

in which there is a hepatitis or disturbance of liver function. (In dogs operated according to the Mann-Williamson method, Fauley and Ivy have not found evidence of histologic change in the liver, but liver function tests have not been used.) Whether an hepatic disorder is associated with the occurrence of ulcer in man cannot be stated, since as far as we have been able to find, no studies of liver function and histology have been made in ulcer patients. In this connection it is of interest that Shapiro and Lifvendahl<sup>13</sup> found at autopsy 4 duodenal ulcers in 15 cases of tumors of the extra-hepatic ducts, in which there occurs, of course, a progressive icterus with liver damage.

## 6637

### Time Factors Concerned in the Germicidal Action of Ultraviolet Light.

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The effect of radiant energy has long been known to be the result of a certain intensity working in a given period of time, during which period a definite amount of energy is being transferred to the object irradiated. Bunsen and Roscoe<sup>1</sup> have correlated these factors and state that identical effects are obtained if the product of the intensity and time is kept constant. This, however, is merely a modification of the Schwartzschild law which states that intensity multiplied by the time to the exponent K must equal a constant. The factor K is a number slightly less than one, whereas the Bunsen-Roscoe law is a special case where the exponent is equal to one, and holds true for a certain limited range of the factors (intensity

<sup>5</sup> Ivy and Fauley, *Am. J. Surg.*, 1931, **11**, 531.

<sup>6</sup> Van Wagoner and Churchill, *J. Am. Med. Assn.*, 1932, **99**, 1859.

<sup>7</sup> Quigley and Helm. Unpublished. (3 ulcers in 10 dogs.)

<sup>8</sup> Thomson. Unpublished.

<sup>9</sup> Berg and Tucker, *PROC. SOC. EXP. BIOL. AND MED.*, 1931, **29**, 68; 1932, **30**, 330.

<sup>10</sup> Bollman and Mann, *Arch. Path.*, 1927, **4**, 492.

<sup>11</sup> Oldberg, *Am. J. Physiol.*, 1930, **9**, 275.

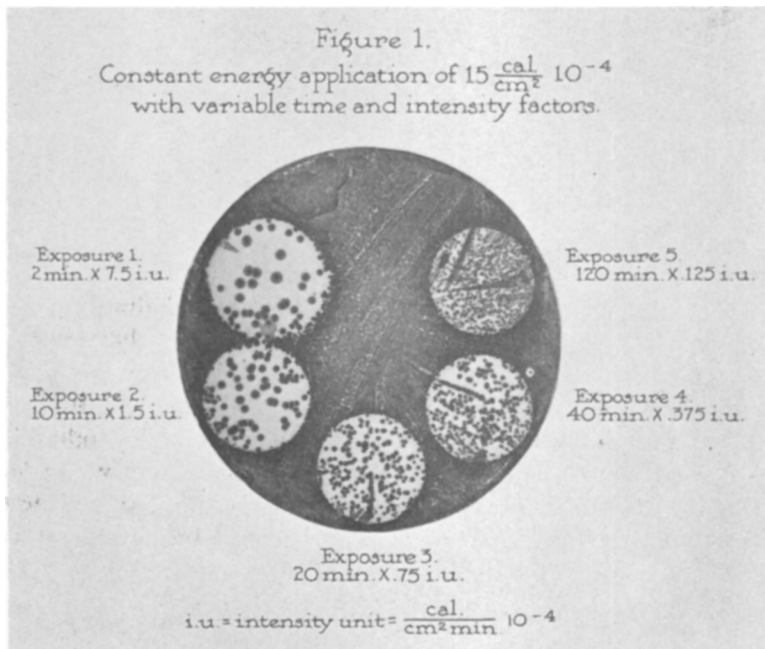
<sup>12</sup> Stewart and Rogoff, 1926, **78**, 693.

<sup>13</sup> Shapiro and Lifvendahl, *Ann. Surg.*, 1931, **94**, 61.

<sup>1</sup> Bunsen, R., and Roscoe, H., *Ann. Physik.*, 1862, **117**, 529.

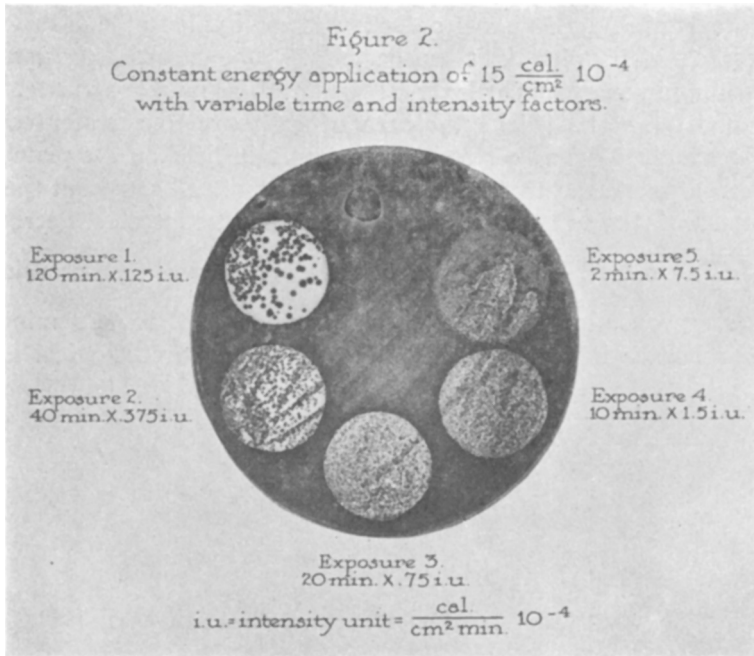
and time), whereas the Schwartzschild law must be applied for excessive variations in these factors. Therefore, with marked decrease in the intensity the time must be increased more than the proportional decrease in intensity.

In this experiment we have attempted to ascertain whether the Schwartzschild or Bunsen-Roscoe law is applicable to the destructive effect of ultraviolet light on bacteria. The method consists of spreading in a unicellular layer *B. prodigiosus* on an agar plate. By means of a metal shield, the area of exposure to a water cooled Kromayer lamp can be restricted to a certain field on the plate and at the same time protect the remaining portion. Throughout the experiment the energy applied was constant, but the intensity decreased from 7.5 to 0.12  $\frac{\text{cal}}{\text{cm}^2 \text{ min}} 10^{-4}$ , whereas the time was increased in an inverse proportion to the intensity, *i. e.*, from 2 to 120 minutes. The result as indicated in Fig. 1 shows a greater biological effect



at short exposures to high intensities and suggests that increased rather than identical energy applications are needed in prolonged exposures to obtain similar biological activity. This would demonstrate the validity of the Schwartzschild law. As a control we performed the same experiment but reversed the order of exposure

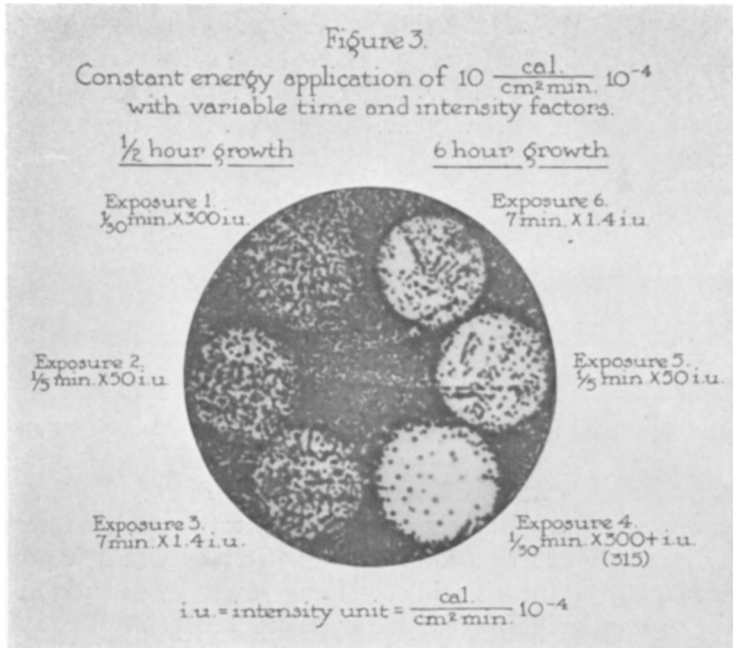
and started with low intensities over prolonged periods. This gave us a diametrically opposed result with greatest biological activity during long exposures with low intensities, a finding which is neither in holding with the Schwartzschild nor Bunsen-Roscoe law. (Fig. 2.)



Therefore, we concluded that the intensity and duration of the exposures were not the only conditions involved, but that some other factor which must be inherent in the bacterial culture itself is also to be considered. To prove this we systematically studied the sensitivity of bacteria to equal amounts of ultraviolet light (keeping time and intensity constant) and found that there was a larger or smaller sensitivity depending upon the duration between the time of plating and time of exposure, the bacteria being kept at room temperature, 70°F.

Time interval	% killed
0	40
2 hr.	94
4 "	97
6 "	98
8½ "	96
10 " .	51

This difference in sensitivity at different periods of bacterial



growth is more fully shown in Fig. 3, in which exposures 1 and 4, 2 and 5, 3 and 6 are identical, but 1, 2, 3 were made after  $\frac{1}{2}$  hr. growth and 4, 5, 6 after 6 hrs. of growth. In our next experiments we selected periods of maximum sensitivity, during which no perceptible change of resistance occurs. By means of a sector we used a ratio of 1:100 and obtained identical results, which aid in ascertaining the non-validity of the Schwartzschild law but sustains the Bunsen-Roscoe law.

These experiments were of importance to us in that our study of the spectral distribution of the germicidal property of ultraviolet light forced us to compare short and long exposures of varying intensities. Thus our time comparisons had to be based on the validity of either the Bunsen-Roscoe or the Schwartzschild law. Liechti<sup>2</sup> reported that the Schwartzschild law is applicable to bacterial destruction by ultraviolet light, while Gates<sup>3</sup> agrees with Coblenz and Fulton<sup>4</sup> in maintaining the non-applicability of the Bunsen-Roscoe law but claims the validity of the Schwartzschild law. We, however, maintain that the Bunsen-Roscoe law is applicable, but only for those periods in which there is no change in the

<sup>2</sup> Liechti, Adolf, *Strahlentherapie*, 1929, **33**, 1.

<sup>3</sup> Gates, Frederick L., *J. Gen. Physiol.*, 1929, **13**, 249.

<sup>4</sup> Coblenz, W. W., and Fulton, H. R., *Sci. Papers Bur. Stand.*, 1924, **19**, 495.

bacterial sensitivity. The results of the authors quoted are probably incorrect in that they have committed our initial error of studying the Schwartzschild factor during a period of decreasing sensitivity; an error, however, which we corrected by means of our controls.

## 6638

**Observations on Administration of Chondroitin in Peptic Ulcers.**

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The effectiveness of mucin in the treatment of peptic ulcer has usually been ascribed to a local coating effect by which it protects the mucous membrane, its acid combining power, or to an inhibition of peptic digestion. Because we observed beneficial effects from mucin in dogs with liver injury,<sup>1</sup> where the results could hardly be ascribed to a local action, we became interested in its possible systemic effects. Mucin is a glycoprotein, a combination of protein with a carbohydrate radical (the prosthetic group). Chondroitin sulphuric acid, the prosthetic group of chondromucoid, is very similar in composition to the mucoitin that is present in mucin and benefits animals with experimental liver injury as does mucin. Chondroitin and mucin both contain glucuronic acid, which is known to be used by the liver for the detoxification of phenol derivatives and other substances. We felt that a study of a group of patients with peptic ulcer treated with chondroitin might indicate whether any of the action of mucin could be ascribed to a systemic effect produced by the glucuronic acid that it contains. Determinations of the uronic acid content of various batches of commercial mucin by Link's modification of the Lefevre and Tollens method<sup>2</sup> gave results varying from 1.2 to 2.5% glucuronic acid. The theoretical glucuronic acid content of chondroitin is 37.6%; the chondroitin that we have used (at first prepared by us, later made for us by the courtesy of Chappel Bros. Inc.) varied from 95 to 98% pure. We have used 3 to 6 gm. of chondroitin per patient per day in divided

<sup>1</sup> Crandall, L. A., Roberts, G. M., and Gibbs, J. W., *PROC. SOC. EXP. BIOL. AND MED.*, 1932, **29**, 1082.

<sup>2</sup> Lefevre and Tollens, *J. Am. Chem. Soc.*, 1930, **52**, 775.