

2007 USABO Semifinal Exam Answer Key – Parts A&B

1) D	23) B	45) A	67) C	89) C
2) D	24) B	46) D	68) C	90) E
3) C	25) A	47) E	69) C	91) B
4) E	26) B	48) D	70) D	92) B
5) C	27) A	49) B	71) D	93) D
6) D	28) A	50) E	72) C	94) B
7) E	29) B	51) A	73) A	
8) C	30) B	52) D	74) C	
9) C	31) C	53) B	75) E	
10) B	32) B	54) C	76) B	
11) C	33) D	55) B	77) D	
12) A	34) C	56) A	78) A	
13) B	35) C	57) D	79) C	
14) B	36) B	58) B	80) C	
15) C	37) C	59) B	81) D	
16) D	38) B	60) C	82) B	
17) E	39) C	61) C	83) E	
18) A	40) A	62) C	84) A	
19) C	41) D	63) B	85) B	
20) D	42) C	64) B	86) D	
21) C	43) C	65) D	87) A	
22) C	44) B	66) B	88) E	

1. In your research on alligators you find some alligators always seem to be angry while others are friendly. You study this trait and find it is inheritable and through repeated crosses find it is due to a single autosomal gene with angry (A) being completely dominant over friendly (a). You cross a homozygous angry alligator with a homozygous friendly alligator. You then cross an F1 generation angry, female alligator with an F1 generation angry, male alligator. What will be the phenotypic AND genotypic ratios of the resulting offspring? (2 points)

F1: Aa ♂ x Aa ♀

F2: genotypes: 1 AA, 2 Aa, 1 aa  
phenotypes: 3 angry, 1 friendly

2. As you continue your study of alligators you notice that oftentimes the angry alligators have long tails while the friendly alligators have short tails. In your study of this condition you find that the short-tailed phenotype is dominant while the long-tailed phenotype is recessive. You want to determine if tail length and attitude are linked.. You cross a true-breeding, angry, long-tailed male alligator with a true-breeding, friendly, female alligator to get an F1 progeny. You then cross your F1 generation and look at the results in the F2 generation. Use A to refer to the dominant attitude allele and a to refer to the recessive attitude allele. Use T to refer to refer to the dominant tail length allele and t to refer the recessive tail length allele. (12 points)

a) What were the genotypes of the parental generation? (2 point)

Male: AAtt Female: aaTT

b) What is(are) the genotype(s) of the F1 generation? (1 point)

AaTt

c) What is(are) the phenotype(s) of the F1 generation? (1 points)

Angry, short-tailed

d) What phenotypic ratio would you expect to see in the F2 generation if the traits are completely linked? (2 points)

1 angry long : 2 angry short : 1 friendly short

e) What phenotypic ratio would you expect to see in the F2 generation if the traits are not linked? (2 points)

9 Angry, short-tailed : 3 angry, long-tailed : 3 friendly, short-tailed : 1 friendly, long-tailed

f) What genotypic ratio would you expect to see in the F2 generation if the traits show complete linkage with no recombination? (2 points)

1 AAtt : 2 AaTt : 1 aaTT

g) What genotypic ratio would you expect to see in the F2 generation if the traits assort independently? (2 points)

1 AATT : 2 AATt : 1 AAtt : 2 AtTt : 4 AaTt : 2 Aatt ; 1 aaTT, 2 aaTt, 1 aatt

3. You decide that studying angry alligators is not a long-term career path for you and you decide to turn your attention to a much less hostile organism, the fruit fly. You begin another research project in a drosophila lab. Your advisor tells you that you have to count thousands of flies and you begin to wonder if alligators might be better after all. (10 points)

You are studying two genes known to be linked, wing shape and body color.

- a) If two genes are linked, where are they located in relation to one another in the genome? Please be precise. (2 points)

The two genes must be located on the same chromosome, and they must be found near one another (usually within 50 mp).

- b) Do two genes showing linked inheritance have to show a related function? Why or why not? (2 points)

No. The chromosomal location of genes in the genome is generally random and not dependent on function. In bacteria, genes with related functions are often organized into operons, but these coregulation sequences do not exist in higher organisms. Function is primarily related to coding, not position on the chromosome.

Rounded wings (R) are dominant over pointed wings (r) and black bodies (B) are dominant over brown bodies (b). You perform the following cross:

Male:  $\frac{R}{r} \frac{B}{b}$  X Female:  $\frac{r}{R} \frac{b}{B}$

- c) What are the expected genotypes and genotype ratios of the offspring if there is no recombination between these two loci? (2 points)

1  $\frac{R}{R} \frac{B}{B}$ , 2  $\frac{R}{r} \frac{B}{b}$ , 1  $\frac{r}{r} \frac{b}{b}$

- d) What are the expected phenotypes and phenotype ratios of the offspring if there is no recombination between these two genes? (2 points)

3 Round wing, black body, 1 Pointed wing, brown body

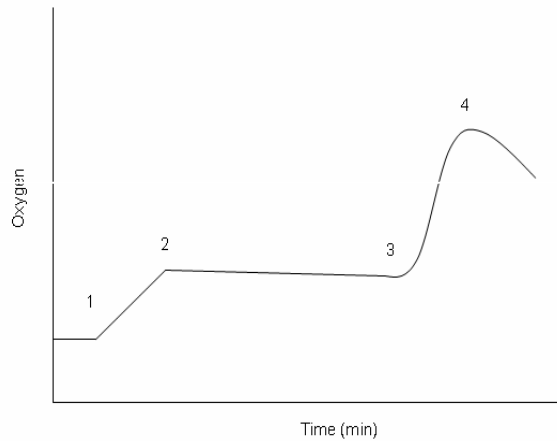
After you perform your cross, you get the following result:

725 Round wing, black body flies  
255 Pointed wing, brown body flies  
12 Round wing, brown body flies  
8 Pointed wing, black body flies

- e) What is the recombination frequency between wing shape and body color? Show your work. (2 points)

$\frac{\text{Recombinants}}{(\text{Parental} + \text{Recombinants})} = \frac{12 + 8}{((725+255)+(12+8))} = 2\%$

4. You and your partner are in lab. You use the oxygen probe to graph oxygen production in a photosynthesis experiment (see graph below). You are distracted and forget to record the order in which you change the chlorophyll solution conditions. (4 points)



- a) Which area on the graph (1, 2, 3, or 4) most likely corresponds to the point at which DCMU was added? Why? (2 points)

4 – DCMU inhibits Photosystem II by inactivating the plastoquinone-binding protein in the electron transport chain. This ultimately results in permanent reduction of the chlorophyll, cannot accept electrons from water, water is not split, and  $O_2$  is not released.

- b) Which area on the graph (1, 2, 3, or 4) most likely corresponds to the point at which  $NH_4Cl$  was added? Why? (2 points)

3 -  $NH_4Cl$  uncouples the electron transport chain from the electrochemical gradient, removing all negative feedback. This increases the speed at which  $O_2$  is released.

5. Compare and contrast a dicot root with the stem of that same plant placing the LETTER(S) of the correct contrasting member of a pair in the blanks provided in the following table. Terms may be used more than once or not at all. (5 points)

Character	Root	Stem
Pith	F	E
Primary xylem	B, H	A, G
Pericycle	E	F
Vascular tissue	H	G
Lateral appendages	C	D

- A. endarch origin ; B. exarch origin  
 C. endogenous ; D. exogenous  
 E. generally present ; F. generally absent  
 G. in bundles ; H. not in bundles

6. The Academic Coordinator for the USABO went to Indonesia as an educational consultant and was provided with a house as living quarters. Soon two geckos moved in with him and shortly thereafter a large cluster of eggs were noted. As a scientist, he observed the population over the next 7 months and found the results shown below (totals in each age category are rounded off for simplicity). (12.5 points)

Table 1 – Number of Geckos in age groups over time.

Month	Age category					Total N
	0 - 0.99	1 - 1.99	2 - 2.99	3 - 3.99	4 - 4.99	
1	1000	0	0	0	0	1000
2	0	1000	0	0	0	1000
3	0	0	1000	0	0	1000
4	200	0	0	200	0	400
5	800	200	0	0	0	1000
6	0	800	200	0	0	1000
7	40	0	800	40	0	880
8	320	40	0	160	0	520

- 1) Construct a life table giving  $x$ ,  $l_x$ ,  $b_x$ , and  $l_x b_x$  placing your calculations in the following table. (5 points)

Table 2 – Life table based on Gecko data in Table 1

Month	$x$	$l_x$	$b_x$	$l_x b_x$
1				
2				
3				
4				
5				

	$x$	$l_x$	$b_x$	$l_x b_x$
1	0	1	0	0
2	1	1	0	0
3	2	1	0.2	0.2
4	3	0.2	4	0.8
5	4	0	0	0

( $b_x$  sometimes notated as  $m_x$ )

- 2) If the investigator had stayed another month, what values would you expect to find for each age category in month 8? (fill out the last line of the projection matrix in Table 1). (1.5 points)

- 3) In the long term (over, say 100 months), will the Gecko population increase or decrease in size? (state which you think will occur) (0.5 point)

Neither – it will remain relatively stable

- 4) Provide a mathematical relationship that will support your answer to the above question. (1.5 points)

$$R_0 = \sum l_x b_x = 0.8 + 0.2 = 1.0$$

5) What type of survivorship curve does this population have? (2 point)

Type 1

6) Explain why you answered as you did in question 5). (2 points)

There is no juvenile mortality with rapid mortality in the last two age classes.

**END OF EXAM**

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## GENERAL COMMENTS ON PART C

In general, **it is important that students carefully follow instructions**. For example, two students put their answers to Part C on the back of their Scantron sheet which was an automatic zero for that section. For question 3e, the student is asked to **show their work**. By that, it meant show the calculations used to arrive at the answer. Some students did not do this. Although the math was extremely simple it was still necessary to follow instructions. For question #5, the chart of root and stem characteristics, the student was told to place the **LETTER** of the appropriate **contrasting pairs** in the blanks provided. Some students wrote in the choices themselves rather than the letter of the choice while others used the **same letter** for root and stem. Clearly the same letters are not contrasting. In the last question, #2) the student was told to “fill out the last line of the projection matrix in Table 1. The intent was for the student to place those numbers in the table. However, I determined this instruction was not as specific as it should have been, thus answers place in the space below 2) was accepted.

In regard to common errors, the one that was most prevalent for the genetics questions was the lack of recognition of what a **phenotypic ratio** and **genotypic ratio** consists of. The description or genotype without the relative numbers of each is not a ratio while the ratio with no descriptive terms or genotypes given is not a phenotypic or genotypic ratio; it is simply a ratio. In addition, in a test of this sort, and this applies to the International ABO as well, if a student works everything out in a Punnett square off to one side or on the back of the page, and then only gives a ratio in the answer space, they will receive no credit for the question. The grader will not count up the number of each phenotype or genotype given in the Punnett square. The answer must be complete.

In question 2 a phrase was inadvertently left out when the Microsoft copy was placed into the pdf format. At the end of the fifth line there should have been the phrase “short-tailed” following friendly,. However that should not have affected the answer as the students are told that study indicated “that oftentimes angry alligators have long tails while friendly alligators have short tails.” Not given information to the contrary, the student should have assumed the most logical possibility, which is that the friendly alligator probably has a short tail.

Question 3b asked the student to consider linkage in relation to function. Many simple said that just because genes are linked doesn't mean they have the same function. True, but **why**? If not linkage, then what does, in general, determine function.

The most difficult of Part C was question 6. It deals with population ecology, an area not generally studied in detail in AP Biology, and thus requires specific interest by the student in this area which would result in reading beyond Campbell. The completion of Table I involves noting that  $b_x$  was 0.2, then 4 so the next logical progression would be 8. Forty x 8 gives 320 for new births. The rest of the table can be completed by logically noting that there is a progression of a population downward through the age groups until group 5 when they fall to 0. thus month 8, age group 1-1.99 would be 40 (the number of individuals for month 7 category 0 – that for 2-2.99 would be 0 – that for age group 3 – 3.99 when mortality begins to occur would be to note that previous mortality was 1/5 of the population, thus 1/5 of 800 would be 160 – the last age group is 0 (all have died) for a total of 520.

Table 2 begins with  $x$ , the age categories which are 0...n, or 0, 1, 2, 3, 4, 5, for the months given.  $L_x$  represents survivorship – for age group 0 all are present thus survivorship is 1 – for age group 1 all are present so survivorship is again 1 – for age group 3 it is again 1 – for age group 4, 200 remain or 0.2 of the original – for age group 5 none remain so survivorship is 0.  $b_x$  (sometimes notated as  $m_x$ ) is new births – 0 in age group 1- 0 in age group 2 – 200 or 0.2 in age group 3 – 800 or four times that of the previous age group, so  $b_x$  is 4 – and 0 in age group 5. When these two are multiplied together  $l_x b_x$  is generated.

In answering question 3) it is necessary to first consider question 4) – to determine rate of increase one needs to consider that  $R_0 = \sum l_x b_x = 0.8 + 0.2 = 1$ . As this represents unity, the population is neither increasing nor decreasing.

A population with this type of life table is characteristic of a Type I population. This can be explained by the lack of infant mortality in the juvenile populations with a rapid die-off in the last two age classes.

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As always, I was very impressed by the performance of your students on this very rigorous examination. They are all winners and deserve to be congratulated. I am looking forward to working with our 20 finalists.

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