after the fashion of a mutation in a very few individuals. There is much to be said for both sides but neither leads us to any definite conclusion. The processes and methods of evolution are clear until we attempt to study any single case.

To the entomologist Dr. Friedmann's studies are unusually suggestive because they disclose so many analogies with the parasitism of social insects (wasps, bees and ants). There are similar indications of an origin of parasitism in struggle and parasitism, of preference for single or multiple hosts, of a lapse of nidificatory behavior owing to precocious readiness for oviposition, and, in one case at least, of a derivation of parasitic from host species. This is clearly shown in the parasitism of *M. rufoaxillaris* on its ancestral species, *A. badius,* a condition strikingly paralleled among parasitic wasps, bumblebees and ants. In other respects, however, the cowbirds, cuckoos, etc., are more like certain non-social insect parasites, such as the Mutillids, Sapygids, Chrysidids, etc., because in these cases we are concerned merely with brood-parasitism as in the cowbirds and not also with an adoption of the mother parasite in the nests of the host as in the case of *Vespa austriaca* and *arctica* among wasps, the various species of Psithyrus among bumblebees and such parasitic ants as *Formica sanguinea, Polyergus, Anergates,* etc.

The volume is well printed though it contains some unfortunate typographical errors; the bibliography is ample and there is an excellent index.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

A VIBRATO TONOMETER

THE recent recognition of the significance of the vibrato in artistic singing has created the need for an apparatus suitable for demonstrating the various forms which the vibrato may take and for carrying on psychological and esthetic experimentation on the perception of the vibrato. The vibrato tonometer has been developed for the purpose and is recommended to experimenters because of its simplicity, convenience and relatively inexpensive construction. With it a vibrato may be produced with the number of oscillations per second, extent of the frequency fluctuation, extent of the intensity fluctuation and frequency-intensity phase relation under separate control.

The apparatus consists of a pipe, similar to an organ pipe, enclosed in a partially sound-proof box. The frequency is varied by an oscillating movement of the plunger, and the intensity by a sliding door in the side of the box. The plunger and the door move back and forth at the same frequency. Both are controlled by scotch-links, which impart a sinusoidal form to their movements. The device is operated by a hand crank, and when turned in rhythm with a metronome, or other timing device, the rate of the vibrato produced can be very accurately controlled. The ratio of the pulleys is such that each revolution of the hand crank produces three vibrato cycles. Thus, by setting the metronome at a known number of beats per minute, a vibrato of any desired number of cycles per second can be produced.

Two scotch-links are used, one controlling the frequency and one the intensity fluctuation. They are mounted on opposite ends of the same shaft, which is turned by a belt from the hand crank. The use of adjustments on the pins of the scotch-links makes it possible to vary independently the amount of the frequency and intensity fluctuations, respectively, from zero to the maximum used in an artistic vibrato.

By changing the position of the scotch-links on the shaft with respect to each other, any phase relationship desired between the frequency and intensity fluctuations can be produced.

The device thus provides for the production of a vibrato with independent control of the extent of the frequency fluctuation, extent of the intensity fluctuation, rate and frequency-intensity phase relationship.

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LABORATORY USES OF ULTRA-VIOLET TRANSMITTING GLASSES

IT may be of interest to those who are not familiar with the special glasses, particularly those biologists and chemists who are studying the effects of ultra-violet on bacteria or on chemical decompositions and syntheses, to learn that satisfactory containers can often be blown of glass. The new glasses vary in short wave-length transmission limit from about 2500 A to 3000 A, so that within this range it is possible to study the effect of wave-length by employing test-tubes, flasks, etc., of different materials. Each container acts as a filter, making external filters unnecessary. Of course, for wave-lengths shorter than 2500 A quartz or else open containers would probably be employed.

I have recently had occasion to study the emission of the 2537 A mercury line under such a variety of conditions that a large number of very special shapes and sizes of discharge tubes was required. To have used quartz with the necessary graded seals or graded

joints with quartz windows would have been prohibitively expensive. Cemented quartz windows proved unsatisfactory because they could not be heated during the evacuation of the tubes. I therefore asked the glass blower to try one of the ultra-violet transmitting glasses, making it about as thin as the wall of an incandescent lamp bulb. He succeeded without great difficulty in joining it to ordinary glass through which the lead-in wires, from two to eleven in number, were sealed. With a few exceptions, the tubes did not crack, and in all cases the transmission of the desired mercury line was satisfactory.

Another fact of great importance in work of this kind deserves mention. One of the first objections raised to the use of ultra-violet transmitting glass was that its transmission might decrease with age, thus making the apparatus useless. This objection obviously was based on the popular notion that solarization, which occurs when such a glass is exposed to sunlight or to short wave-length arc radiation, destroys the properties which distinguish it from ordinary glass. Had this been true the experiments could not have been performed, for quantitative measurements had to be made. A careful study of the matter was made, therefore, to determine the nature of the solarization. My laboratory found that the depreciation in transmission was not serious, that it took place within a short length of time and that the deterioration then ceased so that the glass retained its characteristic properties indefinitely thereafter.

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JUNE 14, 1929

SPECIAL ARTICLES

THE EFFECT OF X-RAYS ON BACTERIA

THE effect of X-rays on certain insects and plants seems to be a popular study at the present time. There seems, however, to have been but little work done on the effect of these rays upon pure cultures of bacteria.[1, 2, 3] The present report is the result of a preliminary study of the effects of irradiation on pure cultures of *B. coli* and *Erythrobacillus prodigiosus*.

The *B. coli* used was isolated from fresh sewage. Its morphology and cultural characteristics were studied in order to prove that it was true to type. The stock culture of *Erythrobacillus prodigiosus* was secured through Dr. F. W. Tanner, of the bacteriology department. The stock culture was "pepped-up" by growing it on agar slants at 20° C. It was transferred daily to a new slant. In this way young and active organisms were available for study. In all cases the characteristic red pigmented colonies developed in twelve hours. The bacterial suspensions which were irradiated were prepared by adding two small loops of the organisms, as removed from a single colony on an agar slant, to 200 cc of sterile physiological salt solution. In each experiment 10 cc of this suspension was added to sterile test tubes of the following specifications:

Soft glass with lip

Length	152.0 mm.
Diameter (inside)	18.0 mm.
Diameter (outside)	21.0 mm.

The test tubes containing the suspension of the organism were placed in an inclined position in an all-wood test tube rack and placed in the lead box containing the X-ray tube. The position chosen for the test tubes was the one which was most convenient and one which did not place the tubes in the beam from the X-ray tube directly perpendicular to the target in order that the effect might be slower and more easily followed. Immediately before starting the X-ray treatment one of the test tubes containing the suspension of the organism was removed and dilutions plated out to determine the original count per cc. The irradiation was then started with a tungsten target tube using a potential of sixty-five kilovolts and a current of three to four milliamperes. At certain time intervals test tubes were removed and dilutions plated out to determine the total counts. The analytical results are summarized in Table I. The rate of sterilization may be noted when the bacterial count is plotted logarithmically against time of irradiation.

RESULTS AND CONCLUSIONS

(1) X-rays act like sterilizing agents upon cultures of *B. coli* and *Erythrobacillus prodigiosus*, in that the curves are characteristic sterilization or death-rate curves showing that the total counts decrease logarithmically with time.

(2) In this experiment *B. coli* did not show variation or mutation when it was treated with X-rays.

(3) With increasing irradiation *Erythrobacillus prodigiosus* showed a tendency toward lack of ability

[1] "Recherches sur l'Action Bactericide des Rayons X," J. J. Trillat, Annales de l'Institut Pasteur, 41, 583 (1927).

[2] "Influence of Temperature on Biologic Action of X-rays," A. Dognon, Arch. Phy. Therapy, X-rays, Radium 9, 55–9 (1928).

[3] Production of Monochromatic X-rays of Long Wave Length," "The Quantum Action on Microbes," F. Holweck, Compt. rend. 188, 197 (1929).