This question of the reason of symmetrical organs having different functions might perhaps be elucidated by a study of the conditions under which deviation from bilateral symmetry occurs in the *structures* of animal life, even among the highest arthropods and vertebrates. P. S.

May 23

The "Chromatic Octave"

RENEWED attention to the "chromatic octave" tempts me to suggest an experiment. There used to be a gentleman, Smith, I believe, by name, who refuted the undulatory theory by means of a disc, divided into black and white ~~sections~~, which he whirled with very high velocities, producing colours (so the *Times* positively stated) varying according to the velocities. It is plain that such a result might on the contrary confirm the theory, if, for instance, the disc were divided into 400 black and 400 white sectors, and whirled at the rate of one or two million million times a second. It is also plain that Mr. Smith, in the words of an authority who has been quoted in your columns for weightier judgments, would have blown his disc into smoke first. But *once* a second is only 40 octaves below a million million times; and it is just possible that something practicable between the two might throw light on the "chromatic octave," among other things. There are some obvious objections: the question is, whether they make it worth while to repeat Mr. Smith's experiments.

I have just received the number of *Poggendorff* (Oct. 1867, CXXXI.) containing Professor Listing's paper (p. 564), referred to by Mr. Barrett in NATURE for Jan. 13 and March 31. I did not expect it would support Mr. Barrett, but I was surprised to find how directly it contradicts him. "Listing," he says, "concludes that, although physiologically and psychologically there may be differences, yet there is an indisputable *physical* basis for the analogy between tones and colours." I had myself, at the end of my remarks in NATURE for Feb. 3, admitted the "physical basis" in that sense "of the word *physical* which excludes biological relations," and the remark is too trivial to have formed Listing's *conclusion*. It forms part of a sentence in the first page of the paper. "The analogy between tones and colours, which has often been pursued with excessive predilection, and which certainly has an indisputable physical basis, has against it numerous points of disagreement (*Discongruenzen*), even now not in general sufficiently attended to, which depend rather on the physiological and psychological aspect of the phenomena." In the same page of the number it clearly appears how much is meant by the *physical basis*. "Physically," he says, "it is the period of vibration that determines both tone and colour; but the physiological effects stand in very different relations to the common element in the two cases." He proceeds to show, as correctly explained by Mr. Barrett, that the several colours divide the spectrum in an arithmetical progression of their rapidities of vibration; and at the end of the paper, contrasting this phenomenon with the geometrical progression of a uniform series of tones, he says: "This point of disagreement, a very vital one in my opinion, between the scales of tone and colour, may be briefly stated thus: *In the musical scale* (chromatic and with equal temperament*) *the logarithms of the tones are in arithmetical progression, in the scale of colour the colours themselves.*" That this should mean what Mr. Barrett understands it to mean, you must read *agreement* for *disagreement*.

Of the reality of Listing's result, I suppose there can hardly be any doubt; and I am glad that Mr. Barrett has corrected my suggestion that it probably represented a conventional demarcation. There does seem something arbitrary in the number of divisions made, but their positions represent a mean among the impressions of different observers as to the boundaries between colours answering to the names assigned; and the accuracy of these determinations may be fairly estimated by likening them to the case of a person who, having to divide a space of nine inches into nine equal parts, should be correct *as often as not* within one 24th of an inch. But the most important point is this, that the observers would not be aided, but must rather have been distracted, by the spaces actually occupied by the colours in the spectrum. For the observations were made on two different spectra, the irregular one obtained from the prism, and the diffraction spectrum in which the colours proceed uniformly by wave-lengths; and the result was a division into equal spaces, not on either of these visible spectra, but on the ideal spectrum, which should proceed uniformly by rapidities of vibration. It would have been in the spirit of good German precedents if we had been given some measure of the variation between different observers.

It must be confessed that all this is damaging to the theory of a "chromatic octave," essentially a theory of geometrical progression. Still more obviously damaging is the fact that "lavender" would be the octave above something so unlike it as "brown," or "brown" and "red."

Mr. Murphy's argument (NATURE, April 28) seems to assume that complementary wave-lengths must be in *some* constant ratio. His theory is, at any rate, inconsistent with his author's; for primary red and blue would be nearly complementary, so that "true white" could not be produced by any mere preponderance of blue, and would be white only to the green-blind.

May 9. C. J. MONRO

* If this is what is meant by "chromatischen gleichschwebenden."

IN Mr. Murphy's interesting letter in No. 26 of NATURE, April 28, 1870, he assumes that the number expressing the frequency of vibration producing a colour complementary to another, is the geometrical mean between the frequency of vibrations corresponding to that other, and its double. By this means he does not get colours complementary from sunlight. Thus red and bluish green (whose numbers are respectively 36·4, 48·3) are not complementary on his hypothesis; which would require the number for bluish green to be 51·47. So for yellow and indigo, the numbers are 41·4, 54·7, but should be 41·4, 58·4. This he attributes to the impurity of the solar spectrum. There seems as much reason, however, for taking the *harmonic mean* instead of the geometric; and, on this supposition (the harmonic mean between two quantities being twice their product divided by their sum), the numbers would be red, 36·4; bluish-green, 48·5; yellow, 41·4; indigo, 55·2. The second and fourth, 48·5, 55·2, are not very different from 48·3, 54·7. Taking then a colour twice over in the spectrum and its intermediate complementary, the relation between the three would be that of a musical note, its fifth and its octave.

Little Wratting, Suffolk, May 16 M.A.

The Colour of the Moon by Day and by Night

CAN any of your readers give me a full explanation of the reason why the moon looks white by day and yellow by night? The light that proceeds from it is of course the same at both periods; whence does the change in appearance arise? Two reasons occur at first thought, but they do not completely satisfy the many requirements of the problem. The one is, that the light, being really somewhat yellow, though less so than it often appears to be, passes in daytime through an atmosphere made blue by the solar rays, and the blue and yellow neutralising each other, the moon looks white. The other reason is, that as the evening closes in, the twilight becomes purple, and the moon being but moderately yellow in itself, looks more intensely yellow by contrast. All this is correct so far as it goes; but I do not see why the moon should often look extremely yellow in the middle of the night after twilight has quite disappeared. Does it show that the light, one knows not exactly whence it comes, which is found even on clouded and moonless nights, is purple? There are some grounds for this hypothesis, because the moon almost always, as I have been assured by a practical astronomer, looks comparatively white through a telescope, which of course isolates the field of vision. Also, it seems to me that the street gaslights are just as yellow at midnight as in twilight; the stars, also, commonly look yellow all the night through. It is strange that the very frequent and beautiful phenomenon of the white moon of the day suddenly turning yellow as the evening closes in, should not have long since attracted scientific comment.

F. G.

What is a Boulder?

A CORRESPONDENT in your journal of the 26th of May inquires about the size of boulders, and states that he cannot find any definition of the word which gives a notion of its size accurate enough for scientific purposes.

There are several definitions of boulder-stones given by geologists and others, which determine their size within tolerably narrow limits.

Dr. Page defines boulders as being "any rounded or water-worn *blocks* of stone, which would not, from their size, be regarded