AP Biology Unit 1 Exam
2020-21
1.2

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Nicholas Chiang
Typed Signature (first and last name)

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	7.81	9.49	11.07	12.59	14.07	15.51
0.01	6.63	9.21	11.34	13.28	15.09	16.81	18.48	20.09

$\bar{x}$ = sample mean

n = sample size

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

o = observed results

e = expected results

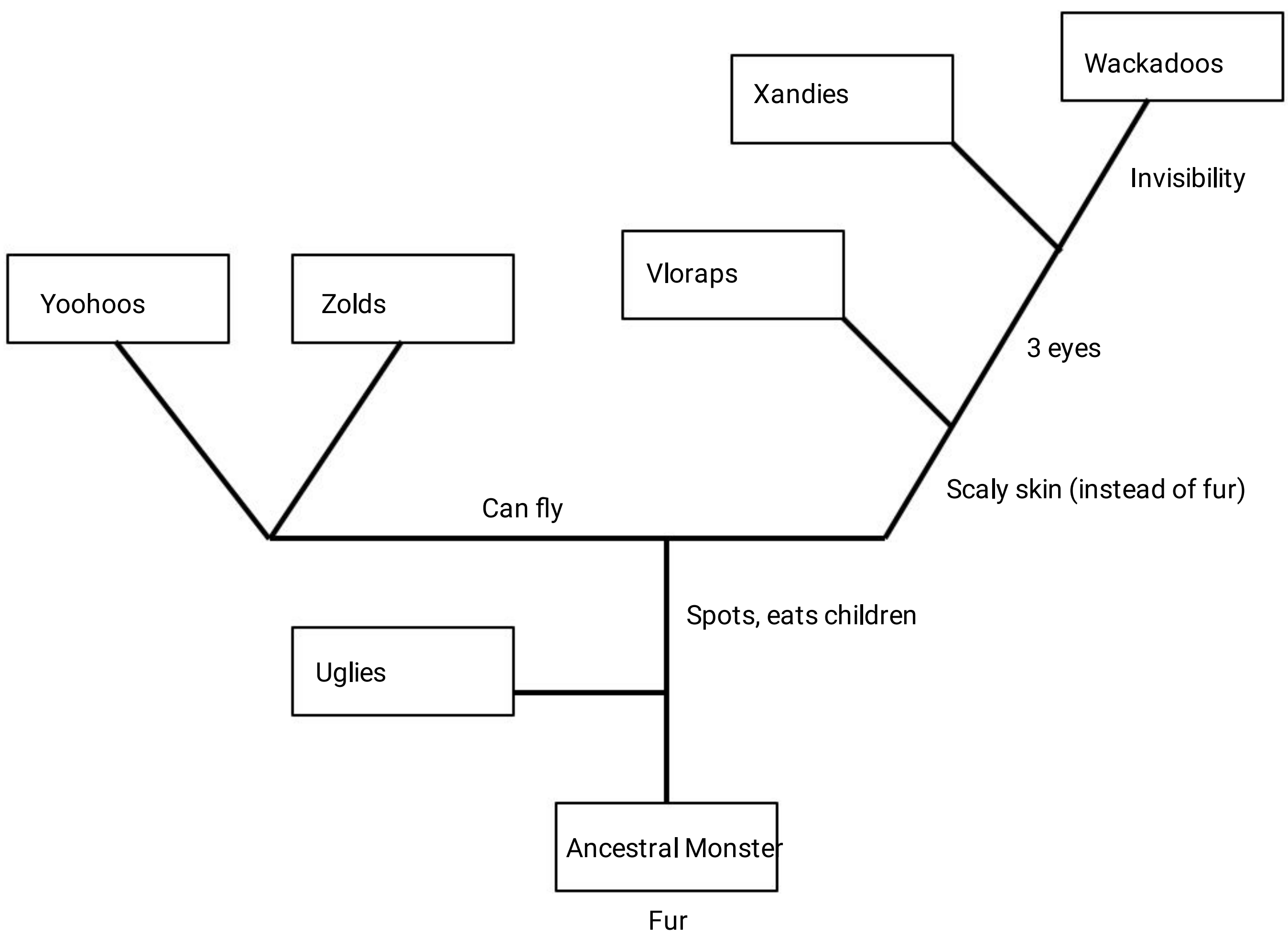
Σ = sum of all

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

AP Biology 2020-21
Unit 1 Test - Evolution

1. **Monster phylogeny:** Using the data below, fill in the phylogenetic tree. Place the monsters' names in the appropriate boxes, and clearly mark the precise location where each trait appears. (6 points)

	ancestral monster	**Uglies**	**Vloraps**	**Wackadoos**	**Xandies**	**Yoohoos**	**Zoids**
spots			x	x	x	x	x
scaly skin			x	x	x		
fur	x	x				x	x
3 eyes				x	x		
invisibility				x			
eats children			x	x	x	x	x
can fly						x	x



2. All human infants can metabolize lactose, but these metabolic genes are switched off during childhood and individuals become lactose intolerant later in life. However, certain populations have developed mutant "lactase persistence genes" that allow continued production of lactose metabolic enzymes throughout their life. Homozygous dominant and heterozygote individuals for the mutation are lactose tolerant, whereas homozygous recessive individuals are lactose intolerant. In California, the frequency of lactose tolerance genes (p) is 0.60, and lactose intolerance genes (q) is 0.40.

In a Gunn High School AP Biology class, 100 students tested their DNA for presence of lactose metabolism genes. Here is what they found:

55 students are homozygous dominant (AA), lactose tolerant
30 students are heterozygous (Aa), lactose tolerant
15 students are homozygous recessive (aa), lactose intolerant

Are the Gunn students' alleles in the same proportion as the state of California? Support your conclusion with a χ2 statistical analysis. Complete the table with the information requested.
HINTS: Every student has **two alleles** for this trait. Use **numbers of alleles**, not people or genotypes, in your calculations. *(10 pts)*

a. Null hypothesis:

The Gunn students' alleles are in the same proportion as the state of CA and thus we expect 36 students to be homozygous dominant (AA), 16 students to be homozygous recessive (aa), and 48 students to be heterozygous (Aa).

b. Calculate the χ2 sum, showing all your work. You may do this math on paper or use Kami functions to type/draw it out here. Draw a box around your answer. Insert a photo here if you did the work on paper:

② $p=0.6$, $q=0.4$, $p^2=0.36$, $q^2=0.16$, $2pq=0.48$
Thus, in 100 students, expect 36 homozygous dominant, 16 homozygous recessive, and 48 heterozygotes.

	observed	expected	$(o-e)^2/e$
homozygous dominant	55	36	10.03
homozygous recessive	15	16	0.0625
heterozygous	30	48	6.75

$\Sigma(o-e)^2/e = \boxed{16.8425}$

c. degrees of freedom:

2 degrees of freedom

d. p-value:

p-value at 16.84 for 2 degrees of freedom is less than 0.01

e. critical value:

Critical value at p = 0.05 for 2 degrees of freedom is 9.21

f. Use your numerical data to explain whether the results are significant.

The results are significant. Our chi-squared sum (at 16.84) was much greater than the critical value (p = 0.05) for 2 degrees of freedom (at 9.21). Instead, our chi-squared sum had a p-value of less than 0.01 (there was less than a 1% chance that these results would occur with our null hypothesis being true). Thus, we reject our null hypothesis; our data *was* the result of a phenomena.

g. Conclude whether Gunn's alleles appear in the same frequency as the rest of California.

No, Gunn's alleles **do not** appear in the same frequency as the rest of CA. Our null hypothesis has been rejected.

3. Show all calculations in the space below the problem, and box in your answer. You may type your work, or insert a photo of your neatly handwritten work. No credit is given if no work is shown!

a. In a mountain village there is a specific mutation that results in a rare type of albinism. This albinism is a recessive trait, and it affects 4 out of every 10,000 individuals in this community. **What is the allele frequency of the <u>dominant</u> gene?** (Assume Hardy-Weinberg equilibrium). *(3pts)*

$\Sigma(O-E)^2/E = 116.8425$

③ a) $q^2 = \frac{4}{10{,}000}$, $q = \sqrt{\frac{4}{10000}} = 0.02$

albinism is recessive trait $\quad p + q = 1 \rightarrow p + 0.02 = 1 \rightarrow \boxed{p = 0.98}$

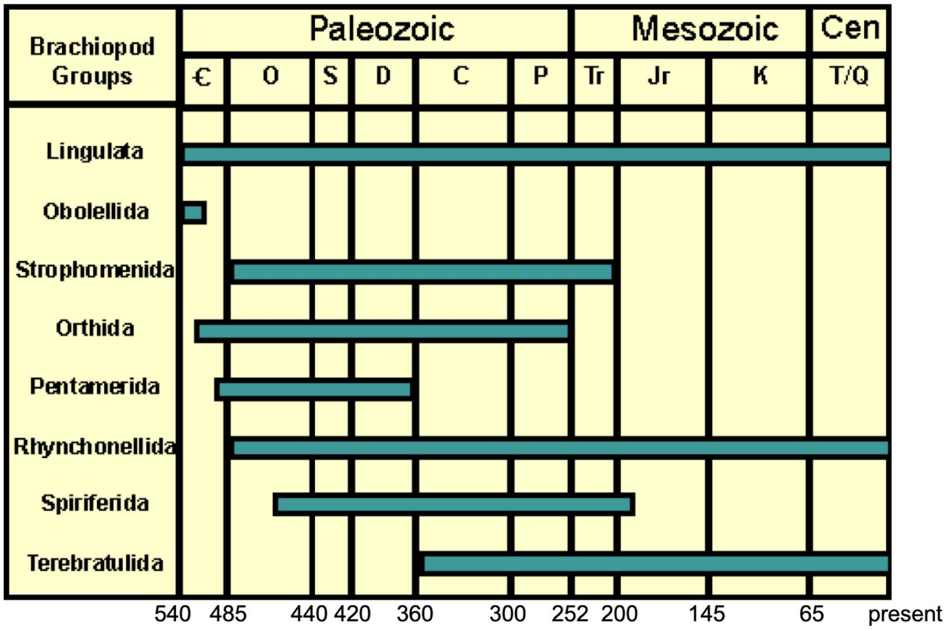
The allele frequency of the dominant gene is 0.98

b. Assume the total population of the aforementioned village is 950. **How many individuals are unaffected carriers (heterozygotes) of the albinism gene?** *(3pts)*

b) $2pq \rightarrow$ heterozygotes $\rightarrow 2(0.98)(0.02) = 0.0392$

$0.0392 \cdot 950$ people $= \boxed{37 \text{ unaffected carriers}}$

4. **Index fossils** are fossils used to define and identify geologic periods. They are distinctive and abundant, and existed for short, well-established ranges of time. This chart shows various important fossil species and the ages in which those animals lived (in millions of years ago, abbreviated mya).



Eureka! You think you've found a new extinct species embedded in limestone among these known types of brachiopods: **Orthida, Spiriferida, & Terebratulida**. Use the chart above to determine the approximate date range of your new species (in mya). Select the best choice from the date ranges given, and circle that answer. For the two choices that are NOT CORRECT, write a justification for why they are wrong in the box. You do not have to write a justification for the correct answer. *(3 pts)*

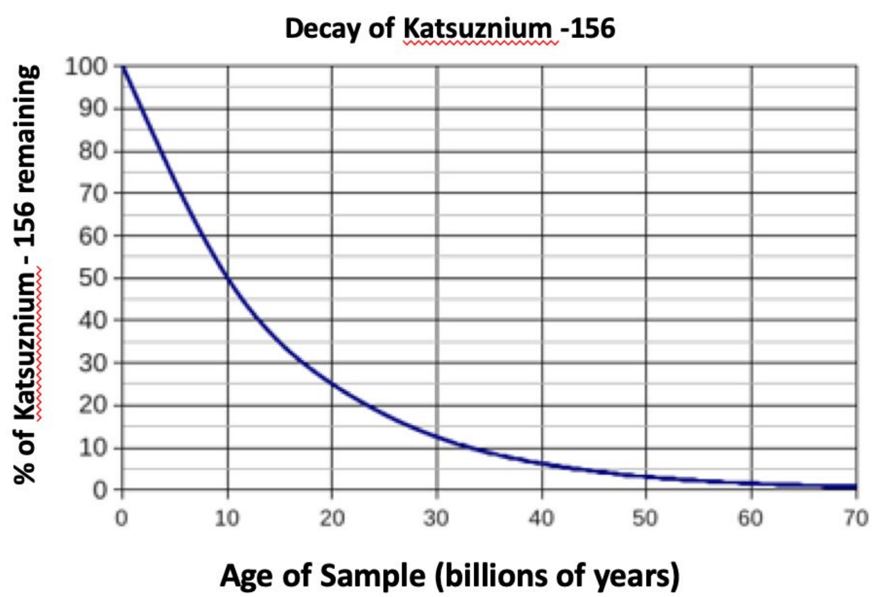
Possible date range of specimen (circle the one you think is correct)	Provide justification for why the wrong answers are wrong (leave blank for the correct answer)
Present-520 mya	Two of the three fossils (Orthida and Spiriferida) do not exist in the present. Thus, this **extinct** species cannot exist in the present (also, it's *extinct*).
250-360 mya	
190-500 mya	Orthida did not exist 190 mya. Terebratulida and Spiriferida did not exist 500 mya. Thus, this extinct species could not have been buried between those fossils if it had this date range (i.e. it can't have this date range *because* it was found between those three fossils).

Instructions: Circle the letter of the correct answer. For the two answers that are incorrect, write their letters in the table and justify why they are NOT correct. *(3 pts)*

5. Experimental evidence shows that the process of glycolysis is present and virtually identical in organisms from all three domains, Archaea, Bacteria, and Eukarya. Which of the following hypotheses could be best supported by this evidence?
    a. Glycolysis is a universal energy-releasing process, and therefore suggests a common ancestor for all forms of life.
    b. The presence of glycolysis as an energy-releasing process in all organisms suggests that convergent evolution occurred
    c. Archaea and Bacteria require more energy than Eukarya.

Incorrect letter choice	Why is this answer choice not correct?
B	Convergent evolution produces analogous structures that are similar in function but differ in underlying biochemistry. Glycolysis *is* biochemistry; it is the same in all organisms indicating that it was inherited from a common ancestor, not the result of convergent evolution.
C	The fact that glycolysis exists in all three domains has nothing to do with those domains' energy requirements. This answer is irrelevant and cannot be derived from the question's info.

6. Use this graph to answer the next two questions: *(4 pts)*



a. Based on this graph, what is the approximate half-life of Katsuznium-156?	a. Approx. 10 billion years
b. You have just discovered a fossil fish embedded in limestone. Your fossil contains 10% of Katsuznium-156 remaining. Approximately how old is your fish??	b. Approx. 33 billion years old

7. Given time and diverse environmental conditions, a group of organisms may evolve into a different species.
    a. **Define** and **explain** the biological concept of a species. *(2 pts)*
    b. **Define**, **explain**, and give a species-specific **example** of how TWO of the following mechanisms might contribute to speciation in organisms *(3 pts each, 6 pts total)*
        a. Habitat (ecological) isolation
        b. Temporal isolation
        c. Sympatry

A species is the largest group of organisms that mate to produce fertile offspring.

Temporal isolation occurs when organisms mate at different times. For example, certain species of toads can produce fertile offspring but are considered different species because one group mates in the early summer while the other mates during the late summer. Due to this time difference, the two groups of organisms will never mate with each other to produce fertile offspring (and thus are considered two different species).

Habitat (ecological) isolation occurs when two groups of organisms are in the same location, but occupy different habitats and thus do not meet each other to mate. For example, one species of frog might reproduce in fast moving streams while another species breeds in permanent, tranquil ponds. Those two species will never meet one another and mate. Thus, they are considered two different species.