Numeric Response Practice Due: April 17th

Complete the following numeric response practice problems. After completion, you will submit your answers to the Google Form found at:

AP® BIOLOGY EQUATIONS AND FORMULAS

Statistical Analysis and Probability

Mean

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

Standard Deviation

$$s = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n-1}}$$

Standard Error of the Mean

$$SE_{\bar{x}} = \frac{s}{\sqrt{n}}$$

Chi-Square

$$\chi^2 = \sum \frac{(o-e)^2}{e}$$

Chi-Square Table

p value	Degrees of Freedom							
	1	2	3	4	5	6	7	8
0.05	3.84	5.99	7.81	9.49	11.07	12.59	14.07	15.51
0.01	6.63	9.21	11.34	13.28	15.09	16.81	18.48	20.09

$\bar{x}$ = sample mean

n = sample size

s = sample standard deviation (i.e., the sample-based estimate of the standard deviation of the population)

o = observed results

e = expected results

Σ = sum of all

Degrees of freedom are equal to the number of distinct possible outcomes minus one.

Laws of Probability

If A and B are mutually exclusive, then:

$$P(\text{A or B}) = P(\text{A}) + P(\text{B})$$

If A and B are independent, then:

$$P(\text{A and B}) = P(\text{A}) \times P(\text{B})$$

Hardy-Weinberg Equations

$p^2 + 2pq + q^2 = 1$

$p + q = 1$

p = frequency of allele 1 in a population

q = frequency of allele 2 in a population

Metric Prefixes

Factor	Prefix	Symbol
10^9	giga	G
10^6	mega	M
10^3	kilo	k
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p

Mode = value that occurs most frequently in a data set

Median = middle value that separates the greater and lesser halves of a data set

Mean = sum of all data points divided by number of data points

Range = value obtained by subtracting the smallest observation (sample minimum) from the greatest (sample maximum)

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Rate and Growth

Rate

$$\frac{dY}{dt}$$

dY = amount of change

dt = change in time

Population Growth

$$\frac{dN}{dt} = B - D$$

B = birth rate

D = death rate

Exponential Growth

$$\frac{dN}{dt} = r_{max}N$$

N = population size

K = carrying capacity

Logistic Growth

$$\frac{dN}{dt} = r_{max}N\left(\frac{K-N}{K}\right)$$

r_{max} = maximum per capita growth rate of population

Simpson's Diversity Index

$$\text{Diversity Index} = 1 - \Sigma\left(\frac{n}{N}\right)^2$$

n = total number of organisms of a particular species

N = total number of organisms of all species

Water Potential (Ψ)

$$\Psi = \Psi_P + \Psi_S$$

Ψ_P = pressure potential

Ψ_S = solute potential

The water potential will be equal to the solute potential of a solution in an open container because the pressure potential of the solution in an open container is zero.

The Solute Potential of a Solution

$$\Psi_S = -iCRT$$

i = ionization constant (1.0 for sucrose because sucrose does not ionize in water)

C = molar concentration

R = pressure constant (R = 0.0831 liter bars/mole K)

T = temperature in Kelvin (°C + 273)

pH = $-\log[H^+]$

Surface Area and Volume

Surface Area of a Sphere

$$SA = 4\pi r^2$$

Volume of a Sphere

$$V = \frac{4}{3}\pi r^3$$

Surface Area of a Rectangular Solid

$$SA = 2lh + 2lw + 2wh$$

Volume of a Rectangular Solid

$$V = lwh$$

Surface Area of a Cylinder

$$SA = 2\pi rh + 2\pi r^2$$

Volume of a Cylinder

$$V = \pi r^2 h$$

Surface Area of a Cube

$$SA = 6s^2$$

Volume of a Cube

$$V = s^3$$

r = radius

l = length

h = height

w = width

s = length of one side of a cube

SA = surface area

V = volume

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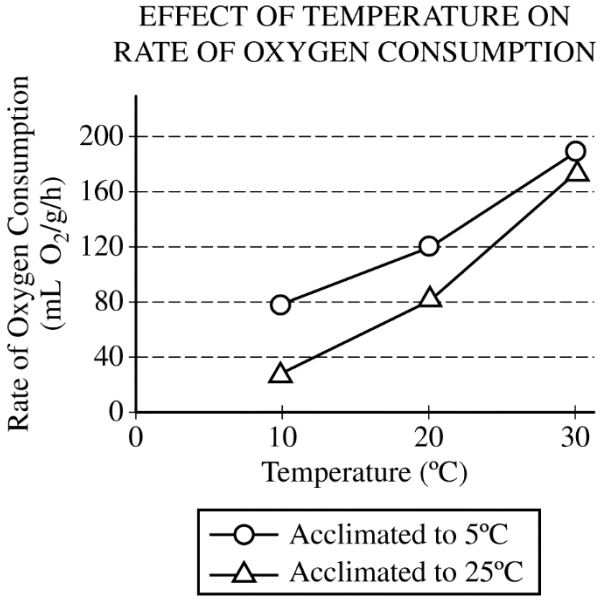
1. Based on the data shown, calculate the average rate of increase in oxygen consumption for animals acclimated to 5°C as the temperature increases from 10°C to 30°C. Give the answer in mL O_2/g/h/°C to the nearest tenth.



2. To estimate the size of an animal population, researchers often use a method known as mark-recapture, which involves marking individuals from a large population for easy identification upon recapture. The mark-recapture method assumes that the proportion of marked individuals in the recapture group is equal to the proportion of marked individuals in the entire population.

   Researchers used the mark-recapture method to estimate the number of individuals in a population. Using the results presented in the table below, estimate the total number of individuals in the population. Give your answer to the nearest whole number.

	Number of Marked Individuals	Total Number of Individuals
Recapture group	18	78
Entire population	210	?

3. A certain species of plant has four unlinked genetic loci, W, X, Y, and Z. Each genetic locus has one dominant allele and one recessive allele. For a plant with the genotype WWXxYyZz, what is the probability that the plant will produce a gamete with a haploid genotype of Wxyz? Give your answer as a fraction or as a value between 0 and 1, to three decimal places.

4. A typical human lymphocyte has a radius of about 10 µm, while a typical bacterium (*e.g.*, *S. pneumoniae*) has a radius of about 2 µm.

   Assuming that both cell types are perfectly spherical, how many times larger is the surface area of a typical human lymphocyte compared to the surface area of a typical bacterium?

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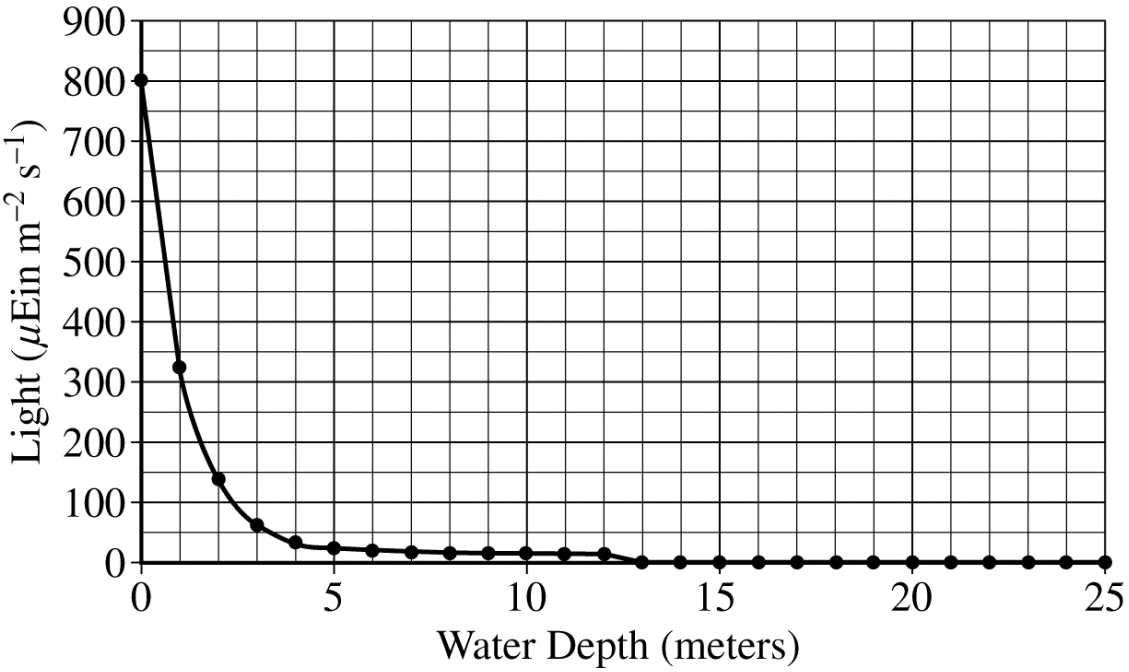
5. 5 '-AGGCGCGACGCGATCTGAC-3'

One method for predicting the average temperature (in °C) at which a short DNA molecule binds with its complement is to calculate a melting temperature (T_m) using the following formula.

$$T_m = 4\ (G + C) + 2\ (A + T)$$

Using the formula, what is the predicted T_m for the short single-stranded DNA molecule shown above?

6. As part of a study to observe the activity of photosynthetic organisms in a temperate-zone lake, measurements of light penetration were made at different water depths. The results are presented in the graph below. Note that higher light-penetration values indicate a greater amount of light reaching the water at that depth.



According to the data above, what is the deepest water level at which light penetration is expected to be at least 50 μE in $m^{-2}s^{-1}$? Give your answer to the nearest tenth of a meter.

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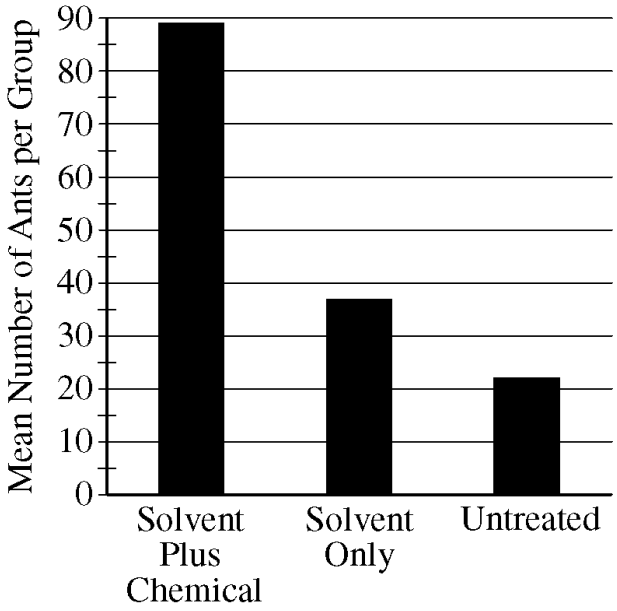
7. An experiment on plant defenses was conducted on three identical groups of lima bean plants. The first group was treated with a solution containing a chemical similar to an organic compound that is released by herbivore-damaged plants (solvent plus chemical). The second group was treated with only the solvent used in the first treatment. The third group was left untreated. One week after the treatment phase, the numbers of carnivorous ants (predators of herbivores) found residing on the plants in each group were determined. The results of the experiment are provided below.



Based on the information in the graph, how many times more ants are found on plants exposed to the solvent plus chemical compared to plants exposed to the solvent only? Give your answer to the nearest tenth.

8. The internal temperature of different organisms was determined under various conditions, as shown in the table below.

Organism	Thermoregulation Strategy	Measurement Conditions	Internal Temperature
Butterfly	Ectotherm	Resting in the shade	15°C
Butterfly	Ectotherm	Flying in the sunlight	23°C
Horse	Endotherm	Resting in the shade	42°C
Horse	Endotherm	Galloping in a field	43°C
Goose	Endotherm	Sitting on a nest	51°C
Goose	Endotherm	Flying above the treetops	?? °C

Predict the internal temperature (in °C) of a goose that is flying just above the treetops when the external temperature is 17°C. Give your answer to the nearest whole number.

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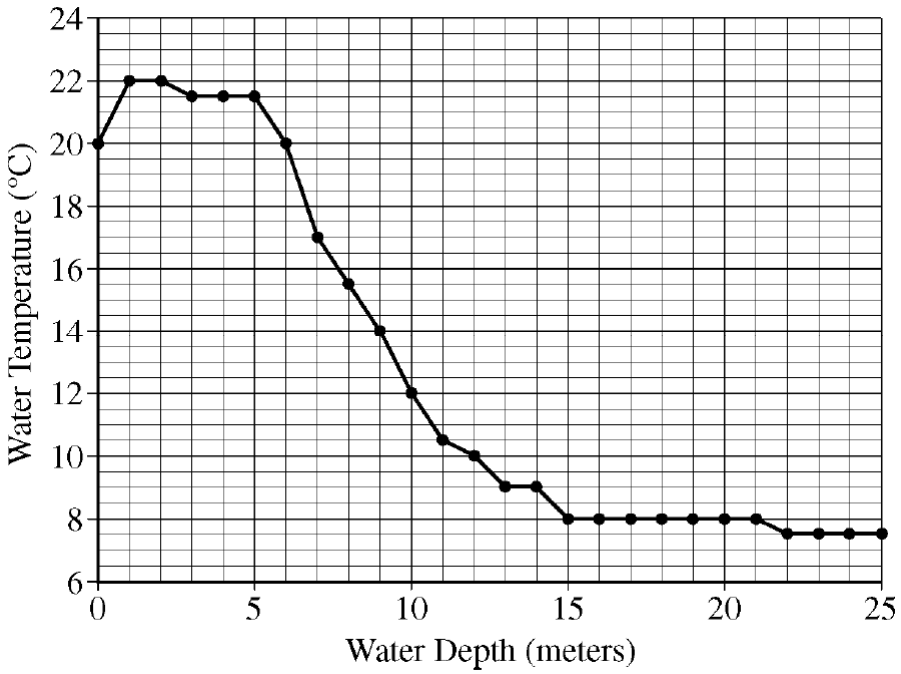
9. As part of a study investigating the temperature profile of a temperate-zone lake, water temperature measurements were made at different water depths at the same time on the same day. The results are presented in the graph below.



According to the data, a strict endotherm that acclimates at 10 meters and again at 15 meters will be exposed to how many degrees change in temperature? Provide your answer to the nearest tenth of a degree.

10. Phenylketonuria (PKU) is an inherited disease caused by an autosomal recessive allele.

If two individuals who are carriers of PKU have three children, what is the probability that none of the children will have PKU? Give your answer as a fraction or decimal.

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11. The effect of temperature on the respiration rate of heterotrophic bacteria in a shallow, slow-moving freshwater stream was investigated by performing the following experiment. The water temperature of the stream was monitored over a continuous 24-hour period (starting at time = 0 hours). The respiration rates of bacteria living in the streambed were determined at 6 hours and at 9 hours. The results are presented below.

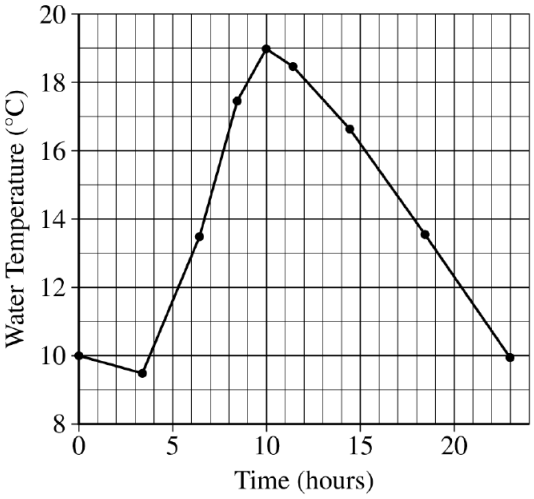

Figure 1. Water Temperature

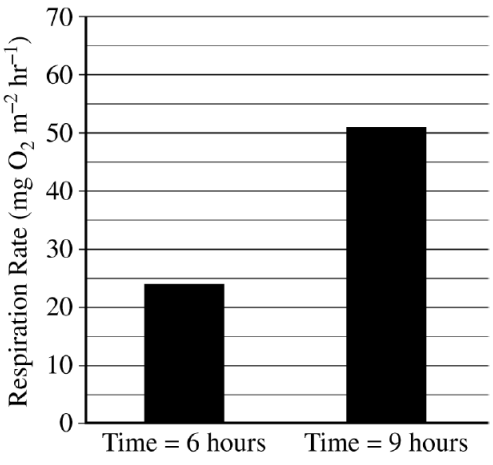

Figure 2. Respiration Rate

Based on the information provided, what was the change (in °C) in water temperature associated with the change in respiration rate shown in Figure 2? Give your answer to one decimal place.

12. In fruit flies, the allele for vestigial wings is recessive to the allele for wild-type wings, and the allele for white eyes is recessive to the allele for red eyes. The gene controlling wing type is carried on an autosome, whereas the gene controlling eye color is carried on the X chromosome.

A true-breeding female with wild-type wings and white eyes is crossed with a male with vestigial wings and red eyes. What proportion of the offspring are expected to be males with wild-type wings and red eyes? Give your answer as a fraction or a decimal value from 0 to 1.

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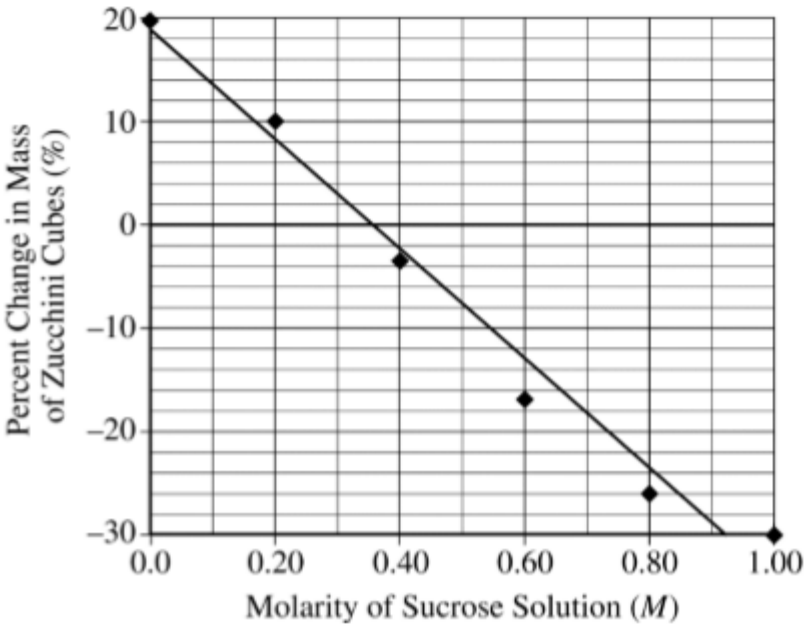
13. A zucchini squash was peeled and cut into six identical cubes. After being weighed, each cube was soaked in a different sucrose solution for 24 hours in an open container and at a constant temperature of 35°C. The cubes were then removed from the sucrose solutions, carefully blotted on paper towels, and weighed again. The percent change in mass (due to a net gain or loss of water) was calculated for each cube, and the results are shown in the graph below. A straight line is drawn on the graph to help in estimating results from other sucrose concentration not tested.



Using the straight line on the graph above, calculate the water potential (in bars) of the zucchini squash at 35°C. Give your answer to one decimal place.

14. A cell has a surface area of 24 μm^2 and a volume of 4 μm^3. A different cell has a surface area of 48 μm^2 and a volume of 12 μm^3. What is the ratio of surface area to volume for the cell that is predicted to exchange materials with the surrounding environment at a faster rate by diffusion? Enter your answer as a fraction or a whole number.

15. A researcher proposes that the transmembrane portion of a certain protein consists of 28 amino acids. Based on the proposed model, calculate the number of nucleotides in the mRNA that encode only the amino acids in the transmembrane portion of the protein.

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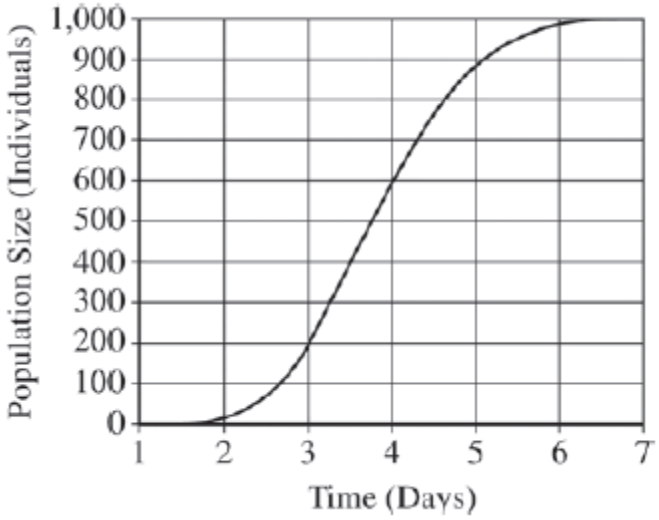
16. Male chickens carry two Z sex chromosomes, while female chickens carry one Z sex chromosome and one W sex chromosome. Located on the Z chromosome is a gene for barring. Barred feathers have black and white stripes. The barred trait is dominant to the unbarred trait.

    Chickens have a fleshy growth on top of the head called a comb. An autosomal trait called rose comb is dominant to a trait called single comb.

    An unbarred male heterozygous for the rose-comb trait is crossed with a barred female heterozygous for the rose comb. What proportion of the resulting progeny are expected to be barred males with single combs? Give your answer as a fraction or as a decimal to the nearest thousandths.

17. Use the graph below to calculate the mean rate of population growth (individuals per day) between day 4 and day 6. Give your answer to the nearest whole number.



18. In a certain species of flowering plant, the purple allele P is dominant to the yellow allele p. A student performed a cross between a purple- flowered plant and a yellow-flowered plant. When planted, the 156 seeds that were produced from the cross matured into 97 plants with purple flowers and 59 plants with yellow flowers.

    Calculate the chi-squared value for the null hypothesis that the purple-flowered parent was heterozygous for the flower-color gene. Give your answer to the nearest tenth.

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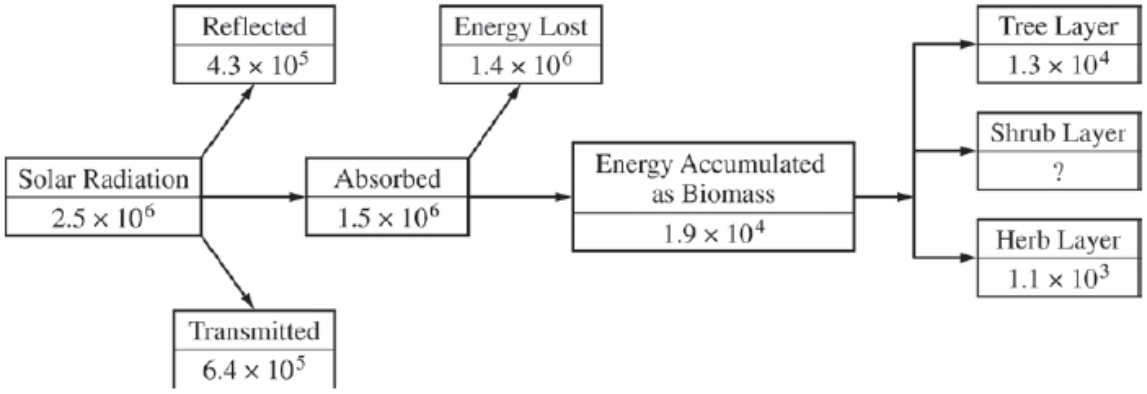
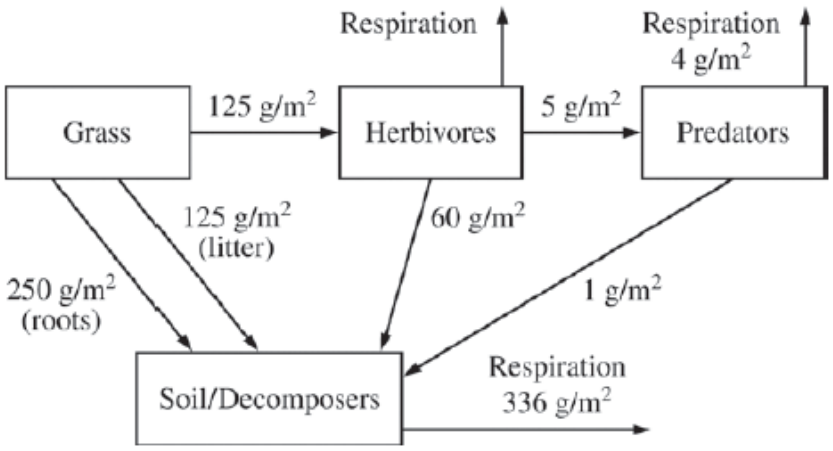
19. What percent of the biomass in the forest community represented above is tied up in the shrub layer? Give your answer to the nearest whole number.



20. How much carbon (in g/m2) is released into the atmosphere as a result of the metabolic activity of herbivores? Give your answer to the nearest whole number.

CARBON FLOW IN A GRASSLAND ECOSYSTEM



21. Hydrogen peroxide is broken down to water and oxygen by the enzyme catalase. The data were taken over 5 minutes. What is the rate of enzymatic reaction in mL/min from 2 to 4 minutes? Round to the nearest hundredths.

Time (min)	O_2 produced (mL)
1	2.1
2	3.4
3	4.8
4	5.9
5	6.2

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22. Paper disks were coated in a yeast mixture containing the enzyme catalase. When these paper disks were placed in a beaker containing 3% hydrogen peroxide, the enzyme catalase broke down the hydrogen peroxide. Students measured the amount of time it took for each disk to rise to the top of the beaker (based on the amount of oxygen gas produced). The amount of time in seconds for each paper disk is listed below. Calculate the average (mean) time for the disks to rise. Give the answer in seconds to the nearest hundredth.

    21.5 21.7 18.4 22.8 17.9 23.6

23. What is the pH of a solution with a hydrogen ion concentration of 1.0×10^{-10}. Express your answer as a whole number.

24. According to the Acid Rain Monitoring Project at the University of Mass, the pH measured at King Phillip Brook on April 10, 2012, was near 4, which the pH measured at Robbins Pond on that same date was near 7. Determine to the nearest whole number how many times greater the hydrogen ion concentration was at King Phillip Brook.

25. The molar concentration of a sugar solution in an open beaker has been determined to 0.4 M. Calculate the solute potential at 29 degrees Celsius. Round your answer to the nearest tenths.

26. In snapdragons (*Antirrhinum*), the phenotype for flower color is governed by two alleles – red (R) and white (W). Heterozygous individuals have pink flowers. Two pink individuals are crossed to produce 485 offspring. Calculate how many of these offspring are expected to have the red phenotype. Round your response to the nearest whole number.

27. Students used *D. melanogaster* for a genetics lab. They chose to look at two traits to see if they were linked. They chose eye color and wing shape. Red is the dominant eye color and normal is the dominant wing shape. After beginning with P generation of EEWW and eeww, they crossed the F_1 with a double mutant. They got the following results.
    Red eyes, normal wings: 174
    Red eyes, stunted wings: 17
    Yellow eyes, normal wings: 41
    Yellow eyes, stunted wings: 62
    What is the recombination frequency in percent? Are these genes linked?

28. In pea plants, smooth seeds are dominant to wrinkled, and purple flowers are dominant to white. In a dihybrid cross where a 9:3:3:1 ratio is expected, the following data was collected:
    Smooth and Purple = 233
    Smooth and White = 74
    Wrinkled and Purple = 79
    Wrinkled and White = 43
    Determine the chi-square value. Round to the nearest hundredths.

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29. Two Wisconsin fast plants are cross. One has the recessive dwarf trait, but the normal pigment anthocyanin, while the other has the recessive anthocyanin less trait, but is of normal height. Their offspring consist of:
    87 plants of normal height and pigment
    91 anthocyanin less plants and normal height
    97 dwarf plants and normal pigment
    93 anthocyanin less, dwarf plants
    A student proposes that the parent plants' genotypes must have been **ddAa** for the dwarf parent and **Ddaa** for the anthocyanin less parent. Calculate the chi square value that would be used to confirm this hypothesis. Round to the nearest hundredths.

30. In a dog breed known as the Mexican Hairless, the "hairless" phenotype is a result of a mutation displaying an autosomal dominant pattern of inheritance. Homozygous recessive individuals (hh) display a "coated" phenotype. Inheriting two copies of the mutation (HH) is lethal during embryonic development. In a cross between two dogs with the hairless phenotype, what proportion of puppies born is expected to be hairless? Give your answer in the form of a fraction.