

and abuts against a vertical extension *K* of the bar *C*. The extension *K* is parallel to the bar *J* and is connected to it at its top by means of a solid spring hinge. Turning screw *I* spreads apart bars *J* and *K* and lifts the whole combination (*A*, *B* and *C*) and imparts an arc movement in the vertical plane to the tip of the needle at *D*. To procure a vertical movement the tip of the needle at *D* must lie in the same horizontal plane *L-D* with the spring fastening *K* and *J* together. When screw *I* is turned the needle tip will then move in an arc *Y* to *Z* more nearly vertical than any other arc on the same circumference of which the point *D* is the center.

The rigid bar *J* can be attached directly to the stage of the microscope, or it may consist of a pillar rising from a metal base. In the latter case the microscope is clamped to the base alongside the pillar. In both cases the needle carrier *X* (Figs. 1 and 2) is arranged to allow the needle to project over the microscope stage with its tip in the field of the microscope objective.

This instrument can be used singly for one needle or with a companion when two needles or a needle and a pipette are to be used simultaneously. When a pair is to be used, one is a left-handed and the other a right-handed instrument.

There are two models of the micro-manipulator, a simple and a more elaborate form. Both are identical in the accuracy and extent of the fine movements. The advantages of the elaborate over the simple form are (1) great steadiness, (2) independence of the microscope from the apparatus and (3) special features for the preliminary adjustments of the needle or pipette.

In the elaborate form the manipulator is fastened on a pillar independent of the microscope. The pillar is screwed into a heavy base to which the microscope is clamped. This ensures great steadiness. The microscope can be removed at any time, thus facilitating greatly the exchange of needles and the preparation of the apparatus for micro-injection. Also the coarse adjustments are controlled by screws which aids greatly

in the preliminary adjustments of the needle or pipette when bringing it into the focal field of the microscope.

The simple form is more compact and can be clamped directly to the stage of the microscope. Its steadiness, therefore, depends upon the steadiness of the microscope stand. The preliminary coarse adjustments of the needle depend upon sliding movements which are operated by hand. They are, therefore, less readily performed than in the case of the elaborate form. However, the essential feature of the instrument is in the fine adjustments and these are identical in their accuracy in both forms.

A very convenient combination is a left-handed needle manipulator of the elaborate type including the base and a right-handed manipulator of the simple type. On the other hand, the simple form either singly or with both a right- and a left-handed manipulator, is very serviceable.

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CHROMOSOME RELATIONSHIPS IN WHEAT

IN 1917 the writer found the chromosome number of *Triticum durum* to be 28 in the fertilized egg cell. Since the number of chromosomes in wheat had been previously reported as 8 by a number of other investigators a systematic study of the chromosome number of the species of wheat was undertaken, together with a study of sterility in interspecific crosses already in progress. This work has been interrupted and in the meantime Sakamura¹ and Kihara² have published short accounts of the chromosome numbers in wheat. Their work seems to have received little attention, possibly due to the lack of convincing illustrations.

The writer has found the same chromosome numbers as reported by Sakamura. Einkorn has 7 haploid chromosomes; the Emmer group, consisting of *T. dicoccum*, *T. durum*, *T. turgidum* and *T. polonicum*, has 14 haploid chro-

¹ *Bot. Mag. Tokyo*, Vol. 32, 1918.

² *Bot. Mag. Tokyo*, Vol. 33, 1919, and Vol. 35, 1921.

mosomes, and the Vulgare group, consisting of *T. vulgare* and *T. compactum*, has 21 haploid chromosomes.

A study of the sterility relationships of species crosses has already been completed and is of considerable interest in connection with the chromosome number. Einkorn with 7 chromosomes crossed with members of the Emmer group with 14 chromosomes or with members of the Vulgare group with 21 chromosomes, results in almost totally sterile F_1 plants. Members of the Emmer group crossed with members of the Vulgare group result in only partially sterile F_1 individuals. Species within each group are inter-fertile.

A review of the wheat crosses made reveals the fact that practically the only hybrids of economic importance are crosses within the Vulgare group. The Emmer group possesses many valuable characters such as drouth and rust resistance, and certain varieties are heavy yielders under some conditions. Many crosses have been made between the members of the Emmer and Vulgare groups, but very few, if any, of the segregates have combined the desirable characters of both parents. It is possible that all F_1 gametes containing approximately half Vulgare chromosomes and half Emmer chromosomes are sterile and only gametes containing nearly all Vulgare or nearly all Emmer chromosomes survive. East³ has suggested that such behavior may occur in certain *Nicotiana* hybrids which are partially sterile. Work now in progress makes this conclusion rather doubtful for wheat hybrids. An analysis of six characters involving 80 F_2 individuals of a cross of *T. durum* \times *T. vulgare* does not indicate that there is greater sterility in the intermediates than in segregates resembling the parents.

There is a rather striking correlation between chromosome number and adaptability among the species of wheat. Einkorn with only 7 haploid chromosomes is of practically no economic value. In the United States it is grown only for experimental purposes. In the Emmer group with 14 haploid chromosomes, *T. durum* is the only species grown

commercially in this country. The durum wheats are for the most part limited to the plains of the Dakotas and Montana. The Vulgare group with 21 chromosomes is in general the most adaptable of the three groups of wheat. It is grown in practically all parts of the United States from Maine to California, in humid sections of the central states, and on the semiarid plains of the western states. There is certainly a high degree of correlation between chromosome number and adaptability of the species of wheat, but it would be difficult to prove that adaptability is due primarily to differences in chromosome number.

The fact that the chromosomes are in multiples of 7 suggests that the species having 14 and 21 chromosomes are the result of reduplication of the 7 chromosomes of Einkorn or wild wheat. There is some evidence that the larger chromosome numbers are due to reduplication rather than fragmentation. If we assume that the size of a given cell is dependent on the chromosome content, the relationship of the three groups of wheat species becomes clearer. We have found that the volume of the mature pollen grains, measured in thousands of cubic microns, is about 72 for Einkorn, 94 for the Emmer group, and 114 for the Vulgare group. The differences in chromosome numbers of the three groups of species are closely associated with corresponding differences in size of pollen grains.

In the reduction divisions of the F_1 hybrids of crosses between members of the Emmer and Vulgare groups we find additional evidence that the larger chromosome numbers are the result of reduplication rather than fragmentation. When the chromosomes pair for the reduction division we find only 14 pairs of chromosomes and 7 single chromosomes on the heterotypic plate. The members of the paired chromosomes separate and pass to the poles leaving the 7 single chromosomes on the equatorial plate. These single chromosomes ultimately divide and pass to the poles. If the 21 chromosomes of the Vulgare group are the result of fragmentation we should expect that homologous segments

³ *Proc. Amer. Phil. Soc.*, Vol. 54, 1915.

segments of the 14 chromosome group and that no single unpaired chromosome would be present in the reduction divisions.

If the 14 and 21 chromosome species are the result of reduplication we might expect a considerable number of characters in the Emmer and Vulgare groups to be dependent on multiple factors. Although many characters of these groups are apparently dependent on single factors there are a number of characters dependent on two or more factors. The red color of grain may be determined by one, two or three factors, and pubescence of chaff and color of chaff have also been found to be dependent on several factors in some cases. A comparatively large number of multiple factors affecting the same qualitative characters are reported in wheat.

If the Vulgare group, the Emmer group, and Einkorn differ only in chromosome combination of 7×3 , 7×2 , and 7×1 , why should the different groups result in sterile or partially sterile F_1 plants and why should the different groups vary so greatly in morphological characters? Morgan has suggested that for similar cases in other plants that changes may occur in the individual chromosomes in the course of time so that the original chromosomes would come to differ in many factors. If the 14 and 21 chromosome species have originated by reduplication of the 7 chromosome group such changes must have occurred. The species within each group overlap considerably, but each group is relatively distinct in morphological characters.

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ASTRONOMICAL MEETING AT THE POTSDAM ASTRONOMICAL OBSERVATORY

THE following is an abstract of a German press report of the international astronomical meeting held at Potsdam, August 24-27 last.

After a lapse of eight years the Astronomical Society met again at Potsdam, under the presidency of Professor Strömberg of Copenhagen. Representatives from sixteen nations were present. About two hundred attended the meeting; from Scandi-

navia, Professor Bohlin, Stockholm; Professor v. Zeipel and Amanuens Askloff, Upsala; Professor Strömberg and assistant Miss Vinter-Hansen, Copenhagen; from Christiania, observer Louis, and from Finland Furuholm; from Holland Professor Kapteyn as well as Van Rheijn and Father Esch; from England Professor Eddington, also Father Cortie, S.J.; among others were Professors Bauschinger, Hartwig, Einstein, Grossman, Nernst, Runge, Schorr, Wiechert, Prey, and Kienle.

Professor Strömberg in his address referred to the continuance of the communication of astronomical phenomena during the years of stress through the instrumentality of the Copenhagen observatory, instead of from Kiel. Copenhagen served also as a medium for the exchange of astronomical and scientific literature.

The scientific program contained many papers showing the progress which astronomy has made of recent years into details of which we can not here enter. However, from Father Hagen we learn of the immense masses of dark nebulae; from Kühl (Munich) explanation was given of many hitherto unexplained astronomical phenomena shown in the telescope as well as on the photographic plate; from Zeipel we learn of the determination of the masses of the stars in the globular clusters and that they obey the same laws as the molecules in a so-called ideal gas.

Rosenberg reported on the improvement of the photo-electric method for the determination of brightness of stars. The accuracy of measurements approaches the 10,000th of a magnitude. v. Tamm (Sweden) surprised the meeting with an ingenious and simple method for the determination of the color of stars photographically with a single exposure. Professor Oppenheim (Vienna) presented an interesting theory on the movement of the stars. Dr. Moll of Utrecht spoke of a new microphotometer for the measurement by means of a thermopile of the distribution of brightness in stellar spectra.

A committee was appointed in connection with an expedition for observing the solar eclipse next year in the Dutch East Indies. It is intended to repeat the experiment of Professor Eddington in connection with the theory of relativity.

A visit was paid to the observatories in Potsdam and Neubabelsberg. They were shown also the Einstein tower, a new structure to further test the effect of relativity, the details of which were explained by Professor Freundlich. Professor Guthnick has been appointed director in succession to would pair with entire chromosomes or larger