Modeling Instruction for High School Earth Science

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With assistance from:

The Modeling Instruction Program

Arizona State University

American Modeling Teachers Association

The Science House & Math-Science Partnership

North Carolina State University

Objectives

- Discuss traditional instruction
  - Generalizations
- Describe modeling instruction
  - Characteristics
- Provide examples from Earth Science
  - Specifics
- Request information
  - Big ideas
  - Paradigm activities.

The Problem

- Traditional science instruction remains highly transmissionist

- Presumes knowledge is distributed to students.

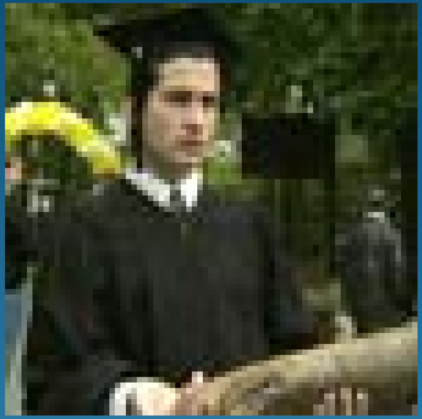
Teaching by Telling

- Ineffective mode for most students
  - Students often miss the point
  - Concepts do not connect to prior knowledge
  - Watching teacher solve problems does not improve problem-solving skills of students.

Mismatched Models

- Teachers operate from mental model that approximates scientific model
- Students operate from mental model based on their experiences
  - Students don't have same schema associated with concepts.

A Private Universe

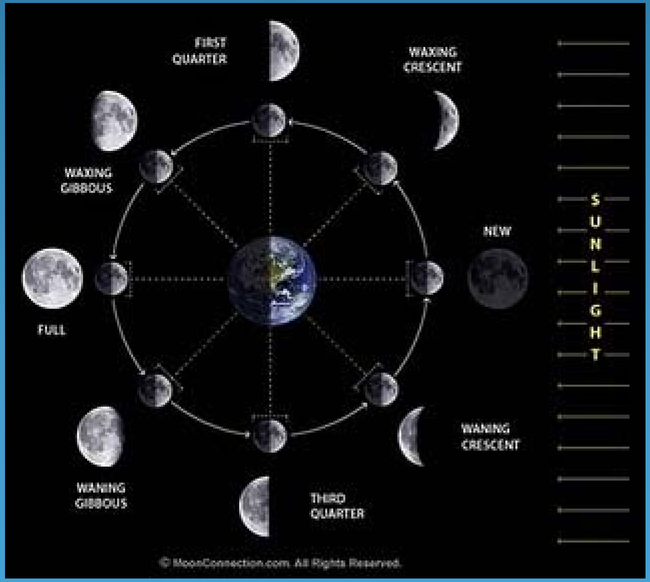


- We go through life collecting memories, and organizing them into mental models, or schema.

- Our memory depends on connections; new inputs which do not fit in an existing schema tend to be "forgotten."

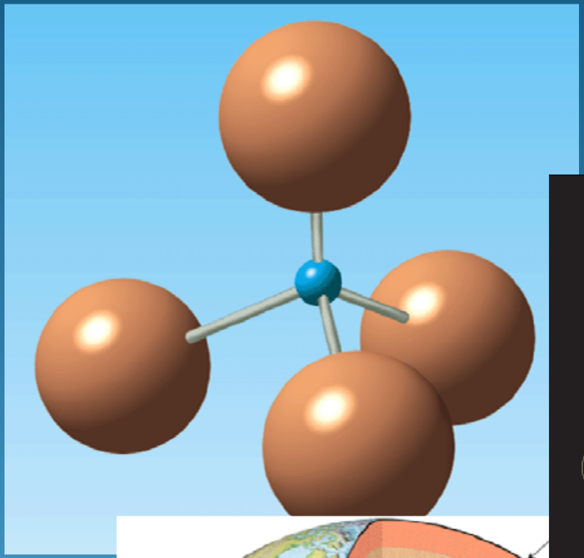
Constructivist Theory

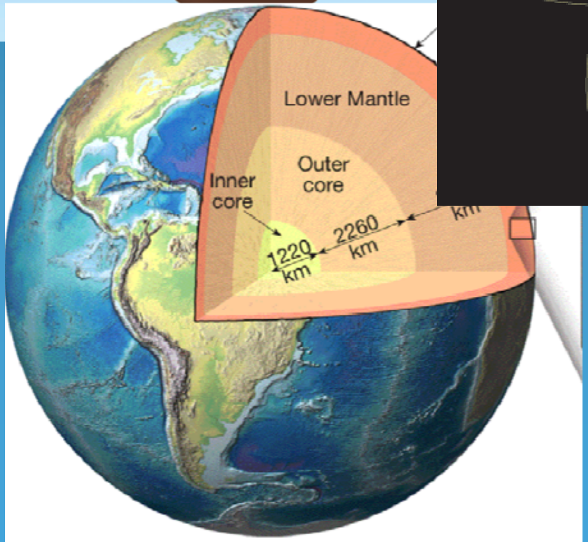
It takes a very discrepant phenomenon to motivate a change in existing schemata.

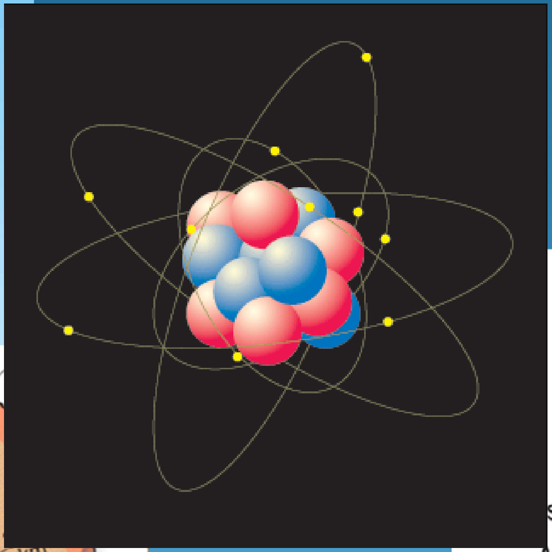


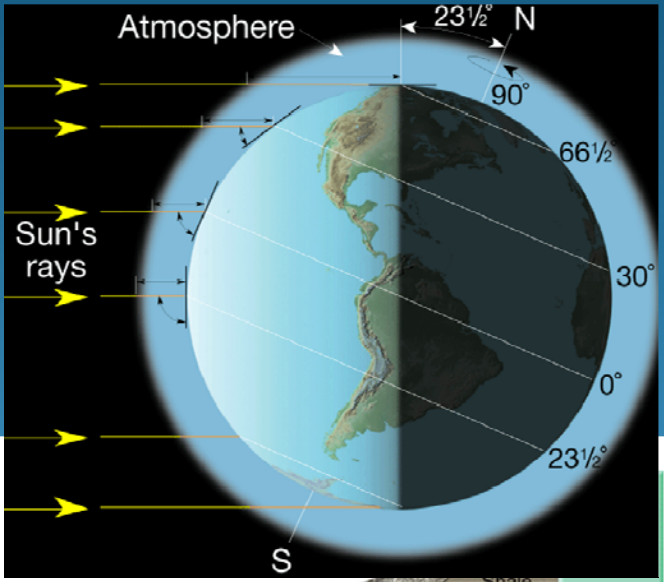
We come to understand the structure and behavior of real objects only by constructing models.

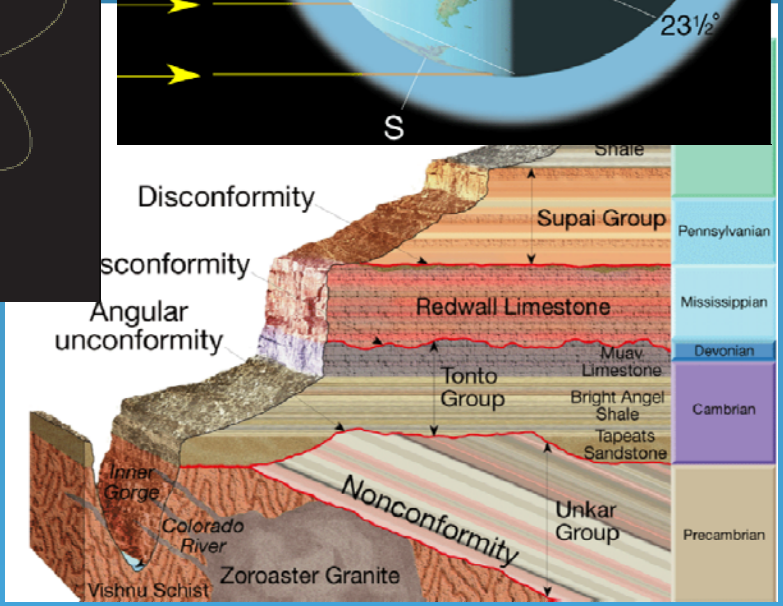
A scientific model is a conception of how the world works, consistent with observation.











Science and Models

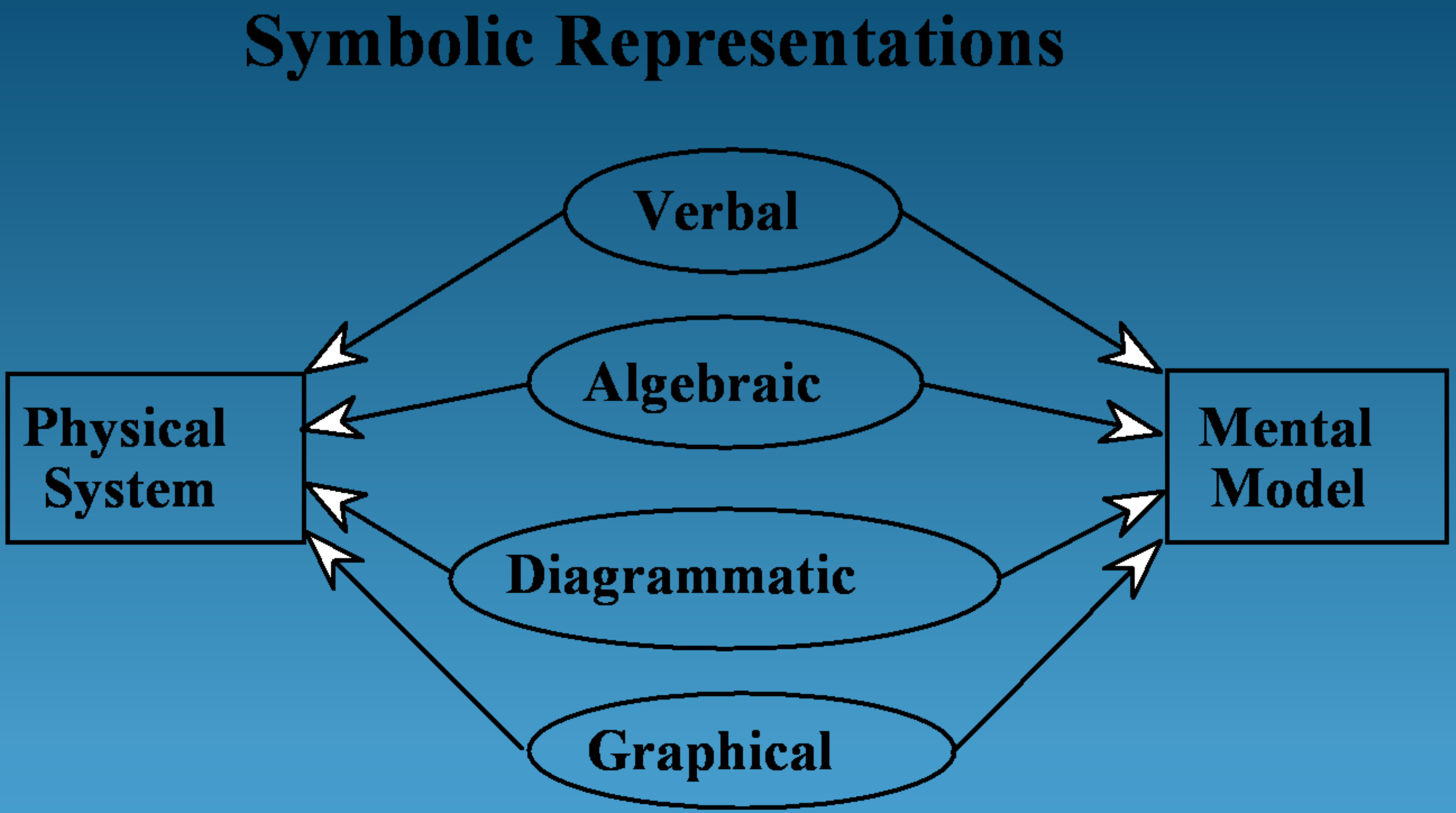
- Scientists construct and use *shared* models to describe, explain, predict and control physical systems
- A small set of basic models form the content core for the sciences
- Models are the basic unit of knowledge.

Students and Models

- Students work from their existing mental models
- By making the process explicit, we help students move from:
  - A private, inconsistently applied model based on miscellaneous experiences

    TO
  - A shared, rigorous model with explicit experimental support.

What Do We Mean by Models



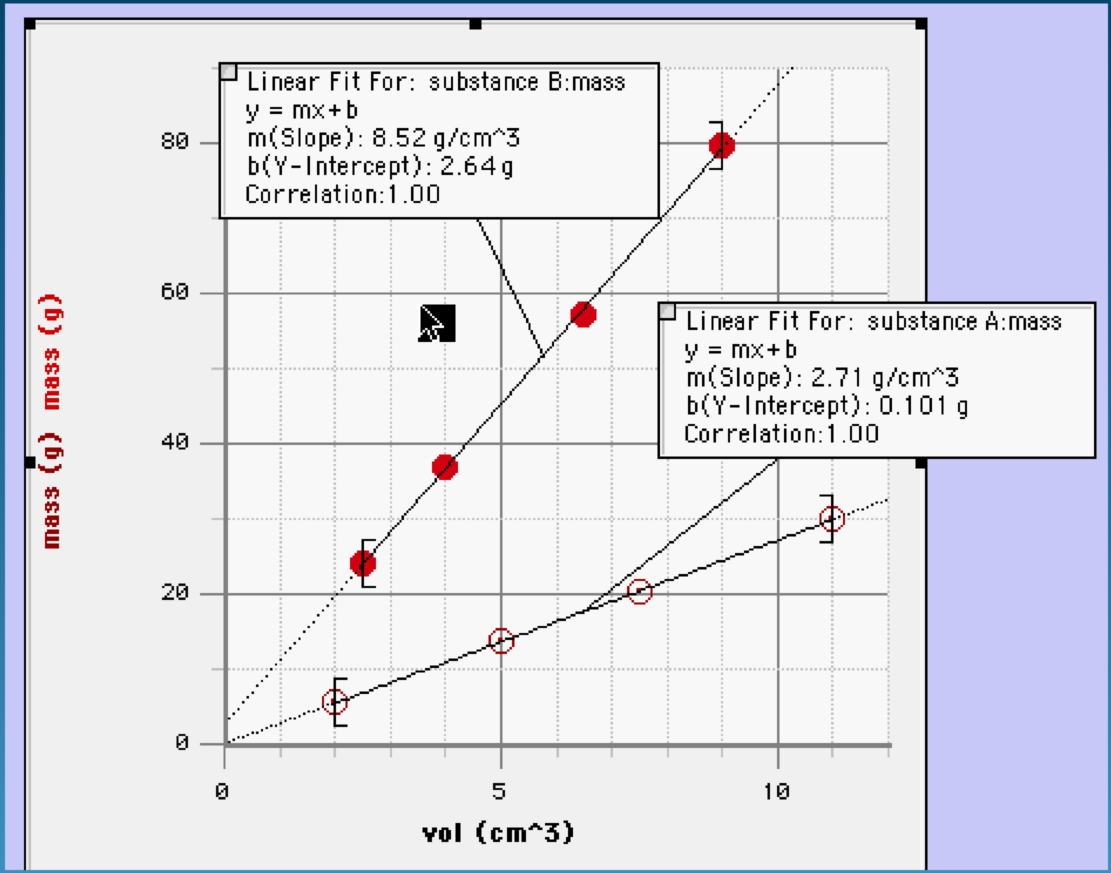
Students are required to explicitly describe the relationships between modes of representation

Multiple Models - Example

Q#1 What is the mass of a 25.0 cm^3 of Substance B that has a density =8.53 g/ cm^3)?

Solution: density = mass / volume

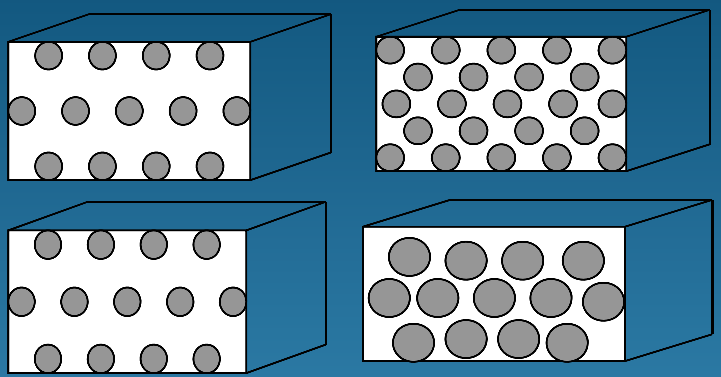
Rearrange: mass = density x volume



Q2: Which substance would occupy a larger volume:

100 g of Substance B or 100 g of Substance A ?

Explain your choice.



Q3: Explain using particle diagrams how Substances A and B differ in density.

Q4: What is the thickness of a sheet of regular aluminum foil?

How many aluminum atoms are represented by that thickness?

Instructional Practices

constructivist vs	transmissionist
cooperative inquiry vs	lecture/demonstration
student-centered vs	teacher-centered
active engagement vs	passive reception
student activity vs	teacher demo
student articulation vs	teacher presentation
lab-based vs	textbook-based.

1st - Model Development

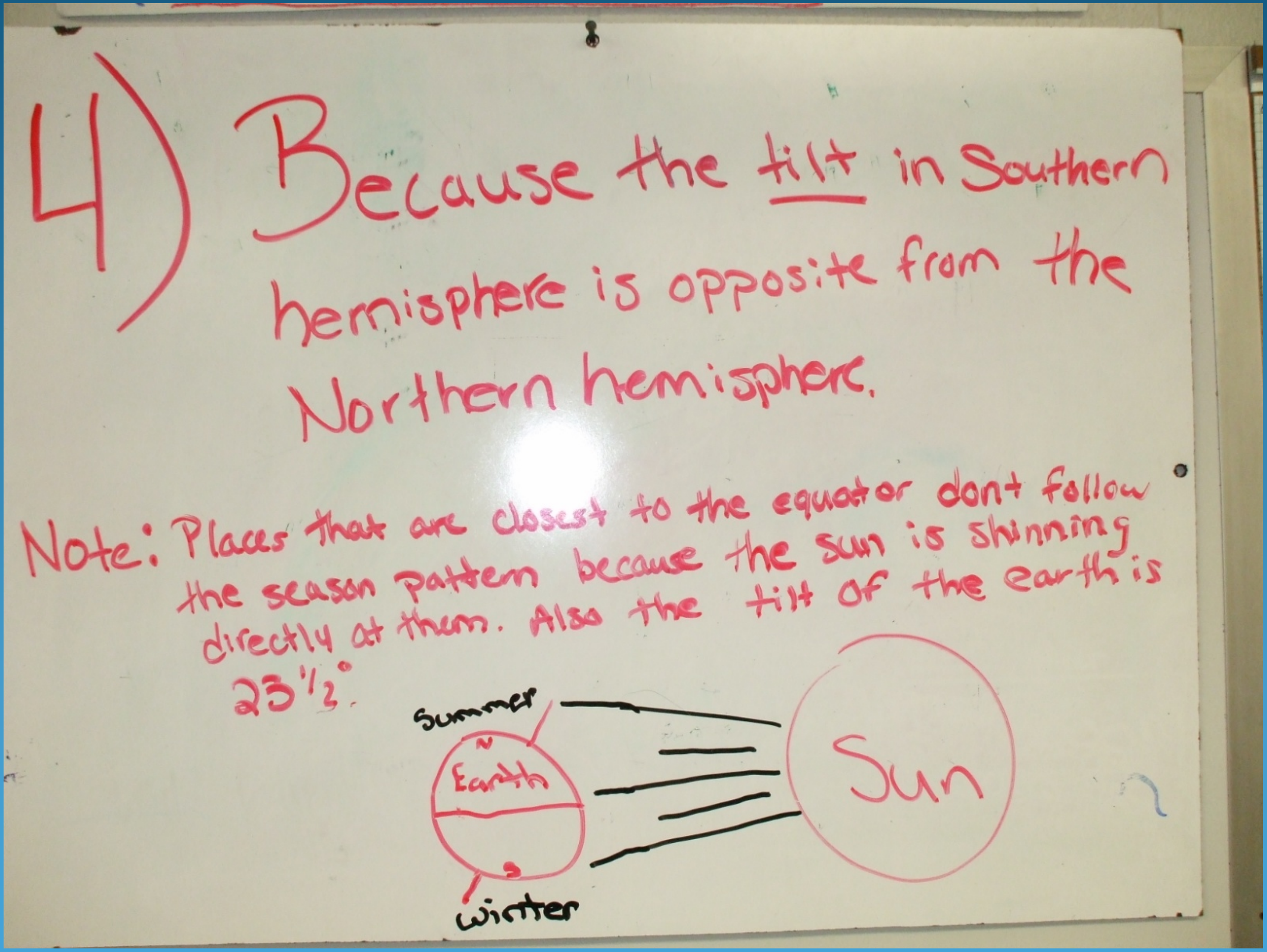
- Students in Cooperative Groups
  - Design and perform experiments
  - Use computers and probeware to collect and analyze data
  - Formulate functional relationships between variables
  - Evaluate “fit” to data.

Paradigm lab providing direct, shared experience with the phenomena to be modeled.

1^{st} - Model Development

- Post-lab Analysis
  - Whiteboard presentation of student findings
  - Multiple representations
    - Diagrammatic
    - Graphical
    - Algebraic
  - Justify conclusions.

Preparing whiteboard to formulate functional relationships.



Presenting whiteboards to articulate concepts and construct models.

2^{nd} - Model Deployment

- Post-lab Extension – teacher:
  - Helps students makes sense of model
  - Elucidates details of the model
  - Relates common features of various representations
  - Scaffolds students in constructing mental model of concept.

2nd - Model Deployment

- Deployment Activities - students:
  - Apply model to variety of related situations
  - Present solutions to class
  - Articulate their understanding
  - Question other student solutions
  - Validate their mental models.

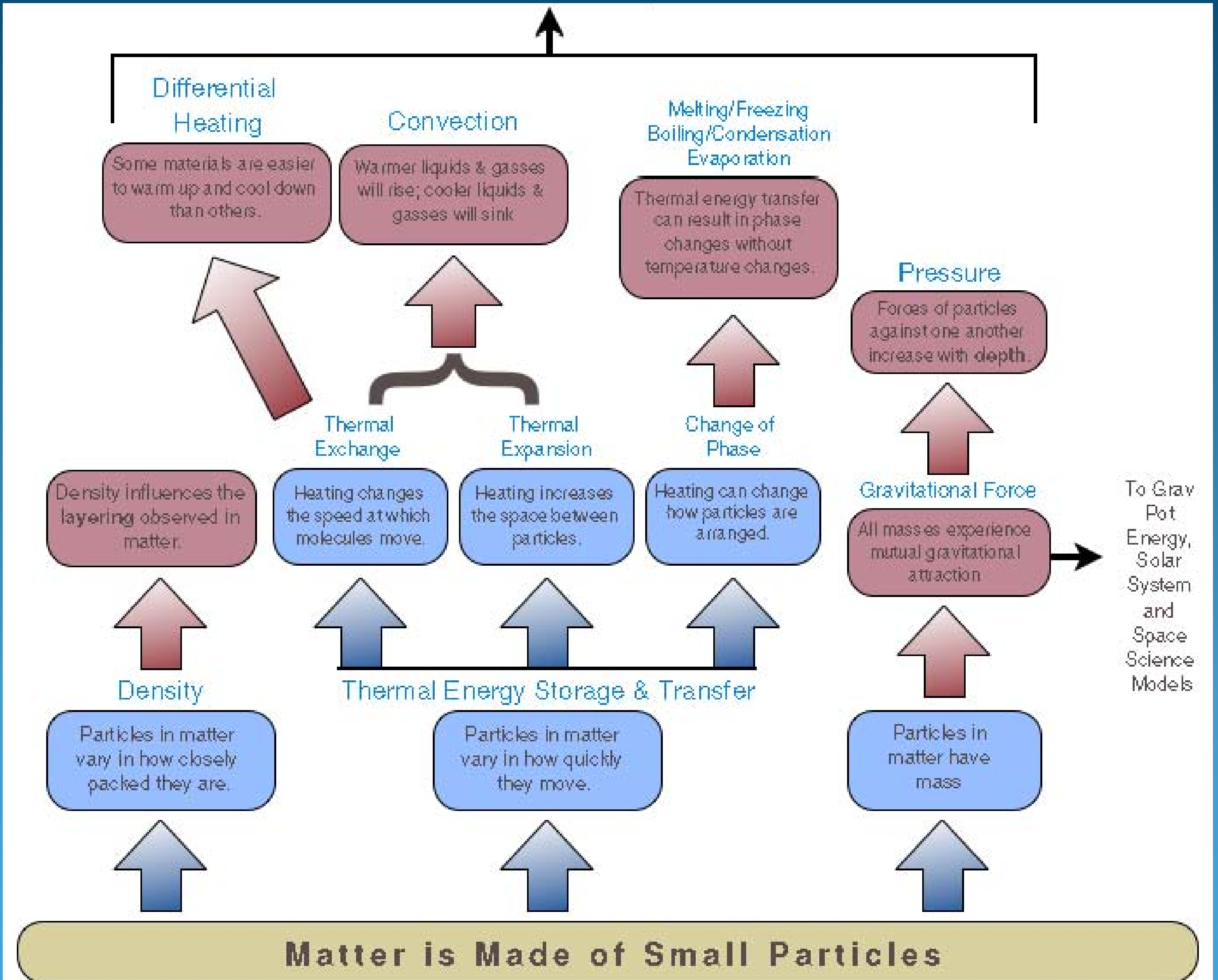
Why It Works

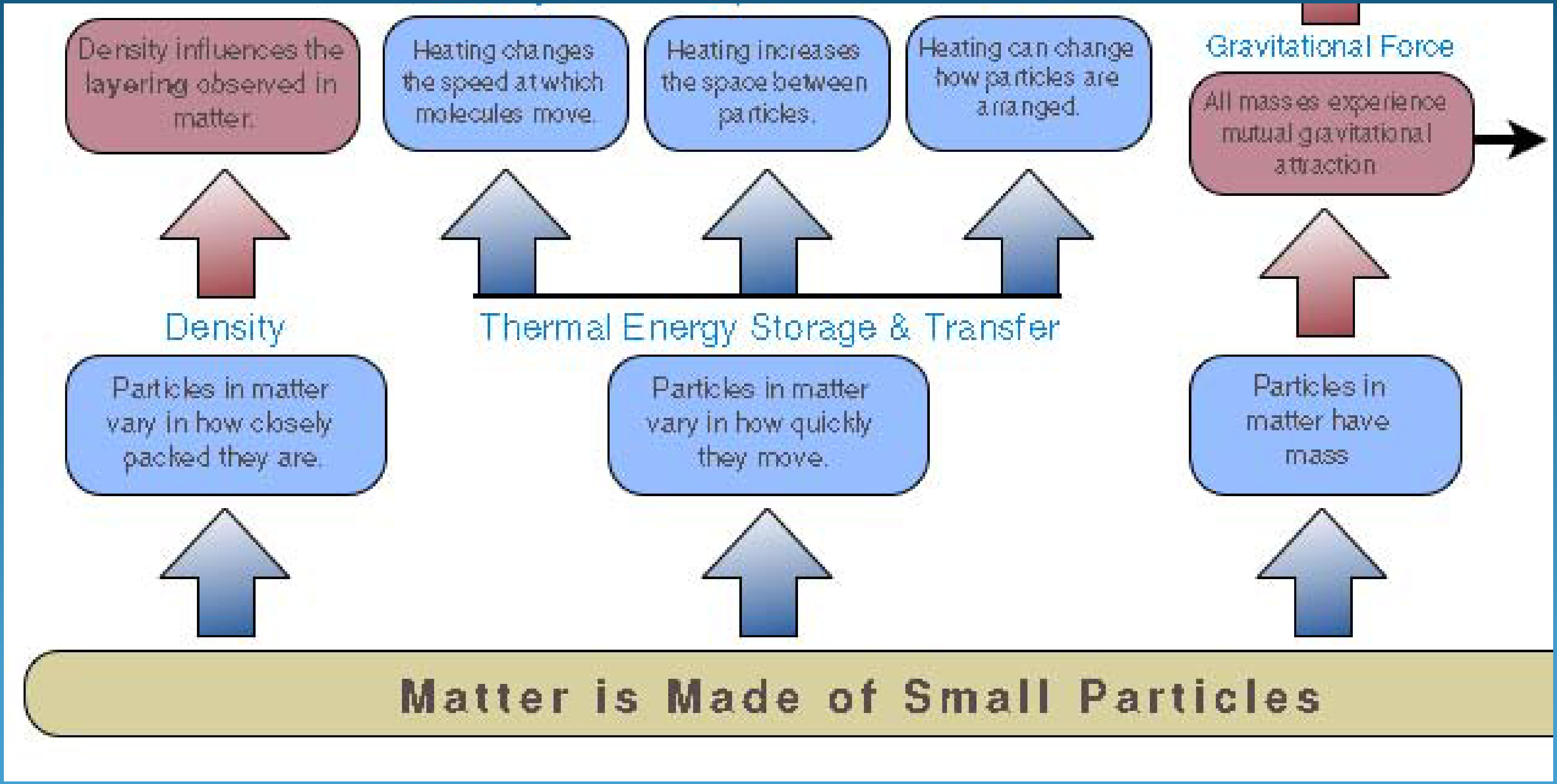
- Interactive engagement
- Student discourse & articulation
- Cognitive scaffolding
- Dynamic differentiation
- Multiple representational tools
- Consensus-building
- Explicit hierarchal organization of ideas and concepts into models.

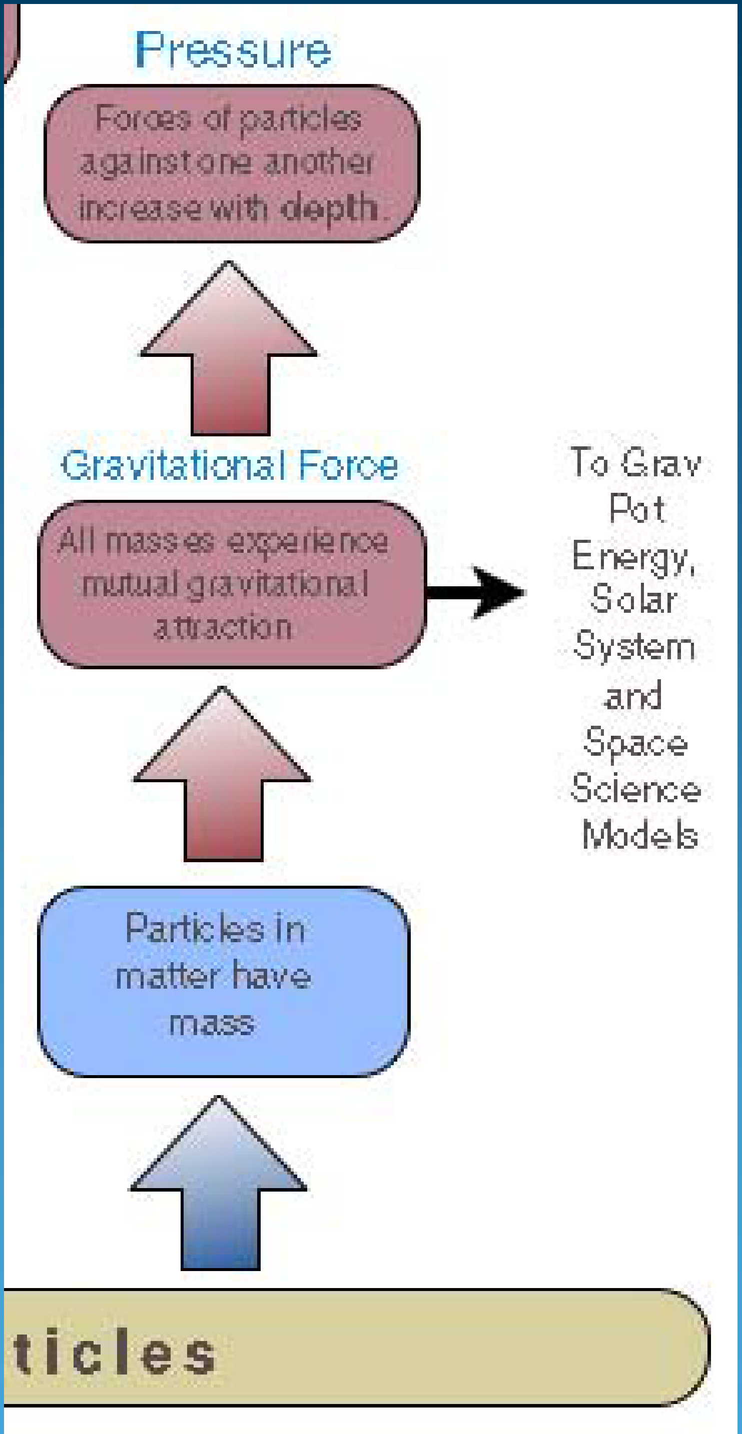
What Is Needed

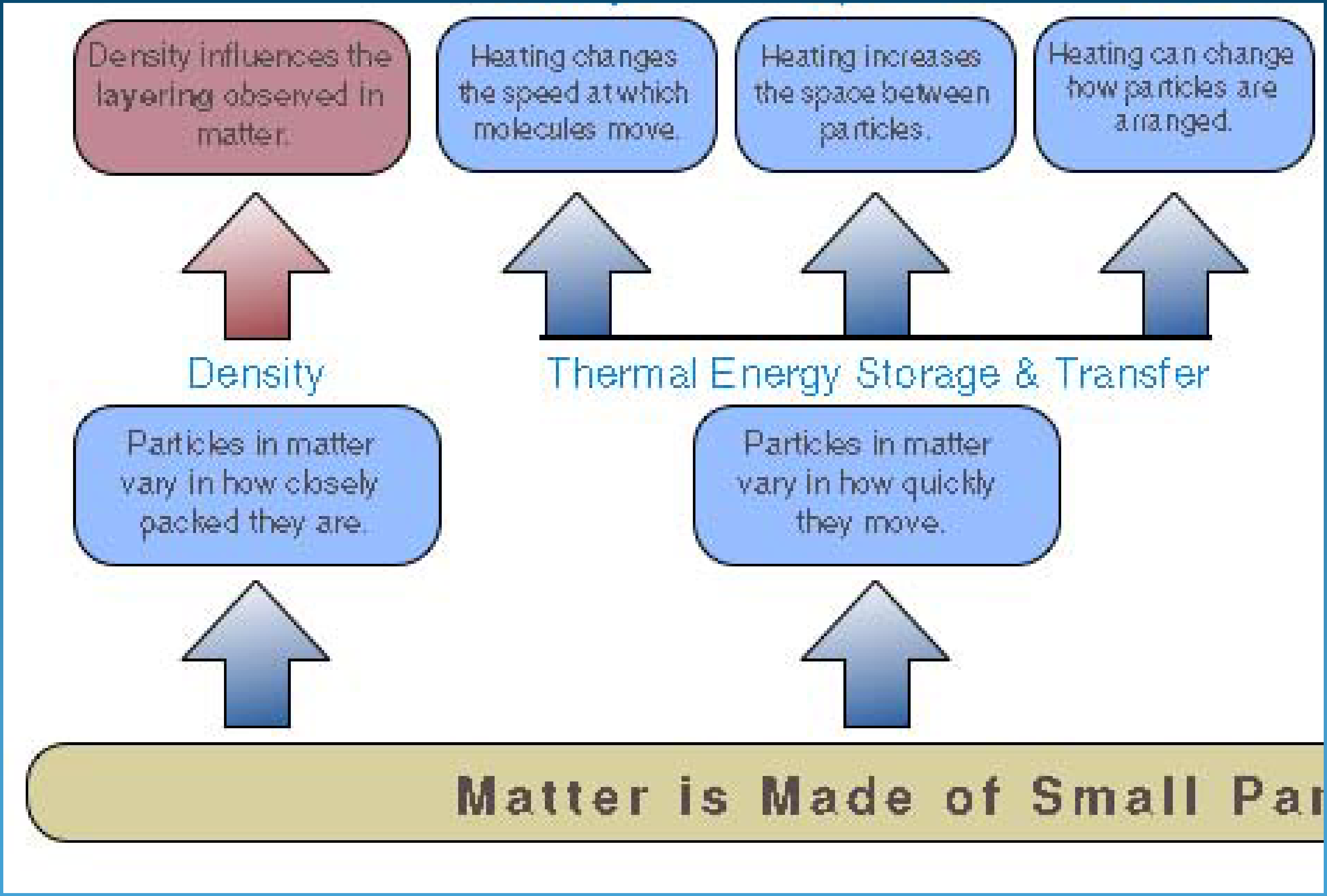
- Describe “Big Ideas” in Earth Science
- Identify foundational models
- Develop curriculum sequence
- Develop paradigm activities
- Develop deployment activities.

Foundational Models in Earth Science




Density influences the layering observed in matter.
Heating changes the speed at which molecules move.
Heating increases the space between particles.
Heating can change how particles are arranged.
Gravitational Force
All masses experience mutual gravitational attraction
Density
Thermal Energy Storage & Transfer
Particles in matter vary in how closely packed they are.
Particles in matter vary in how quickly they move.
Particles in matter have mass
Matter is Made of Small Particles


Pressure
Forces of particles against one another increase with depth.
Gravitational Force
All masses experience mutual gravitational attraction
To Grav Pot Energy, Solar System and Space Science Models
Particles in matter have mass
ticles



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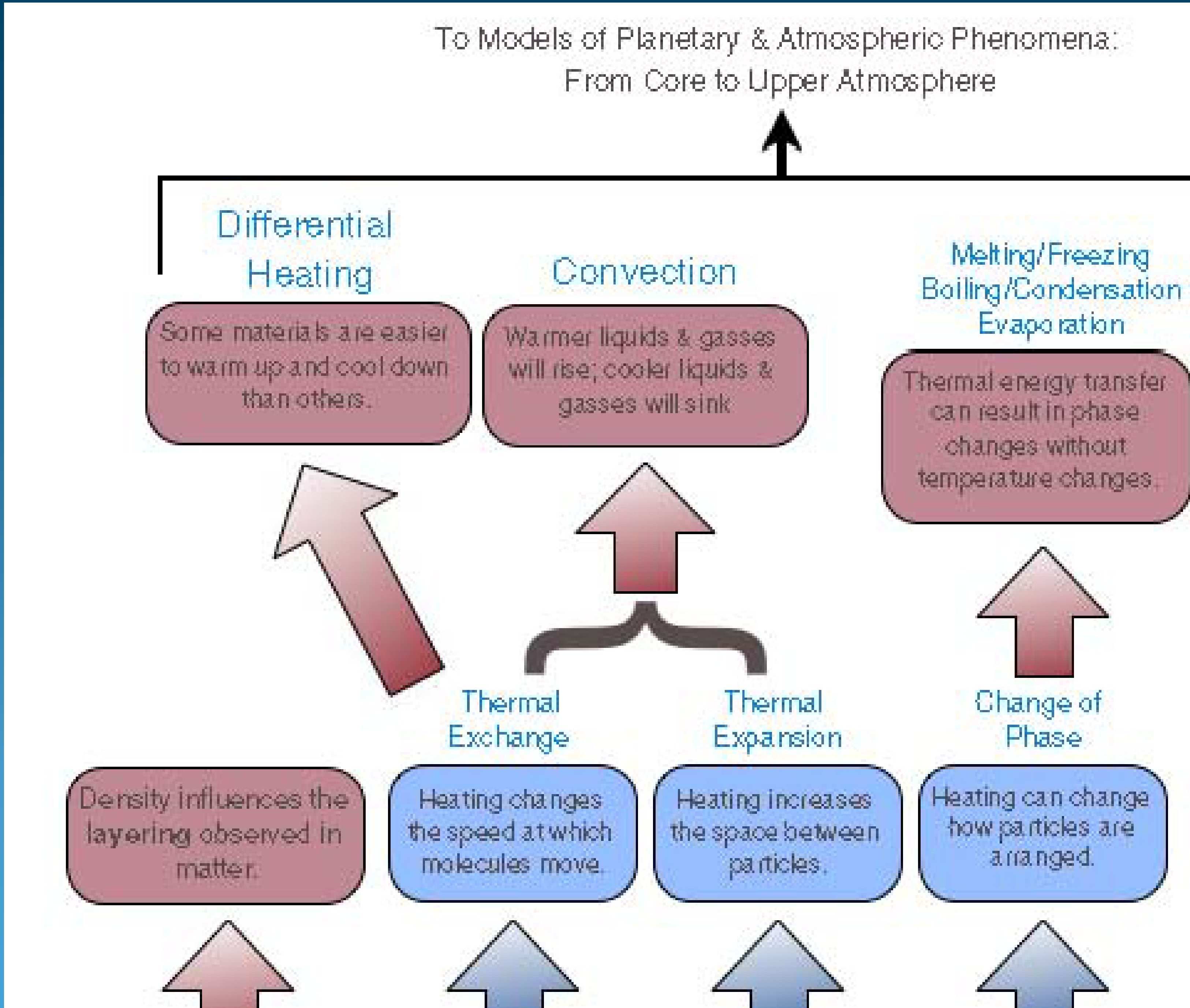
To Models of Planetary & Atmospheric Phenomena:
From Core to Upper Atmosphere
Differential Heating
Some materials are easier to warm up and cool down than others.
Convection
Warmer liquids & gasses will rise; cooler liquids & gasses will sink
Melting/Freezing
Boiling/Condensation
Evaporation
Thermal energy transfer can result in phase changes without temperature changes.
Thermal Exchange
Thermal Expansion
Change of Phase
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Modeling Objectives

- Improve quality of scientific discourse
- Deepen student understanding
- Get students to see models everywhere
- Develop fluency in conceptual and mathematical modeling
- Create autonomous scientific thinkers.

Additional Resources

Arizona State University Modeling website

http://modeling.asu.edu/

American Modeling Teachers Association

http://www.modelingteachers.org

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