We would suggest that these correlations (together with those reported in a previous paper[1]) offer further presumptive evidence that the six-layered pattern of the geniculate nucleus (that is, two sets of three layers for the two eyes) may be related to colour vision. However, further and more detailed correlations need to be established, and much more experimental evidence is required in order to put our thesis to a crucial test.

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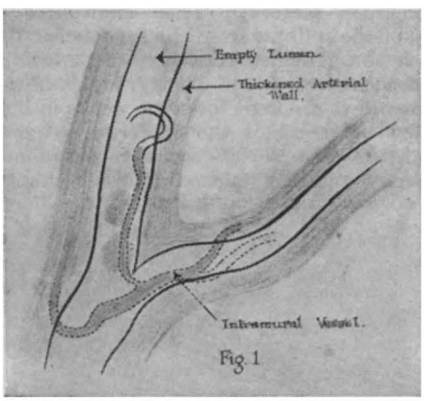
May 27.

[1] Le Gros Clark, W. E., *J. Anat.*, **75**, 225 (1941).
[2] Le Gros Clark, W. E., *Trans. Ophth. Soc.*, **62**, 229 (1942).

Intramural Vessels in the Retina (Vasa vasorum)

Investigating ocular tissue of man and of some animals by a clearing method during the last seven years, I have found intramural vessels in retinal arteries and veins. They were discovered in bulk specimens, their existence proved later on by reconstruction of serial sections. Intramural vessels in the retina run within the wall parallel to the lumen or encircling it or in spirals around it. They often branch and the twigs frequently reunite. I have not found them so far in the retinal vessels of young healthy human beings. Intramural vessels have been described in atheromatous diseased coronary arteries of the heart[1]. The purpose of these newly built retinal vessels in some cases may be to bypass an obstacle in the bloodstream. In other cases with intramural vessels, however, the retinal arteries show hyaline sclerosis with preservation of the lumen. It is possible that in the latter case the intramural vessels act as vasa vasorum and improve the insufficient nourishment of the changed vessel wall. They are considered as an attempt at healing of the sclerotic process. A detailed account of these findings will be published elsewhere.



Intramural vessel in a sclerotic retinal artery, seen in bulk, cleared with glycerin. Unstained. × 75

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May 12.

[1] Winternitz, Thomas, and Le Compte, "Biology of Arteriosclerosis" (Ch. C. Thomas, Springfield, Ill., 1938).

Transient Reception and the Degree of Resonance of the Human Ear

It is now more than eighty years since Helmholtz[1] gave a functional explanation of the architecture of the cochlea, and at the same time supplied a plausible physical basis for the extraordinary pitch discrimination of which the human ear is capable. Recent authorities have implicitly or explicitly rejected Helmholtz's explanation of pitch discrimination. For example, Stevens and Davis[2] say "Everything considered, then, we must conclude that the inner ear is highly damped and that this damping impairs its resolving power in the analysis of sound waves" (p. 287); and elsewhere it is implied that the damping is critical. We cannot here consider the evidence adduced by Stevens and Davis and by others in favour of high damping of the cochlea, and must limit ourselves to the blunt statement that it is inadequate. It is the purpose of this letter to put forward evidence, independent of pitch discrimination, which unequivocally supports Helmholtz's original belief.

We shall use the familiar parameter Q to describe the behaviour of resonators. For all simple resonators there is a resonant frequency, f_0, and a value of Q which is finite and positive. If such a resonator is in forced oscillation, and the frequency of the impressed force is altered from f_0 to $f_0 \pm (f_0/2Q)$, the oscillatory energy stored in the resonator is halved. Q is a measure of the selectivity of the resonator, and when Q is small the resonator is said to be heavily damped. In particular, when $Q = 0{\cdot}5$, it is said to be critically damped. For $Q > 25$ the resonator is said to be lightly damped, and when the impressed force is removed the resonator will continue to oscillate at a frequency which differs from f_0 by less than 1 per cent, and with an amplitude diminishing by $1/e$ every Q/π cycles.

Now let it be assumed that the fibres of the basilar membrane are lightly damped and independent resonant elements arranged, as Helmholtz supposed, like piano wires in ascending order of frequency from the apical to the basal end of the membrane. Further, let it be assumed that for each fibre a particular finite amplitude of oscillation is necessary to produce an audible sensation. Then, if the threshold sound intensity for a continuous pure tone is known and if a value for the Q of the fibre resonant to that tone is assumed, the threshold of audibility for a pulse consisting of any integral number of half-periods can be predicted. Conversely, if the threshold for such pulses can be measured experimentally, the Q can be determined.

We have performed this experiment for a number of frequencies between 1 and 10 kilocycles per second, and for pulse-lengths ranging from 2 oscillations to 250 oscillations. In the accompanying figure the smooth lines are calculated for a number of values of Q. The points are experimental determinations at the frequencies indicated. Considering the well-known difficulty of obtaining reproducible results from subjective auditory measurements, the scatter is small and the agreement with the predicted slope satisfactorily close. We are therefore justified in ascribing to the resonators of the cochlea a Q of about 200–350 from $2\frac{1}{2}$ to 10 kilocycles, falling to about 50 at 1,000 cycles. For technical reasons we have not been able to make measurements at frequencies much below 1,000 cycles, but it is extremely likely that the Q continues to fall with frequency. If it were the same at 100 c./s. as at 10,000 c./s.,