Reprinted from the 'Ophthalmological Society's Transactions,'
Vol. L, 1930.

Modern theories on the nature of light.

By Sir Oliver Lodge.

There are many similarities between sound and light, but there are also important differences. Both represent a means of transmitting energy, and in both there is a pressure exerted on the surface upon which the disturbance falls, though for ordinary intensities the pressure is extremely small. Both, therefore, represent a stream of energy travelling at a certain pace; both take their origin in a material disturbance, and excite such a disturbance when they cease to be. But whereas sound is wholly conveyed by matter and cannot travel through a vacuum, light travels through a vacuum more easily than through anything else, and is only obstructed by matter. One travels, therefore, just a million times faster than the other. The rate of travel of both is independent of the wave-length, so that all rates of vibration travel at the same pace.

As to the differences, sound is a mechanical vibration, light is electrical. The ear is a mechanical organ for detecting vibrations; the eye must be an electrical organ. The ear is able to analyse a composite sound into its constituents, and can tell all the tones appropriate to a compound note. The eye has no such power. White light can be made up in many different ways, and the eye will not be able to distinguish. The ear has a great range of sensitiveness, extending over many octaves. The eye has a range limited to one octave, and its mode of appreciating the frequency or rate of vibration is not by pitch but by what the mind calls "colour." The eye appears to have only three colour sensations; and the mind presumably estimates shades of colour by the proportion in which these are stimulated.

There is strong evidence that both sound and light consist of waves; but the waves differ in an important particular. Consider the transmission along a row of particles, like a file of soldiers. Think of them as marching in single file. A pulse could be sent along them by ordering the hind man to step nearer his neighbour, who should then similarly advance so as to preserve the same distance apart. That would be analogous to a pulse of sound; a condensation or extra compression would travel along the file, but another order might be given that the hind man should step slightly to the right, the next man doing the same, and so on. That would be analogous to a pulse of light. The shift of each man would be transverse to the direction of propagation. But now there is another possibility. The hind man might be ordered to duck; then if each man ducked in succession, that would also be a transverse pulse, but one at right-angles to the first, though travelling in the same direction. Both these would be analogous to a pulse of light; either separately would be polarized light. Sound cannot be polarized. There are thus what are called more degrees of freedom possible to a transverse vibration than to a longitudinal—twice as many in fact; and if both to and fro and up and down vibrations exist together, we have what is ordinarily called common light. But the eye has no means of distinguishing one kind of light from another, except by colour. It can only distinguish colour and intensity.

Sound and light both consist of waves; but the waves are very different in the two cases. In sound the particles are oscillating to and fro in the direction of transmission. In light there is something analogous to a transverse oscillation; but it may not be an oscillation at all. We are not sure what is happening; all we know is that it is something periodic—that is, it repeats itself at regular intervals; and that it is an electrical disturbance with a magnetic component at right angles. If the particles are oscillating, they are oscillating sideways as regards electricity, and up and down as regards magnetism. But to speak thus is rather nonsenical, for electrical motion is necessarily accompanied by magnetism at right angles to the motion; the oscillation is not two but one. Only we are not sure that there is any *movement* at all, and we certainly do not know the extent of the excursion or what is moving; if we did, we should know a great deal more about the substance filling space than at present we do.

When we say that a thing is a wave, the statement has not much meaning except to those who know what a wave is. The orthodox definition of a wave is that it is something periodic in space and time. It repeats itself in space at intervals called a wave-length, and it repeats itself in time at intervals called a period. So long as those conditions are satisfied, the wave definition is satisfied too. We may picture or imagine what is happening more completely, but often illegitimately. The periodic light disturbance may be an excursion, or it might be a twist, or it might be something of which we have no conception. So long as it is periodic in space and time, it satisfies the conditions for a wave; and in its effects when analysed it will reproduce those periodicities.

The evidence for the periodic character of light is overwhelming. The shadows thrown by a fine source of light are fringed in a periodic manner at the edges. This is called diffraction, and was studied by Newton. When a source of light is doubled by any means, as by reflection, and the beams from the two half sources are brought together, a periodic illumination is produced: light and dark spaces alternate. This also was discovered by Newton. He saw rings produced between a flat plate and a lens (in one form of experiment) and measured the rings. Hence, although he thought that light consisted of corpuscles shot out from the source, he felt bound to superpose upon the corpuscles a periodic condition—that is, he made them have poles and revolve, so that alternately they could be reflected and transmitted by the boundary of the substance on which they fell. In that way he could account for the interference phenomena of light. It was neither a corpuscular nor a wave theory, but a mixture of both. The corpuscular aspect was what struck everybody, but Newton realized that some kind of periodic structure was necessary too, though its demonstration required care, and was not obvious to ordinary observation. Diffraction fringes and interference bands need looking for; but everybody can see colours in an oil-film or a soap-bubble—and these colours really demonstrate periodicity.

ŋ̧qdqɏeϒ ƃɆ dəqɆƃϒɜə d ɞɔɑƃɔɏ Ɉqdqϒqɏè