RICE

AP BIOLOGY
EQUATIONS AND FORMULAS

STATISTICAL ANALYSIS AND PROBABILITY

Standard Error	Mean
$SE_X = \frac{s}{\sqrt{n}}$	$\bar{X} = \frac{1}{n}\sum_{i=1}^{n} X_i$

Standard Deviation	Chi - Square
$s = \sqrt{\frac{\sum(x_i - \bar{x})^2}{n-1}}$	$X^2 = \sum \frac{(o-e)^2}{e}$

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

$\bar{X}$ = mean

n = size of the sample

o = observed individuals with observed genotype

e = expected individuals with observed genotype

Degrees of freedom = (# of distinct possible outcomes) - 1

CHI - SQUARE TABLE

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

LAWS OF PROBABILITY

If A and B are mutually exclusive, then P (A or B) = P (A) + P (B)

If A and B are independent, then P (A and B) = P(A) x P(B)

HARDY - WEINBERG EQUATIONS

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

$p + q = 1$

p: frequency of the dominant allele in a population

q: frequency of the recessive allele in a population

METRIC PREFIXES

Factor	Prefix	Symbol
10^{9}	*giga*	G
10^{6}	*mega*	M
10^{3}	*kilo*	k
10^{-2}	*centil*	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: Values obtained by subtracting the smallest observation (sample minimum) from the greatest (sample maximum)

RATE AND GROWTH

Rate

$$dY/dt$$

Population Growth

$$dN/dt = B - D$$

Exponential Growth

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

Logistic Growth

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

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

Temperature Coefficient Q_{10}

$$Q_{10} = \left(\frac{k_2}{k_1}\right)^{\frac{10}{t_2-t_1}}$$

t_2 = higher temperature
t_1 = lower temperature
k_2 = metabolic rate at t_2
k_1 = metabolic rate at t_1
Q_{10} = the *factor* by which the reaction rate increases when the temperature is raised by ten degrees

Primary Productivity Calculation

mg O_2/L x 0.698 = mL O_2/L
mL O_2/L x 0.536 = mg carbon fixed/L

Water Potential (Ψ)

Ψ = Ψp + Ψs
Ψp = pressure potential
Ψs = solute potential

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

The Solute Potential of the Solution

Ψs = -iCRT
i = ionization constant (For sucrose this is 1.0 because sucrose does not ionize in water)
C = molar concentration
R = pressure constant (R = 0.0831 liter bars/mole K)
T = temperature in Kelvin (273 + °C

SURFACE AREA AND VOLUME

Volume of a Sphere

$V = 4/3\,\pi\,r^3$

Volume of a Rectangular Prism

V = l w h

Volume of a Cylinder

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

Surface Area of a Sphere

$V = 4\,\pi\,r^2$

Surface Area of a Cube

A = 6 a

Surface Area of a Rectangular Solid

A = Σ (surface area of each side)

r = radius
l = length
h = height
w = width
A = surface area
V = volume
Σ = sum of all
a = surface area of one side of the cube

Dilution - used to create a dilute solution from a concentrated stock solution

$C_I V_i = C_f V_f$
I = initial (starting)
C = concentration of solute
f = final (desired)
V = volume of Solution

Gibbs Free Energy

ΔG = ΔH - TΔS
ΔG = change in Gibbs Free Energy
ΔS = change in entropy
ΔH = change in enthalpy
T = absolute temperature (in Kelvin)

pH = - log [H+]

Appendix A

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

$\bar{x}$ = 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.

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 = frequency of the dominant allele in a population

$p + q = 1$ — q = frequency of the recessive allele 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)

** 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.*

Rate and Growth

Rate

$\frac{dY}{dt}$

Population Growth

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

Exponential Growth

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

Logistic Growth

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

Temperature Coefficient Q_{10} †

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

Primary Productivity Calculation

$\frac{\text{mg } O_2}{\text{L}} \times \frac{0.698 \text{ mL}}{\text{mg}} = \frac{\text{mL } O_2}{\text{L}}$

$\frac{\text{mL } O_2}{\text{L}} \times \frac{0.536 \text{ mg C fixed}}{\text{mL } O_2} = \frac{\text{mg C fixed}}{\text{L}}$

(at standard temperature and pressure)

dY = amount of change

dt = change in time

B = birth rate

D = death rate

N = population size

K = carrying capacity

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

T_2 = higher temperature

T_1 = lower temperature

k_2 = reaction rate at T_2

k_1 = reaction rate at T_1

Q_{10} = the factor by which the reaction rate increases when the temperature is raised by ten degrees

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 (this is 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 (ºC + 273)

Surface Area and Volume

Volume of a Sphere

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

Volume of a Rectangular Solid

$V = lwh$

Volume of a Right Cylinder

$V = \pi r^2 h$

Surface Area of a Sphere

$A = 4\pi r^2$

Surface Area of a Cube

$A = 6s^2$

Surface Area of a Rectangular Solid

$A = \sum$ surface area of each side

r = radius

l = length

h = height

w = width

s = length of one side of a cube

A = surface area

V = volume

Σ = sum of all

Dilution (used to create a dilute solution from a concentrated stock solution)

$C_i V_i = C_f V_f$

i = initial (starting)

f = final (desired)

C = concentration of solute

V = volume of solution

Gibbs Free Energy

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

ΔG = change in Gibbs free energy

ΔS = change in entropy

ΔH = change in enthalpy

T = absolute temperature (in Kelvin)

$pH^* = -\log_{10} [H^+]$

** 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.*

† For use with labs only (optional).