Illustrative design pattern based on genetics learning progression for grades 5-10 | Design Pattern 2233

Title

Illustrative design pattern based on genetics learning progression for grades 5-10

Overview

This design pattern describes students' evolving knowledge of the characteristics and functions of genes. Its contents are based on a published journal article by Duncan, Rogat, & Yarden (2009) in which the authors posit a learning progression for deepening students' understandings of modern genetics across grades 5-10. This understanding of modern genetics is identified in the paper as consisting of understanding of the genetic model, the molecular model, and the meiotic model. The paper posits 8 main ideas about the three models followed by the characteristics of what students in grade bands 5-6, 7-8, and 9-10 are capable of understanding about the main ideas respectively.

All fields associated with the Duncan, Rogat, & Yarden article contain direct quotes from the article. Each quote is referenced by the number of the page on which it appears. details

Use

U1. Use this design pattern to build assessment arguments devoted to measuring the progression of student understanding about genetics in grades 5-10.

Focal knowledge, skills, and abilities

Fk1. 1. Understanding genes as "informational entities" (Duncan, Rogat, & Yarden, p. 665), present "in most cells in the organism" (Ibid., p. 664), that genes contain instructions for the growth and functioning of all living things, and that "Our body has multiple levels of organization, hence changes at one level may affect another" (p. 660). (Grades 5-6)

Fk2. 2. Understanding that the genetic content specifies "very small biological entities" (proteins) "that carry out the functions in living things" (Ibid., p. 665), that proteins have "shapes and properties that afford their functions" (Ibid, p. 660), that changes to proteins can result from changes to genes and that those changes can "affect...structures and functions in the whole organism" (p. 660). (Grades 7-8) details

Fk3. 3. Understanding the "molecular processes involved in the translation of the genetic instructions into proteins" (Ibid., p. 666), understanding some of the" molecular structures of proteins (such as charge and size)" (Ibid., p. 666), and developing more sophisticated understandings of "genetic mutations...and their biological consequences at the molecular and cellular levels" (p. 666) (Grades 9-10). details

Additional knowledge, skills, and abilities

Ak1. Knowledge of different species of organisms that may be cited in the student tasks. (All bands)

Ak2. Knowledge of parts and functions of different organisms (Grades 5-6)

Ak3. Knowledge of different types of physiological functions that are genetically derived (Grades 7-8)

Ak4. Foundational knowledge about the structures and functions of molecules (Grades 9-10)

Potential observations

Po1. Accuracy of information explicitly or implicitly provided in the student response about how the alteration of a cell's structure or function can affect the structure or function of the organ or organism it resides in (Grades 5-6)

Po2. Accuracy of information explicitly or implicitly provided in the student response about how a change in a proteins' shape might affect the protein function, as well as the structure and function of a cell it resides in, and that of the whole organism (Grades 7-8)

Po3. Accuracy of information explicitly or implicitly provided in the student response about how a genetic mutation might influence the function or appearance of an organism by affecting the function or structure of a protein that acts within a cell, which resides in a tissue, and which functions in an organ. (Grades 9-10)

Potential work products

Pw1. A list of inherited traits of different types of plants and animals (Grades 5-6)

Pw2. A narrative that differentiates between traits that result from alterations to cell structures and functions and those that result from mutations induced by infections or other environmental influences (Grades 5-6)

Pw3. A narrative describing examples of specific cellular changes that affect a body part or entire organism (Grades 7-8)

Pw4. Causal diagram of a model showing directionally appropriate cause and effect relationships between a particular type of genetic mutation and corresponding changes to cells and to the whole organism (Grades 7-8)

Pw5. Before and after sketches showing different types of change in different types of proteins and the impacts on of the changes on cell structures (Grades 7-8)

Pw6. Short narrative identifying a particular type of genetic mutation (Grades 9-10)

Pw7. Describing a plan to research at the molecular level the evolutionary relationships between two specific organisms (Grades 9-10)

Pw8. Report comparing and contrasting how doctors diagnose infectious diseases differently from genetically-inherited diseases in a way that reveals student understanding of the impacts of genetic mutations on cell structures (Grades 9-10)

Potential rubrics

Characteristic features

Cf1. Tasks prompt students to apply principles of cellular and/or molecular biology at grade-level appropriate levels of sophistication in order to give reasonable explanations or make reasonable predictions about the characteristics of genes, proteins, and the outcomes of genetic changes on cells and organisms. In other words, a task meant to determine whether a student is thinking at or above a specified level should present a situation to understand or explain such that the concepts described in the Focal KSAs for the level are required. (All bands) details

Variable features

- Vf1. Which types of organisms to focus on (Grades 5-10)
- Vf2. Which types of cell structures to focus on (Grades 5-10)
- Vf3. Whether to focus on normally varying traits such as eye color or different types of healthy vs. pathological genetic expressions (Grades 5-10)
- Vf4. Which types of information representations to use, such as text, diagrams, tables (Grades 5-10)
- Vf5. Which types of genetic mutations to focus on (Grades 5-10)
- Vf6. Which types of proteins to focus on (Grades 7-10)
- Vf7. Which types of tissues or organs to focus on. (Grades 9-10)

Narrative structure

National educational standards

State standards

State benchmarks

I am a kind of

These are kinds of me

These are parts of me

Templates

Exemplar tasks

Muscular dystrophy task (Duncan, Rogat, and Yarden, 2009). Task description: Some people are born with a genetic disease called muscular dystrophy. People with this disease have great difficulty in walking or exercising. Can you explain what might be causing these problems? Expected responses: Grades 5-6: Maybe these people have muscle cells that do not work well or maybe they have fewer muscle cells. Grades 7-8: Maybe their muscle cells do not move well because the proteins in these cells do not work well. Grades 9-10: Maybe their muscle cells do not move well because the proteins in these cells do not work as a result of a mutation in a gene.

Hemoglobin task (Duncan, Rogat, and Yarden, 2009). Task description: There is a protein called hemoglobin found in red blood cells that binds oxygen. It is possible that gene mutations could arise that prevents hemoglobin from binding oxygen. Explain how a mutation could cause this problem. Expected responses: Grades 5-6: Not applicable. Grades 7-8: Maybe a protein in the cell is changed so the cell cannot carry oxygen. Grades 9-10: Maybe the hemoglobin protein is changed in shape, because of a mutation in a gene, so that hemoglobin cannot bind oxygen.

Online resources

References

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R3. Duncan, R.G. (2007). The role of domain-specific knowledge in generative reasoning about complicated multilevel phenomena. Cognition and Instruction, 25(4), 271-336.

R4. Duncan, R.G., Rogat, A.D., Yarden, A. (2009) A Learning Progression for Deepening Students' Understandings of Modern Genetics Across the 5th-10th Grades. Journal of Research in Science Teaching, 46(6), 655-674.

R5. Duncan, R.G., & Reiser, B.J. (2007). Reasoning across ontologically distinct levels: Students' understandings of molecular genetics. Journal of Research in Science Teaching, 44(7), 938-959.

R6. Duncan, R.G., Ruppert, J., Bausch, A., Freidenreich, H.B. (2008). Promoting middle school students'understanding of molecular genetics. Baltimore, MD: Paper presented at the Annual Meeting of the National Association for Research in Science Teaching.

R7. Krajcik, J., McNeill, K., & Reiser, B.J. (2008). Learning-goals-driven design model: Developing curriculum materials that align with national standards and incorporate project-based pedagogy. Science Education, 92(1), 1-32.

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R9. Roseman, J., Caldwell, A., Gogos, A., Kurth, L.A. (2006). Mapping a coherent learning progression for the molecular basis of heredity. San Francisco, CA: Paper presented at the Annual Meeting of the National Association of Research in Science Teaching.

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R12. Venville, G., & Treagust, D.F. (1998). Exploring conceptual change in genetics using a multidimensional interpretive framework. Journal of Research in Science Teaching, 35(9), 1031-1055.

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List of Examples:

Activity Add'l KSAs: Affective Add'l KSAs: Cognitive Add'l KSAs: Executive Add'l KSAs: Language and Symbols Add'l KSAs: Perceptual Add'l KSAs: Skill and Fluency Continuous Zone Design Pattern Educational Standard Evaluation Phase Evaluation Procedure (rubric) Materials and Presentation Measurement Model Narrative Structure Observable Variable State Benchmark State Standards Student Model Student Model Variable Task Exemplar Task Model Variable Task Specification Template Variable Features: Affective Variable Features: Cognitive Variable Features: Executive Variable Features: Language and Symbols Variable Features: Perceptual Variable Features: Skill and Fluency Work Product

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