Foreword

Issues, approaches *and prospects for* biodiversity research

Global changes under way (climate change, land use change, biological invasions, etc.) are forcing scientists and societies to question the future evolution of biodiversity: Is it a crisis situation? What are, and will be, the impacts of major biodiversity erosion on services provided by ecosystems and on human wellbeing? Is the economic development of societies inconsistent with biodiversity preservation?

The fate of biodiversity is thus on the agenda in large-scale international meetings (Earth Summit, Millennium Development Goals, etc.), of international agencies and organizations (International Union for Conservation of Nature, Food and Agriculture Organization of the United Nations, World Bank, etc.) and major NGOs (Conservation International, World Wide Fund for Nature, World Conservation Society, etc.). However, to be able to adapt to changes affecting biodiversity, it is essential to gain insight into the mechanisms of its evolution, functioning and interactions with human societies that benefit from its trove of ecological, cultural and socioeconomic services.

Agropolis International has federated a community of scientists conducting research on this topic. It is one of the largest in France, and likely in Europe, in terms of the number of researchers, the scientific areas covered—generic (genomic, integrative biology, evolutionary and functional ecology, economic, anthropological, etc.) and targeted (management of living resources, aquaculture, fisheries, forestry, agronomy, conservation, health, public policy, etc.)—and in terms of the variety of environments studied (tropical and Mediterranean, terrestrial and marine) and experimental equipment and facilities (experimental evolution, Ecotron, observatories, etc.).

Many researchers and teams are closely involved in international programmes and networks such as the DIVERSITAS programme*, the European Platform for Biodiversity Research Strategy* and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*.

This scientific community, which is very integrated in French national networks, has close links with the *Fondation pour la Recherche en Biodiversité**.

Montpellier hosts the second largest museum collection in France, including herbaria and other collections (paleontological, entomological, etc.), and it thus has long historical ties with the *Muséum National d'Histoire Naturelle* in Paris. This wealth and diversity will be showcased in a *Dossier* on *'Collections and taxonomic resources'* which is currently being edited as a supplement to this *Dossier*.

The present *Dossier* illustrates biodiversity research that has been carried out by the scientific community of Montpellier and region with the aim of boosting international awareness on this unique French research platform. This research is described in four chapters, along with a final chapter describing research involving joint participation of citizens and scientists:

■ ***Origin and evolution of biodiversity:*** evolutionary science aims to describe and understand diversification mechanisms in living organisms. Research in this field combines descriptions, theories and experiments and, is supported by many technical platforms (gene sequencing, microtomography, cytogenomics, chemical ecology, etc.).

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▲ *A Cambodian market.*

■ ***Functional biodiversity:*** understanding ecosystem functioning may reveal links between biodiversity and services provided by ecosystems (pollination, biological productivity and resources, soil fertility, regulation of major biogeochemical cycles and climate, etc.). Large-scale experimental research is a unique feature in Montpellier, where major equipment and/or field setups (Ecotron, Medimeer, terrestrial research stations, etc.) are available. There is also substantial development of experimental evolutionary research requiring tailored infrastructures and technical expertise (secure insectarium, bacteriology, germplasm collection, mouse conservatory etc.).

■ ***Societies and biodiversity:*** biodiversity uses, awareness and public policies are three general social science research topics. This research is highly involved in the management of living resources and ecosystems supported by international observatories throughout the world (e.g. Ecoscope at the French *Centre de Recherches Halieutiques* in Sète for marine ecosystems) and in the Mediterranean region (e.g. the OSU OREME observatory which is more focused on long-term observations and database organization and management).

■ ***Modelling—biodiversity scenarios:*** there is increasing need for modelling to manage data acquisition—from high throughput genomics to environmental data, including remote-sensing data—and for the analyses and simulations required for experiments, as well as the development of evolution scenarios and biodiversity management. Computer tools and specialized platforms must be developed to facilitate this modelling, and anyone interested should have ready access to them.

■ ***Biodiversity—civic science:*** the aim is to demonstrate the status of biodiversity (gardens and natural parks) in our sociogeographic environment and the position of citizens in the research via civic science. Biodiversity is not only a field for scientists. Scientists need citizens to collect data and, in return, they should boost public awareness on the research that they carry out and the issues involved.

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*** For further information on:**
- the DIVERSITAS programme: **www.diversitas-international.org**
- the European Platform for Biodiversity Research Strategy: **www.epbrs.org**
- the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services: **www.ipbes.net**
- the *Fondation pour la Recherche en Biodiversité*: **www.fondationbiodiversite.fr**

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▲ *Ammonites on the Plaque de Digne.*
◀ Thiaridae *snail diversity.*
▶ Left to right:
Diversity of dates and beetles

Origin and evolution *of biodiversity*

S. Ivorra © UMR CBAE

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Biodiversity—from genes to landscapes—is the outcome of long-term evolutionary processes. The theory of evolution therefore provides the conceptual architecture for understanding its emergence and structuring. Ecological theories, in turn, establish a general framework for understanding the mechanisms underlying interactions between biodiversity units (e.g. individuals, populations) and the environment. It is essential, in a setting of unprecedented anthropogenic modifications, to analyze the evolution of biodiversity from both evolutionary and ecological standpoints. Activities associated with this theme could be roughly pooled into three groups—the description of biodiversity patterns, the analysis of forces affecting biodiversity, and interactions with humans and the changes they induce.

Describing biodiversity fulfils two requirements. The first concerns the classification of living organisms at all integration levels, from genomes to communities, especially from a systematics perspective. The second pertains to the characterisation of biodiversity distribution patterns to highlight forces that could underlie their evolution. The environment must be taken into account because of its tight interactions with biodiversity units.

Evolutionary and ecological theories provide a framework for interpreting this biodiversity and baseline forces that modify it. This includes natural selection and competition among species as deterministic forces, and genetic and ecological drift as stochastic forces. This component is covered by disciplines such as population genetics, quantitative genetics and community ecology.

Human activities have a more or less direct or indirect impact on all ecosystems, so they should be taken into account in all biodiversity research. A gradient of anthropization ranging from virtually soilless agrosystems to ecosystems in some relatively unaltered tropical rainforests could be considered. The scientific topics focus, for instance, on pesticide resistance, the introduction of new species or interactions between wild species and crops.

The research fields range from biology and ecology to humanities and social sciences (HSS) such as economy, geography and ethnobiology, while all of the research is interdisciplinary. Humans—driving forces in the evolution of biodiversity—can also be a focus of study, particularly through classical HSS. In addition, original evolutionary and human ecology studies are under way in Montpellier (France).

Describing biodiversity and gaining insight into its evolution has for several decades been a very active field of research, involving an increasing number of researchers and research units in Montpellier and region, thus ranking it as an international reference site. Research is carried out on living material and fossils and at scales ranging from genes to ecosystems. The range of spatiotemporal scales of investigation is therefore extremely broad, especially since all global ecosystems are taken into consideration, even though Mediterranean and tropical ecosystems are the main focus of research. Studies encompass the full spectrum of living organisms (bacteria, unicellular and multicellular eukaryotes, including plants, fungi and animals), and these organisms may or not be manipulated by humans (e.g. crops). A noteworthy feature of this research is its multidisciplinary and integrative aspect, involving traditional biological fields of ecological and evolutionary sciences (e.g. palaeontology, population genetics, ecophysiology, etc.), as well as mathematical sciences, bioinformatics, chemistry and HSS. This research strikes a balance between academic and targeted approaches, and between theoretical and empirical aspects. The latter may involve monitoring or experimentation, while there has been recent development in experimental ecological and evolutionary approaches. The high number and extent of long-term field programmes, some of which have been under way for almost 40 years, is a noteworthy feature.

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