AP Biology - Math Review

Basics: There are many basic math skills that you must be able to do to work the more complex math problems in AP Biology. It is sad when students know how to do the hard things, and mess up on the basics (which many students do). They don’t see that the question is asking for % or they calculate chi square based on the incorrect expected phenotypic ratio. The first several pages of this review are based on common mistakes students have made.

1. Working with decimals, ratios, fractions and percentages
2. Convert scientific notation to standard numbers
3. Report your answer with the number of significant figures that the question requires

Decimals, Ratios, Fractions and Percentages

In a monohybrid cross, when two heterozygotes are crossed, the phenotypic ratio in the offspring is predicted to be in a 3:1 ratio; approximately 75% will show the dominant phenotype, and 25% will show the recessive phenotype. In a dihybrid cross between two individuals that are both heterozygotes for both traits, the expected ratio is 9:3:3:1, where 9/16 of the offspring have both dominant phenotypes, 3/16 are dominant for the first trait but recessive for the second, 3/16 are recessive for the first trait and dominant for the second, and 1/16 are recessive for both traits. Students should know these ratios off the top of their heads.

Two heterozygotes produce 345 offspring
What is your expected phenotypic ratio?
How many individuals are expected to have the dominant phenotype?
How many individuals are expected to have the recessive phenotype?

In this genetic cross Aa x aa there are 714 offspring
How many individuals are expected to have the dominant phenotype?
How many individuals are expected to have the recessive phenotype?

In a dihybrid cross between two heterozygotes, if you have 360 offspring, what are your expected values?
Both dominant phenotypes
One dominant; one recessive
One recessive; one dominant
Both recessive phenotypes

The following data was observed; fill in the missing values.

<table>
<thead>
<tr>
<th>Stage of the Cell Cycle</th>
<th>Number of Cells in each stage</th>
<th>% of Cells in each stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interphase</td>
<td>62</td>
<td></td>
</tr>
<tr>
<td>Prophase</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td>Metaphase</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Anaphase</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Telophase</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

What percentage of the cells above are in mitosis?
On the AP Biology exam, you will only be allowed to use a four function calculator. You will not be able to enter numbers using scientific notation. You must convert to standard numbers, then simply add or subtract (and maybe convert to percentages) to get the correct answer.

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Study this age structure diagram that shows the human population for India. What percent of the population is under 20?

Calculating Rate of Change (Slope)

Population Growth
Use the graph below to calculate the mean rate of population growth (individuals per hour) between hours 6 and 9. Give your answer to the nearest whole number.
What is the rate of change (individuals per hour)?

The graph shows the growth in cm of a pea plant over a period of 5 weeks. What was the mean growth rate per day between week 1 and week 3?

Examine the data.

**Increase in Atmospheric Carbon Dioxide Concentration at Mauna Loa, Hawaii and Average Global Temperatures**

(a) Calculate the rate of increase in CO$_2$ production from 1974

(b) What will be the approximate CO$_2$ concentration in 2100

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**Hardy-Weinberg Problems**

The allele for the hair pattern called “widow’s peak” is dominant over the allele for no “widow’s peak”. In a population of 100 individuals, 91 show the dominant phenotype.

What is the frequency of the dominant allele?
What is the frequency of the recessive allele?
How many individuals would you expect to be heterozygous for the trait?

The ability to taste PTC is due to a single dominant allele (T). You sampled 215 individuals in biology and determined that 150 could taste PTC and 65 could not.

How many individuals in this population show the TT genotype? Tt?

In a population of robins in which the allele for dark head plumage is dominant to the allele for light head plumage, a cold winter leads to the selection against lighter head plumage. When the winter is over, 8% of the remaining birds exhibit light head plumage.

If the population is now in Hardy-Weinberg equilibrium, what will be the frequency of the light head plumage in the next generation? Give your answer to the nearest tenth.
In a certain population of deer on Fire Island, NY, the allele for a black spot behind the eye is dominant to the allele for no spot. After the hunting season, the percent of deer with no black spot is 17% and the population is in Hardy-Weinberg Equilibrium.

What is the frequency for the allele for having no black spot, to the hundredths?

**Combine Hardy-Weinberg expectations with Chi Square Analysis**

In a certain species of flowering plant, the red allele R is dominant to the white allele, r. A student carried out a cross between a red flowered plant and a white flowered plant. When planted, the 158 seeds that were produced from the cross matured into 92 plants with red flowers and 66 plants with white flowers. Calculate the chi squared value for the null hypothesis that the red flowered parent was a hybrid for the flower color gene. Give your answer to the nearest tenth.

In poultry, the autosomal gene FB produces feathers black in color and another allele, FW, produces white feathers. The heterozygous condition produces feathers of blue color. When a population of white hens was mated to black roosters, the resulting offspring were all blue. These blue offspring were mated with one another. The F2 generation yielded 78 black, 206 blue, and 116 white chickens. Determine the frequency of each allele in the F2 population. Determine if the population is in Hardy-Weinberg equilibrium by calculating the chi-squared value. Give your answer for χ² to the nearest hundredth.

**More Chi Square**

A Cellular Biologist wants to double check that statement that cells spend 90 percent of their time in Interphase as compared to the various stages of Mitosis. She grows some Allium in her laboratory. She then takes one of the plants, cuts off the root tips, stains the DNA in the cells so as to be able to see the stages of the cell cycle. Her hypothesis states “If cells spend 90 percent of their time in Interphase, then she should be able to calculate the relative time existing between Interphase and Mitosis based upon the cells counted in her specimen.” She counted 1000 cells from her preserved specimen under the microscope. Her data are shown below. **Calculate the X² to the nearest hundredth.**

<table>
<thead>
<tr>
<th>Stage of the Cell Cycle</th>
<th>Number of Cells Observed</th>
<th>Number of Cells Expected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interphase</td>
<td>872</td>
<td></td>
</tr>
<tr>
<td>Mitosis</td>
<td>128</td>
<td></td>
</tr>
</tbody>
</table>

**Water Potential**

What is the water potential of a cell with a solute potential of -0.67 MPa and a pressure potential of 0.43 MPa?
You measure the total water potential of a cell and find it to be -0.24 MPa. If the pressure potential of the same cell is 0.46 MPa, what is the solute potential of that cell?

Calculate the water potential of a 0.15 M sucrose solution. Assume a temperature of 27°C.

Cell A has a solute potential of -2.0 MPa and a pressure potential of 0.5 MPa.
Cell B has a solute potential of -4.0 MPa and a pressure potential of 0.9 MPa.
Which way will water flow when the two cells are placed against each other?

A wind borne pollen grain with a solute potential of -3.0 MPa has dried out somewhat after being blown about; this has caused its turgor pressure (pressure potential) to go to 0. It lands on a flower stigma that whose cells have a solute potential of 3.0 MPa and a pressure potential of 1 MPa. Which way will water flow? From the pollen grain to the stigma, or the stigma to the pollen grain? Show how you deduced your answer.

Surface Area

In the Diffusion Lab, agar cubes are used to illustrate the relationship of surface area/volume/diffusion rate. Fill in the values missing in the table

<table>
<thead>
<tr>
<th>Block</th>
<th>cm x cm</th>
<th>Surface Area cm</th>
<th>Volume ml</th>
<th>Surface Area:Volume Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2 x 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>3 x 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>4 x 4</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

You use this data to answer questions like this-

**Predict**- If you put each of the blocks into a solution, into which block would that solution diffuse throughout the entire block fastest? Slowest? How do you explain the difference?

Describe the relationship between the surface area: volume ratio and the percentage of the cube not affected by diffusion.

Gibbs Free Energy

\[
\Delta G = \Delta H - T\Delta S
\]

\[G = \text{Free Energy} \quad H = \text{Enthalpy} \quad S = \text{Entropy}\]

\[T = \text{Temperature in Kelvin} \quad \Delta \text{represents change in value over time}\]

An experiment determined that when a protein unfolds to its denatured (D) state from the original folded (F) state, the change in Enthalpy is \(\Delta H = H(D) - H(F) = 46,000 \text{ joules/mol}\). Also the change in Entropy is \(\Delta S = S(D) - S(F) = 178 \text{ joules/mol}\). At a temperature of 20°C, calculate the change in Free Energy \(\Delta G\), in j/mol, when the protein unfolds from its folded state.

Miscellaneous Math

Geneticists working in an agriculture lab wanted to develop a crop that combines the disease resistance of rye grain with the high crop yielding capacity of wheat grain. Rye grain has a diploid chromosome number (2n) of 14 and wheat grain has a diploid chromosome number of 42. The resulting grain is called triticale and is an alloplody plant. How many chromosomes are found in the pollen grain of triticale?
A study was conducted on the island of Daphne Major in the Galapagos Islands by Peter and Rosemary Grant. This study lasted over 20 years. The study investigated how the type of seeds available to the finches impacted the depth of their beaks. In years when rain and water were plentiful, the available seeds were smaller and easy to crack. In years experiencing drought, fewer seeds were produced, and the finches had to eat the larger, leftover seeds produced from previous years. During years of drought, birds with a greater beak depth had a selective advantage.

Use the data above to determine the increase in the mean of the depth of the beak between the wet and dry years. Give your answer to the nearest hundredth of a millimeter.

### Bird ID Tag Number

<table>
<thead>
<tr>
<th>Bird ID Tag Number</th>
<th>Wet Year Beak Depth (mm)</th>
<th>Bird ID Tag Number</th>
<th>Dry Year Beak Depth (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A</td>
<td>10.81</td>
<td>1B</td>
<td>11.02</td>
</tr>
<tr>
<td>2A</td>
<td>8.74</td>
<td>2B</td>
<td>9.65</td>
</tr>
<tr>
<td>3A</td>
<td>10.04</td>
<td>3B</td>
<td>11.75</td>
</tr>
<tr>
<td>4A</td>
<td>9.75</td>
<td>4B</td>
<td>10.22</td>
</tr>
<tr>
<td>5A</td>
<td>9.76</td>
<td>5B</td>
<td>9.86</td>
</tr>
</tbody>
</table>

Carbon Flow in a Grassland Ecosystem

How much carbon (g/m²) is released into the atmosphere as a result of the metabolic activity of herbivores? Give your answer to the nearest whole number.
The mark and recapture method of estimating population size is used in the study of animal populations where individuals are highly mobile. It is of no value where animals do not move or move very little. The number of animals caught in each sample must be large enough to be valid.

1. In the first capture, each animal that is captured is marked in a distinctive way.
2. The marked animals are released into the natural habitat and left for a period of time.
3. A second capture is done. Only a portion of the second capture sample will have marked animals.

\[
\frac{M}{N} = \frac{m}{n} \quad \text{or} \quad N = \frac{Mn}{m}
\]

- \(M\) is the population size to be estimated.
- \(M\) is the number of members of the population that are captured initially and tagged.
- \(n\) is the number of members of the population that are captured subsequently.
- \(m\) is the number of members of this subsequent captured population that are tagged.

30 turtles are captured in 1 km\(^2\), they are marked and released back into the wild. Two weeks later 30 more turtles are caught. 6 had the marking of the original population. Based on this information, what is the best estimation of the turtle population in the area?

**Recombination Frequency**

In fruit flies, long wings (A) and gray bodies (B) are dominant to vestigial wings and black bodies. In a cross of AaBb x aabb. These are your results-

- 123 long wing, gray body
- 21 long wing, black body
- 27 vestigial wing, gray body
- 129 vestigial wing, black body

Calculate the cross over value (recombination frequency) for the offspring of the test cross. How many map units apart are these two genes?

There are 4 genes on a single chromosome: A, B, C and D. They exhibit the following crossing over frequencies:

- A-B = 35%
- B-C = 10%
- C-D = 15%
- C-A = 25%
- D-B = 25%

Determine the order of the genes on the chromosome

**Multiple Choice**
1. A large population of laboratory animals has been allowed to breed randomly for a number of generations. After several generations, 36% of the animals display a recessive trait (aa), the same percentage as at the beginning of the breeding program. The rest of the animals show the dominant phenotype, with heterozygotes indistinguishable from the homozygous dominants. What is the most reasonable conclusion that can be drawn from the fact that the frequency of the recessive trait (aa) has not changed over time?
   a. The population is undergoing genetic drift.
   b. The two phenotypes are about equally adaptive under laboratory conditions.
   c. The genotype AA is lethal.
   d. There has been a high rate of mutation of allele A to allele a.

2. What is the estimated frequency of allele a in the gene pool?
   a. 0.18
   b. 0.40
   c. 0.60
   d. 0.70

3. In a Hardy-Weinberg population with two alleles, A and a, that are in equilibrium, the frequency of the allele a is 0.7. What is the percentage of the population that is homozygous for this allele?
   a. 3
   b. 9
   c. 30
   d. 49

Questions 4-6 In a hypothetical population of 1,000 people, tests of blood-type genes show that 160 have the genotype AA, 480 have the genotype AB, and 360 have the genotype BB.

4. What is the frequency of the A allele?
   a. 0.001
   b. 0.002
   c. 0.100
   d. 0.400

5. What percentage of the population has type O blood?
   a. 0
   b. 10
   c. 24
   d. 48

6. If there are 4,000 children born to this generation, how many would be expected to have AB blood under the conditions of Hardy-Weinberg equilibrium?
   a. 100
   b. 960
   c. 1,920
   d. 2,000

7. Consider a polysaccharide consisting of 576 glucose molecules. The total hydrolysis of the polysaccharide would result in the production of
   a. 575 glucose molecules.
   b. 575 water molecules.
Refer to the information below to answer question 8 & 9

You are studying three populations of birds. Population 1 has ten birds, of which one is brown (a recessive trait) and nine are red. Population 2 has 100 birds. In that population, ten of the birds are brown. Population 3 has 30 birds, and three of them are brown. Use the following options to answer the questions:

A. Population 1  
B. Population 2  
C. Population 3  
D. They are all the same.  
E. It is impossible to tell from the information given.

8. In which population is the frequency of the allele for brown feathers highest?
   a. A  
   b. B  
   c. C  
   d. D

9. In which population would it be least likely that an accident would significantly alter the frequency of the brown allele?
   a. A  
   b. B  
   c. C  
   d. D

10. Upon chemical analysis, a particular protein was found to contain 556 amino acids. How many peptide bonds are present in this protein?
    a. 139  
    b. 554  
    c. 555  
    d. 556

11. One liter of a solution of pH 2 has how many more hydrogen ions (H⁺) than 1 L of a solution of pH 6?
    a. 4 times more  
    b. 400 times more  
    c. 4,000 times more  
    d. 10,000 times more
12. During a laboratory experiment, you discover that an enzyme-catalyzed reaction has a $\Delta G$ of -20 kcal/mol. If you double the amount of enzyme in the reaction, what will be the $\Delta G$ for the new reaction?
   a. -40 kcal/mol
   b. -20 kcal/mol
   c. 0 kcal/mol
   d. +20 kcal/mol

13. Starting with a fertilized egg (zygote), a series of five cell divisions would produce an early embryo with how many cells?
   a. 4
   b. 8
   c. 16
   d. 32

14. How many unique gametes could be produced through independent assortment by an individual with the genotype $AaBbCCDdEE$?
   a. 4
   b. 8
   c. 16
   d. 32

15. When crossing a homozygous recessive with a heterozygote, what is the chance of getting an offspring with the homozygous recessive phenotype?
   a. 0%
   b. 25%
   c. 50%
   d. 75%

16. Two true-breeding stocks of pea plants are crossed. One parent has red, axial flowers and the other has white, terminal flowers; all $F_1$ individuals have red, axial flowers. If 1,000 $F_2$ offspring resulted from the cross, approximately how many of them would you expect to have red, terminal flowers? (Assume independent assortment).
   a. 65
   b. 190
   c. 250
   d. 565

17. Given the parents $AABBcC \times AabbCc$, assume 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
   d. 3/8

18. A woman and her spouse both show the normal phenotype for pigmentation, but both had one parent who was an albino. Albinism is an autosomal recessive trait. What is the probability that their first child will be an albino?
19. Huntington's disease is caused by a dominant allele. If one of your parents has the disease, what is the probability that you, too, will have the disease?
   a. 1
   b. 3/4
   c. 1/2
   d. 1/4

20. Cinnabar eyes is a sex-linked recessive characteristic in fruit flies. If a female having cinnabar eyes is crossed with a wild-type male, what percentage of the F1 males will have cinnabar eyes?
   a. 0%
   b. 25%
   c. 50%
   d. 100%

21. An achondroplastic male dwarf with normal vision marries a color-blind woman of normal height. The man's father was six-feet tall, and both the woman's parents were of average height. Achondroplastic dwarfism is autosomal dominant, and red-green color blindness is X-linked recessive. They have a daughter who is a dwarf with normal color vision. What is the probability that she is heterozygous for both genes?
   a. 0
   b. 0.25
   c. 0.50
   d. 1.00

22. Cytosine makes up 38% of the nucleotides in a sample of DNA from an organism. Approximately, what percentage of the nucleotides in this sample will be thymine?
   a. 12
   b. 24
   c. 31
   d. 38

23. If \( P = 0.3 \) MPa and \( S = -0.45 \) MPa, the resulting \( \Psi \) is
   a. +0.75 MPa.
   b. -0.75 MPa.
   c. -0.15 MPa.
   d. +0.15 MPa.

24. At the summit of a high mountain, the atmospheric pressure is 380 mm Hg. If the atmosphere is still composed of 21% oxygen, what is the partial pressure of oxygen at this altitude?
   a. 0 mm Hg
25. To measure the population density of monarch butterflies occupying a particular park, 100 butterflies are captured, marked with a small dot on a wing, and then released. The next day, another 100 butterflies are captured, including the recapture of 20 marked butterflies. One would estimate the population to be
a. 200.
b. 500.
c. 1,000.
d. 10,000.

26. A population of ground squirrels has an annual per capita birth rate of 0.06 and an annual per capita death rate of 0.02. Estimate the number of individuals added to (or lost from) a population of 1,000 individuals in one year.
a. 120 individuals added
b. 40 individuals added
c. 20 individuals added
d. 400 individuals added

27. Consider a field plot containing 200 kg of plant material. Approximately how many kg of carnivore production can be supported?
a. 200
b. 100
c. 20
d. 2

28. You are doing a mark-recapture experiment to determine the population size of MendAliens living on an island. Initially you capture, mark, and release 130 MendAliens. A few days later, you capture 90 MendAliens, 20 of which are marked. What is your estimate of the population size of the MendAliens?
a. 14
b. 29
c. 130
d. 585

29. 10,000 kcal of producer would support approximately ____ kcal of tertiary consumer.
a. 1
b. 0
c. 1,000
d. 10