marked. One speaker in particular, as the result of several hearings, in the first half-year was rated at 10 per cent., in the second at 76 per cent.

Of the different speakers, six were heard in both of the semesters, and are thus more directly comparable than the others. Their average for the first semester was 64 per cent., for the second, 92 per cent., that is, while during the first semester more than one word out of every three was unintelligible, only about one in twelve was unheard in the second.

The effect was even more striking in seat V. Before the treatment of the chapel the average audibility was 71 per cent., exactly the same as at the greater distance, showing that the advantage gained by a somewhat nearer approach to the speaker was completely nullified by the disturbances from reverberation. The attention, as in the seat AA, was careful or strained. After the treatment the average audibility rose to nearly 96 per cent., nearly perfect hearing, and the attention in most cases was noted as easy.

In seat Q, about fifty-five feet from the speaker, the audibility rose from an average of 95 per cent. in the first semester to 100 per cent. in each separate case in the second.

The results are summarized below for more easy comparison.

AVERAGE OF ALL SPEAKERS

Seat	First Semester, Per Cent.	Second Semester, Per Cent.
AA	71	91
V	71	96
Q	95	100

The seat in the gallery gave exactly similar results, but the number of experiments made in this seat was so small that the averages are not included in the table.

The condition of the auditorium at present is satisfactory. It is quite possible that a slight further reduction of reverberation might be made with advantage to the spoken word, but the effect of music, which forms an important part of the uses of the building, would be correspondingly injured.

It may be worth while further to remark that the calculations as to the effect of reverberation could have been as well made, plan and materials being given, before the erection of the building as afterward. It is a pity that architects still construct buildings of this kind without giving careful attention to their expected uses, trusting to good fortune for acoustic fitness which might easily and certainly be insured in advance.

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SPECIAL ARTICLES

TWO COLOR MUTATIONS OF RATS WHICH SHOW PARTIAL COUPLING

In the *American Naturalist* for February, 1914, Castle described two yellow-coated varieties of the Norway rat (*Mus norvegicus*) which had recently been discovered in England, and both of which had been found to behave as Mendelian recessive characters in heredity. One of these was called "pink-eyed yellow," the other "black-eyed yellow." A more appropriate name for the latter would be "red-eyed yellow" (which we shall hereafter use), since the eyes in this variety are not as dark as in wild gray or tame black rats, but the red blood of the eye shows through, particularly when the animal is young, giving the eye in a favorable light a reddish tinge.

Upon crossing the two yellow varieties with each other, we found them to be complementary. The F_1 young obtained were none of them yellow, but were all either gray or black coated; yet it should be noted that they were in no case as dark as ordinary gray or black rats. Nevertheless F_2 young with coats of normal intensity were later obtained, so that the paleness of the F_1 young was evidently due rather to their being heterozygous for the two complementary factors, than to any failure of one variation completely to supply what was lacking in the other.

Each of the yellow varieties was also found to be different in nature from ordinary albinism, as seen in white rats, since when it was crossed with albinos it produced only fully pigmented (gray or black) rats, which when crossed with each other produced an F_2 generation consisting of approximately 9 gray or black rats to 3 yellows, and 4 albinos, a typical dihybrid result.

But the most interesting aspect of the two yellow variations is their apparent "negative coupling" or mutual "repulsion," a phenomenon first discovered by Bateson and Punnett in plants, but since observed in insects by Morgan and Tanaka. This repulsion, in the case of the two yellow variations of rats, is incomplete, as is true in most recorded cases of repulsion, and it indicates, if we adopt Morgan's manner of explaining it, a location near together in the germ-plasm of the respective determiners or "genes" for red-eyed and for pink-eyed yellow.

The evidence for this partial repulsion is as follows: When the F_1 gray or black rats, obtained by intercrossing the yellow varieties, were themselves intercrossed, they produced an F_2 generation which contained 102 gray or black young, 55 red-eyed yellows, and 43 pink-eyed yellows.

To ascertain the gametic composition of the yellow F_2 animals, (1) the extracted red-eyed yellows were mated with yellows of the pure pink-eyed race, and (2) the extracted pink-eyed yellows were mated with pure red-eyed yellows. Twenty-eight test matings of the first sort have been made and twenty-seven of the second sort, with the following results.

In 20 matings, extracted red-eyed yellows mated with pure pink-eyed yellows have produced only black-eyed young (grays or blacks), while in the remaining 8 matings both black-eyed young (grays or blacks) and pink-eyed young have been produced. The red-eyed parent, in the former type of mating, must have lacked altogether the gene for pink-eye, while in the latter type of mating it must have been heterozygous for pink-eye. If we designate the (recessive) gene for red-eye by *r* and the (likewise recessive) gene for pink-eye by *p*, then the F_2 red-eyed yellows tested must evidently have been of the two types *rr* (20 cases) and *rrp* (8 cases), respectively. The former type, when mated with pure pink-eyed animals (*pp*), would produce only double heterozygotes (*pr*), whereas the latter would produce either double heterozygotes (*pr*) or homozygous pinks heterozygous for red-eye (*ppr*). On the theory of probability, if red-eye and pink-eye are produced by wholly independent genes, we should expect animals of the former type to be only half as common as animals of the latter type in a population of extracted (F_2) red-eyed yellows, *but observation shows them in this case to be more than twice as common!* Hence there is a strong presumption that red-eye and pink-eye depend upon genes not wholly unconnected with each other. This presumption is strengthened by the results obtained by testing the extracted F_2 pink-eyed yellows by mating them with pure red-eyed yellows. Twenty-seven such animals were tested, of which 19 produced only black-eyed young (grays or blacks), while 6 produced both black-eyed (gray or black coated) and red-eyed (yellow) young, and 2 others produced only red-eyed (yellow) young.

All the pink-eyed F_2 animals tested must have been homozygous for pink-eye (otherwise they would not have shown pink-eye), but as regards the possession of red-eye it is evident that conceivably they might (1) lack it altogether, (2) be heterozygous for it, or (3) might be homozygous for it, conditions which would be expressed by the formulæ *pp, ppr* and *pprr*, respectively. Animals of the first sort (*pp*), if mated with pure red-eyed animals, should produce only black-eyed young (grays or blacks, the observed result in 19 cases); animals of the second sort (*ppr*) should produce some young black-eyed and others red-eyed (the observed result in 6 cases); animals of the third sort (*pprr*) should produce only red-eyed yellow young, an expectation realized in 2 cases. The chance expectations for the occurrence of these three sorts of results are as 1:2:1; the observed occurrences are widely different, viz., 20:6:2.

If the repulsion between the two yellow variations were complete, no F_2 individuals of classes 2 and 3 (*ppr* and *pprr*) would be formed, but all F_2 pink-eyed yellows would be of class 1 (*pp*). The fact that classes 2 and 3 are formed but are much *smaller* than expected shows that *partial* repulsion exists between the two yellow variations. In the origin of the 55 yellow rats which have been tested, 110 gametes were involved. Inspection of the results shows that in 92 of these gametes the factors for red-eye and pink-eye remained apart, as they were originally; but in 18 of them a cross-over must have occurred producing a gamete which contained both factors. This ratio of 92 unchanged to 18 cross-over gametes (or 5.1 to 1) among the gametes which produced the yellow rats, should give nearly, though not quite, the gametic ratio among *all gametes* produced by the F_1 rats. This true gametic ratio may be shown by the foregoing figures to be about 4.6 to 1 and the per cent. of cross-overs to be about 18.

Animals of class 3 (*pprr*), homozygous for both kinds of yellow, should produce gametes in which these two characters would show positive coupling instead of repulsion. This matter is now being investigated with the idea of finding a quantitative expression for the strength of the coupling and comparing it with the strength of the repulsion already demonstrated.

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TOXICITY AND MALNUTRITION[1]

THE concept denoted by the word "toxicity" contains an element essentially physiological in its nature and describes primarily not so much a chemical property of a given substance as the result of a chemical reaction of this substance with one or more constituents of a given organism. Thus the effects produced by the chemical substance on the organism are obviously due to the chemical properties both of the substance itself and of the tissues of the organism. Hence, while derived in part from the chemical properties of the substance, toxicity does not exist apart from the organism and can be asserted of any given substance only after fitting experiments have been carried out on the organism in question. In contrast to this property, the purely chemical properties, such as acidity or alkalinity, exist apart from any relation to the organism. When a given chemical substance possessed of specific properties comes in contact with an organism which of course is essentially made up of substances having likewise definite chemical properties, the reactions which follow in accordance with the laws governing chemical behavior are capable of description by means of chemical terms, but from the standpoint of the organism a physiological result has occurred defined not in terms of ions and molecules, but in terms of function. When, as a result of the chemical reaction, the organism is so modified as to cause the non-performance or imperfect performance of function a more or less marked physiological injury is recognized. If the injury involves sufficiently important functions and the reaction is irreversible, death results. Should functional activity be impaired only in nonessential particulars or should the reaction be reversed, life may persist in spite of permanent injury or recovery may take place. If the arrest or derangement of function is sufficiently thorough and prompt, the organism is said, in popular phrase, to be "poisoned" and the chemical substance entering into the disturbing reaction is said to be a "toxic" substance. In view of these considerations there seems to be no scientific ground for limiting the term "toxicity" to the popular conception.

"Toxicity" results in functional impairment due to chemical reaction and, accurately speaking, is more a matter of kind than of degree. If this impairment proceeds to the point of death there might seem to be a basis for distinction between this result and that of a less serious injury not so terminating. However, if death takes place indirectly and remotely through secondary changes initiated by the chemical reaction, the organism would still have been "poisoned." If functional injury, however slight and remote, should follow from the chemical reaction, it would still be in kind a "toxic" action.

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