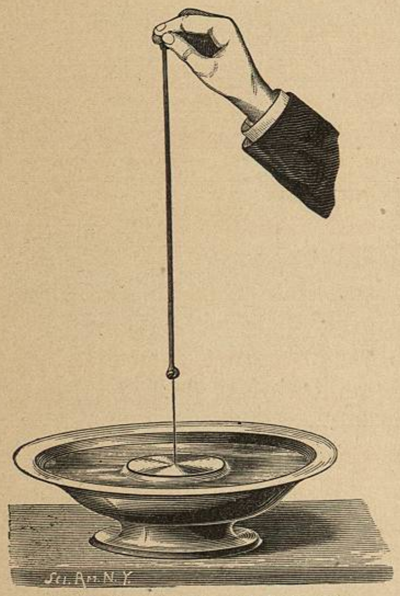
CHAPTER V.

MOLECULAR ACTIONS.

Cohesion and adhesion are forces which hold together molecules or ultimate particles. Cohesion unites molecules of the same nature. It is exerted strongly in solids, to a less degree in liquids, and very little in gases.

Heat causes the mutual repulsion of molecules, and thus diminishes the force of cohesion. Solids, when strongly heated, expand, liquefy, and finally pass into a gaseous state, if not chemically changed at the temperature reached, *e. g.*, wood, leather, etc. The tenacity, hardness, and ductility of bodies is due to cohesion.

FIG. 42.



A Demonstration of Cohesion.

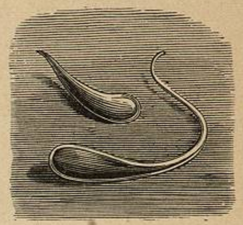
The force of cohesion in liquids may be demonstrated by suspending a disk by a delicate filament of elastic rubber, noting the extension of the rubber, then placing the disk in contact with a body of water, as shown in Fig. 42, finally drawing upon the rubber until the disk separates from the water. It is found that a considerable extension of the rubber is required to detach the disk. By a more delicate experiment, in which the disk is suspended from a scale beam, the force of cohesion may be accurately measured. It is found by this experiment that

the material of the disk has no influence on the result, but that the weight required to detach the disk varies with the nature of the liquid. The fact that the disk retains a film of water after separation from the body of water shows that the force of cohesion of the water is less than the force of its adhesion to the disk.

In solids cohesion is often manifested in different degrees in different parts of the same body. The body is then under strain. Examples of bodies in this condition are to be found among iron castings and in unannealed glass ware.

Prince Rupert's drops, or Dutch tears, show in a striking manner how a body under sufficient internal strain may contain within itself the elements of destruction. These drops have a long, oval form, tapering at one end to a point, which is more or less curved. They are made by dropping melted glass into water, thus suddenly cooling the glass and putting it under great strain.

FIG. 43.



Prince Rupert's Drops.

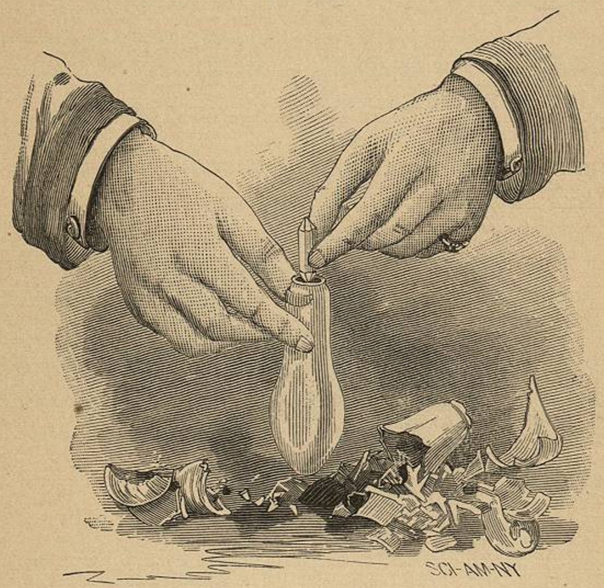
The larger part of the drop may be struck with a hammer without breaking; but on breaking off the point, thus relieving the strain at one place, the glass instantly flies into pieces. So complete is the destruction, that the fragments are often like fine sand.

The Bologna flask is of the same nature as the Prince Rupert's drops. It is an unannealed glass flask, having a very thick bottom, which is under great strain. The flask will receive a hard blow without breaking, and a lead bullet may be dropped into it without producing any effect, but on dropping into it a quartz crystal, or in some other way slightly scratching the inner surface of the flask at the bottom, the flask at once goes to pieces. The action may be compared to the destruction of a superstructure of masonry by weakening or destroying the keystone of the arch which supports it.

A common example of action of this kind is met with in lamp chimneys, which break without any apparent cause. Engineers often find glass water-gauge tubes which will readily stand steam pressure, but which, when scratched even imperceptibly on the inner surfaces, will break.

Adhesion is the term applied to the attraction between the surfaces of two bodies. In the experiment illustrated by Fig. 42 the water adheres to the disk, and the force of adhesion in this case is superior to the force of cohesion as manifested by the molecules of the water. If the moistening of the disk by the water is prevented by lycopodium distributed on the surface of the water, there can be no adhesion.

FIG. 44.



Bologna Flask.

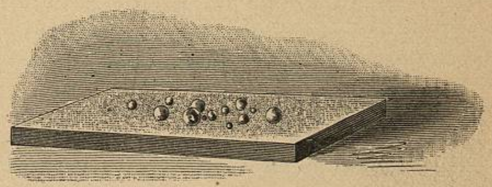
Two pieces of plate glass pressed firmly together adhere strongly. This experiment succeeds in a vacuum, showing that atmospheric pressure plays no part in holding the glasses in contact.

In the arts, examples of adhesion are found in glues, cements, and solders.

SURFACE TENSION.

The surface tension of liquids is manifested in various ways, notably in the formation of drops, as in rain, each drop becoming a perfect sphere Water sprinkled upon a surface it does not wet, for example, a dusty surface, or upon a surface covered with lycopodium, assumes spheroidal forms, as shown in Fig. 45.

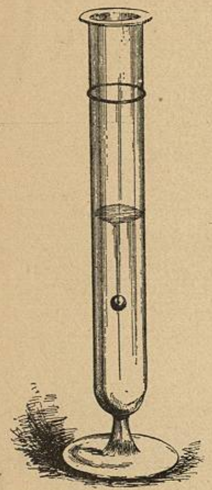
FIG. 45.



Surface Tension exhibited in Water Drops.

A pretty illustration of cohesion and surface tension is shown in Fig. 46. A few drops of olive oil are placed in a suitable vessel, and into the vessel is carefully poured a mixture of alcohol and water having the same specific gravity as the oil. The oil will be detached from the bottom of the vessel, and will, in consequence of the cohesion of its particles, assume a spherical form. Another method of performing this experiment is to introduce the oil into the center of the body of dilute alcohol by means of a pipette. By careful manipulation a large globule of oil may be introduced in this way.

FIG. 46.



Oil Globule suspended in Equilibrium.

Liquids in large masses assume the form of the vessel in which they are contained, in consequence of the superior force of gravity.

From what has been said, as well as from what follows, it will be seen that liquids act as though they were inclosed in a tense superficial film. A glass tube pressed endwise into a body of mercury (Fig. 47) produces a deep depression before breaking the surface of the liquid. When a glass tube is presented in a similar way to the surface of water (Fig. 48), the effect is reversed, the water attaching itself to the surface of the glass with such force as to spread and lift the water in the immediate vicinity of the wall of the tube. In tubes of large diameter, the height to which water is lifted is slight, but in capillary tubes the height is considerable.

Fig. 49 shows the effect of the size of the tube on the height to which the liquid is raised by capillarity. The smaller the area of the upper end of the liquid column, the greater the concavity, and, as a consequence, the greater the strength of the surface film in comparison with the weight of the column raised.

When two glass plates are arranged at a slight angle with reference to each other, with their edges in contact, as

Fig. 47.

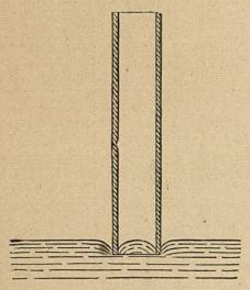
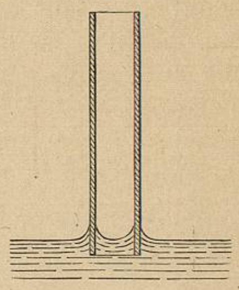


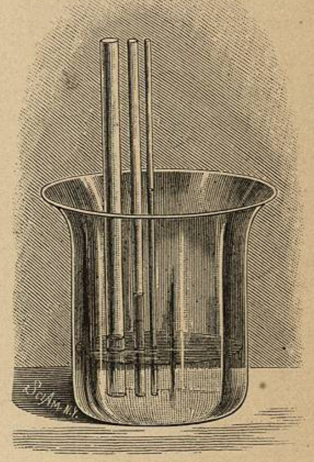
Fig. 48.



shown in Fig. 50, the liquid exhibits the phenomenon shown by the tubes of different diameter, but to a less degree, owing to the contact of the edge of the surface film of the liquid with proportionately a smaller surface. When two glass plates are presented in a similar manner to the surface of a liquid which does not wet them, such as mercury or water covered with lycopodium, the effect is the opposite of that just described (Fig. 51). Capillary elevation and depression are more clearly shown by the experiment illustrated in Fig. 52. Two ½ inch glass tubes terminating in capillary tubes are bent into U shape and mounted upon a support. Into the larger end of one of the tubes is poured mercury, which flows into the smaller branch, but does not reach the level of the mercury in the larger branch.

The upper surface of the mercury in each branch of the tube is convex. When water is poured into the larger branch of the other tube, it rises in the capillary tube above its source, and its upper surface in each branch is concave.

Fig. 49.



A curious example of the effect of surface tension is shown in Fig. 53. The smaller end of a tapering tube is plunged several times into a vessel of water and withdrawn. Whenever it is drawn out of the water, the contraction of the water drop adhering to the lower end of the tapering tube forces the column higher within the tube, until at length a point is reached when equilibrium is established, the contractile force of the drop being balanced by the weight of the column of water contained by the tube and by the upward pull of the film at the upper surface of the water.

Fig. 50.

In Figs. 54 and 55 are illustrated experiments showing the force of capillary attraction and adhesion. In Fig. 54 is shown a ¾ inch tube open at one end and terminating in a capillary tubulure at the other end. By allowing the tube to sink for two or three inches in water, with the larger end downward, then placing a minute drop of water in the capillary end of the tube, the tube may be raised two or three inches, carrying with it the column of water contained by it. If the capillary end of the tube be closed by a small drop of water, and the larger end be plunged into water, as in Fig. 55, air will be retained in