the utmost difficulty in handling keys, setting instruments and entering my observations. Usually so laden was the air with moisture and so very dense and lasting was the cloud-fog that, even when no rain had actually fallen, all the fixings and instruments were dripping; and although, of course, I made a point of wiping the dry bulb, it almost immediately became wet again. Occasionally I timed the interval between wiping and fresh condensation on the bulb, and have found it wet again within *thirty seconds*.

After November 1, then, I had to discontinue the work. The hut had become choked with snow, and the carrying on of the undertaking satisfactorily impossible. I was, however, satisfied; and very pleased that I had secured five months' observations without the break of a single day.

It is not my part to refer in this paper to any results. Such I must in duty leave to be discussed and made known by the Scottish Meteorological Society. But, from what I myself know of the meteorology of Ben Nevis from the experience of two summers and autumns, I do most strongly urge the establishment of a permanent observatory on the summit, firmly believing that most important and unexpected results will accrue to meteorology from continuous observations there. Such, in connection with others at the sea-level, would in my opinion enable the energetic staff at the Meteorological Office, under Mr. Robert H. Scott's able direction, to forecast storms with far greater certainty.

I cannot conclude this account without expressing my best acknowledgments to Dr. Angus Smith for placing at my disposal his apparatus for measuring the actinism of light, which I consider an immense acquisition to a meteorological observatory; to Mr. John Browning for his rainband spectroscope; to Messrs. Negretti and Zambra for their clock-hygrometer; and finally to the Scottish Meteorological Society for the kind encouragement and liberal assistance they have given me.

CLEMENT LINDLEY WRAGGE

HYDROGEN WHISTLES

IT may be recollected by some of the readers of NATURE that a few years ago[1] I contrived a whistle for testing the upper limits of the power of hearing very shrill notes by different men and animals. When properly made, it easily suffices to do this, in the case of men and most animals, but it cannot, neither can any other instrument hitherto devised, emit such notes as it is conceivable that insects may hear. The problem whether any insects can hear notes whose numbers of vibrations per second is manyfold greater than those of the notes audible to men has not yet been fairly put to the test of experiment. I wish to show that this can now be done.

The whistles of which I speak have their lower ends closed with a piston that admits of being inserted more or less deeply, and thus of varying the depth of the whistle and consequently its note; but as a whistle will not give its proper note unless its depth be greater than its width, say, 1½ times as much, and as the depth of a whistle that gives, say, 24,000 vibrations per second is is only 0·14 inch, it follows that their bores must be very small, and that a limit of minuteness is soon reached.

Having had occasion lately to reconsider the subject, it occurred to me that I could greatly increase the shrillness of any whistle by blowing a gas through it that was lighter than common air.

The number of vibrations per second caused by whistles is inversely proportional to the specific gravity of the gas that is blown through them; therefore by the use of hydrogen, which is thirteen times lighter than air, the number of vibrations per second produced by a given whistle would be increased thirteenfold.

I have made experiments with most satisfactory results with common coal gas, whose specific gravity, though much greater than that of hydrogen, is not much more than half that of common air, and I have little doubt in consequence that a number of vibrations may be excited by one of my small-bore whistles through the use of hydrogen gas, that very largely exceeds the number attainable hitherto in any other way. They would of course fail to excite the sense of sound in any of ourselves, or perhaps to produce any physical effect that we can appreciate, whether on sensitive flames or otherwise, and the note to those creatures, if any, who could hear it, would be feebler on account of the lightness of the medium in which the vibrations originated, but it would be (so far as I can anticipate) a true note, and ought to be powerful enough to be audible at the short distances at which small creatures may be tested. The whistle I used was made for me by Hawksley, 357, Oxford Street; its bore is 0·04 inch diameter, and it gives a loud note for its size. After some prefatory trials, I proceeded as follows:—I attached the whistle to a gas jet by a short indiarubber tube. Then, without turning on the gas, I retested my range of hearing by setting the piston at various lengths and giving sharp squeezes to the tube as it lay in the hollow of my hand. The effect of each squeeze was to force a little air through the whistle, and to cause it to emit a sharp "cheep." When I relaxed the grasp, air was sucked in through the whistle, and the tube became again filled with air, ready for another squeeze.

My range of hearing proved to be such that when the depth of the whistle was 0·13 inch, I could hear no musical note at all—only a puff; at 0·14 inch I could just perceive a very faint musical note enveloped, as it were, in much puff; even at 0·20 some little puff remained, but before 0·25 the note had become purely musical. This having been established, I kept the whistle set at 0·25 and turned the gas on, giving it abundance of time to expel all air from the tube. Then, turning the stopcock to shut the indiarubber tube from behind, I gave a sharp squeeze as previously, but the whistle, instead of emitting a pure note, gave to me just the same barely perceptible sound that it did when it was set at 0·14. I relaxed my grasp and instantly retightened it, and then the whistle emitted a pure note. A little common air had regurgitated into the whistle when my grasp was relaxed, and it was the reissue of this that gave the note. I repeated the experiment several times with the same result. With a depth of 0·24 I could hear no note at all when using the gas. Then I pulled out the piston to 0·35, and the gas gave a clear musical note; on the second squeeze the note was considerably deepened. The specific gravity of the gas from the jet, as calculated from these data, would be to that of the air at the time, as 14 to 25, or as 0·56 to 1. This happens to be the specific gravity of carburetted hydrogen, but that of common street gas is heavier. Perhaps my measurements were not quite accurate; probably the note given by the gas being really fainter (though not perceptibly so) than that given by air somewhat falsified the judgment. A very slight difference in the data would raise the 0·56 to 0·60 or more.

By the use of hydrogen the little whistle when set at 0·14 inches would produce 312,000 vibrations per second. I know by experiment on others that it will give a true musical note when made much shorter than this, and I see no cause to doubt that it will sound truly at half the above length, and therefore be capable of emitting twice the above enormous number of vibrations per second.

Mr. Hawksley is making for me an apparatus with small gas bag for hydrogen pure or diluted, valves, and an indiarubber ball to squeeze, to enable hydrogen to be used with the whistle when desired. The whistle is

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[1] "South Kensington Conferences, in connection with Loan Exhibition of Scientific Apparatus, 1876," p. 61.

fixed to the end of a small indiarubber tube in order to be laid near the insect whose notice it may be desired to attract.

FRANCIS GALTON

PRELIMINARY NOTE ON THE BACILLUS OF TUBERCULOSIS (KOCH)

I. THE absorption and consequent retention of certain stains by this bacillus does not appear to be effected by the hydrates of potassium, sodium, and ammonium and by aniline alone. Sodic phosphate, potassic acetate, vegetable alkaloids, &c., appear to exert a similar action. Further experiments are in progress. I have some very good preparations which were rapidly stained with a *very faintly* coloured stain containing sodic phosphate (sod. phos. cryst. B.P.).

II. The sections of tissue shown (by the kind arrangement of Mr. Blaker) at the Brighton meeting of the British Medical Association, in which the bacilli were very distinct, were stained, &c., then floated on to the glass slides, *dried over concentrated sulphuric acid* (or fused $CaCl_2$), and mounted in balsam. Hitherto my attempts to fix the colour of the bacilli, by means of a mordant, in such a way that it might remain unaffected by alcohol, and by oil of cloves, have not proved successful.

III. Treatment with a solution of potassic acetate will probably prove well adapted to free preparations from those last traces of nitric acid which so often cause their ultimate destruction.

From (II.) I should omit a very beautiful and remarkable preparation showing the spores of this bacillus in the lymphatics of the lung. This slide was prepared by Dr. Barron, of University College, Liverpool, and for his kindness in lending it to me and for much invaluable advice I am very grateful.

To Mr. Blaker, M.R.C.S., of Brighton, and to Mr. Black, M.R.C.S., of the Sussex County Hospital, I am under many obligations for their kindly interest and assistance.

J. W. CLARK

THE SHAPES OF LEAVES[1]

III.—*Origin of Types*

THE two most general and distinctive types of foliage among angiosperms are those characteristic of monocotyledons and dicotyledons respectively. They owe their principal traits of shape and venation to the manner in which these two great fundamental classes have been separately evolved from lower ancestors.

Mr. Herbert Spencer has shown that there are two chief ways in which a central axis or caulome may conceivably be developed from an integrated series of primitive stalkless creeping fronds. The *first* way is by the in-rolling or folding of the fronds so as to form a complete tube, often with adnate edges, as represented in the accompanying diagram (Fig. 20), modified by Mr. Spencer's kind permission from the "Principles of Biology." For details of the explanation, the reader must be referred to that work (vol. ii. part iv. chap. iii.); it must suffice here to note that as in such case each frond must envelop the younger fronds within it, the process is there shown to eventuate in an endogenous stem and a monocotyledonous seed—two characteristics found as a matter of fact constantly to accompany one another in actual nature. The *second* way is by the thickening and hardening of a fixed series of midribs, as shown in the next diagram (Fig. 21), also modified after Mr. Spencer; and this method must necessarily result in an exogenous stem and a dicotyledonous seed. The diagrams in Figs. 22 and 23, which represent according to Mr. Spencer (slightly altered) the development of the monocotyledonous and dicotyledonous seedling respectively, will help further to illustrate the primitive characteristics of the two types.

The monocotyledonous type of foliage is for the most part extremely uniform and consistent, in temperate climates at least, for in the tropics the presence of large arborescent forms, such as palms and screw-pines, as well as of gigantic lilies, amaryllids, and grasses, such as the bananas, yuccas, agaves, and bamboos, gives a very distinctive aspect to the *ensemble* of the class. Being in principle a more or less in-rolled and folded frond, every part of which equally aids in forming the caulome or stem, the monocotyledonous leaf tends as a rule to show little distinction between blade and leaf-stalk, lamina and petiole. For the same reason, the free end also tends to assume a lanceolate or linear shape, while the lower part usually becomes more or less tubular or sheathing in arrangement. Again, for two reasons, it generally has a parallel venation. In the first place, since the leaves or terminal expansions are mere prolongations or tips to the stem-forming portion, it will follow that the vascular tissues will tend to run on continuously over every part, instead of radiating from a centre which must in such a case be purely artificial. In the second place it is clear that parallel venation is the most convenient type for long narrow leaves, as is plainly shown even among dicotyledons by such foliage as that of the plantains, descended from netted-veined ancestors, but with chief ribs now parallel. Still better are both these principles illustrated in those cases among dicotyledons where the lamina is suppressed altogether, and the flattened petiole assumes foliar functions, as in *Oxalis bupleurifolia* and *Acacia melanoxylon* (Fig. 24). These phyllodes thus resembling in their mode of development the monocotyledonous type, and continuous throughout with the caulome-portion of the primitive leaf, exhibit both in shape and venation the chief monocotyledonous characteristics. A typical monocotyledon in shape and venation is represented in Fig. 25.

The dicotyledonous type, though far more varied, is equally due in its shape and venation to the original characteristics implied by its origin. Only the midrib instead of the whole leaf being here concerned in the production of the stem, there is a far greater tendency to distinctness between petiole and lamina, and a marked preference for the netted venation. The foliar expansion is not here a mere tip; it becomes a more separate and decided element in the entire leaf. And as the petiole joins the lamina at a distinct and noticeable point, there is a natural tendency for the vascular bundles to diverge there, making the venation palmate or radiating, so as to distribute it equally to all parts of the expanded surface. Fig. 26 shows the resulting characteristic form of dicotyledonous leaf. Its variations of pinnate or other venation will be considered a little later on.

Among monocotyledons, the central type is perhaps best found in the mainly tuberous or bulbous orders, such as the orchids, lilies, and amaryllids. These orders, having rich reservoirs of food laid by underground, send up relatively thick and sturdy leaves; but their shape is decided by the ancestral type, and by their strict subordination to the central axis. Hence they are usually long, narrow, and rather fleshy. Familiar examples are the tulips, hyacinths, snowdrops, daffodils, crocuses, &c. Those which have small bulbs, or none, or grow much among grass, like Sisyrinchium, are nearly or quite linear; those which raise their heads higher into the open, like Listera, are often quite ovate. Exotic forms (bromelias, yuccas, agaves) frequently have the points sharp and piercing, as a protection against herbivores. In the grasses there is generally no large reservoir of food, and their leaves accordingly show the central type in a stringy drawn-up condition. So also in sedges, woodrushes, and many others. But where the general monocotyledonous habit has been more lost, and something

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[1] Continued from p. 466.