# LETTERS TO THE EDITORS

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## Immunity of Lysogenic Bacteria

BACTERIAL virus (phage), in its symbiotic phase (prophage), renders the host bacterium lysogenic, and confers on it immunity against lysis by free phage particles of the homologous type, whether temperate or virulent in character. Hyper-virulent mutants, which are rare, may be exceptions to this rule.

Earlier work suggested that this immunity might cover not only homologous phage but also phages of related types. An extensive survey of the *A* phages of *Salmonella typhi-murium* (which form a closely related group) shows that this conception needs revision. Some cross-immunity does exist, but it is far from being universal or complete. Four different reactions have been found.

(1) Reciprocal cross-immunity may be absolute, so that lysogenic bacteria carrying prophage *L* and lysogenic bacteria carrying prophage *M* (the letters used are symbols only, and do not refer to named phages) are equally resistant to temperate particles of phages *L* and *M*. Neither lysis, nor any change in lysogenesis, occurs, although the free particles may be well adsorbed.

(2) There may be reciprocal sensitivity. Thus, when lysogenic bacteria carrying prophage *L* are exposed to temperate particles of phage *N* or, vice versa, when lysogenic bacteria carrying prophage *N* are exposed to temperate particles of phage *L*, some bacteria may be lysed while others may become doubly lysogenic, and carry both prophages *L* and *M*.

(3) One phage may be partly dominant over the other. In this case, when lysogenic bacteria carrying prophage *L* are exposed to temperate particles of phage *O*, they show complete resistance; but when bacteria carrying prophage *O* are exposed to temperate phage particles of phage *L*, some bacteria are lysed and others survive, showing double infection with prophages *L* and *O*.

(4) One phage may be completely dominant over the other. Thus when lysogenic bacteria carrying prophage *L* are exposed to temperate particles of phage *P*, they show complete resistance: but when lysogenic bacteria carrying prophage *P* are exposed to temperate particles of phage *L*, some are lysed, while in others phage *L* evicts and replaces prophage *P*, so that the surviving bacteria carry only prophage *L*. Sometimes, however, a few of the surviving bacteria are phage-free; the strong phage has apparently turned out the weak, but has failed to take its place, so that the bacterium has been 'cured'.

Certain of the 'cured' bacteria recovered in this way are very efficient indicators. The first to be encountered, strain *Q*1, supports the growth of all the identified phages of *S. typhi-murium*. Hitherto it has been necessary to use two different indicator strains (for some time suspected to contain weak symbiotic phage) to isolate the complete series; this has made exact comparisons of the phages difficult. It is an easy matter to prepare pure suspensions of these temperate phages, and with them to produce lysogenic strains of *Q*1 which are alike except for their prophage content. These lysogenic strains have a specific immunity which provides a delicate means of identifying phages. A test, based on this principle, has revealed differences which were hitherto unsuspected, and has greatly enhanced the accuracy of the method of 'typing' bacteria by determining the prophages they carry.

In the course of these experiments no 'hybrid' phages have been found; but a much larger number of colonies would need to be examined before the possibility of their occurrence could be definitely excluded. Certain of the free phage preparations contain a non-particulate lytic principle which acts on some strains of lysogenic bacteria and not on others. This also has still to be investigated.

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## Role of Non-Protein Nitrogen in the Synthesis of Hæmoglobin in the Reticulocyte *in vitro*

A CONSIDERABLE increase of non-protein nitrogen takes place when washed suspensions of red cells of anæmic rabbits, which are rich in reticulocytes, are incubated in physiological saline. This does not occur in suspensions from animals which are low in reticulocytes (see Table 1). The relation between increase of non-protein nitrogen and respiration, which is indicated by the data, is further borne out by the observations that: (*a*) increase of non-protein nitrogen is lower under anaerobic conditions (Table 2); (*b*) that it is inhibited by 2,4 dinitrophenol (Table 3).

Table 1

| Reticulocytes per cent | Medium | $O_2$-consumption mm.$^3O_2$/h./ml. cells | NPN mgm./ml. cells/6 h. |
|---|---|---|---|
| 1·5 | NaCl | 16·5 | +0·08 |
| 18·1 | NaCl | 164·5 | +0·51 |

Red cells of rabbits, made anæmic by repeated bleeding, were used. They were washed three times with isotonic sodium chloride solution. One part of washed cells was suspended in 3 parts of medium and incubated in Warburg vessels at 37·5°

Table 2

| Medium | Conditions | NPN mgm./ml. cells/6 h. |
|---|---|---|
| NaCl | Aerob. | +0·27 |
| | Anaerob. | +0·08 |

Conditions as in Table 1

Table 3

| Medium | Conditions | Δ NPN mgm./ml. cells/6 h. |
|---|---|---|
| NaCl | Aerob. | +0·33 |
| +2,4 DNP (final concentration $10^{-4}$ *M*) | ,, | −0·04 |

Conditions as in Table 1

Table 4

| Medium | Conditions | Δ NPN mgm./ml. cells | Δ Hb. mgm./ml. cells |
|---|---|---|---|
| NaCl | Aerob. | +0·27 | 0 |
| Phosphate+glucose +11 amino-acids | ,, | +0·05 | +9·8 |

Conditions as in Table 1