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**The Penetration of Living Tissue by Ordinary Radiant Energy.**

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Since water in a layer 10 millimeters or more thick is well known to be impenetrable by ordinary radiant energy (that is, in the ultra-violet, visible, infra-red, and heat spectrum) of wave lengths longer than 1.4 micron, it has been suggested by Coblenz<sup>1</sup> that living tissue will, in general, be permeable only to wave lengths shorter than these. Sonne<sup>2</sup> found penetration of living tissue in his so-called "visible range", but his filters (water and 5% ferro-ammonium sulphate in glass chambers) apparently transmitted waves to a length of at least 1.3 micron.<sup>3</sup> On the other hand, Bachem and Reed<sup>4</sup> have recently shown that wave lengths shorter than 0.6 micron practically do not penetrate living skin. Evidence exists to show then, that the wave length range of ordinary radiant energy capable of penetrating living tissue lies between 0.6 and 1.4 microns, *i. e.*, it includes those infra-red rays lying near the red rays of the visible spectrum. Independent experiments initiated by me furnish further evidence in this regard, and indicate the extent to which these rays penetrate living tissue. The required measurements were made by G. H. Cartwright at the California Institute of Technology under the direction of R. C. Burt.

For convenience, the experiments on transmission were performed on one subject's cheek which averaged 5 mm. in thickness. Initial experiments indicated that this tissue transmitted about 14% of infra-red rays of a wave length of 0.86 micron. These experiments were made by means of a spectrograph and photographic plates. Opal glass 2 mm. thick was placed in front of the slit of the spectrograph to diffuse the light, the source of which was a 15 Watt electric light bulb. The extent of transmission was determined by comparing exposures made by this bulb placed 5 mm. in front of the diffusion glass, with exposures made by the bulb inside the mouth.

To determine the penetrability of living tissue over as great a

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<sup>1</sup> Coblenz, W. W., *Trans. Illum. Eng. Soc.*, 1928, x, 252.

<sup>2</sup> Sonne, C., *Arch. Phys. Therap., X-Ray and Rad.*, 1929, x, 93.

<sup>3</sup> Nichols, E. F., *Phys. Rev.*, 1893, i, 12. Coblenz, W. W., *Bull. Bur. Stand.*, 1911, vii, 4.

<sup>4</sup> Bachem, A., and Reed, C. I., *Am. J. Physiol.*, 1929, xc, 604.

range of radiant energy as could conveniently be measured, a specially sensitive vacuum thermocouple was constructed by G. H. Cartwright to replace the photographic plates. This thermocouple was mounted on a micrometer screw so that it could be moved across the spectrum with no significant change in the zero reading. Readings were made by galvanometer. The sensitivity of the thermocouple was such that energy of  $1 \times 10^{-8}$  calories per second striking the receiver changed the galvanometer reading by 1 microvolt. A light beam from a 500 Watt electric light bulb was concentrated by a lens and reflected from a mirror inside the mouth so that it passed through the cheek to the wide slit of the spectrometer.

With this technique, the percentage penetration of radiant energy through the human cheek was found as shown in Fig. 1. This indicates a maximum transmission of about 21% at a wave length of 1.15 micron. Wave lengths longer than 1.5 micron or shorter than 0.54 micron showed no detectable transmission through the human cheek.

Sonne's work<sup>2</sup> indicates that in this range of the spectrum about 35% of the energy striking the skin is reflected. While no measure-

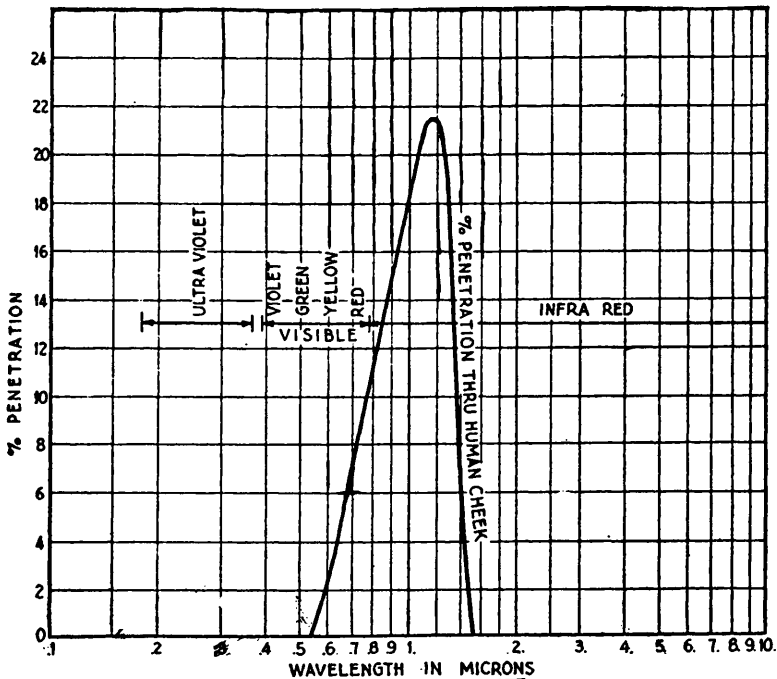


FIG. 1.

Diagram showing penetration of human cheek by ordinary radiant energy.

ments were made of energy reflected by the epithelium inside the cheek, it may still be assumed that about one-third of the energy entering the cheek passed through.

These studies indicate that living tissue is generally impermeable to all but a narrow band of ordinary radiant energy lying between wave lengths of 0.6 to 1.6 micron. Maximum penetration seems to occur at a wave length of 1.15 micron. What physiological or therapeutic effects such radiant energy has is still largely undetermined. A lamp specially designed to deliver rays in the range indicated has been made and is available for study.

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### The Effect of X-Ray Upon Bacteriophage and Upon the Bacterial Organism.

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A number of workers recently have demonstrated that it is possible to produce variants among both plants and animals by exposure to the effect of X-rays. We, in turn, have endeavored to demonstrate change by a similar procedure applied to the Bacteriophage and to the organism susceptible to the Bacteriophage, following suggestions made by Dr. Olson.

Seven strains of *B. coli* bacteriophage were selected and for each of these we cultured the particular strain of *B. coli* acted upon by its respective strain of bacteriophage. There were selected 7 coli bacteriophages and 6 strains of *B. coli* for this series of experiments. These bacteriophages were effective as follows upon the bacterial strains: one for all the strains, one for 5, one for 2 and 3 could lyse only one strain each of the organisms. There were thus 42 combinations possible in such a set up of tubes in case any variation were to appear.

The following methods for exposure were followed. The organisms were young cultures in the phase of positive logarithmic growth in beef infusion broth and the phages were recent filtrates in the same medium. These were contained within lead free glass test tubes. Exposure to X-ray was carried out at a distance of approximately fourteen inches from the target of a Roentgen tube actuated by approximately 75,000 volts of electricity. The exposure period was 30 minutes. Following this treatment each bacterio-