acid levels of the female subjects are responsible for the longer lag times of these same individuals.

The effects of the various experimental manipulations on each variable measured are not significant. Despite a considerable increase in anxiety during the hypnosis plus anxiety occasion, the ceruloplasmin level did not change significantly. The anxiety levels achieved resembled those seen in severely disturbed, hospitalized psychiatric patients. Plasma hydrocortisone levels determined on aliquots of the blood samples drawn from the female subjects in this study were 75 percent higher during the anxiety occasion than during the hypnosis occasion (*2*).

The differences in conclusions between Ostfeld and his co-workers and ourselves concerning the effect of anxiety on serum ceruloplasmin level is not presently clear. They may reflect fundamental differences in the kind of anxiety studied, in the assessment of anxiety, or perhaps in differential effects resulting from chronic as contrasted with acute anxiety.

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Hybridization of Salmonella Species by Mating with Escherichia coli

Abstract. A number of species of *Salmonella* were fertile at low frequency as recipients in crosses with *Escherichia coli,* as evidenced by the isolation of lactose-positive hybrids possessing the *Salmonella* antigenic structure. A hybrid from an initial mating, when crossed again with *E. coli,* behaved then as a high-frequency recipient strain.

Genetic recombination in *Escherichia coli,* discovered by Tatum and Lederberg (*1*), and the fertility system involved in the mating between various strains of this species have been described in much detail (*2*). It is now apparent that a unilateral contribution of genetic material from the donor (Hfr, F^+) strain to the recipient (F^-, F^+) takes place. Recently, Luria and Burrous (*3*) have reported recombination between *E. coli* and many *Shigella* species which acted as F^- strains in these matings. Attempted crosses between *E. coli* and *Salmonella,* however, were unsuccessful until Baron *et al.* (*4*) detected recombination at low frequency between *E. coli* and *Salmonella typhimurium* strain TM-9. Subsequently, a streptomycin-resistant mutant of TM-9 was isolated prior to mating, and this strain (TM-9S^r-2) acted as a high-frequency recipient strain in matings with *E. coli.*

As an extension to the studies with *E. coli* K-12, Lederberg (*5*), using an appropriate screening procedure, surveyed a large number of other strains of *E. coli* for genetic recombination. In a similar study, following the initial observations with *S. typhimurium,* we have examined other species of *Salmonella* for ability to act as recipients in crosses with *E. coli* K-12, employing the following procedure.

The various *Salmonella* cultures were grown on nutrient agar plates, harvested after 18 hours' growth, and washed three times with saline. The donor culture of *E. coli* used was the strain of high frequency of recombination (Hfr) for lactose, isolated by Cavalli (*6, 7*). This culture was grown in Penassay broth, washed, and plated with each of the *Salmonella* cultures at a ratio of one Hfr (donor) cell of *E. coli* to 20 *Salmonella* (potential recipient) cells on minimal lactose agar plates. This medium would not support the growth of the parent methionine-requiring (M^-) *E. coli* Hfr cells or the parent lactose-negative (Lac^-) *Salmonella* species in control platings of the parent cultures alone, but would reveal methionine-independent lactose-positive (M^+Lac^+) progeny.

The results of this study have revealed that, in addition to the three strains of *S. typhimurium* (TM-9, LT-7, and HB) previously reported to be fertile by Baron, Carey, and Spilman (*8*), five strains of *S. typhosa,* two strains of *S. paratyphi* B, the Vi-containing East Africa strain of *S. paratyphi* C, *S. abortus-equi,* and *S. strasbourg* also gave rise to Lac^+ progeny which exhibited the antigenic characteristics of the parent *Salmonella* cultures. These strains and their antigenic structures, according to the Kauffmann-White schema (*9*), are listed in Table 1.

Table 1. *Salmonella* species yielding Lac^+ recombinants in crosses with *E. coli* Hfr.

Species	Antigenic structure	Recombination frequency	Source
S. typhimurium TM-9	4,5,12:i,1,2	4×10^{-8}	P. R. Edwards
S. typhimurium TM-9S^r-2	4,5,12:i,1,2	1×10^{-4}	From TM-9
S. typhimurium LT-7	1,4,5,12:i,1,2	1×10^{-7}	E. Englesberg
S. typhimurium HB	1,4,5,12:i,1,2	$< 10^{-8}$	Mouse
S. paratyphi B3	4,5,12:b,1,2	$< 10^{-8}$	P. R. Edwards
S. paratyphi B7	4,12:b,1,2	$< 10^{-8}$	P. R. Edwards
S. abortus-equi 26	4,12:_, enx	$< 10^{-8}$	P. R. Edwards
S. paratyphi C32	Vi 6,7:c,1,5	1×10^{-7}	P. R. Edwards
S. typhosa Ty2	Vi 9,12:d	$< 10^{-8}$	A. Felix
S. typhosa Ty2W	_9,12:d	$< 10^{-8}$	From Ty2
S. typhosa H-901	_9,12:d	$< 10^{-8}$	A. Felix
S. typhosa 0-901	_9,12:_	$< 10^{-8}$	A. Felix
S. typhosa 643	Vi 9,12:d	$< 10^{-8}$	A. Wolff
S. typhosa 643L$^-$	Vi 9,12:d	1×10^{-4}	From 643L$^+$
S. strasbourg 148	9:d,1,7	$< 10^{-8}$	P. R. Edwards

No recombinants were obtained from approximately 70 other species or strains of *Salmonella* with the same or similar serotypes, although in some instances heavy background growth, probably due to reciprocal feeding of the mixed cultures, may have obscured the results. In any case, there appears to be no evidence for any association between known antigenic components in the *Salmonella* tested and their ability to act as recipients in these crosses.

As a consequence of these and earlier experiments (*4*), it was assumed that populations of *Salmonella* cells generally are unable to act as recipients. For the sake of clarity, these cultures will be referred to as F^0 strains. At a low frequency, the F^0 cells in the population of certain or, perhaps, many species of *Salmonella* mutate to or in some manner acquire the F^- recipient state. These occasional F^- cells in the F^0 population will mate with the Hfr *E. coli.* A hybrid which is isolated from an initial mating (*E. coli* Hfr × *Salmonella*) should, according to this concept, be F^- and, hence, capable of being mated again as a recipient strain to yield hybrids at a high frequency. Recombination of such a strain should be detected also with the lower-frequency donor *E. coli* F^+ strains. The availability of a number of selective markers in *S. typhosa* strain 643 enabled us to test this possibility (*10*). A Lac^+ hybrid of strain 643 was selected for further examination, since it still possessed the antigenic and biochemical manifestations (other than

lactose utilization) typical of its parent typhoid culture (*11*).

This Lac$^+$ hybrid, referred to as strain 643L$^+$, still arabinose-negative (Ara$^-$), was again mated with the *E. coli* Hfr and also with an *E. coli* F$^+$ strain on minimal medium containing *l*-arabinose. Hybrids of the presumably F$^-$ strain 643L$^+$ appeared at a relatively high frequency in the Hfr cross and could also be detected in the F$^+$ cross, whereas the previously unmated F^0 strain 643 failed to yield any recombinants that were able to utilize *l*-arabinose.

An opportunity to determine the frequency of recombination for Lac$^+$ occurred when Lac$^-$ hybrids of 643L$^+$ were obtained from matings of this strain with a Lac$^-$ Hfr strain of *E. coli* (*12*). These Lac$^-$ hybrids, observed in the progeny of crosses selected on minimal *l*-arabinose medium, were able to recombine at a high frequency for Lac$^+$ when mated again with the Lac$^+$ *E. coli* Hfr. The frequency of recombination found here (expressed as the ratio of recombinants to the number of Hfr parent cells) was of the order of 1×10^{-4}. This is typical of the frequency determined for the streptomycin-resistant mutant of *S. typhimurium* (TM-9S^r-2), which is now considered to have been a fortuitous isolation of an F$^-$ strain from the population of F^0 cells of *S. typhimurium* TM-9 prior to mating (*13*).

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Radiation-Induced Crystallization of Sucrose

Abstract. In the presence of gelatine, sucrose crystallizes after a relatively short time (minutes, hours) when exposed to the radiation of an x-ray tube with copper target, or of a medical microwave unit. The formation of sucrose spherulites, visible with the naked eye, was observed.

The crystallization of sucrose from water solutions is inhibited by various substances, such as gelatine, which both hinder the formation of crystal nuclei in supersaturated solutions and reduce the rate of crystal growth. When sweetened and fruit-flavored gelatine (Jello) is dried, the sucrose generally remains in "solid solution." If crystallization does take place, a long period of time (weeks, months, or more) elapses before it is detected. Crystallization of sugar started to take place in a dried raspberry-flavored Jello, however, shortly after it was exposed to x-rays or microwaves.

Figures 1*A* and 1*B* show the x-ray diffraction patterns of Jello before and after a relatively long exposure to x-irradiation from a tube (copper target) operated at 40 kv and 20 ma. While only two amorphous rings appear before irradiation (Fig. 1*A*), the presence of "Laue spots" in Fig. 1*B* indicates that a great number of small single crystals (approximate size, 300 μ) were formed during the 6-hour exposure. The crystals obtained were identified as sucrose by their powder pattern (*1*). Their size increased with the time of exposure.

A similar effect was observed after the dried sample was irradiated by means of a 100-watt medical microwave unit (Raytheon, $\lambda = 12.5$ cm) at a distance of approximately 5 cm. The originally transparent gelatine became opaque in a few (10 to 15) minutes, and the sucrose crystallized in spherical aggregates consisting of radially arranged needles barely visible with the naked eye (Fig. 2). The x-ray diffraction pattern of these spherulites (Fig. 1*C*), obtained with a small pinhole (100 μ di-

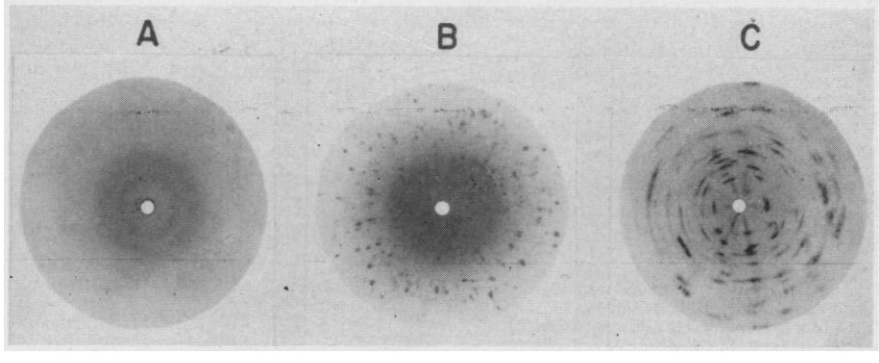

Fig. 1. X-ray diagrams. (*A*) Before irradiation; (*B*) after irradiation; (*C*) sucrose spherulite. (CuKα-irradiation; plane film; specimen-film distance, 15 mm.)

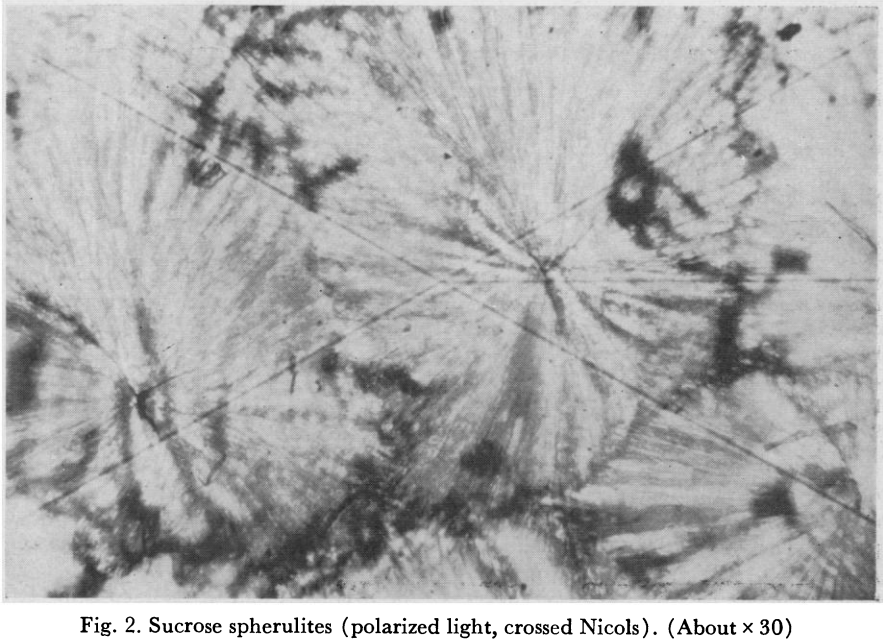

Fig. 2. Sucrose spherulites (polarized light, crossed Nicols). (About × 30)