Learning Progressions

Ravit Golan Duncan
Rutgers University

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Overview

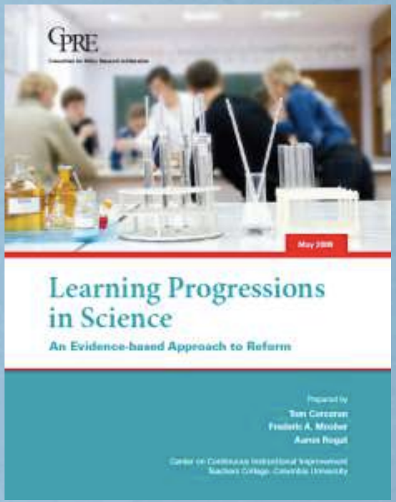
- How I got here
- Learning progressions
- An example: Genetics progression
- Challenges
- Conclusion

Who am I?

- B.Sc. Biological Sciences Hebrew University
- M.Sc. Biological Science University of Illinois at Chicago
- Ph.D. Learning Sciences Northwestern University
- Associate professor Graduate School of Education, Rutgers University

Learning Progressions

- Descriptions of successively more sophisticated ways of thinking about a topic developed as children learn about and investigate a topic over a broad span of time (NRC, 2007)
- Not a simple accumulation of knowledge
  - Developmental approach to learning
  - Goal is understanding that is robust and applicable to broader phenomena
- Concepts are not repeated, but revisited with increasing complexity and epistemological rigor



LeaPS Learning Progressions in Science

Four Characteristics of LPs

1. Focused on foundational and generative disciplinary ideas and scientific practices
2. Begin with a serious consideration of prior knowledge and skills of learners (lower anchor), and aim towards targeted understandings needed for literacy/expertise in the field (upper anchor)
3. Describe intermediate steps or levels that are derived from analyses of research on student learning in the domain
4. Facilitated by carefully designed instruction and curriculum

(Corcoran, Mosher & Rogat, 2009)

Stepping Stone Ideas

Productive 'misconceptions'

- Stepping stones to deep understandings (Wiser et al, 2009)
- Can be substantially different from accepted science concepts

- Middle school: Genetic information as specifying the structure, and consequently function, of proteins
  - Incomplete, but can explain how genes result in observable effects (Duncan et al, 2009)
- Elementary: Establish weight as a property of matter
  - Inaccurate, but supports idea that even invisible things (gas, atoms) have weight
  - Using "mass" at this level is meaningless and not helpful (Wiser et al, 2009)

Brief History of LPs

- Notion of developmentally-oriented approaches to learning is not novel:
  - Spiral curriculum (Bruner, 1960),developmental corridors (Brown & Campione, 1994), learning trajectories in mathematics education (Carpenter & Lehrer, 1999; Clements & Sarama, 2009), cognitively guided instruction (Fennema, Carpenter, Fennema & Franke, 1996).
- LPs appeared in Systems for Science State Assessments (NRC, 2005) and was later elaborated upon in the Taking Science to School (NRC, 2007)
- Several rounds of NSF funding; working group generated consensus report on LPs (Corconran, Mosher & Rogat, 2009), special issue in JRST (Aug, 2009), Alonzo & Gotwals Eds. book (2011)
- LPs served as the organizing structure for the Framework for K-12 Science Education (NRC, 2011), and the Next Generation Science Standards (Achieve, 2013)

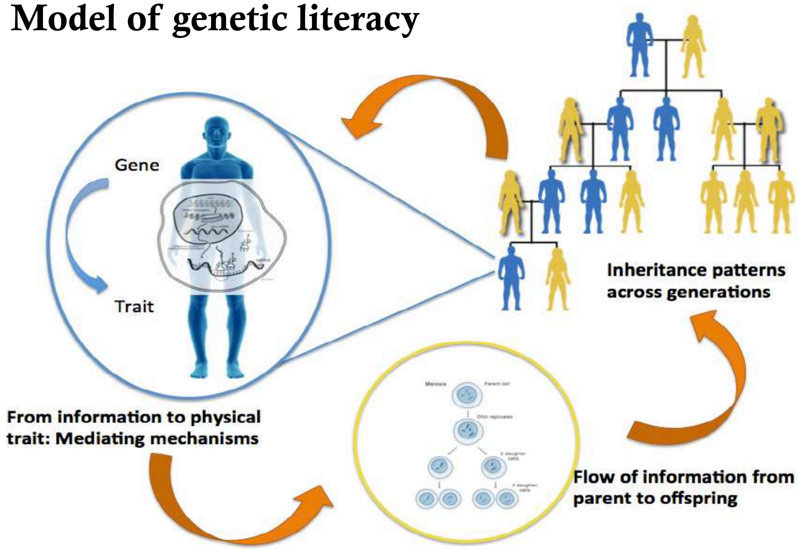
Example: LP in Genetics

Initially developed by Duncan, Rogat, & Yarden, 2009:

- Defining the upper anchor
- Defining the steps
- Designing instruction and assessments

Defining the Upper Anchor

Model of genetic literacy



(Stewart, Cartier & Passmore, 2005)

National Science Education Standards, AAAS Benchmarks, and new strand map for the molecular basis of heredity

NRC, 1996; AAAS, 1993, Roseman et al., 2006)

Experts' views of what the public should know:
[Venville, G., & Donovan, J. (2005). Searching for clarity to teach the complexity of the gene concept. Teaching Science, 51, 20–24]

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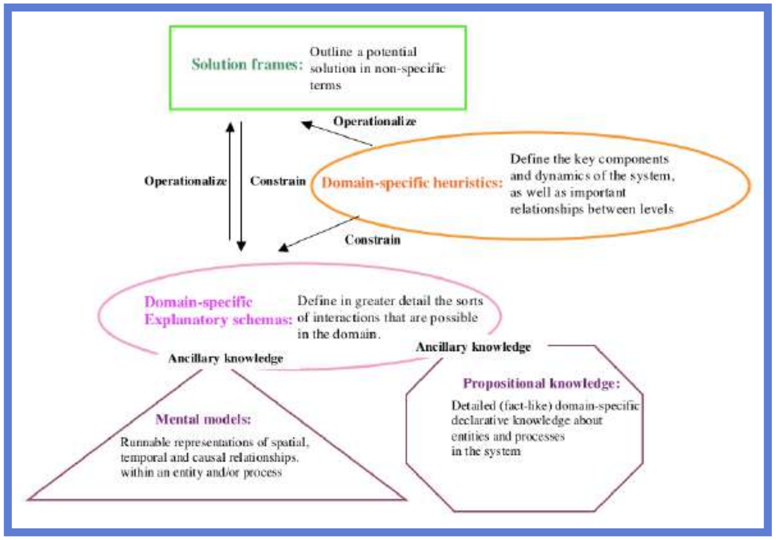
Cognitive model of reasoning in molecular genetics



(Duncan & Reiser, 2007; Duncan, 2007)

Characteristics of the Big Ideas

- Understandings “necessary” for civic and personal engagement in the domain:
  - Informed by standards documents
- Generative conceptual toolkit in the domain:
  - Reason about novel phenomena in domain-appropriate ways
  - Focus on mechanism
  - Provide basis for future learning
- Balance scientific fidelity with learnability:
  - Some ideas at the upper anchor do not reflect our latest scientific understandings (e.g. functions of DNA)
  - Ideas need to be accessible to learners

Unpacking the Big Ideas

How do genes influence how we, and other organisms, look and function?

A. All organisms have genetic information that is hierarchically organized.
B. The genetic information contains universal instructions that specify protein structure.
C. Proteins have a central role in the functioning of all living organisms and are the mechanism that connects genes and traits.
D. All cells have the same genetic information but different cells use (express) different genes.

Why do we vary in how we, and other organisms, look and function?

E. Organisms reproduce by transferring their genetic information to the next generation.
F. There are patterns of correlation between genes and traits and there are certain probabilities with which these patterns occur.
G. Changes to the genetic information can cause changes in how we look and function.
H. Environmental factors can interact with our genetic information

Defining Progress

Big Ideas	Level 1 (5-6)	Level 2 (7-8)	Level 3 (9-10)
A			
B			
C			
D			
E			
F			
G			
H			

Progress means developing more sophisticated understandings of <u>mechanism:</u>

1. Developing more complete and coherent understandings of each model
2. Integrating among and across the three models
3. Reasoning across organization levels- from macro to micro

Progression Along Construct "B"

Construct B	Level1	Level 2	Level 3

Students notions
a view of genes
to a view of gene
and then as proc
instructions for p
Treagust, 1998).
critical for develo
explanations of g
Reiser, 2007)

AAAS Benchmarks 5B
regarding heredity and
9-12. Emphasizes stru
correlations at the mol
(Duncan & Tseng, 201

Students have a theory of kinship (Solomon & Johnson, 2000; Springer & Kiel, 1989) and know that offspring resemble parents because they have the same genes (Venville & Donovan, 2006). Also reflected in 5B/E1&2 of AAAS Benchmarks.

Refining LPs: The Assessment Triangle

Observation

Items and Scorin
Schemes: writ
assessments

Interpretation

eling: IRT approach
late scored items
2004)

The L
develop
sophistica
omain

(NRC, 2007; Smith et al., 20

Curriculum

and

Instruction

Cognition

Knowing What Students Know (NRC, 2001)

Items: Ordered Multiple Choice

In OMC items different response options are linked to levels of conceptual understanding:
(Briggs, Alonzo, Schwab & Wilson, 2006; Briggs & Alonzo, 2012)

- Provide more information than traditional MC items, are easier to score compared to open-ended items
- More difficult to write, and require students to select the "most accurate" response (may not be used to format)
- Require intensive process of validation

Example: OMC for Construct B

Which of the following does DNA provide information for: (Choose most accurate answer)

A. The structure and function of a protein.

B. The traits that an individual inherits.

C. Assembling amino acids into protein molecules.

D. Assembling protein molecules into amino acids.

Analysis as Ordinary MC

Which of the following does DNA provide information for: (Choose most accurate answer)

A. The structure and function of a protein.

B. The traits that an individual inherits.

C. Assembling amino acids into protein molecules.

D. Assembling protein molecules into amino acids.

In a recent pilot with over 300 high school biology students:

Correct	Incorrect
23%	77%

Analysis as OMC- Partial Credit

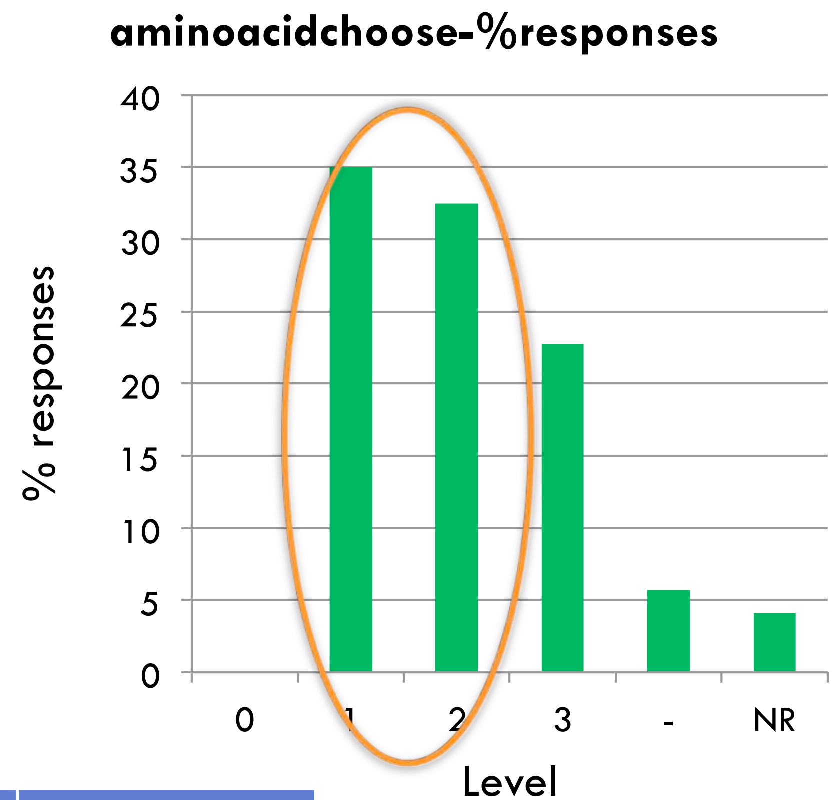
Which of the following does DNA provide information for: (Choose most accurate answer)

A. The structure and function of a protein. [L2]

B. The traits that an individual inherits. [L1]

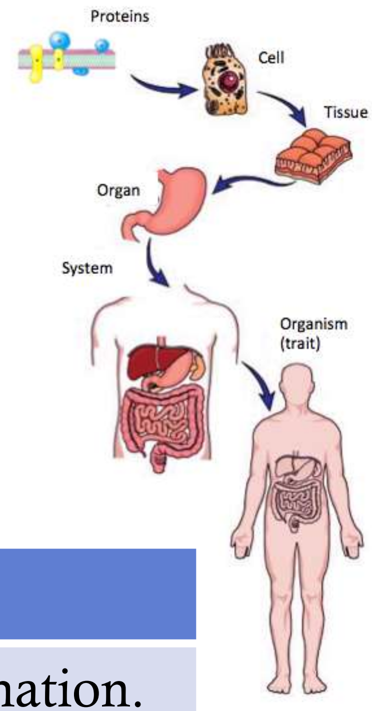
C. Assembling amino acids into protein molecules. [L3]

D. Assembling protein molecules into amino acids. [L-]



Correct	Incorrect
23%	77%

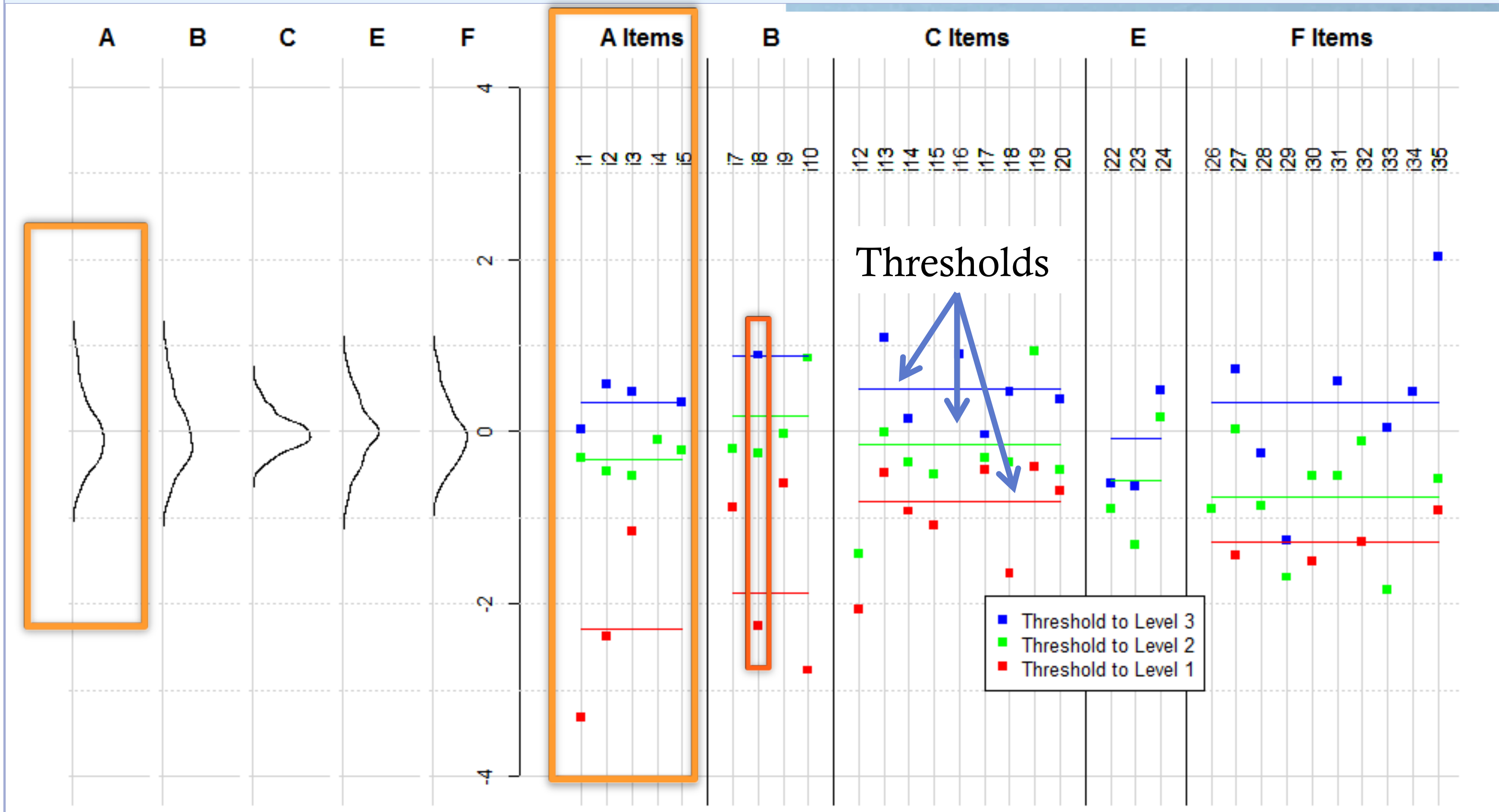
Nature of the Genetic Information



Trajectory of conceptual change for the concept of gene: (Venville & Treagust, 1998)

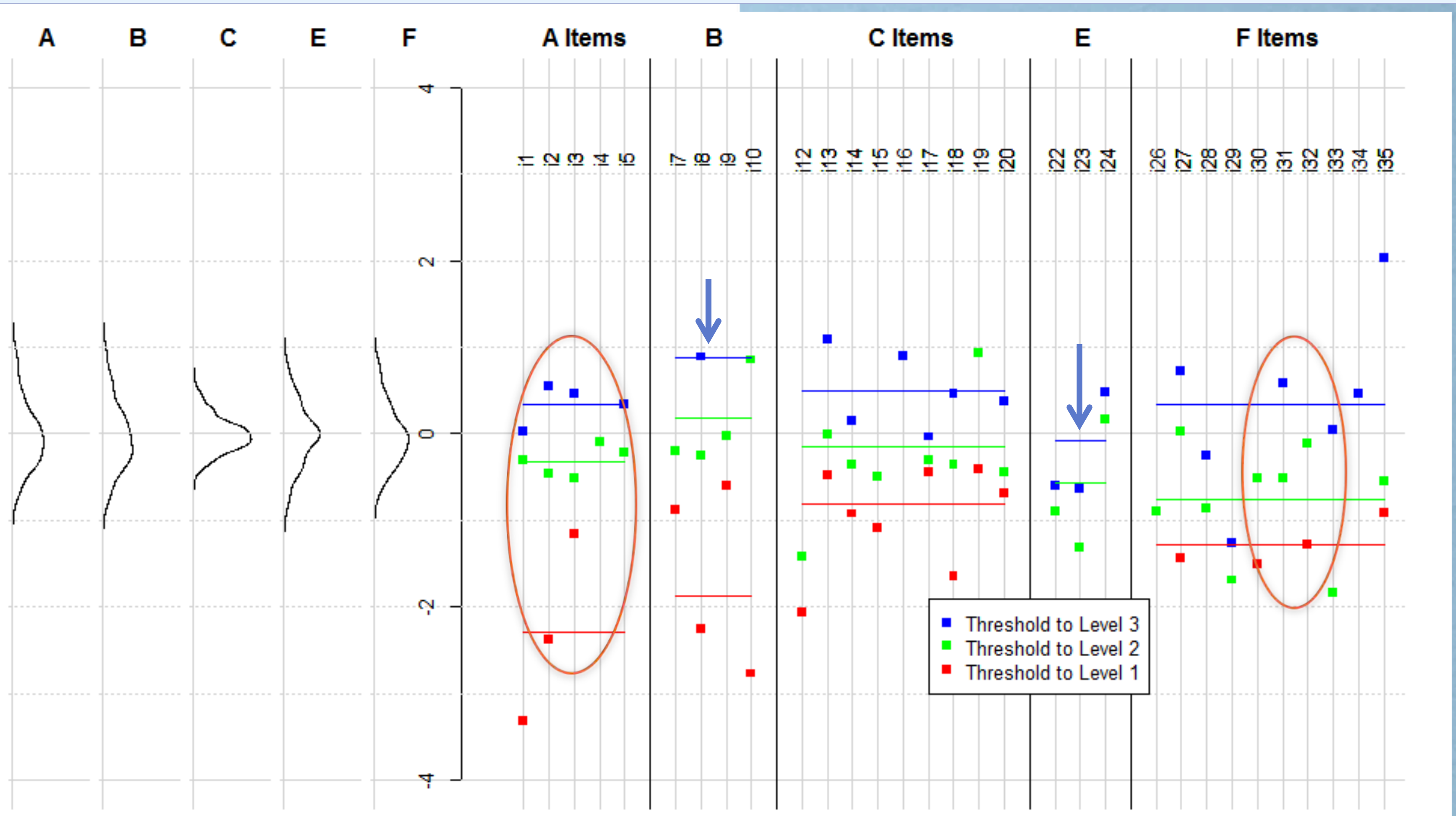
Concept	Example
Genes as passive particles associated with traits	No sense of genetic information. Genes and traits are the same
Genes as instructions	Genes have information for everything about you (all levels)
Genes as productive instructions for proteins	Genes have instructions for making proteins (only protein level)

Wright Map



A
B
C
E
F
A Items
B
C Items
E
F Items
4
2
0
-2
-4
i1 i2 i3 i4 i5
i7 i8 i9 i10
i12 i13 i14 i15 i16 i17 i18 i19 i20
i22 i23 i24
i26 i27 i28 i29 i30 i31 i32 i33 i34 i35
Thresholds
Threshold to Level 3
Threshold to Level 2
Threshold to Level 1

Wright Map


A
B
C
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A Items
B
C Items
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F Items
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2
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-2
-4
i1 i2 i3 i4 i5
i7 i8 i9 i10
i12 i13 i14 i15 i16 i17 i18 i19 i20
i22 i23 i24
i26 i27 i28 i29 i30 i31 i32 i33 i34 i35
Threshold to Level 3
Threshold to Level 2
Threshold to Level 1

Challenges

- **Grain size of constructs and levels:**
  - In mapping data to the model (LP), decisions about when to add, drop, split, or combine levels are not trivial (Shea & Duncan, 2012)
- **Assumptions about the nature of learning paths:**
  - Progress is not simply linear, more like ecological succession (Lehrer & Schauble, 2009)
  - Strength of developmental constraints: how many paths are there?
  - There may not be any clear paths (Shavelson, 2009)
- **Assessment observations and interpretations:**
  - Are our assessment "lenses" allowing us to see "real" cognition (Steedle & Shavelson, 2009)
- **Relation to instruction:**
  - Nature and quality of instruction can impact learning paths and outcomes.

Trying it Out

Look at the answers to the question of "what do genes do in our bodies?" (Construct B)

- Try to classify them into 3 (or more) levels
- Can you come up with an OMC item that would capture these levels (or some of these levels)

Responses:

1. Genes gives our traits and make us what we are.	7. Genes tell our body how to look and function.
2. They are unique information about us, like the DNA identifies who we are.	8.They are like recipes for our cells, and our proteins and everything about us.
3. Genes code for proteins, and proteins do everything in our body.	9. Genes make up our traits.
4. They determine our physical appearance.	10. Genes tell our cells what to do and how to look.
5. Genes are out blueprint, they have information about our eye color, and hair color, etc.	11. They are instructions for making proteins from amino acids.
6. Genes are our genetic information for our traits	12. Genes make you who you are

Questions for Discussion

1. Can there really be one or a few paths that we can identify? Is there one, or two, or three… best paths?
2. How can we tell which path is better? What criteria should we use?
3. Will the progression be the same 20 years from now if we use instruction that is based on current prototypes?
4. What is the role of instruction in promoting and validating LPs?

Future Research

- Research on assessment of LPs: we need more sophisticated instruments and measurement models
- Stitching of LPs across grade bands and domains is a challenge the field has yet to explicitly tackle
- Need to better understand how the learning of concepts and practices bootstrap each other in different domains
- Implementation challenge: How can teachers be supported in potentially using LPs?

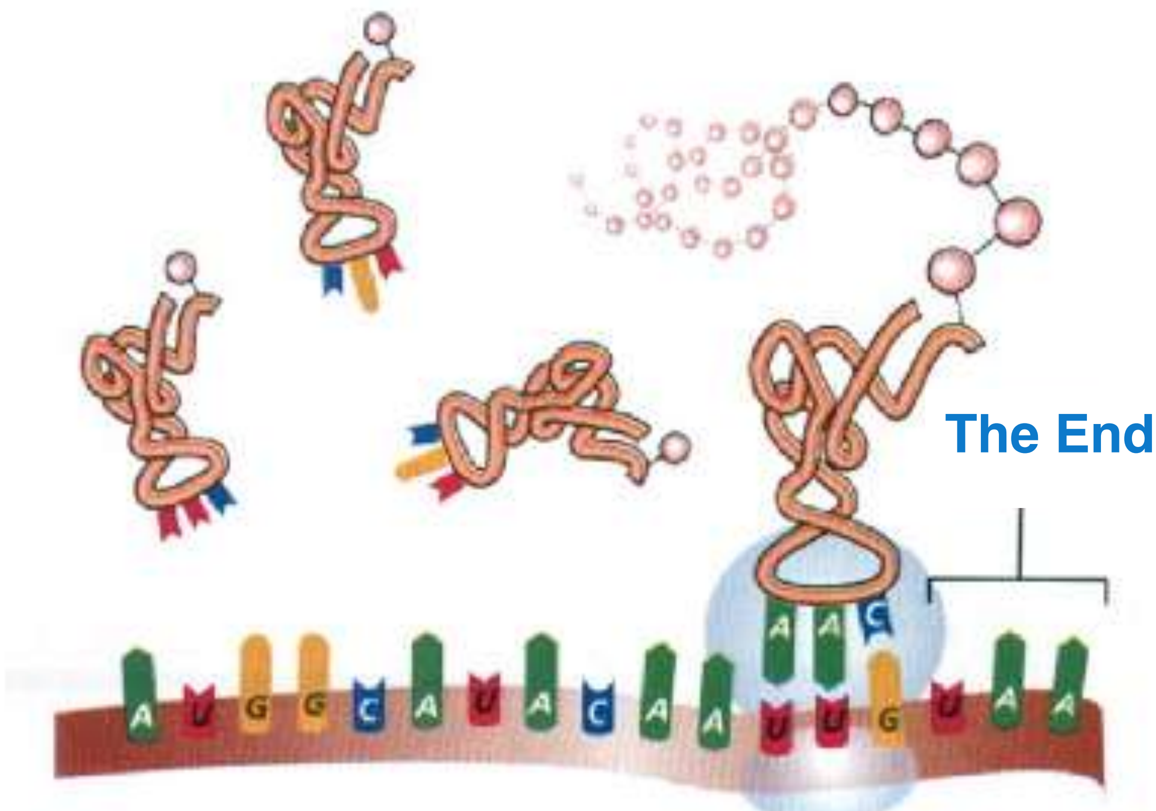
Promise

"To develop a thorough understanding of scientific explanations of the world, students need sustained opportunities to work with and develop the underlying ideas and to appreciate those ideas' interconnections over a period of years rather than weeks or months [1]. This sense of development has been conceptualized in the idea of learning progressions [1, 25, 26]. If mastery of a core idea in a science discipline is the ultimate educational destination, then well-designed learning progressions provide a map of the routes that can be taken to reach that destination. " (NRC, 2011)

Even if they are not ready for prime time, LPs offer an informed starting place for thinking about learning over time

Thank you!

ravit.duncan@gse.rutgers.edu



The End

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