Common Student Ideas about Properties of Matter

	Common Student Idea(s)	Scientific Explanation
General Concepts about Matter	1. Matter is something we can see or hold. Air isn't matter.	Matter includes anything that takes up space and has mass. Matter most commonly exists as a solid, a liquid, or a gas. Air is matter made up of particles (molecules) in a gaseous state (e.g., oxygen or carbon dioxide). Although much less common, plasma is a high-energy form of matter found in such phenomena as lightning or the sparks between two electrical sources.
	2. Matter is everything. Energy, light, sound, electricity, and gravity are all matter.	*Matter* is anything that takes up space and has mass. Light, sound, and electricity are manifestations of energy, and gravity is a force. None of these have mass or take up space.
	3. Mass and weight are the same thing.	*Mass* is a measure of how much of something there is. As long as nothing is added or taken away, the mass of a certain material is constant under any conditions. *Weight*, however, is a measure of the pull of gravity on an object. The weight of an object varies depending on the amount of gravity in a location. Earth's standard gravitational pull is measured at sea level. As elevation increases, the pull of gravity on an object decreases. The Moon has less gravity than Earth, so you would weigh much less on the Moon even though you have the same mass. **Note:** In 2nd grade, students have difficulty understanding the differences between mass and weight, so the term *weight* has been used in the lessons even though *mass* would be more accurate.
	4. Mass and volume are the same thing.	*Mass* is a measure of how much matter, or "stuff," there is of something. *Volume* is a measure of how much space something takes up. A pound of lead takes up less space than a pound of chicken feathers and therefore has less volume even though it has a greater mass.
	5. Air doesn't have mass.	Students often think that air doesn't weigh anything or have any mass. However, air does have mass. Air is always around us, pressing on us all the time even though we don't feel it. One easy way to demonstrate that air has mass is to place two soccer balls on either side of a balance. Make sure the balance is level to

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General Concepts about Matter		show students that the balls have the same mass. Then add air to one of the soccer balls and place it back on the balance. Students will see that the soccer ball with more air also has more mass because it tilts the balance.
	6. We can see atoms and molecules with a strong microscope.	Atoms and molecules are too small to be seen with a microscope, but models can help us understand and explain the phenomena we see in the world.
	7. The amount of matter changes when you change the shape of an object (e.g., rolling a clump of playdough into a long noodle). It also changes if you pour a liquid into a different-shaped container or break an object into smaller pieces.	Matter is neither created nor destroyed. When you change the shape of an object, the amount of matter stays the same as long as nothing is added or subtracted.
	8. Solids are always more dense than liquids, so an ice cube is more dense and heavier *[has more mass]* than a melted ice cube. 9. Solids are less dense than liquids, so an ice cube (that floats!) is less dense and has less mass than a melted ice cube. 10. Liquids have mass, but if the same material is a gas, it has little or no mass.	When matter experiences a change of state, the average motion and arrangement of the atoms or molecules change, not the number of atoms or molecules or their mass. The law of conservation of mass says that if atoms or molecules aren't added or removed, they'll always have the same mass, even if they experience a change of state or phase. For example, if you freeze 10 grams of water in a jar, you'll still have 10 grams of water. If you heat the water, and it evaporates into invisible water vapor, the molecules and atoms will still have a mass of 10 grams.
	11. When two substances like baking soda and vinegar combine and make gas, the gas will weigh less than the baking soda and vinegar before they were mixed together. 12. A bicycle will weigh less when it rusts than it did before rusting. 13. Food weighs more before you eat it and less after it's in your body. 14. If you burn wood, the mass is less afterward than it was before.	The law of conservation of mass states that matter can change from one form to another, substances can be mixed together or separated, and pure substances can decompose, but the total amount of mass remains constant.

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General Concepts about Matter	*[In common chemical reactions, students don't expect the mass of the products to be the same mass as the mass of the reactants. They mistakenly assume that mass is lost in the reaction, but they don't think about where it went.]*	
	15. Solid materials are hard. Materials like dough, a sponge, and sand are in between because they aren't solid or liquid.	There is no intermediate state between a solid and a liquid. The particles (molecules) in a solid are in a rigid, lattice-like arrangement and vibrate in place. Liquids are fluid (meaning they can take any shape), and the molecules move around more freely and slide past each other. Materials like dough, a sponge, and sand are all solid materials based on the arrangement and movement of their molecules.
	16. Steam, clouds, and fog are water in the gas state. They're water vapor we can see. 17. Steam, clouds, fog aren't liquid or gas. They're something in between that happens when water is evaporating or condensing.	Water vapor, or water in the gaseous state, is invisible. As water-vapor particles (molecules) cool, they condense into small droplets of liquid water that appear as steam, clouds, and fog.
	18. Particles that make up liquids and gases move around, but particles in solids don't move at all.	All particles that make up matter are in constant motion, regardless of whether they're in a solid, liquid or gaseous state. In a solid, the particles (molecules) are arranged in a fixed or rigid structure and vibrate in place. In a liquid, the particles have more energy and are able to move around more freely and slide past one another, but they're still attracted to one another. In a gas, the particles exist as individual molecules and are able to move in all directions with little attraction between them.
	19. When water evaporates, the hydrogen and oxygen atoms separate. 20. When water condenses, oxygen and hydrogen molecules in the air combine to form water molecules. *[Both ideas suggest that a chemical change is taking place rather than a physical change.]*	Evaporation, condensation, melting, and freezing are all *physical changes* to matter. When energy is added, the movement and arrangement of the particles (molecules) change, not the nature or substance of the particles themselves. Water (H_2O) in a solid, liquid, or gaseous state is always a combination of hydrogen and oxygen in a 2:1 ratio.

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	21. Melting and dissolving are the same thing.	In everyday language, the word *melting* is often used to describe such things as chocolate melting on a hot day or a hard candy dissolving in a person's mouth. But in science, melting involves changes in the motion and arrangement of molecules that always occur at a particular melting point for a substance. Dissolving involves two materials dispersing in water, such as molecules of salt (or hard candy). Neither process involves a chemical change.
	22. The particles in a liquid are much farther apart than the particles in a solid.	The spacing of particles in both a solid and a liquid isn't very different. In most substances, particles in a liquid state are slightly farther apart than they are in a solid state. Water is one of few substances in which the particles in a solid state are actually farther apart than they are in a liquid state. You can see evidence of this unusual characteristic as water freezes and expands in a bottle, and the bottle bulges or becomes deformed.