

The Beginnings of Physics and Chemistry.

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Unless great pains have been taken with the arguments, it will be found that most young people, after witnessing the usual experiments intended to demonstrate the reasonableness of the molecular and atomic theories, will have failed to see the point. If you ask why they believe that bodies are made up of minute particles too small to be seen (don't use the word *molecules* in this question), they will tell you that they believe this because they expand when heated, contract when cooled, etc.

Now, the immediate ground of their belief in molecules should not be that bodies expand and contract when heated and cooled. They should believe that bodies are made up of molecules because this belief enables them to *explain how* (not *why*) bodies expand and contract when heated and cooled—and to *explain* many other physical phenomena.

In the same way, we believe that molecules are made up of *atoms* because that belief enables us to *explain* the charring of wood, and many other chemical phenomena.

The scientific argument for the existence of a Deity is logically the same as that for the existence of molecules and atoms. The belief in God enables us to explain many things in human life and in the universe beyond, which would otherwise be inexplicable. Indeed, to most of us, without the belief in God, the world and life would be a bewildering chaos. And so would physics and chemistry be without the molecular and atomic theories.

I will now attempt to outline as briefly as I can, a course of arguments, based on simple experiments, suitable for children in the seventh and eighth grades of the public schools.

It seems a pity that the children should leave school, as many, probably most of them, do now, without any insight into these really simple theories which would enable them to explain so many phenomena closely related to their own lives and work.

Molecules.—Mix grains of corn and black beans (beads of different colors would answer). The beans can be seen between the grains of corn. How could the beans have mixed with the corn if either or both of them had been one solid mass? Impossible.

Taste a clear solution of sugar in water? Where is the sugar now? We can't see it, but we know it is mixed with the water by the taste. But how could the sugar have mixed with the water if each had

been one continuous mass entirely filling the space within its boundaries? Impossible. How then did they intermingle? The water and the sugar must be made up of little grains as the corn is, but too small to be seen; and the grains of sugar must have got in between the grains of water. Try to see the grains of water and of sugar by a magnifying glass or a microscope. Too small to be seen even with that help.

Heat colored water in a flask or a large test-tube. The water should fill the flask and rise part way up a small glass tube which passes through the cork. The water, when heated, rises in the tube, and sinks when cooled.

Heat a metal (copper) ball. It will expand so much that it will not pass through a ring through which it will pass easily after it is cooled. How could the water and copper expand and contract if each of them is a continuous mass filling the space within their boundaries? Seemingly impossible. It must be, I think, that the water and the copper are made up of little grains of water and of copper, and the heat caused these grains to move a little further apart thus increasing the apparent size (or volume) of the body; and when the copper and water lost heat, these grains drew more closely together, that is, the body contracted. These minute grains or particles too small for any human eye to see, are called *molecules*.

Now, why do we believe that bodies are made up of minute invisible grains or particles? We believe that bodies are made up of these particles because that belief enables us to *explain how* bodies expand when heated and contract when cooled.

The same belief enables us to *explain how* sugar dissolves in water, and will, we hope, help us to explain many other things.

Atoms.—We believe that wood, starch and sugar, like copper and water, are made up of extremely small grains (called molecules) too small to be seen. Heat slowly in a closed test-tube a piece of either of these substances. Cotton wool will answer well as it is nearly pure wood. The cotton is made up of little grains of wood—wood molecules. Drops of clear water soon condense on the inside of the tube, and a black solid remains in the bottom, which proves to be charcoal (carbon). How much cotton (wood) is there in the tube now? None—not a single molecule of wood. But the wood could not escape out of the *closed* tube. What became of the wood grains (molecules)? There must have been a little charcoal and a little water in each molecule of wood, and the heat drove the water out and left the charcoal. But