What do Science Teachers need to Know about Language in Science?

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Literacy in Science?

Traditionally teachers of science have not paid much attention to the role of texts in learning science.

Phenomena

Ideas

The Practices of Science

1. **Asking Questions and Defining Problems**
2. **Developing and Using Models**
3. **Planning and Carrying out Investigations**
4. **Analyzing and Interpreting Data**
5. **Using Mathematics and Computational Thinking**
6. **Constructing Explanations and Designing Solutions**
7. **Engaging in Argument from Evidence**
8. **Obtaining, Evaluating and Communicating Information**

Chelyabinsk Airburst, Damage Assessment, Meteorite Recovery, and Characterization

Table 1. Atmospheric trajectory and pre-atmospheric orbit for the Chelyabinsk meteoroid, with 2 standard deviation uncertainties. Angular elements are for equinox J2000.0.

Atmospheric trajectory	Chelyabinsk	Pre-atmospheric orbit	Chelyabinsk	Itokawa
H_b (beginning height, km)	97.1 ± 1.6	T_j (Tisserand's parameter)	3.87 ± 0.24	4.90
H_m (peak brightness, km)	29.7 ± 1.4	a (semimajor axis, AU)	1.76 ± 0.16	1.324
H_f (disruption, km)	27.0 ± 1.4	e (eccentricity)	0.581 ± 0.018	0.280
H_e (end height, km)	13.6 ± 1.4	q (perihelion distance, AU)	0.739 ± 0.020	0.953
V_∞ (entry speed, km/s)	19.16 ± 0.30	ω (argument of perihelion, °)	108.3 ± 3.8	162.8
h (entry elevation angle, °)	18.3 ± 0.4	Ω (longitude of ascending node, °)	326.4422 ± 0.0028	69.1
a_z (entry azimuth angle from south, °)	283.2 ± 0.4	i (inclination, °)	4.93 ± 0.48	1.6
V_g (geocentric entry speed, km/s)	15.3 ± 0.4	Q (aphelion distance, AU)	2.78 ± 0.20	1.70
Ra_g (geocentric right ascension of radiant, °)	333.2 ± 1.6	T_p (perihelion time)	2012-12-31.9 ± 2.0	2013-07-10.8
Dec_g (geocentric declination of radiant, °)	+0.3 ± 1.8	Epoch (ET)	2013-02-15.139	2013-04-18.0

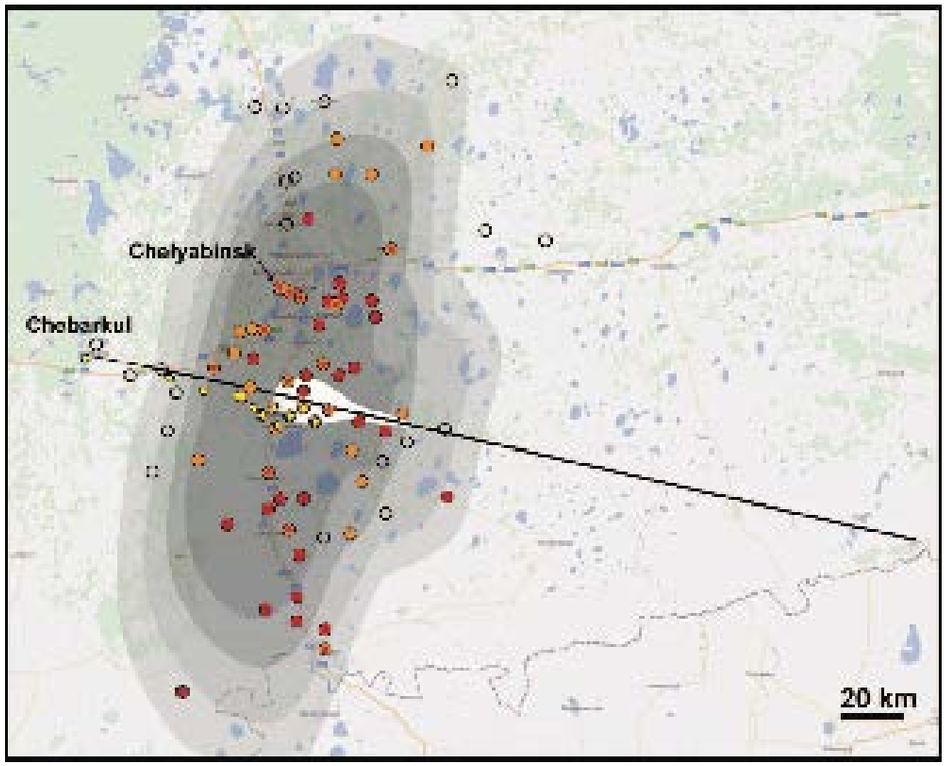


Fig. 3. Map of glass damage on the ground with models of overpressure. Field survey data are shown in solid orange circles for reported damage and open black circles for no damage; solid red circles show the most damaged villages in each district, as reported by the government. Each point, irrespective of population density, represents one of many villages or city districts scattered throughout the area. Model contours (with progressive gray scale) represent kinetic energies and overpressures from inside out: 300 kT Δp > 1000 Pa, 520 kT Δp > 1000 Pa, 300 kT Δp > 500 Pa, and 520 kT Δp > 500 Pa, respectively. Also shown are the locations of meteorite finds (yellow points) and the ground-projected fireball trajectory (black line), moving from 97-km

efficiently decelerated, avoiding the transfer of momentum to lower altitudes and resulting in less damage when the blast wave reached the ground.

Damage Assessment

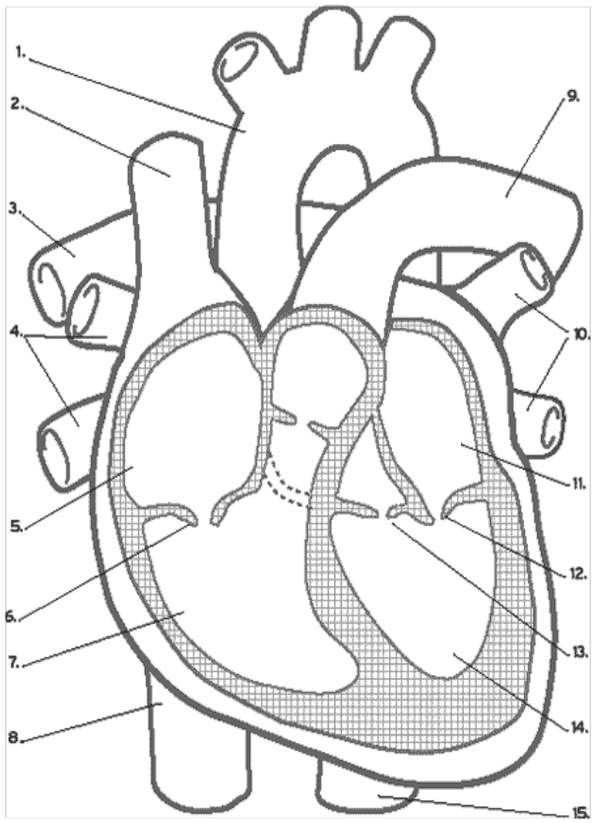
In the weeks after the event, 50 villages were visited to verify the extent of glass damage. The resulting map (Fig. 3) demonstrates that the shock wave had a cylindrical component, extending fur-

abundant dust formation. The meteorite is composed of a breccia (*17*) of mildly shocked lighter clasts and moderately shocked darker clasts with abundant thin to cm-wide shock melt veins (Fig. 4A) (SM section 4.4). A peculiar feature is that some shock veins exhibit a metal layer located ~20 micrometers inside the vein, which follows the outer contours of the vein (Fig. 4B), indicating that metal initially segregated from the most rapidly solidifying rims of the vein. This could contribute to weakness. Metal-rich tendrils also project outward from the vein.

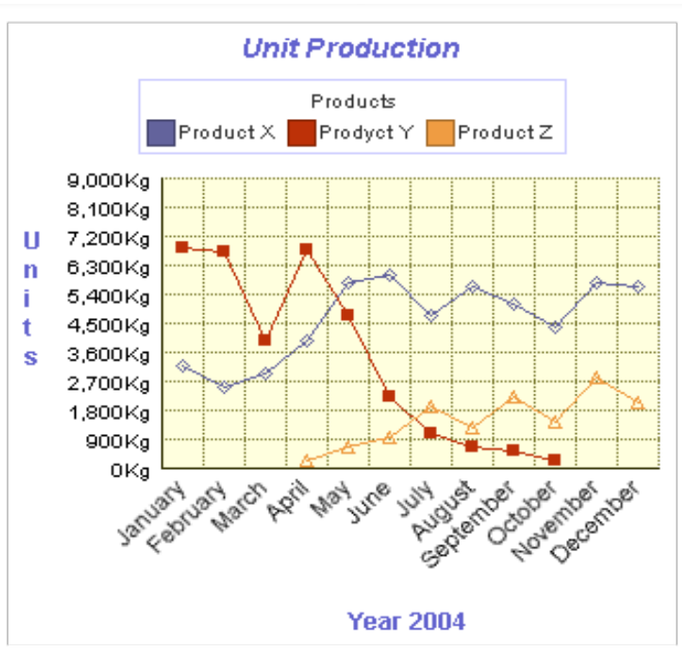
The mineral compositional ranges (SM section 4.4) are slightly larger than those reported before (*18*), but still compatible with a classification as LL5, shock stage S4 (*19*). The classification as LL chondrite is substantiated by oxygen and chromium isotope studies (SM section 4.5 to 4.7), which put the meteorite near the L end of the LL field (*20, 21*) (Fig. 4D and fig. S68). Iron content and oxidation state also support the LL chondrite classification (Fig. 4E and fig. S58). Rare earth element abundances are more similar to L chondrites (Fig. 4F and table S18), whereas one measuring reflectance spectrum better matches that of H chondrites (fig. S72).

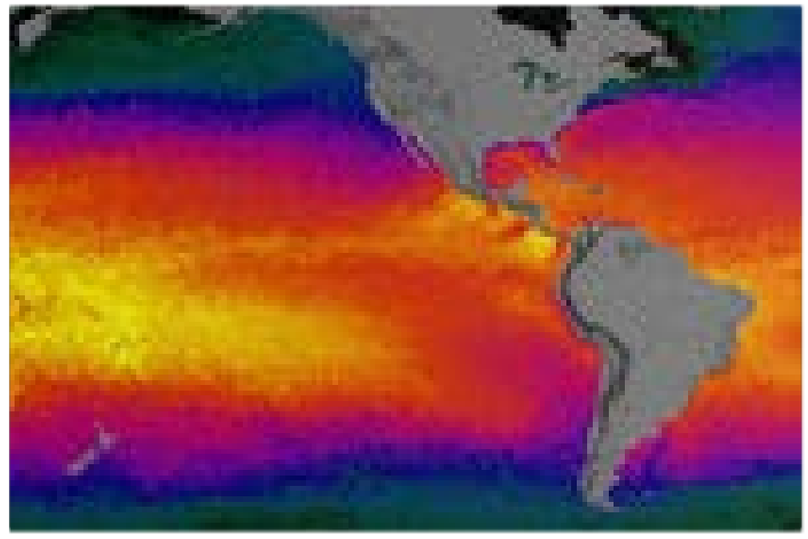
The Chelyabinsk (LL) parent body experienced a substantial thermal and/or collision resetting event 115 ± 21 million years after the formation of the solar system (*25*), not experienced by most other LL chondrites, possibly due to a major impact event near its site of origin on the parent body. The

Diagrams



$$CaCO_3$$





$$\nabla \cdot \mathbf{E} = 0$$

$$\nabla \cdot \mathbf{B} = 0$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

$$\nabla \times \mathbf{B} = \mu_0 \epsilon_0 \frac{\partial \mathbf{E}}{\partial t}$$

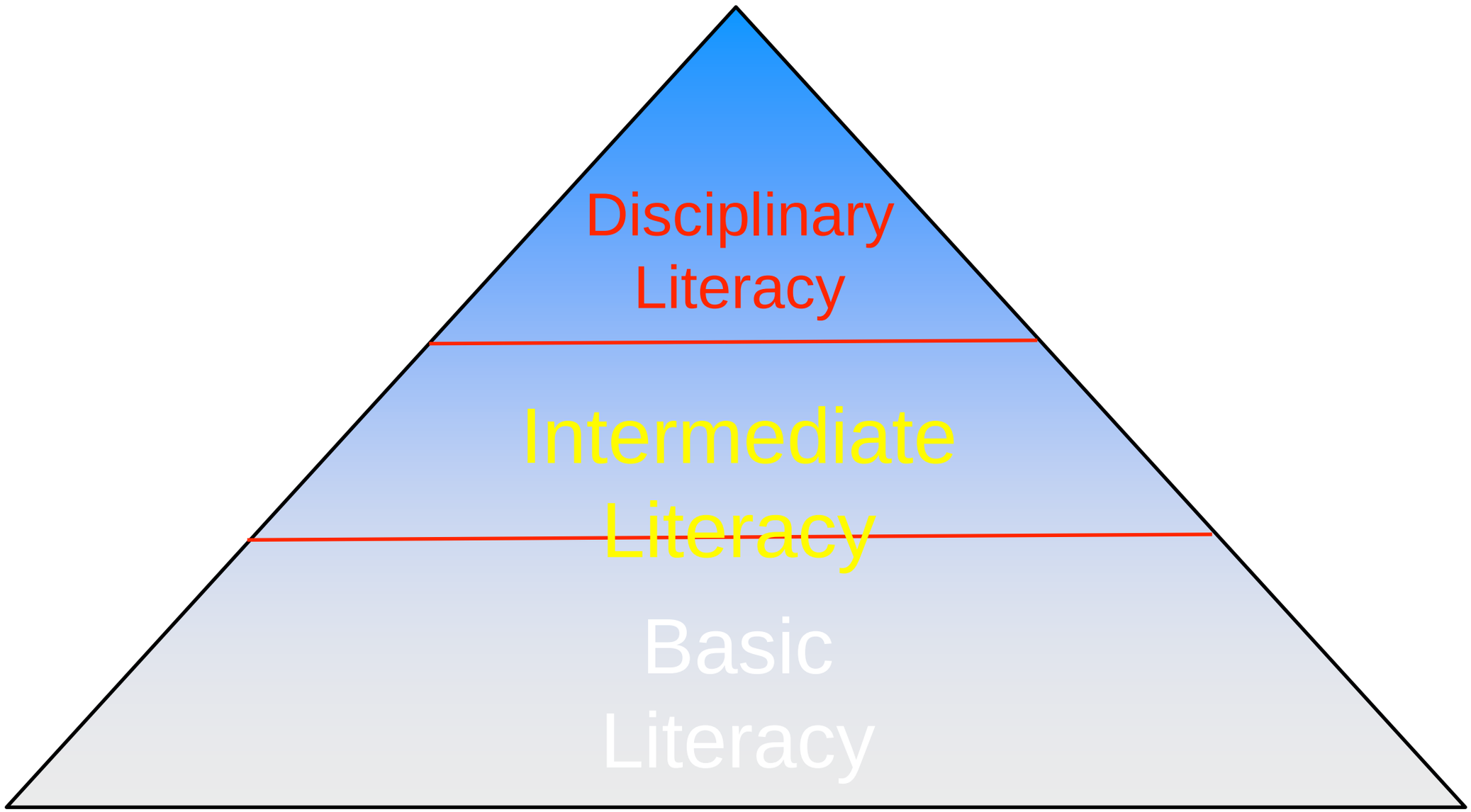
The Meaning of Scientific Literacy

Fundamental

Derived

Norris, Stephen P., & Phillips, Linda. (2003). How literacy in its fundamental sense is central to scientific literacy. *Science Education, 87*, 224-240.

Literacy Development

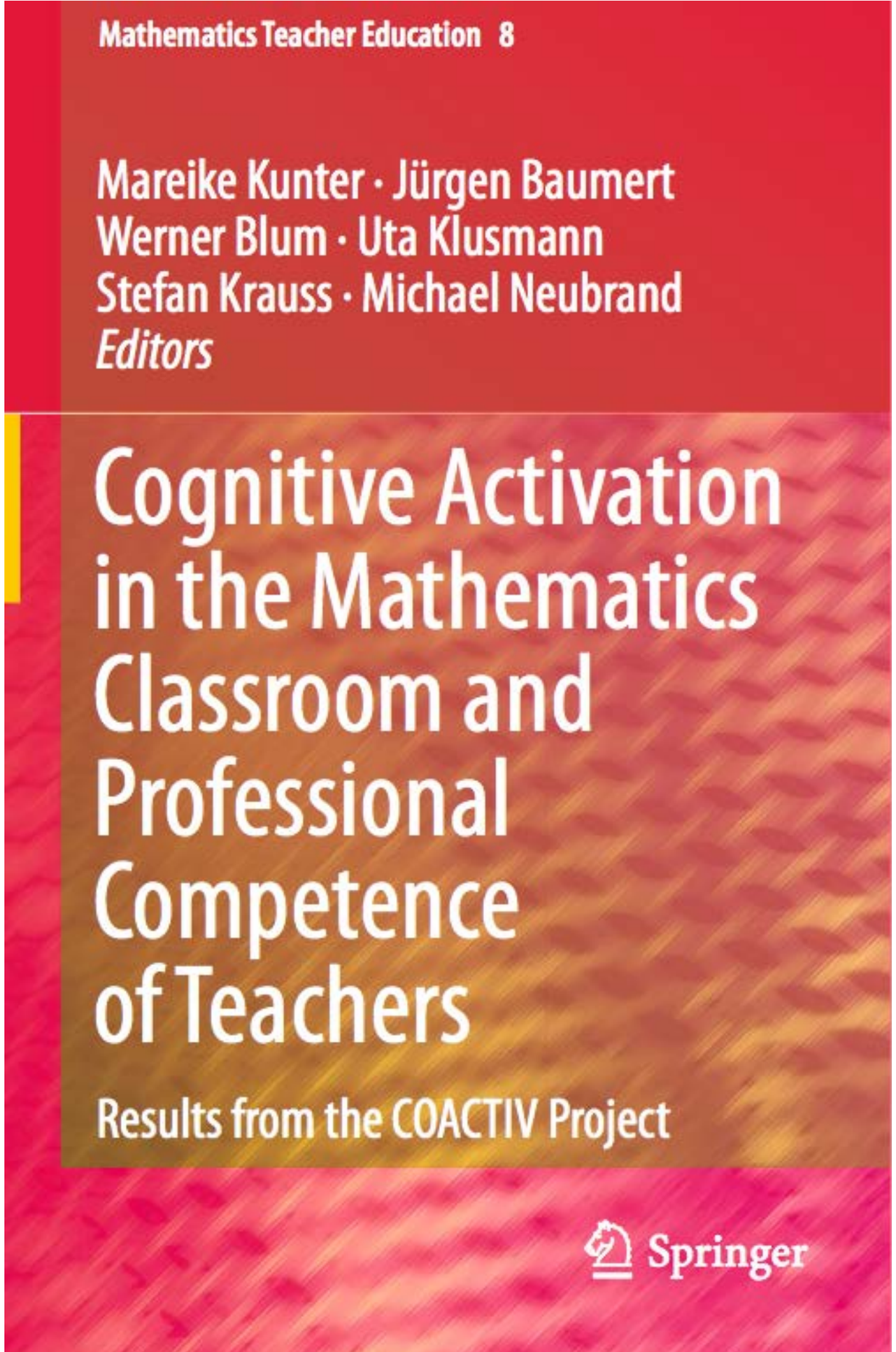


COMMON CORE STATE STANDARDS FOR

English Language Arts
&
Literacy in History/Social Studies, Science, and Technical Subjects

What Knowledge is Required?

- Pedagogical Content Knowledge
  - Knowledge of Instructional and Diagnostic Tasks
  - Knowledge of student cognition and difficulties
  - Knowledge of a range of explanations and ways or representing and communicating ideas



Sadler, Philip M., Sonnert, Gerhard , Coyle, Harold P., Cook-Smith, Nancy , & Miller, Jaimie L. . (2013). T**he Influence of Teachers' Knowledge on Student Learning in Middle School Physical Science Classrooms**. *American Educational Research Journal*.

KNOWLEDGE of the Methods of ASSESSING Student Understanding

ENABLES Elication of STUDENT THINKING

KNOWLEDGE of Common STUDENT DIFFICULTIES

ENABLES Interpretation of Level of STUDENT UNDERESTAN-DING

KNOWLEDGE of a Repertoire of INSTRUCTION-AL STRATEGIES

ENABLES Informed PEDAGOGIC DECISIONS

What Should Teachers of Science Know?

Tiers of Words

- **Tier 1**: The 5-7000 most frequent words in English
  - plant, grow, green, water, chair
- **Tier 2**: Words that are encountered in academic discourse but are not specific to any discipline.
  - compare, therefore, arguably, illustrate
- **Tier 3**: Words that have a specific meaning within the discipline
  - igneous, photosynthesis, energy

Basic Difficulties with Science Texts

- Academic and Technical Language
- Lexically Dense – for a Purpose
- Multi-Modal
- Distinct Genres

Instructional Strategies

1. **Strategies that activate prior knowledge**

2. **Strategies that promote comprehension, thinking and monitoring**

3. **Strategies that encourage organization of text information for recall and review**

Instructional Strategies

1. Strategies that activate prior knowledge

The Mantle

Your journey downward continues. About 40 kilometers beneath the surface, you cross a boundary. Below the boundary is the solid material of the **mantle,** a layer of hot rock. **Earth's mantle is made up of rock that is very hot, but solid. Different layers of the mantle have different physical characteristics.** Overall, the mantle is nearly 3,000 kilometers thick.

The Lithosphere The uppermost part of the mantle and the crust together form a rigid layer called the **lithosphere** (LITH uh sfeer). In Greek, *lithos* means "stone." As you can see in Figure 5, the lithosphere averages about 100 kilometers thick.

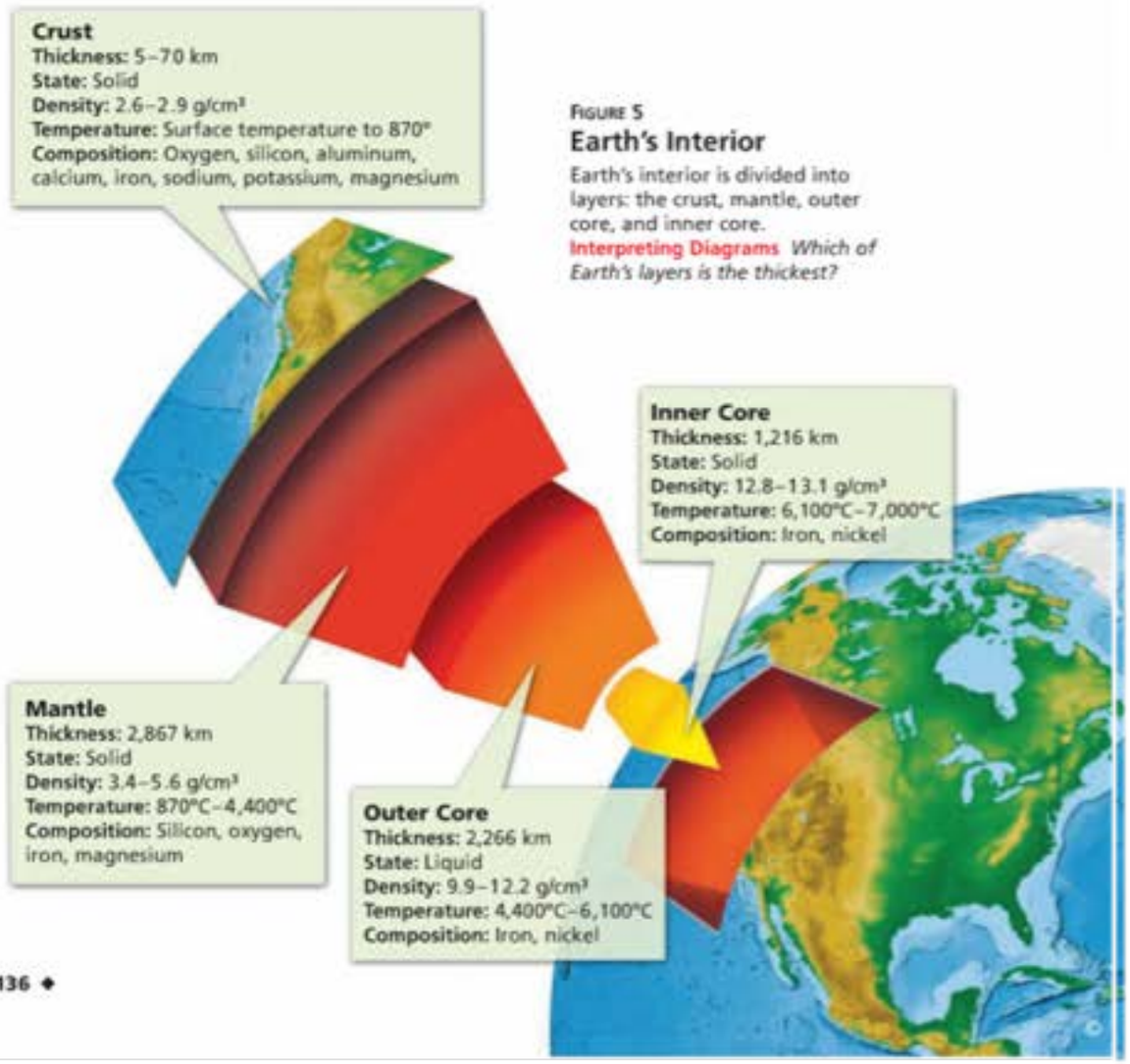


FIGURE 5
Earth's Interior
Earth's interior is divided into layers: the crust, mantle, outer core, and inner core.
Interpreting Diagrams *Which of Earth's layers is the thickest?*

Anticipation Guide

	What I think		What the Text Says	
The Earth has a thin crust	TRUE	FALSE	TRUE	FALSE
The interior of the Earth is Liquid	TRUE	FALSE	TRUE	FALSE
It gets hotter as you get towards the center of the Earth	TRUE	FALSE	TRUE	FALSE
Rocks can be bent	TRUE	FALSE	TRUE	FALSE
There are Mountains under the sea	TRUE	FALSE	TRUE	FALSE

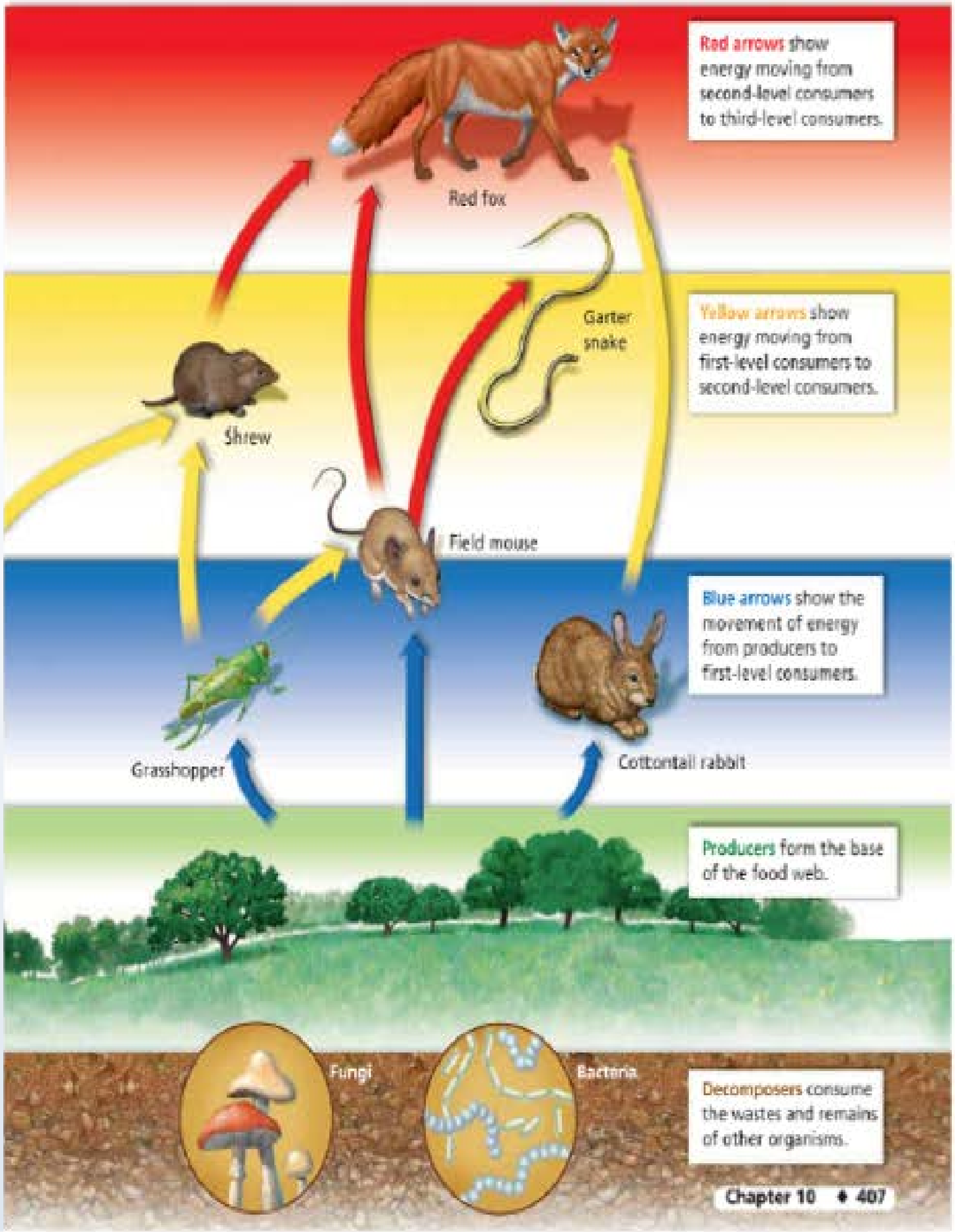
Instructional Strategies

2. Strategies that promote comprehension, thinking and monitoring

Strategies to Support Comprehension

- Directed Activities Related to Text (DARTS) are a set of strategies designed to get pupils to:
  - locate important information and reflect on it
  - to categorize it, and/or
  - to record it

RESTRUCTURING DARTS	ANALYSIS DARTS
Sequencing CLOZE Diagram Completion	Underlining Tabulating Labeling Questioning the Author


Red arrows show energy moving from second-level consumers to third-level consumers.
Red fox
Garter snake
Yellow arrows show energy moving from first-level consumers to second-level consumers.
Shrew
Field mouse
Blue arrows show the movement of energy from producers to first-level consumers.
Grasshopper
Cottontail rabbit
Producers form the base of the food web.
Fungi
Bacteria
Decomposers consume the wastes and remains of other organisms.

Instructional Strategies

3. **Strategies that encourage organization of text information for recall and review**

Frayer Model

Definition (in your own words)

A change in size, shape, or state of matter

Characteristics

New materials are NOT formed.

Same matter present before and after change.

Physical Change

Examples
(from your own life)

Ice melting

Breaking a glass

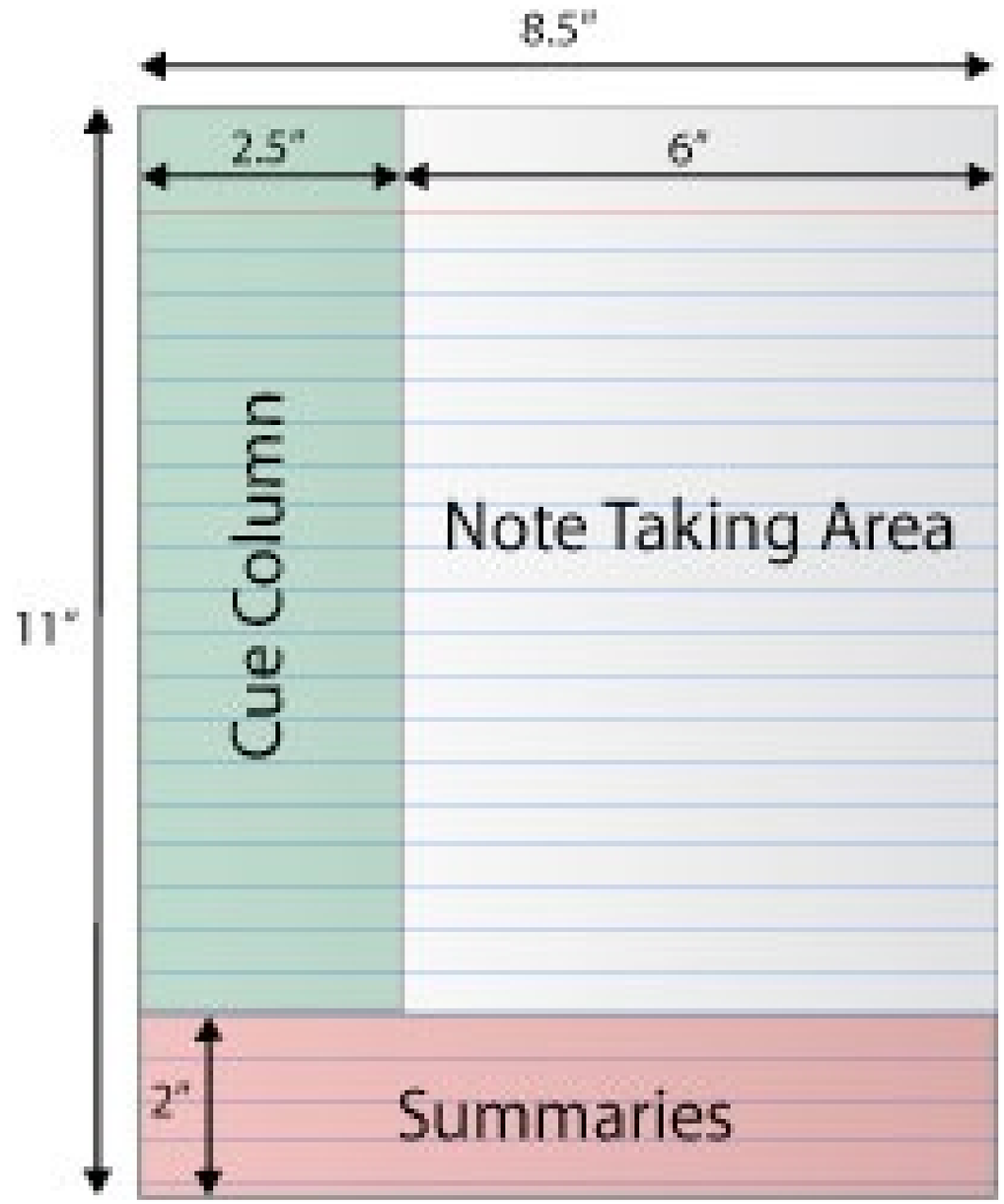
Cutting your hair

Non-Examples

Burning wood

Mixing baking soda and vinegar

Cornell Notes



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Classrooms, Grades 3–8

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Foreword by Sandra K. Abell

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