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August 2018 was a milestone for genetics and agriculture- The International Wheat Genome Sequencing Consortium, announced the complete genome sequence of a variety of wheat called Chinese Spring. That this was done almost 2 decades after the human genome was sequenced and a decade after the genetic mysteries of corn were unlocked is a testament to the complexity of the enterprise. In fact, the wheat genome is by far the most complex genome to be sequenced. For years the genetic sequencing of this critical cereal crop was the holy grail of agricultural genomics.

Some 11,600 years ago, somewhere in the Southern Levant, a wild grass (emmer wheat) was domesticated. The domestication of wheat, along with barley, chickpea, lentils and flax heralded the Neolithic revolution which led to settled agriculture and civilization as we know it. Human ingenuity then took over and with cross breeding of different varieties over many millennia, we got the wheat varieties that we know and love now.

It is hard to overestimate the importance of this humble grass. Wheat commands the largest land area of any crop, about 215 million hectares or roughly the size of Greenland. With about 740 million tons of it being produced every year, it is the second most produced cereal in the world after corn (which is mostly used as animal feed). It provides about 20% of the calories to humanity second only to rice. And being richer in protein than rice or corn, it is a leading source for vegetable protein in low and middle income countries.

Given its importance, one would imagine that scientists would have decoded the genetic mysteries of wheat a long time ago. The problem is the enormously complex nature of the wheat genome. It is not just enormously complex- it is also, well enormous! Rice has about 400 million base pairs in its genome. A base pair is the genetic letter which needs to be "read" and sequenced. Corn which has a very complex genetic structure has about 2.4 billion base pairs compared to the human genome which has about 3 billion base pairs. With about 16 billion base pairs, wheat is the unquestioned winner in these sweepstakes.

It is not just the size of the genome which was a stumbling block. The complexity of the genome was another hurdle. Genetic material, that is DNA, is organized into long structures called chromosomes. DNA of course contains all the instructions that are required for life. These instructions are coded in parts of the DNA called genes which are read by other constituents of the cell to manufacture complex molecules called proteins. Evolution has ensured that different species have different numbers of chromosomes. And to complicate things, different organisms have different number of copies of the chromosomes.

Humans have 2 copies of each of their 23 chromosomes (one from each parent), that is a total of 46 chromosomes. The number of genes in the human genome is around 25,000. It turns out that because of hybridization of wheat with other wild grasses over millennia, the wheat genome typically carries 6 copies of each of its 7 chromosomes. And the number of genes is estimated to be a staggering 160000 to 330000! One can easily see that decoding the wheat genome was not going to be easy.

The Human Genome Project cost about $3 billion and took around 11 years to complete. Since then, sequencing technologies have advanced to such an extent that one can now get one's genome sequenced for under $1000 in a matter of a week or so. Even with these technological developments, the 110000 odd genes of the wheat genome took 14 years to be sequenced at a cost of roughly $70 million.

The sequencing is obviously a stupendous scientific and technological achievement. But it is equally an important step for global food security. The production of wheat has to increase by roughly 1.7% annually to keep up with population increase globally. In addition, wheat, unlike other cereals has gluten proteins which makes it the choice cereal for the production of processed foods. With rising standards of living, the consumption of processed foods is also increasing and hence wheat production needs to keep pace.

What this means is that newer varieties of wheat with higher yields would need to be developed. In addition, varieties which are disease and pest resistant and can better withstand the vagaries of weather conditions would be needed. Changing weather conditions are almost certainly going to be a fact of life with climate change and global warming. We are already seeing the effects of global warming with frequent droughts, unseasonal rains and unusual frost. All these make the development of better varieties imperative if we want to maintain food security.

Of course, humans have been developing better varieties of plants with selective cross breeding over millennia. But this can usually take years and is also largely a trial and error process. Even though the variety of wheat whose genome has been sequenced is not that widely used, scientists think that the techniques and knowledge gained from this would help them in unlocking the genetic mysteries of other varieties. With use of genetic tools like CRISPR which allows for accurate editing of individual genes, it should be possible to come up with varieties with the desired traits quickly.

We have already seen the tremendous difference that genetic engineering has made in the yields of corn and soybean. Wheat and rice, the source of most of the calories of humanity await their turn now. Whether the genetically modified varieties would pass regulatory tests remains to be seen. The first Green Revolution in the 1960s rescued us from the "ship to mouth" situation our country faced then. Only time will tell whether this breakthrough will usher a second Green Revolution.

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