somewhat different from what Jastrow would make us believe. In the first class of sensations there are two reasons for the existence of a threshold, — a physiological and a psychological. As a balance has a certain limit of accuracy beyond which it does not show differences of weight of two bodies, so our organs of sensation are not able to show differences between stimuli varying only to a very small extent. This is the physiological threshold. But, besides, the advocate of the threshold theory says it is necessary that the sensations should differ to a certain degree, else they cannot be distinguished. He does not say, however, as Jastrow assumes, that the magnitude of this least perceptible difference is the same at any moment. On the contrary, it depends on the state of mind of the person, and varies just as Jastrow's sensibility varies, every moment having its own threshold, the average of which is the average threshold of the observer.

The theory of the threshold may be summed up in the following remarks: —

Two sensations are given, the difference of which is to be judged upon. The judgment can have various characteristics. Either a certain phenomenon is observed which has no immediate connection with the sensations to be compared (for instance, the line dividing two fields of various colors is observed), or the sensations are separate in space and time. In this case the conception of the former is compared with the latter sensation. In the former case the physiological threshold is the main consideration, and for this reason it may be omitted in these brief remarks.

In the latter case let the sensations S_1 and S_2 be given, which are produced by the stimuli s_1 and s_2. Let S_1 be the first to be observed. In making the comparison, S_1 will not be correctly remembered; but the probability that another and similar sensation, S_x, which would correspond to the stimulus s_x, is produced, will be

$$W_{S_x} = f(s_x, s_1, C)\, ds,$$

the constant depending upon the conditions of the experiment.

Experiments show that W increases when the difference between s_1 and s_x decreases. Further experiments show that when the two stimuli s_1 and s_2 differ but slightly, in a great number of cases the observer will judge $S_1 = S_2$. According to the theory of probability, W_{S_2} is only very small as compared to all other possible reproductions. Therefore the only possible explanation of the fact that the judgment $S_1 = S_2$ is comparatively frequent, is, that not only in those instances when the conception S_2 is reproduced are both judged to be identical, but that sensations varying only slightly from S_2 cannot be distinguished from it; and the task of psycho-physic methods is to find the limits of these variations. Mathematically the number of observations in which both sensations are considered the same is expressed by the following formula: —

$$W_1 = \int_{s_2 - \delta}^{s_2 + \delta_1} f(s, s_1, C)\, ds.$$

δ_1 and δ are the upper and lower thresholds respectively. This explanation agrees exactly with the observed fact, that slightly different stimuli cannot be distinguished; and Jastrow's objections are founded on a misconception of the mathematical basis of the theory. No advocate of the threshold theory assumes, as Jastrow supposes, that below the threshold the probability of a greater error is the same as that of a smaller error.

In another passage of his critique, Jastrow rejects the use of doubtful cases in the theory of right and wrong cases. It seems to me that his objections cannot be accepted. The fact is, that in a number of cases doubtful answers must be given. In his paper he says, and rightly, that the confidence is increasing with the difference of the sensations. Now, the answer 'doubtful' is nothing else than an expression of the degree of confidence; and, according to the above formula, the proper way to include these answers in the theory is to assume a second threshold which shows the limit of doubtful cases, and this has been successfully done.

It will easily be seen that variations of a sensation such as assumed by the theory outlined above always occur, and that they must prevail in all psycho-physic experiments except in the first class.

Dr. Jastrow's suggestion to measure the sensibility by psycho-physic methods is a good one. It has been successfully applied for measuring various degrees of attention, and the writer fully agrees with Dr. Jastrow's opinion that this is the most promising field of psycho-physic research. DR. FRANZ BOAS.

New York, March 1.

American and Foreign Microscopes.

MY attention having been called to the 'Complaint' in *Science* for Dec. 2, 1887, and the following articles on microscopes, the facts did not seem to me fully presented therein. I immediately addressed the following questions to more than twenty of the leading colleges of the country, the Department of Agriculture, Geological Survey, and Microscopical Society of Washington, D.C., and Messrs. Wolle and Smith, two of the oldest microscopists in the country. The results are herewith presented, with my own ideas on the subject.

The questions were, 1. How many microscopes of American make have you? [659.] 2. How many of foreign make? [434.] 3. How many without a joint? [309.] 4. Do your students work standing, or sitting? 5. Is the instrument used in an inclined position to any extent?

The figures in brackets give the sums total of the replies. Pennsylvania University reports 100 American, 3 foreign; Michigan, 120 American, 30 foreign. Of the foreign instruments, 108 belong to Harvard, and 135 to Bryn Mawr, Johns Hopkins, and Massachusetts Institute of Technology. About 40 jointed instruments are reported used in the upright position; more than two-thirds of the whole number are used inclined. To No. 4, the answer "Sitting," is almost universal; "Standing or sitting," a few. The following extracts from the replies are pertinent: —

"I prefer to work it upright, and teach my students so, but they will incline it whenever possible."

"When long at work, I prefer a vertical tube; but I find for young students the inclined position and the rack and pinion extremely desirable."

"Only by unfortunates. Of course, the joint is a convenience, but is not, in my opinion, essential." — HARVARD COLLEGE, in answer to No. 5.

"The instruments are used almost exclusively in the upright position, the tables being low enough to permit of such use with ease." — UNIVERSITY OF NEBRASKA.

"Mostly foreign instruments, generally inclined, prefer inclined; would use it inclined if I could" [of upright instruments]. — GEOLOGICAL SURVEY.

"The latest purchases are American, which are now preferred." — ALBANY.

"Personally, I believe the best instruments are made in this country." — UNIVERSITY OF MICHIGAN.

"In my laboratory (physiology and hygiene), we use forty. I bought the first in 1876, foreign because then cheaper. In four years they were all worthless. We then bought American: they have stood more rough usage, and had fewer repairs necessary, than any others. My work is especially trying on account of the frequency with which acids must be used."

"I believe the eye is more nearly in its normal and best position when the microscope is inclined." — PRINCETON.

"My constant companion at my table is Zentmayer's army microscope. Have used it twelve or more years, always inclined, or very rarely vertical." — F. WOLLE.

"Twenty-five years ago I got Powell and Lealand's stands. I seldom use their objectives. For long years I have preferred American objectives. I have recently seen letters from purchasers of Zeiss apochromatics, confessing that Spencer's most recent glasses fully hold their own, and at less prices." — H. L. SMITH.

"The facility to incline when needed is indispensable." — J. G. HUNT.

In 1862 I saw much of Dr. Hunt, then unsurpassed as a histologist. He used a Beck best, inclined, in continuous daily work. His experience assisted in the construction of the American Centennial instrument, which he has since used. This is an instance of an elaborate tool employed in actual, original, and long-continued work. After this came the Beck International, costing seventeen hundred dollars, and with the most elaborate accessories ever offered to the public, — no doubt 'brazen elephantiasis,' but not an American instrument. The latest Zeiss instruments brought to this city have just the same nickle plating and lacquer as the American; and without lacquer any instrument would be soon worthless.

In 1860 I used a French upright, then successively a Nachet best, Zentmayer, Beck small best, Popular, and in my laboratory Bausch and Lomb Model and Harvard. In 1875 I brought over a lot of Zeiss's work. I use the inclined position always, except for watch-glasses, or such large vessels. Have used fluids contantly, on tissues, in the examination of fibres according to Vetillart, and numberless examinations of urine, as well as chemical work. The capillary attraction between cover and slide is sufficient, as a rule, to hold all that is required.

I do not see that the disclaimer in the last article affects the statements made in the 'Complaint.' Histological work is the investigation of the minute structure of plants and animals, and this is just what microscopes are made and used for in this country in biological laboratories and by practising physicians. The number of amateurs is very small, and, of instruments used for petrographical and chemical work exclusively, still smaller. In the Washington society, twenty-six members are physicians, nearly all in practice, seven are teachers and investigators, and seven are amateurs.

The American stand has been developed from, and has re-acted upon, the English stand, — a different and radically better type than the German. There are probably as many microscopes made and used by English-speaking people as by all the rest of the world. A Beck was exhibited at one of the late meetings of the Washington Society numbered over 15,000. This means over that number of jointed instruments in use, of one English maker, of which about one-third are in this country. The latest Zeiss here is 11,468 (August), and all but his lowest styles have a joint.

Most English microscopes have a joint, — a feature of the Germans first despised, then condemned, and finally adopted. The jointed stand does all that the upright does, and much that the upright cannot do. The cost of the joint is about two dollars. The Zeiss stand VII, *a* and *b*, is said by Zeiss to be "especially suitable for laboratory use." It has no joint. Its stage is 67 by 72 mm., and 86 mm. high. The price, with two objectives and two eye-pieces, is $34; with another objective, $41. The Zentmayer Histological (American) was put on the market in 1876. It has a joint. Its stage is 65 by 95 mm., and 76 mm. high. With one eye-piece and two objectives and case, it costs $38 and $46. The Bausch and Lomb Harvard has a stage 85 by 90 mm., and 82 mm. high. With two objectives and two eye-pieces, the price is $43. It is well known that the discounts here are larger than on foreign catalogue prices; and in quantity these American instruments, with lower and broader stages than the foreign instruments of equal grade, can be purchased cheaper. No one is obliged to buy a slide-carrier unless wanted. It is priced separate. The glass slip stage was an American invention, was adopted by the French and English makers, and is stated by Dr. Carpenter, in his last edition, "to be the most perfect yet devised." The Iris diaphragm is not generally applied by American makers to college microscopes.

The prices of German low-power objectives are less than American, but high powers are dearer. A Zeiss $\frac{1}{12}$ costs $90, a $\frac{1}{20}$ $112 to $140, to which must be added the cost of special eye-pieces. A Spencer first-class dry $\frac{1}{15}$ costs $60, a $\frac{1}{15}$ homo immersion $80, both high angle; a professional $\frac{1}{8}$ of 175 B.A., $40. If these prices are averaged with the low powers, the American lenses are cheapest, without any regard to duty. We want three classes of microscopes, — the college, the professional, and the complete. The first may have less finish and no substage fittings, the second with substage fittings and better finish, the third with graduated circles, etc. All require a spreading tripod base, a joint, a Jackson arm sitting square on the trunnions, a firm clamp to the latter, and the arm cast solid from the axis of the swinging tail-piece to the barrel.

Our catalogues should give for each instrument the height and size of stage, and the length of barrel.

There has already been much discussion on the uniform construction of microscopes at the meetings of the American Association of Microscopists. A resolution in this direction offered by the writer last summer was ruled out on the ground that the subject was exhausted for the present. An important contribution on tube-length read at Pittsburgh by Professor Gage has already appeared in *Queen's Bulletin*, and will be published in the forthcoming Proceedings of said society.

Colleges pay no duty on their instruments: hence their selection is not affected by the tariff. As to the principle, I am an American citizen and a teacher, and, other things being equal, I prefer to buy my microscopes of my neighbor, who will send his children to my school, and who, if he grows rich making microscopes, may endow my college, rather than to send afar, to one who is not likely to be interested in my success or that of my country. I know professors of political economy do not teach this view; but most business-men act according to it, though the principle may be unwisely applied. Under it as the rule of our national polity, we have made the best and cheapest watches, telescopes, and apparatus for the investigation of radiant heat; and, if the users of microscopes will only cooperate fairly with the makers thereof, we shall soon have the best and cheapest microscopes the world has yet seen. Many who condemn protection, ask for international copyright; and one of their arguments is, that, by raising the price of foreign literature, it will make a better market for domestic productions. So it will, and tend to shut out some excellent foreign work, and is so far just as 'absurd and senseless' as the duty on microscopes.

For details on the above matters, see HARTING, *Das Mikroskop*, vol. iii. p. 262; MAYALL'S 'Cantor Lectures;' and Hon. J. D. COX, 'Microscopic Work,' *American Journal of Microscopy* for 1879, p. 131.

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Howard University, Washington, D.C., Feb. 25.

Indian Wrist-Guards.

IN a review of Professor Morse's 'Methods of Arrow-Release' in *Science* last year (ix. p. 122), I ventured to suggest "whether it is not possible that the so-called 'pierced tablets,' which are described and figured by Professor Rau (*Archeological Collection of the Smithsonian Institution*, p. 23) and other writers, and which have given rise to so much discussion among American antiquaries, may not have been guards worn to protect the wrist against the recoil of the bow-string." Since writing this, I have happened upon an article by R. S. Robertson, in *The American Antiquarian* (i. p. 100), in which he advances the same opinion. He says, "A short time since, when exhibiting one to an old gentleman, who was a clerk for a fur-trader, while the Miamis still occupied the region around Fort Wayne, he assured me he had often seen them in use, and that they were worn on the left wrist to ward off the blow of the bow-string in hunting." I have lately noticed statements in early descriptions of the customs of the Indians, which seem to me to lend some countenance to this view. Capt. John Smith, in his 'Map of Virginia,' p. 23 (Arber's reprint, p. 68), telling how the Indians make their bows and arrows, says, "His arrow-head he quickly maketh with a little bone, which he ever weareth at his bracer, of any splint of stone or glass in the form of a heart." Strachey, in his 'Historie of Travaile into Virginia' (Hakluyt Society edition, p. 106), employing precisely the same language, adds, "and which bracer is commonly of some beast's skin; either of the wolf, badger, or black fox." In the 'General History of Virginia,' which comprises a reprint, with additions, of 'The Map of Virginia,' Third Book, p. 15 (Arber's reprint, p. 397), in an account of the capture of Smith, we are informed that the Indians had "every one his quiver of arrows, and at his back a club; on his arm a fox or an otter's skin, or some such matter, for his vambrace."

Winslow, in 'Good Newes from New England' (Young's edition, p. 365), says, "The men wear also, when they go abroad in cold weather, an otter or fox skin on their right arm, but only their bracer on the left."

As 'bracer,' or 'vambrace,' was the common term employed by old English writers to designate armor worn upon the fore-arm, we are authorized to infer from these statements that the Indians were accustomed to make use of the skin of some animal for a similar purpose. It would seem to be a very easy transition from a piece of leather to a thin, flat tablet of stone, pierced near the centre usually with two holes, which could readily be adjusted to the wrist as a guard.