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Hunt Institute was dedicated in 1961 as the Rachel McMasters Miller Hunt Botanical Library, an international center for bibliographical research and service in the interests of botany and horticulture, as well as a center for the study of all aspects of the history of the plant sciences. By 1971 the Library's activities had so diversified that the name was changed to Hunt Institute for Botanical Documentation. Growth in collections and research projects led to the establishment of four programmatic departments: Archives, Art, Bibliography and the Library.

ask - V.H. to get.
Nat'l Wildlife Federation (in D.C.)
→ Conservation Directory
Fed, State, Private -
Agency -

I think it necessary to "educate the public" on the many variations within species of nearly all important forms of life, as a part of our report (or recommendation).

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1975

PLANT GERM PLASM RESOURCES--
FUTURE FEAST OR FAMINE?

The collection, maintenance, study, and use of vanishing populations is critical: Maize, an example.

by

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In meeting the demands of increasing population and industrialization, society has reduced the array of food production options to an alarming degree. It has been estimated (1) that man has used over 3000 species of plants for food, and cultivated about 1500 species in sufficient quantity to have entered into commerce. The same authority states that about fifteen species actually feed the world. "These include five cereals: rice, wheat, corn, sorghum and barley; two sugar plants: sugar cane and sugar beet; three 'root' crops: potato, sweet potato, and cassava; three legumes: the common bean, soybean, and peanut; and the two so-called tree crops: The coconut and banana."

More startling is the computation from world production figures (2) for wheat, rice, corn, barley, sorghum, oats, rye, the various millets, buckwheat, mixed grains, miscellaneous cereals, beans, peas, broad beans, lentils, chick peas, pigeon peas, cow peas and all the other pulses, and the edible oilseeds such as soybeans, peanuts, sesame, rape, and sunflowers, which reveals that just three crops -- wheat, rice, and corn -- produce over 66% of the world's seed crop. Thus, the fate of millions hangs thread-like on the precarious balance of genetic systems between these three crops and their diseases and pests, and their interactions with their environments.

Two of these crops, rice and wheat, are identified with the so-called Green Revolution. The developmental concepts and research efforts of the Green Revolution, slightly modified, are being used with the third crop, corn. That these efforts have increased food production is undeniable, but they have compounded the problems of increased genetic uniformity and the obliteration of genetic variability. The success of the new cultivars associated with the Green Revolution is destroying the genetic variability which makes success of such programs possible (3). Genetic resources are also being lost by increased grazing pressure, abandonment of old farming systems, and various developmental processes of a burgeoning population. These pressures have destroyed,

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and will continue to destroy, sources of as yet unknown but very valuable genes necessary for future plant improvement. The gradual loss of germ plasm is usually referred to as genetic erosion, but the term of genetic wipe-out (4) is more appropriate and less euphemistic. The wipe-out is occurring not only in wheat, rice, and corn, but in hundreds of species. If it continues, we place man's future in serious jeopardy. Our only recourse is to assemble gene pools and preserve genetic resources in germ plasm banks.

Arguments for germ plasm preservation usually have a chromosomal basis (5), e.g., differences are due to additions, deletions or substitutions of DNA segments on a chromosome, or differences are due to additions, deletions or substitutions of multiple or partial chromosome sets. Unfortunately, the importance of cytoplasmic or extra-nuclear variation has been generally overlooked. The precise nature and location of cytoplasmic factors which control extra-nuclear inheritance of higher plants are not known, as they have not been been directly correlated with genetic activity of mitochondria and chloroplasts of single-celled organisms (6). However, the southern corn blight epidemic of 1970 vividly illustrated the important differences of cytoplasm (7). Uniform cytoplasms are not only a potential hazard in plantings which utilize male sterility, but also in those wide-spread varieties derived from a common female background. Variability of cytoplasms has not been studied, per se, but, from studies associated with cytoplasmic male-sterility, there is ample evidence that variation exists. Cytoplasmic sterility is a useful phenomenon, and yet its occurrence in natural populations is poorly known and poorly understood.

Gene Pools

The concept of a gene pool is a simple one. It is really nothing more than an assemblage of viable genetic variability. It is from such assemblages that man has been able to select genes which modify plants in a manner which

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man deems undesirable. As with most simple concepts, the context in which it is used requires some definition, explanation, and restraint. In particular, the gene pool of the population biologist is often quite different from that of the plant breeder. The gene pool of the evolutionist or population biologist is usually the total genetic wherewithal within a taxonomic unit, albeit a genus, species or variety (8), whereas, the gene pool of the plant breeder is usually much more limited in scope.

A gene pool, in most instances of current plant breeding and germ plasm conservation usage, generally connotes the genetic variation of a population with at least a modicum of intermating, put together and maintained for some purpose other than maintaining the distinctive characteristics and genetic integrities of the individual components. Thus, gene pools, to many a corn breeder, are his private stocks of intermating populations, to which additional material is often added. A gene pool is his source of new variation. It may be composed of locally adapted commercial types. It may be composed of local and exotic material or it may be all exotic. To breeders of self-pollinated crops, a gene pool might be a large bulked population composed of many different kinds of material. It may be a population composed of segregating descendents from any sort of artificial hybridization, or it may have a built-in system of intermating by using male sterility. A gene pool is also commonly identified in terms of immediacy by one who proposes to assemble it or to extract something from it. A gene pool can be many things: the Stiff Stalk Synthetic of Corn-Belt maize; the genetic marker stocks of maize endosperm mutants - perhaps for isolating high lysine content; the short stiff-strawed Mexican wheats; the wheat, soybean, or alfalfa varieties grown in this country 40 years ago; the extant collection of indigenous maize varieties of the Americas; the wild and weedy populations of wheat in the Middle East; a wild species of lintless cotton from a Mexican arroyo; a sample of pine trees

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from the Caribbean; seed from a small grain field in Ethiopia; a grove of fruit trees on the Crimean hillside; the cytoplasms in a collection of a wild Mexican grass. Each of these is an example of a gene pool.

Each gene pool contains a gene or group of genes which may or may not exist elsewhere. Perhaps of more importance are the arrangements of certain genes on individual chromosomes, their balance with those on other chromosomes, the stability of that whole chromosome structure, and the function of that structure in the gene-cytoplasm interactions. The population structure of primitive cultivars or landraces and their related wild and weedy species is a highly integrated system of genetic and environmental balance. It is to these gene pools that man has continually turned in the search for genetic material to improve his foodstuffs. It is to these gene pools that he must turn for present and future plant breeding needs. For millenia, these populations, subjected to natural and artificial selection, have served as conservatories of the heredities of our plant resources.

Crops, Wild Species, and Weeds

Somewhere in the haze of antiquity man began to select and domesticate plants, apparently as a series of independent happenings in widely separated areas (9). Archeological and botanical evidence indicates great amounts of initial variability during the first stages of domestication followed by increasing phenotypic uniformity as the crop became increasingly domesticated (10). Periodic infusions of new germ plasm from wild or related species and cultivars released new genetic combinations, sometimes in an explosive display of diversity. Selection among the myriad offspring of this array often resulted in enormous jumps of productivity and, within any given locale, a gradual return to visual uniformity.

Man in his travels and migrations carried his foods from one region to another. Throughout this process the plant was continually subjected to the

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rigors of the environment into which it had been thrust. On top of such natural selection, man also imposed his own selection criteria for certain characteristics. The interaction of man, the plant, and the environment went on for hundreds and hundreds of years. Thus, for any one species, certain varieties developed in one region, while other similar but distinct varieties developed in other regions. These varieties are called primitive cultivars, indigenous varieties, races, farmer varieties, or landraces. The characteristics of these were and are as varied as their uses, the people that grew them, and the environment in which they were grown. The enormous stores of genetic variability contained in the landraces are now being lost at a continually increasing rate.

Wild species are important as occasional and natural genetic contributors to cultivated crops, and also as possible progenitors of the economic species. Our understanding of how and from what our food plants originated is vague in most instances, but is becoming more clearly understood in others. Interest in the origin of crops is more than academic. In some cases, the immediate predecessor from which the cultivated species evolved is extinct, but the primeval source may still be extant. Some may have evolved as a polyploid derivative of one or more species, others may be simple diploids, and some may have arisen from weeds of a different crop.

Origins are sometimes complex, but once understood, illustrate an evolutionary road map. By following those same pathways, artificial hybridization can often be used more easily to bring a desired gene from the ancestral wild species into the cultivated relative than from a more distant relative. The substituted chromosome carrying the gene from the wild relative will have additional genes which are undesirable in an economic plant. Breaking that linkage and recombining the alien gene into the appropriate chromosome of the economic species would be easier if the chromosomes were reasonably homologous.

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Other things being equal, a putative parental species would be used for gene transfer rather than a more distantly related relative. However, the use of wild relatives is not restricted to the parents. Related and distantly related species have been used in a number of ways to transfer desirable characters to wheat, cotton, tobacco, and rice (11).

The weedy relatives are associated with landraces. They are at various stages of intermediacy between the cultivar and its wild relative. They may accommodate gene exchange in either direction. The variation of a weedy population can be enormous. One segment of the population may mimic the landrace at a particular growth stage, another segment will flower at the same time as the cultivar, while yet another may be easily spotted as closely resembling the wild plant (12). Continued association, gene exchange, and selection of cultivars and their weedy relatives has resulted in weedy populations which assume racial properties. They are highly integrated genetically and buffered cytologically. The blocks of genes from wild and cultivated parents have been broken down through long periods of time by various recombinations of the wild and cultivated genes.

Sterility of hybrids between weedy and cultivated forms is not as severe as that often encountered in crossing wild and cultivated species (13). The value of weedy relatives has been grossly overlooked, and their exploitation for improving cultivated plants is practically non-existent. Most often collectors tend to by-pass them for cultivated varieties and wild species. Even worse, most plans for the collection and preservation of term plasm do not include the weedy forms.

The populations of landraces and their wild and weedy relatives are in states of dynamic equilibrium. They are genetically balanced with the environment. This allows the frequencies of various portions of the populations to ebb and flow in response to natural selection pressures. The greater the

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diversity of the population, the more plastic its response.

The basic population structure is determined principally by the mode of reproduction (14). Individuals in the cross-pollinators are generally in a highly heterozygous state, and each plant of the population is essentially distinct from all others. The self-pollinators are composed of great numbers of homozygous individuals with many identical plants. The self-pollinators have appreciably more diversity, and especially more heterozygosity, than is often realized (15). There is usually a small percentage of out-crossing, and although the return to homozygosity is rapid, occasional out-crossing permits a continuous source of new recombinations, first as segregating heterozygotes and then as a series of stabilized homozygotes. Some species -- cotton and sorghum, for example -- are intermediate in their mode of reproduction, and have characteristics common to self- and out-crossing species.

Asexual species are of a special nature, but they may contain tremendous stores of variability. Their variability is released by occasional out-crossing to nearby related and sexual species, or by a rare breakdown of asexual control and the subsequent completion of fertilization (16). In addition to its relationship to population structure, the mode of reproduction affects collecting or sampling techniques and maintenance of germ plasm (17).

Previous Collections: Good and Bad

With a few exceptions, our past efforts at plant collection have been extremely pragmatic. The collections were sporadic, unsystematic, poorly funded, and usually the effort of a few men racing against time. Too often, we responded as a reaction to a specific need. An expedition would be organized, collections made and distributed to researchers, who would hopefully isolate the resistant gene to be incorporated into breeding material, and then the collection would be discarded. When the next crisis occurred, we went through the same orchestrations. The wild and landrace populations were considered as everlasting

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founts. The concept was, of course, erroneous. The complete disappearance of wild populations and landraces from areas of thousands of square miles is being documented repeatedly. Much of the variability from those areas has been lost. In some cases it all would have been lost, had it not been for all-too-few far-sighted efforts to collect some of that germ plasm. An excellent example would be the corn varieties which preceded the famous Corn Belt hybrids.

Fortunately, we don't operate in a complete vacuum. We do have many thousands of individual collections of our major crops. For example, the world collections may contain 26,000 to 30,000 wheats, 14,000 to 15,000 sorghums, 12,000 to 14,000 rices (4, 18) and maybe 1000 or so finger millets. The USDA wheat collection contains over 19,000 accessions, mostly assembled since 1948 because the original collections were lost (7). The U. S. peanut collection contains approximately 15,000 entries, while cotton and soybeans number around 3,000 and 2,000 respectively (19).

Individual researchers are the principal agents in maintaining significant portions of these collections. Most of the wild and related species are maintained, as are the cytoplasmic, chromosomal, and genetic marker stocks, at the individual discretion, effort, and initiative of a handful of persons. None of the states has a suitable arrangement for the maintenance of germ plasm on a broad scale. The National Seed Storage Laboratory at Fort Collins is not expected to fill the need for some time to come, if ever (20). Recent reorganization of the USDA, aside from its benefits, has demolished national leadership pertaining to specific plants. The newly organized Plant Germ Plasm Coordinating Committee of the USDA Germ Plasm Resources Laboratory will provide a State-Federal forum for considering matters of mutual importance, apparently with appreciable consideration given to U. S. Regional needs as well as to national needs (21). It remains to be seen if the new organization will permit the high level of performance which is needed. Although those associated with the

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former Plant Introduction Service and the New Crops Research Branch have done their utmost (22), they have been severely limited by several inadequacies. Most of forage collections, for example, were and are maintained at various USDA Plant Introduction Stations. Many of these are cross-pollinated. Yet, the Plant Introduction Service was forced to plant these collections in short rows, one collection beside another, and allow fertilization to occur without pollination control. A collection originating from Turkey may then be fertilized by others from Greece, Spain, Algeria, or France. The researcher subsequently trying to use that collection will have no idea of what kind of material he is really working with. If he is trying to locate geographical sources of certain genetic characters, he is beaten before he starts. This is not a condemnation of the Plant Introduction personnel. They are dedicated people. They do the best they can with inadequate funding, inadequate facilities, and inadequate numbers of professional and sub-professional personnel. It's the same story in most areas of the world.

Appreciable portions of these collections are redundant. They may have gone around the world several times, with intervening stops at various experimental stations. Each time they reenter this country they are given a new accession number. Many were collected over periods of years from the same area, sometimes at the same site. The collection areas were limited to those politically accessible, and often times along roads which were the shortest distance between cities containing the creature comforts of life. Now, there is nothing wrong with this, but it does create a false sense of security when collections are considered in terms of numbers only. Our samples of germ plasm are genetically much narrower than their numbers would indicate at first glance. Even at second and third glances, the documentation and peregrinations of many of the collections preclude tracing them to their geographical origin. In addition to the redundancies of the collections, there are geographical and

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evolutionary voids.

A systematic collection is needed. In short, the natural variation of a crop and its relatives must be sampled. This means that we must be concerned about that variation, the areas in which it occurs, to what degree, and of what kind. It matters little if these areas are referred to as Vavilovian centers of origin, areas of diffuse origin, centers of diversity, microcenters, or whatever. What matters is that the variability within those areas be maintained. However, there are problems in doing that. A brief illustration of the situation with corn might be helpful.

Maize and Its Relatives

There is good evidence that at least one kind of cultivated corn originated in the Tehuacan Valley of Mexico (23). To date, there is no other archeobotanical evidence indicating a different site of origin. For several thousand years, the small cobs of this primitive plant, now extinct, sustained its cultivators. Then the primitive corn began to accumulate new characteristics, presumably from hybridizing with a related wild grass, teosinte, and to assume the proportions of present day landraces. However, Corn Belt corn originated in the Corn Belt from types imported from neighboring regions and the center for that kind of diversity was in the Corn Belt (24). Some of that germ plasm is preserved in collections made from farmers' fields several decades ago.

The area of origin and diversity of Andean corn is along the Andes Mountains, an immense, diffuse ribbon of widely different and separate habitats. Andean maize is easily recognized as Andean, yet it contains a vast amount of variability, readily observable as a conglomeration of distinct and widely divergent races (25).

A center of diversity of popcorn is found in the Assamese foothills of the Himalayas (26). Popcorn, and certainly maize, did not originate in Assam, but that is a center of diversity, nonetheless.

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Today in the Valley of Mexico, teosinte, the same species that originally contributed to maize evolution, is found as a weed in maize fields. Its reproductive isolation from maize is not complete, and so a small percentage of hybrids and backcrosses are generated each season. These fields are microcenters of evolutionary activity between a crop and its weedy relative. Other forms of teosinte are also found in different regions as a wild plant, and not intimately associated with the cultivated crop (27). Teosinte has distinct races, and its distribution is limited to Meso-America. All described races are annual. The tetraploid perennial species is extinct, except for individual plants grown in greenhouses and experimental gardens.

Tripsacum, the other relative of maize, is perennial, and can be crossed experimentally with maize. Its role in the evolution of maize is not clear, although it may be associated with certain characteristics of South American maize. The nine described species of tripsacum form a polyploid series which is found in certain habitats from Connecticut to Paraguay (28).

It has only been in the last ten years that a reasonable collection of the maize relatives has been attemped. A fairly systematic collection of teosinte is now in hand (29), but the tripsacum collection is probably less than 1000 plants. These collections were made by students of maize with sporadic funds from philanthropic or granting agencies, and have been maintained under all manner of cooperative word-of-mouth agreements among the interested scientists. Only during the last two years has any institutional interest with suitable facilities and long range probabilities been indicated.

Maize Collections, Races, and Maintenance

When Wellhausen and his colleagues began the cooperative corn program of the Mexican Government and the Rockefeller Foundation, they began by collecting the local varieties of corn. These were to be the basis of the breeding program. The collections soon became a hodgepodge of incomprehensible

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variability. To bring order out of chaos the indigenous strains were classified into races and the study was published as the "Races of Maize in Mexico" (30). This classical example was followed by a series describing the races of maize in South America, the Caribbean, and Central America (25,31). From some 11,000 collections of indigenous varieties in the Western Hemisphere, over 280 races of maize were described. The races were described on the basis of morphological, physiological, genetical, and geographical characteristics, and, in some cases, cytological and ethnobotanical information. It was intended that the racial descriptions be preliminary and that they serve as a logical starting point for additional studies of maize, its evolution and utilization.

The Andean collections were made by obtaining 10 to 15 ears of each sample from farmers' fields and houses, granaries, and market places. The ears were sent to Medellin, Colombia, where they were cataloged, documented, and measured for numerous characteristics. The ears were shelled. However, three ears of each sample were retained as museum specimens, and only two rows of grain were removed from them. These large samples of seed were put into cold storage for maintenance. As an additional precaution against loss, smaller duplicate seed samples were put in cold storage at Medellin and also sent to the seed storage center at Glenn Dale, Maryland, maintained by the Division of Foreign Plant Introduction of the USDA.

The inadequacies of the Medellin storage facilities were alleviated over a ten-year period. In the meantime, it was periodically necessary to rejuvenate the seed stocks to maintain germination. It must be remembered that corn is cross-pollinated and heterozygous. The integrity of the collection could be lost very quickly by natural selection, a small number of plants involved in the increase, or improper pollinating procedures. Attempts to prevent genetic loss were made by using careful pollinating techniques in populations as large as possible, using open-pollination in large blocks spatially isolated from

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other maize, planting single collections on three separate dates to allow for differences in flowering, planting at appropriate altitudes, and sending the long-day responsive stocks to Mexico or Iowa. There were some genetic shifts, and there were some losses of complete samples, but by-and-large the effort was successful. The effort was also extremely costly in terms of manpower, money, and the use of experiment station facilities. It was apparent that the operation of the cooperative Colombian Government-Rockefeller Foundation corn improvement program and the maintenance of the individual samples of the Andean Maize Germ Plasm Bank could not continue at the same level of operation.

The indigenous strains of maize from each of the Andean countries had been classified into races, and the decision was made to begin forming racial composites of the individual strains according to that biological classification (the material from Chile and Peru excluded). It was also decided that certain of the individual strains of each race should be maintained individually. The procedure was initiated with the collections comprising the races of maize in Colombia. From among all the collections from that country designated as representative of a race, usually three to five strains were chosen as "type" or "typical" examples of that race, and these were individually maintained and increased. Taxonomically, these would be analogous to syntypes. The other equally representative collections of that race were designated as "others" -- taxonomically analogous to paratypes. Subsequent monographs emanating from Colombia which described the Andean races listed the collections as "types" (Bolivia, Chile, Ecuador), or "typical" (Venezuela), and "others". Briefly, the compositing system consisted of mixing together equal numbers of viable seeds (as determined by germination tests) of all collections classified as race "A". Race "A" composite therefore included the "type" or "typical" collections as well as "others" (syntypes and paratypes). In the same fashion, "... a second mixture was made of those classified as race 'B', and so on.

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Some races contained subgroups differing, for example, in grain color or kernel characteristics. Therefore, if race 'C' had both yellow and white grain [subgroups], and also flour and flint starch texture, there may have been five different composites made for this race: white flint, yellow flint, white flour, yellow flour, mixed or segregating for starch and color. Likewise, the collections intermediate between races 'A' and 'B' were composited to form one population of'A-B' germ plasm. The intermediates of 'E' and 'F' were composited into an 'E-F' complex." (19). In this paper, the individually maintained "type" or "typical" collections will be referred to as "type" collections, composites of syntypes and paratypes as typical composites.

This system is a compromise. However, it maintains a few "type" individual collections of each race and still permits maintenance of large seed supplies of each of the typical composite races. "Numerous requests from all parts of the world are more easily filled. It also allows more thorough study and evaluation of native races to determine the sources of genes for yield, insect resistance, and other economic characteristics." (19). A request was made for approximately five kilos of each typical composite race and each "type" collection from this increase to be sent to the U.S.A. for long term storage at the National Seed Laboratory at Fort Collins, Colorado. Filling that request was begun. Large quantities of additional seed of that same material were stored at the Colombian Germ Plasm Bank.

The other germ plasm banks in Mexico and Brazil, which maintained all other American collections except those from North America, were faced with problems similar to those referred to for Colombia. There were other problems as well: numerous breakdowns of refrigeration equipment, power failures, various strikes or civil disorders which prevented personnel from entering the facilities, and drought or too much rain during the growing seasons when seed increases were made.

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Duplication of material and effort is no guarantee of preservation. For example, the Chilean collections were sent to Mexico and Iowa for seed increase and for recording plant data to be used in describing the Chilean races. The data and seed from Mexico were sent back to Colombia by air shipment. Both were lost. The duplicate data books and seed samples retained in Mexico for such an eventuality were also lost in a flood. In short order, rejuvenated seed of the collection from the Chilean highlands and the data from those collections were wiped out, although the lowland Chilean increases and data recording by Pioneer Hi-Bred International in Iowa were successful.

By 1963, descriptions of all the known races of maize in Latin America had been published. Much of the North American corn was preserved and described. Workers in Africa, Asia, and Europe were collecting, preserving, and cataloging the races there. For the first time, the variation of an important world crop would be ascribed to workable-sized units of easily recognized groups. Moreover, the variability of that crop would be preserved as a legacy for the future. At least that was the thought.

Current Status: Maize Collections

Once germ plasm is collected, cataloged, described, and stored away in a freezer it tends to be forgotten. The attitude seems to be that it was a job well done and now we must get on with other things. Also, over relatively short periods of time there are changes in personnel and institutional attitudes and policies. Additionally, there is usually little funding and little or no program for maintaining and studying germ plasm collections. However, the general impression was that the corn germ plasm collection was in pretty good shape.

By 1968 it was apparent that, despite the extensive preparations which had been made to preserve maize germ plasm, problems had begun to arise (32). Most all of the standby collections -- duplicate samples of about 4 ounces or

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200 seeds of each of the original collections -- had been shipped to Glen Dale, the USDA's Maryland Plant Introduction Station. These numbered about 11,000 entries. From there they were sent to the National Seed Storage Laboratory, USDA-ARS, Fort Collins, Colorado (Fort Collins), but they were not officially accepted because of variable germination, small seed lots, lack of an agreement for rejuvenation of viability, and perhaps other reasons. After negotiation with the International Maize and Wheat Improvement Center, Mexico City, Mexico (CIMMYT), the Cuban, Guatemalan, and South American collections were shipped to Mexico (about 7600 entries), and the remainder were discarded. Most (about 600) of the Bolivian collections were grown out in the winter of 1969 at Tepalcingo by CIMMYT. Only a few produced seed; the remainder were lost. Thus, seven years after the last of the race bulletins appeared, the standby collections were reduced from about 11,000 entries to 7,000 entries, and two countries -- Mexico and Bolivia -- and one region -- the West Indies -- were essentially eliminated from the group.

The status of the individual standby and "type" collections at the various germ plasm banks varies greatly. Furthermore, the kinds of collections vary. There are collections classified as to race and those which are not. Some of those classified are listed in the race bulletins or elsewhere as being "type" collections; most are not. Only the status of the "type" collections is reasonably available. It is suspected that the status of the other collections is poorer, but this may not always be so. CIMMYT until recently had only relatively few individual "type" collections, despite a rather large number of accessions. Many of CIMMYT's individual collections have been assembled in recent years by E. Hernandez X., A. Blumenschein, and Pablo E. Daza B., as the bank was started only in 1960, after the original collections had been completed. (Personal communication, M. Gutierrez G., CIMMYT). Consequently, seed requests for collections which were used and documented in describing the

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races of maize in Mexico are often filled with seed supplies from collections which are not listed as "types" in The Races of Maize in Mexico (30).

The Instituto Nacional de Investigaciones Agricolas (INIA) has the most complete set of Mexican, Guatemalan, and Caribbean individual collections. INIA inherited the germ plasm bank of the cooperative program of the Rockefeller Foundation and the Mexican government. Some Guatemalan collections have been salvaged by CIMMYT from the standby collections formerly at Fort Collins, but the Guatemalan collections are quite difficult to maintain in Mexico. Many of INIA's Guatemalan collections are original (nonincreased) seed.

Most of the individual collections from eastern South America (the Guianas, Brazil, lowland Bolivia, Paraguay, Uruguay, and Argentina) made by the Institute of Genetics, Escola Superior de Agricultura "Luiz de Quieroz," Universidade de Sao Paulo, at Piracicaba in Brazil, are no longer maintained there. That bank has never utilized modern cold storage equipment and is currently being essentially phased out (33). Many, perhaps most, of these individual collections have been increased by CIMMYT either from the standby collections from Fort Collins or other sources, however, and are still available.

Many of the Peruvian "type" collections are maintained by the Programa Cooperativa de Investigaciones en Maiz, Universidad Agraria - La Molina, Lima, Peru, although many of those adapted to altitudes of about 2000 to 2800 meters were lost due to lack of facilities to increase collections at those altitudes. At present, efforts are underway in Peru to re-collect the representative materials which have been lost. In addition, the Peruvian portion of the standby collections from Fort Collins is being increased in Peru under an agreement with CIMMYT.

The collections from Venezuela, Colombia, Ecuador, Peru, Bolivia, and Chile were originally to be stored in Colombia at what is now the Instituto Colombiano Agropecuario (ICA) with standby samples at Fort Collins. While

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almost all the standby samples made it to Fort Collins (and then to CIMMYT), the Chilean and Peruvian samples are not currently available from Colombia. The story of the Chilean collections has already been presented. The Peruvian collections were unfortunately given two sets of collection numbers. One set was used in Peru and published (25), while another set was used in Colombia, Fort Collins and in the reports by the Committee on Preservation of Indigenous Strains of Maize (34). Thus, use of the Peruvian seeds from the standby collections from Fort Collins to replace lost collections in Peru has been hindered by the lack of a complete cross-listing of the two sets of collection numbers. No cross-listing of the two sets has apparently ever been published. Adequate safeguards for the Peruvian collection were further hampered because the complete set of Peruvian collections was never received in Colombia. Fortunately, the low altitude Chilean "type" collections were increased in the U. S. by Pioneer Hi-Bred International and placed in Fort Collins. These collections were not evicted at the time the standby collections were sent to CIMMYT. They are still there and appear to have good germination. In addition, it has been possible to salvage a number of the high altitude Chilean "type" collections from the standby collections from Fort Collins (which are now at CIMMYT). The Bolivian "type" collections stored in Colombia have been neglected for several years, but are now being increased for transfer to CIMMYT. It appears that a number of them have been lost, but until the increases have been completed, their exact status must remain in doubt. Duplicate samples of many of the low altitude Bolivian "type" collections had been saved by W. L. Brown of Pioneer Hi-Bred International. These have been increased in Florida and sent to CIMMYT as a precaution against still further erosion of the Bolivian collections. The Colombian bank will remain in charge of the collections from Venezuela, Colombia, and Ecuador. The "type" collections from Venezuela and Colombia are generally viable and available from ICA. This is much less so for Ecuador,

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but the standby collections from Fort Collins have filled the gap reasonably well. Many of the Colombian "type" collections were increased and placed in Fort Collins (the only country for which this seems to be true). These increases remained in Fort Collins when the standby collections were removed.

In addition to individual collections, there are several kinds of composites. The typical composites of most Colombian races are still at Fort Collins. The typical Colombian composites, as well as the typical composites of most races from Venezuela and Ecuador, are available from ICA. A smaller proportion of typical composites from Bolivia is available from the same source. The latter three sets apparently were not deposited in Fort Collins. The composites which were developed at the Brazilian germ plasm bank were not deposited in Fort Collins, but were sent to Mexico and are available from CIMMYT. (No "type" collections were ever designated for most of the races of eastern South America.) Mexican racial composites of uncertain origin are still at Fort Collins. Outside the Andean Region, and perhaps within that region in recent years, some collections may have been assigned to a race even though they were not typically representative of that race. They perhaps possessed more characteristics of that race than of any other, but admixtures from other sources should have precluded their inclusion as specimens or in representative racial composites.

Apparently there was some indiscriminate compositing of the individual collections in certain maintenance programs, without proper assurance that those same individual collections were also being maintained. From the plant breeding viewpoint, this can be an acceptable and very logical procedure. In fact, the formation of complex composites of unrelated materials is often indicated, insofar as the immediate needs of feeding people by modern agricultural production is concerned. Broad-base composites are often thought of as gene pools, and a breeding program frequently has several of them. However, as a procedure

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for preserving genetic resources they are completely unacceptable.

In Brazil and at CIMMYT, but not at INIA, in Mexico, the development of racial or sub-racial composites apparently took precedence, for breeding purposes, over the maintenance of many "type" or other individual collections. In fact, relatively few of the "type" collections have been stored at CIMMYT. Before CIMMYT was organized most of these collections had been stored at INIA; relatively few, usually collections of special interest, were utilized in the corn breeding programs centered in Mexico. Therefore, some of the individual and "type" collections were lost. In the case of the Brazilian individual collections, the duplicate or standby samples at Fort Collins were available to replace many of the lost collections. However, the Mexican samples among the Fort Collins standbys were discarded before it was realized that many of them were not available in Mexico.

Tables 1 and 2 summarize the general status of the "type" collections of Latin American maize, when such collections have been designated, and the status of the racially classified collections when "type" collections were not designated. A number of the high altitude collections from Ecuador are in the process of being salvaged from the standby Fort Collins collections, so their availability is limited. The status of collections from Bolivia and Chile is critical, while much of those from Central America remains either undescribed or uncollected.

Several described races have apparently been completely lost (Polulo and Negrito from Chile, several subraces of Quicheño from Guatemala, Amarillo de Ocho and several subraces of Capia from Argentina). All the "type" collections have been lost for the races Rienda and Jora from Peru, Maiz Dulce from Colombia, and Coastal Tropical Flint from Dominica. In addition, all of W. H. Hatheway's collections from Cuba have been lost.

Finally, the North Central Plant Introduction Station of the U.S.D.A. at

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Ames, Iowa, has a large collection of U. S. Indian corns assembled principally by H. C. Cutler, as well as an abundance of poorly documented open-pollinated varieties and miscellaneous undocumented plant introductions (35). These have never been studied in the same detail as have the Latin American races.

That, in brief, is the status of the collections of American maize. What is going on now is a last-ditch stand to prevent further loss of something which many people had assumed was well preserved (36). The situation with other crops is probably not any better. Indeed, it appears uniformly worse.

Summary and Exhortations

Germ plasm resources are fast disappearing, and there are urgent needs to collect and preserve those resources. In the past, there have been mistakes of omission and commission, inadequate support in maintaining the integrity of germ plasm, unfavorable weather conditions, and so forth. But, perhaps, the most damaging to the maintenance of germ plasm and its integrity is the concept of manipulating the formation of gene pools. If the concept of a gene pool, insofar as germ plasm maintenance is concerned, could be likened to a military motor pool composed of separately usable units, rather than a beachcomber's stew pot into which everything was dumped and blended, we would be much better off.

To use genetic variability intelligently, we must know where it originated, not only for disease or insect resistance, but also for yield and quality features of the market. As we search for these genes it is increasingly clear that if we understand the evolutionary relationships of the crops and their relatives, modification of the crop to suit our needs becomes easier. To do all this requires that the essential integrity of the germ plasm be preserved. Only when all individual collections cannot be maintained should composites be initiated. Compositing should be done only on a biologically systematic basis with as many categorical units as possible. (An excellent example where it is much

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better to be a splitter rather than a lumper.)

Methods of conserving genetic resources vary according to the crop. Each nation cannot maintain a complete germ plasm collection of its crops. The scope and cost of the program would be too large and much of the material would be unadaptable. Hopefully, some of the discussions for multi-institutional and/or multi-national germ plasm collection and maintenance will bear fruit (37).

"The maintenance of a living collection is usually regarded as a routine and time-consuming, yet essential, task. Much of the material maintained there seems to be of little current interest -- occasionally, of course, a threatened epidemic or new insight into a disease problem will generate a sporadic interest in screening everything available. A great deal of the material that leaves the bank is discarded; it is regarded as a gift, not as a loan. Surely a more suitable arrangement could be devised. One possibility is the development of germ plasm maintenance centers, in which maintenance is regarded as the primary goal, not as a by-product of breeding activities. In this connection it is worth noting that the plant breeder, entomologist, or plant pathologist tends to regard a germ plasm collection as an inexhaustible source from which he can extract only such experimental material as is of interest for his specific purposes. On the contrary, the experimental taxonomist, crop plant evolutionist, and ethnobotanist consider the entire collection to be necessary experimental material -- quite apart from its potential economic value. They need to preserve and study as wide a variety of material as they can manage and to use it continuously. Because all classifications have to be revised as new material is collected and new analytical procedures developed, the experimental taxonomist's work is never done. A germ plasm maintenance center could effectively serve a dual purpose as experimental material for several disciplines and as a reliable and continuing source of germ plasm for the plant breeder. Coupling

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these two objectives could relieve the plant breeder of a routine chore and provide the taxonomist and others with facilities and experimental material not now available to them." (7).

Regardless of the outcome of the discussions concerning the internationally oriented gene pool maintenance centers, the U. S. needs a maintenance facility in the tropics or subtropics (38). The existing facilities at Miami, Florida and Mayaguez, Puerto Rico are inadequate for the above purposes. Many of the U. S. crops are subtropical. Many of their relatives are also perennial and flower only under short days. A living collection of such plants suitable for the dual objectives just mentioned can be established only in a subtropical, frost-free environment.

The prodigious agricultural production of the United States is based on introduced plants. Some of these plants were from Latin America in Pre-Columbian times, but the fact remains that none of the important food crops is native to this country. Throughout the world, the major crops are being introduced and promoted on an intensifying scale. Aside from the prospects of an uninspired diet, it should not be necessary or otherwise desirable to depend so completely on so few crops. There are scores of minor crops which have never been worked on. Fifty years ago, it would have been difficult to imagine the present day importance of sorghum or soybeans. Many of the minor crops would probably respond, just as soybeans and sorghum, to intensive research efforts. They, too, should be collected and preserved.

Neolithic Man began the Agricultural Revolution by domestication, selection, and transportation of plants. He was able to do this because of variability. We, in the midst of the Green Revolution or of impending shortages and cyclical famines, must maintain what we can of the remaining variation. That variability, maintained in natural gene pools, is valuable stuff. Our

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legacy to future generations should be adequate germ plasm resources, collected from those gene pools, and maintained, distributed, replenished, and studied under the aegis of proper germ plasm banks.

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Table 1. Status of the number of individual "type" collection of the Latin American races of maize as of August 1973.

Country or Region	Typical Collections listed	Typical collections still available
Mexico	131	112
Guatemala	180	115
Honduras	1*	?
El Salvador	2*	?
Nicaragua	1*	?
Coasta Rica	3"	?
Cuba** and the West Indies	49	29
Venezuela	86	86
Colombia	129	125
Ecuador	154	144
Peru	183	147
Bolivia‡	141	90†
Chile	80	55†
Argentina**‡	26	23
Paraguay**‡	13	8
Probable Totals:	1179	934

*Essentially uncollected and unstudied.

**Fairly well collected and studied, but few if any "type" collections have been documented. The western part of Paraguay, much of Amazonas, and the less accessible parts of the Guianas are still largely uncollected.

†Many of these in immediate danger of complete loss.

‡See Table 2 also.

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Table 2. Current status of racially classified individual original collections from the Brazilian germ plasm bank. No "type" collections have been identified for most of the races described at that bank. (Does not include any recent--post 1965--collections.)

Country or Region	Collections Classified	Collections still Available
Argentina	57	50
Uruguay	81	20
Paraguay	48	36
Brazil	984	575
Guianas	21	12
Bolivia	19	18
TOTALS	1210	711

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32. Many of the details and arrangements discussed in this and the subsequent paragraphs are based on personal knowledge or experience. Other details have been obtained at various times by personal communication with: Hermilio Angeles A., Mexico; Louis N. Bass, USA; Climaco Cassalett D., Colombia; Mario Gurierrez G., Mexico; E. Hernandez X, Mexico; Howard L. Hyland, USA; Edwin James, USA; Ernesto Paterniani, Brazil; Ricardo Sevilla, Peru; Howard Sprague, USA; E. J. Wellhausen, Mexico. The co-operation and advice of these specialists is gratefully aknowledged.

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36. A Maize Germ Plasm Committee, under the auspices of the Rockefeller Foundation has formulated a program to recollect in certain areas from which previous collections have been lost, and to collect in previously uncollected

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or poorly sampled areas. Other committees of the same sponsorship have developed similar plans for rice, wheat, sorghum and millets.

37. Various entities under the auspices of the United Nations: 1972 UN Conference on the Human Environment, Stockholm, Sweden, Food and Agriculture Organization; Technical Advisory Committee of the Consultative Group on International Agricultural Research; International Biological Programme; Agency for International Development; The Ford Foundation; The Rockefeller Foundation; U. S. Department of Agriculture: Agricultural Research Policy Advisory Committee, Agricultural Research Service. Much of this activity is of a survey discussion nature, and often reiterative, with one group repeating the work of another, albeit at different levels of planning or organization. A few action programs have been initiated within the past 10 years, but private opinions differ from official positions in regard to success. However, awareness of the germ plasm problem is reaching higher levels of institutional management and it is hoped that well-founded programs will soon emerge from the scores of committee reports, working papers, and organizational charts. The ponderous nature of governments and multinational organizations does not seem to offer much immediate hope. Several of the philanthropic foundations and the regional research centers which they support, CIMMYT, The International Rice Research Institute, and the like are hampered less by demands of protocol and seem to offer the best hope as immediate and interim facilities until governmental organizations are properly established.

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NATIONAL RESEARCH COUNCIL

ASSEMBLY OF LIFE SCIENCES

2101 Constitution Avenue Washington, D. C. 20418

DIVISION OF BIOLOGICAL SCIENCES

November 17, 1976

MEMORANDUM

TO: Members of the Committee on Germplasm Resources

FROM: Veronica Pye Veronica Pye.

SUBJECT: Additional Reading Material

During the meeting it was suggested that a copy of the latest listings of endangered and threatened wildlife and plants would be a useful document for the Committee members to have. The listing that appeared in the Federal Register in October of this year is enclosed.

At the latest meeting of the Executive Committee of the Assembly of Life Sciences there was an item on Biological Research Resources. Dr. Russell is also a member of the Executive Committee and was very interested in the attachment that accompanied this item (see second enclosure). It outlined a matrix of types or groups of organisms and their possible uses. Dr. Russell thought that it would be of interest to the Committee and requested that it be circulated to you. Your comments are invited, both on the groupings of organisms and uses and on the scores attributed to them. The matrix, which was developed by Russell Stevens, is part of a document to be used for an application for a sum of money from a private foundation to serve as a "pump-primer" for continued Assembly activities in this area.

Enclosures

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Research Resources

In the broadest sense, research resources include not only the biological materials themselves, but the buildings, equipm t, supplies and money needed to support the overall enterprise. These latter are not unimportant, but they do differ except perhaps in detail from the resources needed for research and teaching in the sciences generally. It is the living organism, and the materials derived therefrom, that is unique and that confronts the biologist with special opportunities and special problems. In the following comments, "research resources" refers to any aspect of the biologically derived material used in research, teaching, testing, public display, and related activities.

One way of displaying the diversity of research resources and some aspects of their preservation and use is shown in the accompanying matrix. Two dimensions are self-evident: (1) categories of resources, distinguished in a very roughly taxonomic fashion; and (2) categories of "use", in the sense of principal rationales for maintaining the resource category in question. Some explanatory comment is in order, as follows:

Categories

The diversity of materials used in biological and medical research is, of course, very great. Whole animals and plants; microorganisms; parts of organisms; substances produced by or from living organisms, and so on. Thus one could derive an almost endlessly detailed list of categories of resources, but at the risk of losing perspective. In developing the attached chart, some 15 categories have been recognized that are conveniently distinguished by relatively

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large taxonomic groupings and, more subjectively, by a certain coherence in either the manner of their preservation or the major bases for their use, or both. True, one might quarrel with the terminology used, the boundaries established for each category, or other details. Suffice it to say that the fifteen categories represent important--if not either the "only" or the "best" that could be devised. There seem to be no major omissions or distortions.

Uses

Along the horizontal axis of the matrix have been identified some six generalized "uses" to which resources are put. There are obvious overlaps and omissions, and no clear boundaries between one and another. Rather, they have been identified as central points of emphasis--the major "whys" that lie behind the emphasis on the particular biological resource in question. Because the distinctions are highly subjective, it may well be useful to annotate each of the use categories briefly.

Preservation of Germplasm--where the point in keeping a given resource is primarily to maintain genetic diversity, to avoid losing something that might otherwise be lost, but where the emphasis is not on immediate use.

Defined Organisms as Research Tools--where the emphasis is on providing a dependable source of fairly well defined organisms without which a given line of investigation cannot readily go on, but where the organism as such is of little interest.

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<u>Agricultural and Related Purposes</u>--where the chief focus is on developing new crop or livestock strains, new forest types, new ornamentals, etc.

<u>Industrial Use and Testing</u>--where the central point is to maintain uniform materials to be used in industrial production or in the testing of commercially prepared pharmaceuticals.

<u>Systematics Research and Documentation</u>--Included here are museum research collections, herbaria, systematics collections of all kinds, and materials filed away in documentation of ecological research, biota surveys, environmental impact statements, etc.

<u>Educational Uses</u>--includes materials for classroom instruction, public exhibits, indoor and outdoor museums, etc.

<u>Exploiting the Matrix</u>

It would be presumptious to claim much for the matrix other than as a framework that, in a way, defines the outer limits of the overall question of biological research resources. It illustrates in general terms the matter of what resources are involved, and to what purpose. Given such a chart, several attributes become evident, beyond the wholly obvious one that a large variety of things are used in a wide variety of ways. For example, it is clear that weighting on some vertical axes is virtually meaningless--there is simply no way of showing that it is more important to husband stocks of algae for teaching purposes than stocks of protozoans. On the other hand, much more emphasis is placed on holding wild

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and domesticated organisms (#6 and #7) and natural areas (#15), simply lest the germplasm they represent be lost, than is true for viruses, bacteria, algae and fungi.

Comparisons along a given horizontal axis are substantially more meaningful than those along some of the vertical axes. Thus it is critically important to hold virus strains that represent experimental tools, somewhat less important for agricultural research, industrial laboratories, and teaching. Species to be found in arboreta, botanical gardens, and zoos are much more important as reservoirs of germplasm and as educational tools than for research or for agricultural and commercial exploitation.

One can stretch the analogies too far, or argue about the numbers of plusses accorded a given point in the matrix. At worst, however, it tends to demonstrate that the category-use relationship is nonuniform, that there are in fact different uses and different emphases to be accorded a given situation.

Priorities

Assuming that there is an acceptable validity to the categories and uses identified in the matrix, and assuming that the perceived variability within the matrix is real, what is needed is a careful look at the entire package to see where the crisis areas lie. It would be folly to assume either that each element of the package is as well off as each other element; it would be equal folly to undertake a major investment of time and funds to enhance the entire network. Indeed, the responsibility for taking action and the resources to do so will differ from situation to situation.

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Very large amounts of money will be required; it is therefore essential to survey the field carefully to identify critical areas.

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	Preservatio of Germplasm	Defined Organisms a Experimenta Tools	Agricultura and Related Purposes	Industrial Use and Testing	Systematics Research and Documen-tation	Educational Uses	
.Viruses and Similar Organ-isms		+++	+	++		+	
.Bacteria and Similar Organ-isms		++	+	+++	+	+	
.Algae		+++			+	+	
.Fungi		++	+	++	++	+	
.Higher Plants		+			++	+	
.Arboreta and Botanic Gardens; Zoos, etc.	++					++	
.Crop Plants and Livestock	++		+++	+		+	
.Protozoa		++			+	+	
.Invertebrates (except Insects)		+			++	+	
.Insects		+	+	+	++	+	
.Amphibians and Reptiles	+	++				+	
.Birds	+	+			++	+	
.Fish and other Aquatic Forms				+	++		
.Mammals		+		++		+	
.Natural Areas	+++				+	+	

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PRIVILEGED

Committee on Germplasm Resources
Second Meeting, January 29-30, 1977

The Committee met at 9:00 am in room JH-200A. Those in attendance included Dr. Russell (Chairman), Drs. Bachmann, Benirschke, Goodwin, Grassle, Judd, Lewis, Mazur, Roderick and Rogers. Drs. Briggs and Nanney were unable to attend due to bad weather. The Committee was joined by four invited guests on Saturday, namely Dr. Clair E. Terrill, USDA/ARS; Mr. William Sievers, NSF; Dr. Richard Donovick, ATCC; and Dr. Leon Jacobs, NIH. NRC staff present on both days were Drs. Veronica Pye and Nancy Muckenhirn, and Dr. Russell Stevens attended the meeting on Saturday.

The minutes of the first meeting were approved without alteration. Dr. Russell introduced Dr. David Rogers, who was unable to attend the first meeting, and gave him a brief synopsis of what had been decided there. Dr. Lewis announced that a meeting of the National Plant Germplasm Resources Board was scheduled for February 3rd in Washington, D.C. This would be their third meeting and would be a roundtable writing meeting to which the public were allowed. In addition a workshop on plant germplasm organized by the National Plant Germplasm Committee would take place in Denver at the end of March. Dr. Lewis briefly reviewed the differences between the Board and the Committee. Dr. Donovick asked how the committee co-ordinated its efforts with those of the American Association of Systematics Collections (ASSC). In connection with this Dr. Roderick suggested that a list of other groups working in this area should be compiled, together with their committee membership, objectives and source of funds.

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When the invited guests arrived Dr. Russell introduced them to the Committee. Dr. Terrill then opened the day's discussions by describing the situation concerning the preservation of germplasm of livestock. He said little attention had been paid to this area and the few funds available were allocated only to the highest priority research projects. The economically important species are not being preserved as well as the wild species. The overall numbers of livestock are declining in the U.S. despite the need for more food. This is due in part to the shift in use of grain surpluses from animal feed to "people" feed. The non-grain user species include sheep and goats, and the farm prices for these animals has decreased steadily. When decisions about pest control are made, wildlife is given priority, this is exemplified in the reduction in sheep numbers because of coyotes. The U.S. marketing system is such that the farmers must be very efficient to stay in business, and over the last years most of the financial gains from increased consumer prices were swallowed up in the "middleman" profits. Because farm prices have not changed much, many farms have been forced out of business, over 20,000 farms were lost in 1975. This is despite the fact that they are biologically efficient. Dr. Terrill considered that the changing economic situation will lead to a worldwide decrease in meat production, associated with the lack of grain surpluses. This in turn will cause dramatic increase in retail meat prices. Dr. Terrill discussed selective breeding for animals that would fatten on grain rather than grass. The rate of increase per year is limiting in animals. In cattle the average is one calf per year whereas sheep breeders are optimistic about obtaining 4 lambs per ewe in the future. The potential of using by-products such as citrus rind and treated sawdust as feed was

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discussed. Dr. Terrill pointed out that animals are often able to utilize food stuffs that are useless to humans.

Dr. Terrill addressed the problem of the strains and breeds that are in danger of being lost.

1. Cattle: There is less concern here due to the possibility of storing germplasm in the frozen state.

2. Swine: There is no world-wide effort to ensure the survival of efficient and economically important strains. A comprehensive coordinated program is urgently needed.

3. Sheep: Three varieties in the U.S. are endangered, namely the Kara cule, the old type Navaho and the southern native breed. The old type Navaho may already be lost unless it is preserved on a reservation. This type was prolific under rigorous conditions such as those found in New Mexico.

The question arose as to whether the Australian and New Zealand breeds represented a good mix, but it was pointed out that these were mainly British breeds and there were an additional 900 types. Disease quarantine regulations made their importation extremely difficult both for Australia, New Zealand and the U.S. The problem of importing new types is severe for both sheep and swine. With cattle, where the Holstein is the superior breed, a number of new beef cattle breeds have been imported into the U.S. in recent years, mainly because big money was involved. Also it has been possible to freeze cattle sperm but not goat and sheep sperm.

4. Poultry: The only successful maintenance is by breeding colonies. The federal government has no stocks and the role of fanciers, breeders and universities is important.
5. Goats/Rabbits: There are no programs for these animals.
6. Horse: Private concerns look after this with the exception of work horses.

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7. Fish, etc. No efforts.

Needs for New Germplasm (introductions)

1. Cattle and poultry--there is no need.
2. Swine. New varieties from China would be an asset.
3. Sheep. Great need to import but there are restrictions related to disease control. The original importations into the U.S. did not take into consideration the varying environmental conditions here.

It would be an advantage to import the new high fertility breeds, and it would be faster than selecting for twinning from scratch. The funding restrictions for such research occur at the level of Congress, USDA and on down. When asked whether a way round the import restrictions would be to import embryos, if proved that diseases such as the scapie virus could not be introduced in this way, Dr. Terrill replied that USDA had been refused permission for this.

Research Needs Dr. Terrill said that all aspects of cryo-preservation should receive more attention, as should genetic polymorphism, blood traits in economically important species and further research on breed differences.

During the discussion Dr. Terrill was asked whether traditional breeds were being threatened by over adoption of new breeds and he thought this was more of a problem in "central planning" countries such as the USSR. There should be a worldwide effort to maintain traditional species. The question of the overall effect on ecosystems of introducing new domestic breeds was raised but Dr. Terrill considered that most farmers practice "sane management" as their livelihood depends on it. Despite propaganda about overgrazing, production per animal is increasing and the greatest damage is done by the protected horses and burros on public land.

Dr. Lewis considered that animal systems people are still

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trusting to luck that germplasm is maintained and there is no comparable program for animals to that provided for plants by the NPGRB. To preserve the Navahoe sheep a flock of 50-100 would need to be maintained, although thought should be given to cryopreservation. Dr. Benirschke mentioned that the USDA constantly has new laws concerning animal importation. Disease is only one facet, pressure is exerted by conservation groups who fear the results of exotic introductions. The enforcement of the endangered species Act is also hindering zoo importations.

Dr. Peter Mazur reported on the CIBA symposium on Cryobiology that was held in London, January 21, 1977. (Proceedings to be published by Elsevier at the end of the year.) The 3-day meeting was chaired by Dr. Whittingham (London) and was restricted to 25 participants. Success in freezing and resuscitation of embryos has now been achieved for mice, rats, cows, sheep, rabbits and goats. Swine have proved difficult due to their high sensitivity to chilling injury. Heavily granulated embryos with a high lipid content, such as those of swine are the most difficult to freeze. It is also true that seeds with high lipid content, such as those from leguminous plants, do not keep well at low temperatures. With cattle the embryos may only be frozen at a very early stage, non-surgical techniques are used. Concerning long-term stability, frozen material may be stored for 90,000 years before receiving a lethal dose of radiation from normal background levels. Other radiation induced effects would not be apparent for 1200 years, both figures are for storage without lead protection. Transportation of frozen embryos would be simple, in the event that there are

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no proven problems with viruses. This method of transportation is used to import animals into U.K., Canada, Australia and Ireland. Dr. Benirschke, referring to the arabian oryx, asked whether there was a foreign protein problem when the embryos became vasculated. He also noted that most of the research had been carried out in the poorer countries such as the U.K. and little has been done in the U.S. It was thought to be related to the fact that USDA is underfunded for basic research. This is partly due to the fact that there is no food shortage in the U.S. and therefore agricultural research is not rated very high. The figures for USDA research published in the last issue of Science were referred to. The discrepancy in distinguishing between embryos and adults was mentioned. For importation purposes they are considered the same. The NIH guidelines for recominant DNA distinguishes between them on the assumption that the embryo is cleaner re viruses, etc. The question of vertical and horizontal transmission of scrapie was mentioned. Dr. Terrill will send the Committee a written report on U.S. needs and the FAO reports on world-wide needs for livestock germplasm. The budget constraints on this type of program were discussed in terms of competition with military and defense spending. The government tends not to react until faced with an agricultural crisis. The new USDA competitive grants program was mentioned but this money has been earmarked for four specific areas which do not include germplasm resources. Dr. Mazur questioned whether continued inputs into research would result in increased crop productivity or whether we had reached a "flattening out" of the curve. Dr. Goodwin considered that the limiting factor was the amount of available range. It was noted that the project where eland had been substituted for cattle in Texas was financed by the private sector.

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Mr. William Sievers, Research Resources Program, Environmental Biology Division, NSF, opened his presentation by saying he was in the minor leagues when compared with the USDA budget. He distributed a table of Awards for Living Organism Stock Centers from 1975-80 which represented an NSF investment of $3.6 million over five years. He regarded stock centers as being a research tool of basic research. NSF had asked for advice from the specialists in each field on what centers to fund and has or is supporting eleven studies to investigate the projected needs in this area. These studies include that by the Genetics Society of America. Mr. Sievers said that NSF intended to fund centers of excellence for the amount that they require, however he made the point that it was difficult to talk about long-term funding in a political context. He asserted that NSF would try their best to co-operate with identified needs. He pointed out that NSF has supported some stock centers for years. It was mentioned that some of the collections are more systematics collections than genetic stock collections. Dr. Jacobs said that NSF had recognized the importance of the ATCC and had helped support it in the past. Mr. Sievers said that NSF worked closely with NIH, who also had limited funds, a lot of which were devoted to primate centers. Mr. Sievers said that modest funds were available but NSF relied upon the scientists themselves to decide upon the needs and priorities. There is a line-item in the NSF budget for stock centers, controlled environment facilities, field research facilities and systematics collections for $4.5 million per year. He mentioned that the first grant for an ecosystem site in Oregon had been made. This site was for ecosystems type research but germplasm reserves would be a spin off from

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this. When asked about aquatic and marine areas, Mr. Sievers replied that these would be addressed in phase 2, perhaps in 1979. He mentioned that NSF was supporting the Friday Harbor program to the tune of $250,000 this year. He spoke of a forthcoming meeting to be held at Woods Hole on developing a time series data base (baseline studies) for ecosystems. This meeting will be chaired by Dr. Daniel Botkin. When asked whether the figures for support of living collections (in material distributed) included research, Mr. Sievers replied that this was not so, but the collection centers were identified as having a strong research program. In the case where NSF supported collections are threatened, NSF will ask the Society what they want to do with it.

Dr. Roderick elaborated upon the curator concept that the Genetics Society committee had come up with. He said the curator concept involved designated individuals and a "watch-dog" group to keep an interested eye on the collection. The latter group would be able to function immediately to preserve the collection in an emergency, thus preventing its loss as a result of the loss of one individual. He considered such a group would be able advise NSF in emergencies. Dr. Donovick made the point that if it is necessary to break up an existing collection, there is a need to know what must be preserved from that collection. Mr. Sievers said that both quality control and overlap were important issues and as NSF does not have the time nor the trained personnel to do this they rely upon outside reviewers who often paint a too rosy picture. A more critical approach to collections is becoming necessary.

When asked about the funding for collections, Mr. Sievers replied that NSF dispensed $3 million per year for support of

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systematic collections, these were mainly non-living collections. Thirty-six collections at 14 institutions receive funds from NSF. When asked why NSF rather than USDA supported collections of barley, maize, and tomatoes, he replied that USDA had not been in a position to support them. NSF would consider supporting such crop plants if there is a proven need for them in basic research. When the question was asked whether the support of live collections was for genetic research, it became obvious that the distinction between the terms "systematics" and "genetics" is unclear.

Mr. Sievers reiterated his statement that NSF is interested in where the gaps are and what needs to be done. When asked to what extent NSF supported ecological reserves, he said they were extensively funded under the IBP and now only at the Oregon site. The question of feedback between different sections of NSF concerning such topics as preservation was raised as this often fares badly in competition with other research grants. It is difficult to identify agencies or other sources of funds for innovative research such as the question of freezing bird semen. With regard to living stock centers 50-60% of the grant requests are turned down. It was agreed that there was an urgent need for a source of "interim" support until rational decisions can be made about suddenly endangered collections, and that the professional societies can do a good job of presenting the rationale for collections. It was pointed out that the question of who is responsible for the task of designating important collections had not been worked out. In the universities collections grew up from an individual's research and were not designed as collections per se. If recognition is given to such collections, the institutions at which they are housed will often support them in an emergency. There is a need for a commitment both from the

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institution and the individual to ensure the well-being of such collections. The rat collection of the University of Northern Iowa was cited as one such example. In conclusion Mr. Sievers stressed once again that NSF relies upon the scientific societies for information on priorities in stock collections and it was agreed that the societies should be made aware that this is so.

Dr. Richard Donovick, Director of the American Type Culture Collection (ATCC), said that 1975 was their 50th anniversary. Microbiologists were among the first biologists to be concerned about the preservation of germplasm. He cited 2,000 year old Chinese food fungi collections. Major collections of fungi were formed in the late nineteenth and early twentieth centuries. Winslow founded his bacterial collection in 1911, the UK formed a culture collection in 1920. The formation of the ATCC began in 1924 at a meeting of various society representatives. In 1925 it was formed as a nonprofit organization. Initially the collection consisted of bacteria and fungi and was supported by a $24,000 grant from the Rockefeller Foundation for five years. The ATCC now has about 25,000 strains including bacteria, fungi, algae, viruses, etc. It is the largest varied collection. In 1960-64 a new facility was built at Rockville, Md., with money from NSF, NIH, and private sources. The building was designed for a culture collection and has special "once-through" air conditioning systems. Dr. Donovick listed the numbers of strains for each type of organism. In 1976 the ATCC distributed 25,000 cultures, mainly overseas. With regard to the "curator concept", Dr. Donovick said that this would not be possible with an organization such as ATCC. They do quality control work and had pointed out such facts that a KB cell line used for cancer studies differs from the original 12 year old culture.

ATCC also acts as a depository for cultures involved in

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patent application. They publish two lengthy catalogs (copies were left for the Committee's files). Dr. Donovick considered that data and cataloging were extremely important for a workable collection. He mentioned the problems involved with acquisition of new lines and decisions to discontinue keeping old ones. Mixed cultures are discarded. If there is no demand for a culture the ATCC may decide to discontinue it, but allows a year for the reaction of possible users. They maintain 650,000 vials in the museum function inventory and therefore not many vials per strain are kept. The ATCC prefers not to store things in liquid nitrogen due to the danger of explosions on removal if pinhole leaks in the glass are present. For the ATCC long term storage means 25-50 years. Updating and checking the collections is a continuous process. When asked about the stability of the collections. Dr. Donovick said that it was once thought that a stock strain changed characters by losing plasmids, but this has not been found to be so with liquid nitrogen storage. Occasionally a plasmid may be lost but these can be detected in tests when they are sent back to the individual who supplied them.

ATCC has a Board of Trustees with representatives from 14 scientific societies. Financially it is not very secure, 40% of its income is from fees and services for patent cultures, supplies and services such as the taxonomic study of a cell line. It does receive grants from NSF and NIH but competes with other proposals for these. The ATCC will be taking over a large collection of oncogenic viruses from the National Cancer Institute (NCI), it has a cooperative agreement with USDA on plant viruses and also receives a grant from General Medical Services for work on hybridization as a taxonomic tool. ATCC maintains a greenhouse and animal rooms, each with a distinct

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air circulation system. About 100 people are employed with approximately 15 persons per department. Each department is headed by a broad generalist. Fifty-five employees have either an MSc or PhD and these are the only persons who handle the cultures. Research programs are supported on grants and contracts. When asked whether any of the strains could be considered rare or endangered, Dr. Donovick said that strains had been lost and cited the example of a fungus, an 11β hydroxylator of steroids, for which both the ATCC and the original culture had been lost. The smallpox virus is preserved and it is conceivable that the ATCC could set up to preserve such organisms as the Marburg virus. With regard to the importation of pathogens, Dr. Donovick said that the federal agencies are very cooperative but difficulties are encountered with airline pilots and insurance companies. He considered that the present ATCC programs should be increased and not restricted to pathogens. A cell stock information bank (CSIB) is being set up by ATCC. There is not sufficient space in the present building to offer services to the smaller operators such as researchers doing 2-3 year work on one species or strain who wish to store a "safety" sample for that time. Advisory committees decide what strains should be sought and kept. When asked whether phenotypic or genotypic changes are reported by users. Dr. Donovick said not many such reports are received. The original donor is asked to check such strains. It is conceivable that the ATCC could eventually run out of a diploid cell line as the number of passages has a finite life. The question of storage of marine diatoms and nematodes arose, but the ATCC does not deal with these organisms.

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Dr. Leon Jacobs, Assistant Director for Collaborative Research at NIH, spoke about the related activities that NIH is engaged upon or supports. The NIH realizes the need for maintenance and supplies core support for ATCC. It also supports rodent genetic studies in various parts of the U.S. The Primate Centers are supported through the Division of Research Resources (NIH). Together with the Division of Research Services they have funded primate breeding facilities in response to the new export restrictions on primates. It is hoped that these facilities will eventually be self-supporting, but they are very expensive at the present time. The National Heart, Lung and Blood Institute produces its own primates and NIAID supports a colony that supplies hepatitus-free chimps. The laboratory in Panama is also developing a primate source. Large numbers of dogs are bred for open heart surgery research and associated with this is a study on blood types in dogs and a canine blood bank. The NIH has developed new types of E. coli for recombinant DNA work. They are "crippled" and cannot survive without special nutrients. They are also bile sensitive and would therefore be inactivated if inadvertently swallowed. There is an in-house research program on genetics and vectors of parasitic diseases including work on snail genetics and schistosomiasis. There was a program to try and cultivate squid for giant axon work. The Institute of General Medical Sciences has cell strains for genetic disease in humans and also diploid cell lines used to investigate the cellular aging process. These lines are mainly derived from fibro-blasts from human embryonic lung. An example of an unsuccessful program was the breeding of opossums for teratogenic studies. Dr. Russell made the comment that NIH seems more concerned with arranging for a supply of an organism in demand rather than arranging for the preservation of organisms that are threatened. When questioned about maintenance of stocks of

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medicinal plants, Dr. Jacobs said that NIH supported explorations for plants to test as antitumor agents. When these are needed they are grown in large quantities, as is marijuana for studies on carcinogenicity. Dr. Jacobs said that often, built into contracts granted by them, are provisos for maintaining cell cultures and distributing them to qualified investigators. Dr. Jacobs thought that NIH would try and support a collection if convinced that it was required by the scientific community, however surveillance of endangered status is not carried out by NIH. However because of their intermural and extramural contracts, NIH usually hears about such crises very rapidly. NIH has no problems with supporting the conservation of germplasm but it was considered that associated research support reinforces the expertise. Dr. Jacobs was asked whether NIH would support searches for new, useful, spontaneously occurring mutants which cannot be assessed without preliminary testing, but he replied such support would only be considered after the mutant had been detected. The question of assessing the usefulness of a mutant in future years was discussed.
Dr. Benirschke considered that total priorities should be considered, illustrating his argument by stating that resources such as the Blue Whale should not be allowed to disappear as they may be more important than the latest Tay-Sachs mouse mutant.

A discussion followed on the possibility of using micromanipulation to store DNA and then regrow by transplanting the DNA into enucleated ova. It is theoretically possible to do this and it is a realistic hope for the future.

The meeting adjourned at approximately 5:00 pm.

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Sunday, January 30, 1977

The meeting reconvened at 9:00 am.

Dr. Rogers began by referring to the letter he had circulated before the first meeting. He said that although he had personally tried to conserve organisms, he had failed. His interests center on tropical food crops, cassava in particular. This plant grows in the lowland tropics and is a staple food for many lesser developed countries. The variations in cassava are enormous, fitting the plant for many different environments. Dr. Rogers maintained that recognition should be given to such native selection. Cassava is maintained as a root and survives well when left in or covered by soil. The problem with such bulky plants is that they die, are lost, the techniques for their cultivation are not known at the experiment stations and in any case there are not sufficient funds for such programs. Tissue culture techniques are not available. Similar gloomy situations exist for other tropical crops. Many plants, sources of wax, oil, medicines, herbs, etc., are of marginal economic importance and therefore only marginally encouraged or tolerated. Maintenance of such species would involve the maintenance of the whole ecosystem as they could not be dealt with individually. In this context the Brazilian areas reserved totally for the native tribes are an effort in the right direction.

Dr. Rogers' other area of interest is data management. He is working on generalized computer programs. This is also proving a difficult area as it is hard to get a useful program into use. The situation is horrendous due to the difficulty of obtaining the relevant information about each plant, and these difficulties are often due to inadequate data recording on the part of the collector and/or the curator. An inadequate

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description negates the necessity of keeping the plant. He described the FAO program in Rome as total chaos. He described the International Board on Plant Germplasm Resources (IBPGR) which is composed of 14-15 scientists (no Chinese though). It only meets once a year, has no operating arm and therefore was set up to fail. There are too few people to deal with the problems and not enough money to cope. However the IBPGR has been successful in defining the boundaries. Dr. Rogers said that priorities must be assigned as it was impossible to save everything. Certain regions may be considered more fragile than others and consequently the plants there would be in more danger. The Green Revolution did a good job of feeding hungry people at the time, and then it was impossible to predict with any accuracy the future fertilizer shortages, etc. However the fact remains that the Green Revolution causes and has caused great loss of folk varieties.

With regard to wild plants, Dr. Rogers mentioned the project on the Rocky Mountain flora and referred to the publication "Natural History Inventory of Colorado. 1. Vascular Plants, Lichens, and Bryophytes". W. A. Weber and B. C. Johnston, University of Colorado Museum, October 1976. This survey used a computer information service to list the plants and their category, e.g. rare, threatened, endangered, common. Such a base-line study is needed for all areas.

The Morton Arboretum near Chicago attempted to preserve 5-10 acres of prairie, but found that native plants cannot be just reestablished; disease, fire and weeds all prove to be problems, and the whole process is very expensive. The area that the New York Botanical Garden tried to protect is in fact an artifact. The 60 acres were not large enough

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to maintain the genetic base and destruction due to public use was very great.

Dr. Rogers cited the lack of cooperation between institutions as being a problem. Those with the longest history, the botanic gardens, lost their role of distributing plants such as the rubber tree and the oil palm, when agriculture became more scientific. They are now more concerned with the maintenance of floral and decorative plants. They have good seed exchange programs and systematic collections. It was pointed out that many institutions have a "reserve" of land where an effort is made to leave things as they are. Numerous examples are found in the U.S. Such areas are useful and their use should be acknowledged. Land is often diverted into other uses due to lack of information about the value of such land. There should be a nation-wide effort to demonstrate the use.

Dr. Rogers went on to talk about the conservation of certain types of plant material. Seed storage presents both an administrative and a technical problem. On the technical side Harrington (U of C, Davis) and Roberts (Birmingham, UK) are the acknowledged experts. There are no blanket rules and some problems are similar to those encountered in animal preservation. Regeneration of seeds before they lose their viability is a very time-consuming task. Ephemeral desert annual seeds cannot be stored in the same way as those of leguminous crop plants, tropical seeds have different dormancy functions to temperate ones. The cost of storing seeds is increasing as energy supplies are in greater demand, and the backup problems for existing facilities are extreme. He cited the case where the underground power lines for Fort Collins were accidentally severed by a bulldozer. Part of the problem is that the

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federal budget emphasizes military and political stability. Another problem is how to decide what to store, there are all shades of opinion on this. There is a problem concerning knowledge of diversity as taxonomists have not been encouraged to study it. Part of the problem here is that the first U.S. botanists were trained in Germany where the distinction between agriculture and botany had already been made. This resulted in economically and agriculturally important crops being ignored by botanists. There are now good techniques available for the analysis of variability and data but they are not taken advantage of properly. The point was made that it was essential to be able to define diversity before attempts are made to conserve it.

The case of wheat was used to illustrate collection difficulties and exchange difficulties between the USSR and the USA. The USSR are building a new storage facility near the Black Sea and the Leningrad collection will be housed there. It is interesting to note that the seed collection remained unharmed during the siege of Leningrad in the Second World War.

Dr. Mazur asked about the proportion of the U.S. that is conserved in small chunks of ecosystem preserves and how secure they are. There are opposing opinions about this--some say they should be totally protected, others that recreational park use should be permitted and others that grazing rights should be granted. It depends partly on what the land is wanted for. If it is required for gene-pool maintenance and for teaching ecology then it should be left in as undisturbed state as possible. The discussion that took place at the first meeting on public access during Dr. Goodwin's talk was referred to.

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It was agreed that there was no central focus for the concept of genetic resources conservation and that such a focus was urgently needed. The present fragmentation calls for one place where the issues can be discussed.

Dr. Goodwin referred to the NSF and Nature Conservancy inventory of natural diversity in each state. There is a need for a useful data bank but this should not be done on a volunteer basis, must identify a responsible individual or group. Dr. Mazur pointed out that one cannot preserve all species as it would lead to an unnatural static system. However, it was agreed that man should not improperly dominate the earth and its processes vis à vis speeding up loss of species.

When methods of storage were being discussed, mixed seed storage was addressed, and the idea that Antarctica would be an ideal storage place, naturally cold, little threat of invasion, etc. and with a reasonably good record for scientific cooperation. The possibility of the loss of genetic material actually stimulating research into how to prevent such loss was discussed. A diversity of preservation effort is urgently needed, but also it was recognized that any effort on a limited budget should at least be attempted.

Dr. Lewis said that germplasm maintenance involved several stages: (1) gathering, (2) maintenance, (3) evaluation, (4) documentation, (5) distribution of information.
This is how USDA has arranged their plant germplasm efforts. Eventually the NPGRB will go to the Secretary of Agriculture and tell him how to start on an international program for agriculture. A chart of USDA organization is this area is provided.

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With regard to funding for germplasm conservation there was general agreement that NSF efforts were limited due to their concern for research use of the organisms rather than with conservation per se. The listing of stock centers in "Genetics" was mentioned and this will be distributed to the Committee. Research tool animals may be regarded as endangered mutants and varieties but they would be recoverable with a couple of generations of human endeavor. The IUCN effort to conserve mammals was mentioned. Several problems were identified.

1. How should baseline studies be conducted?
2. What can be done to ease the storage problems associated with large animals?
3. How can financial security for important colonies be assured?
4. Curatorial responsibilities should be defined so the possibility of things falling between the cracks is minimized.
5. The question of responsibility for keeping, monitoring and resuscitation of frozen stock should be addressed. In this context Central National Centers were mentioned.
6. Funding and charges for services should be considered.

Questions were asked concerning the Assembly of Life Sciences responsibilities in this area. Dr. Russell summarized some of the relevant activities of the Institute for Laboratory Animal Resources (ILAR). More information on the marine invertebrate group will be sent to Dr. Grassle. Dr. Muckenhirn spoke about the ILAR stock lists and information on animal models. The information is sought out by ILAR staff. She mentioned that it is often an imposition on a research worker

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to provide animals and information when only funded for research. She considered there was a need to discuss <u>how</u> to get information disseminated.

There was a feeling that efforts should be made for animals similar to those that have been made by USDA for plants, but it was pointed out that sympathy and support for zoos was rather thin on the ground. The question of who should decide between maintaining a strain of rat versus oysters was raised. Private industry cannot be expected to assume responsibility for national storage projects; they should be a public responsibility. It was concluded that there are a large number of animals for whom there is no spokesman--perhaps because they are not visual or attractive enough.

After lunch the Committee discussed tasks and objectives for the next meeting. These are summarized below.

A. Committee members were requested to create an organizational chart of their own area ~~or~~ like that of the USDA.

B. VIP will attempt to do the same for federal and private funding institutions with an interest in or responsibility for germplasm resources.

C. The Committee will be provided with the following documents in advance of the next meeting.
   i. Dr. Terrill's summary from USDA and FAO
   ii. Dr. Donovick's summary of the ATCC
   iii. Details of the eleven priority-setting committees funded by NSF.
   iv. A synopsis of the minisymposium on Germplasm Resources held in May 1975 for the Assembly's Executive Committee.

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v. A description of the ILAR programs that are relevant to this study.

vi. A description of any other NRC program that is relevant to this study.

vii. The list of genetic stock centers from "Genetics."

viii. The Genetics Society questionnaire.

D. The Committee members will

i. Compile a list of topics for a table of contents for the final report of the committee.

ii. Indicate the topics that he/she would like to write about or contribute to.

iii. Make a note of suitable contributors for any area of the report.

NB These lists should be sent to Veronica Pye no later than February 21st so that they might be compiled and distributed well in advance of the next meeting.

E. It was suggested that four or five of the following persons be invited to the next meeting.

i. Richard Saunders. New Brunswick. Fish geneticist.

ii. Robert Jenkins. Nature Conservancy.

iii. Someone from the Department of the Interior, for example:

Sid Galler
Clyde Jones

iv. Dr. Kennedy, Biosis, Philadelphia.

v. A forestry specialist. Dr. Herbert Bormann will be asked for suggestions.

vi. Someone from the Smithsonian familiar with the IUCN program.

vii. Someone to talk about birds

a. Wild birds. Dr. Bucheister, former president of the Audubon Society

b. Poultry

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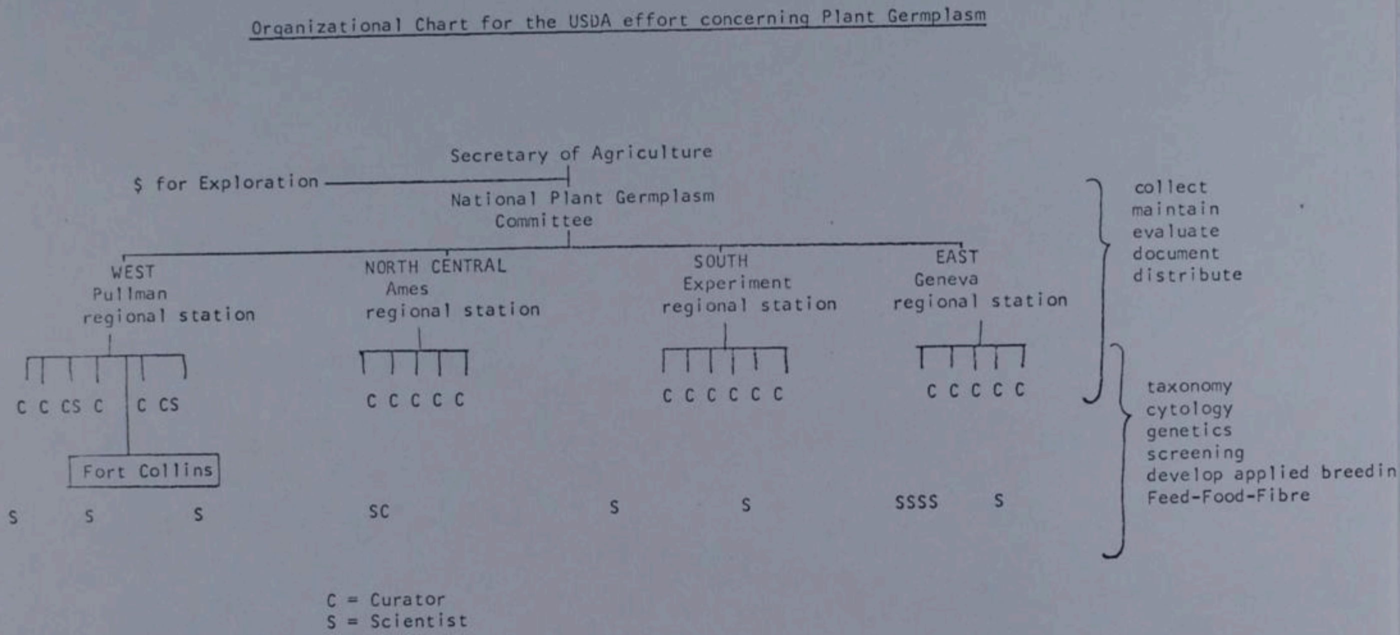

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AAZPA Newsletter #18(3) 1977

AAZPA/ISIS ACTIVITY ACCELERATES

The American Association of Zoological Parks and Aquariums (AAZPA)/International Species Inventory System (ISIS) celebrated its third anniversary in November 1976. AAZPA's ISIS continues to grow as more zoological institutions become active and as new subsystems are proposed and added. The computer data bank now holds records on an estimated 25,000 living mammals and 3,000 living birds. These specimens are housed in the 115 actively participating zoos in the U.S., Canada, and the Netherlands (Rotterdam). Since July, AAZPA/ISIS has been located at permanent offices in the Minnesota Zoological Garden, 12101 Johnny Cake Ridge Road, Apple Valley, MN 55124; telephone (612) 432-9000.

The AAZPA/ISIS Avian Taxonomic Directory, Part I, which includes all orders, with the exception of the passeriformes, was distributed in two sections to all active AAZPA/ISIS ~~participants~~ in May and November of 1976. This volume contains code numbers, scientific and common names, geographic locations, references and three endangered species listings. This volume is available from AAZPA/ISIS at a cost of $50.00 (The Mammalian Taxonomic Directory ($30.00), World Geographic and Zoological Institution Directory ($25.00), and Institution Procedures ($15.00) - the set for $50.00 - are also available from the AAZPA/ISIS office). We hope to have the passeriformes, Part II, ready for distribution in early 1977. Taxonomic directories for reptiles, amphibians, and fishes will be available within the next 12 to 18 months.

The third AAZPA/ISIS Species Distribution Report will be produced and distributed in microfiche form by late January. This report contains information on all living animal specimens in the data bank as of December 31, 1976. Each AAZPA/ISIS participant will also receive its individual inventory and acquisition-release reports on paper and microfiche.

A revision to the Institution Procedures will be available to all active AAZPA/ISIS participants in early 1977. Programming changes are also being inacted at this time, along with a revised New Inventory Data form. These changes and additions will include new codes for circumstances of death, addition of space for sire and dam institution codes, changes to more easily record animal loan transactions, and a repositioning of studbook name/number, tag/tattoo, and house names. Many of these revisions are necessary for the data input of historical records for studbooks and pedigree analysis.

Development of the Physiological Norms subsystem continues with the support of the AAZV (American Association of Zoo Veterinarians). Systems analysis is nearly complete, and computer programming is underway. This subsystem should become operational by mid-1977.

The Life History subsystem development will not be actively pursued for the next year or two. It was felt it would be more beneficial to first concentrate on completing all other facets of AAZPA/ISIS.

In October of 1976, the Board of Directors of AAZPA voted to continue its financial support for the development of the AAZPA/ISIS Studbook-Pedigree Analysis subsystem. With this additional funding, this subsystem could be operational during 1977. This system will evaluate the risks associated with inbreeding and develop computer-based methods to measure and to minimize them. Studbooks, containing historical breeding data, will be produced and will be used to measure the inbreeding in the history of today's animals, an important consideration for future mating choices. Another portion of this program will tabulate all ancestors and descendants of a given animal in studbook fashion. This will be of great value in finding, tracing, and eliminating specific genetic defects. Thus, the studbook-pedigree analysis subsystem of AAZPA/ISIS will provide studbook reports on any and all desired species or subspecies, facilitate genetic management, provide detection of inbreeding-caused problems, and suggest solutions when such problems appear.

The value of the AAZPA/ISIS data bank grows in proportion to participating zoo's submission of accurate and complete data. We urge you to offer support to the AAZPA/ISIS representative at your institution. (Linda Murtfeldt)

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