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# AP Biology

## Sample Student Responses and Scoring Commentary

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#### **Free Response Question 8**

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# AP<sup>®</sup> BIOLOGY

## 2018 SCORING GUIDELINES

### Question 8

Acetylcholine receptor (AChR) proteins are found at the synapse between neurons and skeletal muscle cells. Acetylcholine released from neurons binds to a specific site on the receptor proteins, which causes an ion channel in the receptors to open and allow sodium ions ( $\text{Na}^+$ ) to enter muscle cells. The resulting depolarization of muscle cells initiates muscle contractions. Another molecule, nicotine, can also bind to certain types of AChR proteins and activate the receptors.

A researcher is investigating two different types of AChR proteins: type 1 and type 2. To determine which stimuli activate the receptors, the researcher exposes muscle cells expressing the different types of receptor proteins to stimuli and observes the results indicated in Table 1.

TABLE 1. RESPONSE OF AChR PROTEINS TO DIFFERENT STIMULI

AChR Protein Type	Acetylcholine	Nicotine
Type 1	+	+
Type 2	+	-

+ indicates activation  
- indicates no activation

(a) **Describe** the difference in the structure AND function between AChR type 1 and AChR type 2.

**Description (2 points)**

Points may be earned from only one row.

Structure (1 point maximum)	Function (1 point maximum)
Binding sites differ in shape/specificity/number	<ul style="list-style-type: none"> <li>• Differential binding of molecules to type 1 and type 2 receptors</li> <li>• Activated by one (ACh) molecule or both (ACh and nicotine) molecules</li> <li>• No difference in response (both open channels OR both result in depolarization OR both cause muscle contraction)</li> </ul>
Differential binding of molecules to type 1 and type 2 receptors	<ul style="list-style-type: none"> <li>• Activated by one (ACh) or both (ACh and nicotine) molecules</li> <li>• No difference in response (both open channels OR both result in depolarization OR both cause muscle contraction)</li> </ul>
Receptors activated by one (ACh) or both (ACh and nicotine) molecules	<ul style="list-style-type: none"> <li>• No difference in response (both open channels OR both result in depolarization OR both cause muscle contraction)</li> </ul>

(b) Acetylcholinesterase is an enzyme that breaks down acetylcholine in the synapse. **Describe** the effect of inhibiting acetylcholinesterase on the muscle cells with AChR type 2.

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**2018 SCORING GUIDELINES**

**Question 8 (continued)**

**Description (1 point)**

- Continued activation
- Repeated opening of sodium channels OR repeated depolarization OR muscle spasms

8A

8.e Acetylcholine receptor (AChR) proteins are found at the synapse between neurons and skeletal muscle cells. Acetylcholine released from neurons binds to a specific site on the receptor proteins, which causes an ion channel in the receptors to open and allow sodium ions ( $\text{Na}^+$ ) to enter muscle cells. The resulting depolarization of muscle cells initiates muscle contractions. Another molecule, nicotine, can also bind to certain types of AChR proteins and activate the receptors.

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- (b) Acetylcholinesterase is an enzyme that breaks down acetylcholine in the synapse. Describe the effect of inhibiting acetylcholinesterase on the muscle cells with AChR type 2.

PAGE FOR ANSWERING QUESTION 8

a) AChR Type 1 ~~can be~~ has two binding sites, and can be activated by both Acetylcholine and Nicotine. AChR Type 2 only has one binding site, and can only be activated by Acetylcholine.

b) If acetylcholinesterase is inhibited in muscle cells with type 2, the cells will be unable to break down the Acetylcholine molecule. This will cause the receptor proteins to be constantly stimulated, forcing the  $\text{Na}^+$  ion channels to stay open. Since the opening of the  $\text{Na}^+$  channels causes muscle contractions, the inhibition of acetylcholinesterase would force repeated muscle contractions without end, akin to a seizure.

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8. Acetylcholine receptor (AChR) proteins are found at the synapse between neurons and skeletal muscle cells. Acetylcholine released from neurons binds to a specific site on the receptor proteins, which causes an ion channel in the receptors to open and allow sodium ions ( $\text{Na}^+$ ) to enter muscle cells. The resulting depolarization of muscle cells initiates muscle contractions. Another molecule, nicotine, can also bind to certain types of AChR proteins and activate the receptors.

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PAGE FOR ANSWERING QUESTION 8

a) AChR type 1 has both receptors for Acetylcholine and nicotine. These are neurons in the brain because nicotine affects brain activity. AChR type 2 have only the Acetylcholine receptor so it is a skeletal muscle cell.

b) Since acetylcholine controls depolarization which initiates muscle contractions, inhibiting acetylcholinesterase would make muscles spasm out frequently.

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PAGE FOR ANSWERING QUESTION 8

AChR Type 1 proteins are activated in the presence of both acetylcholine and nicotine, while AChR Type 2 proteins are activated only in the presence of acetylcholine, not nicotine.

Inhibiting acetylcholinesterase will lead to a decrease in breakdown of acetylcholine in the synapse, which will inhibit activation of AChR Type 2 proteins, which will inhibit the entry of Na<sup>+</sup> into muscle cells with AChR Type 2, which will inhibit these muscles from contracting.

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## 2018 SCORING COMMENTARY

### Question 8

#### Overview

This question focused on molecular interactions at a neuromuscular junction. Students were provided with information on acetylcholine receptor (AChR) proteins and the series of events that occurs upon the binding of acetylcholine to an AChR. A data table showed the results of an investigation that exposed two types of AChR proteins (type 1 and type 2) to two different stimuli. Students analyzed the data to describe a structural and functional difference between the two AChR proteins. Information was given about the action of acetylcholinesterase, and the students were asked to describe the effect of inhibiting the enzyme on muscle cells with type 2 AChR proteins.

The key understandings and skills students were expected to demonstrate included the following:

- The relationship between structure and function was used to describe the activation of a specific signaling system and transmission of a signal in the nervous system.
- Data analysis was used to describe molecular interactions.
- Reasoning skills were needed to predict how inhibition of a pathway will alter the propagation of a signal.

#### Sample 8A

##### Score: 3

The response earned 1 point in part (a) for describing that a difference in structure between AChR type 1 and AChR type 2 is AChR type 1 has two binding sites, but AChR Type 2 has one binding site. The response earned 1 point in part (a) for describing that a difference in function between AChR type 1 and AChR type 2 is AChR type 1 can be activated by both acetylcholine and nicotine, but AChR type 2 can only be activated by acetylcholine. The response earned 1 point in part (b) for describing the effect of inhibiting acetylcholinesterase as “repeated muscle contractions.”

#### Sample: 8B

##### Score: 2

The response earned 1 point in part (a) for describing that a difference in structure between AChR type 1 and AChR type 2 is AChR type 1 “has both receptors for acetylcholine and nicotine,” but AChR type 2 “has only the Acetylcholine receptor.” The response earned 1 point in part (b) for describing the effect of inhibiting acetylcholinesterase as making the “muscles spasm.”

#### Sample: 8C

##### Score: 1

The response earned 1 point in part (a) for describing that a difference in function between AChR type 1 and AChR type 2 is “AChR type 1 proteins are activated in the presence of both acetylcholine and nicotine, while AChR type 2 proteins are activated only in the presence of acetylcholine, not nicotine.”