

Supplemental Material

CBE—Life Sciences Education

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Appendix A

Prior Knowledge Assessment (PKA)

Multiple correct answers could be correct but to receive the full point for each question students had to choose all of the correct answers and none of the incorrect answers to reduce guessing.

Multiple Choice Question/Statement	Multiple Choice Answer
ATP:	<ul style="list-style-type: none"> a) Stands for Adenosine Triphosphate b) Is broken down by enzymes such that $ATP \rightarrow ADP + Pi$, with Pi representing an energy source c) Is produced primarily in the liver d) Is used to provide energy for muscle contractions e) Is used by the brain in large quantities in order to absorb glucose
The production of ATP:	<ul style="list-style-type: none"> a) Can only occur in the presence of oxygen b) Requires catabolic and anabolic reactions c) Can only occur if a cell has adequate amounts of glucose d) Always yields byproducts such as CO^2 and H^+ e) Can occur via a process known as substrate level phosphorylation
Choose any of the following that are correctly matched:	<ul style="list-style-type: none"> a) Facilitated diffusion – Process whereby molecules can pass through a cell membrane; the only thing required for this movement is a concentration gradient b) Simple diffusion – Process whereby molecules pass through a cell membrane in order to create a concentration gradient from one side of the cell membrane to the other c) Primary active transport – Process whereby molecules are moved through a cell membrane against their concentration gradient, using ATP directly as a source of energy d) Osmosis – Process whereby water diffuses from an area where there are more dissolved particles to an area where there are fewer dissolved particles e) Secondary active transport – Process whereby molecules are moved through a cell membrane against their concentration gradient, using the

	concentration gradient of another molecule as a source of energy
If a red blood cell is placed into a hypertonic solution of sodium chloride it could:	<ul style="list-style-type: none"> a) Shrink due to osmosis b) Swell due to osmosis c) Shrink due to diffusion d) Swell due to diffusion e) Die due to inability to regulate metabolic processes
The movement of water from the blood and into a cell:	<ul style="list-style-type: none"> a) Is dictated by the tonicity of the cell b) Occurs more efficiently if membrane proteins such as aquaporins are present c) Will slow if too much Na⁺ is present within the cell's cytoplasm d) Could be disrupted if edema developed in the interstitial space e) Is dependent upon the number of pumps within the cell's membrane that actively transport water into the cell
Glucose:	<ul style="list-style-type: none"> a) Is regulated by insulin b) Cannot be used by the brain for production of ATP c) Is covalently linked to fructose to form sucrose d) Is composed of a six-carbon ring structure that also includes oxygen as a component of the ring e) Cannot be synthesized by the body so must be obtained from the diet
Insulin:	<ul style="list-style-type: none"> a) Is secreted by the pituitary gland in response to high blood glucose b) Should cause a decrease in blood glucose if all negative feedback pathways are working normally c) Could cause excess glucose in the blood to be converted to fat and stored within adipose tissue d) Should increase the amount of circulating rather than stored energy, and thus would be elevated in those people who are undergoing high stress conditions e) Is normally required by skeletal muscle cells in order to absorb glucose from the surroundings
Cell membrane proteins:	<ul style="list-style-type: none"> a) Can be upregulated or downregulated by the cell b) Are fixed or set for the duration of the cell's life

	<ul style="list-style-type: none"> c) Require transcription and translation before being inserted into the membrane d) Allow the cell to receive and respond to messages from other cells e) Are the same within every cell of an organism's body
<p>Negative feedback is a crucial component of homeostasis because:</p>	<ul style="list-style-type: none"> a) It allows the body to anticipate changes and prepare for what is about to happen b) It amplifies or increases the deviation of a regulated physiological variable away from its set point c) It returns a regulated physiological variable back to an acceptable range after its deviation has been detected d) It prevents regulated physiological variables from ever deviating outside of their strict set point e) It requires conscious regulation by the brain and thus keeps the organism aware of its physiological condition at all times
<p>Which of the following is a physiologically correct example of negative feedback to help keep body temperature at its normal set point when environmental conditions are much colder than body temperature?</p>	<ul style="list-style-type: none"> a) Increased activity of insulin to catabolize fat tissues b) Increased skeletal muscle activity to liberate energy in the form of heat as ATP is broken down c) Increased blood flow to the skin d) Increased piloerection to improve insulation at the surface of the skin e) Decreased release of hormones that stimulate hunger sensations in order to save energy by reducing digestive processes

Appendix B

Modified version of the Student Approach to Learning (SAL) survey

This version of the SAL was used to assess how students approach new information presented to them in a formal learning setting.

Memorization	5 Item Likert-type scale
When I study, I try to memorize everything that might be covered.	1) Strongly disagree 2) Mildly disagree 3) Neutral 4) Mildly agree 5) Strongly agree
When I study, I memorize as much as possible.	1) Strongly disagree 2) Mildly disagree 3) Neutral 4) Mildly agree 5) Strongly agree
When I study, I memorize all new material so that I can recite it.	1) Strongly disagree 2) Mildly disagree 3) Neutral 4) Mildly agree 5) Strongly agree
When I study, I practice by saying the material to myself over and over.	1) Strongly disagree 2) Mildly disagree 3) Neutral 4) Mildly agree 5) Strongly agree
Elaboration	5 Item Likert-type scale
When I study, I try to relate new material to things I learned in other subjects.	1) Strongly disagree 2) Mildly disagree 3) Neutral 4) Mildly agree 5) Strongly agree
When I study, I figure out how the information might be useful in the real world.	1) Strongly disagree 2) Mildly disagree 3) Neutral 4) Mildly agree 5) Strongly agree
When I study, I try to understand the material better by relating it to things I already know.	1) Strongly disagree 2) Mildly disagree 3) Neutral

	<ul style="list-style-type: none">4) Mildly agree5) Strongly agree
When I study, I figure out how the material fits in with what I have already learned.	<ul style="list-style-type: none">1) Strongly disagree2) Mildly disagree3) Neutral4) Mildly agree5) Strongly agree

Appendix C

Pretest and post-test questions

The pretest and post-test questions were administered to students in both groups and the questions were identical on both. Multiple correct answers could be correct but to receive the full point for each question students had to choose all of the correct answers and none of the incorrect answers to reduce guessing.

Pretest and Post-test Questions	Pretest and Post-test Answers
1. Glucose can enter an enterocyte via:	<ul style="list-style-type: none"> a) GLUT2 transporter b) SGLT-1 co-transporter c) Simple diffusion d) GLUT4 transporter
2. In order for glucose to exit an enterocyte and enter a capillary:	<ul style="list-style-type: none"> a) Insulin must be present and bound to its receptor on the enterocyte's basolateral membrane b) Facilitated diffusion must occur c) Glucose levels inside the enterocyte must be higher than those in the blood d) A transporter is required to move the glucose across the basolateral membrane of the enterocyte
3. Certain African plants contain a poison substance that blocks the activity of the Na ⁺ /K ⁺ pump in enterocytes. How might ingestion of this plant affect glucose metabolism in a person?	<ul style="list-style-type: none"> a) No glucose could be moved from the lumen of the small intestine into the enterocyte b) More glucose than usual would be absorbed into the enterocyte c) Less glucose than usual would enter the blood d) D. Insulin would increase to help meet the increased demand for glucose
4. Assuming the person in the previous question survives, how might ingestion of this poison impact insulin resistance?	<ul style="list-style-type: none"> a) It should decrease release of insulin and prevent down-regulation of the insulin receptor b) It should ultimately result in an increase in Glut-4 on the cell membranes of skeletal muscle cells, and therefore help to reduce blood glucose c) It should increase insulin resistance in the person due to increased insulin secretion d) D. There is no physiological connection between Na⁺/K⁺ pumps in enterocytes and insulin resistance

Pretest and Post-test Questions	Pretest and Post-test Answers
5. In a healthy person, when glucose enters a skeletal muscle cell:	<ul style="list-style-type: none"> a) sodium must also enter the skeletal muscle cell, moving downhill with its concentration gradient. b) blood glucose levels drop, even if only by a tiny bit. c) it can be broken down for energy production. d) it can be used to produce glycogen.
6. Exercise can reduce or even reverse the symptoms of insulin resistance. Which of the following describes a potential benefit of exercise?	<ul style="list-style-type: none"> a) Contracting skeletal muscles can move Glut-4 to the cell membrane without insulin b) Exercise should increase utilization of glucose by cells and thus lower circulating glucose and insulin c) Exercise should increase the secretion of insulin, which then improves the utilization of glucose by cells d) People with insulin resistance should not exercise because they do not have enough glucose for muscle contractions
7. Insulin resistance is:	<ul style="list-style-type: none"> a) A disease in which certain cells become less responsive to insulin. b) A disease in which the pancreas can no longer secrete insulin. c) A disease in which glucose can no longer be absorbed from the small intestine. d) A disease that requires people to inject insulin after each meal
8. How would insulin resistance impact a skeletal muscle cell?	<ul style="list-style-type: none"> a) Insulin resistance would reduce the expression of certain cell membrane proteins b) Insulin resistance would decrease facilitated diffusion of glucose into the cell c) Insulin resistance would lead to a decrease in glycogen replenishment d) Insulin resistance would lead to a decrease in ATP production
9. If you took a blood sample from a person with uncontrolled or untreated insulin resistance several hours after they ate a meal containing only complex carbohydrates, which of the following would you likely find?	<ul style="list-style-type: none"> a) Elevated insulin levels that were well above the normal range b) Elevated blood glucose levels that were well above the normal range c) Elevated levels of complex carbohydrates in their blood, well above the normal range d) None of the above; complex carbohydrates do not contribute to issues associated with insulin resistance

Pretest and Post-test Questions	Pretest and Post-test Answers
<p>10. Which of the following drugs would help reduce blood glucose levels in a person already suffering from insulin resistance?</p>	<p>a) A drug that downregulated the number of SGLT-1 co-transporters on the apical membrane of enterocytes within the small intestine</p> <p>b) A drug that was able to cause expression of SGLT-1 co-transporters on the basolateral membranes of enterocytes with a simultaneous increase in GLUT2 transporters expression on the apical membrane</p> <p>c) A drug that increased the production and release of insulin by beta cells within the pancreas</p> <p>d) A drug that reduced the expression of GLUT4 transporters within skeletal muscle cells, causing them to be retained within the cytosol of these cells</p>