wisest men, disregarding at this juncture mere scientific claims. The council should select for presidents at this time not representatives of science as merely to do honor but men of large experience and sympathy with the association affairs. It is of less consequence what the public thinks about the association than what we shall do for ourselves.

Realizing the gravity of the condition at this critical time the council will make wise decisions only after full discussions in a generous spirit; and the membership should in patience trust the collective wisdom of the council.

HERMAN L. FAIRCHILD.

ROCHESTER, N. Y.,
December, 1904.

'THE PROBLEMS OF EXPERIMENTAL PSYCHOLOGY.'

TO THE EDITOR OF SCIENCE: On p. 788 of your issue of December 9 (second column, line 8), I am made to speak of 'classification *a posteriori*.' What I wrote, what the sense requires, what I saw in proof, and what I left in proof, was 'classification *a potiori*.' On p. 794 (bottom of first and top of second columns), I am made to say: 'we analyze and trace to their conditions total consciousness.' What I wrote, what grammar requires, what I saw in proof, and what I left in proof, was 'consciousnesses.' A little knowledge, even in a proof-reader, is a dangerous thing.

E. B. TITCHENER.

CORNELL UNIVERSITY,
December 10, 1904.

[The errors probably would not have occurred if Professor Titchener had returned his proof to the editor in accordance with the instructions accompanying it. It was sent directly to the printers.—ED.]

## *SPECIAL ARTICLES.*

### A SUGGESTION LOOKING TOWARDS ULTRA-MICROSCOPY.

THE visibility of an object both to ordinary vision and when helped by telescope or microscope depends upon a favorable combination of several physical conditions. (1) The object must send us ethereal waves whose lengths lie between the limits of 0.38 and 0.76 microns or the violet and red ends of the spectrum respectively. (2) The difference between the intensity or color of these waves and those coming from the adjacent background must be appreciable to our nervous system. (3) The focus on the retina must be sharp. (4) The duration of the image on the retina, or, as the photographer would say, the length of the exposure, must be long enough to enable the brain to appreciate the details of the image.

By means of photography we are able to make long exposures and the fourth condition can be satisfied to such extent that fleeting pictures are caught by instantaneous exposures, while the faintest nebulæ and stars are caught by exposures that last many hours. Becquerel's first photograph by the rays that are called after his name was by an accidental exposure of many days.

By means of the schleier method, originally due to Foucault, we can overcome the difficulties of the second condition and photograph moving air waves when properly illuminated, and this method can be applied to microscopic objects and liquid substances as well as to the larger motions of the air that have been photographed by Mach, DuBois and others.

The ultimate limit of visibility is also defined by the second condition or the wavelength and intensity of the illuminating light that can affect the retina, or the sensitized photographic plate. An object that is visible by monochromatic violet light may not be visible by monochromatic red light or *vice versa*, just as a body that can vibrate to a given high pitch is often too small to send out a low note. An ear that is too dull to hear the low notes may hear a high pitch. Our retina is so constructed as to be insensible to ultra-violet light, but we can by fluorescence make short waves become visible, *i. e.*, an object illuminated by ultra-violet light whose wave-lengths may be anywhere from zero to 0.38 microns may be too small to be directly affected by long waves, but will, by fluorescence convert the short waves into longer ones whose lengths may be any given multiple of the ultra-violet wave, and will, therefore, be visible to us if the length of the multiple lies between 0.38 and 0.76.

If, therefore, for botanical, physiological and bacteriological work we stain our preparations with fluorescent substances and illuminate with ultra-violet light, we shall bring into prominence smaller particles or structures than can possibly be seen with the ordinary white or colored light. Or, if we prefer, instead of the retina we may expose a sensitized plate, especially one that is sensitive to the particular fluorescent waves excited by the special ultra-violet light that we employ.

But the success of this modification of the ordinary methods depends also upon having our microscope lenses so ground as to correct for the particular waves that we are employing. In fact, one may conceive that an ultra-violet wave of, for example, 0.09 microns may by fluorescence excite a wave of 0.18, or 0.27, or 0.36 microns, and will, therefore, still be invisible to the eye, while perfectly competent to do photographic work. It will, therefore, be a great labor to grind the lenses properly, since their perfection can only be tested by experiments with invisible fluorescent rays; but when perfected these lenses and the photographs give us a power of what we may at present call 'ultra-microscope research.' The development of such work is limited only by the chemical and physical properties of atoms and molecules, and is not in any way affected by the limitations of the human eye.

The first steps toward realizing this advance in microscopy will naturally be made with the ordinary microscope, and the ordinary soluble fluorescent substances, among which we recall eosine, thallene, quinine, æsculine, chlorophyll, magdala red. If now with the fluorescent staining and ultra-violet illumination we combine the principles of the schleier method it would seem that there will in the future be no limit to the powers of research, except that which is set by the diffraction phenomena. The ultimate limit of actual photographic visibility will be of the dimension of one or two of the very shortest wave-lengths of ether, or of the same dimensions as the larger molecules themselves.

It is possible that Professor Ernst Abbe, of Jena, and his colleagues have been working along some line of thought similar to the preceding, as I notice that in the list of scientific instruments in the German educational exhibit at the St. Louis Exposition, page 213, mention is made of the ultra-microscopic work, but from what little is stated it would seem possible that this refers especially to the ordinary microscope combined with the schleier method; I have not as yet learned of any details and may be entirely wrong. The flood of ultra-violet light given out by the soft-iron electrodes of Dr. Piffard's tube and the magnificent fluorescent effects displayed by Mr. Geo. F. Kunz in his lectures suggested to me the preceding combination of fluorescence, the schleier method, and the microphotograph, and I have been encouraged to publish the idea.

To-day an interview with Dr. Sigfried Czapsky, a colleague of Professor Abbe's, has brought to my attention the fact that great improvements in ultra-microscope work are in progress at Jena, but not yet sufficiently developed to justify publication. I have, therefore, taken the liberty of sending you this communication in hopes that there will be some suggestion in it worthy the attention of these eminent opticians.

CLEVELAND ABBE.

WASHINGTON,
November 6, 1904.

### EXTINCT PEDICULATE AND OTHER FISHES.

WHILE engaged on chapters relative to the Pediculates for a work on fishes, I was extremely pleased to receive just what I wanted —further information respecting the former history of the order. I had received from Dr. C. R. Eastman an interesting 'Bulletin of the Museum of Comparative Zoology' entitled 'Descriptions of Bolca Fishes.' In that were figures and description of a form referred to '*Lophiidæ*' and named *Histionotophorus bassani* (Zigno). A close examination of the reproductions of photographic figures, however, convinced me that the fish was not one of the lophiids but a typical antennariid. The mode of fossilization showed that it was a com-