measure and hence the
etween the diploids and
rphological criterion for

t the peculiar behaviour
yeast—isolated last year
and M. Sreenivasaiya—
s been kept in an active
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rnoy and stained in iron
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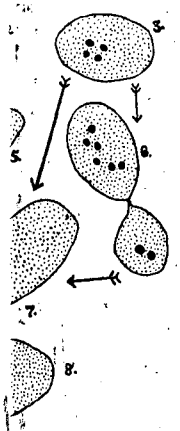

g different cells in the
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three and four chromo-
8 show what may be
of the diploid, triploid
ppears to be 'somatic
aploid (Figs. 3 and 7),
he result of the failure
arate in a vegetative
erved in the behaviour
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is shown a mother cell
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e mother cell has six
as only two. Chromo-
observed by Kater[1]
gging of chromosomes
ge[2] as evidence against
nosomes. Needless to
been observed by the
) in a brewery yeast
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that the chromosomes
This lagging of the
id suggests that it is
nce produces diploids
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om the same ascus of
ge and Laustsen[4]?
r investigation it is
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We are very grateful to Sir J. C. Ghosh and Mr. M. Sreenivasaiya for their encouragement. One of us (M. K. S.) would like to thank Messrs. the K. C. P., Ltd., for the award of a studentship.

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A Specific Effect of High-Frequency Electric Currents on Biological Objects

DURING the last four years, a systematic investigation of the effect of high-frequency electric currents on biological objects has been carried out in this Laboratory with the view of finding a specific effect apart from the heat effect hitherto generally supposed to be the only effect of high-frequency currents on tissue, bacteria, virus, etc. This view is quite natural as, with the technique hitherto used, the heat effect overwhelms any possible specific electric effect.

The frequency of the current experimented with is 20,000 kc. By means of a modulator the current is periodically turned on and off with a frequency of 10–100 kc. in such manner that the recurring current pulses are separated by current-free periods each being n times longer than the single current impulse. With the modulator employed n can be varied between 3 and 20.

Heat developed by such modulated current has a greater possibility of dissipation than heat produced by an unmodulated current. With a certain cooling of the object it is thus possible to adjust n so that the temperature of the object, through which the current passes, is kept below the temperature at which heating effects may occur. Liquids can be passed intermittently between electrodes and cooled between each passage but, as a too rapid flow makes it difficult to secure a uniform velocity of all parts of the liquid and thereby a uniform treatment, it is also in this case important to modulate the electric current. With a modulated current the actual time of treatment to be dealt with is the time only when current is passing through the object, namely, $1/n$th part of the total time of treatment.

The effect described below is due to the electric field set up by the current. The field is characterized by its maximum strength, expressed in volts per centimetre.

Bac. coli in a liquid medium were treated with the modulated current. 99·5 per cent of the bacteria were killed when the field strength was 230 volts cm.$^{-1}$ and the time used was 7 sec.; when applying 288 volts cm.$^{-1}$, the time used was 4 sec. There was no marked difference whether the treatment took place between 12° and 40° C. or 40° and 60° C. In an improved apparatus, 99·6 per cent of the bacteria were killed by 205 volts cm.$^{-1}$ in 5 sec. and 99·98 per cent with the same field in 10 sec. A similar effect produced by heat would require 60° C. in 600 sec.

Milk treated for 2·2 sec. at 340 volts cm.$^{-1}$ or for 1·3 sec. at 620 volts cm.$^{-1}$ acidified when afterwards kept at 35° C. for 18 hours in the same manner as milk previously heated to 75° C. for 30 min. The results were about the same, irrespective of whether the electric treatment took place at temperatures between 6° and 36° C. or 6° and 50° C. (If the temperature after a certain time rose from, for example, 6° to 36°, the current was cut off and the milk cooled to 6° C. before the current was again turned on.)

Foot-and-mouth disease virus was completely inactivated when treated at 260 volts cm.$^{-1}$ for 10 sec. (temperature not above 36° C.) or at 480 volts cm.$^{-1}$ for 2·4 sec. When inactivating the same virus by heat, 60 hours are required at 37° C.

A virus inactivated by heat can be used as a vaccine. The virus inactivated electrically showed no vaccinating effect. This shows that the electrical treatment acts on the virus molecule differently from the heat treatment.

Preliminary experiments with tissue cultures have demonstrated that it is possible to kill the tissue by using a modulated current without raising the temperature above 30° C. when the field strength is 22 volts cm.$^{-1}$ and the time 300 sec. When living tissue of entire organs are to be treated, the heat produced must be carried away by the circulating blood. Experiments seem to indicate that with a field of, for example, 50 volts cm.$^{-1}$, n should be below 1/200. Experiments imply, however, that it will be an arduous undertaking to produce any effect without injury to the skin and that it will be hard to attain a uniform treatment. A kind of cross-firing technique may be developed employing several electrode sets, the current being switched periodically from set to set.

A discharge couple, one in each direction, setting up a field of 5,000 volts cm.$^{-1}$ in 10^{-4} sec. has been tried. An effect similar to that of the high-frequency current is produced by several consecutive discharge couples with intervals for cooling between the discharge couples; but it has up to now been impossible to attain such uniform treatment that a result comparable to that of the high-frequency current is obtained.

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The Scientific Civil Service

THERE is one curious point about the new Scientific Civil Service which is not mentioned in the leading article of *Nature* of December 1. The men of science on whose advice the Service has been framed and those occupying important administrative positions are members of the "A" side in the Royal Society sense. So long as the requirements of the Government are confined to the "A" side, this arrangement is no doubt satisfactory; but, quite apart from medicine and agriculture, it seems probable that there will be a demand for biologists also. Biologists, however, are not likely to take kindly to having their abilities assessed by chemists or physicists, or to working under their direction. Further, biologists who have had pre-war experience of the methods of the research councils and war-time experience of the methods of Ministries still feel that the Scientific Civil Service does not yet ensure the necessary degree of professional freedom.

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