cussed the torque in a beam of *circularly polarized* light. There it is pointed out that Professor Poynting of Birmingham in 1909, basing his ideas on the wave theory, worked out the torque T to be expected for a circularly polarized beam of one square centimeter as $T = M\lambda/2\pi$ where M is the energy density, therefore the pressure, and λ is the wave-length. I then present the argument based on the idea of photons and arrive at the same result.

These views had been presented to my classes for some years before the publication of my text in 1936. But I did not know that A. Sadowsky in Russia had derived a similar result, basing his work on Maxwell's theory.[1]

Now the pressure of light on an absorbing surface in the experiments performed by E. F. Nichols and myself was of the order of 10^{-7} gram per cm^2. Hence theory gives for the torque in a beam of 1 cm^2 cross section an amount of about 5×10^{-12} gm cm or 0.000,000,000,005 (the last digit is of no significance except to show its approximate decimal position) gm cm. This almost infinitesimal amount however is for an intense beam, one square centimeter in cross section of *circularly polarized light*. For a beam of natural or plane polarized light the torque would be exactly zero on either theory. For a beam of light of two one hundredths of a centimeter in diameter of such an intensity that it could be observed in a microscope, the torque, even in the case of circularly polarized light, would be about one millionth of the amount given above or 0.000,000,000,000,000,005 gm cm. For natural light it would be zero.

But though the torque to be looked for in a beam of circularly polarized light (for elliptically it would be less, for plane polarized or natural it would be zero) is extremely small, it can and it has been detected. In my book, page 425, I outlined the experimental method. The experiment, independently devised, was performed by Richard A. Beth[2] in Princeton. He showed extraordinary courage in attempting to measure this minute quantity. The experiment called for prolonged and intense labor and was carried out with excellent technique. He obtained a result of the right order of magnitude as given by the theory. Beth's experiment was not of the show-off kind. He didn't call in the villagers to see the phenomenon "that was going to revolutionize our ideas of the universe." His work and the work of the theoretical physicists who have considered this matter show that the rotating action in a beam of circularly polarized light is exceedingly small and in a beam of natural light nothing whatever.

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[1] A. Sadowsky, *Acta et Commentationes Imp. Universitatis Jurievensis*, 7: No. 1–3, 1899; 8: No. 1–2, 1900.

[2] *Phys. Rev.*, 48: 471, 1935; 49: 411, 1936; 50: 115, 1936.

TEMPERATURE INDUCED STERILITY AND EVOLUTION

IN an over-simplified form the following discussion presents an analysis of a few possibilities that seem to be inherent in a thermal sensitivity of male germ-plasm.

All terrestrial animals that have been investigated with respect to temperature tolerance of the male germ-plasm have shown that applications of heat will produce some degree of infertility. The effects range from lowered fertility to complete sterility. It is notable that in some instances normal body temperatures of warm-blooded animals will cause sterility and that somewhat comparable conditions exist in the cold-blooded animals.

The process of evolution from amphibia to the mammals and birds, the latter having the highest known vertebrate temperatures, displays the progressive adoption of ever-higher temperatures, and it is therefore remarkable that in no known instance are the mammalian testes invulnerable to exposure to high temperature. It would seem inevitable that in the long course of a history of rising temperature, the warm-blooded animals would have established testicular temperature tolerances compatible with their somatic requirements. There does not yet seem to be any known case of a balanced body-germ-plasm temperature harmony in any group of the vertebrates, although it is logical to expect that there would have been some such perfection. The absence of such information may, of course, result from the fact that there has as yet been no search for such an adjustment.

The entire picture seems to be one of a steady somatic advance in utilization of high temperatures with failure of the spermatogenic mechanism to keep up with advance. It is as though the body paced the advance while the germ-plasm acted as a retarding influence.

It also seems clear to me that any failure of the germ-plasm to maintain at least a reasonable tolerance to an advance in the body temperature would endanger the entire complex of the fecundity-mortality balance. A diminution in the reproductive capacity, resulting from heat exposure following such a dislocation, could result in catastrophe to the gene complex allowing the dislocation.

That the scrotal mammals have circumvented this disaster by the purely fortuitous acquisition of a novel, essential, thermoregulatory device is definitely established, as is the fact that non-scrotal forms appear to detour their dilemma by various expedients such as a retention of a poikilothermous temperature fluctuation during spermatogenesis, or by not having acquired the high temperature of the more specialized mammals. It seems possible that the opportunist type of expedient, namely, intermittent spermatogenesis occurring only when body temperatures are lowest, may characterize some birds.

The ectotherms (poikilotherms) have not lost the advantage of a freely fluctuating temperature, but in almost all known cases their reproductive activity is suspended during hot weather and there is a notable regression in the size of the testes which is ordinarily not reversed until the appearance of cool weather. Spermatogenesis like all cellular activity is merely slowed or suspended, but is not destroyed by the effects of cold.

Until recently nothing definite has been known concerning reptilian testicular reactions to high temperatures, but a forthcoming paper to appear in the *American Naturalist* demonstrates that these animals also fit the picture, thus completing a rough sketch of the responses in the terrestrial organisms.

From my standpoint this apparently universal weakness in the thermal accord between somatic and germinal tissues must have played a very dramatic role in evolution and could very well have been responsible for the extinction of many groups of organisms. The necessary heat stresses could have resulted from climatic change alone in some instances, a possible example being that of the dinosaurs, or through the development of poorly coordinated somatic-germinal heat progress or through a combination of these factors. Other possibilities will be suggested in the account scheduled for appearance in the *American Naturalist*.

A review of many of the articles pertaining to this subject will be found in Allen's "Sex and Internal Secretion," in the sections dealing with the testes. A more complete citation of sources is not compatible with the present space limitations, but will accompany the more detailed report.

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"STARRING" IN AMERICAN MEN OF SCIENCE IN RELATION TO THE STATUS OF CHEMISTRY

ACCORDING to the National Roster of Scientific and Professional Personnel,[1] chemists not only outnumber each of the other types of scientists by at least a ratio of seven to one, but they outnumbered by nearly 40 per cent. all other scientists taken together.

Since these figures appear to be startling it seems desirable to go to other sources for further information. On the basis of sampling 20 pages of listings taken at random from the seventh edition of "American Men of Science" it appears that the ratio between chemistry and its nearest competitor, physics, is a little more than 2 to 1, and that about 23 per cent. (about 7,500) of the total listings are chemists. This would make the non-chemists outnumber the chemists by about 3 to 1. This does not agree with the National Roster data, which would indicate a ratio of about 0.7 to 1.

The difference between these two sets of figures is probably due almost entirely to the fact that large numbers of chemists are employed in industry and many of these do not publish scientific articles and hence are not listed in "American Men of Science." Many are engaged in industrial research and are "men of science" in a real sense. Purely routine jobs in chemical industries are more often done by those who are trained for a particular operation, but who have no professional training in chemistry.

This interpretation is borne out by the statistics given in the report of the National Research Council to the National Resources Planning Board.[2] Of all the professionally trained research personnel in industry 15,700 or about 43 per cent. are chemists. If the engineers are excluded, the chemists constitute 72 per cent. of the total, well over ten times the number of its nearest competitor. It should be noted that the number of professionally trained chemists engaged in industrial research (15,700) is about twice the total number of chemists listed in "American Men of Science."

In 1941 and 1942 listings of doctorates in science[3] indicate that chemists, including biochemists, outnumber their nearest competitors (physicists) by more than 4 to 1. The non-chemist doctorate degrees in science outnumber the doctorates in chemistry by about 2 to 1. In the 1944 listing[4] doctorates in chemistry and biochemistry constitute 51 per cent. of the total.

Another method of arriving at the status of the different sciences is to consider membership in the respective professional societies. The major societies in the fields indicated have, according to the latest information available,[5] total memberships as follows: chemistry 29,552 (95 per cent. in the American Chemical Society); physics 7,067; geology 8,177; botany and bacteriology 7,323; zoology 14,118 (scattered in 12 societies). Chemistry membership outnumbers its nearest rival, zoology, about 2 to 1 and is about 45 per cent. of the total in these fields.

The large membership in chemistry exists in spite

[1] SCIENCE, 96: 292, 1942.

[2] "Research—A National Resource." II. "Industrial Research," p. 176. Washington, D. C.: U. S. Government Printing Office. 1941.

[3] E. A. Henry, SCIENCE, 99: 431, 1944.

[4] "Doctoral Dissertations Accepted by American Universities," No. 11, 1943–44, New York. H. W. Wilson Co. 1944.

[5] Compiled from Handbook of Scientific and Technical Societies and Institutions of the United States and Canada, fourth edition. Bulletin 106, National Research Council. Washington, D. C. 1942.