NATIONAL OPEN UNIVERSITY OF NIGERIA

SCHOOL OF SCIENCE AND TECHNOLOGY

COURSE CODE :BIO 404

COURSE TITLE: SYSTEMATIC BIOLOGY

COURSE GUIDE

BIO 404
SYSTEMATIC BIOLOGY

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Introduction

BIO 401: Systematic Biology is a one-semester, 3 credit- hour course in Biology. It is a 400 level, second semester undergraduate course offered to students admitted in the school of science and technology, school of education that are offering Biology or related programmes.

The course guide tells you briefly what the course is all about, what course materials you will be using and how you can work your way through these materials. It gives you some guidance on your Tutor- Marked Assignments.

There is/are Self-Assessment Exercise(s) within the body of a unit and/or at the end of each unit. The exercise(s) is/are an overview of the unit to help you assess yourself at the end of every unit.

What you will learn from this Course

This course contains twenty one (21) units which cover a generalized introduction to biosystematics which is an attempt to produce the system of nomenclature by which more relationship mainly the phyllogenetic relationship could be exclusively rural. However, the term has not been interpreted as it was before. Basically it has been interpreted as application of genetical and cytological criteria, and particular in the description of the basic limit of classification.

Systematic has been in use to mean the branch of biology i.e. concerned with the comparative studies of organisms and all relationships among them. A relationship can be defined as a statement made about two subjects i.e. either true or false. For example a plant may be larger than each other or may not; that a density flower looks exactly like a sun flower is a statement which may be either true or false, establishing a relationship.

Course Aims

The aim of this course is to provide a generalized phyllogenetic relationship or relationship of decent which indicates the degree to which two individuals are related to a common ancestor; relationship of similarities or phenetics relationship, this indicate the degree to which two individuals look alike not only in their external morphology but in all their other facts e.g. anatomy; special geographic relationship which indicate how closely to which two individuals are situated to each other and tropic relationship which indicate interdependent to what extent to which two individual plants depend on each other.

Course Objectives

In addition to the aim of this course, the course sets an overall objective which must be achieved. In addition to the course objectives, each of the units has its own specific objectives. You are advised to read properly the specific objectives for each unit at the beginning of that unit. This will help you to ensure that you achieve the objectives. As you go through each unit, you should from time to time go back to these objectives to ascertain the level at which you have progressed.

By the time you have finished going through this course, you should be able to:

Understand the science of identifying, naming, and classifying all plants. The students should know which plants are related to one another in order to predict their properties.

Working through this Course

In this course, you will be advised to devote your time in reading through the material. You would be required to do all that has been stipulated in the course: study the course units, read the recommended reference textbooks and do all the unit(s) self-assessment exercise(s) and at some points, you are required to submit your assignment (TMAs) for assessment purpose. You should therefore avail yourself of the opportunity of being present during the tutorial sessions so that you would be able to compare knowledge with your colleagues.

Course Materials

You are to be provided with the two major course materials. These are: Course Guide

Study Units

The course comes with a list of recommended textbooks. These textbooks are supplement to the course materials so that you can avail yourself of reading further. Therefore, it is advisable you acquire some of these textbooks and read them to broaden your scope of understanding.

Study Units

This course is divided into 4 modules with a total of nineteen units which are divided as follows:

Module 1:
Unit 1: Introduction to Systematic Biology
Unit 2: Historical Background of Classification I
Unit 3: Historical Background of Classification III
Unit 4: Historical Background of Classification III
Unit 5: Classification I
Unit 6: Classification II

Module 2:

Textbooks and References

I shall like to recommend that you reference the underlisted textbooks as the course progresses:

Bessey, C.E.(1915). Phylogenetic Taxonomy of Flowering Plants, Ann. Mo. Bot. Gard., 2: 109-164.

Core, E.L.(1955). Plant Taxonomy, Prentice-Hall, Englewood Cliffs, N.J., Pp. 9-61. (An excellent history of plant taxonomy).

Gardner, E.J. (1972). History of Biology, 3ed., Burgess, Mineapolis.

Hutchinson, J.(1969). Evolution and Phylogeny of Flowering plants, Academic Press, London, 400pp.

Samuel, B.J. and Arlene, B.L. (1986). Plant Systematics. McGraw-Hill, Inc, San- Francisco. 512pp.

Assessment

There are two components of the assessment for this course:

The Self-Assessment Questions (SAQs) or Exercise
The Tutor-Marked Assignment (TMAs)
The End of Course Examination

Self Assessment Questions (SAQ)

The exercise within each unit is/are meant to probe your understanding of the concept in the unit. It is non-grading and as such does not add up to top the grade in the course.

Tutor-Marked Assignment (TMA)

The TMA is the continuous assessment component of your course. It accounts for 30 percent of the total score you will obtain in this course.

Final Examination and Grading

The course is to be concluded by this examination. The final examination constitutes 70 percent of the whole course. You will be adequately informed of the time of the examination. The examination will consist of questions which reflect all the basic concepts you would have learnt through the duration of the course.

Summary

This intends for you to have an underlying knowledge of the similarities and differences in the external features, ecological adaptations of plants and animals. By the time you complete this course, you will be able to answer conveniently questions that borders on the:

- Phases of Plant systematics
- Plant Nomenclature
- Principles of Plant Taxonomy
- Sources of Taxonomic Evidence
- Specimen Preparation and Herbarium Management.

I wish you success in this course.

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MODULE 1

Unit 1: Introduction to Systematic Biology

CONTENTS

1.0. Introduction

The term 'Biosystematics' was first introduced by Camp & Gilly in 1943. Since then the word 'Biosystematics' has been embraced and used extensively to mean essentially the same thing or definition from several approaches. Before then the term 'Systematic' has been in use to mean the branch of biology i.e. concerned with the comparative studies of organisms and all relationships among them. A relationship can be defined as a statement made about two subjects i.e. either true or false. For example a plant may be larger than each other or may not; that a density flower looks exactly like a sun flower is a statement which may be either true or false, establishing a relationship, in such relationship there are four main types of relationship between plants:

1. Phyllogenetic relationship or relationship of decent which indicates the degree to which two individuals are related to a common ancestor.
2. Relationship of similarities or phenetics relationship, this indicate the degree to which two individuals look alike not only in their external morphology but in all their other facts e.g. anatomy.
3. Special geographic relationship which indicate how closely to which two individuals are situated to each other.

4. Tropic relationship which indicate interdependent to what extent to which two individual plants depend on each other.

Although systematic deals with all four of this relationship. Phyllogentic and phenetics relationships are more emphasized.

The summary of the systematic approach to establishing a relationship between two plants is what is called Biosystematics which 'commit the natural biotic unit (meaning units of revolution) and to apply to this unit a system of nomenclature adequate to the task of conveying precise information, receiving their defined units, relationships, variability and dynamic structure. By this definition of Camp and Gilly, Biosystematics was an attempt to produce the system of nomenclature by which more relationship mainly the phyllogenetic relationship could be exclusively rural. However, the term has not been interpreted as it was before. Basically it has been interpreted as application of genetical and cytological criteria, and particular in the description of the basic limit of classification.

Comparism to description and classification are the operations that are to be performed in biosystematics study. Biosystematics is offshoot of the general plant taxonomy. It is sometimes referred to as experimental taxonomy in contract to the old orthodox/classical taxonomy.

2.0. Objective: At the end of the class students must be familiar with the definition of systematics as the science of identifying, naming, and classifying all plants. The objectives and the need to classify plants.

3.0. Main content

3.1. What is Biosystematy?

Strictly speaking, biosystematics is an aspect of modern day taxonomy rather than a new and different phenomenon in systematics. Biosystematics is the basis of the recent Experimental taxonomy, As opposed to the traditional Classical taxonomy. These two of classificatory methods differ in many respects but have the same goal to identify a biological species.

Classical taxonomy	Exp. Taxonomy (biosystematics)
Aims…. .to describe all existing kinds of plants, to describe them according to their resemblances and differences and to name them according to a body of internationally agreed rules.	….mainly to identify evolutionary units and by experiment to determine their genetic inter-relationships and the role of the environment in their formation.

3.2. What are the Problems and challenges of Biosystematics?

Some problems and challenges- the scientific and vigorous studies of the diversity of living organism has barely began apart from the great magnitude of the task it has, there are several challenges problems that biosystematics offers.

A very important area that needs to be investigated is the genetics structure of population, how diverse systematically is population?

To what extent does the breeding system of the genetics structure of the population? How much heterotogenity is there in the population i.e. different genes or all its. Until recently, there was no practical ways to estimate gene frequencies in population, the new method of gellesprophoresis proteins and enzymes permits biosystematics to obtain estimate or certain genes in the population in a more or less efficient way. Furthermore the electronic computer allows the elaboration of complex mathematical models now a combination of the two species should yield genetic data on the genetic structure or the population.

Another challenging data has to do with a level of organization giving that natural selection acts on phenotypes. How cellular characters are selected which are responsible for the phenotypes selected giving that there are physical chemical restraints imposed on the chemical reaction in the cell. How do they in turn e.g. the numbers of theoretically possible protein is astronomical. However, only very limited number of these proteins is round in living organism, why is this so? Are there some special properties associated with this protein or is it matter or chance.

Another interesting question relate to the diversity of the living organism itself. Why are some plants annuals and others perennials? Why are some inbreeders, others outbreeders and still others apomictics (non-sexual kind of reproduction).
(Self-pollination Cross-pollination) Amphimictics i.e. forms
(In-breeders x Out-breeders) of reproduction in plants.

What forces mold the evolution or this plants and how? The study of the diversity of living organism present a great challenge and it's not only an intellectually fascinating challenge but a very practical one too. Man has so far paid little attention to its environment and the way he has been modifying it polluted air, water and sterile soil over the ever increasing surface of the earth are, clear signs that such a situation cannot continue. To proceed intelligently, we must first know what forces have shaped the environment we called natural environment; here is where the knowledge of the biosystematics is needed.

4.0 Conclusion

Biosystematics have been seen as an attempt to produce the system of nomenclature by which more relationship mainly the phyllogenetic relationship could be exclusively rural. However, the term has not been interpreted as it was before. Basically it has been interpreted as application of genetical and cytological criteria, and particular in the description of the basic limit of classification.

5.0 Summary

The summary of the systematic approach to establishing a relationship between two plants is what is called Biosystematics which ‘commit the natural biotic unit (meaning units of revolution) and to apply to this unit a system of nomenclature adequate to the task of conveying precise information, receiving their defined units, relationships, variability and dynamic structure.

6.0 Tutor Marked Assignment (TMA)

a. Define Systematics Botany.

b. What are Problems and challenges of Biosystematics?

c. What are the objectives of Taxonomy?

7.0 References/Further reading

Core, E.L.(1955). *Plant Taxonomy*, Prentice-Hall, Englewood Cliffs, N.J., Pp. 9-61. (An excellent history of plant taxonomy).

Hutchinson, J.(1969). *Evolution and Phylogeny of Flowering plants*, Academic Press, London, 400pp.

Bessey, C.E.(1915). Phylogenetic Taxonomy of Flowering Plants, Ann. Mo. Bot. Gard., 2: 109-164.

Gardner, E.J. (1972). History of Biology, 3ed., Burgess, Mineapolis.

Samuel, B.J. and Arlene, B.L. (1986). Plant Systematics. McGraw-Hill, Inc, San-Francisco. 512pp.

Unit 2: Historical Background of Classification I

CONTENTS

a. Mention different classifications since Preliterate Humans to Herbalists.

b. Discuss classification according to Albert Magnus.

7.0 References/Further reading

1.0 Introduction

The discoveries of the use of plants for food and later as medicine began at a very early stage in human civilization. Prehistoric people knew and used nearly all the important crop plants that we cultivate today. Food gatherers modified wild species by selecting plants with such features as tastiness in vegetables or higher yield in grains. Contemporary studies indicate that primitive people (ethnic groups) in remote areas today recognize and have precise names for large numbers of plants in their local environment. Some of these people regularly use plants as fish or arrow poisons, others for drugs to treat wounds or sickness, and still others for narcotic or hallucination. Classification by preliterate people is at least partly based on the useful and harmful properties of plants. These groupings often parallel current classification concepts and have been referred to as folk taxonomies i.e., classifications that developed within the society through the need of the society and without scientific efforts. Present day indigenous people can recognize (have names for) thousands of plants that are used for food and medicine.

Preliterate humans actually used all four of the below processes:

• Describe a plant so that others could recognize it.
• Classify it as useful, harmful, etc.
• Identify other individual plants as belonging to this category.
• Giving the category a name so that it could be easily referred to.

It is clear that the evolution of taxonomy as a discipline has four phases.

1. The pioneer or exploratory phase.
2. The consolidation phase.
3. The biosystematic phase.
4. The encyclopaedic phase.

2.0 Objective: At the end of the class, students must have fully understood brief history of
Plant systematics and the students should be familiar with the various classifications.

3.0. Main content

Historical Background of Classification

3.5 Beginning by Preliterate Humans

The beginning of relationship between humans and plants can be traced back to the prehistoric times. The Indus Valley people used to live in villages, cities and towns, wore clothes, cultivated crops including wheat, barley, millet, dates, vegetables, melon and other fruits and cotton; worshipped trees, glazed their pottery with the juice of plants and painted them with a large number of plant designs. They also knew the commercial value of plants and plant products. There are sufficient indications to show that Agriculture, Medicine, Horticulture, developed to a great extent during the Vedic Period.

3.6 Early Western Civilizations

3.2.1. Theophrastus

The student of Plato and Aristotle, later became chief of the Lyceum (Gardens and library) in Athens, named ca. 480 species. His famous works are Enquiry into Plants and The

Causes of Plants. Classified plants by form into trees, shrubs, undershrubs and herbs. He also recognized annuals, biennials, perennials, superior and inferior ovaries, free and sympetalous corollas. He is often called the "Father of Botany".

3.2.2. Pedanius Dioscorides (1st century A.D.): A Greek physician in Roman Army. His most famous work was Materia Medica which described the medicinal qualities of 600 kinds of plants. Many members of currently recognized families were classified together such as mints and umbels. This work was used in various translations and editions for next 1,000 years! A person who had a copy of this book would be guaranteed success and fortune (if he or she could read!). Around 500 A.D., a Byzantine emperor in Constantinople (Istanbul) had an illustrated copy made for this daughter, Princess Juliana. It survived the test of times as 'Codex Juliana.'

3.7 Middle Ages

3.3.1. Islamic Botany

From around A.D. 610 to about 1100, some classical botanical works were preserved by the moslem society because the Islamic scholars had a great admiration for Aristotle and other Greeks scholars. Since their scientific interests were of a practical nature, pharmacy and medicine of the Islamic people were highly developed. Islamic botanists produced practical lists of drug plants but developed no original schemes of classification.

3.3.2. Albertus Magnus, "Doctor Universalis" (c. 1193-1280)

He wrote on aspects of natural history and medicine during the Middle Ages. His botanical work *De vegetabilis* not only dealt with medicinal plants, as had the previous works by the Greeks and Romans, but it also provided descriptions of plants. These excellent descriptions were based on firsthand observations of the plants. He attempted a classification of plants and is believed to have been the first to recognize, on the basis of stem structure, the differences between monocots and dicots. After Albertus Magnus more people looked at the living plants in nature, and more significantly, they began to write and to print books about them.

3.8 Herbalists

3.8.1 Otto Brunfels (1464-1534), Herbarium vivae eicones – excellent illustrations.

3.8.2 Jerome Bock (1469-1554) Neu Kretuerbuck – excellent descriptions.

3.8.3 Leonhart Fuchs (1501-1566) De historia stirpium – illustrations and descriptions.

3.8.4 Casper Bauhin (1560-1631) Pinax theatri botanici – 6000 plants, synonymy, binomial nomenclature.

4.0 Conclusion

Between fall of Roman Empire and the Renaissance, there was little scientific progress. The Ancients were thought to have possessed all knowledge, and their works were copied repeatedly. Albertus Magnus (d. 1280) in his De Vegetabilis recognized monocots and dicots, vascular and nonvascular plants.

Herbalists (15th through 17th century) are the people sought originality, looked at plants, not just accepted and copied what the ancients said. In this period the moveable type of print made books more widely available. Explorations brought new, unknown plants to Europe to be described. Need for medical information. The last herbal had 6000 plants registered known until then, used binomial names, had some idea of genera, etc.

5.0 Summary

6.0 Tutor Marked Assignment (TMA)

a. Mention different classifications since Preliterate Humans to Herbalists.

b. Discuss classification according to Albert Magnus.

7.0 References/Further reading

Core, E.L.(1955). Plant Taxonomy, Prentice-Hall, Englewood Cliffs, N.J., Pp. 9-61. (An excellent history of plant taxonomy).

Hutchinson, J.(1969). Evolution and Phylogeny of Flowering plants, Academic Press, London, 400pp.

Bessey, C.E.(1915). Phylogenetic Taxonomy of Flowering Plants, Ann. Mo. Bot. Gard., 2: 109-164.

Gardner, E.J. (1972). History of Biology, 3ed., Burgess, Mineapolis.

Samuel, B.J. and Arlene, B.L. (1986). Plant Systematics. McGraw-Hill, Inc, San-Francisco. 512pp.

Unit 3: Historical Background of Classification III

CONTENTS

4.0 Conclusion
5.0 Summary
6.0 Tutor Marked Assignment (TMA)
a. Explain in detailed classification according to Carl Linnaeus.
b. Discuss classification according to Luca Ghini.
7.0 References/Further reading

1.0 Introduction: The aggressive exploration of the New World in the 1600s was responsible for the discovery of many new plants. In Europe the herbalists studied these plants and added them to their herbals. Because of the large number of new species, botanists needed to develop a more precise system for naming and arranging plants.

For example in 1952, Fuchs was concerned with 500 species, Bauhin in 1623 with 6,000 and Ray listed 18,000 species in 1682. Coping with such an avalanche of plants required discrimination of species and clearly demonstrated a need to recognize and describe genera.

Linnaeus is another renowned botanist of the eighteenth century. He sometimes called the "father of taxonomy." Today Linnaeus is best remembered for his consistent use of a referable system of nomenclature, that is, the binomial system of nomenclature.

Linnaeus was hailed by many of his contemporaries as starting a new epoch in botany. His three best-known works are the following: *Systema naturae*, 1753, et seq., presenting his system of classification in outline form; *Genera plantarum*, 1737, providing descriptions of many genera; and Species plantarum, 1753, a two-volume catalog used for plant identification.

2.0 Objective: At the end of the class, students must have fully understood brief history of

Plant systematics and the students should be familiar with the various classifications.

3.0 Main content

3.1 PRE-LINNAEAN PERIOD

3.1.1 Andrea Caesalpino (1519-1580): His most famous work is De plantis libri, names 1500 plants. He is considered as "The first plant taxonomist." Classification used the Aristotelian approach, based upon habit (trees, shrubs, herbs), but used also a whole series of floral, fruit, and seed characters. Recognized what today we know as the mustard, aster, carot, and herbaceous and woody legume families. He used two systems at once, intuitive grouping and logical division.

3.1.2 Joseph P. de Tournefort (1656-1708): His most famous work is Institutiones rei herbariae. He was first of the important French botanists. His artificial system included for 9,000 species arranged in 700 genera. He was first to have a real ‘concept of genera’.

3.1.3 John Ray (1628 - 1705): A British botanist, his most famous works are Methodus plantarum nova (1682) and Historia plantarum (1696-1704). Plants that looked alike were grouped together (natural system), the system used many different characters and split natural groups and lumped together unnatural ones. He believed in "essential" characters. The last edition of his Methodus treated 18,000 species.

3.1.4 Hendrik Adriaan Van Rheede tot Draakenstein (1636-1691): He is known as Van Reede. He was a Dutch traveller and naturalist. He worked for the Dutch East India Company to write the Hortus Indicus Malabaricus, usually referred as Hortus Malabaricus, running into 12 volumes (1595 pages of double folio size) and containing illustrations and descriptions of 742 plants. The complete original title of the work is Hortus Malabaricus, continens Regni Malabarici apud Indos celeberrimi omnis generis Plantas rariores. The original work, which deals with the traditional knowledge of the people of Malabar on useful plants, as well as their immense biological value today, undertaken when Van Rheede was the Dutch Governor of Cochin. He mentioned in these volumes are plants of the Malabar region which in his time referred to the stretch along the Western Ghats from Goa to Kanyakumari. The ethno-medical information presented in the work was extracted from palm leaf manuscripts by a famous practitioner of herbal medicine named Itty Achuden. The work took 30 years to compile and was edited by a team of nearly two hundred including physicians, professors of medicine and botany, amateur botanists (such as Arnold Seyn, Theodore Janson of Almeloveen, Paul Herman, Johannes Munnicks, Joannes Commelinus, Abraham a Poot), Indian scholars and vaidyas (physicians) of Malabar and adjacent regions, and technicians, illustrators and engravers, together with the collaboration of company officials, clergymen (D. John Caesarius and Father Mathew of St. Joseph). He was also assisted by the King of Cochin and the ruling Zamorin of Calicut. The descriptions of plants comprising their habit, foliage, flowers, fruits, colour, smell, taste and practical value appear under their Malayalam names. The plates bearing illustrations have been inscribed in Roman, Malayalam and Arabic scripts. Konkani names are given in Devanagari script. His work was made use of by Carolus Linnaeus for naming the plants.

3.2 THE LINNAEAN PERIOD

By middle of 18th century, many developments made science of botany ready for a person to synthesize information. People needed an easy, rapid way to identify and name plants. Advances in navigation, early microscopes, widespread use of herbarium specimens, widely available printed books, groundwork of herbalists, Bauhin, Ray, deTournefort mark the period.

Carl von Linné or Carolus Linnaeus: Son of a Swedish parson, born in Råshult, Sweden on May 22, 1707, became the renowned botanist of the 18th century. He is sometimes called the "Father of taxonomy". Today, Linnaeus is best remembered for his consistent use of a referable system of nomenclature, i.e. the binomial system of nomenclature. Linnaeus entered the University of Lund in 1727 to study medicine. Dissatisfied with Lund, he moved to the University of Uppsala in 1727, where he came under the influence of the Dean, Olaf Celsius, who introduced him to Rudbeck, a professor of botany. On an expedition to Lapland in 1732, Linnaeus greatly increased his knowledge of natural history. In 1735, Linnaeus went to the Netherlands and quickly finished his medical degree at the University of Harderwijk. While in the Netherlands, he became the personal physician to the wealthy banker, George Clifford, who had extensive botanical and horticultural interests. Clifford became the patron of Linnaeus. The three years spent in Netherlands and traveling in Europe were important and creative years in Linnaeus' life. Before returning to Sweden in 1738, he published several books on natural history. He was also able to meet many of the prominent naturalists of the time, including John Frederik Gronovius and Hermann Boerhaave from the Netherlands, Professor J. J. Dillen and Sir Hans Sloane in England, and the de Jussieu brothers in France. After establishing medical practice on his return to Sweden, he became professor of medicine and botany at the University of Uppsala in 1741, a position he held until his death in 1778. His three best-known works are Systema naturae (1735), presenting his system of classification in outline; Genera plantarum (1737), providing descriptions of many genera; and Species plantarum (1753), a two-volume catalog used for plant identification. He named 12,000 species (7.700 plants, 4,300 animals) and 1,105 genera.

Linnaeus was hailed by many of his contemporaries as starting a new epoch in botany. We now view his work as the culmination of an attempt to create a workable system of identifying and classifying plants. Even though his system was useful for identifying plants, natural relationships were not stressed and unlike plants were often grouped together. Linnaeus divided plants into 24 classes based in large part on the number, union, and length of stamens. Plants with one stamen were placed in class Monandria, with two stamens in class Diandria, and then Triandria, Tetrandria, Pentandria, and so on. Classes were divided into orders based on the number of styles in each flower. The strength of Linnaeus's artificial "sexual system" is its simplicity, since botanists could easily use it to apply names to plants. In Species plantarum, each plant had a generic name, a polynomial descriptive phrase intended to serve as a definition of the species analogous to our dichotomous keys, and a trivial name (i.e. specific epithet) printed in the margin, i.e. binomial system of naming.

Linnaeus is most known today for the following reasons:

(i) He popularized a system of nomenclature now called the Binomial System. Actually, polynomials were used in his original work, but a "shorthand" way of referring to the plant simply truncated the long description to two names (generic name and specific epithet),

(ii) His works included brief diagnoses (short descriptions) of the plants,

(iii) He standardized the synonomy (duplicate names) of many plants, and

(iv) He developed a number of technical terms used in plant morphology.

4.0 Conclusion

By middle of 18th century, many developments made science of botany ready for a person to synthesize information. People needed an easy, rapid way to identify and name plants. Advances in navigation, early microscopes, widespread use of herbarium specimens, widely available printed books, groundwork of herbalists, Bauhin, Ray, deTournefort mark the period.

Linnaeus divided plants into 24 classes based in large part on the number, union, and length of stamens. Plants with one stamen were placed in class Monandria, with two stamens in class Diandria, and then Triandria, Tetrandria, Pentandria, and so on. Classes were divided into orders based on the number of styles in each flower. The strength of Linnaeus's artificial "sexual system" is its simplicity, since botanists could easily use it to apply names to plants. In Species plantarum, each plant had a generic name, a polynomial descriptive phrase intended to serve as a definition of the species analogous to our dichotomous keys, and a trivial name (i.e. specific epithet) printed in the margin, i.e. binomial system of naming.

5.0 Summary

Linnaeus work is the culmination of an attempt to create a workable system of identifying and classifying plants. Even though his system was useful for identifying plants, natural relationships were not stressed and unlike plants were often grouped together. Linnaeus divided plants into 24 classes based in large part on the number, union, and length of stamens. Plants with one stamen were placed in class Monandria, with two stamens in class Diandria, and then Triandria, Tetrandria, Pentandria, and so on. Classes were divided into orders based on the number of styles in each flower. The strength of Linnaeus's artificial "sexual system" is its simplicity, since botanists could easily use it to apply names to plants. In Species plantarum, each plant had a generic name, a polynomial descriptive phrase intended to serve as a definition of the species analogous to our dichotomous keys, and a trivial name (i.e. specific epithet) printed in the margin, i.e. binomial system of naming.

6.0 Tutor Marked Assignment (TMA)

a. Explain in detailed classification according to Carl Linnaeus.

b. Discuss classification according to Andrea Caesalpino.

7.0 References/Further reading

Core, E.L.(1955). Plant Taxonomy, Prentice-Hall, Englewood Cliffs, N.J., Pp. 9-61. (An excellent history of plant taxonomy).

Hutchinson, J.(1969). Evolution and Phylogeny of Flowering plants, Academic Press, London, 400pp.

Bessey, C.E.(1915). Phylogenetic Taxonomy of Flowering Plants, Ann. Mo. Bot. Gard., 2: 109-164.
Gardner, E.J. (1972). History of Biology, 3ed., Burgess, Mineapolis.
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Unit 4: Historical Background of Classification III

CONTENTS

1.0 Introduction

The French never really adopted the system of Linnaeus because they had a different experience in the botanical gardens of Paris (Jardin de Botanique de Paris). They developed the first natural system of classification to mention some leading botanists of that time.

2.0 Objective: At the end of the class, students must have fully understood brief history of Plant systematics and the students should be familiar with the various classifications.

3.0. Main content

3.1 Post-Linnaean Period

3.1.1 Michel Adanson (1727-1806): His experience in tropical Africa forced him to develop ways to logically deal with large numbers of characters. He advocated the use of as many characters as possible and on par. So, he is called ‘Father of Numerical Taxonomy’. In his work, Familles des plantes (1763) described 58 families (in the sense of John Ray).

3.1.2 Antoine L. de Jussieu (1748-1836): Genera Plantarum was his famous contribution. Jardin des Plantes (in Paris), the garden had similar plants arranged in the same beds (the plants which ‘looked alike’ unlike in the artificial system of Linnaeus) led to a Natural classification system, based on common sense. Many of the families recognized then are still recognized today. Botanists of time readily accepted this system (over that of Linnaeus).

3.1.3 William Roxburgh (1751-1815): Referred as the 'Father of Indian Botany. He was born in Ayrshire, Eastern Scotland, on June 29, 1751. He studied medicine at Edinburgh University where he was initiated in the rudiments of botany and Linnaean taxonomy by famous British botanist Professor John Hope (1725-1786). He entered the service of the East India Company as a surgeon's mate on the Company's ships. In 1776, he was appointed assistant surgeon in the Madras General Hospital. There, he was influenced by Johan Gerhard Koenig (1728-1785), famous student of Linnaeus. Promoted to full surgeon in 1780, took up a position in Madras and turned his attention to botany. The East India Company recognized his botanical knowledge and made him the Superintendent in the Samalkot garden at Garrison station in the Northern Circars in 1781. Here he made experiments on economic botany and employed native artists to illustrate plants. He had 700 illustrations by 1790. At Samalkot, in established experimental gardens where he grew coffee, pepper, cinnamon, indigo, and breadfruit, and experimented with Opuntia, the host plant of the cochineal insect. In 1790 he had been made MD by the University of Aberdeen and Fellow of the Royal College of Physicians, Edinburgh.1844-1930)

3.2 Intentional Phylogenetic Systems

3.2.1 Charles E. Bassey (1845-1915)

Student of Asa Gray, went to Iowa State and then Nebraska. He developed a set of "dicta" (rules) stating which characters are primitive and which are advanced in flowering plants. The Magnolia type flower was considered primitive, not the unisexual catkin-bearing plants. The paper (1815) “The phylogenetic taxonomy of flowering plants” outlines his work and depicts the relationships of Angiosperms in a cactus diagram, known as Bessey’s CACTUS.

3.2.2 John Hutchinson (1884-1972)

He worked at Kew Gardens. Considered woody and herbaceous habits to be fundamentally different evolutionary trends, published the works the Families of Flowering Plants (1973 3rd edn.) and Genera of Flowering Plants (1964-1967).

3.2.3 Arthur Cronquist (1919 to 1991): He worked most of his life at the New York Botanical Garden. Many of his ideas are Besseyan, with some influence from Takhtajan. His most famous work is “An Integrated System of Classification of Flowering Plants (1981)” which was revised in 1988.

4.0 Conclusion

The French never really adopted the system of Linnaeus because they had a different experience in the botanical gardens of Paris (Jardin de Botanique de Paris). They developed the first natural system of classification which were developed by the leading botanists of that time.

5.0 Summary

6.0 Tutor Marked Assignment (TMA)

a. Mention the 3 taxonomists involved in Post Linnaean Period.

b. Mention the Taxonomists involved in Intentional Phylogenetic Systems

7.0 References/Further reading

Core, E.L.(1955). Plant Taxonomy, Prentice-Hall, Englewood Cliffs, N.J., Pp. 9-61. (An excellent history of plant taxonomy).

Hutchinson, J.(1969). Evolution and Phylogeny of Flowering plants, Academic Press, London, 400pp.

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Unit 5: Classification I

CONTENTS

1.0. Introduction

Strictly speaking, biosystematics is an aspect of modern day taxonomy rather than a new and different phenomenon in systematics. Biosystematics is the basis of the recent experimental taxonomy, as opposed to the traditional classical taxonomy. These two types of classificatory methods differ in many respects but have the same goal to identify a biological species.

2.0. Objective: At the end of the class students must be familiar with the definition of systematics as the science of identifying, naming, and classifying all plants. The objectives and the need to classify plants.

3.0. Main content

3.1. Classical Taxonomy

Unit of study in individual or small numbers of individual, which are usually dead preserved specimens.

3.3 Experimental Taxonomy

The unit in non-sexual organisms, the biotype constitutes the unit of study. In sexual organisms, the breeding populations or large representative sample of it form the unit of study.

3.3 Materials

In Classical taxonomy- dead/Herbarium materials while in experimental taxonomy. Materials are living entities.

4.0 Conclusion

Classical Taxonomy is the unit of study in individual or small numbers of individual, which are usually dead preserved specimens while experimental taxonomy is the unit in non-sexual organisms, the biotype constitutes the unit of study. In sexual organisms, the breeding populations or large representative sample of it form the unit of study.In

Classical taxonomy- dead/Herbarium materials while in experimental taxonomy- materials are living entities.

5.0 Summary

Classical Taxonomy is the unit of study in individual or small numbers of individual, which are usually dead preserved specimens while experimental Taxonomy is the unit in non-sexual organisms, the biotype constitutes the unit of study. In sexual organisms, the breeding populations or large representative sample of it form the unit of study.

6.0 Tutor Marked Assignment (TMA)

a. What is Classical Taxonomy?

b. Differentiate between Classical and Experimental Taxonomy.

7.0 References/Further reading

Core, E.L.(1955). Plant Taxonomy, Prentice-Hall, Englewood Cliffs, N.J., Pp. 9-61. (An excellent history of plant taxonomy).

Hutchinson, J.(1969). Evolution and Phylogeny of Flowering plants, Academic Press, London, 400pp.

Bessey, C.E.(1915). Phylogenetic Taxonomy of Flowering Plants, Ann. Mo. Bot. Gard., 2: 109-164.

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Unit 6: Classification II

CONTENTS

1.0 Introduction

In classical taxonomy, the basic unit is the species which is accepted as having objective reality and this has been so because of dogma on special creation and later through the interpretation of evolution as simply another word for the origin of species while in experimental taxonomy, classification as such is not the primary aim. Where classifications are produced they are intended mainly to be sent in a systematic fashion data which have been obtained about natural populations. The basic units adopted are basic units include ecotypes, topotypes and convivia.

2.0 Objective: At the end of the class, students must have fully understood brief history of Plant systematics and the students should be familiar with the various classifications.

3.0. Main content

3.1 System of Classification

In classical taxonomy, the basic unit is the species which is accepted as having objective reality and this has been so because of dogma on special creation and later through the interpretation of evolution as simply another word for the origin of species. For the taxonomy structure a hierarchy of categories is adopted and this will embrace the whole of the plant kingdom. All the entities will be named according to internationally agreed rules.

In experimental taxonomy, classification as such is not the primary aim. Where classifications are produced they are intended mainly to be sent in a systematic fashion data which have been obtained about natural populations. The basic units adopted are basic units include ecotypes, topotypes and convivia. No general system is adopted for the taxonomy structure but in some groups minor hierarchies have been constructed to reflect the general relationships between populations. None of these hierarchies extend upward beyond the level at which genetical experimentation becomes impossible.

3.4 Source of Data

In classical taxonomy, the source of data is inherent in the plants and it can be determined from dead plant materials e.g. the external morphology and anatomy. A field data can be gathered from the living material e.g. flowering time, flood parts persistency or deciduousness. One character that is non-inherent is the geographical distribution.

In biosystematics, the source of data is also inherent in the plants. It may be obtained from dead materials e.g. morphology and anatomy. Data can also be obtained from living materials and this data would include observations of complete life cycles, study of physiological behaviour, morphological adaptations in different habitant and genetical test of inter-fertility, cytological studies aimed at establishing breeding systems. Non-inherent data include geographical distribution and ecology.

3.5 Test of Characters

In classical taxonomy, the test of characters are based on accumulated experience i.e. intuition. It is also based on trial and error.

In experimental taxonomy, test of characters include observational techniques using statistical methods, experimental techniques using transplanting to test phenotypic variability and controlled crossing to determine modes of inheritance.

4.0 Conclusion

5.0 Summary

6.0 Tutor Marked Assignment (TMA)

a.What are the sources of data in classification?

b. What is the test of characters in experimental taxonomy?

7.0 References/Further reading

Bessey, C.E.(1915). Phylogenetic Taxonomy of Flowering Plants, Ann. Mo. Bot. Gard., 2: 109-164.

Core, E.L.(1955). Plant Taxonomy, Prentice-Hall, Englewood Cliffs, N.J., Pp. 9-61. (An excellent history of plant taxonomy).

Gardner, E.J. (1972). History of Biology, 3ed., Burgess, Mineapolis.

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MODULE 2

Unit 1: Classification III

CONTENTS

1.0 Introduction

In classical taxonomy, description is based upon individuals and the type concept. The giving of names is accepted as an important process while in experimental taxonomy, description is based upon populations or population samples using statistical methods. Nomenclatural matters are considered of little importance.

In natural variation, classical taxonomy is essentially static. It assumes continuity or form within species except for a small amount of variation between individuals. The adaptive significance of difference between plants is not taken into account while in experimental taxonomy, the concept of natural variation is essentially dynamic. Full weight is given to the importance of the genetical system i.e. breeding behaviour that is operating in the gap under study. There is no rigid species concept.

2.0 Objective: At the end of the class, students must have fully understood brief history of

Plant systematics and the students should be familiar with the various classifications.

3.0. Main content

3.1 Method of Description

In classical taxonomy, description is based upon individuals and the type concept. The giving of names is accepted as an important process.

In experimental taxonomy, description is based upon populations or population samples using statistical methods. Nomenclatural matters are considered of little importance.

3.2 Concept of Natural Variation involved

In classical taxonomy, this concept is essentially static. It assumes continuity or form within species except for a small amount of variation between individuals. The adaptive significance of difference between plants is not taken into account. The taxonomic hierarchy is accepted as suitable form of representation of natural variation, and its application in the internationally agreed form is regarded as obligatory in all groups. Higher units than species are based exclusively upon the grace of morphological resemblance or the similarity. In experimental taxonomy, the concept of natural variation is essentially dynamic. Full weight is given to the importance of the genetical system i.e. breeding behaviour that is operating in the gap under study. There is no rigid species concept. The internal variability of sexual populations is recognized and the adaptive nature of the population is acknowledged. Classification is based upon evolutionary units where these can be recognized and is not committed to a set of formal categories. No general classification of plants in the kingdom is attempted.

In general, much of what is included under the title of Biosystematics is simply part of the modern approach to taxonomy and represents an extended knowledge of taxa. The term biosystematics is in fact, largely superfluous and serves mainly to describe one of the stages through which taxonomy passes. The non-classificatory aspects of Biosystematics are concerned with the evolutionary and genetic nature of population might be better termed evolutionary dynamics, and considered as a complementary approach to the general taxonomic study of plants.

3.3 Phases of development in Plant Taxonomy

3.3.1 Pioneer phase: This was the time of the discovery classification, naming and identification of plants.

3.3.2 Consolidation phase: The period of synthesis based mostly on gross morphology of field and herbarium knowledge in the preparation of floras (an amount of plants in a particular area), manuals and monographs.

3.3.3 Experimental or biosystematics phase: Concerned with the analysis of breeding system, variation pattern and evolutionary potentials. Pertinent work was also core in the chemical, numerical, cytological, anatomical and embryological and also palynological aspects of botany.

3.3.4 Encyclopedic or Holotaxonomic Phase: This has to do with the analysis and synthesis of various pieces of information and type of data in the development of one or more systems of classification which is based on evolutionary or phylogenetic relationship.

4.0 Conclusion

Methods of description were differentiated between classical and experimental taxonomy. Concept of variation involved was also differentiated between classical and experimental taxonomy. The four phases of development in plant taxonomy were also mentioned.

5.0 Summary

In general, much of what is included under the title of Biosystematics is simply part of the modern approach to taxonomy and represents an extended knowledge of taxa. The term biosystematics is in fact, largely superfluous and serves mainly to describe one of the stages through which taxonomy passes. The non-classificatory aspects of Biosystematics are concerned with the evolutionary and genetic nature of population might be better termed evolutionary dynamics, and considered as a complementary approach to the general taxonomic study of plants.

6.0 Tutor Marked Assignment (TMA)

a. What are the Phases of Development in Plant Taxonomy?

b. What is Consolidation Phase?

7.0 References/Further reading

Core, E.L.(1955). Plant Taxonomy, Prentice-Hall, Englewood Cliffs, N.J., Pp. 9-61. (An excellent history of plant taxonomy).

Hutchinson, J.(1969). Evolution and Phylogeny of Flowering plants, Academic Press, London, 400pp.

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Unit 2: Population Concept

CONTENTS

1.0 Introduction

Populations are defined in different ways for different purposes but that they are groups of individuals is common to all the definitions. In population genetics, the importance of cohabitation of the particular group of individual is that they can (in sexual organism, amphimicts) exchange genes. A near perfect biosystematics definition of population is that define population as the totality of group of organisms occupying a particular identified area at a particular time and capable of reproducing one another.

2.0 Objective: At the end of the class, students must have fully understood brief history of Plant systematics and the students should be familiar with the various classifications.

3.0. Main content

3.1 Definition

Populations are defined in different ways for different purposes but that they are groups of individuals is common to all the definitions. In population genetics, the importance of cohabitation of the particular group of individual is that they can (in sexual organism, amphimicts) exchange genes.

In Population concept, morpho-geographical taxonomy, although indispensable for evolutionary and genetical studies is the prime source of information and as a reference system, which is no longer adequate for many such investigations into the nature of variation, the operation of natural selection and evolutionary processes.

3.2 The Concept: Need for Biosystematics Approach

Morpho-geographical taxonomy, although indispensable for evolutionary and genetical studies as a prime source of information and as a reference system, is no longer adequate for many such investigations into the nature of variation, the operation of natural selection and evolutionary processes.

The study of evolutionary relationships necessitates the study not only of the morphology as expressed by the phenotypes but also the hereditary basis of the morphological characters, the genotype.

The plasticity of the phenotype and nature or its genetic control under the different environmental conditions, the pattern shown within population, and the role of the reproductive system in affecting the type of variation pattern are also of great importance (Davies and Heywood, l963).

Heslop-Harrison (1952) goes further to suggest that the failure of taxonomist to define populations rather than individuals is due partly to their not adopting methods necessary to acquire knowledge of population structure, and partly to the difficulties of presenting the data in an easily assimilable form for others.

3.3 Population Taxonomy

In sexually-reproducing organisms evolutionary unit is the local breeding populations and this is the basis of units of classification in biosystematics. The populations have therefore to be studied in the Field and sampled statistically in such a way that the sample gives a valid representation of their variation.

Even this is insufficient because statistical sampling methods are not necessarily valid for biological population. Particularly In outbreeding organism where each individual is in some degree unlike every other genetically and with a different evolutionary potential (Mayr 1959a) Johansen (of Davies and Heywood, 1963) commented on this point: “we must work at the study of hereditary with mathematics, not treat it as mathematics.” Horns (1975) concluded that plants have too many characters than can be explained by figures.

4.0 Conclusion

Populations are defined in different ways for different purposes but that they are groups of individuals is common to all the definitions. In population genetics, the importance of cohabitation of the particular group of individual is that they can (in sexual organism, amphimicts) exchange genes.

Morpho-geographical taxonomy, although indispensable for evolutionary and genetical studies as a prime source of information and as a reference system, is no longer adequate for many such investigations into the nature of variation, the operation of natural selection and evolutionary processes.

The study of evolutionary relationships necessitates the study not only of the morphology as expressed by the phenotypes but also the hereditary basis of the morphological characters, the genotype.

5.0 Summary

6.0 Tutor Marked Assignment (TMA)

a. What is Population Taxonomy?

b. What is Population Concept?

7.0 References/Further reading

Core, E.L.(1955). Plant Taxonomy, Prentice-Hall, Englewood Cliffs, N.J., Pp. 9-61. (An excellent history of plant taxonomy).

Hutchinson, J.(1969). Evolution and Phylogeny of Flowering plants, Academic Press, London, 400pp.

Bessey, C.E.(1915). Phylogenetic Taxonomy of Flowering Plants, Ann. Mo. Bot. Gard., 2: 109-164.

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Unit 3: Plant Nomenclature

CONTENTS

1.0 Introduction

The assignment of names to plants is called nomenclature. It involves principles governed by rules developed and adopted by the International Botanical Congresses. The rules are formally listed in the International Code of Botanical Nomenclature and often referred to simply as the "Code". The ultimate goal of this precise system, as embodied in the Code, is to provide one correct name for taxon. The rules of nomenclature are subdivided into articles, which must be adhered to, and recommendations, which are optional.

Although classification schemes may be change with time, the scientific names of plants are relatively stable. The plant retains its name although the family or higher taxonomic categories are changed. Much effort has been devoted to establishing procedures for naming taxa and for changing names that were incorrectly assigned.

Nomenclature and classification are different but inseparable. The placement of a plant or group of plants in the classification scheme may be determined by knowing its name. when the generic name of a plant is known, it is possible with the proper bibliographic aids to determine the family to which that genus is usually assigned.

2.0 Objective: At the end of the class, students must be familiar and understand the principles governed by rules developed and adopted by the International Botanical Congress and the ultimate goals of the system.

3.0 Main content

3.1. Basis of Scientific Names

The present system of nomenclature is the result of a historic series of changes that gradually become formalized. The oldest plant names we now use are the common names used in ancient Greece and Rome. Today all plant names have a Latinized spelling or are treated as Latin regardless of their origin. This custom originates from medieval scholarship and the use of Latin in most botanical publications until the middle of the nineteenth century. The assignment of names was relatively unstructured until the seventeenth century when the number of plants known to botanists began to increase greatly. This resulted in a need for a more precise naming system for plants. During several centuries before 1753, names were often composed of three or more words. These names are called polynomials. For example, in the herbal of Clusius (1583), the name Salix pumila angustifolia altera is used for a species of willow.

This complex name-description system was not workable because it was cumbersome and not readily expandable system. Our present formal nomenclature began with the publication of Linnaeus's Species plantarum (1753). Since 1753 nomenclatural procedures have become standardized through periodic legalistic revision so that plants are not named haphazardly.

Scientific Names versus Common Nam Latinized scientific names often appear formidable. There is a natural inclination to avoid words with unfamiliar and difficult pronunciations. Although scientific names may be difficult to pronounce, uides to pronunciation do exist.

Why do botanists use Latinized scientific names instead of common names? Common names present a number of problems. First, common or vernacular names are not universal and may be applied only in single language. (Scientific names, on the other hand, are universal and are recognized throughout the world.) Second, common names usually do not provide information indicating the generic and family relationship. Third, if a plant is well known, it may have a dozen or more common names. For examples, Chrysanthemum leucanthemum is called daisy, white daisy, ox-eye daisy, Shasta daisy, or white weed; Centaurea cyanus is variously known as cornflower, bluebottle, bachelor's button, or ragged robin. Fourth, sometimes two or more plants may have the same common name. In Georgia, Sida in the family Malvaceae is called ironweed; but in the Midwest, Vernonia in the family Compositae is called ironweed. Fifth, many species, particularly rare ones, do not have common names.

3.1.1 Composition of Scientific Names

The genus name and the specific epithet together form a binomial called the species name. The term species name is often erroneously used to refer to the specific epithet alone, but the species name consists of both the generic name and the specific epithet. A complete scientific name must be followed by the third element, the name of the person or persons who formally described the plant. For example, the complete scientific name for white oak is *Quercus alba* Linnaeus; the genus is Quercus, the specific epithet alba, and the author citation Linnaeus. The author element of a name is often abbreviated and “L” is normally used for the authority in place of “Linnaeus.” To be correct, the species name of white oak is not “alba,” but is *Quercus alba* L. Therefore, a complete scientific name of a species consists of three elements: (1) the genus (plural, genera), (2) the specific epithet, and (3) the author citation.

3.1.2 Generic Names

The generic name is a singular Latinized noun or a word treated as a noun. It is always written with an initial capital letter. After a generic name has been spelled out at least once, it may be abbreviated by using the initial capital letter; for example “Q” for Quercus. Generic names may not consist of two words unless they are joined with hyphen. Latin inflectional endings are used for both generic names and specific epithets. Section three of the International Code of Botanical Nomenclature deals with what makes a generic name. The name may be given from any source, and it may commemorate some person of distinction. Genera such as Linnaea for Linnaeus or Jeffersonia for Thomas Jefferson are commemorative. Many ancient common names, such as Asparagus and Narcissus, were converted into generic names directly from Greek. Features of plants, such as the liverlike leaves of Hepaticae, gave generic names to still others, the word Hepatica being derived from the Latin word for liver. Information about a plant is sometimes expressed in a generic name because it indicates in a general way the kind of plant under consideration. With familiar genera we can recognise the plants by their generic names, for example, Rosa as a rose and Pinus as a pine, both of which are ancient colloquial names.

3.1.3 Specific Epithet

Specific epithets may be derived from any source and may honour a person, or they may be derived from an old common name, a geographic location, or some characteristics of the plant, or they may even be composed arbitrarily (see Article 23 of the Code). The specific epithet is often an adjective illustrating a distinguishing feature of the species. Specific epithets consisting of two words must be hyphenated, as in the case of Capsella bursa-pastoris (L.) Medic.

The specific epithet usually agrees with the gender of the generic name if the specific epithet is an adjective. If the specific name is an adjective placed in a genus that has the masculine ending –us, a species might spelled albus, but if it is a genus with a feminine spelling, it will be alba. In spite of its –us ending, Quercus is feminine for the purposes of botanical Latin as feminine, as was usually the situation in Classical Latin. A specific epithet may also be a noun in apposition carrying its own gender. When the noun is in apposition, it is normally in the case-for example, Pyrus malus for the common apple. When a specific epithet is named after a person and ends in a vowel or er, the letter –I is added (e.g., glazioui), but if it ends in a consonant, the letters ii are added (e.g. ramondii) (Recommendation 73C of the Code). When named for a female, it ends in iae or –ae; e.g., luciliae. Specific epithets derived from geographical names usually are terminated by –ensis, -(a)nus, -inus, -ianus, or –icus; examples are quebecensis, philadelphicus, and carolinianus (Recommendation 73D).

The code recommends that all specific epithets be written with a small initial letter, but capital letters may be used when epithets are derived from a person’s name, from former generic names, or from common names. Both the generic and the specific epithet are customarily underlined when written or typed; when printed, they are in italics or boldface. The author citation is never underlined.

3.1.4 Author

The name of a person or persons following the genus and specific epithet indicates the author. It is a source of historical information regarding the name of the plant. By giving the author's name, one may discriminate among names. The author citation may be abbreviated; for example, "L." for Linnaeus or "Michx." for Andre Michaux. Frequently a name will have two authors, with the first in parentheses. For example, with *Vernonia acaulis* (Walter) Gleason, the positioning of these two authors shows that this species was first described by Walter, who supplied the specific epithet *acaulis*. Walter put it in a genus other than *Vernonia*, and at some later point Gleason transferred this species to *Vernonia*. When the rank of a taxon is changed or when a species is transferred from one genus to another, the name of the describing author is placed in parentheses and is followed by the name of the person who made the change. Transfers are sometimes necessary in taxonomic studies when new information suggests that taxonomic boundaries be realigned. Name changes should be made after careful consideration of taxonomic relationships and must follow the requirements of the International Code of Botanical Nomenclature.

3.2 THE INTERNATIONAL CODE OF BOTANICAL NOMENCLATURE, ICBN (THE CODE)

The plant nomenclature had its origin in Linnaeus "Critical Botanical" (1938) where a formed guideline on the application of names to plants was made. Since the need for a code or unified rule was felt in the plant systematic, the International Botanical Congress in 1866 appointed the great French botanist Alphorse de Candolle to draw up "a code of conduct" for plant taxonomic in nomenclatural matters. This report was accepted by the next congress in Paris in 1867 and was referred to as the "Paris code" or "Candollean code". The congress adopted 3 major rules that:

(1.) One plant may have one and only one name.
(2.) No two different plants may have the same name.
(3.) Priority-if more than one name exists for a plant, the earliest published one is the valid to be used.

The work of Linnaeus was adopted as the valid starting point for all botanical nomenclature, since then i.e. Paris 1867 code, series of nomenclature additions, deletion and modification have been done periodically like in the Rochester 1892, Vietnam 1905, America 1997, Cambridge 1930, Amsterdam 1935, Stockholm 1950, and South 1972.

The current code adopted by the XII (12th) International Botanical Congress in Leningrad (1975) and published in 1978, edited by Dr. F.A Stafleu (Chairman of the congress), has now superseded all the earlier codes of botanical nomenclature.

The ICBN (Lennigrad, 1978) or the code is divided into three divisions:

Division I: Provides a set of six principles which form the basis of system of nomenclature, these principles is:

Principle I: Botanical nomenclature is independent of Zoological nomenclature.

Principle II: The application of names to taxonomic groups is determined by means of nomenclatural system.

Principle III: The nomenclature of taxonomic group is based upon priority of publication.

Principle IV: Each taxonomic group with a particular circumscription position and rank can bear only one correct name, the earliest that is accordance with the rules, except in specified cases.

Principles V: Scientific names of taxonomic groups are treated as Latin regardless derivatives.

Principles VI: The rules of nomenclature are retroactive unless expressly limited.

Division II: deals with detailed Rules and Recommendation of 75 articles, all under 6 chapters.

Chapter I: Ranks of taxa, and term donating them (Arts. 1-5).
Chapter II: Names of taxa (General Provisions) (Art 6-15)
Chapter III: Nomenclature of taxa according to their ranks (Arts. 16-28)
Chapter IV: Effective and valid Publication (Art 29-50)
Chapter V: Retention, choice and rejection of names sand epithets (Art 51-72).
Chapter VI: Orthography of names and epithets and gender of generic names (Art 73-75).

SOME MAJOR RULES

RANK OF TAXA/NAMES OF TAXA ABOVE THE RANK OF FAMILY

The ranks are recognized with their approved endings.

e.g. Division – Tracheophyte – possess tracheid and vessels.
Sub-division - Spermatophytina
Class – Anglospermopsida
Sub-class – Dicotyledonidea
Order – Malvales
Suborder- Malvineae

Names of orders are taken from the type family and has the characteristics ending -ales

Note: The rank order is regarded as the most unsatisfactory taxon in angiosperm classification because most of them (orders) are extremely difficult to define. The naturalness of many of them to open question, and of little use as an aid in identification.

NAMES OF HYBRIDS

They are largely governed by the same rule as species. Species articles are made for them in the code. Hybrids are assigned to taxa of two principle ranks:

(1) Inter-specific Hybrid (2) Inter-genomic hybrid.

The inter-specific hybrids are designated by a formula-the two species names separated by a multiplication sign e.g. *Calystegia sepium* x *Calystegia siluatica*.

In Inter-generic hybrids, they are similarly designed at the generic level by a formula e.g.

Caeloglasium x Gymnadonia
Agrostis x Polypogon

The names of inter-specific hybrids are written in two different ways:

(1.) The names of both parent are connected by a X sign (as above) e.g. *Salix accrita* X *S. caprea*.

(2.) By giving a new epithet form the hybrid. The generic name and the epithet are connected by a X sign.

NAMES OF PLANT IN CULTIVATION

Plants brought from the wild into cultivation retain the names that are applied to the same taxa growing in nature. Variant of intra-specific rank, which arise in cultivation through hybridization, mutation, selection of other processes as which one of sufficient interest to cultivators to be distinguished by names, receive cultivar epithets preferably in common language (i.e. fancy epithets) rankly different from the Latin epithets of species and varieties e.g. Juglars regia "king".

Note that the separate set of rules known as the International Code of Nomenclature of Cultivated Plants (ICNCP) with 57 articles has been produced by a committee of the International Union of Biological Sciences (latest edition 1959). Most of the ICNCP are taken from the relevant ones in the ICBN.

ORTHOGRAPHY OF NAMES AS EPITHETS

Botanists who are forming generic names and/or specific epithets should comply with the following suggestions.

(1) To use Latin termination as far as possible.
(2) To avoid names not readily given a Latin pronunciation.
(3) To avoid long names or those difficult to pronounce.
(4) Not to make names by combining 3 different languages i.e. avoid nomiza hybrida.
(5) To give a feminine form to all personal generic names whether they commemorate a man or a woman.
(6) Not to dedicate genera to persons quite unconnected with botany or at least with natural science.
(7) Not to form generic names by combining parts of two existing generics names e.g. Hordelymus from Hordeum and Elymus because such names are likely to be confused with names of intergeneric hybrids.
(8) To avoid name (for specific epithets) which have same meaning as the generic name.

GIVING OF NEW NAMES

The following recommendations are made for the formation of new names for a genus for intfra-generic taxa, species and/or infraspectification taxa, from the names of person.

GENERAL PROVISION FOR NAMES OF TAXA

This include:

- Typification –type-method (Art 7-10)
- Priority
    - Rules of priority (Art 1-12)
    - Limitation of priority (Art 13-15)
- Effective and Valid Publication (Art. 29-50)
- Condition and Date of effective Publication (Art. 29-31)
- Condition and Date of Valid Publication (Art. 32-45)
- Authors' citation (Art. 46-50).
- Retention, choice and Rejection of names and aptitude
- Citation.

TYPIFICATION or the type-method: A concept or below is determined by name of "nomenclatural types" i.e. types of names of taxa. A nomenclatural type is that constituent element of taxon to which the name the taxon is permanently attached (whether as a correct name or a synonym). Note that the "types" is not necessarily the most typical or representative element of a taxon, it is that element with which the name is permanently associated. It is on the type that the original validating description of the taxon is based. So the type is merely a nomenclatural concept.

The type of species or infra-special taxon is a preserved single specimen or in some cases, a drawing of the specimen. The type of negus or a rank between genus and species is a species. The type of a family is a genus e.g. Malva (Malvaceae) i.e. Malva is the type-genus (a qualifying term).

Names identical in form but based on different types are termed homonyms. All homonyms except the earliest are illegitimate.

Specialized-term (of primary type specimens) in typifying specific or intraspecific categories:

(i) A Holotype is the one specimen or other element used by the author or designated by him as the nomenclatural types.

(ii) An Isotype is any duplicate (part of a single gathering made by a collector at one time) of the holotype; it is always a specimen.

(iii) A Lectotype is a specimen or other element selected from the original material to serve as a nomenclatural type which no holotype was designated at the time of publication or as long as it is missing. When two or more specimens have been designated as types by the author of a specific or infraspecific name (e.g. male and female, flowering and fruiting e.t.c.). The lectotype must be chosen from among them.

(iv) A syntype is any one of two or more specimens cited by the author when no holotype was designated, or any one of two or more specimens simultaneously designated as types.

(v) A paratype, a specimen cited in the protologue other than the holotype, isotype or syntype (s). In most cases where no holotype, was designated there will be no paratypes since all the specimen will be syntypes. However, in cases where an author cited two or more specimens as types, the remaining cited specimens are paratypes and not syntypes.

(vi) A Neotype is a specimen or other element selected to serve as nomenclatural type as long as all of the material on which the name of the taxa was based is missing.

Note, that in typification, if no holotype was indicated by the author who described a taxon, or when the holotype has been lost, a lectotype or a neotype as a substitute for it may be designated.

A lecotype always takes precedence over a neotype. An Isotype if such exist must be chosen as the lecotype. If no isotype exists, the lectotype must be chosen from among the syntype, if such exist. If neither an isotype nor a syntype nor any of the original material is extinct, a neotype may be selected.

SECONDARY-TYPES

Hypotypes, topotypes, homeotypes are useful as comparative material aiding not in identifying specimen but in verifying precious identification.

Hypotype: a described, figure or listed specimen.

Topotype: specimen from the type facility of species.

Heneotype – a specimen compared by a competent observer with the holotype or lectotype or other primary type material of a species and found to be conspecific with it.

Note: The name of an infra-specific taxon which includes the type specimens of that species must have the same epithet as that species and the repeated name bears no author citation. It is known as the “typical or nominate sub-species” e.g. *Hallanthus annus* subsp. *Annus* such repeated names are known as autonyms. The other subspecies bears different names with your citation.

DEFINITION (OF TERMS OF GENERAL PROVISIONS)

Publications (Art 29-45)

Effective publication (29-31) is the publication effected only by distribution ofprinted matter (through sale, exchange or gift) to the general public or at least to botanical institution with libraries accessible to botanical generality.

Valid Publication (in accordance Art 32-45). In order to be validly published, a name of taxon must (1) be effectively published (2) Have a form which complies with the provisions at Art 16-17 i.e. nomenclature or taxa and hybrids. (3) Be accompanied by a description or diagnosis of the taxon or by a reference to a previously and effectively published description or diagnosis of it (a diagnosis of taxon is a statement of that which in the opinion of its author distinguishes the taxon from others). (4) Comply with the special provisions of articles on valid publications.

LEGITIMACY

A legitimate name or epithet is one that is in accordance with all the rules of the ICBN governing publications. Names which have not been so published or contrary to the rules are illegitimate. A legitimate name is the correct name. It must be effectively and validly published and obey the rules concerning the information of names.

PRIORITY (PRINCIPLE OF)

If the principle of priority deals with which exact name is chosen for a taxon. And it refers that taxa, from family to below lower rank, (inclusive) must be only one correct name, special exception being made for 9 families for which alternatives are permitted (see Art 18) and for which certain fungi and fossil plants (see Art 59). For any taxon (family to genus inclusive), the correct name is the earliest legitimate one with the same rank, except in cases of limitation of priority by conservation (Art 14 and 15). The principles of priority do not apply to names of taxa above the rank of family.

The law of priority, for Spermatophyta and Pteridophyta starts with the Linnaeus “Species Plantarum” with effect from 1-5-1753.

LIMITATION OF THE PRINCIPLE OF PRIORITY “NOMINA CONSERVATION” AND “ NOMINA REJICIENDA”

The change of a generic name e.g. due to discovery of earlier name necessitate a covering of a great many new combinations for species included under it. To avoid this cumbersome act, generic names found to be in correct according to the ICBN but whose substitution would cause a lot of inconveniences are conserved and are known as “nomina conservanda” and must be related be useful exception. Conservation aims at retention of these generic names which best serve stability of nomenclature. The name which will be otherwise correct are rejected and known as “nomina rellecienda”.

Many taxa have more than one name and such names apart from the correct ones are known as synonyms (a second name for a given taxon).

Tautonym-when the generic name is the name spelling as the specific epithet e.g. Pinus pinus.

NAME CHANGE

This might be as a result of any of the three causes:

(1.) Change to discovery that the names being used is not correct according to ICBN, this is called Nomenclatural change
(2.) Changes due to taxonomic change of opinion e.g. amalgamation, splitting or transference of taxon. This is enlisted Taxonomic change.

Changes due to discovery that a taxon has previously mistakenly given the name of a different taxon.

It is not permitted to change the name of plant for reason of convenience e.g. Scilla peruvicena were named because it was thought to originate from Peru whereas it originated from Portugal. Nevertheless, that remains its correct name.

CITATION

For the indication of the name of a taxon to be accurate and complete and is order that the date may be readily verified, it is necessary to cite the name of the author(s) who first validity published the name concerned under the provision of Art. 19, 22 or 25 is ruler of nomenclature of taxa, apply e.g. cite common examples:
Roseaceae Juss *Adansonia digitata* Adans
Rosa L.
Rosa gallica L.
Rose gallica var. oriostyla R. Keller.
Rosa gallica L. var. gallica
Vitox Linn. *Vitox tritolla* Linn.

4.0 Conclusion

The present system of nomenclature is the result of a historic series of changes that gradually become formalized. The oldest plant names we now use are the common names used in ancient Greece and Rome. Today all plant names have a Latinized spelling or are treated as Latin regardless of their origin. This custom originates from medieval scholarship and the use of Latin in most botanical publications until the middle of the nineteenth century. The assignment of names was relatively unstructured until the seventeenth century when the number of plants known to botanists began to increase greatly. This resulted in a need for a more precise naming system for plants. During several centuries before 1753, names were often composed of three or more words. These names are called polynomials. The assignment of names to plants is called nomenclature. It involves principles governed by rules developed and adopted by the International Botanical Congresses. The rules are formally listed in the International Code of Botanical Nomenclature and often referred to simply as the “Code”. The ultimate goal of this precise system, as embodied in the Code, is to provide one correct name for taxon. The rules of nomenclature are subdivided into articles, which must be adhered to, and recommendations, which are optional.

5.0 Summary

The International Code of Botanical Nomenclature is a response to the fact that science requires a precise system of naming plants. The Code deals with the terms used to denote the ranks of taxa as well as with the scientific names applied to plants. There are valid reasons for the occasional but necessary changes of familiar plant names.

Davis and Heywood (1963) observe, “To most systematists, however, nomenclature is a time-consuming necessity that comes between them and the plant. Nevertheless, it is one of the tools of the taxonomists’ trade and for that reason its principles must be mastered.” It should be emphasized that for detailed knowledge of the rules of nomenclature, the Code itself must be consulted.

6.0 Tutor Marked Assignment (TMA)

a. What are Specific Epithets?

b. Differentiate between Scientific Names and Common Names.

c. What are Generic Names?

7.0 References/Further reading

Core, E.L.(1955). Plant Taxonomy, Prentice-Hall, Englewood Cliffs, N.J., Pp. 9-61. (An excellent history of plant taxonomy).

Hutchinson, J.(1969). Evolution and Phylogeny of Flowering plants, Academic Press, London, 400pp.

Bessey, C.E.(1915). Phylogenetic Taxonomy of Flowering Plants, Ann. Mo. Bot. Gard., 2: 109-164.

Gardner, E.J. (1972). History of Biology, 3ed., Burgess, Mineapolis.

Samuel, B.J. and Arlene, B.L. (1986). Plant Systematics. McGraw-Hill, Inc, San-Francisco. 512pp.

Unit 4: Principles of Plant Taxonomy

CONTENTS

3.1.5 Families
3.1.6 Orders
3.1.7 Typological Concepts of Taxa
3.2 Characters
3.3 Classification
3.3.1 Numerical Phenetics
3.3.2 Cladistics
3.4 Biogeography
3.4.1 Vicariance Biogeography
3.4.2 Parallelism and Convergence
3.5 Guiding Principles of Angiosperm Phylogeny
3.5.1 Possible Evolutionary Trends in Angiosperms
4.0 Conclusion
5.0 Summary
6.0 Tutor Marked Assignment (TMA)
a. What is the Monophyletic Taxon?
b. Differentiate between Species and Infraspecific Taxa.
c. What are Characters?
7.0 References/Further reading

1.0 Introduction

Taxonomy is based on the similarities and dissimilarities among organisms. Historically, taxonomy has been a descriptive science based on the variation and form of morphological characters. The classification schemes of the taxonomists of the 1700s and 1800s placed similar-appearing organisms together in species, comparable species in genera and genera with resemblances into families.

2.0 Objective: At the end of the class, students must be familiar and must understand the principles of Plant Taxonomy.

3.0 Main content

3.1 Categories

3.1.1 Monophyletic Requirement of Categories

This is derived from one ancestral population system, whereas a polyphyletic taxon has been derived from two or more ancestral population systems or taxa.

3.1.2 Species

In taxonomic practice, a group of individual plants that is fundamentally alike is generally treated as species, ideally, a species should be separated by distinct morphological differences from other closely related species.

3.1.3 Infraspecific Taxa

A species embraces the variation within its populations. To manage some of the recurring variation, three infraspecific categories are used by plant systematists to provide formal taxonomic recognition of variation within species. These are subspecies, variety (Latin, varietas), form (Latin, forma).

3.1.4 Genera

Like species, the genus represents a concept. From practical standpoint, the genus is an inclusive category whose species have more characteristics in common with each other than with species of other genera within the same family. Genera therefore aggregates of closely related species

3.1.5 Families

Much of what has been said about the concept of the genus applies equally to the concept of the family. Ideally, families should be monophyletic and present both a biologically meaningfully treatment and a practical taxonomy. Both the reproductive and vegetative features are used to characterize families.

3.1.6 Orders

This includes one or more families. The monophyletic requirement for establishing orders must be broadly interpreted and should not be too restrictive when developing a workable classification. Orders are much more difficult to define and delimit than families.

3.1.7 Typological Concepts of Taxa

Systematists often remember the essential charactersitics of a species, genus, or family and represent that taxon in their mind by an image embodying its salient features. This symbolism exemplifies what is meant by typological concepts of taxa.

3.2 Characters

The characters of an organism are all the features or attributes possessed by the organism that may be compared, measured, counted, described, or otherwise assessed. From this definition, it is clear that the differences, similarities, and discontinuities between plants or taxa are reflecting in their characters. The characters of a taxon are determined by observing or analyzing samples of individuals and recording the observations, or by conducting controlled experiments.

3.3 Classification

Although the theory of evolution had little immediate impact on the practice of taxonomic research at the level of species, genus, and family, it did impact on taxonomic theory. Systematists began to attempt to develop systems of classifications designed to reflect evolutionary lineages.

3.3.1 Numerical Phenetics

Phenectics involves the organizing of data on the basis of similarity for the purpose of obtaining a classification. Phenecticists, the workers in the field of taxonomy, emphasize the need for objectivity in classification.

3.3.2 Cladistics

Cladistics analysis attempts to summarize knowledge about the similarities among organisms in terms of a branching diagram called cladogram. Cladistics has its goal the production of objective and repeatable branching diagrams depicting hypothetical evolutionary histories, thus eliminating arbitrariness from classifications.

3.4 Biogeography

Classification depends on a hypothesis of the evolutionary development of the taxon, the present day relationships to the environment, and the analyses of the taxon’s distribution pattern in relation to paleoclimatic and paleogeography data.

3.4.1 Vicariance Biogeography

This is a formalized method to analyze the relationships and histories of biotas by searching for common patterns of distributions of organisms.

3.4.2 Parallelism and Convergence

If two organisms of different lineage are alike in their features, the resemblance is usually attributed to either parallelism or convergence. Convergence is the resemblance between two or more distinct phyletic lines brought about through evolution by adaptation to similar environments or similar reproductive biologies. Parrallelism is the resemblance is due to a common ancestry ang genetic background.

3.5 Guiding Principles of Angiosperm Phylogeny

The angiosperm phylogenist is faced with major problems of an inadequate fossil record, the prevalence of convergent evolution, and extreme structural modifications of many flowering plants.

3.5.1 Possible Evolutionary Trends in Angiosperms

In most groups of flowering plants, woody plants usually have preceded the herbs, vines, and climbers. Perennials gave rise to biennials, and annuals have been derived from both. Terrestrial seed plants usually preceded closely related aquatics or epiphytes, saprophytes, and parasites.

4.0 Conclusion

Taxonomy is based on the similarities and dissimilarities among organisms. Historically, taxonomy has been a descriptive science based on the variation and form of morphological characters. The classification schemes of the taxonomists of the 1700s and 1800s placed similar-appearing organisms together in species, comparable species in genera and genera with resemblances into families

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Taxonomy is based on the similarities and dissimilarities among organisms. Historically, taxonomy has been a descriptive science based on the variation and form of morphological characters. The classification schemes of the taxonomists of the 1700s and 1800s placed similar-appearing organisms together in species, comparable species in genera and genera with resemblances into families

6.0 Tutor Marked Assignment (TMA)

a. What is the Monophyletic Taxon?

Monophyletic Requirement of Categories

This is derived from one ancestral population system, whereas a polyphyletic taxon has been derived from two or more ancestral population systems or taxa.

b. Differentiate between Species and Infraspecific Taxa.

Species in taxonomic practice is a group of individual plants that is fundamentally alike is generally treated as species, ideally, a species should be separated by distinct morphological differences from other closely related species while infraspecific Taxa is when a species embraces the variation within its populations. To manage some of the recurring variation, three infraspecific categories are used by plant systematists to provide formal taxonomic recognition of variation within species. These are subspecies, variety (Latin, varietas), form (Latin, forma).

c. What are Characters?

The characters of an organism are all the features or attributes possessed by the organism that may be compared, measured, counted, described, or otherwise assessed. From this definition, it is clear that the differences, similarities, and discontinuities between plants or taxa are reflecting in their characters. The characters of a taxon are determined by observing or analyzing samples of individuals and recording the observations, or by conducting controlled experiments.

7.0 References/Further reading

Core, E.L.(1955). Plant Taxonomy, Prentice-Hall, Englewood Cliffs, N.J., Pp. 9-61. (An excellent history of plant taxonomy).

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Unit 5: Sources of Taxonomic Evidence I

CONTENTS

1.0 Introduction
2.0 Objective
3.0 Main content
- 3.1 Morphology
- 3.2 Comparative Plant Anatomy
- 3.3 Cytology
- 3.4 Embroyology

4.0 Conclusion
5.0 Summary
6.0 Tutor Marked Assignment (TMA)
a. List the various Sources of Taxonomic Evidence.
b. Differentiate between Embrology and Cytology
7.0 References/Further reading

1.0 Introduction

Taxonomic evidence for the establishment of classifications and phylogenies is gathered from a variety of sources. Because all parts of a plant at all stages of its development can provide taxonomic characters, data must be assembled from many diverse disciplines. The use of information from studies on comparative anatomy, embryology, palynology, cytogenetics, chemistry, and so on has greatly improved the modern classification of plants.

2.0 Objective: At the end of the class, students must be familiar with various source of evidence and the sources for the establishment of classifications and phylogenies

3.0 Main content

3.1 Morphology

As a source of taxonomic character, taxonomists still rely till today on morphologic characters both for producing classification and for diagnostic purpose. Usually, morphological character can be divided into 2 broad groups:

3.1.1 Vegetative Characters

These make up the greater part of the phases of most species which allow us to recognize them virtually e.g. the leaf, stem etc., under this we have:

i. Habit: We talk about this size, the branching, portion of the particular plant, the duration of the plant i.e. annual, biennial or perennial.

ii.Underground organs: We refer to all these parts of the plant that are within the ground mainly roots either tap, adventitious or fibers.

iii Stems: The size, the various parts, stem, types, branching.

iv.Leaves: All the various parts of the leaves, the types, the shape and the types of the apex base, margins, petiole (present or absent and the various sizes).

v.Andumentum: This refers to the hairs on the plants. Presence or absence and the various types. The density (spare, or dense depending on the plant).

3.1.2 Reproductive Characters

As the name suggests, these characters pertain to the various parts of the plant that are involved in reproduction:

i. Inflorescence: Parts and types with genera, family and within the plant world.
ii. Flowers: Smell, colour, number of flower and superior or inferior.

A flower is seen to the made of different parts:

a. Pedicel: Presence or absent, size,
b. Calyx: Number of calyx, it varies with species or even a single species, some 4, others 3.
c. Corolla: Very important character colour, size, the venation of the corolla.
d. Androecium: Male part – stamen, filament, they constitute very important character when it comes to discrimination
e. Gynoecium: Ovary, style and stigma
f. Nectaries: The glandular organs which secrete nectar. Present or absent
g. Fruits: Various aspects of the fruits morphology constitute very important morphological characters
h. Seeds: Size

3.2 Comparative Plant Anatomy

Comparative anatomical studies of angiosperm play an increasingly important role in the solution of taxonomic problems and the formulation of natural or phenetic groups.

Some of the early comprehensive anatomical works on various angiosperm families include those of solereder (1908) which is titled Systematic Anatomy of the Dictoyledons and the monumental work of Mekays and Chalk, titled the anatomy of the Dicotyledons which was all that was known at that time of the descriptive anatomy of dicotyledons.

The various parts of the plants that may be investigated anatomically includes:

a. Stem
b. Leaves
c. Leaf – petioles
d. Leaf – nodes

a. Stem: The anatomy of a stem especially those that had undergone secondary thickening have:

i. Growth layers (annual rings) may either be present or absent
ii. Tricheids and fibres: Various types
iii. Wall thickness, cell length
iv. Vessel: The frequency and distribution
The thickness of the wall and the size of the cells.
v. Rays: Types, abundance and the size
vi. Axial Parenchyma – Distribution of the axial parenchymatous cells, the types could be just-team, sample or selerotic.

b. Leaf-Anatomy: The leaf shade can be variously investigated.

i. Cuticular characters: Distribution and orientation of papillae (any outgrowth that projects from the surface of the leaf e.g. hours etc).
ii. Epidermis: may be uniseriate or multi-seriate. Number of cells if multi- serrate, thickness of cell walls, size, shape and contents of cells.
iii. Stomata (stoma): types: about 8 depending on the surrounding cells, distribution of stomata in which stomata may be confined to the upper leaf surface- it is referred to here as being epistomatic. In some cases, they are confined to the lower leaf surface- Hypostomatic; Amphistomatic: when they occur on both upper and lower surfaces.
iv. Hypodermis: This is the general term for layer or layers of cells beneath the epidermis and they are morphologically distinct from underlying cortical cells. They may be present or absent. Then one has to record the location either on the upper epidermis or just above the lower (epidermis) surface. Then the number of cells.
v. Sclerenchyma: mainly used for: - support i.e. mechanical purposes.

i. Present or absent.
ii. Types
iii. Distribution.
In some plants, it may be restricted to outer part of the stem and in some are on the inner part. Sclerenchyma in usually associated with the vascular bundle i.e. they occur in discrete bundles and confined to the outer region of the vascular bundle.

vi. Mesophyll: can be defined as the photosynthetic parenchyma tissue of a leaf located between the epidermal layers.

There are various types:
i. Bifucial i.e. i.e. palisade parenchyma or sides of the blade and spongy parenchyma on the other side.
ii.Isolateral i.e. palisade parenchyma on both sides of the blade.
Numbers of layers of palisade and spongy tissues distribution and shape of chlorenchyma (photosynthetic cell).

Shape of mesophyll cell

Presence or absence of air-lacunae mesophyll whether the mesophyll is loss or compact. Presence or absence and distribution of secretary canals or cavities. Ferrn and distribution of crystal.

vii. Venation: record all the major venation patterns.
viii. Trichomes: hairy covering of leaves, stem, root. Presence/absence
Density
Various types

3.3 Cytology

During the past few decades, cytology either alone or interwoven with genetic has influenced many taxonomic findings. Cytological dates are derived mostly from the nucleus and pertain to chromosome number and morphology and chromosome behavior at meiosis.

They may be used for purpose of comparison or for evolutionary interpretation.

Cyto-taxonomy: is the investigation of chromosomal relationships in populations, races and species in order to educate taxonomic and evolutionary relationships.

Cytogenetical: It is the investigation which combines and synthesizes the methods and results of chromosome cytology with the genetics methods and results of breeding analysis.

The appearance of the somatic chromosomes of mitotic metaphase is termed karyotype. Parts of its plants with rapidly dividing cells e.g. root tips can be prepared for cytological examination by routine techniques e.g. aceto-carmine sequence.

Value features of the karyotype are used in taxonomy. For comparative purposes and these are mainly chromosome number and morphology which form the common and basic phase of cyto-taxonomy chromosome number.
The importance of chromosome number as a taxonomic character is that it is usually constant within a species. All individual within a species usually have the same chromosome number although there are exceptions.

The number of chromosomes recorded in flowering plants range from 2n = 4 in Haplopappus gracillis composite to 2n =265 in Poa litorosa (grass) and very light numbers are found in some ferns e.g. Ophioglossum vulgaris where chromosome number 2n =500 – 520.
Chromosome number may be uniform in a genus or higher group or vary from member to member. Three broad classes of chromosome number relationship within taxonomic groups may be recognized.

(1.) Throughout the whole group such as genus, no derivation in chromosome number is found e.g. all species of Pinus and some related general have 17 = 12. Species also, in Quercus (oak) and also in Fagaceae. In these examples, chromosome number is clearly of no value for taxonomic discrimination within the group. Although the constant number may be a useful character to distinguish the group from others.

(2.) The basic number of chromosome which is usually referred to as X is found to be exactly multiplied in various numbers of a group giving a polyphoid series. The common lowest diploid number 2x by doubling may produce tetraploid (4x) and the tetraploid to give octophoid (8x).

Triploids (3x) and hexaploids (6x) may be formed through hybridization between the different levels and individual species whose somatic chromosome number is an exact multiple of the basic number are termed Euphoids.

(3.) The number of chromosome found within a group bear no simple numerical relationship to each other. In this case, there may be changes in number without multiplication of complete sets of chromosomes and they are most frequent at the diploids level.

The changes in the haploid basic number seem to imply a gain or loss of chromosomes one by one these are known as aneuphiods series.

Aneuphiod is defined as chromosome numbers which are not exact multiples of an original haphoids number, with one of more chromosomes missing i.e. 2n – 1 or in addition to the euphoid number i.e. 2n + 1.

So that aneuphoid serves are:
2n – 1, 2n – 2i 2n – 3
Or 2n + 1 2n + 2, 2n + 3

Various mechanisms by which increases or decreases in chromosome number may be brought about include irregularities during division of cell or changes in the chromosomes themselves and such changes include fragmentation, mis-division of the centromere.

Then apart from these normal types, there are certain B-chromosomes which are usually referred to as ‘accessory chromosomes’. These are super numeracy chromosomes that are in addition to the normal diploids complement which are heterochromatic and occur in varying numbers among different individuals of a population. They may be minute in which cases are referred to as micro-chromosomes or moderately large in comparison with the normal number of the complement.

Chromosome Morphology

Chromosomes vary not only in number but size. Both absolute and relative, shape and volume, and in the amount and distribution of heterochromatin. These features may be observed in karyotypes in certain groups where the individual chromosomes are large enough to be seen in details.

(a) VARIATION IN ABSOLUTE CHROMOSOME SIZE

Chromosomes size including the total DNA contents of the nucleus may vary as much as 20 fold, between genera of the same family having the same or similar chromosomes number.

The chromosomes of vascular plants are found in general to be larger than those of algae, fungi, mosses and various kinds of micro-organism.

(b) VARIATION IN STAINING PROPERTIES

The chromosomes of different species vary greatly in their ability to absorb the dye on their surfaces. Chromosomes of most Liliaceae and Poeaceae are notable for the same stain with which they can be stained. Those of Malvaceae within with much greater difficulty.

In addition, the chromosomes of many species contain some region which stains more usually than others at many stages of the mitotic cycle. This has been designated as regular”.

(c) VARIATION IN CHROMOSOME MORPHOLOGY

Chromosomes Morphology is usually studied at the metaphase of mitosis when chromosomes have become contracted to the maximum amount of nearly the maximum in their cycle. And when they are most easily stained. The principal marks which may be seen at this stage are the centromere to which the spindle fibres are attached and in many chromosomes one or more day constrictions. In addition, one, two, and a larger number of chromosomes pair in the somatic complement of a species bear at one end of a satellite. This usually appears as a single small spherical body or a pair of such bodies attached to the remainder of the chromosome by a blender thread.

In most chromosomes, the centromere is located in one particular region of the chromosomes.

Accordingly to its position, chromosomes are designed as follows:

(a.) Telocentric:- centromere at one and of the chromosome so that the chromosome consists of a single arm.
(b.) Acrocentric:- centromere near one end of the chromosome so that it contains one long arm and one vary short arm.
(c.) Submetacentric:- centromere nearer to one end of the chromosome than the other so that the arms are distinctly unequal but less so than in acrocentric chromosomes.
(d.) Metacentric:- centromere at or near the middle of the chromosomes so that its arms are nearly or quite equal in length.

These joins categories are not sharply distinctive but grade imperceptibly into other.

(d) VARIATION IN RELATIVE CHROMOSOMES SIZE:

The chromosomal complement or karyotypes of most species of plants consist of chromosomes which are comparable to each other in size. There are however, many compliments which contain chromosome of two contrasting size: large and small. The differences are often represented in a diagrammatic form known as a collogram or karyogram.

CHROMOSOMES DIFFERENCES AS TAXONOMIC CHARACTERS

Chromosome morphology can be used for purposes of species identification and classification as well as for purposes of phylogenetic interpretation.

Changes in the morphology of the chromosomes are a reflection of internal rearrangement of the chromosomes. These changes are collectively referred to as “chromosomal aberrations”. Chromosomal differences reflect more or less directly the genetic content of the individual.

Differences in chromosomal size may either reflect differences in the number of different kinds of gene products, or protein which the individual can produce or neglect duplications of genes which influence the kind of protein that can be synthesized. And differences in staining properties often reflect differences in the timing of gene action, differences in karyotype morphology reflects differences in genes arrangements which can reflect drastically the way in which genes can become segregated and recombined in Mendelian heredity.

Differences in chromosomes number may reflect either differences in genes arrangement s or genes duplication, or both in short, chromosomal differences reflect differences in the source of genetic variation. While morphological, physiological and biochemical differences reflect differences in the products of gene action modified by environmental influences.

In other to understand evolution, we must become familiar with and takes into account all of these differences.

CHROMOSOMES AND TAXONOMY

Another aspect of cytology that is mainly employed in taxonomy is chromosomes behaviour at mitosis.

Valuable information can be obtained from a study of the way chromosomes behave at mitosis and this particular aspect may permit a distinction to be made between taxonomy mitotic behaviour is often used frequently as a way of indicating relationship through the kind of the degree of pairing that takes places since it may show that hybridization has occurred. It may also indicate structural differences in the parental chromosomes such as re-duplication or explain the causes of sterility.

Great weight is often placed on the degree of chromosomes homology in hybrids as an estimate of degree to which the parental species are related.

The chromosomes derived from two parents are often not homologous at meiosis and therefore do not pair. If the numbers of parents are different pairing will be uncompleted.

HOW TO MAKE CHROMOSOMES COUNTS UNDER THE MICROSCOPE

(1.) Sow the Seeds on fitter papers in Petri dishes.
(2.) Excise, after germination, the root tip from the seedlings
(3.) Pretreatment: it is carried out either in saturated solution of Paro-dichloro-benzene (P.D.B.) for 2-4 hours at room temperature or use 0.05% aqueous solution of colchicine for 11/2- 2 hours at room temperature instead of P.D.B. There is an alternative because some plants don't react to P.D.B. because you have to try it first before knowing.
(4.) Remove from the solution and fix in fresh 3 + 1 acetic alcohol i.e. 3 parts of absolute alcohol and 1 part of glacial acetic acid. The fresh is very important.
(5.) Rinses in water.
(6.) Hydrolyse in 1molar Hydrochoric Acid (HCl) in a water bath at 600 for 5-8 mins.
(7.) Rinse in water
(8.) Place some of the root tips on the stick one or two at a time and add 1 or 2 drops of propronic orcelin to stain the cells leaves for 2-5 minutes to allow the stain to penetrate.
(9.) Squash the roots tips under a cover slip to spread out the cells. At times, use red to squash.
10. Examine the slide under the microscope, usually it is better to examine under low power microscope.

This is a temporary slide which can last for one or two days. To make it permanent, freeze that area under the cover slip using "arcton 12" spray which is a chemical under pressure. After freezing, remove cover slip, using razor blade and place bottom a Petri dish with the slides containing the cells facing upward.

Then dehydrate in 90% alcohol for 2-3 minutes then in 95% and 100% to get absolute alcohol into this in different Petri dishes to

90% 95% 100%

Add a drop of Euparal to the area of the slide containing the the cell and replace the cover slip in position.
Then warm the slide on a hot plate at 600c for 2-3 days to harden the mountant i.e. Euparal.
Other areas where taxonomic characters can be considered.

3.4 Embrology

It constitutes another field from which other taxonomic character can be drawn.
The team embryology includes the successive stages of:

Megasporogenesis, and Microsporogenesis.
Megagametogenesis and microgamentogenesis and the post-fertilization stage of embryogeny.

Megagametogenesis and micro-gametogenesis refers to the development of male and female gametophytes and post-fertilization stages of embryogeny refers to the developmental stages from the fertilization egg to the mature embryo and the surrounding coat.
The following embryological characters have been considered to be taxonomically significant.

1. Anther:
   - (a) Number and arrangement of loculi
   - (b) Structure and thickness of the endothecium.
   - (c) Nature of tapetum-Glandular or Amoeboid
2. Development and structure of the ovule.
   - (a.) Number and structure of integuments
   - (b) Method of vasculation
   - (c) Structure of vasculation
   - (d) Presence or absence of an endothecium
3. Form and extent of the nucleus:
4. Origin and extent of the sporogenous tissues in the ovule:
   - (a) Number of archesperial cells.
   - (b) Presence or absence of wall layers
   - (c) Nature of cell divisions
5. Megasporogenesis and Development of the Embryo Sac. Characters of special importance are:
   - (a) Time of wall formation in megasporogenesis.
   - (b) Position of functioning megaspores.
   - (c) Size, shape and arrangement of cells and nuclei

Composition the embryo sac.

6. Form and organization of the mature embryo sac, variable characters include:
   - (a) Shape, number and arrangement of the nuclei and cells

(b) Nature of synergies and antipodals

(c) Presence of starch or other food reserves

7. Fertilization.

a. Path of entry of the pollen tube:

i. Porognmous-entry through the micropyle

ii. Chalazogamous- entry through the chalaza of the ovule.

iii. Mesogamous.

b. Interval between pollination and fertilization.

8. Endosperm (Post fertilization development)

(1) Nature of endosperm formation in which the:

(a) Nuclear: endosperm formation in which the initial division is not accompanied by wall formation

(b) Cellular: the first and most of the later divisions are accompanied wall formation.

(c) Helobial: first division accompanied by wall formation and subsequent division are free nuclei.

(2) Presence of ruminate endosperm.

(3) Nature of endosperm food reserves, and fate of endosperm in mature seed.

9. Certain abnormalities of development.

(a) Apogamy: Development of a new embryo from a cell of the gametophyte other than the egg.

(b) Adventive embryony: Embryo development: from diploid cells of the nucleus or the integument.

(c) Polyembryony: The occurrence of more than one embryo in a seed.

4.0 Conclusion

Taxonomic evidence for the establishment of classifications and phylogenies is gathered from a variety of sources. Because all parts of a plant at all stages of its development can provide taxonomic characters, data must be assembled from many diverse disciplines. The use of information from studies on comparative anatomy, embryology, palynology, cytogenetics, chemistry, and so on has greatly improved the modern classification of plants.

5.0 Summary

Taxonomic evidence for the establishment of classifications and phylogenies is gathered from a variety of sources. Because all parts of a plant at all stages of its development can provide taxonomic characters, data must be assembled from many diverse disciplines.
As a source of taxonomic character, taxonomists still rely till today on morphologic characters both for producing classification and for diagnostic purpose. Comparative anatomical studies of angiosperm also play an increasingly important role in the solution of taxonomic problems and the formulation of natural or phenetic groups.

Cytology either alone or interwoven with genetic has influenced many taxonomic findings. Cytological data are derived mostly from the nucleus and pertain to chromosome number and morphology and chromosome behavior at meiosis. Embrology constitutes another field from which other taxonomic character can be drawn.The term embryology includes the successive stages of Megasporogenesis, and Microsporogenesis.

6.0 Tutor Marked Assignment (TMA)

a. List the various Sources of Taxonomic Evidence.

b. Differentiate between Embrology and Cytology

7.0 References/Further reading

Core, E.L.(1955). Plant Taxonomy, Prentice-Hall, Englewood Cliffs, N.J., Pp. 9-61. (An excellent history of plant taxonomy).

Hutchinson, J.(1969). Evolution and Phylogeny of Flowering plants, Academic Press, London, 400pp.

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MODULE 3

Unit 1: Sources of Taxonomic Evidence II

CONTENTS

1.0 Introduction

Taxonomic evidence for the establishment of classifications and phylogenies is gathered from a variety of sources. Because all parts of a plant at all stages of its development can provide taxonomic characters, data must be assembled from many diverse disciplines. The use of information from studies on comparative anatomy, embryology, palynology, cytogenetics, chemistry, and so on has greatly improved the modern classification of plants.

2.0 **Objective:** At the end of the class, students must be familiar with various source of evidence and the sources for the establishment of classifications and phylogenies

3.0 Main content

3.1 Palynology

THE STUDY OF POLLEN

Application of palynological data has proven to be of valuable assistance in interpreting problems related to Paleoecology; archeology and higher plant systematics.

Pollen data have been found to be taxonomically useful at all taxonomic levels and recent advances have been made in palynological research employing the transmission electronic microscope and the scanning electron microscope.

Pollen grains can be obtained from life and herbarium species of plants.

MORPHOLOGICAL CHARACTERS OF POLLEN GRAINS

Pollen units: the pollen may be:

1. Monad: Solitary pollen grain
2. Dyad: Pollen grains united in pairs
3. Tetrad : Four coherent pollen grains
4. Polyad: Compound pollen grains more than four in each groups.

When you use these character other character need will join the same line.

POLARITY OF THE POLLENS

(1.) Apolar: A pollen grains can be described as been "Apolar" when it has no distinct polarity.
(2.) The Equator: is the boarder line of the proximal and distal parts of the pollen grain.
(3.) The equatorial view: a pollen grain viewed when the polar axis is at a right angle to the observer.
(4.) Heteropolar: pollen grain in which the two polar faces are different. One has an aperture, the other has not.
(5.) Polar grains: pollen grains with distinct poles.
(6.) Polar axis: An imaginary straight line connecting the distal and the proximal poles.

SYMMETRY OF THE POLLENS

Bilateral: Pollen grains with two vertical planes of symmetry and the equatorial axis are not equitory.
Radial symmetry: Pollen grains with more than two vertical planes of symmetry.

SHAPE OF THE POLLEN

When one talks about the shape; it could depends very much on the angle at which the pollen is viewed, so as we can talk about:

1. Outline of pollen grain in polar view:-
   a. Non-angular

When viewed from the polar angle, it could be

- i. Circular
- ii. Ovate
- iii. Lanceolate
- iv. Elliptic

b. Angular

- i. Triangular (3-angled)
- ii. Quadrangular (quad) (4)
- iii. Quingangular (5)
- iv. sexangular (6)

2. Outline of grain in equitoral view:
   a. Non-angular
   - i. Circular
   - ii. Elliptic

   b. Angular
   - i. Rectangle
   - ii. Rhombic

THE SIZE OF THE POLLEN

When the pollen grains within a single unit are of various sizes, then this particular character is of no taxonomic importance.

The size of pollen grains is greatly affected by the method of preparation. It is very important to always indicate the techniques that are employed.

POLLEN MORPHOLOGY AND PLANT TAXONOMY

The measurement of pollen grains is namely in micromere (µm)

Very small grains	10 µm
Small grains	10-25µm
Medium size grains	25-50 µm
Large grains	50-100 µm
Very large grains	100-200 µm
Gigantic grains	200 µm

NUMBER, SIZE AND LOCATION OF GENITAL APERTURES:

Aperture: an aperture is any pre-form thining or absence of a part of the exine.
Colpus (colpi): Oblong elliptic aperture. Aid the length, breadth ratio is greater than 2.
Porus (pori): Circular or fauntty elliptic aperture.

TERMS RELATING TO APERATURE CONDITION

The number of apertures is indicated by using:

i. Mono:
ii. Di:
iii. Tri:
iv. Tetra:
v. Penta:
vi. Hexa:
vii. Poly-

You indicate the number before using the terms such as:

(1) Colpate- e.g. Tricolpate pollen grains (3 colpi)
(2) Colporote- pollen grain with compound apertures
(3) Porate- pollen grain with one or more pori.
(4) Pororate- pollen grain with one or more compound pori

A colpate pollen grain is provided with one or more colpi.

STENOPALYNOUS GROUP

It means that they are characterized by slight variation in pollen types.

A whole gene can be sionepalymous, and then you can't employ them for taxonomic proposes.

The outer surface of the pollen grain is not just smooth. We have it differ from group to group. The exine of certain pollen could be spiny or smooth depending on the group.

3.2 Paleobotany

Paleobotany uses microfossils, such as pollen, or macrofossils of leaves, stems and other plant parts as sources of data. Paleobotanists attempt: (1) to elucidate the composition and evolution of the floras of the past; (2) to trace these evolutionary developments through stratigraphic sequences; (3) to integrate paleobotanical data with comparative morphology; and (4) to determine past ecological conditions.

Until recently, most systematists generally agreed that paleobotany could provide little evidence on the origin and diversification of the flowering plants. However, evidence on the origin and diversification of the flowering plants. However, evidence is rapidly accumulating that paleobotany can provide significant information about important aspects of the early history of angiosperms. New techniques and approaches to the study of fossil flowering plants are helping taxonomists discover exciting information. The most encouraging effect of the recent upsurge in research on angiosperm origins is the recognition that the fossil record can furnish critical evidence for the origin and diversification of the flowering plants as it has for the vertebrates. In recent years, the discovery by Dichler and his associates of several angiosperm reproductive structures has greatly modified a number of early ideas about primitive flower types. There have been many marvelous discoveries of new fossils in recent years that have contributed a wealth of information about fossil flowering plants. The application of the technique of SEM has provided a clearer picture of the complex micromorphology of fossil pollen grains, and the application of Transmission Electron Microscope (TEM) is now providing information on the details of pollen ultrastructure. These new approaches have been especially rewarding.

4.0 Conclusion

Taxonomic evidence for the establishment of classifications and phylogenies is gathered from a variety of sources. Because all parts of a plant at all stages of its development can provide taxonomic characters, data must be assembled from many diverse disciplines. The use of information from studies on comparative anatomy, embryology, palynology, cytogenetics, chemistry, and so on has greatly improved the modern classification of plants.

5.0 Summary

Palynology is the study of pollen and spores. As a result of the stimulus and availability of Scanning Electronic Microscopes (SEM), taxonomists no longer overlook pollen as a source of characters. The development and readily availability of SEM has revolutionized the study of the surface features of pollen grains by providing a depth of focus never possible with light microscopy.

Paleobotany uses microfossils, such as pollen, or macrofossils of leaves, stems and other plant parts as sources of data. Paleobotanists attempt: (1) to elucidate the composition and evolution of the floras of the past; (2) to trace these evolutionary developments through stratigraphic sequences; (3) to integrate paleobotanical data with comparative morphology; and (4) to determine past ecological conditions.

6.0 Tutor Marked Assignment (TMA)

a. List the various sources of Taxonomic Evidence.

b. Differentiate between Palynology and Paleobotany.

7.0 References/Further reading

Bessey, C.E.(1915). Phylogenetic Taxonomy of Flowering Plants, Ann. Mo. Bot. Gard., 2: 109-164.

Core, E.L.(1955). *Plant Taxonomy*, Prentice-Hall, Englewood Cliffs, N.J., Pp. 9-61. (An excellent history of plant taxonomy).

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Unit 2: Sources of Taxonomic Evidence III

CONTENTS

1.0 Introduction

Taxonomic evidence for the establishment of classifications and phylogenies is gathered from a variety of sources. Because all parts of a plant at all stages of its development can provide taxonomic characters, data must be assembled from many diverse disciplines. The use of information from studies on comparative anatomy, embryology, palynology, cytogenetics, chemistry, and so on has greatly improved the modern classification of plants.

2.0 Objective: At the end of the class, students must be familiar with various source of evidence and the sources for the establishment of classifications and phylogenies

3.0 Main content

3.1 PHYTOCHEMISTRY

PLANT CHEMOTAXONOMY
(Chemosystematics, chemical plant taxonomy, photochemistry)

It is one of the more fashionable and rapidly expanding areas of plant taxonomy and seeks to utilize chemical information to improve the classification of plants. It has arisen as a major science in only the past 20 years.

The subject of phytochemistry or plant chemistry has developed in recent years as a distinct discipline, somewhere in between natural product organic chemistry and plant biochemistry and is clearly related to both. It is concerned with the enormous variety of organic substances that are elaborated and accumulated by plants and deals with the chemical structure of these substances, their biosynthesis, turnover and metabolism, their natural distribution and their biological function.

Virtually, every chemical component found in plants, including both the primary metabolites (involved in vital function in the cell) and the second products of metabolism (accumulated in cells but not considered to be involved in vital processes has been used in chemical comparison of taxa at various taxonomic levels.

Phytochemical procedure is more useful at a level above the species level.

A summary of some groupings of natural products which have been used in chemotaxonomic information including: some comments on the botanical distribution of these constituents.

Compound grouping Terpenoids, Monoteperes, Sesquiterpenoids, Diterpenes, Triterpenes, Carotenoids, Flavonoids, Lorgrins and Ignous, Cyanogenetic compounds, Quinones, Polysaccharides, Plant Glycosides, Ranunculins, Culfus, Polyol compounds, Amino Acids (non protein).

PHYTOCHEMICAL PROCEDURES

That is, phytochemical analysis requires some procedures which need to be carried out. They include the following:

1. Fresh plant tissues are normally used for phytochemical analysis and the material is plunged into boiling alcohol within minutes of the collection. Alternatively dry plants can be used but the drying operation must be carried out under control conditions to avoid too many chemical changes occurring.

The plant must be dried as soon as possible without using high temperature and if thoroughly dried, they can be stored for a long period of time.

The method of analysis consists of the following steps:

(1) Extraction
(2) Isolation
(3) Separation
(4) Identification

1. EXTRACTION: kill the plant tissue i.e. preventing enzyme oxidation or hydrolysis occurring by plunging the leaf on the flower into boiling ethanol (i.e. when using fresh plant) and this has effect of stopping enzymatic oxidation or hydrolysis. Then macerate (grind up) the material and filter.

2. ISOLATION: consists essentially of removing chlorophyll from extract, when the tissue debars is completely free of green colour, it can be assumed that the low molecular weight compounds have been extracted i.e. under isolation all that is done is to be sure that all the choice chlorophyll is removed from the extracted otherwise it might affect analysis.

3.SEPARATION: the separation and purification of plant constituents is mainly carried out using one or other or a combination of the chromatographic techniques.

(a) The first of this is Paper Chromatography. This is normally referred to as PC.
(b) Another one is Thin Layer Chromatography, referred to as TLC.
(c) Gas-liquid chromatography, GLC.

The choice of technique depends largely on the solubility properties and volatilities of the compounds to be separated.

Paper Chromatography is particular applicable to water soluble plant constitutes namely the carbohydrates, amino acids, nuclei acids, bases, organic acids and phenolic compounds.

Thin Layer Chromatography is successful in separating all lipid-soluble components i.e. the lipids, steroids, carotenoids, simple quinones and chlorophylls.
Gas-Liquid Chromatography finds its main-application with volatile compounds. e.g. jetty acids, moro and ses quiterpenes, hydrocarbon and sulfur compounds.

However, there is considerable overlap in the use of the above techniques. And often, a combination of PC and TLC or TLC and GLC may be the best approach for separating a particular class of plant compound.
One further technique which has fairly wide application in phytochemistry is Electrophoresis. This technique is only applicable to compounds which carry a charge i.e. amino acids, some alkaloids, amino acids and proteins.

4. IDENTIFICATION: it is necessary first to determine the class of compounds and then to find out which particular substance is within that class. The class of compound is determined from its response to colour test, its solubility and RF. Properties and its U. V. spectra characteristics.

Complete identification within the class depends on measuring other properties and then comparing this data with those in the literature. These properties include:

(1) Melting point (for solids)
(2) Boiling point (for liquids)
(3) Optical rotation.
(4) RF value which is mobility relative to front.
(5) RRT, which is the relative retention time

Equality information data on a plant substance are:

Spectre characteristics and this includes:

(i) Ultraviolet (UV)
(ii) Infra-red (IR)
(iii) Nuclear-Magnetic Resonance (NMR)
(iv) Mass Spectra Measurements (MS)

A known plant compound can usually be identified on the above basis.
After all these procedures, you identify the compound and then you compare the compounds from A with that of B.

You may find out that the compounds in species A may be similar to those of B. At times, they might be different in which case it is of taxonomic importance.

3.2 Ecological Evidence

Information on the ecology of flowering plants is basic to systematics in providing an understanding of (1) the distribution of taxa, (2) the variation within taxa, and (3) the adaptations of plants. In delimiting taxa, it is necessary for taxonomists to comprehend developmental responses of plants as distinguished from genetically fixed characters. Ecological studies have demonstrated that the character states of many morphological features are correlated with environmental factors such as light, moisture, and soil fertility. Ecology contributes to systematic interpretations of the evolutionary process by seeking environmental explanations for discontinuities in the structure, function and distribution of plants. Plant Ecologists examine ecotypic variation, edaphic specializations, pollination mechanisms, the effect of habitat on hybridization, plant-herbivore interactions, seed-dispersal mechanisms, ecology of seedling establishment, function of plant structures, and reproductive isolating mechanisms.

3.3 Physiological Evidence

Physiological and biochemical evidence is providing data of increasing importance to plant systematics. Of particular significance are data dealing with metabolic systems and biochemical pathways.

Recently, it has become apparent that a syndrome of anatomical and physiological features, related to a high-efficiency carbon fixation process, occurs in a large number of plants from tropical or warm temperate regions. This syndrome has been called Kranz syndrome, C_4-photosynthesis, or Hatch-Slack pathway. The most common pathway of carbon fixation is the Calvin-Benson cycle, or C_3 photosynthesis. In the algae, mosses, most ferns, gymnosperms, and many families of flowering of flowering plants, C_3-photosynthesis is the only known carbon fixation cycle. C_4-photosynthesis occurs in approximately 10 unrelated families of monocotyledons and dicotyledons. Crussulacean Acid Metabolism (CAM) has been found in both monocotyledon families and in dicotyledon families, and in ferns. CAM and C_4 both represent adaptations to arid climates. It was originally thought that the distribution of CAM would provide a useful taxonomic character; however, the random distribution of CAM has prevented it from being used in classification.

4.0 Conclusion

Taxonomic evidence for the establishment of classifications and phylogenies is gathered from a variety of sources. Because all parts of a plant at all stages of its development can provide taxonomic characters, data must be assembled from many diverse disciplines. The use of information from studies on comparative anatomy, embryology, palynology, cytogenetics, chemistry, and so on has greatly improved the modern classification of plants.

5.0 Summary

Phytochemistry is one of the more fashionable and rapidly expanding areas of plant taxonomy and seeks to utilize chemical information to improve the classification of plants. It has arisen as a major science in only the past 20 years.The subject of phytochemistry or plant chemistry has developed in recent years as a distinct discipline, somewhere in between natural product organic chemistry and plant biochemistry and is clearly related to both. It is concerned with the enormous variety of organic substances that are elaborated and accumulated by plants and deals with the chemical structure of these substances, their biosynthesis, turnover and metabolism, their natural distribution and their biological function.

Information on the ecology of flowering plants is basic to systematics in providing an understanding of (1) the distribution of taxa, (2) the variation within taxa, and (3) the adaptations of plants. In delimiting taxa, it is necessary for taxonomists to comprehend developmental responses of plants as distinguished from genetically fixed characters. Physiological and biochemical evidence is providing data of increasing importance to plant systematics. Of particular significance are data dealing with metabolic systems and biochemical pathways.

6.0 Tutor Marked Assignment (TMA)

a. List the various Sources of Taxonomic Evidence.

b. Discuss on Ecological Evidence as a Source of Taxonomic Evidence.

7.0 References/Further reading

Bessey, C.E.(1915). Phylogenetic Taxonomy of Flowering Plants, *Ann. Mo. Bot. Gard.*, 2: 109-164.
Core, E.L.(1955). *Plant Taxonomy*, Prentice-Hall, Englewood Cliffs, N.J., Pp. 9-61. (An excellent history of plant taxonomy).
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Unit 3: Sources of Variation

Contents

1.0 Introduction

The complexity and diversity of plant life is apparent among species and between individuals of the same species. This variation forms the basis of both evolution and classification. An understanding of the evolution of plants may be discovered by careful analysis of this variation. Systematists are confronted with variability in populations possessing three components: (1) developmental variation, (2) environmentally induced variation and (3) genetic variation.

2.0 **Objective:** At the end of the class, student s must be familiar and must have understood effectively how to use biosystematics to determine the complexity and diversity of plant life which is apparent among species and between individuals of the same species.

3.0 Main content

3.1. Developmental Variation

Adult plants are often strikingly different from the immature seedlings. This developmental variation that is genetically determined can cause confusion in the identification of flowering plants.

3.3. Environmental Variation

Plants are quite variable, and some species may vary by altering their pattern of growth in response to environmental differences. Phenoplasticity (change in appearance) is caused by such variables as light, water, nutrients, temperature, and soil. A classic example of a type of water-controlled variation known as heterophylly may be found among species of the aquatic plant arrowhead (*Sagittaria*). These plants have arrow-shaped leaves when emergent and long strap-shaped leaves when submerged. Similarly, the aqueous water buttercup (*Ranunculus aquatilis*) has dissected submerged leaves, but on the same stem will have lobed emergent leaves. Other environmental influences may produce variation in the sizes of many annuals. Chickweed (*Stellaria media*), for example, will reach only 3 centimetres in height in poor, dry soil but will exceed centimetres in rich, moist soil.

3.3 Genetic variation

The third type of variation in plants is genetic variation (genotypic variation). Genotypic variation, which is heritable, has two sources: (1) mutation and (2) gene flow and recombination. Mutation is a transmissible change in the hereditary materials. It is the ultimate source of variation in species and replenishes the supply of genetic variability. When broadly used, the term mutation includes both genic or point mutations and chromosomal mutations. By way of contrast, gene flow describes the exchange of existing genes among the populations within a species or, through interspecific hybridization, between populations of two distinct but related species. Recombination brings together via meiosis and fertilization the novel genes or alleles carried by different individuals and form a new single genotype, thus multiplying the possible number of genotypes in a population. Although mutation is the ultimate source of genetic variation, gene flow and recombination provide an immediate source of variability in sexually reproducing plants.

3.3.1. Gene Mutations

3.3.2. Chromosomal Mutations

3.3.3. Gene flow and Recombination

3.3.4. Reproductive Systems

4.0 Conclusion

By observing the diversity, structural complexity, and adaptative natures of plants, systematists have described taxa, developed classifications, and unraveled the processes of evolution. Biosystematists attempts to discover the mechanisms and processes in flowering plants that: (1) direct their evolution, (2) influence their variation patterns, and (3) cause speciation. Classical taxonomists emphasize the evolutionary end products and differences between taxa, often using biosystematics information sources in developing their classifications.

5.0 Summary

Adult plants are often strikingly different from the immature seedlings. This is a sign of developmental variation that is genetically determined and can cause confusion in the identification of flowering plants.Plants are quite variable, and some species may vary by altering their pattern of growth in response to environmental differences. Phenoplasticity (change in appearance) is caused by such variables as light, water, nutrients, temperature, and soil.Genotypic variation, which is heritable, has two sources: (1) mutation and (2) gene flow and recombination. Mutation is a transmissible change in the hereditary materials. It is the ultimate source of variation in species and replenishes the supply of genetic variability.

6.0 Tutor Marked Assignment (TMA)

a. What are the Sources of Variation?

b. What is Gene Mutations?

7.0 References/Further reading

Unit 4: Natural Selection

CONTENTS

4.0 Unit 4: Natural Selection

1.0 Introduction

In order for evolutionary change to occur, there must be a source of genetic variation that is, mutation or gene flow and recombination and a driving force. The prime force is called natural selection, and it is the most important of the evolutionary forces or processes. The consequence of natural selection is adaptation, or adjustment to the environment. Natural selection is the mechanism by which populations become modified in response to the environment.

2.0 Objective: At the end of the class, student s must be familiar and must have understood

effectively that there must be a source of genetic variation, i.e. mutation or gene flow which acts as the driving force in order for evolutionary change to occur.

3.0 Main content

3.1. Directional Selection

It operates in a unidirectional changing environment, that is, changes from moist to dry climate following a modification of the weather pattern.

3.2. Stabilizing Selection

This favours normal individual that is it eliminates variants, or deviations from the norm- and operates in a more or less constant environment.

3.3. Disruptive Selection

This is a divergent selection pressured in a heterogenous environment.

4.0 Conclusion

Natural selection operates by differential reproduction of certain genotypes. The favoured genotypes are those that have higher reproductive success and consequently contribute a disproportionate share of individuals to the succeeding generation. The adaptations of plants that permit them to live successfully in given environments given environments generally involve a combination and coordination of characters. Natural selection establishes and preserves favourable gene combinations ranging from flower colour to changes involving the habit of the plant.

5.0 Summary

In order for evolutionary change to occur, there must be a source of genetic variation that is, mutation or gene flow and recombination and a driving force. The prime force is called natural selection, and it is the most important of the evolutionary forces or processes. The consequence of natural selection is adaptation, or adjustment to the environment. Natural selection is the mechanism by which populations become modified in response to the environment.

6.0 Tutor Marked Assignment (TMA)

a. Define Natural Selection.

b. What are the types of Natural Selection?

7.0 References/Further reading

Bessey, C.E.(1915). Phylogenetic Taxonomy of Flowering Plants, Ann. Mo. Bot. Gard., 2: 109-164.

Core, E.L.(1955). Plant Taxonomy, Prentice-Hall, Englewood Cliffs, N.J., Pp. 9-61. (An excellent history of plant taxonomy).

Gardner, E.J. (1972). History of Biology, 3ed., Burgess, Mineapolis.

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Unit 5: Random Selection

CONTENTS

5.0 Summary
6.0 Tutor Marked Assignment (TMA)
a. Define Catastrophic Selection.
b. What is Neutrality Theory?
7.0 References/Further reading

1.0 Introduction

Theoretically, in the absence of natural selection, gene frequencies will remain relatively constant in natural populations. However, gene frequencies may fluctuate because of the random sampling of genes transmitted in each generation. This effect is greatest in small, isolated populations. It may be verified by tossing coins; that is, a few tosses may give a disproportionate number of heads and tails will be almost equal. Random change in gene frequencies resulting from sampling error between parents and their offspring is known as genetic drift.

2.0 Objective: At the end of the class, student s must be familiar and must have understood effectively the essence of Genetic drift and what led to the fluctuation of gene frequencies.

3.0 Main content

3.1. Neutrality Theory

The neutral theory asserts that alternative alleles at variable protein loci are selectively neutral. This does not mean that the locus is unimportant, only that the alternative alleles found at this locus are selectively neutral.

– Glucose-phosphate isomerase is an esssential enzyme. It catalyzes the first step of glycolysis, the conversion of glucose-6-phosphate into fructose-6-phosphate.
– Natural populations of many, perhaps most, populations of plants and animals are polymorphic at this locus, i.e., they have two or more alleles with di erent amino acid sequences.
– The neutral theory asserts that the alternative alleles are selectively neutral.

3.2. Catastrophic Selection

Catastrophic speciation: rapid speciation occurs, leading to genetic isolation with little or no morphological differentiation, but without polyploidy. All due to unknown conditions: mutators; environmental stress; all of which cause drastic chromosomal rearrangements.

4.0 Conclusion

Natural selection operates by differential reproduction of certain genotypes. The favoured genotypes are those that have higher reproductive success and consequently contribute a disproportionate share of individuals to the succeeding generation. The adaptations of plants that permit them to live successfully in given environments generally involve a combination and coordination of characters. Natural selection establishes and preserves favorable gene combinations ranging from flower color to changes involving the habit of the plant.

5.0 Summary

Theoretically, in the absence of natural selection, gene frequencies will remain relatively constant in natural populations. However, gene frequencies may fluctuate because of the random sampling of genes transmitted in each generation. This effect is greatest in small, isolated populations. It may be verified by tossing coins; that is, a few tosses may give a disproportionate number of heads and tails will be almost equal. Random change in gene frequencies resulting from sampling error between parents and their offspring is known as genetic drift.

6.0 Tutor Marked Assignment (TMA)

a. Define Catastrophic Selection.

b. What is Neutrality Theory?

7.0 References/Further reading

Core, E.L.(1955). Plant Taxonomy, Prentice-Hall, Englewood Cliffs, N.J., Pp. 9-61. (An excellent history of plant taxonomy).
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MODULE 4

Unit 1: Isolation and the Origin of Species

CONTENTS

1.0 Introduction

The present definitions of species stress the importance of genetic and morphological continuity within species and the discontinuity among closely related species.

2.0 Objective: At the end of the class, student s must be familiar and must have understood effectively how to use isolating mechanisms to prevent interbreeding of closely related taxa.

3.0 Main content

3.1. Geographical Isolation

This exists between two species whose respective geographical ranges are separated by gaps greater than the normal radius for dispersal of their pollen and seed.

3.2. Ecological Isolation

This results from differentiation in habitat requirements. Although plants might live in the same region, interbreeding is prevented because they grow in different habitats.

3.3. Ethological Isolation

This is a very important isolating mechanism in animals. When interpreted to include plant reproduction, it involves the flower-visiting behavior of some insects and birds.

3.4 Speciation

According to the theory of natural selection, speciation is the creation of new species by genetic modifications of previously existing species, so the resulting organisms can no longer successfully mate and produce fertile offspring. Consequently, the most modern definition of species includes a retrieval of the genetic understanding from ancestral parents into a biological species concept, which states that a species is a population that can interbreed in nature and produce fertile offspring. New species have three principle mechanisms describing their formation, each of which involves reproductive isolation:

3.5 Darwinian Gradualism versus Punctuated Equilibra

More than a century ago, Charles Darwin believed he had the answer to what has brought the astounding diversity of plant and animal. His answer was an eloquently simple one: Darwin suggested that if the fossil record were examined, it would show that today's plants and animals had emerged as survivors during a period of environmental change. The predecessors of the present-day flora and fauna were less able to cope with new or changing environments and produced fewer offspring; the unfit genotypes were eliminated or reduced by natural selection.

4.0 Conclusion

The systematists realize that an array of genetic variation may exist within the species. Infraspecific taxa are based on incomplete morphological separation as reinforced by ecological and geographical isolation.

5.0 Summary

The present definitions of species stress the importance of genetic and morphological continuity within species and the discontinuity among closely related species.

6.0 Tutor Marked Assignment (TMA)

7.0 References/Further reading

Core, E.L.(1955). Plant Taxonomy, Prentice-Hall, Englewood Cliffs, N.J., Pp. 9-61. (An excellent history of plant taxonomy).
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Unit 2: Hybridization

CONTENTS

1.0 Introduction

The role of hybridization in evolution has been a controversial topic in systematics. Linnaeus suggested a hybrid origin for several plant species. In the late 1800s and early 1900s, it was believed that hybridization could be the starting point for new species. Until the early 1950s many floristic botanists were reluctant to recognize hybrids in nature. Today plant systematists regard interspecific hybrids to be common in many genera.

2.0 Objective: At the end of the class, student s must be familiar and must have understood effectively the increased appreciation of the role of hybridization in the adaptation and evolution of plant populations.

3.0 Main content

3.1. Natural Hybridization

This is more frequent in perennial plants than in annuals. The perennial nature ensures that occasional hybridization between species will not interfere with their existence, since the genotypes are preserved by the perennial habit. Therefore, there has not been strong selection against hybridization in perennials.

3.2. Introgressive Hybridization

Following natural hybridization, first generation hybrids typically backcross to one of the parental species. There are several reasons for this. More plants with the parental group.

Fertility of the hybrids may be lower, so that they produce less-viable pollen than do the parents. Therefore, the most common effect of interspecific hybridization is successive backcrossing of hybrids with the parents. This results in the reversion of hybrid offspring toward the parental types.

4.0 Conclusion

The role of hybridization in evolution has been a controversial topic in systematics. Linnaeus suggested a hybrid origin for several plant species. In the late 1800s and early 1900s, it was believed that hybridization could be the starting point for new species. Until the early 1950s many floristic botanists were reluctant to recognize hybrids in nature. Today plant systematists regard interspecific hybrids to be common in many genera.

5.0 Summary

The role of hybridization in evolution has been a controversial topic in systematics. Linnaeus suggested a hybrid origin for several plant species. In the late 1800s and early 1900s, it was believed that hybridization could be the starting point for new species. Until the early 1950s many floristic botanists were reluctant to recognize hybrids in nature. Today plant systematists regard interspecific hybrids to be common in many genera.

6.0 Tutor Marked Assignment (TMA)

a. What is Natural Hybridization?

b. What is Introgressive Hybridization?

7.0 References/Further reading

Core, E.L.(1955). Plant Taxonomy, Prentice-Hall, Englewood Cliffs, N.J., Pp. 9-61. (An excellent history of plant taxonomy).

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Unit 3: Polyploidy and Apomixis

CONTENTS

a. What is Polyploidy?
b. What is Apomixis?
7.0 References/Further reading

1.0 Introduction

Polyploidy: multiple sets of chromosomes in an organism (e.g. tetraploid, octaploid). Each set of chromosomes is capable of independent variation: mutation, recombination events. The resulting organism is in most cases incapable of forming fertile offspring with members of the ancestral diploid population. It has therefore acquired instant reproductive isolation while Apomixis is when the genetic cause of apomixis is identified, apomixis could be applied to plant breeding programs as a means of permanently fixing hybrid vigor, or immediately capturing desirable genotypes.

2.0 **Objective**: At the end of the class, student s must be familiar and must have understood effectively that polyploidy is the multiplication of the chromosome set or genome and apomixis is the replacement of sexual by asexual reproduction.

3.0 Main content

3.1. Polyploidy

Polyploidy: multiple sets of chromosomes in an organism (e.g. tetraploid, octaploid). Each set of chromosomes is capable of independent variation: mutation, recombination events. The resulting organism is in most cases incapable of forming fertile offspring with members of the ancestral diploid population.

It has therefore acquired instant reproductive isolation. If it is capable of reproducing, and finding an ecological niche it can exploit, a new species has been formed. Example: In the foxtail species-group: ancestral diploid green foxtail hypothesized to have hybridized with unknown Setaria sp., resulting progeny were fertile, polyploid, and gave rise to yellow and giant foxtail (both polyploid), which subsequently found niche not fully exploited by green foxtail

3.2. Apomixis

Apomixis is found in over 300 species of at least 35 different plant families (Bashaw & Hanna, 1990). Scientists and geneticists have studied the two broad categories of apomixis—gametophytic and sporophytic—because of their widespread occurrence and potential usefulness in plant breeding. The genetic analysis of apomixis provides researchers with unique obstacles because of ploidy levels, lack of sexual progeny, lethality, and accurate identification and classification of progeny.

Methods of accurately classifying progeny in genetic studies are being identified and currently several methods are available to researchers, none of which provide a complete picture. These include phenotypic analysis, cytoembryological study, methods, and a variety of markers. A combination of these methods may be used to accurately classify progeny. When the genetic cause of apomixis is identified, apomixis could be applied to plant breeding programs as a means of permanently fixing hybrid vigor, or immediately capturing desirable genotypes. Several theories of the genetic control of apomixis have been put forth. Studies suggest one major gene or linkage group with the possibility of modifying genes. None of the theories have been proven to be completely satisfactory due to the lack of inheritance data, inaccurate progeny classification, and recombination.

4.0 Conclusion

Polyploidy: multiple sets of chromosomes in an organism (e.g. tetraploid, octaploid). Each set of chromosomes is capable of independent variation: mutation, recombination events. The resulting organism is in most cases incapable of forming fertile offspring with members of the ancestral diploid population.It has therefore acquired instant reproductive isolation. If it is capable of reproducing, and finding an ecological niche it can exploit, a new species has been formed. Example: In the foxtail species-group: ancestral diploid green foxtail hypothesized to have hybridized with unknown Setaria sp., resulting progeny were fertile, polyploid, and gave rise to yellow and giant foxtail (both polyploid), which subsequently found niche not fully exploited by green foxtail. Apomixis is found in over 300 species of at least 35 different plant families (Bashaw & Hanna, 1990). Scientists and geneticists have studied the two broad categories of apomixis—gametophytic and sporophytic—because of their widespread occurrence and potential usefulness in plant breeding. The genetic analysis of apomixis provides researchers with unique obstacles because of ploidy levels, lack of sexual progeny, lethality, and accurate identification and classification of progeny. Methods of accurately classifying progeny in genetic studies are being identified and currently several methods are available to researchers, none of which provide a complete picture. These include phenotypic analysis, cytoembryological study, methods, and a variety of markers. A combination of these methods may be used to accurately classify progeny. When the genetic cause of apomixis is identified, apomixis could be applied to plant breeding programs as a means of permanently fixing hybrid vigor, or immediately capturing desirable genotypes. Several theories of the genetic control of apomixis have been put forth. Studies suggest one major gene or linkage group with the possibility of modifying genes. None of the theories have been proven to be completely satisfactory due to the lack of inheritance data, inaccurate progeny classification, and recombination.

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Polyploidy: multiple sets of chromosomes in an organism (e.g. tetraploid, octaploid). Each set of chromosomes is capable of independent variation: mutation, recombination events. The resulting organism is in most cases incapable of forming fertile offspring with members of the ancestral diploid population. It has therefore acquired instant reproductive isolation while Apomixis is when the genetic cause of apomixis is identified, apomixis could be applied to plant breeding programs as a means of permanently fixing hybrid vigor, or immediately capturing desirable genotypes

6.0 Tutor Marked Assignment (TMA)

a. What is Polyploidy?

b. What is Apomixis?

7.0 References/Further reading

Core, E.L.(1955). Plant Taxonomy, Prentice-Hall, Englewood Cliffs, N.J., Pp. 9-61. (An excellent history of plant taxonomy).

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Unit 4: Specimen Preparation and Herbarium Management I

CONTENTS

1.0 Introduction

The word ‘herbarium’ was originally coined to a book about dried medicinal plants. Herba in Latin refers to slender weak-stemmed plants. A collection of herbs came to be known as herbarium. Tournefort (c.1700) used the term ‘herbarium’ for the collection of dried plants, the method which was earlier known as hortus siccus. Luca Ghini (1490-1556), the Professor of Botany at the University Bologna, Italy is thought to have been the first botanist to dry plants under pressure and mount them on paper, and recommended this method of preservation. By the time of Linnaeus, the technique was widely known in Europe.

The present concept of herbarium collections is a net result of the efforts of the botanists all over the world. The herbaria also include, a part from plant specimens, the seeds, wood sections, pollen, micro slides, fluid preserved flowers, fruits etc. Herbaria keep all categories of plants

2.0 **Objective:** At the end of the class, student s must be familiar and must have understood effectively that the collections of plant specimens are essential for taxonomic research and are fundamental to study and training in plant systematics.

3.0 Main content

3.1 Index Herbariorum

Index Herbariorum is a detailed directory of public herbaria of the world and the staff and plant specialists associated with them. Each herbarium in the Index is assigned an official acronym (code) that is used as a standard reference for citation. It consists of the herbarium acronym, institution, city, state, staff member, correspondent, and research specialty. It is a joint project of the International Association for Plant Taxonomy (IAPT) and The New York Botanical Garden (NYBG).

3.2 Types of Herbaria

International Herbaria: These are very large herbaria often with more than 4 million specimens and have global representation of taxa, i.e. specimens collected from different countries. Most of these herbaria were founded early in the history of formal taxonomy (c.1550-1800 A.D.) and have grown to their present size over the years. They are rich in type specimens. They provide on loan specimens to other reputed herbaria on request. e.g. Kew Herbarium, Royal Botanic Gardens, Surrey, England.

National Herbaria: Generally these herbaria contain mainly of the plants of the country concerned and may also cover the plant material of neighbouring countries. As far as possible, the representatives of all taxa (of different families and genera) of the country are kept in these herbaria. Most of these herbaria are old and possess good number of collections e.g. Central National Herbarium, Howrah (Kolkata), India, known as CAL. National herbaria have a significant role in writing national and regional floras. Madras Herbarium (MH) is maintained by Botanical Survey of India, Southern Circle at Coimbatore, Tamil Nadu.

Local Herbaria: These herbaria deal with a region in a country such as State, district or even a small area like a nature reserve. They relatively have short history and contain a few or no type specimens. Local herbaria are useful in the presentation of local floras (e.g. district floras). They are of much help in catering the needs of local educational and research institutions.

With the advent of Information Technology, new techniques are adopted for the fast retrieval of herbarium specimen information. This includes the micro-herbaria in the form of photographs and the electronic herbaria in the form of digitized databases.

3.3 FUNCTIONS OF A HERBARIUM

(1.) Herbarium is a conservatory of plant material and data.
(2.) Herbarium serves as a fundamental source in identification of plants.
(3.) Herbarium helps in teaching and research.
(4.) Herbarium serves as a source for biodiversity and other ecological habitat information.
(5.) Herbarium serves as a repository of historic collections.

(6.) Herbarium serves as a source for search of new genetic material, medicinal plants,etc.

(7). Herbarium helps in developing computer databases on plant resources.

3.4 IMPORTANT HERBARIA OF THE WORLD

Herbaria are usually associated with universities, institutions, museums and botanical gardens. As stated earlier, the first herbarium in the world was conceived in 1570 in Bologna, Italy by Luca Ghini. Presently, there are about 4000 recognized major herbaria in over 165 countries. An estimated 300 million specimens are housed in herbaria of different countries in the world. Of these, over 50% of the specimens are housed in herbaria of Europe alone.

The world's largest herbarium is at Paris with record holdings of about 9 million specimens. The second largest is Kew Herbarium in the Royal Botanic Gardens at Kew, London which harbour over 7 million specimens including 3,50,000 type specimens.

4.0 Conclusion

Collections of plant specimens are essential for taxonomic research. They circumscribe species and document their variability, they are the prime sources for floristic studies, and they are vouchers for experimental investigations. Plant materials must be carefully selected, prepared, and preserved, since herbarium specimens become a permanent record for later investigators to examine.

5.0 Summary

Ideally, the best specimen for identification and research is an intact and complete plant. Attempts to identify a specimen from a single flower or leaf usually fail. Such specimens have little or no scientific value.

6.0 Tutor Marked Assignment (TMA)

a.What are the functions of Herbaria?

b.What is the Field Notebook?

7.0 References/Further reading

Bessey, C.E.(1915). Phylogenetic Taxonomy of Flowering Plants, Ann. Mo. Bot. Gard., 2: 109-164.

Core, E.L.(1955). Plant Taxonomy, Prentice-Hall, Englewood Cliffs, N.J., Pp. 9-61. (An excellent history of plant taxonomy).

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Unit 5: Specimen Preparation and Herbarium Management II

CONTENTS

1.0 Introduction

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The present concept of herbarium collections is a net result of the efforts of the botanists all over the world. The herbaria also include, a part from plant specimens, the seeds, wood sections, pollen, micro slides, fluid preserved flowers, fruits etc. Herbaria keep all categories of plants

2.0 Objective: At the end of the class, student s must be familiar and must have understood effectively that the collections of plant specimens are essential for taxonomic research and are fundamental to study and training in plant systematics.

3.0 Main content

3.1 PREPARATION OF HERBARIUM

Collection, poisoning and drying the specimen:

The plants which you are interested in should be fresh and not wet (apart from plants which live in aquatic environments of course). So you keep away from old or damaged plants as long as you can find fresh ones of the same kind. When you pick up plants or twigs from the natural environment, keep in mind that you will have to fix up all of them once you return home, and you will have to classify them too, in order to achieve scientific value to your collection. You will have to dissect and sections of flowers during your identification process. So, you pick some flowers of each species when you collect. Otherwise, you will use every flower collected for the identification or to simply give up the job. Some plants have short lived flowers which are deliquescent and will drop in pieces unless picked early in the day and immediately pressed. Before putting your specimens in the collection bag you should carefully remove all the insects, spider-webs and foreign bodies attached to your specimens.

To avoid deterioration and damage to collected specimens, the specimens are duly poisoned. Poisoning kills the plants and prevents the formation of abscission layer and thereby the leaves, flowers and fruits will be intact with the specimen (twig) will not be getting detached from the plant. The poisoning is generally done by dipping the whole plant in a saturated solution of mercuric chloride in ethyl alcohol (usually 20 gm in a litre of alcohol). The plant is again put between the blotters in the presser till it gets completely dried. Mercuric chloride is corrosive for metals, and hence enamel trays and disposable gloves are used. Lauryl Pentachlorophenate (LPCP) is also used (3.75% in white spirit) for poisoning the specimens. It is safer than mercuric chloride and leaves the plant features more intact. The solution can also be applied to mounted specimens by spraying.

Then, the specimens are spread out for pressing and drying. It is important that the plants are put under sufficient pressure, otherwise more time will be required to achieve a good desiccation, besides they could be damaged by dampness and moulds. Every specimen in the press must be linked with the data in the field note book. Detailed notes should be entered in the field note book at the time of collection in the field itself.

The best one can do is to use a tag for each specimen. Bulky plat parts can directly be placed in contact with corrugated material to speed up drying. If no such material is available, keep the filled press size small. Instead of newspapers, use blotting papers. Anyway you must always be sure to have enough paper at home. During long field trips, a large amount blotting paper is required. You may use newspapers, which are cheap and readily available. Once a specimen has become dry and stiff, it is ready for mounting.

Some particular group of plants must be specially treated to achieve a good drying and durability to specimens. Cacti and the succulent plants must loose their high percent water before being put to dry. To that, they must be placed below some blotting sheets, on them you will rapidly pass a hot iron. That must be done a few times, always changing the blotting paper. Before the iron treatment, the softening of the cactus can be aided by the immersion in boiling water for half a minute, taking care of avoiding the immersion of the flowers. Instead of boiling, one can employ dilute acetic acid or strong alcohol or formalin (1.5 parts formalin, 1 part water). Some plants have tubers or bulbs and they must be treated before drying. As with cactus plants, a few minutes keeping in boiling water softens the plant parts. Remember to immerse in water only the roots that you have to treat.

A well-designed field notebook has numbered sheets in printed form with standard pro-forma for entering field data. Usually a field note book has 100 leaves and the pages are serially numbered (called field numbers) to be suffixed to the collector’s name, when cited.

3.2 MOUNTING AND LABELING

Collected, poisoned, pressed and dried plant specimens are now ready for mounting on herbarium sheets. Fixing the processed plant specimen on herbarium sheet is called mounting. A standard herbarium sheet is 28 cm (breadth) x 42 cm (length) and usually made up of heavy long-lasting white handmade paper or thick sheet.
The sheet is usually stiff and flexible so as to prevent damage during the handling of mounted specimens. The common technique is pasting specimens to sheet with glue (usually Gum Arabic or locally called as Vajram in local Andhra markets). The glue paste is made by adding flakes of glue to boiling water, gradually and in small quantities, till it makes a thin paste. As the paste become thick and hard on cooling, the vessel containing glue should be kept on low heat during the mounting work. Small quantity of mercuric chloride or thymol crystals or copper sulphate may be added to the glue as insect repellent. In some cases, when glue is not available or not considered desirable, fevicol can be used. Never use cellotapes to mount/stick the specimens. It is advised to have a paper bag/pouch attach to the herbarium sheet to keep any seed/fragments detached from the specimens.

3.3 ARRANGEMENT AND MANAGEMENT OF HERBARIUM

The mounted, identified and accessioned herbarium sheets are incorporated in specially prepared almirahs with pigeon holes. All the sheets of the same species are placed in lighter covers called the 'species cover or folder’ and all the species (with species covers or folders) belonging to one genus are placed in one or more folders of heavy paper, called the 'genus cover'. The genus and species covers are useful in the protection of specimens, easy reference, and for convenience in handling. The pigeonhole in which the bundles of a new family start is marked by a fixed label or by hinged flap-board separator cardboard. The name of the family is printed or written on this in bold letters.

The specimens are usually arranged in the herbarium according to some recognized system of classification. In many Indian herbaria, the order and numbering of families and genera of Magnoliophyta is according to Bentham and Hooker's classification.

All duplicates of the specimens other than those mounted on herbarium sheets, are maintained as stock. The duplicates should be maintained separately, not in the main herbarium rooms. These are useful for research in palynology, anatomy, etc.
An index-card system should be maintained in the herbarium for easy reference to locate the species of interest. These provide an abstract of the specimens preserved in that herbarium. The index cards should contain information about the specimens species-wise–field number, dates of collection, localities of collection, names of collectors, etc. Now-a-days, computerized databases are being maintained in several herbaria.

The herbarium specimens are generally in dried condition and hence are not prone to any damage due to fungi, bacteria, but may be easily attacked by pests like silverfish, beetles, etc. The pest control can be done by heating the sheets at 60 oC for 4-8 hr in heating cabinet or kept in deep-freezers where the temperature maintained is in the range of -20 to -60^{o}C. Microwave ovens are also used for pest control. Insect repellent chemicals such as Para dichlorobenzene (PDB) and naphthalene balls are used for pest control. Usually these are powdered and sprinkled on sheets or else the balls are put in small muslin cloth bags and kept in pigeon holes. Since these chemicals are toxic, care should be taken. Further PDB should not be used along with naphthalene.

Regular fumigation is done in herbaria for killing pests in mounted as well as unmounted duplicate specimens. This process involves use of any one of the volatile poisonous liquids like methyl bromide, carbon disulphide or carbon tetrachloride. A mixture of ethylene dichloride (3 parts) and carbon tetra chloride (1 part) is commonly used in many herbaria. These are placed in small saucers or petri dishes in each herbarium case and the cases are kept closed for about a week. Till then, the herbarium is not open for users.

Any dried material that enters a herbarium must be subjected to the process of decontamination. It is done by heating, fumigation, deep freezing or by using insect repellents.

3.4 GENERAL INSTRUCTIONS FOR HERBARIUM USERS

(1.) Do not shuffle the sheets kept in folders. They are all arranged in a sequence for the users.

(2.) Store the specimens properly and perfectly. Do not crowd too many specimens into a box or in a pigeon hole. Specimens are brittle and easily get damaged.

(3.) Do not write anything on herbarium sheets.

(4.) Do not lay books or other heavy objects on specimens.

(5.) No flower and fruit is to be taken for dissection from herbarium sheets. Such material can be taken and studied from stock, or spared in folder on sheet.

(6.) Those specimens which need care should be brought to the notice of the herbarium curator.

(7.) While handling, full bundles should be taken out form the racks; pulling one or more sheets from a bundle will surely damage the specimens.

(8.) Putting bundles again in the racks after use should be done with extreme care and order.

(9.) Specimens should not be kept on tables for longer periods as they may be exposed to infection by pests.

(10.) Almirahs should be closed after taking the bundles and keeping them back.

(11.) Smoking is strictly prohibiting in the herbarium premises.

(12.) If any incorrect identification is there, it can be brought to the notice to the curator of the herbarium. An expert will make the correction on a ‘Determinavit slip’.

4.0 Conclusion

Collections of plant specimens are essential for taxonomic research. They circumscribe species and document their variability, they are the prime sources for floristic studies, and they are vouchers for experimental investigations. Plant materials must be carefully selected, prepared, and preserved, since herbarium specimens become a permanent record for later investigators to examine.

5.0 Summary

Ideally, the best specimen for identification and research is an intact and complete plant. Attempts to identify a specimen from a single flower or leaf usually fail. Such specimens have little or no scientific value.

6.0 Tutor Marked Assignment (TMA)

a. What are the challenges facing Herbaria?

b. What are Herbarium Ethics?

7.0 References/Further reading

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