produced in us the sensation of vision. This was the opinion held by Descartes and Newton, and on account of the great influence possessed by the latter was with the greatest difficulty overthrown.

The theory held in opposition to it makes a hypothesis to the effect that all space, not excepting the pores of the densest bodies, is occupied by an imponderable matter of extreme tenuity and infinite elasticity. This subtle matter is called the luminiferous ether, and light is nothing else than a rapid vibratory motion of this ether, propagated in the form of waves. But this theory also supposes a difference in the mode of propagation of these waves, both in sound and in light. In sound the atoms of the air vibrate in the same direction in which the sound travels: while in light the vibrations of the ether are transversal, that is, they take place in a plane at right angles to the direction of the ray.

Heat, as we have already seen, is also considered as a vibration. The phenomenon of radiant heat, as experienced in its instantaneous perception when a cloud drifts from the face of the sun,—in which case the intervening medium is not warmed--also calls to its aid the hypothetical ether.

Thus the modern theory of heat holds that the particles of a heated body, being in a state of exceedingly rapid vibration, transmit their motion to the ether, throwing it into waves which move with the velocity of light from one body to another, whose particles receive the vibrations from the ether and in turn become heated.

From the theories just enumerated we see that each of them is based upon a similar principle,—that of vibrations. But this is not the only similarity existing amongst them: we have many others, the most marked of which I will now mention. We all know that light falling on a polished surface is reflected, and that the angles of incidence and reflection are equal and lie in the same plane. Exactly the same laws have been found in heat, and were known even so far back as the time of Archimedes, who by means of a great number of mirrors burned the vessels of the enemy besieging his native city. In sound also, do we find them: a common example of which is heard every day in the echo, and a complete verification can be had by a visit to the famous whispering galleries of Europe.

Another point of similarity is seen in the phenomena of refraction. Refraction is the change of direction which light and heat experience in passing from one medium to another of different density. For example, a stick plunged into water appears broken, and we see the sun when in reality it is below the horizon. Hajech and Sondhaues, using tubes filled with various gases and balloons inflated with carbonic acid, demonstrated the analogy between sound-waves and those of light. Another of the phenomena of light and heat which has its counterpart in sound is that of absorption. Different bodies absorb light and heat in different degree, depending on their nature. Sound also is absorbed, as can be seen by comparing the sound of a musical instrument in a carpeted and furnished room with that of one heard in an empty room.

The phenomena of interference furnish still another analogy between light and sound. Light and sound, we have seen, are propagated in the form of waves. By observing the waves produced by a pebble cast into a pond, we will see that they consist of two parts, the crest or upper portion of the waves, and the depression or hollow. Now supposing that immediately after the first pebble was cast into the pond, another followed, this second one would produce its own series of waves, and it is obvious that by sufficient practice and dexterity, the second stone could be thrown after such an interval of time that the crests of the second series would correspond with the hollows of the first, and thus the waves would disappear. Now, if our theories of light and sound are correct, we should find in them the phenomena of interference. This was seen to be the case. For light, it was first shown by Dr. Thomas Young, whose experiments, as perfected by Fresnel, that distinguished French physicist who is said to have penetrated deeper than any other man into the secrets of nature, is considered one of the most elegant and instructive in science, and was the "*experimentum crucis*" of the undulatory theory. By inclining two mirrors at a very obtuse angle, Fresnel caused the reflected waves to interfere, and found that in places where, according to the emission-theory, we should have a brighter light, the opposite effect—darkness—was produced. Dr. Young, by holding a vibrating tuning fork in a certain position near the ear or a sounding box, showed the interference of the waves proceeding from each prong of the fork: for no sound was audible to the ear.

Thus far we have considered sound, light, and heat in their principal properties,—reflection, refraction, absorption, and interference,—and have found these phenomena explained by the same theory and governed by exactly the same laws. Now, the question arises, is there not some close relationship between these natural forces? If the effects are the same, should they not proceed from one sole cause? The solution of this problem has occupied the minds of the greatest philosophers of our time, and their investigations tend to demonstrate that light, heat, and sound have essentially the same principle—that of vibrations. But if heat, light and sound are vibrations, what then distinguishes them? We shall see.

Science was not satisfied with wresting from nature the essential principle of her forces, but went farther and measured even the length and duration of the vibrations, discovering at last the distinguishing cause. It was found that of all vibrations, those of sound were the least and those of light the most rapid, while the vibrations of heat occupied an intermediate position; and that light of different colors vibrated with different velocities.