Hello everyone, the document below shows the original GCA questions, with the % of students selecting each answer on a post-test (n=751 from 6 different classes). Below each GCA question, I show the reword for short answer, and a short description of complexity.

Original GCA question

1. Which of the following human cells contains a gene that specifies eye color?

a) Cells in the eye. (1.6%)

b) Cells in the heart. (0.1%)

c) Gametes (sperm and egg). (7.6%)

d) Cells in the eye and gametes. (20.2%)

e) All of the above. (70.4%)

Reword:

1. You are looking at two cell types in the human body. Not thinking about human physiology and focusing on genetics, explain why these two cells are different at the molecular level.

Complexity: not more complex than original question

In my opinion, this question is unlikely to yield additional information, because both questions are really getting at the idea that the genome is the same in all cells of the body, despite their function.

Original GCA question

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| 11: (abbrev)# The following DNA sequence (coding strand) occurs near the middle of the coding region of a gene.  5’—A A T G A A T G G G A G C C T G A A G G A G –-3’  Which of the following DNA mutations is almost certain to result in a shorter than normal mRNA?  a) A→G at position 50 (2.0%)  b) G→A at position 53 (46.5%)  c) C→A at position 58 (1.6%)  d) None of the above (49.5%)  \* a small percent picked e) |
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Reword (a pair of questions):

1. The following DNA sequence occurs in the coding region of a gene whose protein product is involved in human sight.



There is a G to A base change at the position marked with an asterisk. As a result, the codon becomes a stop codon. Trace any potential impact on the flow of information from the DNA sequence to the phenotype of the person as a consequence of this change in DNA.

Complexity: more complex than original GCA question, because the answer should include correct flow of information (DNA-RNA-protein), as well as application that stop codon will not stop transcription, but will affect the protein, making it shorter and likely non-function. There is an extension in this question to phenotype, which was not explicitly required in original question.

We already know that students think a stop codon stops transcription. This question may allow us to see where in the process their understanding breaks down—is it always at the level of transcription, or is it elsewhere instead/as well.

3. Here’s the same sequence as in the previous question. If the base change shown is in a non-coding region of the genome, trace any potential impact on the flow of information from the DNA sequence to the phenotype of the person as a consequence of this change in DNA.



Complexity: an extension to the concepts addressed in original question. Student now needs to trace the flow and also realize that a base change in a non-coding region is unlikely to affect that flow, and unlikely to result in a phenotype, because the non-coding region will not be included in the protein.

Original GCA question

4. Suppose that a single DNA base change of an A to a T occurs and is copied during replication. Is this change necessarily a mutation?

a) Yes, it is a change in the DNA sequence. (70.0%)

b) Yes, if the base change occurs in a gamete (sperm or egg cell); otherwise no. (0.8%)

c) Yes, if the base change occurs in the coding part of a gene; otherwise no. (3.7%)

d) Yes, if the base change occurs in the coding part of a gene and alters the amino acid sequence of a protein; otherwise no. (24.9%)

e) Yes, if the base change alters the appearance of the organism (phenotype); otherwise no. (0.5%)

Reword:

1. In a bacterial cell, a single DNA base change of an A to a C occurs and is copied during replication. Under what conditions would this be considered a mutation?

Complexity: not necessarily more complex. However, without the cues present in the multiple choice distractors, it is possible that students will come up with alternatives or partially correct/incorrect ideas. They are still likely to specify that this is considered a mutation only if it changes the amino acid, or results in a phenotypic change.

Entirely new:

1. The base change described in the previous question (a change of an A to a C that is copied during replication) is passed on for several generations in bacteria. This base change has an affect on the subsequent amino acid sequence, but not the protein function. Over time, the environment these bacteria are living in becomes more acidic. In these new conditions, the base change now has an effect on the protein function. Explain why there is an impact on protein function in the second scenario and not the first.

Complexity: This question is more complex. It addresses concepts not included in the original GCA question, such as the impact of environmental on an organism, and impact of environment on function of a protein (affect on protein folding resulting in change in protein function). This question could potentially be extended to include testing whether students could connect this change in environment and subsequent impact on protein function on viability of organisms with this mutation, etc. Michelle and I were not entirely sure about this question, as it brings together some ideas that are not really tested elsewhere on the GCA. The only other related GCA item that one could argue tests a related concept is shown below:

5. An isolated population of prairie dogs has longer than average teeth. As a result they can eat more grass with less effort and are better able to survive. The mutation(s) that resulted in longer teeth:

a) allowed the teeth to grow longer over several generations until they reached an optimal length for eating grass (10.3%)

b) arose in many members of the population at the same time. (.9%)

c) happened by chance.(67.6%)

d) occurred because the prairie dogs needed to be more efficient at eating grass to survive and reproduce.(14.2%

e) would only occur in a prairie dog population that eats grass and would not occur in a population that lives on seeds. (6.8%)