenic
   e. resourceful

22. The two members of a homologous pair of chromosomes are most likely to differ from each other in
   a. their length
   b. identity and relative position of gene loci
   c. banding patterns
   d. the position of their centromeres
   e. the precise sequence of DNA comprising each gene

23. Frequency of double crossovers between two linked loci can be measured via incorporation of an intervening locus. If the intervening locus is not included, then double crossovers between the two outside loci would make it appear that the two outside loci are actually ____________ than they really are.
   a. farther apart
   b. closer together
   c. more closely linked
24. In an Hfr bacterium, the F plasmid is
   a. associated with the nucleoid region  
   b. free in the cytosol                 
   c. likely to promote the lytic cycle  
   d. incorporated into the chromosome  
   e. incorporated into the pilus

Use the following information to answer questions #25 - 32

Fun with flies! You are breeding a species of colorful, tropical flies whose wild type individuals have a purple abdomen, green thorax, and blue head. Each of these traits is controlled by a single locus, and all three loci are on chromosome #3, though you don't know their relative positions. Fortunately, there are recessive, mutant alleles of each gene that result in a fly having a black abdomen (b), orange thorax (o), and silver head (s), respectively.

You crossed a true breeding female, wild type fly with a male expressing the black abdomen, orange thorax and silver head. You then took females from the F1 generation and bred them to their father until you had 10,000 little maggots. Once these had emerged from their pupae as adults, you found the following proportions of each phenotypic class. (Use the grid provided for calculations, if you wish.)

<table>
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<th>phenotype</th>
<th>count</th>
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<tr>
<td>wild type</td>
<td>2700</td>
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<tr>
<td>black abdomen</td>
<td>950</td>
</tr>
<tr>
<td>orange thorax</td>
<td>900</td>
</tr>
<tr>
<td>silver head</td>
<td>60</td>
</tr>
<tr>
<td>black abdomen/silver head</td>
<td>1100</td>
</tr>
<tr>
<td>black abdomen/orange thorax</td>
<td>40</td>
</tr>
<tr>
<td>silver head/orange thorax</td>
<td>950</td>
</tr>
<tr>
<td>black abdomen/orange thorax/silver head</td>
<td>3300</td>
</tr>
</tbody>
</table>

25. The matings between the daughter flies and the father fly should be considered
   a. dihybrid crosses  
   b. trihybrid crosses  
   c. test crosses  
   d. more than one of the above

26. If crossing over between the three loci occurs in the parental (P) generation, what phenotypes would you expect to see in the F1 flies?
   a. wild type only  
   b. black abdomen/orange thorax/silver head only  
   c. all 8 possible phenotypes are present in the F1  
   d. none of the above  
   e. need more information to determine

27. What is the most probable order of the gene loci in question?
   a. b o s  
   b. o b s  
   c. b s o  
   d. o s b  
   e. more than one of the above

28. The crossover that produced flies with black abdomen, orange thorax also produced flies expressing
   a. wild type  
   b. silver head/black abdomen  
   c. silver head/orange thorax  
   d. orange abdomen/black thorax

29. What is the measured map distance between loci b and s?
   a. 19  
   b. 20  
   c. 39  
   d. 41  
   e. 80

30. What is the actual map distance between loci b and o?
   a. 19  
   b. 20  
   c. 39  
   d. 41  
   e. cannot determine
31. If crossovers between the two outside loci and the middle locus had been completely independent of one another, how many flies (out of your 10,000) would you have expected to express the phenotypes resulting from a double crossover?
   a. 200       b. 210       c. 380       d. 420       e. none of the above

32. Judging from your answer to the previous question, it appears that a crossover between one outside locus and the middle marker ______________ the likelihood of a crossover between the other outside locus and the middle marker.
   a. increased
   b. decreased
   c. did not affect
   d. just confuses

33. Horses have one coat color gene with two alleles, bay (B) and chestnut (b), and a second coding for solid color (P) versus piebalding (p). You bred a true-breeding solid chestnut stallion to 40 solid bay mares known to be heterozygous at both loci. Of the 40 foals born, 10 were solid bay, and 30 were solid chestnut. What is the probability that any variation from the expected relative frequencies of possible phenotypes is due simply to random chance? (HINT: Consider every possible genotype to be one independent category in this system, even if the phenotypes are the same.)
   a. 0.9 > P > 0.5
   b. 0.5 > P > 0.1
   c. 0.05 > P > 0.02
   d. 0.02 > P > 0.01
   e. P < 0.005

34. Given your answer to the previous question, could the two loci possibly be linked?
   a. yes
   b. no
   c. only in certain states

35. Which of the following statements about a new, mutant allele of an existing gene is FALSE?
   a. It could possibly become the new "wild type" allele in a natural population
   b. It is certain to be deleterious rather than beneficial to the organism expressing it.
   c. It may confer a selective advantage, depending on environmental context
   d. It may result in a phenotype that is either adaptive, maladaptive, or neutral.
   e. all of the statements above are TRUE of a new, mutant allele

36. Your own muscle and nerve cells owe their differences in structure and function to the fact that they
   a. have different genomes
   b. have different chromosomes
   c. have different ribosomes
   d. express different genes

37. An F+ and F- bacteria undergo conjugation during which three genes pass from the F+ strain into the F- bacteria before conjugation is interrupted. The F- bacterium containing some of the F+ bacterium's genes is now
   a. an endogenote
   b. a merozygote
   c. an exogenote
   d. transformed
   e. transduced

38. An Hfr bacterium
   a. has at least one plasmid present in the cytosol
   b. has a special recognition site that will take up closely related DNA from the environment
   c. has several insertion sequences scattered throughout its chromosome
   d. has several copies of a phage genome inserted into its chromosome
   e. has an F plasmid, bordered by insertion sequences (IS) integrated into its chromosome

39. Every cell in the human body contains 46 chromosomes. How many individual DNA molecules should you find in a cell?
   a. one
   b. two
   c. 23
   d. 46
   e. impossible to determine

40. A prophage is
   a. a specialized plasmid
   b. a viral genome inserted into a bacterial chromosome
   c. a plasmid that prevents viral infection in bacteria
   d. a genetic marker used to determine gene sequence in viruses infecting E. coli
   e. a virus who gets paid for infecting E. coli
Consider the following pedigree of a trait we'll abbreviate as "A" to answer #41 – 44.

41. What type of inheritance is most likely exhibited here?
   a. autosomal dominant  c. X-linked dominant  e. Y-linked dominant
   b. autosomal recessive  d. X-linked recessive

42. What is the genotype of individual #3?
   a. a a  b. A a  c. X^A X^a  d. X^A Y  e. X^a Y

43. Individual #8 is
   a. an unaffected individual  c. expressing a dominant lethal  e. male
   b. the proposita  d. mated to individual #9

44. Which of the following individuals have the allele in question?
   a. #2 and #6  c. #9 and #11  e. none of these have the allele
   b. #1 and #7  d. #5 and #6

Consider the following scenario to answer #45-46.
You have allowed four different strains of Hfr E. coli bacteria—all derived from the same F+ strain—to conjugate with F- bacteria. Analysis of the resulting donated strands of DNA found in the recipient cells indicate the four Hfr strains each donated genes in the following order

<table>
<thead>
<tr>
<th>Strain I:</th>
<th>lac</th>
<th>str</th>
<th>pro</th>
<th>pur</th>
<th>gly</th>
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</thead>
<tbody>
<tr>
<td>Strain II:</td>
<td>azi</td>
<td>pen</td>
<td>his</td>
<td>gly</td>
<td>pur</td>
</tr>
<tr>
<td>Strain III:</td>
<td>pen</td>
<td>azi</td>
<td>thr</td>
<td>trp</td>
<td>amp</td>
</tr>
<tr>
<td>Strain IV:</td>
<td>str</td>
<td>lac</td>
<td>amp</td>
<td>trp</td>
<td>thr</td>
</tr>
</tbody>
</table>

45. In what order do these genes occur on the E. coli chromosome?
   a. pen azi thr trp lac str amp pro pur gly his
   b. lac str amp pro pur gly his azi pen thr trp
   c. pen azi thr trp amp lac str pro pur gly his
   d. pro pur gly his azi pen thr trp lac str amp
   e. none of the above

46. In Strain IV, the O site is most specifically located between
   a. str and lac  c. azi and thr  e. need more information to determine
   b. lac and amp  d. str and pro
47. In an Hfr strain, location of the inserted plasmid in the bacterial chromosome can be determined by
   a. radioactively labeling a lysed plasmid
   b. inserting another plasmid into the Hfr to see where it binds
   c. determining the sequence of the entire genome, and subtracting the plasmid genes
   d. locating insertion sequences on either side of the plasmid
   e. cytoplasmic segregation and recombination

48. An embryonic plant containing both a mutant (unable to produce chlorophyll) and normal line of
   chloroplasts will eventually grow up to have leaves that are a patchwork of white and green areas, as
   the two different chloroplast lines separate into daughter cells unequally. This happens because
   a. chloroplasts with similar genomes are bound together by protein complexes during mitosis
   b. in such a small organelle population, segregation occurs due to random chance (genetic drift)
   c. mutant chloroplasts are more likely to die than normal chloroplasts.
   d. normal chloroplasts reproduce more rapidly than mutant ones, displacing them.
   e. chloroplasts are basically racist, and can't stand to be around chloroplasts unlike themselves.

49. A mitochondrial cytopathy is usually due to an error in a cytochrome protein necessary for cellular
   respiration. Such a condition
   a. is maternally inherited
   b. is inherited equally by both sexes
   c. should affect tissues such as liver and muscle most severely
   d. is not affected by the nuclear genome
   e. all of the above

50. Mapping of the bacterial genome can be done only by analyzing dominant and recessive expression of a trait
    in merozygotes.
   a. true
   b. false
   c. what?

Bonus Question:
T shirt with Totoro?

If you want to be the popular one at a party, here’s a good thing to do: Go up to some people who are talking and
laughing and say, “Well, technically that's illegal.” It might fit in with what somebody just said. And even if it doesn’t so
what, I hate this stupid party.

Deep Thoughts by Jack Handey
YOU MAY KEEP THIS SHEET AND USE IT TO CHECK YOUR ANSWERS AGAINST THE KEY THAT WILL BE POSTED OUTSIDE THE LECTURE HALL DOOR AFTER THE LAST PERSON HAS FINISHED THE EXAM. KEEP IT FOR THE REST OF THE SEMESTER, IN CASE YOU EVER WISH TO COMPARE YOUR ANSWERS TO THE ACTUAL EXAM KEY DURING OFFICE HOURS.

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Equations you might find useful:

Sum Rule = \((a/n) + (a/n) + (a/n)\)...

Product Rule = \((a/n) \times (a/n) \times (a/n)\)...

Binomial Theorem = \([n!/s!t!] (p)^s (q)^t\)

Chi Square = \(\sum [(O-E)^2/E]_n\)

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