PROFILE

Profile of Jorge Dubcovsky

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Science Writer

Growing up in Argentina in the 1960s and 1970s, plant biologist Jorge Dubcovsky witnessed poverty and malnutrition. Driven by social consciousness and a will to help others, Dubcovsky has since dedicated his life's work to making a positive impact on the world's food supply. By identifying a gene that increases wheat grain protein, iron, and zinc content, Dubcovsky and his team improved the nutritional value of wheat, which the Food and Agriculture Organization of the United Nations estimates provides around one-fifth of the food available for daily human consumption around the globe (1). Dubcovsky also leads efforts to understand the genes that regulate wheat development and flowering time, and to improve wheat frost tolerance and disease resistance. For these and other achievements, Dubcovsky was elected a member of the National Academy of Sciences in 2013.

Teacher of Middle School Math and Science

Dubcovsky was born in 1957 in Buenos Aires, Argentina. He says of his parents, "They were caring parents who provided a very supportive environment and a strong emphasis on education. They also gave me a lot of freedom to explore and pursue my interests." His parents also instilled a strong work ethic in him, as well as compassion for those who were less fortunate. "During my adolescence in Argentina, working in very poor neighborhoods of Buenos Aires, I saw the devastating effects poverty, lack of education, and malnutrition had on the lives of real people," he says. "I realized the privileges I had, and got a sense of obligation to contribute to the solution of those problems."

Dubcovsky became an elementary school teacher at the tertiary school Mariano Acosta in 1977. He taught middle school math and science classes, completing all of his undergraduate studies while working as a teacher. He earned a bachelor's degree in biological sciences from the University of Buenos Aires in 1984. After nearly a decade of elementary school teaching, Dubcovsky decided to pursue a doctorate in biology, which he earned at the same university in 1989, studying the chromosomes and evolution of South American wild forage grasses.

Passion for Wheat Genetics

In 1991, Dubcovsky completed postdoctoral training at the Molecular Biology Institute in Argentina before taking a fellowship at the University of California, Davis. There, he met Jan Dvorak, a professor in the Department of Plant Sciences who is a pioneer in the field of plant structural genomics. Dubcovsky says Dvorak has been an influential mentor. "He is a very productive and creative scientist who is passionate about wheat genetics, evolution, and genomics," Dubcovsky explains. "I learned all my basic wheat knowledge and most of my molecular genetics from him. The three years in his lab were the most productive years of my life."

After the fellowship, Dubcovsky returned to Argentina, where he worked for two years as a scientist at Instituto Nacional de Tecnología Agropecuaria, the Argentinian equivalent of the US Department of Agriculture (USDA). During these two years, Dubcovsky focused on the implementation of molecular marker technologies in the wheat program. In 1996, he returned to the University of California, Davis, accepting a position as assistant professor in the Department of Agronomy and Range Science. In 2003, Dubcovsky became a full professor in the Department of Plant Sciences. He now directs the university's wheat breeding program and wheat molecular genetics laboratory.

Wheat Varieties and Flowering Times

Dubcovsky's work in the wheat breeding program has led to over a decade of significant findings in the field of wheat genetics. As he explains, "During my PhD and postdoc, my research was more basic. As I became the wheat breeder for the University of California, my research focus switched to areas that I perceive can have positive, practical implications in wheat improvement, including both agronomic and nutritional traits."

In 2003, Dubcovsky and his colleagues reported detailed genetic and physical maps for the first known wheat vernalization gene, *VRN1* (2). Vernalization refers to the cold-weather requirement for accelerating flowering.

Jorge Dubcovsky. Image courtesy of Jorge Dubcovsky.

Winter wheat requires several weeks at low temperature, usually in the range of 4–6 °C, to flower. By mapping, isolating, and characterizing the *VRN1* gene, Dubcovsky and his team helped to reveal how wheat shifts from a vegetative to a reproductive state.

Building on that finding, Dubcovsky and his colleagues isolated and cloned two additional vernalization genes, *VRN2* (3) and *VRN3* (4). The latter is required to promote *VRN1*, and *VRN2* is a repressor of *VRN3* that prevents the initiation of wheat reproductive development. When the wheat plant undergoes vernalization, the *VRN2* expression is diminished, thereby allowing the plants to initiate flowering in the spring. Together, the studies on the three vernalization genes have provided breeders with tools to develop improved wheat varieties by adjusting wheat's flowering time. The studies also help explain how wheat adapts to a wide range of climates, with wheat continuing to be one of the world's staple food grains.

This is a Profile of a recently elected member of the National Academy of Sciences to accompany the member's Inaugural Article on page 10037.

Boosting Wheat's Nutrient Content

Working with researchers from the USDA and the University of Haifa, in 2006 Dubcovsky cloned a gene from wild wheat that increases the protein, zinc, and iron content in the grain (5). The cloned gene, named *GPC-B1* for its effect on grain protein content, accelerates nutrient remobilization and increases grain protein and micronutrient content by 5–10% in wheat. Almost all cultivated pasta and bread wheat varieties analyzed so far have a nonfunctional copy of *GPC-B1*, suggesting that this gene was lost during the domestication of wheat. The discovery, therefore, supports the value and importance of conserving wheat's wild germplasm. "Wheat is one of the world's major crops, providing approximately one-fifth of all calories consumed by humans; therefore, even small increases in wheat's nutritional value may help decrease deficiencies in protein and key micronutrients," Dubcovsky says.

Several breeding programs use the *GBC-B1* gene that is already present in many commercial varieties. Dubcovsky holds patents for nine new wheat varieties developed through his university work. He has also developed an additional five wheat varieties in collaboration with industry.

Improving Wheat's Freezing Tolerance

In a 2010 study, Dubcovsky and his colleagues demonstrated that when *VRN1* is expressed in wheat plant leaves, it initiates a process that leads to decreased expression of freezing tolerance genes (6). Dubcovsky explains that the system enables wheat and other temperate grasses to respond differently to cool temperatures in the fall, when winter is approaching, than to cool temperatures in the spring. This aspect benefits the plant because cold acclimation requires the plant to expend a lot of energy. More recently, Dubcovsky's team, along with colleagues from USDA-Pullman, showed that plants carrying multiple copies of *VRN1* and the allele *FR-A2-T* exhibited increased ability to withstand frost, providing a simple strategy to reduce freezing damage in winter wheat (7).

For these and prior achievements, Dubcovsky has received numerous awards over the years. In 2001, he won the Excellence in Research award from the National Association of Wheat Growers. He received the USDA-National Research Initiative Discovery Award for best research program in 2007, and the USDA Secretary's Honor Award in 2011. Argentina granted Dubcovsky the Platinum Konex 2003–2013 award for advances in genetics and genomics, and in 2014 he received the Wolf Prize in Agriculture, documenting the international impact of his research. "My recent appointment as a Howard Hughes Medical Institute Investigator," Dubcovsky says, "has provided me the resources to explore more freely areas I consider important for wheat research."

Adapting Wheat to Changing Environments

Dubcovsky's Inaugural Article (8) describes the acceleration of wheat flowering under long days. He explains, "Plants perceive day length as a critical environmental signal to trigger major changes in development. Multiple light sensors participate in day-length perception, the most important of which are the phytochromes." In other grains, such as rice, phytochrome C requires other phytochromes to function. The researchers found that in wheat, phytochrome C is functionally active even in the absence of other phytochromes. The results provide an entry point to modify wheat flowering and to accelerate the development of wheat varieties better adapted to new and changing environments.

Dubcovsky's group and his colleagues at the John Innes Centre in the United Kingdom are currently developing a collection of sequenced mutants from wheat that will allow researchers around the world to identify, with a simple Web search, mutants for almost all wheat genes. Through an experimental approach known as reverse genetics, researchers can investigate the impact of variation within a specific gene to infer the gene's function. The mutants can also be used to engineer novel traits in wheat. Dubcovsky's group has already used such mutants to significantly improve the amount of fiber in wheat grains (9).

"We need to be more aware that food does not grow in the supermarkets," he says. "A continuous research effort is required to maintain and increase food production." Dubcovsky adds, "A large and well-trained workforce is required to address these challenges and investment is required to train the next generation of plant breeders. Changing environments and pathogen populations, and rapid increases in the human population, make these investments in research urgent."

1 Food and Agriculture Organization (2006) *FAO Statistical Yearbook, 2005–2006* (FAO, Rome).

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5 Uauy C, Distelfeld A, Fahima T, Blechl A, Dubcovsky J (2006) A NAC gene regulating senescence improves grain protein, zinc, and iron content in wheat. *Science* 314(5803):1298–1301.

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9 Hazard B, et al. (2012) Induced mutations in the *Starch Branching Enzyme II* (*SBEII*) genes increase amylose and resistant starch content in pasta wheat. *Crop Sci* 52:1754–1766.