DISCUSSION

ON THE STRUCTURE OF CHROMOSOMES

THERE is no element of the cell which has excited more interest than the chromosome. It has been realized in recent years that only by the instantaneous application of the very best fixing reagents immediately to the cells can a really satisfactory insight into the organization of chromosomal structures be obtained. The smear method used on individual cells and very small organs is a result of this realization. This method, although extremely advantageous in a narrowly restricted range of cellular structures, has very serious limitations. It can not be employed on massive somatic tissues and even in the case of the reproductive elements, which frequently in the course of their development become isolated from one another in such a manner as to make possible the direct action of the best reagents, the earlier, texturally continuous stages are from the very nature of the smear method excluded from adequate fixation. Obviously a situation in cytology involving relatively few cells perfectly preserved and a large and important group representing the continuous tissues, in which good preservation is conspicuous by its absence, is undesirable and even impossible from the standpoint of clear interpretation. Conscious of this defect in our present methods, the writer has devoted a large amount of time during the past three years to the problem of the adequate fixation of the cells constituting the continuous tissues. After many failures a very simple solution of the problem has been reached which is described elsewhere. The results achieved by the improved technique have been exhibited to a number of competent cytologists both botanical and zoological and have met with general approval.

It is proposed in the present communication to give some general account of the results reached by the employment of this new procedure over a wide range of forms both animal and vegetable. It is now possible to follow in detail the behavior and organization of the chromosome in the actual divisions (mitosis) of the somatic tissues and also in the resting, preparatory and requiescent stages. These may further be compared in detail with the similar conditions in the case of the meiotic or reproductive conditions. The details of these observations and the necessary illustrations are to be published elsewhere.

When the somatic chromosomes have reached a certain size in proceeding from the resting condition to mitosis, they are clearly seen to be made up of a matrix, around the outside of which are coiled two filaments or chromatids spiralling in opposite directions, in such a manner that the gyres or coils of them cross one another, often presenting the optical illusion of a series of particles or chromomeres, which in recent years have been interpreted by some as the loci of the genes. The spirals tend to straighten out as the nucleus passes into the metaphase and the spirals as a consequence, in parts of the chromosomes at any rate, are often obliterated. In the later stages of the metaphase the two chromatids or filaments present in each chromosome lose completely their curled character and come to lie parallel side by side. At this stage and even earlier the two daughter filaments of the metaphase or even the prophase chromosomes, clearly separate from one another and each in turn becomes double, as in the mother chromosomes. At this stage and still more in the anaphase of mitosis these newly formed chromatids or filaments are strongly coiled around one another in reverse directions. Thus in later metaphase there are clearly present four filamentous elements in each metaphase chromosome, precisely as has been described recently for the meiotic metaphase studied by the smear method. As the anaphase sets in and verges towards the telophase, the spirals in its chromosomes become more or less obscured by contractions. As the chromosomes emerge from the telophase, their two filaments or chromatids are again quite obvious. The spirals become ever broader and shorter and thus pass into the resting stage. With the onset of the prophases of the next division the two filaments in each chromosome are again established and are at first very narrowly twined in the slender chromosomes. These become thicker and thicker and the pair of chromatids or filaments become more pronounced and spirally wound in reverse. With the onset of the metaphase the same situation as described above repeats itself.

The course of events in the case of the meiotic or reproductive chromosomes is closely similar; a striking contrast, however, is presented in the halved number of chromosomes, long known to be typical of normal meiosis. Apart from their halved number and corresponding larger size the chromosomal events in meiosis in general present a very close resemblance to that described in the preceding paragraph for the divisions of the somatic or body cells (mitosis). The same spiralization of the chromatids or chromonemata is seen, and in many cases—for example, Allium, Lilium and Vicia, classic objects for the investigation of the reproductive or meiotic divisions—the spirals are in reverse directions, precisely as in the case of the somatic (mitotic) divisions. A striking contrast in this respect, however, is presented by species of Tradescantia and Trillium, as described recently by Sax, Huskins and Matsuura, and confirmed in part by the present writer. Here the paired filaments or chromonemata of the individual chromosomes are spiral but run parallel to one another. Thus in certain cases the reproductive chromatids or chromonemata are contrasted with the somatic ones by the fact that they run parallel instead of in opposite directions. The present author has found the parallel condition to be present in the gametophytic soma of species of Trillium.

The situation outlined in the foregoing paragraphs seems to set the whole cytological situation in the somatic (mitotic) and reproductive (meiotic) divisions in a new light and establishes if confirmed by other observers a much closer resemblance between the two than has in the past been realized. The mode in which the contrast in chromatidal behavior between reproductive and somatic elements in Trillium and Tradescantia, etc., is achieved still remains to be elucidated.

It is worth while to add perhaps that the present course of investigation, which covers not only plants but a considerable number of animals, serves to set in relief the great superiority of good vegetable objects, such as Tradescantia, Trillium, etc., over the tailed Amphibia, such as Amblystoma, Necturus and Cryptobranchus, for the fundamental study of the chromosomes. Apparently, however, the same general chromosomal conditions prevail in the two great divisions of living beings.

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THE ROLE OF KINESTHESIS IN MAZE LEARNING

FROM the results of an early investigation by Watson[1] in 1907 the idea prevailed for some time that the only sense indispensable to maze learning in rats is the kinesthetic. However, in 1929 Lashley and Ball[2] demonstrated that the elimination of kinesthetic impulses by means of spinal sections did not abolish the perfected maze habit. Evidence showing that kinesthesis was unnecessary to the *learning* of the maze habit was soon forthcoming when Ingebritsen[3] demonstrated learning in rats that were deprived, prior to training, of kinesthetic impulses by sectioning of the cervical cord. Thus, kinesthesis was found unnecessary not only to the perfected habit but also to the learning of the habit.

There is now evidence that if all senses but the kinesthetic are abolished maze learning in rats is impossible. Previous tests by the writer had shown that the senses of vision, olfaction and audition, but not the tactual sense, play a rôle in maze learning, and it was therefore necessary only to render a group of rats blind, deaf and anosmic, but not tactually anesthetic, in order to show whether or not learning is possible when only the kinesthetic sense remains. A group of 45 blind-deaf-anosmic rats trained on a 14-blind elevated maze showed no signs of learning after 22 days of training (44 trials on the maze). The performance of these animals, measured by entrances into blinds, at the end of training was no whit better than the performance on the first trial; the performance of the group on the 22nd day was a "chance" performance.

It may be concluded, therefore, that not only is kinesthesis unnecessary both to learning and to the perfected habit, but that learning on the basis of kinesthesis alone is impossible. The evidence against kinesthesis would seem to be overwhelming. Far from being the one indispensable sense, kinesthesis appears to have no rôle whatever in the acquisition of the maze habit. But this conclusion, in view of other facts, would be hazardous. The smooth functioning of a well-learned motor habit or skill no doubt has in it a large kinesthetic element. It has been assumed that each movement in such a habit furnishes the stimulus for the succeeding movement, and that the smooth succession of movements is due to the close chaining of movements made possible by movement-produced stimuli. Our evidence shows, however, that the close chaining is possible only after the correct order of movements is learned on the basis of other classes of stimuli. Kinesthesis, in other words, seems to be essential to the acquisition of skill, that is, to the smooth flowing of movements, but this function it can assume only in conjunction with other classes of stimuli and only after learning has begun on the basis of other stimuli. Though Ingebritsen's animals learned the maze it is improbable that they could ever run through it with the speed and skill possible to normal rats.

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[1] J. B. Watson, *Psychol. Rev. Monog.*, 7: 2, 1907.
[2] K. S. Lashley and J. Ball, *Jour. Comp. Psychol.*, 71–106, 1929.
[3] O. C. Ingebritsen, *Jour. Comp. Psychol.*, 14: 279–294, 1932.

THE DATES OF PUBLICATION OF THE EARLIER NEW YORK STATE MUSEUM REPORTS

THE assertion has been repeatedly heard by members of the museum staff that the dates of publication of the earlier museum reports and bulletins are not reliable.

A typical case came to the writer's attention in connection with the catalogue of Devonian types now under preparation. The question of the priority of the term *Dolichocephala lacoana* Claypole, over *Stylonurus excelsior* Hall, which has been claimed by Beecher (1900) and others, came up. Investigation