The Behavior of the Chromosomes in Pinus and Thuya.

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A more uniform interpretation prevails among botanists today concerning the reduction of chromosomes in the spore mother cells of the higher seed plants than at any time in the history of this most perplexing of all questions. The view once prevalent that the reduction is brought about by two longitudinal fissions of the chromatin has been almost entirely abandoned, and there is a growing belief which is now almost universal that a true numerical reduction takes place as proposed by Weismann several years ago, although this occurs in the first instead of the second mitosis.

The question of the occurrence of a true reducing division may be taken, therefore, as quite definitely settled. The investigations which have brought about this condition have, however, raised new questions which are almost as difficult. Chief among these questions may be mentioned: the individuality of chromosomes, the origin of chromosomes from the spirem and the manner in which the characters are distributed to the germ cells. Concerning these questions there are various conflicting views. It is quite generally accepted among cytologists, that the maternal and paternal chromatin remain in a state of complete segregation throughout the growth phase of the organism and that they become more or less completely united at the time of synapsis. The behavior of chromosomes in hybrid forms has had a great influence in bringing about this conception.

It is concerning the origin of the chromosomes from the resting nucleus and their union in synapsis that the widest difference of opinion is held. There is one group of investigators among whom Strasburger, Guignard, Allen, Overton and others are prominent who maintain that the chromosomes of each ancestry become arranged into a complete spirem previous to synapsis, that these two spirems then approach each other and apparently fuse side by side into one during the synaptic phase. Following synapsis the spirems again separate somewhat and cross segmentation takes place. The somatic chromosomes which have been so united side by side become variously oriented toward each other and thus give rise to the heterotype bivalents typical of this mitosis.

The opposite view which has been supported by Farmer and Moore, Mottier, Shaffner, Juel and others, holds that two spirems are not formed previous to synapsis, but that the spirem is formed singly and the chromosomes are arranged tandem in the spirem. The bivalent chromosomes are formed by the spirem segmenting into pieces the length of two chromosomes. These pieces have often formed loops, but this is not always the case. Some of the pieces become approximated after cross segmentation.

In the two genera investigated there are no signs of a complete spirem previous to synapsis. The chromatin content of the nucleus always exists as rather large granular chromatic lumps connected by delicate anastomosing strands of linen. The number of these lumps is quite large, much exceeding the number of somatic chromosomes typical of the species. There is, therefore, no support in these genera for the theory of the individuality of chromosomes based on the idea of prochromosomes as suggested by Rosenburg for Drosera and by Overton for Thalictrum.

The first indication that the synaptic condition is approaching is the withdrawal of the nuclear net work toward one side of the nuclear cavity. There is no change whatever in its structure or staining reaction. Some of the chromatin bodies may be seen lying together in close proximity, but this is not interpreted as an indication that they are preparing for subsequent fusion. It is likewise clear that an occasional linen thread follows for some distance the same course as one lying near it, but this does not occur with anything like the regularity figured by Allen, Cardiff and others and is regarded as occurring too irregularly to have any significance. The synaptic condition is reached while the nuclear content is still in the form of a reticulum. There is no pairing of chromomeres or of the linen threads connecting them.

The chromatin emerges from the synaptic knot in the form of a rather broad spirem or skein which frequently reveals a double nature and this is interpreted as due to a longitudinal fission. The spirem becomes quite evenly distributed throughout the cavity. It may frequently happen, however that the more regular spirem gives rise to a very irregular and somewhat lumpy reticulum before cross segmentation. Formation of the chromosomes now takes place. The chromosomes consist of two somatics, which have either become approximated together or were not separated from each other during segmentation.

The chromosomes now become arranged in the spindle plate by the action of the fibers and their distribution to the daughter nuclei takes

place. This is affected in such a way that the members of the bivalent are separated and one member passes entire to each daughter nucleus, thus bringing about a qualitative division. The retreating chromosomes undergo longitudinal fission as they pass to the poles. Having arrived at the poles, they soon break up into smaller pieces, lose entirely their identity and form a complete resting nucleus. This condition lasts but a short time when a spirem is again formed which segments into rod shaped univalent segments. These segments have been quite generally assumed to be identical with the ones which appeared at the poles of the spindle at the close of the first mitosis, but since these segments were seen to lose their identity entirely there is no basis in fact for such a supposition. If these segments are not identical with the grand daughter segments of the first mitosis then this division is not equational. The first division in both genera is qualitative and reductional; the second may be conceived either as equational or qualitative.

The investigations on which this preliminary report is based will appear later in a more complete form, together with figures illustrating the entire process of mitosis.