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GALLERY OF CEREAL WORKERS

Ernest Robert Sears

Ernie Sears arrived at the University of Missouri on the 1st of May, 1936, and, even though he has now retired, he is still working full time on a variety of wheat cytogenetic problems. The contributions of this man, not only to a better understanding of wheat genetics, evolution and cytogenetics, but to the wider comprehension of genetic and cytogenetic processes in general, is immense.

At the dinner to help Ernie celebrate his transition to the noble estate of retirement, letters of congratulation from his colleagues world wide were presented to him. Quotations from two of them provide estimates of the scientific appreciation of his many contributions. A cable from Olga Maystrenko in Novosibirsk described him as "... the architect and the mason" and a letter written by Colin Law but signed by many of Ernie's friends at the Plant Breeding Institute in Cambridge said "To attempt to catalogue all that you have done for wheat cytogenetics would be as insulting as to try to list Shakespeare's plays in order of importance".

It is not the intent of this contribution to list all of his efforts, let alone put them in any order, but to redirect our attention to the theoretical implications and practical importance of his unique additions to the knowledge of mankind.

Early in his career he produced many hybrids in the wheat group and developed amphiploids from them. This led to the contribution with McFadden on the genome approach to wheat breeding, a concept that still provides the basis for some types of genetic engineering in wheat. Typically, he still keeps the slides of the meiosis of these hybrids and amphiploids, and when a new study was made recently, he was able to lend the original material for re-examination. One hybrid (**Triticum turgidum** x **T. tauschii**), when its chromosome number was doubled, was clearly identical to **T. spelta**. In this work two things were demonstrated. First, the synthesis of a species previously only known in nature and, second, when the amphiploid was crossed with **T. aestivum**, the unequivocal demonstration of the origin of the D genome in bread wheats.

The identification and subsequent collection of chromosome aberrations in the progeny of a haploid was the start of the collection of the many aneuploids now available. Nullisomics, monosomics, trisomics, isochromosomes and telocentrics were all recognized in various publications prior to 1946. By 1954 Ernie published what would be a **magnum opus** for average cytogeneticists but for him only the starting point of further studies: "The Aneuploids of Common Wheat". In this one publication he described the origin of the aneuploids, their morphology and the morphology of the individual chromosomes, the breeding behavior of nullisomics, monosomics, trisomics and tetrasomics, the origin and behavior of telocentrics and isochromosomes, and discussed the genic basis of the nullisomic effect, homoeologous grouping, ineffective hemizygous genes, gene evolution and the practical value of the aneuploids, including monosomic analysis and intervarietal and interspecific chromosome substitution.

During his long career he has written reviews of the cytology and genetics of wheat and its relatives at least four times (1948, 1956, 1969, 1974). In 1967, with R. Morris, a chapter in the Agronomy Society Monograph on wheat summarized the considerable work on wheat and provided a classification (based on the work of Bowden) in which all the species of the former genus **Aegilops** were amalgamated into the genus **Triticum.** Not all workers use this classification, even though the basis for its establishment in the rules of nomenclature are indisputable.

In 1956 the cornerstone of the edifice, still under construction, called "Genetic Engineering" was laid. Ernie Sears deliberately, and with characteristic cytogenetic finesse, translocated a small segment of a chromosome of **T. umbellulatum** which carried a gene for leaf-rust resistance into bread wheat. This first step has led to many other induced translocations and to an impressive array of techniques developed by Ernie and his world-wide colleagues for the introduction of alien variation. Ernie's work in this area still continues. In 1972 he described the induction of whole-arm translocations, and, in another paper, the induction of translocations between Agropyron and wheat as a result of homoeologous chromosome pairing. More recently, not content with the mere introduction of alien variation, he has devised methods for reducing the length of the alien segment once it has been transferred into wheat. Only once was he forced into digesting, publicly, his own work. At the banquet of the 4th International Wheat Genetics Symposium (of which he was elected Honorary Chairman) the bread rolls were made from flour milled from the variety Riley 66 which carries the Lr9 gene Ernie first translocated in 1956.

One other large section of his work concerned chromosome pairing in wheat. Early work showed that chromosome 3B (originally III) carried a gene, which when absent, allowed asynapsis to occur. With Okamoto he recognized that chromosome 5B (originally numbered V) carried a gene regulating the normal meiotic chromosome pairing in the polyploid wheats. Later other

genes were identified affecting chromosome pairing and, with typical practical intent, Ernie set about making mutants of the pairing regulators so that they could be used for the pragmatic techniques of genetic engineering. In 1982 he published work concerning yet another mutant of a pairing regulator.

All the work on chromosome pairing was not directed towards the pairing regulators. With Fu, Ernie elegantly corroborated that cytogenetic principle that there really was a one-for-one correspondence of chiasmata and recombinatorial events. He also recorded reduced crossing-over in the proximal regions of telocentric chromosomes. Earlier work involved the recognition of a transmissible dicentric chromosome and the observation and consequences of the misdivision of univalent chromosomes.

With so many projects reaching fruition during such a long time, it is difficult to describe them in a chronological order for they overlap with each other. The work on the many aspects of the aneuploids is typical. Not only were new types produced (and he still is producing them) but they were applied to the solution of many problems. The concept of the orthogonal arrangement of the 21 chromosomes into three genomes each with seven homoeologous chromosomes is the theoretical floor upon which many ideas have been built. The demonstration of the validity of this concept was made by the laborious production of all the possible compensating nulli-tetras (and of many bizarre non-compensating ones also). This work was published in 1966. Here we have the clearest demonstration of Maystrenko's comment ".. the architect and the mason".

Monosomic analysis, using the aneuploids provided by Ernie, leads to the most powerful analytical genetic technique in the Plant Kingdom. Development of the telocentrics increased the power of this analysis many times. Not only is it possible to assign genes to individual chromosomes (and so demonstrate a basic fact of genetics), but they can be identified with a specific arm and generally they can be mapped with respect to the centromere. The power of these techniques was recognized by many workers, and those in Europe formed an organization (EWAC) to exchange data, material and ideas concerning the use of aneuploids in wheat. The most elegant techniques were developed by various workers, using aneuploids derived from those made by Ernie, allowing superbly detailed analyses to be made of the quantitative effects of individual genes. This type of work continues, as does Ernie's contributions to it.

With so many outstanding achievements it is not surprising that he has received a number of honors. The Hoblitzelle National Award in the Agricultural Sciences, Gamma Sigma Delta Award for Distinguished Service to Agriculture, Superior and Distinguished Service Awards of the USDA, Distinguished Service Award of Oregon State University (his **alma mater**) and the Agri-Business National Award for Agricultural Excellence are some of

the many. He was elected to the National Academy of Sciences, awarded an honorary degree of Göttingen University, elected an Honorary Fellow of the Japanese Society of Genetics and of the Indian Society of Genetics and Plant Breeding, and President of the Genetics Society of America.

With formal retirement you might expect the productivity to at least abate, but no. He has developed some of the perhaps most elegant, efficient and practical aneuploids of all - the dimonotelos. These lines, all 42 of them, are essentially euploid (they are hemizygous for only one arm), fertile and are easily maintained. They provide new tools for the investigation of many situations. New hybrids, and single chromosome additions and substitutions of chromosomes from **Haynaldia villosa** are being developed. The introduction and investigation of the genetic system causing the very high protein levels in some wild tetraploid wheats. The mutant for the pairing regulator on chromosome 5B has been located very close to the centromere. Just an interesting observation? Not so. Think of the practical possibilities for the introduction of alien variation. Ernie already has.

So much for the scientist, what of the man? Ernie is the stuff of which legends are made. Gentle, kind, helpful, humorous and considerate. Loved, admired and respected by his many colleagues the world over. We all shine in the reflected glory of his work.

Concluding by returning to comments delivered at his retirement dinner, Wouter Lange summarized, in a letter, for all of us, the scientific pleasure Ernie has generously provided. "...you should be honored as the main producer of a series of very special scientific toys, which have been effective to keep many persons - young and old - amused and busy. As a real toy-man you took care that the original type of toys remained available, but also that ever again other types were developed, with new possibilities for more fun!"

Gordon Kimber

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