may lead to confusion of true herpetomonads with Crithidia or young trypanosomes, such as has actually occurred in more than one instance.

He closes thus:

> As the life-cycles and general structure of the three human parasites are similar to those of well-known Herpetomonads, I see no reason for placing them in a distinct genus. The differences in their development, such as the formation of the flagellum, methods of division and the fact that their preflagellate stages are passed in man only justify their being regarded as specifically distinct from such species as *H. muscæ-domesticæ*, *H. sarcophagæ*, *H. culicis*, *H. lygæi* and many others.

In the opinion of others, just the points noted justify including the three human parasites in a separate genus, Leishmania.

H. B. WARD.

PLANT CYTOLOGY

The Permanence of Chromosomes in Plant Cells.—The problem of the individuality of the chromosome is receiving the attention of a number of plant cytologists. Briefly stated the problem concerns the permanence of the chromosome as an organ of the cell, enquiring whether the chromosomes are present as structural entities in the resting nucleus and whether they have come down from a line of ancestral structures reproducing by fission in the mitoses throughout the life histories.

In 1904 Rosenberg presented claims that the chromosomes may be recognized in the resting nuclei of certain plants and cited *Capsella bursa-pastoris* as a favorable type for their demonstration. Overton in 1905 traced the chromosomes of certain dicotyledons to aggregates of chromatin in the resting nuclei which he designated as prochromosomes, believing them to be autonymous structures representing the chromosomes in this stage of nuclear activity. Other investigators have reached similar conclusions. Nevertheless a number of plants is known in which the forms of the chromosomes during the interkineses are so changed by progressive alveolization or vacuolization as well as by the reticular union of chromatic masses through anastomoses that the outlines of the structures can not be followed in the irregularities of the chromatic and linin network. Whether the chromosomes in such nuclei really lose their identity as autonymous structures is not of course established simply by the negative evidence that they have not been traced by the technical methods at our command. These difficulties, however, have been clearly set forth by Mottier and other authors, some of whom are unwilling to accept the hypothesis of the permanence of the chromosome.

Four papers have recently appeared which give further evidence of the presence of prochromosomes in the resting nucleus and also present some important conclusions on the history of the chromatin during synapsis. In the latter feature these authors (Overton, Lundegardh and Rosenberg) support the view that during synapsis the sporophytic chromosomes by the parallel association of two spirems become grouped in pairs to form the reduced number of bivalent chromosomes characteristic of the heterotypic mitosis.

Overton[1] presents the results of studies on the pollen mother-cells of *Thalictrum purpurascens, Calycanthus floridus* and *Richardia africana*. He finds that the sporophytic (somatic) nuclei previous to the heterotypic mitosis have their chromatin in the form of definite bodies arranged in pairs with linin intervals between. The bodies are prochromosomes and were traced through synapsis to the chromosomes of the heterotypic mitosis. Overton interprets the grouping of the prochromosomes in pairs to mean that there are two spirems of paternal and maternal origin in the sporophytic nuclei which he believes remain distinct throughout the sporophytic phase of the life history. The parallel threads become more distinct just before synapsis and become very closely associated during the synaptic contraction, but remain distinct from one another.

The association of the sporophytic chromosomes in pairs is most intimate during postsynaptic stages when these elements become more or less closely united in various ways to form the bivalent chromosomes (in the reduced number) characteristic of the heterotypic mitosis. This is the period in the life history when the sporophytic chromosomes are most likely to influence one another by conjugation or by the mutual interchange of substance.

The first or heterotypic mitosis in the pollen mother-cells distributes the sporophytic chromosomes associated in pairs. At this time each sporophytic chromosome undergoes a longitudinal

[1] Overton, J. B., "On the Organization of the Nuclei in the Pollen Mother-cells of Certain Plants, with Especial Reference to the Permanence of the Chromosomes," *Ann. of Bot.*, XXIII, p. 19, 1909.

fission in preparation for the second or homotypic division so that chromosome tetrads are present during the metaphase of the heterotypic mitosis. The split chromosomes remain distinct during the interkinesis between the two mitoses and the halves are distributed by the homotypic division to the nuclei of the pollen grains.

The nuclei of the pollen grains show prochromosomes arranged in a single series and it seems probable that they retain this arrangement throughout the gametophytic phase of the life history. It also seems probable that the fertilization of the egg nucleus effects the close association of two such series of chromosomes, thus accounting for the pairs of prochromosomes arranged on parallel threads, and that this association is maintained throughout the history of the sporophyte until the distribution of the sporophytic chromosomes by the heterotypic mitosis. Nevertheless it is but fair to point out that these inferences are not as yet supported by direct evidence, that is to say, the history of the chromosomes has not been followed throughout the life history of any of these seed plant.

Lundegardh[2] introduces his paper with a good summary of the two views concerning the origin of the bivalent chromosomes of the heterotypic mitosis, (1) the theory of the parallel association of two spirems (Junktionstheorie), and (2) the theory of the folding of a single spirem (Faltungstheorie). His investigations are based on several types of the *Compositæ* (*Calendula officinalis, Achillea millifolium, Anthemis tinctoria* and *Matricaria chamomilla*), and on *Trollius europæus* of the *Ranunculaceæ*. Unfortunately these forms are not treated serially but with reference to the critical phases of the processes of the reduction divisions so that it is very difficult for the reader to follow the text and figures consecutively for any of the types. The difficulty is further increased by the crowding and ill arrangement of the figures. In deference to the reader too much care can not be given to these matters.

Lundegardh finds for the types of the Compositæ that the prochromosomes (*Gamosomen*) are generally arranged in pairs (*Gamomiten*) in the resting nucleus of the pollen mother-cell. In Trollius, on the other hand, the chromatin is in the form of numerous granules distributed on a delicate linin network and

[2] Lundegardh, H., "Ueber Reduktionsteilung in den Pollenmutterzellen einiger dicotylen Pflanzen." *Svensk. Bot. Tidsk.* III, p. 78, 1909.

prochromosomes could not be recognized. As the nuclei of these Compositæ approach synapsis the pairs of prochromosomes become connected with one another by delicate threads along which the chromatic substance is distributed so that two parallel systems of threads are constructed which finally become so closely associated as to form a single spirem. The chromatin granules of Trollius gather and fuse into larger masses which are at first more numerous than the chromosome count but show a tendency to pair. These are distributed over a delicate linin network upon which the chromatin becomes distributed. Finally the chromatic masses fuse thus forming a single spirem.

The later history of the reduction processes is similar in all of the types. The spirem splits (strepsinema stage) and segments into the reduced number of bivalent chromosomes which become distributed in the nuclear cavity (diakinesis) as pairs of chromosomes. The halves of the split segments of the spirem may then be regarded as the sporophytic chromosomes to be distributed in two sets by the heterotypic mitosis. A contraction during the strepsinema stage (second contraction) is not regarded as of special significance, but merely as an accompaniment of this period in the development of the bivalent chromosomes. The phenomenon of synapsis is regarded as especially significant since it is the period when the sporophytic chromosomes are in their most intimate relation to one another.

Rosenberg in two recent papers gives additional evidence in support of his belief (1904) in the permanence of the chromosomes, and develops further his views on the significance of synaptic phenomena. The first paper[3] deals especially with *Hieracium venosum* and *H. auricula.* A brief introduction outlines clearly the problems concerned with the prochromosome or gamosome theory and their relation to the views on the interpretations of the events of synapsis and the reduction divisions.

The chromatin is present in the resting nuclei of the archesporium as irregular deeply-staining masses almost always situated at one side of the nucleus. These are interpreted to be prochromosomes or gamosomes, their number corresponding generally to the number of chromosomes which for the sporophyte is fourteen and eighteen in these two species of Hieracium. As the nuclei of the pollen mother-cells approach synapsis the prochro-

[3] Rosenberg, O., "Zur Kentniss der präsynaptischen Entwicklungsphasen der Reduktionsteilung," *Svensk Bot. Tidsk.*, I, p. 398, 1907.

mosomes are found associated in pairs distributed over a network. The further history of the reduction mitoses is not described, so that the investigation is incomplete in a number of important features.

The second paper of Rosenberg[4] deals with *Crepis virens*, one of the Compositæ, a form remarkable for the small number of chromosomes, which are six for the sporophyte and three for the gametophyte generation. A further important peculiarity is a difference in the size of the chromosomes which makes it possible to follow the individual elements through succeeding mitoses with some degree of certainty. This is, so far as the reviewer is aware, the first account for plants of such a differentiation of chromosomes as has been described for animals by a number of zoologists.

The nuclei of the sporophyte (somatic) show six small prochromosomes in the resting stage from which are organized during the prophases of the vegetative mitoses two short rod-shaped chromosomes, two very long bent elements, and two chromosomes about midway in length between these extremes. The resting nuclei of the pollen mother-cells have six prochromosomes more or less clearly grouped in pairs. Synapsis presents a series of parallel threads intimately united at intervals. From this condition a thick coiled spirem is organized which clearly shows its double nature in the frequent longitudinal separation of portions as though it were split. The free ends of the chromosomes composing the spirem may at times be distinguished. A gradual contraction of the spirem leads through stages comparable to those described as a second contraction by various authors to the period when the six chromosomes, grouped in three pairs, may be clearly recognized (diakinesis).

The chromosome group on the approach of the heterotypic mitosis consists then of a pair of small, almost spherical, chromosomes, a pair of long rods, and a pair of short rods. These correspond to the three different sizes of chromosomes present in the vegetative sporophytic mitoses, but are more condensed or shortened. Thus the heterotypic mitosis is a true reduction division distributing the six chromosomes in two sets each of which consists of a spherical chromosome, a long rod, and a chromosome intermediate in shape between these two. These

[4] Rosenberg, O., "Zur Kenntniss von den Tetradenteilungen der Compositen," *Svensk Bot. Tidsk.*, III, p. 64, 1909.

chromosomes divide during the anaphase of the heterotypic mitosis in preparation for the second or homotypic mitosis so that they appear at the poles of the heterotypic spindle in the form of three split chromosomes or pairs.

The chromosomes change their form in the interkinesis, becoming long spiral threads which shorten on the approach of the homotypic mitosis when the six chromosomes again appear as three pairs showing the same characteristic range of form. The members of these three pairs are distributed by this division so that the nucleus of each pollen grain receives three chromosomes, a short, a long, and a middle-sized element, and these may be recognized in the resting nucleus by three prochromosomes.

A brief examination of the mitoses in the embryo-sac supported the conclusions above outlined.

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