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Genetics of Bacteria

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WARF - 2  
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Bacterial Genetics--Research Report for 1955

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The work in this laboratory continues to center on the genetic recombinational mechanisms of bacteria: sexuality, transduction, and virus infection. This past year has seen no remarkable new advances, and has been devoted mainly to clarifying minor discrepancies, and consolidating earlier advances.

1. A considerable amount of time was spent to try to reach a definite conclusion concerning the residual unit which is propagated, without multiplying, in succeeding cell divisions of some *Salmonella* cells after "abortive" or "phenotypic" transduction (5,18). The main conclusion is that no definite decision could be made whether the unit is particulate, and if so whether it represents a partly inactivated "gene", or simply a gene product. Other workers have sought to make more conclusive inferences from the same kind of data.

2. Additional work on conjugal pairs of *E. coli* has corroborated earlier indications of their significance in the sexual cycle of this bacterium, so that a preliminary account is now justified (9). However, no further progress has been made in tracing the morphogenetic details of sexual conjugation by microscopic methods.

3. Further study of the relationship between a provirus and other genes of *E. coli* (7,8,16) substantiates the hypothesis that a virus is equivalent to a segment of the bacterial chromosome and that the lysogenization for a virus corresponds to a special transduction. Some aspects of this relationship are still obscure and require further study.

4. As an important tool for the preceding studies, considerable effort has been devoted to the development of properly marked diploid stocks of *E. coli* (normally haploid) which can be used more informatively for routine crossing purposes. This has proved to be more laborious than had been anticipated, and is not yet completed, but should repay the effort in due course.

5. Some second-order discrepancies of observation (3) have been clarified by the finding that different stocks of the Hfr mating type of *E. coli* show different segregational behavior. The genetic basis and origin of these differences are being studied now, and are the most promising leads to clearing up some of the remarkable peculiarities of the genetics of this organism, as quoted in previous reports and elsewhere (1).

6. As a renewal of some preliminary experiments in 1951-52, a study has been made of *Streptomyces* species to determine whether a system of genetic recombination could be detected (17). This study was motivated by the interesting taxonomic and morphogenetic status of these "bacteria", on the one hand, and on the other by their economic importance in the fermentation industries as sources of antibiotics and feed supplements, which has led in turn to their close physiological study by other workers. However, almost no genetic work had been done with these organisms until recently. A number of species have been examined, including *S. griseus*, by the same basic technique formerly employed with other bacteria, the combination of different nutritional mutants. No definite evidence for genic recombination has been found. However, it has been verified that hyphae of different strains will fuse, to allow the intermixture of different nuclei in a common cytoplasm, namely heterokaryosis. These nuclei are capable of interacting to produce new physiological effects. This system, while it may be of some industrial application in the development of suitable strains, is far less advantageous than true genic recombination for the prospects of controlled breeding. While this work was proceeding, a fragmentary report appeared on the occurrence of recombination in another species, *S. coelicolor*. This work complements ours in many respects; it also raises the question of why the strains should behave differently, perhaps because of sexual compatibility factors which can now be investigated.

7. Previous reports have outlined the facts of flagellar "phase variation" in Salmonella. Briefly, clones of this organism can persist in two almost stable states, according to which of two potential antigens are actually produced. The two antigens are controlled by two different genes: we may ask the question: What controls which of two genic potentialities is actually realized?-- a question analogous to those posed by differentiation of tissue cells, but one which is not often encountered in genetically analysable material. Transduction analysis has now shown that one of the two genes exists in either of two states: an "active" state which promotes its own realization, and suppresses that of the other, and, conversely an "inactive" state. In technical terminology, we may refer to these states as "epistatic" and "hypostatic", respectively. While the differentiation has thus been localized at the actual site of one of the involved genes (and not, for example, in the cytoplasm or at the second gene) we still do not know its ultimate chemical or physiological basis. This narrowing may, however, lead to further advances in this direction. It is perhaps significant that during the very course of these studies, the interest of morphogeneticists has been turned again to the nucleus, and away from the cytoplasm, as the seat of differentiation by such studies as the nuclear transplantations (in frogs, not bacteria) of Briggs and King.

8. As a remarkable example of "pleiotropy", or manifold physiological effects of a single gene mutation, it has been found that the same mutation which inhibits maltose fermentation also makes the bacteria resistant to a virus, lambda-2 (6). There is no perceptible causal relationship between these phenotypes.

## 1955 Publications

1. Lederberg, J. 1955. Recombination mechanisms in bacteria. *Jour. Cell. Comp. Physiol.* 45, Suppl. 2, 75-107 (May).
2. Lederberg, J. 1955. Genetics and microbiology. In *Perspectives and Horizons in Microbiology* (S. A. Waksman, Ed.) Rutgers Univ. Press.
3. Lederberg, J. 1955. Genetic recombination in bacteria. *Science* 122:920. (November).
4. Bernstein, A. and Lederberg, J. 1955. Agglutination of motile Salmonellas by acridines. *Jour. Bact.* 69:142-146.
5. Lederberg, J. and Stocker, B.A.D.S. 1955. "Phenotypic" transductions of motility in Salmonella. *Genetics* 40:581. (abstr.)
6. Lederberg, E. M. 1955. Pleiotropy for maltose fermentation and phage resistance in *Escherichia coli* K-12. *Genetics* 40:580-581. (abstr.)
7. Morse, M. L. 1955. Cis-trans position effect in transduction heterogenotes of *Escherichia coli*. *Genetics* 40:586-587. (abstr.)

## In Press (1956)

8. Morse, M. L., Lederberg, E. M. and Lederberg, J. 1956. Transduction in *Escherichia coli* K-12. *Genetics* 41:142-146.
9. Lederberg, J. 1956. Conjugal pairing in *Escherichia coli*. *Jour. Bact.* 71.
10. Lederberg, J. 1956. Prospects for the genetics of tumor and cancer cells. *Ann. N. Y. Acad. Sci.*
11. Lederberg, J. 1956. Commentary on gene-enzyme relationships. *International Symposium on Enzymes, Henry Ford Hosp., Detroit, Michigan.*
12. Lederberg, J. 1956. Genetic transduction. (acceptance pending).
13. Nelson, T. C. 1956. Sexual competence in *Escherichia coli*. *Jour. Cell. Comp. Physiol.*

14. Cavalli, L. L. and Lederberg, J. 1956. Isolation of preadaptive mutants of bacteria by sib-clone selection. *Genetics* 41.
15. Lederberg, J. and Lederberg, E. M. 1956. Infection and Heredity. Symp. Soc. Growth and Development.

Almost ready for submission

16. Morse, M. L., Lederberg, J. and Lederberg, E. M. Transduction heterogenotes in *Escherichia coli*.
17. Bradley, S. G. and Lederberg, J. Heterokaryosis in *Streptomyces*.
18. Lederberg, J. Hereditary chains of descent in *Salmonella*. (tentative title).
19. Lederberg, J. and Iino, T. A duplication of antigen-determining loci in *Salmonella*.