caterpillars turned into males; E. Maupas, in the case of Rotifers, and other observers in the cases of some Crustacea, have similarly pointed to a relation between abundant nutrition and the excessive production of females. In nearly every case, however, other observers have either obtained conflicting results, or placed another interpretation on similar results, whilst in none of the cases has the factor of selective mortality been sufficiently excluded. Even were it proved that a correlation existed between excessive diet and over-production of females, it might be that the incidence of mortality was differential. Many attempts have been made to derive information by examining the statistics of human births in times of plenty and of hardship, but the results are inconclusive. C. Darwin, reviewing the evidence, was disposed to believe that the proportions of the sexes varied, that the tendency to produce male and female offspring was inherited, and that by a process of natural selection it was adjusted to the needs of the species, but he was too cautious to lean to any particular view as to the nature of the determining factors. C. Düsing (1883 and 1885) also believed in the existence of such a power of adaptation or adjustment, and attributed it to the action of a large number of external conditions. P. Geddes and J. A. Thomson (1889) similarly came to the conclusion that factors external to the sexual cells had a predominating importance, and these authors linked the determination of sex with their general theory of the nature of sex. They regarded sex as an expression of an alternating rhythm of anabolism and katabolism to be observed throughout the living world, and supposed that femaleness was specially associated, was in fact an outcrop of the anabolic or constructive processes of living matter, whilst maleness represented the katabolic, destructive or liberating processes. Their view ranges many diverse facts in apparent harmony, but has to encounter many facts that apparently contradict it. In a later work J. A. Thomson himself (1907) assigns less weight to his own theory, and quotes with approval T. H. Morgan’s suggestion that the determination of sex may be brought about in different fashions in different cases.

Theories as to sex being predetermined in the sexual cells have been numerous, but it is only recently that any exact evidence appearing to point to such a conclusion has been adduced. When parthenogenesis (see Reproduction) was first being investigated, it was found that eggs which gave rise to females were different from those which produced males, but when it was demonstrated that at least in many cases there was the further difference as to whether the eggs were fertilized or not, it was assumed that the presence or absence of fertilization determined the sex. Physicians have repeatedly propounded the theory that one ovary produces eggs capable of developing only into females, the other only those capable of becoming males, and the suggestion has been made that in the case of human beings ovulation takes place alternately from the ovaries. From this it would follow that were the sex resulting from one fertilization known, the sex of a subsequent fertilization could be predicted, or by choosing the date of fertilization, selected. These views, however, rest on no satisfactory evidence and remain un- correlated with any observations as to the structure of the eggs themselves. On the other hand, more exact workers, using modern cytological methods, have accumulated striking facts as to the existence of different kinds of sexual cells, the differences relating chiefly to the nuclear changes which occur in ovogenesis and spermatogenesis, and have been established with more certainty in the case of the spermatozoa. E. B. Wilson (1909) has given a full summary and discussion of various interpretations of these observations. In over a hundred species of insects, Myriapods and Arachnids, two kinds of spermatozoa are produced. The spermatozoa are formed in pairs, and the mother cell which gives rise to each pair exhibits, in the ordinary fashion of nuclear division, paired chromosomes, one member of each pair passing into each spermatozoon. The mother cell contains also an unpaired element, consisting in its simplest form of a single large chromosome, but sometimes represented by a group of peculiar chromosomes, which, for convenience, Wilson terms the “X” element, or “heterochromosome.” The “X” element passes into one or other of the spermatozoa, from which it results that spermatozoa of two kinds are formed in equal numbers, the difference being the presence or absence of the “ X ” element. Eggs fertilized by spermatozoa containing the “ X ” element become females, those fertilized by spermatozoa without it become males. There is evidence that in some cases *(e.g.* bees) the spermatozoa devoid of the “X” element degenerate, with the result that any fertilized eggs must produce females.

E. B. Wilson’s suggestion, advanced in the most cautious way, is

that the “X” element referred to in the last paragraph is the determinant, or at least the index, of sex, and further that the differ- ence between the male and female organism is that the male comes from an egg which, developing either parthenogenetically or after fertilization, contains only a single unit of the “X” element, while the female starts from an ovum which, whether developing after fertilization or parthenogenetically, contains the two “X” units. The ovum of a sexual egg in the process of maturation discards half its normal complement of the “ X” element; if it be fertilized by a spermatozoon containing an “X” unit it gives rise to a female; if it be fertilized by one without this it becomes a male. A large number of different forms of nuclear change have been described in the maturation of normal and parthenogenetic eggs, and by the exercise of a little ingenuity it is easy to select from these various processes modes of nuclear division which if they actually occurred in the appropriate instances would adapt Wilson’s hypothesis to cases in which parthenogenetic eggs give rise to males or to females. In some individual instances the process which the hypothesis would demand appears actually to occur.

Various workers on Mendelian lines (see Mendelism) have endeavoured to correlate the facts discussed by Wilson and their experimental inquiries into the inheritance of primary and secondary sexual characters, with the additional difficulty, absent from Wilson’s hypothesis, that their theory requires them to suppose the unfertilized cells to be unisexual. W. E. Castle suggested that both males and females were Mendelian male-female hybrids with respectively male and female dominance, and that in the usual way disruption took place in the formation of the germ cells, with the result that male and female spermatozoa and male and female ova were produced. He assumed further that there was a selection or repulsion in fertilization, so that ova and spermatozoa bearing the same sex never conjugated. C. Correns assumed the male to be sex-hybrid, the female to be homozygous or pure female, the male character being dominant. Ova were, therefore, unisexual, always female, while spermatozoa were either male or female, and when a female egg was fertilized by a female spermatozoon the result natur­ally was a female, but when it was fertilized by a male spermatozoon the result was a sex-hybrid appearing as a male because of the dominance of male characters. Correns's theory avoids the unlikely supposition of selective fertilization, but breaks down in those cases of parthenogenesis where the unfertilized egg produced by a female gives rise to a male. W. Bateson reverses the theory of Correns and supposes that the female is a hybrid with femaleness dominant, while the male is pure male. The female in fact contains a factor which makes her female whilst the male is a male because it is without this factor This view, however, leaves unexplained the existence of two kinds of spermatozoa and involves a series of elaborate hypotheses to reconcile it with cases of parthenogenesis. L. Doncaster has elabo- rated the extremely ingenious suggestion that the Mendelian pairs are not male and female, but male and absence of sex and female and absence of sex. The male is a pure male but produces two kinds of spermatozoa, those with the determinant for sex and those without it. The normal female is a sex-hybrid and produces male and female eggs in equal numbers, and it is assumed that there is a selective fertilization, female eggs being fertilized by male spermatozoa and giving rise to females, whilst male eggs are fertilized by spermatozoa without the sex factor and give rise to males. In cases of parthenogenesis, it is supposed that there are two kinds of females, the result of fertilization by different kinds of spermatozoa, and that those going through different kinds of maturation processes give rise with­out fertilization to males or to females. Doncaster has discovered many interesting details of the maturation processes in insects which agree with his suggestion. The Mendelian interpretations, however, are more ingenious than conclusive, but at least they combine with other work in supporting the probability that the determination of sex depends on the sexual cells and not on conditions influencing the developing embryo. Similarly they combine with other work in pointing to the conclusion that the male organism differs from the female by the absence of something present in the female. The Mendelian interpretations suggest that male and female sex determinants are different in kind; Wilson's interpretation suggests that they differ only, so to say, in quantity. Both interpretations harmonize with the observed fact that cases in which a female assumes male characters are much more frequent and much more definite than cases in which a male assumes íemaleness.

*Theory of Sexual Dimorphism,—*Males and females may be alike, apart from their possession of male or female gonads, or may differ to almost any degree. It is plain, therefore, that although the presence and the maturity of the gonads may be, and probably are, the immediate stimulus to the appearance of the secondary differences, they cannot be the prime cause. Why, although equally potent sexually, do some males and females differ, others resemble one another? This is a question distinct from that of the primary determination of sex and the mechanism by which it is brought about. C. Darwin’s theory of sexual selection remains the only comprehensive suggestion. Tike his