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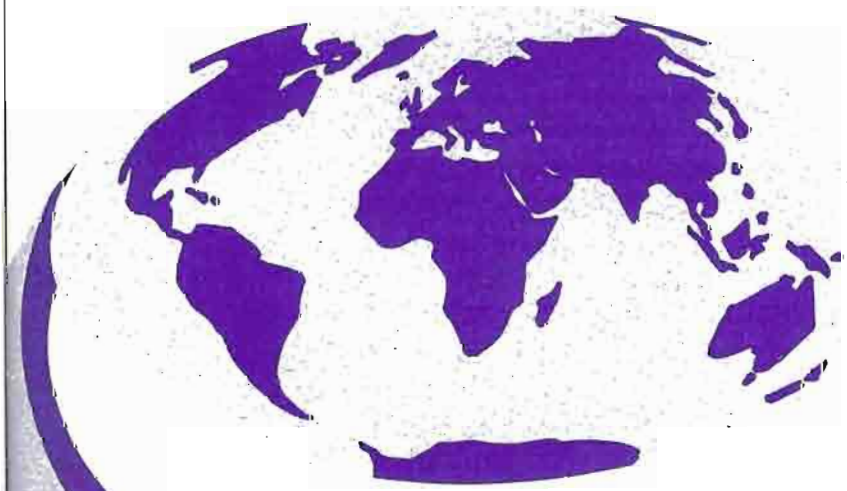

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Contents (No. 5, 1982)

1 **Editor's Note**

FEATURE ARTICLES

2 **Plant Genetic Conservation : Recalcitrant Seed and Tissue Culture, by L.A. Withers, The University of Nottingham, U.K.**

10 **A New Approach to Membership Dues' Schedules for Use by International Organizations, by J.R. Vallentyne, Department of Fisheries and Oceans, Burlington, Ontario, Canada.**

NEWS HIGHLIGHTS

13 **Applied Microbiology in Developing Countries : the MIRCEN Networks, by J.W.M. La Rivière, Chairman of UNEP/UNESCO/ICRO Panel on Microbiology, Delft, the Netherlands.**

15 **XIII International Botanical Congress, by Professor N. Grobbelaar, Chairman, IUBS Division on Botany and Mycology.**

18 **The First World Congress of IBRO.**

18 **The Second Arab Scientific Conference of Biological Sciences.**

IUBS NEWS

19 **The XXI IUBS General Assembly 22-27 August, 1982, Programme and Scientific Symposia.**

22 **Financial Statements of IUBS for 1981.**

23 **Publications Review.**

24 **Calendar of Meetings.**

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Editor's Note

If we review briefly the history of biological sciences in the XXth century, two main factors determined the creation and evolution of the International Union of Biological Sciences : the first being cooperation and integration, and the second, diversification.

In the post World War I period, the necessity for international cooperation in the field of scientific research, as well as the exchange of ideas, experiences and information became established. This lead to the creation of many international scientific unions such as IUBS, coordinated within the general framework of the International Research Council, which became the I.C.S.U. in 1931.

The tremendous development in biological research and the increasing diversification of major biological disciplines in such areas as botany, zoology, microbiology, cellular biology, physiology, biochemistry, biophysics, and the applied biology-related disciplines such as agricultural and medical sciences, precipitated the establishment of even more specific bio-unions.

In the meantime. the great need for integrated and multidisciplinary research resulted in the initiation of the International Biological Programme (IBP) in 1964, and the more recently established ICSU Committees such as SCOPE, COGENE, CASAFA and IBN.

In response to the demand for more specifically oriented and inter-disciplinary scientific activities, which was clearly expressed at the IUBS XX General Assembly in Helsinki, an Ad Hoc Committee of Review was established in order to examine and report upon the present structures, functions, responsabilities and activities of the Union.

The upcoming XXI General Assembly in Ottawa will have the important task of discussing the Review Committee Report and reaching decisions upon the future Scientific Programme of the IUBS whose objectives shall continue to be based on international cooperation, to meet the needs and priorities among the world's community of biologists, and to ensure their active participation in national, regional and international development.

Plant Genetic Conservation : Recalcitrant Seed and Tissue Culture*

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Seed storage techniques go a long way towards meeting requirements in the genetic conservation of many crop plants. However, a significant number of species cannot be conserved by routine methods of seed storage. They are unresponsive for one of two reasons. Either their seeds lose viability when subjected to standard storage conditions of low moisture content and low temperature (i.e. they are short-lived or "recalcitrant"), or, they are vegetatively propagated plants for which seed storage is genetically irrelevant, or even impossible due to sterility.

The urgent need for effort to be directed towards the solving of the consequent problems was embodied in a resolution put by Sir Otto Frankel to the XXth General Assembly of the IUBS. Sir Otto, who has for decades been instrumental in mobilizing world opinion to the need for the conservation of crop genetic resources, highlighted two particular areas where new technical developments could make an impact : i) in the storage of recalcitrant seeds; and ii) in the preservation of vegetative material in the form of cell, tissue, meristem or embryo cultures. The value of the first is self evident; the second could have potential applications in the conservation of both vegetatively propagated crops and those which produce recalcitrant seeds.

Sir Otto's resolution, presented in his capacity as a representative of the International Genetics Federation, called for the organization of a conference to examine problems and potential in the storage of the two types of specimen. The resolution was duly adopted and the conference took place in Reading, UK, in September 1980. It took the form of a workshop and was organized by a committee comprising Sir Otto Frankel (Canberra), Professor E.C. Cocking (Nottingham), Professor E.H. Roberts (Reading), Dr. J.T. Williams (IBPGR, Rome), and Dr. Lyndsey A. Withers (Nottingham).

It was felt that the workshop would be most fruitful if the number of participants was kept low, and if a proportion of the available time was given over to structured discussions. In view of the important international aspects of crop genetic resource conservation, every effort was made to ensure a wide geographical coverage in the enrollment of participants. In the event, 18 countries were represented. A number of the overseas participants were fortunate to receive financial assistance in the form of grants from the IGF and the IBPGR. The general organization of the workshop benefited from a donation from the IUBS.

In drawing up the scientific programme for the workshop, emphasis was placed upon drawing together points which the two main subject areas have in common. It was hoped that in this way there could be the maximum "cross fertilization" of ideas between participants from different specialties, perhaps leading to a new look at some of the problems. The programme fell into four sections : an introduction, reviews, discussions, and finally, conclusions and recommendations.

Setting the scene

The workshop was introduced by Professor N.W. Simmonds (Edinburgh), speaking under the title *"Genetic Conservation : the Context of the Workshop"*. Taking the recalcitrant seed producing and vegetatively propagated crops, five different approaches to their storage were offered for consideration : 1) in plantations; 2) as seeds, if appropriate, and if methods could be developed; 3) as shoot-tip cultures; 4) as cell or callus cultures; and 5) as shoot-tip, cell or callus cultures stored in the frozen state, by cryopreservation. The first approach is important as will be revealed in later discussion, but the remaining four approaches formed the main topics for treatment in the workshop.

Some of the relative advantages and disadvantages of the different approaches were pointed out and it became clear that although tissue culture may carry some very useful features such as facility in clearing quarantine and a far smaller unit size than some recalcitrant seeds, serious reservations could be expressed regarding the state of development of the relevant technology. There was, however, no doubt that considerable scope existed for useful discussion.

Four review papers then followed. Three of these examined practical aspects of germplasm storage, but first, attention was concentrated upon more fundamental aspects of the storage of biological material — the nature of freezing injury (and by implication, dehydration injury) and means of minimizing this injury. Dr. H.T. Meryman (Bethesda) presented a talk prepared by himself and his colleague Dr. R.J. Williams and entitled *"The Mechanisms of Freezing Injury and Natural Tolerance, and the Principles of Artificial Cryoprotection"*.

The freezing process in living tissues

Knowledge of the behaviour of a cell when subjected to cooling is central to an understanding of the cryopreservation process and the nature of freezing injury. During the early stages of slow cooling, ice nuclei form in the suspending medium and this creates an osmotic gradient leading to the flow of water from the cell. Provided that the rate of cooling is sufficiently slow, this process of dehydration will continue to relatively low temperatures and intracellular ice will not form unless initiated from outside the cell, penetrating by a surface lesion. In rapid freezing, ice nuclei are initiated both inside and outside the cell and dehydration does not take place. It is clear that gross ice formation will be

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* Report on a Workshop of the same name, held under the auspices of the IUBS, the International Genetics Federation and the International Board for Plant Genetic Resources, September 1980, University of Reading, UK. The Workshop Proceedings have been published jointly by IUBS and IBPGR Under the title *"Crop Genetic Resources — the Conservation of Difficult Material"* (eds. Lyndsey A. Withers & J.T. Williams; IUBS publication No. 42, 1982).

injurious, (note the loss of texture in frozen foods). Even if the ice forms so rapidly that the individual crystals are small, they can cause damage upon thawing by recrystallizing to a damaging size.

For many biological systems, it is observed that damage is in fact incurred at both rapid and slow rates, an optimum rate lying between the two extremes. The mechanism whereby slow freezing injurious has been the subject of much discussion. Early considerations were that increased solute concentration resulting from cellular dehydration was the critical factor. However, more recent studies have implicated a phenomenon related to the behaviour of the cell membrane during dehydration and cellular shrinkage.

The concept of membrane stress and associated damage can be explored using various model systems. For example, in cells of the giant alga *Nitella* it can be shown that cell volume reduction (as would be induced by slow cooling and extracellular freezing) is associated with the development of resistance to shrinkage. Non-hardened cells of Champlein wheat subjected to plasmolysis can be shrunken to the extent that when deplasmolysis is induced, the cell is unable to fill its original volume and the plasma membrane ruptures. This suggests that membrane material has been lost during plasmolysis. The extent to which shrinkage can proceed without reaching the "point of no return" can vary considerably with the degree of cold-hardiness.

A fascinating example of a natural mechanism for accomodating this loss of membrane material and permitting re-expansion of the cell to its original size can be seen in the hardy wheat variety Kharkov. Lipid from the plasma membrane is, during shrinkage, sequestered in granules in the cytoplasm, to be returned to the membrane during deplasmolysis and re-expansion. The special properties of the membrane lipids of this plant can be revealed by use of the Langmuir trough. In this device, the compressive forces generated in a shrinking membrane can be simulated. Under compression, lipid is forced out of the membrane layer once a certain point has been reached. Lipids of Kharkov wheat uniquely show a capacity to become reincorporated into the membrane upon release of the compressive force and re-expansion of the area of membrane.

More recent studies on the quite different system of sea urchin eggs throw further light upon the process of cell shrinkage. Exposing the egg, attached to a substratum, to external solutions of increasing osmolarity, permits the examination of the relationship between cell shrinkage and surface tension in the membrane. As the cell shrinks, the surface tension decreases and its surface energy increases — it is storing energy. The forces of surface energy are implicated in the maintenance of membrane integrity. The behaviour of the membrane is altered by a reduction in temperature, lysis occuring at much higher external osmolarities, although cell volume reduction ceases at the same osmolarity.

Freeze tolerance - natural mechanisms

The implication that osmotic cell volume reduction is responsible for injury points to possible ways of avoiding injury through forestalling volume reduction. In nature there are, in fact, several such methods, including the synthesis of internal cell solutes, thus producing a higher internal osmolarity. This can protect against injury caused by exposure to temperatures as low as — 15 °C. This mechanism is found in certain herbaceous plants. A second one found in a wide range of organisms involves the binding of water to proteins, for example. This bound water cannot be frozen and for shrinkage to reach the critical volume, much more of the freezable water must now be lost from the cell. Hardened cells of *Catalpa* exhibit tolerance of freezing to — 28 °C by this mechanism.

Resistance to cell volume reduction as observed above in sea urchin eggs cooled to a certain temperature, is exhibited by some hardened plants. A fourth mechanism involves the storage of lipids in the cytoplasm as described earlier for Kharkov wheat. A fifth, shown by the dehydration tolerant moss, *Tortula ruralis,* involves cellular collapse rather than the more familiar convex plasmolysis. This breaks the link between cell volume and cell surface area, thus permitting volume reduction to occur at the *same* surface area. This point was demonstrated very clearly in a film prepared by Professor J.D. Bewley and colleagues (Calgary) and shown to the workshop participants. A sixth, and final mechanism demonstrable in model systems but rarely found in plants in nature is leakage of extracellular solutes into the cell. This helps to restore the osmotic imbalance which had been created by extracellular freezing. Plants are not restricted to just one of the mechanisms. Indeed a combination of resistance to shrinkage in the cell membrane and the binding of cellular water are commonly found in hardy woody plants.

Artificial enhancement of freeze-tolerance cryoprotection

A large number of solutes are potential cryoprotectants, provided that they can penetrate the cell membrane and have a low toxicity at effective concentrations. Cryoprotectants such as glycerol (others include dimethyl sulphoxide, methanol and some glycols) provide cryoprotection by reducing, on a colligative basis, the amount of ice formed at any one temperature. It is interesting to note that certain insects synthesize and accumulate glycerol up to concentrations of ca. 25 % as a natural cryoprotection mechanism.

In plants, care should be taken with the application of glycerol, since its rate of penetration can be low resulting in the possibility of the creation of damaging osmotic gradients, unless added and removed slowly. Thus it is necessary to determine the osmotic and temperature limits of the cell and the kinetics of permeability of the cryoprotectant into and out of the cell. The use of 14C labelling techniques and direct observation of cell size alterations aid the determination of these factors.

Freezing, storage and thawing

Once cryoprotected, the cell can now be frozen at a rate which permits the exit of a certain proportion of freezable water from the cell. In the colligatively frozen specimen, the storage temperature should be sufficiently low to prevent further concentration of intracellular solutes and prevent metabolic reactions. Thawing is normally carried out rapidly, but in theory need not be.

The above situation is an ideal one which is less dependent upon cooling rates and storage temperatures than the more familiar (to cryopreservationists) situation of "kinetic freezing". By this mechanism, survival is achieved by finding the "window" in freezing rates which falls between under-dehydration and ice damage and over-dehydration and damage due to shrinkage. The additions of adequate levels of cryoprotectants will broaden this window. The cryoprotectants can be added at lower levels than those which are effective

in colligative cryoprotection since the cooling rate will cause adequate dehydration. However, as a result, the cell is metastable and must be stored below — 120 °C and then warmed rapidly to prevent damage by recrystallization of intracellular ice. Critical factors in the practice of kinetic freezing are the choice of cryoprotectant, the cooling regime and the storage temperature. A wider range of cryoprotectant compounds can be used since low concentrations are effective. As an alternative to carrying out slow cooling at a continuous rate, stepwise cooling may be used. The exact requirements are determined empirically.

In comparing the two approaches to freezing, colligative and kinetic, the former can be seen to have advantages in that the rate of cooling and warming, and storage temperatures are less demanding. The latter has advantages in that lower levels of cryoprotectant can be used, avoiding toxicity.

Having established some of the important factors involved in cooling and freezing cells for storage, and learned that there are important implications for material undergoing dehydration by other means for storage, attention then turned to the two classes of material of central interest — recalcitrant seeds and tissue cultures.

Seed storage - the problem of recalcitrant behaviour

Professor E.H. Roberts presented a paper entitled *"Storage of Recalcitrant Seeds"* on behalf of himself and his colleague Dr. M.W. King. Throughout the plant kingdom, desiccated propagules are used as means of dispersal and survival of environmental extremes. In the dry state, these propagules are able to withstand relatively high or low temperatures and can remain inactive for long periods of time without requiring inputs of the essentials normally needed to sustain a fully hydrated tissue.

Seeds, the propagules of Angiosperms and Gymnosperms, are in many cases capable of being dried to moisture contents of 5 % or less, in which state their response to storage conditions can be predicted according to simple mathematical rules. The behaviour of these "orthodox" seeds can be summarized as follows : the logarithm of any measure of longevity (e.g. time taken for half of the seeds to die) shows an approximately linear relationship to temperature and moisture content. This relationship permits accurate prediction of the behaviour of seeds in storage and therefore management of seed collections.

Seeds which are incapable of being dried below relatively high water contents are termed "recalcitrant". They lose viability in a relatively short time, even in the fully hydrated state, in contrast to orthodox seeds. This classification of seeds into orthodox and recalcitrant is a relatively recent one. Early classifications have involved a separation into short, medium and long-lived (or micro-, meso-and macrobiotic) seeds, for example. Microbiotic, i.e. recalcitrant seeds, are considered to be typical of trees and shrubs of the tropical rain forest, those of temperate gallery forests and plants of aquatic environments. A further character which can usefully be added is that they are usually large in size.

In the case of the aquatic plants, drying out would not normally be expected to occur in nature. Tropical woody perennials produce seeds at intervals, and the seeds show little dormancy, germinating and growing more or less throughout the year in a conducive environment. However, dormancy is shown often in recalcitrant seeds produced by temperate trees. This permits survival of the seeds over winter, under conditions which would kill seedings.

An important stage in the investigation of storage methods for a given specimen is to first establish that its seeds are indeed recalcitrant. The behaviour of some seeds can be misleading. An instructive example is that of *Citrus* spp., the seeds of which appear to be killed by drying below 5 % moisture content. However, further investigation has shown that their storage and viability characters do in fact follow the guidelines for orthodox seeds, and that the apparent recalcitrance due to a requirement for a very long period of germination after drying. Other examples of incorrect classification could be cited. Nonethless, there remains a significant number of seeds which are truly recalcitrant — those of 57 species drawn from 27 families — and for which improved moist storage methods are required.

Moist storage

A number of factors govern current methods for moist storage. Microbial attack must be minimized by hot water treatment or the application of fungicides. It is desirable to use as low a temperature as possible for storage but the temperature range which induces freezing injury to hydrated tissues must be avoided. Indeed, for some recalcitrant seeds, lethal chilling injury may be induced at relatively high temperatures (ca. 10 °C). Sensitivity to low temperatures is shared by orthodox seeds if they are hydrated sufficiently.

Since the use of low temperatures to inhibit germination is limited by the risk of chilling and freezing injury, other methods must be sought. Osmotica such as polyethylene glycol inhibit germination by effectively drying the seed and their use is subject to the same constraints as conventional means of desiccation. Chemical inhibitors have drawbacks in that they may kill the seed after prolonged contact and may themselves be unstable over the duration of the storage period.

Oxygen is required for the maintenance of viability in hydrated orthodox seeds and it may be predicted that this will be the case for recalcitrant seeds (although a relatively unexplored area). It is reasonable to assume that oxygen will be required to provide energy through respiration for the repair of damage which inevitably occurs in moist tissues. Capacity for repair may explain the phenomenon of survival for relatively long periods of orthodox seeds when hydrated almost fully or if just wetted intermittantly (provided that they do not germinate). However, one should be aware that oxygen can have deleterious effects through peroxidase activity. This may be countered by the application of antioxidants, for example.

A strategy for future research

Despite attention being given to the maximizing of storage periods for recalcitrant seeds, they are still inadequate for the purposes of genetic conservation, as will be revealed in the following section. We are seeking periods of decades, yet current methods only offer days, weeks, or in the best, exceptional cases, up to 5 years. It is clear, therefore, that new approaches are needed. A framework within which to conduct further research work can be suggested. The first point is to establish recalcitrance thereby avoiding mistaken classification. Capacity to survive drying, especially by the use of desiccants, should

be explored and if this proves feasible, then storage at sub-zero temperatures should be available. Otherwise, cryopreservation, taking into account all of the relevant factors including cryoprotection, cooling and warming rates, etc., can be attempted. Failing the possibilities of dry or cryogenic storage, then improvements must be made in traditional moist storage methods. This will involve investigations into means of inducing dormancy, means of preventing microbial attack and determination of oxygen requirements.

Although storage for very long periods must be the ultimate aim for genetic conservation purposes, small improvements in seed longevity do have a practical value. Collection and distribution of material are important components of conservation programmes and would be facilitated if conventional storage methods could be improved to provide more time for these procedures. Thus research into such refinements is justified.

How to conserve genetic diversity ?

Speaking under the title *"Genetic Conservation of Recalcitrant Species - an Overview"*, Professor J.G. Hawkes (Birmingham) pointed out to the workshop participants some of the practical realities of genetic conservation. The genetic diversity of, for example a field crop species comprises a climal or geographical component, inter-population diversity and intra-population diversity. For one species, 10,000 - 20,000 samples, each containing 2,500 - 3,000 units are required to capture this diversity. Thus we are talking in terms of numbers of up to tens of millions. Given this ideal, what methods are available to conserve the genotypes for the future ?

At present, several methods are available or under consideration for the conservation of genetic diversity. The most satisfactory involves the storage of orthodox seeds at low moisture and low temperature in seed banks. Although suitable for most tropical and temperate field crops, the economically important recalcitrant seed producers (and these include crops such as cocoa, coconut, tea and a large number of timber crops) are excluded at present, as established above. However, it may become possible in the near future to devise methods for the storage of recalcitrant seeds for periods of 5 - 10 years. The true significance of the storage period is seen when compared with the regeneration time of the species in question. For many temperate and tropical fruit trees, shrubs and small trees including the beverage crops of tea, coffee and cacao, the regeneration times are such that even with improved storage periods as indicated above, and the minimizing of juvenile phases, up to half of the germplasm collection may, at any one time, be undergoing regeneration in plantations rather than in storage as seeds. For tropical timber trees where the regeneration cycles are up to 80 years, the seed bank will eventually become a plantation since more material will be growing up than in storage.

In situ biosphere reserves currently make a major contribution to the genetic conservation of recalcitrant seed producing crops. They have limitations in that they cannot conserve all of the genotypes in a widely distributed species and since cultigens have no natural ecosystem. The long-term establishment of these reserves can involve risks relating to various human factors. We are too late to conserve the total genetic diversity of some species in this way due to the destruction of natural habitats.

Ex situ plantations can in part solve the problems of conserving long-lived woody species. They can be established in regions where land and labour are cheap, but they are still exposed to various risks including disease, disasters and pressure on land use. To carry out storage in this way, it may be necessary to plant very large areas containing large numbers of individual plants. By using *ex situ* reserves, it is inevitable that much of the original genetic diversity will be lost, in part due to ignorance of natural breeding systems in some cases, and past failures to conserve wild populations in others. Nonetheless, they have a unique role to play in the conservation of cultigens and clonal fruit crops.

A large number of staple crops including potatoes, cassavas and yams are maintained at present in growing collections which are harvested and replanted on a year by year basis. Practical limitations restricting the range of genotypes which can be planted each year, problems in storage and various other threats to the material in the collections militate against this as a satisfactory approach to long-term conservation. It may be possible to convey some collections to seed storage but a high level of sterility and/or the need to preserve exact genotypes will render this impossible for others.

A solution to the latter problem may be found in the storage of meristems or shoot-tips *in vitro* (as will be described later). The prospects are good also for the application of this approach to woody crops, given certain improvements in the general tissue culture technology. For a number of fruits, seed storage is not suitable for the preservation of exact gene combinations (even when technically possible) since the genotypes have been propagated by grafting for long periods of time. *In vitro* techniques could play a useful role here.

The arithmetic involved in the storage of meristems as opposed to plantations is particularly impressive. The procedure of subculturing short-circuits the long regeneration time of the species when grown in plantations. Instead regeneration cycles ranging form 3 - 5 years, even up to 80 years, we are talking about culture transfer times of a few minutes. Further, some of the practical constraints involved in the maintenance of genetic integrity of samples subjected to recycling via seed regeneration are avoided. Meristems need only be regenerated via the long regeneration cycle when a whole, independently growing plant is required, unlike material stored as seeds where regeneration is necessary when seed viability drops below a certain level.

An alternative approach - seedling banks

Thus, for "recalcitrant species" the following storage methods are available at present : for wild material, *in situ* biosphere reserves, *ex situ* plantations and meristem banks, and with the qualifications given above, recalcitrant seed banks; for cultivated material, the foregoing possibilities excluding *in situ* biosphere reserves. However, the possibilities do not end there.

As pointed out earlier, only orthodox seeds possess the mechanisms which enable them to withstand environmental extremes and therefore storage at low moisture content and low temperature. However, in the humid tropics, rapid to intermediate germination is the most successful evolutionary strategy. This pattern of behaviour which is successful in nature, is the very one which presents a problem in storage. Similarly, the large size of recalcitrant seeds aids rapid growth and resistance to fungal attack enabling the young seedling to become established, but hinders storage in seed

banks. Therefore, rather than trying to turn recalcitrant seeds into orthodox ones, a daunting task, a better approach might be to devise a storage method which takes advantage of the natural behaviour of the seeds.

In the humid tropical forest, the seedlings once established wait for up to decades for an opening to appear in the tree canopy, and then grow rapidly up into the light. Perhaps we should store the material in this seedling stage under low lighting levels. Research should be directed to determining the most suitable conditions for storage of the seedlings and then all that would be required to stimulate resumption of rapid growth would be an increase in light levels.

Professor Hawkes took the opportunity of addressing the workshop participants to launch this very imaginative and potentially valuable approach to storage of germplasm. The final review to be described here involves an approach which is far removed from most natural mechanisms and which, although discussed for some years, is a long way from being widely applied, despite its great potential.

Plant tissue culture - basic principles and storage methods

Dr. Lyndsey A. Withers introduced this topic under the title *"Storage of Tissue Cultures"*. The storage cycle involves the excision of tissue from the plant in question, introduction of the explant into culture, establishment of a healthy culture, storage by one of several methods, recovery of viable tissue from storage and regeneration of a whole plant capable of independant growth and propagation in the field.

Many different parts of the plant may be used to initiate cultures and the types of culture which may be developed are several, ranging from isolated protoplasts to shoots and embryos. The system of choice in any one circumstance will depend upon a number of factors, not the least of which is genetic stability, a point of great relevance in genetic conservation.

The most simple approach to storage involves maintenance of the culture in growth at a "normal" rate. However, this rate is often rapid and demands that the culture be transferred to fresh medium relatively frequently (e.g. weekly or monthly). The transfer operation exposes the culture to risks of accidental loss and the culture may become modified in genotype. An important factor to be considered is that of cost. It is expensive in terms of consumables, labour and energy to maintain cultures in rapid growth.

Growth limitation by one of several mechanisms will reduce (but not eliminate) many of the problems involved in culture maintenance. However, it is not possible to reduce growth to zero without threatening viability and therefore is necessary to take a completely different approach if all subculturing demands are to be relieved. Several options are open when considering the storage of micro-organisms, but for higher plant tissue cultures, there is only one - cryopreservation.

A number of general points can be made here concerning the cryopreservation of cultures. With very few exceptions, cryoprotectants are required. Dimethyl sulphoxide is one of the most common ones and is effective when used alone, as are some amino acids such as proline. Glycerol is usually incorporated into mixtures of cryoprotectants. Two or three component mixtures are becoming more common features of cryopreservation protocols, particularly for cell and callus cultures. Some care is required in the preparation and application of cryoprotectants, to avoid toxicity and to maximize efficacy.

Once cryoprotected and transferred to a suitable container, the specimen is frozen at a predetermined rate. For most cultures slow freezing appears to be most suitable, but for some (notably shoot-tips of certain species) rapid freezing may be effective. Both purpose-built and simple, improvised units may be used to carry out slow freezing, or the effective alternative of step-wise freezing. Since kinetic freezing (see above) is usually involved, slow freezing rates should be optimized and storage carried out using a liquid nitrogen cooled refrigerator to ensure and adequately cold environment. It is possible to obtain refrigerators which will hold several thousand samples in organized storage. Thawing is usually carried out using a warm water bath (ca. 40 °C) although slower thawing in air at room temperature is used in some exceptional cases.

The foregoing comprise the core of the cryopreservation procedure. However, the culture conditions and other treatments applied before freezing and the handling of the specimen after thawing are also critical to survival. These are best considered in the context of the different culture systems as below.

Shoot-tip cultures - successes in the laboratory and some practical application

These have been most widely investigated in terms of the range of possible storage methods. Many are maintained in continued growth at a normal rate, and in the literature we can find reference to the storage of at least 13 species in growth limited by a reduction in the culture temperature. In most of the latter cases, the subculture interval has been extended to one year at least. One of the best examples is the storage of a range of potato genotypes at 6 °C. Some variation in response from genotype to genotype is observed, however, indicating that if viability is to be maintained, both subculture intervals and storage temperatures need to be determined carefully. As an alternative, retardants such as abscisic acid or mannitol can be added to the culture medium and this approach, along with temperature reduction is under examination at the International Potato Centre (CIP). At CIP there is the enormous task of conserving more than 10,000 genotypes and it is clear that *in vitro* techniques could make an important contribution.

The importance of distribution of material has already been mentioned in the context of the extension of longevity in recalcitrant seeds and can be reintroduced here since shoot-tip cultures may be ideal for the international exchange of germplasm. The feasibility of this has been tested by scientists at CIP with success. A similar record of achievement can be given for investigations into the storage and distribution of shoot-tip cultures of cassava at the International Centre for Tropical Agriculture (CIAT).

Cryopreservation has been applied successfully to shoot-tip cultures of more than 10 species, all but one of which (strawberry) have recently been excised from parent plants. The treatments given prior to cryopreservation can seriously affect survival. For example, cold-hardening parent plants or pre-incubating shoot-tips on a basal medium supplemented with dimethyl sulphoxide can improve survival dramatically. The latter compound is the most useful cryoprotectant for shoot-tips. Rapid, slow and step-wise freezing are effective for

different species, although evidence is accumulating to suggest that a method dependent upon extracellular freezing (i.e. slow or step-wise) may be most generally suitable.

No generalizations can be made about the immediate post-thaw treatments applied to shoot-tips. Recovery growth is most easily monitored by direct observation of the formation of new tissues. Electron microscopical methods have been used here and have revealed that recovery may not always follow the expected pattern. For example, adventitious meristems may form, rather than recovery proceeding by continued development of the apical dome.

Embryos, plantlets and seedlings - some pointers for recalcitrant seed species

Mature zygotic embryos of orthodox seeds present no real challenge in the dried state. However, hydrated nature and immature embryos may provide realistic model systems for the development of cryopreservation methods for recalcitrant seeds. Work with such material suggests that the potential may be considerable here both for storage and recovery of embryos and the application of *in vitro* methods to rescue shoot apices from otherwise inviable embryos and seeds.

Somatic embryos and clonal plantlets are more akin to shoot-tip cultures in their morphology and water content and are more demanding subjects for storage. Early stage embryos of carrot have been stored in the partially dry state but otherwise under normal culture conditions for two years. They "germinated" when supplied with fresh liquid medium. Using the same species, a special cryopreservation technique has been developed in which the embryos are pretreated with cryoprotectant, blotted dry, enclosed in a foil envelope and then frozen slowly. Thawing is carried out relatively slowly and the embryos are returned to culture on semi-solid medium. Recovery ensues at a very high rate from entire early stage embryos and from the meristems of older embryos and their derivatives, clonal plantlets. Many zygotic embryos have been shown to produce secondary, somatic embryos and such structures, if produced on recalcitrant seed embryos might be ideal subjects for cryopreservation, rather than the large zygotic embryo itself.

Only limited attention has been given to the *in vitro* role of seedlings but it should be noted that they may be stored under conditions where growth is limited by light quality. Seedlings of two species, have been cryopreserved with some success, in both cases by rapid freezing.

Callus cultures and cell cultures - varying degrees of success and a potential yet to be realized fully

Callus cultures, being highly disorganized are thought by many to have one of the most pressing requirements for storage in a stable state, since they carry a higher risk of genetic instability than do organized cultures. Growth limitation by means of oxygen limitation, mineral oil overlay, desiccation and temperature reduction, all have been attempted. However, no widely applicable methods emerge. Regarding cryopreservation, there have been at least 4 successes suggesting that given sufficient attention, suitable methods may be developed for a wider range of species. In all cases, slow or step-wise freezing is used and there is some evidence that cold hardening of the callus may improve freeze-tolerance.

Growth limitation with cell cultures growing in liquid medium is technically difficult to carry out and there is, again, a very high risk of genetic instability which might lead to selection of certain genotypes under conditions of stress. In consequence, most attention has centred upon the development of cryopreservation methods. In all, over 30 species have been cryopreserved as cell cultures. The experimental work which has been carried out here tells us a great deal about the effect of pregrowth and post-thaw conditions upon survival potential. Exponentially growing cells are more tolerant of freezing, in part due to their lower water content and smaller size. As well as chosing material at this stage, further improvements can be brought about by preculturing the cells in medium, containing osmotic additives such as proline or mannitol, to further reduce the mean cell size. This treatment may mimic naturally occuring stress tolerance inducing mechanisms.

Without exception, cryoprotectants are required. Dimethyl sulphoxide and proline may be effective when used alone, but mixtures of dimethyl sulphoxide, glycerol and one other compound such as sucrose or proline, giving a total molarity of 2M are widely successful. Slow or step-wise freezing are invariably required, and thawing is usually carried out rapidly.

In early studies, post-thaw washing and establishment of recovery growth in liquid medium was used. However, more recent work suggests that these procedures may induce damage which would otherwise be avoidable. Direct transfer of the thawed cells to semi-solid medium, without washing or even removing the cryoprotectant containing medium is most conducive to survival and rapid recovery growth. Under such conditions, cell division may be resumed within two days or less. The nature of the injury in the washed cells may relate to deplasmolysis stress in the plasma membrane (see above). This is consistent with findings that freshly thawed cells are incapable of yielding stable protoplasts. Within two days, this capacity is restored, by which time lesions to the respiratory apparatus of the cell also appear to have healed.

Overall, some of the greatest successes in cryopreservation have been with cell cultures in particular, and it is unfortunate therefore that they carry, with some justification, the stigma of genetic instability. In the future however, success here may be taken advantage of in one of two ways. The knowledge gained about the nature of freezing stress and freeze tolerance in culture systems may be applied more widely to other types of culture. Alternatively, methods may be developed to stabilize cell and callus cultures so that they can be used directly for genetic conservation.

Present inadequacies but future optimism

In summary, growth limitation methods have been developed for a number of shoot-tip cultures with considerable success, but the wider application of this approach must await further technical development. Cryopreservation has been applied successfully to all culture systems, the most responsive being shoot-tips and cell cultures. (Some success has been recorded for protoplasts, pollen and pollen embryos also, but no comprehensive studies have yet been carried out). However, despite these successes, insufficient information is available at present to recommend generally applicable methods. We do not know which variables in the cryopreservation procedure are influenced by taxonomic factors and which are influenced by morphology. Thus, the techniques suitable for carrot

cell cultures are known to be unsuitable for shoot-tips of potato, but would they be suitable for cell cultures of potato ? We lack the answer because far more work is needed to fill in the details of the presently sketchy picture.

In the future, we should aim to develop widely applicable techniques which yield recovering cultures from a large proportion of the cell population in the specimen. The regenerating cultures should be capable of producing plants and both the cultures and plants should be tested for phenotypic and genotypic stability — only rarely carried out at present. Most important of all, attention should be directed towards species of interest from the point of view of genetic conservation. If we examine the entire procedure from culture initiation to storage and plant propagation, we find that the full range of techniques can be applied only in the case of strawberry : Techniques for potato are the next most fully developed. Clearly there is a long way to go, starting with the development of good tissue culture competence for the individual species, followed by the application of storage technology. However, when the current situation is compared with that of 5 or 10 years ago, progress is manifest, boding well for the future, provided that interest and effort are sustained.

Discussion sessions - a summary

The five discussion session topics were chosen to cut across the boundaries between seed storage and tissue culture storage by identifying common phenomena and common problems. In such discussions it is clear that the greatest benefit goes to those actually participating and written accounts can only convey the main themes. Harder still is the task of making a precis of the accounts. Therefore, just a few of the important points are included here and the interested reader is directed to the Workshop Proceedings for more detail.

The first session entitled *"The Establishment of Plant Tissue Cultures and the Development of Plants from Cultures"* and led by Professor Y.P.S. Bajaj * (Ludhiana) emphasized the importance of producing healthy cultures capable of regeneration at will. A general lack of expertise in the tissue culture of recalcitrant seed producing species, indeed all woody plants, was highlighted and the consensus was that this resulted from a combination of neglect and difficulty. Two particular problems provoked extensive discussion : the relative merits of non-adventitious and adventitious development and the problem of browning in cultures. It was agreed that ideally non-adventitious development was most desirable but that in some plants, notably palms, bananas and plantains, insufficient meristems are present in the plant to yield explants for culture. Therefore an adventitious route to plant regeneration may be unavoidable. Browning in cultures, often with lethal consequences, hinders many attempts at culture of woody plants. Some simple practical measures were recommended to overcome this problem but it was also felt that physiological studies to examine the underlying mechanisms (phenolic metabolism ?) would repay effort.

The question of stability in storage is central to any consideration of genetic conservation techniques. A discussion on this area, under the title *"Genetic Stability and the Deterioration of Stored Material"* was led by Professor G.G. Henshaw (Bath). Concern was expressed over the lack of required standards of genetic stability and over exclusive reliance on viability data to imply the degree of genetic stability in stored seeds. Matters are far less clear cut in tissue culture where different culture systems carry different risks of instability. Even within the callus culture system there are important interspecific differences in tendency to genetic variation. A careful choice of explant, avoidance of the over-administration of hormones, avoidance of stress conditions and the application of a storage method which minimizes risks of genetic change or selection, are all indicated. Non-genetic deterioration is mainly a problem of seed storage rather than tissue culture and the solution appears to lie in the development of methods to combat microbial contamination and (less easy) avoid the total depletion of reserves in the seed.

The two following sessions : *"Dehydration and Desiccation Injury; Membrane Damage"*, led by Professor Peter L. Steponkus (Cornell), and *"Cold Hardening and Cryoprotection Recovery of Stored Material"*, led by Professor M.J. Burke * (Florida) examined some of the cellular effects of storage conditions and the possible ways in which measures could be taken to mitigate resultant stress and injury. When the freezing process is examined, three components of injury can be identified — decrease in temperature, presence of ice crystals and dehydration. The latter is considered to be the most disruptive and injurious, linking the stresses that a frozen specimen is exposed to, with those suffered by desiccated material such as seeds in storage at a low moisture level. The light microscope linked to video-taping or filming facilities emerged as a very useful tool in the examination of cells under stress (either osmotic or freezing), and the workshop participants enjoyed two very instructive demonstrations of the behaviour of protoplasts and cells, prepared by Professor Steponkus and Dr. D. Reid (URL, Colworth). Electron microscopial observations corroborate the film evidence that the plasma membrane is a primary site of damage and further reveal damage to organelles. It is clear that injury may be massive, underlining the need for careful handling of material after storage.

The various mechanisms whereby the plant cell may acquire natural cold tolerance were examined in the second of these two discussions and it was emphasized that the potential for using such mechanisms should always be explored. The problem of cryoprotection itself causing stress was reiterated, underlining the importance of chosing the cryoprotectant and its means of application with a view to minimizing stress. The important role of proline, a naturally occurring compound in stress hardened tissues, in both pregrowth and cryoprotection was emphasized. Experience with a range of culture systems leads to the conclusion that there is great potential for "rescue" in freeze damaged cells such as those showing organelle damage as described above. The discussion led to the general conclusion that all of the stages in the cryopreservation procedure contribute to the final outcome and that every effort should be made to understand the factors influencing survival so that protocols may, in the future, be designed logically.

So far, the discussions have implied cryopreservation as a favoured approach to storage. However, it was realized that the time may be some way off before it can be widely adopted; some specimens may never be amenable to cryopreservation. Therefore, the importance of growth limitation for tissue cultures and the induction of dormancy in

* The discussion account in the Proceedings is co-authored by Lyndsey A. Withers and Y.P.S. Bajaj.

* The discussion account in the Proceedings was prepared by Dr. B.W.W. Grout (London).

recalcitrant seeds are acknowledged. These aspects received consideration in a discussion led by Dr. G. Staritsky (Wageningen) and entitled *"Growth Inhibition and Dormancy"*. Some time was spent discussing the relative merits of whole seeds, excised embryos and cultures as subjects for storage, and it was agreed that the adoption of some features of *in vitro* methodology (asepsis and the culturing of small regenerable explants) might greatly benefit work with recalcitrant seeds. First-hand experiences in the application of growth limitation in programmes at the international centres (CIP, CIAT and the International Institute for Tropical Agriculture, IITA) were recounted and some useful supplementary pieces of information on this approach to storage were volunteered by other participants. Overall, it emerged that quite a wide range of approaches to limiting growth and inducing dormancy exist and we are a long way from having fully explored all of these.

Conclusions and recommendations

The final session in the workshop took the form of an "Open Forum" introduced and chaired by Dr. J.T. Williams, under the title *"Techniques for Genetic Conservation — the Way Ahead"*. Dr. Williams opened by commenting that those working in tissue culture and those working with recalcitrant seeds have developed methods which benefit their own specialties but which could be much more widely useful given liaison between the two groups. Some areas of particular neglect by workers can be identified : 1) the failure of physiologists to give adequate attention to crops which have a pressing conservation problem; 2) a lack of tissue culture studies on recalcitrant seed producing species; and 3) until recently, little effort being directed towards an understanding of the physiology of recalcitrant seeds.

Some specific examples may help to convey the nature and urgency of the conservation problem. The genetic variability of coconuts in South East Asia is being lost at an alarming rate but the necessary collection of germplasm has not been carried out. Grape germplasm collection from various parts of the world including the Near-, Middle- and Far-East and North Africa has been recommended but not carried out. Practical difficulties in collecting the germplasm, transporting it and maintaining germplasm collections have prevented action. The development of appropriate new technologies could overcome these problems.

Numerical aspects of conservation are of central importance, as pointed out earlier by Professor Hawkes. Decisions in this area depend upon knowledge of the genetics and breeding systems of the species in question and on the aims of conservation. The important question of costs, so far left out of discussion, must be raised. In view of the large numbers of specimens involved, the expense of conservation must be acknowledged and it would be instructive to calculate the comparative costs of traditional approaches to conservation and of tissue culture storage.

The recommendations which would go forward from the workshop were influenced by the discussion following the above comments and by inputs from the preceding discussion sessions, and were drafted by a committee comprising Professor N.W. Simmonds, Professor J.D. Bewley, Professor H.F. Chin (Serdang, Malaysia), Professor E.C. Cocking, Professor E. H. Roberts, Dr. G. Staritsky, Dr. J.T. Williams and Dr. Lyndsey A. Withers. The main recommendations with comments from the discussions are conveyed in the following :

All agreed that work should continue on recalcitrant seeds. Problems in obtaining adequate supplies of seeds might be resolved by relocating the research work in the relevant, often developing, countries, where ample material is available. The work should aim to establish recalcitrance and investigate means of extending the life of truly recalcitrant seeds.

The immediate relevance of shoot-tip (meristem) cultures was generally agreed but the potential role of other types of culture, especially calluses and cell cultures was questioned. Investigations into their genetic stability should aid resolution of this point as well as being of fundamental importance to the overall application of tissue culture methods in genetic conservation. The contribution which tissue cultures could make to overcoming quarantine barriers was acknowledged but the continuing need to certify cultures free of pathogens and carry out work on tropical diseases was emphasized. Attention needs to be concentrated on the tissue culture of crops with a genetic conservation problem to provide the essential raw material for the application of tissue culture storage methods. The immediacy of a useful role for cryopreservation was questioned, although its future potential was accepted. Research work should continue to elucidate underlying mechanisms and develop good methodology.

Collaboration between physiologists, geneticists and workers in genetic conservation will be essential if success is to be realized in the above areas. Until new techniques are fully developed a very important part will continue to be played by plantations, and every effort should be made to ensure their security. Further, the alternative approaches to conservation as expounded here will be supplements to, not substitutes for plantations in the future.

Finally, the workshop recommended that IUBS should establish a Working Group to consider action on its detailed report and recommendations. The need for action in the areas of genetic conservation research identified by the workshop can best be expressed by a quotation from the Foreword of the Workshop Proceedings... "It is hoped that this book will stimulate universities, foundations and research institutions to support research in these areas where practical methodology could help genetic conservation. We must not allow useful biological diversity to be lost forever to mankind for the lack of a book of recipes. Although the alarm bells have been ringing for many years, the scientific community has not yet solved the problems".

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A New Approach to Membership Dues Schedules for Use by International Organizations

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It is an accepted practice among international organizations with nations as members to apportion dues according to the ability of the member nation to pay. Similar practices are coming into use in international nongovernmental associations predominantly composed of individuals residing in different nations. While it is generally agreed that these are just and reasonable practices, no rationally justifiable, quantitative foundation exists for such practices.

This paper attempts to provide such a foundation. An equation is described that permits dues schedules to be set by consensus procedures based on values for a basic dues factor, a factor related to population and a factor related to technological energy consumption.

The approach is based on the concept of demophora (*demos,* population; *phora,* technological production/consumption) expressed in terms of energy (Vallentyne and Tracy 1972; Vallentyne 1978). In effect, populations are compared on the basis of their combined physiological and technological energy consumption. The interconversion of physiological and technological energy consumption is accomplished by expressing both in terms of D-units (demophoric units). One D-unit is defined as the physiological (food) energy consumption of a "standard" human at a rate of 2,300 kilocalories per day over the course of one year (840,000 kilocalories per year). The physiological energy consumption (P_i) of a population in D-units is thus numerically equivalent to the population number in heads.

Technological energy consumption (T_i, as coal, oil, natural gas, hydroelectric and nuclear power) generally is expressed in millions of metric tons of "coal equivalent" per year or kilograms of coal equivalent per capita per year. The burning of one metric ton of coal equivalent per year corresponds to 8.33 D-units (Vallentyne, 1978). Conversely, the physiological energy consumption of one standard human over the course of a year corresponds to the energy yielded on burning 120 kg of coal equivalent. *

* The values listed by Vallentyne (1978) were 8.1 D-units per metric ton of coal equivalent or 120 kg of coal equivalent per standard human. These are corrected here.

The D-index (demophoric index) is the ratio of technological energy consumption (T_i) to physiological energy consumption (P_i) of a population, with both expressed in D-units. It currently varies from less than 1.0 for many nations of Africa to about 90 for the United States, and Canada, and even higher values in special situations.

The proposed formula for computing dues schedules of international organizations with nations as members is :

$$x_i = a + \frac{(bP_i + cT_i)(X - ka)}{\Sigma b P_i + \Sigma c T_i}$$

where x_i = dues of an individual member nation expressed in a standard currency; X = the sum of the dues of member nations expressed in standard currency; P_i = physiological energy consumption of an individual member nation in D-units; ΣP_i = the sum of the physiological energy consumption of member nations; T_i = technological energy consumption of an individual member nation in D-units; ΣT_i = the sum of the technological energy consumption of member nations; "a" is the basic component of the dues schedule applicable to each member nation, expressed in a standard currency; "b" is a population modifier; "c" is a technology modifier; and k is the number of member nations.

This equation provides a rationally defensible consensus procedure for weighting dues schedules by assigning specific values to a, b and c. Values for P_i and T_i are annually up-dated in publications of the United Nations, permitting dues schedules to be responsive to change.

Table 1 shows the "claimed" dues schedule and three possible new dues schedules for the 51 member nations of the International Union of Biological Sciences. The data for physiological energy consumption (P_i) are based on mid-1980 population estimates (United Nations 1981). The data for technological energy consumption (T_i) are 1979 estimates (United Nations 1980). The "claimed" 1981 dues are those proposed by the Union, based on a total budget of U.S. $ 200,000. These were recalculated to a total of U.S. $ 350,000 to provide

Table 1. Present and three demophoric dues structures for the International Union of Biological Sciences. See text for explanation.

Countries	Population (10^6) (P_i)	T_i in D-units (10^6)	$P_i + T_i$ (10^6)	D-index (D_i)	Claimed 1981 dues *	Recalculated 1981 dues US $	Demophoric dues schedules		
							A US $	B US $	C US $
Argentina	27.1	411.9	439.0	15.2	2,000	3,500	3,036	3,688	4,341
Australia	14.6	736.6	751.2	50.4	5,000	8,750	4,483	4,889	5,295
Austria	7.5	260.2	267.7	34.7	1,000	1,750	2,241	3,030	3,818
Belgium	9.9	498,9	508.8	50.4	11,500	20,125	3,359	3,957	4,554
Brazil	123.0	762.6	885.6	6.2	2,000	3,500	5,106	5,406	5,706
Bulgaria	8.9	367.6	376.5	41.3	1,000	1,750	2,746	3,448	4,150
Canada	23.9	2,088.8	2,112.7	87.4	5,000	8,750	10,796	10,125	9,455
Costa Rica	2.2	11.2	13.4	5.1	200	350	1,062	2,052	3,041
Chile	11.1	91.0	102.1	8.2	200	350	1,473	2,393	3,312
Cuba	9.8	104.9	114.7	10.7	600	1,050	1,532	2,441	3,350
Czechoslowakia	15.3	804.8	820.1	52.6	1,000	1,750	4,803	5,154	5,506
Denmark	5.1	229.5	234.6	45.0	2,000	3,500	2,088	2,902	3,717
Egypt	42.0	159.6	201.6	3.8	432	756	1,935	2,775	3,616
Finland	4.8	205.0	209.8	42.7	1,000	1,750	1,973	2,809	3,641
France	53.7	1,868.8	1,922.5	34.8	10,000	17,500	9,915	9,394	8,873
Fed. Rep. Germ. (FRG)	61.6	2,987.6	3,049.2	48.5	20,000	30,500	15,139	13,727	12,316
Dem. Rep. Germ. (DRG)	16.7	948.6	965.3	56.8	10,000	17,500	5,476	5,713	5,949
Hong Kong	4.7	55.9	60.6	11.9	200	350	1,281	2,233	3,185
Hungary	10.7	329.6	340.3	30.8	1,000	1,750	2,578	3,309	4,040
Ghana	11.5	17.3	28.8	1.5	400	700	1,134	2,111	3,088
India	663.6	955.6	1,619.2	1.44	1,000	1,750	8,508	8,227	7,947
Iraq	13.1	68.1	81.2	5.2	2,000	3,500	1,377	2,312	3,248
Ireland	3.4	89.8	93.2	26.4	400	700	1,432	2,358	3,285
Israel	3.9	71.8	75.7	18.4	400	700	1,351	2,291	3,231
Italy	57.0	1,402.2	1,459.2	24.6	5,000	8,750	7,766	7,612	7,458
Japan	116.8	3,515.7	3,632.5	30.1	10,000	17,500	17,844	15,970	14,098
Korea (rep. of)	38.2	443.1	481.3	11.6	1,080	1,890	3,232	3,851	4,470
Lebanon	3.2	21.1	24.3	6.6	200	350	1,113	2,093	3,074
Libya	3.0	19.8	22.8	18.3	8,000	14,000	1,106	2,088	3,070
Mexico	71.9	870,0	941.9	12.1	1,000	1,750	5,368	5,623	5,878
Monaco	0.03	1.07	1.07	34.8	200	350	1,005	2,004	3,003
Morocco	20.2	46.5	66.7	2.3	—	—	1,309	2,257	3,204
Netherlands	14.1	743.1	757.2	52.7	4,000	7,000	4,511	4,912	5,313
New Zealand	3.1	86.8	89.9	28.0	1,000	1,750	1,417	2,346	3,275
Nigeria	77.1	48.6	125.7	0.63			1,583	2,483	3,384
Norway	4.1	216.1	220.2	52.7	1,000	1,750	2,021	2,847	3,673
Philippines	48.4	125.8	174.2	2.6	200	350	1,808	2,670	3,532
Poland	35.6	1,641.1	1,676.7	46.1	2,000	3,500	8,775	8,449	8,123
Romania	22.3	827.3	849.6	37.1	1,000	1,750	4,940	5,268	5,596
South Africa	29.3	562.6	591.9	19.2	4,000	7,000	3,745	4,276	4,808
Spain	37.4	718.1	755.5	19.2	2,000	3,500	4,503	4,906	5,308
Sudan	18.7	18.7	37.4	1.0	1,000	1,750	1,173	2,144	3,114
Sweden	8.3	382.6	390.9	46.1	4,000	7,000	2,813	3,503	4,194
Switzerland	6.4	186.2	192.6	29.1	4,000	7,000	1,893	2,741	3,588
Taiwan	17.7	318.6	336.3	(18.0)	1,000	1,750	2,559	3,293	4,027
Thailand	46.5	125.6	172.1	2.7	200	350	1,798	2,662	3,526
United Kingdom	55.9	2,325.4	2,381.3	41.6	10,000	17,500	12,042	11,158	10,275
U.S.A.	227.6	20,939	21,167	92.0	40,000	70,000	99,150	83,409	67,668
U.S.S.R.	265.5	11,948	12,213	45.0	20,000	35,000	57,631	48,972	40,312
Yugoslavia	22.3	381.3	403.6	17.1	1,000	1,750	2,871	3,552	4,233
Zaire	28.3	15.0	43.3	0.53			1,201	2,167	3,132
IUBS TOTALS	2,427.0	62,056	64,482		200,000	350,000	350,000	350,000	350,000

Values listed for P_i are mid-1980 estimates from the United Nations Monthly Bulletin of Statistics (vol. 35, No. 6, June, 1981). Values listed for T_i and D_i were calculated from 1979 estimates of consumption in metric tons of coal equivalent listed in the 1979 Yearbook of World Energy Statistics (United Nations Publication Sales No. E/F. 80. XVII. 7).

* Dues claimed in 1981 represent those for 1981 together with the outstanding dues for previous years.

Table 2. Hypothetical demophoric dues schedule for an international organization with individual and institutional members. Calculations based on : a = U.S. $ 20, and c = 0.01.

Nation	D_i	Members	Dues	Σ Dues
A	90	452	38.00	17,176.00
B	51	277	30.20	8,365.40
C	39	45	27.80	1,251.00
D	28	32	25.60	819.20
E, F	6	14	21.20	296.80
G, H	2	6	20.40	122.40
I, J, K	1	4	20.20	80.80
		Σ = 830	Mean = $ 33.87	Σ = 28,111.60

a realistic basis for anticipated increases over its next triennium to take account of inflation and other factors.

Three possible demophoric dues schedules are shown in Table 1. In case A, a = $ 1,000; in B, a = $ 2,000; and in C, a = $ 3,000. In each of these cases, b and c were assigned values of 1.0 of course, other values of a, b and c could be used; however, assignment of very low values to any one of a, b or c would probably negate the possibility of decision by consensus. If interested, readers can calculate other sets of values.

Apart from the extremely low "claimed" 1981 dues of certain nations, it can be seen that the demophoric dues schedules do not depart drastically from the "claimed" 1981 dues schedule in most instances. In any event, adoption of the demophoric approach by the Union would be based on particular values of a, b and c determined by consensus, rather than the values used to calculate the results shown in Table 1.

A different approach to the setting of dues schedules is necessary for international organizations based on individual memberships. In such cases, it is the number of members from different nations that is of interest, rather than the populations of the nations in which they are resident. A simple formula for use in such circumstances is :

$x_i = a (1 + c D_i)$,

where x_i represents the dues in standard currency for a given member; as is the basic dues component in standard units; c is a technological modifier; and D_i is the D-index of the nation in which the member is resident. Table 2 shows a hypothetical example of how dues might be distributed differentially among 830 members from 11 nations. Since the bulk of the membership of international non-governmental associations is in nations with high D-indexes, the demophoric surcharge should encourage membership from residents of nations with low D-indexes without heavily penalizing members resident in nations with high D-indexes.

My colleague Dr. R.A. Vollenweider (personal communication) reminded me of the strategic importance of institutional memberships (libraries, research centers, etc.) in countries with low D-indexes. If the demophoric rationale is accepted as the basis for adjusting individual membership dues, it applies with much greater force to institutional memberships.

Adoption of the demophoric, consensus approach proposed here would, in my opinion, provide a more rational basis than currently exists for the setting of dues schedules by international organizations.

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Applied Microbiology in Developing Countries the MIRCEN Networks

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The importance of applied microbiology to developement is great and diverse. Stimulation of competence in this area yields benefits in fields as diverse as agriculture, fermentation industry, public health, water supply and sanitation, environmental conservation and resource management, and the production of food, fodder and energy. Applied microbiology — or biotechnology — thus has a strong interdisciplinary character, possessing interfaces with engineering and applied mathematics, medicine, agricultural and veterinary sciences, food science, toxicology etc. In addition, microbiology provides an excellent framework for teaching basic biology, at the same time holding the front line in advanced biological research, e.g., genetics.

Recognizing this great potential, UNESCO — in response to a resolution of Japan — initiated in the early sixties, a programme to promote applied microbiology in developing countries. Scientific guidance was provided by the microbiology panel of the International Cell Research Organization (ICRO). When in 1975 the programme was expanded by the participation of UNEP, this panel became known as the UNEP/UNESCO/ICRO Panel on Microbiology. The programme consists of the following elements :

GIAM Conferences

Under the name "Global Impacts of Applied Microbiology" six major conferences have been held in Stockholm (1963), Addis Ababa (1967), Bombay (1969), Sao Paulo (1973), Bangkok (1977) and Lagos (1980). These conferences bring together some 100 microbiologists from developed countries, with as many colleagues as possible from the developing region where the conference is held; the latter often meet one another on that occasion for the first time. In addition, decision-makers, UN officials and representatives of universities and industries attend, local students participating as observers.

The programme is broad and focuses on the problems of the region; it may include, for instance, food and agricultural microbiology, fermentation industry, energy production, public health, water supply, waste utilization, environmental microbiology, teaching programmes and collaborative research possibilities. Besides plenary sessions with invited speakers, parallel specialized paper-sessions may be held.

Besides the expected benefits, these conferences have also yielded unexpected spin-offs, like the setting up of a new microbiology department, the foundation of a national society or a regional federation or the initiation of bilateral assistance projects. On the whole, the formula of these conferences has proved itself successful, and in this regard it is interesting to note that the formula of the recently started CHEMRAWN conferences on chemistry closely resembles that of the GIAM meetings.

Training courses

About sixty training courses, based upon the now traditional ICRO pattern, have so far been held in developing countries on a great variety of subjects, such as nitrogen fixation, fermentation technology, waste treatment and recycling, fermented foods, biological pest control, veterinary microbiology, environmental microbiology including biomass and biofuel production, culture collection maintenance, etc. These courses last about 3 weeks and have 15-30 participants, not more than one third originating from the host country. About half of the time is devoted to bench work. The teaching faculty consists of experts from the region, supplemented with teachers from abroad selected in consultation with the Panel. Normally the host country provides for board, lodging, local transportation and the teaching facilities, UN funds being mainly destined for foreign travel of participants and faculty. Students and teachers live under one roof, informal discussions continuing well into the night.

The success of these courses hinges on the enthusiasm and competence of the local organizer. Spin-offs have been as remarkable, as with the GIAM Conferences. A special benefit is the lasting ties forged among the participants. They also offer excellent occasions for identifying willing and capable young researchers in a given region, to undertake responsibility in follow-up activities for instance, networks.

Networks and MIRCEN's

Gradually, as an outcome of surveys carried out in cooperation with IUMS (—ex IAMS), supplemented with experience from GIAM conferences and training courses, an overview emerged of the status of microbiology in developing countries. This served as a basis for further action in various forms.

With the aid of funds from Japan, the *Regional Microbiology Network for S.E. Asia* was set up in 1974, with participation from Australia, Hong Kong, Indonesia, Japan, Korea, Malaysia, New Zealand, the Philippines, Singapore and Thailand. Institutes in these countries cooperate in research projects, exchange of staff and the organization of specialized training courses. Important additional strength is provided by the International Center of Cooperative Research and Development in Microbial Engineering (ICME) at Osaka, which — sponsored by UNESCO — has organized every year since 1973, one-year training courses for microbiologists from Asia; these courses consist of group training at Osaka followed by individual research work at one of the collaborating Japanese universities.

In 1975, at the initiative of UNEP, a pilot project on *Microbiological Resources Centres* (MIRCEN's) was started. This envisages regional networks of collaborating institutes with one coordinating laboratory serving as a reference source, a training centre, a depository of cultures and a focal point for a regional newsletter, all with the general aim to promote the development of an effective infrastructure for applied microbiology, adapted to the specific needs of the region. In the pilot stage no attempt was made to cover all area's in applied microbiology; nor were all geographical areas initially included. Thus MIRCEN's for biological N_2 fixation were set up in Nairobi and Porto Alegre, and for biotechnology and culture preservation in Bangkok and Cairo, later followed by one in Guatamala. These were complemented by the Karolinska Institute in Stockholm as an auxiliary.

These MIRCEN's are now all in operation : they regularly organize training courses, have sent out newsletters, distribute cultures, receive guestworkers, and thus gradually are building up regional networks.

Among these MIRCEN's, a special and central position is occupied by the *World Data Centre on Microorganisms (WDC)* in Brisbane. This MIRCEN houses in its computer the continuously updated master-copy of the *World Directory of Collections of Cultures of Microorganisms*. It fosters culture collections in developing countries, provides information on where specific cultures can be obtained and trains future collection curators. It can provide print-outs of catalogues of selected microbial groups and can assist collections in "stream-lining" their holdings by telling them which of their cultures are unique and not kept elsewhere.

This system of MIRCEN's is now rapidly growing out of the pilot stage; the number of institutes to be added to the list of MIRCEN's is steadily growing and in the area of N_2 fixation a world-wide scope is being reached.

A general newsletter covering all MIRCEN's and related activities has recently been started. It is called *MIRCEN NEWS* and can be obtained from the Panel secretariat.

In 1980, the UNESCO General Conference decided on the setting up of a major regional network in biotechnology and applied microbiology in Africa and the Arab States, which will be developed upon the basis of the experience gained with earlier activities in these regions.

The programme has furthermore made attempts to help integrate microbiology infrastructures of developed and developing countries with one another by promoting the holding of international conferences in developing countries. The Panel has helped to introduce problems of developing countries into the programmes of conferences held in developed countries, and has assisted in finding travel funds for microbiologists from developing countries to participate in them.

The success of these vigorously growing activities is largely due to a policy of versatile and flexible cooperation at working level, with a great many governmental, intergovernmental and non-governmental organizations. In diverse constellations, tailored to each specific occasion, these are helping to provide the core funding from UNEP/UNESCO with a high multiplier factor.

Cooperating ICSU organizations include, depending on the nature of the activity : IUBS, ICOME, WFCC, SCOPE, IUPAC, IUPAB, COSTED and of course, IAMS, now IUMS. In this regard ICRO and its Microbiology Panel are particularly happy to note the ICSU/UNESCO/UNDP initiative for an International Biosciences Network. Having conformed its policy of pluriform cooperation, the Panel stands ready to share its experience in applied microbiology and biotechnology networks with ICSU so as to help promote networks so urgently needed in other branches of biology.

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XIII International Botanical Congress

By Professor N. Grobbelaar
Chairman, IUBS Division of Botany and Mycology
University of Pretoria - Pretoria 0002 - South Africa

An International Botanical Congress is held every six years under the auspices of the Division of Botany & Mycology of the IUBS. The 13th Congress was held in Sydney, Australia from the 21st to the 28th of August 1981. About 3 000 people from most of the Sections and Commissions of the Division of Botany and Mycology attended the Congress. With about 20 parallel sessions running all the time in addition to two sessions of posters in each of two large halls, the program offered such a rich variety of activities that nobody could complain of boredom.

During lunch time, three lectures with a wide appeal were offered simultaneously every day, in addition to a series of films which were run during the remainder of the day. The various societies and commissions used most of the evenings for their business meetings and banquets.

Reorganization of the Board of the Division of Botany & Mycology

In the past each Section of the Division was represented on the Board according to the minimum requirements of the IUBS statutes. Apart from the ordinary Board members, the Board also had a Secretary and a Chairman which normally held office for the six years in between Congresses. The President of a Congress acted as the Chairman of the Board until the next Congress. None of the Board members necessarily represented the Division of Botany & Mycology on the Executive Committee of the IUBS.

Because these arrangements which do not appear to have been documented in the past, leave much to be desired, the Board of the Division formally reorganized itself during the Congress by accepting the following proposals :

a) Composition of the Board of the Division of Botany and Mycology of the IUBS

The Board will consist of a chairman, a secretary and ordinary members who normally will be the chairman of the Sections and Commissions of the Division, together with the President of the Congress as an *ex officio* member who will be the President of the Division for a period from 3 years before tp 3 years after the International Botanical Congress. The Chairman will normally chair all meetings of the Board.

The Board will normally elect, from within its own ranks, its chairman and secretary. The Section or Commission whose chairman is elected chairman or secretary of the Board will delegate its secretary to represent it as an ordinary member of the Board.

The chairman and secretary of the Board will hold office for three years at a time and the chairman will not hold office for more than two consecutive terms.

An ordinary member of the Board may, if necessary, be represented by an alternate at any Board meeting provided prior notice to this effect has been given to the secretary of the Board in writing.

In the absence of the chairman and/or of the secretary at a Board meeting, the members present will elect from their own ranks, an acting chairman and/or secretary to officiate at the meeting.

b) Voting within the Board of the Division of Botany and Mycology of the IUBS

Each member of the Board will have one vote. A motion will be carried by a simple majority of the votes cast provided that at least 2/3 of all the Sections of the Division participated in the voting and that the majority of them also voted in favour of the motion.

c) **International Botanical Congresses**

The Board will ensure that the body sponsoring the next International Botanical Congress sets up an organizing committee for that Congress in a timely fashion, and that the requisite procedures for arranging the following Congress and for consideration of resolutions are observed.

The Board of the Division of Botany and Mycology also unanimously decided to submit the following resolution to the General Assembly of the Congress :

Resolution on the future organization of botanical activities within the IUBS

Considering

(a) the present role of the botanical scientific community in selecting representatives to the Executive Committee of the IUBS as inadequate.

(b) the virtual lack of defined functions for the Board of the Division of Botany and Mycology as being a major cause for the lack of liaison between the scientific community of the Division and the IUBS Executive Committee.

Resolves to urge the IUBS to

(a) maintain the present Division of Botany and Mycology in any proposed restructuring of the IUBS.

(b) refrain from creating new Divisions until their impact on the existing Divisions and adhering bodies has been fully considered.

(c) recognize the Chairman of the Division of Botany and Mycology as the voting representative of the Division on the Executive Committee of the IUBS.

(d) delegate to the Board, the budgetary responsibility for the Division of Botany and Mycology.

Although this motion was carried unanimously at the General Assembly of the Congress, the Executive Committee of the IUBS during its subsequent 1981 meeting, unfortunately decided not to consider it until the final recommendations of the IUBS Ad Hoc Committee of Review have been considered by the 21st General Assembly of the IUBS in Ottawa during August, 1982. Should the recommendations of the Committee of Review be adopted, the Divisional structure of the IUBS will be abolished and therefore make the above decisions irrelevant. Should the General Assembly, however, decide to maintain the Divisional structure of the IUBS, the decisions above which were taken at the 13th International Botanical Congress would become relevant and would therefore be considered.

Other resolutions which were approved by the General Assembly of the Botanical Congress include the following :

1. Resolutions for a Global network of virgin tropical forest preserves :

The XIII International Botanical Congress notes with concern the rapid conversion to commercial exploitation of virgin tropical forests throughout the world. In view of the exceptionally high species richness of many; in view of the highly specialized requirements for reproduction, and the unique and intricate biological interdependences, of the species components; and in view of our ignorance of the means to manage these forests on a sustained and productive basis, it is urgently recommended that the *IUBS be requested* to consider ways and means to institute the establishment of a global network of strict preserve of virgin forest, each of adequate size and together containing adequate representation of all important community types, for research and genetic conservation.

2. Resolution on setting up a Decade of the Tropics programme :

The destruction of the tropical biota resulting from increasing population pressures and industrial and agricultural development in the tropics has been documented repeatedly. The tropics contain a much greater diversity of species and life forms of plants and animals than do the temperate regions. Scientific knowledge of these species is however, highly rudimentary. At present only a fraction of species have been named and very few have been investigated for their biochemistry, genetics, or potential economic value. The tropics nevertheless furnish a variety of economically useful and unique natural products from woods to compounds of pharmaceutical importance. It is possible that by the end of this century many of those species may become extinct, depriving humankind of potentially useful products, as well as an opportunity to investigate processes and structure that may not be found anywhere else. It is imperative that research efforts be mounted to study these species, as well as efforts to slow down their destruction. At present there are several international, national and individual projects to study the tropical biota, such as the Man and the Biosphere project under the auspices of the United Nations. Such effort must be encouraged and publicized, as well as the plight of the tropical biota.

Consequently the XIII International Botanical Congress resolves :

a) **That the International Union of Biological Sciences** consider the establishment of a programme aimed at publicizing the problems posed by the destruction of the tropical biota; and the encouragement and facilitation of tropical research by individuals, groups, and national bodies. This programme to be known as the "Decade of the Tropics".

b) **That the International Union of Biological Sciences** communicate to ICSU (International Council of Scientific Unions) its intention to set up a "Decade of the Tropics" for further transmission to the United Nations in order to obtain the widest possible support.

3. Mediterranean Ecosystems

The XIII International Botanical Congress appeals to governments and scientists of all nations in the regions of the world with Mediterranean climates, to encourage ecological (in particular ecosystem and ecophysiological) research, as a basis for management and conservation of Mediterranean ecosystems, all of which have been considered under extreme threat by the International Union for the Conservation of Nature in its *"World Conservation Strategy"* (launched internationally, early 1981).

4. **Concerned** at the rate of destruction of the natural vegetation in many parts of the world often before adequate botanical survey has been carried out,

Aware of the fundamental importance of plants to the survival of other living creatures and the maintenance of healthy land,

Recognized the possible potential value of many plants not yet named or even discovered,

The XIII International Botanical Congress :

Urges continued and expanded support by Governments and appropriate United Nations agencies for :

- botanical survey and taxonomic study leading to a greater understanding of the world's flora.
- the establishment of representative habitat reserves.
- the introduction of appropriate protective legislation and incentives for flora conservation.
- public and private organizations such as International Council for the Conservation of Nature, World Wildlife Fund, botanic gardens, nature conservation authorities and other bodies engaged in flora conservation.
- public education and awareness of the importance of plants for human cultural and economic development.

5. Global Mapping of Earth Vegetation

The XIII International Botanical Congress :

1. Finds that global mapping for the first time of the existing plant cover of the earth by direct observation with orbiting satellites would be of significant scientific value.

2. Therefore, resolves that a committee of the Division of Botany and Mycology of the International Union of Biological Sciences be asked to establish global mapping or earth vegetation to define reasonable objectives considering potential problems and their possible solutions, and further, to organize a special international symposium to evaluate available scientific and technical resources and represent other interests of world institutions and nations.

6. Rainforest Resolution

Considering the benefits to man of rainforests as a valuable reservoir of useful plants, as a means of protecting water catchments, and as a living part of the world's heritage.

Bearing in mind that rainforest is disappearing at a rate of 70,000 ha/day (or an area the size of Great Britain each year).

Realizing that 2 million of the earth's possible 5 million biological species stand to become extinct because of rainforest logging.

The XIII International Botanical Congress urges the governments of the world to make rainforest conservation a national priority.

To this end the XIII International Botanical Congress urges the government of Australia to make an example of rainforest conservation in the South-East Asian Region by immediate protection of its small but scientifically important rainforests.

7. Resolutions

Realizing that all manners of ecodisasters loom large in Man's and Nature's future, the Symposium on Plants and our Environmental Future (of the XIII International Botanical Congress) resolves that the education of people in environmental awareness and care throughout the world has to be extended and intensified, and to such ends the declaration of the World Decade of the Biosphere, 1982-92 should be supported in every possible way.

First World Congress of IBRO

Under the general heading of "The Brain in Health and Disease", the first international Congress of IBRO was held in Lausanne (Switzerland) between March 31 and April 6, 1982. More than 1300 scientists from 50 countries met to discuss the progress made in the study of the central nervous system with its tremendous complexities of structure and function. This analysis was developed in 9 general conferences and 28 symposia which covered the most basic to the more applied aspects, such as those of the biology of schizophrenia, demyelinating, neuromuscular and parasitic diseases as well as tumors of the nervous system. The most recent progress in research was presented in more than 700 posters which covered the many integrative studies that are being held on the brain.

The congress was preceded by a three-day meeting of the Executive and Central Councils of IBRO in which the many activities of this organization related to UNESCO were reported. Among these, the most important are : the workshops, mainly held in developing countries; the symposia that are partially supported by IBRO; the fellowship program and the important publication activities. These publication activities include *The IBRO News, The Series of Symposia,* a series on *Methodology in Neurosciences* now starting, and the very important international journal *Neuroscience,* demonstrate that IBRO is very active in disseminating knowledge and promoting research on the brain, the central organ that controls all human and animal activities.

The Second Arab Scientific Conference of Biological Sciences

Sponsored by the Arab Biologists' Union, the Second Arab Scientific Conference of Biological Sciences was held from March 17 to 20, 1982 at the Faculty of Sciences, Fès, Morocco.

The participants included biologists representing the following countries : Algeria, Egypt, Jordan, Iraq, Kuwait, Lebanon, Morocco, Saudi Arabia, Syria and Tunisia. 277 research papers, divided into four groups of basic biological sciences, medical sciences, veterinary, and agricultural production, were presented and discussed.

Dr. M. Clor of the UNESCO Regional Office for Science and Technology in the Arab States, and Dr. T. Younès, Executive Secretary of the IUBS attended the conference and participated in a meeting of the executive board of the Arab Biologists' Union.

At the executive board meeting, the establishment of an Arab Biosciences Network was discussed, and an agreement in principal was reached as to the organization of a symposium on "the State of Biology in the Arab States" in Baghdad, Iraq, late 1983.

The conference was considered to be a beneficial success as to the promotion and coordination of biology in the Arab States.

21st GENERAL ASSEMBLY - IUBS

PROGRAMME

August 22 - 28, 1982
Carleton University, Ottawa, Canada

Sunday, August 22

12:00 - 20:00 — Registration (University Residence).
18:00 - 20:00 — Reception (Lounge, University Residence).
20:00 — Dinner (Green Room, University Residence)

Monday, August 23

08:00 - 10:00 — Registration (University Residence).
10:00 - 12:30 — Opening of the General Assembly (Theatre A, Southam Hall) :
- Welcoming Address by the Chairman/Canadian National Committee for Biological Sciences, Professor W.A. Fuller.
- Address by the President/National Research Council of Canada, Professor L. Kerwin.
- Address by the President/International Union of Biological Sciences, Professor E. De Robertis.
- Address by the Honorable J. Roberts, Minister of State for Science and Technology.
- Plenary Lecture by Professor O.T. Solbrig (Harvard University, Cambridge, MA, U.S.A.) - "Decade of the Tropics".

12:30 - 14:00 — Lunch (University Residence).
14:00 - 17:30 — Plenary Sessions (Great Hall, Unicenter) :
Report of the President, Professor E. De Robertis.
Approval of the Proceedings of the XX General Assembly.
Adoption of the Agenda.
Report of the Secretary General, Professor E.S. Ayensu.
Report of the Treasurer, Professor E.S. Ayensu.
Reports of National Members.
Reports of Scientific Members.
Appointment of Ad Hoc Committees, Working Groups and Tellers.
17:30 — Dinner.
20:30 — N.R.C. Reception (National Arts Centre).

Tuesday, August 24

09:00 - 12:30 — Plenary Session (Great Hall)
Report of the Ad Hoc Committee of Review by Sir Otto Frankel.
12:30 - 14:00 — Lunch.
14:00 - 17:30 — Working Sessions, Plenary and/or Groups.
17:30 — Dinner.
20:30 - 22:00 — Plenary Lecture (H.M. Tory Theater), "Forestry - A Global View", by Professor B. Zobel (North Carolina State University, U.S.A.).
22:00 — Post-Lecture Reception (Tory Foyer).

Wednesday, August 25

09:00 - 17:00 — Symposium (Tory Theater), "Biology of the Northern Oceans", jointly presented by N.R.C. and the Royal Society of Canada.
17:00 - 18:30 — Post-Symposium Reception (Tory Foyer).

Thursday, August 26

09:00 - 12:30 — Working Sessions, Plenary and/or Groups
Reports of the Ad Hoc Committees and Working Groups.
12:30 - 14:00 — Lunch.
14:00 - 18:00 — Symposium, "Environmental Education through Biological Education", organized by the IUBS Commission on Biological Education.
20:00 — Evening Lecture, a topic in molecular biology.

Friday, August 27

09:00 - 12:30 — Working Sessions, Plenary and/or Groups.
12:30 - 14:00 — Lunch.
14:00 - 17:30 — Plenary Working Session.
18:00 - 20:00 — Reception (University Residence).
20:00 — Banquet.

Saturday, August 28

08:00 — Breakfast.
— Departure of Delegates.
10:00 — Executive Committee Meeting.

Scientific Symposia

I. SYMPOSIUM ON BIOLOGY OF NORTHERN OCEANS

August 25, Wednesday

As a highlight of the General Assembly, this symposium, jointly sponsored by the National Research Council of Canada and the Royal Society of Canada, is being organized by Drs. Max Dunbar of McGill University and William Fuller of the University of Alberta. The tentative programme is as follows :

— Overview and Introduction, Including Primary Production and Climatic Change - M.J. Dunbar, Institute of Oceanography, Montreal, P.Q.
— Dynamics of Ice Edges - O.M. Johanessen, U.S. Navy, Monterey, CA.
— Marine Ecosystem Patterns - C.P. McRoy, University of Alaska, Fairbanks, AK.
— Polynyas and Marine Life - I. Stirling, Environment Canada, Edmonton, Alta.
— Invertebrate Life Cycles in Arctic and Subarctic Water - O.A. Skarlato, USSR Academy of Sciences, Leningrad, USSR.
— Zooplankton in the Arctic Ocean - E.H. Grainger, Fisheries & Oceans, Ste Anne de Bellevue, P.Q.

— The Micro-organic Level in Northern Seas - J.N. Bunch, Fisheries & Oceans, Ste Anne de Bellevue, P.Q.

— Oil in Cold Water - D. Mackay, University of Toronto, Toronto, Ont.

This symposium will be published as part of the Royal Society Symposium Series.

II. SYMPOSIUM ON ENVIRONMENTAL EDUCATION THROUGH BIOLOGY

August 26, Thursday

This symposium, organized by the IUBS Commission for Biological Education in cooperation with the UNESCO/UNEP International Environmental Education Programme, strives to accomplish the following :

— To review current types of activities in environmental education, especially those in developing countries and relevant to the UNESCO/UNEP programme.

— To define key issues in environmental education for which biology has an especial significance, particularly in developing countries.

— To explore practical ways in which professional biologists can cooperate with educators in environmental education.

— To develop guidelines for the preparation of teaching and learning materials, and for other future activities involving the IUBS/CBE as well as other members of IUBS.

For further information on this symposium, please contact :

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III. PLENARY EVENING LECTURES

Internationally recognized researchers will be invited to speak on topics such as :

— August 24, Tuesday
"Forestry - A Global View"
B.J. Zobel, North Carolina State University, U.S.A.

— August 26, Thursday
A topic in molecular biology.

Financial Statements of IUBS for the Year 1981

Statement 1. Balance sheet at December 31, 1981 (in US Dollars)

ASSETS

Cash and Banks		
Petty Cash	47	
The Chase Manhattan Bank - Frankfurt Main in US $	96 450	
The Chase Manhattan Bank - Paris in US $	11 075	
The Chase Manhattan Bank - Paris in FF	3 151	
Amro Bank Utrecht, in Dutch Guilders	5 898	
Deposit Account - Paris, in US $	50 000	
		166 621
Other Assets		
Marketable securities (market value 9 423)	12 030	
Other receivables	14 881	
Loans	4 000	
		30 911
		197 532
Less : Liabilities		
Sundry Creditors		15 999
Contingent liability		—
Excess of assets over liabilities		181 533
Represented by		
Accumulated Fund		181 533

Statement 2. Income and expenditure accounts for the year ended December 31, 1981 (in US Dollars)

1. Income			
ICSU/UNESCO Basic allocation		9 600	
ICSU Subvention		5 000	
UNESCO grants for Scientific Meetings		13 200	
Contributions from National Members		162 800	
Interest and dividends		10 967	
Gain on exchange		(1 776)	
Other income		1 368	
	Total Income		201 159
2. Expenditure			
A. Meetings			
General Assembly and Executive Committee Meeting		8 792	
Officer's Meeting		7 942	
Representation at Meetings		11 569	
			28 303
B. Publications			7 272
C. Scientific Activities			
Grants to Scientific Meetings		20 500	
Support scientific activities		18 042	
Contributions to other Scientific Organizations		5 184	
		—	
			43 726
D. Administrative Expenses			
Offices of the President and Secretary		2 000	
Salaries		37 836	
Related charges		26 043	
General office expenses		10 566	
			76 445
E. Other			
Bank charges		620	
Audit fees		1 462	
			2 082
	Total Expenditure		157 828
Excess of Income over expenditure			43 331
Accumulated balance brought forward			138 202
Accumulated balance carried forward			181 533

PUBLICATIONS REVIEW

BIOLOGY EDUCATION FOR THE NEXT DECADE

Proceedings of the 8th Biennial Conference of the Asian Association for Biology Education (AABE), October 26 - November 1, 1980.
Edited by Kozo Imahori, R.A. Kille and Yutaka Koshida. (451 pages).

The content is a compilation of papers presented to the AABE Conference co-organized with the IUBS Commission for Biology Education. Topics covered include linking biology to social studies, using living organisms for field study and laboratory work, environmental education, biology education, teacher's education, educational evaluation, educational technology and biological technology.

FISH GENE POOLS

Preservation of Genetic Resources in Relation to Wild Fish Stock.
Edited by N. Ryman, 1981. (112 pages).

This issue of Ecological Bulletins includes papers presented to the International Symposium held in Stockhom, 1980, to discuss the various aspects of the prevention of genetic erosion of naturally occurring fish populations which are under the influence of human activities.

FOOD FOR ALL IN A SUSTAINABLE WORLD

Edited by Kirit Parikh and Ferenc Rabár, 1981. (250 pages).

A summarization of the material presented to the Status Report Conference of the Food and Agriculture Programme/the International Institute for Applied Systems Analysis (IIASA). Held in February 1981, the purpose of this conference was to communicate research results, to describe present activities and the consideration of topics for future research.

HUMAN EXPERIMENTATION AND MEDICAL ETHICS

Edited by Z. Bankowski and N. Howard-Jones, published by the Council for International Organizations of Medical Science (CIOMS), 1982. (505 pages).

This volume consists of the proceedings of the XVth CIOMS Round Table Conference in Manila, 13-16 September, 1981. The conference was jointly organized by WHO, the National Research Council of the Philippines and the Philippines Medical Association to discuss the proposal of the international ethical guidelines for bio-medical research involving human subjects, a document prepared by the WHO/CIOMS joint project initiated in 1978.

MUSHROOM SCIENCE XI

Proceedings of the 11th International Scientific Congress on the Cultivation of Edible Fungi, Sydney, Australia, 1981.
Edited by N.G. Nair and A.D. Clift.

Part I of the Proceedings (766 pages) contains papers contributed to the general sessions of the congress mainly concerned with species of Agaricus and oriented to growers. Part II (905 pages) consists of papers presented to the scientific sessions dealing with Agaricus species as well as other genera and species of edible mushrooms.

NATIONAL LIST OF SCIENTIFIC PLANT NAMES

1982 edition, United States Department of Agriculture. (854 pages).

Published for the first time in 1971 by the US Department of Agriculture's Soil Conservation Service, the *National List of Scientific Plant Names* (NLSPN) has been useful for preparing technical guides/handbooks, soil surveys, abstracting research documents and coordinating plant testing programmes.

The 1982 edition has been divided into three categories : the Caribbean region, Hawaii and the 49 continental United States and Canada. A volume of synonyms is also included.

THE RYTHMS OF LIFE

Edited by E.S. Ayensu and Ph. Whitfield, published by Marshall Editions Ltd., 1982, (199 pages).

Highlighted with descriptive photos, drawings, graphs, and easy, comprehensible prose, this book explores the whole of nature through the expression of life rhythms. Growth, sex, sleep, nutrition, respiration, motion, fate, health and disease are all explored as well as daily, seasonal and cosmic rhythms of life. This edition is oriented to those interested in the world and the various life patterns of its inhabitants.