

A Few Important References.

¹ Frye, T. C. "Development of the pollen in some *Asclepiadaceae*." *Bot. Gaz.*, **32**, 325, 1901.

² Willis, J. C. Cambridge Biological Series: "Flowering Plants and Ferns," 1925.

³ Coulter and Chamberlain. *Morphology of Angiosperm*, 2.

The Physics of Olfaction.

NUMEROUS workers since Liégois and Prevost have tried to formulate a physical basis for smell, Teudt's (1919) electronic theory being one of the most recent. It is unlikely that a satisfactory theory would be derived from a consideration of physics alone, owing to the psychological and other factors intimately bound up with the oldest and most neglected of our senses. However, it is not correct to say that no physics of olfaction exists at all.

In 1904 Berthelot suggested that the lower limit of the number of molecules perceptible by smell lay between 10^8 and 10^{11} . Zwaardemaker and Heyninx arrived independently at a figure of the order of 10^9 . Lord Rayleigh, following Töpler and Boltzmann, equated the energy of minimal stimuli of sound and light at about 40 ergs, which, in the case of sound, can be expressed as a change of compression of the order of 10^{-10} atmospheres. Assuming an olfactory inspiration of about 1 cubic inch, this figure is of the same order as the smallest number of odorous molecules which require to be drawn into the nasal passage to excite the sense of smell, as I have shown in the *Perfumery and Essential Oil Record*, **17**, 1926, p. 176.

The quantity of odorous material perceptible to the nose may be inconceivably small when expressed in fractions of a milligram, yet be numerically large if regarded as a number of molecules. The molecules in a cubic inch of ordinary air would form a line many times longer than the circumference of the earth, if they were placed side by side, but a number of molecules perceptible by smell could be strung along a length of less than a meter. For comparison with the intensity of sound stimuli, it may be of interest to mention that a crowd of a hundred thousand persons would need to shout for an appreciable period to emit as much sound energy as would equal the heat in a cup of tea.

Tyndall suggested a theory of odour based upon the heat absorbed by odorous

substances. Grijns in 1919, and the writer more recently, have shown that the heat absorption of essential oils can be referred almost entirely to an adventitious content of water. A physical investigation of odorous substances at the concentrations at which they are perceptible to the nose would require very delicate apparatus, as it would be necessary to deal with partial pressures of considerably less than a millionth of an atmosphere.

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On the Development of the Intervertebral Ligament in Teleostean Fishes.

MACBRIDE¹ in summarising the observation of Ramanujam³ on the development of the vertebral column of herring, states with reference to the formation of the intervertebral ligament that "the notochordal tissue intervening between the chorda centra projects as a series of gelatinous pads which are ultimately transformed into intervertebral ligaments". The various species of teleostean fishes that I have studied so far present, however, a different story altogether.

The sclerotomic cells aggregate round the notochord as perichordal sheath; soon after this, the perichordal sheath of the vertebral portions becomes osseous, while the intervertebral portions remain membranous (Fig. 1). Outside these membranous intervertebral portions of the perichordal sheath, migratory connective tissue cells become arranged side by side into three bands and these enter the membranous portions of the perichordal sheath (Fig. 2). I^{2(a) & 2(b)} have shown how such migratory connective tissue cells enter through the intervertebral portions of the vertebral columns both in Urodela and Anura in order to form ophisthocœlous and procœlous vertebræ respectively. The middle band of the connective tissue cells situated at the intervertebral portions of the teleostean fishes, contributes to the formation of the intervertebral ligaments, whereas the two lateral bands of the connective tissue cells which ultimately become cartilaginous give rise to the formation of the two surfaces of the centrum. This sort of formation of the intervertebral ligaments