Developing a model for both energy and entropy

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FACET INNOVATIONS

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The Energy Project

Professional development program for K-12 teachers on the learning of **energy** and practices of **formative assessment**

Research program on:

- teaching and learning of energy
- **relating "school energy" to sociopolitical concerns**
- learning theory development
- assessment of teacher learning

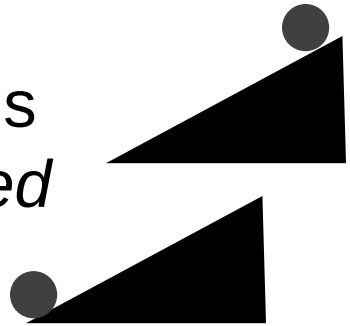
Goal

- **Create a K-12 conceptual model** (statements, metaphors, and representations) **of energy *degradation*, including entropy and the second law of thermodynamics.**

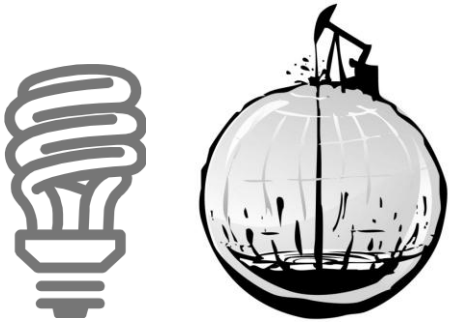
Motivation:

Reconnect physics energy to sociopolitical energy

Energy is *conserved*



Energy is *wasted*



Degraded Energy

Textbooks identify degraded energy as
energy unavailable for the performance of work.
(e.g., Cutnell & Johnson, 2009)

In order to keep the focus on energy (not forces) and avoid awkwardness about "energy doing work," we identify degraded energy as:

- Energy **unavailable for mechanical transfer**
- Energy that **cannot be converted to kinetic energy** without the addition of outside energy or a change in the system
- **Thermal energy at equilibrium**

Goal

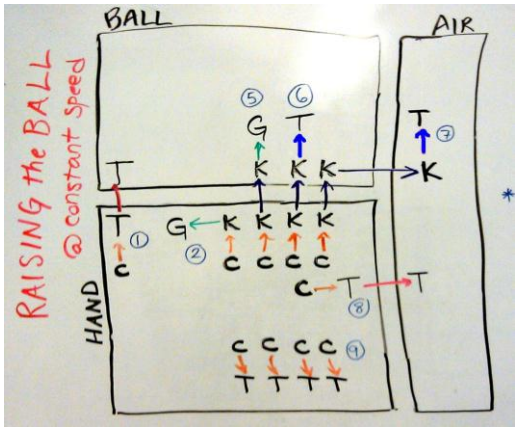
- **Create a K-12 conceptual model** (statements, metaphors, and representations) **of energy *degradation*, including entropy and the second law of thermodynamics.**
  - Include energy degradation in our representations.

Energy Tracking Representations

Energy Theater

Energy Cubes

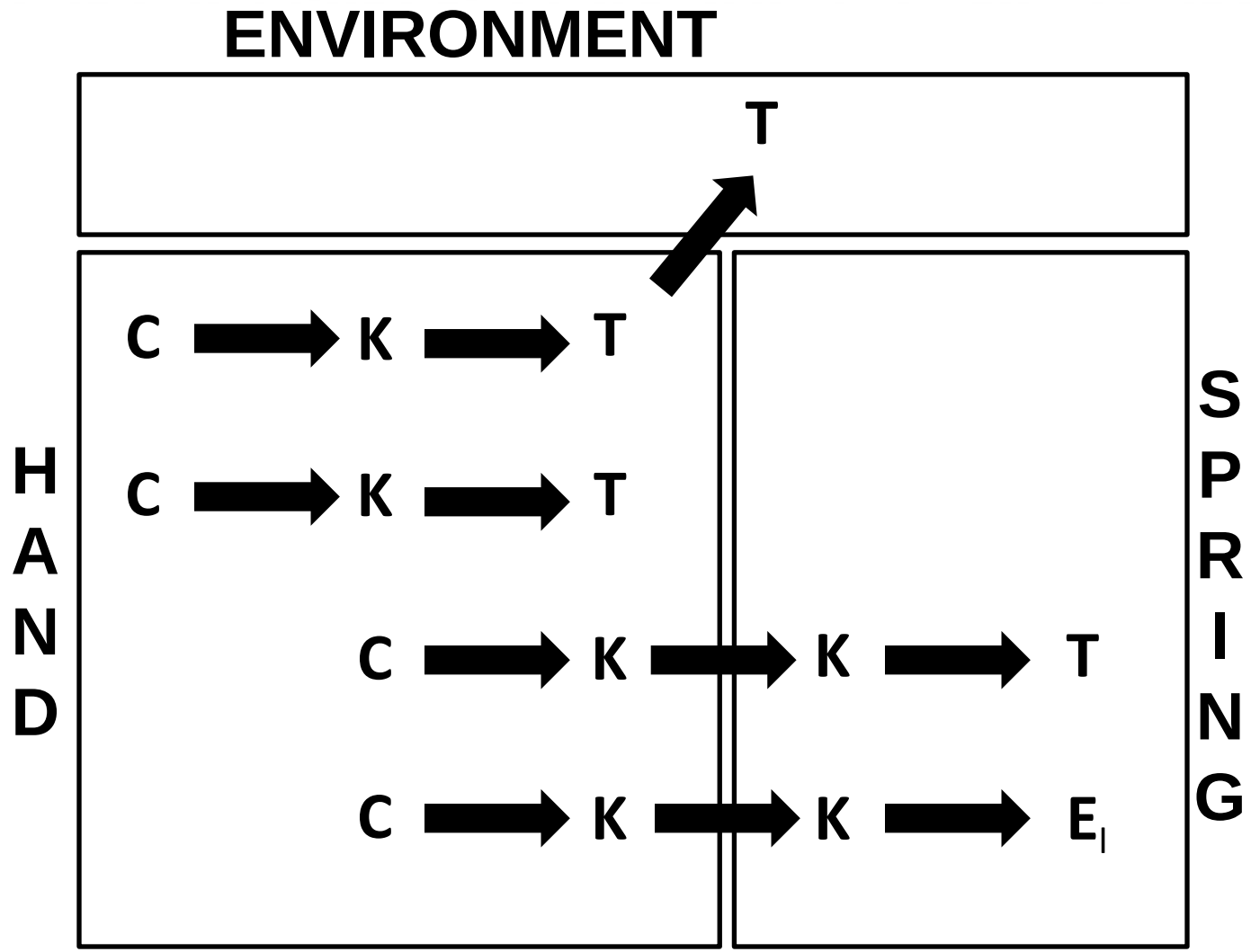
Energy Tracking Diagram (ETD)

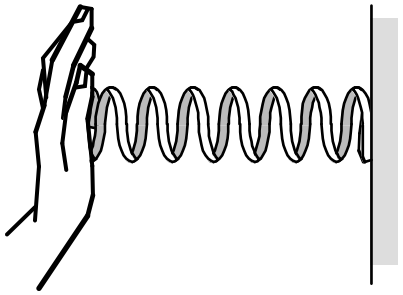


Energy Tracking Representation Rules:

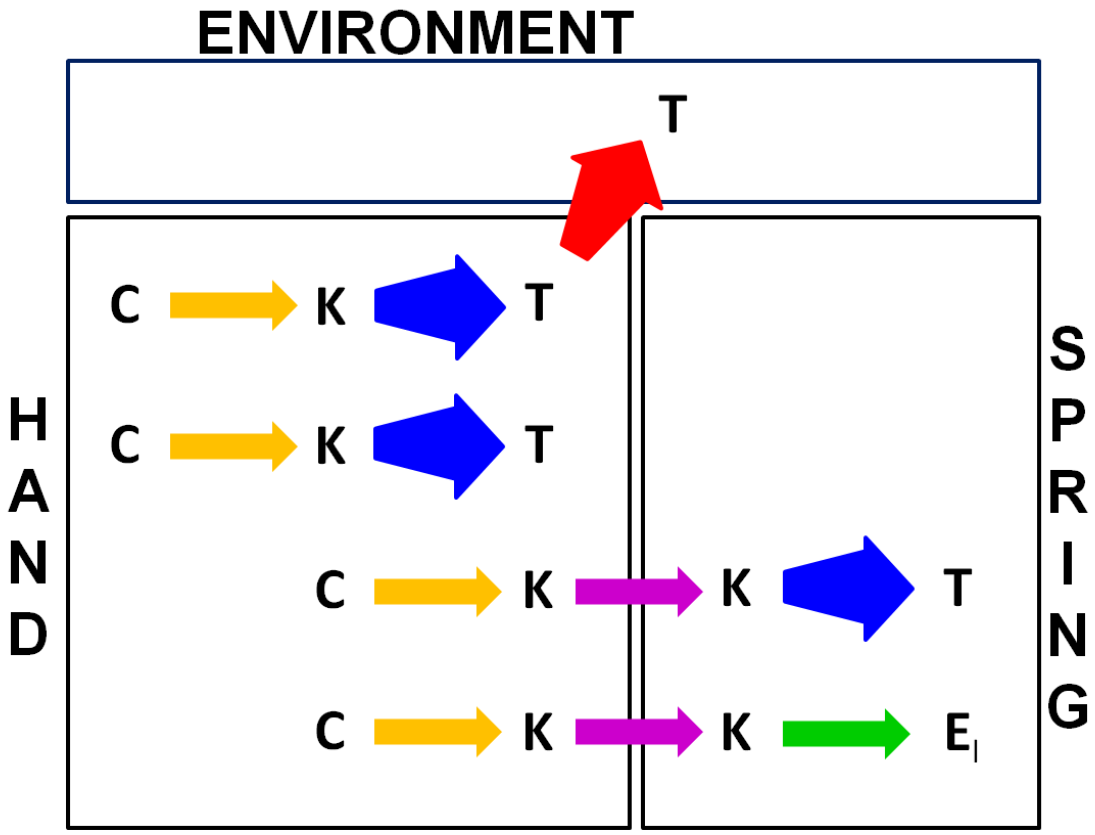
- Each person (cube, letter) is a ‘chunk’ of energy
- Objects in the scenario correspond to locations on the floor (white board)
- Energy forms are indicated with movements, hand signs, or letters
- As energy transfers and transforms among objects, people (cubes, letters) move and change label

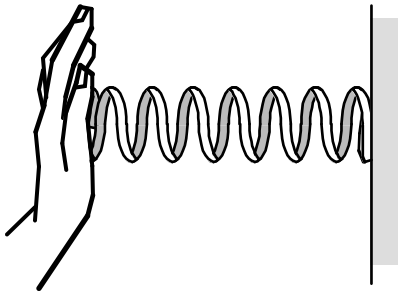
Example: ETD for spring compression





Example: ETD for spring compression





Processes of Energy Transfer and Transformation

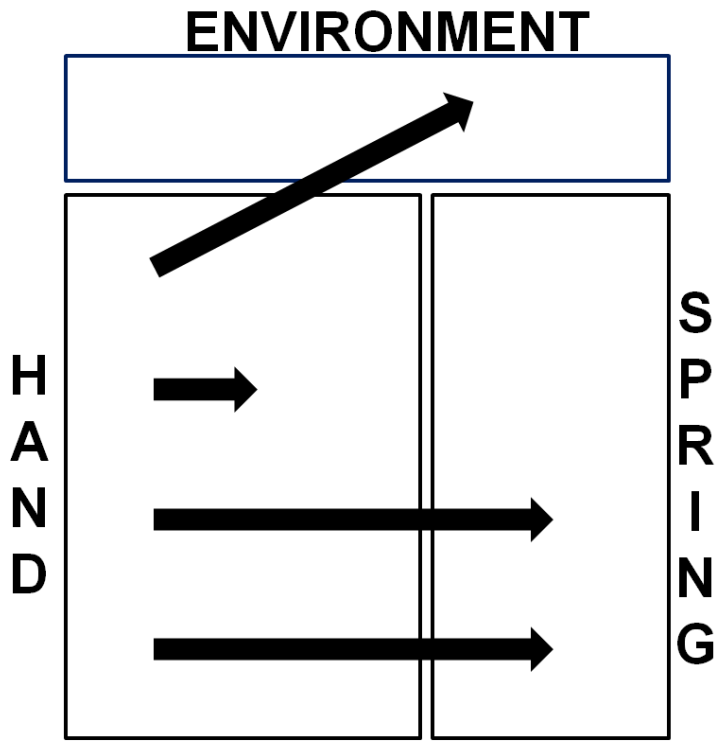
- Metabolism
- Thermal Conduction
- Elastic Compression
- Mechanical Work
- Dissipation

How does degradation fit into this model?

Degradation as *spreading*

During physical scenarios, energy tends to spread

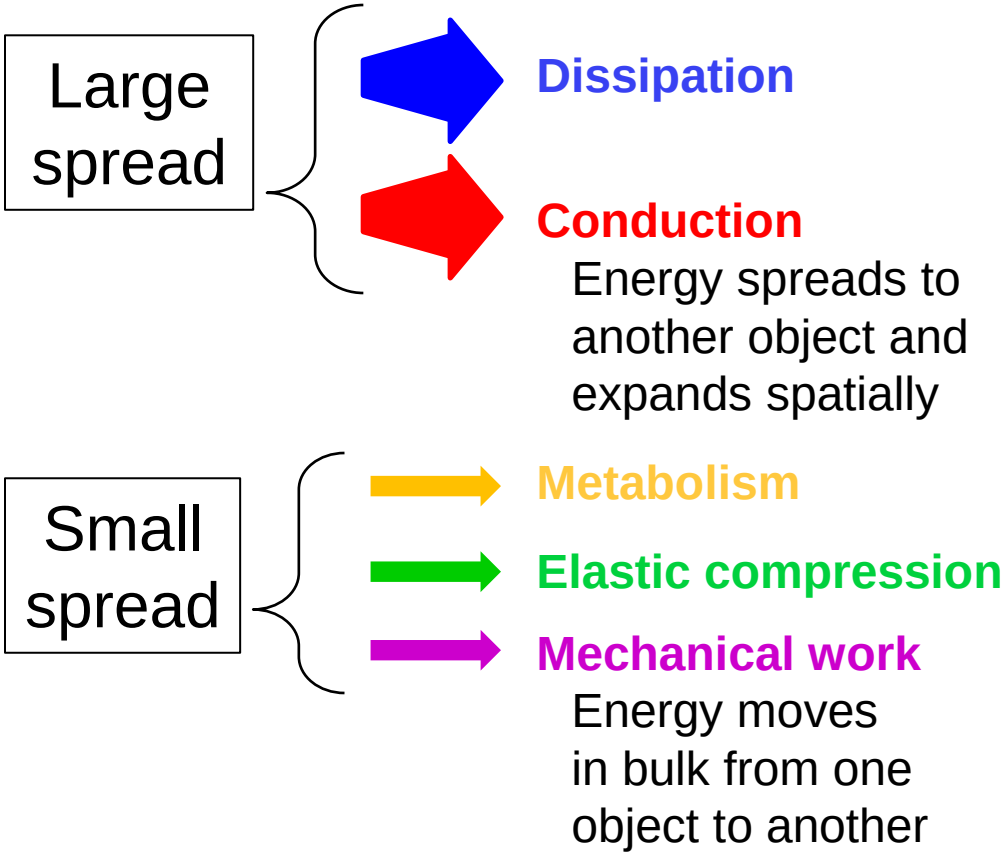
1. Energy spreads to **more and more objects**
2. Energy spreads **spatially within objects**



Degradation as *spreading*

During physical phenomena, energy tends to spread

3. Energy spreads **spatially during processes**



Leff (2012):
"Energy spreading is entropy increase."

Degradation as *thermal equilibrium*

1. As energy spreads, thermal energy never decreases

2. As thermal energy increases, other forms decrease.

Transfer or Transformation	Status of Thermal Energy
K → **T**	Increases
T → **T**	Stays the Same

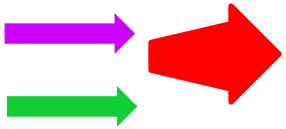
By energy conservation:

As **T**'s ↑, Other forms ↓

making the resulting energy configuration more and more unlike the original.

Goals

- **Create a K-12 conceptual model** (statements, metaphors, and representations) **of energy *degradation*, including entropy and the second law of thermodynamics.**

  - ✓ Include energy degradation in Energy Tracking Diagrams.
    - *Show energy spread* 
    - *Focus on transfer/transformation processes* 
  - ❑ Determine how entropy fits into the model.
  - ❑ Test model with teachers.