I found that the liquid gradually penetrated into and filled the canals which were open. Fig. 4 shows the central parts of crystals with canals partly filled with the coloured liquid. Near the centre small air-bubbles are still visible. Fig. 6 is the central part of a star powerfully magnified. The interesting structure may be judged by the photograph.

Phenomena attending the Compression of Snow Crystals.—A stellate plate was slowly compressed by screwing down the objective upon the cover-glass. After this pressure it was still entire. In the interior of the crystal *new curvilinear figures or pressure lines had appeared*, following a regular course analogous to that of the organoid figures. This analogy suggests that the latter may possibly be explained as tensional phenomena.

Exceptional Symmetrical Conditions.—The fine cavities in the centre of the stars are sometimes regularly ar-

FIG. 6.

ranged after only *two* symmetrical planes at right angles to each other and of different value (see Fig. 4), in accordance with the symmetrical conditions that we find in crystals belonging to the orthorhombic system.

Hoar-frost.—In addition to the photographing of snow crystals, I have also examined and reproduced by photography crystals of hoar-frost deposited on window-panes. Even these crystals formed often hexagonal tables, but were entirely without the remarkable cavities observed in snowflakes.

The investigations of which I have here given a brief account show that the structure of snow crystals is very complicated, and display several peculiarities which, so far as we know at present, are unexampled in other crystals. I hope to be able to resume these investigations next winter on a more extensive scale, in order to obtain, if possible, a complete elucidation of the interesting phenomena alluded to in the present paper.

G. NORDENSKIÖLD.

BÜTSCHLI'S ARTIFICIAL AMÆBÆ.¹

PROF. BÜTSCHLI, of Heidelberg, so well known by his valuable work on the Protozoa, and his contributions to Bronn's "Klassen und Ordnungen," has, in the monograph under review, approached a subject of deep interest and great difficulty, namely, the cause of protoplasmic movement. His researches in this direction are already known to readers of the *Quarterly Journal of Microscopical Science*, for in 1890 Prof. Lankester inserted a letter from Prof. Bütschli, in which the latter gave a short account of his experiments. In the present monograph his researches are given in a

completed form and in great detail. The gist of the whole subject may be put as follows:—Prof. Bütschli makes an artificial oil and water emulsion in a way suggested by Nuincke, and finds that under certain conditions drops of this emulsion exhibit streaming movements and changes of shape: according to Prof. Bütschli, protoplasm is itself a natural emulsion, and the streaming and amœboid movements of protoplasm are, like those of the artificial emulsion, due to surface tension.

Working at emulsions, Nuincke had previously found that if substances soluble in water be finely powdered and rubbed up with oil, and the oil subsequently surrounded with water, the latter diffuses into the oil, which it converts into a foam or emulsion of little water droplets closely packed together in the oily matrix. The emulsion may obviously be compared with the sea-foam, in which we find air globules closely packed in a water matrix, the oil in the emulsion and the water in the sea-foam having an alveolar or honeycomb build or form. The Nuincke emulsion is obviously, too, the reverse of the emulsions made by Johannes Gad with weak K_2CO_3 and oil, in which the oil droplets lie closely packed in a water matrix; it is also the reverse of the numerous emulsions made every day by the druggist who uses oil in mucilage, malt-extract, &c. When Bütschli first tried the Nuincke method he used common salt, sugar, and nitre, taking these as examples of substances readily soluble in water. He succeeded, however, better by using Na_2CO_3 , or K_2CO_3 , and proceeded as follows. The salt, preferably K_2CO_3 , was obtained pure and dry, and was finely powdered in an agate mortar. He then breathed upon it until it was slightly moist, and rubbed it up with olive oil until a thick white paste was formed. A tiny drop of the paste was then placed on the centre of a cover-glass, and inverted over a drop of water, and in order that the drop might not be pressed out of shape by the weight of the cover, the latter was supported by little pellets of wax or paraffin. The preparations so obtained were placed on one side in a damp chamber for twenty-four hours, and then washed out with water by inserting a piece of blotting-paper into the chink between the slide and cover, and supplying fresh water at the opposite side of the cover by means of a pipette. The water was then replaced by equal parts of glycerine and water, after which the drops of emulsion became clear and transparent, exhibiting changes in shape and streaming movements very much like those of an amœba. It appears that the consistency of the olive oil is a very important factor in determining the successful issue of one of these experiments. Ordinary oil is of no use, it must be kept for some time in an open vessel, though the time may be shortened by keeping it in a hot-air chamber at $50^\circ C$. and testing the oil from day to day. It must be thick and viscous, but not too much so.

When examined by the aid of a microscope the emulsion appears as a network of oil enclosing the water droplets, for the structure is, of course, seen in optical section. Curious streaming movements may be observed within the emulsion, and these may continue for hours; movements of the drop as a whole occur, and always in the direction of the stream. If the emulsion drop be carefully watched it will be seen to change its shape, and to throw out processes—which, by the way, are always club-shaped—and to withdraw others. Up the centre of these processes a streaming movement takes place, and the streams at the tops of the processes spread out and flow back in a layer next the surface. These movements are influenced by warmth and electricity, and we have, therefore, in these Bütschli's drops something which might deceive one into supposing that actual amœbæ were in the field of observation.

The movements of the oil emulsion are due, no doubt, to changes in the surface tension of the fluids in contact with each other, Bütschli's case being an illustration of

¹ "Untersuchungen über mikroskopische Schäume und das Protoplasma." Von O. Bütschli. (Leipzig: Wilhelm Engelmann, 1892.)

the effects of surface tension, effects which are more simply shown in the contracting films, and tears of wine of the laboratory and dinner-party. It is well known that surface tension is capable of producing important and curious changes in the form of fluids, and will induce well-defined movements of a streaming character; surface tension, and the movements resulting from it, are modified and influenced by heat and electricity, and many biologists have suggested that surface tension may play an important part in producing amoeboid movement. Prof. Bütschli takes many steps in advance of this; for having formed his artificial emulsion, he sees in all living protoplasm nothing but a similarly constructed emulsion, and concludes that because it is so similar its movements must be of the same nature. We feel in reading his work that not only does he in his enthusiasm twist the appearances of protoplasm to suit his own especial view of what its structure must be, but he is guilty of want of logical treatment of his premises when he has got them. Frommann, Hertzmann, Klein, and, indeed, most histologists regard protoplasm as consisting of a network of less fluid material, the interstices of which network are filled with a more fluid material, and this structure has been demonstrated in almost every animal cell. This view of the nature of protoplasm is open, however, we think, to criticism, for histologists are in the habit of preserving and hardening their tissues in fluids such as alcohol, picric acid, corrosive sublimate, which act as precipitants to protoplasm, and they blindly conclude that what they see in these preparations are present in the living cells. On this account many have questioned whether these networks are ever present in the living cells, and Berthold and Bütschli view living protoplasm as an emulsion of two fluids, one forming an alveolar honeycomb, the other filling its cavities. This honeycombed structure—emulsion—Bütschli finds everywhere, from the protoplasm of the protozoa to that of the higher vertebrates; where there was once a network now there is an emulsion. The interfibrillar substance of muscle mistaken by a few observers for a network is, for Bütschli, a honeycomb with frequent transverse partitions, and the fibrillated axis cylinder of a nerve has cross strands indicating that this is a honeycomb too. In the apparently structureless protoplasm of the outer part of an amoeboid cell, such as is figured by Schäfer in the last edition of "Quain's Anatomy," this structure is present to Bütschli, and as he cannot see it there, even with the eye of faith, it is believed to be too delicate and the meshes too finely drawn out to be seen.

As to the chemical nature of protoplasm, about which most biologists who have had anything of a chemical training feel themselves rather in the dark, Prof. Bütschli has fairly definite views, and these it must be admitted fit in admirably with the emulsion theory. The honeycomb he regards with Reinke as a nucleo-albumen, containing some molecules of a fatty acid, and not miscible with water; the more fluid portion of protoplasm, filling the interstices of the honeycomb, he regards as a watery fluid containing albumen and an alkali free or combined with it.

Holding the above views concerning the structure of protoplasm, which indeed, according to Bütschli, resembles both in minute anatomical structure and chemical and physical properties the microscopic froth which he can manufacture, he looks upon the cause of the movements of the froth as the cause of the movements of the amoeba, and also in all probability of striped muscle itself. Let Prof. Bütschli speak for himself:—

"Die Bewegung einfacher Amöben, wie *A. guttula*, *limax*, *A. blattæ*, *Pelomyxa*, ist den früher beschriebenen strömenden Oelseifenschaumtropfen so ungemein ähnlich, ja in allen wichtigen Punkten, so ganz ihr Ebenbild, dass ich von der Uebereinstimmung der

wirksamen Kräfte in beiden Fällen vollkommen überzeugt bin" (page 198, see also pages 200 and 208.)

Now, for some time past it has been held that surface tension plays a part both in the streaming movements of protoplasm and in the production of amoeboid movement, but no one has pushed this idea to the extent that Bütschli has done. Let us see if the facts of the case justify him in so doing. It is true that the picture of the moving foam and of the moving protoplasmic mass present many points of similarity to the eye of the observer, but what of that? The waxwork figure may deceive us all into imagining that it is a man, but once we know what it is the most ignorant of us would hardly venture to argue from its mechanism to our own. So when we look at Bütschli's foam particles, and when we are told that they do not consist of protoplasm, and merely of rancid olive oil and a weak carbonate of potash, then we may exclaim at their interest and novelty, but we shall not seriously compare them with living protoplasm. Science is passing through two phases—the first spiritualistic, the second mechanical. Psychology is still very much in the first stage, and physiology in the second. There are still those among us to whom the circulation is a thing of tubes and force-pumps, and nothing more, and absorption a process that can be imitated by a parchment dialyzer. Fortunately, we are getting rapidly through these two stages, and are beginning to recognise that the force-pump and parchment paper have led us often into wrong conclusions. Studies in evolution have taught us that protoplasm, made up no doubt of elements of the inorganic world, is nevertheless a complex of these elements of unique character, and with properties distinct from everything that is not protoplasm. The oil emulsion may, to the eye of the observer, conduct itself in a way exactly similar to an amoeba—which, by the way, it does not, its processes being club-shaped, and never pointed—but this does not indicate that amoeboid movements are similar in their nature. With equal right would the to-day representative of Madame Tussaud urge, on the strength of their waxwork show, that human arms move by springs and clockwork. Not only do these foam particles tell us nothing about protoplasm, but for the investigation of questions of surface tension they are evidently ill fitted. They are toys for the physicist, not for the physiologist. We know that surface tension can well account both for changes in shape and flowing movements of fluids; it is only by experimenting on protoplasm itself that it will be possible to determine what part this agency plays in protoplasmic activity.

In Professor Bütschli's work the reader will find much valuable information as to the views held from time to time as to the structure of protoplasm; and the production of this monograph is a strong indication of the single-mindedness both of German scientific men and of German publishers. It is a large quarto volume of two hundred and thirty pages, well printed, and illustrated with six beautiful plates, and upon a subject which of necessity appeals to a very limited number of readers.

JOHN BERRY HAYCRAFT.

FINGER-PRINTS IN THE INDIAN ARMY.

IT may interest some of your readers to see the terms of the order by which the method of finger-prints for purposes of identification has now been introduced into the Indian Army. A copy of it, sent by Lieut.-Colonel Surgeon Hendley, of Jeypore, has just reached me.

Army Headquarters, Medical Division, Simla,
August 25, 1893.

In continuation of this Office Circular, No. 5, dated January 16, 1891, it is requested that as a means of identification of recruits for the Native Army, examining medical officers will