2023 AP Daily: Practice Sessions

AP Biology

Session 3 – FRQ (Question 2: Interpreting and Evaluating Experimental Results with Graphing)

1. Malaria is a disease that is caused by the eukaryotic parasite *Plasmodium* and is transmitted between individuals by the bite of infected mosquitoes. Different species of *Plasmodium* cause disease in different vertebrate species, but in all cases the parasite infects and destroys red blood cells. The repeated emergence of drug-resistant strains of *Plasmodium* parasites responsible for human infections has caused researchers to continually search for new drugs or combinations of drugs that can provide an effective treatment. A drug that has proven effective in recent years is artesunate, but now artesunate-resistant *Plasmodium* strains have also appeared.

   Researchers investigated whether artesunate-resistant *Plasmodium* strains could be effectively treated by other drugs. In a mouse model of malaria, the researchers determined that a particular strain of artesunate-sensitive *Plasmodium* (ART-S) could be largely eliminated from the mice at a dose of 0.15 mg/kg. By repeated exposure of the artesunate-sensitive strain ART-S to increasing concentrations of artesunate, the researchers developed a *Plasmodium* strain that is highly resistant to artesunate (ART-R) and requires a minimum dose of 240 mg/kg to eliminate the parasites.

   The researchers then compared how effectively several common antimalarial drugs eliminate the ART-S and ART-R strains *in vitro*. The researchers infected human red blood cells with the ART-S and ART-R *Plasmodium* strains and incubated the infected cells in tissue culture medium. They added serial dilutions of the drugs to replicate cultures and determined the IC50 for each drug, the concentration of the drug that reduced the parasite load in the red blood cells by 50% (Table 1).

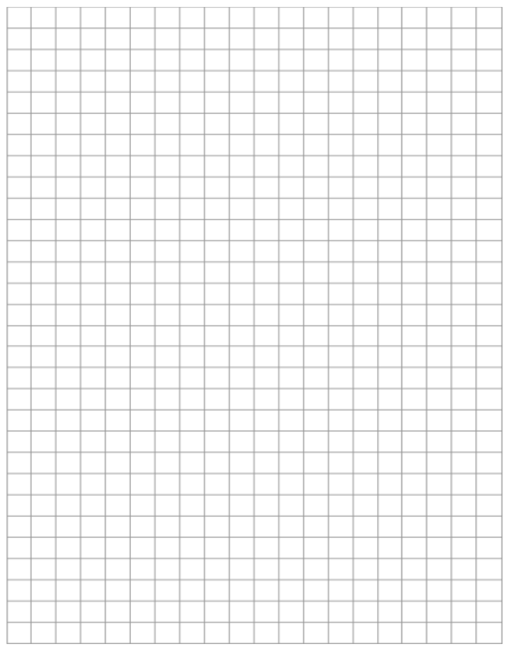
Table 1. IC50 for common antimalarial drugs tested on artesunate-sensitive (ART-S) and artesunate-resistant (ART-R) *Plasmodium* strains.

Drug	ART-S: $IC50 \pm 2SE_{\bar{x}}$ (nM)	ART-R: $IC50 \pm 2SE_{\bar{x}}$ (nM)
Amodiaquine	11.3 (0.8)	132.4 (16.9)
Chloroquine	50.1 (3.6)	53.0 (11.3)
DHA	13.8 (0.7)	49.5 (6.8)
Mefloquine	41.7 (2.7)	39.1 (5.4)
Quinine	49.7 (3.1)	216.9 (81)

Source: Topic Question; Taken from: AP Classroom

a. *Plasmodium* is an organism with both sexual and asexual life cycles. **Describe** the most likely cause of a heritable phenotypic change in some members of a population of asexually reproducing organisms. **Explain** how repeated exposure of the artesunate-sensitive *Plasmodium* strain to increasing concentrations of artesunate led to the development of the artesunate-resistant *Plasmodium* strain.

b. Using the template, **construct** an appropriately labeled graph to represent the data in Table 1. Based on the data, **determine** the antimalarial drugs that are likely to be significantly less effective at treating disease caused by the ART-R strain than by the ART-S strain.



c. Based on the data, **identify** the drug that, from the ART-S strain to the ART-R strain, has the largest relative increase in the IC50. Based on the information provided about the mouse model, **calculate** how many times more sensitive the original ART-S *Plasmodium* strain is to artesunate than is the ART-R strain.

d. In the mouse model of malaria, the researchers injected *Plasmodium*-infected human red blood cells into the mice because the *Plasmodium* species had surface ligand proteins that bound only to cell membrane proteins of human red blood cells. Assume that the researchers noticed that some of the parasites no longer infected human red blood cells but instead infected mouse red blood cells. **Predict** the most likely cause of this change in the host specificity of the parasites. *Plasmodium* reproduces both sexually in the host vertebrate and asexually in mosquitoes. The researchers claim that the *Plasmodium* organisms that infect the two different types of red blood cells are likely to evolve into two separate species of *Plasmodium*. Based on the biological species concept, **provide reasoning** that would support the researchers' claim.

2. Students in a class are studying patterns of inheritance using genes involved in determining the body color and wing shape of *Drosophila* flies. Each of the genes has only two alleles, one of which is completely dominant to the other.

   Each student in the class performed a parental cross between a fly that is true-breeding for ebony body and vestigial wings and a fly that is true-breeding for gray body and long wings. Each student then crossed several pairs of the F_1 flies and determined the phenotypes of 500 of the resulting F_2 flies with respect to body color and wing shape. The students in the class averaged their data for the frequencies of the four possible phenotypes (Table 1).

   Table 1. Averaged phenotypic data of F2 files.

Fly Phenotype	Number of Flies $\pm 2SE_{\bar{x}}$
Ebony body and long wings	98±10
Ebony body and vestigial wings	28±7
Gray Body and long wings	293±25
Gray body and vestigial wings	81±10

   The students performed a second cross. The parental cross was between flies that are true-breeding for gray bodies and long wings and flies that are true-breeding for ebony bodies and curly wings. They crossed pairs of F_1 flies and determined the phenotypes of the resulting F_2 flies. The students found an approximate 3:1 ratio of flies with the dominant phenotype (gray bodies and long wings) to flies with the recessive phenotype (ebony bodies and curly wings). Only a few of the flies expressed the dominant phenotype of one trait and the recessive phenotype of the other trait.

   a. In the first analysis, all of the F_1 flies from the students' crosses have the identical phenotype with respect to body color and wing shape, but the F_2 flies have four different phenotypes. **Describe** how fertilization contributes to this genetic variability.

   b. Using the template, **construct** an appropriately labeled graph, including error bars, to represent the data in Table 1. Based on the data in Table 1, **determine** whether there is a significant difference between the number of flies in each of the four phenotypes.

   c. Based on the data in Table 1, **describe** why the dominant alleles for body color and wing shape are the alleles that produce a gray body and long wings, respectively. Based on the data, **describe** why the two genes are most likely on different chromosomes or why they are most likely on the same chromosome. **Calculate** the probability of producing flies that have gray bodies and vestigial wings if a cross is performed between one of the F_1 flies from the first analysis and a fly that is homozygous for a gray body and vestigial wings.

   d. **Predict** the most likely cause of the F_2 ratio obtained by the students in the second analysis between parental flies that are true-breeding for gray bodies and long wings and flies that are true-breeding for ebony bodies and curly wings. **Provide reasoning** to justify your prediction.