PHILOSOPHY OF SCIENCE *IN ACTION*
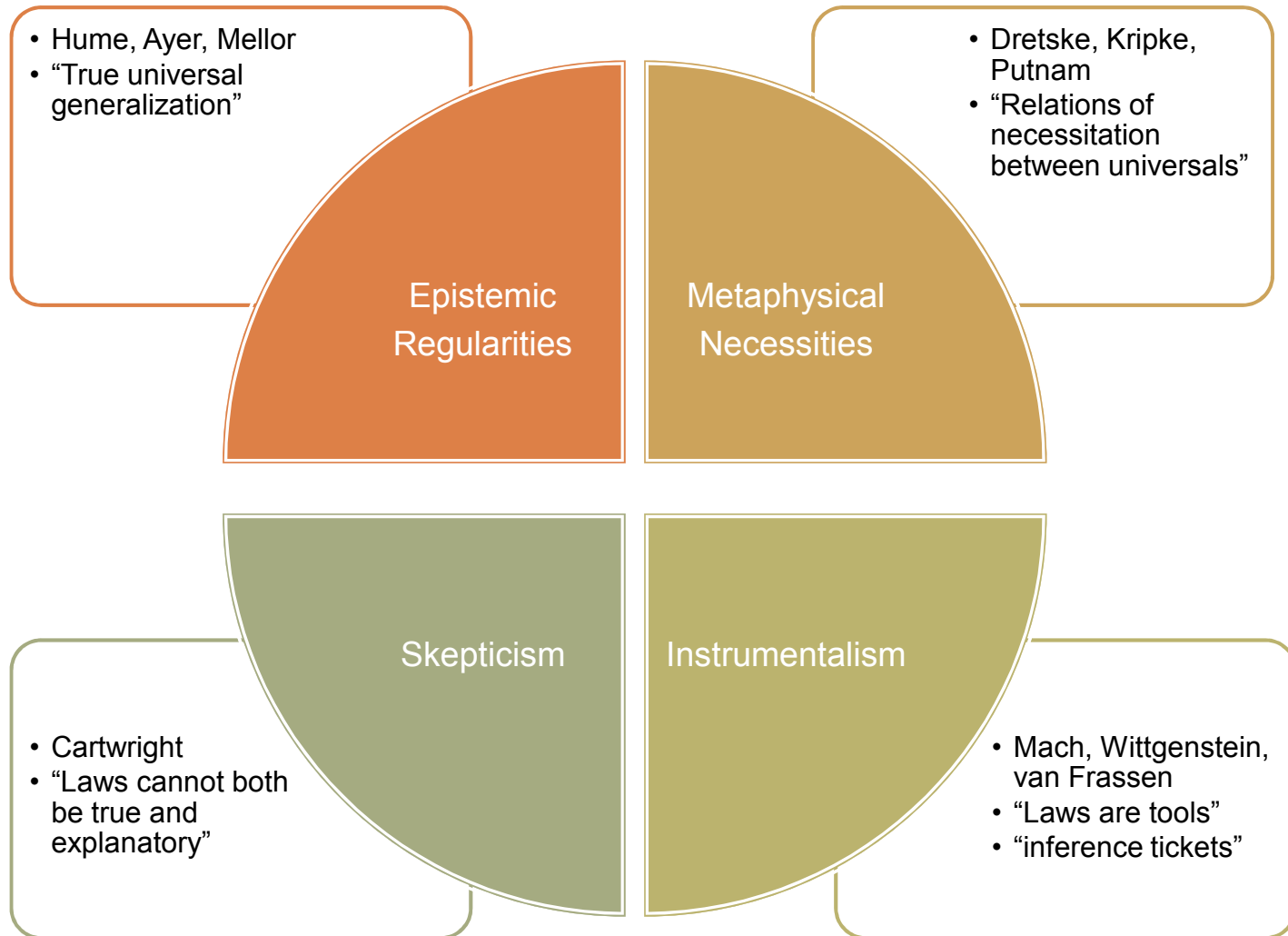
The science of learning science

A Brief Summary

- What are the laws of nature?
- Debunking "Laws" of Teaching
- Searching for Laws of Learning
- Philosophy of Science "in action"
  - Student Epistemologies
  - Mechanistic Reasoning

What are the laws of nature?

- Hume, Ayer, Mellor
- "True universal generalization"

- Dretske, Kripke, Putnam
- "Relations of necessitation between universals"

Epistemic Regularities

Metaphysical Necessities

Skepticism

Instrumentalism

- Cartwright
- "Laws cannot both be true and explanatory"

- Mach, Wittgenstein, van Frassen
- "Laws are tools"
- "inference tickets"

What are the laws of nature?

Mass conservation

- But, as E=mc^2 taught us, mass is not always conserved

Consider context

- Perhaps it is a law that, in non-nuclear chemical reactions, mass is conserved
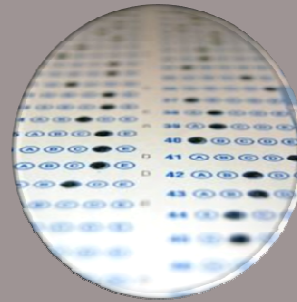
Skeptic's worry

- But aren't we just saying "mass is conserved when it's conserved"?

Debunking "Laws" of Teaching

Two traditionally held "laws" of teaching:

Good lectures lead to good learning

Tests precisely measure ability

1ˢᵗ law of traditional teaching
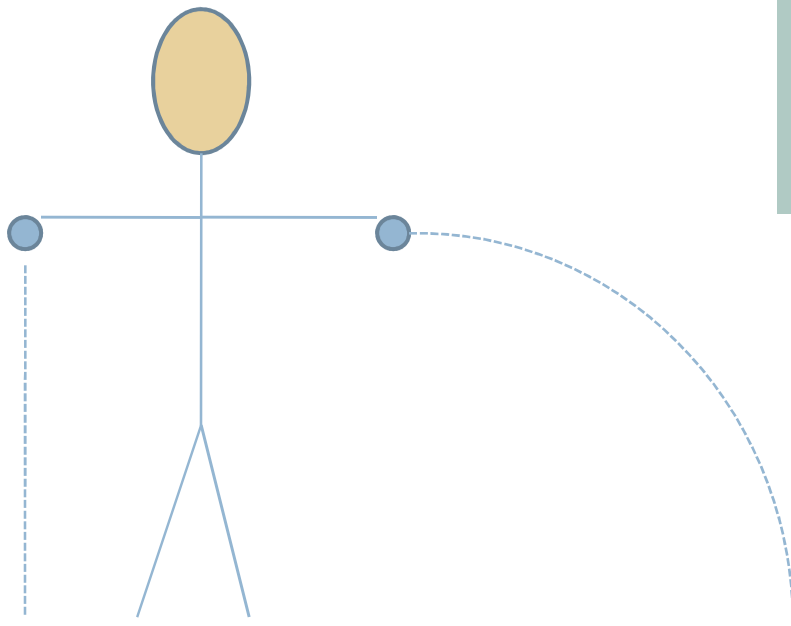
Good lecturer **+** Good student → Good learning
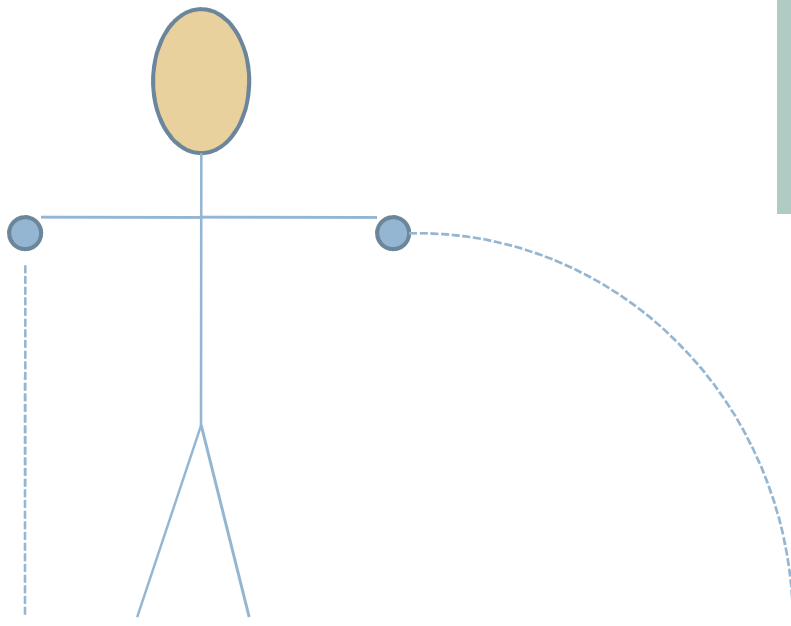
Really?

Misconceptions

A ball is dropped straight down, while simultaneously another ball is thrown horizontally from the same height. Which ball hits first?

1. The dropped ball
2. The thrown ball
3. They hit at the same time
4. Need more info

This question elicits a commonly reported 'misconception'; the answer defies common sense

Resources

A ball is *thrown* straight down, while simultaneously another ball is thrown horizontally from the same height. Which ball hits first?

1. The ball thrown down
2. The thrown ball to the side
3. They hit at the same time
4. Need more info

Students who haven't taken physics *always* get this right → they use 'common sense'
After a semester of physics, many students answer '3'…they don't see common sense as appropriate to use n physics class.

Paradigm Shifts in Ed. Research

Traditionalists (1900's)

Students are empty containers to be filled up with knowledge	Lecturers & students must be 'good' for learning to occur

Misconceptions (1980's-present)

Wrong, but persistent beliefs	Must be challenged for learning to occur

Resources (emerging now!)

|	
Beliefs that are based on experience and are neither right nor wrong	Must be *applied appropriately in context* for learning to occur

Paradigm Shifts in Ed. Research

Why don't the students change their views about heat?

Traditional/Piagetian View:
The students are not at the right developmental level to understand the nature of heat, since it's an abstract concept

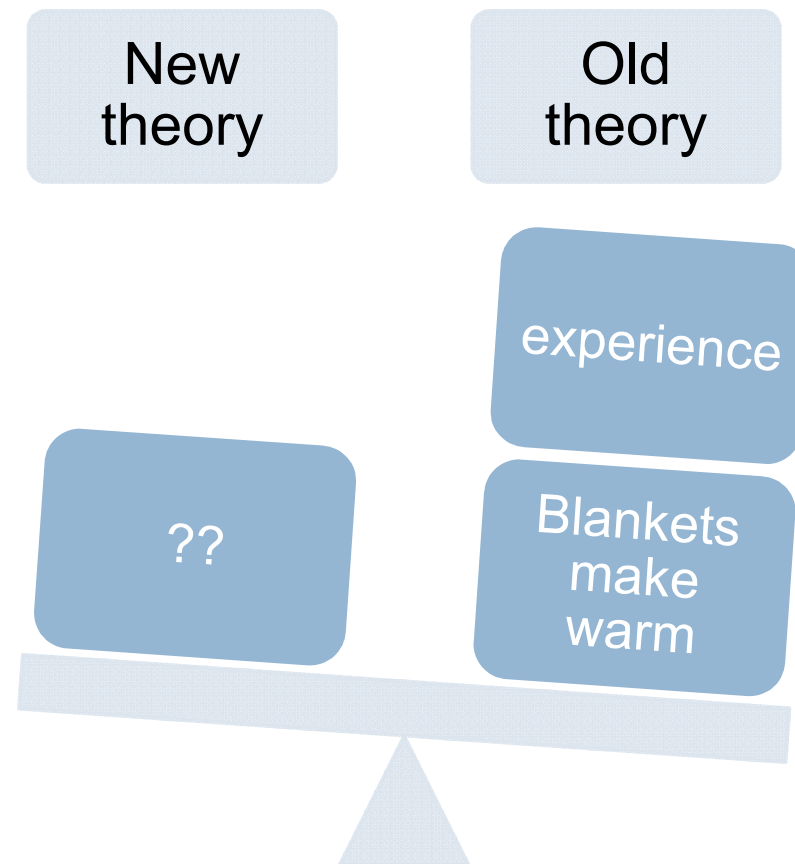| sensorimotor | concrete | abstract |
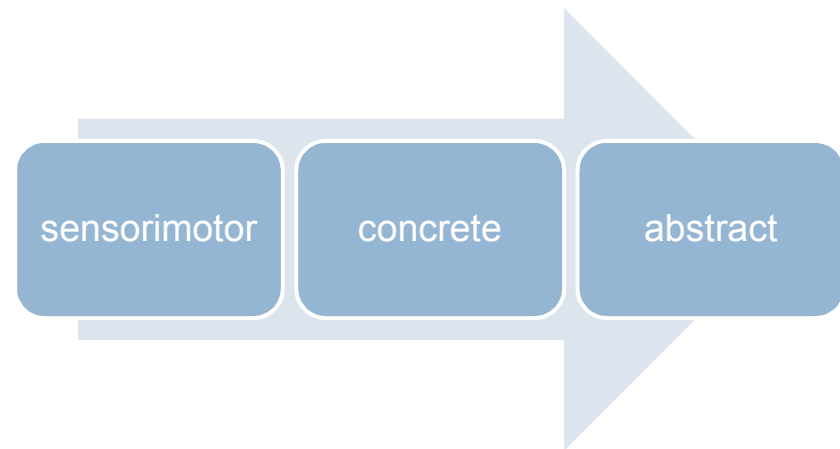
Paradigm Shifts in Ed. Research

Why don't the students change their views about heat?

Kuhnian View:
The students can't just throw out their successful theory; they need to be shown a *better* theory

New theory

Old theory
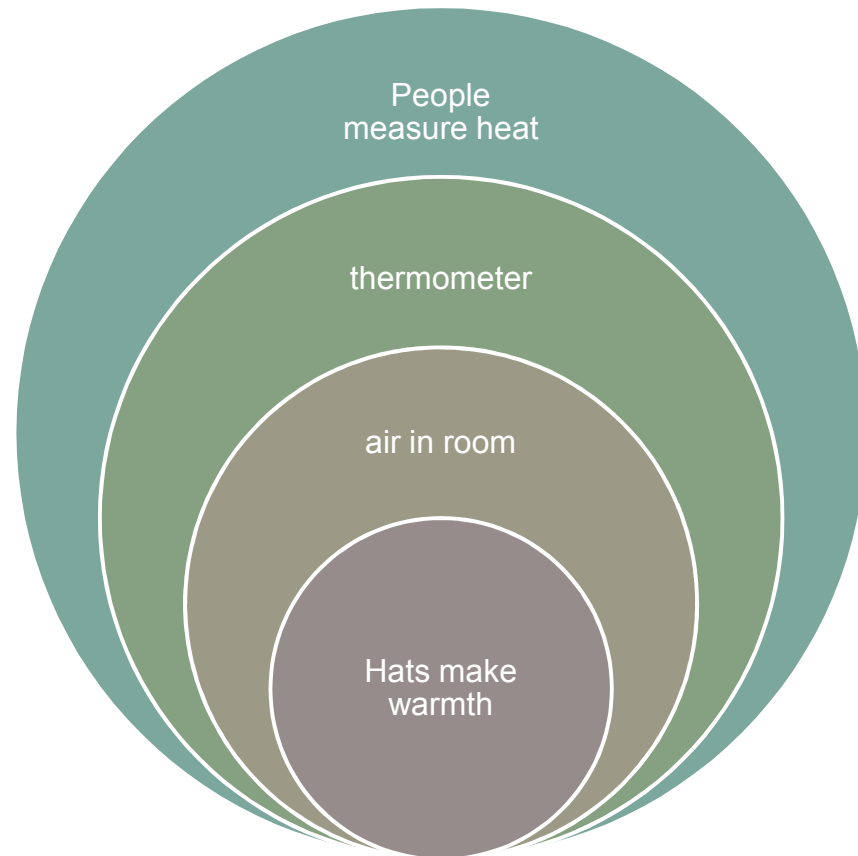
experience

??

Blankets make warm

Paradigm Shifts in Ed. Research

Why don't the students change their views about heat?

Lakatosian View:
There are a host of 'protective belt' assumptions that the students will question before they question their core assumptions
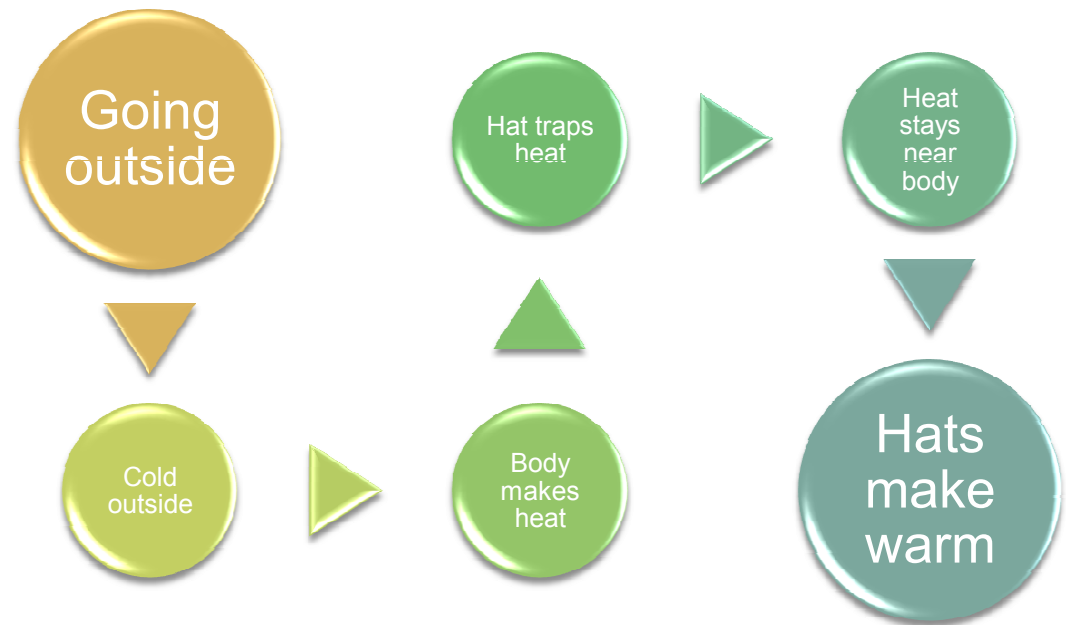
People measure heat

thermometer

air in room

Hats make warmth

Paradigm Shifts in Ed. Research

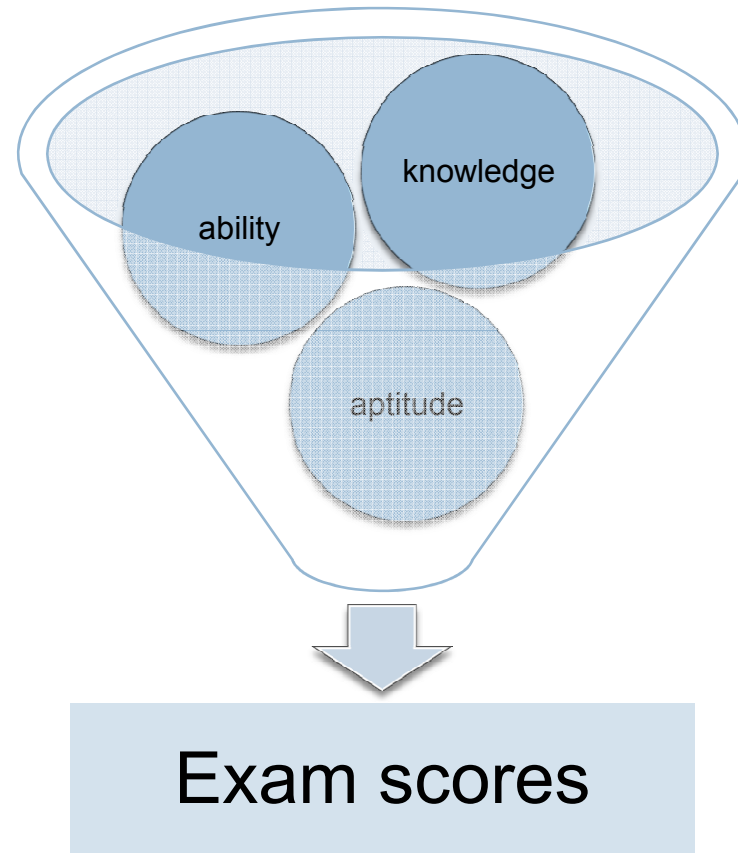## Why don't the students change their views about heat?

Resources View:
"Hats make warm" is not right or wrong.

Students need to reconcile their own ideas with 'science' ideas in order to apply the 'hats make warm' resource appropriately
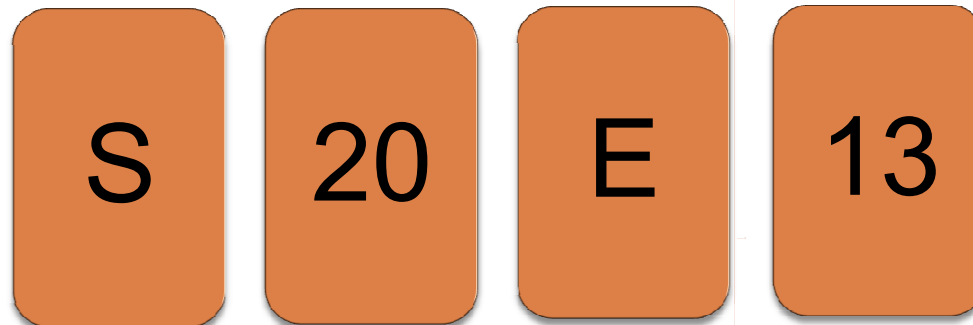
2nd law of traditional teaching

"A good test measures the abilities and knowledge of a student"

A puzzle

- <u>Rule</u>: If a card has a vowel on one side, it *must* have an even number on the other side

- <u>Question</u>: which card(s) do you *need* to turn over to check if this rule is obeyed?

| S | 20 | E | 13 |

A puzzle?

- <u>Rule</u>: If a person has an alcoholic beverage, they must be 21 or older

- <u>Question</u>: which card(s) do you *need* to turn over to check if this rule is obeyed?

Coke	16	Scotch	52

Reasoning 'skills' are context dependent!
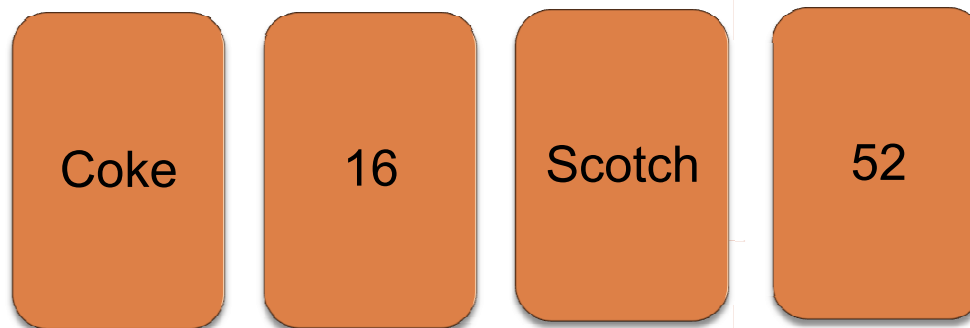
A challenge

- Count the number of basketball passes made by the "white shirt" team

http://viscog.beckman.uiuc.edu/grafs/demos/15.html

# Debunking "Laws" of Teaching

- A couple of traditional 'laws' of teaching
  - ~~Good lectures beget good learning?~~ <u>NO</u>!
    - Even the best students do not *learn* this way
  - ~~Tests precisely measure knowledge & skills~~? <u>NO</u>!
    - Skills & knowledge are *context dependent!*
    - *Biological Perception* is even context dependent!

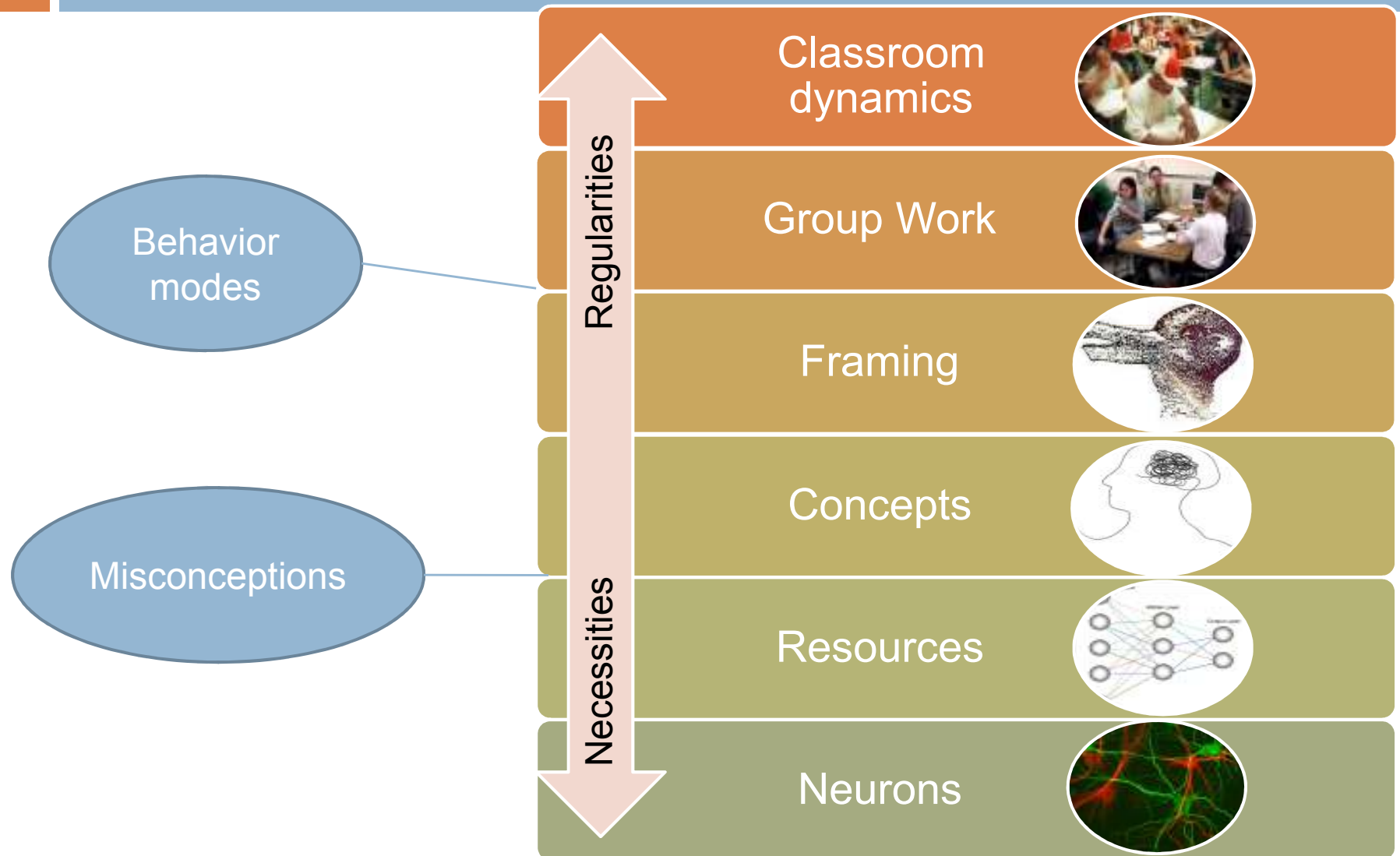CAN there be laws of *learning*?

Searching for Laws of Learning

- Finding laws of learning is *wicked tough!*
  - Context dependence, complicated dynamics
- A lesson from chaos theory:
  - Even chaotic systems follow laws, but they are too complicated to analyze with those laws!
  - But there is order to the chaos: <u>global patterns</u>
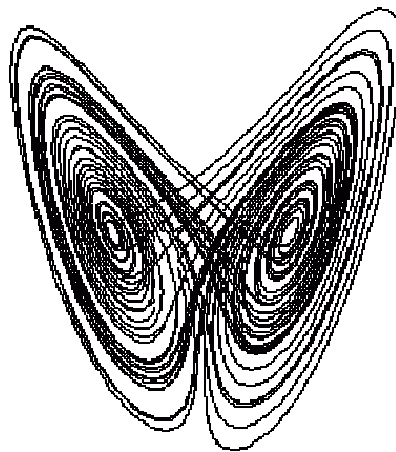
Lorenz Attractor

The Nature of Laws of Learning

"Applied" Philosophy of Science

- A "personal epistemology" is one's stance toward knowledge
  - Personal epistemologies develop over time (Schommer)
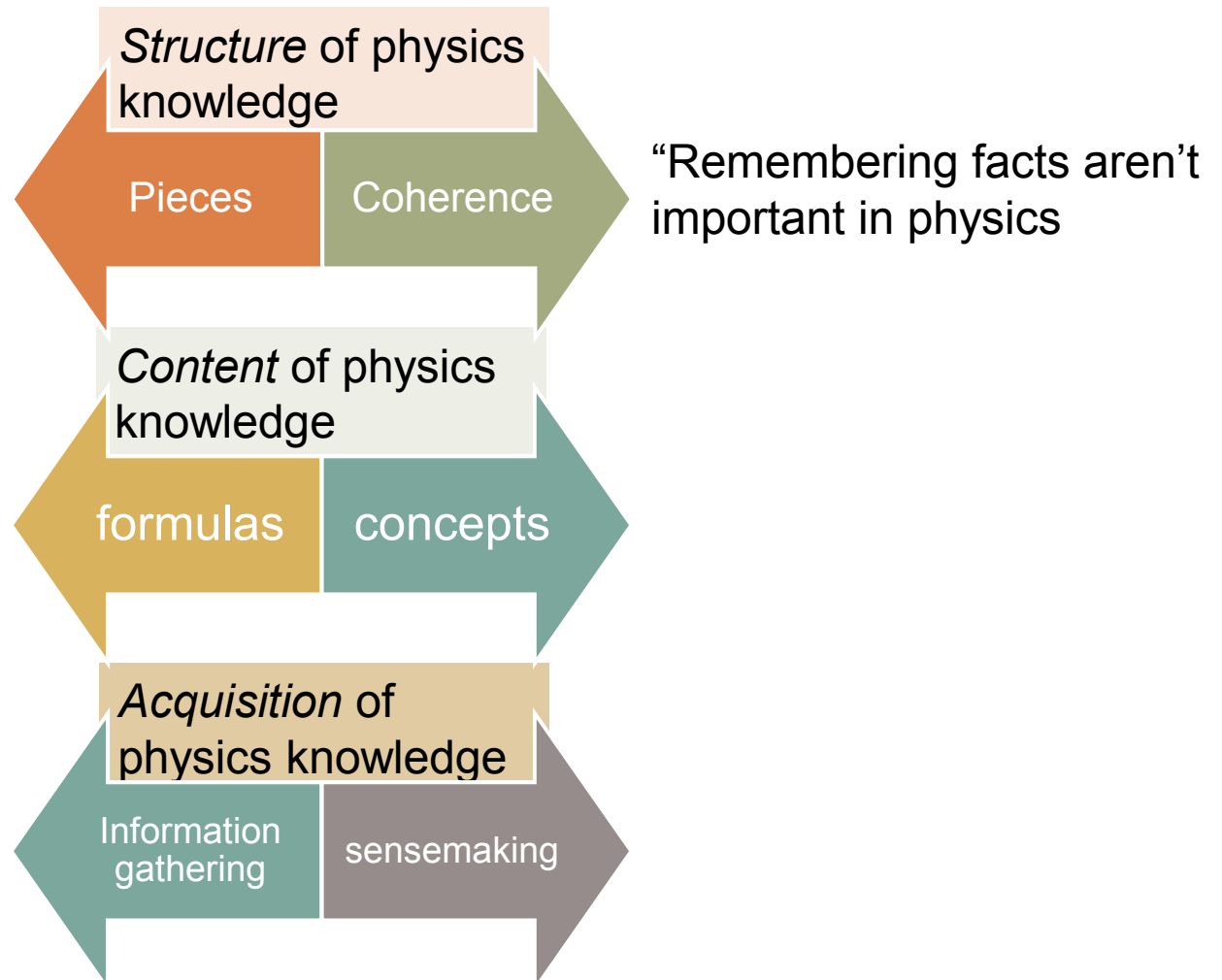 - Personal epistemologies affect learning
    (Dweck, Elby, Hammer)

Personal Epistemology Quiz

A: Strongly disagree B: Somewhat disagree C: Neutral D: Somewhat agree E: Strongly agree

1. Shelly just read something in her science textbook that seems to disagree with her own experiences. But to learn science well, Tamara shouldn't think about her own experiences; she should just focus on what the book says.

2. When it comes to understanding physics or chemistry, remembering facts isn't very important.

3. Obviously, computer simulations can predict the behavior of physical objects like comets. But simulations can also help scientists estimate things involving the behavior of *people*, such as how many people will buy new television sets next year.

4. If someone is having trouble in physics or chemistry class, studying in a better way can make a big difference.

5. When it comes to controversial topics such as which foods cause cancer, there's no way for scientists to evaluate which scientific studies are the best. Everything's up in the air!

"Applied Philosophy of Science"

Epistemological spectra used by Hammer (1994)

Structure of physics knowledge

Pieces ← → Coherence

"Remembering facts aren't important in physics"

Content of physics knowledge

formulas ← → concepts

Acquisition of physics knowledge

Information gathering ← → sensemaking

"Don't think about your own experiences, just pay attention to what the book says"

On the Substance of a Sophisticated Epistemology

- We shouldn't equate 'realism' with novices, nor 'relativism' with experts
- A sophisticated epistemology may be *dynamic* and *context dependent*
  - We all have varied epistemological resources
    - Knowledge as coming from within ('made up stuff')
    - Knowledge as coming from authority (truths about the world)
  - Having a sophisticated epistemology is a matter of applying these resources *appropriately*

Mechanistic Reasoning

Increasing quality of evidence

Level	Name
7	**Chaining: Forward or Backward**
6	**Identifying Organization of Entities**
5	Identifying Properties of Entities
4	Identifying Activities
3	Identifying Entities
2	Identifying Set up Conditions
1	Describing Target Phenomenon

Framework developed by Russ (2006)
• Used to asses student reasoning
• Matches with sense of 'good scientific reasoning'

Mechanistic Reasoning

Example:

Target phenomenon: Why don't your hands spark when you rub them together?

"its <u>not going to let charge build on your hands</u> because <u>moisture's a conductor</u> so it's like <u>going to dissipate</u> off <u>into the atmosphere</u> before it actually builds up enough so that you'd <u>see a spark</u>."

moisture

conductor

Charge will dissipate before it builds up
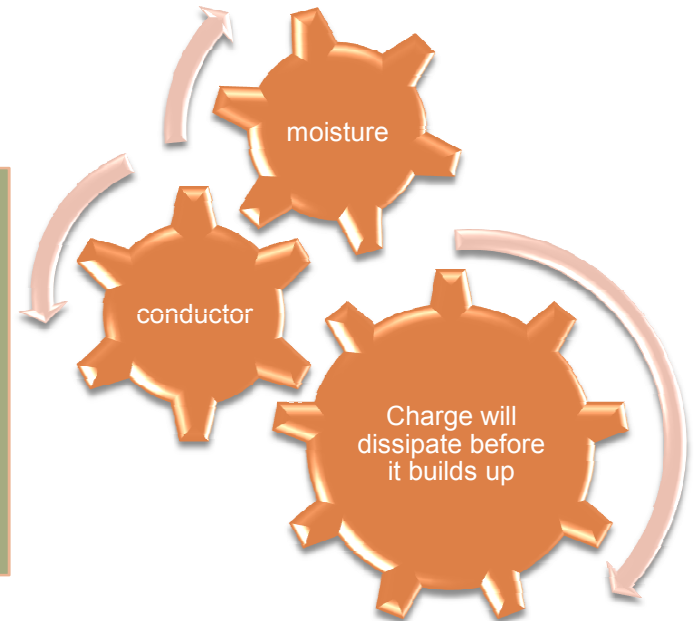
Code: <u>CHAINING</u>

students reason about one stage of a mechanism based on what is known about another stage of the mechanism

Summary

- Laws as exceptionless regularities; laws as metaphysical necessities
  - Skeptic response: there are always exceptions, and when we correct for them we lose explanatory power
  - Response to skeptic: we can account for context
- 'Laws' of teaching are no longer useful as 'inference tools' in their full generality
- We can search for 'laws' of learning, while trying to account for context

Thank You!

- Thanks to William Kallfelz

- Thanks to YOU!

- If you'd like to know more:
  - http://www.physics.umd.edu/perg/
  - Luke.conlin@gmail.com

Turtles all the way down

- Methodological Level
  - Is Education Research a Science?
  - Research Paradigms
- Curricular Level
  - Should N.O.S. be taught?
- Student Level
  - How does philosophy of science affect learning?
  - How can we model conceptual change?
    - Popperian vs. Kuhnian theory change
  - Framing & Context
    - Theory-laiden observations
- Neurological Level
  - Framing & the hippocampus