$$p + q = 1$$

AP BIOLOGY QUANTITATIVE SKILLS

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

$$dN/dt = r_{max}N$$

$$\Delta G = \Delta H - T\Delta S$$

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

$$K = {}^\circ C + 273$$

$$dN/dt = r_{max}N$$

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

WORKSHEET #1: BASIC STATISTICAL TESTS

Mode = value that occurs most frequently
Median = middle value
Mean = average
Range = dispersion of data points (value obtained by subtracting the smallest observation from the greatest observation)

$\bar{x}$= sample mean
n = size of sample
s= sample standard deviation
o= observed results
e=expected results

SD= $\sqrt{\frac{\Sigma(x_i - \bar{x})^2}{n-1}}$ **standard deviation**

$SE_{\bar{x}} = \frac{s}{\sqrt{n}}$ **standard mean error**

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

Example problem:

One of the lab groups collected the following data for the heights (in cm) of their Wisconsin Fast Plants:

5.4 7.2 4.9 9.3 7.2 8.1 8.5 5.4 7.8 10.2

Find the mode, median, mean, and range. Show your work where necessary.

Mode(s):__________ Median: __________ Mean: __________ Range: __________

Find the standard deviation by filling in the following table.

Heights (x)	Mean ($\bar{x}$)	$x - \bar{x}$	$(x-\bar{x})^2$
5.4			
7.2			
4.9			
9.3			
7.2			
8.1			
8.5			
5.4			
7.8			
10.2			
			← $\Sigma(x-\bar{x})^2$

Standard deviation:

Interpret the standard deviation in the context of the problem.

What is the standard mean error? Calculate it for this data set.

Formulas:

Chi Square $\chi^2 = \Sigma\left(\frac{(o-e)^2}{e}\right)$ o = observed individuals with observed genotype

e = expected individuals with observed genotype

Degrees of freedom equals the number of distinct possible outcomes minus one

	Degrees of Freedom							
p	1	2	3	4	5	6	7	8
0.05	3.84	5.99	7.82	9.49	11.07	12.59	14.07	15.51
0.01	6.64	9.32	11.34	13.28	15.09	16.81	18.48	20.09

Example problem:

Wisconsin Fast Plants have two very distinctive visible traits (stems and leaves). Each plant will either have a purple (P) or green (p) stem and also have either have green (G) or yellow (g) leaves. Suppose that we cross a dihybrid heterozygous plant with another plant that is homozygous purple stem and heterozygous for the leaf trait. Make a Punnett square to figure out the expected ratios for the phenotypes of the offspring.

Suppose a class observed that there were 234 plants that were purple stem/green leaves and 42 that were purple stem/yellow leaves. Does this provide good evidence against the predicted phenotype ratio?

Using your understanding of genetics, what might be one reason why the class got these results?

WORKSHEET #3: HARDY-WEINBERG A

<u>Formulas:</u>

$p^2 + 2pq + q^2 = 1$ p = frequency of the dominant allele in a population
$p + q = 1$ q = frequency of the recessive allele in a population

For people, being right handed (R) is the dominant trait over being left handed (r). Suppose there is a sample of 20 people that reveals the following genotypes:

(RR)	(Rr)	(RR)	(Rr)	(rr)	(Rr)	(RR)	(RR)	(Rr)	(RR)
(Rr)	(rr)	(Rr)	(Rr)	(RR)	(RR)	(Rr)	(RR)	(rr)	(Rr)

What percentage of the people are right handed? Left handed?

Find p and q and interpret each in the context of the problem.

Now suppose that we took another sample of 10 people. This time we only know their phenotypes.

(Right) (Left) (Right) (Right) (Right) (Right) (Right) (Right) (Left) (Right)

What percentage of the people are right handed? Left handed?

Can you find p and q exactly? Why?

Estimate p and q and interpret each in the context of the problem.

Estimate how many of the right handed people are homozygous and how many are heterozygous.

WORKSHEET #4: HARDY-WEINBERG B

Formulas:

$p^2 + 2pq + q^2 = 1$	p = frequency of the dominant allele in a population
$p + q = 1$	q = frequency of the recessive allele in a population

Example problem:

In 1988 the Garces Memorial High School student body was made up of 90% right handed students. Being right handed (R) is the dominant trait over being left handed (r).

What is p and q for the population of 1990 GMHS High School students. Interpret each.

Find the percent of the student body in 1990 that are homozygous right handed, heterozygous right handed, and left handed.

Fast forward to today at Garces. We took a random sample of 100 students today and found that 18 of them were left handed.

What are the new p and q values? How do they compare with the values from 1990?

There are many reasons why this apparent change could have occurred. Come up the five you will be expected to know and give an example for each: (Hint: Why did I choose 1988, the year I graduated?)

WORKSHEET #5: POPULATIONS A

Rate	**Population Growth**	**Exponential Growth**	**Logistic Growth**
dY/dt	dN/dt = B – D	$\frac{dN}{dt} = r_{max} N$	$\frac{dN}{dt} = r_{max} N\left(\frac{K-N}{K}\right)$

dY = amount of change B = birth rate D = death rate N = population size
K = carrying capacity r_{max} = maximum per capita growth rate of population

Notes

$$\frac{dN}{dt} = \frac{\Delta N}{\Delta t} = \frac{\text{change in population size}}{\text{change in time}}$$ = population growth rate

Example 1:

There are 300 falcons living in a certain forest at the beginning of 2013. Suppose that every year there are 50 falcons born and 30 falcons that die.

What is the population growth rate (include units)? Interpret the value.

What is the per capita growth rate of the falcons over a year? Interpret the value.

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

c. Fill in the table and construct a graph.

Year	Population
2013	
2014	
2015	
2016	
2017	
2018	

Year	Population
2019	
2020	
2021	
2022	
2023	
2024	

Find the average rate of change for the falcon population from 2013 to 2018 (include units). Interpret the value.

Worksheet #6: Populations B

Bakersfield had a population of 347,500 in the year 2010. The infrastructure of the city allows for a carrying capacity of 450,000 people. $r_{max} = .9$ for Bakersfield.

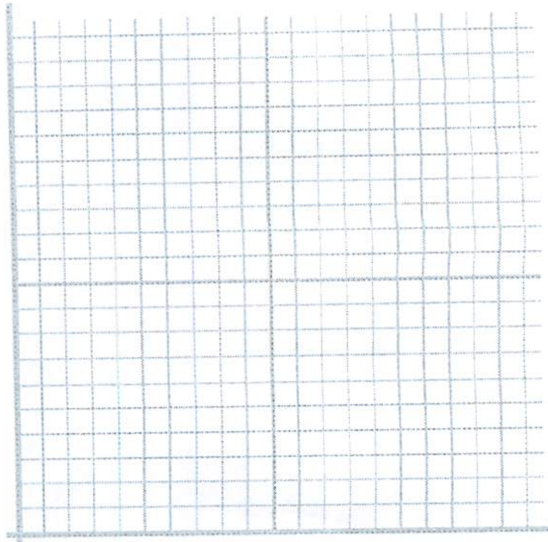
a. Is the current population above or below the carrying capacity? Will the population increase or decrease in the next year?

b. What will be the population growth rate for 2010 (include units)?

c. What will be the population size at the start of 2014.

d. Fill in the following table:

Year	Population size at start of year	Population growth rate (new people added)
2010		
2011		
2012		
2013		
2014		



e. What happened to the population size over the years?

f. What happened to the population growth rate over the years?

g. f. Explain your answer from part (e) using what you know about carrying capacity.

h. g. Explain your answer from part (e) using the formula: $\frac{dN}{dt} = r_{max} N\left(\frac{K-N}{K}\right)$

WORKSHEET #7: TEMPERATURE COEFFICIENT

$$Q_{10} = \left(\frac{k_2}{k_1}\right)^{\frac{10}{T_2 - T_1}}$$

T_2=higher temperature
T_1 = lower temperature
k_2= reaction rate at T_2
k_1=reaction rate at T_1
Q_{10}=factor by which the reaction rate increases when the temperature increases by 10°C

$R2 = R1 \times Q_{10}$

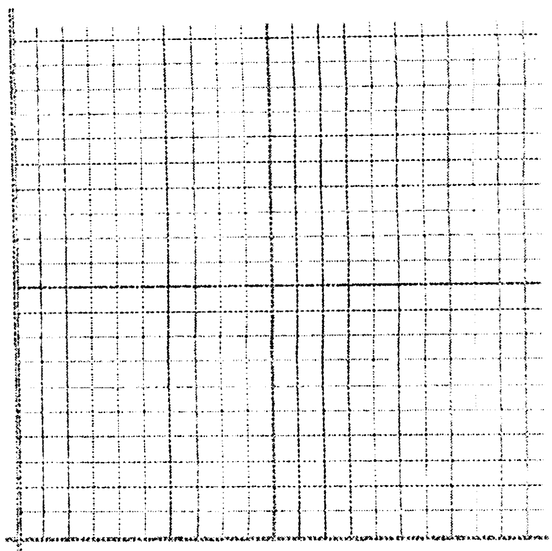
The rate of metabolism of a certain animal at 10°C, is 27 μL O_2 $g^{-1}h^{-1}$.

1. What are its rates of metabolism at 20, 30, and 40°C if the Q_{10} is 2? If it is 2.5?

Temperature °C	**Rate2 if $Q_{10} = 2$**
20	
30	
40	

Temperature °C	**Rate2 if $Q_{10} = 2.5$**
20	
30	
40	

2. Graph the two tables above showing the effect of Temp on reaction rate



Temperature (°C)	**Rate of Metabolism (μLO_2 $g^{-1}h^{-1}$.)**	**Q_{10}**
15	10	
20	13.42	
30	21.22	

The table above reports the rates of metabolism of a species at a series of ambient temperatures:

3. Calculate the Q_{10} values for each temperature interval
4. Within which temperature interval (15-20 or 20-30) is the rate of metabolism most sensitive to temperature change?

5. For this species, would a Q_{10} calculated for 15 to 30°C be as useful as several for smaller temperature ranges? Calculate that Q_{10} as part of your answer.

The reaction rate for a certain process at 14°C is 15 units/time. What would be the reaction rate at 20°C if the $Q_{10} = 1$?

Worksheet #8: Dilutions

$$C_1V_1 = C_2V_2 \text{ aka. } M_1V_1=M_2V_2$$

$$1M\ AgNO_3= 1\ mol\ AgNO_3/L$$

C_1 = original concentration of the solution, before it gets watered down or diluted.
C_2 = final concentration of the solution, after dilution.
V_1 = volume about to be diluted
V_2 = final volume after dilution

For all dilution problems $C_1 > C_2$, and $V_1 < V_2$. It makes sense because to dilute, we add water.

Joe has a 2 g/L solution. He dilutes it and creates 3 L of a 1 g/L solution. How much of the original solution did he use?

What is the molarity of a solution with 360 g glucose in 500 mL of distilled water?

Since Joe did such a good time before, the teacher asked Joe to make a set of solutions. For the lab the students need 2-L of each NaCl stock solution at 1.0M, 0.75M, 0.50M, and 0.25M. If the molar mass of NaCl is 58.45 g/mol, what are the directions for ***each*** of the solutions. Be specific and show your calculations.

WORKSHEET #9: SA:V

Surface area to Volume and Water Potential Review

Cells throughout the world have variable shapes and sizes. Because of this, and because structure is designed around function, certain shapes are optimal for certain processes.

$V_{sphere} = 4/3\,\pi\, r^3$
$V_{rectangle} = l\,w\,h$
$A_{sphere} = 4\,\pi\, r^2$
$A_{rectangle} = \Sigma$ (SA for each side)

Analyze the following cells (units not to scale), and determine the following...

Cell 1 (spherical) where the diameter is 6 mm

Cell 2 (flat and rectangular) where the height is 0.5mm, length is 4mm, width is 2mm

Cell 3 (cube) where side length is 6 mm

Cell	Surface area	Volume	Surface area to Volume Ratio
Cell 1			
Cell 2			
Cell 3			

A) What is the surface area to volume ratio of each cell? Complete the table above.

B) Conclusion: Compare the ratios and explain why one cell would be more efficient than another.

C) If the volume of two cells are identical, but one is a sphere and the other a cube, what are their respective surface areas? Use an arithmetical example.

D) Are you made of lots of large cells or lots of small cells? Why? How do you grow in height?

E) Provide 5 specific examples of ways organisms use SA:V ratio to survive.

WORKSHEET #10: WATER POTENTIAL

$\Psi = \Psi_P + \Psi_S$ Ψ_P= pressure potential; Ψ_S = solute potential

$\Psi_S = -iCRT$ i = ionization constant; C = molar concentration; R = 0.0831; T=Temp (K)

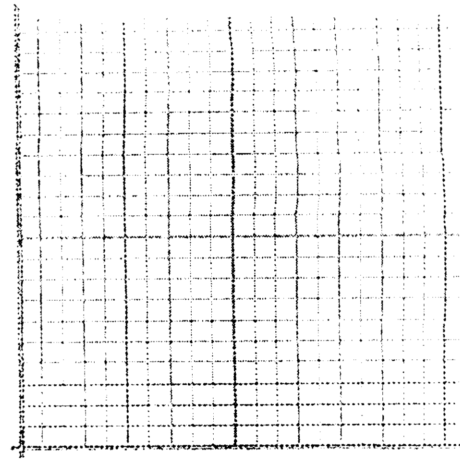
The water potential will be equal to the solute potential of a solution in an open container

i is 1.0 for sucrose because sucrose does not ionize in water

Water potential in potato cells was determined in the following manner. The initial masses of six groups of potato cores were measured. The potato cores were placed in sucrose solutions of various molarities. The masses of the cores were measured again after 24 hours. Percent changes in mass were calculated. The results are shown below

Molarity of Sucrose in Beaker	Percent Change in Mass
0.0 M	18.0
0.2	5.0
0.4	-8.0
0.6	-16.0
0.8	-23.5
1.0	-24.0

Graph these data. From your graph, label where the cells were hypotonic and hypertonic. Determine the apparent molar concentration (osmolarity) of the potato core cells.



<u>Looking at the water potential equation.</u>

Pressure potential is always (positive/negative), while solute potential is always (positive/negative).

When Solution potential goes down (gets more negative), water potential (increases/decreases)

When Pressure potential goes down (gets smaller), water potential (increases/decreases)

When would the pressure in a cell rise? (Under what conditions?)

What would happen to the solute potential when Concentration is increased (justify with equation)? WHY?

What would happen to the solute potential when Temperature is increased (justify with equation)? WHY?

What would happen to the solute potential when the dissolved substance is glucose vs. salt (justify with equation)? WHY?

Why is water potential important for plants? What are they lacking?

Predict what would happen to animal cells placed in 0.0M and 1.0M concentration solution

WORKSHEET #11: GIBBS FREE ENERGY BASICS

$\Delta G = \Delta H - T\,\Delta S$

What is Entropy (ΔS) = a measurement of ____________________

When ΔS is positive this means there is ____________________

When ΔS is negative this means there is ____________________

What is ΔH? = a measurement of ____________________

When ΔH is positive this means the reaction is ____________________

When ΔH is negative this means the reaction is ____________________

What is Gibbs Free energy? = a measurement of ____________________

When ΔG is positive this means the reaction will happen ____________________

When ΔG is negative this means the reaction will happen ____________________

ΔG (Joules)	ΔH (Joules)	T (Kelvin)	ΔS (J/K)
	1000	300	5
	1100	300	5
	1200	300	5
	1300	300	5
	1400	300	5
	1500	300	5
	1600	300	5
	1700	300	5
	1800	300	5
	1900	300	5

What happens to ΔG when ΔH goes up ? WHY?

What happens to ΔG when ΔH goes down ? WHY?

ΔG	ΔH	T	ΔS
	1700	300	5
	1700	310	5
	1700	320	5
	1700	330	5
	1700	340	5
	1700	350	5
	1700	360	5
	1700	370	5
	1700	380	5
	1700	390	5

What happens to ΔG when T goes up ? WHY?

What happens to ΔG when T goes down ? WHY?

ΔG	ΔH	T	ΔS
	7500	300	5
	7500	300	10
	7500	300	15
	7500	300	20
	7500	300	25
	7500	300	30
	7500	300	35
	7500	300	40
	7500	300	45
	7500	300	50

What happens to ΔG when ΔS goes up ? WHY?

What happens to ΔG when ΔS goes down ? WHY?

Complete the sentences below.

As the reaction requires less and less energy, its spontaneity will (increase, decrease).

As randomness increases, the free energy will (increase, decrease) because ______________
____

$$\frac{mg\,O_2}{L} x \frac{0.698mL}{mg} = \frac{mL\,O_2}{L} \qquad \frac{mL\,O_2}{L} x \frac{0.536mg\,C\ fixed}{mL\,O_2} = \frac{mg\,C\ fixed}{L}$$

One can determine Primary Productivity by measuring dissolved oxygen in the water (as it is hard to measure it in the air)

1 ml of O_2 = 0.536 mg of Carbon assimilated
mg O_2/L x 0.698 = ml O_2/L; ml O_2/L x 0.536 = mg carbon fixed/L

$$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$$

Fill in the table and Graph Net and Gross Productivity vs. % of light

% light	DO_2 (mg O_2/L)	Gross PP = DO_2-dark (mg O_2/L)	Net PP = DO_2 -initial (mg O_2/L)	Gross carbon fixed in mg C/L Gross PP x 0.698 x 0.536
Initial	8.4	—	—	—
Dark	6.2	—	—	—
100%	10.2			
65%	9.7			
25%	9.0			
10%	8.5			
2%	7.1			

Using your data table, what seems to be the trend as the % of light decreases? WHY?

Using your data table, what seems to be the trend as the % of light increases? WHY?

Where would you say this organism is using as much energy as they are making? WHY?

Using your table and graph, explain why most of the time there are bigger plants on land than in the sea? Explain this in terms of evolution.

WORKSHEET #14: pH AND METRIC SYSTEM

$pH = -log[H^+]$ $pOH = -log[OH^-]$ $pH + pOH = 14$ recall $[H^+]$ is really $[H_3O^+]$

Which is more acidic? $[H^+]$ 1.0×10^{-8} or 1.0×10^{-12}

Which is more basic? $[H^+]$ 1.0×10^{-6} or 1.0×10^{-3}

The pH of stomach acid is about 1.5. what is the $[H^+]$?

Blood has a pH of about 7.40. What is the $[H^+]$?

[H+]	Scientific notation	pH	Metric prefix
1 000 000		—	
1 000		—	
100		—	
10		—	
1		—	
0.1			
0.01			
0.001			
0.000 001			
0.000 000 001			
0.005			
0.05			
0.000 026			

Write answers in scientific notation: (NO CALCULATORS)

$4.00x10^5 \times 2.00x10^3$

$4.00x10^{-5} \times 2.00x10^{-3}$

$4.00x10^5 \times 2.00x10^{-3}$

$4.00x10^{-5} \times 2.00x10^3$

$8.00x10^7 / 2.00x10^3$

$8.00x10^7 / 2.00x10^{-3}$

$8.00x10^{-7} / 2.00x10^3$

$8.00x10^{-7} / 2.00x10^{-3}$

When you divide in scientific notation, you need to __________________ the exponents.

When you multiply in scientific notation you need to __________________ the exponents.

WORKSHEET #13: PRIMARY PRODUCTIVITY

$$\frac{mg\,O_2}{L} x \frac{0.698mL}{mg} = \frac{mL\,O_2}{L} \qquad \frac{mL\,O_2}{L} x \frac{0.536\,mg\,C\,fixed}{mL\,O_2} = \frac{mg\,C\,fixed}{L}$$

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10%	8.5			
2%	7.1			

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Using your data table, what seems to be the trend as the % of light increases? WHY?

Where would you say this organism is using as much energy as they are making? WHY?

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