

Curriculum Topic Study (CTS) Summary

Select a key lesson that allows you to see your students' thinking or stands at an important intersection for further learning. Use the Curriculum Topic Study Topic list to identify the topic most relevant to this lesson. This topic will be the basis of your CTS summary.

CTS Topic Guide: States of Matter and Heat and Temperature Page: pg. 173 and pg. 216

Curriculum: Interactions in Physical Science Grade: 10

Accessing Prior Knowledge	<ol style="list-style-type: none"> 1. What important ideas or skills make up this topic? <ul style="list-style-type: none"> • <i>Change in temperature affects substances.</i> <ul style="list-style-type: none"> ○ <i>Matter comes in three phases, Solid, Liquid, and Gas. (We'll ignore Plasma in this lesson).</i> ○ <i>Solid – melting point – Liquid – boiling point – gas</i> ○ <i>Matter expands and contracts depending on the temperature.</i> ○ <i>Boiling points and freezing points are different for different substances.</i> • <i>Skills:</i> <ul style="list-style-type: none"> ○ <i>Careful measurement, ability to read a thermometer, making observations, critical reasoning</i> 2. What is important for students to know and be able to do about this topic? <ul style="list-style-type: none"> • <i>Heat is a form of energy.</i> • <i>Thermal energy (Heat) affects matter in predictable ways.</i> • <i>During phases changes thermal energy is transferred to or from matter without a resulting temperature change.</i> 3. What learning opportunities or teaching strategies are most effective with this topic? <ul style="list-style-type: none"> • <i>Students running experiments illustrating phase changes and graphing the temperature as the substance goes through the phase changes.</i> • <i>Comparing temperature v. time graphs (while being heated) of different substances.</i> • <i>Have students explain the observable changes that are occurring at the different times on the graph at the macroscopic level, and make inferences about what is happening at the microscopic level.</i> • <i>Completing energy diagrams to describe the interactions that are occurring.</i> • <i>Classroom demonstrations are moderately successful in helping students understand these concepts .</i> 4. What difficulties or misconceptions are associated with his topic? <ul style="list-style-type: none"> • <i>Misconceptions:</i> <ul style="list-style-type: none"> • <i>Students may incorrectly think that gasses don't have mass.</i> • <i>Students may incorrectly think that a loss of mass occurs when matter changes state.</i> • <i>Students may incorrectly think that melting and dissolving are the same.</i> • <i>Students may incorrectly think that changes of state are not related to temperature.</i> • <i>Students may incorrectly think that a change of state is a result of a chemical reaction.</i> • <i>Students may incorrectly think that freezing points are lower than melting points.</i> • <i>Students don't differentiate between heat and temperature.</i> • <i>Students often don't relate heat transfer with an interaction. (Students tend to believe that objects cool down or release heat spontaneously).</i> • <i>Some students think that 'cold' is being transferred from a colder to a warmer object.</i> • <i>Some students think that 'cold' and 'heat' are being transferred simultaneously between two objects of different temperature.</i>
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Using CTS: Choose a CTS study guide that best describes the topic covered in this set of lessons. You will use this study guide to complete your CTS summary.

<p>I. Identify Adult Content Knowledge</p>	<p>IA: Science for All Americans</p> <ul style="list-style-type: none"> ▶ Readings: _ ▶ Chapter 4, Structure of Matter, pages 46-49 ▶ Chapter 4, Energy Transformations, pages 49-52 <p>IB: Science Matters- Achieving Scientific Literacy</p> <ul style="list-style-type: none"> ▶ Readings: ▶ Chapter 7, <i>The States of Matter</i>, pages 95-99 ▶ Chapter 2, <i>Heat</i>, pages 26-28, <i>Bad news: The Second Law</i>, pages 29-33
<p>Examine the resources indicated in Section I of the CTS study guide.</p>	<ol style="list-style-type: none"> 1. What big ideas and major concepts make up this topic? SFAA: <ul style="list-style-type: none"> • <i>Heat energy is the random motion of molecules.</i> • <i>Increasing temperature means increasing the average motion of atoms.</i> • <i>Heat always tends to diffuse from warmer places to colder places.</i> • <i>Whenever the amount of energy in one form or place diminishes, the amount in another place or form increases by an equivalent amount.</i> • <i>When matter gets cold enough atoms or molecules lock in place in a more or less orderly fashion as solids. At higher temperatures, the atoms and molecules are more agitated and can slide past one another while remaining loosely bound as in a liquid. At still higher temps the agitation of the atoms and molecules overcomes the attractions between them and they can move around freely as in a gas.</i> 2. What examples or contexts were used to explain the ideas? <ul style="list-style-type: none"> • <i>Everyday phenomena such as boiling water on a stove, leaving a paint brush without cleaning it and ice cubes falling on a warm floor were used to explain these ideas.</i> 3. What insights about the topic did you gain from this reading and how might these insights inform your classroom practice? <ul style="list-style-type: none"> • <i>These ideas were mostly familiar.</i> • <i>Reading through the materials reminded us that students may need multiple experiences with phase changes with substances other than water.</i>

Check with your facilitator before going on to the next section.

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<p>II. Consider Instructional Implications</p>	<p>IIA: Benchmarks for Science Literacy</p> <ul style="list-style-type: none"> ▶ Readings for selected grade levels: ▶ 4D Structure of Matter general essay, page 75; grade span essay, pages 76 – 79. ▶ 4E Energy Transformations general essay, pages 81-82; grade span essay, pages 83 - 86. <p>IIB: National Science Education Standards</p> <ul style="list-style-type: none"> ▶ Readings for selected grade levels: ▶ Grades 9-12, Standard B essay, page 177-178
<p>Examine the resources indicated in section two of the CTS study guide.</p>	<ol style="list-style-type: none"> 1. What suggestions are provided for effective instruction at your grade level? <ul style="list-style-type: none"> • <i>Introductions to energy should be done primarily through energy transformations.</i> • <i>In HS, concepts should be extended to nuclear realms and living organisms.</i> • <i>When introducing quantum theory, bring attention to the atom/energy relationship by examining the phenomena of distinctive light energies being emitted or absorbed by different atoms.</i> • <i>This atom/energy relationship enables us to identify different atoms on earth, on our sun and elsewhere in the universe. This fact is a prime example of the “rules are the same everywhere” principle.</i> 2. What insights about the topic did you gain from this reading and how might these insights inform your classroom practice. <ul style="list-style-type: none"> • <i>I would want to relate the “rules are the same everywhere” principle to other similar principle or laws such as conservation of energy, conservation of matter.</i>
<p>III. Identify Concepts and Specific Ideas</p>	<p>IIIA: Benchmarks for Science Literacy</p> <ul style="list-style-type: none"> ▶ Readings for selected grade levels: ▶ 4D Structure of Matter general essay, page 76-80 ▶ 4E Energy Transformations general essay, pages 83-86 <p>IIIB: National Science Education Standards</p> <ul style="list-style-type: none"> ▶ Readings for selected grade levels: ▶ Grades 9-12, Standard B <i>Structure and Properties of Matter</i>, page 178- 179, <i>Conservation of Energy and the Increase in Disorder</i>, page 180
<p>Examine the resources indicated in section three of the CTS study guide.</p>	<ol style="list-style-type: none"> 1. What learning goals align well with this topic? <ul style="list-style-type: none"> • <i>Heat energy is the random motion of molecules.</i> • <i>Increasing temperature means increasing the average motion of atoms.</i> • <i>Heat always tends to diffuse from warmer places to colder places.</i> • <i>Whenever the amount of energy in one form or place diminishes, the amount in another form or place increases by an equivalent amount.</i> • <i>When matter gets cold enough atoms or molecules lock in place in a more or less orderly fashion as solids. At higher temperatures, the atoms and molecules are more agitated and can slide past one another while remaining loosely bound as in a liquid. At still higher temperatures the agitation of the atoms and molecules overcomes the attractions between them and they can move around freely as in a gas.</i> 2. How do these goals help you clarify what is important to teach in this topic? <ul style="list-style-type: none"> • <i>There are a number of concepts and observable phenomena related to this topic. The Benchmarks and NSES readings help us streamline our thinking and focus on the key concepts we want students to learn.</i>

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	<p>3. How does the learning goal change from one grade span to the next?</p> <ul style="list-style-type: none"> • <i>The learning goals become more sophisticated and move from concrete observations towards a theoretical model. For instance, high-school students develop the ability to relate the macroscopic properties of substances that they study in grades K-8 to the microscopic structures of substances.</i> <p>4. What insights about the topic did you gain from this reading and how might these insights inform your classroom practice?</p> <ul style="list-style-type: none"> • <i>Since so many of these ideas involve making inferences at the microscopic level based on observations at the macroscopic level, it is important to provide students opportunities to: 1) share their emerging ideas; 2) have these ideas recorded publically; 3) engage in discourse around these ideas; and 4) have time to make sense of the phenomena.</i>
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IV. Examine Research on Student Learning	<p>IVA: Benchmarks for Science Literacy</p> <ul style="list-style-type: none"> ▶ Readings: ▶ 4B, Water Cycle, page 336 ▶ 4D, Structure of Matter, pages 336-337 ▶ 4E, Heat and Temperature, page 337; Energy Forms and Transformation, page 338 <p>IVB: Making Sense of Secondary Science- Research Into Children's Ideas</p> <ul style="list-style-type: none"> ▶ Readings: ▶ Chapter 9, Solids, Liquids, and Gases, Pages 79-84 ▶ Chapter 11, Development of Particles Ideas About Change of State, Pages 94-95 ▶ Chapter 12, Water as a Liquid, pages 98; Freezing Water and Melting Ice, page 98; Boiling Water, pages 98-99; Evaporation, pages 99-100; Condensation, page 100 ▶ Chapter 13, Existence of Air, pages 104-105 ▶ Chapter 19, Heat and Temperature, pages 138-141; Energy transfer Processes, pages 141-142
Examine the resources indicated in section four of the CTS study guide.	<p>1. What specific misconceptions or alternative ideas might a student have about this topic?</p> <ul style="list-style-type: none"> • <i>Even after years of Physics instruction, students do not distinguish well between heat and temperature when they explain thermal phenomena. Their belief that temperature is the measure of heat is particularly resistant to change.</i> • <i>Few middle and high-school students understand the molecular basis of heat transfer even after instruction.</i> • <i>When particle ideas are used with students aged 11-16, there is a tendency to attribute macroscopic properties such as melting or expanding to the microscopic particles.</i> • <i>Many students believe that different materials in the same surroundings have different temperatures if they feel different (e.g. touching wood and touching metal).</i> • <i>Students tend to use their intuitive conceptualizations of energy to interpret energy conservation ideas. For example, some students interpret the idea that "energy is not created or destroyed" to mean that energy is stored up in the system and can even be released again in its original form.</i> • <i>Students believe incorrectly that if you increase the amount of heat, you will increase the temperature.</i>

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	<p>2. Which ideas might be more resistant to change?</p> <ul style="list-style-type: none"> • <i>Few middle and high-school students understand the molecular basis of heat transfer even after instruction.</i> • <i>Their belief that temperature is the measure of heat is particularly resistant to change.</i> • <i>Many students continue to think incorrectly that if boiling water continues to be heated, the temperature of the liquid water will increase above 100 degrees Celsius (at normal pressure).</i> <p>3. Are there examples of questions or tasks that could be used to find out what students know about this topic?</p> <ul style="list-style-type: none"> • <i>What happens to the temperature of the water, if boiling water continues to be heated?</i> • <i>What would happen if you have a pot of boiling water and the setting on the stove is increased?</i> <p>4. What insights about the topic did you gain from this reading and how might these insights inform your classroom practice.</p> <ul style="list-style-type: none"> • <i>There are many misconceptions related to the study of heat and temperature and to phase changes in particular. It is critical that these misconceptions are not ignored, but are surfaced so that instructors have the opportunity to provide questions and/or experiences which will help students recognize the inconsistencies in their thinking, and resolve these inconsistencies.</i>
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V. Examine Coherency and Articulation	<p>V: Atlas of Science Literacy</p> <ul style="list-style-type: none"> ▶ Selected maps to read: States of Matter p. 58-59
Examine the resources indicated in section five of the CTS study guide.	<p>1. What connections can you identify among concepts or skills in the topic? <i>Grades 9-12: An enormous variety of biological, chemical, and physical phenomena can be explained by changes in the arrangement and motion of atoms and molecules. Students need to be aware of this content in the larger context of 'transfer of energy' in a number of systems and disciplines.</i></p> <p>2. What prerequisite ideas can you identify for learning the topic at your grade level?</p> <p>K-2</p> <ul style="list-style-type: none"> • <i>Things can be done to materials to change some of their properties. Water can be a liquid or a solid and can go back and forth from one form to another.</i> • <i>Water left in an open container disappears; water left in a closed container does not disappear.</i> <p>3-5</p> <ul style="list-style-type: none"> • <i>Heating and cooling cause changes in the properties of materials. When liquid water disappears, it turns into a gas (vapor) in the air and can reappear as a liquid when cooled, or a solid if cooled below the freezing point of water.</i> <p>6-8</p> <ul style="list-style-type: none"> • <i>Most substances can exist as a solid, liquid, or gas depending on the temperature. Energy appears in different forms. Heat energy is the disorderly motion of molecules. Atoms and molecules are perpetually in motion. Increased temperature means greater average energy of motion. In solids, the atoms or molecules are closely locked in position, and can only vibrate. In liquids, they have higher energy, are more loosely connected and can slide past each other; some molecules may get enough energy to escape into a gas. In gases, the atoms or molecules have still more energy and are free of one another except during occasional collisions.</i>

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	<p>3. What insights about the topic did you gain from this reading and how might these insights inform your classroom practice.</p> <ul style="list-style-type: none"> <i>The instructional tendency is often to focus on the content at hand and think more narrowly about whether the students get the content or not. This reading reminded me that there is also a need to help students make explicit connections among the content they are learning in a given discipline and relate it to knowledge that they have in other disciplines. So, I will want to make sure I craft the learning sequence to include explicit connections between thermal energy transfer in the physical systems we're studying and transfer of energy in earth and life systems.</i>
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VI. Clarify State Standards and District Curriculum	<p>VIA: State Standards- Link Sections I-V to learning goals and information from your state standards or frameworks that are informed by the results of the topic study.</p> <p>VIB: District Curriculum Guide- Link Sections I-V to learning goals and information from your district curriculum guide that are informed by the results of the topic study.</p>
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Examine the state standards document and your district curriculum guide.	<p>1. What learning goals and information from the state standards are informed by the results of your topic study?</p> <p><i>GLEs that are addressed:</i> <i>GLE 1.1.4 Analyze the forms of energy in a system, subsystem or parts of a system.</i> <i>* (10) Explain the forms of energy present in a system (e.g. thermal energy).</i> <i>* (10) Measure and describe the thermal energy of a system...in terms of molecular motion (temperature) and energy from a phase change (e.g. observe, measure and record temperature changes over time while heating ice to boiling water.)</i></p> <p><i>GLE 1.2.2 Analyze energy transfers and transformations within a system, including energy conservation.</i> <i>* (9) Examine and explain how energy is transferred within and among systems.</i> <i>* (10) Explain the relationship between the motion of particles in a substance and the transfer or transformation of thermal and electrical energy (e.g. conduction of thermal energy as particles collide or interact)</i> <i>* (10) Explain how or whether a phase change, a chemical reaction, or a nuclear reaction absorbs or releases energy in a system (e.g. water vapor forming rain or snow releases energy).</i></p> <p><i>There may be many forms of energy in a system. Studying changes of state is one way to explore the broader grade level expectations.</i></p> <p>2. What learning goals and information from your district curriculum are informed by your curriculum topic study?</p> <p><i>Our district standards reflect the state standards, so the answer to this question is virtually identical to the answer above.</i></p>
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