LES CHROMOSOMES DES VERTÉBRÉS. By R. Matthey, professeur ordinaire à l'Université de Lausanne.

Robert Matthey for more than twenty years has been engaged on chromosome studies of vertebrates. He is thus well qualified to survey the field of vertebrate cytology. In his book Professor Matthey deals first with the all-important preservation of the natural structures of the cell. Then follow some witty pages about the technique of observation. There is a lot of truth to be found here. Preconceived ideas and hasty conclusions have often led to most remarkable " discoveries."

Matthey's work can conveniently be divided in two parts ; the sex chromosomes, and chromosome numbers and evolution.

The study of sex chromosomes consists in tracking down the unequal pair, their morphology and behaviour, such as mode of pairing, hetero- pycnosis, etc. Now we probably know the main types of sex mechanisms in vertebrates. In critically studied Anamniotes no sex chromosomes can be detected morphologically. The same is true in reptiles, but in birds and mammals distinguishable sex chromosomes are present and point to an over-all XY-XX mechanism. In birds the females carry the XY, while in mammals the males are the heterozygous sex. The pairing of the sex chromosomes in animals, on the whole, is very incompletely understood. Two facts must always be considered : (1) The phenomenon of hetero- pycnosis (precocious condensation) found in these chromosomes during meiotic prophase, and (2) the existence of a pairing segment, shown by the cytological and genetical evidence of crossing over. Any theory explaining the pairing processes has to include these facts.

The second part of Matthey's work concerns the possible deductions that can be made from the chromosome complements, as to the affinities between species or higher systematic units. This is a much more intricate question, involving loss and addition of whole chromosomes as well as changes in the individual chromosome, like fragmentation, fusion, inversion, translocation, duplication and deficiency. In 1916 Robertson suggested that the variations in chromosome numbers found in grasshoppers were caused by fragmentation and fusion. This means that a chromosome can break up into two or more pieces, thus increasing the number of units. Alternatively, fusion of chromosomes may reduce the number. We know to-day that the centromere is an essential part of a chromosome, and that acentric fragments must necessarily be lost. Apart from chromosomes with multiple centromeres (where the " centromere genes " are spaced along the chromosome) as in some Nematodes and Hemiptera-Heteroptera, the breaking up of a chromosome will not alter the number, since there will be only one fragment carried on, i.e. the centric piece. (In the above- mentioned examples the different fragments maintain their existence in the cell. They constitute the somatic chromosomes in Ascaris, and in Hemiptera-Heteroptera they can lead to multiple systems of X and Y's). In plant material, however, it has been demonstrated by Darlington (1939), Upcott (1937) and others, that a centromere can divide in the wrong plane, and break up a chromosome in its two arms. These new parts, with each a " centromere-half," can maintain their existence in the cell. It is true that the chromatids of such fragments can split apart except at the centro- mere region, thus forming an equal-armed V-shaped chromosome. But we know that this need not necessarily happen (Campanula). We can get

chromosomes with only one arm, strictly speaking, although they are not very common. The best evidence for centric splitting and union of chromosomes comes from comparative study of *Drosophila* species. Here we find several examples of rod-shaped chromosomes fused into V-shaped, and genetical analysis shows that the main structure of the arms of the rods corresponds with that of the V's. On the other hand we know that the development of V-shaped chromosomes from rods need not be caused by fusion—pericentric inversions and translocations can give the same result. From the comparative study of *Drosophila* species, we learn that of the gross morphological changes, the inversions slip most easily through the selective processes. (The hypothesis that a new centromere must always come from the pre-existing ones is not quite certain. Centromere chromomeres are known to have developed outside the heterochromatic centromere region, as shown by Kattermann, Müntzing, Prakken, Rhoades and Vilkomerson.)

Professor Matthey has applied the modernised Robertsonian theory on Anamniotes and reptiles, and in some cases on mammals. But the reader is left in doubt on the main issue. Is there a general tendency towards numerical reduction during evolution, or does the tendency differ in the various systematic groups ? Is there an oscillation caused by polyploidy although never observed in higher vertebrates ? Or is there no law for numerical variations except those of chance rearrangements ?

In order to compare the different vertebrate species, Matthey has introduced the term " nombre fondamentale " (N.F.), meaning the total number of chromosome arms in the complement. If this N.F. shall mean anything at all, we must accept the hypothesis that chromosomes with only one arm exist. There are certainly many who deny that. From my own observations of the mouse I believe one can talk about strictly terminal centromeres. The difficulty of deciding this merely by looking at ordinary mitotic plates in animals with small chromosomes can be shown by an example from Matthey's own experience. Matthey (1945) : " En ce qui concern le Rat, l'inexistance d'un bras court par les chromosomes sexuels est *facile* à démontrer à condition que le matériel ait été convenablement fixé (Matthey, 1938, contra Koller and Darlington, 1934)." There can be no doubt that Matthey is wrong about this, which he also admits in 1948, after having seen a preparation made by his pupil Guenin. It is unfortunate that he did not take mouse chromosomes as an example instead. One must be very critical when determining the position of the centromere, and there will be considerable difficulties in deciding whether an arm is so short that it can be ignored, or whether it is sufficiently defined to be scored in the estimation of the N.F. In the rat the short arm of the X is not at all minute. It represents about one-fifth of the length of the long arm. I cannot help feeling that Matthey in his book has been somewhat uncritical when using old sources for determining the N.F. One should give the Robertsonian theory a fair chance !

However, Professor Matthey expresses criticism on other items. He throws some doubt upon the work of Koller (1936) and of Pontecorvo (1943). He questions Koller's count of 28 chromosomes in the grey squirrel, Cross (1931) having counted 48 in the subspecies *Sciurus carolinensis carolinensis*. I think that Cross's illustrations indicate preparations inferior to what one should use for chromosome work. I have studied the same material as Koller, and I have confirmed his findings.

With regard to Pontecorvo's remarkable results on the striped hamster, Matthey tells us that the material " a été fixé au liquide de Bouin seize ans auparavant par un missionaire voyageant en Chine." Bouin's fixative always gives a high degree of clumping of the chromosomes. This should account, according to Matthey, for Pontecorvo's findings of only $2n = 14$, the lowest number found in Eutheria ! In fact, however, the material was fixed in Zenker as well—and the fixation was made by Professor E. Hindle during the Kala Azar expedition of the Royal Society—which certainly fulfilled a mission, although one would hardly refer to the participants as missionaries. Moreover, I have lately had the opportunity to examine Dr Pontecorvo's slides, and he is certainly right about the number : *Cricetus griseus* has 14 chromosomes.

Matthey devotes several pages to the surprising discovery by Bovey and himself of a " sex trivalent" in males of *Sorex araneus* ($2n = 20+XXX$). This number was found in " at least 3 cells," but the authors cannot agree on the N.F. (Bovey 44, Matthey 46). In the British subspecies *Sorex araneus castaneus*, however, I have determined the number to be 24. There are 4 chromosomes of different sizes which may be associated in a chain, or in two bivalents. This is obviously the sex-determining mechanism.

Matthey has not tried to reduce the list of references. With regard to vertebrate chromosomes there is a tremendous lot of work done, but our true knowledge seems to be inversely correlated with the number of publications. It is high time that somebody started weeding out this overgrowth. The sense of piety is always in one's way—a work may be quite good considering the time when it was undertaken, but such an argument is no good to the student trying to orient himself in a new field of science.

On the other hand there is no excuse for leaving out the best references. In dealing with human chromosomes, Matthey still raises the question of the chromosome number in the male. Is it 47 or 48 ? Is the sex system XO or XY? Here an important work is left out, namely L. F. La Cour's " Mitosis and Cell Differentiation in the Blood " (*P.R.S. Edin.* B. **62** : Pt. I, 1944). The pre-myelocyte metaphase illustrated there is probably the best mitotic plate observed in Man, showing 10 median pairs, 8 sub-terminal and 6 terminal pairs, $2n = 48$ (N.F. $= 84$). It is really pointless to argue this question any further.

A general exposé of the work done on vertebrate chromosomes has never been given before. The present book will thus be welcomed both because it was needed and because it is well written. The arrangement of the different items is excellent, and the pictures and diagrams are well chosen. Professor Matthey's way of dealing with the problems is clear and thorough without being dull. His work will stimulate enquiry in a new and important field. SYLFEST MULDAL.