sites stained well. In slides thus treated the cytological details of *Babesia bigemina* were brought out very clearly. Good results with iron-hematoxylin have also been obtained following wet fixation by formaldehyde. For this purpose the thin smears were dropped into a coplin staining jar that contained about 3 cc of 40 per cent. formalin and were then treated with alcoholic sublimate as for dried smears. The erythrocytes took the stain but were destained easily. It has been found difficult to make good dried smears of the blood of anemic cattle. This was especially the case when a high relative humidity retarded drying. The erythrocytes of such smears appeared full of air bubbles when examined under oil immersion. This difficulty has been overcome by the use of the wet formaldehyde fixation described above. Blood and blood parasites thus fixed stain well in Giemsa's.

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SPECIAL ARTICLES

A NEW BASIS FOR FERTILIZER EXPERIMENTS

EARLY in this century, Mitscherlich, the German experimenter of Königsberg, had discovered that the equation expressing the relation between yield of a crop and increase in the amount of a growth factor made available to the crop has the form

$$y = A(1-e^{-kx}) \tag{1}$$

in which y is yield per acre, x is the quantity of the growth factor available, A is the maximum yield obtainable by the use of any amount of the factor and k is a constant.

Some years later, the writer, without knowledge of Mitscherlich's work—I was not then interested in this field of research—discovered that this law has the form

$$y = A(1-R^{x}) \tag{2}$$

in which y, A and x have the same significance as in (1), while R is the ratio of a decreasing geometric series the terms of which are the increments of y corresponding to successive equal increments in x. I was also able to show that the e^{-k} of the Mitscherlich formula has the same significance as the R of my formula.

The German mathematician Baule pointed out, and Mitscherlich confirmed the same experimentally, that when two or more growth factors are varied simultaneously, this equation assumes the form

$$y = A(1-R_1^{x_1})(1-R_2^{x_2})(1-R_3^{x_3}) \tag{3}$$

in which x_1 represents the quantity of the first growth factor, R_1 the ratio of the series of increments in yield due to increases in this factor; x_2 and R_2 have a similar relation to the second growth factor; x_3 and R_3 to the third, and so on.

Equation (3) applies to plants grown in water or sand cultures, in which the only amounts of the first, second, etc., factors available are those supplied by the experimenter, and which are therefore measurable directly. The purpose of the present preliminary note is to point out that in field experiments, on a soil containing n, p and k available units per acre of nitrogen, phosphoric acid and potash respectively, the above formula takes the form

$$y = A(1-R_1^{n+x_1})(1-R_2^{p+x_2})(1-R_3^{k+x_3}), \tag{4}$$

and, further, to show how, with results from three fertilized plots, with suitable check plots, with sufficient replication to make the results reliable and with sufficient repetition from year to year to eliminate seasonal variations in yield, it is easily possible to calculate the values of the four constants A, n, p and k (the constants R_1, R_2 and R_3 are known from Mitscherlich's work) in equation (4), and then to use this equation for calculating the yield to be expected from the application of any quantities whatever of the three fertilizer ingredients, nitrogen, phosphoric acid and potash. The addition of other growth factors to the list requires only the addition of a single experimental plot for each factor, and, of course, the determination of the value of R for that factor. Mitscherlich has shown that the value of R is the same for all crops and all soils for a given growth factor when the unit of the growth factor is properly chosen.

The fertilizer treatment necessary on the four plots (three fertilized and one check plot) is shown in the following tabular statement:

	Units of fertilizer per acre			
	N	P_2O_5	K_2O	Yields
Plot 1.	a	0	0	y_1
" 2.	0	b	0	y_2
" 3.	0	0	c	y_3
" 4. (Check)	0	0	0	y_4

in which a, b and c are the respective amounts of nitrogen, phosphoric acid and potash, in units of 100 lbs. per acre, applied in fertilizer on the plots. The values of a, b and c should be such as to give considerable effect on yield so as to lessen the percentage of experimental error, yet should not be so large as to cause the results to lie far out on the nearly horizontal portion of the yield curve. These quantities are best determined by preliminary tests with the growth factors in question.

The four observation equations which, by proper substitution in (4), these four experimental plots give are

$$\text{Plot 1. } y_1 = A(1-R_1^{n+a})(1-R_2^{p})(1-R_3^{k}) \quad (5)$$
$$\text{'' 2. } y_2 = A(1-R_1^{n})(1-R_2^{p+b})(1-R_3^{k}) \quad (6)$$
$$\text{'' 3. } y_2 = A(1-R_1^{n})(1-R_2^{p})(1-R_3^{k+c}) \quad (7)$$
$$\text{'' 4. } y_4 = A(1-R_1^{n})(1-R_2^{p})(1-R_3^{k}) \quad (8)$$

Dividing (5) by (8)

$$\frac{y_1}{y_4} = \frac{1-R_1^{n+a}}{1-R_1^{n}}$$

From this equation the value of n is easily found.

In a similar manner the values of p and k are found. The value of A is then found by substitution of the known values of n, p and k in (8). Equation (4) is then available for calculating the yield to be expected from any amounts of nitrogen, phosphoric acid and potash applied as fertilizers.

This matter will be presented in detail in a paper soon to be offered for publication.

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THE EFFECT OF UNILATERAL SECTION OF THE MIDBRAIN UPON COSTAL MOVEMENTS OF RESPIRATION

I WISH to add to an earlier statement[1] some recent results of unilateral section of the midbrain combined with unilateral division of the dorsal roots of the thoracic spinal nerves.

Cats were used throughout the experiments. Respiratory movements were recorded by tambours attached to Crile stethographs. One stethograph placed well up on the chest measured costal movements; the other, at the level of the diaphragm, measured diaphragmatic movements.

Experimental procedures and results were as follows: (1) Section of the dorsal roots of the spinal nerves in the thoracic region of one side, followed by section behind the inferior colliculus of the opposite side. (2) Section behind the inferior colliculus of one side, followed by section of the dorsal roots of the spinal nerves of the opposite side. (3) Section of the dorsal roots of one side, and of the inferior colliculus of the *same* side.

(1) Unilateral section of the dorsal spinal nerve roots in the thoracic region produced some slowing of the respiratory rate and some diminution in amplitude of the costal respiration, but neither of these changes was as marked as when the dorsal roots of both sides were divided. Complete cessation of the costal movements was observed on the side on which section of the dorsal roots had been done. The movements of the other side were unchanged, but naturally the amplitude recorded was not as great as normal.

In doing unilateral section of the midbrain behind the inferior colliculus, the skull was trephined over the tentorium, and, guided by the tentorium, a knife was slid perpendicularly down its caudal surface, cutting the midbrain just below the inferior colliculus. Hemorrhage was controlled by means of bone wax. The extent and location of the lesion were determined at autopsy. The result of unilateral section was to slow somewhat the respiratory rate and, in some cases, to diminish costal respiration, particularly on the side of the lesion. Diaphragmatic respiration was adequately maintained at all times. Unilateral section of the midbrain below the inferior colliculus, then, appears not to interfere greatly with the respiratory rhythm.

When, however, section behind one inferior colliculus is followed by section of the dorsal roots of the thoracic nerves *on the opposite side,* costal respiration of both sides disappears, such slight excursions of the tambour lever as are shown being induced by the diaphragmatic contractions.

(2) When the procedures are reversed, the same result is obtained as in the preceding series. True costal respiration disappears.

(3) When both operations are done on the same side, costal respiration on that side only disappears.

These results appear to show that: (1) The central station in the midbrain for afferent respiratory impulses from the dorsal roots of the spinal nerves is ipsilateral. (2) Costal respiration only is affected by section of the dorsal spinal nerve roots, or by section behind the inferior colliculus.

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[1] F. H. Pike and H. C. Coombs, SCIENCE, 56: 691–692, 1922, and the papers there cited.

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