ences in intelligence, whether measured by Alpha or Beta, are to be interpreted in similar terms.

In an early survey of the results of Army intelligence testing during World War I, W. C. Bagley (*Determinism in education.* Baltimore, Md.: Warwick and York, 1925) emphasized the large difference between the levels of northern and southern states. "This difference is not a gap," he remarked, "it is a chasm" (p. 69). What will the results for World War II show? The relationship between test scores and educational expenditures described above affords a basis for prediction.

The rank-order correlation between state expenditures for education in the years 1910 and 1932 is .85. The ratio of expenditures by the 10 highest states to those of the 10 lowest states in 1910 is 5.5:1, while the ratio for 1932 is 4.2:1. The same 10 southern states comprised the lowest group both in 1910 and 1932. In neither year was a southern state included in the highest group. From these data it seems reasonable to predict that the results for World War II will show north-south differences which, if not on the order of a 'chasm,' will nevertheless represent a wide gap. The validation of this prediction would imply the failure of social plans based on the doctrine of states' rights and the need for a stronger federal emphasis in meeting the problems implicit in the data under discussion. (It should be recognized, of course, that differences in educational expenditures are paralleled by a variety of other socioeconomic differences; educational expenditures merely provide a convenient index of the totality of other factors.) A national rather than a state-wide perspective would be indicated to ensure the democratic development of the human resources of the United States.

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### Embryonic Induction in Regenerating Mesenchyme

A series of reports have been made by the undersigned on the development of various regions of the early embryo differentiating in the midst of regenerating tissue of *R. pipiens larvae* (*J. exp. Zool.*, 1940, 83, 191; 1941, 87, 403; 1942, 90, 353; 1943, 93, 185; 1944, 95, 61; 1944, 97, 1). The development of some of the same early embryonic areas in salt solution has also been studied (*J. exp. Zool.*, 1945, 100). The work has shed light on the embryonic induction of several different organs, including epidermis, nose, horny jaws, and suckers. For these and other organs the series of studies have provided data on the appearance and extent of competence, the location of the normal inductor, the time during gastrulation at which the inductor acts, and the presence of similar inductors in regenerating tissue. These results make up the bulk of the various reports, but it is the effect of the embryonic grafts on the regenerating tissue which now requires brief comment.

It now appears that the effect of embryonic transplants on blastema mesenchyme is not as great as was at first believed. In the first of the blastema studies referred to above the presumptive medulla from the neurula stage was grafted into regenerating tissue, and in some cases (11 per cent) a small vesicle was formed from the blastema tissue next to the embryonic medulla. Since these vesicles were about the same size and shape as an early ear vesicle, were composed of a single layer of cells, and were situated just adjacent to the transplanted medulla, they were interpreted as probably an abortive attempt on the part of the blastema tissue to form an ear vesicle. However, it was emphasized that none of these vesicles ever developed an endolymphatic duct, or sensory and nonsensory areas, and that the method of formation of the vesicles from the blastema tissue was entirely different from the normal formation of an ear. Hence, these vesicles were described as structures similar to ear vesicles, but not definitely identifiable as such.

In the five extensive subsequent reports on embryonic grafts in regenerating tissue and in several unpublished studies, many different embryonic inductors were grafted into the blastema. These include the eyecup, and all regions of the roof of the archenteron of the late gastrula and of the early neurula (unpublished). Several hundred such transplants have been studied, and in no case is there any indication of a definite inductive action of the embryonic inductor on the regenerating tissue. To test this question further, a series of grafts was made of the dorsal lip of the early and middle gastrula into the blastema (unpublished). Although this is perhaps the most powerful embryonic inductor known, the regenerating tissue again showed no inductive response.

These results, based on such an abundance of data, suggested that the small vesicles originally found adjacent to the grafted medulla were probably not abortive ear vesicles after all. A restudy of the protocols of the original experiments showed that during the course of the work the method of grafting the embryonic tissue into the blastema was slightly changed. In all cases a thin flap of regenerating tissue was separated in part from the blastema, and the graft placed under this flap. However, at first a small amount of blastema tissue, including a part of the regenerating notochord, was cut out and discarded in order to make room for the graft. During the course of the work, however, it was found that better results followed merely making the blastema flap, without removing any regenerating tissue. The small vesicles adjacent to the grafted medullas all appeared in the first experiments made, in which the regenerating notochord was purposely somewhat injured during operation. It seemed possible, therefore, that the host filum terminale was also injured during operation, and that occasionally a small section of the growing filum was separated from the rest of the filum, forming a small vesicle.

To test this possibility a series of control operations was recently performed in which a blastema flap was made and a small portion of the regenerating notochord and adjacent mesenchyme removed, but no embryonic tissue was transplanted beneath the flap. In three of the four cases studied, the host filum terminale was definitely affected by the operation. A partial twinning of

the filum occurred, so that a short extra spur of filum tissue was present at the point of original injury. This short branch is histologically identical with the small vesicles hitherto interpreted as probably abortive ear vesicles. Moreover, the branch of the filum is morphologically identical with the vesicles previously described, except that the vesicles were not attached at any point to the host filum. In a large series of well over 100 experiments it seems clear that occasionally a small amount of filum tissue might be separated from the rest of the filum and reconstitute itself into a small vesicle.

This is now believed to be the explanation of the formation of small vesicles next to the grafted medullas for the following reasons: It clearly explains the sporadic and infrequent appearance of these vesicles in the original study. It explains the location of the vesicles adjacent to the medulla, since the grafts were purposely placed immediately adjacent to the injured notochord and filum. The method of formation of the vesicles, described in detail in the original report, is just what would be expected according to this explanation, whereas it is entirely different from the normal development of an ear vesicle. The histology of the wall of the small vesicles is identical with that of the wall of the filum terminale, even down to small cytological details. Finally, the results are now brought in line with all the subsequent blastema studies, which showed that blastema mesenchyme does not react morphogenically to such embryonic inductors as the eyecup, archenteron roof, or dorsal lip of the blastopore. It is concluded, therefore, that although induction is undoubtedly concerned in regeneration as well as in embryonic development, no specific inductive response by regenerating tissue to an embryonic inductor has yet been shown. On the other hand, the reciprocal effect, the inductive action of regenerating upon embryonic tissue, seems to have been clearly demonstrated.

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### Mustard Gas Mutations in *Neurospora*

The production of mutations in *Drosophila* by treatment with mustard gas has been reported by Auerbach and Robson (*Nature, Lond.*, 1946, **157**, 302). (See also Gilman and Philips. *Science*, 1946, **103**, 409.) In view of the great potential significance of this discovery we have carried out an experiment designed to test the effectiveness of mustard gas in inducing mutations in *Neurospora*, with the results reported below.

Asexual spores of wild-type stock 1A of *Neurospora crassa* were placed in the side arm of a sterile Thunberg tube, and two drops of β,β′-dichlorodiethylsulfide (mustard gas) were placed in the main compartment. The tube was closed at atmospheric pressure and immersed in a constant temperature bath at 29° C. At the end of 30 minutes the spores were removed, suspended in sterile water, and applied to protoperithecia of wild-type strain E5297a. As a control, the same cross was made with untreated spores. Following sexual fusion and the development of ripe perithecia, single ascospores were isolated on "complete" medium for germination (Beadle and Tatum. *Amer. J. Bot.*, 1945, 32, 678). The isolation of only one ascospore from each perithecium insures that each mutation will be counted only once. The cultures were first examined for morphological (*i.e.* visible) variants and then were tested for biochemical mutations by the method of Beadle and Tatum (*loc. cit.*).

In the treated series, 760 spores germinated. Of these, 29, or 3.8 per cent, were mutants. In the control series, 769 spores germinated, of which one, or 0.13 per cent, was classified as a doubtful mutant. This spore germinated but grew so poorly on the complete medium that it could not be tested further.

The 29 mutants resulting from the treatment included 17 visible and 12 biochemical mutants. The visibles, together with the number of independent occurrences of each, were as follows: albino, 1; pink, 2; surface-growing types, 6; cauliflower types, 4; plumose, 1; crew cut, 3. Among the biochemical mutants, strains unable to synthesize the following substances occurred with the frequencies indicated: methionine, 4; cystine and methionine, 2; leucine, 1; adenine, 1; *p*-aminobenzoic acid, 2; thiamin, 1; unidentified amino acids, 1. Growth of each biochemical mutant takes place when the basal medium is supplemented with the substance it cannot synthesize but not on unsupplemented basal medium.

The frequency of mutant spores found in the treated series compares favorably with that obtained following irradiation with ultraviolet light (Beadle and Tatum, *loc. cit.*). The actual mutation rate is close to twice the percentage of mutants found, or about 7.6 per cent for the treated series. This is because the probability of choosing a mutant spore from a perithecium carrying a mutant gene is 0.5 when only one spore is isolated per perithecium. If the perithecium carries more than one mutant gene, the probability of recovering them in a single spore depends on the degree of linkage between the genes. We have not attempted to determine the maximum mutation rate attainable with mustard gas. It is possible that by varying the exposure time or other conditions a higher rate than that reported here might be obtained. In *Drosophila*, Auerbach and Robson found the frequency of sex-linked lethals to run as high as 24 per cent.

At least one of the mustard gas mutants appears to be of a new type. This is the "albino," which is not a true albino but has a yellow tint. This form has not been encountered previously in this laboratory. No new kinds of growth-factor requirements were positively identified among the biochemical mutants. The strain requiring unidentified amino acids responds to casein hydrolysate and to a synthetic mixture of the 10 "essential" amino acids but not to any single amino acid. The minimum number of amino acids required by this mutant has not yet been worked out. It does not grow on a mixture of isoleucine and valine, shown by Bonner, *et al.* (*Arch. Biochem.*, 1943, 3, 71) to be required by one *Neurospora* mutant. This strain cannot