The many facets of biological diversity

A Biodiversity Research Centre has been established in Heidelberg in order to explore the spatio-temporal development of biological diversity and its interaction with constantly changing environmental factors. The centre, in which the Botanic Garden of the University of Heidelberg with its plant inventory and collections also participates, involves scientists from a broad range of different disciplines. Projects range from basic research to nature and species conservation strategies and education programmes for the general public.

Biodiversity is not only the diversity of organisms, but also the diversity of habitats that have been created as a result of interactions between the environment and organisms. The complexity of the interaction of a variety of factors – including anthropogenic ones – requires researchers of different disciplines other than the traditional subjects and faculties to work together. The University of Heidelberg has therefore pooled the competences in biodiversity and environmental research of ten institutes and institutions in an interdisciplinary research consortium, the Heidelberg Center for the Environment (HCE).

The Biodiversity Research Centre is a central element of the HCE, which is funded under the German Excellence Initiative as part of Heidelberg University’s Future Concept. This centre brings together scientists of different disciplines who carry out cooperative projects in the field of biodiversity research. The centre is headed up by botanist Prof. Dr. Marcus Koch from the Centre for Organismal Studies Heidelberg (COS) and palaeontologist Prof. Dr. Wolfgang Stinnesbeck from the Institute of Earth Sciences.
The two researchers represent two complementary approaches to biodiversity research: research into recent biological diversity on the horizontal time axis and changes in biological diversity during the course of the Earth’s history (palaeodiversity research). Today’s diversity is the result of the emergence and extinction of species under changing environmental conditions of the geological past. The genetic material of living species also reflects past evolutionary processes.

According to the Biodiversity Research Centre’s homepage, biodiversity research that is focussed on understanding and maintaining existing diversity applies approaches used in palaeodiversity and evolutionary research and complements these approaches with biological-organismic methods from the fields of ecology and population biology, to name but two examples (see www.biodiversity.uni-heidelberg.de/forschung.php).

Biodiversity is the degree of variation of life forms within a given time period; however, as these changes occur within specific habitats, the environment also plays a key role in the development of biodiversity. Methods from the field of physical geography are indispensable for biodiversity research. Interdisciplinary research characterises the projects carried out by the Biodiversity Research Centre, and the centre’s integration into the activities of the HCE, which also involves the Institute of Geography, the Institute of Earth Sciences and the Institute of Environmental Physics, has further strengthened interdisciplinary cooperation in the field of biodiversity. In recognition of its new approaches, the Biodiversity Research Centre was awarded the “Innovation Star” by the Rhine-Neckar Metropolitan Region in 2010/2011. The award honours scientific institutions and companies in the region for conceiving and designing pioneering innovations.

In addition to his post as director of the Biodiversity Research Centre, Prof. Marcus Koch also heads up the Department of Biodiversity and Plant Systematics at the Centre for Organismal Studies in Heidelberg and is the director of the University of Heidelberg Botanic Garden and Herbarium, which, with its broad range of plant species and collections, is a modern facility for contemporary
biodiversity research. Moreover, it is a conservatory for endangered plants, thereby contributing to the protection of the biological and genetic diversity of plants.

A botanic garden for the protection of biodiversity

The Heidelberg University Botanic Garden was established in 1593, just 50 years after the botanic garden of Padova in Italy, the world’s oldest academic botanic garden founded in 1545. Today, the Heidelberg University Botanic Garden plant collections exceed around 10,000 species, most of which are grown in greenhouses. The garden’s vast, internationally reputed collections of succulents, orchids and bromeliads are the result of the efforts of Prof. Dr. Werner Rauh who undertook countless expeditions to regions of Central and South America, southern Africa and Madagascar between 1965 and 1995.

Many of the plants’ natural habitats have been subject to progressive destruction, which has led to the reduction and even extinction of a large number of plants in their native lands. The Heidelberg University Botanic Garden therefore possesses an important collection of extinct and endangered species from around the world. Rauh was director of the Botanic Garden from 1960 to 1982; the “Werner Rauh Heritage Project”, initially funded by the Klaus Tschira Foundation, continues Rauh’s research and documentation work. Type specimens are collected in the type collection HEID, which is associated with the Garden and originates from the early 19th century. The collection includes around 50,000 higher plant species, catalogued in more than 250,000 documents, making it one of the largest and most important herbariums in Germany.

In addition to research, the Heidelberg Botanic Garden also caters for the increasing public demand for education. The Garden’s ‘Grüne Schule Heidelberg’ (green school) offers garden tours, events and other activities for primary and secondary schools, providing information and
explanations about the Earth’s biodiversity. Koch sees these educational activities as a contribution towards fulfilling the Convention on Biological Diversity signed in Rio de Janeiro on 5th June 1992. Under this agreement, Germany and 153 other governments agreed to develop national strategies for the conservation and sustainable use of biological diversity.

Biodiversity research involving Brassicaceae

Koch and his team of researchers are specifically focussed on the systematics and phylogenetic relationships of plant species; phylo-biogeography (the distribution of genetic variation in space and time), genome evolution, speciation processes, breeding system evolution and differentiation on the population level as well as structure, morphology and evolution of angiosperm flowers. DNA libraries, genome sequencing and molecular genetics analyses of ribosomal DNA encoded in the cell nucleus, plastid DNA, promoter regions and microsatellites play a crucial role in research into the evolution of molecular marker systems and developmental processes in plants.

Many of the team’s projects focus on cruciferous plants (mustard family, Brassicaceae), which comprise cabbage, rapeseed, mustard, cress, radish and horseradish as well as the thale cress (Arabidopsis thaliana), the most important model plant for plant molecular biologists and geneticists. The family contains about 3,700 species worldwide; around 160 wild cabbage species are known in Germany (information from the ‘Atlas der Farn- und Blütenpflanzen Deutschlands’ published by Hennig Haeupler and Thomas Muer in 2007).

The diversity of this plant family is not only down to the number of species, but also to the huge morphological and genetic variability of cabbage varieties originating from wild cabbage (Brassica oleracea) (see BioPro article of 29th April 2013: “Bioactive plant foods: plant substances against cancer stem cells”; see link on right-hand side). Originating from many areas, the Heidelberg collections focus specifically on wild populations in order to highlight the importance of genetic variation and diversity for evolution and speciation.

The cabbage family is also the subject of a priority programme of the German Research Foundation (DFG-SPP1529: "Adaptomics"), which is focussed on studying the molecular mechanisms that underlie the adaptive features of cruciferous plants in order to understand how plants evolve and adapt to environmental changes.

As part of the DFG-SPP1529 priority programme, Koch and his team have developed BrassiBase, an online knowledge and database system containing all available information and resources on
Brassicaceae taxonomy, systematics and evolution, including chromosome numbers, genetic traits and characters, germplasm resources, etc. The next priority programme workshop (“Brassicaceae – introduction to family-wide biodiversity part II”) will also be held in the Heidelberg Botanic Garden on 24th/25th October 2013.