hearing, and objectively the vibratory motion which produces the sensation of sound. The physiological and psychical aspects of sound are treated in the article Hearing. In this article, which covers the science of Acoustics, we shall consider only the physical aspect of sound, that is, the physical phenomena outside ourselves which excite our sense of hearing. We shall discuss the disturbance which is propagated from the source to the ear, and which there produces sound, and the modes in which various sources vibrate and give rise to the disturbance.

*Sound is due to Vibrations.—*We may easily satisfy ourselves that, in every instance in which the sensation of sound is excited, the body whence the sound proceeds must have been thrown, by a blow or other means, into a state of agitation or tremor, implying the existence of a vibratory motion, or motion to and fro, of the particles of which it consists.

Thus, if a common glass-jar be struck so as to yield an audible sound, the existence of a motion of this kind may be felt by the finger h\*ghtly applied to the edge of the glass; and, on increasing the pressure so as to destroy this motion the sound forthwith ceases. Small pieces of cork put in the jar will be found to dance about during the continuance of the sound; water or spirits of wine poured into the glass will, under the same circum­stances, exhibit a ruffled surface. The experiment is usually performed, in a more striking manner, with a bell-jar and a number of small light wooden balls suspended by silk strings to a fixed frame above the jar, so as to be just in contact with the widest part of the glass. On drawing a violin bow across the edge, the pendulums are thrown off to a considerable dis­tance, and falling back are again repelled, and so on.

It is also in many cases possible to follow with the eye the motions of the particles of the sounding body, as, for instance, in the case of a violin string or any string fixed at both ends, when the string will appear through the persistence of visual sensation to occupy at once all the positions which it successively assumes during its vibratory motion.

*Sound takes Time to Travel.—*If we watch a man breaking stones by the roadside some distance away, we can see the hammer fall before we hear the blow. We see the steam issuing from the whistle of a distant engine long before we hear the sound. We see lightning before we hear the thunder which spreads out from the flash, and the more distant the flash the longer the interval between the two. The well-known rule of a mile for every five seconds between flash and peal gives a fair estimate of the distance of the lightning.

*Sound needs a Material Medium to Travel Through.—*In order that the ear may be affected by a sounding body there must be continuous matter reaching all the way from the body to the ear. This can be shown by suspending an electric bell in the receiver of an air-pump, the wires conveying the current passing through an air-tight cork closing the hole at the top of the receiver. These wires form a material channel from the bell to the outside air, but if they are fine the sound which they carry is hardly appreciable. If while the air within the receiver is at atmospheric pressure the bell is set ringing continuously, the sound is very audible. But as the air is withdrawn by the pump the sound decreases, and when the exhaustion is high the bell is almost inaudible.

Usually air is the medium through which sound travels, but it can travel through solids or liquids. Thus in the air-pump experiment, before exhaustion it travels through the glass of the receiver and the base plate. We may easily realise its trans­mission through a solid by putting the ear against a table and scratching the wood at some distance, and through a liquid by keeping both ears under water in a bath and tapping the side of the bath.

*Sound is a Disturbance of the Wave Kind.—*As sound arises in general from vibrating bodies, as it takes time to travel, and as the medium which carries it does not on the whole travel for­ward, but subsides into its original position when the sound has passed, we are forced to conclude that the disturbance is of the wave kind, We can at once gather some idea of the nature of sound waves in air by considering how they are produced by a bell.

Let AB (fig. 1 ) be a small portion of a bell which vibrates to and fro from CD to EF and back. As AB moves from CD to EF it pushes forward the layer of aîr in contact. with it. That layer presses against and pushes forward the next layer and so on. Thus a. push or a compression of the air is transmitted onwards in the direction OX. As AB returns from EF towards CD the layer of air next to it follows it as if it were pulled back by AB. Really, of course, it is pressed into the space made for it by the rest of the air, and flowing into this space it is extended. It makes room for the next layer of air to move back and to be extended and so on, and an extension of the air is transmitted onwards following the compression which has already gone out. As AB again moves from CD towards EF another compression or push is sent out, as it returns from EF towards CD another extension or pull, and so on. Thus waves are propagated along OX, each wave consisting of one push and one pull, one wave emanating from each complete vibration to and fro of the source AB.

*Crova's Disk.—*We may obtain an excellent representation of the motion of the layers of air in a train of sound waves by means of a device due to Crova and known as "Crova,s disk.” A small circle, say 2 or 3 mm. radius, is drawn on a card as in fig. 2, and round this circle equidistant points, say 8 or 12, are taken. From these points as centres, circles are drawn in succes­sion, each with radius greater than the last by a fixed amount, say 4 or 5 mm. In the figure the radius of the inner circle is 3 mm, and the radii of the circles drawn round it are 12, 16, 20, &c. If the figure thus drawn is spun round its centre in the right direction in its own plane waves appear to travel out from the centre along any radius. If a second card with a narrow slit in it is held in front of the first, the slit running from the centre outwards, the wave motion is still more evident. If the figure be photographed as a lantern slide which is mounted so as to turn round, the wave motion is excellently shown on the screen, the compressions and extensions being represented by the crowding in and opening out of the lines.

Another illustration is afforded by a long spiral of wire with coils, say 2 in. in diameter and ½ in. apart. It may be hung up by threads so as to lie horizontally. If one end is sharply pressed in, a com­pression can be seen running along the spring.

*The Disturbance in Sound Waves is Longitudinal.—*The motion of a particle of air is, as represented in these illustrations, to and fro in the direction of propagation, *i.e.* the disturbance