GENOMICS

# Poplar Tree Sequence Yields Genome Double Take

Black cottonwoods are the lab rats of the tree world. It's relatively easy to add or knock out genes, and like other members of the poplar genus, they grow quickly enough that researchers can check the outcome of some experiments in less than a year. Foresters love poplars too: Their fast growth rate makes them a good source of fiber for paper, lumber, plywood—and a possible source of biofuels. All these reasons motivated more than 100 researchers to sequence the tree's genome.

**Unveiled.** The genome of black cottonwood should provide insights into how to improve commercial varieties of it and other poplars.

On page 1596, the team, led by Gerald Tuskan of Oak Ridge National Laboratory (ORNL) in Tennessee and Daniel Rokhsar of the Joint Genome Institute (JGI) in Walnut Creek, California, describes its first analysis of the more than 45,000 likely genes in black cottonwoods (*Populus trichocarpa*). The group has begun to sketch out the evolutionary history of *Populus*, finding, for example, that a doubling of the genome about 65 million years ago freed up many genes to acquire functions important for trees, such as wood formation.

Cottonwood is the first tree and the third plant genome to be sequenced, coming after the herbaceous annual *Arabidopsis* and rice. The bulk of the sequencing was done at JGI and ORNL, with researchers around the world contributing genetic markers—such as 324,000 expressed sequence tags—which aided in the search for genes. Four groups then independently trained computer algorithms to search for coding sequences, and they all agreed on 45,555 likely nuclear genes.

By comparing the new sequence to that of *Arabidopsis* and sections from other plants, the team determined that the ancestral genome of poplars had been duplicated at least three times: first, at the base of all angiosperms, then about 100 million to 120 million years ago, and most recently 60 million to 65 million years ago. "The genome sequence shows this incredibly complicated evolution, full of diversity," says Gail Taylor of the University of Southampton, U.K., who is not an author. "It's like an Aladdin's cave." Similar doublings also occurred in rice and *Arabidopsis*, so they appear to be widespread among plants, Tuskan says.

Genome duplications offer new grist for natural selection because a second copy of a gene can evolve a new function. Although the *Populus* genome has lost some of its extra copies, it retained others that might be particularly useful for fending off pathogens, synthesizing lignin and cellulose, transporting metabolites, and bringing about programmed cell death (which may be important for seasonal growth and autumnal senescence).

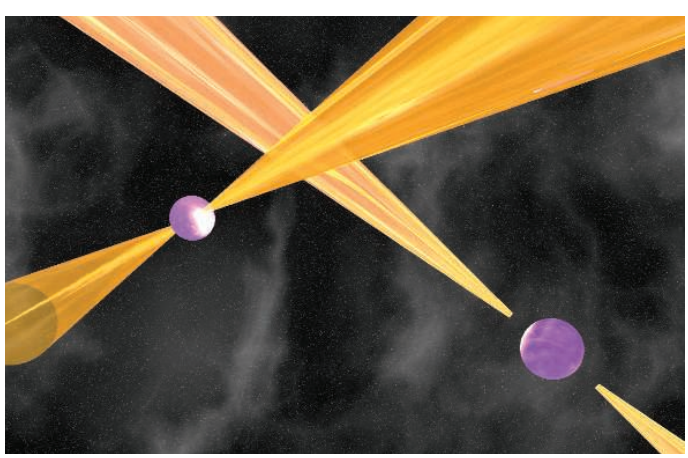
The next step is to figure out what more of the genes do—half have no known function—by creating mutants with genes that are under- or overexpressed. "There will be thousands of new functions that were not known or fully appreciated in other species," predicts Steven Strauss of Oregon State University in Corvallis. This will help lead to the development of new varieties of poplars that might have longer growing seasons or pack on more biomass. It could also have payoffs for ecologists, clarifying the keystone role of poplars in riparian and other ecosystems. "There's a whole new area of science opening up," Taylor says.

–ERIK STOKSTAD

ASTROPHYSICS

# Pulsars' Gyrations Confirm Einstein's Theory

Comparing a pair of massive stellar clocks known as pulsars, an international team of astronomers has put Einstein's theory of gravity to its toughest test yet. Published online by *Science* this week (www.sciencemag.org/cgi/content/abstract/1132305), the results show that the theory of general relativity (GR) is accurate to within 0.05%, even in the ultrastrong gravity of a pulsar, a spinning neutron star measuring roughly 20 kilometers wide but weighing more than the sun. Further observations could enable researchers to peek into the structure of neutron stars, the hearts of which may contain a bizarre form of nuclear matter that flows without resistance.



**Timepieces.** Taking the pulses of two pulsars as they whiz around each other, astronomers have determined their orbit and tested general relativity.

Most physicists agree that GR cannot be the last word on gravity because it clashes with quantum mechanics. The new observation limits the possibilities for tinkering with GR, says Joseph Taylor, a physicist at Princeton University. "They're tightening the constraints on any alternative to Einstein's theory," he says.

According to GR, matter and energy warp space and time, making free-falling objects travel along curved paths and producing the effects ▶

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