the case of globin. Some internal alteration takes place during denaturation, as evidenced by the change in reactivity of the sulphur groups,[5] but neither acid or base binding capacity [6] nor osmotic pressure [7] are affected—that is to say, there is no scission. Clearly, loss of isoelectric solubility must be due to change in some internal tautomeric configuration.

It is difficult to avoid the suggestion that a change, similar to that postulated by Astbury and Woods in explanation of the behaviour of the stretched and unstretched wool fibre, may in reality be the essential happening attending denaturation. The –CO–NH– group possesses strong polarity, but, by the rearrangement of peptide linkages into what are virtually closed ring systems, affinity for water would be enormously diminished. At present there exists no satisfactory hypothesis offering an explanation of denaturation. Such a scheme as the above may reasonably be entertained until further evidence can be brought forward of a chemical or physico-chemical nature which will throw more light upon the problem. Considering the remarkable and wholly unexpected results, mentioned above, of Gorter and Grendel, working upon protein surface films, it would seem that quantitative data bearing upon denaturation is likely to be obtained most readily by studies having a similar approach. The forces at play within the liquid and at the interface possess no mean magnitude. They are, however, susceptible of more precise control and exact manipulation than those involved in, let us say, heat coagulation or the application of vigorous chemical reagents. From a study of the surface phenomena exhibited by proteins under varying conditions, coupled possibly with an application of the X-ray method to films of such proteins as can be made to give readily detectable diffraction photographs,[8] a solution not only of the denaturation process but also of the structure of native proteins may, in the future, be obtained.

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[1] Astbury and Woods, NATURE, **126**, 913; 1930
[2] Svedberg, *Koll. Zeit.*, **51**, 10; 1930.
[3] Gorter and Grendel, *Proc. Acad. Sci. Amsterdam*, **32**, 770; 1929.
[4] Anson and Mirsky, *J. Gen. Physiol.*, **13**, 469; 1930.
[5] Harris, *Proc. Roy. Soc.*, B, **94**, 426; 1923.
[6] Booth, *Biochem. J.*, **24**, 158; 1930.
[7] Huang and Wu, *Chinese J. Physiol.*, **4**, 221; 1930.
[8] Ott, *Kolloidchem. Beih.*, **23**, 108; 1926.

Stellar Structure.

THE current argument against Helmholtz's contraction hypothesis concerning the origin of the sun's heat may be summarised as follows. The gravitational potential at a point within the sun is of the order of magnitude of its value at the surface, 2×10^{15} c.g.s. units. Thus contraction may have supplied energy 2×10^{15} ergs per gram of the sun's mass. The sun now radiates 1·9 ergs per second for each gram of its mass. Further, the earth's crust has been solid for at least $1{\cdot}5 \times 10^9$ years, during which time the sun may have radiated 9×10^{16} ergs for each gram of its mass. Hence "it appears that the Helmholtz contraction-hypothesis cannot account for more than about two per cent of the energy which has been radiated by the sun during the earth's life" (Jeans, "Astronomy and Cosmogony", p. 106). Further, there is astronomical evidence that the whole life of the sun has been at least of the order of 10^{13} years.

It seems to have been overlooked that modern theories concerning the internal temperature and density distribution in the stars very much weaken, if they do not quite destroy the above argument. If, following Milne,[1] we suppose that the mass of the star is much concentrated towards the centre, the first part of the above argument loses its force. Fifty times as much energy can be accounted for. The longer time period of 10^{13} years may be due in part to the sun's not having in the past radiated so much as it does at present.

If the opacity of the stellar material varies as $T^{-\frac{1}{2}}f(\rho/T^3)$, where ρ is the density and T the temperature (the only theoretical formula in the field is of this form), it is possible that gaseous spheres of such material should contract to homologous density distributions and obey Lane's law. Such spheres can exist possessing any mass, radius, and luminosity within certain limits, though, as I have shown,[2] this homologous contraction is a very special case. The mass, radius, and luminosity, however, determine the rate of contraction. The whole time required for the star to contract to its present size is $2(3R - C_v)MT/L$, where L and M are its present luminosity and mass, R and C_v the gas constant and specific heat of the material, and T the mean internal temperature.

For the sun, taking mean temperature 10^9 degrees, and $(3R - C_v)$ to be $2{\cdot}5 \times 10^8$ ergs per gram per degree, this gives a past life of 8×10^9 years. This would be increased proportionately if, following Milne, we estimated the mean temperature of the sun higher. The total energy radiated in the above life works out at $2{\cdot}4 \times 10^{17}$ ergs per gram and the corresponding mean gravitational potential is $4{\cdot}8 \times 10^{17}$ c.g.s. units, not at all impossible if there is much concentration of mass towards the centre. In its early stages, however, the contraction would have been much slower, since, for smaller T, R would have been larger, and the opacity also would have been larger than that given by the above formula. Indeed, opacity varying as $T^{-1}f(\rho/T^3)$ gives an infinite time scale.

Helmholtz's hypothesis appears, therefore, by no means to be untenable.

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Feb. 6.

[1] NATURE, Aug. 16, 1930, p. 238.
[2] *Monthly Notices of the Royal Astronomical Society*, November 1930, p. 122.

Replacing the Telephone by a Loud Speaker in Conductivity Measurements.

IT seems improbable that nobody should have ever tried replacing the telephone by a loud speaker in conductivity measurements, but I have never heard of it, nor read anything about its possibility and advantages; I will, therefore, describe it very briefly, as I feel convinced that it represents a real improvement over the customary procedure.

It consists simply in a two-stage amplifier, with a factor of amplification of about 500, connected to a Kohlrausch bridge for measuring electrolytic conductivity, instead of the usual telephone, which is replaced by loud speaker. If, instead of a buzzer, a shielded oscillator is used, and if all the leads are lead covered and properly earthed, the apparatus can be adjusted to give a musical note of variable intensity which permits the determination of the minimum sound much more easily, agreeably, and even a little more accurately than with the telephone. I have found it a great improvement, and I hope this letter will encourage those interested in resistance measurements to try this scheme, which possibly they have not used before simply because they were doubtful about its advantages.

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