CRITICAL REVIEW

THE RIDDLE OF OLFACTION.

By DAN M'KENZIE.*

SCIENTIFIC medicine in general, and rhinology in particular, have both, it must be confessed, neglected the study of olfaction, and we are indebted to Dr Heyninx for directing our attention to the subject in the voluminous *Thèse de Bruxelles* now before us.

Most of the modern works on physiology deal but scantily with olfaction, contenting themselves with a brief summary of the findings of Tyndall and a few other experimenters. We must remember, however, that it is only quite recently that the most important and enlightening work in this department of physiology has been done, since the stimulus to that work, and to the theories it has originated, is a direct result of the change which modern chemistry and physics have brought about in our conception of the nature of matter.

Attempts to refer all natural odours to the combinations of a series of primitive or fundamental odours have now, as the modern perfumer's art would seem to show, been successful, and largely though not wholly as a result of this chemical triumph, Zwaardemaker in 1895, and again in 1910, set about constructing a more or less rational classification of those primitive scents. M. Heyninx, however, goes a step further than Zwaardemaker, and, as the finishing touch to his present work, makes the interesting claim that he is now able to classify them, as colours are classified, in accordance with their wave-length. For it is the thesis laid down and defended in this book that the olfactory sense is stimulated, not mechanically as the ancients with their "odoriferous particles" believed, nor yet chemically as the medical student a few years ago was taught, but physically, by the intra-molecular vibrations of odorous bodies setting up waves in the ether like the waves of light that stimulate the visual sense. Indeed, M. Heyninx is even bold enough to assign a place to odorous waves in the ultra-violet region of the spectrum, so that it would appear, if his views are correct, that the olfactory sense begins where the visual sense leaves off, and that vibrations which are too minute and rapid to be received by the eye are nevertheless received by the nose, to be apprehended by the mind as smell.

At the outset, we must confess, it is difficult for us to conceive how ethereal waves, akin in form and differing only in rate, can give rise to mental sensations so fundamentally unlike as vision and olfaction, and it is but reasonable to expect that the evidence in support of such

* Essai d'Olfaction Physiologique, par Heyninx (A.). Thèse présentée à la Faculté de Bruxelles pour l'obtention du titre de docteur spéciale. Vve. L. Larcier, Editeur: Bruxelles, 1919.

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a strange conclusion must be thoroughly convincing before this natural reluctance to entertain it can be overcome. *Entia non sunt multiplicanda præter necessitatem*, or as the tag has been paraphrased: Miracle (meaning in this present instance something opposed to the evidence of the senses) is not to be presumed until natural (or simple) causes have been excluded.

This evidence, then, or as much of it as seems to be cogent, we shall now endeavour to place before our readers as clearly and as plainly as its intricate and recondite character will permit.

A detailed survey of the known physical facts connected with *odorivectors* (bodies, the pure chemical molecule of which possesses the quality of odour) shows that, whatever may be the normal physical state of the odorivector, whether it be solid, liquid, or gaseous, its odorous molecules are disseminated and reach the olfactory end-organ as gas (or vapour) in an aërial medium, and as liquid (in solution) in a watery medium.

The proofs of this statement are to be found in the observation of odorous bodies and of the odours they exhale.

For example—to deal only with the aërial medium as that with which we are most familiar—the evaporation of water, that is, its conversion into the gaseous state, varies with the barometric pressure, and the same is true of odours arising from an odorivector. The scents of flowers, as everybody knows, are less noticeable in heavy, thundery weather than they are after the shower has fallen and the air is, as we say, "cleared," not only because the impact of the rain-drops has mechanically disturbed and laid open the odorous bodies, but also because the atmosphere has become lighter and more permeable. So that odours obey the law of vapours in being more rapidly diffused when pressure is reduced.

Further, it is known that many, if not all, solids and liquids exposed to gas adsorb to their surfaces a thin but dense layer or film of that gas. And the same must be true of substances exposed to odours, since we know how readily smells "cling" to materials.

Moreover, this adsorption satisfactorily accounts for the fact, well known to fox-hunters, that in misty weather odours are but faintly perceived, since the odours given off are then both adsorbed to and absorbed into the minute droplets of water which constitute the mist.

Again, just as volatile liquids evaporate and gases are diffused more rapidly when warm than when cold, so, when the temperature of the air is raised, odours are stronger than when it is lowered. The afternoon and evening of a summer day are richer in perfume than the forenoon, and the poet Gray's epithet of the morn as "incense-breathing" is, we must admit, not very appropriate. The morning, indeed, "smells fresh" just because it is odourless, and this is particularly true of a frosty morning when the odorivectors are sealed

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up with the water which is wont to carry them into the air. For there can be no doubt that many natural odorous molecules are dissolved in water and are only set free as vapour or gas when, under the influence of warmth and a decreased barometric pressure, the water containing them evaporates.

Thus everything goes to show that the odours which reach us travel in the gaseous state.

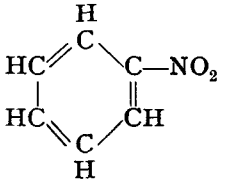
There is one important point here which requires further investigation, investigation which we should have been glad to note had our author undertaken it. This is the point. Many odorous liquids are volatile, and in giving off their odours lose weight, as we might expect. But on the other hand there are many odorous substances (? the essential oils) which seem to suffer no loss of weight in parting with their odours. This we may explain, perhaps, by assuming that the odorous molecules emitted by them are of infinitely minute mass and weight. It is, of course, a well-known fact that an odour may be enormously diluted and yet remain perceptible. Vanillin, for example, can be smelt when it amounts to no more than 0.000,000,005 gm. in a litre of air! This means no doubt that the sensitiveness of the olfactory organ is highly acute for this particular odour. In any case, here is a problem that calls for solution.

Admitting then as proved, that odours to be perceived must become gaseous bodies, we shall now turn to consider what information can be obtained from the chemical structure of odorous molecules. This is instructive, more, perhaps, in telling us what an odour is not, than in telling us what an odour is.

When we run the eye down the list of primitive odorivectors drawn up by Zwaardemaker, and compare their scent with their chemical composition and structure, we find many instances to show that similar or identical atomic groupings belong to the same class of odorivector, or, to put the matter in simpler language, we find that similar compounds give off the same kind of smell.

On the other hand, and here we have a fact of high significance, we also find that there are some substances which have the same smell and yet are chemically quite different from one another, and none show this remarkable combination of likeness and unlikeness more plainly than our nitrobenzol and hydrocyanic acid.

The graphic formula of nitrobenzol is:—



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While hydrocyanic acid, HCN, with the same odour, has the graphic formula of H – C ≡ N.

From this it is clear that the solution of the mystery of olfaction is not to be found solely in the chemical composition of odorous bodies. But in this consideration of the chemical composition, the ultimate physical state of the odorous molecule and the vibration of the atoms within the molecule are not discussed. In the following section they are, however.

We turn now to the *undulatory theory of odour*. This theory states that the odorous molecules in gaseous form, coming into contact with the olfactory mucosa, act by virtue of their own intra-molecular atomic vibrations, and that the ultimate odorous energy is a vibratory energy having a definite wave-length, which wave-length is always the same for the same variety of odour — just as the wave-length of any monochromatic light is always the same.

That in compound chemical bodies the atoms are grouped in certain definite morphological forms we know; that these atoms are in a constant state of vibration, an-ion and kat-ion attracting and repelling each other within a space, which is to these ions as the solar system is to an orange, we are taught; that these vibrations may communicate some of their energy to the ether to form ethereal waves, as do the vibrations of luminous bodies, we may admit.

To the physicist, therefore, there is in the undulatory theory of odour nothing improbable or even startingly new. Very much the other way indeed. And his assent to the theory may be granted if he is able to admit the validity of the many facts and arguments adduced by Heyninx in its favour.

Many of these we shall now proceed to relate, though briefly, and it is to be noted that they depend to a large extent upon the results obtained from the spectrum analysis of odours in the gaseous state, and more particularly from the spectrum analysis of the ultra-violet region, effected, of course, by photography since the ultra-violet rays are invisible to the eye.

Most, though not all, of the primitive odours have been examined in this way by many different observers, and it is interesting to learn that these odours absorb more or less of the ultra-violet rays of light. Not only so, but it is claimed that the position of the absorption bands shows some degree of correspondence with what is surmised to be the period of their intra-molecular vibration, and also, as we shall see later on, with the quality of their odour.

Certain bodies, for example, are known to give off different odours according to the degree of their concentration. Thymol is one of these, and when thymol is diluted it smells of thyme, whereas a bottle filled with thymol crystals has a repulsive, a fæculent odour. And we also find that, when concentrated thymol solution is exposed to the

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penetration of the ultra-violet rays, Vierordt's curve is seen to be displaced towards the region of longer wave-lengths, that is towards the visible violet. (Corresponding probably with the position occupied by scatol, though this has not yet been worked out.)

Again, when the olfactory apparatus is exposed to too great a quantity of perfume, as with the pure essence of violets, nothing but an indefinite odour can be perceived, "like dust and without precise quality." In harmony with this is the fact that when a hyper-concentrated odour is submitted to the spectrum it is seen that the ultra-violet rays are entirely absorbed, without any separation into the usual absorption bands. For this reason, Heyninx compares the characterless odour of concentrated violets with the uniform impression made by colourless light on the visual sense.

Moreover, as in colours and sounds, so in odours there is a harmony between certain kinds of perfume, and some authorities go so far as to refer the quality of certain odours to the presence of harmonics, similar to those which give the *timbre* to musical tones.

Furthermore, just as one sound may silence another, so one odour may "kill" another, as in the familiar instance of iodoform and coffee —a curious circumstance which certainly does look as if we were dealing with waves.

But of all these considerations, and of many more submitted by the author for which we have no room, obviously the most important are those observations of the absorption by odorous bodies of the ultra-violet rays of the spectrum.

Now it is a law of physics that the intra-molecular wave-length of a body absorbent of colour corresponds in period to the wave-length of the colour it absorbs. In other words, waves of a certain length when they meet waves of the same length absorb them. If that is so, and if odorous bodies absorb the ultra-violet rays, then obviously their intra-molecular vibration must be equivalent to the vibration of the ultra-violet rays of light. There is no escape from this conclusion.

Here we pause to interpolate a possible objection to the theory which M. Heyninx does not seem to have considered to be worthy of discussion. It may be said: is not this absorption of the ultra-violet rays of light due perhaps to some chemical or physical property unconnected with odour? Why should we suppose that odour and this peculiar property of absorbing ultra-violet rays are inseparable companions?

Many other facts and deductions from facts are given by the author in support of his hypothesis, and so far as we have gone it must be conceded that if these facts stood alone we could have no hesitation, in spite of *à priori* reasoning, in accepting not only the undulatory theory, but also the ultra-violet refinement of that theory as correct. But alas for our whole-hearted agreement, several other considerations

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arise which serve, if not to throw doubt upon the theory, at least to lead us to regard it as not yet firmly and incontestably established!

Before we proceed, however, to discuss those conflicting facts and arguments, we would ask our readers to accompany us into a digression or diversion from the main argument, a diversion which Heyninx very ingeniously contrives to turn to his own advantage while at the same time he seeks to account for what everybody who has at any time pondered over the olfactory sense-organ must always have felt to be a very mysterious fact.

Why is the olfactory sense-organ so highly pigmented? What conceivable olfactory purpose can pigment-granules serve? Yet they do—they must serve a purpose of the utmost importance, since albinos, it is said, have no sense of smell!

(This question, it is interesting to note, was asked by Wm. Ogle,* an English physician, as long ago as 1870, and was answered by him with a suggestion which anticipates in a remarkable way much of what M. Heyninx is now endeavouring to expound.)

Moreover, it is an equally curious fact that the labyrinth also and the retina contain pigment.

As regards the retina, we are here introduced to a new theory of vision, the *optic resonance* theory of Castelli, and as M. Heyninx has adapted this theory to olfaction, we shall devote a little time to its exposition.

We are all familiar with the phenomenon of resonance in acoustics. But perhaps we are not all so familiar with the fact that a like phenomenon exists in connection with electric radiations and also with the waves of light. And, just as an acoustic resonator bears a definite relationship to the wave-length of the sound it picks up, so the optic resonator, there is good reason to believe, bears a similar relationship to the wave-lengths of the light to which it responds. Now, an optic resonator consists of a thin layer of silver, finely divided and arranged in tiny rectangles, and this layer is shown by the microscope to be made up, in reality, of minute granules of the metal, *the dimensions of which correspond to those of the waves of light.*

Again, something akin to a resonating action has been claimed for the spherical granules of a butterfly's wings, and their diameter also is said to be exactly equal to the length of the wave-light of the colour of the wing at the spot from which they are taken.†

* Ogle's original paper will be found in full in the *Med.-Chir. Trans.*, vol. liii., p. 263. M. Heyninx has only been able to obtain a translation of a summary of the paper which appeared in the *B. M. J.*, 1870, i., p. 166.

† Is this correct? The colour emitted can only be that of white light after the absorption of some of its constituents, and the diameter of the granules ought surely to correspond not to the wave-length of the colour they emit, but to that of the colour they absorb!—D. M.

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This brings us to the retinal pigment-granules, and the imaginative reader will already be able to foretell what we are about to say.

The retinal pigment-granules are said to vary in size from 0.3 μ to 1.1 μ, that is to say, they are equal in size to the several wave-lengths of visible light. And here we have the resonance theory of Castelli. "The granules," says Castelli, "struck by the rays of white light, are set vibrating with diverse periods in accordance with their varying dimensions, and in correspondence with the different monochromatic rays exciting them"—that is, the longest rays, or reds, activate the largest granules, and so on to the blues, which activate the smallest granules—"and thus the rods and cones are set in motion, and that motion is in turn communicated to the first neurone."

Many of the phenomena of vision seem to support Castelli's theory. They need not detain us.

But it will be observed that the theory rests entirely upon the accurate measurement of these microscopically minute granules of pigment. Now, it is a fact, we are authoritatively informed, that bodies may be accurately measured as low as 0.7 μ, but below that point an optical effect is produced, even in the best microscopes, which renders precise measurement difficult if not impossible. We are, to be sure, in these minute dimensions admittedly dealing with the wave-lengths of light itself.

Let us turn to the olfactory pigment. M. Heyninx states that he has measured the olfactory granules and has found that their diameters vary between 0.2 μ and 0.3 μ. That is to say, they approximate in size to the wave-lengths of the violet and the (invisible) ultra-violet rays. The significance of this observation will at once strike the reader. It supports M. Heyninx's view of odours having a wave-length equal to that of the ultra-violet rays, and it prepares our mind for his suggestion of an *olfactory resonance* theory on all fours with the optic resonance theory of Castelli.

But M. Heyninx does not inform us how he has effected the measurement of the olfactory granules, and, as we have just seen, any figure below 0.7 μ is open to serious question. He promises, indeed, that he will detail his method in a future work, but we wish that he had included it in the present treatise, since its importance is paramount.*

* A critical thought occurs to me. The theories, both of Castelli and of Heyninx, depend upon the size of the granules, but they do not account for their colour. Why should they be dark-brown or black? Why pigmented at all? If it be replied that, being black enables them to absorb all light-rays and to repel none, this does not account for the pigmented granules of the cochlea which, we are told, act as resonators also, this time for sound-waves. But the waves of sound are in a different physical category altogether from those of light and odour. Moreover, the waves of sound are of enormous size compared with those of light.—D. M.

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Before we leave this section let us add that, just as some people are colour-blind, so, it is said, some people are anosmic to certain odours.

We have called this excursion of Heyninx's a digression from his main theme, although, perhaps, this is the wrong word to use, seeing that this particular section is intended to explain how it is that the olfactory sense-organ is stimulated by the ethereal waves.

Having completed our brief summary of the author's theories, and of the facts and arguments with which he supports them, we shall now indicate what appear to us to be the weak links in his chain of reasoning.

Speaking generally, we are compelled to note that, as is perhaps natural, our author is rather inclined to show a little impatience with adverse facts and arguments, and this is nowhere so unfortunately manifested as in his discussion of Tyndall's findings. More than forty years ago Tyndall, experimenting with odorous vapours, made the observation that these vapours absorb radiant heat rays, that is to say, the invisible infra-red rays at the other end of the spectrum from the ultra-violets. This, to be sure, is a very awkward fact! Because, if as Heyninx contends, the absorption of the ultra-violet rays proves that odorous vapours have an intra-molecular vibratory period of from 0.2 μ to 0.3 μ, so, we must admit, this finding of Tyndall's proves that they have also a wave-length equal to that of the radiant heat rays, namely, of from 60 μ to 0.76 μ!

It may be possible, of course, that Tyndall made a mistake. But the only way to prove that he did so would be to repeat his experiments, and this M. Heyninx does not seem to have attempted.

It may also be possible to show that the absorption of the infra-red rays is due to some factor other than the vibration of the odorous molecule, and this is how a recent worker, Gryns, whom M. Heyninx briefly quotes, would account for the phenomenon. But the experiments upon which this opinion is based are not detailed, and the reader is left with his doubts still active and his curiosity unsatisfied.

Turning from Tyndall's findings to consider in a critical spirit M. Heyninx's work on the ultra-violet theory, we are disposed to ask why it is that the orthodox experiments on the ultra-violet rays have not been applied to odorous vapours.

It is true that the ultra-violet rays are absorbed by the atmospheric air; nevertheless, their absorption does not take place so rapidly as to prevent their being subjected to experimental investigation as rays in an aërial medium. That being so, we are entitled to ask why our author has not shown their direct action upon the photographic film. He

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has undertaken photographic experiments, it is true, but not with the view of demonstrating the presence of ultra-violet rays in odours.

Secondly, we ask, do odorous vibrations communicated to the ether obey like ultra-violet rays the laws of light in being capable of reflection (by quartz mirrors) and of refraction (through quartz prisms)?

Thirdly, do they traverse a vacuum unaffected?

Fourthly, are they or are they not obstructed by the interposition of quartz or tourmaline, substances which are not opaque to ultra-violet rays?

M. Heyninx, however, we must add, assumes that the ultra-violet rays emitted by odorous molecules are very rapidly absorbed by the air, so that they cannot affect the olfactory end-organ in the nose unless they are brought very close to it.

But what influence does the mucus of the nose exercise upon ultra-violet rays? Blood-plasma, we know, absorbs them.

Finally, if we admit that the intra-molecular atomic vibration is the cause of odour, and that, as M. Heyninx states, contact between the odorous molecule and the nasal mucus covering the olfactory end-organ is necessary, why drag in ethereal waves at all? Why should not the atomic vibration be considered as acting directly upon the olfactory end-organ? This possibility, which we find difficult to exclude, brings us round again to something very like the old chemical theory. Obviously, the whole debate is one which deals with the vague and ill-defined boundary line where chemistry and physics meet and mingle.

The need for clearing up these doubtful points we commend to M. Heyninx, and we conclude our long but very imperfect summary of his fascinating book with an expression of gratitude to him for a powerful effort to throw new light into a corner of our workroom which has been too long left in obscurity and neglect.

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