

AP BIO EQUATIONS AND FORMULAS REVIEW SHEET #1

Formulas:

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 the number of data points

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

$$\text{Standard Deviation} = \sqrt{\frac{\sum(x_i - \bar{x})^2}{n-1}} \text{ where } \bar{x} = \text{mean and } n = \text{size of the sample}$$

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.

4.9 5.4 5.4 7.2 7.2 7.8 8.1 8.5 9.3 10.2

Mode: 5.4, 7.2

Median = average of middle 2 values = (7.2 + 7.8) / 2 = 7.5

Median: 7.5

Mean = $\frac{4.9 + 5.4 + 5.4 + 7.2 + 7.2 + 7.8 + 8.1 + 8.5 + 9.3 + 10.2}{10} = \frac{74}{10} = 7.4$ Mean: 7.4

Range = 10.2 - 4.9 = 5.3

Range: 5.3

Find the standard deviation by filling in the following table.

Heights (x)	Mean (\bar{x})	$x - \bar{x}$	$(x - \bar{x})^2$
5.4	7.4	-2	4
7.2	7.4	-.2	.04
4.9	7.4	-2.5	6.25
9.3	7.4	1.9	3.61
7.8	7.4	-.2	.04
8.1	7.4	.7	.49
8.5	7.4	1.1	1.21
5.4	7.4	-2	4
7.8	7.4	.4	.16
10.2	7.4	2.8	7.84
			<u>27.64</u>

$\leftarrow \sum(x - \bar{x})^2$

Standard deviation: $\sqrt{\frac{27.64}{9}} = 1.75$

Interpret the standard deviation in the context of the problem.

The heights of Wisconsin Fast Plants in this sample are, on average, is about 1.75 cm away from the mean height of 7.4 cm.

AP BIO EQUATIONS AND FORMULAS REVIEW SHEET #2

Formulas:

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

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. **PpGg**

x PPGg

	PG	Pg	PG	Pg
PG	PPGG	PPGg	PPGG	PPGg
Pg	PPGg	PPgg	PPGg	PPgg
pG	PpGG	PpGg	PpGG	PpGg
pg	PpGg	Ppgg	PpGg	Ppgg

Purple stem/Green leaves 12

Purple stem/Yellow leaves 4 so the expected ratio of the phenotypes is 12:4 or 3:1.

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?

Find expected values. $234 + 42 = 276$ total. $276 * \frac{3}{4} = 207$ $276 * \frac{1}{4} = 69$ **df= n - 1 = 1**

o	e	o - e	$\frac{(o - e)^2}{e}$
234	207	27	3.52
42	69	-27	10.57

so $X^2 = 3.52 + 10.57 = 14.09$

Because $14.09 > 3.84$, the data did not occur purely by chance.

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

One of the conditions must have been violated, probably the random or independent condition. This could lead you to a test cross for linkage, of which you could check map units. But most likely, sample size is the culprit.

AP BIO EQUATIONS AND FORMULAS REVIEW SHEET #3 Answer Key

Formulas:

$$p^2 + 2pq + q^2 = 1 \quad p = \text{frequency of the dominant allele in a population}$$

$$p + q = 1 \quad q = \text{frequency of the recessive allele in a population}$$

Example problem:

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)

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

17/20 are right handed so 85%

3/20 are left handed so 15%

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

$p = 25/40 = .625$ 62.5% of the alleles in the sample are dominant R.

$q = 15/40 = .375$ 37.5% of the alleles in the sample are recessive r.

Note: p and q are NOT telling us the percent of people that are right and left handed.

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)

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

Right handed = $8/10 = 80\%$ Left handed = $2/10 = 20\%$

c. Can you find p and q exactly? Why?

No. We can't see the genotypes of each person. For each right handed person, we do not know if they are homozygous (RR) or heterozygous (Rr).

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

$q^2 = .20$ so $q = .447$ We estimate that 44.7% of the alleles in the sample are recessive r.

$p + q = 1$ so $p = .553$ We estimate that 55.3% of the alleles in the sample are dominant R.

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

Homozygous = $RR = p^2$ so $(.553)^2 = .305$ $.305 \times 10 = 3.05$ so we would guess 3 are homozygous.

Heterozygous = $Rr = 2pq = 2(.553)(.447) = .494$ $.494 \times 10 = 4.94$ so we would guess 5 are heterozygous.

3 homozygous + 5 heterozygous = 8 right handed people.

AP BIO EQUATIONS AND FORMULAS REVIEW SHEET #3

Formulas:

$$p^2 + 2pq + q^2 = 1 \quad p = \text{frequency of the dominant allele in a population}$$

$$p + q = 1 \quad q = \text{frequency of the recessive allele in a population}$$

Example problem:

In 1990 the East Kentwood 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).

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

90% right handed means 10% are left handed. $q^2 = .10$ so $q = .316$. $p + q = 1$ so $p = .684$.

$p = .684$ 68.4% of all the alleles at EKHS in 1990 are R.

$q = .316$ 31.6% of all the alleles at EKHS in 1990 are r.

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

$p^2 = (.684)^2 = .468$ so 46.8% of students are homozygous right handed (RR)

$2pq = 2(.316)(.684) = .432$ so 43.2% of students are heterozygous right handed (Rr)

$q^2 = (.316)^2 = .10$ so 10% of students are left handed (rr)

Fast forward to today at East Kentwood. Mr. V. took a random sample of 100 East Kentwood students today and found that 18 of them were left handed.

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

$q^2 = 18/100 = .18$ so $q = .424$. $p + q = 1$ so $p = .576$

p has decreased and q has increased. There are more recessive alleles in the population today.

There are many reasons why this apparent change could have occurred. Come up with an East Kentwood example for each:

Large Sample Size: Maybe Mr. V's sample size is too small to accurately predict the proportion of the population that is left handed. Maybe his small sample just selected many lefties purely by chance.

Random Mating: Women are more naturally attracted to lefties and have had more babies with left handed males than right handed males since 1990.

Mutations: The chemicals in Mr. V's room are modifying student's brain structure, causing right handers to mutate and become lefties.

Gene Flow: Lefties are generally smarter than righties and love AP classes, so lefties from other school districts have been moving to Kentwood because of the strong AP program here.

Natural Selection: Left handed people are better drivers and are much less likely to die in a car accident. Car accidents have been killing off the right handed students since 1990.

AP BIO EQUATIONS AND FORMULAS REVIEW SHEET #4 – Answer Key

Formulas:

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

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

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.

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

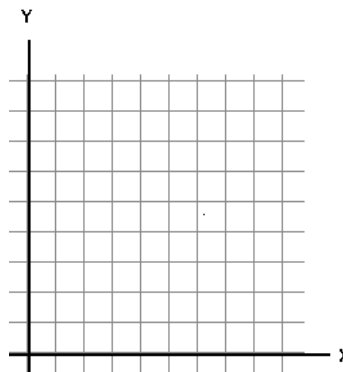
$dN/dt = B - D = 50 - 30 = 20$ falcons/year. Each year the falcon population will increase by 20 falcons.

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

$$\frac{dN}{dt} = r_{\max} N \text{ so } 20 = r_{\max} 300 \text{ so } r_{\max} = .0667 \text{ The falcon population will increase by 7\% each year.}$$

c. Fill in the table and construct a graph.

Year	Population
2013	300
2014	330
2015	363
2016	399.3
2017	439.23
2018	483.153



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

We have two data points: (2013, 300) and (2018, 483). Average rate of change = slope

$$\text{slope} = \frac{\Delta y}{\Delta x} = \frac{483 - 300}{2018 - 2013} = 36.6 \text{ falcons/year.}$$

Over the past five years, the falcon population has increased by 36.6 per year on average.

Example 2:

Kentwood, Michigan had a population of 49,000 in the year 2013. The infrastructure of the city allows for a carrying capacity of 60,000 people. $r_{\max} = .9$ for Kentwood.

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

Current population is below the carrying capacity so we would expect the population to increase.

b. What will be the **population growth rate** for 2013 (include units)?

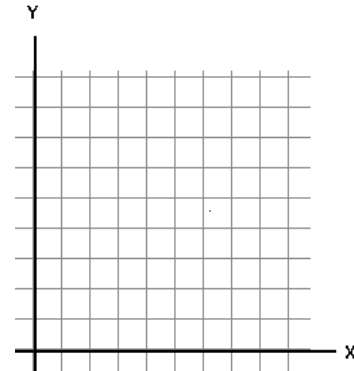
$$\frac{dN}{dt} = r_{\max} N \left(\frac{K - N}{K} \right) = (0.9)(49,000) \left(\frac{60,000 - 49,000}{60,000} \right) = \underline{\underline{8085 \text{ people/year}}}$$

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

$$\underline{\underline{49,000 + 8085 = 57,085 \text{ people}}}$$

d. Fill in the following table:

Year	Population size	Population growth rate
2013	49,000	8085
2014	57,085	2496.041625
2015	59,581	374.4296457
2016	59,955	40.04611425
2017	59,996	4.034052134



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

Population size got closer and closer to the carrying capacity of 60,000.
Population growth rate got smaller and smaller.

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

As the population gets closer and closer to the carrying capacity, the resources of the environment start to deplete and the growth rate slows. Limiting factors take over (especially density-dependent ones, space, food, water, shelter, etc)

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

Look at this part of the formula: $\left(\frac{K - N}{K} \right)$ As the size of the population (N) gets closer and closer to the carrying capacity (K), then this part of the formula gets smaller and smaller, thus reducing population growth rate.

Q10, Dilution, pH Review Key

1. The rate of metabolism of a certain animal at 10°C, is $27 \mu\text{O}_2 \text{ g}^{-1}\text{h}^{-1}$.
What are its rates of metabolism at 20, 30, and 40°C if the Q10 is 2? If it is 2.5?

$$((T_2 - T_1)/10)$$

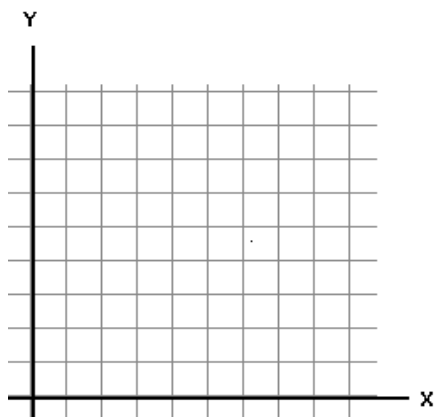
$$R_2 = R_1 \times Q_{10}$$

$$R_2 = 27 \times 2^{((20 - 10)/10)} = (27 \times 2^1) = \underline{54 \mu\text{O}_2 \text{ g}^{-1}\text{h}^{-1}}$$

Temperature °C	Rate2 if Q10 = 2
20	$R_2 = (27 \times 2^1) = 54 \mu\text{O}_2 \text{ g}^{-1}\text{h}^{-1}$
30	$R_2 = (27 \times 2^2) = 108 \mu\text{O}_2 \text{ g}^{-1}\text{h}^{-1}$
40	$R_2 = (27 \times 2^3) = 216 \mu\text{O}_2 \text{ g}^{-1}\text{h}^{-1}$

Temperature °C	Rate2 if Q10 = 2.5
20	$R_2 = (27 \times 2.5^1) = 67.5 \mu\text{O}_2 \text{ g}^{-1}\text{h}^{-1}$
30	$R_2 = (27 \times 2.5^2) = 168.75 \mu\text{O}_2 \text{ g}^{-1}\text{h}^{-1}$
40	$R_2 = (27 \times 2.5^3) = 421.875 \mu\text{O}_2 \text{ g}^{-1}\text{h}^{-1}$

graph showing the effect of Temp on Rx rate



2. The following table reports the rates of metabolism of a species at a series of ambient temperatures:

Temperature (°C)	Rate of Metabolism ($\mu\text{O}_2 \text{ g}^{-1}\text{h}^{-1}$)
15	10
20	13.42
30	21.22

(a) Calculate the Q10 values for each temperature interval

$$(10/(T_2 - T_1))$$

$$Q_{10} = \{R_2/R_1\}$$

$$\text{Interval (15-20)} = (13.42/10)^{10/(20-15)} = 1.342^2 = \underline{1.8}$$

$$\text{Interval (20-30)} = (21.22/13.42)^{10/(30-20)} = 1.58^1 = \underline{1.58}$$

$$\text{Interval (20-30)} = (21.22/10)^{10/(30-15)} = 2.122^{(2/3)} = \underline{1.6}$$

(b) Within which temperature interval (15-20 or 20-30) is the rate of metabolism most sensitive to temperature change?

SLIGHTLY MORE SO BETWEEN 15 AND 20 SINCE THE Q10 IS LARGER

(c) For this species, would a Q₁₀ calculated for 15 to 30°C be as useful as several for smaller temperature ranges? Calculate that Q₁₀ as part of your answer.

YES, IT AGREES REASONABLY CLOSELY WITH VALUES (I.E. THE VALUES DO NOT DIFFER MUCH FROM EACH OTHER)

3. The reaction rate for a certain process at 14°C is 15 units / time.

(a) What would be the reaction rate at 20°C if the Q₁₀ = 1?

15 UNITS/TIME -- A FLAT Q10 BY DEFINITION IS TEMPERATURE INDEPENDENCE (1 to any power is still 1)

Surviving $C_1V_1 = C_2V_2$

C₁ = original concentration of the solution, before it gets watered down or diluted.

C₂ = final concentration of the solution, after dilution.

V₁ = volume about to be diluted

V₂ = final volume after dilution

By drawing the "X" through the equal sign and filling in the formula with letters of a size permitted by the borders of the "X", it reminds you that :

for all dilution problems $C_1 > C_2$ and $V_1 < V_2$.

It makes sense because to dilute, we add water. This increases the volume but lowers concentration.

Examples by Type:

1. Easiest: 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 dilute?

Solution: We are looking for V₁:

$$C_1V_1 = C_2V_2$$

$$2x = 1(3)$$

$$x = 1.5 \text{ L}$$

2. A little trickier: Joe has 20 L of a 2 g/L solution. He diluted it, and created 3 L of a 1 g/L solution. How did he make such a solution?

We're only going to use part of the 20 L. Remember we have to end up with 3 L after dilution, so not only do we have to start with less than 20 L but also less than 3 L. How much is unknown = V_1 , and it amounts to the same problem as in example 1, but don't use the 20L.

$$C_1V_1 = C_2V_2$$

$$2x = 1(3)$$

$$x = 1.5 \text{ L}$$

3. Trickier too: Joe has 20 L of a 2 g/L solution. To this solution he adds 30 L. What is the final concentration of the solution?

If 30 L is added to the 20 L, then the volume about to be diluted, V_1 , is 20 L. And adding 30 L of water to a 20 L solution creates a final volume, V_2 , of 50 L. Our unknown is C_2 .

$$C_1V_1 = C_2V_2$$

$$2(20) = x(20 + 30)$$

$$x = 40/50 = 0.80 \text{ g/L}$$

pH Reminder: $\text{pH} = -\log(\text{H}^+)$

Which is more acidic? (H^+) of 1.0×10^{-8} or 1.0×10^{-12}

Which is more basic? (H^+) of 1.0×10^{-6} or 1.0×10^{-3}

Stomach acid has a pH of about 1-2. What would the H^+ concentration be around?

Between 1×10^{-1} and 1×10^{-2}

$[\text{H}_3\text{O}^+]$ or $[\text{H}^+]$	scientific notation	pH
0.1	1×10^{-1}	1
0.01	1×10^{-2}	2
0.001	1×10^{-3}	3
0.0001	1×10^{-4}	4
0.00001	1×10^{-5}	5
0.000001	1×10^{-6}	6
0.0000001	1×10^{-7}	7
0.00000001	1×10^{-8}	8
0.0000000001	1×10^{-10}	10
0.000000000001	1×10^{-11}	11

As $[\text{H}^+]$ gets smaller, scientific notation exponents get MORE NEGATIVE, and pH goes UP

As $[\text{H}^+]$ gets larger, scientific notation exponents get LESS NEGATIVE, and pH goes DOWN

Surface area to Volume and Water Potential Review

1) 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.

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

Cell 1 (spherical) where the radius is 3 mm

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

A) What is the surface area to volume ratio of both cells?

How to calculate Surface Area?	Surface area	How to calculate Volume?	Volume	Surface area to Volume Ratio
Cell 1 = $4\pi r^2$	$4\pi(3)^2 = 113 \text{ mm}^2$	$\frac{4}{3} \pi r^3$	$\frac{4}{3} \pi (3)^3 = 113 \text{ mm}^3$	$113/113 = 1:1$
Cell 2 = Σa	$16 + 4 + 2 = 22 \text{ mm}^2$	$L \times W \times H$	$0.5 \times 2 \times 4 = 4 \text{ mm}^3$	$22:4 = 11:2$

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

Cell 2 has a much higher surface area to volume ratio, hence it would be more efficient as substances could diffuse in and out faster, allowing for quicker chemical processes.

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

Made of small cells. They have a high surface area to volume ratio, making communication between them, and processes within them much more efficient. You grow in height by making MORE cells. While cells will grow in size, they will reach a limit of efficiency, and then perform mitosis.

2) 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 to the right of the table. From your graph, label where the cells were hypotonic and the solution was hypertonic, and vice versa. Determine the apparent molar concentration (osmolarity) of the potato core cells.

Osmolarity = 0.3M cell and beaker are isotonic

Above 0.3M cells are hypotonic while beaker is hypertonic (as cells are gaining mass = water is moving in)

Under 0.3M cells are hypertonic and beaker is hypotonic (as cells are losing mass = water is moving out)
Looking at the water potential equation,

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

When Solution potential goes down (gets more negative), water potential **DECREASES**

When Pressure potential goes down (gets smaller), water potential **DECREASES**

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

When a cell is in a hypotonic environment, where water is entering the cell (hence building up pressure)

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

When Concentration is INCREASED Solute potential would go DOWN. $-iCRT$ (when C is increased, that is a bigger multiplier to the negative equation)

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

When Temperature is INCREASED Solute potential would go DOWN. $-iCRT$ (when T is increased, that is a bigger multiplier to the negative equation)

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

When Ionization constant is INCREASED Solute potential would go DOWN. $-iCRT$ (when i is increased, that is a bigger multiplier to the negative equation) Salt ($i=2$) glucose ($i=1$)

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

Allows for the movement of materials through the organism. Drives water up the plant through xylem by transpiration and cohesion-tension theory. Also builds up pressure for translocation of sugar through phloem. While plants have a vascular system, they lack the muscular pump (heart) to move materials and create pressure for them.

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

0.0M solution = the cell would swell and possibly lyse from the pressure.

1.0M solution = the cell would shrivel and become very inefficient.

$$\underline{\Delta G = \Delta H - T \Delta S}$$

What is Entropy? = a measurement of Disorder/randomness

When ΔS is positive this means there is MORE Disorder/randomness

When ΔS is negative this means there is LESS Disorder/randomness

What is ΔH ? = a measurement of ENTHALPY

When ΔH is positive this means the reaction is ENDOTHERMIC (taking in energy)

When ΔH is negative this means the reaction is EXOTHERMIC (releasing energy)

What is Gibbs Free energy? = a measurement of SPONTANEITY

When ΔG is positive this means the reaction will happen IF ENERGY IS ADDED

When ΔG is negative this means the reaction will happen SPONTANEOUSLY

<u>ΔG (Joules)</u>	<u>ΔH (Joules)</u>	<u>T (Kelvin)</u>	<u>ΔS (J/K)</u>
-500	1000	300	5
-400	1100	300	5
-300	1200	300	5
-200	1300	300	5
-100	1400	300	5
0	1500	300	5
100	1600	300	5
200	1700	300	5
300	1800	300	5
400	1900	300	5

What happens to ΔG when ΔH goes up ? WHY?

ΔG INCREASES when ΔH INCREASES. This happens because the reaction needs more and more energy to occur (more endothermic), and therefore will not happen as spontaneously.

What happens to ΔG when ΔH goes down ? WHY?

ΔG DECREASES when ΔH DECREASES. This happens because the reaction needs less and less energy to occur (more exothermic), and therefore becomes more and more likely to happen spontaneously.

<u>ΔG</u>	<u>ΔH</u>	<u>T</u>	<u>ΔS</u>
200	1700	300	5
150	1700	310	5
100	1700	320	5
50	1700	330	5
0	1700	340	5
-50	1700	350	5
-100	1700	360	5
-150	1700	370	5
-200	1700	380	5
-250	1700	390	5

What happens to ΔG when T goes up ? WHY?

ΔG DECREASES when T INCREASES. AN INCREASE IN TEMPERATURE INCREASES KINETIC ENERGY OF MOLECULES MAKING IT MORE LIKELY THAT SPONTANEOUS COLLISIONS AND REACTIONS WOULD TAKE PLACE.

What happens to ΔG when T goes down ? WHY?

ΔG INCREASES when T DECREASES. AN DECREASE IN TEMPERATURE DECREASES KINETIC ENERGY OF MOLECULES MAKING IT LESS LIKELY THAT SPONTANEOUS COLLISIONS AND REACTIONS WOULD TAKE PLACE.

<u>ΔG</u>	<u>ΔH</u>	<u>T</u>	<u>ΔS</u>
6000	7500	300	5
4500	7500	300	10
3000	7500	300	15
1500	7500	300	20
0	7500	300	25
-1500	7500	300	30
-3000	7500	300	35
-4500	7500	300	40
-6000	7500	300	45
-7500	7500	300	50

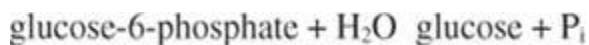
What happens to ΔG when ΔS goes up ? WHY?

ΔG DECREASES AS ΔS INCREASES. AS DISORDER INCREASES (SINCE THAT IS THE NATURAL TENDANCY OF PROCESSES) SPONTANEITY WILL ALSO BECOME MORE LIKELY.

What happens to ΔG when ΔS goes down ? WHY?

ΔG INCREASES AS ΔS DECREASES. AS DISORDER DECREASES (SINCE THAT IS NOT THE NATURAL TENDANCY OF PROCESSES) SPONTANEITY WILL BECOME LESS LIKELY.

Biochemical free energies are usually given as standard free energies of hydrolysis. For example, the hydrolysis of glucose-6-phosphate:



has $\Delta G^\circ = -4.0$ kcal/mole (-16.5 kJ/mole) under standard conditions. Therefore, the opposite reaction, the phosphorylation of glucose, is unfavored. However, the phosphorylation of glucose occurs readily in the cell, catalyzed by the enzyme hexokinase:

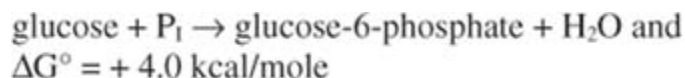


The other half of the phosphorylation reaction is the hydrolysis of ATP to yield ADP and inorganic phosphate (P_i):



under standard conditions has $\Delta G^\circ = -7.3$ kcal/mole (-31 kJ/mole).

The standard free energy change of the reaction can be determined by adding the two free energies of reaction:

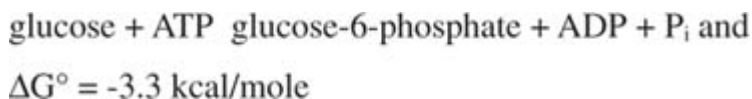


Note that the reaction as written is unfavored; its free energy change is positive. Another way of stating this is that the reaction is **endergonic**, that is, the reaction involves a gain of free energy.

For the **exergonic** hydrolysis of ATP (the reaction involves a loss of free energy):



The two reactions are summed:



This is a simple example of energetic **coupling**, where an unfavorable reaction is driven by a favorable one, as shown in Figure [1](#).

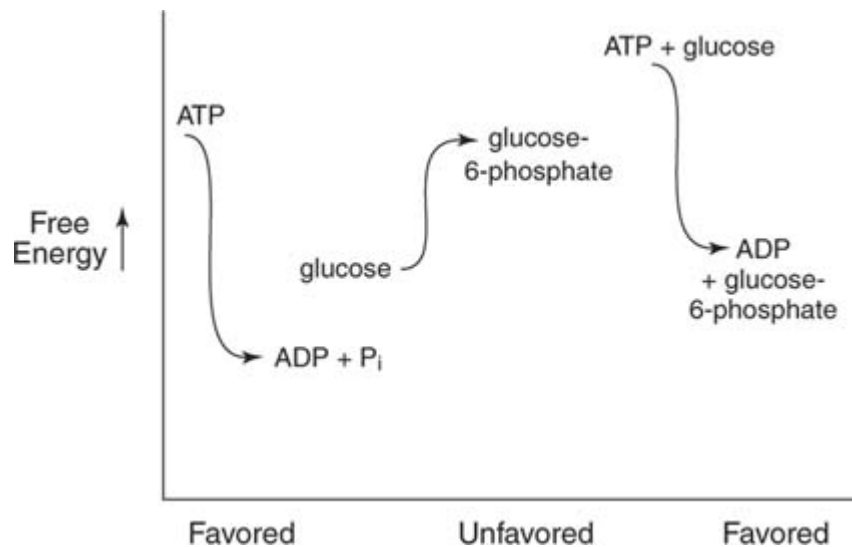


Figure 1

Coupling doesn't occur all by itself. In this example, if this experiment were set up so that the ATP would have to be hydrolyzed in one tube and the glucose phosphorylated in another, no coupling would be possible. Coupling can occur only when the partial reactions are part of a larger system. In this example, coupling occurs because both partial reactions are carried out by the enzyme hexokinase. In other cases, coupling can involve membrane transport, transfer of electrons by a common intermediate, or other processes. Another way of stating this principle is that coupled reactions must have some component in common.

The “orderliness” of your body is not favored by free energy. Explain (in terms of free energy and disorder) why you need to perform digestion?

Energy coupling. You digest food (natural tendency toward disorder) to harness that energy to build ATP (ordered), of which the breaking of ATP (natural tendency toward disorder), can be used to order your body.

Why does decomposition of a dead animal happen in terms of energy? What would happen if we increase temperature? Why do we freeze food?

Decomposition is the breakdown of ordered cells into disorder. It should happen naturally ΔG is negative.

If you increase temperature, ΔG becomes more negative. So increasing temperature will speed up decomposition.

We freeze our food to LOWER TEMPERATURE, which also increases ΔG . This slows down decomposition.

Explain why plant cells need light to build sugar (in terms of energy).

Building sugar (ordering molecules) would not happen spontaneously. Energy must be added (aka sunlight).

Primary Productivity – The rate at which organic materials are stored

$$6\text{CO}_2 + 6\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$$

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

Conversion Factors:

1 ml of O₂ = .536 mg of Carbon assimilated

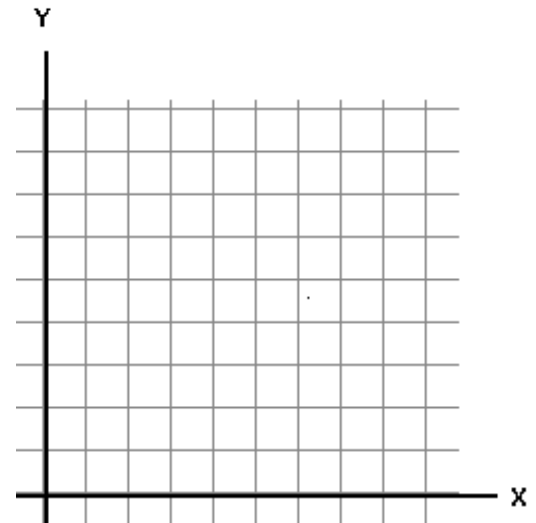
To convert: ppm O₂ = mg O₂/L

mg O₂/L x 0.698 = ml O₂/L

ml O₂/L x 0.536 = mg carbon fixed/L

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

% light	DO (mg O ₂ /L)	Gross PP = Bottle – Dark (mg O ₂ /L)	Net PP = Bottle – Light (mg O ₂ /L)	Gross Carbon fixed in mgC/L Gross PP x 0.698 x 0.536
Initial	8.4	--	--	--
Dark	6.2	--	--	--
100%	10.2	4	1.8	1.50
65%	9.7	3.5	1.3	1.31
25%	9.0	2.8	0.6	1.05
10%	8.5	2.3	0.1	0.86
2%	7.1	0.9	-1.3	0.34



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

As % of light decreases, productivity decreases resulting in less carbon assimilated. Less light = Less photosynthesis = Less carbon dioxide used = Less oxygen released into the water

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

As % of light increases, productivity increases resulting in more carbon assimilated. More light = more photosynthesis = more carbon dioxide used = more oxygen released into the water

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

When Net = 0 (about 9%) This is where photosynthesis and respiration of the plant seem to be equal. No net oxygen is being released into the water, what is being released is equally being used by the plant in respiration.

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. **Plants evolved to live on land because it is easier to acquire carbon dioxide (more abundant), and there is more light available as it doesn't have to pass through water.**