

In connexion with work\* on the rate of growth of *Patella* an area 5 m. by 5 m. at Port St. Mary, Isle of Man, was cleared completely of limpets in January 1946. The situation was on flat limestone rock somewhat below mean sea-level. There was no growth of *Algae* on the cleared square or on the surrounding rock, except in a few small pools and crevices. Most of the area was covered with a dense population of *Balanus balanoides*, and the limpets were scattered fairly evenly over the rock but were rather less abundant among the barnacles. The total population of *Patella vulgata* in the square was 2,184 individuals, of which the majority ranged between 16 mm. and 30 mm. in shell-length.

In April it was seen that various species of *Algae* were commencing to establish themselves in the cleared area. These grew until, in June, they had formed a fairly thick felt covering most of the square. The most important constituent of the felt was *Enteromorpha compressa*, with some *Porphyra umbilicalis* and *Ulva linza*. A number of plants of *Fucus vesiculosus* were scattered among the felt. At the same time about a hundred limpets had migrated into the square from the outside and prevented the algal felt from covering its outer edges. It was distinctly noticeable that there was no growth of *Algae* on the rock outside the square, though this was in every way similar except for the presence of limpets. The shells of the limpets themselves, however, were covered with *Algae*. In July the algal felt was decreasing in extent as more limpets moved into the area and started to browse upon it. The plants of *Fucus vesiculosus*, however, were growing strongly, and by August 6 were well established, apparently having been protected during their early stages by the felt of *Enteromorpha*, which by that date had largely disappeared. The population of *Patella vulgata* in the square was then 324 individuals which had moved in from the surrounding rock, and in addition 499 of the present year's spat.

Confirmation of the growth of *Algae* in the absence of limpets comes from Eslick. In 1937 he cleared an area 2 m. by 2½ m. at Port St. Mary of its *Patella* population\*. The tidal-level was about the same. He informs me that during the following year he observed this area and found it entirely covered with a strong growth of *Fucus vesiculosus*. In this case the area was sharply outlined, indicating that there had been little movement by the limpets on the surrounding rock. The difference would appear to be due to the fact that the surface of the rock is very much rougher in the location where Eslick worked than at the site of the 1946 experiment, and that this factor limits the movements of *Patella*.

The conclusion to be drawn is that *Patella vulgata*, by browsing over the rocks, removes the *Algae* which settle before they can become established, much as goats prevent the growth of trees. In the case of *Fucus*, once it reaches a certain size it is not eaten by the limpets. It is not too much to suppose that in the absence of *Patella* the whole of the foreshore where it is suitable for their settlement would be thickly covered with *Algae*.

Experiments are continuing on a larger scale.

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### Gene Recombination in *Escherichia coli*

ANALYSIS of mixed cultures of nutritional mutants has revealed the presence of new types which strongly suggest the occurrence of a sexual process in the bacterium, *Escherichia coli*.

The mutants consist of strains which differ from their parent wild type, strain K-12, in lacking the ability to synthesize growth-factors. As a result of these deficiencies they will only grow in media supplemented with their specific nutritional requirements. In these mutants single nutritional requirements are established at single mutational steps under the influence of X-ray or ultra-violet\*<sup>1,2</sup>. By successive treatments, strains with several requirements have been obtained.

In the recombination studies here reported, two triple mutants have been used: Y-10, requiring threonine, leucine and thiamin, and Y-24, requiring biotin, phenylalanine and cystine. These strains were grown in mixed culture in 'Bacto' yeast-beef broth. When fully grown, the cells were washed with sterile water and inoculated heavily into synthetic agar medium, to which various supplements had been added to allow the growth of colonies of various nutritional types. This procedure readily allows the detection of very small numbers of cell types different from the parental forms.

The only new types found in 'pure' cultures of the individual mutants were occasional forms which had reverted for a single factor, giving strains which required only two of the original three substances. In mixed cultures, however, a variety of types has been found. These include wild-type strains with no growth-factor deficiencies and single mutant types requiring only thiamin or phenylalanine. In addition, double requirement types have been obtained, including strains deficient in the syntheses of biotin and leucine, biotin and threonine, and biotin and thiamin respectively. The wild-type strains have been studied most intensively, and several independent lines of evidence have indicated their stability and homogeneity.

In other experiments, using the triple mutants mentioned, except that one was resistant to the coli phage T2 (obtained by the procedure of Luria and Delbrück<sup>3</sup>), nutritionally wild-type strains were found both in sensitive and in resistant categories. Similarly, recombinations between biochemical requirements and phage resistance have frequently been found.

These types can most reasonably be interpreted as instances of the assortment of genes in new combinations. In order that various

genes may have the opportunity to recombine, a cell fusion would be required. The only apparent alternative to this interpretation would be the occurrence in the medium of transforming factors capable of inducing the mutation of genes, bilaterally, both to and from the wild condition. Attempts at the induction of transformations in single cultures by the use of sterile filtrates have been unsuccessful. The fusion presumably occurs only rarely, since in the cultures investigated only one cell in a million can be classified as a recombination type. The hypothetical zygote has not been detected cytologically.

These experiments imply the occurrence of a sexual process in the bacterium *Escherichia coli*; they will be reported in more detail elsewhere.

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<sup>1</sup> Tatum, E. L., *Proc. Nat. Acad. Sci.*, **31**, 215 (1945).

<sup>2</sup> Tatum, E. L., Cold Spring Harbor, Symposia Quant. Biol., vol. 11 (in the press, 1946).

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### Assay of Toxic Effect of 'Gammexane' on Man and Animals

THE widespread use of the two new insecticides D.D.T. and 'Gammexane' (gamma isomer of benzene hexachloride) has led to considerable interest being taken in their possible toxic effect upon man and animals. In the case of D.D.T., a considerable literature is already available on this aspect, and both acute and chronic toxicity has been discussed by various authors. With regard to 'Gammexane', Cameron<sup>1</sup> has given some notes on its acute toxicity, and Slade<sup>2</sup> has reported the toxicity of the four benzene hexachloride isomers to rats, but little or no information is available as to the possibility either of chronic poisoning or of a cumulative effect.

The following experiments show that the possibility of any toxic effects from residues of 'Gammexane' dust on foodstuffs is extremely remote. The additions daily of 10, 20 and 30 mgm. per kgm. body-weight of pure 'Gammexane' in powder form to the diet of rats showed no effect whatsoever over a period of twenty-seven days. A longer experiment with much heavier dosages was carried out with benzene hexachloride containing 13 per cent of the gamma isomer. As most 'Gammexane' formulations are based on benzene hexachloride of this composition, the possibility of the other isomers having cumulative or chronic effects would also be demonstrated. The median lethal dose of this substance to rats is 1,250 mgm. per kgm. body-weight, and doses of 500 mgm. per kgm. body-weight were fed daily, mixed with the normal diet. The five rats treated were half-grown at the beginning of the test, and during the period of the experiment, namely, 57 days, their growth-rate was the same as that of untreated littermates. Appetites remained good, the daily ration being readily eaten, and no toxic symptoms of any kind were noted. At the end of the period the animals were killed and all organs found to be normal.

A similar experiment was carried out with pure D.D.T. powder, but a daily dose of 500 mgm. per kgm. body-weight gave rise to nervous symptoms within two days. A dose of 350 mgm. per kgm. body-weight was tolerated, but nervous symptoms occasionally appeared. Rats were kept under experiment for 48 days with this daily dose, but the growth-rate was less than in the control animals. No abnormalities were found in the internal organs.

These doses are much larger than generally reported in the literature, for example, Smith and Stohman<sup>3</sup>, but it should be noted that pure D.D.T. powder was used and not the commercial product, and that no oil was used to incorporate it in the diet.

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<sup>1</sup> Cameron, G. R., *Brit. Med. Bull.*, **3**, 233 (1945).

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### Active Aurora of September 28, 1946

THE aurora visible at Cambridge on the night of Saturday, September 28, showed considerable activity from 9 to 10 p.m. (B.S.T.). When most disturbed, there was a definite change of colour with increasing altitude, the lower portion being bright green, gradually changing to reddish from about altitude 30° up to and beyond the Pole.

The main structure was composed of several long triangular streamers in the red region, sharply terminated at their upper extremities, with broad bases gradually merging into the greenish lower portion.

A special feature was a long more rectilinear luminous streak, almost vertical, and extending from near  $\gamma$  Ursa majoris to  $\epsilon$  Ursa minoris. This lasted for about ten seconds, and was decidedly not a meteor, although these were being looked for as forerunners of the expected stream from the Giacobini-Zinner Comet.

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