WELCOME

- **Conceptual Learning Challenges in Learning Progressions:**
- **Their use in Spaced Assessment**

Please introduce yourself to your “tablemates”.
We’ll begin promptly at 2:00 ☺

Housekeeping

- Start and Ending times
  - 2 PM- 5PM
- Break
  - About 3:30
- Bathrooms
- Cell phones
- Table Stuff
- Table Dots
- Partner Tables

THE 21ST CENTURY CENTER FOR
RESEARCH & DEVELOPMENT IN

COGNITION & SCIENCE INSTRUCTION

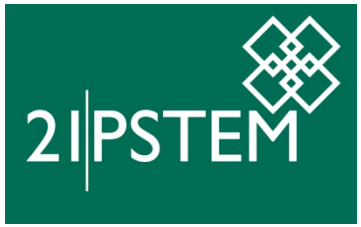
The Partners

INSTITUTE OF EDUCATION SCIENCES

UNIVERSITY OF PITTSBURGH

LRDC

Learning Research & Development Center



Temple University

Institute for Research in Cognitive Science

Four Cognitive Science Principles

- Analogical Reasoning using Contrasting Cases
- Diagrammatical Reasoning using Visualizations
- Misconceptions in Learning Progressions
- Assessment
  - Spacing
  - Diagnostic Items

Agenda

- Learning Progressions – Reasons for Student Difficulties
  - Review using Density
  - Introduction of
    - Plate Tectonics
    - Natural Selection
- Item Analysis and Mapping to Learning Progressions
- Writing New Items
- Spacing Assessments

Who's Here?

- Returning Participants
  - Purpose for returning
- New Participants
  - Expectations

Modified Agenda

- Learning Progressions – Reasons for Student Difficulties
  - Review using Density
  - Introduction of
    - Plate Tectonics
    - Natural Selection
- Item Analysis and Mapping to Learning Progressions
- Writing New Items
- Spacing Assessments

I

If this is not what you expected,please feel free to “go find that other session that sounded so good!!

Who's Who

- Please take a minute and discuss the 10 questions with the 10 people at your table.
- No one person can be listed for more than one question so Find the Best Fit.
- If you are a person with a BLUE DOT you will report out for the group.

Spaced Testing

- Why do students forget what they have been taught so quickly?

- Research has shown that forgetting can be dramatically reduced by occasionally revisiting old concepts in later tests (Rohrer & Pashler, 2007)
  - Spaced testing - where the test is spaced out over time instead of being massed

- Repeated testing is better than re-study, or a lecturing again, even controlling for the same amount of time (Roediger & Karpicke, 2006)

Spaced Testing

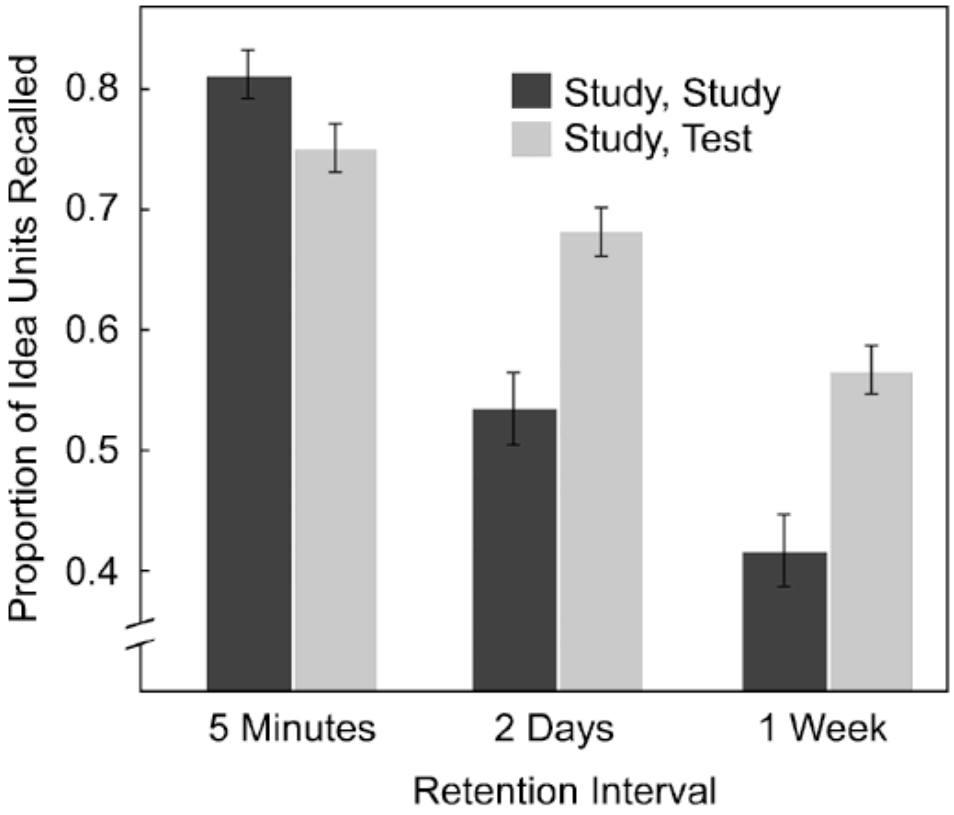


Fig. 6. Mean proportion of idea units recalled from a prose passage after a 5-min, 2-day, or 1-week retention interval as a function of whether subjects studied the passages twice or studied them once before taking an initial test. Error bars represent standard errors of the means. From Roediger and Karpicke (2006).

Spaced Assessment

- Well-designed assessment items can be more effective for learning than further review or practice
- Modifications include
  - daily warm-ups,
  - weekly quizzes (7 -20 items),
  - end of unit tests
- Mapped to the Big Ideas of the Unit

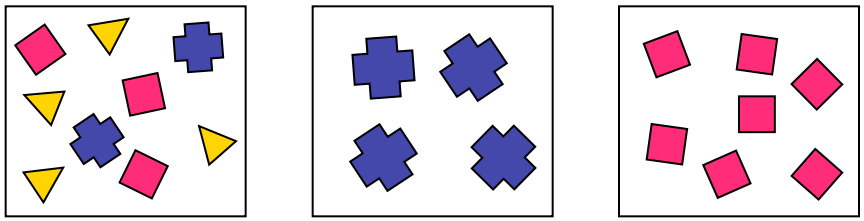
Warm-Up

= a particle of an element

= a particle of another element

= a particle of a compound

The figures below show the particles of three substances. Which substance is a mixture?



A B C

A, because it is made up of two elements and a compound

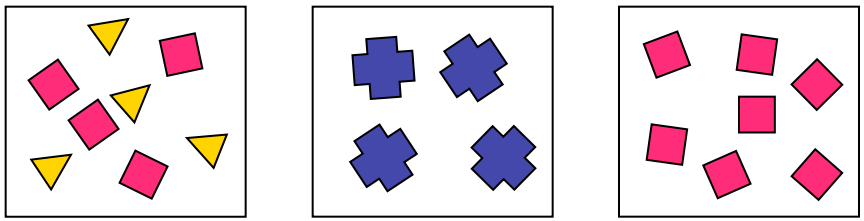
Day 33

■ = a particle of an element

▲ = a particle of another element

✚ = a particle of a compound

The figures below show the particles of three substances. Are any of these pure substances?



A B C

B & C, because they both contain only one type of particle

Day 5

Imagine you use displacement to measure two balls. You find that one ball displaces twice as much as the other. What can you conclude?

One ball takes up twice as much space as the other. It has twice the volume.

Day 8

Imagine you have two balls that have the same mass. You use displacement to measure each ball. Will they displace the same or different amounts?

There's no way to know, because we don't know how their sizes compare.

Overview of Earth History Warm-Up Exercises

	warm-up day 2	warm-up 3	warm-up 4	warm-up 5
days 1 & 2 intro fly-over & cc 8a -- compare rock types (ign,met,sed)		day 3 cc 8b -- compare rock formation, part 1 (ign,met)	day 4 8.1 -- igneous & metamorphic rocks	day 5 8.2 -- salol crystals
warm-up 6	quiz 1	warm-up 8	warm-up 9	warm-up 10
day 6 8.3, step 5 -- tectonic forces reading	days 7 & 8 cc 4 -- compare rock formation, part 2 (sed, rock cycle)		day 9 8.1, step 15 (Wrightwood Marble reading)	day 10 re-teach based on quiz 1 results
warm-up 11	warm-up 12	warm-up 13	warm-up 14	warm-up 15
day 11 4.2 -- observe sand samples	day 12 4.3 -- stream table	day 13 4.4 -- video on weathering & erosion	day 14 4.5 -- make sandstone	day 15 4.6 -- make shale

Quiz Assessment Matrix

	Inv 1	Inv 2	Inv 3*	Inv 4	Inv 5	Inv 6*
Current Inv	6	4	5	4	4	5
Previous Inv	0	2	5	2	2	4
2-3 Inv(s) ago	0	0	5	0	0	4
More than 3 Invs ago	0	0	0	0	0	2
Open ended	1	1	1	1	1	1
Vis	1	1	1	1	1	1

Overview of Earth History End-of-Investigation Quizzes

quiz 1, item 1	quiz 1, item 2	quiz 1, item 3	quiz 1, item 4	quiz 1, item 5
days 1 & 2		day 3	day 4	day 5
intro fly-over & cc 8a -- compare rock types (ign,met,sed)		cc 8b -- compare rock formation, part 1 (ign,met)	8.1 -- igneous & metamorphic rocks	8.2 -- salol crystals
quiz 1, item 6	**quiz 1**			**quiz 2, item 1**
day 6	days 7 & 8		day 9	day 10
8.3, step 5 -- tectonic forces reading	cc 4 -- compare rock formation, part 2 (sed, rock cycle)		8.1, step 15 (Wrightwood Marble reading)	re-teach based on quiz 1 results
quiz 2, item 2	**quiz 2, item 3**	**quiz 2, item 4**	**quiz 2, item 5**	**quiz 2, item 6**
day 11	day 12	day 13	day 14	day 15
4.2 -- observe sand samples	4.3 -- stream table	4.4 -- video on weathering & erosion	4.5 -- make sandstone	4.6 -- make shale

Summative Tests

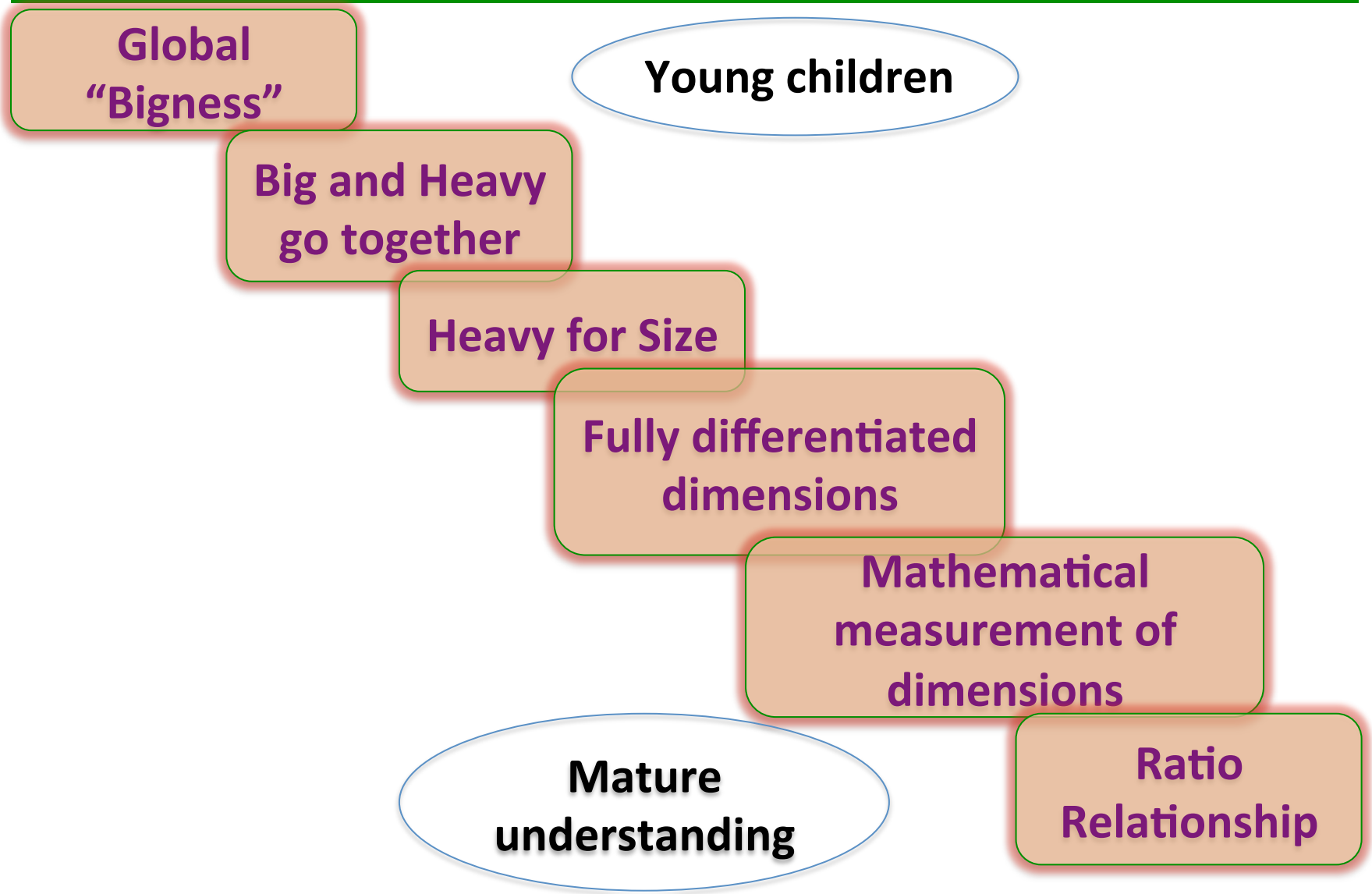
End of Unit Matrix

- 18 items chosen from standardized state and national tests released items
- 3 items based on Contrasting Case material
- 3 items based on Visualization conventions

End of Year Test

Why is learning about density hard for so many students?

Density Learning Progression



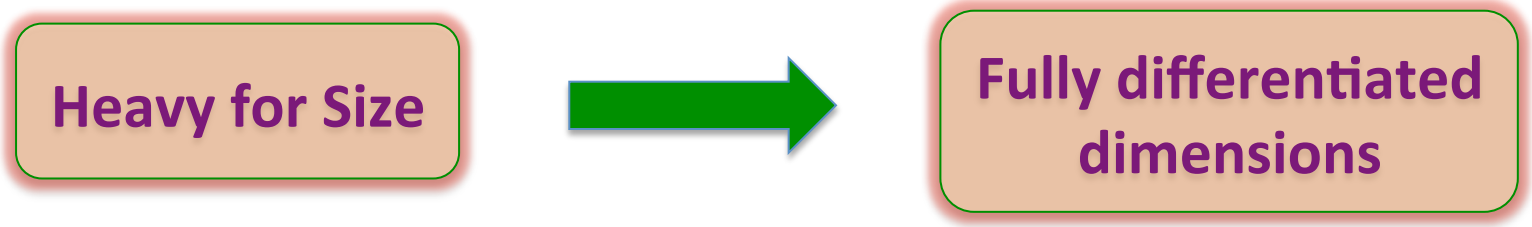
Global "Bigness"

Big and Heavy go together

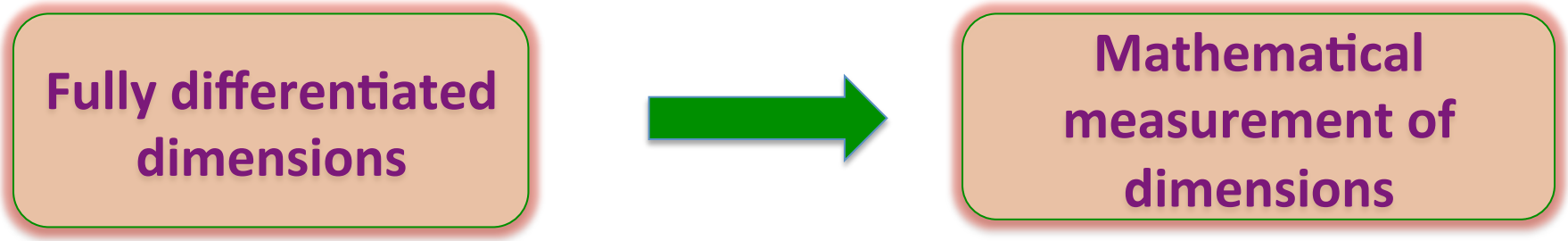
Differentiating size from weight is a gradual process

- Initially magnitude dimensions (length, area, volume, weight) are not differentiated from each other. Objects are simply big or little.
- Preschoolers have a very rough sense of size and weight and expect them to be correlated (big things are heavy)
- Things are heavy if they feel heavy
- Density is absent from their conceptual system

Smith, Carey & Wiser, Cognition, 1985

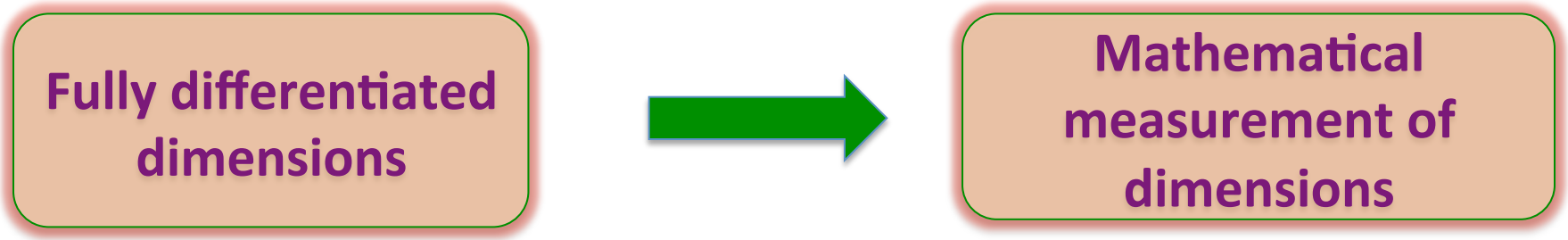


- In early school years, children start to distinguish between “heavy” and “heavy for size”: a rock may be small but heavy; a beach ball is big but light.
- In the middle elementary school years children start to differentiate weight from density more consistently and to separate size dimensions (linear, area, volume) from each other.
- They also start to see weight as a fundamental property of matter (i.e., all matter—even a tiny little bit—has some weight).



Measurement

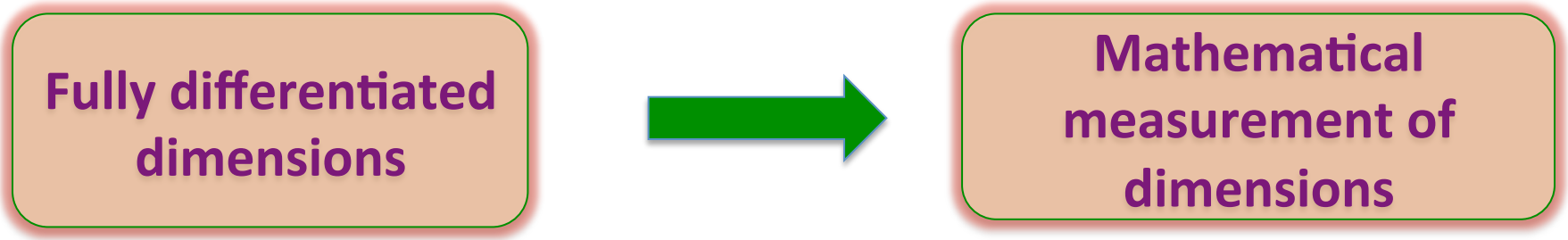
- Many students struggle with measurement skills and concepts
- Confusion between counting and measuring; difficulties with the mathematics of *continuous quantities*
- Incomplete understanding of the properties of measurement units, the attributes they measure, and use of measurement tools



Measurement

"Quantifying involves being able to measure (quantify) important physical magnitudes such as volume, weight, density, and temperature using standard or nonstandard units. Measuring is a simple form of mathematical modeling: comparing an item to a standard unit and analyzing a dimension as an iterative sum of units that cover the measurement space."

Smith et al., 2004. NRC Commissioned Paper.



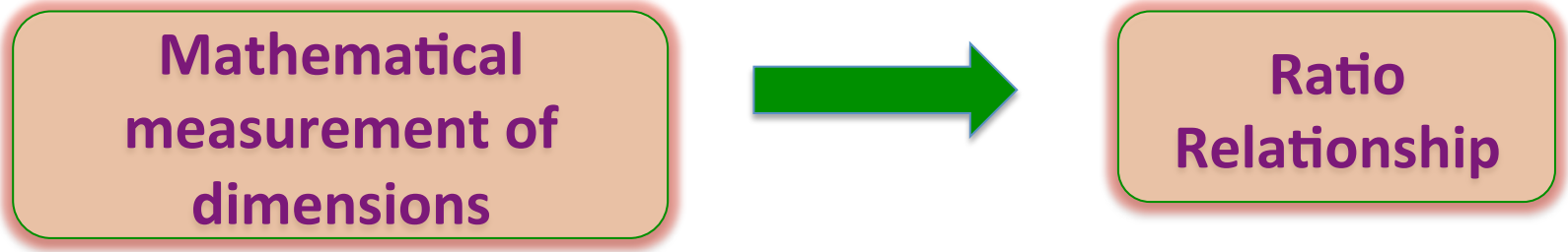
Sense Impressions vs. Measured Properties

"Most of our everyday physical concepts are sensory in origin. . . Sense impressions do not provide reliable data about scientific concepts; instead, scientists rely on measuring tools and instruments."

Moving from sense impressions to measured properties helps students distinguish properties that were initially confounded.

Measurement is an important part of doing science and thinking scientifically.

Smith et al., 2004. NRC Commissioned Paper.



It takes time to translate intuitive concepts into explicit concepts in math and science classes

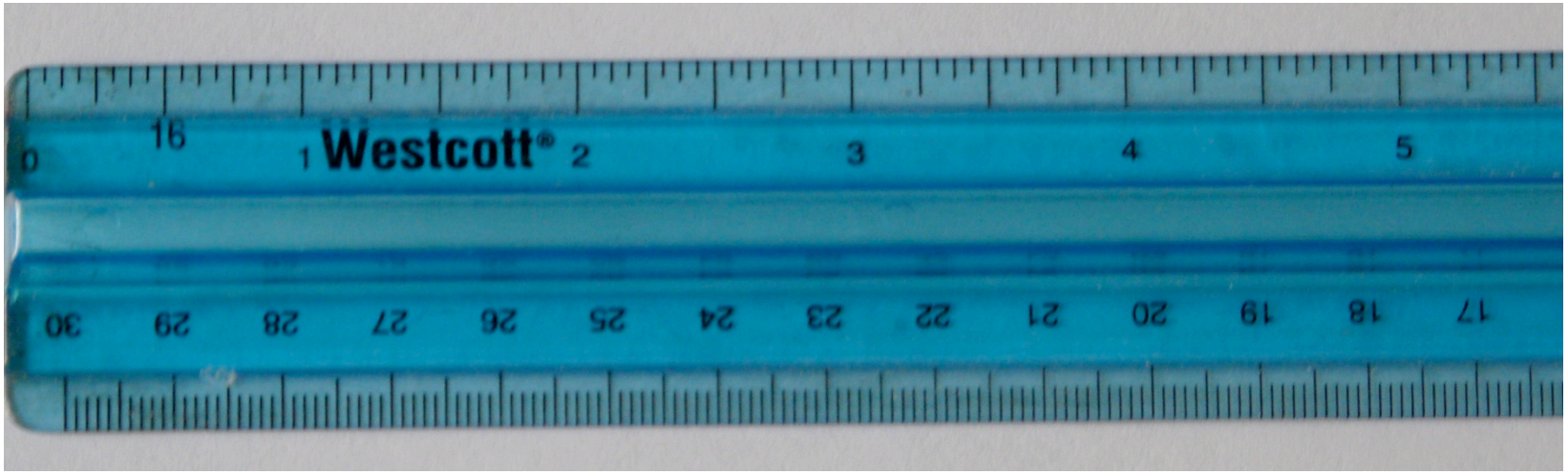
- Separating and quantifying length, area, and volume as different dimensions of size, measured with different units
- Distinguishing between mass and weight as theoretical constructs
- Relating mass and volume to construct a concept of density that is a ratio of two continuous measures

Assessment for Learning

- Formative rather than summative
- Diagnostic of common misunderstandings as well as understanding
- Tests individual components of learning as well as targeted combinations
- Patterns across sets of items can be particularly informative

Mathematical measurement of dimensions

Linear Measurement Units

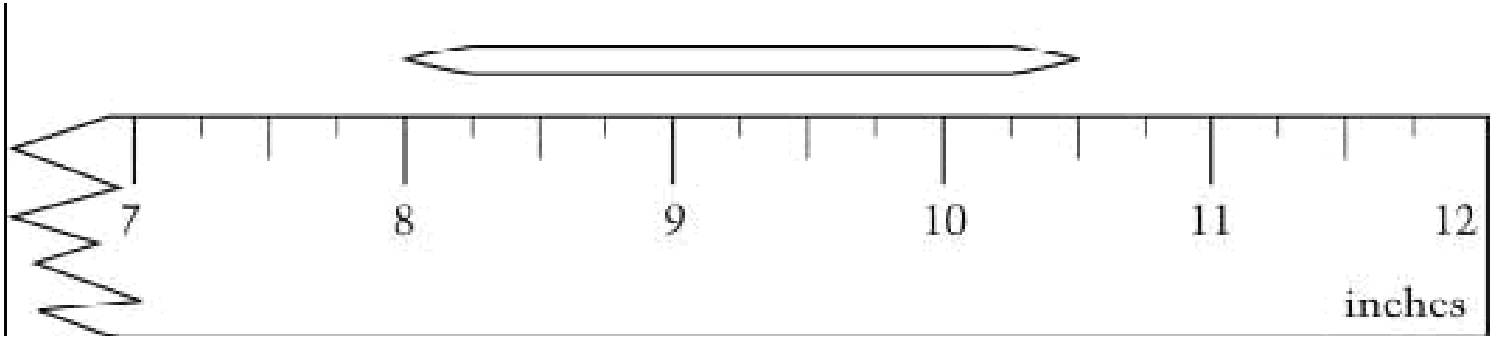


Students need help extracting the unit structure that is embedded in rulers.

Mathematical measurement of dimensions

Linear Measurement Units

NAEP 2003, released item, National Data



What is the length of the toothpick in the figure above?

Answer	4th Grade	8th Grade
2.5 in	20%	58%
10.5 in	14%	7%
3.5 in	42%	20%

Mathematical measurement of dimensions

Area Measurement Units

How many square tiles, 5 inches on a side, does it take to cover a rectangular area that is 50 inches wide and 100 inches long?

Answer: _____

Only 16% of 8th graders give correct response of 200.
73% give incorrect response of 1000.

NAEP 2009 Released Item: Grade 8, National Data

Mathematical measurement of dimensions

Volume Measurement Units

Which of the following is a unit of volume?

A. Acre (6%)
B. Gram (16%)
C. Liter (56%)
D. Meter (16%)
E. Ton (4%)

NAEP 2011 Released Item: Grade 8, National Data

Quiz items with student data from pilot classroom

1. Suppose you are given a clay ball. You use a balance to get its mass. Now you flatten this ball into a pancake-shaped piece and you measure its mass. *Which of these statements is correct?*

    a. The pancake-shaped piece has more mass than the ball **5%**

    b. The pancake-shaped piece still has the same mass **74%**

    c. The ball has more mass than the pancake-shaped piece **21%**

2. *because*

    a. when something is flattened it has less mass **21%**

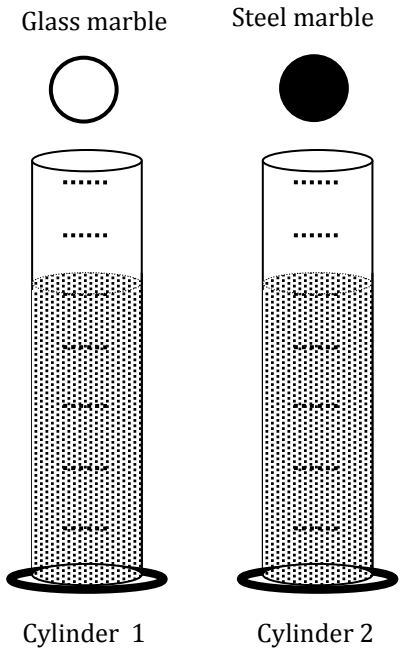
    b. more gravity acts on the flattened piece **2%**

    c. clay has not been added or taken away **77%**

Quiz items with student data from pilot classroom

3. Two identical graduated cylinders are filled to the same level with water. Suppose we have two identical looking marbles, one made of glass and one made of steel. When the glass marble is lowered into the first cylinder, it sinks to the bottom and the water level rises to the 6th mark. If we lower the steel marble into the second Cylinder, the water level will rise

   a. to the 6th mark **35%**
   b. higher than the 6th mark **60%**
   c. lower than the 6th mark **5%**



4. *because*

   a. the marbles are made of different materials. **23%**
   b. the steel marble is heavier than the glass marble. **42%**
   c. the marbles have the same volume. **35%**

Mathematical measurement of dimensions → **Ratio Relationship**

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

Density is neither a count nor a measure: Density is a **RATIO** of two continuous quantities, each of which is measured in different units.(Mathematicians refer to this as an *intensive* quantity.)

Grams per cubic centimeter
Grams per liter
Pounds per cubic inch

Ratio Relationship

A Closer Look at Density

- As a ratio, density has some particular mathematical qualities that are new to students.
- Science application: A uniform sample of a given material will have the same density, no matter what quantity you have of that material. Characteristic density can be used to identify certain substances. Density remains constant as long as the ratio stays the same. So whether you have a small sample of a given material or a large sample, the density can be exactly the same.
- Relative density is still more complex: comparing two ratios to each other.
- Density, changes in density, and relative density are important in scientific explanations, such as states of matter, convection currents, sinking and floating, pressure laws, etc.

An example: Price per pound

- Suppose your favorite coffee costs $12 per pound. This ratio remains the same no matter how much you spend or how much coffee you get.

Cost per pound ratio:	$3 per ¼ lb = $12 / lb	$6 per ½ lb = $12 / lb	$24 per 2 lb = $12 / lb	$60 per 5 lb = $12 / lb.
Cost of coffee in $	$3	$6	$24	$60
Quantity of coffee in lbs.	¼ pound	½ pound	2 pounds	5 pounds

Notice that if you double the quantity of coffee you are buying, you also double the amount of money you pay, but you DO NOT double the cost per pound.

Useful Source:

Implications of Research on Children's Learning for Assessment: Matter and Atomic Molecular Theory

Carol Smith, Marianne Wiser, Charles W. Anderson, Joe Krajcik, and Brian Coppola:

NRC Commissioned Paper, 2004

Available at:
http://www7.nationalacademies.org/bota/Big%20Idea%20Team_%20AMT.pdf

Assessment of Learning Progressions

- Diagnostic Assessment Items use misconceptions as distractors
- Our Sources:
  - CASEBook tests; MOSART tests
  - Implications of Research on Children's Learning for Assessment: Matter and Atomic Molecular Theory (Smith, Wiser, Anderson 2004 - NRC commissioned paper)

Some Principles for Item Analysis

(Limited to Paper & Pencil MC)

Taylor and Smith "How do you know if they're getting it?" Science Scope 2009

Item Analysis

1. Define and clarify the content.
   Learning Progressions
2. Target the item. One sub-idea per item if possible.
   Example: How to measure volume
   Caveats: Cognitive load gets higher as more sub-ideas are being assessed within one item
   More difficult to unpack why the student missed the item.
   Use a battery of targeted items.

Item Analysis

3. **The Necessity Principle:**

The knowledge in the sub-idea is needed to answer the item.

OR

The item cannot be answered correctly without knowing the sub-idea.

(Stern and Ahlgren 2002)

Item Analysis

4. **The Sufficiency Principle:**

The knowledge in the sub-idea is ALL a student needs to know to answer the item correctly.

OR

Answering the item correctly requires NO knowledge outside the sub-idea.

Stern and Ahlgren 2002

Item Analysis

5. Item should not teach content that is to be tested elsewhere in the test.

   Example: The earth's crust is made of tectonic plates which are moving. How fast do these plates move?

   Caveats: There may be times when you DO want to give content in the stem in order to target the item. Just be aware!

Item Analysis

6. Mirroring: Answer choices should reflect the question being asked.

   Bad Example: How do plants **get** their food?

   A. Plants **make** food from minerals, water, and sunlight.
   B. Plants **make** food from carbon dioxide, water, and sunlight.
   C. Plants **get** food by absorbing water through their leaves.
   D. Plants **get** food by absorbing nutrients through their roots.

Item Analysis

7. Facilitating Comprehension:

Keep sentences brief and straightforward, with a simple phrase structure and no additional clauses

Example: A shopping cart is pushed so that it moves faster and faster. What is true about the situation?

A man is pushing a shopping cart. The cart is moving faster and faster. What must be true about the situation?

Item Analysis

7. Facilitating Comprehension:

Visuals should facilitate the understanding of what is being asked not add to cognitive load with unnecessary or distracting details.

Don’t include a visual just to include a visual.

Item Analysis

8. Avoiding Test-wiseness:

   Students tend to…

      Choose the longest answer

      Choose the most “science-y” answer

      Rule out answers with strong qualifiers (e.g., only, never, always)

Most Important Rules

1. Target the item.

   One sub-idea per item if possible.

2. Necessity principle

   What do you need to know to answer?

3. Sufficiency principle

   Is that all you need to know?

Questions

Practice Applying Principles

Item 1

Which one of the following is true about Earth's plates?

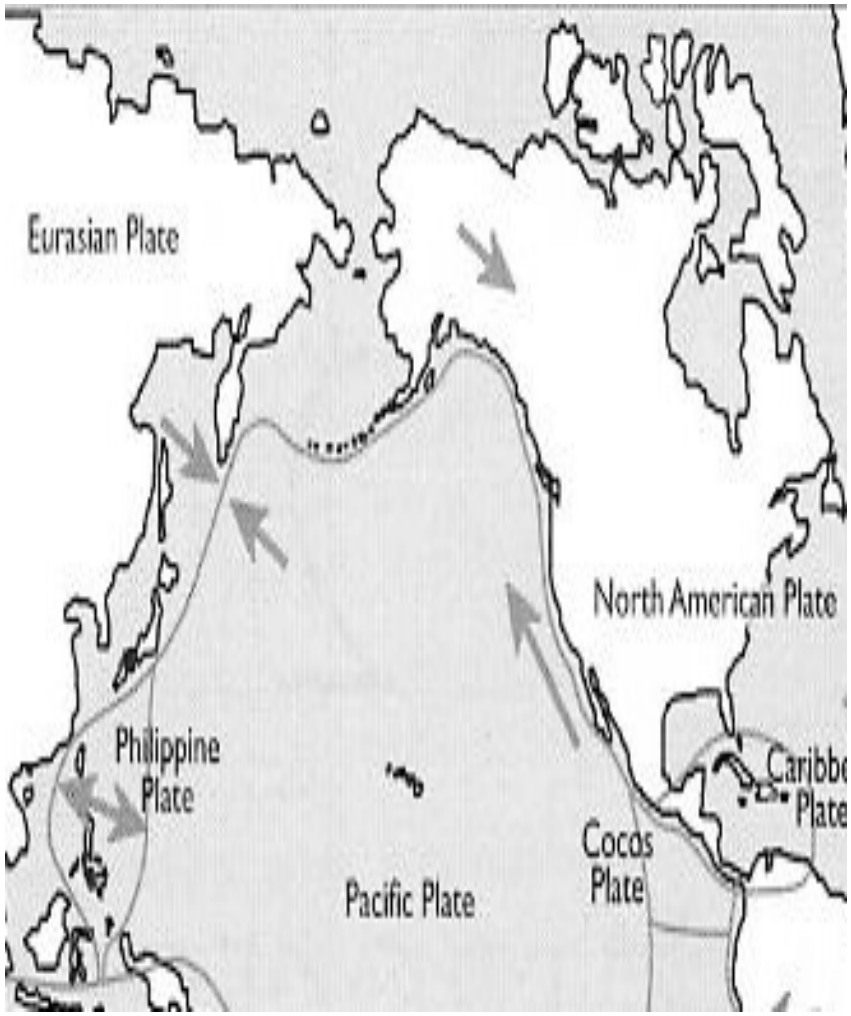
A. Earth has one large plate of solid rock.

B. Earth has one large plate that has some solid parts and some liquid parts.

C. Earth has a number of plates of mostly solid rock.

D. Earth has a number of plates, all of which are liquid.

Item 2



In which one of the following places would it be most likely for an earthquake to happen?

A. Along the Pacific coast of North America

B. Along the Atlantic coast of North America

C. In the middle of the Pacific Ocean

D. In the middle of North America

Item 3

Which one of the following energy transformations happens in a plant?

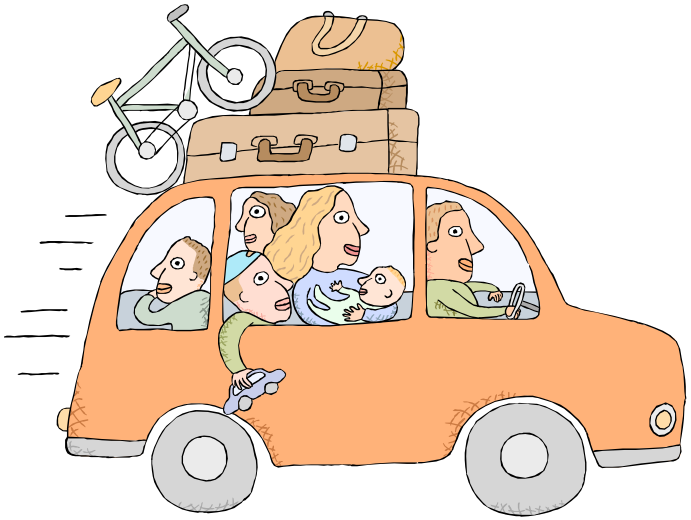
A. Light energy is transformed into chemical energy.

B. Heat energy is transformed into chemical energy.

C. Heat energy is transformed into motion energy.

D. Motion energy is transformed into heat energy.

Item 4



A car is moving faster and faster along a straight, level section of road. Which of the following must be true about the forces on the car?

A. The total force in the direction of the car's motion is greater than the total force in the opposite direction.

B. There is an increasing total force in the direction of the car's motion.

C. The total force in the direction of the car's motion is greater than the car's force.

D. There are no forces in the direction opposite to the car's motion.

Assessment Activity

- Find a partner, an envelope of items and a Learning Progression Map.
- Put each item through Item Analysis.
  - What do you need to know?
  - Is that ALL you need to know?
- Group the items which target a particular concept from the Learning Progression together.
- Identify the concept with a Post-It note.
- Prioritize the items. Which would you discard? Why?

Assessment Activity

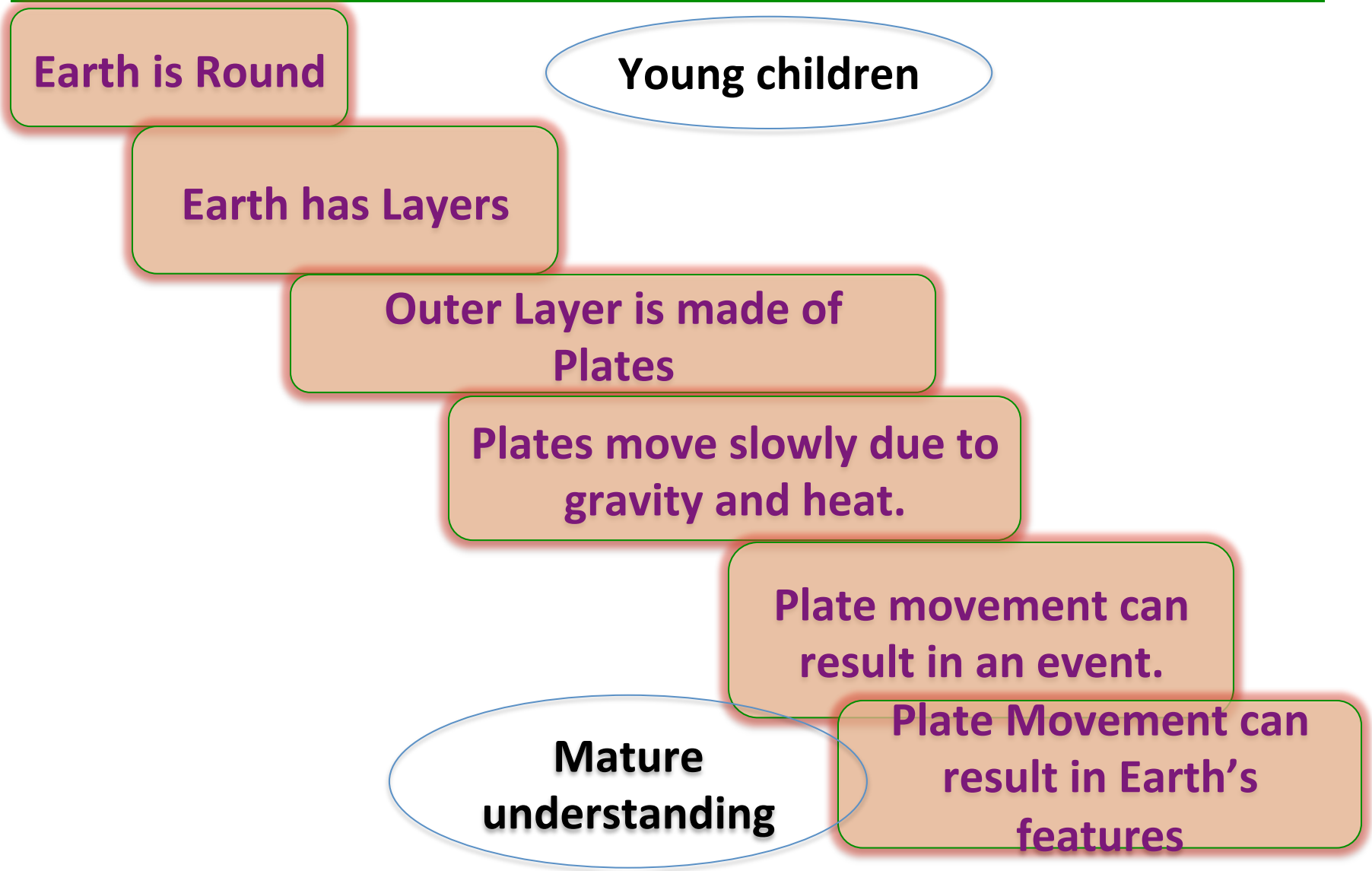
- Divide your table into two groups.
- Decide what parts of the Learning Progression were not assessed well.
- Find a different partner.
- Brainstorm what an item to “Fill the Gap” might look like.
- Write it on an index card.

Assessment Activity

- Put your index card in the middle of the table.
- "Go Fish"
  - Take an index card out of the middle.
  - If it was written in pen, use pencil to make suggestions for improvement.
  - Replace it in the center of the table and take another card.

- RED DOTs go over the items and choose one to share with the Large Group.

Plate Tectonics Learning Progression



Understanding the Earth

How do children think about the Earth?

How do their ideas change over time?

Vosniadou and colleagues, 1990, 1992, 1994, 1996
Nussbaum and colleagues, 1976, 1979,1983

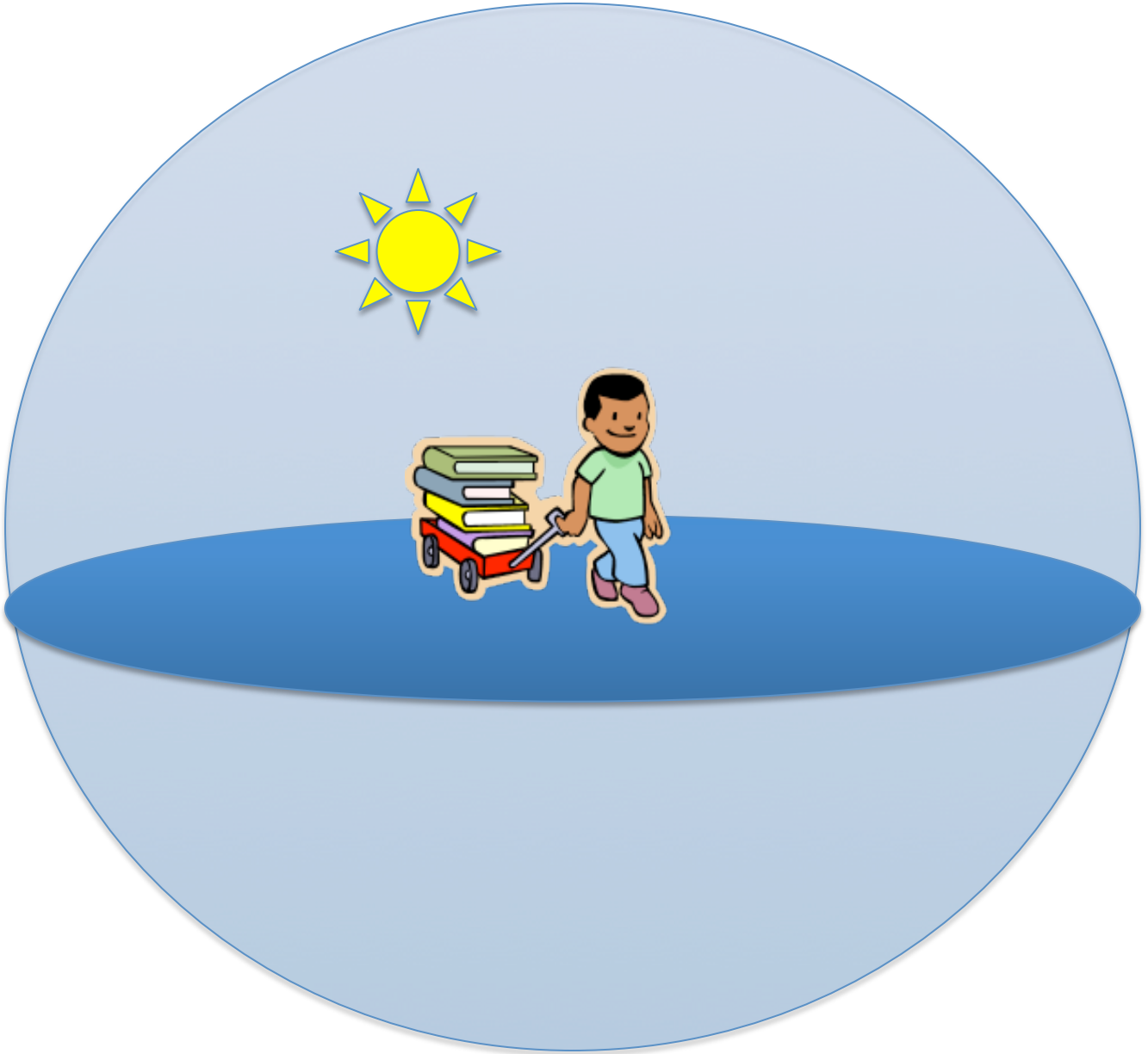
Understanding the Earth

Child: The earth is flat.

Adults: No – the earth is round.

Child: Oh, okay, it's round. Like a pancake.

Adults: No, round like a ball.



How students construe what is offered to them depends on and interacts with ideas they bring to the learning situation.

Transitioning to Middle School Science

For most of their young lives, middle school students have had deep-seated intuitions that:

- Earth is solid
- Earth is a flat plane
- Up and down are perpendicular to that plane and objects fall down (contrasts with gravitational force toward *center* of the Earth's mass)

In middle school, we ask them to reason with much more complex models of the Earth and the Earth-Sun system.

Working with Complex, Abstract Representations

To learn and think and talk about these systems in a scientific way, we have to resort to theoretical descriptions, analogies, and models – which may take many different forms, such as—

- 2D diagrams
- 3D models
- verbal discourse
- written text
- mathematical representations
- classification systems
- simulations

Earth has a complex internal composition different from what is visible on the outside.

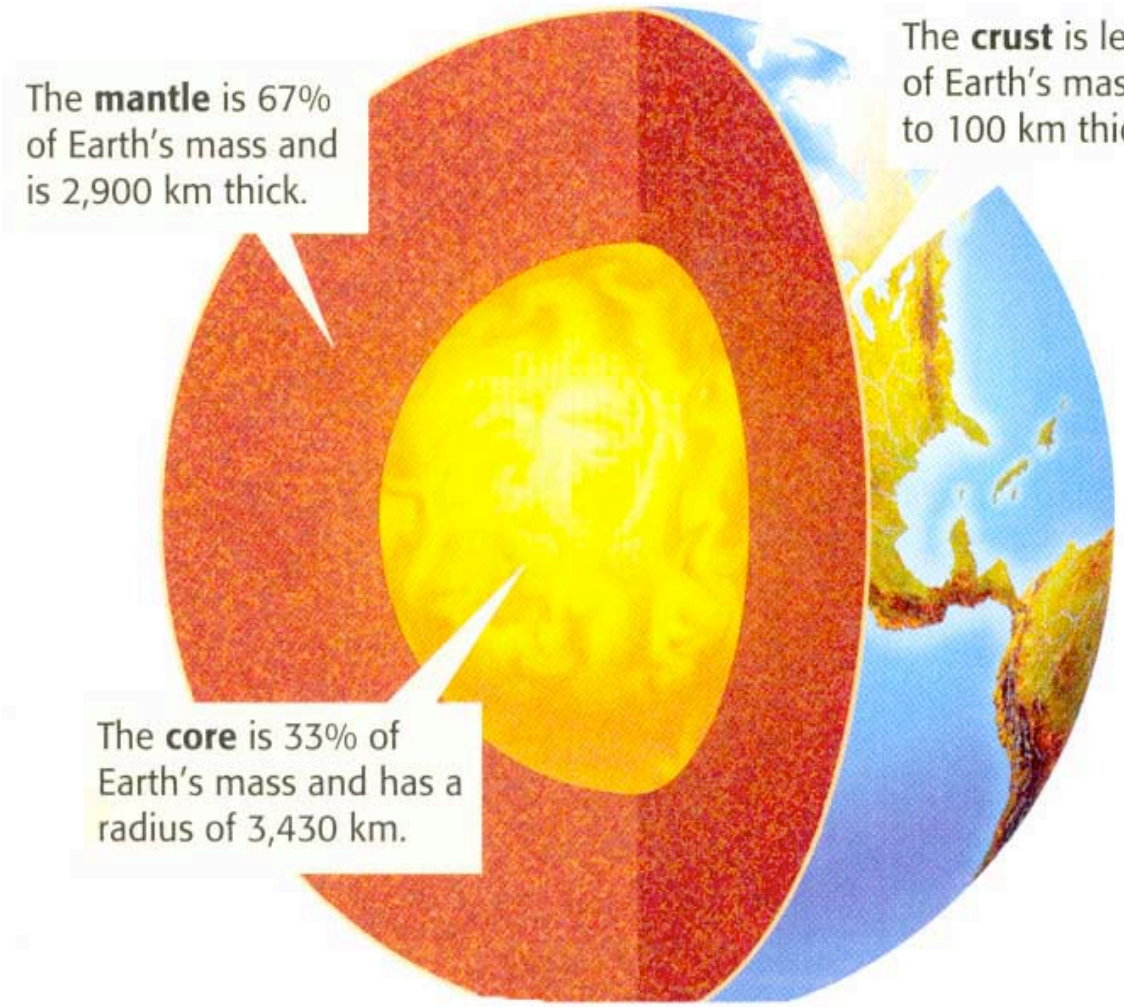
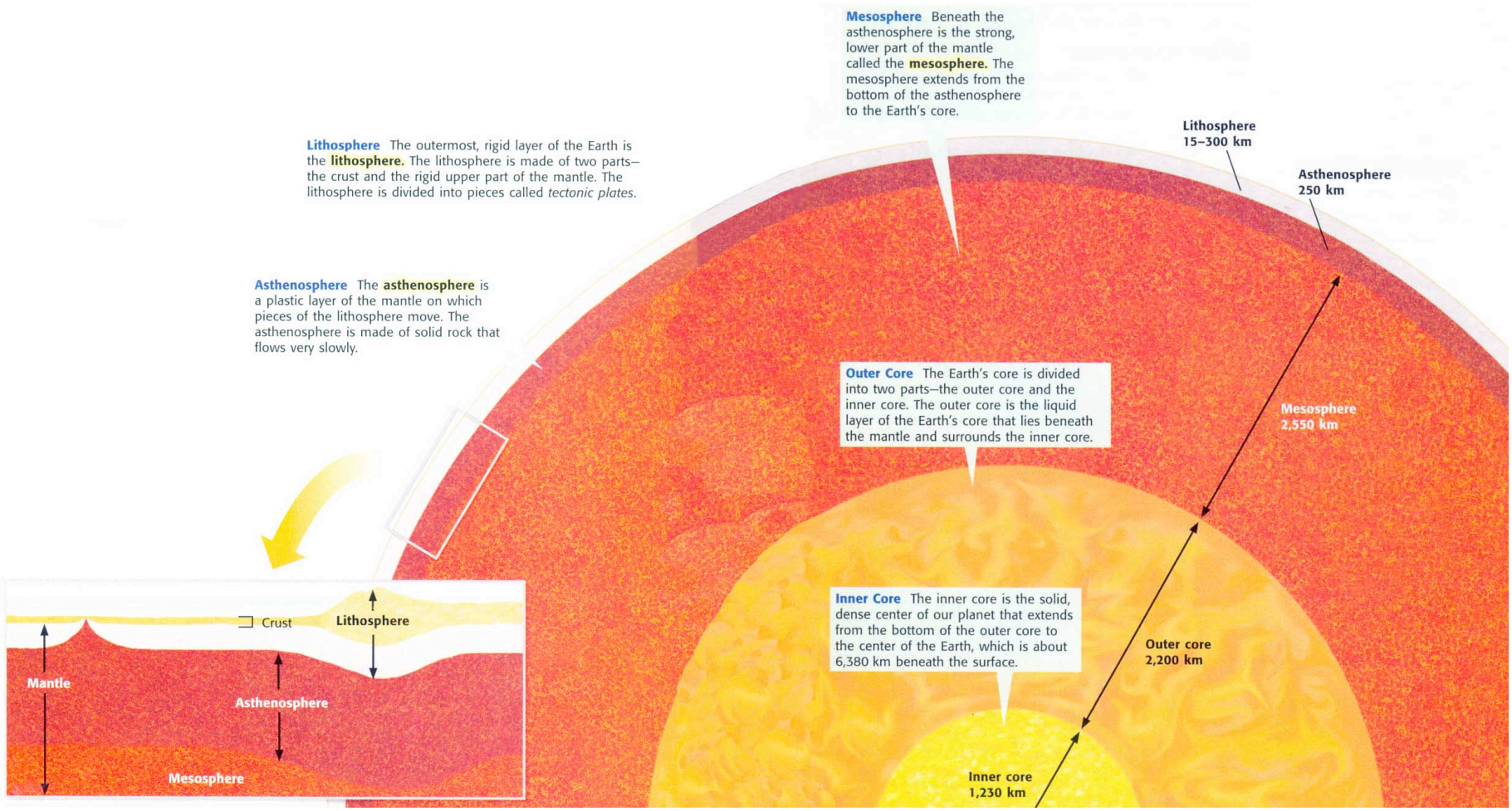


Figure 3 *The Earth is made up of three layers based on the composition of each layer.*


Mesosphere Beneath the asthenosphere is the strong, lower part of the mantle called the mesosphere. The mesosphere extends from the bottom of the asthenosphere to the Earth's core.
Lithosphere The outermost, rigid layer of the Earth is the lithosphere. The lithosphere is made of two parts—the crust and the rigid upper part of the mantle. The lithosphere is divided into pieces called tectonic plates.
Asthenosphere The asthenosphere is a plastic layer of the mantle on which pieces of the lithosphere move. The asthenosphere is made of solid rock that flows very slowly.
Outer Core The Earth's core is divided into two parts—the outer core and the inner core. The outer core is the liquid layer of the Earth's core that lies beneath the mantle and surrounds the inner core.
Inner Core The inner core is the solid, dense center of our planet that extends from the bottom of the outer core to the center of the Earth, which is about 6,380 km beneath the surface.
Lithosphere 15–300 km
Asthenosphere 250 km
Mesosphere 2,550 km
Outer core 2,200 km
Inner core 1,230 km
Crust
Lithosphere
Mantle
Asthenosphere
Mesosphere

There are movements and transformations taking place inside, with extremes of temperature and pressure.

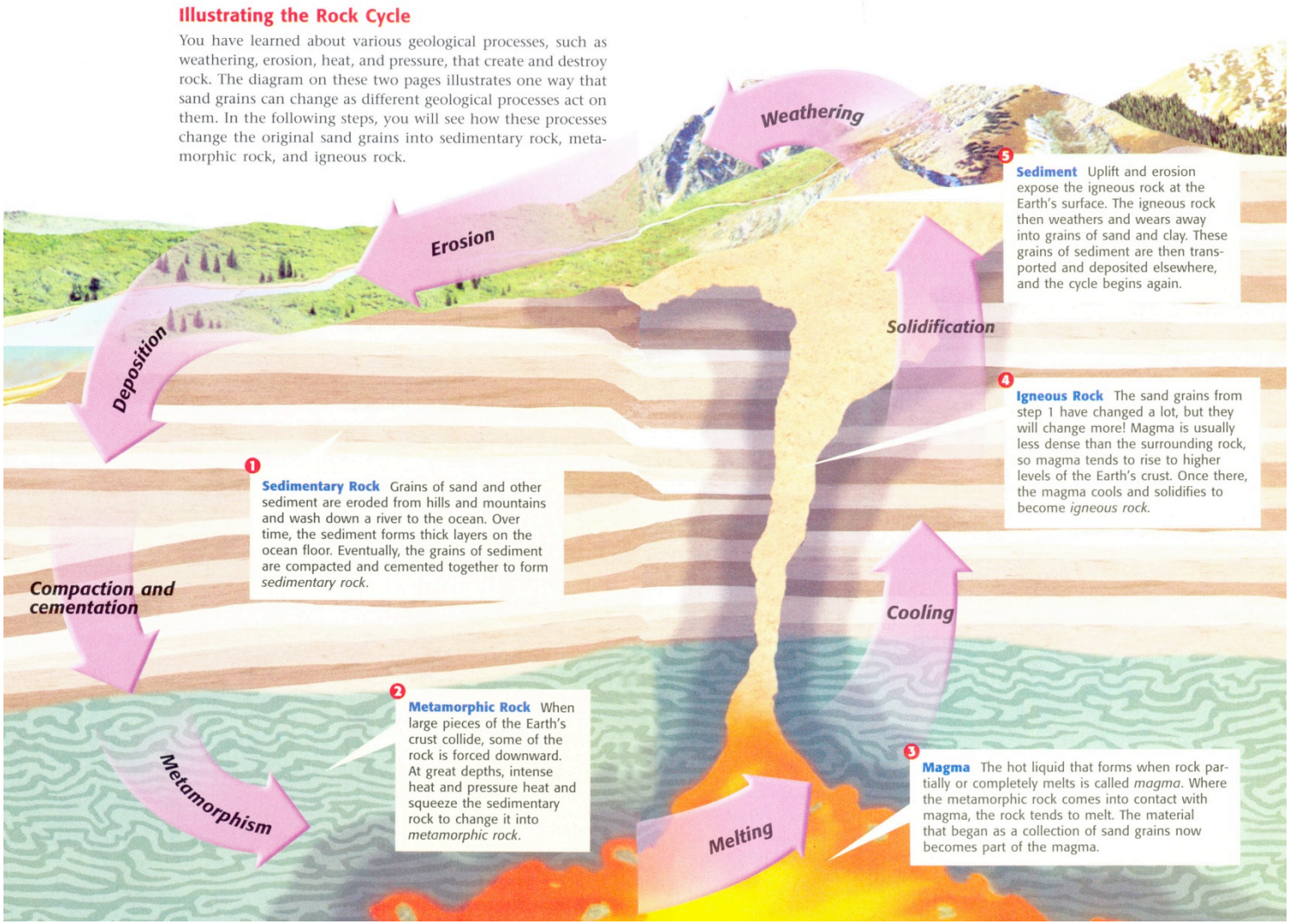


Figure 1 **Three Possible Driving Forces of Plate Tectonics**

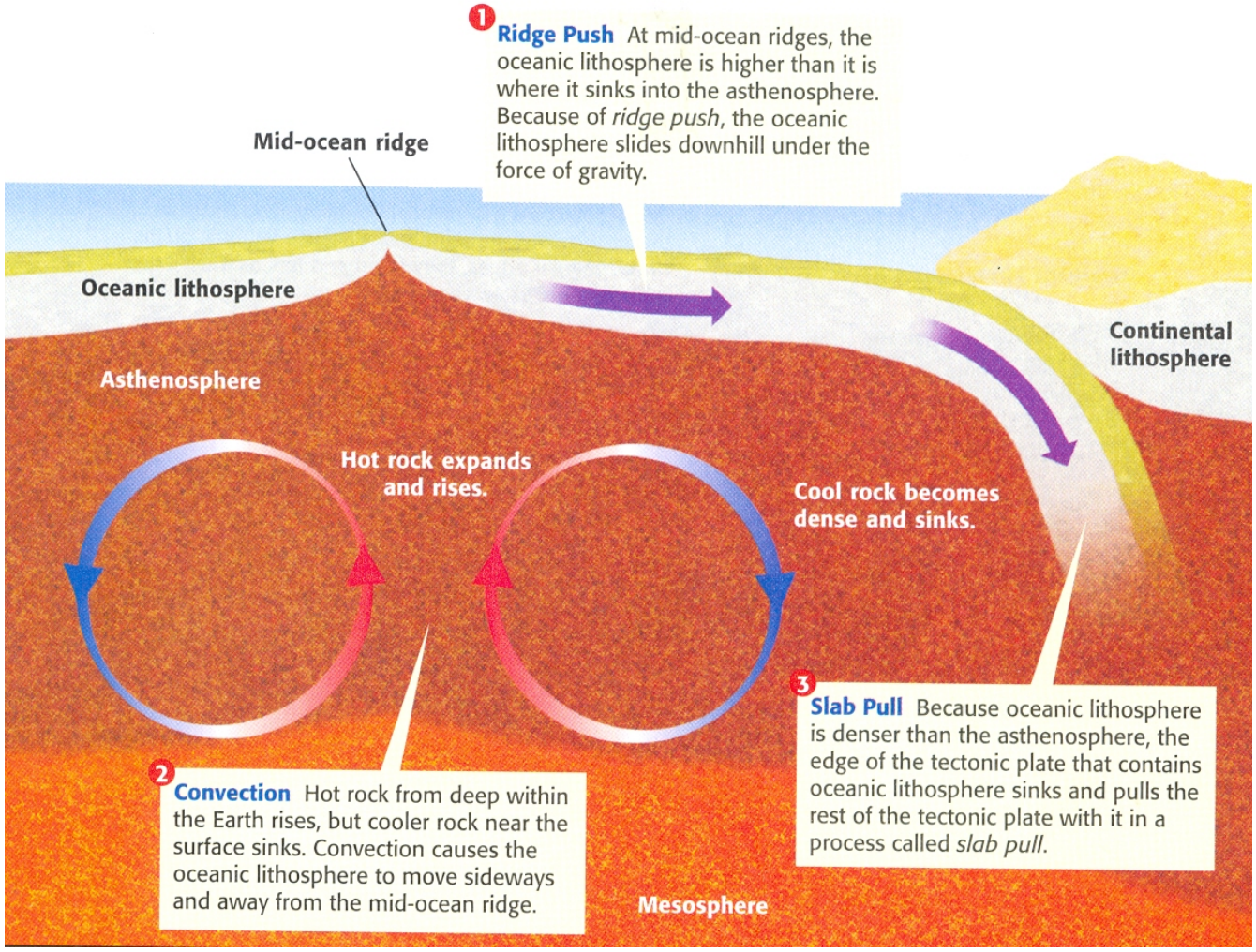


Plate Tectonics Learning Progression

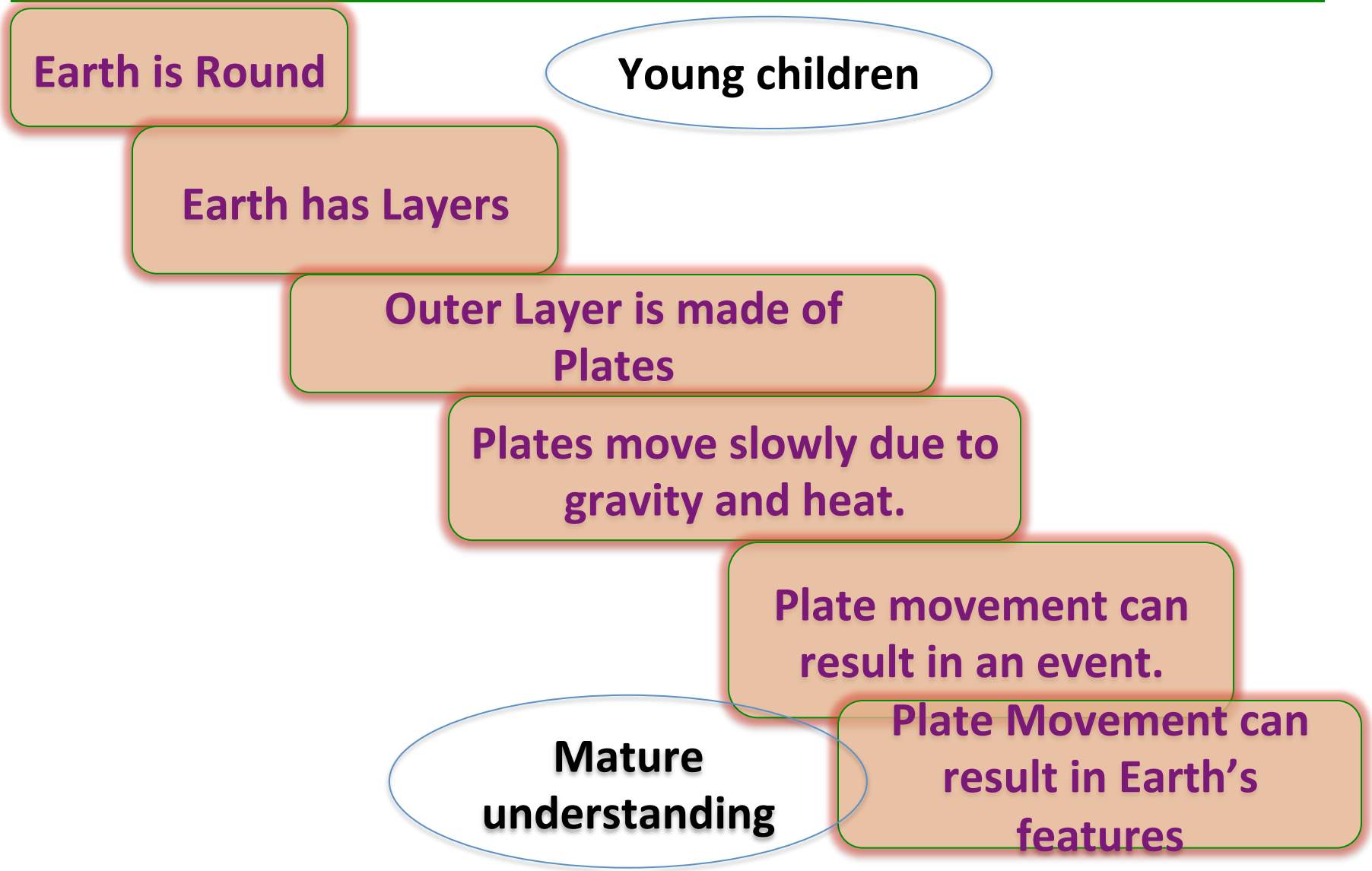


Plate Tectonics Learning Progression

- Outer Layer is made of plates of solid rock that are “floating on” a layer of less solid rock.
  - Common versus scientific use of Plates
  - If the plates are rock, they must be the continents
  - Rocks don’t float.
  - Things float in water. Continents must be floating on oceans.

Plate Tectonics Learning Progression

- Plates move slowly due to gravity and heat.
  - Idea of "Forces"
    - Invisible
    - Scale – Gravity might act on a ball but nothing can move a whole continent.
  - Idea of Heat
    - Scale – Nothing can soften a rock. There isn't enough heat to MELT a rock.

Plate Tectonics Learning Progression

- Plate movement results in events (earthquakes) or Earth's features (volcanoes, mountains, ocean ridges and ocean trenches).
  - Geologic Time
    - Moving 2 cm. a year can't build a mountain
    - Moving 2 cm a year can't split continents apart
  - Density
    - Decides what happens at Plate Boundaries

Evolution by Natural Selection

Individuals vary within a species

Individuals within a species vary in traits.

Some traits affect an individual's reproductive fitness

A trait may increase, decrease, or have no effect on the likelihood that individual will survive and reproduce and that their offspring will also survive and reproduce. Traits that increase or decrease reproductive fitness are involved in evolution by natural selection.

Traits affected by genetics can be passed to offspring. Acquired traits cannot.

The mechanism of evolution involves the distribution of ***heritable*** traits over multiple generations in a population or species.

Evolution by Natural Selection

Two processes are involved in change of traits across generations.

Changes in heritable traits are due to random changes in the genotype

Genetic variation arises from random mutations or sexual recombination – random processes that take place in the genotype.

Competition for scarce resources and changes in the environment can create selection pressure

Not all individuals survive. Individuals with traits that are advantageous in a given environment will be more likely to survive and reproduce (reproductive fitness).

Natural selection is a non-random process in the environment acting on phenotypes

Natural selection acts on pre-existing genetic variation among individuals. It is a selective process, not a random one, and it acts on the phenotype.

Teaching and Learning Challenges

Inherently interdisciplinary:

- **Ecology, population dynamics**
- **Genetics**
- **Comparative anatomy and physiology**
- **Geology**

Complex dynamic systems: To understand mechanisms student must connect inter-related ideas that work together

Competing naïve conceptions get in the way: Students think they already understand the process or that no explanation is needed because phenomena are self-evident

Evolution by Natural Selection

Mayr's 1982 analysis of the logic of natural selection:

Fact 1: All populations have the potential to grow at an exponential rate.

Fact 2: Most populations reach a certain size, then remain fairly stable over time.

Fact 3: Natural resources are limited.

Inference 1: Not all offspring survive to reproductive age in part because of competition for natural resources.

Fact 4: Individuals in a population are not identical, but vary in many characteristics.

Fact 5: Many of the characteristics are inherited.

Inference 2: Survival is not random. Those individuals with characteristics that provide them with some advantages in a given environment will survive to reproduce, whereas others will die.

Inference 3: Populations change over time as the frequency of advantageous alleles increases. These could accumulate over time to result in speciation.

Naïve Conceptions & Learning Difficulties

Naïve Conception	versus	Scientific Conception
Single process of gradual change driven by perceived need or purposeful improvement		**Two interacting processes of random mutation and non-random selection**
Implicit Larmarckian view that acquired traits can be passed to offspring		**Only heritable traits can be genetically passed to offspring**
Individual variation is unimportant (or doesn't exist)		**Individual variation is essential to natural selection**
Gradual progressive change in the traits themselves for entire population		**Change in the proportion of individuals in a population with various traits**

Naïve Conceptions & Learning Difficulties

Naïve Conception	versus	Scientific Conception
Everyday meanings for "adaptation" and "fitness"		**Specific scientific meanings for "adaptation" and "fitness"**
Difficulties comprehending timescale for history of life on earth		**Understanding of geologic timescale, mutation rates, and accumulation of changes over many, many generations**
Essentialist view that species are fixed		**View that species change or become extinct, that new species can come into being, and that existing species share common ancestors**
Confusion between phenotype and genotype		**Distinction between phenotype and genotype, which processes act on each, and how they are connected to each other**

Assessment for Learning

- **Formative rather than summative**
- **Diagnostic of common misunderstandings as well as understanding**
- **Tests individual components of learning as well as targeted combinations**
- **Patterns across sets of items can be particularly informative**

Which of the following is TRUE about the history of living things on earth?

A. **All of the species alive today have existed since life began on earth.**

B. Only a small fraction of all of the species that have existed on earth since life began are still alive today.

C. Although a few of the species that have existed throughout time are now extinct, most of them still exist today.

D. Life on earth began with a small number of species, and that number has increased continuously up until today.

*** Project 2061 Middle School Science Assessment Items - Evolution (Pilot 2009)**

A. All of the species alive today have existed since life began on earth.
B. Only a small fraction of all of the species that have existed on earth since life began are still alive today.
C. Although a few of the species that have existed throughout time are now extinct, most of them still exist today.
D. Life on earth began with a small number of species, and that number has increased continuously up until today.

Grades 6-8

Table 8: Number and percentage of student who chose each answer choice for item

	A	B	C	D	Multiple	NR/NS	Total
#	1	29	8	17	18	17	90
%	1.1%	32.2%	8.9%	18.9%	20%	18.9%	100%

Grades 9-12

Table 8: Number and percentage of student who chose each answer choice for item

	A	B	C	D	Multiple	NR/NS	Total
#	2	24	7	29	11	16	89
%	2.2%	27%	7.9%	32.6%	12.4%	18%	100%

Can organisms living today look and act differently from their ancestors of the same species that lived many years ago? Why or why not?

A. Yes, environmental changes can cause individuals in each generation to try to develop new heritable traits that are better suited to the new environment.

B. Yes, after many years of environmental change and selection for the traits that are favorable after each change, organisms can look and act very different from their ancestors.

C. Yes, over generations, species can lose or develop features depending on how much they use those features.

D. No, members of the same species cannot look or act differently from each other, even after many generations.

Can organisms living today look and act differently from their ancestors of the same species that lived many years ago? Why or why not?

A: Many students think that individual organisms can deliberately develop new traits because they need them for survival. Organisms change heritable traits to meet their needs.

B: (correct answer)

C: Change occurs in the appearance or behavior of a population of organisms over time because of the use or disuse of a particular body part or behavior.

D: Except for differences between males and females, and between young and old, all organisms of the same species look and act the same.

A. Yes, environmental changes can cause individuals in each generation to try to develop new heritable traits that are better suited to the new environment.

B. Yes, after many years of environmental change and selection for the traits that are favorable after each change, organisms can look and act very different from their ancestors.

C. Yes, over generations, species can lose or develop features depending on how much they use those features.

D. No, members of the same species cannot look or act differently from each other, even after many generations.

Grades 6-8

Table 8: Number and percentage of student who chose each answer choice for item

	A	B	C	D	Multiple	NR/NS	Total
#	9	4	1	0	9	8	31
%	29%	12.9%	3.2%	0%	29%	25.8%	100%

Grades 9-12

Table 8: Number and percentage of student who chose each answer choice for item

	A	B	C	D	Multiple	NR/NS	Total
#	9	13	8	3	7	13	53
%	17%	24.5%	15.1%	5.7%	13.2%	24.5%	100%

According to the theory of natural selection, what would happen to a population of birds of the same species when a major change occurs in the kind of seeds that are available for those birds to eat?

A. The birds that already have the kind of beak they need to eat the new seeds would be more likely to survive and reproduce, and the ones who do not would be less likely to survive and reproduce.

B. All of the birds would try to develop new beaks so that they could eat the new seeds.

C. Some of the birds would try to develop new beaks so that they could survive, and the other birds would die.

D. Because all birds of the same species have the same physical traits, one bird would never have an advantage over another bird. They would either all survive or all die.

According to the theory of natural selection, what would happen to a population of birds of the same species when a major change occurs in the kind of seeds that are available for those birds to eat?

A: (correct answer)

B: Many students think that individual organisms can deliberately develop new traits because they need them for survival. Organisms change heritable traits to meet their needs.

C: Many students think that individual organisms can deliberately develop new traits because they need them for survival. Organisms change heritable traits to meet their needs.

D: Except for differences between males and females, and between young and old, all organisms of the same species look and act the same.

A. **The birds that already have the kind of beak they need to eat the new seeds would be more likely to survive and reproduce, and the ones who do not would be less likely to survive and reproduce.**
B. All of the birds would try to develop new beaks so that they could eat the new seeds.
C. Some of the birds would try to develop new beaks so that they could survive, and the other birds would die.
D. Because all birds of the same species have the same physical traits, one bird would never have an advantage over another bird. They would either all survive or all die.

Grades 6-8

Table 8: Number and percentage of student who chose each answer choice for item

	A	B	C	D	Multiple	NR/NS	Total
#	13	5	1	7	8	8	42
%	31%	11.9%	2.4%	16.7%	19%	19%	100%

Grades 9-12

Table 8: Number and percentage of student who chose each answer choice for item

	A	B	C	D	Multiple	NR/NS	Total
#	30	2	4	15	8	12	71
%	42.3%	2.8%	5.6%	21.1%	11.3%	16.9%	100%

According to the theory of natural selection, what would happen to a species of lizards when a new predator is introduced into the environment where the lizards live?

A. The lizards that already have the physical traits needed to avoid the new predator would be more likely to survive and reproduce, and the ones that do not would be less likely to survive and reproduce.

B. All of the lizards would try to develop new physical traits to avoid the new predator.

C. Some of the lizards would try to develop new physical traits to avoid the new predator, and the other lizards would die.

D. Because all lizards of the same species have the same physical traits, one lizard would not have an advantage over another lizard. They would either all survive or all die.

A. **The lizards that already have the physical traits needed to avoid the predator would be more likely to survive and reproduce, and the ones that do not would be less likely to survive and reproduce.**
B. All of the lizards would try to develop new physical traits to avoid the new predator.
C. Some of the lizards would try to develop new physical traits to avoid the new predator, and the other lizards would die.
D. Because all lizards of the same species have the same physical traits, one lizard would not have an advantage over another lizard. They would either all survive or all die.

Grades 6-8

Table 8: Number and percentage of student who chose each answer choice for item

	A	B	C	D	Multiple	NR/NS	Total
#	62	16	14	19	27	29	167
%	37.1%	9.6%	8.4%	11.4%	16.2%	17.4%	100%

Grades 9-12

Table 8: Number and percentage of student who chose each answer choice for item

	A	B	C	D	Multiple	NR/NS	Total
#	104	10	14	23	29	28	208
%	50%	4.8%	6.7%	11.1%	13.9%	13.5%	100%

Big Ideas and Common Misconceptions

Individuals vary within a species

Some traits affect an individual's reproductive fitness

Competition for scarce resources and changes in the environment can create selection pressure

Changes in heritable traits are due to random changes in the genotype

Natural selection is a non-random process in the environment

Traits affected by genetics can be passed to offspring. Acquired traits cannot.

Misconception: Acquired traits can be inherited by offspring

Misconception: Changes in traits arise because individuals want or need them

Misconception: Adaptations can be acquired in an individual's lifespan

Misconception: Whole population changes rather than distribution of traits within a population changing

Misconception: Only a few species have become extinct; most are still alive today

Misconception: A trait can change in a species due to use (or lack of use)

Reflections

Think, Pair, Share

Think about this Assessment Activity.

What part was the most valuable?

What part was the most challenging?

How can that be overcome?

How can this process be used in your classroom?

SUNSHINE and BLUES

Thanks for Coming!