

A Botanic Oak Collection Recruited for Science

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What do you do if you are a geneticist studying the evolution of the genus *Quercus* and in great need of DNA samples of several hundred different oak species found nearly everywhere in the northern hemisphere from 0 to 4500 metres above sea level?

For Antoine Kremer, Research Director at l'Unité Mixte de Recherche BIOGECO (INRA, Université de Bordeaux) and François Hubert, who is preparing his doctoral thesis, the solution is at hand: not two hours from their laboratory in Pierroton near the city of Bordeaux, the oak collection at l'Arboretum des Pouyouleix (St. Jory de Chalais) offers a vast choice of botanic species of oak, grown from wild-collected seeds and for which the seed collection data has been scrupulously recorded.

Created in 2003 by Béatrice Chassé and Gérard Lionet, l'Arboretum des Pouyouleix covers 25 ha in the north Dordogne region of France. Bordered on one side by the river Côle, the altitudinal variation is from 270 to 210 m above sea level. Situated between the Aquitaine basin and the Massif Central, it is a metamorphic region in which the soils are largely the product of mineral decomposition. There are different soil types locally at the Arboretum (although the pH is always below 7): in the valleys as well as alongside the river the soil is rich and deep, whilst in other places the soil is sandier and shallower, and still others are composed of a coarse clay. Over the past 7 years rain fall has varied from 716 mm (2005) to 1021 mm (2007). The Arboretum is at the northern limit of USDA Hardiness Zone 8.

The wild-collected biological resources that are now available in the oak collection at the Arboretum des Pouyouleix represent an invaluable contribution to the research in progress in the phylogeny of the genus *Quercus*. "This Arboretum is a clear demonstration of the scientific value of a botanic oak collection" declares Antoine Kremer, underlining the importance of the work carried out by Béatrice Chassé and Gérard Lionet over the past 7 years.

Systematics

Systematics is that branch of biology that attempts to classify living things. Since Linnaeus (1707-1778) and up until very recently, all living things were classified based on morphological criteria. Thus, much as one would separate out forks, knives and spoons, systematics identifies separate categories for frogs, dinosaurs, human beings and so on for birds, roses, baobabs, etc...

As of the second half of the 19th century, two major events have greatly influenced the science of systematics. The first one is the formulation of the theory of evolution and its central fact that all species are related, and the second is the development of the science of genetics based on the discovery of DNA (deoxyribonucleic acid).

With the advent of genetics, criteria for classification are based on “the content” of the genome (genomics is thus the study of living organisms based on their genome). DNA is a macromolecule shared by all living organisms and whose architecture and component molecules are identical but the physical sequence of which is different and specific for each species. The “content” of a genome



Quercus hintoniorum, one of the rare oaks from Mexico being established at Arboretum des Pouyouleix. The leaves are put into tea bags that are placed in a box containing silica gel that ensures slow and uniform desiccation. Using a specific technique, the leaves will be ground to extract the DNA.

is thus the DNA it contains but more specifically the precise sequence of these component molecules, traditionally represented by the first letter of their names : A(denine), T(hymine), C(ytosine), G(uanine). Molecular systematics is based on the comparative study of the specific sequences (i.e., the genetic code) of each species.



Arboretum des Pouyouleix



Researchers François Hubert and Antoine Kremer at work at the arboretum with oak seedlings from seeds collected by Béatrice Chassé in Autumn 2009 in Mexico. A few leaves of each species is sufficient to extract the quantity of DNA needed.

Phylogeny and evolutionary history

Phylogeny is the science that tries to reconstruct species' genealogy, in other words their shared evolutionary history. The discovery of the genetic code was a revolution for phylogeny because the universality of the genetic code is a key instrument in this reconstruction. Put simply, the degree of difference between the genetic codes of two species can tell us a part of their evolutionary history.

This history is often reconstructed using information from different disciplines (phylogeny, paleontology, paleoclimatology, etc.). It is a synthesis of knowledge acquired in different domains, and frequently scientists propose multiple scenarios because this knowledge is incomplete.

Oaks

In the world of trees, the genus *Quercus* (the latin word for oak which comes from the Celtic, *kaër quez*, and means "beautiful tree") is second only to the genus *Eucalyptus* in the number of species that compose it. The American oak (*Quercus rubra* L.), as it is called in Europe, is only one of the 244 species of oak spread across the United States of America, Mexico and Central America. In Asia, there are 183 and in Europe, poor cousin in this story, only 38. These numbers change quite frequently as taxonomists do their work, but this gives a good idea of order of magnitude per geographic region.

By studying the genetic differences in several specific DNA sequences of each of these species, M. Kremer and his team are trying to understand how they have differentiated in order to reconstruct their evolutionary history. This project is part of a larger program whose objective is the reconstruction of the evolutionary history of oaks and pines. It is financed by l'ANR (Agence Nationale pour la Recherche) and coordinated by Alain Franc (Directeur de recherches à l'INRA à l'UMR BIOGECO).

"Phylogenetic reconstruction is all the more precise if it is based on great number of species. That we have at our disposal at l'Arboretum des Pouyouleix such a vast collection of oaks is particularly valuable" adds Antoine Kremer.

As of the summer of 2010, the botanic oak collection at l'Arboretum des Pouyouleix included 240 species of this genus. But not all of the trees can participate in this project.

"Of the 240 taxa represented in the collection, we only have precise provenance information for about 150. For phylogenetic research this information is vital" explains Béatrice Chassé. "Shortly after the creation of the Arboretum we understood that the quality of our collection depended on planting trees grown from seeds collected in the wild where the species live. Most of the time, nurseries do not have this information. Since 2006, through seed-collecting expeditions and exchange we can furnish a precise "address" for all of our trees. Today, this makes our Arboretum a useful tool for the science of evolution."

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