Using Learning Progression Research in Classroom Settings

Friday, June 15, 2012

Concurrent Session at DRK-12 PI Meeting, Crystal City, VA

“Ambitious Teaching”

- Longtime goal for science educators
- Includes:
  - Powerful scientific knowledge integrated with practices
  - Organization of curriculum around big ideas
  - Dialogic rather than monologic teaching, built around effective formative assessment and responsiveness to student ideas
  - Productive disciplinary engagement of students in scientific practices
  - Successful learning for all students
- Question: How can we use these new tools to meet longstanding challenges?

Three Claims

1. **Goals for student learning:** Learning progressions can help us to describe goals for student learning that better connect students initial understanding with powerful scientific knowledge and practices.
2. **Formative and summative assessment:** Learning progressions can provide teachers with assessments that uncover students' reasoning and measure progress toward learning progression goals.
3. **Scaffolding students' scientific practices fused to core science content**: Learning progressions can help teachers to engage students in practices that support the development of deeper conceptual understandings of core content, support content that is personally meaningful to students, and encourage more sophisticated forms of practice.

Questions for This Session

- How are our LP-based projects enacting these claims in classrooms?
- What issues arise in our attempts to enact LP-based teaching practices?
- What tensions do we see between LP-based practices and longstanding needs and practices of classroom teachers?

Outline of Activities

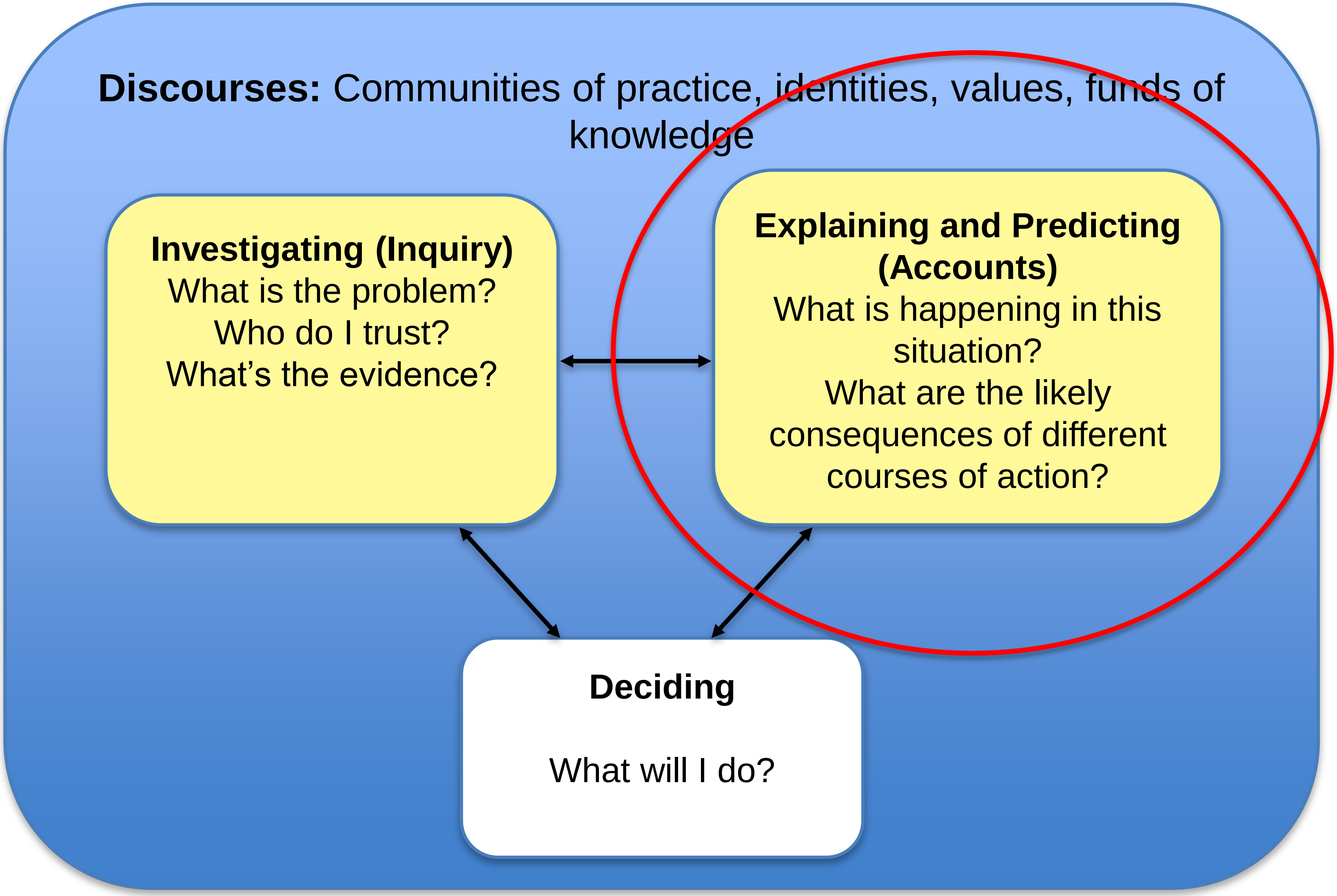
1. Presentations from each project centered on these claims and issues (15 minutes each)
   a. Brian Reiser and Leema Kuhn Berland
   b. Kristin Gunckel
   c. Nancy Songer
   d. Marianne Wiser
   e. Andy Anderson and Dan Gallagher
2. Open discussion (40 minutes)

A Learning Progression-based System for Promoting Understanding of Carbon-transforming Processes

Charles W. (Andy) Anderson, Michigan State University
Dan Gallagher, Seattle Public Schools

Issue 1: Goals for Student Learning

Practices of Environmentally Literate Citizens: Accounts



What Progresses?

- **Discourse:** “a socially accepted association among ways of using language, of thinking, and of acting that can be used to identify oneself as a member of a socially meaningful group” (Gee, 1991, p. 3)
- **Practices:** inquiry, accounts, citizenship
- **Knowledge** of processes in human and environmental systems

Contrasts between Force-dynamic and Scientific Discourse (Pinker, Talmy)

- ***Force-dynamic discourse**: **Actors*** (e.g., animals, plants, machines) make things happen with the help of enablers that satisfy their "needs."
  - This is everyone's "first language" that we have to master in order to speak grammatical English (or French, Spanish, Chinese, etc.)
- ***Scientific discourse**: **Systems*** are composed of enduring entities (e.g., matter, energy) which change according to laws or principles (e.g., conservation laws)
  - This is a "second language" that is powerful for analyzing the material world
- We often have the illusion of communication because speakers of these languages use the same words with different meanings (e.g., energy, carbon, nutrient, etc.)

Learning Progression Levels of Achievement

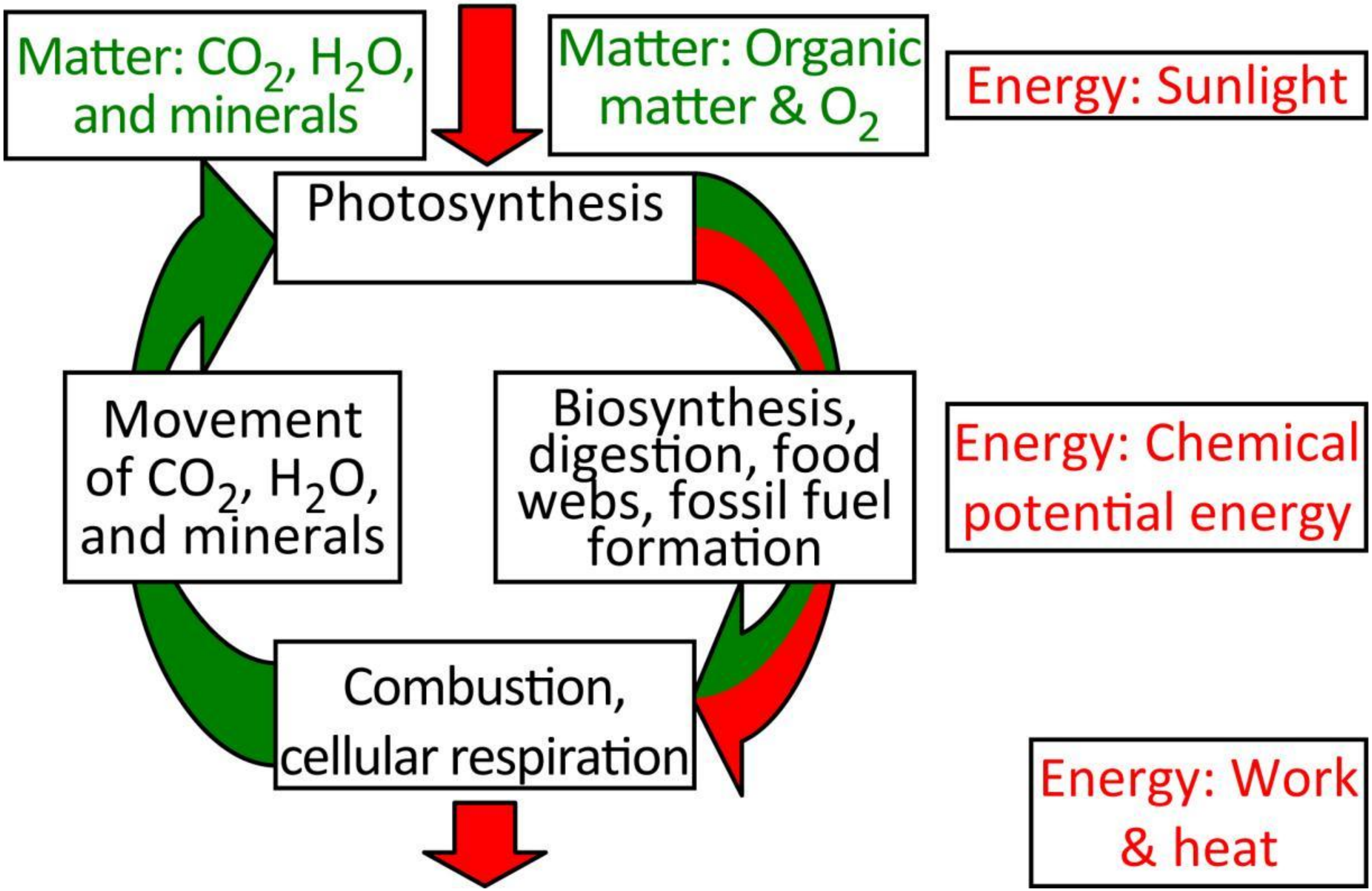
Level 4: Correct qualitative tracing of matter and energy through processes at multiple scales.

Level 3: Attempts to trace matter and energy, but with errors (e.g., matter-energy confusion, failure to fully account for mass of gases).

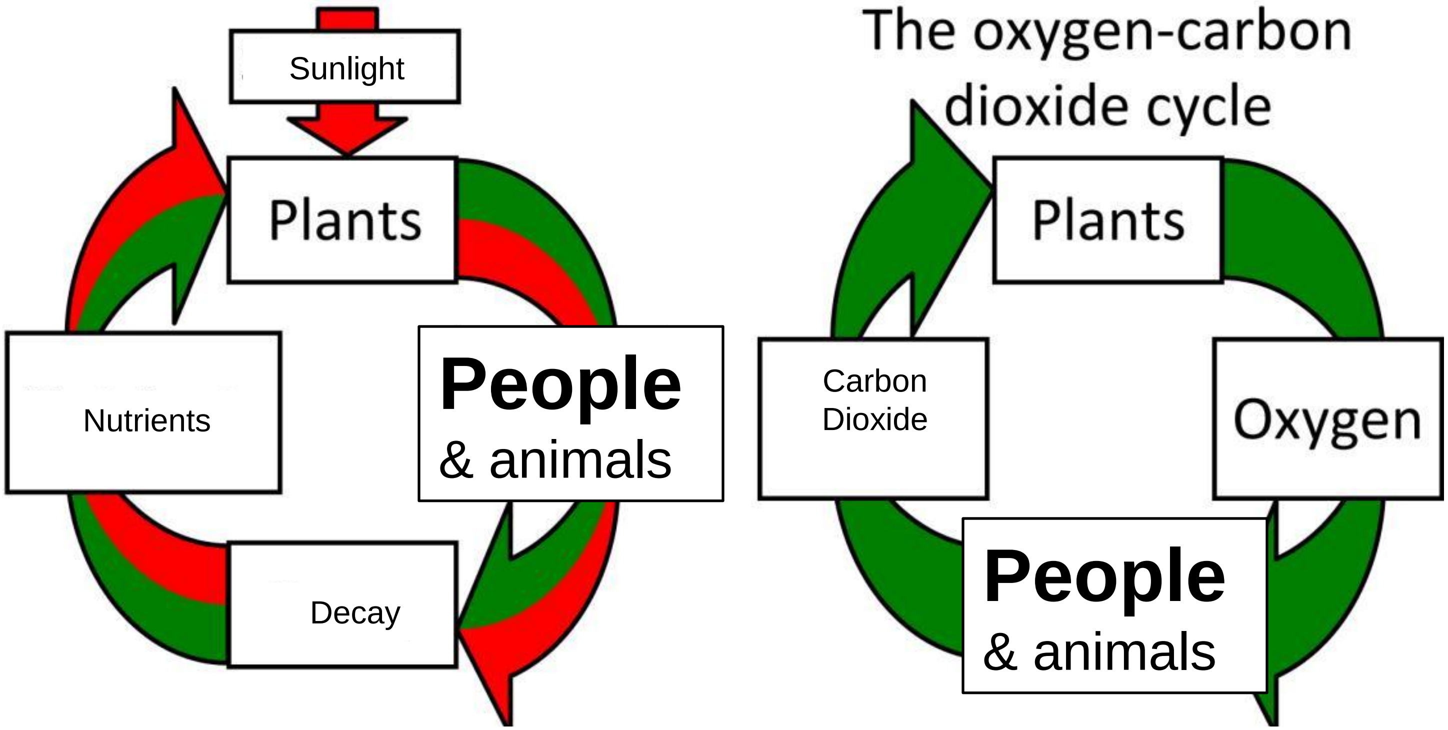
Level 2: Elaborated force-dynamic accounts (e.g., different functions for different organs)

Level 1: Simple force-dynamic accounts.

Level 4 Account Carbon Cycling and Energy Flow



Level 2: Learners' Accounts "Matter and Energy Cycles"



- This is really about actors and their actions.
- People are the main actors, then animals, then plants
- Everything else is there to meet the needs of actors

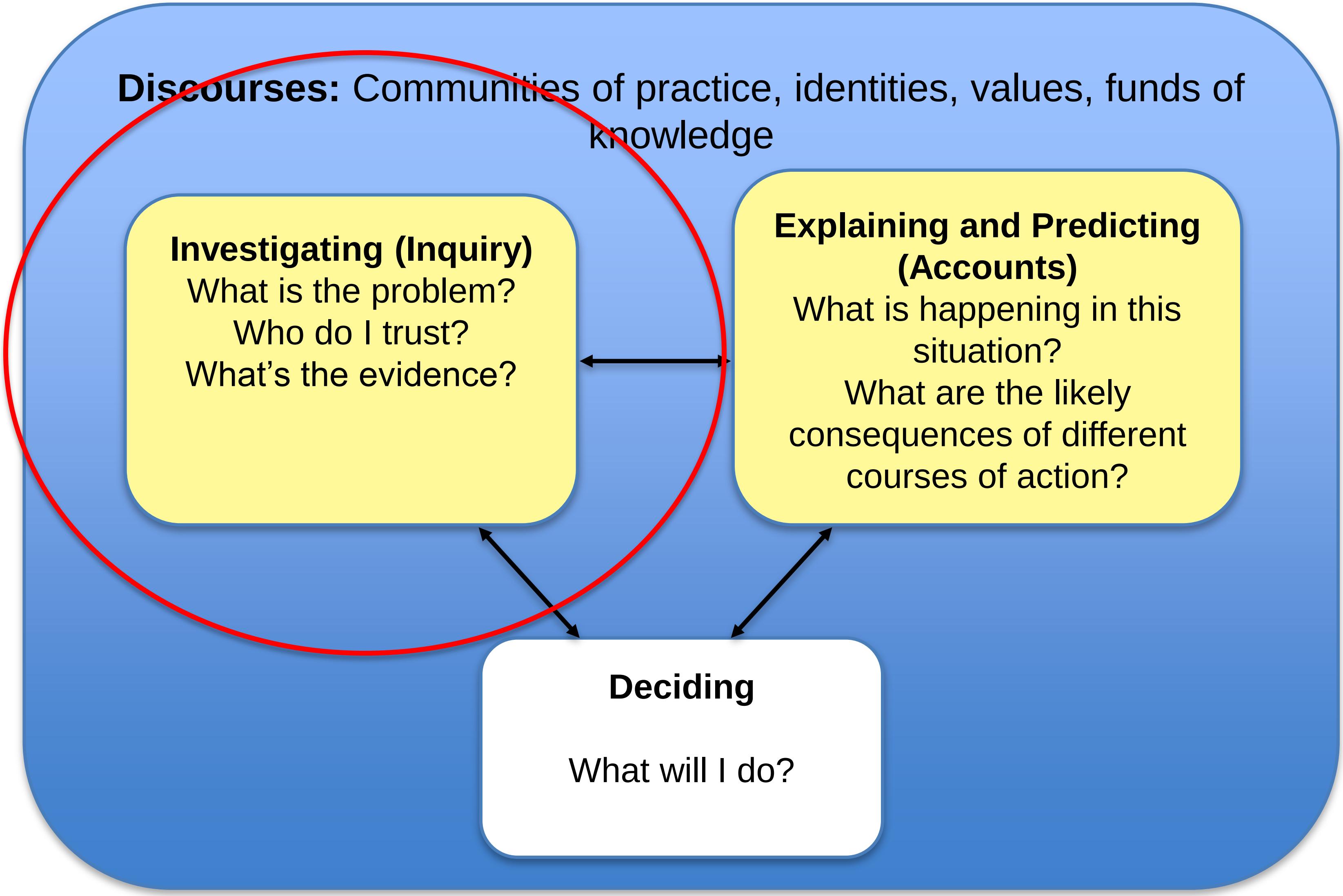
Goal for Level 2 Learners: Productive Level 3

- What we mean by “productive”
  - Productive for students in their terms: They develop new knowledge and practice that is personally satisfying
  - Productive in terms of future learning: Level 3 serves as an effective transition from Level 2 to Level 4
- Empirical Level 3: What we currently see in high school and college students
  - Conservation laws as facts
  - Accounts constructed out of these “facts” along with others, but with a few missing
- Productive Level 3: Our goal for Level 2 learners
  - Conservation laws as rules and tools for analysis
  - Missing details don’t affect a “sense of necessity” associated with these rules

Contrasting Level 3 Explanations: Weight Loss

- Empirical Level 3: The man loses weight through the process of cellular respiration, which converts his fat into energy and carbon dioxide
- Productive Level 3: The fat is being used for energy, but the atoms in the fat have to go somewhere. I guess I'm not quite sure where they go.

Practices of Environmentally Literate Citizens: Inquiry



Possible Learning Goals for Classroom Inquiry

- Epistemological: Establishing authority of evidence over authority of people or texts
- Learning inquiry practices
- Supporting development of more sophisticated accounts (e.g., productive Level 3)

Issue 2: Formative and Summative Assessment

Some necessary features of classroom assessments

- Based on goals that are clear to students, teachers, administrators, and parents
- Reliably provide an interpretable response from *each* student
- Interpretable in relation to a clear goal, with the evaluation criteria understandable to students, teachers, administrators, and parents

- Remember… grades are coin of the realm

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Student: "What am I supposed to do?"

Teacher: "What do I put in the grade book?"

Everyone: "Why did _____ get a C?"

We cannot dismiss these problems. LP-based tools must work within this environment

How can teachers mark progress?

- The learning progression is not an accumulation of equivalent pieces that sum to form a complete account
- BUT typical classroom rubrics tally pieces of a whole or a percentage of possible
- Counting up or subtracting down

Typical teacher grading of Level 4 and 3 Explanations: Weight Loss

- Level 4: The man loses weight through the process of cellular respiration, which converts the his fat molecules and oxygen into carbon dioxide and water. The chemical energy in the fat ended up as heat.

- Empirical Level 3: The man loses weight through the process of cellular respiration, which converts his fat into energy and carbon dioxide
- Productive Level 3: The fat is being used for energy, but the atoms in the fat have to go somewhere. I guess I'm not quite sure where they go.

Typical teacher grading of Level 4 and 3 Explanations: Weight Loss

- Level 4: The man ✓ (process name) through the process of cellular respiration, which converts the his fat molecules and oxygen into carbon dioxide ✓ (matter inputs & outputs) and water. The chemical energy in the fat ended up as heat. ✓ (energy inputs & outputs)

- Empirical Level 3: The man loses weight through the process of cellular respiration, ✓ (process name) which converts his fat into energy and carbon dioxide ✓ (matter output)

- Productive Level 3: The fat is being used for energy, but the atoms in the fat have to go somewhere. I guess I'm not quite sure where they go. **??**

Typical assessment practices inhibit a productive learning progression

- This might be an OK way to grade a summative assessment
- This is NOT a helpful way—for students or teachers—to grade a formative assessment
  - Potentially supports attainment of “empirical Level 3” but inhibits “productive Level 3”

How can LP-based tools meet this challenge?

Utility of LP-based tools

- Identifying important elements of an account (summative and formative)

- Identifying productive and assessable (i.e. gradable) goals and tasks early in a unit
  - NOT a piece-by-piece accumulation of a final account
  - Understandable, interpretable, and fair

Goal for Level 2 Learners: Productive Level 3

- Productive Level 3: Our goal for Level 2 learners
  - Conservation laws as rules and tools for analysis
  - Missing details don't affect a "sense of necessity" associated with these rules

Example: Tracing mass—particularly tracing mass between solid and gaseous states—is an assessable practice targeted early in a unit

Issue 3: Classroom Practice

How can we teach toward a productive Level 3?

In Development:

- Carbon TIME (Transformations in Matter and Energy): Six units to be available through National Geographic Website in 2014
  - Systems and Scale
  - Plants
  - Animals
  - Decomposers
  - Ecosystems
  - Human energy systems

Teaching Experiments: Inquiry and Application Activity Sequences

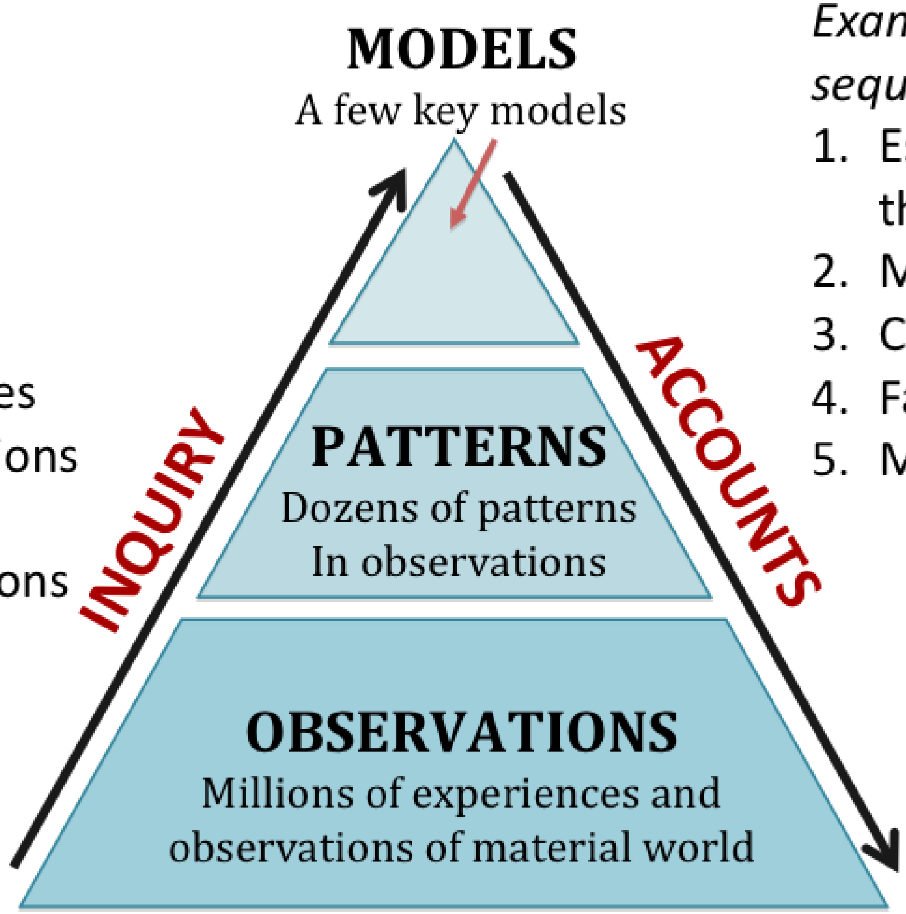
INQUIRY

Example activity sequences:

1. Predict
2. Explain
3. Observe
4. Explain

--OR--

1. Techniques
2. Observations
3. Patterns
4. Explanations



ACCOUNTS/ CITIZENSHIP

Example activity sequence:

1. Establishing the problem
2. Modeling
3. Coaching
4. Fading
5. Maintaining

Inquiry Sequences

- Focus on common carbon-transforming processes
  - Burning ethanol
  - Animal growth and metabolism
  - Plant growth and metabolism
  - Decay (fungus growth and metabolism)
- Measuring mass changes in organisms and materials they depend on (soil, food, fuel)
- Measuring changes in CO_2 concentration

Accounts Pilot Version

- Conservation of matter as empirical finding
  - Using soda lime to track role of gases in mass transfer
    - Soda water losing its fizz
    - Burning ethanol
  - General rule: mass is always conserved
  - Atomic model: atoms are always conserved
  - Apply this rule to other carbon-transforming processes
- Preliminary result: Still a lot of empirical Level 3 accounts—students are not developing a strong sense of necessity about tracing matter

Accounts Revised Version

- Conservation of matter and energy as rules we have to follow
  - In physical and chemical changes….
    - Atoms last forever (and atoms make up the mass of materials)
    - Energy lasts forever (and we can observe indicators for forms of energy: chemical, light, heat, motion)
- Because atoms and energy endure, we can understand processes by figuring out what is happening to atoms and energy

Grading Students' Accounts

If conservation of matter/atoms and energy are rules that students are expected to follow, it creates possibilities for "fair" grading that focuses on key scientific practices. For example:

- Accounts that do not attempt to trace matter and energy: low grade
- Accounts that trace matter and energy with acknowledged "gaps."
  - High grade early in the unit
  - Lower grade after accounts sequence
- Accounts that successfully trace matter and energy: high grade

Three Questions for Inquiry Sequences

1. How are atoms moving in this system (based on mass changes)?
2. How are carbon atoms moving (based on identifying organic materials and measuring changes in CO_2 concentration)?
3. What’s happening to chemical energy (based on energy indicators and changes in mass of organic materials)?

Closing Question

What are the tradeoffs among our goal for inquiry sequences?

- Epistemological: Establishing authority of evidence over authority of people or texts
- Learning inquiry practices
- Supporting development of more sophisticated accounts (e.g., productive Level 3)

Thanks to Funders

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Website

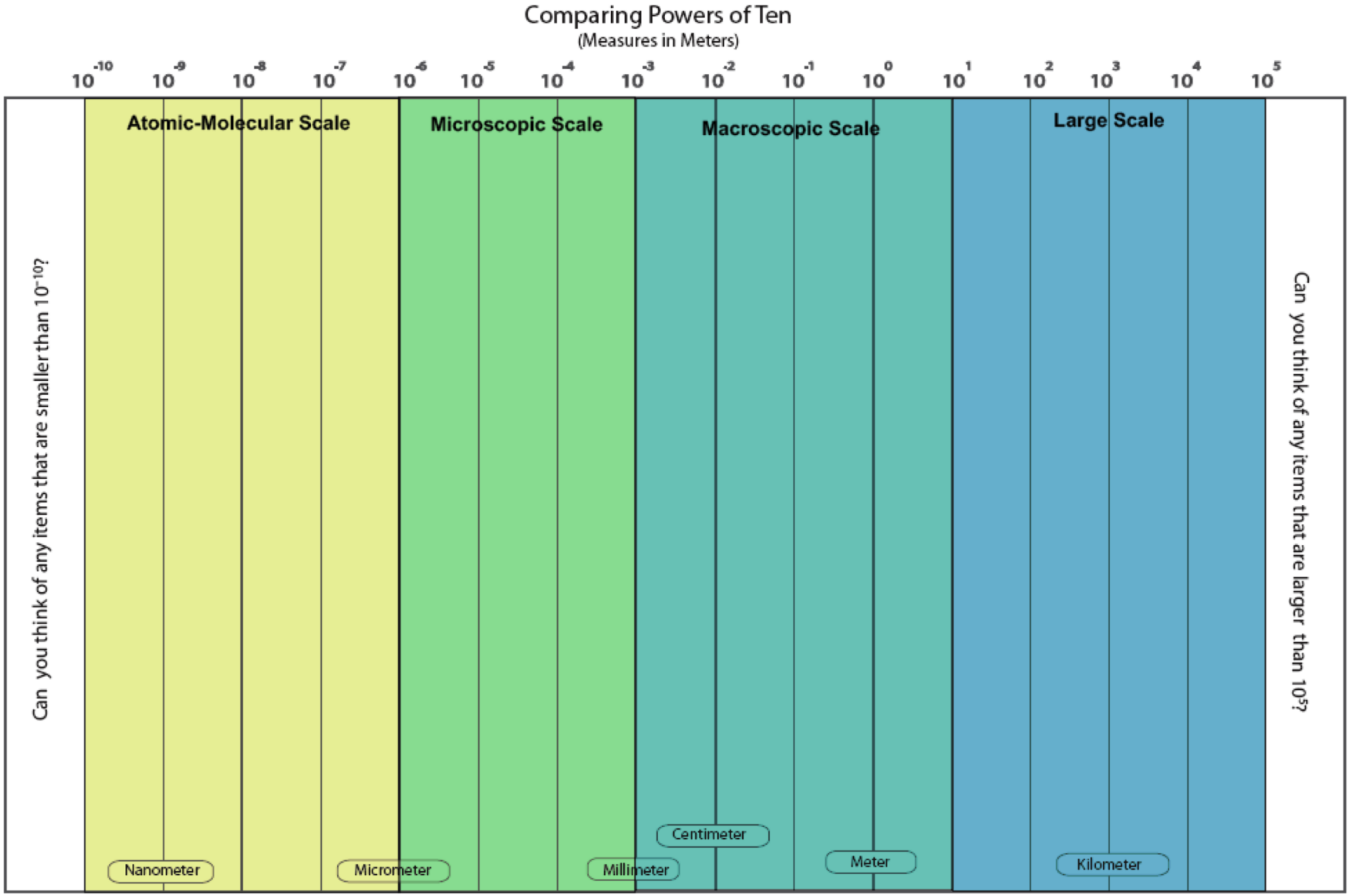
- http://edr1.educ.msu.edu/EnvironmentalLit/publicsite/html/tm_cc.html

Extra Slides

Development Products

1. *Learning progression framework*: Based on current carbon framework.
2. *Tools for Reasoning to enact fundamental principles:* Based on current tools for reasoning.
3. *Teaching strategies for responsive teaching:* General instructional model for all units.
4. *Formative and summative assessment tools*: Interactive formative assessments for each unit developed with NREL and BEAR.
5. *Teaching materials and activities:* six units at Middle and High School levels: Systems and Scale, Plants, Animals, Decomposers, Ecological Carbon Cycling, Human Energy Systems. Available online through NGS website.
6. *Professional development materials.* General and unit-specific, face-to-face and facilitated online versions.

Powers of 10 Chart



Matter and Energy Process Tool

scales

Large scale

Macroscopic

Microscopic

Atomic molecular

Ethanol burning

Analyzing

Matter

☐ Material identity and transformation ☐ Matter Movement

Energy

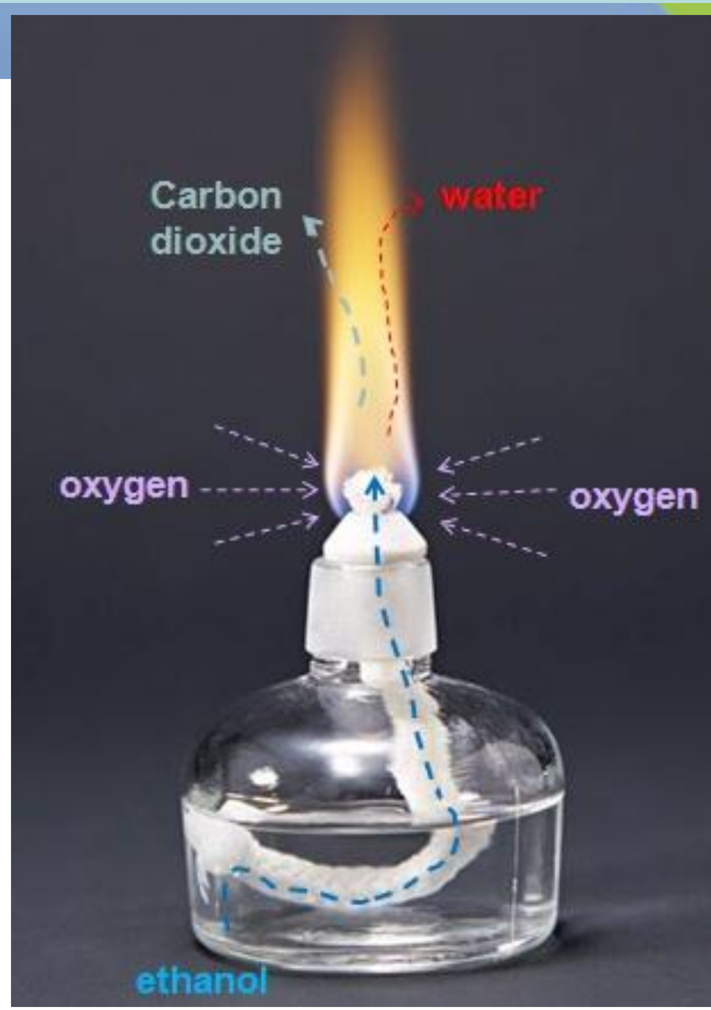
☐ Energy forms and transformation

☐ All filters

Driving question

What's the hidden chemical change when alcohol burns?

Movement of ethanol burning at macroscopic world



scales

Large scale
 **Macroscopic**
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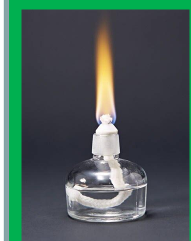
Transformation of ethanol burning at macroscopic world

scales

Large scale



Macroscopic

Microscopic

[Atomic molecular]

Chemical energy

Ethano r
(from wick (liquid) to flame (vapor))

oxyge n
(From air to flame)

Light and heat energy

Ethanol burning

Heat energy
(in the air)

wate r
(From flame to air)

carbon dioxide
(From flame to air)

Analyzing

Matter
☒ [Material identity and transformation] ☒ [Matter Movement]
Energy
☒ [Energy forms and transformation]
☒ [All filters]

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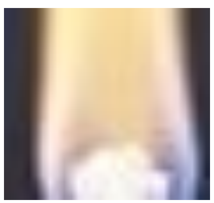
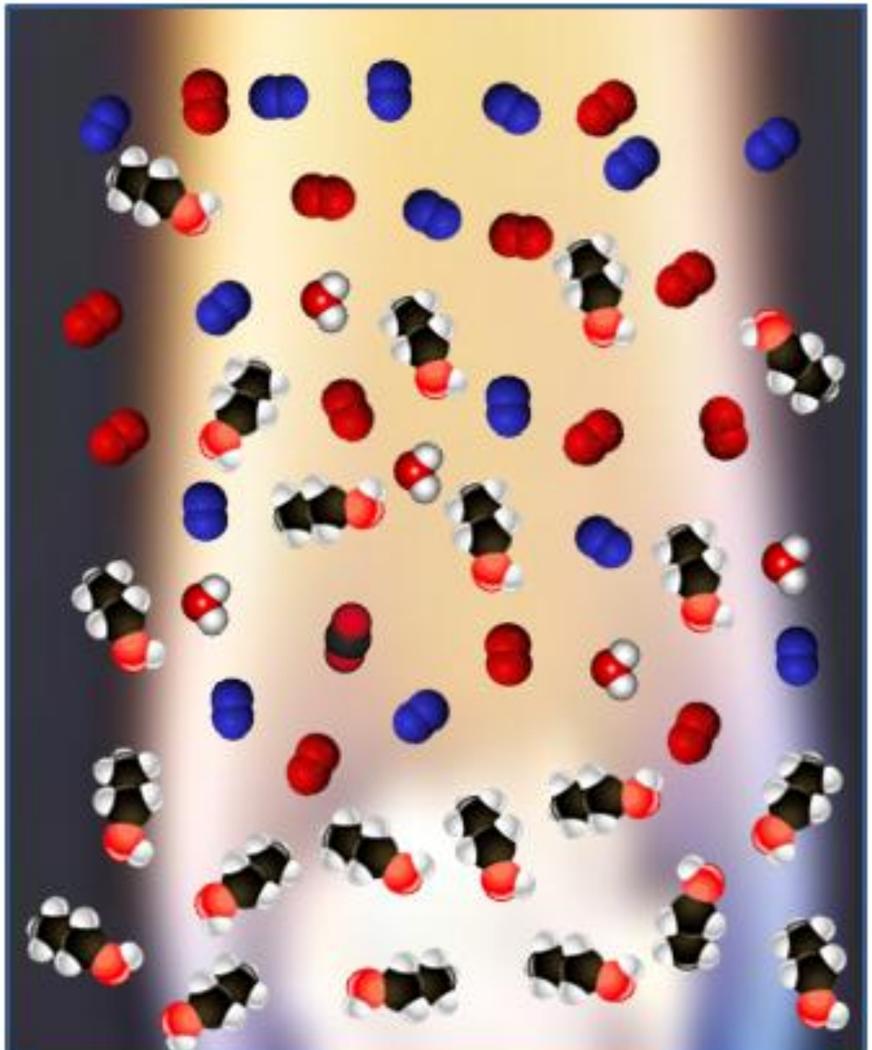
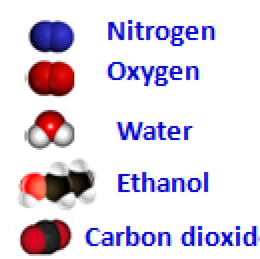
The bottom of flame at atomic-molecular scale



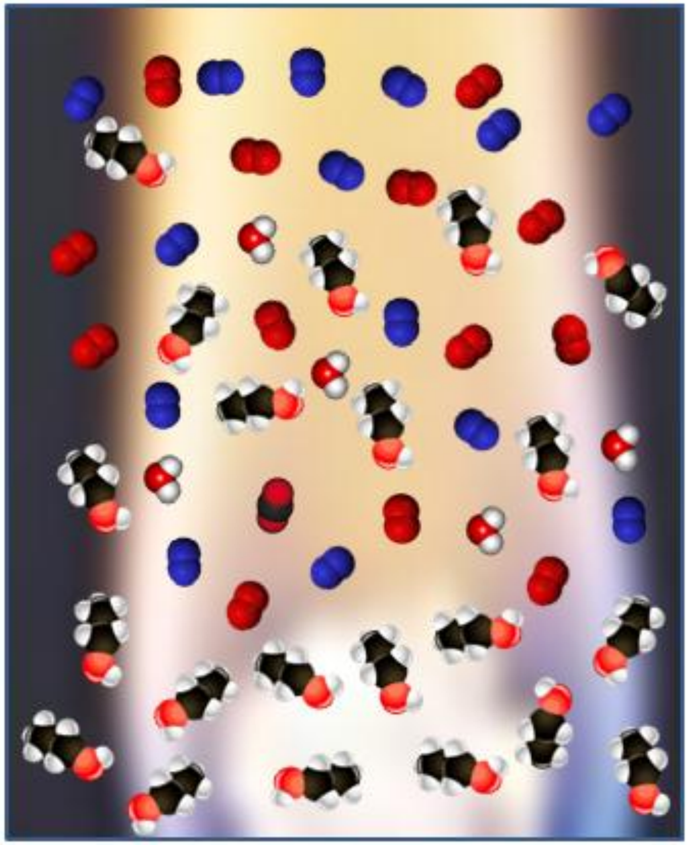


Ethanol mixed with air

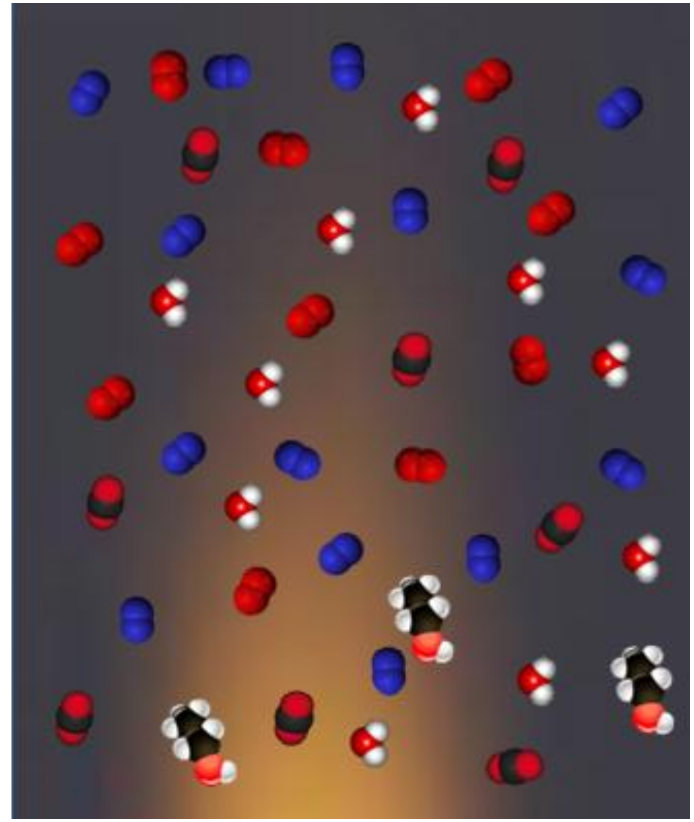
Ethan ol vapor



What happened between the bottom and the top of the flame?



Bottom of the flame



Top of the flame

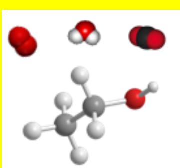
Transformation of ethanol burning at atomic-molecular world

scales

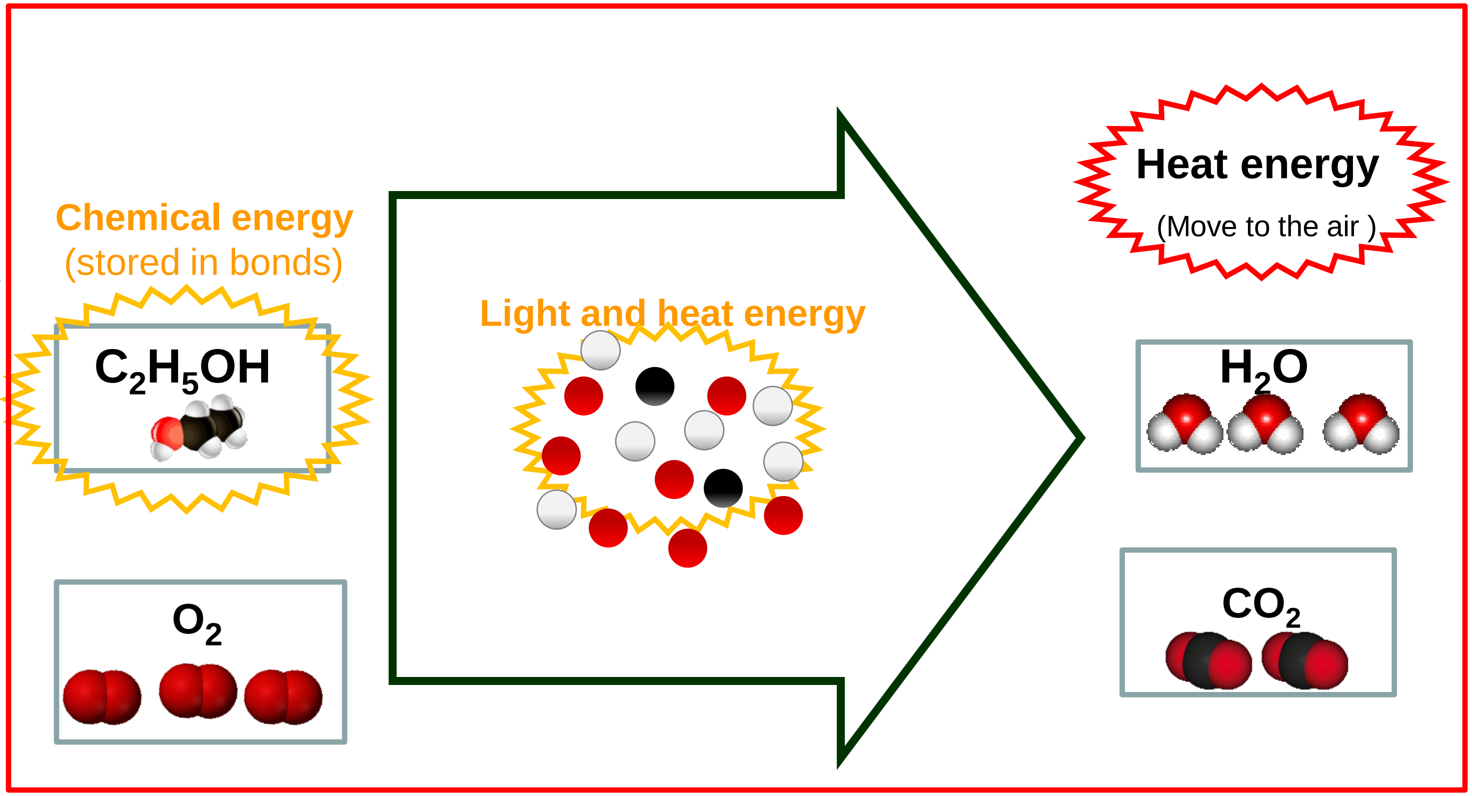
Large scale

Macroscopic

Microscopic



Atomic molecular



Analyzing

Matter

☒ Material identity ☒ Matter transformation

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☒ Energy forms and transformation

☒ All filters

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