

AP[®] BIOLOGY
2006 SCORING GUIDELINES

Question 4

The evolution of circulatory systems allowed larger and more-complex animals to arise.

- (a) **Describe** the respiratory and digestive systems' specialized structures that facilitate the movement of oxygen and glucose into the circulatory system of mammals. **(4 points maximum)**

Oxygen Uptake (2 points maximum)

Glucose Uptake (2 points maximum)

<ul style="list-style-type: none"> • Alveoli/air sacs <p><u>Description of structures</u></p> <ul style="list-style-type: none"> • Grape-like clusters • Large surface area in lungs or alveoli • Thin-walled • Moist lungs or alveoli • Proximity to capillaries 	<ul style="list-style-type: none"> • Villi/microvilli/plicae <p><u>Description of Structures</u></p> <table style="width: 100%; border: none;"> <tr> <td style="width: 50%; vertical-align: top;"> <ul style="list-style-type: none"> • Single cell layer • Increased surface area • Associated with capillaries • Villi are finger-like projections • Enzymes related to carbohydrate digestion hydrolyze polymers to monomers (amylase, maltase, sucrase, lactase). </td> <td style="width: 50%; vertical-align: top;"> <ul style="list-style-type: none"> • Plicae are folds (of submucosa) • Microvilli are hair-like projections (of cells) </td> </tr> </table>	<ul style="list-style-type: none"> • Single cell layer • Increased surface area • Associated with capillaries • Villi are finger-like projections • Enzymes related to carbohydrate digestion hydrolyze polymers to monomers (amylase, maltase, sucrase, lactase). 	<ul style="list-style-type: none"> • Plicae are folds (of submucosa) • Microvilli are hair-like projections (of cells)
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- (b) **Explain** how oxygen and glucose are transported within the circulatory system of mammals. **(4 points maximum)**

Oxygen Transport (3 points maximum)

Glucose Transport (1 point maximum)

<ul style="list-style-type: none"> • RBC or Hemoglobin (oxyhemoglobin) attachment to oxygen • Description of structure of RBC (biconcave, no nucleus or mitochondria) as related to oxygen transport OR Description of hemoglobin, e.g., iron, quaternary structure, number of O₂ molecules bound • Cooperative binding (increased affinity as each molecule binds) • Small percent dissolved in plasma • 4-chambered heart allows separation of oxy/deoxy blood 	<ul style="list-style-type: none"> • Dissolved in blood or carried in plasma (NOT merely "carried in blood") • Explanation of small percent attached to Hb or other proteins, e.g., glycoproteins
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- (c) **Explain** the transfer of oxygen and glucose from the blood and into the active cells of mammals. **(4 points maximum)**

Oxygen Transfer (2 points maximum)

Glucose Transfer (2 points maximum)

<ul style="list-style-type: none"> • (Simple) diffusion/down a concentration gradient • Bohr effect described (↓pH, ↑CO₂ causes dissociation) • Pathway—hemoglobin, plasma, leaky capillary, interstitial fluid, cell membrane • Description of membrane permeability, e.g., phospholipid bilayer and small molecules, polarity • Binding to myoglobin increases movement into muscle 	<ul style="list-style-type: none"> • Facilitated diffusion/definition (to say diffusion alone is not enough) • Down a concentration gradient • Membrane transporter required for polar/large molecules, polarity • Arterial pressure in capillaries • Pathway as described for oxygen, plus transporter • Insulin increases glucose uptake by cells
<ul style="list-style-type: none"> • Exchange occurs in the capillaries*** <p>*** Can only award this point once, either for glucose OR oxygen</p>	

4. The evolution of circulatory systems allowed larger and more-complex animals to arise. 4A₁

- (a) Describe the respiratory and digestive systems' specialized structures that facilitate the movement of oxygen and glucose into the circulatory system of mammals.
- (b) Explain how oxygen and glucose are transported within the circulatory system of mammals.
- (c) Explain the transfer of oxygen and glucose from the blood and into the active cells of mammals.

A) The respiratory system moves oxygen into the circulatory system beginning with either the nose or the mouth. It moves down the throat (pharynx) past the epiglottis and down the trachea. The trachea splits at the lungs, creating bronchial tubes and then the smaller bronchioli. Covering these small tubes are aveoli, which greatly increase the surface area and allow O_2 to be moved into the circulatory system of a mammal.

The digestive system's digestion of glucose begins in the mouth (amylase), then as the food moves down through the pharynx, down the esophagus, into the stomach, the digestion of carbohydrates stops. The food leaves the stomach for the small intestine. Glucose can be absorbed here. The small intestine is covered with villi, which are covered with microvilli. These greatly increase surface area to aid in digestion. The glucose absorbed here is then transported into the bloodstream.

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B) Oxygen is mainly transported in the hemoglobin protein of Red blood cells. A very small amount of oxygen is dissolved in the plasma. The arteries ~~transport~~ ^{transport} oxygen-rich blood to different parts of the body, while veins return oxygen-poor blood to the heart. Between the arteries and veins are capillaries which is where the oxygen is transferred.

Glucose is dissolved in the plasma of the blood. It is transported along with oxygen through the arteries, veins, and capillaries. The heart acts as the pump that moves the blood. Veins have valves that prevent blood from flowing backward. Arteries have smooth muscle to contract or dilate themselves.

C) Oxygen is transferred into the active cells of mammals through capillary beds. The Oxygen diffuses through the thin capillary walls to an area of lower concentration (cells). Oxygen is going down its concentration gradient and therefore does this freely. Glucose is also moved down its gradient. Unlike oxygen, which can move freely through the cell membrane, glucose must move through an integral protein. This is because glucose is too large to fit through the cell membrane.

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 - (c) **Explain** the transfer of oxygen and glucose from the blood and into the active cells of mammals.

The evolution of circulatory systems allows larger and more complex organisms to arise. Incorporated into this is the evolving complexity of the respiratory and digestive systems. These two systems compliment the circulatory system by providing the blood with oxygen and glucose through specialized structures.

The facilitation of oxygen into the blood takes place in the lungs. Once air enters the lungs, it comes into small sacs called alveoli. ~~These~~ The alveoli's thin walls are lined with capillaries. Due to active transport, the oxygen in the air diffuses through the alveoli and capillaries and into the blood!

The facilitation of glucose into the circulatory system occurs in the intestines. Once food begins digestion in the mouth and stomach, it enters the intestines. The specialized structures in the intestines that facilitate glucose into the blood are the villi. The villi line the intestinal wall and absorb nutrients which then enter the bloodstream. Like the

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4B2

alveoli, the villi ~~are~~ contain capillaries.

Once oxygen and glucose enter the blood stream, they are transported in two different ways. Oxygen binds to the hemoglobin found in red blood cells. Glucose is dissolved in the plasma. Both oxygen ~~are~~ and glucose are then pumped throughout the body by the heart and through arteries.

Once oxygen and glucose reach their destination (an active cell), they are diffused through the cell wall by active transport. They are then utilized by the cell and eventually converted into energy.

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4C

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the respiratory system has a system of two bronchi, which consist of smaller bronchioles & even smaller aveoli. the aveoli increase the surface area of the lungs making the transport of oxygen throughout the body & into the circulatory system easier.

the digestive system releases enzymes into it's structures during digestion. these enzymes aid in the breaking down of food into smaller substances. many of the large polysaccharides are broken down into di- or monosaccharides which are then released into the blood stream. this occurs with the sugar glucose, which is released into the circulatory system of mammals.

oxygen in the circulatory system is transported by red blood cells.

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AP[®] BIOLOGY

2006 SCORING COMMENTARY

Question 4

Overview

This question required students to integrate principles of physiology from three mammalian systems. Students were asked to identify specialized structures that facilitate the movement of oxygen (alveoli in lungs, respiratory) and glucose (villi in small intestine, digestion) into the blood (circulatory). The students were asked to explain the transport of oxygen and glucose within the circulatory system and how oxygen and glucose are transferred from the circulatory system into the cells. Finally, the students had to recognize and explain the differences in specialized structures and processes for oxygen and glucose uptake, respectively, as well as the commonalities of both.

Sample: 4A

Score: 10

In part (a) the response earned the maximum of 4 points by identifying the alveoli and the villi and by describing the increased surface area in each case. In part (b) the student correctly explains the association of oxygen to red blood cells, earning a point, and states that a small percentage is dissolved in the plasma, earning a second point. Glucose dissolved in the plasma earned a third point. In part (c) the student correctly explains the transfer of oxygen to the cells at the capillary bed, earning a point, and to an area of lower concentration, earning a second point. The explanation that glucose needs a transporter because of its larger size earned the final point.

Sample 4B

Score: 6

In part (a) the response earned the maximum of 4 points by identifying the alveoli and the villi and describing the close association of the capillaries with each. In part (b) a point was earned for describing oxygen binding to hemoglobin, and another point for stating that glucose is dissolved in the plasma. No points were earned in part (c).

Sample: 4C

Score: 4

In part (a) the response earned a point for the role of the alveoli, and another point for the increased surface they provide. A description of polymers being converted to monomers (polysaccharides to di- or monosaccharides) earned a point. In part (b) the association of oxygen to red blood cells earned a point. No points were earned in part (c).