

Pedigree
race of
Paramecium

cover a length of 277 metres. Under properly controlled laboratory conditions, L. L. Woodruff has succeeded in cultivating a pedigree race of *Paramecium aurelia* for seven years through 4,500 generations, without conjugation (Woodruff and Rhoda Erdmann: *Periodic Reorganization in Paramecium*, Journ. Exp. Zool., vol. 17, 1914, and vol. 20, 1916). From time to time there occurs a readjustment of the nuclear apparatus by an automatic process of "endomixis."

Conjugation
of
Paramecium

Under natural vicissitudes there comes a time when, instead of dividing, paramecia conjugate in pairs, undergoing a temporary fusion during which they continue to swim about for some hours like Siamese twins. Whilst this is going on, the vegetative macronucleus becomes disintegrated and dissolved; and the reproductive micronucleus divides twice over, giving rise to four micronuclei in each conjugant. Three of these dwindle away and the remaining one becomes the generative nucleus in each conjugant; this nucleus then divides a third time to produce two *pronuclei*, of which one is migratory, behaving like a male gamete; the other stationary, behaving like a female gamete. Next follows an interchange of migratory pronuclei, which move over from one conjugant to the other across the bridge of union. Each conjugant now contains its own stationary pronucleus and a migratory pronucleus derived from its mate; internuclear fusion occurs and each conjugant finally possesses a single zygote nucleus. The mating paramecia now separate; the characteristic nuclear apparatus is regenerated by division from the zygote nucleus and a new epoch of binary fusion is inaugurated. In *Paramecium* it would appear that there is no regular recurrence of conjugation; it depends entirely upon the positive or negative stimulus of the environment. The natural food of *Paramecium* consists principally of minute flagellata and bacteria, which are swept into the mouth (cytostome) by the cilia lining the oral groove. As long as the food supply is continuously sufficient in quantity and right in quality, *Paramecium* will divide without conjugation. Woodruff's earlier method of treating his cultures consisted in constantly varying the concentration of the culture medium. Later he found that *Paramecium* can be reared indefinitely without conjugation in a 0.025 per cent. solution of Liebig's beef extract. If the environment does not yield the necessary motive for conjugation, it may be said to be neutral as regards that reaction.

Food of
Paramecium

Vegetal
Gametes

The history of the nuclear changes during conjugation was elucidated in 1889 by E. Maupas and R. Hertwig, working independently. Professor G. N. Calkins (*Protozoan Germ Plasm*, Popular Science Monthly lxxix, New York, 1911, pp. 568-580), states that the migratory pronucleus is smaller than the stationary pronucleus, and he suggests that the three successive micronuclear divisions which precede the interchange can be interpreted "as the reminiscence of a process of gamete formation, which obtained in remote ancestral forms." If this is correct, it means that the mode of reproduction in *Paramecium* and other ciliate infusoria is highly specialized. Conjugation is unknown in the life-history of *Amaba*, and there is no phase of encystment in that of *Paramecium*.

A. WILLEY.