Visualized Molecular Misconception Decision Tree:

Common student misconceptions on molecular interactions have been studied using an adaptive decision tree based assessment created Jodie Jenkinson, Gaël McGill, Stuart Jantzen, and Andrea Gauthier. This project approaches these same misconceptions using a series of short animations in addition to text as assessment choices.

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Introduction:

Undergraduate level of conceptual understanding at the molecular level are often superficial and punctured with misconceptions when tested. Students in particular have trouble understanding the role of random movement in the molecules that take place in all biological processes (Chi 2005). An adaptive decision tree assessment put together by Jodie Jenkinson, Gaël McGill, Stuart Jantzen, and Andrea Gauthier was given to undergraduate biology students at the University of Toronto – Mississauga. The data collected from this assessment have given us insight on the various points where a student's understanding of random movement broke down. Formative assessments are important in science education in that not only can we use them as a way to quantitate education progress of students, but they are often the only way we receive feedback to revise classroom instruction (Bell 2002.)

The use of visual aid in the assessment is of interest due to the additional information that can be grasped intuitively through visualizations. This project will utilize animated clips in addition to text as the answer choices for the assessment questions. Animation has proven in various studies to be effective in information processing (Mayer 2002). Can students recognize their own misconceptions by seeing them visualized? As a comparison to the same assessment with only text, we would like to see if there is a difference with student choices with the introduction of short animations.

Goals and Objectives:

The primary goal of this project is to discover areas of weakness in student's understanding of molecular biology while determining the value of having visual aids in scientific assessments.

The objectives of this project is: to create a visual treatment of the developed decision tree that will accurately reflect text answer choices without adding bias towards any one choice. Students should not feel that they are pressured to choose the correct answer but rather feel encouraged to choose the one that most accurately reflects what they envision. The completed animations should be precise and transparent, utilizing various visualization methods to minimize misinterpretation.

Target Audience:

Undergraduate biology students with some background of molecular biology who are interested to look for areas of weakness in their understandings. The intended audience for the assessment will be students who are enrolled in an undergraduate level biology course dealing with molecular biology, cellular biology, or biochemistry. First users of the assessment will likely be from the University of Toronto – St.George campus.

Functional Specifications:

This project is intended to be used as a web based scientific assessment to discover areas of weakness in student's understanding of molecular biology. The pure of the visual component is to provoke further student thinking or understanding of the answer choices. Students will be encouraged to answer as honestly as possible and will be given equal academic incentive regardless of how well they do.

General science literacy questions will be given prior to questions on molecular misconceptions. An evaluation of the two assessments will be conducted among a student population where half the students will receive the text-only assessment and the other half will receive a text plus animation assessment.

Students will be asked to answer each assessment question by picking one of the animations. The clips component will be added in addition to the text and will consist of short 5-10 second long animation clips for each assessment question. Students will be able to choose to play any animation first, and as many times as they would like before picking their choice. An emphasis will be placed on viewing all animations prior to choosing an answer. A confidence bar will be included to collect the student's sureness on their decision.

Data to be collected from each student participant are: their background in science, their answer choices, and their confidence level. The assessment will be web based, and the answers will be collected and stored on server side so further analysis can be done. Once a student submits their answer, they must not be able to go back and redo their answer.

Once the final question has been answered, the student will be allowed to review all their answers in comparison to correct answers in a side-by-side view.

Technical Specifications:

Cinema4D and/or Maya will be used to create models and animations for the project. Aftereffects will likely be used for inserting additional visual aids into the short animations. Molecular models will be imported from PDB to ensure accuracy. Web creation part of the assessment will be based off the template of the existing text-only decision tree. Animations with a full playback bar will be embedded into the page. Input data will be collected and stored on server.

Creative Content:

The interface of the assessment will be nearly identical to the text version of the assessment to be as consistent as possible. Special attention will be given to 3D animations, which should take a significant portion of the webpage. Animations will be rendered in a realistic style, with a neutral/technical color scheme that is not distracting. Confidence bar for each question will be clearly displayed.

Metric of Success:

Visual elements should invoke students to reimagine their understanding of molecular environments. Student input data from both the text and visual assessment should be compared, and hopefully will provide meaningful insight on their performance, ie: Students become more confident with visual assessment.

The project will be successful if: overall students find animations to be helpful in addition of text choices; students find animations to be intuitive and aid their understanding of the answer choices; students find overall ease of use of the assessment with the addition of the animations; and students find animations to be helpful in correcting their misconceptions.

Content Specifications and Quality Assurance:

Assessment questions and text answer choices are provided by Jodie Jenkinson and Gaël McGill. Animations will be built to best reflect answer choices, and verified with committee to assure accuracy and non-bias. Certain questions, especially True and False questions might be reworded or adjusted to flow better with animations. A small focus group might be necessary to survey for the effectiveness of the animations and the overall flow of the visual assessment.

Content
A. An extracellular molecule tries to move towards a complementary receptor
B. Based on your previous answer and assuming there are several instances of the complementary receptor present, an extracellular molecule tries to move toward:
a. One specific predetermined instance of the complementary receptor
b. Any of the complementary receptor instances that are present
c. Whichever instance of the complementary receptor is closest
C. An extracellular molecule knows the physical location of its receptor
D. Based off your previous answer, how an extracellular molecule know the location of its receptor?
a. It can sense the receptor from a distance
b. It has hard-wired knowledge

c. It receives a message from else where
d. It can sense the receptor when it is close to it
E. What is the mechanism of an extracellular molecule's movement towards a receptor
a. The extracellular molecule propels itself
b. The extracellular molecule is released from its source with the correct initial trajectory
c. The extracellular mole uses other helper molecules to be carried closer to the receptor
d. The extracellular molecule collides randomly with other molecules
F. An extracellular molecule can change direction on its own
G. If extracellular molecules move through random collisions, what determines the chance of a binding event occurring between one of these molecules and a complementary receptor?
a. If the cell depends upon the binding event, it will happen regardless of other factors
b. Factors such as concentration and temperature determine the chance of binding
H. A large molecule has a more direct path of motion, whereas a small molecule has a more random path
I. A molecule's path of motion is more direct when it has been activated, whereas its path is more random when it is inactive
J. Inside a cell, large molecules are densely crowded so much so that the average distance between two macromolecules is typically less than the width of a single macromolecule
K. Inside a cell, empty space is not a factor in the overall direction of diffusion of water and other molecules
L. In the case of simple diffusion across a permeable membrane, once solute molecules reach an equilibrium, they cease to cross the membrane
M. A drop of dye is placed in some water The water, activing as a solvent, diffuses into the dye in the same wat as the dye, acting as a solute, diffuses into the water

Risks and Barriers:

Challenges in creating the visual components of the assessment involve with the design of effective animations that do not accidentally introduce bias. Because conceptual questions are by nature difficult to visualize, we will need to pay extra attention in communicating incorrect answer choices without making them noticeable or obvious. Also, because the questions of the decision tree are built upon each other, some of the students' misconstructions will be carried throughout the course of their assessment. There will be challenges in accommodating their scaffold understanding of the molecular environment within the animations. Unsuccessful visual treatments might lead students to become aware of their mistakes by influences outside of their own intuition from the animation.

References:

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Mayer, R. E., & Moreno, R. (2002). Animation as an aid to multimedia learning. *Educational Psychology Review*, *14*(1), 87–99. doi:10.1023/A:1013184611077