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About the Institute
The Hunt Institute for Botanical Documentation, a research division of Carnegie Mellon University, specializes in the history of botany and all aspects of plant science and serves the international scientific community through research and documentation. To this end, the Institute acquires and maintains authoritative collections of books, plant images, manuscripts, portraits and data files, and provides publications and other modes of information service. The Institute meets the reference needs of botanists, biologists, historians, conservationists, librarians, bibliographers and the public at large, especially those concerned with any aspect of the North American flora.

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.

A) Introduction: classification, identification, nomenclature, ... floristics etc.

1) The biological categories. (ranks)

2) The evolution (genesis) of the categories.

3) The recognition of the categories (Rothmaler etc.).

4) The identification of the categories.

5) Nomenclature.

"The Burbank Institute for Genetics and Horticulture."

= "The Burbank Institute".

Bill Locke, Waller Seed Co., Guadalupe, Calif.

1) Sterilitetsbarriärer hittas:

- ~~a) kromosomtalsskillnader~~
- b) kromosommorfologi
- c) sterila hybrider — eller inga hybrider (växer sympatriskt)
- d) klara morfologiska discontinuities — (inte lätta att definiera).

1. Introduction (History, etc).

2. Diversity.
   a. General
   b. Morphological
   c. Physiological
   :

3. Causes of variation
   a. Genotypical
   b. Phenotypical
   c. Cytological

~~5. Classification of variation~~

4. Classification of variation
   Philosophy.
   methods.

5. Recognition of groups (methods).
   a. Morphological
~~6.~~
   b. Geographical,
   c. Cytological,
   d. Experimental.
   e. Chemical
   :

6. Nomenclature and description (Phytography) (Collection and distribution?).

~~Herb. technique, gardens, culture techniques; Petri dishes, silica, culture — in vitro techniques.~~

Plant identification?

1

Plant taxonomy is a classical subject with a long history, but it is also a field strongly affected by the theory of evolution, because ~~most taxonomists agree~~ most modern taxonomists agree that a system of biological classification ought to reflect the actual history of the evolution of taxa at various ~~levels~~ taxonomic levels. Until 1930, ~~[illegible]~~ ~~only theoretical~~ the understanding of evolutionary processes leading to ~~the~~ increase in diversity ~~at the~~ below the level of species were supposed to be the same as those leading to the conservation of gene pools at and above the levels of species, exactly as believed by Darwin. This has been used as an argument for the ~~[illegible]~~ almost ~~[illegible]~~ immemorial belief that species are of so many kinds, as to make a universal definition of species impossible and so allowing the acceptance of categories based on feelings rather than facts. In 1930, however, ~~the first evidence~~ a cytogeneticist making a very detailed study of inheritance between and within a number of species of a certain plant genus, discovered that the evolutionary process leading to diversity is fundamentally distinct from that leading to reproductive isolation, which is the classical characteristic of species. Thousands of later experiments have confirmed this observation, which opened the door to clearly biological and exact definitions of ~~the species and~~ the categories below it, and above the level of reproductive isolation at which an evolutionary species begins.

Although several animal geneticists, mainly German and Russian, but also the two outstanding zoologists, George Gaylord Simpson and Ernst Mayr of the United States, have strongly affected the acceptance of the biological species concept through their fine textbooks in animal taxonomy, the field of ~~botanical~~ plant taxonomy still has not seen a single textbook in this field written by a cytogeneticist. Naturally, several ~~textbooks in plant taxonomy are~~ noncommittal and almost mechanical textbooks on plant taxonomy are in use in this century, whereas the ~~two classic~~ three almost classical texts are: (1) R. Wettstein: Handbuch der systematischen Botanik (1924), G. H. M. Lawrence: Taxonomy of vascular plants (1951), ~~and~~ W. Rothmaler: Allgemeine Taxonomie und Chorologie der Pflanzen (1955), and P. H. Davis & V. H. Heywood: Principles of angiosperm taxonomy (1963). ~~They are~~, Although stimulating and well written, all these texts are, nevertheless, ~~however~~, authored ~~written~~ by classical taxonomists who more or less ignore the evolutionary principles as ~~cytogeneticists~~ explained by cytogeneticists, ~~or [illegible]~~ so that their point of view (as Mayr and many others has termed) 18th century philosophy.

This indicates that there is a strong need for a plant taxonomy text that emphasizes the ~~biological~~ evolutionary background as strongly as do the animal taxonomy texts mentioned above. There can be no doubt that the slow development of this important field, especially in America, is to a large extent caused by the lack of an appropriate textbook, because although descriptions of individual observations and theories in research papers influence the elite group of research workers, they do not excite much attention outside that groups or ~~[illegible]~~ gain proselytes among the young generation during their formative student years. With other words, the experience in this field is the same as that of Darwin, who at long last found it necessary to explain at length his new ideas, with a revolution in thinking as an inevitable result.

Since I and my wife have contributed considerably to the ~~A~~ experimental evidence and discussion in the field of evolutionary plant taxonomy since our first research papers was published in 1940, we have not been able to avoid to nurse the idea to write such a much needed textbook, although I have also tried to avoid it in the hope that ~~somebody~~ some other cytogeneticist with a deep knowledge of classical ~~tax~~ and nomenclatural taxonomy and their methods would free me from this task. A few years ago, ~~however, I began to~~ ~~task~~ when a younger colleague made some such efforts that were judged inferior and indeed ~~[illegible]~~ negative by most reviewers, I and my wife discussed the matter seriously and made some initial planning for such a book. It was, however, not until a ~~[illegible]~~ couple of years ago, when the above-mentioned Dr. Mayr and the proliferous botanical evolutionist Verne Grant enthusiastically insisted upon that we be the only ones who could write such a text, that we began serious thinking and planning about what should be included in such a book without making it unduly large and without losing the historical and practical perspective when the new evolutionary philosophy replaces the old and more artistic approach. Last year ~~at this~~ [illegible] we have been organizing these ideas, ~~at writing preliminary chapters~~ reading extensively the classical and modern literature, and composing preliminary chapters for the book. Now we feel that when we have done this during our leisure hours this winter also, time will be ripe for an extensive writing of the text next year. Therefore this application.

Since the planned text is to be based — the evolutionary concept, its first major part is to be a review of the principles of inheritance and cytogenetics as they affect the diversity of morphological and other characteristics of taxonomical importance. Chapters in this part will describe various ~~cytogenet~~. evolutionary concepts, as, e.g., the gene pool, the deme, the population, the genotype, the phenotype, and considerable efforts will be made to demonstrate methods to separate phenetic from genetic influences and to recognize various kinds of modifications, which are caused by environmental factors and, thus, of little ~~a~~. taxonomical significance. Other chapters will describe the ~~causes~~ cytogenetical causes of various kinds of sterility, both those that ~~a~~ are tolerated within a genepool and the others, that definitely effect reproductive isolation. Chapters on abruptly and gradually formed sterility barriers are a must, and so are others ~~and~~ on various kinds of polyploidy and agmatoploidy.

5.

Although we intend to write the book as a text that combines modern evolutionary cytogenetics and classical taxonomy, the proportion of each of these approaches will have to be determined during the course of the final writing. Without mentioning only a few (the hundreds of items that describe the details to be included, our present plans divide the book into the following main chapters:

1. Introduction (history; problems and objectives; philosophy).
2. Diversity (general, morphological, physiological, geographical, etc.)
theory of evolution.
3. Causes of diversity (Genetical, phenetical, cytological, etc.)
4.

1, 2, 3. 4, 5, 6, 7, unchanged or little changed.

Although we intend to write the book as a text that ~~co~~ combines modern evolutionary cytogenetics and classical taxonomy, the proportion of each of these approaches will have to be determined during the course of the final writing. ~~However~~ The presently intended division of the book, however, may be understood from the following preliminary division into main chapters:

1. Introduction (History; Problems and objectives of taxonomy; Philosophical background; Special botany (incl. of general botany, idiobotany, synbotany); Systematic botany (incl. of taxonomy, phytography, phylogeny); Description and order).

2. Auxiliary sciences of taxonomy (Phytography; Morphology (incl. organography, anatomy, histology, cytology); Inner and outer structure; Developmental physiology (= ontogeny); Genetics; Cytogenetics; Modifications; Phylogenetics; Paleobotany; Chorology (incl. geobotany, autecology, synecology, genecology); ~~Biochemistry~~ Chemotaxonomy; Serodiagnostics, etc.).

3. ~~Diversity and its~~ nature of diversity? (Definition; Theory of evolution; Constancy and homeostasis; Variability; Modification; Variation; Probability; Necessity; Combination; Mutation; ~~Comb~~ Recombination; Selection; Aptitude; Antagonism; Synergism; Isolation; Population undulation; Differentiation; Integration; Development of diversity).

~~3.~~ 4. ~~Diversity and its~~ Causes of Diversity (Selection theory; Polytopy; Homologous variation; Monophyly; Polyphyly; Pedigrees; Kladogenesis (incl. Epacme; Acme; Paracme); Divergence; Successive diversity; Convergent diversity; Hybridization; Reticulate diversity; Recombination; Orthogenesis; Parallel diversity; Preadaptation; Evolution of ~~species; Evolution of~~ genepools; Isolation of species and genera;

[Anagenesis; Progression; Specialization; Degeneration; Reduction; Irreversible evolution).

5. Chorology (Geobotany; Areal; Mapping; Forms of areas (incl. Continuous areas; exclaves; disjunct areas; stenochory; eurychory; cosmopolite; endemite; ~~[illegible]~~); Types of areas; Flora regions).

6. Areal and environment. (Distribution; Karpobiology (incl. allochory; zoochory; hydrochory; autochory; myxospermy; trypanospermy; synaptospermy; hygrochasy; xerochasy; vivipary); Dispersal; Anthropochory; Anthropophily; Biotype; Locality; Ubiquists; Specialists; Vegetation lines; Climate; Biological spectrum; Soils; Vicariism; Biotic factors).

7. Age and area (Distribution; Adventives; Anthropophiles; Dispersal; Historical plant geography; Paleobotany; Palynology; Disjunctions; Glacial relics; ~~[illegible]~~ Continental drift; Endemism; Floras; Radiation; Maps; Special plant chorology).

~~8. The Geographical-Morphological Method.~~

~~(Preamble; Size of Area and stability of taxa; Time and Space; Isolation; Morphology and area; Geography of characteristics; Phenoareas; Isosemes; Phylogeny of characteristics; Isospor~~

8. The ~~Geographical~~ Chorological morphological approach.

(Basic philosophy; ~~#~~ Size and stability of areas; Time and space; Isolation; Morphology and distribution; Phylogeny of characters; ~~# Concentration~~; Center of origin and genecentrum; Development of categories).

9. The chemo-serological approach.

(Techniques; amino acids; fatty acids; carbohydrates; alkaloids; cyanogenetic substances; phenolic substances; quinones; ~~terpenti~~ terpenoids; miscellaneous compounds; serology; ~~limitations of methods~~); chemical and physiological races; chemical phylogenies).

10. The ~~[illegible]~~ biosystematic ~~method~~ approach.

(Basis ~~[illegible]~~ of cytogenetics; ~~genotype; phenotype; modification;~~ Hereditary substance, fertilization and nuclear division; Reduction division; Haplophase and diplophase; Genes and chromosomes; Mendelism; Phenotype and genotype; Populations, clones and pure lines; Chromosome mechanism, linkage and crossing-over; Meiosis and crossing-over; Quantitative characters; Adaptation; Sex determination; Multiple alleles; Self-sterility; Structural chromosomal alterations; ~~Spontaneous~~ Gene mutations; The nature of genes; Inbreeding and heterosis; Race formation; ~~Reproductive isolation~~ Polyploidy and agmatoploidy; Aneuploidy and dysploidy; Species formation, abrupt and gradual}

~~Def. Definition of races within species. Definition of genera and family. categories.~~

~~11. Recognition of categories~~

~~(Morphological; geographical; genetical; cytological; chemical; experimental).~~

~~12~~.

11. The Taxonomical categories.

(Definition; ~~Categories; of categories~~; ~~Individual~~;
~~Deme~~; ~~population; pure line; biotype; clone~~;
Species (according to previous and present philosophies); Subspecies; ~~varieties, forms;~~
Agamosperms, ~~Clines~~; Ecotypes; Clines; Demes; Pure lines;
Clones; Biotype; Chores; Variety; Form; Race; Hybrid;
Cultivated plants; Genus; Family; ~~Order~~; Other higher categories;
Examples of diversity of categories).

12. Nomenclature:

(Categories; ~~Bo~~ Vernacular names; Phrases; Generic names;
Binomes; ~~Nomenclature Rules~~ Code of Nomenclature; ~~Rules~~
Basic rules of naming; Synonyms; Homonyms; Priority rules;
The Type method; ~~Change of~~ Transfers; Form of names;
~~Author~~ Citations of authors; Tautonyms; Rejection of names;
Conservation of names; Botanical Congresses).

13. Phytography:
(Taxonomic Technique; ~~D~~Description of individual; Type; Herbarium material; Habit; Morphology; Distribution; Diagnosis; Name; Synonymy; Monographs; Revision; Flora; Checklist; Synopsis; Prodromus; Floristics; Characters; Variability, discordant and concordant; Mass collection; Hybrid-index; Polygon method; ~~Hybrid index;~~ ~~Examples of descriptions and translations;~~ ~~Keys~~ Dichotomous keys; Botanical Latin; Examples of descriptions).

14. History of plant systems.
~~(Aristoteles, Dioscorides, Matthioli; Brunfels, Bock, Bauhin;~~
~~Classi~~
(~~Descriptive~~ Classical period: Aristoteles, Dioscorides, Matthioli; —
Descriptive period: Brunfels, Bock, Bauhin; —
Artificial systems: Gesner, Lobelius, Caesalpinus, Morison, Ray, Rivinus, Clusius, Tournefort, Linnaeus; —
Natural systems: Jussieu, Adanson, De Candolle, Brongniart, Endlicher, Lindley, Braun, Eichler, Engler, von Wettstein; —
Phylogenetic systems: Bessey, Hallier, Busch, Hutchinson, Kusnetzov, Bertrand, Tippo, Lotsy, Pascher, G.M. Smith, Fritsch; ~~Skottsberg;~~ —
General evolutionary systems: Franz, Haeckel, Barkley, Copeland, Skottsberg, Rothmaler, Zimmermann, Takhtajan, Cronquist.)

15. Glossary,
16. Bibliography.

Although we have been working with this scheme in mind, it does not necessarily mean that a considerable revamping will not take place during the year of the fellowship; indeed, we expect to have to use the latter part of that year to select among the topics and to concentrate the book into a text of a reasonable length, ~~and~~ select pictures and make the manuscript ready for the printer. Perhaps above all, the manuscript as a whole and also selected chapters will be sent to colleagues in various disciplines in America and Europe for criticism and advice in order to ascertain that ~~it is~~ the book will ~~be an acc~~ become a generally acceptable a basis of ~~evolutionary~~ teaching ~~in evolutionary~~ taxonomy all over the world. Also, the entire manuscript will be scrutinized by an English-speaking person with a good sense for a fine language, because we realize that ~~only a born~~ nobody ~~else is able to master~~ is able to master a foreign language ~~with enough~~ so that his writings are flawless.

Writing of a textbook in Evolutionary Plant Taxonomy.

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a) Outside support: 1967 – 1972:

NSF. grant ... 1965-67, 67-69.

NSF. grant: 1965-68?

Smithsonian Institution Foreign Currency Grant 1971

– – – 1972

c) Writing of a textbook in Evolutionary Plant Taxonomy.

Fellowship – Guggenheim Mem. Foundation (repeat of 1964 grant).

~~The work applied for is a book~~

(1) A textbook of evolutionary plant taxonomy has long been needed, since the lack of such work in all languages has forced students in this field to rely upon zoological texts, mainly by Ernst Mayr of Harvard, though even that has been very insufficient. Because of strong encouragement from colleagues as Dr. Mayr and Dr. Verne Grant of Texas, another of the leading evolutionists in the States, I have been working on a skeleton of such a book for some time, and ~~have just almost reached~~ expect to reach the stage of intensive writing the coming summer. The book will review in its first main group of chapters plant ~~variation~~ diversity and its genetical and phenetical causes, with ~~a~~ a strong emphasis on ~~genetical~~ explanation of genetical and cytological phenomena of evolutionary importance. This will be followed by a detailed discussion on how this ~~variation~~ diversity is studied by aid of morphology, chorology, cytogenetics, chemogenetics, statistics and taximetrics at deme, population and taxonomic levels. The third main group of chapters discusses principles of classification of natural ~~[illegible]~~ diversity into various levels of categories, and defines each category from different points of view. It is likely that considerable historical and philosophical discussion will be intermingled into this part of the book. ~~Whereas~~ and information retrieval by [illegible]?

Whereas the last group of chapters will give practical information on the rules and methods to be followed in phytology and the description of new taxa, classical and modern methods of revision and monographing plant species, genera and families, and the methods to be followed in ~~an~~ the compilation of checklists, flora lists, floras, indexes etc.

The book is expected to be written in a very concentrated style because it must cover large material needed for a modern course in plant taxonomy which is important as a basis for studies in ecology and other botanical sciences. Nevertheless, it looks as if it will have to be allowed to fill over 500 printed pages, including a limited number of explanatory pictures.

~~The book~~ The lack of such a text has greatly hampered the development of evolutionary taxonomy, since, as Darwin once observed, even the best of journal articles of which we and others have written much in the last three decades, do not excite enough attention for a revolution of the kind we have seen in this field in the last generation, thus showing how necessary it is that any new view should be explained at length and in a full context in a good textbook.

Since no such textbook is available in any language, no relevant literature is available for citation.

And it is my hope that my sometimes boundless energy ~~strong~~ combined with my excellent personal library in this field (ca. 32000 reprints over 6000 books) will allow me to complete the writing during the period of the fellowship so that the manuscript can then be prepared for printing

Darwin once said that although research papers ~~not~~ usually include the seeds to revolutionary progress, they often do not excite much attention — which shows how necessary it is that any new view should be explained at length. This was evident from his personal experience until his famous book changed the world. It has also been evident in the modern approach to evolutionary plant taxonomy, which is mainly known from the research papers of numerous cytotaxonomists, although most students still are being fed the opinions of textbooks which ~~present~~ propagate ~~opinions of the far~~ the taxonomical philosophy of bygone generations. But ~~standard~~ textbooks in ~~evolution~~ general evolution ~~sitting~~ are numerous, though they touch upon taxonomy they only argument and ignore taxonomic practice. In zoology this is different, to a great deal thanks to German sys~~tematists~~ Ntaxonomists of the now older generation and to a handful of enthusiastic systematists at Harvard and other eastern centers, notably George Gaylord Simpson and Ernst Mayr. Progressive botany professors have advised their students to supplement their plant science books with these zoology texts, but although this certainly has strongly affected their thinking, it has been insufficient for the normal development of evolutionary botany, which is the most important basis for progressive botany of all leanings and then especially ecology and biogeography.

~~A~~ I have long been nursing the idea to write such a botanical textbook, but not until Professor Mayr and ~~Prof~~ the equally well-known botanical evolutionist Verne Grant a couple of years ago ~~enthusiastically~~ enthusiastically prodded me to write such a book based on my long experience in the field, did I seriously think about this possibility. For the past two years I have been playing with this idea and thinking about what should be included in such a book without making it unduly large and too expensive to the student. Last year and this winter I am working on the organization of these ideas and feel that I will need one year of relative peace to get the work done. Therefore this application.

~~Although~~

To synthesize the cytotaxonomical background of evolutionary plant taxonomy.

Plant taxonomy is a classical subject with a long history — —

To synthesize present knowledge about polyploidy as an evolutionary process.

Although polyploidy is one of the most important phenomena of evolution, the immense knowledge collected by workers all over the world, has been synthesized only twice, in 1936 by Müntzing, and in 1950 by Stebbins, although shorter reviews of one of its processes have also been published.

Polyploidy and distribution.

Cytogenetical and physiological sex determination in plants.?

Together with Goblanski?

To synthesize in a book the

To synthesize present knowledge of evolutionary botany

To complete and prepare for publication the first volume of a comprehensive data bank for cytotaxonomy — cytotaxonomical atlas of ferns?

To work on a book synthesizing present knowledge of cytotaxonomy and evolutionary botany?

Plant taxonomy:
1) Identification
2) Classification
3) Nomenclature.

Necessary for good taxonomy: (leaving as little as possible to chance)

A sound knowledge of all the facts (not just those which favor your views), present them clearly, and draw reasoned conclusions from them that are in conformance with evolutionary theory and diversity.

1. Variation
    1) Phenotype
    2) Genotype
    3) ~~Chromosome~~ Karyotype
    4) Polyploidy etc.
2. Geography?
3. Classification
    a) Theory
    b) Practice
4. Identification.

[illegible] in major groups?

Methods?
Chem. Cyt. —
Numerical

For identification, morphology is at least the best and usually the only (method) reliable), whereas for classification into biological categories its reliability varies.

Omit to use earlier observations

Hultén's Elymus for Elytrigia, [illegible]

~~The authors of this paper have added new information, by aid of two mainly of two methods~~

This paper is the result of studies of limited but important material of ~~[illegible]~~ American plants the taxonomy of which at two levels has been greatly confused, mainly because of misunderstanding or shallow observations of past botanists. The authors' additions are substantial but because of still limited experience and of innocent timidity to draw required conclusions that must differ from those of earlier ~~and~~ American authors and of their advisers, they fail to solve the problem and even add to the confusion ~~[illegible]~~ by ignoring earlier observed facts that are at least as important for its solution as are the new observations. In addition, the paper ~~[illegible]~~ includes unnecessary and shallow discussions of ~~problems of~~ matters of no significance for the problems to be solved, and the presentation is verbose, ~~[illegible]~~ often lacks sound logic and clearly reflects ~~[illegible]~~ lack of familiarity with the basic ~~principles of~~ knowledge of taxonomy, phytogeography and evolutionary cytogenetics. These are strong judgments, but I believe they are fair, - - -

The solution of any biological problem requires not only new observations but still more a new scrutiny of the entire evidence of the past.

This neatly but not always carefully written paper is packed with ~~ing~~ information, although some of it bears little relation to the problem to be attacked. It adds new chemical data that seem to contradict the opinion of the authors as to the generic status of the group in question, and support their opinion as to the ~~hybrid origin and type~~ hybrid character and hybrid derivation of two of the taxa they studied. Since I am not a chemist, I cannot judge the validity of conclusions based on this ~~[illegible]~~ restricted analysis, but since the authors also are only amateurs in chemistry, perhaps their discussions in this field ought to be evaluated by a specialist, although I ~~[illegible]~~ have no reason to doubt the ~~validity of~~ correctness of the observations? ~~They have also~~

Although this is a neatly written paper, ~~I have come to the conclusion~~ detailed scrutiny and repeated rereading of it have led me to conclude that it would be wiser not to publish it as it stands but instead propose to its authors that they rewrite it more carefully. - -

Actually a report of a ~~chemical~~ study of the occurrence of certain chemicals another genus in ~~populations~~ limited NW Am populations of a group of plants supposed (to hybridize a ~~[illegible]~~

Chamaepericlymenum: Fl. SSSR, Rydberg, ([illegible], [illegible] 1911), L.&L. (Nt. World), | Clapham, Tutin & Warburg 31, Dandy 1958, Wangerin ([illegible]), Löve 1970, 1978,

Innocently unaware.
Without realizing it, they have added material that together with earlier observations is sufficient not only to solve the problem presented but to urge the solution of the generic status of the group that they study. Let us first look at the earlier data.

Evolutionary ecology — [illegible], is [illegible] [illegible] the human environments are [illegible].

Ecosystem — balanced & unbalanced.

Coined by Tansley ((1935?) —

replaces [illegible], which is meaningless evolutionarily.

Balanced as long as little is taken from it,
unbalanced: Greece etc. (goats, fire), Iceland: forestry; N.Z. —
Unbalanced only for some time, then adjusts to it and balances again: prairies ——

Man needs to balance the ecosystem in his favor.
Therefore, conservation with human ecosystems in mind.
We breed plants and animals to increase productivity of ecosystems, but need to balance them in a new way for man, everywhere. Also improve soils...

Engineering needs to decide about what changes are needed in the ecosystem for every particular program.

Hunger is the result of disturbed ecosystems.

Much written about the need to conserve plants and animals, but little on why they should be conserved.

[illegible]: — Relation of pollen sterility in Russia?! Austria?!

Send big book ads.

Big bang - theory: 10.000 million years, stable stage?

Ernst Mayr (65) President's science medal!

[illegible]:
Dudley Bibliography.

cf. [illegible]

Understanding chromosomes.

It is an old experience that the greatest truths are those which being simple in themselves illuminate a large and complex body of knowledge science. This becomes evident when we try to understand the chromosomes. The plainness of their appearance and replication is such, that it would be difficult to believe that they carry within themselves the basis of diversity and inheritance in the living world and that they indeed are the fundamental units of all evolutionary processes. To understand their simplicity is to understand the complexity of the living world and to comprehend the evolution of the entire system of biota.

On basis of the ~~phenom~~ simple phenomena connected with chromosomes that are described on these pages, certain generalizations of significance for evolutionary biology may be drawn. We may state at the beginning that the chromosomes are the site of the genes, or of DNA chains if the reader so prefers; ~~they are studied by gen~~ ~~their influences are~~ their effects are studied by geneticists whereas their chemistry and function is studied by molecular geneticists ~~applying~~ with the electron microscope and applying the methods of physics to their investigation. It is the subtle variation between these chemical units that is the basis of the diversity of the living world. Since constancy and permanence of these units of life is of an immense importance, ~~a complex~~ a relatively simple mechanism for their replication has developed early in the history of life and penetrated from the lowest to the highest ~~eukar~~ eukariotic biota. This is mitosis and its later deviation called meiosis, which multiply the number of cells without changing the number of constitution of the chromosomes and arrange for a thorough mixing of the genes in consecutive generations. No process has ever been more exact or more conservative.

Although the genes are extremely conservative, ~~it is~~ they are not entirely unchangeable, since it lies in their nature to form new variations. This nature has taken care of by building into the chromosomes certain possibilities of errors, or accidents, that change genes and produce new ones. This we call mutations, Mutations are constantly being found

Farris Hollmann (1971)

For Allium:

1) Pretreat root-tips in a saturated solution of paradichlorobenzene for 4-6 hrs.
2) Fix for 24 hrs in acetic acid - ethanol (1:3).
3) Store in refrigerator in 70% ethanol.
4) Stain in 2% aceto-orcein. Squash.

which is, the total gene information encoded in the ~~[illegible]~~ sum total of the genes, in a breeding population or biological species.

in a very low frequency, so low that they are rarely observed even in the most common of organisms, though actually all ~~[illegible]~~ genetic variation descends from this process. Mutation may be formed by hits of invisible radiation and by some chemicals, but ~~[illegible]~~ most frequently they are the results of minor accidents during the pairing and replication of the chromosomes, usually at meiosis. Most of these mutations consist of loss of material or of a change that makes the gene recessive or inactive; such changes are steps backward and detrimental to the individuals and population, so chromosome thus maimed will be at a disadvantage and soon be lost from the genepool. An infinitely small number of these rare accidents, however, will cause changes which add new material to the genes or strengthen them in one respect or another, forming among others what we call codominant genes. Such positive mutations will survive and strengthen the population when combining with older genes, and increase the diversity to make the deme in every respect more virtuous.

~~Positive mut~~ Constructive mutations in the conservative chromosomes are the main source of increased diversity, but their real effects become observable only after they have had a chance to combine and recombine with other genes. This is done through hybridization. Although it is believed that natural selection will decide about the viability of such new combinations as are produced through this process, ~~[illegible]~~ we should not underestimate the influence of socalled genetic drift, or random fluctuations in gene frequency caused by the limiting effect of small ~~populations~~ demes or small populations on the ~~[illegible]~~ possibilities of recombination. ~~Because most selection~~ However, selection will help in refining and polishing the new product so that it fits the environment perfectly or nearly so. About this the learned men still argue and divide themselves into ~~[illegible]~~ almost religious groups of believers and non-believers.

These ~~purely~~ essentially genetic processes produce and shape the diversity of the genepool. They are basic for the development of clinal variations which are combined with selection by a gradation in the environment, and by aid of other ~~[illegible]~~ extraneous ~~[illegible]~~ or geographical isolations (allopatric) ~~variation~~ they shape into minor geographical races, which the taxonomist calls varieties, and major geographical races, which we regard as subspecies. That, however, is the end of the genetical evolutionary line, because other processes are required to form a new genepool that is effectively isolated from its relatives by ~~reproductive~~ internal reproductive barriers which are characteristic of the biological species. At no level are races of the genepool an incipient species as has been believed by non-geneticists, ~~because~~ for the single reason that their creation ~~is~~ requires ~~[illegible]~~ an undisturbed or at least only little disturbed miscibility, so that whenever new combinations arise, they will be carried back into the original pools with which they always share the great majority of their homozygous gene combinations.

The chromosomes have another inbuilt mechanism that affects their constancy above the level of the gene or shuffles around blocks of genes without causing their mutations. By aid of accidents of a greater magnitude, moderate or extensive parts of one or two chromosomes may break and unite again in a way different from what formerly was. These are the inversions, segmental interchanges and duplications, but also deletions and fragmentation of chromosomes. All affect the fertility and viability of

XX. Basic number and polyploidy.

The processes of mitosis just described are the same irrespective of the number of chromosomes, ~~at the~~ which in the somatic or body cell of the organism is said to be diploid, usually designated 2n, whereas the gametic number in the sex cells it is haploid, designated n. Frequently, species of a genus are characterized by a multiple of the same low number of gametic chromosome sets, which are called haplomes, in contrast to genomes, which are the sets of all genes of any diplophase in a taxon at any polyploid level. Such a series, which may reach up to 80 times or more the original haplomes, as in some ferns, is called a polyploid series, and the constituents are called polyploids, with the prefixes tetra-, hexa-, octoploid, etc. depending upon the multiples they represent. At any level, haploid designates the number of chromosomes in the gametic cell, or haplophase and diploid that of the somatic cells or diplophase, whereas the latter is also the term for the lowest diploid number in the series. The lowest haploid number of a polyploid group, including only a single haplome, is ~~called~~ said to be monoploid, and it is also the basic number of the series, designated x. When more than one basic number is met within the same or closely related genera, this is called dysploidy.

the individual harboring them in a heterozygous condition, but whereas the first three may strengthen the deme when homozygous, and even add to the variation through socalled position effect, deletions and fragments are ~~at~~ invariably deleterious and will soon be bred or selected away.

Inversions, segmental interchanges, and duplications may survive in the population without appreciable effects, although in hybrids they will cause sterility which disturbs genetic segregation, and ~~they may~~ even that may be tolerated for a long time. However, sooner or later such hybridization increases the chromosome rearrangements through additional breaking ~~at meiosis~~ because of mechanical disturbances at meiosis. ~~Slowly~~ By time, hybridization accumulates such changes in populations that will become increasingly isolated because of limited interfertility and other factors leading to somewhat separate variation. Such populations, which may or may not be morphologically distinct at this stage, are the real incipient species, and they are the most frequent cause of confusion among taxonomists for various reasons. Slowly but certainly such an accumulation of chromosomal rearrangements will lead to what is called gradual speciation or the creation of an effective reproductive isolation between the new and the original ~~population~~ genepools. It is reproductive isolation of such an internal kind that is the only general characteristics of the biological units which are traditionally called species, or of the evolutionary stage when gene exchange ceases and two populations become effectively launched onto different channels of evolution.

Gradual speciation sometimes commences allopatrically as the result of an accidental but effective geographical isolation; it is then an extremely slow process. More frequently, however, it starts sympatrically within a deme, and is then most effectively accelerated when parapatric demes differing in chromosomal rearrangements meet and hybridize and increase and accumulate new breakages on a grand scale. If the new chromosome arrangements are deleterious, they will soon disappear, ~~but when they become homozygous or reach the~~ Sometimes they may succeed to avoid ~~isolation by~~ ~~[illegible]~~ complete isolation by developing into permanent heterozygotes, as, e.g., *Oenothera*, which is either a deadend or an intermediate state which later may continue towards complete reproductive isolation. But when they get past all the dangerous hurdles on their way towards homozygosity of the advantageous new chromosomal combinations, they have ~~[illegible]~~ formed a new gene pool (and launched it on its way towards new and distinct diversity of its own.

The gradual speciation process is the common means of evolution of reproductive barriers ~~between gene~~ that isolate genepools. There is, however, still another chromosomal mechanism which leads to the most effective reproductive barriers known and produces it instantaneously. This is ~~[illegible]~~ the socalled abrupt speciation, ~~by which~~ which by aid of polyploidy doubles the chromosome number of a deme or a hybrid, as has been closer described in the text. Because this is a process as irreversible as is gradual speciation, the new genepool with its double number of genes and chromosomes will strive towards homozygosity, and its hybrids with the original genepool will be sterile and unable to form viable offspring simply because ~~of its [illegible]~~ its numerical unbalance, and ~~so it will continue its way as a new~~ so the polyploid will ~~be effectively~~ also have reached the stage when gene exchange between it and the parental demes will have definitely ceased. If the new combination is genetically advantageous, it will survive. If not it will soon succumb and disappear.

Polyploids are of different kinds, depending upon their origin. First, they are either ~~divided~~ ~~into~~ autoploids and alloploids, the former having originated by the duplication of essentially the same haplome, the latter by the duplication of the chromosome number of a more or less sterile hybrid of two more or less distinct ~~haplomes~~ species. Second, ~~each of these groups are~~ it has been found to be practical to subdivide each of these kinds into two groups. Then, typical autoploids, which are the result of the duplication of the haplomes of a single diploid population, preferably a group of strictly autogamous plants or at least of reasonably purebred groups of allogamous taxa, are named panautoploids. Such a taxon is supposed to be very similar to the original population, though it is isolated from it reproductively and is likely to have different adaptive properties caused by the difference in chromosome number alone. The alternative type of pattern is that of the rare and difficult hybridization between two species which are so widely distinct that their ~~chromosomes~~ haplomes are almost completely non-homologous so that the hybrid is completely sterile. Its polyploid is a constant alloploid, or panalloploid, combining the morphological and physiological characters of the parent species, and with essentially the properties of a fully fertile diploid. In between these two

4.

Wilson, E. B. 1900: The cell in development and heredity, 2nd edition. - Macmillan, London.

~~[illegible]~~

This carries us to the statement that a good biological species is characterized by a single chromosome number and by a limited variation in the linear arrangement of the genes in its chromosomes. ~~Two related species~~ ~~The difference between two rel~~ The difference in morphological characters between two related species may be large or small, and the variability inside each group also may be limited or wide, but this is secondary to the reproductive isolation, because, as Mayr (1963) so ~~[illegible]~~ ~~correctly~~ aptly has put it, "to be a different species is not a matter of difference but of distinctness". For identification of the isolated genepools the taxonomist may sometimes be able to select between hundreds ~~[illegible]~~ of characteristics, but in other cases a single difference may be sufficient for this purpose. In both cases, however, the species is equally well defined.

When a biological species has been ~~identified~~ recognized, either by aids of its deviating chromosome arrangements or by its chromosome number, the next step will have to be a search for morphological characteristics to identify it as a systematic unit. These characteristics ought, preferably, to be connected with ~~flowering~~ ~~others~~ the flowers and fruits, because these parts of the plant are known to be less modifiable than others, and a genetic species concept needs to avoid phenetic identifications. ~~[illegible]~~ The last step, then, will be to select the nomenclaturally correct name from possible older but ~~unnoticed~~ ignored descriptions, or to give the plant a new name based on a new description.

Although every biological species is, as claimed by Wilson (1900) and since then amply confirmed by thousands of studies, characterized by a single chromosome number, there are species which taxonomists of the past have given so wide delimitation that cytologists sometimes find them to include more than one number. For an evolutionist this is then an indication that former classifications have not succeeded in distinguishing the biological species within the group in question, and so a search for ~~characters~~ differentiating characteristics useful for their identification is needed, and also a selection of a correct name. But to classify such taxa at a level lower than that of a species because earlier generations ~~did not succeed~~ could not agree upon their distinction is a misunderstanding of the basic facts of evolution. Nevertheless, there are still many ~~distinguished~~ botanists, who claim an ~~[illegible]~~ acceptance of the theory of evolution, but who do not believe in or understand chromosome numbers and their connection with the isolation of the gene pool, exactly as there still are independent thinkers who believe in the flat earth. That is their matter, which changes nothing in the logical understanding by others of the chromosomes and their evolutionary significance.

Chromosomes and their behavior is of importance for the understanding of several ecological phenomena, although only a few preliminary efforts have been made to utilize this in explanations of these matters. ~~Also~~ Also, polyploidy is of a considerable geobotanical significance because it is a strong ~~[illegible]~~ phenomenon of preadaptation. Chromosome morphology and rearrangements are of an immense significance for plant breeding because they ~~may~~ influence genetic behavior and thus may present some activities of interest to plant breeders; understanding this may save efforts and point to new and more effective ~~methods~~ practical methods. ~~[illegible]~~ Breeding by aid of an artificial polyploidy was done already by those who selected our most important cultivated plants, and recent experiments with the effects of x-rays have revealed several agriculturally positive so-called mutations, which actually seem to be positive effect from artificial segmental interchanges or inversions.

extreme cases, without any distinct limit, are the hemialloploids, which are formed from not fully sterile species hybrids, and the hemiautoploids, which are produced either from more or less fertile intraspecific hybrids or by differentiation of the ~~chromosome sets~~ ~~[illegible] three~~ ~~the~~ chromosome set or genome of successful panautoploids. These two intermediate groups constitute the majority of known natural cases ~~at once~~ and seem also to include a considerable number of cultivated polyploids. ~~[illegible] tend to change change~~ The chromosomes of such polyploids tend to change in such a way that multivalents are reduced and bivalents increased; that is called [illegible] (alloploidization) or diploidization

In this connection it ought to be emphasized that the creation of a polyploid of any kind from a stabilized gene pool at all times results in the creation of a strong barrier to gene exchange which is the basic requirement of the biological species concept. ~~Therefore, the process of polyploidization is also named abrupt.~~ Since this is an ~~[illegible]~~ instantaneous procedure, the process of polyploidization is termed abrupt speciation, in contrast to the ~~(more~~ stepwise progressive ~~gradual~~ process of the linear differentiation of the chromosomes in what is called gradual speciation, which will be described later.

A phenomenon that ~~rarely affects sex cells~~ rarely may affect sex cells and then be the cause of sudden polyploidy, is socalled endomitosis, or the ~~division of the nucleus~~ replication of the chromosomes without division of the nucleus. It results in socalled endoploidy, ~~and~~ or polysomaty ~~which~~ the visible outcome of which

We have just begun to understand some of the general evolutionary phenomena that the chromosomes affect, although books could be and have been written about what is presently known. The most comprehensive discussion available in this field is that of White (1973), who emphasizes chromosome phenomena in animals as does also Dobzhansky (1972), but for plants good reviews are available in texts by Stebbins (1950) and Grant (- - - -). But although the understanding of the chromosomes by cytogeneticists is thorough and deep, there are still many botanists, who profess ~~a belief~~ an acceptance of the principles of evolution but who do not believe that the chromosomes are more important ~~th~~ in taxonomy and geobotany than are hairs and colors or ~~[illegible]~~ devices related to special ecological conditions. There are also still left some independent thinkers who believe in the flat earth, though this ~~[illegible]~~ does not change the principles of the earth sciences, ~~[illegible]~~ and we may feel confident that when ~~chromosome knowledge~~ the knowledge of the chromosomes becomes more widespread, the understanding of their strong role in all kinds of evolutionary processes also will become generally accepted.

may be occasional polyploid cells or sectors in the tissues where it occurred. Its evolutionary importance remains obscure, though it apparently is typical of certain ~~organs in plants and~~ ~~[illegible]~~ ~~diversified~~ specialized tissues. ~~Endomitosis is also the process~~ Repeated endomitosis without ~~the~~ subsequent separation of the chromatids and without division of the nucleus is also the process forming socalled multistranded or polytene chromosomes, which are found especially in cells of the salivary glands of larvae of some dipterous insects.

~~I. Diversity and its causes~~

II.

Introduction

Part I. Diversity and its causes.

Part II. The morphological characters

Part III. The categories

Part IV. Determination and identification of categories.

Part V. Nomenclature and description.

Diversity and its causes

The morphological characters ([illegible]).
The geographical differentiation (in [illegible]).

Genepools, major and minor geographical races, local races . . .
biotype —

Variation in DNA content = polyploidy, [illegible]

Hartung?
Wagner?
Darwin
[illegible]

~~Distinct~~ Genepools / in plants are usually distinguishable by aid of distinct morphological and geographical features, exactly as are man and the other hominids.

Geographically they may be either allopatric or sympatric or both; if they are / even partially sympatric, they do not mix, contrary to what happens with sympatric races at any level, whereas ~~allopatry~~ a complete allopatry is a less conclusive characteristic because it is shared both by genepools and by races that have occasionally ~~[illegible]~~ been separated either by historical events as e.g. continental drift, ~~[illegible]~~ submergence of connecting lands, or by dispersal by a small founder element.

Much diversity is of no taxonomical significance although it is important [illegible] for the survival of the taxon; we consider mainly the former, but mention the latter only in cases where it may be exploitating for the success of the taxon and its further evolution.

Founder: the Indians contrasted to all Mongols, Turks mixed

Causes: 1/ ~~[illegible]~~ in demes (mutations etc.), 2/ minor races (selection isolation), 3/ major races (isolation) 4/ genepools (isolation).

Tolerate a considerable number of negative genes (genetic load), and of chromosomal rearrangements (Anderson) which are a kind of a [illegible] that can become effective in gradual speciation later, when hybridization and selection work them out in new [illegible].

All evolutionary processes in all biota are based on gene mutations, genetic recombination, natural selection, and ~~[illegible]~~ isolation, but in various degrees at various levels.
Isolation is geographical and external at lower levels, reproductive and internal at the levels of the genepools (and above)

Related genepools have, evidently, evolved from the same original genepool, but that differentiation has started at a lower level and later been accentuated by ~~[illegible]~~ extinction of intermediates, if any.

Small, or single, chromosomal rearrangements occur in individuals; if they are not selected away, they will soon become homozygous and as such form a deme of their own; ~~but~~ whenever ~~individuals~~ individuals of that deme cross with the former deme, cytological disturbances will decrease but not prevent gene exchange, but not to the extent of a reproductive isolation. However, if demes differing in more than one such rearrangement hybridize, changes or leaps described as saltation occur: most of the new combinations will not be tolerated by selection, but if some survive, they may have gained reproductive isolation and genetical balance that allow the launching of a new ~~[illegible]~~ and independent gene pool.

Genetic diversity chromosomal diversity

Cytotaxonomy: Biosystematics

Book I: Causes of diversity variation, eller Part I: Genetical background.

Genepool, population, deme, diversity

DNA-gene, chromosomes.

Genotype, phenotype, modification.

Autogamy, allogamy, apomixis.

Polymorphism, mendelian inheritance.

[illegible] i taxonomins idéerna om genom och arter mycket [illegible] efter Darwin, men [illegible]
The diversity and its ladderlike grouping was evident to all, the reason for it was dim until the time of cytogenetics. [illegible]

It was evident to Linnaeus and many before him, that all living beings are related and that they have developed according to the same principles, although these were less known to him than they are to us. ~~And~~ Therefore, when he proposed his classification of animals and plants into categories, he selected those in such a way that were clearly repeated within every group of living beings, from the smallest ~~plant~~ lilies of the field and the fowls of the air to man himself and his relatives.

When man first tried to classify natural variability, he used himself as a basis for his grouping of animals and plants. . .

Biosystematics is classical taxonomy at which the methods of ~~[illegible]~~ cytogenetics are applied to secure the evolutionary evaluation of the basic categories. . .

(See Wiggins)

The diversity of the stones on the beach is caused mainly by external factors, whereas internal factors predominate in creating the diversity of living beings.

Biosyst. incl. not only tax. but also evol. — here only what is of int. for classification

Since the uncertainty of morphological judgements has resulted in the creation of names for most critical taxa at various levels, we do not expect to have to propose new names for many of the taxa involved, but only select them differently from what accepted at present without knowledge of their chromosome condition.

Splitting, when not known about reproductive condition.

See Pierre's review —

Show Borge!

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~~Deme~~:

Nodum: an abstract vegetation unit of any category (Poore 1955-).
Taxon: a unit of any taxonomic category.
Deme:

Populations – small — adapt phenotypically like Solidago, then if genetically different — also permanently.

Polyploidy example: Györffy's mosses, with wider reaction of phenotype first — then selection. That is ~~[illegible]~~ selection of not inheritance of acquired characteristics of populations, cf. Lamarck.

Systematic biology is basically a logical science, and it gets its meaning when it accepts (follows) the theory of evolution so that its categories are so defined that they reflect the stepwise and continuous variation which is the signature of the historical succession of living beings.

Systematic biology is also an historical science which reflects the evolution of thinking from times ~~immemorial~~. Thus, the system into which living beings are being classified, is ~~an~~ a logical invention of times when nothing was known about the laws which decide about the variability observed ~~and~~ so the classes selected reflect the observation of effect without the understanding of the cause. But they are nevertheless a good reflection of the natural conditions. ~~Therefore,~~ ~~Therefore, most classification~~ Since the higher categories are very distinct because of extinction of intermediates through the eons of evolution, they are not or slightly affected by

new definitions caused by the acceptance
evolution as their cause
of the theory of evolution, whereas newer
methods that separate the results of
different changes affect somewhat the
groupings at ~~lower~~ ~~the~~ lower levels.

(Cytotax. methods for abrupt species, do. for gradual species)

Systematic biology and ~~geobot~~ historical geobotany are basically logical sciences, which get their meaning when they are conceived as based on the principles of evolution.

Understanding plant taxonomy.

I. Introduction.

II. Evolutionary background: Diversity. see Ehrendorfer & Stebbins.

III. Identification: Morphology.

IV. Nomenclature.

V. Practice: actual examples (monographs etc.).

Same process, stepwise, always repeated:

Diversity, isolation, diversity higher - - - -

Explanation:

Polyploidy and endemism. (survival of endemics).

Endemism is low in the arctic flora, not because it is young, but because selection has been strong, especially at the diploid level, at which most endemics are being formed.

Most endemics are ~~[illegible]~~ alpine or insular?

All isolates will by time become extinct. . .

Most endemics are rupicole (Pawlowski p. 213 (Braun-Blanquet-)) from rocks.

[illegible]-Hagen: ? polyploidy & life form?

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Potentilla rupestris L.

Voucher: Provincia de Teruel: Sierra de Albarracin, Sierra Alta, N. 0490.

$2n = 14$.

A confirmation of several earlier reports.

Potentilla recta (L.) Räusch.

Voucher: Provincia de Teruel: Sierra de Albarracin, 30 km from Tragacete on the road towards Cañete, N. 0476.

$2n = 28$.

A confirmation of more than twenty previous reports.

Potentilla reptans L.

Voucher: Provincia de Jaén: Sierra de Cazorla, Laguna de Valdeazores, N. 019.

$2n = 28$.

A confirmation of about a score of earlier reports.

Potentilla reuteri Boiss.

Voucher: Provincia de Teruel: Sierra de Albarracin, San Felipe, N. 0444.

$2n = 42$.

This is the first chromosome number report for this taxon. According to Ball, Pawlowski & Walters (1968), it is probably a hybrid between *P. recta* L. and *P. nevadensis* Boiss. ~~The f~~ The former species is known to have $2n = 42$, but the latter remains cytologically unknown.

Taxonomy of plants.

Modern Taxonomy:

I. Explain methods of evolution that lead to speciation and subspeciation — Later Rothmaler's chapters on how to detect each group of evolution.
van Steenis descriptions,

Expl. of correct contra wrong classification in one chapter:
Veronica hederifolia + V. sublobata, not ssp. lucorum.
J. Saarisalo 1971. Act. Bot. Fen. 8: 152-155.

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YUGOSLAVIA

REF.:

An attack on the taxonomical and cytogenetical problems of endemism.

1) Yugoslavia (general)
2) Gentianaceae (special)
3) " "

Kušan, Josifović, Favarger, Böcher,
Stebbins

~~Endemism~~ Cytogenetical and biogeographical study of endemism.

: Meusel, Hultén, etc. contours.
Favarger, Stebbins, Major,
Gentianaceae & arctic plants.
: Concentrate on SE Alps, Balkan & Adriatic, Rocky Mts.

PREFACE

Systematics, that branch of biology which deals with the classification of animals and plants, has two reasons for its existence. One reason is that biologists in all fields need to recognize the identity of the plants and animals which they are studying , and for this purpose a sure system of classification is indipensable. In the biological world as in any other, we need to know what we are studying before we can ask ixx intelligent questions regarding why it is as we find it. The second purpose of systematics is to explore the relationships between species and other groups of organisms of which the identity is known , and in this way to learn more about one of the basic phenomena of biology, organic evolution.

Before Darwin , these two goals were indistinguishable. Species were regarded as part of the great design of xx the Creator, and their interrelationships as simply another facet of His design. Even the advent of the " Origin of Spedies " had relatively little effect on biologists actually working in systematics. Although they recognized that the relationships which they were revealing would have to be regarded as the outcome of a long process of evolution rather than as part of a single master plan, they had little k or no understanding of the processes which bring about evolution , ~~and~~ They could analyze relationships only by studying more intensively the same specimens which xxxxxdxtxx provided the basis for identifying and delimiting species and other categories . For ~~both~~ the purpose of identification and definition, as well as for determining relationships , systematics was based almost entirely on comparisons between the outward appearance of adult organisms.

The first serious challenge to this unity of purpose and method in systematics was made by the rediscovery of the Mendelian laws of heredity and the almost simultaneous publication , at the turn of the century , of deVries's " Mutation Theory . " At first , systematists tended to minimize the importance to them of these discoveries. They judged correctly that the single gene differences which the Mendelians were finding in all of the species ~~which~~ of animals and plants which they were studying could not by themselves account for the origin and differentiation of these species. They also recognized that the " mutations " which were thought by ~~R~~ deVries to represent new species originating in his garden ~~were in fact~~ actually represented a peculiar type of variation within species , ~~and~~ They were fully prepared for later discoveries which showed that the evening primrose (Oenothera) , in which most of these " mutations" were found , possesses a distinctly abnormal genetic behavior , ~~of~~ which is manifested by the sudden appearance of unexpected genetic recombinations. Hence the first discoveries of Mendelism ~~provided~~ did little ~~little basis for changes by~~ to make systematists change ~~of~~ either their methods or their basic concepts.

During the first quarter of this century , however, Mendelism widened its scope , while its phenomena ~~xxxxx~~ were found to be based upon the behavior of those all important nuclear ~~bits of xxxxx living matter found in the nucleus and~~ structures known as chromosomes. Meanwhile ~~, differences in the number and appearance of the chromosomes were being used more and more t~~

while , more and more species , as well as " races " within species, were found to differ from each other in the number and appearance of their chromosomes. These differences , moreover, were found to be not only associated with differences in the geographical distribution and habitat preferences of the species concerned, but in some instances ~~were~~ also ~~associated~~ with a very particular and previously unsuspected past evolutionary history of the species concerned. New species were found to arise ~~xkxkixmxxxk~~ from some interspecific hybrids by doubling the chromosome number. At the same time doubling of the chromosome number even without hybridization was found to occur spontaneously and lead to reasonably normal progeny, while halving the chromosome number ~~was found to~~ produced as a rule either weak or sterile ~~x~~ offspring. Consequently ~~chromosome numbers, although they might be regar~~ the chromosomes , although they might be regarded by systematists interested only in identification as ~~xnxyx~~ simply another morphological character , have a special significance for those who want to discover relationships. They may indicate the direction of evolution , and in addition may ~~xxxxixx~~ reflect the past occurrence of specific evolutionary processes which can ~~xxx~~ be repeated in the experimental garden.

To the student of species and other natural populations, the discovery of multiple factor or ~~xkxxxi~~ polygenic inhertance had a special significance , since it showed that the presence or absence of definite segregation ratios, such as 3:1 or 9:3:3:1 , could not be regarded as diagnostic criteria to indicate whether or not a particular character is determined by Mendelian genes. " Blending inheritance , " which is characteristic of most differences between natural races and species , is also Mendelian . It indicates, however, a complex , indirect connection between genes and characters, since one character difference is determined by many genes.

The ~~xx~~ complexity of the ~~xxixtixxxhixx~~ connections between Mendelian genes and the character differences used by the taxonomist has been revealed even more dramatically by ~~the~~ numerous studies of wild species under controlled garden conditions, beginning with the work of Turesson which established the ecotype concept. Most Species are now known to represent complex systems of genetic variation, both within and between populations. This variation ~~is~~ forms an orderly pattern, reflecting the needs of the habitats which the species occupies. Differences between species are of an equally complex nature. Some of the most significant of these cannot be recognized at all by looking at the species concerned, however minutely. They are revealed only when the chromosomes of two species are placed together in the cells of a hybrid, and there show that they cannot work together to form normal adult structures or viable gametes. Finally, garden studies within species have shown that ~~some such characteristics as the ability or inability of a plant to ~~xxx~~ produce vigorous offspring through self fertilization~~ characteristics of reproductive biology, which by themselves may have litle to do with outward appearance, are nevertheless of great importance in determining evolutionary relationships. We know now that until we have determined whether a race is usually self fertilized, or whether it requires cross fertilization to produce vigorous offspring, we cannot fully understand its relationships. Moreover, in certain groups of plants the relationship between populations is dominated entirely by the~~t~~ fact that they have given up sexual reproduction partly or entirely ~~a~~ and have substituted for it parthenogenesis or some other type of asexual reproduction.

When we consider the meaning of all of these discoveries to the daily tasks as well as the outlook and purpose of systematic biology, we are ~~forcedxtox~~ driven to ~~this~~ the following conclusion. If the primary purpose of a systematist is to delimit species and to ~~determine~~ establish a stable system for determining their identity, ~~the relationships between them~~ , the knowledge which he must have and the methods by which he may acquire it are very different from those needed for a genuine understanding of evolutionary relationships between species. In the past , most systematists could work successfully ~~by assuming~~ if they assumed that the morphological " key characters" by which they determined species were also the principal ~~factors~~ guides to determining the relationship between species and their course of evolution. Now this is no longer possible. We can still construct adequate systems for identification purposes in most groups of plants by careful studies of differences in external morphology , based upon dried herbarium specimens. In fact, this is the wisest procedure for such purposes in most groups for which an adequate system is not now available. ~~The amount of time and labor xx needed to xxxx~~ In order to obtain the kind of cytogenetic information mnetioned above , so much time and labor is needed that if we delay completion of a system until ~~such xxx information~~ all of it is available, we will never finish. On the other hand, we can be sure that any hypotheses about evolutionary interrelationships , including such constructions as phylogenetic trees and charts , which are based solely on studies of gross external morphology ~~are based upon~~ take into account such a small fraction of the knowledge needed for even an approximate determination of evolutionary relationships that they are worse than useless, since they can be very misleading.

By recognizing these facts, we come to appreciate the significance of the modern discipline which has come to be called biosystematics. It includes all of those systematic studies which have as their primary purpose the determination of evolutionary interrelationships between species. Its difference from the conventional systematics of the past is one of emphasis. To the great systematists of the past, such as Linnaeus , DeCandolle , Bentham, Hooker , and Engler, the system was the paramount goal. Evolutionary relationships, though important , were secondary aims , and the belief was implicit that they could be determined by the same kinds of ~~ax~~ data and methods which were the basis for the system. The biosystematist, on the other hand, is interested primarily in the interrelationships between individual populations and species , as a means of understanding evolutionary processes. If he can finally synthesize all of his facts to construct a logical system and monograph , well and good, but this is a secondary aim, the Failure to achieve this objective ~~which~~ does little or nothing to detract from the value of the initial information which has been acquired.

x) The introductory paper of the present series, by ~~D.H.~~ Valentine, defines biosystematics further , and ~~introduces~~ discusses some of the terms which biosystematists must use. By referring to the systematic treatment of groups in which sexuality is replaced by asexual reproduction, ~~Dr.~~ Valentine brings up one of the most difficult problems facing the biosystematist . This problem is taken up in more detail by ~~Dr.~~ J. Heslop-Harrison in the last paper of the series.

Specific examples of the genetic diversity within species are presented to us by the contribution of M. Nobs , who draws upon the wide experience with experimental work in this field which he has obtained as an associate of ~~the Dr.~~ Jens Clausen and his group of workers at the Carnegie Institution of Washington at Stanford, California. He emphasizes the fact that genetic linkage can cause separate morphological characters to become "tied together , " so that partical correlations are found in the segregation patterns of progeny from crosses between different ecotypes. Another way in which separate characters can become tied together is through pleiotropic action of genes. Examples of single genes which affect many characteristics are well known., and have been discussed ~~by the writer~~ elsewhere (Stebbins 1950).

The principle of coherence of morphological characters is of the utmost evolutionary significance. Linkage and pleiotropy are powerful forces for preserving the valuable gene combinations which natural selection has built up. Because of them, each progressive step in adaptive complexity can be built upon a solid foundation of genetically determined adaptiveness which has been acquired in the past. Many biologists have thought that the evolution of such complex and highly adaptive structures as the flowers of orchids and composites through natural selection of chance mutations involves ~~so many improbable events that we cannot conceive~~ a succession of improbable events which taken together add up to impossibility. If each plant family had to acquire its distinctive characteristics anew, without reference to its predecessors, this reasoning would be logical. But in fact the number of characteristics which are radically changed in the evolution of one family from another is tiny in comparison with those which remain essentially the same. Genetic coherence , by tying together this great bulk of constant characteristics , greatly increases the probability that any new mutation will be quickly placed on a series of adaptive genetic backgrounds. Because of ~~it~~ coherence, each separate improbable event of mutation and selection is surrounded by so many highly probable events that the building of one improbability upon another ceases to be a problem. The operation of this principle on a small scale is illustrated by the probable course of evolution of the remarkable series of species and subspecies of Ceanothus , section Cerastes , briefly described by Nobs in his paper.

Genetic coherence is one of the most important but by no means the only characteristic of genetic variation in populations which emphasizes the evolutionary importance of the systems by which genes segregate and recombine. Other such characteristics are the retention of adaptively inferior recessive genes in cross breeding populations , the adaptive superiority of many heterozygotes, and the effects of chance in small populations or in types having a high proportion of inbreeding by self fertilization. Taken together , these characteristics emphasize the fact that the particular system which a species has evolved for preserving adaptive combinations of genes and for generating new ones is one of its most important adaptive properties. The contributions of Baker and Fryxell present to us some of the most widespread systems for genetic recombination in plants . They also show us that the particular system which a species possesses has been acquired not through chance but through natural selection acting in particular ways, especially ~~particularly~~ in relation to the past geographic distribution of the species concerned.

The extension of genetic recombination systems to crossing between species is illustrated by Heiser's discussion of introgression in Helianthus. This genus is a splendid illustration of the way in which species living in the same region can retain their identity but nevertheless increase their supply of adaptive variability by " borrowing " genes from each other. The origin of new species by recombination and selection following interspecific hybridization is also regarded as a distinct possibility in ~~xHaix~~ Helianthus , and is even more likely in other genera. ~~(Stebbins 1959a)~~

Two of the contributions in this volume, those of Jones and Reese, have discussed the effect on genetic recombination of chromosome doubling or polyploidy, a phenomenon which because of its widespread occurrence has rightly ~~occupied~~ attracted the attention of many plant biosystematists. Both authors have concluded that the significance of this phenomenon is connected only partly with the actual change in chromosome number, which is its most easily observable feature, and which serves to isolate polyploids from their nearest relatives and start them out on an independent course of evolution. Of equal and perhaps greater importance is the effect of polyploidy on the genetic recombination system. Reese has shown that this effect is (largely) responsible for the fact that polyploids have become widespread in regions opened to colonization by plants in recent geological epochs, such as the glaciated portions of northern Europe, and it may also have affected their survival on the islands to the north of that continent.

Heslop-Harrison has considered the effect on genetic recombination of systems in which cross fertilization and its complete antithesis, apomixis, exist side by side in the same individuals. His discussion leads to the same conclusions as the preceding ones--the greatest possible evolutionary opportunities are available when ways of preserving gene combinations are blended harmoniously with methods of acquiring new variation. In his final resumé, ~~the present writer~~ Stebbins has tried to bring out the most important generalization which biosystematic studies of the last quarter century have given us. This is that the ways in which the units of genetic variability are recombined are far more important in determining the course of evolution than is the nature of the individual units or mutations themselves.

Direction in evolution is provided chiefly by the interaction betweeen the environment and the genotype, acting through the medium of natural selection. But while this direction may be occasionally influenced by the particular mutations which are available, it is affected much more often by the extent and nature of genetic recombination. This latter process provides the pattern of variation which is studied by the evolutionist under the name of biosystematics.

Einkorn, Emmer, Dinkel.

Wheat:

Wheat is the world's most widely cultivated plant. The wheat plants growing on the earth may even outnumber those of any other species, wild or domesticated. Every month of the year a crop of wheat is maturing somewhere in the world. It is the major crop of the U.S. and Canada and is grown on substantial acreages in almost every country of Latin America, Europe, ~~and~~ Asia and Australia ~~Asia, Africa~~.

Apparently this grain was one of the earliest plants cultivated by man. Carbonized kernels of wheat were found recently by ~~the~~ a University of Chicago archaeologist ~~Robert Braidwood~~ at the 6,700-year-old site of Jarmo in eastern Iraq, the oldest village yet discovered — a village which may have been one of the birthplaces of man's agriculture. ~~Dr. Paul C. Mangelsdorf of the Harvard University had the opportunity to study these ancient kernels and compare them with modern kernels, carbonized to ~~simulate~~ the archaeological specimens.~~ The resemblance between the ancient and modern grains is remarkable. There were two types of kernels in the Jarmo site; one turned out to be almost exactly like present-day cultivated wheat of the type called einkorn, and the other almost ~~exactly like~~ identical with a wild wheat still growing in the Near East. Evidently there has been no appreciable change in these wheats in the 7000 years since Jarmo.

When he domesticated wheat, man laid the foundati of (~~western~~) civilization. No civilization worthy of the name has ever been founded on any agricultural basis other than the cereals (~~[illegible]~~). The ancient cultures of Babylonia and Egypt, of Rome and Greece, and later those of northern and western Europe, were all based upon the growing of wheat, barley, rye and oats. Those of India, China, and

Japan had rice for their basic crop. The pre-Columbian peoples of America – Inca, Maya and Aztec – looked to corn for their daily bread.

What are the reasons for this intimate relation between the cereals and civilization? It may be primarily a question of nutrition. The grain of cereal grasses, a nutlike structure with a thin shell covering the seed, contains not only the embryo of a new plant but also a food supply to nourish it. Cereal grains, like eggs and milk, are foodstuffs designed by nature for the nutrition of the young of the species. They represent a five-in-one food supply which contains carbohydrate, proteins, fats, minerals and vitamins. A whole-grain cereal, if its food values are not destroyed by the over-refinement of modern processing methods, comes closer than any other plant product to providing an adequate diet. Man long ago discovered this fact and learned to exploit it. Guatemalan Indians manage to subsist fairly well on a diet which is 85 per cent corn. In India people sometimes live on almost nothing but rice. Such diets do not meet the approval of modern nutritionists, but they are better than those made up too largely of starchy root crops such as potatoes, sweet potatoes or cassava, or of proteinaceous legumes such as beans, peas and lentils.

Perhaps the relationship between cereals and civilization is also a product of the discipline which cereals impose upon their growers. The cereals are grown only from seed and must be planted and harvested in their proper season.

In this respect they differ from the root crops, which in mild climates can be planted and harvested at almost any time of the year. Root-crop agriculture can be practiced by semi-nomadic peoples who visit their plantations only periodically. The growing of cereals has always been accompanied by a stable mode of life. Moreover, it forced men to become more conscious of the seasons and the movements of the sun, moon and stars. In both the Old World and the New the science of astronomy was invented by cereal growers, and with it a calendar and a system of arithmetic. Cereal agriculture in providing a stable food supply created leisure, and leisure in turn fostered the arts, crafts and sciences. It has been said that cereal agriculture alone among the forms of food production, taxes, recompenses and stimulates labor and ingenuity in an equal degree."

Today wheat is the cereal par excellence for breadmaking, and it is used almost exclusively for that purpose. But it is quite unlikely that breadmaking, a complex and sophisticated art, came suddenly into full flower with the domestication of wheat. Man may have begun by merely parching or popping the grain to make it edible. Primitive wheats, like other cereals, were firmly enclosed in husks, called glumes. Heating makes the glumes easy to rub off and allows the kernel itself to be more easily chewed or ground into meal. The scorching and parching of grains is still practiced on unripened cereals in parts of the Near East. In Scotland until recently barley glumes were sometimes removed by setting fire to the unthreshed heads. The Chippewa Indians still prepare wild rice by heating the unhusked kernels and tramping on them in a hollow log.

Hard-textured cereal grains with a certain moisture content explode and escape from their glumes when heated. In America the first use of corn was undoubtedly by popping. The earliest known corn had small ~~vitreous~~ glassy kernels, and archaeological remains of popped corn have been found in early sites in both North and South America. In India certain varieties of rice are popped by stirring the kernels in hot sand. Many villages in India have a village popper who performs this service for his neighbours and provides himself with food by taking his toll of the product.

The botanical as well as archaeological evidence, though meager, indicates that wheat was first used as a parched cereal. The dwellings at Jarmo contain ovens which prove that this primitive economy knew the controlled use of heat. All the very ancient prehistoric kernels so far found are carbonized as if they had been over-parched. In itself this evidence is not telling, since only carbonized grains would be preserved indefinitely, but it is in harmony with other evidence. Finally, the most ancient wheats are species whose kernels would not be removed from the husks merely by threshing. The simplest method of husking them to make them edible would have been parching.

Probably the second stage in progress was to grind the parched grains and soak the coarse meal in water to make a gruel. For the toothless, both old and young, this must have been a lifesaving invention. Gruel or porridge is well known as a primitive form of food. A porridge prepared from parched barley was the principal food of the common people of ancient Greece. American Indians prepared a kind of porridge from corn, which has its modern counterpart in "polenta".

A gruel allowed to stand for a few days in a warm dwelling would become infested with wild yeasts. Fermenting the small amounts of sugar in cereals, the yeasts would have produced a mild alcoholic beverage. This would have pointed the way to leaved (leavened) bread. It is questionable what art developed first – brewing or breadmaking. But there is no doubt that brewing and the making of leavened bread are closely related arts, both depending upon fermentation by yeasts.

Modern breadmaking, however, had to await the appearance of new types of wheat. It is as much a product of the evolution of wheat as it is one of human ingenuity.

Wheats differs from most cultivated plants in the complexity of its variations. True, the other major cereals, rice and corn, are each differentiated into thousands of varieties, but these form a continuous spectrum of variation and hence are classed as a single botanical species. Wheat is separated into distinct groups which differ from one another in many ways and are therefore classified as separate species under the single Old World genus Triticum. The domesticated wheats and their wild relatives have been studied more intensively than any other group of plants, cultivated or wild, and from these studies, truly international in scope, a picture is beginning to emerge of the evolution of wheat under domestication.

Authorities differ on the number of distinct species of wheat. Most scientists follow the classification of Nikolai Vavilov, the Russian geneticist and botanist who, with his colleagues, brought together for study more than 31,000 samples of wheat from all parts of the world. Vavilov recognized 14 species; other botanists have recognized fewer or more. All authorities agree, however, that the wheat species, whatever their number, fall into three distinct groups, determined by the number of chromosomes in their cells. The chromosome numbers (in the body cells) of the three types are, respectively, 14, 28, and 42. They were discovered by T. Sakamura in Japan in 1918. The numbers are closely associated with differences in anatomy, morphology, resistance to disease, productiveness and milling and baking qualities. It is interesting to note that August Schulz, a German botanist, had arranged the wheats into these three groups in 1913, well before their chromosome numbers were known.

The 28- and 42-chromosome wheats have all arisen from 14-chromosome wheat and related grasses, through hybridization followed by chromosome doubling. The cultivated wheats are the most conspicuous example of this evolution by polyploidy. It is the only known mechanism by which new true-breeding species can be created almost overnight.

Since different wild grasses have been involved in wheat's evolution, the species differ not only in the number but also in the nature of their chromosomes. Relationships of different sets of chromosomes are determined by studying the degree of chromosome pairing in the reproductive cells of hybrids. If the pairing is complete, or almost so, the chromosome sets (or genomes) of the parents are regarded as identical or closely related.

If there is no pairing, the parental chromosome sets are considered to be distinct. Four different chromosome sets, each comprising seven chromosomes, designated A, B, D, and G, are recognized in wild and cultivated wheats.

~~Another~~ The 14-chromosome wheats, ~~probably~~ actually the most ancient, consist of two species, *T. aegilopoides* and *T. monococcum*, known as wild einkorn and einkorn. Carbonized kernels of both were found at Jarmo, but whether they are the only wheats occurring in this ancient village site remains to be seen. Their spikelets contain but a single seed, hence their name. Each has the same set of chromosomes, set A, and they hybridize easily together to produce highly fertile offspring. Cultivated einkorn has slightly larger kernels than the wild form and a slightly tougher stem. Its heads do not fall apart quite so easily when ripe. Except for these slight differences the two species are essentially identical, and einkorn is undoubtedly the domesticated counterpart of the wild species. Apparently little significant change has been produced (wrought) in them over the centuries.

Fig. 1,

Wild einkorn has its center of distribution in Armenia and Georgia of the Soviet Union, and in Turkey. It also occurs in the eastern Caucasus and in western Iran. Westward from Asia Minor it is a common grass on the sides of low hills in Greece and Bulgaria and a weed in the well-drained vineyards of southern Yugoslavia. Cultivated einkorn originated, according to Vavilov, in the mountains of northeastern Turkey and the southwestern Caucasus. However, the kernels at Jarmo may point to that ~~the~~ einkorn has been domesticated first slightly further south in eastern Iraq. Certainly it is an ancient cereal, which also has been found in neolithic deposits ~~of~~ in central and northeastern Europe all the way to Britain and Ireland, but there are no records of its prehistoric occurrence in India, China, or Africa.

Einkorn is still grown in some parts of Europe and the Middle East, usually in hilly regions with thin soils. Its yields are low, usually not more than 8 to 15 bushels per acre. A bread can be made from it, but it is more commonly used as a whole grain, like barley, for feeding cattle and horses. Einkorn's importance lies not in its present use but in its progeny. It is the ancestor of all other cultivated wheats, ~~which~~ all of which have in common the set of chromosomes called set A.

~~Fig.~~

In the next stage of evolution are the 28-chromosome species, of which Vavilov recognized seven. All these have come from the hybridization and chromosome doubling of a 14-chromosome wheat with a 14-chromosome related wild grass. The wheat parent in each case was undoubtedly einkorn, or possibly in one instance its wild relative, since all the species possess the chromosome set A. But the wild-grass parent remains to this day unidentified and is the chief botanical mystery in the origin of cultivated wheats. This parent contributed the set B to all in the group except one species. It has been suggested that the chromosome set B may have been derived from a species of Eremopyrum, a genus often confused with Agropyron, ~~[illegible]~~ or the couch grasses. Only one of the 28-chromosome wheats is found wild. This species, which is called wild emmer, is indigenous to southern Armenia, northeastern Turkey, western Iran, Syria and northern Palestine.

Closely resembling wild emmer, and possibly ~~derived~~ formed directly from it by domestication, is emmer, the oldest of 28-chromosome cultivated wheats and once the most widely grown wheat of all. Well-preserved spikelets of this wheat scarcely different from those of modern emmer have been found in Egyptian tombs of the Fifth Dynasty. Emmer may well have been the chief cereal of the Near East from very early times to the Greco-Roman period, and it was common in western Europe in neolithic times.

The 28-chromosome wheats were the first to produce species with tough stems and with kernels that thresh free from their glumes. Four such species are known: *durum* (macaroni), *persicum* (Persian), *turgidum* (rivet) and *polonicum* (Polish). All have a more recent history than einkorn or emmer. The oldest, *durum*, first appeared in about the

first century B.C. And the most recent, Polish wheat, did not appear until the 17th century. None of these wheats except *durum* is of great importance today. *Durum* wheat is grown fairly extensively in Italy, Spain, and parts of the U.S. Rivet wheat is of some interest because it can grow up to six feet high, and one of its varieties, called "miracle" or ~~mummy~~ "mummy" wheat has been claimed to have been propagated from prehistoric grains discovered in the wrappings of an ancient Egyptian mummy. The story in all of its versions, is a complete fabrication, partly due to the fact that Rivet wheat was never grown in Egypt, and partly ~~di~~ ~~wheat~~ the metabolic systems of wheat seeds have a maximum life span of ten years.

Fig. 2

One additional 28-chromosome wheat, *T. Timopheevi*, ~~which~~ has no common name. This species is known only in western Georgia, where it is grown on a few thousand acres. The species is of botanical interest because its second set of 14 chromosomes, designated as set G, is different from that of any other wheat. It is also of great practical interest because it is resistant to virtually all diseases attacking other cultivated wheats, including rusts, smuts, and mildews. In the hands of skilled wheat breeders it may become the ancestor of improved wheats for the next century.

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Fig. 3.

The 42-chromosome wheats, of which there are five, are as a group the most recently evolved and the most useful today. All are cultivated; none has ever been known in the wild. All are products of the hybridization of 28 chromosome wheats containing the sets A and B with a wild 14-chromosome relative of wheat, which we now know must have been the weed species *Ægilops squarrosa*, containing the chromosome set D. All are believed to have arisen from

Such hybridization after man unwittingly exposed his earlier cultivated wheats to hybridization with native grasses which grew as weeds in his fields.

Fig. 4. ~~[illegible]~~ The 42-chromosome wheats, ~~which~~ are often ~~are~~ collectively called Dinkel wheats. Two of them, T. spelta (spelt) and T. macha, are, like einkorn and emmer, hard-threshing species. T. macha, like T. Timopheevi, is confined to western Georgia, where it is grown on not more than a few thousand acres. Spelt was once the principal wheat of central Europe. No archaeological remains of it have been found in the Near East or any part of Asia. There is no doubt about the hybrid origin of spelt, for it has now been synthesized, first by Dr. Thompson, the President of the University of Saskatchewan, and then later ~~by~~ independently by Dr. Kihara in Japan and Drs. McFadden and Sears in Missouri. In all these cases the researchers concluded that the botanical characteristics to be sought in the unknown 14-chromosome parent of spelt were possessed by Aegilops squarrosa (common name?), a completely useless wild grass which grows as a weed in wheat fields from the Balkans to Afghanistan. All researchers hybridized this wild grass with wild emmer. Thompson as well as McFadden & Sears

doubled the chromosome number of the sterile hybrid by treatment with colchicine; Kihara was fortunate in discovering a case of natural doubling. The new 42-chromosome plant was highly fertile and similar in characteristics to cultivated spelt. As a final step in a brilliant piece of inductive reasoning and genetic experimentation, the scientists crossed their synthesized spelt with natural spelt and obtained fully fertile hybrids. The results leave no doubt that the wild grass used in this experiment is one of the parents of cultivated spelt, and they suggest strongly that the other four 42-chromosome wheats are likewise doubled hybrids in which the chromosome set D has been derived from the same grass or a species very close to it.

Fig. 5 – 10

These experiments suggest that cultivated spelt originated in the region where the species of wild grass and wild emmer overlap. But the primitive hulled form of spelt has not been found there. An alternate possibility is that the wild grass hybridized not with wild emmer but with the cultivated species which has had a much wider distribution. Vavilov concluded that hulled spelt originated in southern Germany. Earlier Elizabeth Schiemann

Germany's leading student of cereals, had placed it in Switzerland and southwest Germany. Both centers are not far from the northeastern limits of the area in which cultivated emmer and the wild grass are known to have occurred together. Thus the botanical and historical evidence are not far apart in indicating a central European origin.

The remaining three species of 42-chromosome wheats are *T. aestivum* (common), *sphaerococcum* (shot) and *compactum* (club). They are the true bread wheats, accounting for about 90 per cent of all the wheat grown in the world today. The three are closely related and easily intercrossed. Whether they are the product of three different hybridizations between 28-chromosome wheats and wild grasses, or of three diverging lines of descent from a single hybridization, is not known. Club and shot wheat differ from common wheat in a number of details whose inheritance is governed by a relatively small number of genes. It is possible, therefore, that the three species are descended from a single common ancestor. Common wheat or something very like it has recently been produced by Kihara by crossing 28-chromosome Persian wheat with the wild grass used to synthesize spelt. ~~The chromosome number~~

Where and when the modern bread wheat first occurred are still matters for ~~conjecture~~ dispute. Since Persian wheat is known only in a limited area in northeastern Turkey and the adjoining states of the Soviet Union, common wheat very probably originated there. Kernels of shot wheat have been found at the most ancient site in India, dated about 2500 B.C. A wheat found in neolithic store-chambers in Hungary has been identified as club wheat. Impressions of grains of bread wheat, either common or club, have been found from about 2000 B.C. in Europe. And since the 28-chromosome wheats evidently are recent introductions in China, it is possible that the wheat described in the Chinese classics for the Chou period, about 1000 B.C., is a 42-chromosome bread wheat. All these items, none in itself conclusive, indicate that the bread wheats originated before the time of Christ but later than einkorn and emmer. A conservative guess would put their origin at approximately 2500 B.C.

Whether the bread wheats originated earlier than this or later, and whether they had one hybrid origin or three, they represent today the most rapid increase in geographical range and numbers of any species of seed-plant in history. They are now grown in all parts of the world from the Equator ~~to~~ ~~the Arctic~~ cir almost to the Arctic and Antarctic circles. Originating probably not more than 5000 years ago in the general region of Asia Minor, the new species have increased at an average rate of about 75,000 acres per year until they now occupy almost 400 million acres. Their evolution and dispersal have been explosive phenomena in which man's principal part has been to recognize ~~th.~~ their usefulness and to open up new agricultural areas for their culture.

All known species of cultivated wheats, ~~came into~~ except cultivated einkorn and possibly emmer, came into existence spontaneously. Man played no part in their origin except as he spread their culture and their opportunities for natural hybridization ~~a~~ over the earth. There is no evidence that ancient man gave much attention to selection of superior forms, or if he did, no evidence that he succeeded. The cultivated einkorn of today is scarcely different from the einkorn of millennia ago, and it, in turn, is no great improvement over wild einkorn. Essentially the same can be said about emmer. Consequently, to speak of primitive man as a plant breeder is to attribute more purposefulness to his activities than the evidence warrants.

Within the past century, especially since the rediscovery of Mendel's laws of inheritance in 1900, vast programs of wheat improvement have been undertaken in almost all the wheat-growing regions of the world.

This is not the ~~place~~ time to give a review of the methods the plant breeder uses in improving our wheats, others in Winnipeg know more about them than I do. It can be said, however, that while early in the century the most common method of wheat breeding was "pure-line" selection as invented by Wilhelm Johansen, a Danish botanist, most of our present wheat varieties are the results of hybridization of pure lines followed by intense selection, as invented by the Swedish plant breeders in Svalöv in about 1885 and first ~~employ~~ employed on this continent by Saunders in Ottawa some few years later.

A future possibility in wheat breeding is the creation of wholly new types of cereal by species hybridization followed by artificial chromosome doubling, a man-made counterpart of wheat's earlier evolution in nature. In several countries wheat has been crossed with rye to produce a fertile true-breeding cereal which combines the qualities of both. The ~~hyb~~ new species, neither a wheat nor a rye, but a ryewheat, is more resistant to cold than wheat is, and the bread has the nourishing value of rye and the baking quality of wheat. It will be released for the farmers in Sweden after two years. Wheat has been crossed with a perennial wild grass to produce a new ~~cereal~~ perennial cereal for which Russian agronomists have made fantastic claims. A field of this wheat, once planted, will, according to the Russians, yield a crop of grain year after year with little or no further attention except manuring and harvesting. It turns out that this perennial wheat as produced so far has great promise as a forage grass for livestock in arid and semiarid regions, but its value as a bread-producer is still very disputable.

Fig. 14

Fig. 13

Fig. 14.

Without hybridization, the chromosome number of grasses and cereals can be doubled to form new species with characters somewhat different from their original stock. One such plant, the double-rye, which has 28 instead of 14 chromosomes, has been released for cultivation in Sweden some few years ago, and its quality is somewhat higher than that of ordinary rye. Also in Sweden new varieties of barley with doubled chromosomes ~~are~~ will be released very soon, and this method of plant breeding has been found to be very promising in several species of cultivated plants.

The researches on wheat have ~~amply~~ given ample demonstrations of that although the classical methods of plant breeding still continue to be extremely useful and necessary, nature itself has used other and more drastic methods to produce the basic variations within new species. When man now not only knows this methods but also has gathered power to reproduce ~~what~~ in some short time what ~~nature~~ previously was made by haphazard in thousands of years, the idea of producing new cereals by hybridization and chromosome doubling is constantly gaining ground among plant breeders. Some day new wheat species consciously created by man may replace those which arose spontaneously in nature, and it is very likely that our ancestors ~~greatgrandchildren~~ sometimes in the late next century will have replaced all the present cultivated cereals by artificially produced polyploids giving fantastic yields.

Plans f. book(s)
on biol. species
concepts.

G. palustris 2n = 48
G. ~~[illegible]~~ ?
G. subglabra 2n = 96.

Myrica Gale – a complex of [illegible] species.

The species Myrica Gale L. is one of the many taxa of higher plants that have been regarded as nearly identical in their more or less isolated areas in the boreal zone because ~~they approach~~ their populations from ~~[illegible]~~ these areas approach each other so nearly in gross morphological characters. The plant varies greatly in growth form, type ~~[illegible]~~ and size of leaves, size and colour of inflorescences, ~~[illegible]~~ as well as in hairiness. ~~[illegible]~~ ~~whereas~~ The variation in most of these characters between populations not far apart is, however, considerable, ~~[illegible]~~ so that most students have claimed inability to ~~distinguish~~ use them for distinguishing races of the main species. However, C. DeCandolle (1866?), regarded the Pacific plant with more pubescent ~~leaves~~ and blunter leaves as a variety *tomentosum*, lifted to a specific status, *M. tomentosum*, by Ascherson and Graebner

~~The genus *Gale* – a~~

Gale palustris – a taxon in need of revision.

One of the many species of plants commonly regarded as conspecific in North America and Europe is the taxon usually listed as *Myrica Gale* L., or, perhaps more correctly, G*ale palustris* (Lam.) Chev. since the type species of the genus *Myrica* in its strict sense is M.

Myrica Gale L. — a collective species.

Many are the ~~species~~ taxa of higher plants that are regarded as common to Europe and North America because they approach each other so nearly in gross morphological characters, though they in reality are different species.

7133: 96
7015: 80

~~Myrica Gale – a collection~~

Myrica Gale – a pseudo-amphiatlantic plant.

It is a well-known fact that although a certain number of species of higher plants are common to northern Europe and northern North America, ~~a number~~ several such taxa ~~which seem to~~ ~~as~~ which approach each other so nearly in their ~~external~~ gross characters ~~as to be reg~~ as to be known by the same names, are in reality different species. Indisputable conspecificity ~~is also~~ has been proven for ~~spec~~ taxa in the far north of both continents and then also for a number of plants now occurring in mountains farther south, whereas less arctic plants tend, firstly, to be represented by different subspecies in Europe and North America, and, further south, by different species or even differ at the generic level. ~~In addition~~ In addition, there are the rather numerous taxa which have been found to ~~differ in chromosome number to~~ represent different levels of ploidy

One of the many taxa of higher plants that have been regarded as conspecific in their more or less isolated areas in the boreal zone because they

A. & Gr. 1910 (IV. p. 353):

Myrica tomentosa (M. Gale β tomentosa Cas. DC. in DC. Prodr. XVI. 2. 148 [1864]). Strauch breit buschig. Zweige dicht, grau behaart. Blätter stumpfer, an der Spitze abgerundet, beiderseits besonders unterseits dicht grauzottig behaart.— Kamtschatka; Amurgebiet; Insel Sitka. Gedeiht in den Gärten hier auf verschiedenen Bodenarten viel besser als M. Gale, ist daher öfter in Baumschulen als solche zu finden.— Scheint uns nach langjähriger Cultur in allen Theilen wesentlich verschieden und nicht unmittelbar in den Formenkreis der M. Gale gehörig.

(Chev. Mogr. 93. 1902: 6. japonica) op. cit. A. & Gr.

This is a strong indication that there may be three species of Gale involved, whereas it is perhaps premature here to propose their naming as long as the Pacific plant remains cytologically unknown and other clear distinctions have not been found between the ~~A~~ variable American and the European plant.

Myrica Gale — a complex of incipient species.

Among the variable ~~species~~ taxa represented by populations in western Europe, boreal North America, and easternmost Asia is the plant usually regarded as the ~~type~~ single species Myrica Gale L. It is admitted by Hultén (1958) that it varies in hairiness and leaf form although he seems to be in no doubt that the three varieties mentioned by him differ only slightly from the European plant. According to Fernald (1950), the typical race is the plant common in North America from Labrador to Alaska, whereas the var. subglabra (Chev.) Fern. of eastern North America is regarded as distinct because of its almost glabrous leaves. The Pacific taxon was distinguished as the variety *tomentosum* by C. DeCandolle (1864), and lifted to the rank of species, *M. tomentosum*, by Ascherson & Graebner (1910), and as such it is accepted by . . . in the Flora SSSR. It has, however, an older name at the species level, since it was described as Gale *japonica* by Chevallier (1902).

The chromosome number of the European plant has been counted by Hagerup (1941), Löve (1954), and [illegible] (1955), who all ~~determined the~~ found 2n=48 in different Scandinavian populations. The number for the Pacific plant remains unknown, whereas the present writers have counted 2n=96 chromosomes in material from the Gaspé Peninsula and from the Laurentian mountains. The population from the former locality ~~[illegible]~~ belongs to the var. *subglabra*, whereas the latter is ~~doubtfully~~ identified with this variety with some doubt, since it is . . . . . (see plant! Lac Ouareau)

It is evident from these preliminary observations that the ~~European~~ eastern North American plant is not ~~conspecific~~ ~~[illegible]~~ identical with the European species, ~~[illegible]~~ though more detailed studies are needed in order to ascertain their morphological distinctions. The claim by Fernald (l.c.) ~~that two races occur in eastern and arctic North~~ and Hultén (1958) that not only the var. *subglabra* but also the typical race of the species occur here needs confirmation by aid of biosystematical studies. It would, likewise, be advisable to make a cytological study of the Pacific plant before the American material is revised taxonomically.

Chromosome numbers ~~of plants~~ from northern Canada.
I . . .

Introduction. (Fernandes, JSW.).

Material and methods.

Observations and discussion.

1. Sparganium angustifolium Michx. – Macbride Lake, Manitoba.
2n = 30.
2. Potamogeton Richardsonii; 2n = 52. Macbride Lake.
3. P. filiformis v. borealis 2n = 78 : Churchill.
4. Scheuchzeria palustris v. americana 2n = 24?, Macbride Lake.

5. Sagittaria cuneata $2n = 22$: Macbride Lake

6.

Monocots fr. Macbride Lake:

975 Carex tenuiflora 2n = 62
976 C. disperma 2n = 64
979 C. aquatilis 2n = 64
980 Calamagrostis canadensis 2n = 42,
1007 Scheuchzeria palustris americana 2n = 24?
1024 Carex heleonastes 2n = 52 56.
1075 Sparganium angustifolium 2n = 30
1076 Potamogeton Richardsonii 2n = 52.
1142 Carex paupercula 2n = 56
1143 C. leptalea 2n = 46
1148 C. chordorrhiza 2n = 66
1181 Sagittaria cuneata 2n = 22
1204 Calla palustris 2n = 72
1218 Carex vesicaria 2n = 70
1308 Juncus brevicaudatus 2n = 80.
912 Carex disperma 2n = 70,

↓

1039 Carex brunnescens 2n=56,
958 Eriophorum opacum 2n=54,
963 Carex diandra 2n=60.
965 Carex limosa 2n=64.
968 C. heleonastes 2n=52,

Dicots fr. Macbride Lake:

970: Ranunculus abortivus v. acrolasius 2n=16.
971: R. Gmelinii 2n=16
972: R. lapponicus 2n=16.
977: Fragaria glauca 2n=56,
981: Comarum palustre 2n=42,
983. Betula glandulosa 2n=56
1015. Menyanthes trifoliata v. minor 2n=60?
1077. Myriophyllum exalbescens 2n=42
1078 Callitriche palustris 2n=20
1080 Lysimachia thyrsiflora 2n=20

↓

1088. Parnassia palustris v. neogaea 2n = 18
1096 : Ranunculus subrigidus 2n = 16
~~1146 Cicuta mackenziana 2~~
1217. Hippuris vulgaris 2n = 32
1288 Epilobium palustre 2n = 36

Monocots fr. Churchill:

12.71 : Orchis rotundifolia 2n = 42
12.78 : Habenaria obtusata 2n = 42
12.711 : Carex scirpoidea 2n = 60
12.712 : C. miliaris v. major 2n = 64
13.72 : Poa alpina 2n = 42.
13.73 : Elymus mollis 2n = 28.
13.726 : Cypripedium passerinum 2n = 22.
13.727 Eriophorum angustifolium 2n = 58
13.729 : Potamogeton filiformis v. borealis 2n = 78

↓

19.71: Carex limosa 2n = 64
19.72: Smilacina trifolia 2n = 36
19.74: Scirpus Hudsonianus 2n = 58
19.76: Carex gynocrates 2n = 52
19.77. C. adelostoma 2n = 106
19.78 C. vaginata 2n = 32
19.710 Eriophorum Scheuchzeri 2n = 58
19.711 Habenaria hyperborea 2n = 84
21.72 Puccinellia airoides 2n = 42
21.710 Carex maritima 2n = 60
21.711 Trisetum spicatum 2n = 42.
~~35.71~~ +

↓

Dicots fr. Churchill:

12.75 Pedicularis lapponica 2n=16.
12.77 Distorta vivipara 2n=110.
13.74 Pyrola rotundifolia 2n=46
13.722 Parnassia kotzebuei 2n=36.
13.723 Rubus chamaemorus 2n=14
14.71 Primula stricta 2n=126
14.73 Myriophyllum exalbescens 2n=42
14.75 Rumex occidentalis 2n= c. 200
17.71 Menyanthes trifoliata 2n=60
19.79 Comarum palustre 2n=42.
20.76 Hippuris vulgaris 2n=32
21.71 Polygonum aviculare 2n=60
21.73 Potentilla egedii v. groenlandica 2n=28
21.75 Cochlearia officinalis 2n=14
21.76 Ranunculus cymbalaria 2n=16
21.78 Hippuris tetraphylla 2n=32.

↓

21.79: Rumex occidentalis 2n = 200
3.81: Parnassia palustris 2n = 18
3.813: Erigeron elatus 2n = 27 or 28
3.817: Rumex occidentalis 2n = 60 & 2n = 140.

Southampton Island:

25.71: Pleuropogon Sabinei 2n = 40
25.72: Colpodium fulvum 2n = 42
24.72 Carex atrofusca 2n = 40
24.73 Dupontia Fisheri v. psilosantha 2n = 56.
24.76 Arctagrostis latifolia 2n = 62
24.77 Tofieldia pusilla 2n = 30
24.727 Hierochloë alpina 2n = 56
24.728 Carex aquatilis v. stans 2n = 80 or 78.

↓

Tulita Lake:

752: Heuchera Richardsonii 2n = 28 or more.
772: Linnaea borealis ssp. americana 2n = 32
778: Saxifraga virginiensis 2n = 28
785: Panicum sp. 2n = 18.
786: Cypripedium acaule 2n = <u>20</u>.
789: Carex brunnescens 2n = 56
791: Poa interior 2n = 42?
792: Antennaria canadensis v. athabascensis 2n = 84
869: Chenopodium gigantospermum 2n = 36
870: Ranunculus macounii 2n = 32?
881: Pyrola virens Schweigg. 2n = 46.
887: Cicuta mackenzieana 2n = 22.

Canadian chromosome numbers.

I. Arctic and subarctic grasses.

During the past nine years the present authors have been gathering cytotaxonomical material from species of the Canadian flora from different parts of the country. Most of the collections have been made by the authors themselves, ~~but many others have assisted in getting~~ whereas much material has been gathered by different colleagues, notably in northern regions, and from seed collections on herbarium material from ~~[illegible]~~ ~~to~~ places not accessible to us. Such collections have been made for us in northern Manitoba and the Hudson Bay area by Dr. J. C. Ritchie; ~~and~~ from Ungava by Dr. J. Rousseau, and from different parts of northern Labrador by numerous graduate students at the Department of Geography during [illegible] based on the [illegible] McGill University. We are grateful for their contributions and also for the continuous financial support of the National Research Council.

I. Historical review

II. ~~[illegible]~~ Subdivisions of biosystematics.

III. ~~Cytotax~~ Genecology – the study of variation.
a . b . c . . .

IV. Cytotaxonomy – the study of chromosomes

V. Biometry . . .

50 species pairs – polyploid.

Discuss after differentiation and age,
bring → panallo – [illegible] and panauto?
[illegible] corrections:
American [illegible] : European = Dysgenetic
[illegible] differentiation

Polyploidy and speciation,
Dysgenetic?

~~50 qualifying examples.~~

Polyploidy and speciation —
examples ranging from panauto- to
panallopolyploidy.

(grain) Darwin [illegible] and genic differentiation.

Lycopodium – Diphasium – Lepidotis – Huperzia?.
Athyrium – Diplazium
Dryopteris – Lastrea – Phegopteris – Gymnocarpium
Potamogeton – Groenlandia

In 1898 Wettstein pointed out, that morphological studies alone . . . _ _
He added the geographical method.
Mayr (1942) showed, that even this is insufficient and defined the sp. with regr. is.
Even this may later be found to be too little, but the method is as useful as the chorology was.
– it carries us closer to the truth + Lin. Species

Although cytotaxonomical studies often have reinstated old and misunderstood species, or discovered new taxa previously unknown, ~~it~~ ~~& more commonly such investigations~~ ~~but~~ such investigations sometimes have shown the incorrectness of identification of species from widely separated regions:

Dryopteris
Sisyrinchium,

Arten

Ophioglossum vulgatum – azoricum
Cystopteris fragilis – regia
Woodsia glabella – alpina
Dryopteris Filix-mas – abbreviata
Polypodium vulgare – cambricum – interjectum,
Ruppia maritima – spiralis
Triglochin maritima —
Elodea canadensis – Nuttallii
Arum maculatum – immaculatum – italicum.
Acorus Calamus –
Typha angustifolia —
Dupontia Fisheri – pelligera – psilosantha
Glyceria fluitans – declinata.
?Glyceria maxima – grandis ?
Sesleria.
Festuca hyperborea – brachyphylla
F. pratensis – Uechtritziana – arundinacea
Vulpia myuros – ambigua – major
Poa supina^{14} – infirma^{14} – annua^{28}
Puccinellia phryganodes – vilfoidea
P. limosa – distans
↓

Dactylis glomerata – polygama
Bromus Benekenii – ramosus
Triticum –
Aegilops triaristata – recta
Aegilops . . . . .
Agropyron cristatum – cristatiforme
Elytrigia juncea – junceiformis
E. repens – Smithii
Hordeum murinum – leporinum
Leymus arenarius – mollis
Avena
Trisetum spicatum – molle
Agrostis stolonifera – gigantea – stolonizans.
A. canina – stricta – borealis
A. pyrenaica – rupestris
Phleum phleoides – montanum
P. pratense – Bertolonii (nodosum)
P. alpinum – commutatum
Hierochloë odorata –
H. alpina – orthantha
Anthoxanthum odoratum – alpinum
Spartina Townsendii – alterniflora – maritima.
↓

Eleusine indica – africana
Bothriochloa Ischaemum –
Eriophorum angustifolium – triste
Carex capillaris – Krausei –
Carex lagopina – glareosa
Carex dioica – parallela
Luzula campestris – multiflora – sudetica – congesta
Eriocaulon septangulare – pellucidum.
Asparagus officinalis – prostratus
Sisyrinchium Bermudiana – hibernicum
Allium Victorialis – platyphyllum
Platanthera oligantha – ?
Dactylorchis maculata – Fuchsii,
D. Traunsteineri – Russowii
D. majalis – incarnata
Salix glauca – callicarpaea
Salix phylicifolia – borealis,
Salix dasyclados – calodendron – stipularis
Gale palustris – subglabra – tomentosa
Carpinus Betulus – orientalis.
Betula verrucosa – pubescens.
Morus alba – rubra – nigra
Acetosella vulgaris – tenuifolia – angiocarpus – graminifolia

↓

Rumex triangulivalvis – mexicanus,
Polygonum aviculare – arenastrum
Salsola Kali – Soda –
Salicornia –
Celosia argentea – cristata
Herniaria ciliolata –
Scleranthus annuus – polycarpos
~~Stellaria longipes –~~
Cerastium brachypetalum – Tenoreanum
C. pumilum – subtetrandrum
C. semidecandrum – glutinosum
C. alpinum – (Regelii) – arcticum.
C. tomentosum – Biebersteinii
Arenaria multicaulis – ciliata – gothica – [illegible],
A. leptoclados – serpyllifolia – (Marschlinsii ?)
Dianthus?
Kohlrauschia prolifera – Nanteuilii
Thalictrum minus – kemense –
Ranunculus montanus – carinthiacus – Breyninianus,
Papaver radicatum – Nordhagenianum
Papaver dubium – Lecoqii
Rorippa islandica – palustris ?
R. Nasturtium-aquaticum – microphylla.

↓

Cardamine pratensis —
C. flexuosa — hirsuta
Draba lactea — fladnizensis
Cochlearia officinalis —
Biscutella laevigata — varia - - - -
Brassica —
Crambe maritima — tatarica — hispanica,
Drosera anglica —
Sedum Telephium — maximum
Parnassia palustris — obtusiflora
Saxifraga stellaris — foliolosa
S. nivalis — tenuis,
S. tridactylites — osloënsis — adscendens,
S. rivularis — hyperborea
S. caespitosa — rosacea
Chrysosplenium ... (see Packer 1953)
Spiraea latifolia — septentrionalis
Sanguisorba officinalis — polygama
(Dryas octopetala : Böcher)
Potentilla argentea — impolita
P. norvegica — monspeliensis
Pentaphylloides fruticosa — floribunda
Rosa acicularis — Sayii
Medicago falcata — quasifalcata
↓

Medicago sativa — coerulea — hemicycla
Trifolium repens —
T. medium — pannonicum
Lotus uliginosus — corniculatus — Borbasii — tenuis.
Vicia Cracca — pseudocracca
Geranium Robertianum — purpureum
G. phaeum — lividum
Erodium cicutarium — glutinosum — danicum
Mercurialis —
Callitriche stagnalis — platycarpa —
Gossypium
Tuberaria guttata — Breweri
Viola Reichenbachiana — Riviniana
Lythrum Salicaria — j8.
Hedera Helix — hibernica
Pimpinella Saxifraga — nigra
Monotropa Hypopitys — hypophegea
Vaccinium uliginosum — gaultherioides,
Oxycoccus palustris — Hagerupii — microcarpus,
Empetrum nigrum — Eamesii
Primula farinosa — [illegible] — scotica — scandinavica — stricta.
Myosotis silvatica — frigida,

↓

Lamium Galeobdolon – montanum
Galeopsis Tetrahit: speciosa – pubescens.
Glechoma hederacea – hirsuta
Thymus ..
Solanum nigrum –
Nicotiana
Veronica prostrata – Scheereri
V. longifolia – maritima
Euphrasia –
~~Phelipaea – Orobanche~~
Pinguicula villosa – alpina – vulgaris.
Globularia vulgaris – elongata – –
Plantago Coronopus –
Galium boreale – septentrionale . . . .
G. verum – Wirtgenii
G. Mollugo – elatum
G. campanulatum – octonarium
Galium [illegible] Ehrendorfer)
Valeriana officinalis – collina – procurrens
Wallrothii, sambucifolia/
Campanula rotundifolia – /Giesekiana
Tragopogon ([illegible])
Sonchus arvensis – uliginosus

↓

Antennaria carpatica — villifera

Arnica alpina — montana ?

Senecio cambrensis — squalidus — ...

Helianthus ?

Ambrosia

Solidago

Achillea · – ([illegible])

Tripleurospermum inodorum — maritimum — [illegible].

Leucanthemum Hultenii — arcticum

L. ircutianum — vulgare — maximum — montanum — [illegible].

Artemisia borealis — bottnica

A. maritima — vallesiaca — salina

The present paper reports chromosome numbers of grasses from the northlands of Canada. Fixations have been made in the Svalöv modification of Navashin's fixative (cf. Müntzing –, Löve & Sarkar 1956) and the slides were stained in crystal-violet. The arrangement of the species follows ~~that~~ the same system as used by L. & L. (1961).

(Canadian source and number pls return!)

Hierochloë alpina (Sw.) R. & S.

The material of this species originated from Southampton Island and also from a couple of localities in Ungava. The collections had 2n = 56 chromosomes, or the same number as previously reported by several workers on material from Spitsbergen, Greenland, Japan, ~~[illegible]~~ Arctic Siberia and arctic Canada.

Biosystematics - aims and methods.

Introduction.

Biosystematics is the trend in taxonomy which has as its main purpose the classification of ~~natural~~ taxa into a natural system of hierarchy based on the successive relationships of different ~~levels~~ stages of evolution. It is based on the belief that a system of natural classification is not only desirable but also possible and that it is unavoidable if taxonomy is to cease to be an art and begin to be a science. The methods of this recent approach are those of classical taxonomy and chorology with an addition of the methods of cytogenetics in particular, but also those of chemistry, physiology and other ~~ancillary~~ ~~branches~~ ~~sciences of the life~~ sciences of use for studies on ~~similarities and~~ dissimilarities between taxa of related biota.

Much has been written about biosystematics in the past, and there is hardly published a paper in taxonomy at present without mentioning of the methods of this approach. However, no introductory text to this science as a whole has ever been published. . .

In connection with a national symposium on an international topic one cannot avoid thinking about the words of Rudyard Kipling in his poem about the English Flag: Winds of the World, give answer! They are whimpering to and fro— And what should they know of England, who only England know?

Of all the problems of the world, nothing is of greater concern than the enigma of the environment, because it is the most universal of all the questions of the future that man must face today. ~~[illegible]~~ Actually, it has always been with us and will always so remain, because it is tightly connected with the process of evolution and the influence of man and his industries and of all animals, climates etc. on everything else, ~~[illegible]~~ animate or inanimate. But we see it more sharply at present because man has suddenly become a force so strong, that he disturbs everywhere the supposed balance of nature, that never has been.

The problem of the environment is actually the problem of evolution, its utilization for mankind and its regulation for the world as a unit. It is by aid of applied evolution that we are able to feed all men and prevent starvation, and it is by aid of applied evolution that we can breed better men and regulate the size of the population.

Balance of nature.

Man — appointed:

Huxley, p. 14: (1953).

Conservation of the environment, and, indeed, of any single of its species, is a process of evolution, because protection against selection of any kind affects the genetics of the species and, thus, shapes its future.

When travelling through the magnificent landscapes of the most industrialized of countries, an evolutionist cannot avoid feeling that man has been appointed the managing director of the biggest business of all, the business of evolution, and appointed to this most important of positions without being asked if he wanted it, and without proper preparation for the responsibility and without an acceptable planning. What is more, he ~~has~~ cannot refuse the job, because there is no ~~other~~ pretender. Whether he wants to or not, whether he is conscious of what he is doing or not, he ~~is not~~ must in point of fact determine the future direction of evolution on this earth. That is our inescapable destiny, and the sooner we realize it and start believing in it, the better for all concerned.

Talleyrand: War is much too serious a thing to be left to military men — —

The shaping of the future by evolution is much too serious a thing to be left to the politicians, it is a matter of concern to everybody but most of all to the biologists, whose responsibility it is to guide the life processes in such a way as to secure the best life to all future men without endangering that of other kinds of living beings and without defacing the beauties of ~~the~~ inanimate nature or devastating its power reserves.

Talleyrand: They have learnt nothing, and forgotten nothing.

Kipling: Winds of the World, give answer! They are whimpering to and fro —
And what should they know of England who only England know?

Conservation: of beauty, of resources, dead or alive, of amenities.

THE ARCTIC BASIN

Áskell Löve:

BIOLOGICAL RESEARCH.

The arctic environment originated when the Laurasian continent drifted into the climate of the north in the middle or late Tertiary, perhaps only a few million years ago. Prior to this, the lands which now are situated in the cold regions of the norths, were covered by plants and animals which are characteristic of humid and temperate climates, similar or identical to the fauna and flora of the nemoral vegetations of presently temperate eastern North America, eastern Asia, and western Europe. When the living conditions deteriorated because the continent floated away from the equitable climates where these biota developed, the tender trees and forest plants dispersed southward, followed by migration of less hardy animals, whereas the hardy conifers and tundra plants and adaptable animals stayed behind on the raft. These plants, which formed the present boreal forest and tundra vegetation, had evolved on isolated mountains in the then northern nemoral zone or close to the ocean, though at that time they did not find appropriate conditions to spread widely and develop into their present conditions. This happened in the late Tertiary. Certain animals had developed preferences for this vegetation and its conditions and stayed behind, though most of the animals of the northern nemoral migrated with it when it dispersed southward. Later, the Pleistocene glaciations may have affected the evolution of the plants and animals which became trapped in unglaciated refugia in the northlands, although the adaptive responses of these biota to the cold are likely to have been caused by extinction of non-adaptive types rather than by direct genetical adaptation.

Biological research in the arctic regions is of recent date, partly because these lands have long been sparsely populated and, thus, not regarded as important by those who lived under more equitable conditions in the temperate zone, but perhaps more because those people who live under arctic conditions spend more time than others gathering necessities of life. Biological research work in the arctic regions has followed the same pattern as in more southern lands. The original and basic approach was inevitably descriptive, because the biologists set out to describe as fully and accurately as possible the variety of organisms and the phenomena they display. This approach is designed to answer the question about what are the facts. The descriptive approach is soon supplemented by the comparative, which is first focused round the question of grouping or classification on basis of differences in morphology or anatomy. By aid of the comparative approach one gets informations as to the pattern or system of characters which an assemblage of organisms have in common, and what distinct types there are at various levels of characterization. It is this that leads to classification of organisms in a hierarchical system of groups, species grouped in genera, genera grouped in families, families in orders, orders in classes, and so on.

Implicit in such a system is the idea of physical relationship. With the acceptance of the fact of evolution, this implicit postulate becomes explicit, and the question posed by the comparative method becomes correspondingly altered, because behind common pattern one reaches for common origin. The result is a phylogenetic classification intended to express evolutionary descent and relationship rather than just a pigeon-holing system. However, while common ancestry accounted for the shared resemblances of a group, the problem of the differences exhibited by its members remained. For this, a new method of approach is needed, a method which we may call that of differential analysis, which wants to know what is the cause of the differences between the members of a related group. The science of genetics tries to answer the part of this question which is related to the inheritance of such differences, whereas studies of the geographical distribution of different taxa and also studies of their physiological differences under various conditions tackle other parts of the question. Modern biological sciences combine all these kinds of methods in order to distinguish between hereditary and environmental influences on all kinds of variations of living beings and their survival ability under different conditions. These sciences were formerly regarded as more or less unrelated branches of botany, zoology, and microbiology, whereas recent investigations in molecular biology and genetics have clearly shown that biology is a unitary science which is more wisely approached by aid of programs which study plants and animals together at the levels of cellular and molecular biology, organismic biology, developmental biology, evolutionary biology, environmental biology, systematic biology, and psychobiology. It goes without saying that the classical approaches remain useful as a basis for the more novel methods and that the latter would hardly have been invented without the former.

All biological research is ultimately related to problems of human health, welfare, and survival, even when it concentrates on problems of classification or molecular composition. This is perhaps nowhere more evident than in the arctic regions, where human beings live under conditions extremely adverse to their survival. If we are to conquer the arctic lands and use them for the ever-increasing population of mankind without disturbing the harmony of arctic life, then it is essential that we learn what plants and animals live there, how they are distributed, in what way they utilize the available possibilities, and how they can be made beneficial to future generations. Every piece of knowledge of these living beings is important for the understanding of the possibilities of the northlands. Without such an understanding it will be difficult to produce the animals and plants which are needed for survival of human beings, or to understand the importance or danger of various microorganisms which survive in the cold regions of the world. It is because of the increased understanding of the needs for more basic knowledge of the arctic environments and their effects on organisms inhabiting the colder parts of the earth that various biological studies have expanded more rapidly during the past generation than during all previous generations of arctic habitation.

Appropriate subject headings in the Arctic Bibliography will provide much fuller listing of biological literature dealing with arctic organisms than can be included in a brief review of the status and needs of biological research in the Arctic. Therefore, opinions bearing on certain fields in which research offers good opportunities to increase our knowledge about the biota of the cold regions will be given below, and some suggestions made concerning fields with exceptionally urgent needs.

Cellular and molecular biology.

The most startling advances in the biological sciences in the past decade have come in cellular and molecular biology where researchers, working with individual molecules and other minor biochemical and biophysical units, have made remarkable progress in determining the basic constituents of life. Although most work in this field can best be made in large laboratories in temperate regions, certain cellular phenomena need to be studied also in the northlands themselves on microorganisms in their natural environment. It is to be expected that these fields of biology may prove as important for the understanding of life in the Arctic as they have been shown to be under more equitable conditions. Not a single such study has so far been performed on arctic organisms.

Organismic biology.

Greater emphasis has been put on various studies of organismic biology, especially physiology, than on most other fields outside systematic biology in the Arctic. Excellent special laboratories where emphasis is laid on physiological research of animals are available in various places in the American and Soviet Arctic. Investigations are carried out to determine all kinds of physiological processes in mammals and birds, whereas less emphasis is being put on the physiology of lower forms of animal life. The importance of such studies for our understanding of the functions of organisms under extreme conditions of cold in the winter and in the nightless days in the summer cannot be overemphasized, though such investigations ought to be brought also to those animals with cold blood which survive under these conditions.

Plant physiological studies have been performed in some few places, mainly in the Soviet Arctic, though very much is still to be done before we have gained a proper understanding of the functions of plant organisms under the conditions of the long arctic day when the temperature varies from some few degrees above to some few degrees below freezing, with small variations in the light.

It is highly desirable that continued strong encouragement be given physiologists to work on all kinds of living beings in the northlands, and to study the influence of the climate on the organisms as a whole and on their individual tissues. It is likely that some special physiological characteristics of organisms have been important for their survival after selection by these severe environments, though these processes, of course, are genetically determined as are other physiological characteristics.

Organismic biologists also study the morphology and anatomy of plants and animals and try to explain the form of their organs by aid of their function, with or without experiments. Outside physiology, such experimental investigations are rare in arctic lands, though their importance cannot be doubted.

Studies on the sexual processes of animals and plants and of pollination biology of arctic plants and of the biology of their insect vectors have been made in much too few groups in only a few regions. Such investigations, which are of an immense importance to evolutionary biology and plant breeding, ought to be strongly supported as should also all other investigations concerning flower biology and symbiosis of plants and animals.

Organismic biologists ought to be encouraged to set up more broadly organized laboratories in the high-arctic regions, or to kove high-arctic organisms to laboratories where various arctic conditions can be exactly simulated, so that a greater variety of experimental organisms from the animal and plant kingdoms and bacteria can be studied from all physiological and morphological points of view. In such laboratories studies ought to be made of various methods of biological control and their influence on the stability of the delicately balanced communities of living beings under arctic conditions.

Developmental biology.

Studies on the developmental morphology and anatomy of arctic plants were made by Danish investigators in Greenland late in the last century, and some work has later been added from the Soviet Arctic. Field studies based on microscopical examinations of arctic plants and their tissues have scarcely begun. Very little is known about the embryological and anatomical development of plants under the conditions of the short and bright arctic summer, though it has been shown that development of seeds can continue after an interval of a too early beginning winter. Apomixis is common in northern plants, both hereditarily conditioned and affected by the light, but its embryological and molecular basis remains obscure. Comparative developmental biology of arctic plants and their temperate relatives is a field completely untouched, though such experimental studies are likely to be highly rewarding.

The condition of developmental biology of animals in the northlands is no better than that of the plants. Development of various organs of lower animals has not been studied in these regions, and only preliminary investigations have been made on a few mammals of land and sea, although it is known that the conditions of the climate may affect some of the basic developmental processes, especially those of the embryo. Programs in these fields need to be initiated promptly.

Evolutionary biology.

Comparatively little has been done on the evolutionary biology of arctic organisms, except some basic cytological studies of plants and some insects. Counting of chromosomes of higher plants and mosses and morphological analysis of insect chromosomes are the kind of evolutionary investigations which have been made most extensively in the arctic regions. These studies, which combine evolutionary and systematic biology, have not only demonstrated relationships previously unknown, but also helped to solve many taxonomical problems of critical genera. Thanks to intensive work by cytologists in Scandinavia, Iceland, Greenland, Canada, and the Soviet Union, arctic higher plants are better known chromosomally than those of any other area of the globe, and the biological species concept can nowhere be more consistently applied, except in birds. It has been shown that polyploidy attains a high incidence in the Arctic, and further investigations of the genetics and physiology of polyploids may well solve some problems of survival and asexuality in arctic plants. Especially in the American Arctic such studies ought to be encouraged and strongly supported through long-range planning, permitting skilled investigators to make collecting trips for several summers to selected areas until various populations of all the species have been studied.

An almost endless row of problems of population genetics and quantitative genetics of arctic plants and animals still remain untouched, and so do various other evolutionary approaches to several arctic biological phenomena. It is possible to gain a good deal of results by aid of simulated conditions in temperate areas under which arctic plants and small animals are investigated, but such studies are likely to give less valuable results than if facilities for evolutionary biology were made available in the more amiable parts of the northlands themselves. It is known that apomixis, or asexual reproduction, is more common in arctic lands than elsewhere, and that an apomictic plant may turn amicit when cultivated under temperate conditions. Likewise, parthenogenesis is more common in arctic than in temperate animals. The reasons for this remain obscure, and so are also the causes of the drastic cyclic fluttuations in population density of small mammals and birds and their influence on gene frequencies in arctic populations.

All kinds of studies of the evolutionary biology of arctic organisms ought to be strongly encouraged since a proper knowledge of the influence of these special conditions on the genetics of biota is of an utmost importance for animal and plant breeding, which will form one of the main pillars for the agriculture of the future communities of the northlands.

Environmental biology.

Investigations on the composition of vegetation and animal life and the influence of soil and climate on their growth and productivity were among the earliest approaches to arctic biology, especially in Eurasia and Greenland. In North America such studies have also been made rather extensively, especially in recent decades. At the same time as European ecologists have developed clear philosophical concepts and effective methods for a sociological approach to environmental problems, their American colleagues have put stronger emphasis on productivity studies with a more practical aim in mind. Although a good deal of such studies are now being carried out in Canada and the Soviet Union, much remains unknown within this basic field which is important for arctic agriculture.

Plant ecology studies by a single or a few investigators studying limited areas have been typical of environmental biology in the past, and ecological mapping has hardly been tried in the arctic regions outside the Soviet Union, except recently in the Icelandic highlands. Time has come for planned teamwork in studies over much wider areas, combining the methods of various botanists and zoologists with those of climatologists, meteorologists, soil scientists, agronomists, physiologists, cartographers, and others who are likely to bring new ideas into this field and widen its basis considerably. Cooperation with planners of various activities could also be beneficial, since skilled ecologists can often assess the stability and weather conditions of sites with considerably greater success than other specialists, as has been demonstrated by the road and railway botanists in mountainous Norway.

Environmental biology is not only concerned with vegetation and the animals utilizing it, but also with life in lakes, rivers, and the ocean, which are the most valuable sources of food for human inhabitants of the northlands. Productivity of such environments can often be increased by relatively simple methods, or by implantation of new kinds of fishes, though close analysis of the natural conditions must be made prior to all such activities in order to prevent harmful and unnecessary disturbance of the balance of nature. Environmental studies of factors affecting the health of animals and human beings are also important, especially in regions recently made available for human activities, and safety of drinking water is best assured on basis of a firm knowledge of the ~~possible~~ environmental effects of possible contaminants.

Conservation of certain environments and their life is the concern of all biologists, though environmental biologists are best able to judge the importance of every special condition to be selected for protection against man's technological and agricultural advances. It has hardly been started in the northlands.

Systematic biology.

Descriptive accounts of arctic biota, animals and plants, were among the first results of scientific investigations in the northlands, and they continue to be basic to all other investigations for the simple reason that research in every biological field is of little value without an exact identification of the material. Although these accounts have resulted in flora and fauna manuals for all parts of the Arctic, the amount of detailed knowledge of the plants and animals of different regions varies considerably, so that much work still needs to be done in these fields. All groups of biota need to be studied in much greater detail in the field and laboratory, in order to ascertain their variation, distribution, and abundance. Collection work by field biologists needs to be encouraged, and if expensive facilities, as airplanes and helicopters, could be made available to energetic biologists collecting plants and animals, in a similar way as they are now used by geologists looking for minerals and oil, then we will soon know as much about the variation and distribution of arctic biota as those of the best known temperate lands.

Taxonomy and geography of all kinds of plants and animals need continued study, and new methods and new approaches must be sought and applied to increase the exactness in classification, among others to make it possible to evaluate dispersal and survival ability. Since it is important for the understanding of the history and evolution of every taxon of living beings that we understand its place in evolution, emphasis ought to be made to define all species and their lower units exactly and biologically, by aid of intrinsic characteristics. For this, chromosome studies and other cytotaxonomical methods are important. In vascular arctic plants and mosses such studies have already given considerable, though still incomplete results. The cytology of lower plants and of animals of the arctic lands is, however, very little known. Arctic and alpine regions provide unique circumstances for the study of the evolution of various kinds of adaptations to physical environmental stress, though very few studies of such phenomena have so far been performed. It is known that ecotypic variations occur in arctic plants, but very little is known about the intraspecific evolution of animals and plants under arctic conditions, and many races described by zealous taxonomists from various parts of the Arctic often have been found to be less distinct than originally expected.

It is important that studies of grasses, sedges, and shrubs in the Arctic be intensified, because these plants are the basic food for animals which make these regions livable to man. Other higher plants should be studied as possible source for food and recreation, and perhaps also for their medicinal properties, which may be no less important than those of southern regions. Mushrooms and lower fungi of the Arctic are only sporadically known, and so are also lichens and algae. These lower plants have been eaten by arctic inhabitants in the past, but their importance for health may well surpass their nutritional value. The algae in lakes and rivers and in the ocean are the food of animal life and, ultimately, man himself. Even poisonous plants occur in the northlands, but their importance as producers of drugs still remains ignored by others than the natives of the cold regions. Although studies of higher plants ought to be encouraged everywhere in the cold countries, it seems still more important to stimulate a much greater interest in the systematics of the lower plant groups in the lands and waters of the Arctic.

Bacteria in the northlands are mainly beneficial and nonpathogenic, and their importance to soil formation and chemical assimilation is likely to be greater than in more equitable climates. This field is almost untouched. Pathogenic bacteria of plants, animals, and man also occur in the northlands and may not always behave as their relatives further south, though even this field has been little studied outside the more densely populated regions.

The systematics of arctic mammals is reasonably well known, both on the land and in the sea. So is also the taxonomy of arctic birds, which probably are the best understood group of arctic biota. As to other animals, fishes are reasonablyt well known as to species but less well as to variations at lower levels of classification. The variability and distinction of most species of ocean fish and even of salmon and trout still are in dire need of detailed investigation, as is the importance of isolation in lakes and rivers for the processes of subspeciation and speciation.

Studies of insects and other invertebrates in arctic lands have been extensive though mainly concerned with pests, as mosquitos, or parasites. In order to make it possible to list all these lower animals and to understand their place in the biology of the northlands, studies of their taxonomy, variation, and distribution ought to be greatly intensified, since these animals may be considerably more important in the balance of northern nature than surmised and more valuable for the understanding of northern living conditions than all the other arctic biota together.

Paleobiology is a special branch of systematic biology, the one studying animals and plants now extinct, or the past distribution of present biota. Only limited studies of this kind have been made on arctic animals, and most studies of the plants of the past have been connected with studies of the far past, when the now arctic lands were situated in more equitable climates which allowed the growth of forests. These investigations need to be intensified to give us a better picture of the changes of climates and dispersal of plants before and during the creation of the arctic conditions. However, much greater emphasis needs to be put on studies of the paleobotany of Pliocene and Pleistocene conditions, especially by aid of palynology of subrecent times, because such studies are of importance for our understanding of the evolution of the present conditions in arctic lands. These methods are reasonably well known in northern Europe and the Soviet Union, whereas they have been much ignored in the American northlands.

Another branch of systematic biology is anthropology, which in the Arctic and elsewhere is closely connected with archeology and other studies of the history of human societies. It is likely that physical anthropology has already completed its studies of the morphological and physiological peculiarities of the human races in the Arctic, whereas social anthropology and archeology still are at their beginning stages. They are not parts of biology in the common sense of the word.

Psychobiology.

Psychobiology, or behavioral biology, studies the reaction of animals to their environment, to both its animate and inanimate aspects. This behavior is adaptive since it affects the survival of the species. Observations of behavior are supposed to demonstrate what is inherited and what is acquired, and cnahges in behavioral patterns are believed to be of importance for the understanding of the hormonal and nervous systems of the animal.

Psychobiology has been studied most extensively in birds and small animals in the temperate regions, but studies of this kind still are almost absent in the Arctic. It is to be expected that investigations of the behavior of birds and mammals, fishes, invertebrates, and even flies and other insects in arctic lands could reveal a good deal of information of great interest to the well-being of those humans, who spend their lives at higher latitudes.

Agriculture.

Ultimately, all biological research aims at an improvement of the living conditions under which human communities thrive. In the Arctic, it is extremely important that we pool our experience from various fields in order to make it possible to produce good and sufficient food for present and future inhabitants. Studies in fields basic to agriculture in the wide sense of the term ought, therefore, to be strongly encouraged. Special support ought to be given to experiments with various kinds of plants and animals that can be cultivated for human consumption. The Scandinavian Lapps and the Icelandic farmers have made such experiments without planning for thousand years, and so have also the new Greenland farmers for a generation. Their grooping in uncertainties have demonstrated that although domestication of animals, such as the reindeer, may be useful under certain conditions, the acclimatization of sheep, cows, horses, and other well domesticated animals is much more effective and recommendable. Agricultural experiment stations are almost absent from the American sector of the Arctic, though such stations are important as places for introduction of new cultivated crop and horticultural plants and the domestication of wild grasses and other plants of the northlands. At the same time as such research stations are basic for the improvement of living conditions of the present inhabitants of the northlands, they could be made centers of other biological research from which could develop new possibilities for the utilization of the resources of these lands.

Conclusions.

Although a number of individual scientists in many lands have shown a great interest in arctic research, international organization in these fields is still lacking. Even at the national level the understanding of the importance of arctic biological research still remains limited. As a result, only a few and small sections of this vaste area are reasonably well known biologically, whereas the general level of information in these fields is low. The most comprehensive knowledge is within the fields of systematic, environmental, and organismic biology, though much can still be added to all these fields, whereas the knowledge within the fields of evolutionary, developmental, and cellular and molecular biology, and psychobiology is so limited as to be almost absent. Some of the most startling advances in biological sciences in the past two decades have come from evolutionary and molecular biology, but these fields have been much ignored by arctic biologists. This is explainable by the fact that it may be difficult for non-specialists to see the importance of some such studies for the understanding of the profound problems of survival which is all-important in the northlands, though actually every phase of biology is significant for the solution of such problems.

Unsolved questions of biology and human welfare in arctic lands abound. In addition to those already mentioned under special headings, several others requiring interdisciplinary study ought to be attacked. The uneven distribution of organisms on land and in the sea calls for surveying and mapping entire distributions of species at all life stages and also of various ecosystems, combined with studies on the relation between population size and food supply and other factors of general importance. It is supposed that extremes of temperature, moisture, radiation levels, salinity, pressure, and gravity, limit the activity and distribution of plants and animals, though this has not been thoroughly investigated under the stress of arctic conditions. Also, little is known about the influence of drought, soil fertility, and cold on photosynthesis and metabolism under the extreme light conditions of arctic climates. Among other problems requiring collective studies in the northlands are investigations of the effects of various pollutants on the plant and animal life, studies of the speed of evolutionary processes on small and isolated populations, investigations of the effects of diseases of humans and animals on natural selection under the extremes of summer and winter conditions, observations of various pests and predators, and last but not least a very comprehensive interdisciplinary study of the all-important marine ecosystems under various arctic conditions.

Although all kinds of arctic biological research needs to be encouraged all over the northlands, limitation of available funds requires that the most effective studies be stimulated in places of greatest importance. A strong emphasis ought to be put on international planning of well-equipped and well-staffed research centers in places in the northlands where people have already aggregated or can be expected to aggregate in the near future because of richness in non-biological resources. At the same time as such centers ought to emphasize research of importance for these populations, they would be ideal as bases for further research in the less attractive parts of the cold regions of the world.

Cooperation between research workers in various lands needs to be stimulated and organized, and it would be beneficial if fund-giving institutions in more favored areas could make it possible for scientists in the less developed areas to get economic support for their research. Even this could be done by aid of international organization, as could most other encouragement in these fields.

One of the most serious problems of arctic research is the lack of possibilities for a speedy and effective publication of the results obtained. Special journals for various aspects of arctic research ought to be established on an international basis to ensure that no results from any field of arctic biology will need to be delayed for more than half a year, and short notices ought to be made available almost at once in a special monthly journal. It is likely that subsidies making it possible to pay the authors of scientific papers reasonably for their work could greatly stimulate them to prepare their reports promptly and accurately.

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The Arctic Basin.

Áskell Löve:

BIOLOGICAL RESEARCH.

The arctic environment originated when the Laurasian continent drifted into the climate of the north in the late Tertiary, perhaps only a few million years ago. Prior to this, the lands which now are situated in the cold regions of the north, were covered by plants and animals which are characteristic of humid and temperate climates, similar or identical to the fauna and flora of the nemoral vegetations of presently temperate eastern North America, eastern Asia, and western Europe. When the living conditions deteriorated because the continent floated away from the equitable climates where these biota developed, the tender trees and forest plants dispersed southward, followed by migration of less hardy animals, whereas the hardy conifers and tundra plants and adaptable animals stayed behind on the raft. These plants, which formed the present boreal forest and tundra vegetation, had evolved on isolated mountains in the then ~~[illegible]~~ northern nemoral zone or close to the ocean, ~~when the tender trees belonged to the northernmost growth on earth~~, though at that time they did not find appropriate conditions to spread widely and develop into their present conditions. This happened in the late Tertiary. Certain animals had developed preferences for this vegetation and its conditions and stayed behind, though most of the animals of the northern nemoral migrated with it when it dispersed southward. Later, the Pleistocene glaciations may have affected the evolution of the plants and animals which became trapped in unglaciated refugia in the northlands, although the adaptive responses of these biota to the cold are likely to have been caused by extinction of non-adaptive types rather than by direct genetical adaptation.

Biological research in the arctic regions is of a recent date, partly because these lands have long been sparsely populated and, thus, not regarded as important by those who lived under more equitable conditions in the temperate zone, but perhaps more often because those people who live under arctic conditions spend more time than others ~~for~~ gathering necessities of life. ~~and then prefer cultural work that does not require more fighting with of the elements, when they had~~ve ~~some leisure time~~. Biological research work in the arctic regions has followed the same pattern as in more southern lands. The original and basic approach was inevitably descriptive, because the biologists set out to describe as fully and accurately as possible the variety of organisms and the phenomena they display. This approach is designed to answer the question about what are the facts. The descriptive approach is soon supplemented by the comparative, which is first focused round the question of grouping or classification on basis of differences in morphology or anatomy. By aid of the comparative approach one gets informations as to the pattern or system of characters which an assemblage of organisms have in common, and what distinct types there are at various levels of characterization. It is this that leads to classification of organisms in a hierarchical system of groups, species grouped in genera, genera in families, families in orders, orders in classes, and so on.

Implicit in such a system is the idea of physical relationship. With the acceptance of the fact of evolution, this implicit postulate becomes explicit, and the question posed by the comparative method becomes correspondingly altered, because behind common pattern one reaches for common origins. The result is a phylogenetic classification intended to express evolutionary descent and relationship rather than just a pigeon-holing system. However, while common ancestry accounted for the shared resemblances of a group, the problem of the differences exhibited by its members remained. For this, a new method of approach is needed, a method which we may call that of differential analysis, which wants to know what is the cause of the differences between the members of a related group. The science of genetics tries to answer the part of this question which is related to the inheritance of such differences, whereas studies of the geographical distribution of different taxa and also studies of their physiological differences under various conditions tackle other parts of the question. Modern biological sciences combine all these kinds of methods in order to distinguish between hereditary and environmental influences on all kinds of variations of living beings and their survival ability under different conditions. These sciences were formerly regarded as more or less unrelated branches of botany, zoology, and microbiology, whereas recent investigations in molecular biology and genetics have clearly shown that biology is a unitary science which is more wisely approached by aid of programs which study plants and animals together at the levels of cellular and molecular biology, organismic biology, developmental biology, evolutionary biology, environmental biology, systematic biology, and ~~behavioral biology which actually is a branch of what could be called~~ psychobiology. It goes without saying that the classical approaches remain useful as a basis for the more novel methods and that the latter would hardly have been ~~discovered~~ invented without the former.

All biological research is ultimately related to problems of human health, welfare, and survival, even when it concentrates on problems of classification or molecular composition. This is perhaps nowhere more evident than in the arctic regions, where human beings live under conditions extremely adverse to their survival. If we are to conquer the arctic lands and use them for the ever-increasing population~~s~~ of mankind without disturbing the harmony of arctic life, it is essential that we learn what plants and animals live there, how they are distributed, in what way they utilize the available possibilities, and how they can be made beneficial to future generations. Every piece of knowledge of these living beings is important for the understanding of the possibilities of the northlands. ~~and~~ Without such an understanding it will be difficult to produce the animals and plants which are needed for survival of human beings, or to understand the importance or danger of various microorganisms which survive in the cold regions of the world. It is because of the increased understanding of the needs for more basic knowledge of the arctic environments and their effects on organisms inhabiting the colder parts of the earth that various biological studies have expanded more rapidly during the past generation~~s~~ than during all previous generations of arctic habitation.

Appropriate subject headings in the Arctic Bibliography will provide much fuller listing of biological literature dealing with arctic organisms than can be included in a brief review of the status and needs of biological research in the Arctic. Therefore, opinions bearing on certain fields in which research offers good opportunities to increase our knowledge about the biota of the cold regions will be given below, and some suggestions made concerning fields with exceptionally urgent needs.

Cellular and molecular biology.

The most startling advances in the biological sciences in the past decade have come in cellular and molecular biology where researchers, working with individual molecules and other minor biochemical and biophysical units, have made remarkable progress in determining the basic constituents of life. Although most work in this field can best be made in large laboratories in temperate regions, certain cellular phenomena need to be studied also in the northlands themselves on microorganisms in their natural environment. It is to be expected that these fields of biology may prove as important for the understanding of life in the Arctic as they have been shown to be under more equitable conditions. Not a single such study has so far been performed on arctic XXXXXX organisms.

Organismic biology.

Greater emphasis has been put on various studies of organismic biology, especially ~~or~~ physiology, than on most other fields outside systematic biology in the Arctic, ~~and~~ Excellent special laboratories where emphasis is laid on physiological research of animals are available in various places in the American and Soviet Arctic. Investigations are carried out to determine all kinds of physiological processes in mammals and birds, whereas less emphasis is being put on the physiology of lower forms of animal life. The importance of such studies for our understanding of the functions of organisms under extreme conditions of cold in the winter and in the nightless days in the summer cannot be overemphasized, though such investigations ought to be brought also to those animals with cold blood which survive under these conditions.

Plant physiological studies have been performed in some few places, mainly in the Soviet Arctic, though very much is still to be done before we have gained a proper understanding of the functions of plant organisms under the conditions of the long arctic day when the temperature varies from some few degrees above to some few degrees below freezing, with small variations in the light.

It is highly desirable that continued strong encouragement be given physiologists to work on all kinds of living beings in the northlands, and to study the influence of the climate on the organisms as a whole and on their individual tissues. It is ~~at least~~ likely that some special physiological characteristics of organisms have been important for their survival after selection by these severe environments, though these processes, of course, are genetically determined as are other physiological characteristics.

Organismic biologists also study the ~~form~~ morphology and anatomy of plants and animals and their organs and try to explain their form by aid of their function, with or without experiments. Outside physiology, such experimental investigations by organismic biologists are rare in arctic lands, though their importance cannot be ~~underestimated~~ doubted.

Organismic biologists ought to be encouraged to set up more broadly organized laboratories in the high-arctic regions, or to move high-arctic organisms to laboratories where such conditions can be simulated, so that a greater variety of experimental organisms from the animal and plant kingdoms and bacteria can be studied from all physiological and morphological points of view. In such laboratories studies ought also to be made of various methods of biological control and their influence on the stability of the delicately balanced communities of living beings under arctic conditions.

Studies on the sexual processes of animals and plants and of pollination biology of arctic plants have been made in much too few groups in only a few regions. Such investigations, which are of an immense importance to evolutionary biology, ought to be strongly supported as should also all other investigations concerning flower biology and symbiosis of plants and animals.

Developmental biology.

Studies on the developmental morphology and anatomy of arctic plants were made by Danish scientists in Greenland ~~in the late~~ late in the last century, and some work has later been added from the Soviet Arctic. Field studies based on microscopical examinations of arctic plants and their tissues have scarcely begun. Very little is known about the embryological and anatomical development of plants under the conditions of the short and bright arctic summer, though it has been shown that development of seeds can continue after an interval of a too early beginning winter. Apomixis is common in northern plants, both heriditary conditioned and affected by the light, but its embryological and molecular basis remains obscure. Comparative developmental biology of arctic plants and their temperate relatives is a field completely untouched, though such experimental studies are likely to be highly rewarding.

The condition of developmental biology of animals in the northlands is no better than that of the plants. Development of various organs of lower animals has not been studied in these regions, and only preliminary investigations have been made on a few mammals of land and sea, although it is known that the conditions of the climate may affect some of the basic developmental processes, especially those of the embryos. ~~A~~ Programs in these fields need~~s~~ to be initiated promptly.

Evolutionary biology.

Comparatively little has been done on the evolutionary biology of arctic organisms, except some basic cytological studies of plants. [These preliminary studies have explained the relationships between species of many complexes, and they have also shown the importance of polyploidy for survival under extreme conditions.] [Though there can be no doubt that these studies are of the greatest importance for our understanding of evolution under arctic conditions, granting agencies seem ~~to tend~~ to show little understanding for supporting this kind of work, at least in the American part of the Arctic, which still remains considerably less known in this respect than the European and Asiatic parts of the northlands.]

~~Studies combined with~~ counting of chromosomes of higher plants and mosses and ~~with~~ morphological analysis of insect chromosomes, are the kind of evolutionary investigations which have been made most extensively in the arctic regions. These studies, which ~~are~~ belong to both evolutionary and systematic biology, have not only demonstrated relationships previously unknown ~~in many cases~~, but also helped to solve many taxonomical problems of critical genera of plants. Thanks to intensive works by cytologists in Scandinavia, Iceland, Greenland, Canada, and the Soviet Union, arctic higher plants are better known chromosomally than those of any other area of the globe, and the biological species concept can nowhere be more consistently applied, except in birds. It has been shown that polyploidy attains a high incidence in the Arctic, and further investigations of the genetics and physiology of polyploids may well solve many problems of survival and asexuality in arctic plants. Especially in the American Arctic such studies ought to be encouraged and strongly supported through long-range planning, permitting skilled investigators to make collecting trips for several summers in a row to selected areas until various populations of all the species have been studied ~~from various populations~~.

An almost endless row of problems of population genetics and quantitative genetics of arctic plants and animals still remains untouched, and so do various ~~other~~ other evolutionary approaches to several ~~other~~ arctic biological problems. It is possible to gain a good deal of ~~variable~~ results by aid of simulated conditions in temperate areas under which arctic plants and small mammals and insects are investigated, but such studies are likely to give less valuable results than if facilities for evolutionary biology were made available in the more amiable parts of the northlands themselves. It is known that apomixis, or asexual reproduction, is more common in arctic lands than elsewhere, and that an apomictic plant may turn amictic when cultivated under temperate conditions. The reasons for this remain obscure, and so are also the drastic cyclic fluctuations in population density of small ~~makk~~ mammals and birds and their influence on gene frequencies in the populations of arctic regions.

All kinds of studies of the evolutionary biology of arctic organisms ought to be strongly encouraged since a proper knowledge of the influence of these special conditions on the genetics of biota is of an utmost importance for animal and plant breeding, which will form the basis for the agriculture of the future communities of the northlands.

Environmental biology.

Investigations on the composition of vegetation and animal life and the influence of soil and climate on their growth and productivity were among the earliest approaches to arctic biology, especially in Eurasia and Greenland. In North America such studies have also been made rather extensively, especially in recent decades. At the same time as European ecologists have developed clear philosophical concept~~a~~s and effective methods for a sociological approach~~es~~ to environmental problems, their American colleagues have put stronger emphasis on productivity studies with a more practical aim in mind. Although a good deal of such studies are now being carried out in Canada and the Soviet Arctic, much remains unknown within this ~~important~~ basic field which is ~~basic~~ important for arctic agriculture.

Plant ecology studies by a single or a few investigators studying limited areas have been typical of ~~this approach~~ environmental biology in the past, and ecological mapping has hardly been tried in the arctic regions outside the Soviet Union, except recently in the Icelandic highlands. Time has come for planned teamwork ~~ax~~ in studies over much wider areas, combining the methods of botanists and zoologists with those of climatologists, meteorologists, soil scientists, agronomists, physiologists, ~~and~~ cartographers, and others who are likely to bring new ideas into this field and widen its basis considerably. Cooperation with planners of various activities could also be beneficial, since skilled ecologists can often assess the stability and weather conditions of sites with considerably greater success than other specialists, as has been demonstrated by the road and railway botanists in mountainous Norway.

Environmental biology is not only concerned with vegetation and the animals utilizing it, but also with life in lakes, rivers, and the ocean, which are the most valuable sources of food for human inhabitants of the northlands. Productivity of such environments can often be increased by relatively simple methods, or by implantation of new kinds of fishes, though close analysis of the natural conditions must be ~~basic for~~ made prior to all such activities in order to prevent harmful and ~~effects of~~ unnecessary disturbances of the balance of nature. Environmental studies of factors affecting the health of animals and human beings are also important, especially in regions recently made available for human activities, and safety of drinking water is best secured on basis of a firm knowledge of the environmental effects of possible contaminants.

Conservation of certain environments and their life is the concern of all biologists, though environmental biologists are best able to judge the importance of every special condition to be selected for protection against man's technological and agricultural advances. It has hardly been started in the Netherlands.

Systematic biology.

Descriptive accounts of arctic biota, animals and plants, were among the first results of scientific investigations in the northlands, and they continue to be basic to all other investigations for the simple reason that research in every biological field without an exact identification of the material is of little value. Although these accounts have resulted in flora and fauna manuals for all parts of the Arctic, the amount of detailed knowledge of the plants and animals of different regions varies considerably, so that much work still needs to be done in these fields. All groups of biota need to be studied in much greater detail in the field and laboratory, in order to ascertain their variation, distribution, and abundance. ~~The~~ Collection work by field biologists needs to be encouraged, and if expensive facilities, as airplanes and helicopters, could be made available to energetic biologists collecting plants and animals, in a similar way as they are now used by geologists looking for minerals and oil, we will soon know as much about the variation and distribution of arctic biota as those of the best known temperate lands.

~~The~~ Taxonomy and geography of all kinds of plants and animals need continued study, and new methods and new approaches must be sought and applied to increase the exactness in ~~their~~ classification, among others to make it possible to evaluate ~~their~~ dispersal and survival ability. ~~and also their sexual systems and pollination mechanisms.~~ Since it is important for the understanding of the history and evolution of every taxon of living beings that we understand its place in evolution, emphasis ought to be made to define all species and their lower units exactly and biologically, by aid of ~~their~~ intrinsic characteristics. For this, chromosome studies and other cytotaxonomical methods are important. In vascular ~~plants~~ arctic plants and mosses such studies have already given considerable, ~~results~~, though still incomplete results. b~~een made in the majority of species from Iceland, Greenland, and the Soviet Arctic, whereas in most parts of the American Arctic such studies still are insufficient~~. The cytology of lower plants and of animals of the arctic ~~regions~~ lands is, however, very little known. Arctic and alpine regions provide ~~also~~ unique circumstances for the study of the evolution of various kinds of adaptations to physical environment stress, though very few studies of such phenomena have sofar been performed. ~~in the arctic regions.~~ ~~Though~~ It is known that ecotypic variations occur in arctic plants, but very little is known about the XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX intraspecific evolution of animals and plants under arctic conditions, and many races described by zealous taxonomists from various parts of the Arctic often have been found to be less distinct ~~valuable~~ than originally expected.

It is important that studies of grasses, sedges, and shrubs in the Arctic be intensified, because these plants are the basic food for animals which make these regions livable to man. Other higher plants should be studied as possible source for food and recreation, and perhaps also for their medicinal properties, which may be no less important than those of southern regions. Mushrooms and lower fungi of the Arctic are only sporadically known, and so are also lichens and algae. These lower plants have been eaten by arctic inhabitants in the past, but their importance for health may well surpass their nutritional value. The algae in lakes and rivers and in the ocean are the food of animal life and, ultimately, man himself. Even poisonous plants occur in the northlands, but their importance as producers of drugs still remains ignored by others than the natives of the cold regions. Although studies of higher plants ought to be encouraged everywhere in the cold countries, it seems still more important to stimulate a much greater interest in the systematics of the lower plant groups in the lands and seas of the Arctic.

Bacteria in the northlands are mainly beneficial and nonpathogenic, and their importance to soil formation and chemical assimilation is likely to be greater than in more equitable climates. This field is almost untouched. Pathogenic bacteria of plants, animals, and man also occur in the northlands and may not always behave as their relatives further south, though even this field has been little studied outside the more densely populated regions.

The systematics of arctic mammals is reasonably well known, both on the land and in the sea. So is also the taxonomy of arctic birds, which probably are the best understood group of arctic biota. As to other animals, fishes are reasonably well known as to species but less well as to variations ~~inside the species~~ at lower level, of classification. The variability and distinction of most species of ocean fish and even of salmons and trout still are in dire need of detailed investigation~~s~~, as is the importance of isolation in lakes and rivers for the processes of subspeciation and speciation.

Studies of insects and other invertebrates in arctic lands have been extensive though mainly concerned with pests, like mosquitos, or parasites. In order to make it possible to list all these lower animals and to understand their place in the biology of the northlands, studies of their taxonomy, variation, and distribution ought to be greatly intensified, since these animals may be considerably more important~~s~~ in the balance of northern nature than surmised and more valuable for the understanding of northern living conditions than all the other arctic biota together.

Paleobiology is a special branch of systematic biology, the one studying animals and plants now extinct, or the past distribution of present biota. Only limited studies of this kind have been made on arctic animals, and most studies of the plants of the past have been connected with studies of the far past, when the now arctic lands were situated in more equitable climates which allowed the growth of forests. These investigations need to be intensified to give us a better picture of the changes of climates and dispersal of plants before and during the creation of the arctic conditions. However, much greater emphasis needs to be put on studies of the p~~e~~aleobotany of Pliocene and Pleistocene conditions, especially by aid of palynology of subrecent layers? times, because such studies are of importance ~~to~~ for our understanding of the evolution of the present conditions.

These methods are reasonably well known in northern Europe and the Soviet Union, whereas they have been much ignored in the American northlands.

Another branch of systematic biology is anthropology, which in the Arctic and elsewhere is closely connected with archeology and other studies of the history of human societies in the past. It is likely that physical anthropology has already completed its studies of the morphological and physiological peculiarities of the human races in the Arctic, whereas social anthropology and archeology still are at their beginning stages.~~there~~. They are not parts of biology in the common sense of the word.

Psychobiology.

Psychobiology, or behavioral biology, studies the reaction of animals to their environment, ~~to~~ to both its animate and inanimate aspects. This behavior is adaptive since it affects the survival of the species. Observations of behavior are supposed to demonstrate what is inherited and what is acquired, and changes in behavioral patterns are believed to be of importance for the understanding of the hormonal and nervous systems of the animals in question.

Psychobiology has been studied most extensively in birds and small mammals in the temperate regions, but studies of this kind still are almost absent from the Arctic. It is to be expected that investigations of the behavior of birds and mammals, fishes, invertebrates and even flies and other insects in arctic lands could reveal a good deal of informations of great interest to the wellbeing of those humans, who spend their lives at higher latitudes.

Agriculture.

Ultimately, all biological research aims at an improvement of the living conditions under which human communities thrive. In the Arctic, it is extremely important that we ~~interpolate~~ pool our experience~~s~~ from various fields in order to make it possible to produce good and sufficient food for present and future inhabitants. Studies in fields basic to agriculture in the wide sense of the term ought, therefore, to be strongly encouraged. Special support ought to be given to experiments with various kinds of plants and animals that can be cultivated for human consumption. The Scandinavian Lapps and the Icelandic farmers ~~forxthousandxyears~~ have made such experiments without planning for a thousand years, and so have also the new Greenland farmers for a generation. Their groping in uncertainties have demonstrated that although domestication of animals as the reindeer, may be useful under certain conditions, acclimatization of sheep, cows, horses, and other well domesticated animals is much more effective and recommendable. Agricultural experiment stations are almost absent from the American sector of the Arctic, though such stations are important as places for introduction of new cultivated crop and horticultural plants and the domestication of wild grasses and other plants of the northlands. At the same time as such research stations are basic for the improvement of living conditions of the present inhabitants of the northlands, they could be made centers of other biological research from which could develop new possibilities for the utilization of ~~other~~ the resources of these lands.

Conclusions.

Although a number of individual scientists in many lands have shown a great interest in arctic research, international organization in these fields is still lacking~~, and~~ Even at the national level the understanding of the importance of arctic biological research still remains limited. As a result, only a few and small sections of this vaste area are reasonably well known ~~from these points of view~~ biologically, whereas the general level of information in these fields is ~~rather~~ low. The most comprehensive knowledge is within the fields of systematic, environmental, and organismic biology, though much can still be added to all these fields, whereas the knowledge within the fields of evolutionary, developmental, cellular and molecular, and psychobiology is so limited as to be almost absent. Some of the most startling advances in the biological sciences in the past two decades have come from evolutionary and molecular biology, but these fields have been ignored by arctic biologists. This is explainable by the fact that it may be difficult to see the importance of some such studies for the understanding of the profound problems of survival which is all important in the northlands, though actually every phase of biology is significant for the solution of such problems.

Unsolved questions of biology and human welfare in arctic lands abound. In addition to those already mentioned under special headings, several others requiring interdisciplinary study ought to be attacked. The uneven distribution of organisms on land and in the sea calls for surveying and mapping entire distributions of species at all life stages and also of various ecosystems, combined with studies on the relation between population size and food supply and other factors of general or special importance. It is supposed that extremes of temperature, moisture, radiation levels, salinity, pressure, and gravity,? limit the activity and distribution of plants and animals, though this has not been thoroughly investigated under the stress of arctic conditions. Also, little is known about the influence of drought, soil fertility, and cold on photosynthesis and metabolism under the extreme Light conditions of arctic climates. Among other problems requiring collective studies in the northlands are investigations of the effects of various pollutants on the plant and animal life ~~of the lands of the midland sun~~, studies of the speed of evolutionary processes on small and isolated populations, investigations of the effects of diseases on humans and animals on natural selection under the extremes of summer and winter conditions, observations of various pests and predators, ~~in the northlands~~, and last but not least a very comprehensive interdisciplinary study of the all-important marine ecosystem under various arctic conditions.

Although all kinds of arctic biological research needs to be encouraged all over the northlands, limitation of available funds requires that the most effective studies be stimulated in places of greatest importance. A strong emphasis ought to be put on international planning of well-equipped and well-staffed research centers in places in the northlands where people have already aggregated or can be expected to aggregate in the near future because of richness in non-biological resources. At the same time as such centers XXXXX ought to emphasize research of importance for these populations, they would be ideal as bases for further research in the less attractive parts of the cold regions of the world.

Cooperation between research workers in various lands needs to be stimulated and organized, and it would be beneficial if fund-giving institutions in more favored areas could make it possible for scientists in the less developed areas to get economic support for their research. Even this could be done by aid of international organization~~s~~, as could most other encouragement in these fields.

One of the most serious problems of arctic research is the lack of possibilities for a speedy and effective publication of the results obtained. Special journals for various aspects of arctic research ought to be established on an international basis to ensure that no results from any field of arctic biology will need to be delayed for more than half a year, and short notices ought to be made available almost at once in a special monthly journal. It is likely that subsidies making it possible to pay the authors of scientific papers properly ? for their work could greatly stimulate them to prepare their reports promptly and accurately.

(Senecio)

Greenman 1915:

Synopsis of the subgenera and sections.

Subgenus I. Eusenecio Hoffm. Style-branches truncate, rounded-obtuse or occasionally terminated by a penicillate tuft of hairs.

A. Stems erect or ascending, not climbing.
  a. Stems not abruptly terminated by a fore-shortening of the main axis; oil-tubes not richly developed in the peripheral portion of the stem
    α Leaves pinnately veined; lateral nerves not numerous or conspicuous
      I. Annual herbs . . . . §1. Annui.
      II. Biennial or perennial herbs (rarely annual)
        1. Stems herbaceous
          * Heads usually radiate; flowers yellow, except in S. Greenei and S. crocatus.
            + Stem leafy to the inflorescence; leaves laciniately pinnatifid to triternately divided.
              0. Native species. §2. Eremophili
              00. Introduced species §3. Jacobaeae
            ++ Stem not uniformly leafy to the inflorescence; leaves pinnate or the lower simple and undivided.
              0. Leaves pinnate or pinnatisect, rarely undivided §4. Sanguisorboidei
              00. Lower leaves rotund-ovate, simple and undivided §5. Bolanderiani
            +++ Stem not uniformly (not pappus) . . . §6. Aurei. §7. Lobati. §8. Tomentosi
            ++++ Stem leafy to the inflorescence (except in §9); pubescence usually of long jointed hairs.
              0. Stem leaves not amplexicaul.
                δ Leaves not digitately divided. §9. Columbiani
                δδ Leaves digitately divided. §10. Digitati
              00. Stem-leaves amplexicaul.
                δ. Involucre ecalyculate. §11. Cineraroidei.
                δδ. Involucre calyculate. §12. Amplectentes
          ** Heads discoid; flowers whitish or purplish.
            +. Heads 2 cm or more high; corollas deeply 5-lobed. §13. Rugelici
            ++ Heads 1 cm high; corollas shortly 5-toothed. §14. Mulgediifolii
        2. Stems ligneous at the base.
          x. Involucre barely calyculate; plants ~~[illegible]~~ white-tomentose throughout. §15. Incani
          xx. Involucre calyculate; plants glabrous or pubescent. §16. Suffruticosi.
        3. Shrubs or tree-like plants. §17. Fruticosi
    β. Leaves palmately veined . . §18. Palmatinervii
    γ. Leaves pinnately veined; lateral nerves parallel-arcuate, numerous or conspicuous. . § Multinervii
  b. Stems abruptly terminated by a fore-shortening of the main axis and bearing at the top two to several, more or less pedunculate axillary compound corymbose cymes; oil-tubes richly developed in the peripheral portion of the stem . . §20. Terminales
B. Stems climbing . . . §21. Streptothamni

Subgenus II. Pseudogynoxis Greenm. Style-branches terminated by triangular acute or acuminate hispidulous appendages. §22. Convolvuloidei [illegible] Hervier.

Hippocrepis ~~scabra DC. var~~. bourgaei (Nyman) ~~Löve & K~~jellqvist

Voucher: Provincia de Teruel: Sierra Albarracín, Casa Forestal; N. 0432. 2n = 28.

This endemic Spanish species has not been previously studied cytologically. It is a variable taxon, which BALL (1968a) defines as encompassing also the two taxa H. commutata Pau and H. bourgaei (Nyman) Hervier, though without accepting them as distinct at any level, because he finds each population to vary considerably and does not find the distinguishing characters to be satisfactory. In our experience, it is evident that these taxa are races of the same variable species, but since their areas of distribution are small and their characteristics and even geographical limits are not very distinct and intermediates caused by occasional hybridization and back-crossing are rather frequent where their areas meet, they seem to be best accomodated as three varieties. The typical var. scabra is a taxon of southern Spain. In southeastern Spain it is gradually replaced by var. bourgaei (Nyman) Löve & Kjellqvist, stat. nov., (based on Hippocrepis bourgaei Nyman, Conspectus (1878 - 1882), p. 186, and Hervier, Bull. Acad. Int. Géogr. Bot. (Le Mans) 17 (1907), p. 37) which in turn is gradually replaced in central and northern Spain by var. commutata (Pau) Löve & Kjellqvist, stat. nov., (based on Hippocrepis commutata Pau, Bol. Soc. Aragon Ci. Nat. 2 (1903), p. 274). Our material from the Sierra Albarracín belonged to the var. bourgaei and showed no signs of any hybridization.

H. commutata 2n = 14: Valdés 1970!

Greenman 1915:

Sect. Annui Hoffm., in Engl. Prantl Nat. Pflanzenfam. IV, 5 (1892), p. 297. = Obaejacae DC (Prodr. 5 (1837), p. 341. (annual weeds).
Senecio viscosus L.
S. mohavensis A. Gray
S. vulgaris L.
S. sylvaticus L.
S. aphanactis Greene (= S. sylvaticus Gray not L.; Calif., N. Mexico, adj. islands)
S. californicus DC. (C. Calif. to N. Mexico).
S. ampullaceus Hook. (eastern Texas)

Sect. Eremophili Greenm. (annual or biennial/perennial)
S. MacDougalii Heller (N. Mex. & Ariz.)
S. ambrosioides Rydb. (= S. eremophilus A. Gray) (Wyo. to N. Mex., Idaho, Arizona)
S. eremophilus Richards. (NW Canada to Nebraska, Colo., Utah)
S. Townsendii Greenm. (N. Mexico)
S. chihuahuensis Watson (N. Mexico).
S. durangensis Greenm.

Sect. Jacobaea DC (biennial to perennial)
S. rupestris W. & K. (intr.)
S. erucifolius L. (intr.)
S. Jacobaea L. (intr.)

Sect. Sanguisorboidei Greenm. (Annuals, biennials, perennials)
S. sanguisorboides Rydb. (Mts of N. Mex.)
S. glabellus Poir. (N. Car. - Illinois, Mo., S.D., Florida, E. Texas)
S. Greggii Rydb. (S. N. Mex., W. Texas, ~~[illegible]~~ Northern Mexico).
S. imparipinnatus Klatt (W. Louisiana, Oklahoma, Texas)
S. Millefolium T. & G. (Mts. of N. Car. & S. Car.).
S. tampicanus DC. (E. Mexico).
S. hypotrichus Greenm. (C. Mexico)
S. Sanguisorbae DC. (S. Mexico)
S. pinnatisectus DC. (S. Mexico).
S. coahuilensis Greenm. (North Mexico.)
S. leonensis Greenm. (Sierra Madre)
S. zimapanicus Hemsl. (E. Mexico).

Sect. Bolanderiani Greenm. (perennials)
S. Bolanderi A. Gray (Calif. + Oregon)
S. Harfordii Greenm. (Mts. of Wash. & Oreg.)
S. Flettii Wiegand (Washington).

Anthyllis vulneraria L. ssp. reuteri Cullen

Voucher: Provincia de Jaén: Sierra de Cazorla, El Chorro; N. 0380. 2n = 12.

This is apparently the first report of the chromosome number of this endemic race of southern and eastern Spain, the same number as known for several other races of the species.

Anthyllis vulneraria L. ssp. maura (G. Beck) Lindb.

Voucher: Provincia de Jaén: Sierra de Cazorla, Laguna de Valdeazores; N. 028. 2n = 12.

This is also the first chromosome number report for this western Mediterranean race. Some of our specimens belong to the var. font-queri (Rothm.) Cullen, which perhaps is better regarded as a hybrid between the ssp. maura and ssp. reuteri.

Physanthyllis tetraphylla (L.) Boiss.

Voucher: Provincia de Jaén: Sierra de Cazorla, Quesada; N. 0332. 2n = 16.

This is a confirmation of three earlier chromosome reports for this Mediterranean species. Since it differs not only in morphology but also in basic chromosome number from other taxa included in the then unnatural genus Anthyllis by CULLEN (1968), we regard it as wiser to retain it in a genus of its own, as previously proposed by BOISSIER (1839 - 1845).

Barkley, T.M. 1962:

Only 22 species of Aurei:

1. S. aureus L.
2. S. robbinsii Oakes
3. S. pseudaureus Rydb.
4. S. obovatus Muhl.
5. S. smallii Britt.
6. S. pauperculus Michx. (inc. v. crawfordii (Britt.) T.M. Barkley)
7. S. quaerens Greene
8. S. dimorphophyllus Greene (incl. 3 vars).
9. S. crocatus Rydb.
10. S. streptanthifolius Greene
11. S. tridenticulatus Rydb.
12. S. cardamine Greene
13. S. hartianus Heller
14. S. plattensis Nutt.
15. S. debilis Nutt.
16. S. pauciflorus Pursh
17. S. indecorus Greene
18. S. porteri Greene
    2n=
19. S. newcombei Greene (Queen Charlotte Islands)
20. S. hyperborealis Greenm.
21. S. resedifolius Less.
22. S. cymbalarioides Buek (not sensu DC p.405, [illegible] 428)

23.

Scorpiurus muricatus L.

Voucher: Provincia de Jaén: Sierra de Cazorla, El Chorro, & Pantano del Tranco; N. 0124, N. 0207. 2n = 28.

This is a confirmation of earlier counts for this southern European species, by COUTINHO & RIBEIRO (1945) and FRAHM-LELIVELD (1957), whereas SENN (1938) reported both 2n = 14 and 28 from Botanical Garden material. We agree with BALL (1968b) that the two taxa sometimes identified as the distinct species S. subvillosus L. and S. sulcatus L. are not even worthy of varietal rank and so ought to be regarded as synonymous with S. muricatus. COUTINHO & RIBEIRO (1945) reported the same chromosome number for all three taxa. Our material could, with some imagination, be regarded as representing populations intermediate between S. muricata s.str. and S. sulcatus, with N. 0124 resembling the latter more closely in the majority of features.

GERANIACEAE

Geranium rotundifolium L.

Voucher: Provincia de Jaén: Sierra de Cazorla, Pantano del Tranco; N. 0175. 2n = 26.

This is a confirmation of earlier reports for this almost cosmopolitan weed of Mediterranean origin.

Geranium molle L.

Voucher: Provincia de Jaén: Sierra de Cazorla, Pantano del Tranco; N. 0157. 2n = 26.

This confirms numerous earlier reports for this probably Mediterranean species, which has become a very widespread weed.

Greenman, J. M. 1918: Monograph of the North and Central American

Species of the genus Senecio — Part II. — Ann. Miss. Bot. Garden 3: ~~85-134~~ 573-626.

Senecio L.

Subg. I. Eusenecio Hoffm.

" II. Pseudogynoxis Greenm.

~~3. [illegible]~~ § 22 Convolvuloidei

Subg. Eusenecio
§ 20: Terminales
§ 21: Strepto~~ta~~thamni.

Subg. I. (key to 21 sections): β probably viney § 18 & 19: Palmatinervii, Multinervii;

Subg. Eusenecio
sect. 1-17..

A. Stems erect or ascending not climbing

a. Stems not abruptly terminated by a foreshortening of the main axis; oil tubes not richly developed in the peripheral part of the stem.

~~β. Stems abruptly terminated by a fore-shortening of the main axis and bearing at the tip~~

α Leaves pinnately ~~[illegible]~~ veined; lateral nerves not numerous or conspicuous

II. Biennial or perennial herbs (rarely annual).

1. Stem herbaceous

* Heads usually radiate; flowers yellow, except in S. Greenei & S. crocatus

††† Stems not uniformly leafy to the inflorescence; leaves simple and entire to lyrate-pinnatifid; plants either quite glabrous from the start or more or less permanently tomentose; pubescence never of long jointed hairs.

0. Plants glabrous or early glabrate; leaves upwardly reduced on the stem . . . §6 Aurei

00. Plants at first tomentose, later glabrate; leaves more uniform throughout and mostly pinnately divided . . §7. Lobati

000 Plants permanently tomentose or more or less glabrate; stem-leaves upwardly reduced. . . . §8. Tomentosi

Sect. Lobati → which author? (Rydberg?)

Erodium cicutarium (L.) L'Hér.

Vouchers: Provincia de Jaén: Sierra de Cazorla, Pantano del Tranco, and Nava de San Pedro; N. 0160, N. 0291. 2n = 40.

This is a confirmation of numerous reports for this species in its strict sense, which originates from the Mediterranean region but has become an almost cosomopolitan weed.

Erodium primulaceum (Lange) Welw.

Voucher: Provincia de Jaén: Sierra de Cazorla, El Chorro; N. 0135. 2n = 20.

This is a confirmation of a previous report of the diploid number, by GUITTONNEAU (1966), for this southwest European taxon, which was, in our opinion mistakingly, regarded as synonymous with E. cicutarium ssp. cicutarium by WEBB & CHATER (1968).

Erodium moschatum (L.) L'Hér.

Voucher: Provincia de Jaén: Sierra de Cazorla, Pantano del Tranco; N. 0206. 2n = 20.

This is a confirmation of several previous reports for this southern and western European species of cultivated grounds and waste places.

Tephroseris (Rchb.) Rchb.

Greenm.: 1916, p. 85: Monograph of the North and Central American species of the genus Senecio — Part II. — Ann. Mo. Bot. Gard. 3 (1916), pp. 85–188.

§ Aurei Rydb. Bull. Torrey Bot. Club 27 (1900), p. 173;

Herbaceous perennials, glabrous or in the early stages floccose-tomentose and more or less glabrate except in the axils of the leaves and occasionally at the base of the stem; stems erect or ascending, 1 to 10 dm high, one to several from a common base or rootstock; leaves variable, the lowermost petiolate, rotund-ovate, oblong-ovate, obovate to narrowly oblanceolate, entire, crenate or dentate to more or less lyrate; stem-leaves petiolate to sessile, pinnatisect to entire, usually reduced towards the cymose inflorescence; heads radiate or discoid; achenes glabrous or hirtellous along the angles. (Sp. 33–80)

33. S. fedifolius Rydb. Bull. Torr. Cl. 27 (1900), p. 183
34. S. Fendleri Greenm. l.c. p. 90
35. S. pauciflorus Pursh, Fl. Am. Sept. 2 (1814), p. 529
36. S. idahoensis Rydb. l.c. p. 173
37. S. debilis Nutt., Trans. Am. Phil. Soc. 7 (1841), p. 408
38. S. hyperborealis Greenm., Monogr. Senecio I. Teil (1901), p. 24
39. S. resedifolius Less. Linnaea 6 (1831), p. 243
40. S. ovinus Greene, Pittonia 4 (1901), p. 110
41. S. conterminus Greenm. l.c., p. 101.
42. S. hesperius Greene, Pittonia 2 (1891), p. 166
43. S. Newcombei Greene, Pittonia 3 (1897), p. 249
44. S. subnudus DC., Prodr. 6 (1837), p. 428
45. S. Rosei Greenm. Monogr. Senec. I. Teil (1901), p. 24
46. S. Porteri Greene, Pittonia 3 (1897), p. 106
47. S. Soldanella A. Gray, Proc. Acad. Nat. Sci. Phil. 15 (1863), p. 67
48. S. obovatus Muehl. ex Willd. Sp. pl. 3 (1804), p. 1999
49. S. Cardamine Greene, Bull. Torr. Bot. Cl. 8 (1881), p. 98
50. S. cyclophyllus Greenm., Field Col. Mus. Bot. Ser. 2 (1907), p. 276
51. S. quebradensis Greenm. l.c. (1916), p. 117.
52. S. Pammelii Greenm. l.c. p. 118
53. S. aureus L., Sp. pl. (1753), p. 870
54. S. Robbinsii Oakes, ex Rusby, Bull. Torr. Cl. 20 (1893), p. 19
55. S. pseudaureus Rydb. Bull. Torr. Cl. 24 (1897), p. 298
56. S. Burkei Greenm. Ottawa Nat. 25 (1911), p. 114
57. S. gaspensis Greenm. l.c. p. 118
58. S. Crawfordii Britt., Torreya 1 (1901), p. 21
59. S. quaerens Greene, Leafl. Bot. Obs. & Crit. 1 (1906), p. 214.
60. S. platylobus Rydb. Bull. Torr. Cl. 27 (1900), p. 181
61. S. crocatus Rydb. Bull. Torr. Cl. 24 (1897), p. 177
62. S. aquariensis Greenm. l.c. p. 144.
63. S. dimorphophyllus Greene, Pittonia 4 (1901), p. 109
64. S. Farrise Greenm. Bot. Gaz. 42 (1906), p. 147
65. S. Hartianus Heller, Bull. Torr. Cl. 26 (1899), p. 622
66. S. plattensis Nutt. Trans. Am. Phil. Soc. N.S. 7 (1841), p. 413
67. S. Willingii Greenm. Ottawa Nat. 25 (1911), p. 117
68. S. Smallii Britt., Mem. Torr. Bot. Cl. 4 (1894), p. 132
69. S. pauperculus Michx. Fl. Bor. Am. 2 (1803), p. 120.
70. S. flavovirens Rydb., Bull. Torr. Cl. 27 (1900), p. 181.
71. S. multnomensis Greenm., Monogr. Senec. I (1901), p. 24
72. S. laetiflorus Greene, Pittonia 3 (1896), p. 88
73. S. Suksdorfii Greenm. Bot. Gaz. 53 (1912), p. 511
74. S. rubricaulis Greene, Pittonia 3 (1896), p. 89.
75. S. cymbalarioides Nutt. Trans. Am. Phil. Soc. N.S. 7 (1841), p. 412
76. S. acutidens Rydb., Bull. Torr. Cl. 27 (1900), p. 180
77. S. tridenticulatus Rydb., l.c. p. 175
78. S. Wardii Greene, Pittonia 4 (1901), p. 116.
79. S. anacletus Greene, Pittonia 4 (1901), p. 307.
80. S. Toluccanus DC. Prodr. 6 (1837), p. 428.

LINACEAE

Linum narbonense L.

Voucher: Provincia de Cuenca: Serrania de Cuenca, 10 km S. of Tragacete; N. 0464.

$2n = 28$.

KIKUCHI (1929) reported $2n = 18$ chromosomes only from Botanical Garden material identified as this western and central Mediterranean species, whereas OCKENDON & WALTERS (1968) list only the number $2n = 30$. However, we do not hesitate to regard both these numbers as wrong, since we could confirm, without the slightest difficulty, the number $2n = 28$ previously reported by RAY (1944) and BARI & GODWARD (1970), though our number seems to be the first one counted on individuals belonging to a distinctly natural population.

EUPHORBIACEAE

Tithymalus helioscopia (L.) Scop.

Voucher: Provincia de Jaén: Sierra de Cazorla, Pantano del Tranco; N. 0168.

$2n = 42$.

This is a confirmation of numerous previous reports for this European taxon.

Tithymalus peplus (L.) Gaertn.

Voucher: Provincia de Jaén: Sierra de Cazorla, roadsides 1 km N. of Cazorla;

N. 0183. $2n = 16$.

This is a confirmation of several earlier reports for this Mediterranean and western Asiatic plant.

~~[illegible]~~

Greenman 1918: - Part II: Ann. Mo. Bot. Gard. 5(1918): 37-103.

Sect. 8. <u>Tomentosi</u> Rydb., Bull. Torrey Cl. 27 (1900), p. 184.

(S. canus Hook. type selected lectotype)

Species 97-130:

Perennial and usually caespitose herbs with erect or ascending stems, densely and permanently white-tomentose throughout, or tomentose in the early stages and more or less glabrate in age; inflorescence a few to many-headed corymbose cyme; heads radiate or discoid; achenes glabrous or hirtellous. (Sp. 97-131)

97. S. arizonicus Greene
98. S. sordidus Greenm.
99. S. neo-mexicanus A. Gray
100. S. oresbius Greenm.
101. S. Hartmanii Greenm.
102. S. bernardinus Greene
103. S. eurypterus Greenm.
104. S. mutabilis Greene
105. S. Fendleri A. Gray
106. S. Muirii Greenm.
107. S. saxosus Klatt
108. S. wernericaefolius A. Gray
109. S. Thurberi A. Gray
110. S. Actinella Greene
111. S. molinarius Greenm.
112. S. gerberaefolius Schultz-Bip.
113. S. Greenei A. Gray
114. S. convallium Greenm.
115. S. Leonardii Rydb.
116. S. tomentosus Michx.
117. S. antennariifolius Britton
118. S. canus Hook.
119. S. Harbourii Rydb.
120. S. Purshianus Nutt.
121. S. Howellii Greene
122. S. oreopolus Greenm.
123. S. Hallii Britton
124. S. candidissimus Greenm.
125. S. bellidifolius H.B.K.
126. S. loratifolius Greenm.
127. S. cynthioides Greene
128. S. fastigiatus Nutt.
129. S. umbraculifer Wats.
130. S. atratus Greene
131. S. sphaerocephalus Greene

Geranium dissectum L.

Voucher: Provincia de Jaén: Sierra de Cazorla, roadsides N. of Cazorla;
N. 0178. 2n = 22.

This is a confirmation of numerous previous reports for this weedy species, which seems to have spread from the Mediterranean region.

Geranium lucidum L.

Voucher: Provincia de Jaén: Sierra de Cazorla, Torre del Vinagre; N. 0268. 2n = 20.

This confirms a previous report by WARBURG (1938) forthis originally Mediterranean species.

Geranium robertianum L.

Voucher: Provincia de Jaén: Sierra de Cazorla, Laguna de Valdeazores; N. 026.
2n = 64.

This confirms numerous earlier reports for this widespread European species.

Geranium purpureum Vill.

Voucher: Provincia de Jaén: Sierra de Cazorla, near El Tranco; N. 0229. ~~2n = 32~~.
Pantano del Tranco; N. 0158. 2n = 321

This is a confirmation of several previous reports for this southern and western European species.

Erodium malacoides (L.) L'Hér.

Vouchers: Provincia de Jaén: Sierra de Cazorla, El Chorro; roadsides 1 km
N. of Cazorla; N. 0134, N. 0180. 2n = 40.

four? - some

This confirms three previous reports of the tetraploid number for this southern European species in its strict sense.