These old chemists had some strange names in their dictionaries, viz., the "Blacker than Black," and others like it, and we, in these days, are apt to laugh at their doings, but we must remember that they lived in days of darkness and superstition, and there is little doubt that these names were used to hide the real nature of the substance, with which the alchemists themselves by a species of free masonry were perfectly familiar. And just how much they did or did not know we, to-day, are hardly in a fair position to judge.

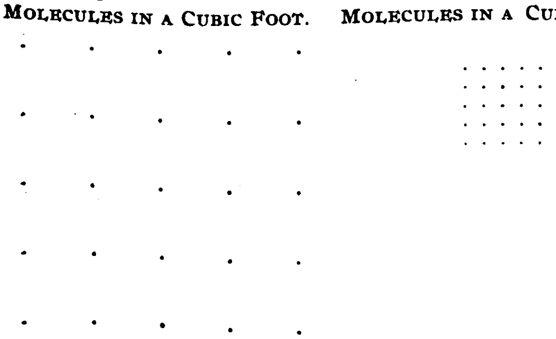
We now come to chemistry as it exists in our age, and in the short time at my disposal during this course of lectures, I have thought it best to dwell more practically on the general principles which govern the science than to go minutely into what I might call the individual chemistry of the element.

Our starting point in the exposition of moden chemistry must be the great generalization which is known as the law of Avogadro. It was stated by Avogadro in Italian in 1811, and holds the same place in chemistry that the law of gravitation holds in astronomy.

The law of Avogadro is, that equal volumes of all substances when in the gaseous state and under the same conditions contain the same number of molecules. Now to understand this law we must first know what is meant by the term molecule. It is of Latin origin, and simply means a "little mass" of matter. A short definition of a molecule is, that it is the smallest particle of a substance which still contains all the properties of a mass of the same substance.

Water can be easily changed into solid ice or æriform steam, and with this substance let me illustrate what I mean by a molecule. We believe that in a cubic inch of water (or any other quantity) small particles which we call molecules are not subdivided by heat, thus, if we raise the temperature of the water till the resulting steam fills a cubic foot we will not have a greater number of molecules in the cubic foot than we had in the inch; they will simply be further separated from each other. This diagram will serve to make my meaning plainer:

MOLECULES IN A CUBIC FOOT. MOLECULES IN A CUBIC INCH.



An experiment will make clear that there are spaces between these molecules. Into this globe, which we have made a vacuum, we will form a cubic inch of water and by heat we will convert this into steam. If the globe was entirely full of steam we would expect that vapor to fill it to the exclusion of everything else. Now, what is the case? If we add more water it will not evaporate, but if we add alcohol we will find that it at once evaporates as if there were no steam present, and if we add yet again a quantity of ether we will find that it will evaporate as if neither the steam nor the alcohol were present. Thus the globe contains all three at the same time; evidently then no vapor completely fills the space which it occupies although equally distributed through it; and we can give no satisfactory explanation of this phenomenon of evaporation except on the assumption that each substance is an aggregate of particles which become separated by heat.

Liquids and solids have each their own rates of expansion. If we take liquid ether, alcohol, and water we will find on heating them that the ether expands more than the alcohol and the alcohol far more than the water, but if we raise the temperature of these three liquids till they are all in the condition of gas, and continue to raise the temperature we will find that they now expand in *exactly* equal proportions. Why, now, this difference between the two states of matter? If the material fills space as completely in the æriform as it does in the liquid condition then we cannot conceive why the nature of the substance should not have the same influence on the phenomenon of expansion in both cases. If, however, matter in an aggregate of definite small masses or molecules which while comparatively close together in the liquid state become widely separated when the liquids are converted into vapors, then it is obvious that the action of the particles on each other, which might be considerable in the first state, would become less and less as the molecules were separated until at last it was inappreciable, and further, if, as Avogadro's law assumes the number of these particles in a given space is the same for all gases under the same conditions, then it is equally obvious that there being no action between the particles all vapors may be regarded as aggregates of the same number of isolated particles similarly placed, and we should expect that the action of heat on such similar masses would be the same.

Thus these phenomena of heat almost force upon us the conviction that the various forms of matter we see around us do not completely fill the spaces they appear to occupy, but consist of isolated particles separated by comparatively wide intervals.

I have shown, I am afraid, but imperfectly, the molecular structure of gases. I will now draw your attention for a few moments to the molecular structure of solids.

The structure of solids is most frequently manifested by their crystalline form, and this is one of the most marked features of the solid state, but although, under definite conditions, most substances assume a fixed geometrical form, yet to ordinary experience these are the exceptions and not the rule.

I will therefore make the crystallization of solid bodies the subject of a few experimental illustrations.

You will see sal-ammoniac crystallizing, and notice that as the crystalline shoots ramify over the plates, the sprays are always kept at right angles to the stem or else branch out at an angle of 45 degrees, which is the half of a right angle.

Here we have urea crystallizing. The general order of the phenomena in this experiment is the same as in the last: but notice how different the details.

We do not see here that tendency to ramify at a definite angle, but the crystals shoot out in straight lines and cover the plate with a bundle of crystalline fibres which meet or intersect each other irregularly as the accidental directions of the several shoots may determine.

You cannot see here crystals of large size, as they can only be grown slowly and with circumstances which favor their development.

In ice melting we notice how heat dissects it, showing crystals which Tindall called ice flowers. They are hexagonal or six sided and make with each other an angle of 60 degrees, and in snow crystals we notice that they have the same structure as the ice crystals.

You will now see the effect of a magnet on some iron filings that have been polarized by induction, and you will see how they have arranged themselves in a most wonderful way, radiating in lines from the poles.

Next we see the effect of polarized light on a plate