it is also possible to change points with the same result.

From the above description it will be seen that the new micro-manipulator is presented as a universal instrument, adapted to micro-operation in its widest range. It is believed by its designer and by its sponsors, the Bausch and Lomb Optical Company, to have met the laboratory requirements as above outlined.

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SPECIAL ARTICLES

OVULATION, OESTRUS AND COPULATION WITH CONSEQUENT DYSTOCIA DURING PREGNANCY, IN THE MOUSE

As has been pointed out recently by Swezy and Evans[1] two cases of copulation during pregnancy were observed by Long and Evans[2] in the course of their observations on the rat. Nelson[3] also reported a case of oestrus in the rat, occurring at regular intervals during pregnancy, with copulation taking place at three of these intervals. Swezy and Evans report that the cycle of ovogenesis is not interrupted during pregnancy in the rat, for they observed the periodic appearance of mature follicles and young corpora lutea in the ovary throughout gestation, although they were not able to demonstrate the presence of ova in the oviducts.

I have recently noted a case in which ovulation occurred during pregnancy in the mouse, and furthermore, as in the case reported by Nelson, copulation occurred as was evidenced by the presence of a vaginal plug. During routine examination this mouse which was in labor was observed to be in distress. Examination showed the presence of a vaginal plug which was so firmly attached that it could not be removed by means of a forceps. The animal was observed at intervals from 8:30 A. M. until 11:00 A. M. Frequent strong muscular contractions occurred, after which she made attempts to deliver the young. She was left alone, and at 3:45 P. M. observations were again continued. At this time she was still in labor, but three young had been born. The vaginal plug was found adherent to the vulva and apparently had been forced out by the muscular contractions on the first young to be born. The placenta was attached to one of the dead newborn young, suggesting that the mother probably was too fatigued to dispose of it properly. Since vigorous, periodic labor contractions were still occurring frequently with no results, the animal was killed at 4:30 P. M., or eight hours after she was first noticed to be in labor. Six fetuses, two of which were alive, were found in the uterus. No movements were observed in the other four, which were still in loco.

Histological examination of the ovaries and oviducts showed that ovulation had occurred. One ovary contained eight young corpora lutea which were about seven hours old, according to Allen's[4] criteria for the age of corpora lutea. The distal portion of the corresponding oviduct contained eight ova. The other ovary contained three seven-hour corpora lutea, and three ova were found in the oviduct. Ovulation evidently had occurred synchronously, because the ova were clumped together and were surrounded by discus cells. Fertilization had not yet taken place, for all but two ova contained the second maturation spindle. These two appeared to be in the prophase of the second maturation division. Twenty-one mature follicles were found in one ovary and sixteen in the other, an unusually large number.

The mouse, a virgin, had been put with a male on May 14. Neither a vaginal plug nor the placental sign had been observed. Twenty-two days later a vaginal plug was found, although pregnancy had not terminated. Presumably the gestational period was of normal length, since the litter did not appear more mature than usual.

It is apparent from these things that not only did ovulation occur during pregnancy but that it was accompanied by oestrus and copulation, the influence of the corpora lutea of pregnancy being insufficient to suppress ovulation until after parturition, as is usual. The number of mature follicles in the ovary suggests the possibility of hyperactivity of the hypophysis, with consequent formation of more than the usual number of follicles, which in turn might secrete sufficient folliculin to cause oestrus to be superimposed upon pregnancy.

This case, together with that of Nelson and the observations of Swezy and Evans, suggests that superfetation may occur during pregnancy in the mouse and hence also in allied forms, provided that ovulation takes place either before the closing of the uterine lumen due to the gestational changes, or after reestablishment of the lumen, before the advent of parturition. If it occurred in the first instance, the difference in the age of the fetuses in the same litter

[1] O. Swezy and H. M. Evans, "Ovarian Changes during Pregnancy in the Rat," SCIENCE, 71 (1828): 46, January 10, 1930.

[2] J. A. Long and H. M. Evans, "The Oestrus Cycle in the Rat and its Associated Phenomena," *Memoirs of the University of California*, 6, 1922.

[3] W. O. Nelson, "Oestrus during Pregnancy," SCIENCE, 70 (1819): 453, November 8, 1929.

[4] E. Allen, "Oestrus Cycle in the Mouse," *Am. J. Anat.*, 30, 1922.

should not be more than four or five days, though it might be less, because of some variability in the length of the oestrus cycle, as well as in that of gestation. Such a course of events might explain the cases in which some of the young of the same litter are much smaller than the rest.

On the other hand, if ovulation occurred after the reestablishment of the uterine lumen, the birth of full-term young about sixteen days after the previous litter might be accounted for, though I have found no reports of such cases. However, since implantation would not occur until the fifth day, that is, until after parturition, in such cases, they could not be considered true cases of superfetation, unless the onset of pregnancy were counted from fertilization rather than from implantation.

In the cases cited by King[5] and Sumner[6] in which from twelve to fourteen days elapsed between two consecutive litters it is conceivable that the first pregnancy may have been confined to one horn of the uterus and that subsequent ovulation resulted in implantations in the other horn, a possibility which was suggested by King.

I wish to express my sincere appreciation to Dr. A. W. Meyer, to whom I am indebted for assistance and suggestions during the progress of this study.

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DETERMINATE EVOLUTION IN THE GENUS SPIRIFER

SINCE March, 1920, the writer has engaged in a study of variation and evolution in two groups of organisms belonging to the inclusive brachiopod genus *Spirifer*. Work first was done at the Walker Museum of the University of Chicago, and from September, 1926, to September, 1928, at the University of Cincinnati, under a National Research fellowship in the biological sciences. Since the latter date, results have been correlated and a manuscript report prepared which will be published by the Wagner Free Institute of Science of Philadelphia.

The Linnaean species *Spirifer orestes* Hall and Whitfield and *S. hungerfordi* Hall comprise two widely divergent groups within the genus *Spirifer*. The former fall within the *Aperturati* of Hall and Clarke, which include the genotype, *S. striatus* (Martin); the latter are rather primitive members of the section or subgenus *Choristites* Fischer. Both are characteristic of the uppermost Devonian (Hackberry) strata of Iowa, though closely related forms (kindly loaned by Dr. C. R. Stauffer) are found in the Martin formation of Arizona.

Since the description of *Spirifer hungerfordi* by Hall,[1] and *S. orestes* by Hall and Whitfield,[2] paleontologists have recognized that these two Linneans exhibit considerable variation or speciation, but no serious published effort has been made to distinguish them. Even in our account of the Hackberry fauna,[3] Mrs. Fenton and I merely called attention to the existence of such speciation and illustrated a few examples.

This study began, therefore, with a careful taxonomic revision, little attention being given to evolution. In the *Spirifer orestes* group (here designated a *phratry*) this revision is based primarily upon the striae, nodes and pustules which form the minute ornament of the shell, since they have been found to be much more reliable than gross characters of shape, plications, sinus or fold. In the *S. hungerfordi* gens, however, the minute ornament is essentially uniform, so that gross characters must be relied upon. In consequence, there is some discrepancy between the taxonomic units determined in the two groups, those in the former being much the more precise.

Although work at first was concentrated upon pure taxonomic differentiation, it soon became evident that the taxonomic units, when arranged stratigraphically, automatically were arranged in apparently determinate evolutionary series, distinct, parallel or homeomorphic, and non-contemporaneous. The existence of such series and a provisional interpretation of them were reported in June, 1926, although not published until 1927.[4] In September, 1926, a collection of about six thousand additional specimens, with exceptionally precise data, was secured from the late Mr. C. H. Belanski. Work was begun *de novo,* even the taxonomic units previously determined being put aside. They at once reappeared, however, as did the evolutionary series; and again it was found that series based only on characters of surface (in the *Spirifer orestes* phratry) showed regularly correlated changes in form and character and number of plications. The situation may be summed up as follows.

In the *Spirifer orestes* phratry, the primitive surface ornament consists of minute, subradial to oblique ridges or striae, which are not broken and which bear neither nodes nor pustules. In every one of the divisions (gentes, subgentes, species) into which the phratry may be divided there is an apparently determinate evolution of these striae involving three or

[5] H. D. King, "Some Anomalies in the Gestation of the Albino Rat (*Mus Norvegicus Albinus*)," *Biol. Bul.*, 24, 1913.

[6] F. B. Sumner, "Notes on Superfetation and Deferred Fertilization among Mice," *Biol. Bul.*, 30, 1916.

[1] *Geol. Iowa,* 1 pt. 2: 501, pl. 4, figs. 1a–k, 1858.

[2] *Ann. Rep. N. Y. State Cab. Nat. Hist.*, 23: 237, pl. 11, figs. 16–20, 1873.

[3] "Stratig. and Fauna of the Hackberry Stage of the Upper Devonian," 1924.

[4] *Univ. Chicago Abs. of Theses,* sci. ser. 5: 223–226, 1927.