Numeric Response Practice (AP Review Notebook)

Science Practices

1. A plant geneticist is investing the inheritance of genes for bitter taste (Su) and explosive rind (e) in watermelon (*Citrullus lanatus*). Explosive rind is recessive and causes watermelons to burst when cut. Non-bitter watermelons are a result of the recessive genotype (susu). The geneticist wishes to determine if the genes assort independently. She performs a testcross between a bitter/nonexplosive hybrid and a plant homozygous recessive for both traits. The following offspring are produced:

BN bitter/non-explosive – 88
BE bitter/explosive – 68
NN non-bitter/non-explosive – 62
NE non-bitter/explosive – 81

	E	e
e	Ee	ee
e	Ee	ee

	Su	su
su	Susu	susu
su	Susu	susu

1 : 1 : 1 : 1

Calculate the chi-squared value for the null hypothesis that the two genes assort independently. Give your answer to the nearest hundredth.

phenotype	O	e	O-e	$(O-e)^2$	$(O-e)^2/e$
BN	88	74.75	13.25	175.563	2.349
BE	68	74.75	-6.75	45.563	0.610
NN	62	74.75	-12.75	162.563	2.175
NE	81	74.75	6.25	39.063	0.523
	299				

$\chi^2 = 5.657 =$ **5.66**

2. Results of a *Drosophila* mating between F_1 flies resulted in 58 flies showing red eyes (a dominant trait) and 42 flies showing sepia eyes (recessive). Calculate the Chi-square value for the hypothesis that both F_1 flies were heterozygous for eye color. Give your answer to the nearest tenth.

	R	r
R	RR	Rr
r	Rr	rr

$\frac{3}{4}$ Red
$\frac{1}{4}$ sepia

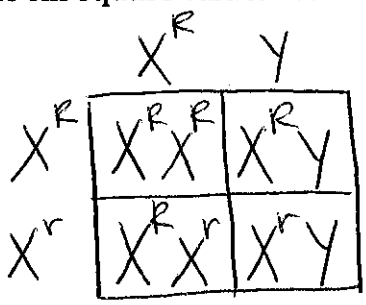
phenotype	O	e	O-e	$(O-e)^2$	$(O-e)^2/e$
Red	58	75	-17	289	3.853
sepia	42	25	17	289	11.56
	100				

$\chi^2 = 15.413 =$ **15.4**

$X^R X^r$ $X^R Y$

3. A hetero red eyed female was crossed with a red eyed male. The results are shown below. Red eyes are sex-linked dominant to white, determine the **chi-square value.** Round to the nearest hundredth.

Phenotype	# flies observed
Red Eyes	134
White Eyes	66



$\frac{3}{4}$ Red
$\frac{1}{4}$ white

phenotype	O	e	(O-e)	$(O-e)^2$	$(O-e)^2/e$
Red	134	150	-16	256	1.707
white	66	50	16	256	5.12
	200				

$\chi^2 = 6.827 = \boxed{6.83}$

4. In corn (*Zea mays*), purple kernels (R) are dominant to yellow kernels (r). Cobs from the offspring of a cross between a purple plant and yellow plant were used in a lab. A student counts 329 purple and 299 yellow kernels on one cob.

   Calculate the chi-squared value for the null hypothesis that the purple parent was heterozygous for purple kernels. Give your answer to the nearest hundredth.

Rr

	R	r
r	Rr	rr
r	Rr	rr

$\frac{1}{2}$ purple
$\frac{1}{2}$ yellow

phenotype	O	e	(O-e)	$(O-e)^2$	$(O-e)^2/e$
purple	329	314	15	225	0.717
yellow	299	314	-15	225	0.717
	628				

$\chi^2 = 1.434 = \boxed{1.43}$

5. 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 146 seeds that were produced from the cross matured into 87 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.

Pp

	P	p
p	Pp	pp
p	Pp	pp

½ purple
½ yellow

pheno	O	e	O-e	$(O-e)^2$	$(O-e)^2/e$
purple	87	73	14	196	2.68
yellow	59	73	-14	196	2.68

$\chi^2 = 5.36 = \boxed{5.4}$

6. Treatment of tomato plants with a growth hormone yielded the following weights of tomatoes: 100 g, 86 g, 123 g, 98 g, 104 g, 71 g. What is the average weight of a tomato after treatment?

$$\frac{100 + 86 + 123 + 98 + 104 + 71}{6} = \frac{582}{6} = \boxed{97}$$

7. A certain mutation found in fruit flies (*Drosophila melagaster*) is hypothesized to be autosomal recessive. The experimenter crossed two *Drosophila* flies that were heterozygous for the trait. The next generation produced 80 wild-type males, 65 wild-type females, 26 males with the mutation, and 40 mutant females. Calculate the chi-square value for the null hypothesis that the mutation is autosomal recessive.

gender does not matter

	M	m
M	MM	Mm
m	Mm	mm

¾ wild type
¼ mutant

WT = 80 + 65 = 145
M = 40 + 26 = 66

pheno	O	e	(O-e)	$(O-e)^2$	$(O-e)^2/e$
wild-type	145	158.25	-13.25	175.563	1.109
mutant	66	52.75	13.25	175.563	3.328
	211				

$\chi^2 = 4.437 = \boxed{4.43}$

S s P p

8. In pea plants, smooth seeds are dominant to wrinkled, and purple flowers are dominant to white. In a dihybrid cross where 9:3:3:1 ratio is expected, the following data was collected:

Smooth and Purple = 223
Smooth and White = 84
Wrinkled and Purple = 89
Wrinked and White = 33

$\frac{9}{16}$ = smooth & purple $\frac{3}{16}$ = wrinkled & purple

$\frac{3}{16}$ = smooth & white $\frac{1}{16}$ = wrinkled & white

Determine the **chi-square value.** Round to the nearest hundredths.

phenotype	O	e	O-e	$(O-e)^2$	$(O-e)^2/e$
smooth/purple	223	241.313	-18.313	335.366	1.390
smooth/white	84	80.438	3.562	12.688	0.158
wrinkled/purple	89	80.438	8.562	73.308	0.911
wrinkled/white	33	26.813	6.187	38.279	1.428
	429			3.89	$= X^2 = 3.887$

9. Grasshoppers in Madagascar show variation in their back-leg length. Given the following data, determine the standard deviation for this data. Round the answer to the nearest hundredth.

Length (cm): 2.0, 2.2, 2.2, 2.1, 2.0, 2.4, and 2.5

$\bar{X} = \frac{2.0+2.2+2.2+2.1+2.0+2.4+2.5}{7}$

$\bar{X} = 15.4/7 = 2.2$

$\frac{\sum (2-2.2)^2 + (2.2-2.2)^2 + (2.2-2.2)^2 + (2.1-2.2)^2 + (2-2.2)^2 + (2.4-2.2)^2 + (2.5-2.2)^2}{6}$

$.04 + 0 + 0 + .01 + .04 + .04 + .09 = .22/6$

sd = 0.04

10. Initial mass of pumpkin cores was measured in grams. What is the **average** initial mass for the pumpkin cores? Round to the nearest hundredth.

29.15, 28.45, 30.92, 29.25, 32.09, 31.67

$$\frac{29.15 + 28.45 + 30.92 + 29.25 + 32.09 + 31.67}{6}$$

$$\frac{181.53}{6} = 30.255 = 30.26$$

11. Two Wisconsin fast plants are crossed. One has the recessive dwarf trait, but the normal pigment anthocyanin, while the other has the recessive anthocyaninless trait, but is on normal height. Their offspring consist of:

89 plants of normal height and pigment
93 anthocyaninless plants and normal height
96 dwarf plants and normal pigment
94 anthocyaninless, dwarf plants

	d	d
D	Dd	Dd
d	dd	dd

	A	a
a	Aa	aa
a	Aa	aa

expected: 1:1:1:1

A student proposes that the parent plants' genotype must have been **ddAa** for the dwarf parent and **Ddaa** for the anthocyaninless parent. Calculate the **chi square value** that would be used to confirm this hypothesis. Round to the nearest hundredths.

pheno	O	e	O-e	$(O-e)^2$	$(O-e)^2/e$
normal, pigment	89	93	-4	16	0.172
antho, normal	93	93	0	0	0
dwarf, normal	96	93	3	9	0.097
antho, dwarf	94	93	1	1	0.011
	372				0.28

$\chi^2 = 0.28$

12. In a certain species of plant, the allele to produce green melons (G) is dominant over the allele to produce yellow melons (g). A student performed a cross between a plant that produced green melons and a plant that produced yellow melons. When the student observed the next generation, the 94 seeds that were produced from the cross matured into 53 plants with green melons and 41 plants with yellow melons. Calculate the chi-squared value for the null hypothesis that the green-melon parent was heterozygous for the melon-color gene.

	G	g
g	Gg	gg
g	Gg	gg

$\frac{1}{2}$ green $\frac{1}{2}$ yellow

phenotype	O	e	O-e	$(O-e)^2$	$(O-e)^2/e$
Green	53	47	6	36	0.766
yellow	41	47	-6	36	0.766
	94				1.532

$\chi^2 = 1.53$

13. Data taken to determine the effect of temperature on the rate of respiration in a goldfish is given in the table below. Calculate Q_{10} for this data. Round to the nearest whole number.

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

Temperature (C)	Respiration Rate (Min)
16 t_1	16 K_1
21 t_2	22 K_2

$$Q_{10} = \left(\frac{22}{16}\right)^{\frac{10}{(21-16)}}$$

$$= \left(\frac{22}{16}\right)^{10/5}$$

$$= (1.375)^2$$

$$= 1.89$$

$Q_{10} = 2$

Unit 1: Biochemistry

14. If $C_iV_i = C_fV_f$, where *i* is the initial solution concentration and *f* is the final concentration, how many milliliters of a 0.5 M glucose solution would you need in order to make 250 milliliters of a 0.1 M glucose solution?

$0.5M\,(V_i) = (0.1M)(250mL)$

$V_i = \frac{(0.1M)(250mL)}{0.5M} = 50$

$V_i = 50$

15. 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 5, which the pH measured at Robbins Pond on that same date was near 9. Deremine to the nearest whole number how many times greater the hydrogen ion concentration was at King Phillip Brook.

$10^{-9} - 10^{-5} = 10^{-4}$

10,000

16. An enzyme in the liver removes a phosphate group from glucose so the glucose molecule can enter the bloodstream, providing energy for cellular respiration to the cells of the body. The rate of enzyme activity can be monitored by measuring the phosphate concentration over time. In this experiment, liver cells were placed in a phosphate solution, and every 5 minutes cells were removed and the intracellular concentration of phosphate was measured. What is the rate of phosphate formation per minute from 15 to 20 minutes?

Time (min)	Phosphate Concentration (μmol/mL)
0	0
5	10
10	90
15	180
20	270

$$\text{Rate} = \frac{\Delta y}{\Delta x}$$

$$\text{Rate} = \frac{270 - 180}{20 - 15}$$

$$\text{Rate} = \frac{90}{5} = 18$$

17. An enzyme in the liver removes a phosphate group from glucose so the glucose molecule can enter the bloodstream, providing energy for cellular respiration to the cells of the body. The rate of enzyme activity can be monitored by measuring the phosphate concentration over time.

Data from the experiment:

Time (min)	Phosphate Concentration (μmol/mL)
0	0
5	10
10	90
15	180
20	270

$$\text{Rate} = \frac{\Delta y}{\Delta x}$$

$$\text{Rate} = \frac{180 - 10}{15 - 5}$$

$$\text{Rate} = \frac{170}{10} = 17$$

What is the rate of phosphate formation per minute from 5 to 15 minutes?

18. Joe has a 2g/L solution. He dilutes it and creates a 3L of 1 g/L solution. How much of the original solution did he dilute? Round to the nearest tenth.

$$C_i V_i = C_f V_f$$

$$2\,g/L\,(V_i) = 1\,g/L\,(3L)$$

$$V_i = \frac{1\,g/L\,(3L)}{2\,g/L} = 1.5L$$

19. Hydrogen peroxide is broken down to water and oxygen by the enzyme catalase. The following 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 hundredth.

Time (mins)	Amount of O_2 produced (mL)
1	2.3
2	3.6
3	4.2
4	5.5
5	5.9

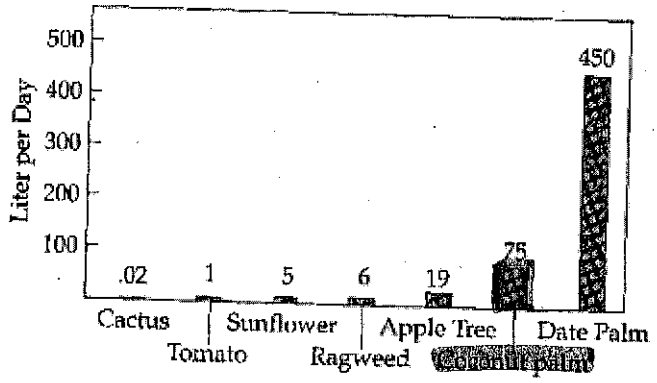
$$\text{Rate} = \frac{\Delta y}{\Delta x}$$

$$\text{Rate} = \frac{5.5 - 3.6}{4 - 2}$$

$$\text{Rate} = \frac{1.9}{2}$$

$$\boxed{\text{Rate} = 0.95}$$

20. The loss of water by evaporation from the leaf openings is known as transpiration. The transpiration rates of various plants are shown below.



Transpiration Rates for Plants

How many liters of water per week are lost by a coconut palm?

$$\frac{75 \text{ liters}}{\text{day}} \mid \frac{7 \text{ days}}{1 \text{ wk}} = \boxed{525 \text{ L/wk}}$$

21. Compare the number of H+ ions in a solution with a pH of 2 to a solution with a pH of 6. If appropriate, include a negative sign in your answer.

$pH = 10^{-6}$ $pH = 10^{-2}$ $10^{-6} - 10^{-2} = 10^{-4}$

10,000

Unit 2: The Cell

22. A cell is in equilibrium with its surroundings. The molarity of the surrounding solution is 0.8 M. Calculate the solute potential of the surrounding solution.

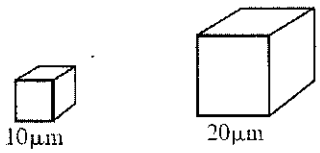
$\Psi_S = -1.95$

The equation for solute potential is: $\Psi_s = -iCRT$
where:
i = ionization constant (assume that it is 1)
C = molar concentration
R = pressure constant (R = 0.00831 liter MPa/mole K) ← note: this is a different unit than the AP Bio formula sheet
T = temperature in Kelvin (assume a room temperature of 293 K)

$\Psi_S = -(1)(0.8M)(0.00831\ ^{LMPa}/_{molK})(293K)$

$\Psi_S = -1.947$

23. Simple cuboidal epithelial cells line the ducts of certain human exocrine glands. Various materials are transported into or out of the cell by diffusion. (The formula for the surface area of a cube is $6 \times S^2$, and the formula for the volume of a cube is S^3, where S = the length of a side of the cube.) How many of the small cell could fit inside the larger cell?



$V_{small} = (10)^3 = 1000$

$V_{large} = (20)^3 = 8000$

$\frac{8000}{1000} = 8$

24. Scientists are trying to determine under what conditions a plant can survive. They collect the following data and would like to know the water potential of the plant cell. The solute potential is -0.6 MPa and the pressure potential is -1.0 MPa. What is the **water potential**? Round to nearest hundredths.

$\Psi = \Psi_p + \Psi_s$

$= -1.0MPa + -0.6MPa$

$\Psi = -1.6MPa$

$i = 1$ $T = 22°C + 273 = 295$

25. Potato cores were placed in solutions of varying concentrations and were found to neither gain nor lose mass in a sucrose solution of 0.32M. Use this information to calculate the solute potential of the potato cores. The temperature of the solution is 22°C.

$\Psi_S = -iCRT$

$= -(1)(0.32M)(0.0831)(295)$

$= -7.844$

$\boxed{\Psi_S = -7.84}$

26. How many molecules of ATP are required for the transport of 600 sodium ions out of the cell? Refer to the process of sodium and potassium transport. See the following equation.

ATP + H_2O + 3 Na^+ INSIDE CELL + 2 K^+ OUTSIDE CELL -> ADP + $H_2PO_4^-$ + 3 Na^+ OUTSIDE CELL + 2 K^+ INSIDE CELL

$\frac{600 Na^+}{} \left| \frac{1 ATP}{3 Na^+} \right. = \boxed{200 ATP}$

27. Determine the surface area-to-volume ratio for a cube that has a side length of 2.5 cm. The volume of a cube = $(l)(w)(h)$. The surface area = 6 x area of a single side.

$SA = 6(2.5)^2$

$= 6(6.25)$

$= 37.5$

$V = (2.5)^3$

$V = 15.625$

$\frac{SA}{V} = \frac{37.5}{15.625} = \boxed{2.4}$

28. How many potassium ions can be transported into the cell with the hydrolysis of 200 ATP molecules? Refer to the process of sodium and potassium transport. See the following equation.

ATP + H_2O + 3 Na^+ INSIDE CELL + 2 K^+ OUTSIDE CELL -> ADP + $H_2PO_4^-$ + 3 Na^+ OUTSIDE CELL + 2 K^+ INSIDE CELL

$\frac{200 ATP}{} \left| \frac{2 K^+}{1 ATP} \right. = \boxed{400 K^+}$

$i = 1$ $T = 27^\circ C + 273 = 300$

29. The molar concentration of a sugar solution in an open beaker has been determined to be 0.3M. Calculate the solute potential at 27 degrees Celsius. Round your answer to the nearest tenths.

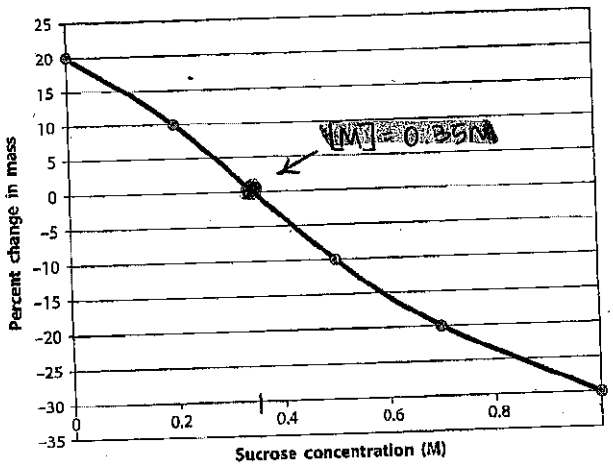
$\Psi_S = -iCRT$

$= -(1)(0.3M)(0.0831)(300)$

$= -7.479$

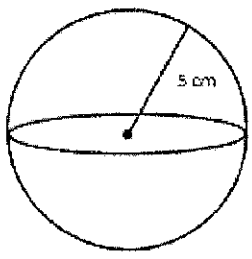
$\Psi_S = -7.5$

30. Refer to the following data taken from osmosis experiments on potato cores.



What is the solute concentration of the potato cells? Record your answer to two decimal places (hundredth place).

31. What is the SA/V for this cell? Round your answer to the nearest hundredth?



SA sphere: $4\pi r^2$

$= 4\pi(5)^2$

$= 100\pi$

V sphere: $\frac{4}{3}\pi r^3$

$= \frac{4}{3}\pi(5)^3$

$= \frac{4}{3}\pi(125)$

$= \frac{500\pi}{3}$

$\frac{SA}{V} = 100\pi / \frac{500\pi}{3}$

$= \frac{3}{5}$

$\frac{SA}{V} = 0.60$

32. What is the water potential for a solution that is 0.1 M? The solution is in an open container. The equation for water potential is:

water potential (Ψ) = pressure potential (Ψ_p) + solute potential (Ψ_s)

The equation for solute potential is:

$\Psi_s = -iCRT$

$\Psi_s = -0.24$

where:
i = ionization constant (assume that it is 1)
C = molar concentration
R = pressure constant (R = 0.00831 liter MPa/mole K) ← This is different than AP formula sheet
T = temperature in Kelvin (assume a room temperature of 293 K)

$\Psi_s = -(1)(0.1M)(0.00831\ LMPa/molK)(293K)$

$= -0.243$

33. Four blocks of phenolphthalein agar are placed in a vinegar solution. The pH indicator solution changes to pink when in contact with an acidic solution,

Block A: 2 cm x 4 cm x 4 cm

Surface Area: 64

$SA = 2(2\times4) + 2(2\times4) + 2(4\times4)$
$= 64$

Volume: 32

$V = 2\times4\times4$
$= 32$

Surface Area/Volume: 2

$\frac{SA}{V} = 64/32 = 2$

34. Four blocks of phenolphthalein agar are placed in a vinegar solution. The pH indicator solution changes to pink when in contact with an acidic solution,

Block B: 2 cm x 8 cm x 4 cm

Surface Area: 112

$SA = 2(2\times8) + 2(8\times4) + 2(2\times4)$
$= 32 + 64 + 16$
$= 112$

Volume: 64

$V = 2\times8\times4$
$= 64$

Surface Area/Volume: 1.75

$\frac{SA}{V} = 112/64 = 1.75$

35. Four blocks of phenolphthalein agar are placed in a vinegar solution. The pH indicator solution changes to pink when in contact with an acidic solution,

Block C: 1 cm x 8 cm x 8 cm

Surface Area: 160

Volume: 64

Surface Area/Volume: 2.5

$SA = 2(1\times8) + 2(1\times8) + 2(8\times8)$
$= 16 + 16 + 128$
$= 160$

$V = 1\times8\times8$
$= 64$

$\frac{SA}{V} = 160/64 = 2.5$

36. Four blocks of phenolphthalein agar are placed in a vinegar solution. The pH indicator solution changes to pink when in contact with an acidic solution,

Block D: 1 cm x 1 cm x 64 cm

Surface Area: 258

Volume: 64

Surface Area/Volume: 4.03

$SA = 2(1\times1) + 2(1\times64) + 2(1\times64)$
$= 2 + 128 + 128$
$= 258$

$V = 1\times1\times64$
$= 64$

$\frac{SA}{V} = 258/64 = 4.03$

a. Which block would the vinegar solution penetrate most thoroughly into after ten minutes?

$\frac{SA}{V}$

A = 2
B = 1.75
C = 2.5
D = 4.03

* D because it has greatest SA/V *

b. Which block would have the greatest volume of pink phenolphthalein at the end of ten minutes?

V

A = 32
B = 64
C = 64
D = 64

* A because it has smallest volume *

37. The following chart shows the energy products produced in various stages of the breakdown of glucose.

Process	ATP Produced	NADH/$FADH_2$ Produced
Glycolysis	2	2 NADH
Pyruvate Oxidation (*per molecule of pyruvate*)		1 NADH
Citric Acid (Krebs) Cycle *per molecule of pyruvate*	1	3 NADH 1 $FADH_2$

Each molecule of NADH results in approximately 2.5 molecules of ATP, whereas each molecule of $FADH_2$ results in approximately 1.5 molecules of ATP when these molecules are fed into the electron transport chain.

What is the difference in the total number of ATP molecules produced between three molecules of glucose that undergo fermentation compared to three molecules of glucose that undergo aerobic respiration?

Fermentation ⇒ glycolysis alone

2 ATP

~~2 NADH~~ ⇒ NO ETC

total = 2 ATP x 3 glucose = 6 ATP

Cell Respiration ⇒ all 3 steps

glycolysis

2 ATP

2 NADH ⇒ 2(2.5) = 5 ATP

Pyruvate OX

1 NADH ⇒ 2 (2.5) = 5 ATP

(x 2 pyruvates)

Krebs cycle

1 ATP ⇒ 2(1) = 2 ATP

3 NADH ⇒ 6(2.5) = 15 ATP

1 $FADH_2$ ⇒ 2(1.5) = 3 ATP

(x 2 pyruvates)

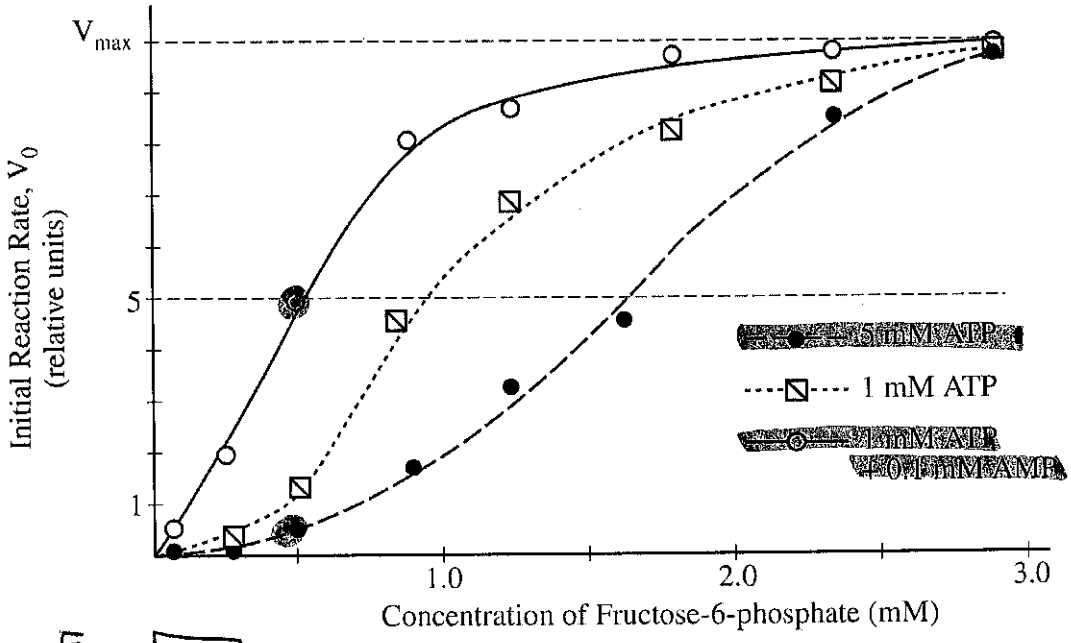
32 ATP x 3 glucose = 96 ATP

96 − 6 > 90 ATP difference

38. The enzyme phosphofructokinase (PFK) is an allosterically regulated enzyme that catalyzes the following reaction.

Fructose-6-phosphate + ATP ↔ Fructose-1,6-bisphosphate + ADP

The graph below shows that at certain concentrations ATP inhibits the enzyme, whereas AMP activates it. According to the information presented in the graph, when the concentration of fructose-6-phosphate is 0.5 mM, how many times more active is PFK in cells with 1 mM ATP + 0.1 mM AMP than in cells with 5 mM ATP? Express your answer to the nearest whole number.



$\frac{5}{0.5} = \boxed{10}$

39. Refer to the following table.

Location	Substrate	Product	NADH	$FADH_2$	ATP
Cytosol	Glucose	2 pyruvate	2	0	2
Mitochondria	Pyruvate	Acetyl-CoA + CO_2	1	0	0
Mitochondria	Acetyl-CoA	2 CO_2	3	1	1
Mitochondria	Palmitoyl-CoA	8 Acetyl-CoA	7	7	0

According to the table, how many NADH are produced from the complete oxidation of 1 molecule of palmitoyl-CoA to 16 carbon dioxide molecules?

$\frac{1\ \text{Palmitoyl-CoA}}{1\ \text{Palm.}} \left| \frac{8\ \text{Acetyl}}{1\ \text{Acetyl}} \right| \frac{3\ \text{NADH}}{} = 24\ \text{NADH}$

$= \boxed{31\ \text{NADH}}$

$\frac{1\ \text{Palmitoyl CoA}}{1\ \text{Palmitoyl}} \left| \frac{7\ \text{NADH}}{} \right. = 7\ \text{NADH}$

40. Glutamine is formed from glutamic acid by adding an ammonium molecule to glutamine. The overall reaction is endergonic, requiring 3.4 kcal/mole. The energy for the reaction comes from the exergonic splitting of a phosphate from ATP to form ADP, which releases 7.3 kcal/mole. What is the free energy change for this coupled reaction?

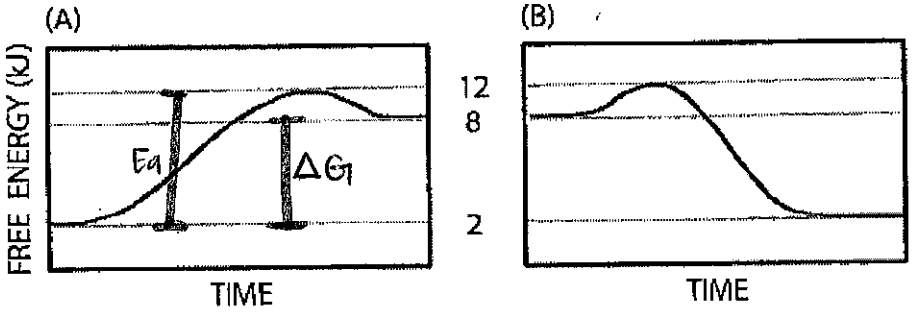
glutamic acid + ammonium ⇒ glutamine +3.4 Kcal/mol

ATP ⇒ P_i + ADP -7.3 Kcal/mol

-3.9 Kcal/mol

-3.9

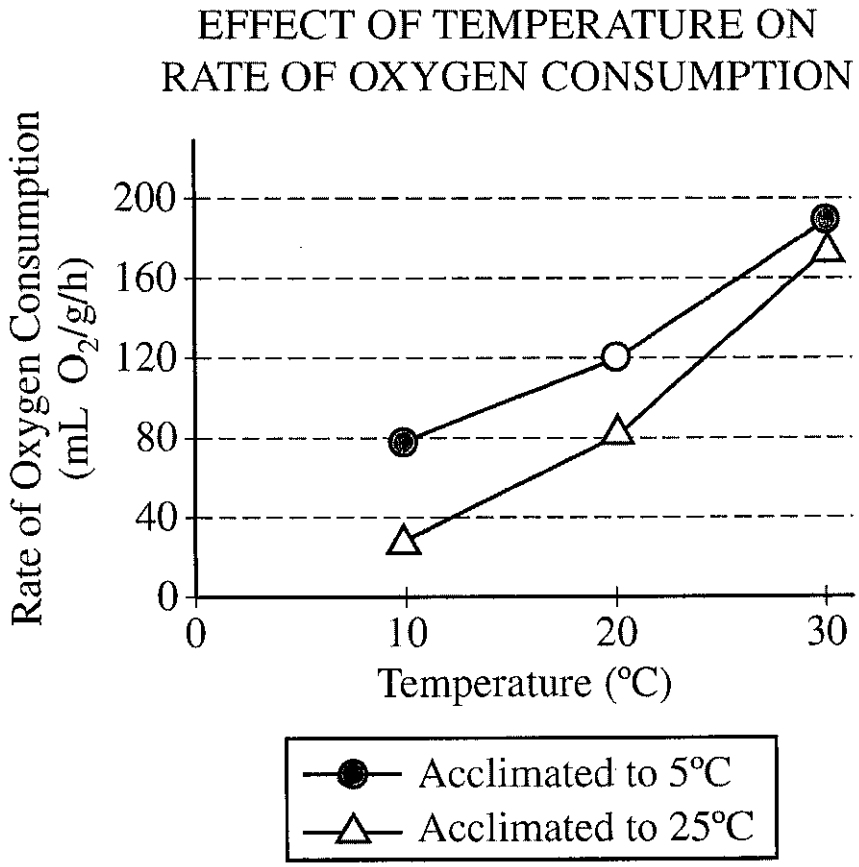
41. Refer to the following graphs.



Calculate the activation energy (E_A) of the process represented in graph A.

$E_a = 12 - 2 =$ 10

42. 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.



$$\text{Rate} = \frac{\Delta y}{\Delta x} = \frac{190 - 80}{30 - 10} = \frac{110}{20}$$

Rate = 5.5

43. Refer to the following table.

Location	Substrate	Product	NADH	$FADH_2$	ATP
Cytosol	Glucose	2 pyruvate	2	0	2
Mitochondria	Pyruvate	Acetyl-CoA + CO_2	1	0	0
Mitochondria	Acetyl-CoA	2 CO_2	3	1	1
Mitochondria	Palmitoyl-CoA	8 Acetyl-CoA	7	7	0

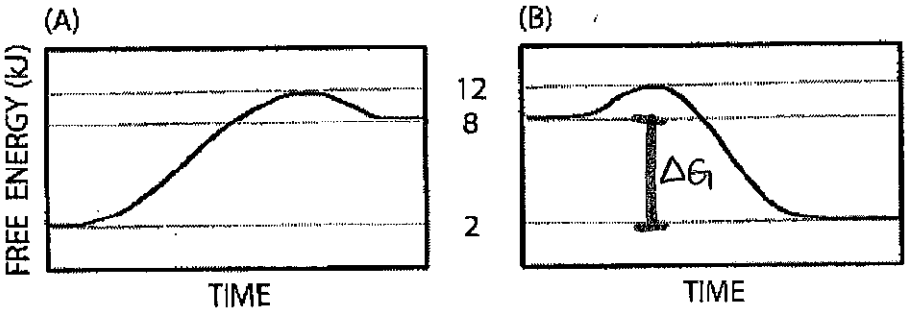
How many ~~pruvate~~ pyruvate molecules need to be completely oxidized to carbon dioxide to produce 24 NADH molecules?

Acetyl CoA $\Rightarrow 2CO_2$ = 3NADH

Pyruvate $\Rightarrow$ acetyl CoA = 1 NADH

$$\frac{4\text{NADH}}{\text{Pyruvate}} \Rightarrow \frac{24\text{NADH}}{4\text{ NADH}} \left| \frac{1\text{ PYRV.}}{} \right. = \boxed{6\text{ pyruvate}}$$

44. Refer to the following graphs.



Calculate the free energy change (ΔG) of the process represented in graph B.

8 - 2 = **-6**

Unit 4: Genetics & Molecular Genetics

45. In *E. coli* the DNA is 24% adenine. Based on this, what percentage of this DNA is guanine?

A=T 24% A = 24% T ⇒ 48 %G = 52/2 = **26**

C=G 100 - 48 = 52

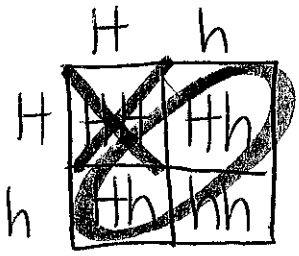
46. A certain species of plant has four unlinked genetic loci, W, X, Y, and Z. Each genetic locus has one dominant allele and one recessive allele. For a plant with the genotype WwXxYyZz, what is the probability that the plant will produce a gamete with a haploid genotype of Wxyz ? Give your answer as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

Ww Xx Yy Zz
↓ ↓ ↓ ↓
½ ½ ½ ½

½ × ½ × ½ × ½ = **1/16 or 0.0625**

47. 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 <u>lethal</u> 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.



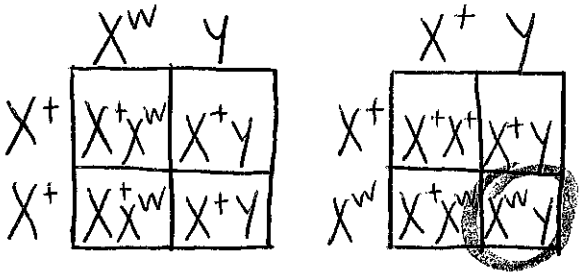
Hh = hairless

2/3 hairless

48. Wild-type fruit flies have red eyes (+). The "white-eyed"phenotype (w) is recessive and results from a mutation on the X chromosome. During a lab, students cross a white-eyed male with a homozygous red-eyed female. A red-eyed female and a red-eyed male from the F_1 generation are then bred to produce 573 offspring.

$X^wY \times X^+X^+ \rightarrow X^+Y \times X^+X^w$

How many of the offspring are predicted to be white-eyed males? Round your response to the nearest whole number.



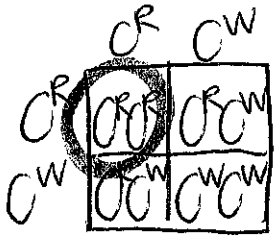
$\frac{1}{4}$ white eyed male

$\frac{1}{4} \times 573 = 143.25 =$ **143**

49. 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 465 offspring.

$C^RC^W \times C^RC^W$

Calculate how many of these offspring are expected to have the red phenotype. Round your response to the nearest whole number.

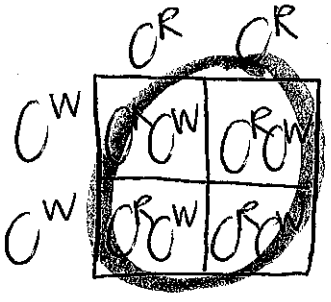


$\frac{1}{4} C^RC^R$

$\frac{1}{4} \times 465 = 116.25 =$ **116**

50. In snapdragon plants that display intermediate dominance, the allele C^R produces red flowers and C^W produces white flowers. In a homozygous red-flowered snapdragon is crossed with a homozygous white-flowered snapdragon, what will the percentage of pink offspring be?

$C^RC^R \times C^WC^W$



100% pink

51. In fruit flies gray body is dominant to black body and normal wings are dominant to vestigial wings. Flies heterozygous for both gray bodies and normal wings were crossed with flies that had black bodies and vestigial wings. The following results were obtained:

Phenotype	Number of Flies
Gray body/Normal wings	482
Black body/Vestigial wings	472
Black body/Normal wings	92
Gray body/Vestigial wings	103

] parental

] Recombinants

The results indicate that the genes for wings and body color are on the same chromosome. The recombinant offspring are a result of crossing over. How many map units (expressed as a percent) apart are the two genes? The formula for calculating recombination frequency is:

Recombination frequency = number of recombinants/total number of offspring x 100

$$\frac{92+103}{482+472+92+103} = \frac{195}{1149} = 0.1697 \times 100 = 16.97$$

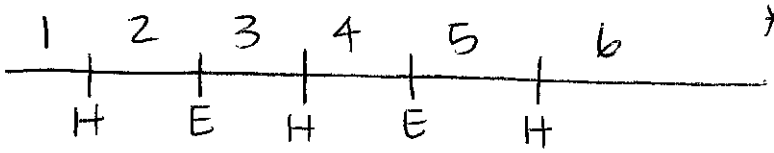
$$= \boxed{17}$$

52. **Calculate** the number of different gametes that can be produced by a plant that is heterozygous for seed shape and color, flower color, and stem length.

Ss Cc Ff Ll
↓ ↓ ↓ ↓
2 2 2 2

$2 \times 2 \times 2 \times 2 = \boxed{16}$

53. A linear strip of DNA has two restriction sites for the restriction enzyme EcoRI and three restriction sites for the restriction enzyme HindIII. If the strip of DNA was incubated with the restriction enzymes then the cut DNA was collected and run on an electrophoretic gel, how many bands would be expected on the gel?

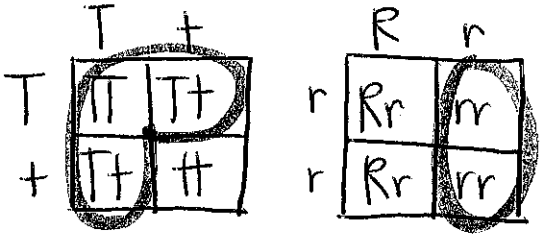


Note I am just drawing the cuts on a strand of linear DNA

6 fragments ⇒ **6 bands**

Note: if the fragment is same size, it will appear as 1 band

54. In pea plants T = tall, t = dwarf, R = round seeds, and r = wrinkled seeds. If a TtRr plant is crossed with a Ttrr plant, what fraction of the offspring will be tall and wrinkled?



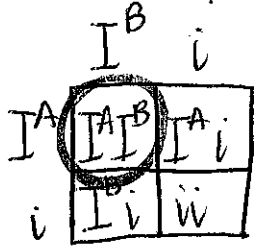
3/4 tall 1/2 wrinkled

3/4 x 1/2 = 3/8

55. In a diploid organism with the genotype AaBbCCDDEE, how many genetically distinct kinds of gametes would be produced?

Aa Bb CC DD EE
↓ ↓ ↓ ↓ ↓
2 x 2 x 1 x 1 x 1 = 4

56. A woman with blood genotype I^Ai and a man with blood genotype I^Bi have two children, both type AB. What is the probability that a third child will be blood type AB?



1/4 I^AI^B

1/4

57. A yeast cell in the early portion of interphase of meiotic cell division has 24 fg of DNA (fg = 1 x 10^{-15} grams). If the yeast cell completes meiotic division to form four haploid cells, how many fg of DNA would be expected in each haploid cell?

early interphase 24

S 48

M I 24

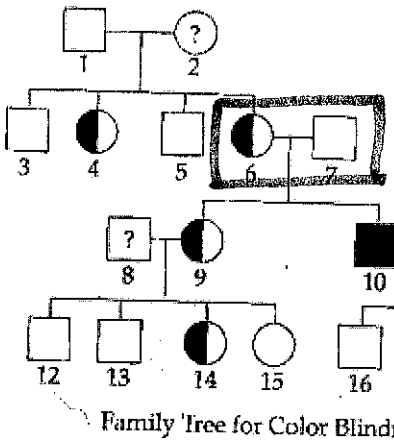
M II 12

12 fg of DNA

58. Based on the pedigree below, what is the probability that a male child born to individuals 6 and 7 will be color-blind?

	X^+	Y
X^+	X^+X^+	X^+Y
X^c	X^+X^c	X^cY

$\frac{1}{2}$ males born are color-blind



Family Tree for Color Blindness

sex-linked X^+X^c & X^+Y

$\frac{1}{2}$

Unit 5: Evolution

59. Some people have the ability to taste a bitter chemical called phenylthiocarbamide (PTC). The ability to taste PTC is due to the presence of at least one dominant allele for the PTC taste gene. The incidence of nontasters in North America is approximately 45%. Assuming the population is in Hardy-Weinberg equilibrium, what percent of the North American population is homozygous dominant for the ability to taste PTC? Provide your answer as a number between 0 and 1 to the nearest hundredth.

p	q	p^2	$2pq$	q^2
0.33	0.67	.109	.44	0.45

$p^2 = 0.11$

60. In a population of grasshoppers, the allele for tan color is dominant to the allele for green color. A drastic increase in rainfall leads to selection against the tan phenotype. When the rainy season ends, 23 percent of the remaining grasshoppers have the green phenotype. If this population is now in Hardy-Weinberg equilibrium, what will the frequency of the tan allele be in the next generation?

p	q	p^2	$2pq$	q^2
0.52	0.48	0.27	0.50	0.23

$p = 0.52$

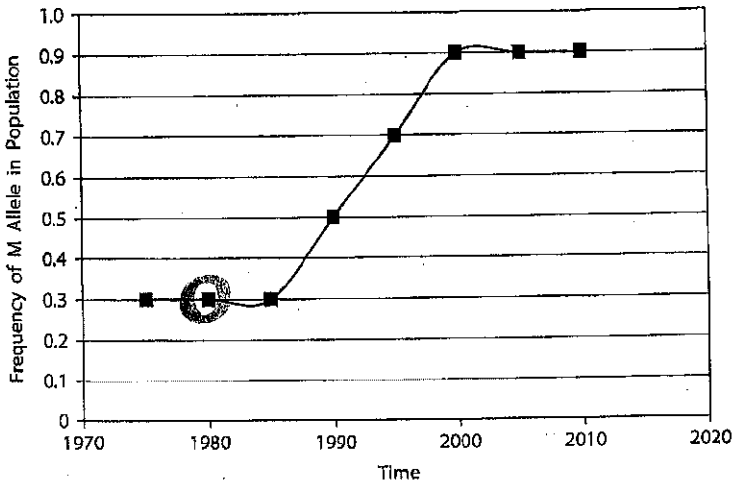
61. The radioisotope potassium-40 can be used to date past events older than 60,000 years. Potassium-40 has a half life of 1.3 billion years, decaying into Argon-40. If the igneous rock layer that scientists wish to date shows a ratio of Potassium-40 to Argon-40 at one-fourth the current ratio, what is the age of the rock layer? Express your answer in billions of years.

$1 \rightarrow \frac{1}{2} \rightarrow \frac{1}{4}$ so... 2 half lives

1.3 billion years x 2 =

2.6 billion years

62. Refer to the following graph of allele frequencies in a hypothetical population of tropical insects. Their color is determined by a single gene with two alleles. M (red) is dominant to m (black). Allele frequencies over 35 years are summarized as follows.



heterozygotes

p	q	p^2	2pq	q^2
0.3	0.7	0.09	0.42	0.49

Red: $p^2 + 2pq$

$0.42 + 0.09 = 0.51$

In 1980, what percentage of **red** insects are heterozygous?

$\frac{0.42}{0.51} = 0.82 \times 100 =$ **82%**

63. Twenty people decide to start a new population, totally isolated from anyone else. Two of the individuals are heterozygous for a recessive allele, which in homozygotes causes cystic fibrosis. Assuming this population is in Hardy-Weinberg equilibrium, what fraction (expressed as a decimal) of people in this new population will have cystic fibrosis?

18 CC

2 Cc

C allele = 2x18+2

= 38

$p = \frac{38}{40} = 0.95$

$q = \frac{2}{40} = 0.05$

p	q	p^2	2pq	q^2
0.95	0.05	0.90	0.095	0.0025

↑ cystic fibrosis

0.0025

64. In a population of turtles, the allele that causes a yellow shell (Y) is dominant to the allele that results in a red shell (y). If the dominant allele is present in the population at the 0.72 level and the population is in Hardy-Weinberg equilibrium, what percent of the population would be expected to have a red shell? Express your answer to the nearest tenth of a percent.

p	q	p^2	$2pq$	q^2
0.72	0.28	0.518	0.403	0.078

↑ 7.8%

65. Refer to the data below. The alleles show complete dominance (the heterozygote has the dominant phenotype). The population from which the data were taken has random mating. Assume all individuals are diploid.

Generation	Number of Individuals with the dominance phenotype	Number of individuals with the recessive phenotype
1	880	120
2	800	200
3	740	260
4	710	290
5	660	340
6	650	350
7	655	345

generation 1

$\frac{120}{1000} = 0.12 \; q^2$

$q = 0.346$

generation 7

$\frac{345}{1000} = 0.345 \; q^2$

$q = 0.587$

What is the change in the recessive allele frequency between generations 1 and 7? Provide your answer to the ones place (zero decimal places).

$0.587 - 0.346 = 0.241 \Rightarrow$ 24

66. Refer to the data above in #65. What percentage of the population in generation 5 is heterozygous? Provide your answer to the ones place (zero decimal places).

p	q	p^2	$2pq$	q^2
0.42	0.58	0.176	0.487	0.34

↑ 340/1000

Heterozygous ⇒ 0.487

49

67. In a population of certain frogs in which the allele for brown skin is dominant to the allele for green skin, a drought leads to selection against green-skinned frogs. When the drought ends, 12 percent of the remaining frogs exhibit the green-skin phenotype. If the population is now in Hardy-Weinberg equilibrium, what will be the frequency of the green-skin allele in the next generation? Provide your answer to the nearest hundredth.

p	q	p^2	$2pq$	q^2
0.65	0.35	0.42	0.46	0.12

↑ green allele

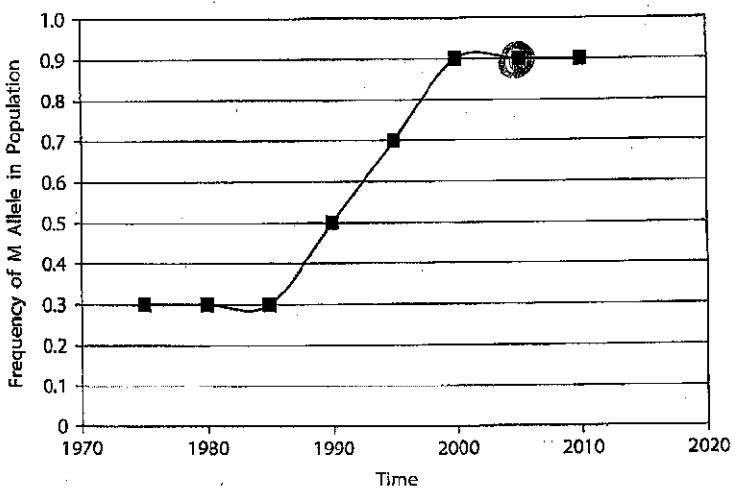
0.35

68. In a population of king snakes the banded pattern (*B*) is dominant to no banding (*b*). If 12% of the population shows no banding, what percentage of the population, to the nearest tenth, is heterozygous for banding?

p	q	p^2	$2pq$	q^2
0.65	0.35	0.42	0.455	0.12

↑ 45.6

69. Refer to the following graph of allele frequencies in a hypothetical population of tropical insects. Their color is determined by a single gene with two alleles. M (red) is dominant to m (black). Allele frequencies over 35 years are summarized as follows.



p	q	p^2	$2pq$	q^2
0.9	0.1	0.81	0.18	0.01

In 2005, what percentage of the population is expected to be homozygous?

$0.81 \times 100 =$ 81

70. If 250 people out of a population of 1,000 are born with sickle-cell anemia, **how many** people in the population will be more resistant to malaria because they are heterozygous for the sickle-cell gene?

p	q	p^2	$2pq$	q^2
0.5	0.5	0.25	0.5	0.25

↑ 250|1000

$0.5 \times 1000 = \boxed{500}$

71. Refer to the data in #65. The alleles show complete dominance (the heterozygote has the dominant phenotype). The population from which the data were taken has random mating. Assume all individuals are diploid.

Generation	Number of Individuals with the dominance phenotype	Number of individuals with the recessive phenotype
1	880	120
2	800	200
3	740	260
4	710	290
5	660	340
6	650	350
7	655	345

Estimate the number of recessive alleles in generation 1 of the population.

p	q	p^2	$2pq$	q^2
0.654	0.346	0428	0.453	0.12

↑ 120|1000

$0.453 \times 1000 = 453$ hetero

Recessive = $2aa + 1Aa$
$= 2(120) + 453$
$= \boxed{693}$

72. A census of birds nesting on a Galapagos Island revealed that 24 of them show a rare recessive condition that affected beak formation. The other 63 birds in this population show no beak defect. If this population is in HW equilibrium, what is the frequency of the dominant allele? Give your anwer to the nearest hundredth.

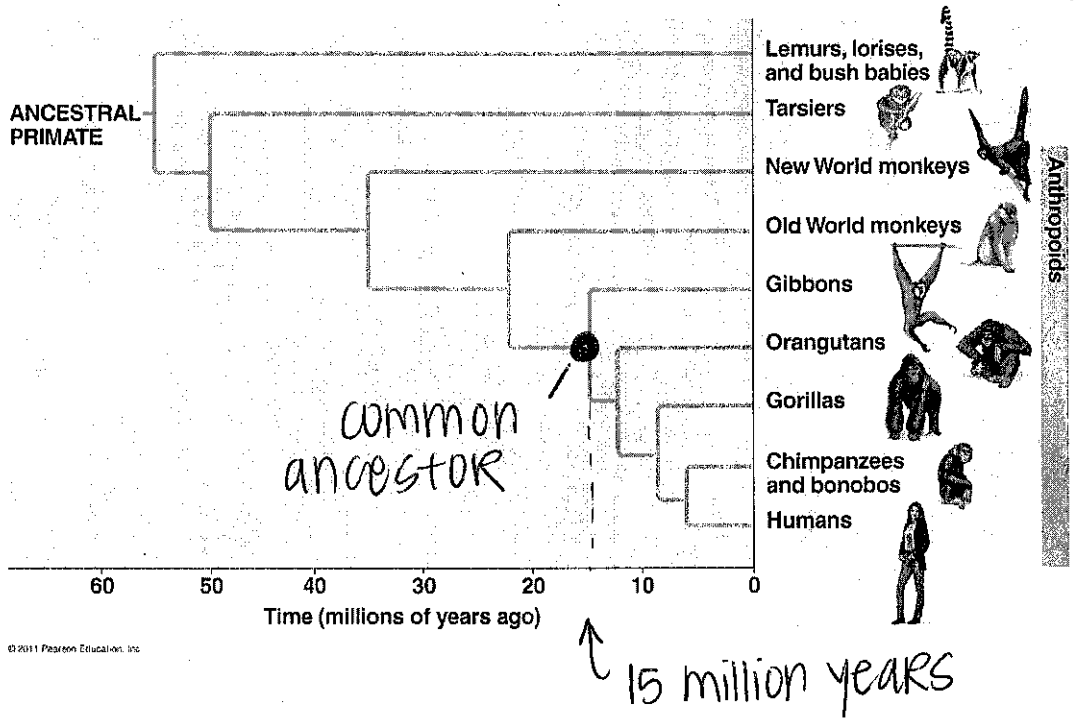
p	q	p^2	$2pq$	q^2
0.475	0.525	0.226	0.499	0.276

↑ 24/87

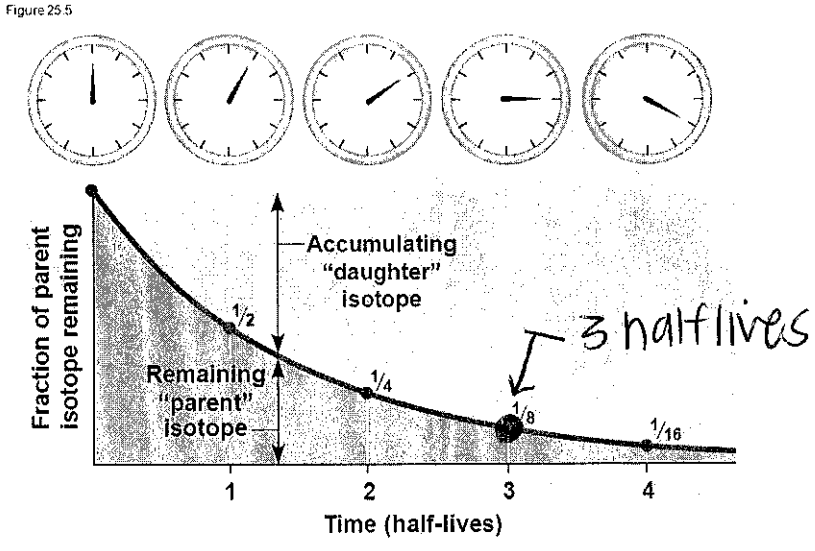
↑ dominant allele

$\boxed{0.48}$

73. Using the figure below, approximately how long ago did the last common ancestor for gibbons, orangutans, gorillas, chimpanzees, and humans diverge?



74. The figure provides information about radiometric dating. Note that the radioactive "parent" isotope decays to a daughter "isotope" at a constant rate. The age of artifacts containing wood can be dated accurately to about 75,000 years old using carbon dating. The half-life of radioactive decay of carbon-14 to carbon-12 is about 5,730 years. In a sample to be analyzed, the carbon-14 to carbon-12 is 1/8. What is your estimate of the age of the artifact to the nearest year?



$$\frac{3 \text{ half lives}}{1 \text{ halflife}} \left| \frac{5730 \text{ YRS}}{} \right. = \boxed{17190}$$

75. In a population of trogons (a type of bird) tail banding (*B*) is dominant to no tail banding (*b*). If 68% of the population shows tail banding, what percentage of the population to the nearest tenth, is heterozygous for tail banding?

p	q	p^2	$2pq$	q^2
0.434	0.566	0.188	0.491	0.32

↑ 1 − 0.68

$0.491 \times 100 = \boxed{49.1}$

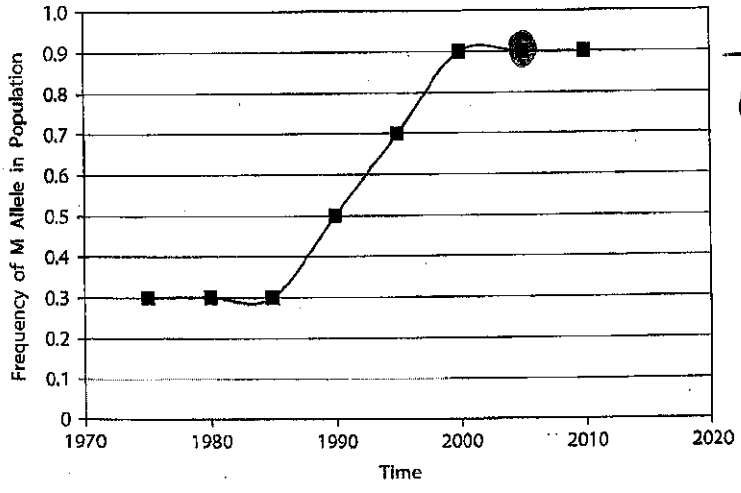
76. In a population of 250 peas, 16% of the peas are homozygous recessive wrinkled and the rest are smooth. What is the frequency of the dominant allele for smooth peas?

p	q	p^2	$2pq$	q^2
0.6	0.4	0.36	0.48	0.16

↑ dominant allele

$\boxed{0.6}$

77. Refer to the following graph of allele frequencies in a hypothetical population of tropical insects. Their color is determined by a single gene with two alleles. M (red) is dominant to m (black). Allele frequencies over 35 years are summarized as follows.



p	q	p^2	$2pq$	q^2
0.9	0.1	0.81	0.18	0.01

↑ Red

In 2005, what percentage of the population is expected to be red?

$0.81 + 0.18 = 0.99 \times 100 = \boxed{99\%}$

78. In a population that is Hardy-Weinberg equilibrium, the frequency of the homozygous recessive genotype is 0.09. What is the p and q value for this population?

p	q	p^2	$2pq$	q^2
0.7	0.3	0.49	0.42	0.09

$p = 0.7$
$q = 0.3$

79. In a population that is Hardy-Weinberg equilibrium, the frequency of the homozygous recessive genotype is 0.09 What is the frequency of individuals homozygous for the dominant trait?

p	q	p^2	$2pq$	q^2
0.7	0.3	0.49	0.42	0.09

↑ homozygous dominant

0.49

80. In a population that is Hardy-Weinberg equilibrium, the frequency of the homozygous recessive genotype is 0.09. What is the frequency of individuals that show the dominant trait?

p	q	p^2	$2pq$	q^2
0.7	0.3	0.49	0.42	0.09

dominant trait

$0.49 + 0.42 = 0.91$

Unit 6: Ecology

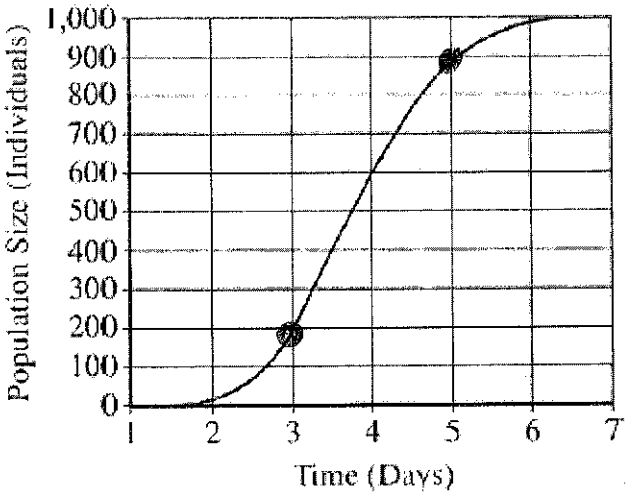
81. Use the graph below to calculate the mean rate of population growth (individuals per day) between day 3 and day 5. Give your answer to the nearest whole number.

$$\text{Rate} = \frac{\Delta y}{\Delta x}$$

$$= \frac{900 - 200}{5 - 3}$$

$$= \frac{700}{2}$$

$$= \boxed{350}$$



82. After seven days of growth, a plant's weight was 14.3 grams. The percent biomass of that plant was determined to be 23.1 percent. What amount of energy (in kcal) is stored in the plant, if the amount of stored energy = (g biomass) x 4.35 kcal?

$$\text{g biomass} = 14.3\text{g} \times 0.231$$

$$= 3.3033$$

$$\text{stored energy} = (3.3033\text{g})(4.35\text{kcal}) = 14.369 = \boxed{14.4}$$

83. A population of deer mice on an island has a carrying capacity of 350 individuals. If the maximum rate of increase is 1.0 per individual per year and the population size is 275, determine the logistic population growth rate to the nearest mouse.

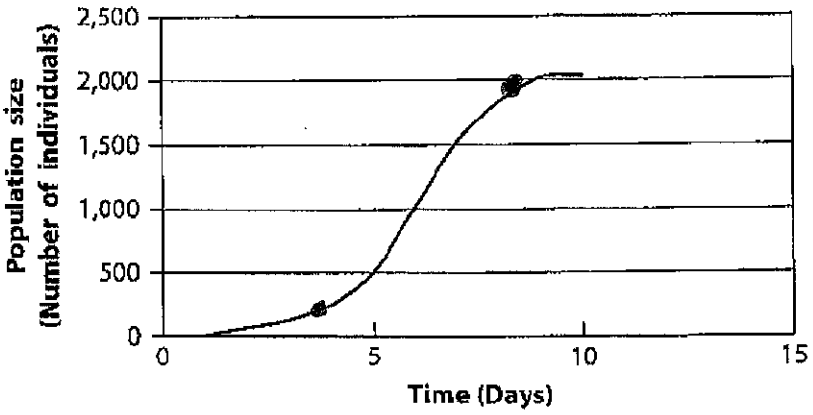
$$\frac{dN}{dt} = rN\left(\frac{K-N}{K}\right)$$

$$= 1.0(275)\left(\frac{350 - 275}{350}\right)$$

$$= 58.9$$

$$\boxed{\frac{dN}{dt} = 59}$$

84. Use the graph to calculate the mean rate of population growth per day between days 4 and 8. Give your answers to the nearest whole number.



$$\text{Rate} = \frac{\Delta y}{\Delta x}$$
$$= \frac{1900 - 200}{8 - 4}$$
$$= \frac{1700}{4}$$
$$\text{Rate} = 425$$

* There will be a range on the exam *

85. A hypothetical population has a carrying capacity of 1,500 individuals and rmax is 1.0. Fill out the following table:

Population size	Population growth rate
1,600	

$$\frac{dN}{dt} = rN\left(\frac{K-N}{K}\right)$$
$$= 1.0(1600)\left(\frac{1500-1600}{1500}\right)$$
$$= \boxed{-106.7}$$

86. A hypothetical population has a carrying capacity of 1,500 individuals and rmax is 1.0. Fill out the following table:

Population size	Population growth rate
1,750	

$$\frac{dN}{dt} = 1.0(1750)\left(\frac{1500-1750}{1500}\right)$$
$$= \boxed{-291.7}$$

87. A hypothetical population has a carrying capacity of 1,500 individuals and rmax is 1.0. Fill out the following table:

Population size	Population growth rate
2,000	

$$\frac{dN}{dt} = 1.0(2000)\left(\frac{1500-2000}{1500}\right)$$
$$= \boxed{-666.7}$$

88. Under favorable conditions, bacteria divide every 20 minutes. If a single bacterium replicated according to this condition, how many bacterial cells would one expect to find at the end of three hours?

$\frac{3\text{hrs}}{1}\left|\frac{60\text{ min}}{1\text{ hr}}\right|\frac{1\text{ division}}{20\text{ min}} = 9\text{ divisions}$ $\quad 2^9 = \boxed{512}$

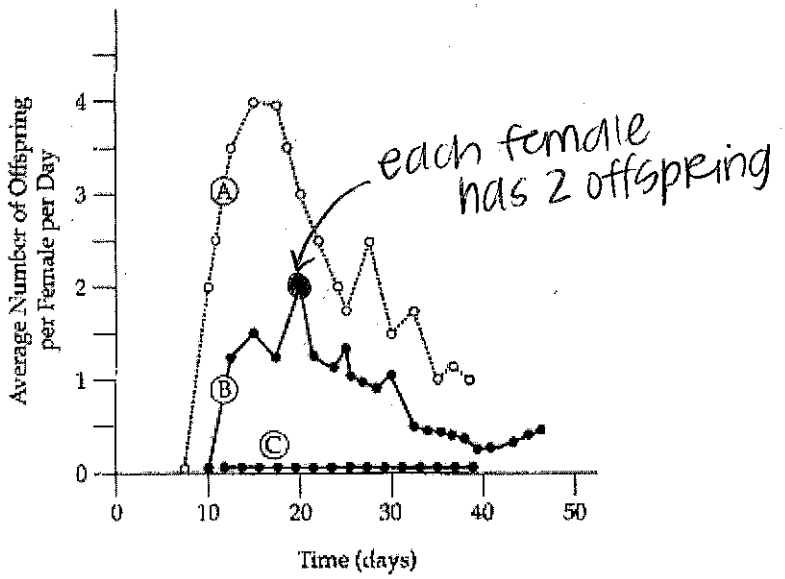
89. A population of 20 bobcats was introduced to a barrier island to help control the large rodent population. The bobcat population's birth rate is 0.48 bobcats/year per capita, and the death rate is 0.21 bobcats/year per capita. Given the initial bobcat population, predict the population size after 2 years on the island. (Round to the nearest whole number). $r = b - d = 0.48 - 0.21 = .27$

1st yr: $\frac{dN}{dt} = rN$ $= 0.27(20)$ $= 5.4$ $N = 25.4$

2nd yr: $\frac{dN}{dt} = rN$ $= 0.27(25.4)$ $= 6.858$

$N = 32.3$ $= \boxed{32}$

90. A group of 100 *Daphnia*, small crustaceans known as water fleas, were placed in one of three culture jars of different sizes to determine their reproductive rate. The graph below shows the average number of offspring produced per female each day in each jar of pond water.

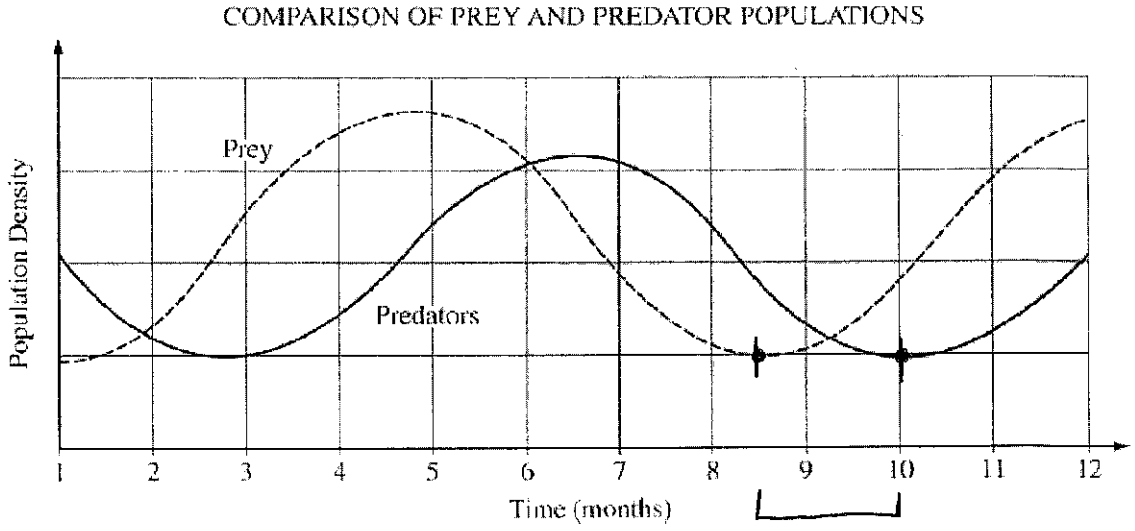


Key: (A) Water fleas in a 1-liter jar of pond water
(B) Water fleas in a 0.5-liter jar of pond water
(C) Water fleas in a 0.25-liter jar of pond water

What is the total number of offspring found in the 0.5-liter jar on the twentieth day, assuming all survive?

$100 \times 2 = \boxed{200}$

91. Use the graph below to calculate the lag time in months between the change in the densities of the prey and the predator populations. Give your answer to the nearest tenth of a month.



1.6 months

92. The trophic level efficiency of large herbivores such as elks is frequently only about 5 percent. In tons, what volume of plants would be required to maintain 24,000 lbs of elk?

$$\frac{24000\text{lbs}}{0.05} = 480{,}000\text{lbs} \left| \frac{1\text{ton}}{2000\text{lbs}} \right. = \boxed{240\text{ tons}}$$

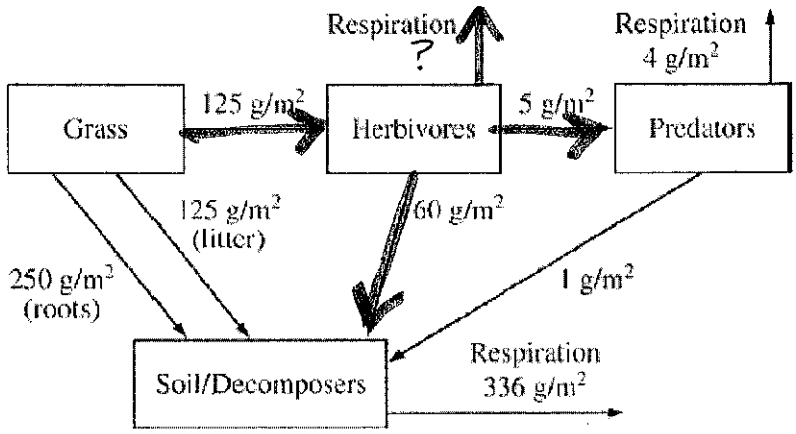
93. There are 2000 mice living in a field. If 1000 mice are born each month and 200 mice die each month, what is the per capita growth rate over a month? Round to the nearest tenths.

$$b - d = r$$

$$\frac{1000 - 200}{2000} = \frac{800}{2000} = \boxed{0.4}$$

94. How much carbon (in g/m^2) 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



$125\ g/m^2 - 60\ g/m^2 - 5\ g/m^2 - \text{Respiration}$

Respiration = $\boxed{60\ g/m^2}$

95. Ecologists often cannot count all the individuals in a population. In such cases, the mark-recapture method may be used to estimate population size. An ecologist wished to estimate the population of snapping turtles in an isolated farm pond. On the first trapping 19 turtles were caught and marked with a harmless mark on the top of the shell. Two weeks later a second trapping was conducted where 22 turtles were caught, of which 9 were marked using the formula

$N = sn/x$ $\quad s = 19 \quad n = 22 \quad x = 9$

where N = population size estimate, s = number of turtles marked in the first trapping, n = number of turtles caught in the second trapping, and x = number of turtles that were marked in the second trapping, what is the population estimate of snapping turtles to the nearest *hundredth*?

$N = \frac{19(22)}{9} = \boxed{46.44}$

96. On average, there is a 90 percent reduction of productivity for each trophic level. Based on this information, 10,000 pounds of grass should be able to support how many pounds of crickets?

$10{,}000 \times 90\% = \boxed{1000}$

97. The net primary productivity of a particular wetland ecosystem is found to be 8000 kcal/m^2. If respiration by the aquatic producers is 12,000 kcal/m^2 per year, what is the gross annual primary productivity for this ecosystem in kcal/m^2 per year? Round to the nearest whole number.

net = gross - respiration

8000 = gross - 12000

gross = 20000

98. 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.

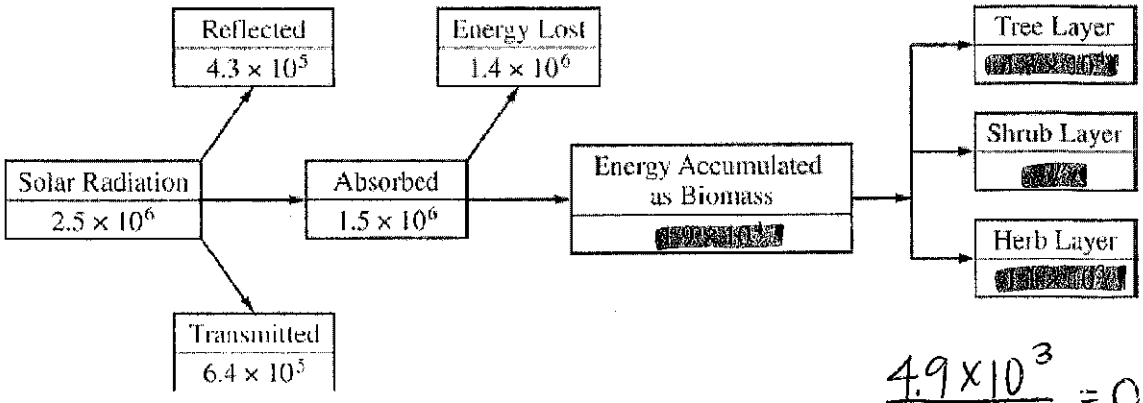
Researchers used the mark-recapture method to estimate the number of individuals in a population. Using the results presented in the table below, estimate the total number of individuals in the population. Give your answer to the nearest whole number.

	Number of Marked Individuals	**Total Number of Individual**
Recapture group	14	88
Entire population	180	?

$$\frac{14}{180} = \frac{88}{X} \rightarrow X = \frac{88(180)}{14} = 1131.4$$

1131

99. 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.



$1.9 \times 10^4 = 1.3 \times 10^4 + X + 1.1 \times 10^3$

$19 \times 10^3 - 13 \times 10^3 - 1.1 \times 10^3 = X$

$4.9 \times 10^3 = X$

$$\frac{4.9 \times 10^3}{19 \times 10^3} = 0.258$$

25%

Unit 7: Animal Systems

100. At this moment your heart is pumping about 70 mL of blood per heartbeat and your heart is beating at a rate of 72 beats per minute. How many liters of blood will you pump in the next hour? (Answer to the nearest tenth

$$\frac{1\ \text{hour}}{1\ \text{hR}} \left| \frac{60\ \text{min}}{1\ \text{min}} \right| \frac{72\ \text{beats}}{1\ \text{beat}} \left| \frac{70\ \text{mL}}{1000\ \text{mL}} \right| \frac{1\ \text{L}}{} = \boxed{302.4\ \text{L}}$$