AP® BIOLOGY
2015 SCORING GUIDELINES

Question 7

Smell perception in mammals involves the interactions of airborne odorant molecules from the environment with receptor proteins on the olfactory neurons in the nasal cavity. The binding of odorant molecules to the receptor proteins triggers action potentials in the olfactory neurons and results in transmission of information to the brain. Mammalian genomes typically have approximately 1,000 functional odorant-receptor genes, each encoding a unique odorant receptor.

(a) **Describe** how the signal is transmitted across the synapse from an olfactory sensory neuron to the interneuron that transmits the information to the brain.

Description (1 point)

- Neurotransmitters are released from the olfactory neuron and bind to receptors in the postsynaptic neuron.

(b) **Explain** how the expression of a limited number of odorant receptor genes can lead to the perception of thousands of odors. Use the evidence about the number of odorant receptor genes to **support** your explanation.

Explanation and support (2 points maximum: points may be earned from only one row)

	Explanation (1 point)	**Support (1 point)**
Molecular	• One odorant molecule can be recognized by more than one odorant receptor • One odorant receptor can bind to more than one odorant molecule	Mathematical combinations expand possible odors detected
CNS Control	Signals integrated in the brain	Multiple interactions among neurons in the brain
Genetic	Alternate processing/splicing (of pre-mRNA/primary transcript)	Multiple receptors can be produced from a gene

7 A,

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   (a) **Describe** how the signal is transmitted across the synapse from an activated olfactory sensory neuron to the interneuron that transmits the information to the brain.

   (b) **Explain** how the expression of a limited number of odorant receptor genes can lead to the perception of thousands of odors. Use the evidence about the number of odorant receptor genes to **support** your answer.

PAGE FOR ANSWERING QUESTION 7

a. When an action potential reaches a synapse, it triggers the opening of gated calcium channels, and calcium flows into the synapse. Influx of calcium stimulates the formation of vesicles around neurotransmitters to perform exocytosis and release neurotransmitters in the synapse. These neurotransmitters from the sensory neuron then bind to the receptors of sodium channels at the dendrites of the interneuron. This depolarizes the postsynaptic neuron's membrane because sodium rushes in, which leads to the formation of an action potential in the interneuron so it can transmit the information to the brain.

b. A small number of genes can lead to the perception of thousands of orders through alternative splicing during post-transcriptional modification. Once a pre-mRNA transcript is transcribed, a spliceosome removes noncoding introns and splices together the remaining exons, but these can be put together in multiple combinations to be made into different odor receiving proteins.

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7B,

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(b) **Explain** how the expression of a limited number of odorant receptor genes can lead to the perception of thousands of odors. Use the evidence about the number of odorant receptor genes to **support** your answer.

PAGE FOR ANSWERING QUESTION 7

a. The signal trigger the release of neurotransmitter by the olfactory neuron into the synapse between the axon terminals of the olfactory neuron and the dentrites of the interneuron. Then, signal receptors in the dentrites of the interneuron receive the neurotransmitters, when enough neurotransmitter bind to the receptors, it induce the opening of ion gated channel in the dentrites, resulting in action potential in the interneuron that then transmits the information to the brain.

b. As there is a complex system of neurons each relaying messages to the brain, a combination of signals brought about by the limited number of odorant receptor gene expression can results in a miracle of different receiving receptors of odors. Thus, the combination of signals from olfactory neurons due to the expression of the limited number of

7B2

ADDITIONAL PAGE FOR ANSWERING QUESTION 7

gene results in the sensing of odors perceived by the brain.

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7C

7. Smell perception in mammals involves the interactions of airborne odorant molecules from the environment with receptor proteins on the olfactory neurons in the nasal cavity. The binding of odorant molecules to the receptor proteins triggers action potentials in the olfactory neurons and results in transmission of information to the brain. Mammalian genomes typically have approximately 1,000 functional odorant-receptor genes, each encoding a unique odorant receptor.

   (a) **Describe** how the signal is transmitted across the synapse from an activated olfactory sensory neuron to the interneuron that transmits the information to the brain.

   (b) **Explain** how the expression of a limited number of odorant receptor genes can lead to the perception of thousands of odors. Use the evidence about the number of odorant receptor genes to **support** your answer.

PAGE FOR ANSWERING QUESTION 7

a. The signal is released from the sensory neuron's synapse terminals ~~dendrites~~ into the synapse gap. The interneuron contains target receptors on its dendrites that pick up the neurotransmitter.

b. Although only a limited number of odorant receptor genes are expressed at a time, the mammalian genome has a total of around 1000 different ones. Therefore, different smells can trigger different sensory neurons that will ultimately activate one of those genes in order for the mammal to perceive a smell.

AP® BIOLOGY
2015 SCORING COMMENTARY

Question 7

Question 7 was written to the following Learning Objectives in the AP® Biology Curriculum Framework: 3.43, 3.44, 3.46, and 4.22.

Overview

This question focused on the structure and function of olfactory neurons and on the transmission and integration of sensory information to the brain. Students were asked to describe how signals are transmitted across a synapse from an olfactory sensory neuron to an interneuron. Students were then asked to explain how the expression of a limited number of odorant receptor genes could lead to the perception of thousands of odors. Students were finally asked to use evidence about the total number of odorant receptor genes to justify their response.

Sample: 7A
Score: 3

The response earned 1 point in part (a) for describing that neurotransmitters are released into the synapse and subsequently bind to receptors of the interneuron.

The response earned 1 point in part (b) for explaining that alternative splicing during post-transcriptional modification will increase the number of receptors, leading to the perception of thousands of odors. The response earned 1 point for supporting the answer by stating that multiple spliced combinations can produce many odor receiving proteins.

Sample: 7B
Score: 2

The response earned 1 point in part (a) for describing the release of the neurotransmitter into the synapse and the subsequent binding of the neurotransmitter by the receptors on the interneuron.

The response earned 1 point in part (b) for supporting the answer by stating that a complex system of neurons relays messages to the brain through a combination of signals.

Sample: 7C
Score: 1

The response earned 1 point in part (a) for describing that the neurotransmitter is released from the sensory neuron and is picked up by the receptors on the interneuron.