J. Shellenberger of Kansas State University made the statement in 1932 and it remains true today, Morris said.

Although cereal chemists report that ash has little-to-no relationship to flour baking performance, ash content of flours remains among the most pervasive specifications imposed upon millers. That's because the majority of a wheat kernel's inorganic material is located in the bran. In the days of stone ground milling, ash wasn't a consideration because every part of the kernel ended up in the flour. The same largely holds true for whole-grain flour. In fact, some researchers are interested in higher ash content wheat varieties because of their nutritional aspects. Zinc and iron are micronutrients that are especially important for vegetarians and impoverished populations that get the majority of their calories from cereals. Organic wheat producers might also want to emphasize higher ash content as a nutritional advantage.

Today, however, most flour is produced using modern roller mills that scrape rather than pound the kernel. As a result, the amount of bran in the finished product can be controlled by limiting the extraction. Testing the amount of ash in a flour sample gives millers an indication of the yield that can be expected during milling, and serves as a proxy for bran contamination which can show up by giving a darker color to finished products—something a Japanese noodle manufacturer would be loath to accept. The ash content test means he doesn't have to.

Although there is "firm genetic evidence" that varieties can account for a "couple of tenths" variation in ash content, Morris said it's certainly not enough for him to recommend breeders rush out to develop ash-reduced cultivars. "You can't do much to breed low ash wheat," Morris concludes, "but you can breed for good milling wheat which will give you low ash." ■

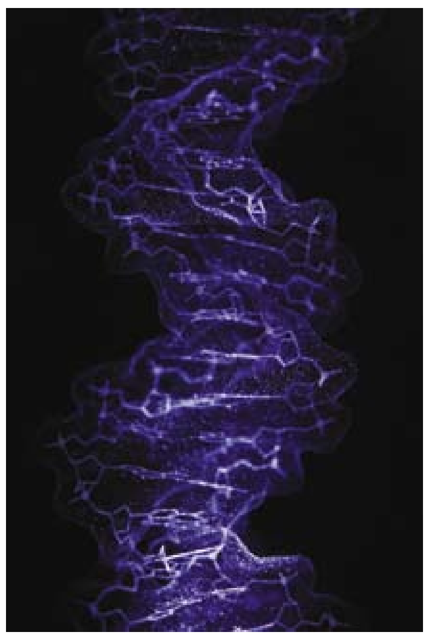
Up-and-coming wheat research revealed Down Under

by Camille M. Steber, PhD

The best and brightest in bread and durum wheat research were to be found at the 11th International Wheat Genetics Symposium held in Brisbane, Australia, August 24-29, 2008. This symposium is held every five years for the purpose of bringing together scientists from many nations, representing the state-of-the-art in wheat genetics and genomics. Conference proceedings are available at:

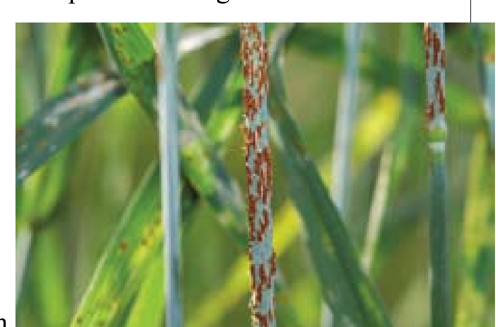
http://wheat.pw.usda.gov/GG2/Triticum/events/11IWGS/.

Presentations were made by scientists from Australia, the USA, Japan, Canada, Russia, France, and other nations. Exciting topics included news on the sequencing of the wheat genome, rust diseases, grain quality, drought tolerance, and grain preservation.



Gene sequencing. It seems that every time you turn around the genome of another organism has been sequenced. The list of sequenced organisms includes among others: humans, bread yeast, fruit fly, nematodes, silk worm, honey bee, mouse, rat, cat, dog, cow, the short-tailed oppossum, puffer fish, poplar tree, grapes, rice, maize, soybean, cocoa bean, and the model weed *Arabidopsis.* With this virtual cornucopia of gene sequences, you can see why the wheat research community is anxious to be next in line. A genome sequence compares to an ordinary genetic map like Google™ streetview and satellite compare to an ordinary paper roadmap. It shows the genes down to the finest base pair detail. And it makes it much easier for geneticists to see where they are going as they breed, clone, and characterize the function of wheat genes. Every wheat plant contains two copies of 21 chromosomes comprised of the A, B, and D genome versions of 7 chromosome groups.

Catherine Feuillet of the French National Institute for Agricultural Research (INRA) presented her groups' progress in sequencing Chromosome 3B, "the Big-B of bread wheat." Katrien Devos of the University of Georgia presented her NSF project to randomly sequence cloned segments of the wheat genome. Bikram Gill's group at Kansas State University will be working with chromosome 3A, while Jan Dvorak of UC Davis will prepare to sequence the D genome donor *Triticum tauschii.* The race to sequence the wheat genome has begun.



Rust. The symposium included a rust workshop that delivered the message, "old pathogens never die, they simply mutate." The big news is the Borlaug Global Rust Initiative and International Collaboration aimed at preventing an outbreak of Ug99 stem rust. Highly durable resistance to stem rust has been provided by the *Sr31* gene for many years. Basically, stem rust was considered a finished problem, but as Pacific Northwest growers know, any time you rely too heavily on a single resistance gene, pathogens will eventually overcome that gene. New mutant lines of stem rust able to infect wheat carrying the *Sr31* resistance gene were identified in Uganda, Africa in 1999. Since then Ug99 has migrated into Kenya, Ethiopia, and Iran. It is expected to show up next in south and west Asia.

Relatives of Ug99 with the ability to infect wheat carrying resistance genes *Sr24* and *Sr36* have also been isolated in Africa. The initiative to combat this problem is being funded in part through a $26.8 million grant to Cornell University from the Bill and Melinda Gates Foundation entitled the *Durable Rust Resistance in Wheat* (DRRW) project (www.wheatrust.cornell.edu). This project will provide funds to 16 institutions over 3 years and is focused on providing resistant wheat varieties to high-risk farmers in Africa and Asia.

Aphids. How can a wheat plant outsmart an aphid? This is a question under investigation by Anna-Maria Botha (University of Pretoria, South Africa) and Nora Lapitan (Colorado State University). Tolerant cultivars use the simplest strategy by increasing photosynthesis/energy production to try and outrace the drain on their systems.

Antiobiotic cultivars are more clever. As soon as the aphid starts to suck on the plant through a straw-like body part called the stylus, these plants produce a sticky substance called "callose clog," and seal off the straw. Still other cultivars produce volatile compounds that act as aphid repellents. This talk highlighted how plants can take advantage of the energy provided by photosynthesis to become chemical factories that outmaneuver the enemy.

Drought. The importance of improving wheat yields under warmer or drier conditions was a hot topic at the symposium. Whether due to climate change or to the vagaries of nature, farmers in many nations have suffered recent losses due to drought. The southeastern United States suffered severe drought in 2008. Simultaneously, Israel and Iraq suffered their worst droughts in 10 years. Australia has experienced severe regional droughts since 2003. There is growing concern that India's water table is falling because farmers are using groundwater for irrigation at an unsustainable rate. India spends an estimated $9 million per year subsidizing electricity for irrigation water pumps.

Strategies for drought stress were reviewed by Richard Richards, an eminent crop physiologist from Commonwealth Scientific and Industrial Research Organisation (Canberra, Australia). Under drought stress, a plant may increase the depth of its root system, allowing it to tap into deeper moisture. Alternatively, a plant can use the water available more efficiently, achieving more yield for the amount of water lost to transpiration. Finally, a plant can put more energy into producing grain than into stems and leaves. Presentations on drought included use of the "stay green" phenotype to maximize yields under drought (J.T. Christopher, Australia), use of the emmer wheat relatives to identify drought tolerance genes (Y. Saranga, University of Haifa, Israel), and use of mutation breeding to increase transpiration efficiency (C. Steber, USDA-ARS Pullman, Washington).

Vernalization. Dr. Jorge Dubcovsky (University of California, Davis) presented the cloning of wheat genes governing vernalization *(Vrn1, Vrn2, and Vrn3)* and stripe rust resistance *(Yr36).* Winter wheat contains vernalization genes that cause a requirement for 6-8 weeks exposure to cold in order to induce flowering. The same genes that control vernalization also participate in control of flowering by day length. Winter days are short on daylight. If wheat is exposed to short 8-hour days at warmer temperatures for 6-8 weeks, these short days can stimulate flowering and replace the vernalization/chilling requirement. Closer to home, Dr. Dubcovsky collaborated with pathologist Dr. Xia-ming Chen at WSU's Pullman campus to clone the stripe rust resistance gene *Yr36.* This should help Dr. Chen understand what makes a wheat plant resist or succumb to stripe rust. Dr. Dubcovsky is also collaborating with Dr. Kimberly Garland Campbell (USDA-ARS Pullman) on the molecular mechanisms of cold tolerance.

Seedbank. When do you find wheat in the land of the polar bears? Answer: when you store wheat in a natural deep freeze. Dr. Cary Fowler of the Global Crop Diversity Trust (www.croptrust.org) presented a talk on the Doomsday Seed Bank. Seed banks preserve wild collections of wheat grain and other seeds. Such seeds are valuable sources of natural disease and stress resistance genes (GMO wheat not allowed). Recently, one such seed bank in the Philippines was wiped out by a hurricane, taking unique accessions with it. Dr. Fowler said that this catastrophe demonstrates why the world needs a backup seed collection. The Doomsday Seedbank is carved into a frozen mountain on the island of Svaalbard, Norway and serves as a natural deep freeze for crop seeds. If you ever find yourself the last person on earth, you'll know where to look for seed to start over. ■