TEACHER BACKGROUND INFORMATION

(*States of Matter*)

Matter exists in different physical forms known as **states**. The three common states of matter are **solids**, **liquids**, and **gases**. There is a fourth state known as **plasma** (ionized gas) found mostly inside stars. The properties of each state are best understood at the molecular level.

A. ATOMS:

Matter is made up of tiny particles known as **atoms** (building blocks of matter). Different or identical atoms can attract each other and combine to form **molecules**. For example water is made up of one atom of Oxygen and two atoms of Hydrogen, forming the molecule H_2O.

The particles that make up matter attract each other and in general the greater the attraction, the closer the molecules get. Furthermore, the particles of a substance are constantly in motion, bumping into each other and the speed at which the particles are moving is related to the temperature of the substance. The speed of particles and the attraction between them determines the state of the substance. That is, whether it is solid, liquid or gas.

B. SOLIDS, LIQUIDS, AND GASES:

Solids:

In a **solid** the molecules are packed tightly together (high **density**), usually in a definite arrangement (suggesting **order**). High density basically translates into the fact that a solid cannot be compressed into a smaller

volume. The molecules in a solid are strongly attracted to each other. This tight packing (See Fig. 1) gives little room for the molecules to move; actually they can only wiggle or vibrate slightly in their otherwise fixed positions, unless there is an opening/hole within the solid in which atoms can move into. Because the molecules only have room to vibrate, solids have a fixed or definite rigid shape (See Table 1).

Liquids:

In a **liquid** the molecules are packed less tightly together (See Fig. 1). They are slightly less dense than solids and also have less order. Liquids may be less dense than solids but they are still too dense to compress into a smaller volume. The type of packing found in liquids gives the molecules a little more room to move, mostly to vibrate and to slide over each other allowing liquids to pour easily. Because the molecules in liquids slide past each other, they do not have a fixed or definite shape. Instead, they take the shape of their container (See Table 1).

Gases:

In a **gas** the molecules are far apart (low **density**) and moving rapidly, colliding repeatedly with each other and with the walls of the container (**suggesting disorder**). The molecules of gases fill their container completely, meaning they have an indefinite shape and volume (See Fig. 1). Unlike solids and liquids, gases can be compressed into a smaller volume (See Table 1).

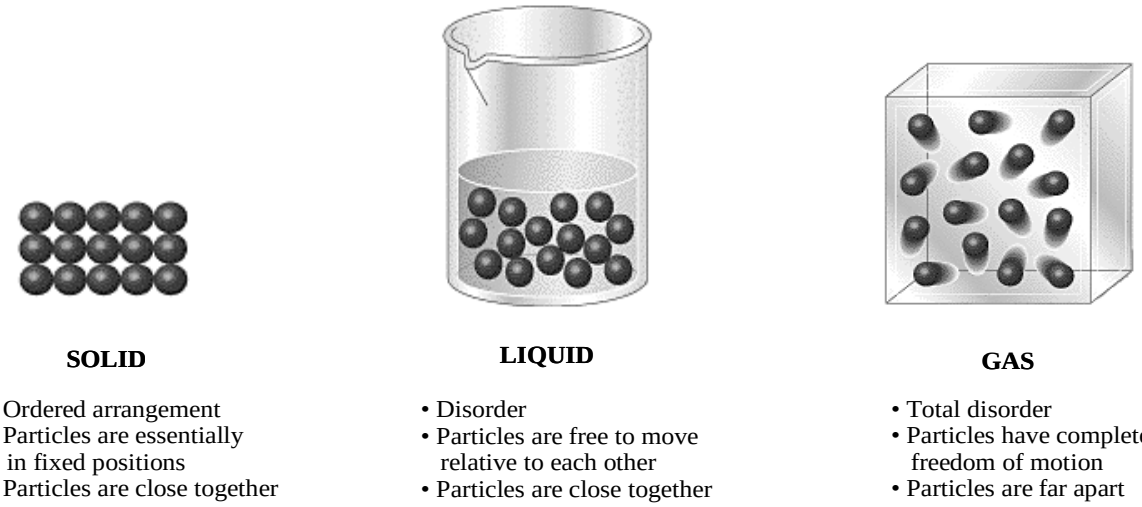

Figure 1- Molecular spacing of a solid, liquid and gas.

Analogy:

Students in a classroom can be used as an analogy to the particles of a solid, since they have a regular arrangement and a limited freedom of movement. Students moving around in their seats represent the vibrational motion of solid particles. During recess, students have a wider range of motion which is analogous to particles in a liquid. The students are able move among one another to the doorway and through the halls, but they are still confined to the volume of the school. At the end of the day, students running out of the school building are like gas particles. They have unrestricted motion which causes them to escape from the building and diffuse throughout the community.

Table 1 – Properties of the common states of matter

State	Example	Properties
Solid	Brick	• Definite volume and shape (order) • Cannot be compressed (constant volume) • Molecules tightly packed • Molecules can only vibrate
Liquid	Water	• Definite volume but no specific shape (less order) • Assumes the shape of the portion of the container it occupies • Cannot be compressed (constant volume) • Molecules less tightly packed • Molecules can vibrate and slide over each other
Gas (vapor)	Oxygen (breath)	• No fixed volume or shape (disorder) • It conforms to the volume and shape of its container • Can be compressed to occupy smaller volume or expand to occupy larger one • Molecules are far apart • Molecules can vibrate and move in all directions
Plasma	Interior of the sun	• Exists only at extremely high temperatures

A. UNIQUE FEATURES OF LIQUIDS:

Cohesion:

Cohesion occurs when molecules of the same substance stick together. If you use a dropper to drop water onto any surface, the droplets will attract to one another, like certain metals to a magnet, due to the molecules' similarity. The water droplets will form into the shape of a dome.

A consequence of cohesion is **surface tension**. For example, water molecules at the surface of water are attracted mostly by water molecules beneath it (cohesion), while water molecules below the surface are attracted equally in all directions by water molecules around them (cohesion). This difference between molecules at the surface and below the surface causes

water to “contract” and act like it is covered with a film or skin (See Fig. 2). This is what allows a drop of water to hold its shape. The surface tension of water is strong enough to hold up some objects denser than water and it also gives insects the ability to walk on water.

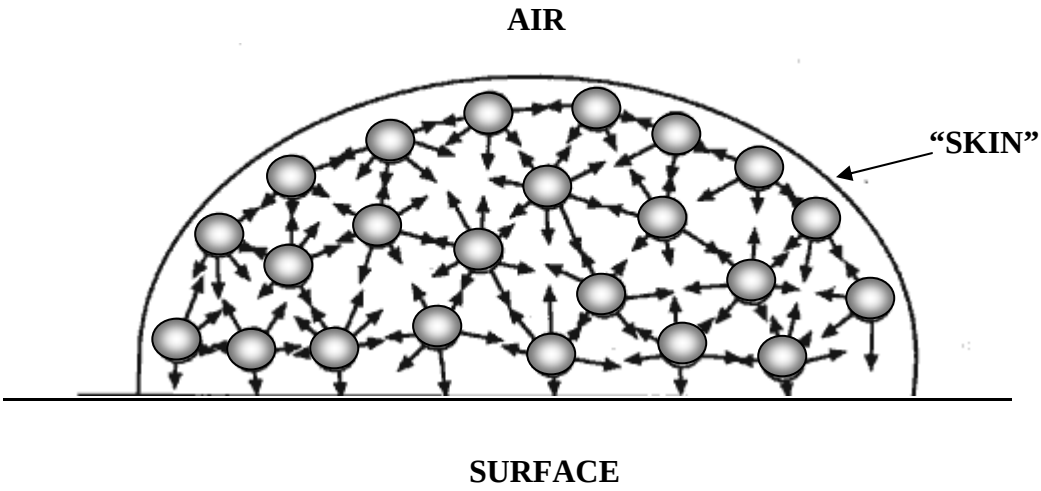

Figure 2 – Drop of water showing molecules at the surface attracted towards molecules on the inside, while molecules inside are attracted in all directions.

Adhesion:

Molecules in the liquid state also stick to other substances. **Adhesion** is a force that holds the surfaces of different substances together. For example water and paper towels stick together because the adhesive force that exists between water molecules and paper fibers is greater than the cohesive force between water molecules. But when water is put on wax paper the cohesive force between water molecules is stronger than the adhesive forces between the two substances. This results in water beading on the wax paper and not soaking in.

Capillary action is the drawing of a liquid along an adherent (sticky) solid surface, despite the forces of gravity. Capillary action is the result of adhesion and surface tension. It is possible to observe capillary action by placing a straw into a glass of water. The water "climbs" up the straw because the water molecules are attracted to the straw molecules (adhesion). Furthermore, the adhesion of water to the walls of the straw will cause an upward force on the liquid at the edges resulting in a **meniscus** (curved surface of a liquid) (See Fig. 3). As the water moves up, the surface tension (cohesion) acts to hold the surface intact, so instead of just the edges moving upward, the whole liquid surface is dragged upward. Capillary action is limited by gravity and the size of the straw. The thinner the straw or tube the higher up capillary action will pull the water. This is how narrow tubes in plants carry water from the roots to the leaves.

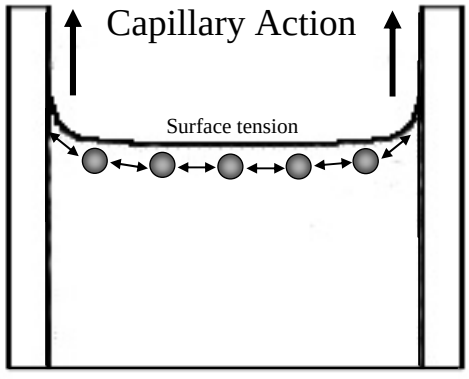

Figure 3 – Capillary action up a tube.