

# Resistance to Arsenic Compounds Conferred by a Plasmid Transmissible Between Strains of *Escherichia coli*

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A plasmid, R773, which confers resistance to arsenic compounds, is transmissible between strains of *Escherichia coli*. It is a member of compatibility group F<sub>1</sub>.

Elek and Higney (3) reported variability in the level of resistance to sodium arsenate between strains of *Escherichia coli* isolated from nature. This paper described the genetic determination of arsenate resistance in one of these strains (no. 1).

This strain was markedly more resistant to sodium arsenate, sodium arsenite, and arsenic trioxide than are most strains of *E. coli* (including K-12 derivatives). It was also resistant to tetracycline and streptomycin. All three resistances could be transferred, by conjugation, to *E. coli* J62.1 (K-12:F<sup>-</sup> *pro*, *his trp lac*, *nal<sup>r</sup>*) and whichever antibacterial compound was used as selective agent for the unselected resistances were always co-transferred (10 colonies tested, in each case). The plasmid responsible for these resistances was designated R773.

From J62.1, R773 was transferred to other derivatives of *E. coli* K-12. It was transferred to strain J53 (K-12:F<sup>-</sup> *pro*, *met*) using tetracycline as the selective agent, and the level of resistance to arsenic compounds was measured. J53 R<sup>-</sup> was markedly inhibited by 0.1% sodium arsenate and showed no trace of growth on agar containing 0.4%, whereas J52 R773<sup>+</sup> showed no reduction in colony-forming ability or growth rate on such media. The R<sup>-</sup> strain was strongly inhibited by 0.0125% sodium arsenite and was totally incapable of colony formation in the presence of 0.05%, whereas the R773<sup>+</sup> was not visibly affected by these concentrations.

From J62.1 R773<sup>+</sup>, the R factor was transferred to HfrC (K-12:*met*), and in this strain, prevented visible lysis by the male-specific phage MS2 (1). R773 was thus *fi*<sup>+</sup>. R773 was, however, rapidly lost from HfrC, and the *fi* test gave consistent results only if selection for its

retention was maintained (by the use of tetracycline).

Since the majority of *fi*<sup>+</sup> R factors belong to compatibility groups F<sub>1</sub> or F<sub>11</sub> (4), we tested the ability of R773 to coexist with R1, a plasmid of group F<sub>11</sub> (4), and R455, a representative of group F<sub>1</sub> (R. W. Hedges, N. Datta, J. N. Coetzee, and S. Dennison, *J. Gen. Microbiol.*, in press). Since R455 determines resistance to both streptomycin and tetracycline, a spontaneous segregant, R455-2, which had lost the ability to confer tetracycline resistance, was isolated. Neither R1 nor R455 conferred resistance to arsenic compounds.

R773 coexisted with R1 but was incompatible with R455 (Table 1). It is thus a member of compatibility group F<sub>1</sub>. There was slight but significant mutual exclusion between R773 and R455-2 (Table 1). Since the F factor is also a member of group F<sub>1</sub>, the instability of R773 in HfrC is explicable as incompatibility between R773 and the integrated F.

Other members of the F<sub>1</sub> group were tested for ability to confer resistance to arsenic compounds: presence of F, ColV2, or R386 (5.2) all failed to increase the arsenate resistance of K-12 strains.

Resistances to compounds of various metals including arsenic are determined by plasmids in *Staphylococcus*. In this genus, arsenate and arsenite resistances seem to be determined by different genes, although the two resistances are closely linked and tend to be present or absent together on naturally occurring plasmids (7).

That resistance to mercury salts may be determined by R factors of enterobacteria is well established (6, 8, 9). We tested several R factors which carried mercury resistance and

TABLE 1. *Incompatibility of R773 with R455-2*

Donor	Recipient	Selective agent	Frequency of transfer <sup>a</sup>	Character of transipients <sup>b</sup>
J53 (R455-2)	J62.1	Chloramphenicol	$1 \times 10^{-2}$	20 of 20 C <sup>r</sup> T <sup>s</sup> As <sup>s</sup>
J53 (R455-2)	J62.1 (R773)	Chloramphenicol	$4 \times 10^{-3}$	
J62.1 (R773)	J53	Tetracycline	$2.5 \times 10^{-2}$	20 of 20 C <sup>r</sup> T <sup>r</sup> As <sup>r</sup>
J62.1 (R773)	J53 (R455-2)	Tetracycline	$3 \times 10^{-3}$	

<sup>a</sup> Frequency of transfer was measured per donor cell after 1-h matings by using the technique described in reference 2.

<sup>b</sup> Abbreviations: C, Chloramphenicol; T, tetracycline; As, arsenic compounds; <sup>r</sup>, resistant; <sup>s</sup>, sensitive.

found none to confer resistance to arsenic compounds, whereas R773 determined little if any mercury resistance. Thus, resistance to arsenic compounds is distinct from mercury resistance.

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