membrane into the scala tympani. It may be due to some oversight on my part, but I cannot see how there is a difference of pressure on the two sides when the column of liquid is a continuous one. This is a fundamental question in the Wrightson theory. It may further be pointed out that if the vibrations in the liquid to which the basilar membrane responds are the same as those of sound, there is naturally no difficulty with regard to hearing through the bone when the stapes has become fixed.

In the third place, objections made to the possibility of the basilar membrane acting as a series of resonators seem to me to have forgotten some facts pointed out by Helmholtz himself. The rate of vibration of a string is related, not only to its length, but also to its tension, and there is no reason why the range of the basilar membrane should not be increased by being more tightly stretched at its narrower end. So far from it being necessary to have a series of separate strings, Helmholtz demands only that a membrane of the shape of that of the basilar membrane should be more tightly stretched transversely than longitudinally, and in an appendix to the "Tonempfindungen" he gives a complete mathematical analysis of the vibration of such a membrane. I regret that this is beyond my mathematical capacity, but we may surely accept it. Prof. McKendrick has shown experimentally that resonance is possible in membranes immersed in water, as would be expected from theory.

On the other side, Held has stated that a single fibre of the cochlear nerve may supply a comparatively long stretch of the basilar membrane—undoubtedly a difficulty in the Helmholtz view. But the statement requires confirmation, and it must be a matter of great difficulty to decide it.

The explanation of the way in which the movements of the basilar membrane are altered in direction so as to stimulate the hair-cells is given very clearly by Sir Thomas Wrightson, and I have no objections to make to it. On the other hand, it is not clear why there are so many Corti arches and nerve-fibres present. One would have thought that a few would suffice to transmit the vibration if it occurs throughout the membrane at the same time and in the same form, no analysis taking place.

Sir Thomas Wrightson does not refer in his book to the interesting experiments of Yoshii, who found localised lesions in the organ of Corti as a result of prolonged exposure to a musical note.

Prof. Keith describes in great detail the minute structure of the organ of Corti, and states that various structures conform more to what is demanded by the Wrightson theory than to that of Helmholtz. I would demur somewhat to his view that every structure must have its function, although with deference to Prof. Keith's wide knowledge of the question.

It must be admitted that there are objections to be brought to both theories; but, on the whole, it seems to me that there are no vital ones to that of Helmholtz, whereas there are some to that of Sir Thomas Wrightson unless a satisfactory answer is forthcoming to those pointed out above. W. M. BAYLISS.

University College, London.

Rainbow Brightness.

It would, I suppose, be very difficult to compute theoretically the brightness of any selected part of a rainbow in terms of the sun's actual brightness.

But it occurred to me that we might compute the relative brightnesses of two selected portions of the primary and the secondary bow, simultaneously presented and situated along a common radius. The luminosities would be due to the same sun, and to raindrops of practically the same size, so that any

differences would arise from the fact that for the primary bow there is one internal reflection, but for the secondary there are two, and from the fact that the angular constants differ. This difference in the angles will affect both the polarisation and the intensities of the light reaching the eye, and will also increase the breadth of the secondary bow to about 1.61 of that of the primary, thus further reducing the brightness of the secondary.

But by restricting attention to portions of the red in each bow, situated along a common radius, I think we may leave out of account the influence of the increase in breadth.

Let P , S denote the brightnesses of the two portions selected (along a common radius) from the red of the primary and of the secondary bow. Then, using Fresnel's formulæ, with $\mu=4/3$, I get

$$P = \frac{k}{22.40}, \quad S = \frac{k}{52.20},$$

where k is an unknown factor. Thus $P/S=2.33$ for the relative brightness of the red of the primary to that of the secondary, as viewed by the naked eye.

Now the light of both bows is very considerably polarised in the planes of reflection, which are radial and pass through the sun, the eye, and the element of arc observed. For the primary, 96.69 per cent. is polarised in, and only 3.31 per cent. polarised perpendicular to, the reflection plane. For the secondary, the corresponding quantities are 90.64 per cent. and 9.36 per cent.

Through a Nicol prism, placed first so as to transmit the "in" light, and next so as to transmit the "perpendicular" light, we get for the primary bow

$$\frac{P(\text{in})}{P(\text{perp.})} = 29.20.$$

Similarly, for the secondary bow:

$$\frac{S(\text{in})}{S(\text{perp.})} = 9.69.$$

Thus for the two positions of the Nicol the primary bow is reduced about twenty-nine times, and the secondary nearly ten times.

I have often experimented on the primary bow, and the element of arc practically disappears for the second position of the Nicol. I hope to experiment similarly on an element of arc of the secondary bow, which, though losing a smaller fraction of its light, is originally fainter than the primary, and so may also be expected to disappear, though for the "perpendicular" azimuth of the Nicol the remnant left of the secondary bow is a trifle (1.21 times) brighter than that of the primary.

Finally, we can compare the brightnesses of the bows, first with the Nicol in, and next with the Nicol perpendicular to, the polarisation plane:

$$\frac{P(\text{in})}{S(\text{in})} = 2.49,$$

so that the relative brightness with the Nicol slightly exceeds 2.33, that to the naked eye, when the Nicol transmits its maximum of each.

$$\text{Next, } \frac{P(\text{perp.})}{S(\text{perp.})} = 0.83,$$

so that the primary bow, as already stated, is slightly fainter than the secondary, when each is reduced by the Nicol to its minimum value. It would be of interest to test these cases by observation.

For the red light I gave 2.33 as the ratio of P to S for the naked eye. But to me the primary bow, viewed generally, appears brighter than this in comparison with the secondary. It is very difficult to make any true comparison on account of the varied colours. If we may assume that the secondary bow,

owing to its greater breadth, is additionally weakened by the factor 1.61, we obtain $P/S=3.75$ for a rough estimate of the relative brightness without restriction to any particular colour.

So far I have not met with any published estimates of the relative brightness of the bows or of the precise character of their polarisation, so that these figures may be of interest. CHAS. T. WHITMELL.

Invermay, Hyde Park, Leeds, October 4.

An "Arbor Day."

At the meeting of the conference of delegates from provincial scientific societies to the British Association, held on July 4, a resolution was passed establishing October 21 as an "Arbor Day," and all the delegates present pledged themselves each to plant a tree if possible on that day, and to endeavour to induce members of all their societies and others to do the same. The time is now approaching for this to be carried into effect, and this letter is intended as a reminder.

By the wholesale cutting down of trees in this country during the last few years the scenery of our few woodland areas is losing its beauty, and we are greatly entrenching upon our very small reserve of timber. Although it is only by State action that the re-afforestation of our country can be adequately effected, it is hoped that by the carrying out of this resolution some little benefit may be derived, and that year by year our "Arbor Day" may remind us of the paramount necessity of augmenting our home supply of timber.

JOHN HOPKINSON.

Weetwood, Watford, October 14.

Students' Microscopes on Loan.

WE are conducting science classes on the lines of communication in France, and it has been suggested to us that some of your readers might care to loan students' microscopes for use in this work. If any who possess such instruments care to help us in this way, I shall be glad to hear from them. It will be understood that the instruments will be carefully kept and returned intact when finished with.

RICHARD WILSON,

The Librarian, Red Triangle Library.

Wimborne House, Arlington Street, S.W.1.

THE FUTURE OF THE COAL TRADE.

THE Coal Conservation Committee of the Ministry of Reconstruction has recently issued its final report, which forms, it need scarcely be said, a document of first-rate importance. Its form is decidedly curious, inasmuch as the report in itself is confined to a bare statement of the action taken by the Committee in appointing sub-committees, and the general adoption of the reports of these sub-committees, which are printed as appendices to the report; these reports are by the Power Generation and Transmission Sub-Committee, the Geological Sub-Committee, the Mining Sub-Committee, and the Carbonisation Sub-Committee. Of these the final report of the Mining Sub-Committee is undoubtedly the most interesting, and the most valuable in so far as it contains a number of recommendations of great technical and economic importance. Indeed, the reference to this sub-committee, which instructs it "to consider and advise what improvements can be effected in the present methods of mining coal

with a view to prevent loss of coal in working and to minimise cost of production," covers a subject of most vital importance to the entire nation. British industrial supremacy is built up essentially upon a cheap and abundant coal supply, and whenever that supply becomes either less than sufficient for British industrial requirements, or more expensive than that of competing nations, Britain will cease to be a first-class Power. The safety and welfare of the nation thus depend so absolutely upon the coal supply that the recommendations of the Committee charged with its consideration assume a character of wide national interest.

The two principal subjects discussed are the loss and waste of coal and the cost of production. The former is subdivided into waste at the pit-head and loss underground. Waste at the pit-head is essentially confined to the excessive amount of coal used for colliery consumption. Relatively complete returns, representing 97 per cent. of the coal output of the country, have been obtained, so that tolerably trustworthy data are available, though it may be readily granted that the collieries that have failed to make returns are those at which the consumption is unduly high. The average colliery consumption for the kingdom is given as 6.8 per cent. of the output, or 18,400,000 tons of coal; in one of the other reports an estimate is given of the power employed in the mines and quarries of the United Kingdom, which is stated as 4000 million h.p.-hours. Taking this figure as due to the collieries alone, it would appear that our collieries consume no fewer than 10.3 lb. of coal per h.p.-hour, so that there is obviously room for much improvement. The report makes no reference to another source of waste, namely, the "free coal" which is allowed to coal-miners in some districts. Everyone who has had experience of these districts knows that the collier uses his free coal most extravagantly, and that quite considerable economies might be effected in this item without causing the slightest hardship, or even inconvenience, to the men concerned. Loss of coal underground is considered as arising from various causes, each of which is duly investigated.

The Committee considers that there has been a substantial improvement in respect of the small coal cast back into the goaf within the last ten years, and estimates the loss due to this cause as 0.91 per cent. of the output in 1915. It is obviously difficult to obtain accurate figures on this point, the collieries that are the worst offenders being, of course, those which furnish no returns, so that it is safe to say that the figures published by the Committee are below the actual wastage.

The only recommendation made is that a greater demand for small coal should be created—for example, by extending the market for briquettes. The present moment, when pitch is unusually cheap and the demand for household coal acute, is peculiarly suited to the generalisation of this convenient form of fuel, which has never come into public favour in this country, although it is deservedly popular on the Continent. This