AP Biology

Sample Student Responses and Scoring Commentary

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AP® BIOLOGY 2017 SCORING GUIDELINES

Question 3

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

Figure 1. The universal genetic code

(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 a 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. (2 points)

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

(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. **(1 point)**

Prediction (1 point maximum)

- $G \leftrightarrow A$ in the first position (of the codon)
- 5'-GCN-3' ↔ 5'-ACN-3'
- 5'-NGC-3' \leftrightarrow 5'-NGT-3' in the template strand of DNA
- (c) **Describe** how individuals with one (heterozygous) or two (homozygous) copies of the wild-type GA3H allele can have the same phenotype. (1 point)

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.

3. 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 F₁ generation are tall. When the F₁ plants are crossed with each other, 75 percent of the plants in the F₂ generation are tall and 25 percent of the plants are short.

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PAGE FOR ANSWERING QUESTION 3

a) The change from a nonpolar amino acid to
a polar amono acid (thr) disrupts the structure
of the enzyme (terriary structure). Because the
molecule is non charged, weak interactions (such

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occur between the amino acid and other polar amino acids (will be attracted to each other, thus attermy the folding of the protein). If the folding and twisting of the enzyme is changed, the active site with change and the precureor to gib beralin won't be able to bind and convert to the active form of gibborethin. This means theat stem elongation will not be promoted due to decreased amounts of the active form of gibborethin. 5) G.C.A to A.C.A (replace first mattered a with a A base). C) The G. and wild type GiBit could be dominant to the mutant allete, so the wild-type gene in a heterozygous plant could be expressed rather than the mutant gene. In a homozygous wild-type, the wild-type gene would be expressed as well. Both heterozygous and homozygous would be capte to protest gibberethins to promote stem ewn gation, resulting in the Same phenotype.	as van der wards extratego interactions) will
amino acids (will be attracted to each other, thus aftering the folding of the protein). If the folding and twisting of the enzyme is changed, three active site will change and the precursor to gib berdlin won't be able to bind and convert to the active to mot gibborellin. This means that stem elongation will not be promoted due to decrased amounts of the active form of gibborellin. b) GCA to ACA (replace first mediate G with a A base). c) The Godf wild-type GA3H could be dominent to me mutant allete, so the wild-type gene in a heterozygous plant could be expressed rather than the mutant gene. In a hemozygous wild-dype, the wild-type gene would be expressed as well. Both heterozygous and homozygous would beable to protect gibborellins to promote stem evengation,	
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decreased amounts of the active form of gibberellin. b) GCA to ACA (replace first metalities G with a A base). c) The Godf wild-type GR3H could be dominent to me metant allete, so the wild-type gene in a heterozygous plant could be expressed rather than the metant gene. In a homozygous wild-type, the wild-type gene would be expressed as well. Both heterozygous and homozygous would be caple to promote stem elengation,	Stem elongation will not be promoted due to
gibberellin. b) Gica to Aca (replace first motioned G with a A base). c) The Godf wild-type Girst could be dominent to the mutant allete, so the wild-type gene in a heterozygous plant could be expressed rather than the mutant gene. In a homozygous wild-type, the wild-type gene would be expressed as well. Both heterozygous and homozygous would beable convert gibberellins to promote stem elongation,	decrased amounts of the active form of
c) The Gasti wild-type G1R31t could be dominent to the mutant allete, so the wild-type gene in a heterozygous plant could be expressed rather than the mutant gene. In a homozygous wild-type, the wild-type gene would be expressed as well. Both heterozygous and homozygous would be able to promote stem ewngation,	gibheretlin.
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than the mutant gene. In a homozygous wild- type, the wild-type give would be expressed as well. Both heterozygous and homozygous would be able to promote gibberellins to promote stem elongation,	
type, the wild-type give would be expressed as well. Both heterozygous and homozygous would be able to promote stem ewngation,	
to promote stem ewngation,	
well. Both heterozygous and homozygous would beable to promote stem elingation, resulting in the same phenetype.	type, the wild-type give would be expressed as
to promote stem elingation, resulting in the same phenotype.	well. Both heterozygous and homozygous would beable
resulting on the same phenotype.	to promote stem elongation,
	resulting in the same phenetype.

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PAGE FOR ANSWERING QUI	STION 3
20 this muta	ton would result in the enzyme
not being a	ble to catay ze the ocum that
conserva a	preamor of gibberellin to the active
from of	gibberelling so the mulation would ultimately
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ADDITIONAL PAGE FOR ANSWERING QUESTION 3
result in a short plant phenotype. The enzyme's
shape could be changed affecting its function
- since proteins nock through induced tot. The order
of coding and nuteindes affect the resulting
protein.
36. The first base in the coden changed to an
a 6 to an A as a smilt of a point
mmahin.
31. They can have the same phenotype if the
GASH WID type GASH allele is completely
dominant for the recessive allele. The
phenshipe is the give being represented
physically or usually Complete dannance "
the closure allele is the one that
shown The dominant allele is the one that
I expressed wer the recessive allele.

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			QUESTION 3						
a	The	Mu	utation	cha.	ngls	the	amino	acid	
Se	anenc	e '	Mich	alter	r th	e fr	nction	o F	the
ent	zy me	it	creates	The	ma	tatio	n alte	red a	ι
0)1	row t	lye	entr	me	which	h th	en de	RECHIPAL TO THE PARTY OF THE PA	led

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ADDITIONAL PAGE FOR ANSWERING QUESTION 3
to short height being a Albansona a homozygou
reccesiu phenotype.
b. Insted of producing Ala by having GL-
for the colon the mutaled enzyme product the
which has AC- as its codon. So a substitution
between bank A resulted in the mytation.
c Tall plants are dominant over small plants
which means that Aa has both alleler,
but expresses a full phenotype because fall is
but expresses a full phenotype because fall is dominant So two plants could have the
genotypes of Aa and AA, and still have
the same phinotope of being tall.
•

AP® BIOLOGY 2017 SCORING COMMENTARY

Question 3

Overview

This question focused on the genetics behind the inheritance of stem growth in plants. Students were presented with a description of the role of the plant growth hormone gibberellin in stem elongation and an explanation of how the presence of GA3H, an enzyme, results in the biochemical synthesis of gibberellin. Students were then provided with a description of a cross between GA3H wild type and GA3H mutant plants and the outcome of the cross, as well as a description of a specific amino acid substitution that occurred in the GA3H mutant enzyme. Students were also supplied with a genetic code chart. Students were asked to describe the effect of the mutation on the enzyme and to provide reasoning to support the observed results from the cross. Then the students were asked to predict the change in the codon sequence that resulted in the change in the amino acid sequence of the enzyme. Students were also asked to describe how both individuals who are heterozygous and individuals who are homozygous for the wild type GA3H allele could have the same phenotype.

Sample: 3A Score: 4

The response earned 1 point in part (a) for describing that the change in amino acid sequence disrupts the structure of the enzyme. The response earned 1 point in part (a) for providing reasoning that the enzyme won't be able to bind and convert gibberellin to the active form. The response earned 1 point in part (b) for predicting that the sequence changes from GCA to ACA. The response earned 1 point in part (c) for describing that the wild-type gene in a heterozygous plant could be expressed and would be able to convert gibberellins to promote stem elongation

Sample: 3B Score: 3

The response earned 1 point in part (a) for providing reasoning that the mutation would result in the enzyme not being able to catalyze the reaction that converts a precursor of gibberellin to the active form of gibberellin. The response earned 1 point in part (a) for describing that the enzyme's shape changed. The response earned 1 point in part (b) for predicting that the first base in the codon changed from a G to an A.

Sample: 3C Score: 2

The response earned 1 point in part (a) for describing that the mutation alters the function of the enzyme. The response earned 1 point in part (b) for predicting that codon will change from a GC- to an AC-.