

# FRQ Friday – 3/19

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2016 #7

2015 #4

2019 #3



# FRQ 2018 #4

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The common bedbug (*Cimex lectularius*) is a species of insect that is becoming increasingly resistant to insecticides. Bedbugs possess several genes suspected of contributing to the resistance, including *P450*, *Abc8*, and *Cps*. To investigate the role of these genes in insecticide resistance, researchers deleted one or more of these genes in different strains of bedbugs, as indicated in Figure 1, and treated the strains with the insecticide beta-cyfluthrin. Each strain was genetically identical except for the deleted gene(s) and was equally fit in the absence of beta-cyfluthrin. The percent survival of each strain following beta-cyfluthrin treatment is shown in Figure 1.

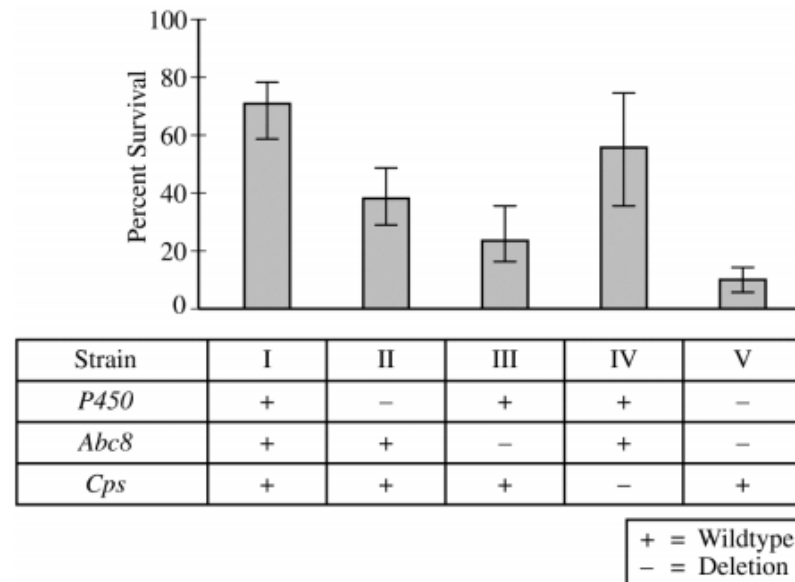


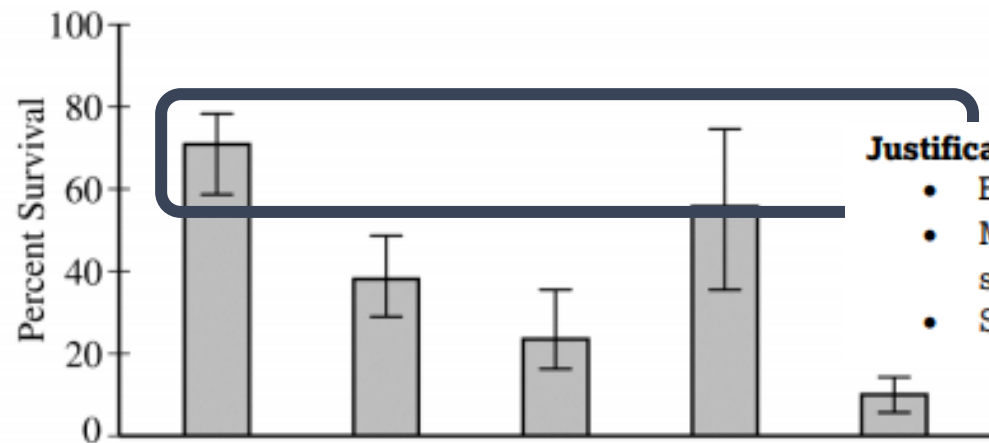
Figure 1. Percent survival of five strains of bedbugs treated with beta-cyfluthrin. A (+) indicates the gene is present; a (-) indicates the gene is deleted. Error bars represent the 95% confidence interval.



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(a) **Identify** the control strain in the experiment. Use the means and confidence intervals in Figure 1 to **justify** the claim that *Abc8* is effective at providing resistance to beta-cyfluthrin.



Strain	I	II	III	IV	V
<i>P450</i>	+	-	+	+	-
<i>Abc8</i>	+	+	-	+	-
<i>Cps</i>	+	+	+	-	+

+ = Wildtype  
- = Deletion

### Identification (1 point)

- Strain I

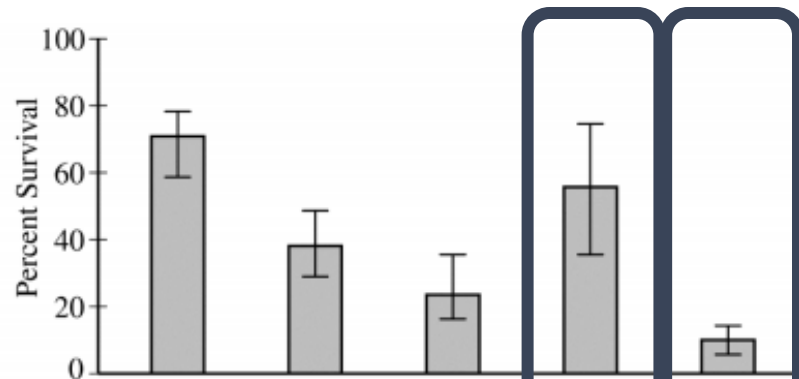
### Justification (1 point)

- Error bars/CIs from strain I/control/WT do not overlap with strain III/*Abc8* deleted strain.
- Mean % survival of strain III/*Abc8* deletion falls outside the 95% confidence interval of strain I/control/WT.
- Strain III/*Abc8* deletion shows a statistically significant difference from strain I/control.

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(b) *P450* encodes an enzyme that detoxifies insecticides. *Abc8* encodes a transporter protein that pumps insecticides out of cells. *Cps* encodes an external structural protein located in the exoskeleton that greatly reduces the absorption of insecticides. Based on this information and the data in Figure 1, explain how a deletion of both *P450* and *Abc8* results in lower survival in bedbugs compared with a deletion of *Cps* only.



Strain	I	II	III	IV	V
<i>P450</i>	+	-	+	+	-
<i>Abc8</i>	+	+	-	+	-
<i>Cps</i>	+	+	+	-	+

+ = Wildtype  
- = Deletion

Explanation (1 point per row; 2 points maximum)

Strain	<i>P450</i> and <i>Abc8</i>	<i>Cps</i> only	Explanation
V	Deleted	Present	Bedbugs can neither detoxify nor pump out insecticide, which results in a lower chance of bedbug survival.
IV	Present	Deleted	Bedbugs can detoxify and pump out insecticide, which results in a higher chance of bedbug survival.





# FRQ 2017 #3

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Gibberellin is the primary plant hormone that promotes stem elongation. GA 3-beta-hydroxylase (GA3H) is the enzyme that catalyzes the reaction that converts a precursor of gibberellin to the active form of gibberellin. A mutation in the *GA3H* gene results in a short plant phenotype. When a pure-breeding tall plant is crossed with a pure-breeding short plant, all offspring in the  $F_1$  generation are tall. When the  $F_1$  plants are crossed with each other, 75 percent of the plants in the  $F_2$  generation are tall and 25 percent of the plants are short.

		Second Base in Codon				
		U	C	A	G	
First Base in Codon	U	UUU } Phe UUC } UUA } Leu UUG }	UCU } UCC } Ser UCA } UCG }	UAU } Tyr UAC } UAA Stop UAG Stop	UGU } Cys UGC } UGA Stop UGG Trp	U C A G
	C	CUU } CUC } Leu CUA } CUG }	CCU } CCC } Pro CCA } CCG }	CAU } His CAC } CAA } Glu CAG }	CGU } CGC } Arg CGA } CGG }	U C A G
	A	AUU } AUC } Ile AUA } AUG Met or Start	ACU } ACC } Thr ACA } ACG }	AAU } Asn AAC } AAA } Lys AAG }	AGU } Ser AGC } AGA } Arg AGG }	U C A G
	G	GUU } GUC } Val GUA } GUG }	GCU } GCC } Ala GCA } GCG }	GAU } Asp GAC } GAA } Glu GAG }	GGU } GGC } Gly GGA } GGG }	U C A G

Figure 1. The universal genetic code

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- (a) The wild-type allele encodes a GA3H enzyme with alanine (Ala), a nonpolar amino acid, at position 229. The mutant allele encodes a GA3H enzyme with threonine (Thr), a polar amino acid, at position 229. **Describe** the effect of the mutation on the enzyme and **provide reasoning** to support how this mutation results in a short plant phenotype in homozygous recessive plants.

Recall, GA3H is the enzyme that catalyzes the conversion to active gibberellin which promotes stem elongation

<b>Description (1 point)</b>	<b>Reasoning (1 point)</b>
The amino acid substitution changes the shape/structure/function of the protein.	The mutation decreases/eliminates gibberellin production.





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(b) Using the codon chart provided, **predict** the change in the codon sequence that resulted in the substitution of alanine for threonine at amino acid position 229.

		Second Base in Codon				
		U	C	A	G	
First Base in Codon	U	UUU } Phe UUC } UUA } Leu UUG }	UCU } UCC } Ser UCA } UCG }	UAU } Tyr UAC } UAA Stop UAG Stop	UGU } Cys UGC } UGA Stop UGG Trp	U C A G
	C	CUU } CUC } Leu CUA } CUG }	CCU } CCC } Pro CCA } CCG }	CAU } His CAC } CAA } Gln CAG }	CGU } CGC } Arg CGA } CGG }	U C A G
	A	AUU } AUC } Ile AUA } AUG } Met or Start	ACU } ACC } Thr ACA } ACG }	AAU } Asn AAC } AAA } Lys AAG }	AGU } Ser AGC } AGA } Arg AGG }	U C A G
	G	GUU } GUC } Val GUA } GUG }	GCU } GCC } Ala GCA } GCG }	GAU } Asp GAC } GAA } Glu GAG }	GGU } GGC } Gly GGA } GGG }	U C A G
						Third Base in Codon

## Prediction (1 point maximum)

- G ↔ A in the first position (of the codon)
- 5'-GCN-3' ↔ 5'-ACN-3'
- 5'-NGC-3' ↔ 5'-NGT-3' in the template strand of DNA

Figure 1. The universal genetic code



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(c) **Describe** how individuals with one (heterozygous) or two (homozygous) copies of the wild-type *GA3H* allele can have the same phenotype.

## **Description (1 point)**

- Enough active enzyme is produced from one wild-type/dominant allele.
- Enough gibberellin is produced in the presence of one wild-type/dominant allele.





# FRQ 2019 #6

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The yeast *Saccharomyces cerevisiae* is a single-celled organism. Amino acid synthesis in yeast cells occurs through metabolic pathways, and enzymes in the synthesis pathways are encoded by different genes. The synthesis of a particular amino acid can be prevented by mutation of a gene encoding an enzyme in the required pathway.

A researcher conducted an experiment to determine the ability of yeast to grow on media that differ in amino acid content. Yeast can grow as both haploid and diploid cells. The researcher tested two different haploid yeast strains (Mutant 1 and Mutant 2), each of which has a single recessive mutation, and a haploid wild-type strain. The resulting data are shown in Table 1.

	MEDIUM	STRAINS		
		Wild Type	Mutant 1	Mutant 2
Treatment I	All amino acids present	+	+	+
Treatment II	No amino acids present	+	-	-
Treatment III	All amino acids present EXCEPT methionine	+	-	+
Treatment IV	All amino acids present EXCEPT leucine	+	+	-

Table 1. The data show the growth of haploid *Saccharomyces cerevisiae* yeast strains on media that differ in amino acid content. A plus sign (+) indicates that the yeast strains grow, and a minus sign (-) indicates that the strains do not grow.

# FRQ 2019 #6

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	MEDIUM	STRAINS		
		Wild Type	Mutant 1	Mutant 2
Treatment I	All amino acids present	+	+	+
Treatment II	No amino acids present	+	-	-
Treatment III	All amino acids present EXCEPT methionine	+	-	+
Treatment IV	All amino acids present EXCEPT leucine	+	+	-

(a) **Identify** the role of treatment I in the experiment.

## Identification (1 point)

- (Positive) control (for yeast growth).
- To test the viability of all yeast strains.
- Treatment I allows the researcher to be confident that changes in experimental outcome are due to differences in treatments.



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	MEDIUM	STRAINS		
		Wild Type	Mutant 1	Mutant 2
Treatment I	All amino acids present	+	+	+
Treatment II	No amino acids present	+	-	-
Treatment III	All amino acids present EXCEPT methionine	+	-	+
Treatment IV	All amino acids present EXCEPT leucine	+	+	-

(b) **Provide reasoning** to explain how Mutant 1 can grow on treatment I medium but cannot grow on treatment III medium.

## Reasoning (1 point)

- Mutant 1 can use methionine when it is present in the medium, but Mutant 1 cannot synthesize methionine.

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(c) Yeast mate by fusing two haploid cells to make a diploid cell. In a second experiment, the researcher mates the Mutant 1 and Mutant 2 haploid strains to produce diploid cells. Using the table provided, **predict** whether the diploid cells will grow on each of the four media. Use a plus sign (+) to indicate growth and a minus sign (-) to indicate no growth.

	MEDIUM	STRAINS			Diploid Cells Produced by Mating Mutant 1 and Mutant 2
		Wild Type (haploid)	Mutant 1 (haploid)	Mutant 2 (haploid)	
Treatment I	All amino acids present	+	+	+	+
Treatment II	No amino acids present	+	-	-	+
Treatment III	All amino acids present EXCEPT methionine	+	-	+	+
Treatment IV	All amino acids present EXCEPT leucine	+	+	-	+



Next FRQ Friday (3/26)

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2018 #4

2017 #3

2019 #6

