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Editorial

An Integrated Approach to the Biology of Biodiversity

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Much of the focus on biodiversity science to date has emphasized ecology, systematics, conservation, and to a lesser degree, evolution. There is good reason for this: those elements of biology provide both basic and applied information in direct and crucial ways. However, several other areas of biology, e. g., morphology, development, physiology, endocrinology, immunology, genetics, and biochemistry--are not often recognized as "key players" in the analysis of biodiversity, but they have much to offer in both theory and empiricism. Each of these arenas has made contributions to our understanding of what biodiversity is how its components work--individually and together--, and what causes change and what resists change. I emphasize three points: first, nearly every component of biological science has a major role to play in the analysis and understanding of biodiversity and in the assessment of its importance to human society; secondly, that a synthesis and integration of several approaches to research in biodiversity science will provide greater understanding than uni-directional avenues, and, thirdly, that education in these several spheres now regarded as separate domains of biology will allow our non-scientist colleagues, that is, the public, to have a realistic basis for assessing the significance of biodiversity to their lives.

I believe that an integrative approach to issues in biodiversity will yield better defined information and applications than will that of single disciplines, in many instances. Further, a comparative perspective often will yield results that transcend those from single-taxon studies. What, then, is comparative biology as practised today? For many workers, it is simply the comparison of aspects of morphology or physiology or whatever in more than one species. For others, it is working on any non-human species. For others of us, though, the comparative method imposes a rigorous approach to deductive science. The comparative method is a means of assessing similarities and differences; similarities can be either the product of being closely related, or of being unrelated, and finding different pathways to the same end (convergent evolution--wings of bats and butterflies). Therefore, comparative biology, done in a phylogenetic context--that is, the comparison of related taxa in particular lineages of plants or animals or microorganisms-- gives us an understanding of the nature and often the direction of change, and even its environmental correlates; that is, evolution.

I will illustrate the potential contributions of several fields of biology, and of comparative and integrative perspectives, to understanding the nature and maintenance of biodiversity with three examples. They all reflect the study of species of amphibians and reptiles, and I have chosen them for several reasons: they represent some of the kinds of contributions possible from biologists, they are broadly comparative, they deal with research on animals mostly the field--their natural environments--and in the laboratory (something we can't do with human populations, at least in the same way), each deals with situations in which populations of the animals are in decline, apparently because of human-induced factors. This research is often considered esoteric, but it has significant relevance to the human condition.

Example 1: developmental biology, coupled with ecology and life history biology, can tell us about changes in biodiversity. The habits of *Ambystoma macrodactylum*, the California Long-toed Salamander, an endangered species, were being assessed to find and perhaps protect its breeding sites. In two breeding ponds, the populations of both the salamanders, and a frog, *Hyla regilla*, had a high proportion of individuals with limb abnormalities, including extra legs. These ponds had been part of a mark-and-recapture study of the endangered salamanders for 12 years, with no occurrence of individuals with extra limbs from 1974 until 1986. The scientific literature has reported amphibians with extra limbs for centuries, usually odd individuals. When they are single individuals, they are usually dismissed as isolated developmental anomalies. When they occur in greater numbers in populations, though, it is assumed that a biological perturbation of some sort has spread through the population. People have suggested genetic mutation, viruses, parasites, injury, temperature, radiation, and chemical pollution as possible causal agents. However, until recently, neither the cause nor the developmental mechanism for the extra legs had been identified. Because of their endangered status, nearly all of the specimens of the salamanders captured were examined for anomalies (and other data taken) and then returned to their ponds. 39% of late larvae, 38.5% of juveniles, and 4.6% of adults had such anomalies (N = 5011), and of both limbs. 280 of the abundant frogs were collected; 72% had hind limb anomalies, and fully 50% had extra limbs, ranging from one extra on one side to 9 on the left side and 3 on the right. There were very few front limb anomalies. Water samples from the ponds were tested, and heavy metals, chlorinated hydrocarbons, and petroleum hydrocarbons were not present.

Puzzled, the ecologist investigating the biology of the salamanders enlisted the aid of a developmental biologist who studies limb development. The latter immediately recognized that all the specimens of both species were infected with metacercarial cysts of a trematode flatworm parasite, and that there were concentrations of cysts in the tissues at the bases of the hind limbs, but also elsewhere. The cysts were in close association with the extra limbs in both the frogs and the salamanders. But the question remained whether the cysts caused the extra limbs, or whether they were just infections of already anomalous animals. Based on knowledge of vertebrate limb development, a straightforward experiment on laboratory populations of the frog *Xenopus* and the salamander *Ambystoma mexicanum*, the axolotl (both being "model organisms" in the study of limb development) was developed: resin beads the size of the metacercarial cysts were implanted in the developing limb buds of larvae of the two species; extra limb structures occurred in 20% of his experimental animals. Sessions

and Ruth (1990) concluded that mechanical disruption of tissue interactions in the developing limb bud resulted in duplication of limb structures; this is consistent with what is known of the pattern of extension and bifurcation as limb cartilages develop, and the fact that tissue damage during development causes duplication events in a number of animals, including vertebrates and insects.

This case is an example of a morphological and developmental perturbation caused by an environmental factor--parasitic flatworms. What does this mean in terms of biodiversity, and perhaps the endangered status of the salamander? First, ecologically, the life history of the particular flatworm involves the adult flatworm parasitizing a primary host, in this case, garter snakes. The eggs of the flatworm are shed into pond water in the feces of the snake; the first larval stage that hatches from the eggs parasitizes pond snails, the primary intermediate host. After several stages of development in the snails, free-swimming larvae find a secondary intermediate host--amphibians that visit the ponds to breed. Most of the multilegged animals did not survive long after their metamorphosis, so extra limbs certainly appear to be disadvantageous to survival. The authors of the study suggest that this may give a selective advantage to the parasitic flatworms by rendering the secondary intermediate host ready prey to garter snakes, which then act as the primary host for the next generation of flatworms. But one major set of questions remains unanswered: was this a localized occurrence of a population explosion of the flatworms that affected the amphibians breeding in the pond, and if so, why did it occur? Or were the amphibians particularly susceptible to infection by the parasites for some other reason? This is being investigated. The key point is that developmental biology and morphology gave the answer as to the mechanism by which the extra legs occurred in the populations, so we can better understand the ecological implications of the situation.

Example 2: a comparative approach, and the need for synthesis of several fields of biology, is illustrated by an analysis of another question of the decline of numbers and species of amphibians. Andrew Blaustein, a behavioral ecologist, and his colleagues, recognize that there likely is not a single cause for the declines, especially since they occur in widely scattered habitats and some species are severely affected, but some not at all. However, the world-wide nature of declines of amphibians suggests that global agents might be involved in some cases, such as increased UV-B radiation as a consequence of depletion of stratospheric ozone. Blaustein, *et al.* (1994) addressed the hypothesis that different species have different sensitivities to UV radiation, so they are affected differently by its increase. They chose two parameters to measure the effects of UV radiation: species-specific differences in the abilities of eggs to repair UV radiation damage to their DNA, and then the differential hatching success of embryos exposed to solar radiation at natural breeding sites. As their measure of ability to repair UV radiation damage, they assessed, using the techniques of comparative biochemistry, levels of the repair enzyme photolyase, which repairs dimers that are UV photoproducts that impede gene expression by blocking transcription. They compared ten species of frogs (four species, four families) and salamanders (six species, four families) (nine native to the Cascade Mountains of Oregon and the introduced bullfrogs) that have different UV exposures, different UV resistance or repair, and different levels of decline or persistence. They examined three components of the UV-sensitivity hypothesis: 1) differences among species with respect to UV-repair activities in eggs and differential hatching success of embryos exposed to solar radiation; 2)

correlation of these differences with exposure of the eggs to sunlight in nature; 3) higher repair activity for species not in decline compared to those in decline, where exposures to sunlight are similar. They found that activity of photolyase was reproducibly characteristic for each species examined, but varied more than 80-fold among the species. For the nine species of amphibians native to Oregon, it is clear that salamanders have the least photolyase, frogs have more, and one frog, *Hyla regilla*, the Pacific Tree Frog (the abundant animal of the last example that is doing well despite its propensity for many legs) has the highest activity of photolyase, and is not in decline apparently anywhere. The Western toad (*Bufo boreas*) and the Cascades Frog (*Rana cascadae*) have significantly lower photolyase levels (1/6 and 1/3, respectively), and are in decline in many localities. Levels of photolyase correlated with exposure of eggs to sunlight. Blaustein did both field and laboratory experiments, using a block design that controlled for a number of variables. Pacific Tree Frog eggs, which have the highest photolyase activity, also appeared in the field experiments (unfiltered sunlight, sunlight filtered to remove shorter wavelengths but not UV-B, and UV-B blocked) to be highly resistant to UV-B containing sunlight. However, hatching success of the Western Toad and the Cascades Frog was significantly higher under sunlight lacking UV-B. The key point is that the two frog species with the lowest levels of photolyase activity, the Cascades Frog and the Western Toad, have undergone drastic population declines, during a period of apparently increased incidence of UV-B. Repair activity appears to be a significant determinant of survival under natural sunlight.

What do these carefully designed field and laboratory experiments and observations tell us? First, a diversity of species are affected by apparent environmental changes that seem to be global. Secondly, comparative biochemistry, coupled with experimental ecology and developmental biology, give information about the mechanisms and responses of organisms to environmental factors. Thirdly, the predictive power of the data can be assessed. DNA repair enzymes are ubiquitous among living organisms. Enzyme levels appear to be correlated with degree of exposure to DNA-damaging factors to some degree and in some species, but as levels of the toxic factors increase at a rate that cannot be compensated physiologically or evolutionarily, the decline of species is predicted. This must be considered in terms of effects on species and their relationships in ecosystems, including the human species.

Example three: comparative endocrinology, developmental morphology, and ecology give new insight into modification of reproductive biology. It has long been known that several compounds, such as DDT and DDE, and DES, are significant disrupters of reproductive activity in a great diversity of animals, including humans. However, it has not been known for most of the compounds exactly how they function to disrupt reproduction. A major spill of agricultural DDT, DDE and other compounds in a lake in Florida gave an opportunity to investigate the effects of these compounds on the reproductive biology of alligators, because the biology of alligators from the lake where the spill took place could be compared to those from a lake that was not contaminated.

Environmental contaminants have been shown to mimic naturally occurring hormones, particularly estrogens, and DDT is thought to be one of these. Guillette, *et al.* (1994) tested the hypothesis that an estrogenic contaminant caused the current failure of recruitment of alligators in the contaminated lake. Blood samples to measure circulating hormone levels and developmental morphology were assessed, with the

following results: at six months of age, female alligators from the contaminated lake had plasma estradiol- 17B concentrations two times greater than that in normal females from the control lake; the females from the contaminated lake had abnormal ovarian morphology; male juvenile alligators from the contaminated lake had depressed plasma testosterone levels, similar to normal females but more than three times lower than normal males; and the males with low testosterone had poorly organised testes and abnormally small penises. Guillette, *et al.*, found that the testes and ovaries of juveniles that entered the contaminated lake were permanently modified before the eggs hatched, in other words because of maternal exposure, so that normal steroidogenesis is not possible and normal sexual maturation and reproduction is unlikely. Such chemicals are sequestered in lipids in the bodies of many animals; lipids are mobilized to yolk up eggs. This study has only begun to address what could be a serious, widespread threat to wildlife populations, and one that might affect the health of other species, including humans, living adjacent to sites of contamination. A footnote to this study is that threats to human reproductive capacity are real. Data are accumulating for human populations throughout the world that sperm counts and seminal volume have declined dramatically in the last fifty years, so that they are roughly half what they used to be (Carlsen, *et al.*, 1992)--and we don't know why--but integrative studies of amphibians and reptiles give important insights.

I do not wish to be an alarmist. I have cited just a few examples for which there are solid and objective data. They only open a window to parts of problems, but they do have import to our understanding of the biology of a diversity of species, and have major relevance to our own biology. These examples illustrate 1) that all parts of biology have much to offer to our understanding of the nature and maintenance of biodiversity through an increased appreciation of the nature of environmental effects; 2) that a synthetic approach to issues in biodiversity science will give clearer answers to many kinds of questions--a meshing of ecology, systematics, evolution, physiology, development, etc., contributes to a greater whole than the sum of its parts; and 3) it is important that such synthetic approaches to science, to the training of scientists, and to the development of broadly based programs of research be developed now. Change in biodiversity is occurring as we speak; what does it mean? A goal of the *Diversitas* program is to build the bridges among scientists and their research approaches by promoting broadly-based research in many countries, especially developing nations. The work of Declining Amphibian Populations Task Force, organized internationally and sponsored by the Species Survival Commission of the International Union for the Conservation of Nature but dependent on the efforts of volunteer scientists, has nearly 100 Working Groups in many regions and many nations, focusing on documenting the biological basis of the decline of amphibians and their maintenance in areas in which they are not in decline. This provision of basic and applied research gives new understanding to the nature of biodiversity, and contributes to our appreciation of the relevance of our own society on this planet. I urge policy makers, and especially the public, to recognize the contributions of this kind of research to our own destiny. We are all teachers; our mission is vast, and time is short.

A version of these comments was presented in a symposium on "Biodiversity Science and Policy Issues: Meeting Societal Needs" at the meeting of the American Association for the Advancement of Science in February, 1995.

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The Current Status of the *Diversitas* Program and its Implementation

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Introduction

Diversitas is a program that deals with the science of biodiversity, adopted by the International Union of Biological Sciences at its 24th General Assembly in Amsterdam in 1991 as its theme for the next decade. As a number of other international organizations were developing an interest in issues concerning biodiversity, the program was developed in collaboration with UNESCO and SCOPE. The history of the program to July, 1994, was summarized in detail by di Castri and Younès (1994), and this report includes information therein as necessary to understand the current status and projected goals of the program.

Diversitas is designed to consider better understanding of the structure, function, and change in biodiversity world-wide, and its conservation and management. Four scientific themes were adopted at an IUBS-SCOPE meeting in 1989: 1-Ecosystem Function of Biodiversity; 2-Origins, Maintenance and Loss of Biodiversity; 3-Inventorying and Monitoring of Biodiversity; 4-Conservation of Wild Relatives of Cultivated Plants and Domesticated Animals (now called Conservation of Genetic Diversity of Wild Species). More recently, cross-cutting emphases on marine biodiversity, microorganismal biodiversity, and the human dimension of biodiversity have been implemented. Primary concerns include a hierarchical approach to questions in biodiversity, the need for a global biodiversity network, and the taxonomic basis of understanding biodiversity.

The Convention on Biodiversity in 1992 provided added impetus for the elaboration of international cooperation in developing approaches to the science of biodiversity. Several IUBS documents that describe all or part of *Diversitas* have been prepared for the Convention meeting and the "meeting of the parties" in 1994. The United Nations Environment Programme (UNEP) developed a Global Biodiversity Assessment (GBA) with the support of the Global Environmental Facility (GEF). The GBA program is very similar to that of *Diversitas*, and involves many of the same individuals, but it cannot be said that the programs have worked cooperatively--rather, they have had independent directions, despite the initial expectation that there would be joint development of scientific goals.

The four original themes of *Diversitas* are described by di Castri and Younès (1994). The membership of the overall *Diversitas* Coordinating Committee at the inception of the program, and the memberships of the steering committees of the themes are listed in that reference. The progress of the program and its themes was reviewed by the Scientific Program Committee for the IUBS General Assembly, held in Paris in September 1994.

Several recommendations for changes were made, including some suggested by di Castri and Younes (1994). The Ecosystem Function theme is the only one that has achieved significant progress; this is described below. Two other themes were implemented only shortly before the General Assembly; this is discussed in di Castri and Younes (1994), and below. Major recommendations included the establishment of a new Coordinating Committee, and a new steering committee for the Monitoring and Inventorying theme. The recent suggestion that a broader partnership might better facilitate the goals and programs of *Diversitas* (special meeting called by ICSU, February, 1995) has provided further examination of the role that *Diversitas* should play in the implementation of scientific efforts to understand and maintain the world's biodiversity. The success of the Forum on "Biodiversity, Science and Development. Towards a New Partnership" held at the IUBS General Assembly illustrated the need for global communication. It also indicated that more strategic mechanisms for communication and interaction are needed.

This report presents summarizes the current status of *Diversitas* scientific programs as described by the nominal heads of the groups designing the efforts, and presents their plans for further progress. These summaries are followed by a series of suggestions presented to assist in directing the discussion of implementation of the *Diversitas* program.

Ecosystem Function of Biodiversity

The accomplishments of this component of *Diversitas* were a provision of the partnership of SCOPE in the program. Work focused on a synthesis of knowledge about two questions:

> 1) Does biodiversity "count" in system processes (e. g., nutrient retention, decomposition, etc.), including atmospheric feedbacks, over short and long-term time spans, and in face of global change (climate change, land use change, invasions)?
>
> 2) How is system stability and resistance affected by species diversity and how will global change affect these relationships?

The goals of the program were met by initiating a background symposium in Bayreuth, Germany, in October, 1991, followed by nine full-scale workshops that included 20 or more international participants and six expert group fast-track workshops that included fewer than 10 international participants, each focused on a particular biome (e. g., tropical forests, tundra, coral reefs, lakes and rivers, etc.). A final synthesis workshop was held in February, 1994, to review the biome results and a crosscut of processes and functions of biomes. The Biodiversity and Ecosystem Function part of the *Diversitas* program was incorporated into UNEP's Global Biodiversity Assessment, and also had been broadened to include more biomes than initially planned by its steering committee. Three edited volumes and two reports in journals have been published, four volumes are in press, and four more are in final preparation.

Plans for continuation of the program emphasize two new activities to be brought to the SCOPE General Assembly for action in June, 1995. One follows directly from the initial program and was requested by scientists at the final workshop and by IGBP, the other is new; both would involve a three-year synthesis of information and evaluation of research needs.

1) Ecosystem Function of Biodiversity -- Soils and Sediments.

A conclusion of the synthesis meeting was that central ecosystem processes in the soil and sediments are particularly sensitive to shifts in biotic composition. Certain key processes are evidently driven by only a few taxonomic groups. These biotic shifts are being driven by land and water use change, and in the future, potentially by climate change. Further, knowledge of the organisms of the soil and sediments, and of their relationships to key ecosystem processes, is rather limited. It is proposed that the SCOPE Ecosystem Function of Biodiversity Program (presumably in partnership with *Diversitas*) focus its next efforts on the organism and processes of soils and the sediments of fresh water and salt water systems. This study would bring together scientists who normally work separately to work on common issues. A series of key questions for soils and sediments has been identified, emphasizing the need for information at the species level and on the ways that individual taxa affect functional processes.

2) A Global Strategy on Invasive Species.

Attention to the magnitude and impact of biological invasions has increased in recent years. Both ecological and economic consequences of invasives may be considerable. Thus there is a need to address the invasives issue in a holistic context that could lead to a set of international guidelines on the import, and protection from, potentially invasive species. We have developed a global strategy for addressing biodiversity, and we now need to do the same for invasive species. Five issues are specified for exploration, including an update of scientific understanding of invasives, assessment of the reduction of biodiversity incurred through the impact of invasives, analysis of economic and environmental costs and benefits of control of invasives, assessment of education programs for the public and of legal instruments for controlling invasives internationally. The program would seek partners from national and international organizations and many disciplines.

Origins, Maintenance and Loss of Biodiversity

The general framework for this theme of the *Diversitas* program was conceived at a Harvard Forest Workshop on "From genes to ecosystems: a research agenda for biodiversity", convened by Otto Solbrig and published in 1991. A follow-up workshop, in collaboration with UNEP's Global Biodiversity Assessment, was held in Paris in November, 1993, and convened by the chairman of the theme's steering committee. Six topics were addressed, including origins of biodiversity, paleorecords, population- and ecosystem-level dynamics of biodiversity, the ecology and genetics of extinctions, and the role of humans in shaping biodiversity. A series of specific workshops is planned.

The chair of the theme steering committee, Robert Barbault, suggests that a series of research topics be emphasized during the next phase of *Diversitas*. In addition to having sound scientific bases (e. g., concentrating on factors that both determine and change biodiversity, defining hypotheses to be tested and the experimental protocols and/or models appropriate to do so), such research programs should be designed so that they ensure coupling with similar programs (e. g., IGBP, SBI), and that they promote the organization of international networks that focus research around common projects. The six research topics include:

1) Dynamics of biological diversity, emphasizing underlying evolutionary mechanisms that generate and maintain intra- and interspecific biological diversity. Research would concentrate on combining population genetics and ecological studies, and integrate levels of organization from the individual to the ecosystem.

2) Community dynamics, life-history strategies, organization of biodiversity and rare species. This program would emphasize the genetics and ecology of rare species, and their role in biodiversity. Both conservation and use perspectives will be considered.

3) Responses of populations and communities to global change (climate, land-use, land-cover). Projects developed should be interlocked with those of IGBP.

4) Microbial diversity in the functioning of ecosystems. Several research questions are posed, and they interface with those of the cross-cutting microbial diversity theme (see below).

5) Biodiversity and functioning of marine ecosystems. Possible activities recommended within the theme of origin, maintenance, and loss of biodiversity that emphasize marine systems interface as well with the cross-cutting marine biodiversity theme (see below).

6) Biodiversity in an environmental and developmental context. Research in this arena would emphasize sustainable use of biodiversity, and the relationship of biodiversity preservation to the concept of sustainable development. Population growth and economic development have major impacts on biological diversity, and their influences must be better understood.

In summary, the *Diversitas* theme should emphasize several general scientific priorities as listed above, develop common research strategies and unified experimental approaches, and select specific sites for activity and build international research networks among them.

Inventorying and Monitoring of Biodiversity

Two workshops have been held to clarify the issues involved in monitoring and inventorying biodiversity (e. g., key biomes and groups, and appropriate methods and scales for the work), the first in Paris in January, 1992, at UNESCO Headquarters in Paris, the second at La Selva Biological Station in Costa Rica in October, 1992. A

network approach that includes both intensive and extensive studies is advocated. The Steering Committee for the theme met in March, 1993, and decided that position statements should be developed regarding 1) taxonomy, 2) sampling, ecological concepts, and monitoring, and 3) networking.

The *Diversitas* Coordinating committee decided that the theme should be reformulated, and a new Steering Committee established. There are many reasons for the difficulty in developing the theme, chief among them the relative absence of coordination of the efforts of a number of nations and agencies.

Nigel Stork, a prospective chair of the theme as it reformulates, noted that IUBS and UNESCO were among the first organizations to recognize the importance of inventorying and monitoring, and that it was included as a theme during the organization of *Diversitas* in 1989. The Harvard Forest Workshop, alluded to above, had one of its four working groups consider monitoring and inventorying biodiversity from genes to ecosystems. Major obstacles were identified, such as the lack of a global register of described species, the lack of an international biosystematic network, how, what and where to sample, how to analyze the resulting data, etc. Following that meeting, an application to GEF was presented for funding of an outline program. The proposal was for the intensive inventorying of all species at a few sites, and the extensive inventorying of a selected range of taxa at several sites. The UNESCO Man and the Biosphere Reserve network was suggested as a possible core of sites. The GEF application was not funded, but many aspects of it were discussed at the La Selva meeting, and the "All Taxa Biodiversity Inventory" now being conducted by Daniel Janzen and his colleagues in Guanacaste, Costa Rica, is the first example of the successful application of the approach.

The role of *Diversitas* in monitoring and inventorying must be clearly elucidated. A number of initiatives are under way that might be brought together, such as:

1) Systematics Agenda 2000, which is fast becoming international after its development in the US and has many parts to its program;
2) Species 2000, which has as its goal the preparation of a global master species database;
3) Bionet International;
4) ATBIs of the Costa Rican sort;
5) European Science Foundations Systematic Biology Network;
6) the Smithsonian Institution/UNESCO MAB Network of Biodiversity Plots; and
7) the Smithsonian Institution/National Biological Service Manuals for Sampling of Biodiversity.

Stork notes that in the UNEP GBA, a Global Inventorying and Monitoring Programme (GIMP) is proposed as a coordinating mechanism, and that it parallel other global programs that deal with abiotic aspects of current concern. The *Diversitas* Coordinating Committee should establish a working group to consider the role of *Diversitas* in monitoring and inventorying, priorities for action, whether monitoring and inventorying needs are being adequately promoted (including

strengthening human resources and capacity building), and the way that *Diversitas* can work closely with the international and national agencies involved in the Biodiversity Convention. It is not unrealistic that an expanded *Diversitas* could implement the GIMP, and Stork outlines four priorities for such a program, involving establishment and coordination of 1) targets and timetables for systematics, including collection databasing, revisions, and field guides, 2) standards for sampling and analysis, 3) networks of areas for monitoring and inventorying at different levels of intensity, and 4) priorities for training at all levels.

The views of Gonzalo Halffter parallel those of Stork, but with some different emphases. He emphasizes that concrete results should be produced within three years, using *Diversitas* as the international coordinator and a forum for the discussion of ideas. *Diversitas* (within a limited budget) should propose paradigms and "promote the use of methodologies that allow results to be compared and global syntheses to be drawn from regional...or national studies..." Two strategies, one directed toward groups that are taxonomically well studied and well represented in collections to produce a complete "geopositioned" inventory and recommendations for the preservation of endangered species and for conservation measures, and one directed toward the majority of invertebrates and other organisms not well known, but the majority of biomass and significant indicators, are recommended. For the latter strategy, *Diversitas* could prepare the selection of parameter groups in different ecosystems (coordinate with Ecosystem Function theme?), and then design a mechanism to pursue intensive and extensive studies simultaneously. A coordinator would be designated who would establish the largest group of collaborators possible. This would produce quantitative data to be produced in a short period of time, and facilitate more specific hypotheses about biodiversity change and preservation. Diversitas' role in organizing common guidelines and methodologies, so that comparable results are produced internationally, is emphasized. *Diversitas* could also play a major promotional and publicity role so that programs become well known internationally.

Conservation of Genetic Diversity of Wild Species

The theme was proposed at an IUBS-SCOPE workshop on Ecosystem Function of Biodiversity in 1989, but only in June, 1993, was the proposal to develop the theme approved by the *Diversitas* Coordinating Committee. Vernon Heywood (U.K.) was designated Chair, invited to develop a Steering Committee, a schedule of activities, and a list of prospective funding sources. The provisional Steering Committee includes L. de Boer (Netherlands), A. Demissie (Ethiopia), D. Hawksworth (U.K.), K. Hammond (FAO, Italy), E. Hernandez Bermejo (Spain), T. Hodgkin (IPGRI, Italy), L. Olivier (France), R. S. Rana (India), and D. Zohary (Israel). The committee held its first meeting in May, 1994, supported by funding from IUBS. The committee agreed to expand its membership to include representatives of several other areas, and modified its theme title to "Conservation of the genetic diversity of wild species, especially those used in human activities". They discussed their mandate, and determined that *Diversitas* should undertake the conceptual work on the conservation of germplasm of wild species that is necessary to support national programs that would undertake the actual conservation. Nine theme topics were proposed as activities (e. g., how to

explore and sample populations for the conservation of genetic diversity, the effectiveness of different techniques available for assessing genetic diversity, conservation of species vs. ecosystems, conservation as a dynamic intervention, etc.). The committee agreed that it is essential that the activities of the theme be coordinated with those of national genebanks, the IUCN SSC Captive Breeding Group, ISIS, Regional Zoo Association, and other groups involved in similar activities.

Considerable attention has been paid to conserving samples of the genetic diversity of cultivated plants and domesticated animals, but less to genetic resources of wild species, such as those of forests, and marine species and microorganisms are particularly neglected. Several national, regional, and international (e. g., FAO and IPGRI) institutions have assumed responsibility for the conservation of germplasm of domesticated species. However, there is no principal focus for conservation of the genetic resources of wild species. Though interest in such conservation is increasing, and some organizations are engaged in specific activities, coordination of efforts seems imperative. The Steering Committee has proposed that the Council of Europe hold a joint workshop on germplasm conservation with their Specialist Group on Wild Relatives, and it is proposed that the group be affiliated with *Diversitas* (they have agreed to this). The committee will prepare a report on the theme for a special issue of Biology International, including several papers.

The chair has approached UNEP about submission of an application through them for major GEF funding. UNEP wishes to see a full application, following their review of the project concept. The chair is now seeking UNEP project development funds so that the Steering Committee can meet to develop the proposal. Approaches to the European Union and to other aid agencies also are being planned.

Marine Biodiversity

Following the 1991 General Assembly at which the *Diversitas* program was adopted, it was recognized that certain areas of concern would benefit from the establishment of "cross- cutting" themes, e. g., marine biodiversity, microorganismal biodiversity, and the human dimension of biodiversity. Some of the activities of the Ecosystem Function theme, and potentially others, contribute to the cross-cutting themes. In particular, marine biodiversity was explored by several of the biome discussion groups in the Ecosystem Function program, and in addition a series of meetings has produced a special publication of Biology International that deals with the establishment of a "Marine Laboratory Networks for the Study of the Biodiversity, Function and Management of Marine Ecosystems". It remains that understanding of biodiversity and its relationship to oceanic processes is rudimentary, and only a small fraction of marine organisms have even been described. Diversity estimates are not yet possible. Many other aspects of marine biodiversity are virtually unknown, and this is especially alarming because oceanic systems are changing rapidly as a consequence of human impact.

The marine biodiversity "theme" is an integrated program for the study of biodiversity and ecosystem function. Each of the main themes of *Diversitas* will be addressed. The international network of marine research stations and research sites would support

research proposed. Marine laboratories throughout the world have long been concerned about biodiversity, and have collections and other data of importance of biodiversity research. Their common scientific culture facilitates cooperation in regional studies. Several networks are well under way. The primary goal of the *Diversitas* marine program is to capitalize on the facilities and support of marine stations for promoting interchange of data, collaborative research programs, courses and workshops, and exchange of scientists between laboratories. Another goal is to make marine station facilities more accessible to universities, museums, and inland research laboratories. The research program emphasizes a regional approach, so that coastal marine biodiversity and ecosystem function are studied simultaneously. The full range of regional systems would be investigated (e. g., estuaries and lagoons, rocky shores, coral reefs, deep sea, open ocean, etc.). The integrated research program would have a number of specific goals, both scientific (e. g., provision of better measures of temporal and spatial patterns of marine biodiversity, testing hypotheses of the origin and maintenance of biodiversity) and applied (e. g., a scientific basis for the implementation of conservation measures and the protection and sustainable use of the coastal oceans). Grassle states that the program will need to 1) rejuvenate marine systematics, 2) develop physical/biological models of processes that maintain diversity, and 3) improve the theoretical bases for studying marine communities.

Microorganismal Biodiversity

In collaboration with the International Union of Microbiological Societies (IUMS), a "cross-cutting" theme to consider the biodiversity of microorganisms has been established. Because of the limited understanding of the function of microorganisms in ecosystem processes, their value as a genetic resource, and even the identity of the taxa, a coordinated program that examines microorganisms will contribute to and derive from each of the four main themes of the *Diversitas* program. Several IUBS-IUMS activities have already taken place: a joint meeting in September, 1991, in Amsterdam on Biodiversity Amongst Microorganisms and its Relevance (proceedings published in Biodiversity Conservation in1992); an ad hoc working group on microorganismal diversity in Barcelona in September, 1992, followed by a workshop at the 7th International Congress on Culture Collections in Beijing in October, 1992; a workshop on the "Needs and Specifications for a Biodiversity Information Network" held at Campinas, Brasil, in July, 1992, and made available through electronic networks, which elicited 200 accesses and 30 sets of contributions to the discussions; a workshop on Microorganisms and the Maintenance of Biodiversity, co-sponsored by the European Community, in August, 1993, at Egham, U.K., with the proceedings to be published by CAB International.

Several problem areas in dealing with microorganismal biodiversity have been identified. These include:

1) Culture Collections. A major re-thinking about funding and organization of culture collections must be done. Further, trained taxonomists must be available to deal with the collection, identification, and maintenance of the material.

2) Data Networking. A management system for the sharing and coordination must be established; various efforts are under way.

3) Quality Control. Comparison and harmonization of entries of strain properties in culture collection catalogues should be done, especially for those that are reference strains for industrial and medical purposes. A proposal for funding will be submitted to the European Community.

4) All Taxa Biodiversity Index. The purpose is to identify biosphere's diversity and discuss methods of rapid biodiversity assessment.

5) Structure and Function Programs. Because relatively little is known about the identity and function of prokaryotes and lower eukaryotes in the environment, and especially little of the safety aspect of release of genetically altered strains to natural populations, a diversity of programs to examine these questions in a diversity of ecosystems is appropriate. Several are already established by various nations and agencies, but there is apparently little coordination of them internationally.

6) Strain Differentiation. Strains of microbial species may differ significantly in their biochemical reactions and properties, of major interest to pharmaceutical and biotechnological industries. Programs to assess strain differentiation should be established, and might well attract funding from Biotechnology programs.

Human Dimensions of Biodiversity

The 1991 General Assembly of IUBS recognized that attention should be paid to the human interaction with and impact on ecosystems, and proposed that a workshop be held. At its meeting in April, 1994, the workshop participants considered possible contributions of human studies to the aim of the *Diversitas* program, and potential recommendations to IUBS for topics. The workshop, organized by G. Hauser and her colleagues, has resulted in publication of a special issue of Biology International that includes papers by an international set of researchers representing different fields of human sciences. The participants decided that several topics deserved further pursuit:

1) the scientific evaluation of traditional ecotechnologies;
2) the biodiversity-generating practices of human communities;
3) human intraspecific biological diversity, its nature, extent, mechanisms, intrinsic and extrinsic determinants; and
4) the historical time depth of the human impact on biodiversity.

Planning for several workshops to explore these topics is under way. Hauser is working with M. Monasterio to organize a conference in Merida, Venezuela, on the traditional ecotechnologies topic. One on "Biodiversity and Human Resource Use: Biocultural Modelling of Research Design" will be held in the Philippines in June, 1995; some funding has been obtained from the US National Science Foundation, and more is being sought. Two additional workshops are in the planning stages. A successful symposium on "Human intraspecific biological diversity" was held in Cambridge, U.K., in April, 1995, as a joint IUBS-ISHB effort. It explored the

contributions of molecular techniques and the effects of population size and structure, bottlenecks, and migration and isolation on diversification. The participants determined that they might make a useful contribution to a diversity of programs (e. g., HUGO, the Human Genome Project) with regard to enhancement of the efficiency of proposed investigations.

Following extensive consultation, Hauser proposes that an interim steering committee be established, to include herself as convenor, H. Garruto and M. Little (US), D. Roberts (UK), P. Ramakrishnan (India). The steering committee would have as its first tasks to explore funding for further activities on the human dimension of biodiversity, to seek out a cross-disciplinary set of researchers who could contribute to understanding of the human dimension, to learn of work in progress, and to propose new topics for research, and finally to identify locations of special significance. The steering committee would propose coordinated programs of field work for each topic developed, plan a sequence of conferences on each topic, and interact with relevant on-going programs.

General Considerations

UNESCO has a strong interest in promoting "an exciting, focused" *Diversitas*, in cooperation with ICSU (IUBS, SCOPE, and perhaps other participants), and views itself as the intergovernmental political forum for making links among scientific, socio-economic, and cultural dimensions of biodiversity, and ICSU as the venue for uniting the world's scientific communities to explore ideas and methods of comparative study of biological diversity. Several parameters should help to shape the next phase of *Diversitas* (e. g., an emphasis on quality of research, articulated program design, a combination of both scientific and practical goals in a selective, rather than comprehensive, framework, mechanisms for substantive review, monitoring, and evaluation of proposed projects, an attempt to develop common experience and understanding among specialists of several disciplines, working at a range of scales, etc.). Two critical structural requirements are identified: 1) a small group of individual scientists who will commit time, enthusiasm, and their reputations to success of the program, and 2) a full-time program director and an associated secretariat.

Several UNESCO activities contribute to *Diversitas* at present (e.g, the Regional Networks of Biosphere Reserves and the establishment of a World Network and the People and Plants program that provides support to ethnobotanists in developing countries to preserve indigenous ecological knowledge). UNESCO participants also recommend that *Diversitas* pay attention to the activities of such groups as the International Oceanographic Commission, with its biodiversity and taxonomic programs, and the Smithsonian Institution/Man and the Biosphere Biodiversity Program, which is developing standardized methodologies for analyzing biodiversity, and training courses to aid countries in building their infrastructure for maintaining biodiversity. These programs might well be incorporated into the *Diversitas* structure.

P. S. Ramakrishnan, currently Chair of the Interim Coordinating Committee for *Diversitas*, requests that particular attention be paid to the linkage of biodiversity conservation to sustainable livelihood/development issues in developing countries

(where much of the world's biodiversity is located). He urges that taxonomic work and monitoring hot spots should be emphasized (and, by inference, that more taxonomists should be trained). Linking biodiversity with rehabilitation ecology is equally important in developing countries, where population pressures are high and resource depletion rapid.

Conclusions and Points for Discussion

It is clear that good ideas abound, and that talented and committed individuals share a concern that *Diversitas* be made a successful and energetic vehicle for international coordination and facilitation of research, in the broadest sense, in biological diversity. At the same time, it is equally clear that international coordination, program development, and appropriate funding are difficult to achieve, especially as nations, regions, and agencies develop programs dealing with various aspects of biodiversity science. *Diversitas* must develop a clear vision of its unique role, and establish a scientific and intellectual coherence for its overall plan. It is in a special position to provide a leadership role in international activities for several reasons: the successful history of IUBS in such ventures, the equally successful role of ICSU in supporting its Unions and implementing interdisciplinary activity, and the established partnerships with both ICSU components and UNESCO, and now the realistic possibility of enlisting a greater diversity of partners, including both agencies and scientific programs. But how should *Diversitas* go about establishing itself as an international coordinating body for biodiversity study? The program is not as well known as it deserves to be; it needs both additional successful results from its programs and more publicity for them. It must establish greater credibility, again through successful work (some already done, and much more in progress) and the commitment of individual participants, as well as programs and agencies. Our colleagues have presented several ideas; these are summarized above, and common themes run through them, such as the need for coordination of programs, methodologies, and communication.

Points for Discussion

1. The nature of the "partnership" for an expanded *Diversitas*. The evolution of *Diversitas* will provide new opportunity, and would provide highly beneficial and reciprocal interactions. However, mechanisms for the expansion should be considered. What agencies and programs are appropriate? How will they be selected and incorporated? How will their roles be identified? How will they interact with the *Diversitas* leadership? How will their needs be identified? How will they be represented? How will their activities be reviewed in the *Diversitas* context?

2. A Secretariat for *Diversitas*. Certain benefits to the program are obvious. Still, we must consider how the Secretariat would interact with the *Diversitas* partners. What would be the funding source for the Secretariat? Where would it be located? What would the level (kinds of skills) and number of its staff be? What would its role(s) be (seeking funding, facilitating workshops and conferences, coordinating training programs, coordinating databases, communication, etc.)?

3. What should the role of *Diversitas* be? Several different themes, thrusts, attitudes, kinds of programs, etc., are indicated by the current participants in *Diversitas*, as described above. What is the clear, coherent, and unique role that *Diversitas* can play as an international structure? THIS NEEDS CAREFUL CONSIDERATION. What kinds of programs are reasonable under the aegis of *Diversitas*? How should they be implemented? How can more participation be engendered, among partners, nations, agencies, local scientists, and when feasible, the people of the regions involved? Should Diversitas' goal be to assist the reorganizing Convention on Biodiversity Secretariat, perhaps as the research arm coordinator?

4. What is the role of IUBS in the expanded *Diversitas*? The program was generated by IUBS, and the Union has welcomed the participation of its partners. At the same time, *Diversitas* is not its only activity, though Biodiversity is its designated theme and *Diversitas* its program for the decade. Should IUBS and *Diversitas* take on the role of coordinating the several biological unions in ICSU (most spun off of IUBS as it was initially designed), at least in terms of biodiversity activities, with the cooperation of the unions and the other partners? This could be a non-threatening, facilitating role, if done well. *Diversitas* has much potential to contribute to leadership and communication for international activities dealing with the science of biodiversity. This is a critical time for the program as it seeks to implement its agenda. Your comments and suggestions about implementation of the *Diversitas* program, and recommendations for new activities and additional participation are welcome. Please address your concerns and comments to the Executive Director, IUBS, 51 Boulevard Montmorency, 75016 Paris, France.

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Monitoring of Biodiversity in Freshwater Fish Populations

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Introduction

There are many water bodies within the European and Asian parts of Russia. The total area of lakes, water reservoirs, ponds and canals is about 28 M ha (Table 1); the rivers stretch for over 340 000 km.

Table 1 : Total area of lakes, water reservoirs, ponds and canals in Russia (in M ha).

Lakes		Water reservoirs	Ponds & canals
large, with area over10 000 ha each	average & small		
(8.85)	(11.15)	(8.0)	(0.4)

During the last 50 years, most of the freshwater bodies in the territory of Russia and of the present day adjacent states (former republics of the USSR) have experienced serious anthropogenic impacts of different natures:

1. Most large rivers (the Volga, Don, Kuban', Dnieper, Dnester, Neman, West Dvina, Yenisei, etc.) were dammed by hydropower stations, yielding scores of large water reservoirs.

2. There has been a steady growth of eutrophication in freshwater bodies resulting in water-blooming of lakes and water reservoirs, and augmented levels of bacterial pollution.

3. We observe the ever accelerating rates of contamination in freshwater ecosystems, polluted with heavy metals, pesticides, phenols, radionuclides and other toxicants.

4. Freshwater becoming diluted by waste waters (often thermal) from industrial enterprises, thermal and nuclear power stations; such dilution has brought about considerable changes in the thermal, gas and mineral regimes of numerous water bodies: it has disturbed the processes of production and self-purification.

5. As a result of careless amelioration of river pollution and of the formation of water reservoirs in the upper reaches of rivers, ecosystems of many small rivers were disturbed or have disappeared, particularly in the European part of Russia.

6. The population set-up and functioning of fish communities are being heavily, and in most cases, adversely, affected by irrational commercial fisheries.

7. Fish communities in freshwater bodies and populations of individual fish species are adversely affected by careless acclimatization. Natural water bodies receive man-made hybrids and genetically impoverished production of fishery plants.

This presentation considers problems of anthropogenic dynamics and monitoring of biodiversity in freshwater fish communities and populations by using the examples of some rivers, lakes and water reservoirs chiefly from the European Russia and also from a number of water bodies in Eastern Europe which formerly comprised the USSR.

In general, the above anthropogenic impacts lead to structural and functional disturbances in freshwater ecosystems, communities and population systems of individual species of aquatic animals, to impoverishment and degradation of aquatic biota, to reduction of trophic links, to decreases in fodder resources available to aquatic animals, to decline in predatory activities and in competition between animals, to drastic impoverishment in genetic resources. Finally, biodiversity at different levels of animal organization becomes drastically reduced.

Reduction of species diversity of fishes in freshwater bodies

When water reservoirs are formed on the rivers of the European part of the former USSR, the stenobiotic, mainly reophylic species of fishes and their transient forms disappear (Table 2).

Limnophylic fish species, however, have a considerable advantage during such process. For instance, within the forty years of observations (Bodareu, 1993) the composition of the fish population of the Dniester lost 7 fish species and received a number of new ones, chiefly penetrated to natural water bodies from fishery farms. Similar phenomena were observed in the lower reaches of the Volga (Kizina, 1990). *Vimba vimba* is found to be gradually disappearing in the basins of the regulated rivers of the Baltic Sea (the Neman and West Dvina).

Due to biogenic eutrophication and pollution, individual species of salmons and white-fishes (especially the large white-fishes) are disappearing from lakes and rivers in the northern European part of Russia (Table 2). The northern fish communities are rather poor in terms of their species, therefore the loss of such salmon fishes as *Salvelinus alpinus* or *Salmo trutta* drastically affects the functioning of fish communities, because these predatory species occupy the highest links in the trophic chain.

As to the southern rivers of Russia, it is often found that in addition to the pollution of their lower reaches with plant-eating species from the Far East, their upstreams recieve fishes of marine origin, i.e., *Clupenolla cultriventris* in the middle stream of the Volga.

It is necessary to pay special attention to the problem of decreasing biodiversity ofwhite-fishes in the freshwater northern ecosystems of Russia. Already today we have found a real threat to the existence of white-fish populations in the lakes of the Kola Peninsula, in the Ladoga Lake, in the Vozha Lake, and in the basins of the Pechora, Ob', Vilyui rivers (Bolotova, Zuyanova, 1990; Andriyasheva *et al.*, 1994).

Table 2 : Changes in the fish species composition in some freshwater bodies of Eastern Europe (after Bodareu, 1993; Kuzina, 1990; Reshetnikov, Amundsen, 1994).

Fish Species	Freshwater Basin		
	The Dniester river	The Volga river	Some lakes of Northern Russia
Extinct & Endangered Fish spp.	*Huso huso* *Acipenser gueldenstaedti* *A. stellatus* *Umbra krameri* *Leuciscus borysthenicus* *Abramis ballerus* *Anguilla anguilla*	*Stenodus leucichthys* *Rutilus frisii kutum* *Barbus brachycephalus* *Vimba vimba persa* *Lota lota* *Stizostedion volgensis*	*Lampetra planeri* *Lampetra fluviatilis* *Salmo salar* *Salmo trutta* *Salvelinus alpinus* *Thymallus thymallus* *Coregonus lavaretus* (big forms)
New Fish Species	*Hypophthalmichthus* *Aristichthys nobilis* *Ctenopharyngodon idella* *Mylopharyngodon piceus* *Ictiobus cyprinellus* *Ictiobus bubalis* *Ictalurus punctatus* *Huso huso x Acipenser ruthenus*	*Ctenopharyngodon molitrix idella* *Aristichthys nobilis* *Hypophthalmichthys molitrix* *Clupeonella cultriventris caspia*	*Coregonus peled* (west from Petchora-river) *Cyprinus carpio* *Salmo gairdneri*

The decrease of predatory fishes in fish communities and the simplification of trophic structure

According to the observations made during the last 50 years both in the regulated rivers and lakes of Russia and in the Baltic region, the share of predatory fishes in fish communities has been decreasing (Table 3).

Table 3 : Biomasses of ichthyophages and of other species of fishes as correlated in some freshwater ecosystems (after Bodareu, 1993; Il'yina, 1966; Kizina, 1990).

Indices	Water bodies and years of observations									
	Lower reaches of the Dniester				The Ivan'kov water reservoir, the Upper Volga		The Volga delta			
	1950	1960	1970	At present	1950	1960	1965-1975		1975-1990	
Correlation of biomass: ichthyophages/ peaceful fishes	1:2	1:3	1:4	1:8	1:5	1:10	1:5		1:7	
Shannon index (H')	3,2	3,0	2,7	2,3	2,3	1,8	3,0		2,7	

The reasons behind such a decrease is in the worsened conditions of fish reproduction and in the pollution of water bodies. When water bodies become polluted with heavy metals and pesticides over many years, the highest concentrations of these pollutants are discovered in the organism of predatory fishes which occupy the terminal links in the trophic chain.

During the first five to ten years after the water reservoirs are built, increasing numbers of such limnophilic eurybiontic fishes as *Abramis brama, Rutilus rutilus, Carassius carassius, Alburnus alburnus*, are found together with growing numbers of predatory fish species such as *Esox lucius, Perca fluviatilis*. Then the numbers of the two latter species begin declining. However, of the generally diminishing numbers of predatory fishes, such species as *Lucioperca lucioperca* may suddenly have an outburst in numbers at the further stages of development in such water reservoirs.

In many lakes of the Kola Peninsula, north-eastern part of the European part of Russia, and in water bodies of the Northern Asian part of Russia, a great decline was observed in the numbers of *Salvelinus alpinus, Thymallus thymallus, Salmo trutta*, as well as other salmon fishes, mainly due to the pollutions occuring within the last 20-30 years.

The increased share of predatory fishes in more diversified animal communities was mentioned by several authors (Pianka, 1966; Thorp and Cothran, 1984; Alimov, 1992).

Decline of intraspecies and intra-population diversity of fishes

In some water bodies of the middle and northern parts of European Russia, several intra-species ecological forms of the same species, dwell simultaneously. For instance, scientists know well that in very many lakes and water bodies, two forms of *Perca*

fluviatilis co-exist, namely the coastal and the abyssal ones, which differ from each other by their morphology and ecology. In many water bodies there are two forms of *Rutilus rutilus*, the plant-eating species and the mollusc-eating one. In almost all medium-size and large lakes of North-East Russia and of the Kola Peninsula one can find several forms of *Corogonus lavaretus*, which differ in their nutrition, morphology and dimensions living simultaneously together.

Almost everywhere, due to eutrophication and chemical contamination, we can see a decrease in both the numbers and the biomass of large forms of the above species, up to their complete extinction, as is the case with large white-fishes extinct from some large lakes. This is true for the Ladoga Lake and the lakes of the Kola Peninsula (Bolotova, Zuyanova, 1990). The disturbed homeostasis and genetic losses in the populations of *Rutilus rutilus* caused by the eutrophication of the Pleshcheyev Lake has drastically increased the domination of the plant eating form of this species. Smaller forms, with short cycles of reproduction have the considerable advantage everywhere and result in decreasing the biodiversity of fish communities.

Such a decrease in the biodiversity of freshwater fishes is also due to the destruction of population systems of individual fish species which completely disappear or become impoverished because of water pollution and of irrational commercial fishery industry of some sub-populations (Altukhov, 1989). Unfortunately, the scales of this phenomena are difficult to assess. Thirty to forty years ago, before the mass-scale annihilation of small rivers and the regulation of large ones, there were technical and methodological reasons precluding any thorough structural studies of individual fish species, even if they were quite numerous. Today, we can only analyze their present status, and are not able to assess the scale of lost genetic pool. We can only furnish studies estimates. For instance, the decrease in the indices of the genetic polymorphism in the populations of salmons and white-fishes in Russian water bodies was assessed only an extent of 40-60% (Andriyasheva *et al.*, 1994).

Biodiversity decrease due to the impoverished structure of population in some individual fish species.

In eutrophicated and toxicated freshwater bodies, many fish populations (particularly stenobiontic ones), undergo negative changes which have a certain sequence with the ever-growing gradient of toxicants, leading to an early elimination of the population. For example, in many eutrophicated and polluted lakes of the northern European part of Russia under study during the last twenty years were the population changes in salmons and white-fishes. Such investigations were effected by the Laboratory of Lower Vertebrate Ecology, attached to the Severtsev Institute, together with our Armenian and Astrakhan colleagues. The studies were carried out on the Sevan Lake and in the Volga delta, involving some carp species (Bolotova, Zuyanova, 1990; Reshetnikov, Amundsen, 1994; Kizina, 1990; Gabrieliya, Shatunovskii, 1984).

The changes were found to be similar. First established are the reduction in the life span of fishes, reduction in the age groups participating in the reproduction of the population, and acceleration of sexual maturity. Then we see the growing variability of growth rate within some populations, the impoverished links between the absolute fecundity and

biomass of fishes. As the pollution of water bodies increases, the greater number of fishes reveal disturbances in their gametogenesis and in their spawning cycle, their population fertility decreases and their death rate augments, while the intensity of nutrition goes down. Even when there is no one-time elimination of a fish population, which prove to be the most sensitive to pollution, we can see that in calamitous situations the growing rates of death and the disturbed gametogenesis and reproduction during several generation, can lead to the complete elimination of such a population from a water body. Even if at some lower stage the reproduction of such population may become stabilized, then, due to drastically decreasing numbers of its age groups which often take different trophic niches, there is still a decline in this population's biodiversity. The ability to use fodder resources are diminished and its inter-species competition deteriorated. And if populations of several species living in one water body undergo similar changes, it means that biodiversity is getting reduced even more drastically.

In this way, our analysis of the few examples (and their number can be essentially enlarged) shows that complex anthropogenic effects upon water bodies decreases the biodiversity of fish communities and of populations of some fish species. In addition to actual elimination of stenobiotic species and of transient fishes, the diminished role of predatory fishes leads to the impoverishment of the plankton trophic chain and of the structure of trophic relations of fishes; eurybiontic fishes of low value develop in gigantic numbers. The structure of population systems becomes simplified, both in species with growing numbers and those with declining numbers; the genetic diversity is declining- and the age structure of populations is getting worse; small rivers disappear and old water bodies undergo silting. In general, the river runoff becomes transformed due to water reservoirs, reducing the number of fish biotopes and the range of food resources available to fishes, as well as the genetic polymorphism even in the few remaining sub populations. Voluntary or inadvertent introduction of new species, such as plant-eating fishes in the lower reaches of Russian rivers, or the introduction of representatives of *Clupeonella* to the middle reaches of the Volga, does not much alter the general picture, because in some cases these species make use of vacant food resources of zoo- and phytoplankton, while in other places they adversely compete with young or adult individuals of aboriginal species.

Monitoring of fish communities and fish populations

Unfortunately, despite the many years of observations of fish communities and populations in some lakes and river systems of Russia, their practical complex monitoring including the genetic one, has not yet been effected. At present, in view of the greatly augmented processes of eutrophication and toxication of water bodies leading to the reduction of their biodiversity and the degradation of their biota, it is of vital importance today to initiate complex hydrobiological and ichthyological monitoring in this country, particularly the freashwater bodies of federal importance, such as the Baikal Lake, the Ladoga lake, the Onega Lake and others; in the basins of the Volga, Northern Dvina, Pechora, Ob', Yenisei, and Lena.

As we see it, a comprehensive ichthyological monitoring programme must include the following regular observations:

1. the numbers of species and ecological forms of fishes in a particular water body
2. the numbers and biomass of individual species
3. changes in the trophic structure
4. distribution of individual fish species by various biota
5. changes in the pattern and quantities of predatory fishes and in the competition between fishes
6. changes in ecological heterogeneity of a particular freshwater ecosystem (patchiness, biodiversity)
7. population changes in individual fish species (age structure, reproduction, death rate)
8. changes in the genetic structure of populations in individual fish species due to anthropogenic effects.

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Life Returns to the Empty Quarter

Re-introduction of Native Wildlife Species in Saudi Arabia

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According to customs, the princes and tribal chiefs in Saudi Arabia invite their fellow tribesmen and neighbours to celebrations following desert game hunts, where guests enjoy the delicacy of food and the intellectual enchantment of poetry. These gatherings represent a traditional practice in the desert social life aimed at providing fora to discuss common concerns and strengthening the social bonds within and between the tribes.

In keeping with this tradition, the large gathering invited by HRH Prince Saud Al Faisal on 28 March 1995 at 'Uruq Bani Ma'arid, in Rub'al Khali was however, quite unusual. Instead of admiring the various trophies of a successful game hunt, guests were invited to enjoy the scene of watching herds of antelopes and gazelles being released back to the wild. Indeed, more than 350 dignitaries and top ranking officials from both the Kingdom and neighbouring countries were invited to witness the re-integration of the breeding herds of both the Arabian Oryx and Arabian sand gazelle, under the patronage of HRH Prince Sultan Ibn Abdulaziz, Second Deputy Prime Minister, Minister of Defense and Aviation and Chairman of the National Commission for Wildlife Conservation and Development (NCWCD).

Re-introduction of Arabian Oryx and Gazelle into the Wild

This ceremony, inaugurating the return of the Kingdom's flagship species to the wild, marked an important event in the history of wildlife conservation in Saudi Arabia. The NCWCD, aiming to restore and enhance the Kingdom's biological diversity, launched the national programme of captive breeding and re-introduction of native wildlife species, using a two-pronged approach of protected areas development and species introduction. The 'Uruq Bani Ma'arid Reserve, where the release of 23 Arabian oryx and 102 sand gazelles took place, is an example of successfully coupling the two approaches.

The Arabian oryx (*Oryx oryx leucoryx*) is the largest indigenous antelope, weighing up to 100 kg, and feeds only on grasses. It can live for months without drinking, deriving its moisture from dew by grazing at night and digging for juicy roots. The oryx were plentiful over most of present day Saudi Arabia. However, with the advent of four-wheel drive vehicles and the encroachment of its grazing ground by man's domestic flocks, even the last stronghold in the Rub'al Khali was no safe haven for its survival. Indeed, this species was last observed there in the late 1970's.

The Arabian sand gazelle "*reem*" (*Gazella subgutturosa marica*) is an inhabitant of the sands and bordering gravel plains. The reem is a stocky, pale gazelle which congregates in large herds of 50 to 100 individuals. It runs very fast with its neck outstretched and when disturbed packs closely together for protection. The refuge in the great sand desert have probably saved reem from extinction, as elsewhere its numbers have been greatly diminished due to mechanised hunting.

The newly-created protected area of 'Uruq Bani Ma'arid is situated on the western edge of the Rub'a-Khali desert. Also known as "The Empty Quarter", the great desert of the Arabian peninsula is the combined size of France, Belgium and Holland, with temperature ranging from 45°C to over 60°C in the summer. 'Uruq Bani Ma'arid represents the western fringe of this vast desert, stretching from the southern extreme of the Tuwayq escarpment. It is characterised with a variety of landscapes including wadis, plains, and low mountains, and some of the largest sand dunes on earth, separated by longitudinal inter-dunal corridors. The Reserve is spread over an area of 12000 km^2 which is demarcated into three distinctive zones: a 2400 km^2 area of strict nature reserve where grazing, hunting or any other form of resource use is prohibited; a resource use area of 5200 km^2 where controlled grazing is permitted and a 4400 km^2 zone of hunting area.

Despite its arid profile, 'Uruq Bani Ma'arid holds striking biodiversity. The variety of physiognomic features has led to the existence of a diversity of plant species which differ in distribution, richness and density according to the dominant physical features. Distinct plant associations are found in the wadis, sand dunes and plateaus. There are four species of acacias found in the reserve, and *Panicum turgidum*, *Lasiurus spp.* and *Penisetum divisum* form the dominant grasses. The wadis have relatively high biomass and the reserve's flora includes over fifty species. Arabian oryx were present in the area but are now extinct, and reem gazelle are still seen, though very rarely. Tuwayq escarpment contains a small population of Nubian ibex and other mammals such as wolf, sand fox, wild cat and sand cat. Avifauna include sand partridge, rock dove, desert lark, and Egyptian vulture and shrikes. The endangered houbara bustard and the rare Lappet-faced vulture are also seen in the reserve. Ostrich were also present in the area in the past. The chief occupation of the local people is grazing. Several traditional grazing areas (*dirah*) have been incorporated into the reserve, and nomadic herders move around the area with their livestock (camels, sheep and goats) according to the changes in habitat conditions.

With the restoration of the original flora and fauna, enhanced by the re-introduction of Arabian oryx and reem gazelle, all combined with a system of varying resource use and partnership with local population for conservation, the 'Uruq Bani Ma'arid reserve provides a remarkable model of a sand desert ecosystem. Furthermore, this reserve is part of a network of eleven protected areas, both terrestrial and marine, in Saudi Arabia. The NCWCD has also initiated similar captive breeding programmes of endangered native species for re-introduction into these protected areas.

Captive Breeding Programme

Saudi Arabia adopted a national strategy for captive breeding of endangered species and developed programmes at two research centres: the National Wildlife Research Centre (NWRC) established in 1986 near Taif, and the King Khaled Wildlife Research Centre (KKWRC) in Thumamah in 1987. The facilities at both centres use the most modern veterinary and animal husbandry equipment and expertise. It was decided that the captive breeding of the four native gazelle species would be the responsibility of KKWRC. At NWRC, attention would be focused on other mammal species, mainly Arabian oryx and on the avifauna, especially the houbara bustard. Other species to be

included were the Nubian ibex, guinea fowl, ostrich and the two endemic Arabian partridges, Philby's rock partridge and the Arabian red-legged partridge.

The oryx, for example came from both private collections in Bahrain, Qatar and the USA, as well as caught in the wild. This mixture provided a broad genetic base and made the animals ideal for a captive breeding programme. The NCWCD's Arabian oryx captive breeding programme has been so successful that from a founder herd of 37, the national herd now numbers over 400.

The four gazelle species and sub-species being bred at KKWRC are the sand gazelle or reem; *"Idmi"* or mountain gazelle *Gazella gazella*; *G. g. erlangeri;* and *G. dorcas saudiya* the Saudi gazelle or *"Afri"*. At this Centre ongoing research includes investigation of gazelle ecophysiology and reproductive biology, and sophisticated diagnostic facilities. The total national herd now numbers over 800. Mountain gazelles have been successfully re-introduced into the Ibex Reserve at Hawtah Bani Tamim.

Another significant achievement of the NCWCD has been the captive breeding programme of the houbara bustard. The breeding population in the wild was considered to be less than fifty birds. Through a process of artificial insemination, a fertility level of over 80% is being maintained, and during the 1993 season more than 300 chicks were successfully raised. Most of these birds will be released into protected areas.

Future Prospects and Conclusions

The release operation of oryx and reem in 'Uruq Bani Ma'arid' represents an important large scale experiment of ecological restoration. Consequently, the NCWCD has planned an intensive monitoring programme. The monitoring programme has been developed in such a way, that not only the spatial distribution of the released game is recorded. It also offers the opportunity to gather other vital biological information necessary for the development of a viable management programme for the Protected Area. The follow-up actions will take place as follows:

- Rangers will ensure the security of 'Uruq Bani Ma'arid' protected area by preventing the poaching of oryx and reem, and preventing grazing by camels, sheep and goats in the reserve's core area.

- Trained wildlife biologists, as well as the NCWCD ranger staff will closely watch the re-introduced species to monitor their well-being in the wild. Some ecological and behavioural studies on the released animals will also be undertaken.

- Biological monitoring (including aerial monitoring) of re-introduced animals will be carried out and all biological data recorded. Oryx and reem are fitted with a radio-collar which will enable scientists to track the animals to see how successfully they adapt in the wild. Several other releases are planned for the near future to establish a viable population of re-introduced animals in the reserve.

- A public awareness campaign will be conducted and directed primarily at the local people in order to obtain their support for the re-establishment of these two species.

In the few months since the release the monitoring programme has been successfully executed. Aerial patrols take place two days a week, and based on their survey, the biologists report weekly to the head office. The rangers, however, report the position of the oryx and gazelle and interesting information on a daily basis. The animals have established themselves into social groupings and have settled in home ranges. Until now they have stayed relatively close to the point where they were released. The oryx are in an area to the north and the gazelle mostly to the south east. The reem have already dropped their first calves in 'Uruq Bani Ma'arid and the first generation to born there number 28.

This ambitious programme provides lessons of far-reaching significance for ecological restoration efforts world-wide. For example, two essential conditions have already been fulfilled: strong political leadership and cultural acceptance/public partnership. Without the leadership and strong support of the highest political authorities, in particular HRH Prince Sultan Ibn Abdulaziz and HRH Prince Saud Al Faisal, this programme could never been realised! To facilitate the cultural acceptance and public's cooperation and understanding of the concern for wildlife conservation, the NCWCD was inspired in selecting among the three possible different Arabic words relating to wildlife, the one, "*Hayat Fetriah*", which refers to purity, originality and non-sophisticated people's life in the desert, instead of "*Hayat Wahshiah*" or "*Barriah*", which would translate into "wildlife", or the French "*vie sauvage*". It is also hoped that involving the local population as guardians or liaison-officers in the reserve area will facilitate its protection and preservation.

DIVERSITAS in Western Pacific and Asia (DIWPA)

-An International Network-

by Hiroya Kawanabe and Eitaro Wada
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In drawing imaginary longitudinal belts from the Globe's north pole across the equator to the south pole, you will find deserts or at least grasslands in the middle of every such belt except one, which is situated in Western Pacific and Asia including the eastern end of Australia and New Zealand. This long green belt consists of boreal forests in Far East Russia, temperate forests distributed throughout the Chinese Continent and Japanese Archipelago, then tropical forests in the Indochinese Peninsula, the Philippines and Malasian Islands and New Guinea, and finally to cold temperate forests in south-eastern Australia and New Zealand.

Various important specific features of this belt are such that it contains the tallest tropical rainforests which reach over 70 m in height; and that these are areas which no glacier covered even in northern part in comparison to Europe and North America. For example, the Lake Baikal area had not been completely covered by ice during the last glacial period, which has resulted in higher biodiversity, including rich endemic species both plants and animals in terrestrial communities as a whole. In this belt, high biodiversity is also observed in aquatic ecosystems, both freshwater and marine.

International Network of DIVERSITAS in Western Pacific and Asia

The initiative for establishing *Diversitas* network in the Western Pacific and Asian region (DIWPA) has been made through the biodiversity project in Japan. The Centre for Ecological Research was established in April 1991 at Kyoto University, to promote fundamental research in various ecological topics and provide facilities for the collaborating ecologists from Japan as well from the rest of the world. The centre has been active in developing the scientific studies concerning global environmental issues and promoting collaboration with international programmes, such as IGBP and *Diversitas*.

Indeed, the "SymBiosphere: Ecological Complexity for Promoting Biodiversity" initiative was proposed by Kawanabe and colleagues, and adopted as a contribution to the *Diversitas* Programme in 1992 (Kawanabe,1995; Kawanabe *et al.*, 1993). This project was launched with some finanical support by Japan's Ministry of Education, Science and Culture.

In October, 1993 was established a National Committee of *Diversitas* in Japan, thanks to the strong support provided by Professor Emeritus Tokindo S. Okada, Vice-President of the IUBS. Also, in 1993, the international symposium "Ecological Perspective of Biodiversity", was held and partly dedicated to the International Prize of Biology, the laureate being Professor Edward O. Wilson. The syposium was held at Kyoto under the auspies of INTECOL, IUBS, SCOPE-Japan, IGBP-Japan, etc. More than 100 scientists from countries including Asia, Australia, Europe, Middle East and North America had discussed the theme of "Ecological Perspectives of Biodiversity", and as a result DIWPA was launched.

The Purpose and Region of DIWPA

The principal objective of the DIWPA Network is to promote collaborative studies and research activities, and the exchange of information in the Western Pacific and Asian region, in close cooperation with and following the guidelines of the *Diversitas* Programme. DIWPA focusses not only on inventory and monitoring aspects of biodiversity but also the other themes, aspects and domains relating to *Diversitas*.

Specific objectives of the DIWPA organization are as follows: (1) Establishment and networking of biodiversity field stations, (2) Promotion of international research projects, (3) Promotion of eco-tour and international citizen programme and (4) Activities for conservation of biodiversity.

The region of the DIWPA was originally proposed to cover wet climate terrestrial regions and surrounding oceanic regions such as East Asia, Southeast Asia, a part of South Asia, Micronesia, a part of Melanesia, a part of Australia and New Zealand. However, as a result of the second planning meeting held in September, 1994 in Paris, Polynesia and the remaining part of Melanesia were also included. The main reasons for this expansion were as follows: comparative studies of biodiversity should be done also among terrestrial, freshwater and estuarine marine ecosystems in/along continents, large continental islands and small oceanic islands; and fauna and flora of almost all the islands in the Pacific are originally derived from Asian and Australian Continents.

Current DIWPA International Research Projects

The following are examples of current activities and research projects included within the DIWPA Network:

- *Diversitas* in Lake Baikal Region (under the auspices of Baikal International Centre for Ecological Research, Russia);
- *Diversitas* around Japan and Okhotsk Seas (Russia, Korea and Japan);
- Narathiwat Coast Swamp Forest Research Project (Thailand);
- Long-term study of biodiversity in Sarawak (Malaysia);
- Forest tree diversity in west Kalimantan (Indonesia);
- Termite-symbiont system in Thailand and Australia; and
- A joint study project of African Great Lakes between Japan and African countries (Zaire, Zambia, Burundi, Rwanda, Tanzania and Malawi).

DIWPA Coordianting Activities 1995-96

In the early stages of the DIWPA Network, the main activities were to proceed with a series of consultations with the various national authorities and institutions in the region. The Chairman and Secretary General of the Network undertook a series of missions to Thailand, Singapore, Malaysia, Taiwan, Korea and China. Also, the DIPWA information brochure was published in December, 1994, and the first issue of the *DIWPA Newsletter* prepared and circulated in April 1995.
Research and training activities in 1995 include: (1) a contribution to a workshop on freshwater biodiversity to be held during the International Congress of Limnology, at

Sao Paolo, Brazil; (2) A one-month seminar and field work will take place in Miri, Sarawak in collaboration with the University of Malaysia Sarawak and the Sarawak Forest Development; (3) The DIWPA Workshop "Integration of Regional Projects Towards a New partnership" to be held in Singapore in collaboration with the National University of Singapore and Nanyang Technological University.

An international symposium on "Transect Studies on Global Change and Biodiversity" will be held on 6-8 May, 1996 in Beijing, China, with the co-sponsorship of DIWPA and the National Science Foundation of China (NSFC), the Chinese Academy of Sciences (CAS), the Chinese Committee for IGBP (CNC-IGBP), and the Biodiversity Committee of CAS.

For information concerning DIWPA activities please contact:

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The Ten Years of

INTERNATIONAL PRIZE FOR BIOLOGY

The International Prize for Biology, established in 1985 in commemoration of Emperor Showa's longtime research in biology and his sixty year reign, recently celebrated its tenth awarding ceremony on November 28, 1994. The Committee of the International Prize for Biology, presently chaired by Professor Yoshio Fujita, annually determines the awarding field of the Prize.

The recipients of the Prize from 1985 through 1994, together with the selected field of the year are as follows: (1985) E. J. H. Corner, Taxonomy/Systematic Biology; (1986) P. H. Raven, Systematic Biology /Taxonomy; (1987) J. B. Gurdon, Developmental Biology; (1988) M. Kimura, Population Biology; (1989) Sir Eric J. Denton, Marine Biology; (1990) M. Konishi, Behavioral Biology; (1991) M.Davidson Hatch, Functional Biology of Plants; (1992) K. Schmidt-Nielsen (Comparative Physiology and Biochemistry; (1993) E.O. Wilson, Ecology; and (1994) Ernst Mayr, Systematic Biology and Taxonomy.

The 1996 King Faisal International Prize for Science (Biology)

Invitation to Nominate

The General Secretariat of the King Faisal International Prize is pleased to invite universities, scientific societies, research centres and other learned circles throughout the world to nominate qualified candidates for the above Prize. Nominations will not be accepted from individuals or political parties.

Nominated work must:

a) be published and original;
b)represent a contribution of the highest distinction in the Prize category;
c) benefit mankind and advance scientific knowledge;
d) not have been awarded another international prize.

Nominations should include:

- an official letter of nomination detailing the scientific justification for the nomination;
- a typed CV detailing the nominee's academic background and experience, and listing all published works;
- six (6) copies of each nominated work (no nomination works will be returned);
- three (3) recent colour photos;
- full contact details.

The above information must be received by the King Faisal International Prize no later than 1 September 1995.

The decision of the Prize Selection Committee is final.

Winners will be announced in February 1996 and will receive the Prize at an official ceremony later in the year.
Each winner receives:

An abstract of his/her winning work, written in Diwani calligraphy and presented in a leather folder;
A commemorative 22-carat, 200-gram gold medallion;
SR 350000 (approximately US$ 93000).
Joint winners in any category share the cash prize.

Nominations should be sent by registered airmail to :

The General Secretariat
The King Faisal International Prize
P.O.Box 22476
Riyadh 11495
Saudi Arabia
Telephone 966 1 465 2255
Fax 966 1 465 8685

Biology International N° 31 (July 1995)

Frontiers in Plant Morphogenesis

Report of a Keystone Symposium 29 March-4 April, 1995
Hilton Head Island, South Caroline, U.S.A.

by Frédéric Berger
Marine Biological Association, Citadel Hill, Plymouth, PL 1 2PB, U.K.

The "Keystone Symposium on Molecular and Cell Biology" held 29 March-4 April, 1995, at Hilton Head Island, South Carolina, U.S.A, focused on "Frontiers in Plant Morphogenesis". The symposium addressed the following subjects: (1) cytoskeleton and development in plant cells; (2) genetic analysis of plant morphogenesis; (3) signal transduction in developmental processes in plants; (4) cell wall and development in plants; and (5) intercellular communications during plant development.

The following consists of an overview of the scientific reports and poster presentations during the meeting. The acts and abstracts of the various communications and posters were published in the *Journal of Cellular Biochemistry Supplement* 21A (1995).

Cytoskeleton and development in plant cells

Four major reports were given on the **nature and the roles of cytoskeleton** in plant development. Imaging cytoskeleton in plant cell using immunofluorescence for the microtubules and specific fluorescent dyes for actin has been achieved mainly on fixed cells. Imaging in living cells has been achieved using microinjection of antibodies against microtubules (Peter Hepler, University of Massachusetts). This allowed to study cytoskeleton dynamics during cell division. It was known that during interphase, microtubules are organised in an array perpendicular to the major elongation axis of the cell. During preprophase, a new structure is formed, the preprophase band which predicts the site of cell division where the phragmoplast forms. Microtubules further participate to the spindle. A new step was also described *in vivo*, the rearrangement of microtubules around the nucleus before spindle formation. Actin microfilaments are arranged around the preprophase band and this structure breaks down during phragmoplast formation.

The **dynamic of the microtubules** in the cortical array was assessed by photobleaching a small area and measure the time for recovery, i.e. formation of new microtubules. Interestingly, recovery time was very rapid, equivalent or faster than in animals which is surprising considering the relatively slow speed of cytoplasmic events in plant cells. Linking microtubule dynamics with the cell cycle begins to be possible as was shown by the results of coinjection of Maturation Promoting Factor and antitubulin. This prevents preprophase band formation and microtubules accumulate on the nuclear envelope.

Another approach linking cytoskeleton and development has been undertaken by Jan Traas (INRA, Versailles). Various mutants impaired for cell division plane alignment have been

isolated from *Arabidopsis* and *Nicotiana plumbaginifolia*, providing a great potential for analysing the factors controlling cell division plane alignment in plants as well as other aspects of cell division.

Two other major reports were obtained from algae, the unicellular *Acetabularia* shows some interesting features of cytoskeletal arrangement during morphogenesis (D. Menzel, Max Plank Institut). An unexpected role for actin has been revealed in the brown multicellular alga *Pelvetia* related to *Fucus* (D. Kropf, University of Utah). Although, *Fucus* zygotes polarise epigenetically according to the prevalent light vector, polarisation occurs in the dark as well.

Genetic analysis of plant morphogenesis

Genetic analysis of plant development has been initially focused on the patterning of the embryo (Mayer *et al.*, 1991). However, various mutants altered for the development of specific organs have been described and was illustrated by three main examples during the meeting. The framework has been established to study the determination of lateral root development in *Arabidopsis* (I. Sussex, Harvard University). Mutants for *Arabidopsis* root organisation were presented by P. Benfey (New York University). The mutants *shortroot*, *scarecrow* and *pinochio* are characterised by the absence of a specific cell layer. Cell expansion mutants such as *cobra* and *sabre* are under study and could be connected with other mutants obtained by Jan Traas (INRA, Versailles). Curious mutants affected for leaf organogenesis in maize were described by L.Smith (University of North Carolina). Cell division is abnormally oriented and the longitudinal arrangement of the epidermis is altered, as well as the inner structure of the leaf.

Arabidopsis mutants belonging to another class has been presented. These are affected for the function of the apical meristem in time or space. Transitions from juvenile to adult and reproductive development take place throughout plant life. Mutants impaired for the correct timing or the occurrence of these transition have been characterised (S. Poethig, University of Pennsylvania). Spatial function of the apical meristem is affected in another class of mutants defective in normal phylotaxy (J. Medford, Penn State University).

Very exciting presentations were made on *Arabidopsis* mutants for epidermal structures, such as root hairs, trichomes and stomata. An extensive analysis of stomata developmental mutants has been launched by F. Sachs (Ohio State University).

Epidermal cells in *Arabidopsis* leaves can develop into very peculiar structures, the trichomes which developmental origin has been thoroughly described by work done in D. Marks lab (University of Minnesota).

Cell wall and development in plants

The **plant extracellular matrix** constituted of polysaccharides and proteins is no longer considered as a simple skeleton surrounding the cell but rather like a dynamic structure in constant dialogue with the plant cell during its development. Several illustrations of this interactions were given. The role of the cell wall structure in regulating the cell expansion was

illustrated by the report from D. Cosgrove (Penn State University).

A genetic approach towards cell wall structure and biochemistry was presented by R. Williamson (Australian National University) with the isolation of temperature-sensitive mutants in *Arabidopsis* displaying swelling in root cells. This leads to the characterisation of mutations which impair the synthesis of cellulose and other wall polysaccharides.

A cell biology approach using *Chara* isolated cells showed the role of the cell wall in response to gravity (R. Wayne, Cornell University). Gravity response in *Chara* is characterised by an unequal speed of cytoplasmic streaming, higher along the main gravity vector. Calcium fluxes have been shown to be involved in the gravity response in *Chara* and these could be controlled by tension-sensitive channels. Such channels have been reported by A. Taylor (Marine Biological Association, Plymouth) in *Fucus* zygotes.

Other presentations were focused on the cell wall as a source of **molecular information**. In *Fucus* embryos, the cell wall has been shown to be a source of positional information and induction (F. Berger, Marine Biological Association). The nature of the molecules involved in the process remains unknown but an active extract with fate-switching properties has been isolated. In higher plants, the scene was set by M. Hahn (University of Georgia). Monoclonal antibodies have been generated against cell wall poly-saccharides, or against sugar moieties of proteins.

If most of the aspects related to this theme remain unknown, some light has been provided by various presentations on the role and functions of lipo-oligo-saccharides in *Rhizobium,* a bacteria involved in symbiotic interactions with legumes. Sharon Long (Stanford University) presented the first evidence for a calcium response to lipooligosaccharides. The application of the specific molecules at active concentrations triggers an oscillation of concentration of cytoplasmic calcium. It is also speculated that lipoligo-saccharides produced by the plant itself are involved in organogenesis (E. Kamst *et al.*, Leiden University).

Intercellular communication during plant development

Cell to cell communication in plant development is rather poorly documented. Even if the analysis of mutant phenotype for development has led to the possibility that regions in the embryos interact on a cell to cell basis, the cell wall has appeared as a boundary which would prevent major interaction from happening. However, it has been shown that calcium oscillations can propagate from cell to cell in stamen hairs (W. Boss, University of North Carolina). A thought-provoking report was given by W. Lucas (University of California) on the role of plasmo-desmata as a route for molecular trafficking of protein and their consequent potential involvement in developmental processes.

Bryozoology Today

A report of the10th International Bryozoology Association Conference held 30 January-3 February, 1995, Wellington, New Zealand

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The International Bryozoology Association (IBA), a Scientific Member of the International Union of Biological Sciences (IUBS), was founded at an inaugural meeting in Stockholm in 1965. The goal of the association was to promote continuing research and a wider knowledge of bryozoans (moss animals, lace corals). The Bryozoa, a predominantly marine phylum of colonial invertebrates, number around 5660 living species and an estimated 15 000 fossil species. IBA members comprise approximately equal numbers of biologists and palaeontologists.

The first official conference was held in Milan in 1968. Subsequent conferences have occurred every three years, traditionally in Europe or North America, the Wellington conference being the first in the southern hemisphere. The usual conference programme covers most aspects of the biology and palaeobiology of bryozoans. Average attendance at all meetings since 1968 has been 72. In addition to the conference, there are normally pre- and post-conference field trips, each lasting several days.

Wellington 1995

The Wellington conference was attended by 73 delegates from 19 countries and consisted of 4 days of meetings with 61 papers spread over 8 sessions: Marine Natural Products, Reproductive Ecology and Life History, Functional Morphology and Physiology, Biogeography, Phylogeny and Systematics, Colonial Morphologies and Substrata, and Bryozoa and Sediments.

The first session was designed to capitalize upon the recent interest in bryozoans as a source of biochemicals of potential medical significance. Accordingly, David Newman of the National Cancer Institute was invited to speak about brystatin, a chemical from the well-know marine-fouling bryozoan *Bugula neritina*. This species is now in aquaculture in California and the efficacy of bryostatin itself (effective against leukaemia and melanoma in mice) is in the phase-1 stage of human clinical trialling in the U.S. New Zealand research in **marine natural products** from Bryozoa was well represented at the meeting by 3 academic generations - M. Munro (University of Canterbury), M. Prinsep (Waikato University), and B. Morris. They reported several local species showing significant bioactivities.

Studies on **growth and reproduction** revealed the effects of environmental parameters on these functions, illustrating the wide range of strategies that occur in superficially similar bryozoan encrusters. It was demonstrated by J. Jackson (Smithsonian Institute, Panama) that self-fertilization at a low rate in

Stylopoma species enhances the occurrence of recessive homozygotes, of significance to speciation. Specialists of the small pseudocoelomate phylum Entoprocta (Kamptozoa) also attend IBA conferences, entoprocts having some morphological similarities to bryozoans. K. Wasson (University of California, Santa Cruz) demonstrated how studies of reproductive allocation within a colony can help in discriminating between species of the widespread entoproct genus *Barentsia.*

In the session on **Functional Morphology and Physiology**, J. Whitehead (University of Wales, Bangor) demonstrated that external spines in the algal-encrusting genus *Flustrellidra* are no mere decoration having neutral selective value but have definite functional significance related to water flow. Degree of spinosity is at least partly genetically controlled, larvae from short- and long-spined parents retaining the characteristics of parent colonies. In other work on algal-encrusting species, a Chilean team from Conçepción demonstrated that *Membranipora* zooids are able to absorb oxygen and other substances from the alga through their uncalcified basal walls, which may help explain the exceptionally rampant growth that *Membranipora* species exhibit on short-lived seasonal kelps.

The session on **Biogeography** (and palaeobiogeography) included papers relevant to New Zealand. H. Moyano (Conçepción University) documented genus- and species-level occurrences of recent bryozoans common to New Zealand and/or magellanic South America, Antarctica, and Australia. This paper demonstrated the urgent need for taxonomic studies on the Cenozoic bryofauna of these regions to explain the present-day distributions. A joint paper by P. Schäefer (Kiel University, Germany) and J. Grant-Mackie (University of Auckland) demonstrated the palaeobiogeographic significance of the New Zealand and New Caledonian bryofaunas. These are unusually rich in number and diversity in contrast to the relative scarcity of this phylum following the Permian mass extinction. Whatever the reason, Triassic Bryozoa flourished in the nutrient-rich non-tropical seas of the region.

Several papers in the **Phylogeny & Diversity** session considered the phylogenetic position of the Bryozoa as well as diversification and radiation within the phylum. C. Nielsen's (University of Copenhagen) cladistic studies unexpectedly support a relationship between the Brachiopoda and Phoronida but not with the Bryozoa. V. Gontar (Russian Academy of Sciences, St. Petersburg) argued from her studies of early colony development that the most speciose group of living Bryozoa (the cheilostomate suborder Ascophorina) is polyphyletic. June and Charles Ross's (Western Washington University) studies of Palaeozoic species diversity showed that bryozoan radiations and extinctions correlated with sea-level fluctuations, low diversity accompanying low sea levels. D. Gordon (NIWA) and E. Voigt (University of Hamburg, Germany) reported discovering the origin of skeletal morphologies that are correlated with, and possibly explain, the spectacular radiation of ascophorine Bryozoa from the Late Cretaceous onwards. And, in their studies of Cenozoic bryozoan diversity, A. Horowitz and J. Pachut (Indiana University) report that the Miocene has the largest absolute species diversity

prior to the present day, and that the percentage of Cenozoic species occurring in Recent seas is ~13%.

The **Systematics** session was noteworthy for the number of papers describing important Australian, Japanese, and British species or collections from the last century previously considered missing or lost. By the use of modern techniques including scanning electron microscopy, species otherwise poorly known only from the literature have been definitively characterized for the first time. These discoveries are particularly significant in light of the current interest in documenting global biodiversity. Other papers in the session added to a knowledge of bryozoan diversity by describing new species, genera, and families.

A range of papers in the **Colonial Morphologies and Substrata** session covered patterns of settlement on various substrata and/or subsequent colonial growth. D. Barnes (British Antarctic Survey), for example, reported on the role of Bryozoa in early community development on settlement panels in the waters of the Antarctic Peninsula - initially numerically abundant bryozoans (predominating below 25 m depth) could be competitively excluded by sponges and ascidians whereas rarer, competitively more successful, large bryozoans were rare on panels. L. Stevens (ex-University of Auckland, now Tasman District Council) reported on the remarkable diversity (58 species) of bryozoans fouling drift plastic debris in New Zealand waters. *A priori*, this was not expected and in fact bryozoans predominate over other organisms. Surprisingly, these bryozoans include new records (including a rare Queensland species not reported since its description in 1891) and new species. Some other papers in this session reported palaeoecological aspects of settlement and growth.

The last session, **Bryozoans and Sediments**, documented the significant contribution of Bryozoa to sediments in some environments, including parts of the continental shelves and coastal lagoons of southern Australia (Y. Bone and S. Hageman, University of Adelaide) and New Zealand (A. Smith, University of Otago and C. Nelson, Waikato University). The independent studies of Smith, Bone, and Hageman further considered the taxonomy of Bryozoa in shelf sediments, i.e., the processes determining in what form different colonial morphologies persist in sediments and into the fossil record - of particular significance to palaeoenvironmental interpretation, the subject of other papers in this session.

The 10th IBA Conference was judged to be very successful, and the proceedings are now in the editing process. The Conference offered 3 excursions, one Pre-Conference field trip to the North Island, a Mid-Conference one day excursion, featuring Wellington and the Wairarapa, and the Post-Conference field trip to the South Island.

1st Announcement

International Symposium

Carbon and Nutrient Dynamics in Natural and Agricultural Tropical Ecosystems

Harare, Zimbabwe, 29 April - 4 May 1996

Research on carbon and nutrient dynamics in savanna ecosystems and in the agricultural systems derived from them has been conducted for nearly ten years at the University of Zimbabwe by a collaborative group of scientists with support from SAREC and other donors. A symposium sponsored by SAREC will be held to review current understanding of the major themes addressed by the research. Topics to be covered include soil carbon dynamics, quality of inputs, decomposition and mineralisation processes, carbon budgets, tree crop relationships, on-farm variation in soil carbon and nutrients, farmers' management of organic matter and farmers' perceptions of soil fertility. A proceedings will be published of peer-reviewed articles.

The symposium will have three sections: keynote presentations by invited international speakers; presentations of results by the scientists collaborating on the project; and offered papers and posters.

The registration fee is US$100 which will cover lunches, airport collection, local transport, documentation and a field trip to research sites. Hotel costs are approximately US$50 per night (bed and breakfast). A limited number of sponsored places at the symposium will be available to African Scientists.

A post-congress tour will be conducted to cover a diverse range of farming systems, national parks culminating with a visit to the Victoria Falls. The cost of a four-night tour will be approximately US$400 covering accommodation, food, vehicle transport, return flight from Victoria Falls to Harare and tour documentation. Persons wishing to attend and present a paper or poster should submit a one page abstract by 30 Sept., 1995, and papers selected for publication in the symposium volume will be required to be submitted in advance of the symposium to the organising committee for review by the end of 1995.

For information and registration please contact:

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IUBS Financial Statement for the Year 1994

STATEMENT 1: Balance sheet at December 31, 1994 (Expressed in US$)

ASSETS:		
Cash and Banks		
Crédit Lyonnais, Paris		
in US$	83 508	
in FF	81 891	
in US$ (Deposit Account)	100 000	
Merrill Lynch, New York(in US$)	501 731	
Other Receivables	112 143	
TOTAL ASSETS		**879 273**
LESS: LIABILITIES		
Sundry Creditors	(6485)	
EXCESS OF ASSETS OVER LIABILITIES		**872 788**
Represented by		
General fund	232 788	
Mandatory Reserve	640 000	

STATEMENT 2: Income and Expenditure for the year ended December 31, 1994 (Expressed in US$)

1. INCOME		
ICSU Subventions	39 900	
Special Subventions from International Organisations	168 298	
Contributions from National Members	324 428	
Sales of publications	2 920	
Interests and Dividends	15 425	
Other Income	9 046	
TOTAL INCOME		**560 017**
2. EXPENDITURE		
Business Meetings		
General Assembly, Executive Committee & Officers Meetings	35 238	
Publications	7 546	
Scientific Programmes and Activities		
Grants to IUBS Scientific Programmes	203 120	
Representations at scientific meetings	3 677	
Contribution to other organisations	7 052	
Scientific Activities of IUBS Scientific Members	4 000	
Secretariat		
Salaries	195 559	
Related charges		
General Office expenses	47 035	
Bank charges & Loss over Exchange	1 877	
Audit fees	4 475	
TOTAL EXPENDITURE		**523 086**
EXCESS OF INCOME OVER EXPENDITURE		**36 931**