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The quantitative action of ultraviolet light on Staphylococcus aureus.

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By means of a compensated thermocouple of extreme sensitivity kindly made for us by Professor Pfund of Johns Hopkins University, direct measurements have been made of the ultraviolet light energy, at various wave lengths, required to kill *Staphylococcus aureus*. The organisms were exposed on agar plates to the lines of the quartz mercury arc spectrum, isolated by a monochromatic illuminator with quartz lenses and prism. After incubation, counts were made of the colonies produced by surviving organisms in the exposed areas.

Comparison with control counts from adjacent, unexposed, areas shows that the bacteria vary widely in individual susceptibility so that the most resistant may survive an exposure 12 to 20 times that to which the least resistant succumb. The average values of a number of observations at each wave length produce a smooth curve which shows the ratio between the incident energy in ergs per square millimeter and the percentage of organisms killed. The light energy required to kill 50 per cent of the exposed bacteria, at each wave length, has been taken as the mean value of the bactericidal effect of incident ultraviolet light.

Measured thus, as incident energy, wide differences were found in bactericidal power at different wave lengths of the mercury arc spectrum. The lethal energy for 50 per cent of the exposed organisms ranged from 154 ergs per square millimeter at 2378 A.U., through 88 ergs at 2675 A.U, to 3,150 ergs at 3022 A.U. In a single determination the corresponding light energy at 3126 A.U. was 25,000 ergs per square millimeter. Intermediate wave lengths gave intermediate values in an orderly sequence and a line through the observed points produced a curve similar to, but not identical with, that for the absorption of ultraviolet light by *S. aureus* in the same region of the spectrum.

It is only the energy absorbed by the bacteria which can effect

a chemical change and the figures for incident energy must therefore be corrected for the percentage of incident light actually absorbed. Measurements of absorption by thin layers of *S. aureus* pressed between quartz plates gave the first values used for this correction. For a layer of organisms one coccus thick the figures for the absorption of light lay between 4.4 per cent at 3022 A.U. and 10.7 per cent at 2535 A.U. When this correction was applied to the observations on incident energy it was found that the absorbed energy involved in the death of *S. aureus* was approximately equal at different wave lengths from 2482 A.U. to 2804 A.U., an interval that corresponds roughly to a broad absorption band of these organisms in the far ultraviolet.

Further consideration suggests, however, that the absorption of ultraviolet light by *S. aureus*, or any cell, is not a function of the entire organism, but the summation of the absorption factors of numerous chemical entities composing its protoplasm. It is necessary to look further for the particular substances that are responsible for light absorption, with the prospect that one or more may be found to be light-sensitive to the degree implied by the bactericidal power of ultraviolet light. Although other protoplasmic constituents may absorb light, they are not necessarily involved in this particular phenomenon. This phase of the subject is at present under investigation.

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A chart showing graphically the respiratory quotient and the percentage of calories furnished by protein, fat and carbohydrate.

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The percentages of calories furnished by the various foodstuffs can be shown graphically and with satisfactory accuracy on a chart which is almost an equilateral triangle. The base represents the respiratory quotient. The lower left hand corner