would give for the hydrogen *atom* a volume equal to that of a sphere of radius $0{\cdot}53 \times 10^{-8}$ cm. But the normal hydrogen atom, as is now known from the researches of Bohr, consists of two electric charges, describing a circular orbit, one about the other, of radius precisely equal to $0{\cdot}53 \times 10^{-8}$ cm. As regards collisions with other molecules, this invertebrate structure, consisting of two point-charges with no material connexion between them, appears to reserve for itself a three-dimensional spherical volume with as much precision as though it were a sphere of infinite hardness.

The explanation of this infinite hardness is to be found in the intangible fetters of the quantum dynamics. The nature of these fetters is not in the least understood, but it is believed that they are such that no force in creation can cause the electron of the hydrogen atom to describe a smaller orbit than the normal orbit of radius $0{\cdot}53 \times 10^{-8}$ cm. If it is further supposed that this orbit is free to assume all orientations in space we begin to understand why it is legitimate, for kinetic theory purposes, to treat the hydrogen atom as an infinitely hard sphere of radius $0{\cdot}53 \times 10^{-8}$ cm. The quantum theory brings us back, in a sense, to the infinitely hard spherical atoms of Lucretius, and the radius of these spherical atoms can now be calculated with precision from the quantum theory; their infinite hardness is beautifully exemplified in the experiments of Franck and Hertz.

It is thus seen that the *a* and *b* of Van der Waals admit of exact interpretation in terms of the physical conceptions of to-day. His *b* arises from what we may call the quantum forces—the perfectly unyielding restraints which bind the electrons of an atom down to definite orbits—while his *a* arises from the ordinary electric field of force. It is the *b* of Van der Waals which saves us from immediate annihilation, through positive and negative charges rushing together to their mutual destruction, just as it is his *a* which saves us from rapid disintegration.

## The Nerves of Plants.[1]

By Prof. HENRY H. DIXON, F.R.S.

THE general similarity of the distribution of the fibro-vascular bundles in plants and that of the nerves in animals was early noticed. These structures in plants were in consequence often called nerves. However, anatomists and physiologists alike have long held the view that the likeness is merely superficial, and is not based on any real physiological or anatomical resemblance.

In plants—as in animals—the receptive and responsive regions are often quite distinct from one another, and may be widely separated. What becomes of the stimulus between the two, and how is it transmitted? Remarkable experiments during the last ten years have given the answers to these questions.

First may be summarised, in a few words, Ricca's work on the sensitive plant, Mimosa. The phenomena of transmission of stimuli in this plant are as striking as they are well known. The stimulus is propagated through its organs at velocities variously estimated at 2-20 mm. per sec. This speed is fast among plants, but very slow when compared with the velocity of transmission of stimuli along animal nerves.

Two views were suggested to account for this propagation. The first referred the passage of the stimuli to those excessively fine strands of protoplasm which, penetrating the walls of the living cells, place the protoplasts of adjacent cells in communication with one another. This view was a product of a period obsessed with the physiological importance of these then recently discovered protoplasmic fibrillæ, which, in all probability, have only a developmental significance. These fibrillæ composed of living matter were supposed to convey stimuli just as the living processes of the nerve cells do in the animal body.

This view was soon rendered untenable when it was shown that stimuli are effectively transmitted even after the protoplasm of the cells of the transmitting organs was killed by the application of heat.

To meet this new growth of knowledge Haberlandt developed his theory, that the stimuli are transmitted in Mimosa in the form of a pulse in the water filling certain elongated tubular cells situated in the bast of the bundles. At the best this was an unsatisfactory theory. For this method would require a much higher velocity of transmission than is observed, and it was wellnigh impossible to imagine how the turgor requisite to transmit this pulse could be maintained after the protoplasts of these tubes had been rendered permeable by heat.

In 1914 Ricca gave the *coup de grâce* to the pulse theory. He showed that the stimulus is transmitted through a strand of Mimosa wood from which all the bast, including the tubes of supposed transmitting function, had been removed for a considerable length. By a series of beautiful experiments Ricca showed that the wood, as Dutrochet long ago believed, transmits the stimulus, and that it does this even when all its living elements are eliminated. Further, he demonstrated that the mechanism of the transport is the transpiration current. This carries in its stream a substance, or hormone, originating from the receptive cells, to the cells of the reactive region and so evokes their response. Ricca's work also disposes of a more recent view that the stimulus is transmitted as an electrical disturbance in the bast.

Almost at the same time as Ricca was disposing of the older views regarding the transmission of stimuli in Mimosa, Boysen-Jensen was carrying out experiments on the phototropic reactions of seedlings, which were bound to have a profound effect on the received views regarding the propagation of stimuli.

When the tip of a grass-seedling is illuminated on one side a stimulus is transmitted from the receptive region downwards in the seedling and evokes a curvature in the shaded part. Boysen-Jensen found that this stimulus was transmitted downwards even when the protoplasmic continuity of the cells of the receptive apex with those of the responsive region was severed by complete section.

[1] Synopsis of a lecture delivered before the Royal Dublin Society on November 9.

Paál repeated and confirmed Boysen-Jensen's results and added the important observation that the stimulus can pass a slice of pith 0·1 mm. thick impregnated with gelatin intercalated between the receptive and responsive regions. Similar work has been since carried out by Stark on thigmotropic and traumatotropic stimuli. This experimenter brought to light the fact that the receptive tip of one plant may be transferred to the base of another and after stimulation may determine curvature in the latter. Furthermore, the certainty of this response to thigmotropic stimuli depends, other things being equal, upon the phylogenetic affinity of the two parts. Recently Snow has shown that the gravitational stimulus is transmitted across protoplasmic discontinuities in the seedlings of *Vicia faba*.

From the foregoing it is quite evident that protoplasmic continuity is not requisite for the transmission of stimuli in the higher plants. The localisation of the positive and negative responses respectively to one side of the reacting region and the velocity of transmission will not allow us to assign the propagation to simple diffusion; but these characteristics point clearly to the transpiration-stream. It affords the localised delivery and the necessary velocity. Introduction of the requisite hormones may be effected through uninjured cells, or along moist wound surfaces. This consideration explains how it is that continuity between the vascular bundles of the receptive tip and those of the responsive base is not necessary to secure the reaction. Thus, there is great probability that in these plants, as in Mimosa, the transmission of stimuli is effected by the transport in the transpiration-stream of a substance derived from the receptive cells, and conveyed by this means in the wood of the vascular bundles to the responsive region. We may imagine that this substance is first liberated into the transpiration stream by changes in the permeability of the receptive cells, and response is evoked in the reactive cells by similar alterations in permeability.

Whatever the intimate mechanism of the system is, the subject of the transmission of stimuli through plant tissues offers a striking example of the swing of the pendulum of scientific opinion. The view based upon superficial resemblances, that the vascular bundles are the nerves of plants, was long abandoned, but now we see there is clear evidence that they actually transmit stimuli from the sensory to the motor regions, and so perform the function of nerves. The foregoing summary of recent work indicates how differently in detail this connexion is established in plants and animals.

## Obituary.

### Mrs. Hertha Ayrton.

APPEAL is made to me to give some account of Hertha Ayrton, the wife of my former colleague, who died last August.

"Is the study of heredity a science or a pure romance?" asks Mrs. Trevelyan, in her biography of her mother, Mrs. Humphry Ward. I would set the question in another form: Is *das ewig Weibliche* to be suppressed by science? Mrs. Ayrton was one of those who aspired to prove that woman can be as man as an original scientific inquirer. Did she succeed? If we are to frame a psychology of the scientific mind, regarding this as a species apart, we must carefully note and analyse the doings of such as she. I have but small qualification for the office, yet as she was my colleague's wife and we often met and were in fair sympathy, I was able to take notice of her idiosyncrasies and of the conditions under which she was placed.

Ayrton and I met originally in the autumn of 1879, when we were appointed the first two professors of the City and Guilds Institute and set the ball of technical education rolling in London; the ball rolled well and proved to be fissiparous but no one of the small band who gave it shape in the City and West End ever received the slightest recognition from the Guilds, their masters—and most of these have committed *hari-kari* as concerted workers in education. A strange world is ours and if we worked otherwise than for the sake of working, we should do little.

Ayrton had a peculiar experience: his then (first) wife—his cousin, Mathilda Chaplin—was a woman who had acquired merit in the cause of women's rights, as she was one of the three, I believe, over whom the fight first raged in Edinburgh whether women should be admitted to the study of medicine. When I met her, her health was more than failing. She was an ethereal being, a woman of infinite charm of manner but above the world—a mature Melisande; indeed, when I first heard Debussy's opera her memory was recalled to me by the peculiar rhythm and tone of its melody. Her daughter, Mrs. Zangwill, has inherited not a few of her mother's characteristics—especially her charm of voice. Her chief occupation was novel-reading, from penny-dreadfuls upwards, in which she ran a caucus race with our erratic friend, John Perry.

Ayrton married his second wife in 1885. If I were to compose an opera with my scientific friends as the characters, I should associate the Melisande theme with the first Mrs. Ayrton; I should not quite know where to place the second musically but it would be near to Brunhilde, as she had much of the vigour of Wotan's masterful daughter and, at least, aspired to be an active companion of scientific heroes—a race far above Wagner's dull and degenerate Teutonic gods, be it said.

Sarah Marks was the daughter of intelligent but poor Jewish parents in Portsmouth. She was a clever child and was early sent to a school in London kept by her paternal aunt, who became Mrs. Hartog; Mr. Hartog was a teacher of French in London. Mrs. Hartog was the mother of Numa Hartog, Philip Hartog and the professor of botany in Cork; also of two daughters, one very clever, a talented painter, who married Dr. Darmstadter of Paris; the other earned her living as a musician. Numa Hartog died early, after a most brilliant university career and seems to have been unusually clever. Mrs. Marks had four undistinguished children, besides Sarah; nothing is known of her parents. Mrs. Ayrton's ability, however,