and accessible. Except for the questionable attempts to estimate the size of the gene, the main conclusions concerning the mechanism of heredity and the orderly arrangement of specific genes in the chromosomes rest on quantitative data and on analytical deductions that are tested by further experiments wherever possible. The theory that the chromosomes carry the hereditary factors, and that these factors lie in linear order in the chromosomes, enables us to predict, with a high degree of certainty, how any new character will be inherited with respect to all the other 300 known characters of Drosophila. If the accuracy of prediction is a test of the usefulness of a theory, then we may claim some justification for our view. More than this, I think, it is not necessary to claim for a scientific theory.

The evidence has given us a glimpse at least of processes that are so orderly and so simple as to suggest that they are not far removed from physical changes; and the order of magnitude of the materials is so small as to suggest that its component parts may come within the range of molecular phenomena. If so, we may be well on the road to the promised land where biological results may be treated as physical and chemical events.

The Sympathetic Innervation of the Vagina.

By J. A. Gunn and K. J. Franklin.

(Communicated by Sir Charles Sherrington, Pres.R.S. Received August 4, 1922.)

(From the Pharmacology Laboratory, Oxford.)

The main facts in regard to the origin, course, and function of the nerves to the internal generative organs, were established by Langley and Anderson (1). They found that, in the cat and rabbit, efferent fibres to the uterus and vagina come from the third, fourth, and fifth lumbar nerves, "run by the white rami communicantes to the sympathetic, and nearly all of them run then to the inferior mesenteric ganglia. From the inferior mesenteric ganglia they proceed by the hypogastric nerves. The efferent fibres are motor to the muscular walls. The effect on the uterus and vagina is more constant in the rabbit than in the cat, though in both it varies with the state of the uterus with regard to parturition. In the cat, pallor of the uterus, with little or no contraction, is not infrequently seen."

"In no part of their course have the lumbar nerves, in our experiments, shown any inhibitory or vaso-dilator action on the uterus or vagina."

"The sacral nerves send neither motor nor inhibitory fibres to any of the internal generative organs."

Those conclusions of Langley and Anderson have been confirmed by subsequent observers and supplemented in a few particulars. They had observed that the motor effect was inconstant in the cat and varied with regard to pregnancy. Cushny (2) and Dale (3), independently, showed later that a motor effect on the uterus is obtained by hypogastric stimulation in the cat only when the uterus is pregnant, while in the non-pregnant cat the effect is actually inhibitor. They also showed that, in the cat, adrenaline contracts the pregnant, but inhibits the non-pregnant uterus.

Gunn and Gunn (4) showed that in the guinea-pig and in the rat still a third type of uterine innervation occurs, for in both those animals adrenaline produces relaxation of the uterus not only when non-pregnant but also when pregnant.

The object of the present investigation was to determine whether the sympathetic innervation is qualitatively the same for the vagina as for the uterus, the chief interest, of course, attaching to those cases in which the sympathetic is an inhibitor nerve to the uterus. In the cat, guinea-pig, and rat the sympathetic is inhibitor to the non-pregnant uterus. Yet, during coitus, which occurs in the non-pregnant condition, there is reason to suppose that there occurs contraction of the vagina under nervous influence, and the only efferent nerve supply that the vagina receives is through the sympathetic. There was therefore *a priori* ground for supposing that in these—and indeed in all—animals the sympathetic innervation of the vagina must be motor, at least in the non-pregnant animal, regardless of whether it is motor or inhibitor to the uterus.

Waddell (5) found that adrenaline has a motor effect on the isolated vagina of the rabbit, dog, pig and sheep, but an inhibitor effect on that of the cat, rat, guinea-pig and cow; in other words that the effect of adrenaline is qualitatively the same on vagina and uterus in any particular species. In a preliminary communication, Gunn and Davies (6) showed that the isolated vaginal muscle of the non-pregnant cat, of the rat, and of the guinea-pig contracts under the influence of adrenaline, though the uterus relaxes. In the present paper these experiments have been extended so as to include the effects of stimulation of the hypogastric nerves, and the effects on both uterus and vagina have been recorded. It will be convenient to take separately the different species of animals used.

Rabbit.—As was shown by Langley and Anderson the sympathetic is pre-

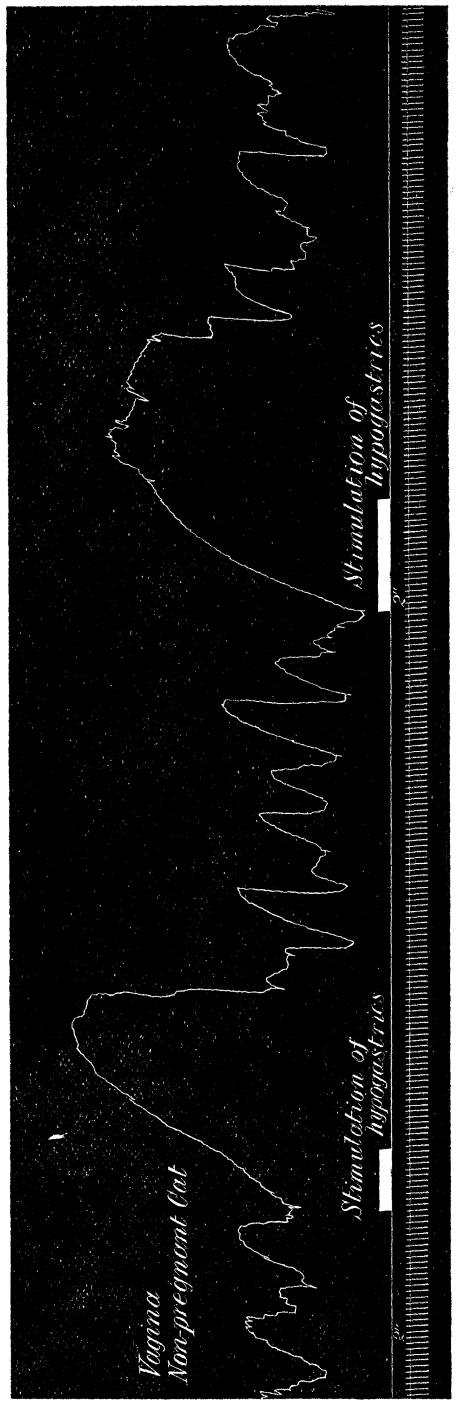

FIG. 1.—Cat, non-pregnant, decerebrated. Showing contraction of the vagina by stimulation of hypogastric nerves.

dominantly motor both in vagina and uterus, pregnant and non-pregnant. We have confirmed this also by the effects of adrenaline on the vagina, *in situ*, and on isolated vaginal muscle.

Cat: (a) *Pregnant.*—Both uterus and vagina contract to hypogastric stimulation or to adrenaline.

(b) *Non-pregnant.*—As shown by Cushny and Dale the uterus relaxes to hypogastric stimulation or to adrenaline. The vagina, however, contracts to both those influences. Fig. 1 shows the effects of hypogastric stimulation on the vagina of a non-pregnant cat. The cat was decerebrated by Sherrington's method, part of the pubic bone removed, the urethra cut off, and a hook in the vagina connected with a lever. The hypogastrics were cut just below the inferior mesenteric ganglia, and the peripheral end stimulated. Two periods of stimulation are shown and the contraction of the vagina is convincing.

The hook was then transferred from vagina to uterus and the hypogastrics again stimulated. Fig. 2 shows the relaxation that occurred. The same

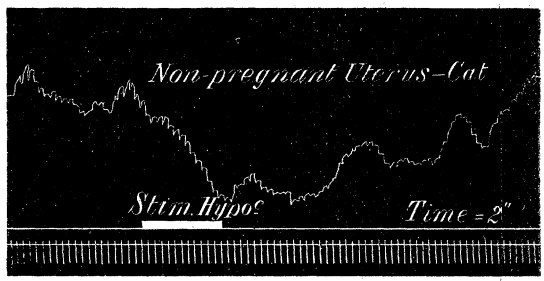

FIG. 2.—Cat as in fig. 1.—Showing relaxation of uterus by stimulation of hypogastric nerves.

result was obtained with adrenaline, whether records were similarly taken *in situ* in decerebrate cats or when the isolated vaginal muscle was used. Fig. 3 shows the effect of adrenaline on the isolated vagina and uterus by the usual method of experiment for isolated tissues. That the vagina contracts while the uterus relaxes is clear.

The motor response to sympathetic stimulation or to adrenaline is more marked in the half of the vagina nearest to the vulva, the effect diminishing as the uterus proper is approached. A motor effect is obtained whether one takes a record of longitudinal or circular contraction.

Guinea-pig and Rat.—Gunn and Gunn showed that adrenaline causes inhibition of the uterus in those animals whether pregnant or non-pregnant. We have found, as was to be expected, that hypogastric stimulation has the same effect. The vagina in both these animals, however, contracts when the hypogastrics are stimulated, or as the result of the action of adrenaline.

Fig. 4 shows the effect of two successive periods of stimulation of a hypogastric nerve on the vagina of a pregnant guinea-pig. In this case the animal was anæsthetised by urethane and ether, and the movements of the vagina recorded by a narrow elongated balloon inserted into the vagina and connected with a tambour.

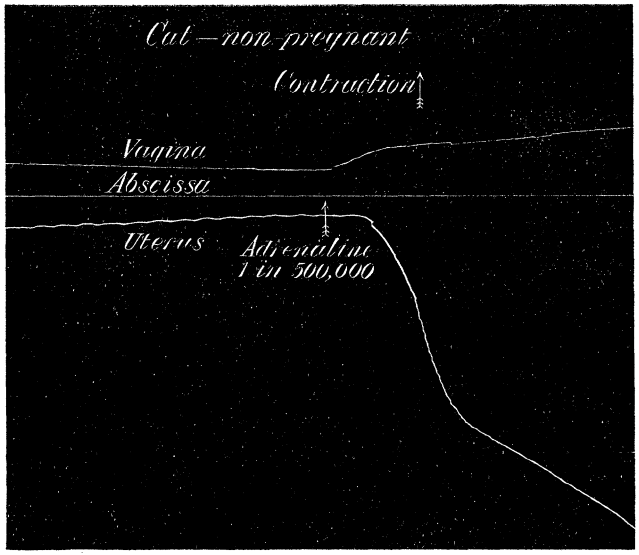

FIG. 3.—Cat, non-pregnant. Isolated vagina and uterus. Showing contraction of vagina and relaxation of uterus by adrenaline.

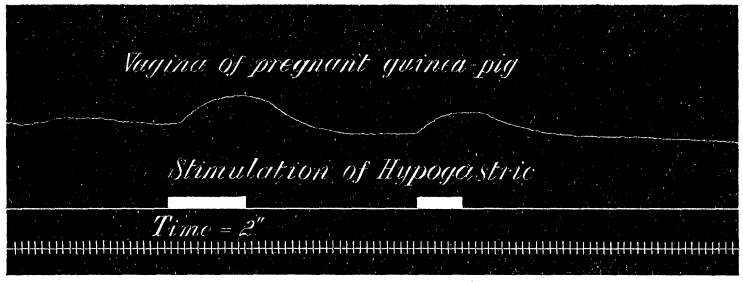

FIG. 4.—Guinea-pig, pregnant, urethane-ether anæsthesia. Showing contraction of vagina by stimulation of a hypogastric nerve.

In fig. 5 is shown a simultaneous record of both vagina and uterus, the former by balloon-tambour, the latter by hook and lever. Stimulation of a hypogastric nerve caused contraction of the vagina and relaxation of the uterus. Fig. 6 shows the effect of adrenaline added to a saline bath containing both uterus and vagina, the organs having been separated and individually

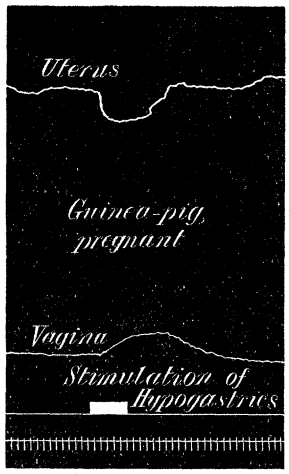

FIG. 5.

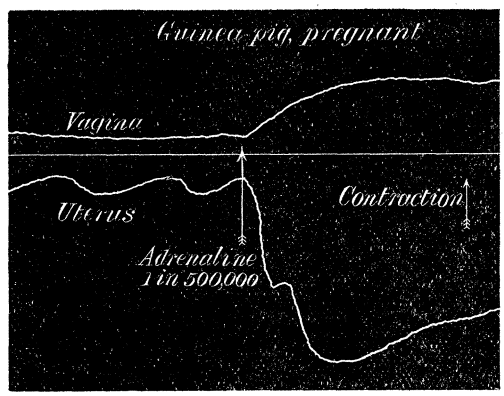

FIG. 6.

FIG. 5.—Guinea-pig as in fig. 4. Showing contraction of vagina and relaxation of uterus by stimulation of a hypogastric nerve.

FIG. 6.—Guinea-pig, pregnant. Isolated vagina and uterus. Showing contraction of vagina and relaxation of uterus by adrenaline.

attached to separate levers. The vagina contracts and the uterus relaxes. The result is the same whether the uterus be pregnant or not.

Having established these facts for the guinea-pig, we have contented ourselves with determining, in the case of the rat, the response of the isolated vagina to adrenaline. Fig. 7 shows contraction of the vagina of the rat produced by adrenaline. In this experiment the longitudinal contraction was recorded; the same effect was obtained with a ring of vaginal muscle.

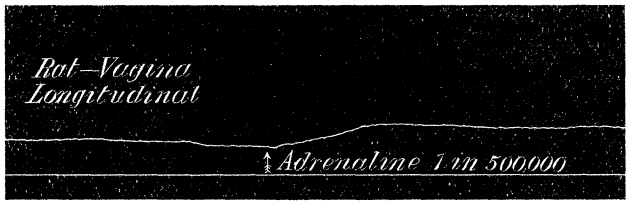

FIG. 7.—Rat; non-pregnant. Isolated vagina. Showing contraction of vagina by adrenaline.

It is clear from these experiments that the sympathetic nerve supply to the vagina is motor not only in the rabbit and pregnant cat when it is also motor to the uterus, but also in the non-pregnant cat, in the rat and in the guinea-pig when it is inhibitor to the uterus. Efferent sympathetic impulses probably produce contraction of the vagina during coitus; this would be

impossible if the sympathetic were inhibitor. In animals such as the cat and guinea-pig reflexes through the sympathetic to the internal generative organs during coitus, leading to simultaneous contraction of the vagina and relaxation of the uterus, may aid in the injection of spermatozoa into the uterine cavity.

Conclusion.

In the rabbit, cat, guinea-pig and rat (and by analogy probably in all animals) the sympathetic nerve supply of the vagina is predominantly motor in quality, whether it be motor or inhibitor to the uterus.

REFERENCES.

1. Langley and Anderson, 'Journ. of Phys.,' vol. 19, p. 122 (1895).
2. Cushny, *ibid.*, vol. 35, p. 1 (1906).
3. Dale, *ibid.*, vol. 34, p. 163 (1906).
4. Gunn and Gunn, 'Journ. Pharmacol. Expt. Ther.,' vol. 5, p. 527 (1914).
5. Waddell, 'Journ. Pharmacol. Expt. Ther.,' vol. 9, p. 411 (1911).
6. Gunn and Davies, 'Journ. of Phys.,' vol. 54 ('Proceedings,' November, 1920).

An Investigation of the Colour Vision of 527 Students by the Rayleigh Test.

By Dr. R. A. Houston.

[This paper is published in Series A, No. 716, December, 1922.]
