

LETTERS TO THE EDITORS

GENETICS

Salmonella-Escherichia Hybrids

UNTIL recently, genetical studies with *Salmonella typhimurium* have been carried out mainly by the transduction method. In an effort to facilitate such studies, we attempted to develop a means of applying conjugation techniques also, using *S. typhimurium* and *Escherichia coli*, since Baron and his collaborators¹ had been able to produce hybrids between these two bacteria. We have been successful in experiments with a *Salmonella* culture carrying a mutator gene (*mut*) and a culture of *E. coli* strain K-12 carrying the factor for high frequency of recombination (*Hfr*). The mutator strain was isolated by Miyake² from strain LT-7. Its main characteristic is a 10- to 100-fold increase in spontaneous mutability.

Our procedure for the detection of recombinants is as follows. Equal volumes of over-night broth cultures of the *S. typhimurium mut* strain and *E. coli Hfr* are mixed; 0.1-ml. samples of the mixture are plated immediately on appropriate medium; and the plates are incubated for 24-36 hr. at 37°C. Under these conditions the frequency of recombinants is about 1 per 10⁶ plated bacteria. Thus it is considerably lower than the frequency observed in recombination between two strains of *E. coli*.

Two *E. coli* strains have been used so far: *HfrCS101* and *HfrC*. With the first we obtained hybrids in which the following *S. typhimurium* mutant genes were replaced by their wild-type alleles from the *E. coli* genome: ability to ferment lactose (*lac*); requirements for leucine (*leu*), arginine (*arg*), threonine (*thr*), aspartic acid (*asa*), thiamine (*thi*), proline (*pro*), glutamic acid (*glt*) and pantothenate (*pan*). With *HfrC* we have obtained hybrids incorporating the *lac*, *pro*, *leu* and *thr* wild-type alleles.

Thus it appears likely that the hybrids may carry any region of chromosome of the donor bacterium.

The results so far can be summarized as follows:

(1) Hybrids have been obtained which combine certain genetic markers carried separately by the two parent bacterial strains.

(2) Among these hybrids three types have been recognized: (a) sensitive to virulent *Salmonella* phage H5, but resistant to *E. coli* phage T6; agglutinated by *Salmonella* serum; (b) resistant to phages H5 and T6; very slight or no agglutination by *Salmonella* serum; (c) resistant to phage H5, but sensitive to T6; not agglutinated by *Salmonella* serum.

(3) Temperate *Salmonella* phage (PLT-22 H1) grown on a type-(a) hybrid will transduce markers carried in the *Salmonella* part of the chromosomal complex, provided the recipient *Salmonella* bacteria have the *mut* (mutator) gene.

(4) This same phage forms about 10¹-10² times more plaques on hybrid-(a) bacteria than on LT-7 bacteria carrying the *mut* gene, and 10²-10⁴ times more plaques than on LT-7 bacteria without *mut*. Adsorption tests indicate no difference between hybrid LT-7 *mut* and LT-7 *mut*⁺ bacteria with regard to phage adsorption.

(5) The approximate order of certain loci in the *Salmonella* genome as determined by these recombination tests is: *mut*-*thr*-*leu*-*pan*-*pro*-*lac*. There is evidence that *pro* and *lac* are close together and close also to *asa*, *glt* and *arg*.

T. MIYAKE
M. DEMEREC

Department of Genetics
(Carnegie Institution of Washington),
Cold Spring Harbor,
New York.

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A Further Example of the Kell Blood Group Phenotype K-,k-,Kp(a-b-)

IN an earlier communication¹, we reported two sisters having the Kell phenotype K-,k-,Kp(a-b-). The parents were second cousins, and it was assumed that the sisters were homozygous for a Kell gene the product of which does not react with any of the known Kell antisera. Allen *et al.*² later gave this gene the abbreviation K^o. Alternatively, there may be a deletion or suppression. We have sought for other examples of this phenotype by using the serum of the propositus of the above family by the capillary-papain method³; by this method the serum reacts with all K+ or k+ bloods. The 3,122nd blood so tested did not react, indicating that it was of the phenotype we sought. This was confirmed by testing with anti-K, anti-k, anti-Kp^a and anti-kp^b; it reacted with none of these.

The parents of the propositus, Mrs. Kan, are first cousins. Her husband, two children, daughter-in-law and four grandchildren are all K-,k+,Kp(a-b+). While the two children are presumably of genotype kKp^b.K^o, titration with anti-k and with anti-Kp^b failed to differentiate between assumed genotypes kKp^b.kKp^b and kKp^b.K^o. The family is of Finnish descent. The mother and six brothers and sisters of the propositus live in Finland.

It may or may not be significant that two members of the original family in which K^o occurred, and two of the nine members examined in the present sibship, had suffered abnormal bleeding for which they were transfused; further, the new-born baby of the propositus in the first family suffered from a form of erythroblastosis foetalis in which petechial haemorrhages of the skin were a prominent sign.

HIROKO KAITA
MARION LEWIS
BRUCE CHOWN
EILEEN GARD

Rh Laboratory,
735 Notre Dame Avenue,
Winnipeg 3, Canada.

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