Dr. H. S. Allen, was originally expounded by Mr. A. L. Parson (Smithsonian Miscellaneous Collections, vol. lxv., p. 1, 1915). The advantages of such a theory were ably expressed recently by Dr. Allen in an opening address before the Physical Society of London.

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Aquarium Cultures for Biological Teaching.

The increase in the number of students in biology during the last few years has created a demand for large quantities of such animal types as Amœba, Actinosphærium, brown Hydra, and Daphnia. It is often very difficult to obtain to time vast numbers of these types; for in Nature the supply is exceedingly precarious, depending as it does on conditions which are constantly fluctuating. In endeavouring to secure a continuous and plentiful supply of *Amoeba proteus*, I have accumulated a certain amount of experience in aquarium-keeping on a large scale, the results of which will be useful to others who, like myself, have to deal with large numbers of students.

Information with regard to Amœba culture has already been given in "Notes on the Collection and Culture of *Amoeba proteus* for Class Purposes" (Proc. Roy. Phys. Soc. Edin., vol. xx., part 4, p. 179). Since the publication of that note, however, I have tried, as an alternative plan for procuring the material necessary to inoculate a culture, a modification of the respective methods described by J. B. Parker ("A Method of Obtaining a Supply of Protozoa," *Science*, N.S., vol. xlii., No. 1090, p. 727, 1915), Libbie Hyman (*Journ. Exp. Zool.*, vol. xxiv., No. 1), and Asa A. Shaeffer (*ibid.*, vol. xx., No. 4), and with success.

Water from such places as the drainage-cuttings in birch, alder, and willow woods, or from the margins of ordinary pools and ponds, together with the filamentous algæ and the brown scum and included diatoms overlying the dead leaves and the other decaying organic matter forming the floor of such places, is gathered in autumn or in early spring. This is allowed to stand in tap-water for some time, until a rich brown scum appears on the top. The top water with the scum is poured off into another glass vessel, and wheat is added (1 gram to a litre of water). In February minute Amœbæ begin to make their appearance; these become fully grown in May and June, and will then divide rapidly, forming a luxuriant culture until the late autumn, when encystment of most individuals again takes place.

Once started, Amœba cultures require no further attention than a supply of water to compensate for evaporation, and the addition of wheat from time to time.

I am indebted to Prof. Bourne, of Oxford, for information that boiled rain-water can be used in those districts, *e.g.* Oxford, where the tap-water contains much mineral matter.

Actinosphaerium.—My principal difficulty in the culture of Actinosphæria has been in maintaining for them a sufficient food-supply. Stentors and vorticelloids, their favourite food, appear to require running water, and therefore quickly die off when introduced into the laboratory (except the green stentor, which thrives well when once established, and a small vorticelloid which appears in infusions of certain pond-weeds). The common rotifer is an excellent food, and this can be obtained from rubbish left over from pond-gatherings by means of wheat or hay infusion. Members of the family Cathypnadæ (especially Monostyla, which is of frequent occurrence in Amœba cultures, and therefore easily grown in wheat-water) are the most useful of the above-mentioned foods.

Since Actinosphæria disappear very quickly when their food is exhausted, and since, on the other hand, they grow and multiply very rapidly when the food-supply is good, and very quickly exhaust this food-supply, it is necessary to give the Rotifer culture a good start before introducing the Actinosphæria into it. In practice I have several Monostyla cultures in readiness, and then, about three months before requiring large numbers of Actinosphæria, I inoculate one or more of the Monostyla cultures with a few Actinosphæria and set the jar aside. These latter soon multiply and appear in myriads.

Hydra.—Large brown Hydra showing buds and reproductive organs can be obtained in considerable numbers and very quickly in laboratory cultures (especially in rooms with a fairly uniform temperature of 60° F.) if they are systematically fed on a generous diet of Crustaceans, which latter can be obtained by the culture of Daphnia. The Daphnia should be strained off by means of a small net, and a concentrated mass of them in a small quantity of water should be added periodically to the jar containing the Hydra. Several hundreds of Hydra by this means can be obtained from one or two individuals in a few weeks.

Interesting colour-changes, varying from dingy brown to a bright pink, can easily be effected in brown Hydra by varying the Crustacean diet.

Daphnia.—I am indebted to Mr. P. Jamieson for the discovery of the value of small pieces of earthworm for the cultivation of Daphnia. If an infusion of dead earthworms in water be allowed to stand in a warm place (*i.e.* near the radiators in the laboratory) it is quickly converted into a rich food, which can be added to the Daphnia cultures as required. A few Daphnia introduced into a large wide-mouthed glass bottle or beaker of water, to which the worm-water is regularly added, very quickly multiply. Several of these cultures should be kept going if the cultivation of Hydra is very intensive, as they must be allowed to recuperate after they have been depleted by use.

A variety of other Protozoa, Crustaceans, Oligochætes, etc., make their appearance in the above-mentioned cultures, commonly sufficient to supply abundant material for demonstration purposes.

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Ionisation in the Solar Chromosphere.

It is well known that the spectrum of the upper layers of the solar chromosphere is chiefly composed of those lines which are relatively more strengthened in the spark than in the arc, and which Sir Norman Lockyer originally styled enhanced lines. The best-known examples are the calcium H and K and the strontium pair (4216, 4077). According to modern theories of spectral emission, these lines are due to an atom which has lost one electron. The principal line due to the normal atom of calcium is the *g*-line 4227, and the corresponding Sr line is 4607, both of which occur at much lower levels. According to modern theories, therefore, Ca, Sr, and Ba atoms are more and more ionised as we approach the upper layers of the solar atmosphere, while in the lower layers both normal and ionised atoms occur.

If we assume that ionisation is a sort of reversible chemical process taking place according to the scheme $Ca \rightleftharpoons Ca^{+} + e - U$, where e is the electron, Ca^{+} is a positively charged Ca atom, and U is the energy of ionisation, we can apply Nernst's theorem of the "reaction-isobar" to calculate the amount of ionisation under any given thermal stimulus. The method is based upon a remark of Nernst in his book, "Der Neue Wärmesatz . . ." (p. 154), that the electron may be regarded as a monatomic gas of molecular weight $\frac{1}{1830}$, and that its chemical constant can be calculated according to the Tetrode-Sackur relation

$$C = \log \frac{(2\pi m)^{\frac{3}{2}} k^{\frac{5}{2}}}{h^3}.$$

It has recently been applied by Eggert (*Ver. d. D. Phys. Gesell.*, December 15, 1919) for the calculation of the degree of ionic dissociation in the interior of a star, as supposed by Eddington in his theory of stellar structures. But Eggert calculates U in a rather artificial manner for iron from assumed atomic dimensions and structures of the iron atom.

We can, however, calculate U directly from the value of the ionisation potential as experimentally determined by Franck and Hertz, MacLennan, and others, or from the quantum relation

$$V = \frac{h\nu}{e}, \ \nu = (1.5, s).$$

Using the value of U determined in this way for calcium, barium, strontium, hydrogen, and helium, the following remarkable results appear:

(1) About 30–40 per cent. of the Ca atoms are ionised just over the photosphere; in the chromosphere, when the pressure falls to 10^{-4} atms., almost all the Ca atoms are ionised. The same conclusion holds to a varying degree for Ba and Sr.

(2) Hydrogen and helium are not ionised anywhere in the solar atmosphere. (This is due to their high ionisation potential. V is 13·6 for H and 20·5 for He, while for Ca, Sr, and Ba the figures are 6·12, 5·7, and 5·12.) Helium can become ionised only in stars of which the temperature exceeds 16,000 K.

(3) Pressure has a great influence on ionisation, a reduction in pressure causing great enhancement of ionisation.

It therefore appears that the ionisation in the upper layers of the solar atmosphere, as revealed by the enhanced lines of Ca, Sr, and Ba, and probably also of Fe, Ti, and Sc, is due to reduced pressure and the low ionisation potentials of these elements, and not to an increased temperature.

The full theory has been worked out in a paper communicated to the *Phil. Mag.*

M. N. Saha.
University College of Science, Calcutta,
March 8.

Gravitational Deflection of High-speed Particles.

In a letter published in Nature of March 11 Prof. Eddington has shown that the statement made by me in an earlier letter to the effect that Einstein's law of gravitation seems to lead to a zero deflection for a material particle moving with the velocity of light is not in accord with the exact equation of the orbit contained in his report to the Physical Society, and suggests that my approximations were not sufficiently close to warrant my conclusion. The line element from which Prof. Eddington derives the equation of the orbit is expressed in co-ordinates which make the velocity of light different in different directions at any one point, whereas the one used by me requires that the velocity of light should be a function of position only, and not of direction. In terms of my co-ordinates the equation of the orbit of a particle moving with the velocity of light is

$$u = 2\frac{m}{R^2} + \frac{1}{R}\left(1 - 2\frac{m}{R}\right)\cos\theta,$$

which leads to the same deflection $4\frac{m}{R}$ for a material particle moving with the velocity of light as for a light-ray. Hence it is clear that my previous conclusion was based on an insufficiently close approximation, and therefore erroneous.

I am glad to see that Prof. Eddington has verified the other principal conclusion of my letter.

Leigh Page.
Sloane Laboratory, Yale University, New Haven, Connecticut, March 29.

Science and the New Army.

It requires some courage to offer any opposition to the chorus of approval which has greeted the suggestion that a proportion of officers endowed with the scientific spirit should be included in the General Staff; but I venture to think that it is by no means so easy to give effect to this proposal as some correspondents in Nature seem to suppose. No doubt it would be delightful if we could have Staff officers who knew all about everything, but in actual practice the man who does useful work in the world is a specialist in one particular subject or in one particular branch of work.

A good regimental officer requires a particular kind of training and possesses a certain set of qualifications. Similarly, a good Staff officer requires a different training and possesses a different set of qualifications. A man of science, again, is different from either of the other two.

The proportion of officers in the Army as a whole who possess any scientific training is comparatively small. There are a certain number of specialists whose ordinary duties are of a technical nature, and there are a few officers who take up some branch of science as a hobby, but the work of the average officer is not such as to bring him into touch with scientific thought and scientific methods. Men are to be found who are good Staff or regimental officers and also scientific workers, but they are exceptions, and it seems to me that a system which demands a regular supply of exceptional men is not one which is likely to work in practice.

There is also a further difficulty. Granting, for the sake of argument, that there are sufficient officers in the Army who possess both the scientific spirit and the qualities necessary for potential Staff officers, it is still necessary to devise a method of selecting them from their more ordinary fellows. Two methods are in common use, namely, examination and nomination.

An examination is a good method of testing that form of knowledge which is acquired by study, but it will be generally agreed that it is not a good method for detecting the scientific spirit. The difficulty in the case of nomination is that the candidates must be selected by ordinary regimental officers who can alone be acquainted with the qualifications of the individual candidates. The average regimental officer, however, is not himself a man of science, and I cannot see that he can ever become a judge of another officer's scientific attainments.

Without arguing, therefore, against the desirability of a General Staff containing an appreciable proportion of scientific officers, I suggest that the ideal is unattainable except in so far as specialists are attached to the Staff for their own particular work, and I think the object in view must be attained by some other means. It might be done by raising the general standard of education in scientific matters throughout the country but this is a very large question, and not a very easy one.