

# 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	7.82	9.49	11.07	12.59	14.07	15.51
0.01	6.64	9.21	11.34	13.28	15.09	16.81	18.48	20.09

### Laws of Probability

If A and B are mutually exclusive, then:

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

If A and B are independent, then:

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

### Hardy-Weinberg Equations

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

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

$\bar{x}$  = sample mean

$n$  = size of the sample

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

$o$  = observed results

$e$  = expected results

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

### 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	$\mu$
$10^{-9}$	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)

\* For the purposes of the AP Exam, students will not be required to perform calculations using this equation; however, they must understand the underlying concepts and applications.

**INSERT E (continued)**

<p align="center"><b>Rate and Growth</b></p> <p><b>Rate</b>  <math>\frac{dY}{dt}</math></p> <p><b>Population Growth</b>  <math>\frac{dN}{dt} = B - D</math></p> <p><b>Exponential Growth</b>  <math>\frac{dN}{dt} = r_{\max} N</math></p> <p><b>Logistic Growth</b>  <math>\frac{dN}{dt} = r_{\max} N \left( \frac{K - N}{K} \right)</math></p> <p><b>Temperature Coefficient <math>Q_{10}</math><sup>†</sup></b>  <math>Q_{10} = \left( \frac{k_2}{k_1} \right)^{\frac{10}{T_2 - T_1}}</math></p> <p><b>Primary Productivity Calculation</b>  <math>\frac{\text{mg O}_2}{\text{L}} \times \frac{0.698 \text{ mL}}{\text{mg}} = \frac{\text{mL O}_2}{\text{L}}</math>  <math>\frac{\text{mL O}_2}{\text{L}} \times \frac{0.536 \text{ mg C fixed}}{\text{mL O}_2} = \frac{\text{mg C fixed}}{\text{L}}</math>                      (at standard temperature and pressure)</p>	<p><math>dY</math> = amount of change</p> <p><math>dt</math> = change in time</p> <p><math>B</math> = birth rate</p> <p><math>D</math> = death rate</p> <p><math>N</math> = population size</p> <p><math>K</math> = carrying capacity</p> <p><math>r_{\max}</math> = maximum per capita growth rate of population</p> <hr/> <p><math>T_2</math> = higher temperature</p> <p><math>T_1</math> = lower temperature</p> <p><math>k_2</math> = reaction rate at <math>T_2</math></p> <p><math>k_1</math> = reaction rate at <math>T_1</math></p> <p><math>Q_{10}</math> = the factor by which the reaction rate increases when the temperature is raised by ten degrees</p>	<p><b>Water Potential (<math>\Psi</math>)</b>  <math>\Psi = \Psi_p + \Psi_s</math></p> <p><math>\Psi_p</math> = pressure potential</p> <p><math>\Psi_s</math> = solute potential</p> <p>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.</p> <p><b>The Solute Potential of a Solution</b>  <math>\Psi_s = -iCRT</math></p> <p><math>i</math> = ionization constant (this is 1.0 for sucrose because sucrose does not ionize in water)</p> <p><math>C</math> = molar concentration</p> <p><math>R</math> = pressure constant (<math>R = 0.0831</math> liter bars/mole K)</p> <p><math>T</math> = temperature in Kelvin (<math>^{\circ}\text{C} + 273</math>)</p>
<p align="center"><b>Surface Area and Volume</b></p> <p><b>Volume of a Sphere</b>  <math>V = \frac{4}{3} \pi r^3</math></p> <p><b>Volume of a Rectangular Solid</b>  <math>V = lwh</math></p> <p><b>Volume of a Right Cylinder</b>  <math>V = \pi r^2 h</math></p> <p><b>Surface Area of a Sphere</b>  <math>A = 4\pi r^2</math></p> <p><b>Surface Area of a Cube</b>  <math>A = 6s^2</math></p> <p><b>Surface Area of a Rectangular Solid</b>  <math>A = \sum</math> surface area of each side</p>	<p><math>r</math> = radius</p> <p><math>l</math> = length</p> <p><math>h</math> = height</p> <p><math>w</math> = width</p> <p><math>s</math> = length of one side of a cube</p> <p><math>A</math> = surface area</p> <p><math>V</math> = volume</p> <p><math>\Sigma</math> = sum of all</p>	<p><b>Dilution (used to create a dilute solution from a concentrated stock solution)</b>  <math>C_i V_i = C_f V_f</math></p> <p><math>i</math> = initial (starting)      <math>C</math> = concentration of solute  <math>f</math> = final (desired)      <math>V</math> = volume of solution</p> <hr/> <p><b>Gibbs Free Energy</b>  <math>\Delta G = \Delta H - T\Delta S</math>  <math>\Delta G</math> = change in Gibbs free energy  <math>\Delta S</math> = change in entropy  <math>\Delta H</math> = change in enthalpy  <math>T</math> = absolute temperature (in Kelvin)</p> <hr/> <p><math>\text{pH}^* = -\log_{10} [\text{H}^+]</math></p>
<p>* For the purposes of the AP Exam, students will not be required to perform calculations using this equation; however, they must understand the underlying concepts and applications.</p> <p>† For use with labs only (optional).</p>		