Molecules and the Molecular Theory of Matter. By A. D. Risteen. Boston: Ginn & Co. 1895. Pp. 223.

MR. RISTEEN'S object is to give, in elementary form, a complete and connected account of what is known of the constitution of matter. Such a book has long been wanting, for a very good reason--namely, that there are few physicists who are not painfully aware how far they fall short of competence to produce such a treatise. In the main, Mr. Risteen has done very well. He has taken account of almost all the greater contributions, mathematical and experimental; he has so put them together as to render his pages intensely interesting, by virtue of the thread of cunning reasoning and apposite observation that surely leads to the heart of the great puzzles which he follows out; and he argues some points with real power. The work will prove extremely useful to all who wish to know what the scientific theory of molecules is in detail, and what are the grounds upon which it rests.

The great memoir of Helmholtz upon the conservation of force assumes that all material forces are between pairs of particles--in short, are attractions and repulsions. But measurements upon the elasticity of bodies have thrown grave doubts upon that assumption; and some writers upon elasticity profess to demonstrate that the forces between the parts of solids cannot be of that description. In reprinting his memoir, Helmholtz undertook to modify his expressions, so as to give room for the modern doctrine; but such modifications leave his arguments without much force, and deprive the theory itself of the greater part of its significance. It is on account of those observed facts about the elasticity of solids that Kelvin invariably expresses himself with reserve about molecules--saying that he believes that matter "has some kind of grained structure." It is not too much to say that this question is the principal question of to-day in natural philosophy. If central forces will suffice, so that the conservation of energy is to retain its full meaning, then the Boscovitchian conception (it ought not to be called a hypothesis) is the only rational way of thinking. But if central forces will not suffice, we are driven, it would appear, to conceive of matter as continuous, and therefore as a fluid in some respects homogeneous, throughout space. Thus we come to that order of ideas about media for the action of forces, the attraction of force-lines, etc., which have marked the physics of Great Britain since the time of Faraday. Here, we find a rational motive for the vortex theory of atoms. Something of this great discussion might well have been allowed to appear in the introductory chapter of a work on the constitution of matter; but Mr. Risteen finds no place between his covers for any portion of it. Though he touches upon crystals, he never speaks of any doubts as to the sufficiency of central forces. He never mentions the name of Boscovitch. He speaks of the vortex theory, but does not show in what its real peculiarities consist, nor where the suggestion really came from.

The kinetical theory of gases, which now begins to take on the highest degree of certitude and something like completeness, is very well elucidated in Mr. Risteen's second chapter; yet we are amazed that the vast researches of Amagat should be passed by without mention (except that one constant is borrowed from him).

In the molecular theory of liquids nothing is said, either pro or con, in regard to the theorem of the virial of Clausius, which, it seems to us, ought to be the cynosure to guide our speculations upon this subject. In one passage we are said to be ignorant what the quadratic mean of the molecular translational velocities in a liquid may be at a given temperature; in another place it would seem to be assumed that the velocities in liquids and solids are less than in the gases of the same constitution at the same temperature. If the theorem of the virial is true, this question is easily answered; if it is not admitted, the objections to it ought to be stated. A strong attraction between the molecules of a liquid is manifest in its surface-tension, its heat of vaporization, etc. Its definite destiny is an effect of equilibrium between this attraction and the translational velocities of the molecules. It would thus seem to be evident that the velocities of molecules in the liquid cannot be less than they are in its saturated vapor above it. Mr. Risteen very promisingly commences an explanation of the incompressibility of liquids, by attributing it to the centrifugal force of the molecules. No doubt he is right, as far as he goes; but a more precise elucidation is desirable.

The molecular theory of solids appears to be beyond Mr. Risteen's present powers. At all events, he has not entered into the considerations which are prerequisite to any serious attempt at an outline explanation of the properties of these bodies.

In a chapter on the size of molecules, the author calls attention to the extreme vagueness of the idea of the size of a molecule. One might as well attempt to measure in inches the diameter of a crowd of people before a street show. It has no definite limits. We measure the length of a bar, because if we attempt to compress it we meet with a counter-pressure which, before we have sensibly reduced its length, exceeds any force we can bring to bear upon it. But it is not likely that molecules have this property to anything like the same degree. When we speak of their size we do not know what we mean; and one method of determination might perfectly well give one result, and another a widely different result, and yet both might, in their several senses, be correct. It is, therefore, a very remarkable fact that different calculations of the size of molecules based upon the most widely diverse considerations turn out to agree very well. Nobody ever supposed that in asking how large a molecule was, he was asking anything much more definite than if he had asked what the average size of an ordinary portable object is. The answer in the latter case might be, its size is somewhere from a fraction of an inch to a few yards. The size of molecules seems to be known quite as definitely. The diameter is somewhere about a ten-millionth or hundred-millionth of an inch.

A final chapter is devoted to speculations in regard to the constitution of molecules. Mr. Risteen defends very ingeniously the equation by which the number of "degrees of freedom" of a molecule is supposed to be determined. He has, on the whole, proved that he has the power to produce a treatise upon the subject adequate to the needs of students; and if the weak spots of his first essay receive the necessary attention, we may hope that a perfected edition will meet every desideratum.