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Influence of Light Rays on Coagulation of Plasma and Fibrinogen.

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It has been shown by many experiments that proteins are highly susceptible to the action of ultraviolet rays.[1, 2] Mond[3] claims an increase in stability of globulin and fibrinogen solutions when irradiated with U. V., which may correspond to the behavior of a well defined colloid, congorubin.[1] Howell[4] was able to demonstrate delayed coagulation of fibrinogen solutions and when hematoporphyrin was added to such solution before irradiation no coagulation occurred.

The experiments recorded in this paper are concerned with: (1) comparison of various kinds of light on the coagulation-time; (2) comparison of the coagulation time of plasma on one hand and solutions of fibrinogen on the other.

Fresh beef blood from full grown animals was oxalated and the plasma separated by centrifugation. A portion of the plasma was used to prepare fibrinogen according to the method described by Hektoen and Welker.[5]

The light sources used for the experiments were: (1) The high pressure mercury-quartz lamp, characterized by its very effective U. V. spectrum with only a few visible lines. (2) The carbon-arc lamp, used with carbons containing various metals to produce different kinds of continuous spectra.

(a) The C-carbon, producing besides visible rays a very large quantity of ultraviolet.

(b) The SS-carbon, giving much energy in the infra-red, visible and near ultraviolet regions but a very low output in short wave U.V.

(c) The E-carbon, emitting large quantities of visible and infra-red light but practically no ultraviolet.

Small quartz tubes containing 1 cc of oxalated plasma or of fibrinogen solution were exposed to the influence of the rays for 10, 20 and 30 minutes. Use of a fan prevented temperature variations exceed-

1 Pincussen, L., *Photobiologie*, Leipzig, 1930.

2 Spiegel-Adolf, M., *Ergeb. der Physiol.* (Asher-Spiro), 1928, **27**, 382.

3 Mond, R., *Arch. ges. Physiol.* (Pflueger), 1922, **196**, 540; 1923, **200**, 374.

4 Howell, W. H., *Arch. internat. de Physiol.*, 1921, **18**, 269.

5 Hektoen, L., and Welker, W. H., *J. Infect. Dis.*, 1927, **40**, 706.

ing 3°C. The total energy reaching the tubes was practically the same for all experiments and amounted to 200 micro-cal. cm²/min.

For testing the coagulation time we proceeded as follows:

(1) *Plasma.* To the tubes containing the irradiated specimens and the nonirradiated control an excess of $CaCl_2$ solution was added for eliminating the oxalate and activating the prothrombase, and the coagulation time tested in a water-bath at 37°C.

(2) *Fibrinogen.* The same quantity of a suspension of dry thrombase[6] in water was added to the irradiated specimens and to the control and the coagulation time tested at 37°C.

In the graphs the results are recorded. Fig. 1 deals with the effect on fibrinogen, Fig. 2 with the effect on plasma in 2% NaCl solution. The abscissa gives the time of irradiation, the ordinate the

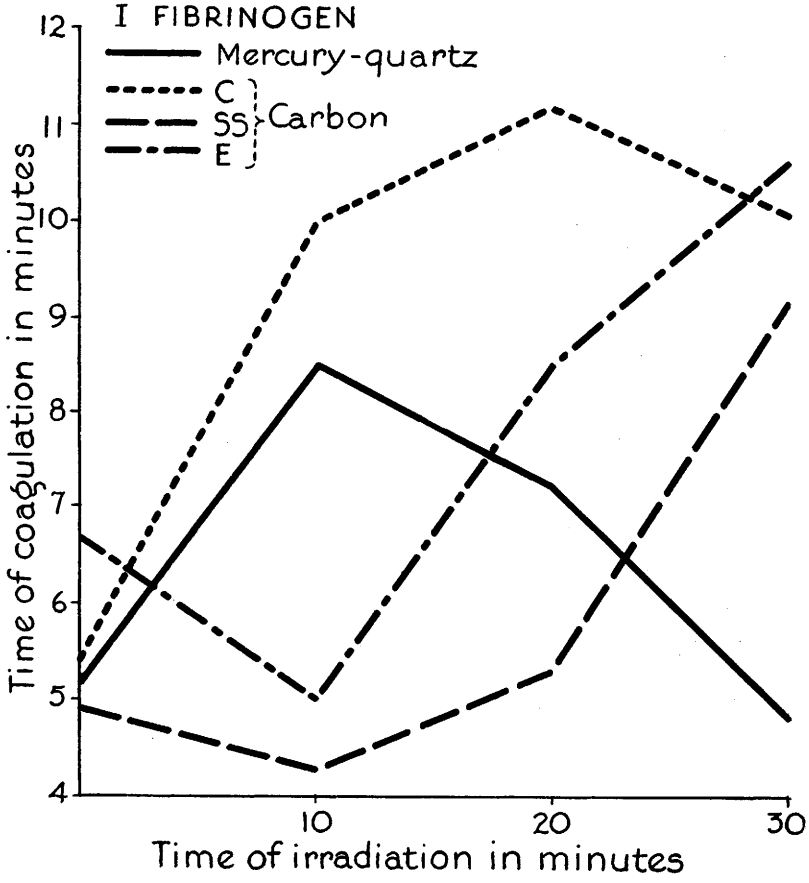

FIG. 1.

[6] Mellanby, J., *Proc. Roy. Soc. B.*, 1933, **113**, 93.

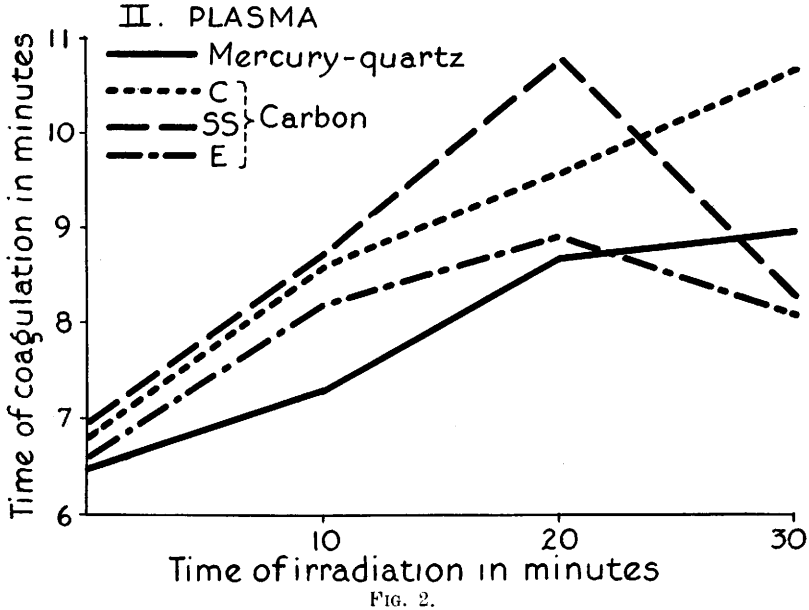

FIG. 2.

time of coagulation, both in minutes. Each curve in the graphs shows the average of 12-15 experiments.

From these graphs 2 groups seem to emerge: the first including the light sources with the strong U. V. output, the second including those with little or no U. V. and a highly effective visible and infra-red spectrum. This is true for the coagulation time of fibrinogen solutions and of plasma, although the trend of these two groups is different.

For the strong U. V. emitters, mercury-quartz light and C-carbon light, the coagulation time of the fibrinogen solution goes up after being irradiated and goes down again when the irradiation lasted longer than 10 or 20 minutes. For plasma, there is an upward trend too, but there is no reverse action after longer exposure to the light; the longer the irradiation lasts, the more coagulation is delayed.

After irradiation with light sources containing less U. V. and more visible and infra-red rays (Carbon SS and E) the coagulation time of fibrinogen is decreased when the solutions were exposed to the rays for 10 minutes, whereas longer irradiation shows a very distinct trend toward delayed coagulation. For plasma there is after an irradiation for 10-20 minutes an increase of the coagulation time followed by a reverse behavior after prolonged exposure to the rays.

For explaining these results we have, besides the differences in the applied radiation, to consider the differences in physico-chemical and chemical composition of the irradiated solutions. In both cases, we

deal with colloids. The differences are: (1) the fibrinogen solutions are supposed to contain practically only fibrinogen whereas the plasma contains all of the other proteins of the blood. (2) The fibrinogen solutions are colorless while the plasma shows a yellowish color. (3) The plasma contains the enzyme prothrombase which like other enzymes[1] may be affected by the ultraviolet rays.

To account for the effect of the rays on fibrinogen it seems probable that the differences in coagulation-time are at least partially due to changes in the colloidal behavior which, if the strong U. V. emitters were used, are more or less reversible. The same may be true for short time irradiations with the light sources SS and E which contain mostly visible and infra-red wave-lengths, whereas in the second phase an irreversible change takes place, probably due to an alteration in the molecule itself effected by the heat-rays.

In the plasma the 3 factors mentioned above combine in their effect. The color of the liquid delays the effect of the U. V. whereas on the other hand more visible and infra-red rays are absorbed. Some of the rays are taken up by the proteins other than fibrinogen; thus, in all the effect of the rays on the plasma is expected to be smaller than on fibrinogen-solutions, and the curves in Graph 2 are running much smoother than those for fibrinogen coagulation. Nevertheless the action on the colloid persists and we explain the curves for E and SS by changes in the colloidal behavior.

For the strong U. V. emitters (mercury-quartz and C-carbon) these effects are obviously overpowered by the action of the short waves on the enzyme prothrombase. In spite of the protection given the enzyme by the colloids present in the plasma the activity of the prothrombase is lowered and even annihilated by U. V., the same as observed for all enzymes tested until now.