Using Learning Progressions to Map High School Student Understandings of Molecular Genetics

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Using Learning Progressions to Map High School Student Understandings of Molecular Genetics

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What Did We Do?

- Theoretical framework for study is based on:
  - Duncan et al. (2009) molecular genetics LP
  - Swaffield et al. (2005) - molecular genetics literacy is being to understand and integrate three main inter-related conceptual models
  - Duncan & Reiser (2007) - “hybrid hierarchical” structure of molecular genetics
  - Different 10th grade biology classes in 2011-2012 school year
    - Suburban public school (6-12) with a STEM focus (Context A)
    - Two classrooms in urban public school with arts focus (Contexts B & C)
  - Three molecular genetics intervention units created
    - Different from normal class instruction
      - Introduce concepts and their functions before addressing DNA and its structure
      - Specifically targeted instruction to components from Duncan et al. (2009) LP
      - Teacher A taught three units in their entirety
      - Teacher B taught the first unit and shortened version of second unit
      - Teacher C did not teach any of the units
    - Pre/post written assessments (n = 121) were administered to all the students
      - Interviews conducted (n = 54) with students in contexts A & B
- Student ideas mapped to the Duncan et al. (2009) LP
- Coding scheme based on the LP empirically developed for each of the eight big ideas
- Data shown in this poster is preliminary, reliability has not yet been established

RQ1: Where do students align with the Duncan et al. (2009) LP?
RQ2: How can the Duncan et al. (2009) LP be revised and refined?

What Do We Already Know?

- Concepts in molecular genetics are difficult to teach and learn (e.g., Stewart, Carter, & Paxson, 2005; Stewart & Van Kirk, 1996; Wende & Tintner, 1998)
- Two learning progressions (LPs) have been produced (Duncan, Rogat, & Yarden, 2006; Roseman, Caldwell, Gogos, & Kurth, 2006) in molecular genetics
- Both LPs are hypothetical as neither have been fully empirically tested
- Makes LPs more practical and useful for teachers and researchers to support students
- Mappers provide more practical and useful for teachers and researchers to support students

Number of Students in Each Context

<table>
<thead>
<tr>
<th>Interview</th>
<th>Written Assessments</th>
<th>Interviews</th>
<th>Written Assessments</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>A</td>
<td>B</td>
<td>Pre</td>
<td>Post</td>
</tr>
</tbody>
</table>

Reframes of Construct B

<table>
<thead>
<tr>
<th>Original LP</th>
<th>Revised LP</th>
<th>Description</th>
<th>Level</th>
<th>My Proposed LP</th>
<th>No knowledge of genes</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>Genes are non-informational in nature.</td>
<td>0</td>
<td>No knowledge of genes</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>Genes are non-informational in nature, some are associated with traits.</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>Genes are non-informational in nature, some are associated with traits.</td>
<td>2</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>Genes are active instructions that “tell” proteins what to do.</td>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>Genes are instructions about biochemical actions and functions</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>Genes are instructions about biochemical actions and functions</td>
<td>5</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
<td>Genes are a translated sequence of RNA that makes up proteins</td>
<td>6</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>

Reframes of Construct F

<table>
<thead>
<tr>
<th>Original LP</th>
<th>Description</th>
<th>Level</th>
<th>My Proposed LP</th>
<th>No understanding of genes or traits</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>There are different versions of traits, organisms can differ in character</td>
<td>0</td>
<td>No understanding of genes or traits</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Each chromosome can be typed and can have non-informative areas</td>
<td>1</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Organisms are different organisms</td>
<td>2</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>Alleles differ in nucleotide sequence affecting protein which gives rise to functional differences</td>
<td>3</td>
<td>15</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>Alleles differ in nucleotide sequence which affects the protein to give trait differences</td>
<td>4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>Alleles differ in nucleotide sequence which affects the protein to give trait differences</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Reframes of Construct G

<table>
<thead>
<tr>
<th>Original LP</th>
<th>Description</th>
<th>Level</th>
<th>My Proposed LP</th>
<th>No idea how genes affect phenotype</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Different organisms vary in look and function because they have different genetic information</td>
<td>0</td>
<td>No idea how genes affect phenotype</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Organisms have different traits/functions</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Different organisms have different genetic information</td>
<td>2</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>Organisms have different genetic information, even within a species</td>
<td>3</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td>4</td>
<td>Organisms of other species often share some of their genetic information</td>
<td>4</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>5</td>
<td>Organism DNA codes for things crucial to the proper functioning of the cells</td>
<td>5</td>
<td>9</td>
<td>0</td>
</tr>
</tbody>
</table>

What do students think genes do?

- Revised levels 1 & 2 can be combined
- Few students thought that genes were non-informational in nature (proposed levels 0-2)
- Passive vs. active distinction removed, very few distinctions between two

New level added to progression

- Students understand genes code only for proteins and that the proteins are made of amino acids
- Students do not know how the rules DNA is translated into a sequence of amino acids which make up the protein (proposed level 8)

How are alleles related to traits?

- Data supports the three original levels of the construct
- Also supports addition of three new levels

Molecular model introduced to genetic model at this level

- Students have firm grasp of the molecular model (Construct B) and genetic model (Construct F) after instruction
- Students do not have difficulty integrating the two models
- "Stuck" at level 3 because unable to add in molecular model

How different are humans and fruit flies?

- Ideas about genes changing and evolution moved to Construct H
- Modified to include genetic changes through recombination, mutations, environmental factors
- Creation of new construct for molecular evolution ideas

Ideas from original levels combined

- Ideas about the genetic similarities/differences between individuals found in all levels of original LP
- Ideas combined into one level (proposed level 3)

New lower and higher levels added to progression

- Lower levels added for more basic ideas
- Higher level added to the progression
- Ideas discussed in the original LP, not included in the progression
- Many students able to achieve proposed level 4; some students may be able to achieve this higher level