COURSE CODE: *PBS 503*

COURSE TITLE: *Course evolution and taxonomy*

NUMBER OF UNITS: *2 Units*

COURSE DURATION: *2 hours per week*

COURSE DETAILS:

Course Coordinator: Dr. Isaac Oludayo Daniel
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COURSE CONTENT:

Theory of evolution. Mechanics of crop evolution. Roles of hybridization recombination and natural selection in crop evolution. Isolation mechanism. Modes of speciation. Concepts of primary and secondary centers of origin. Origin of commonly cultivated crops. Genetic variation in populations. Genetic drift. An introduction to the principles of taxonomy, plant nomenclature, succession, mechanism of survival.
Practicals: A survey of crop species and their wild relatives. Consideration of crop varieties and how they fit into a species. Collection of various species within a genus and seeing how they relate to each other.

COURSE REQUIREMENTS:

This is a compulsory course for all 500 level PBST students. All registered students must have minimum of 70% attendance to be able to write the final examination

READING LIST:

1. Observed Instances of Speciation by Joseph Boxhorn. Retrieved 28 October 2006.
2. *J.M. Baker (2005). "Adaptive speciation: The role of natural selection in mechanisms of geographic and non-geographic speciation". Studies in History and Philosophy of Biological and Biomedical Sciences 36: 303–326.* doi:10.1016/j.shpsc.2005.03.005. available online
3. Katharine Byrne and Richard A Nichols (1999) "Culex pipiens in London Underground tunnels: differentiation between surface and subterranean populations"
4. *Matthew L. Niemiller, Benjamin M. Fitzpatrick, Brian T. Miller (2008). "Recent divergence with gene flow in Tennessee cave salamanders (Plethodontidae: Gyrinophilus) inferred from gene genealogies". Molecular Ecology 17 (9): 2258–2275.* available online
5. Ridley, M. (2003) "Speciation - What is the role of reinforcement in speciation?" adapted from *Evolution* 3rd edition (Boston: Blackwell Science) tutorial online

6. Hiendleder S., *et al*. (2002) "Molecular analysis of wild and domestic sheep questions current nomenclature and provides evidence for domestication from two different subspecies" *Proceedings of the Royal Society B: Biological Sciences* **269**:893-904
7. Nowak, R. (1999) *Walker's Mammals of the World* 6th ed. (Baltimore: Johns Hopkins University Press)
8. *Rice, W.R. and G.W. Salt (1988). "Speciation via disruptive selection on habitat preference: experimental evidence". The American Naturalist 131: 911–917.* doi*:*10.1086/284831.
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11. *W.R. Rice and E.E. Hostert (1993). "Laboratory experiments on speciation: What have we learned in forty years?". Evolution 47: 1637–1653.* doi*:*10.2307/2410209.
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13. University of Rochester Press Releases
14. *Masly, John P., Corbin D. Jones, Mohamed A. F. Noor, John Locke, and H. Allen Orr (September 2006). "*Gene Transposition as a Cause of Hybrid Sterility in Drosophila*".* Science *313 (5792): pp. 1448–1450.* doi*:*10.1126/science.1128721. PMID 16960009.
15. Minkel, J.R. (September 8, 2006) "Wandering Fly Gene Supports New Model of Speciation" *Science News*
16. *Coyne, J. A. & Orr, H. A. (2004). Speciation. Sunderlands, Massachusetts: Sinauer Associates, Inc.* ISBN 0-87893-089-2.
17. *Grant, V. (1981). Plant Speciation, 2nd Edit., New York: Columbia University Press.* ISBN 0-231-05113-1.
18. Mayr, E. (1963). *Animal Species and Evolution*. Harvard University Press. ISBN 0-674-03750-2
19. *White, M. J. D. (1978). Modes of Speciation. San Francisco, California: W. H. Freeman and Company.* ISBN 0-716-70284-3.
20. *Avers, Charlotte (1989), Process and Pattern in Evolution, Oxford University Press*
21. *L.L. Cavalli-Sforza and A.W.F. Edwards (Sep., 1967). "*Phylogenetic analysis: Models and estimation procedures*". Evol. 21 (3): 550–570.* doi*:*10.2307/2406616.
22. Simpson, George Gaylord *(1967). The Meaning of Evolution (Second ed.), Yale University Press*

LECTURE NOTES

LECTURE 1: Theory of evolution

1. Evolution is the scientific idea of the gradual development of the various types of plants, animals etc from fewer a simple to a more complex ones.
2. Evolution is a gradual change in development of organisms.
3. Evolution is an example of basic concepts of biology. It is a process that has produced the fantastically diverse array of organisms that are alive today. From the primitive

particulate aggregate of organic molecules that arise over several billion years ago to the exceedingly complex and highly integrated multi-cellular organisms of the present.

4. Evolution can be seen as a modeling force, which are more specifically natural selection.
5. Edger Anderson (960) wisely put evolution "as the origin of cultivated plant" as a process not an event" and by this he certainly must have meant that the evolution of plant species did not cease, but on the contrary becomes more intense and diversified.
6. Darwin (1868) defined evolution as descent with modification. Modification may result from the differential success in reproduction by individuals possessing different heritable characteristic.
7. Evolution can also be seen as a change in the genetic composition of a population.

The needs of the people give rise to evolution which give rise to the modification in different types of organisms, and the various forces interaction that are involved make the subject become more complex Many scientists and people believe that evolution occurs and still occurring and strongly contributes to diversity of existing organisms.

Diversity: Is the condition of being different or having differences.

Descent: family origin of the stated type. i.e Ayola is a yoruba descent.

Similar organisms are closely related by descent. In general, the more closely related two groups are the more similarity is there between then and vice versa.

Therefore, the central theme of evolution is that all existing organisms are descendant of the types of simple primitive organisms, that first occurred several billion of years ago. **2.0. THEORY OF EVOLUTION**

Darwinian theory of evolution, (1868).

Many scientists have proved the theory of evolution but a comprehensive and convenience prove come from Darwin. His careful and objective collection and compilation of evidences indicated that the species have changed and do change. He was able to present a very convincing, logical, and convenience explanations for the occurrence of these changes, i.e. natural selection

Though Darwin was not the first to introduce the concept of natural selection but he was the first to fully comprehend the relationship between natural selection and heritable change in a population.

The basic tenants of Darwinian Theory of evolution can be summarized as follow.

1. The number of individuals in any population tends to increase geometrically when the condition permits the survival of all progenies. There is no exception to this rule that organic beings are naturally increased at so high rate that if not destroyed the earth will soon be covered by a progeny of a single pair. **(Individual in population increase geometrically).**
2. The potential for rapidly increase is seldom realized in the case of every species. Many different pairs acting at different periods of life and during different seasons, or sometimes year. **(potential for rapid increase is seldom)**
3. Darwin deduced from this fact that a competition or struggle for survival occurs in which many individuals are eliminated, as more individuals are produced that can possibly survive there must in every case be a struggle for existence. **(Competition or struggle for survival).**
4. Variation in the form of individual differences exists in every species or populations. Individual differences are of highest important as they are often inherited. Evolution of organisms depends on variability within and between the species existing in natural conditions and the variability created by man. **(Variation exists in species/population**)
5. From the observed differences between individuals as well as close related variety. Darwin deduced that elimination processes are selective. The surviving one are considered to be more fit, but fitness doesn't define in the limited sense of the organism relative ability to struggle to recompletes for food, space or simply by

chances of escaping predation and disease. Darwin analyzed that fitness is best defined as the relative capacity to live offspring behind. **(Elimination processes are selective).**

6. Evolution is a gradual change in the hereditary make-up of the species. **(Evolution is a gradual change).**

However, the modern ideas of evaluation include several features that were not part of Darwin theory.

They have various names e.g.

1. Modern Synthesis
2. The Neo-Darwinism Synthesis
3. Neo- Darwinism

In these syntheses, natural selection is still the model force but our knowledge about particulate nature of things enables one to understand more fully the origin of variation by mutation. The preservation of conceived variation in different organisms and in the shift of genes by genetic recombination, so that new combinations are always available for natural selection to act upon.

Evaluation can be seen as 2-part process:

1. The origin of variation
2. The modification of the variation by natural selection

LECTURE 2: Evolution of cultivated plants

The evolution of crop plants has given rise to more diversity and of a more complex nature that can be seen in any comparable group of wild plants.

As Edger Anderson (1960) so widely put it "The origin of a cultivated plants is a process, not an event" and by this he certainly must have meant that evolution of a plant species did not cease, but certainly become more intense and diversified, once it had been domesticated

The origin, the first home of the plants most useful to man and which have accompanied him from the remotest epochs, is a secret as impenetrable as the dwelling of all our domestic animals.

For agriculture to begin, the Candolle thought that the following conditions should be present

1. A suitable plant should be available
2. The climate should not be too rigorous
3. There should be security and a settled mode of living
4. There should be a pressing need for food, such as insufficient game, a restricted terrain (such as enclosed mountain valleys) or no abundant plant that was there for the picking.

The contributions of N.I. Vavilov to crop plant origins.

N.I Vavolov, a Russian (1987-1941), began his studies of crop plants with the very practical purpose of breeding new varieties for the widely differing ecological conditions of the Soviet Union. To do this, he felt it necessary to explore the total genetic diversity of crop plants throughout the world, as well as that of related wild species.

Before Vavilov's time, plant breeders were content to make crosses and selections based on local varieties, rather than of those from different areas of the world. The collection of living specimens, which were brought back and evaluated in laboratories and in sub-station in different parts of the well-know research work on plant breeding that, has since been done. For the first time, plant breeders began to look at the genetic diversity of our ancient crop plants as well as related wild species. Very detailed morphological and cytogenetic studies often helped classify the taxonomy of a species very considerably.

Vavilov showed that cultivated species, during the course of their dispersion from their areas of origin, had become differentiation into distinct, morphological, ecological, and geographical groups. Students of the genetics and ecology of cultivated plants then, as now, were interested particularly in Vavilov's agro ecological groups, this classified the multiplicity of crop plant variants on an eco-geographical basis, thus enabling breeders to choose materials with a greater like hood of success in a breeding programme (Vavilov, 1957).

Vavilov described plant breeding as evolution directed by the will of man. Also Frankel defined plant breeding as genetic adjustment of plant to the genetic of time.

GENETIC BASIS FOR EVOLUTION OF CULTIVATED PLANTS

Four main methods have been identified for transforming cultivated plants from their wild progenitors.

1. Mendelian variation by mutation of genes
2. Interspecific hybridization
3. Polyploidy
4. Introgression

Mendelian variation by mutation of genes: According to Darwin, variation is mainspring of evolution. Variation arise in natural population and then nature selects the adapted individuals. Mutation includes only the hereditary changes that involve alterations in genes. Mutations are detected because they bring about phenotypic changes in an organization. Many traits and flowers of commercial use arose due to somatic mutation. E.g golden delicious apples arose from somatic mutation only a few twigs bore such apples and the vegetative propagation of these twigs resulted into a clone of golden delicious apples.

A simple gene mutation is *Pisum sativum* changes in seed coat colour from green to white and flower colour from red to white. Other crops that are product of mutation are core, sugar beet etc.

N. B. ***A clone*** *is a vegetative materials used as a variety for continuation. A variety is a group of plant within a spp with identical properties or characteristics.* ***Strain*** *is a group of plant within a variety with more identical properties or characteristics*

Interspecific hybridization: distantly related speciesp have contributed little to hybridization except through introgression or well accompanied by alloploidy.

N.B. **Introgression** is transfer of genetic materials from one species to another.

Alloploidy: Is a situation where the genotype of an organism having two different genomes.

B-A- Haploid

BB-AA- Diploid

BBB-AAA- Triploid

BBBB- AAAA – Tetraploid

N.B. **Germplasm**: is the sum total of genetic materials in a spp.

The reasons are:

1 Crossing is difficult because the gene number are not the same

2 The hybrid is sterile AA x BB

(A) (B)

F_1--AB – homologous chromosome

3 segregation production – are usually inferior to their parents.

Polyploidy :. this has been very useful in evolution. About 40% of all species of flowering plants are polyploids and one would therefore expect to find the same phenomenon occurring quite frequently in crop plant also. It is often stated that polyploidy occurs more frequently in cultivated than it does in wild species.

Induced polyploidy is used by plant breeders for improving yield especially where luxuriant vegetative growth is useful as in fodders. On many occasions, man has inadvertently selected and multiplied polyploidy materials.

Table 1: Levels of ploidy in certain widely grown species of field and tree crops

Diploid	Polyploids
Almond	Apple (2x, 3x)
Cocoa	Bananas (2x,3x,4x)
Coconut	Cassava (4x)
Cocoyam	Coffee (2x,4x)
Maize	Cotton (2x,4x)
Oilpalm	Peanut (4x)
Pineapple	Tobacco(4x)
Rice	Wheat(2x,4x,6x)
Tea	Yam (variable)
Tomato	
Cabbage	
Barley	
Chicken pea	
Etc	

Polyploidy is thus a source of variation and helps in evolution. More recently, allopolyploid has been used by plant breeders to obtain vital habit from one species to another.

Origin of many species and their inter-relationships have been evident due to studies on unto and allopolyploid. Genome is the basic number of chromosomes of a species and is normally haploid. Every production of meiosis is a genome(n). Two species of different genome can be used to produce a hybrid AA x BB =AB

If the chromosome number is doubled, we have AABB (allodiploidy), AABB-also called Anephidiploid. Alloploids are usually sterile because of their two genomes that are so divergent and they fail to pair and doubling of the chromosome restores diploid and also fertility.

4. Introgression: Involves transfer of small amount of germplasm from species to species. It is accomplished by hybridization of two species and backcross from the recombinant production (over several prod)to the parental spp. This will result into the transfer of certain features or other from one species to another without impairing the letter's taxonomic integrity. There is a good evidence that maize borrowed characteristics from its wild family/relatives. Teosinte and Tripsacum through a system of introgression. Sorghum, in area of Africa, where it was domesticated, appeared to have absorbed some characteristics from closely related weedy types and vice-versa

LECTURE 3: Roles of hybridization

Hybridization is the fusion of genetically different gametes resulting in hybrid organisms heterozygous for one or more allelic genes. It is the same thing as crossing.

Through hybridization changes are induced or incorporation directly into the genotypes of the crop. The ratio of homozygous genotypes to heterozygous genotypes 50: 50 %

No two plants breeders carrying out hybridization have completely identical roles. Yet despite differences of emphasis here and there, depending on the crop and the climatic cultural and economic different of the country where it is grown, there are underling similarities in all hybridization/breeding programme. The basic roles/objectives of most crop plant breeding/hybridization are for hybridization process (breeding) to be able to contribute both to a more secure world food supply.

(1.) High crop yields

(2.) High quality

(3.) High nutritional levels and wide range of end uses

(4.) The maintenance or extension of adaption to soil and climate and as well as varieties for local, specific

(5.) Pest and disease resistance and development of varieties with better resistance to pest and disease.

(6.) Produced varieties which have improved resistance to various abiotic stress condition and which make better use of crop inputs.

The details of such a list are much more complex and deserves careful examination

1. **Yield**: The breeding /hybridization must consider what type of yield is desired; more seeds, tubers and so forth, of the same size, or the same number of seeds or tubers of the greater size, or both. Yield is obviously connected with the nutritional value of the plants. The four components of increased crop production are:

- increase in yield per hectare per crop and

-displacement of lower yielding crop by higher yielding ones.

-the factors that all breeding /hybridization for yield should be based on a thorough understanding of the physiological processes of growth, assimilation and photoperiodic response.

-Response to moisture and fertilizer is important to obtain good yields.

Quality: The general palatability, acceptable colour, texture, and flavor of raw, cooked or baked produce, and factors affecting marketing. Keeping, storage, ease of handling or packing are all qualities that are important, no less in developing than in developed countries. Because consumers have become accustomed to certain flavours, colors, textures and so on, Breeder must provide these aspects of quality in their new produce, even though it would often be easier not to have to do so.

High Nutritional Levels: Improving the nutritional value of a crop is of obvious importance. It is the hybridizations aim to increase protein in cereals and tuber crops wherever possible. The protein should contain reasonable levels of amino acids, lysine, tryptophan etc. Nowadays, hybridization has brought about a very wide range of plants used for oils or fats, including soybeans, cottonseed, groundnut, maize, sunflower, rapeseed, safflower, sesame, olive, copra and oil palm. The main concern of the breeder is to select varieties with an ever higher oil content in the harvested product, thus the proportion of oil-bearing to non oil bearing tissue in the seeds or fruits is of great importance. Questions of vitamin and mineral contents must not be overlooked, especially in fruits and vegetables and appropriate substances must be bred for in stimulants spices and condiments.

Adaptation: Adaptation is an immensely complex subject. Not only does the crop plant need to be generally adapted to the soil and climate of a particular region, it can also be bred to tolerate a wide or a narrow range of conditions. Resistance to drought is becoming of ever greater importance in the modern world, because as land with good soils and rainfall becomes used up and as still more is needed to grow food, marginal lands must be brought into production.

Disease resistance: Breeding crop for resistance to pests and pathogens has perhaps occupied more breeders time and more space in the literature tham any other breeding activity. Resistance to fungi, bacteria, viruses, vivoids, insects, mites and nematodes must be sought out by appropriate screeming methods.

SELECTION

For all the enormous impact that cultivated plants have made on us, it comes as something of a shock to realize that of the approximately 200,000 species of flowering plants in exsistence only about 3000 species have been used for food even though most have probably been sampled at one time or another, often, perhaps, with disastrous consequences. Possibly only some 19-20 are now crops of major importance (Heiser, 1973).

There are three types of selection.

-Natural selection

-Artificial selection

-Aesthetic selection

Natural selection: Natural selection operates on the fitness of individuals. Individuals that have low adaptive values are eliminated in favour of high adapted ones. The versatility of a plant thus ensures its survival.

In general, cultivated plants respond to the same processes of natural selection as wild ones and this selection acts on the variation derived from gene mutation and recombinations. Changes caused by natural selection may have different evolutionally co-sequences depending on the circumstances.

The first occurs when the environmental factors determining natural selection are fairly uniform throughout the population of a species in this, the entire population will tends to become better and better adapted to its environment and as the environment change the entire species will change with it, giving enough time more changes can occur in this way. This is called **PHYLETIC EVOLUTION.**

The 2nd consequence of changes caused by natural selection occurs when the different populations in a species somehow become isolated and subjected to different environmental conditions with natural selection acting non-uniformly; so different lines of changes will occur in various combinations. In this way, they may become more and more divergent unit the single original species are split into two or more new ones. The latter case is the way which the number of species can increase and is referred to as **SPECIATION or SPECIE FORMATION.**

Artificial selection: As is practiced by man when he deliberately chooses plants that suit his goal, in fact, the act of plant breeding is an artificial selection.

However, in addition to the natural selection presumes to which wild plants are exposed, cultivated plants also face artificial selection by man, which in some instances, is of greater importance in effecting rapid change than natural selection. Much artificial selection was, and perhaps still 'unconscious selection' in which a man acts without any awareness of his role as an agent of selection.

Aesthetic selection: Early ancestors designed and decorated basketry, pottery, weaving, metal work, bone, and stone carvings, bark paintings and many other objects. They select interesting colours, and shapes of mutants of pepper, gourd, and tomato fruits and colour of potato tubers and maize grains as well, domesticated plants are partly creations of human.

LECTURE 4: Origin of cultivated plants

For thousands of years, farming communities have grown wild plants, adapted some of them, and carried out selection in cultivated plants. By focusing on specific traits to improve plant performance and by growing crops in different and specific agro-ecosystems, gradually the combined human and natural selection pressure has altered the characteristics of plants to adapt to newly evolving farming environment. This process called **crop domestication** has provided the basis of the major food crops as we know them today.

Centre of diversity

Crop domestication started about 8,000 years ago. Places where the first crops originally developed are known as primary Centres of Diversity. These centres usually show a rich reservoir of both wild and cultivated plants belonging to the same or closely related species. The spread of Agriculture in the past to other parts of the world by early colonists and traders resulted in a further increase in the diversity of plant genetic resources not only in the pry centres of origin of specific crops but in additional areas as well creating Secondary Centres of diversity.

Important of plant genetic diversity

Genetic diversity remains extremely important not only to individual farmers and farming communities but also to Scientists and Breeding institutions and humanity as a whole.

1 The availability of diversity enables farmers to grow crops under a range of varying conditions and adverse environments.

a Better manage uncertainties

b Spread their risks of production

c Sustain live hood in marginal production areas. N.B such production areas are often exposed to stresses such as infertility, pest, diseases and drought.

2. Diversity assists both farmers and breeders to select and breed for better crops and varieties to satisfy present and future demands in production and consumer preferences.

3 Diversity continues to satisfy the diverse demand by households and consumers in different cultural settings, e.g for taste, appearance, cooking quality and by-products and to suit niche markets as source for fixed food, fibre and other uses.

Unfortunately, the diversity is threatened like all bio-diversity. The decrease in diversity in farming systems is called **genetic erosion.** Genetic erosion nowadays is considered one of the main threats to sustainable crop production and food security, especially in the mid- and long term.

In summary.

1. Primary Centre: This is the centre where maximum diversity occurs.
2. Secondary Centre: It develops from types that migrated from the primary centre. For example pry centre of maize is mexico but secondary centre for waxy type maize is china

PRIMARY CENTRES	CROPS
1. China	Rice, Soybean, Orages, Chinese, Cabbage
2. India/Southeast Asia	Rice, Cucumber, Eggplant, Pigeon Pea, Sugar cane, Banana, Jute
3. Central Asia	Pea, Carrot, Sesame, Safflower, Onion, Garlic, Apple
4. Near East(Turkey/tran)	Wheat, Barley, Rye, Pea, Flex, Lentil, Chicken pea
5. Mediterranean	Drum wheat, Cabbage, Sugar beet, Olive, Grape, Almond
6. Sub-saharan Africa	Pearl millet, Sorghum, Cowpea, Coffee, Okra
7. Mexico/Cental America	Maize, Melon, Tomatoes, Pumpkin, Cocoa, Avocado
8. Andes, Brazil, Paragnay	Pepper, Potato, Rubber, Cassava, Sweat potato.

Examples of Secondary Centres of genetic diversity are:

a. The horn of Africa (Ethiopia) is a major secondary centre of diversity for barley, wheat and Sorghum

b. Tomato was carried to Europe and subsequently to other parts of the world by Spanish traders some 400 years ago.

c. Bananas originates from southeast Asia and spread in ancient times to Africa to create a rich secondary centre of diversity.

d. Southeast Asia is considered a secondary centre of sweat potato diversity, a crop that originated in South America.

e. Sub-Saharn Africa can be regarded a centre of diversity of cassava, a crop that originated from the tropical Amazon region of South America.

LECTURE 5: Introduction to the principles of plant taxonomy

a. **Definition of plant taxonomy**

Taxonomy can be defined as a study aimed at producing a system of classification of biological organism, which best reflects the totality of their similarities and differences.

Taxonomy is the study and description of the variation that exists among organisms the investigation of the cause and consequence of these variations and the use of the data obtained for identifying the variants and the causes of these variations to produce a system of classification. If it is applied to plants, it is called **plant taxonomy.**

Importance of plant taxonomy

1. it provides inventory on the world of plant floral
2. it provides method of identification of plants and communication in plant science.
3. It produces a co-herent and universal system of classification of plants.
4. It demonstrates the evolutionary implication of plant diversity.

Aims of plant taxonomy

The aims of plant taxonomy are three-fold

1. To provide a convenient method of identification and communication

2. To provide a classification which as far as possible express the natural relationship of organisms
3. To detect evolution at work, discovering its processes and interpreting its results.

The aims can be summarized as to produce a system of classification through the study and understanding the origin of the organisms and tracing the phyllogenetic relationships between the organisms.

Scope of Taxonomy

There are three inter-related aspects of taxonomy

1. Identification
2. Nomenclature
3. Classification

1. **Identification:** it deals with the determination of a taxon as being identical with or similar to another and already known organism.

a. It is also the naming of a plantt by a reference to an already existing classification.
b. It must be known that identification precedes naming. It is from the different features or characteristics of a system of identification that an organism desires its name.

2 **Nomenclature:** It is also clear that a set of methods, rules, interpretations etc are considered when naming an organism. Therefore, when a researchers/scientist interests at a point in the study of these rules in the course of naming a plant, this exercise is called Nomenclature.

Nomenclature deals with the determination of the correct name of the organisms and is governed by international Code of Botanical Nomenclature (ICBN). It permits only a single valid name for each plant.

3 **Classification:-** It is the placing of plants in group or categories according to particular plan or system of classification can be viewed in two perspectives, as a process and also as a concept.

As a process:- is the production of a reasonable/logical system on itself is such that allows for easy reference to be made about its components.

As a concept:- Classification is seen as an entity that is made up of many members.

Basically, there are two systems of classification: **natural and artificial classifications**

Artificial classification is based on a few convenient characters for the purpose of identification.

Artificial system of classification does not group organism most alike in their genetic constitution. It has little or no predictive value. It is a special purpose classification chosen to suite the purpose for which it is designed e.g. plants can be classified on the basis of habit as trees, shrub or herbs. Also animal into two groups on the basis of a single trait i.e presence or absence of a trait.

Natural system of classification **:** it groups organisms most closely related phyllogenetically and takes genetic constitution of an organism into account. It has predictive value and is based on total similarities. Now-a-days there are new ways of testing differences e.g chromosome, morphology immunological reaction, nutrient required etc.

PLANT NOMENCLATURE

Man has always been a nomenclaturist. He has used names for plants, animals and objects and has classified plants, animals and other objects with or without special terminology or system.

Yon can ask why do we need such difficult *Latin* names for plants? Why not in local languages'? According to Benson (1962), vernacular or common names cannot replace scientific names due to the following reasons:

- Names in common languages are not universal.
- In most part of the world, relatively few species have common names in any language
- Common names are applied indiscriminately to species or varieties.

- Two or more related plants are known by the same name or single species may have two to several common names applied either in the same or different localities e.g in Nigeria, Raphia palm: Yoruba- Ogoro, Ibo-Ngwo or Agwo, Efik-Ukot. So you can see the inconsistency in the use of local names.

With the rapid increase in the number plants and animal known to man, it has become apartment that there should be some guiding rules which will have uniformity, consistency and precision in naming plants. In Botany/ plants, these rules are governed by ICBN. The rules ensure stability and accuracy in the application of names.

Binomial System of Nomenclature

The BSN was suggested by Carlous Linnaeus (1753). In this system, there are two components of scientific names and the scientific name of a plant is a binary combination of the two components

1. The generic name
2. The specific epithet

The generic name:- is the name given to the genus while to the species is called specific name/epithet. The generic name begins with a capital letter and the species name with small letter. The scientific names are italicized in print or underlined when typed or hand written e.g *Glycine max* - is the scientific name for soybean and *Dioscorea rotandata* is the botanical name for white yam, Therefore, *Glycine* and *Dioscorea* are the representative of generic names and *max* and *rotundata* are the specific epithets.

According to ICBN, there can be only one group of plant with the generic names e.g Mamhot. Within each genus, there can be only one valid specific epithet which may apply to plants of different germs e.g *Manihot esculentus, Abelmoscus esculentus.*

Citation and Authority

Since every taxon (may it be family, genus or species) is originally described and published by one or two persons, so the name of the persons written after the specific epithet is known as the **authority of that taxon or name.** The authority of that taxon or name i.e the author's name may be written out completely or it may be abbreviated. Thus sweet potato plant *(Solanum tuberosum)* was first named and described by Carlous Linnaeus, so Linnaeus becomes the authority for the name and it is written as *Solanum tuberosum* L when the rank of a plant is changed or when a species is transferred from one genus to another, the name of the original by the name of the original author is placed in parenthesis and is followed by the name of the person making the change e.g *Medicago polymovpha* variety or bicularis was first described by Linnaeus. Later on it was raized to the rank of a species by Allioni and thus it became *Medicago orticularis* also, *Abelmoscus esculentus* (L) Moaench, *Vigna ungniculata* (L) Walp.

LECTURE 6: Taxonomic hierarchy

Just as a continent is divided into various nations, nations into countries, countries into states, states into provinces or local goverment areas as in Nigeria, Provinces into divisions, divisions into distinct etc. Similarly, the plant kingdom is divided into a number of categories which differ in size, rank and nature when these categories are so arranged, they constitute the taxonomic hierarchy, the list of categories into which plants are classified is known as Taxonomic hierarchy Any of these groups at any level, may be referred to as taxon (plural taxa).

Taxon is the different categories in a system of classification e.g family, order, specics etc.

Description : A desicripti of a taxon is the statement of it's character i e is the description of characteristics of the tixon and is also known as taxonomic characters.

Hierarchy: classification places plant in categories or steps or ranks that often procede each order in order to make it easy to make reference to them. The categories form an hierarchy to them. The categories form a hierarchy in which in turn contains other smaller components in a seeming descending order. The International Code of Botanical Nomenclative (ICBN) recognizes 12 main categories in the hierarchy of all plant kingdom. The acceptable system of Nomenclature provides a hierarchical arrangement of the rank of taxa in an ascending sequence e.g species, genus, family, order, class and division each with sub categories. The rank represents level of relationships required for classification purposes in treating different group of plants.

Ranks in Taxonomic hierarchy

1. Kingdom
2. Division - classes are grouped into divisions or phyla
3. Class - consists of group of related order.
4. Order
5. Family
6. Tribe
7. Genus (generic name) plural genra
8. Section
9. Series
10. Species (specific name)
11. Variety
12. Form

Form : A group of individuals give rise to Form

Variety : is a group of plants within a species with identical properties or characteristics

Species : A Species is a group of organisms having close resemblance with each other both structurally and functionally.

S**eries** A group of closely related species form series.

Section: A group of closely related series from a section.

Genus: A group of closely related sections from a Genus (Generic name)

Order: is a major taxon immediately superior to the family and it will formed the name of the order by adding ales to stem of the included generic name e.g poales, malvales(cotton). A group of closely related family form an order.

Family: it consists of groups of related genera e.g Hibiscus family is composed of many genera, among which is the cotton *Gossypium*, okro genus. Hibiscus- the name ending aceae poaceae, Fabaceae

Sub family: is a major sub division of the family is sometimes used when the six of the family justifies it. The name is ending with 'Oldeae' panicoldeae

Tribe: is a sub division of the family panicoldeae but subordinate to the sub-family. The tribe name is ending with 'eae' Festhceae- grass family.

Class: consists of group of related orders. A number of class share a great deal of diversity but do have a specific set of characters in common.

Division: is the categories of highest magnitude with the plant kingdom. It is characterized by a few very specific features and its members share all these traits, but may be much diversified. Thus, the whole idea of taxonomic hierarchy can be best described in form of a box-in-box manner.

DESCRIPTIVE FEATURES OF PLANT TAXONOMY

The following sequence is commonly followed when describing a flowering plant.

1. **Habitat-** is the natural abode of the plants ornamental, cuttivated or wild plants.
2. **Habit-** is the growth form e.g a). herb, shrub, or tree b). annual, biennial or perennial
3. **Root system** – top root or adventitious

   Branched or unbranched

   Modification- Fibrous, prop, aerial etc
4. **Stem system-** - erect, weak, stem climbing/ twining,

   -modification such as rhizome, tuber, bulb, runer

   -branched and unbranched or mode of branching

   -shape cylindrical angular, Hairy or glabrous
5. **Leaf system** - Alternate, opposite or whorled

   -Staled or sessile
   - Ventation of leaf
   -Kind of leaf – simple or compound
   -Texture
   -Apex as acute, acuminate or obtuse

- Leaf lamina – linear, oval, ovate, lanceolate

6. **Inflorescence system-**simpler or compound, panicle, spike.

7. **Flower system** - pedicellate or sessile
   -bracteate, ebracteate or bracteal
   -complete or in complete, bisexual or unisexual
   -regular or irregular hypogynous, epigynous or perigynous

8. **Perianth** – present or absent. If present, then their aestivation and fusion e.g gamophylous or polyphyllons and sepaloid, petaloid or all alike. When the calyx and corolla are fused and could not differentiated usually of the same colour. The individual unit is called **Tepals.**

9. **Calyx-** made up of individual unit called **sepals** which could be free (polysepalous or fused gamosepalous. The number of sepals making up the calyx, the shape, size and colour are very tendrils. Importantt consideration –number and shape of sepals, (b) free or fused (c) persistent or caducous (d) aestivation such as valvate, inbricate or contorted.

10. **Corolla-** Number and shape of petals (b) free or fused (c) aestivation of corolla, (d) colour of the petals

11. **Androecium** – Is the general name of male part. The individual is called microsporophy or stamen. The anther can be labeled pollen sac.
   - consider the nos of stamen.
   - consider the free or fused
   - consider filament short or long.

12. **Gynoecium-** Pistil is the female part and made up of individual units called carpels, stigma style and ovary.- Consider the number of carpels, - Consider free or fused carpels - Consider ovary superior or inferior, - Consider placentation- Consider number of loculli, - Consider style free or united. If an ovary is on top of the receptacle is superior and if otherwise it is interior

13. **Fruit-** nature and dehiscence of fruits

LECTURE 7: Floral formula

Floral formula: it is a very useful short-hand method of recording floral structure and is the numerical representation of various floral parts. Floral formula also depicts the inter-relationship, symmetry, bi-sexuality and unisexuality of the flowers

Floral formula

1. Calyx =K

2. Corolla = C

3, Perianth =P (if K and C are not separable)

3. Androecium =A

4. Gynoecum = G

5. Calyx with 5 fused sepals = K(5)

6. Corolla with 5 free petals = C5

7. Gynoecium is made of 2 free carpels and ovary superior = $\underline{G2}$

8. Gynoecium is made of 1 carpel with inferior ovary = G1

9. Perianth made of 2 fused tepals P(2)

10. Adhension between calyx & gynoecuim= K5G1

11. Infinite Number (Usualy more than 10) = x

12. Mother axis = -

13. Regular (Actinomorphic) = ɵ

14. Irregular (zygomorphic) = %

15. Bisexual = ♂̲

16. Unisexual Staminate = ♂

17. Unisexual pistilate = ♀

18. Absence or suppression of stamens and pistil = X

Examples

1. **Family** = Malvaleae e.g Hibiscus: ɵ, ♂̲, $K_{(5)}$ $C_{(5)}$ $A_{(\alpha)}$ $\underline{G}_{(5-\alpha)}$

   Regular, bisexual, calyx made of 5 fused sepals, corolla made of 5 fused petals, Androcieum made of infinite number of stamens. Gynoecium made of 5 to infinite number of fused carpels with superior ovary.

2. **Family** ; Caesalpiniaceae e.g Casia *Angustifolia delonic*, regia, Flame of forest

   Floral Formula = %, ♂̲, $K_{5,}$ $C_{5,}$ $A_{10,}$ $\underline{G}_1$

Irregular, bisexual, calyx made of five free sepals, corolla made of five free petals. Androecium made of 10 free stamens and Gynoecium made of one carpel with superior ovary.

3. **Family**; Mimosaceae e.g *Mimosa Pudica, Acacia nitolica* –

   floral formula; ɵ ⚨ $K_{(4-5)}$, $C_{(4-5)}$, Aα or few $\underline{G}_1$

   Regular, bisexual, calyx made of 4-5 fused sepals, corolla made of 4 to 5 fused petals. Androecium made of infinite number of free stamens or few. Gynoecium made of one free carpel with superior ovary.

4. **Family**: %, ⚨ $K_{(5)}$, C_5, $A_{(9)+1}$, $\underline{G}_1$ e.g *Crotolaria retusa, Vigna unguiculata, Arachis hypogeal*. floral formula; Irregular, bisexual, calyx made of 5 fused sepals, corolla made of 5 free petals. Androecium made of 9 fused stamens and one free stamen and Gynoecium with one carpel with superior ovary.

LECTURE 8. Modes of Speciation

Speciation is the evolutionary process by which new biological species arise. There are four modes of natural speciation, based on the extent to which speciating populations are geographically isolated from one another: allopatric, peripatric, parapatric, and sympatric. Speciation may also be induced artificially, through animal husbandry or laboratory experiments. Observed examples of each kind of speciation are provided throughout.[1]

Natural speciation

All forms of natural speciation have taken place over the course of evolution, though it still remains a subject of debate as to the relative importance of each mechanism in driving biodiversity. [2]

There is debate as to the rate at which speciation events occur over geologic time. While some evolutionary biologists claim that speciation events have remained relatively constant over time, some palaeontologists such as Niles Eldredge and Stephen Jay Gould have argued that species usually remain unchanged over long stretches of time, and that speciation occurs only over relatively brief intervals, a view known as punctuated equilibrium.

Allopatric speciation

During allopatric speciation, a population splits into two geographically isolated allopatric populations (for example, by habitat fragmentation due to geographical change such as mountain building or social change such as emigration). The isolated populations then undergo genotypic and/or phenotypic divergence as they (a) become subjected to dissimilar selective pressures or (b) they independently undergo genetic drift. When the populations come back into contact, they have evolved such that they are reproductively isolated and are no longer capable of exchanging genes.

Observed instances

Island genetics, the tendency of small, isolated genetic pools to produce unusual traits, has been observed in many circumstances, including insular dwarfism and the radical changes among certain famous island chains, like Komodo and Galápagos, the latter having given rise to the modern expression of evolutionary theory, after being observed by Charles Darwin. Perhaps the most famous example of allopatric speciation is Darwin's Galápagos Finches.

Peripatric

In peripatric speciation, new species are formed in isolated, small peripheral populations which are prevented from exchanging genes with the main population. It is related to the concept of a founder effect, since small populations often undergo bottlenecks. Genetic drift is often proposed to play a significant role in peripatric speciation.

Observed instances

- Mayr bird fauna
- The Australian bird Petroica multicolor
- Reproductive isolation occurs in populations of Drosophila subject to population bottlenecking

The London Underground mosquito is a variant of the mosquito *Culex pipiens* which entered in the London Underground in the nineteenth century. Evidence for its speciation include genetic divergence, behavioral differences, and difficulty in mating.[3]

Parapatric

In parapatric speciation, the zones of two diverging populations are separate but do overlap. There is only partial separation afforded by geography, so individuals of each species may come in contact or cross the barrier from time to time, but reduced fitness of the heterozygote leads to selection for behaviours or mechanisms which prevent breeding between the two species.

Ecologists refer to parapatric and peripatric speciation in terms of ecological niches. A niche must be available in order for a new species to be successful.

Observed instances

- Ring species
  - The Larus gulls form a ring species around the North Pole.
  - The Ensatina salamanders, which form a ring round the Central Valley in California.
  - The Greenish Warbler (*Phylloscopus trochiloides*), around the Himalayas.
- the grass *Anthoxanthum* has been known to undergo parapatric speciation in such cases as mine contamination of an area.

Sympatric

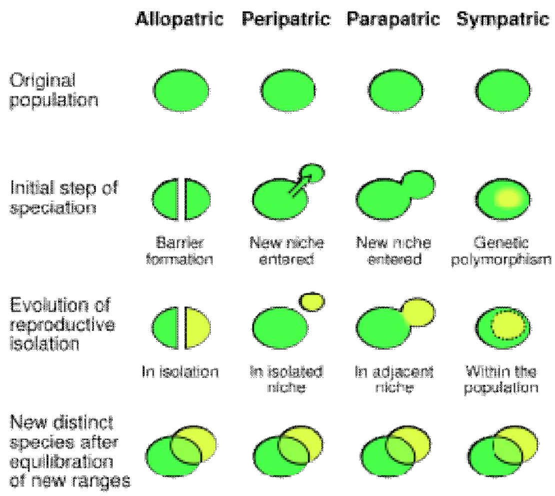
In sympatric speciation, species diverge while inhabiting the same place. Often cited examples of sympatric speciation are found in insects which become dependent on different host plants in the same area. However, the existence of sympatric speciation as a mechanism of speciation is still hotly contested. People have argued that the evidences of sympatric speciation are in fact examples of micro-allopatric, or heteropatric speciation. The most widely accepted example of sympatric speciation is that of the cichlids of Lake Nabugabo in East Africa, which is thought to be due to **sexual selection**. Sympatric speciation refers to the formation of two or more descendant species from a single ancestral species all occupying the same geographic location.

Until recently, there has a been a dearth of hard evidence that supports this form of speciation, with a general feeling that interbreeding would soon eliminate any genetic differences that might appear. But there has been at least one recent study that suggests that sympatric speciation has occurred in Tennessee cave salamanders. [4]

The three-spined sticklebacks, freshwater fishes, that have been studied by Dolph Schluter (who received his Ph.D. for his work on Darwin's finches with Peter Grant) and his current colleagues in British Columbia, provide an intriguing example that is best explained by sympatric speciation. They have found:

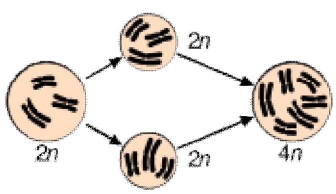
- Two different species of three-spined sticklebacks in each of five different lakes.
    - a large benthic species with a large mouth that feeds on large prey in the littoral zone
    - a smaller limnetic species — with a smaller mouth — that feeds on the small plankton in open water.
- DNA analysis indicates that each lake was colonized independently, presumably by a marine ancestor, after the last ice age.
- DNA analysis also shows that the two species in each lake are more closely related to each other than they are to any of the species in the other lakes.
- Nevertheless, the two species in each lake are reproductively isolated; neither mates with the other.
- However, aquarium tests showed that
    - the benthic species from one lake will spawn with the benthic species from the other lakes and
    - likewise the limnetic species from the different lakes will spawn with each other.
    - These benthic and limnetic species even display their mating preferences when presented with sticklebacks from Japanese lakes; that is, a Canadian benthic prefers a Japanese benthic over its close limnetic cousin from its own lake.
- Their conclusion: in each lake, what began as a single population faced such competition for limited resources that
    - disruptive selection — competition favoring fishes at either extreme of body size and mouth size over those nearer the mean — coupled with
    - assortative mating — each size preferred mates like it - favored a divergence into two subpopulations exploiting different food in different parts of the lake.
    - The fact that this pattern of speciation occurred the same way on three separate occasions suggests strongly that ecological factors in a sympatric population can cause speciation.

Sympatric speciation driven by ecological factors may also account for the extraordinary diversity of crustaceans living in the depths of Siberia's Lake Baikal.



Diagramatic summary of natural speciation

Speciation via polyploidization



Speciation via polyploidy: A diploid cell undergoes failed meiosis, producing diploid gametes, which self-fertilize to produce a tetraploid zygote. Example is IITA's polyploidy cassava.

Polyploidy is a mechanism often attributed to causing some speciation events in sympatry. Not all polyploids are reproductively isolated from their parental plants, so an increase in chromosome number may not result in the complete cessation of gene flow between the incipient polyploids and their parental diploids (see also hybrid speciation).

Polyploidy is observed in many species of both plants and animals. In fact, it has been proposed that all of the existing plants and most of the animals are polyploids or have undergone an event of polyploidization in their evolutionary history.

Speciation via hybrid formation

Hybridization between two different species sometimes leads to a distinct phenotype. This phenotype can also be fitter than the parental lineage and as such natural selection may then favor these individuals. Eventually, if reproductive isolation is achieved, it may lead to a separate species. However, reproductive isolation between hybrids and their parents is particularly difficult to achieve and thus hybrid **speciation** is considered an extremely rare event.

Reinforcement

Reinforcement is the process by which natural selection increases reproductive isolation.[5] It may occur after two populations of the same species are separated and then come back into contact. If their reproductive isolation was complete, then they will have already developed into two separate incompatible species. If their reproductive isolation is incomplete, then further mating between the populations will produce hybrids, which may or may not be fertile. If the hybrids are infertile, or fertile but less fit than their ancestors, then there will be and donkeys.) The reasoning behind this is that if the parents of the hybrid offspring each have naturally selected traits for their own certain environments, the hybrid offspring will bear traits from both, therefore would not fit either ecological niche as well as the parents did. The low fitness of the hybrids would cause selection to favor assortative mating, which would control hybridization. If the hybrid offspring are more fit than their ancestors, then the populations will merge back into the same species within the area they are in contact.

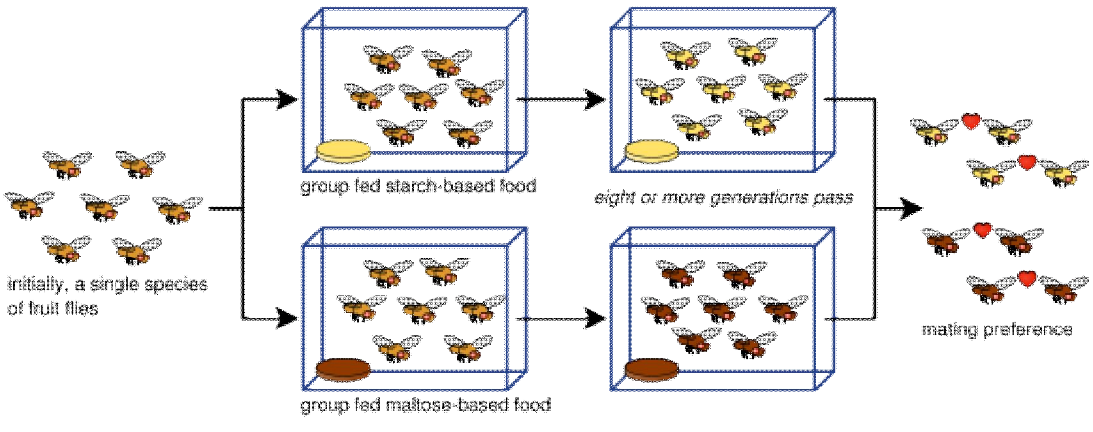
Reinforcement is required for both parapatric and sympatric speciation. Without reinforcement, the geographic area of contact between different forms of the same species, called their "hybrid zone," will not develop into a boundary between the different species. Hybrid zones are regions where diverged populations meet and interbreed. Hybrid offspring are very common in these regions, which are usually created by diverged species coming into secondary contact. Without reinforcement the two species would have uncontrollable inbreeding. Reinforcement may be induced in artificial selection experiments as described below.

Artificial speciation

New species have been created by domesticated animal husbandry, but the initial dates and methods of the initiation of such species are not clear. For example, domestic sheep were created by hybridisation, and no longer produce viable offspring with Ovis orientalis, one species from which they are descended.[6] Domestic cattle, on the other hand, can be considered the same species as several varieties of wild ox, gaur, yak, etc., as they readily produce fertile offspring with them.[7]

The best-documented creations of new species in the laboratory were performed in the late 1980s. William Rice and G.W. Salt bred fruit flies, Drosophila melanogaster, using a maze with three different choices of habitat such as light/dark and wet/dry. Each generation was placed into the maze, and the groups of flies which came out of two of the eight exits were set apart to breed with each other in their respective groups. After thirty-five generations, the two groups and their offspring were isolated reproductively because of their strong habitat preferences: they mated only within the areas they preferred, and so did not mate with flies that preferred the other areas. [8]

Diane Dodd was also able to show allopatric speciation by reproductive isolation in *Drosophila pseudoobscura* fruit flies after only eight generations using different food types, starch and maltose.[9] Dodd's experiment has been easy for many others to replicate, including with other kinds of fruit flies and foods.[10]



The *Drosophila* experiment conducted by Diane Dodd in 1989.

The history of such attempts is described in Rice and Hostert (1993).[11]

Hybrid speciation

Hybridization between two different species sometimes leads to a distinct phenotype. This phenotype can also be fitter than the parental lineage and as such natural selection may then favor these individuals. Eventually, if reproductive isolation is achieved, it may lead to a separate species. However, reproductive isolation between hybrids and their parents is particularly difficult to achieve and thus hybrid speciation is considered an extremely rare event. The Mariana Mallard arose from hybrid speciation.

Hybridization without change in chromosome number is called homoploid hybrid speciation. It is considered very rare but has been shown in Heliconius butterflies [12] and sunflowers. Polyploid speciation, which involves changes in chromosome number, is a more common phenomena, especially in plant species.

Gene transposition as a cause

Theodosius Dobzhansky, who studied fruit flies in the early days of genetic research in 1930s, speculated that parts of chromosomes that switch from one location to another might cause a species to split into two different species. He mapped out how it might be possible for sections of chromosomes to relocate themselves in a genome. Those mobile sections can cause sterility in inter-species hybrids, which can act as a speciation pressure. In theory, his idea was sound, but scientists long debated whether it actually happened in nature. Eventually a competing theory involving the gradual accumulation of mutations was shown to occur in nature so often that geneticists largely dismissed the moving gene hypothesis.[13]

However, recent research shows that jumping of a gene from one chromosome to another can contribute to the birth of new species.[14] This validates the reproductive isolation mechanism, a key component of speciation.[15]

Interspersed repeats

Interspersed repetitive DNA sequences function as isolating mechanisms. These repeats protect newly evolving gene sequences from being overwritten by gene conversion, due to the creation of non-homologies between otherwise homologous DNA sequences. The non-homologies create barriers to gene conversion. This barrier allows nascent novel genes to evolve without being overwritten by the progenitors of these genes. This uncoupling allows the evolution of new genes, both within gene families and also allelic forms of a gene. The importance is that this allows the splitting of a gene pool without requiring physical isolation of the organisms harboring those gene sequences.

LECTURE 9. Genetic drift

In population genetics, **genetic drift** (or more precisely **allelic drift**) is the evolutionary process of change in the allele frequencies (or gene frequencies) of a population from one generation to the next due to the phenomena of probability in which purely chance events determine which alleles (variants of a gene) within a reproductive population will be carried forward while others disappear. Especially in the case of small populations, the statistical effect of sampling error during random sampling of certain alleles from the overall population may result in an allele, and the biological traits that it confers, to become more common or rare over successive generations, and result in evolutionary change over time. The concept was first introduced by Sewall Wright in the 1920s, and is now held to be one of the primary mechanisms of biological evolution. It is distinct from natural selection, a non-random evolutionary selection process in which the tendency of alleles to become more or less widespread in a population over time is due to the alleles' effects on adaptive and reproductive success.[1]

Basic concept

Genetic drift is the process of change in allele frequencies that occurs entirely from chance. As an analogy, imagine representing organisms in a population with a large number of marbles, half of them red and half blue. These two colors correspond to the two different gene alleles present in the population. Put 10 red and 10 blue marbles in a jar; this represents a small population of these organisms. Each generation the organisms in this population will reproduce at random and the old generation will die. To see the effects of this, imagine randomly picking a marble from the jar and putting a new marble of the same color as the one you picked into a second jar. After your selected marble has "reproduced", put it back, mix the marbles, and pick another. After you have done this 20 times, the second jar will contain 20 "offspring" marbles of various colors. This represents the next generation of organisms.

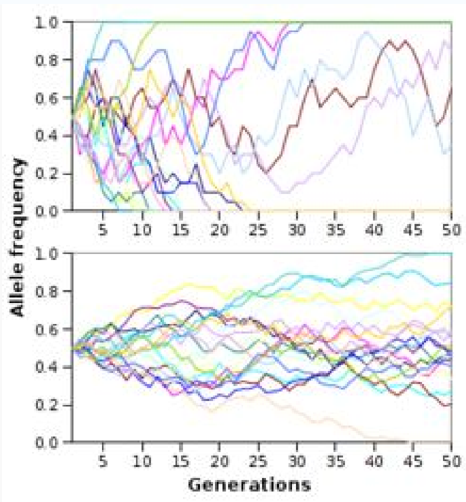
Now throw away the marbles remaining in the first jar - since the older generation of organisms eventually die - and repeat this process over several generations. Since the numbers of red and blue marbles you pick out will fluctuate by chance, the more common color in the population of marbles will change over time, sometimes more red: sometimes more blue. It is even possible that you may, purely by chance, lose all of one color and be left with a jar containing only blue or red offspring. When the jar only contains one color (allele), say red, the other allele, in this case the blue, has been removed or "lost" and the remaining allele (red) becomes fixed. Given enough time, especially in a small population, this outcome is nearly inevitable. This is genetic drift - random variations in which organisms manage to reproduce, leading to changes over time in the allele frequencies of a population.

Probability and allele frequency

Chance events can affect the allele frequency of a population because within that population any organism's reproductive success can be determined by factors other than adaptive pressures. When chance events preserve the survival of randomly selected organisms of a given population, and the resulting allele frequency of the descendant group differs statistically from the allele frequencies in the ancestral group, evolution can result from probabilistic phenomenon rather than selective pressures. A shift in the frequency distribution of alleles over time which occurs as a consequence of sampling error is called genetic drift.

Genetic drift depends strongly on small population size since the law of large numbers predicts weak effects of random sampling with large populations. When the reproducing population is large, the allele frequency of each successive population is expected to vary little from the frequency of its parent population unless there are adaptive advantages associated with the alleles. But with a small effective breeding population, a departure from the norm in even one individual can cause a disproportionately greater deviation from the expected result. Therefore small populations are more subject to genetic drift than large ones.[2]

By definition, genetic drift has no preferred direction, but due to the volatility stochastic processes create in small reproducing populations, there is a tendency within small populations towards homozygosity of a particular allele, such that over time the allele will either disappear or become universal throughout the population. This trend plays a role in the founder effect, a proposed mechanism of speciation.[1] With reproductively isolated homozygous populations, the allele frequency can only change by the introduction of a new allele through mutation.



Simulations of genetic drift for 20 alleles with initial frequency 0.5, for populations of size N=10 and 100, respectively. In general, alleles drift to fixation (frequency of 0 or 1) significantly faster in smaller populations.

When the alleles of a gene do not differ with regard to fitness, probability law predicts the number of carriers in one generation will be relatively unchanged from the number of carriers in the parent generation, a tendency described in the Hardy-Weinberg principle. However, there is no residual influence on this probability from the frequency distribution of alleles in the grandparent, or any earlier, population--only that of the parent population. The predicted distribution of alleles of the offspring is a memory-less probability described in the Markov property. In large populations, where sampling error is a weak factor, the allele frequencies will change little from one generation to another over time unless there are selective pressures acting on those alleles. However, in small populations where sampling error is more likely to result in greater change in an allele frequency from one generation to the next, the allele frequencies in a population can vary considerably from those further back in their lineage.

The lifetime of a neutral allele is governed by the effective population size. In a very small population, only a few generations might be required for genetic drift to result in fixation. In a large population, it would take many more generations.

Drift versus selection

Genetic drift and natural selection do not act in isolation; both forces are always at play in a population. However, the degree to which alleles are affected by drift and selection varies

In a large population, where probability predicts little change in allele frequencies over many generations will result from sampling error, even weak selection forces acting upon an allele will push its frequency upwards or downwards (depending on whether the allele's influence is beneficial or harmful). However, if the population is very small, drift will predominate. In small populations, weak selective effects may not be seen at all as the small changes in frequency they would produce are overshadowed by drift.[3]

Evolution of maladaptive traits

Drift can have profound effects on the evolutionary history of a population. In very small populations, the effects of sampling error are so significant that even deleterious alleles can become fixed in the population, and may even threaten its survival.

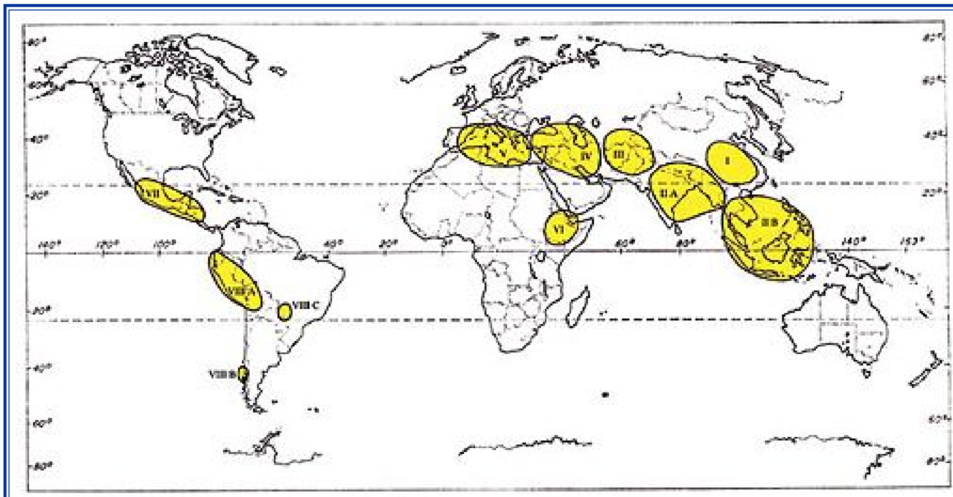
In a population bottleneck, where a larger population suddenly contracts to a small size, genetic drift can result in sudden and radical changes in allele frequency that occur independently of selection. In such instances, the population's genetic variation is reduced, and many beneficial adaptations may be permanently eliminated.

Similarly, migrating populations may see a founder effect, where a few individuals with a rare allele in the originating generation can produce a population that has allele frequencies that seem at odds with natural selection. Founder's effects are sometimes held to be responsible for high frequencies of some genetic diseases.

LECTURE 10. Centers of Origin of Crop Plants

The origin of crop plants is now basic to plant breeding in order to locate wild relatives, related species, and new genes (especially dominant genes, sources of disease resistance).

Knowledge of the origins of crop plants is vitally important in order to avoid genetic erosion, the loss of germplasm due to the loss of ecotypes and landraces, loss of habitat (such as rainforests), and increased urbanization. Germplasm preservation is accomplished through gene banks (largely seed collections but now frozen stem sections) and preservation of natural habitats (especially in centers of origin).



The eight Vavilovian centers of origin for crop plants.

The Eight Vavilovian Centers

Old World

I. Chinese Center:

The largest independent center which includes the mountainous regions of central and western China, and adjacent lowlands. A total of 136 endemic plants are listed, among which are a few known to us as important crops.

Cereals and Legumes

1. Broomcorn millet, *Panicum miliaceum*
2. Italian millet, *Panicum italicum*
3. Japanese barnyard millet, *Panicum frumentaceum*
4. Kaoliang, *Andropogon sorghum*
5. Buckwheat, *Fagopyrum esculentum*
6. Hull-less barley, *Hordeum hexastichum*
7. Soybean, *Glycine max*
8. Adzuki bean, *Phaseolus angularis*
9. Velvet bean, *Stizolobium hassjoo*

Roots, Tubers, and Vegetables

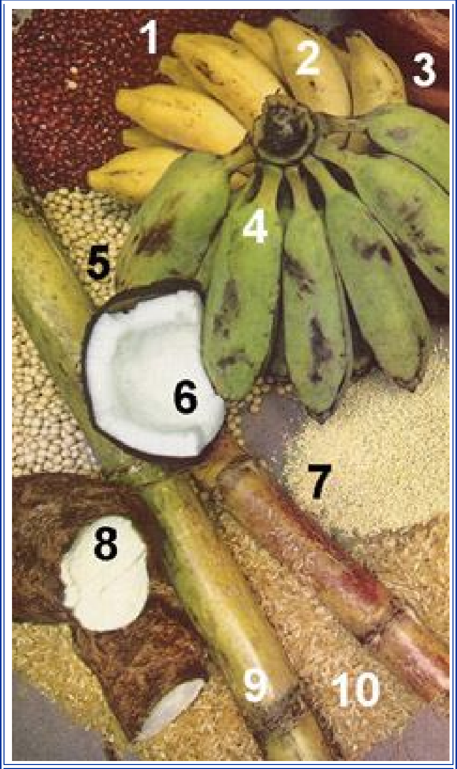
1. Chinese yam, *Dioscorea batatas*
2. Radish, *Raphanus sativus*
3. Chinese cabbage, *Brassica chinensis, B. pekinensis*
4. Onion, *Allium chinense, A. fistulosum, A. pekinense*
5. Cucumber, *Cucumis sativus*

Fruits and Nuts

1. Pear, *Pyrus serotina, P. ussuriensis*
2. Chinese apple, *Malus asiatica*
3. Peach, *Prunus persica*
4. Apricot, *Prunus armeniaca*
5. Cherry, *Prunus pseudocerasus*
6. Walnut, *Juglans sinensis*
7. Litchi, *Litchi chinensis*

Sugar, Drug, and Fiber Plants

1. Sugarcane, *Saccharum sinense*
2. Opium poppy, *Papaver somniferum*
3. Ginseng, *Panax ginseng*
4. Camphor, *Cinnamomum camphora*
5. Hemp, *Cannabis sativa*



Origins of basic crops. Source: J.N. Leonard 1973, First Farmers.

Far East	
1. Adsuki bean	2. Yellow banana
3. Red banana	4. Green banana
5. Soybean	6. Coconut
7. Millet	8. Yam
9. Sugar cane	10. Rice

II. Indian Center:

This area has two subcenters.
A. Main Center (Hindustan): Includes Assam and Burma, but not Northwest India, Punjab, nor Northwest Frontier Provinces. In this area, 117 plants were considered to be endemic.

Cereals and Legumes

1. Rice, *Oryza sativa*
2. Chickpea or gram, *Cicer arietinum*
3. Pigeon pea, *Cajanus indicus*
4. Urd bean, *Phaseolus mungo*
5. Mung bean, *Phaseolus aureus*
6. Rice bean, *Phaseolus calcaratus*
7. Cowpea, *Vigna sinensis*

Vegetables and Tubers

1. Eggplant, *Solanum melongena*
2. Cucumber, *Cucumis sativus*
3. Radish, *Raphanus caudatus* (pods eaten)
4. Taro, *Colocasia antiquorum*
5. Yam, *Dioscorea alata*

Fruits

1. Mango, *Mangifera indica*
2. Orange, *Citrus sinensis*
3. Tangerine, *Citrus nobilis*
4. Citron, *Citrus medica*
5. Tamarind, *Tamarindus indica*

Sugar, Oil, and Fiber Plants

1. Sugar cane, *Saccharum officinarum*
2. Coconut palm, *Cocos nucifera*
3. Sesame, *Sesamum indicum*
4. Safflower, *Carthamus tinctorius*
5. Tree cotton, *Gossypium arboreum*
6. Oriental cotton, *Gossypium nanking*
7. Jute, *Corchorus capsularis*
8. Crotalaria, *Crotalaria juncea*
9. Kenaf, *Hibiscus cannabinus*

Spices, Stimulants, Dyes, and Miscellaneous

1. Hemp, *Cannabis indica*
2. Black pepper, *Piper nigrum*
3. Gum arabic, *Acacia arabica*
4. Sandalwood, *Santalum album*
5. Indigo, *Indigofera tinctoria*
6. Cinnamon tree, *Cinnamomum zeylanticum*
7. Croton, *Croton tiglium*
8. Bamboo, *Bambusa tulda*

B. Indo-Malayan Center: Includes Indo-China and the Malay Archipelago. Fifty-five plants were listed, including:

Cereals and Legumes

1. Job's tears, *Coix lacryma*
2. Velvet bean, *Mucuna utilis*

Fruits

1. Pummelo, *Citrus grandis*
2. Banana, *Musa cavendishii*, *M. paradisiaca*, *H. sapientum*
3. Breadfruit, *Artocarpus communis*
4. Mangosteen, *Garcinia mangostana*

Oil, Sugar, Spice, and Fiber Plants

1. Candlenut, *Aleurites moluccana*
2. Coconut palm, *Cocos nucifera*
3. Sugarcane, *Saccharum officinarum*
4. Clove, *Caryophyllus aromaticus*
5. Nutmeg, *Myristaca fragrans*
6. Black pepper, *Piper nigrum*
7. Manila hemp or abaca, *Musa textilis*

III. Central Asiatic Center:

Includes Northwest India (Punjab, Northwest Frontier Provinces and Kashmir), Afghanistan, Tadjikistan, Uzbekistan, and western Tian-Shan. Forty-three plants are listed for this center, including many wheats.

Grains and Legumes

1. Common wheat, *Triticum vulgare*
2. Club wheat, *Triticum compactum*
3. Shot wheat, *Triticum sphaerocoecum*
4. Pea, *Pisum sativum*
5. Lentil, *Lens esculenta*
6. Horse bean, *Vicia faba*
7. Chickpea, *Cicer arientinum*
8. Mung bean, *Phaseolus aureus*
9. Mustard, *Brassica juncea*
10. Flax, *Linum usitatissimum* (one of the centers)
11. Sesame, *Sesamum indicum*

Fiber Plants

1. Hemp, *Cannabis indica*
2. Cotton, *Gossypium herbaceum*

Vegetables

1. Onion, *Allium cepa*
2. Garlic, *Allium sativum*
3. Spinach, *Spinacia oleracea*
4. Carrot, *Daucus carota*

Fruits

1. Pistacia, *Pistacia vera*
2. Pear, *Pyrus communis*
3. Almond, *Amygdalus communis*
4. Grape, *Vitis vinifera*
5. Apple, *Malus pumila*

Origins of basic crops. Source: J.N. Leonard 1973, First Farmers.			
Near East			
1. Lentil	2. Chickpea	3. Salt	4. Pea
5. Raisin	6. Olive	7. Barley	8. Walnut
9. Almond	10. Pistachio nut	11. Apricot	12. Date
13. Wheat	14. Fig	15. Fava Bean	

IV. Near-Eastern Center:

Includes interior of Asia Minor, all of Transcaucasia, Iran, and the highlands of Turkmenistan. Eighty-three species including nine species of wheat were located in this region.

Grains and Legumes

1. Einkorn wheat, *Triticum monococcum* (14 chromosomes)
2. Durum wheat, *Triticum durum* (28 chromosomes)
3. Poulard wheat, *Triticum turgidum* (28 chromosomes)
4. Common wheat, *Triticum vulgare* (42 chromosomes)
5. Oriental wheat, *Triticum orientale*
6. Persian wheat, *Triticum persicum* (28 chromosomes)
7. *Triticum timopheevi* (28 chromosomes)
8. *Triticum macha* (42 chromosomes)
9. *Triticum vavilovianum*, branched (42 chromosomes)
10. Two-row barley, *Hordeum distichum, H. nutans*
11. Rye, *Secale cereale*
12. Mediterranean oats, *Avena byzantina*
13. Common oats, *Avena sativa*
14. Lentil, *Lens esculenta*
15. Lupine, *Lupinus pilosus, L. albus*

Forage Plants

1. Alfalfa, *Medicago sativa*
2. Persian clover, *Trifolium resupinatum*
3. Fenugreek, *Trigonella foenum graecum*
4. Vetch, *Vicia sativa*
5. Hairy vetch, *Vicia villosa*

Fruits

1. Fig, *Ficus carica*
2. Pomegranate, *Punica granatum*
3. Apple, *Malus pumilo* (one of the centers)
4. Pear, *Pyrus communis* and others
5. Quince, *Cydonia oblonga*
6. Cherry, *Prunus cerasus*
7. Hawthorn, *Crataegus azarolus*

V. Mediterranean Center:

Includes the borders of the Mediterranean Sea. Eighty-four plants are listed for this region including olive and many cultivated vegetables and forages.

Cereals and Legumes

1. Durum wheat, *Triticum durum expansum*
2. Emmer, *Triticum dicoccum* (one of the centers)
3. Polish wheat, *Triticum polonicum*
4. Spelt, *Triticum spelta*
5. Mediterranean oats, *Avena byzantina*
6. Sand oats, *Avena brevis*
7. Canarygrass, *Phalaris canariensis*
8. Grass pea, *Lathyrus sativus*
9. Pea, *Pisum sativum* (large seeded varieties)
10. Lupine, *Lupinus albus*, and others

Forage Plants

1. Egyptian clover, *Trifolium alexandrinum*
2. White Clover, *Trifolium repens*
3. Crimson clover, *Trifolium incarnatum*
4. Serradella, *Ornithopus sativus*

Oil and Fiber Plants

1. Flax, *Linum usitatissimum*, and wild *L. angustifolium*
2. Rape, *Brassica napus*
3. Black mustard, *Brassica nigra*
4. Olive, *Olea europaea*

Vegetables

1. Garden beet, *Beta vulgaris*
2. Cabbage, *Brassica oleracea*
3. Turnip, *Brassica campestris, B. napus*
4. Lettuce, *Lactuca sativa*
5. Asparagus, *Asparagus officinalis*
6. Celery, *Apium graveolens*
7. Chicory, *Cichorium intybus*
8. Parsnip, *Pastinaca sativa*
9. Rhubarb, *Rheum officinale*

Ethereal Oil and Spice Plants

1. Caraway, *Carum carvi*
2. Anise, *Pimpinella anisum*
3. Thyme, *Thymus vulgaris*
4. Peppermint, *Mentha piperita*
5. Sage, *Salvia officinalis*
6. Hop, *Humulus lupulus*

VI. Abyssinian Center:

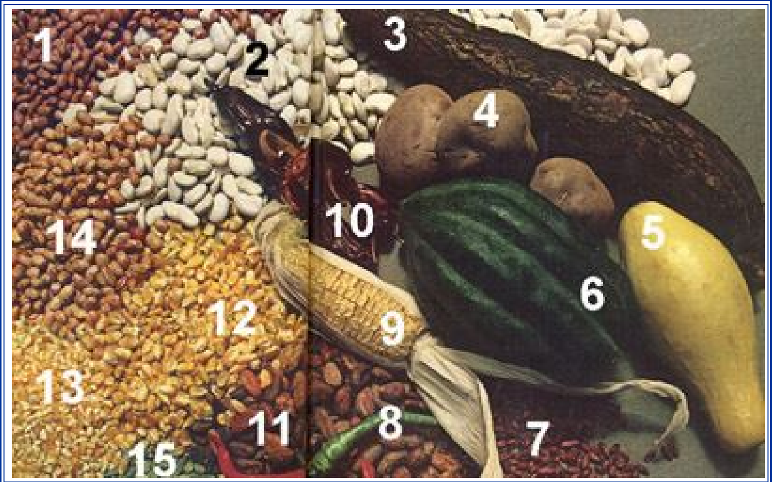
Includes Abyssinia, Eritrea, and part of Somaliland. In this center were listed 38 species. Rich in wheat and barley.

Grains and Legumes

1. Abyssinian hard wheat, *Triticum durum abyssinicum*
2. Poulard wheat, *Triticum turgidum abyssinicum*
3. Emmer, *Triticum dicoccum abyssinicum*
4. Polish wheat, *Triticum polonicum abyssinicum*
5. Barley, *Hordeum sativum* (great diversity of forms)
6. Grain sorghum, *Andropogon sorghum*
7. Pearl millet, *Pennisetum spicatum*
8. African millet, *Eleusine coracana*
9. Cowpea, *Vigna sinensis*
10. Flax, *Linum usitatissimum*

Miscellaneous

1. Sesame, *Sesamum indicum* (basic center)
2. Castor bean, *Ricinus communis* (a center)
3. Garden cress, *Lepidium sativum*
4. Coffee, *Coffea arabica*
5. Okra, *Hibiscus esculentus*
6. Myrrh, *Commiphora abyssinicia*
7. Indigo, *Indigofera argente*



Origins of basic crops. Source: J.N. Leonard 1973, First Farmers.		
Americas (New World)		
1. Pink bean	2. Lima bean	3. Manioc
4. Potato	5. Summer squash	6. Acorn squash
7. Small dried chili pepper	8. Fresh chili pepper	9. Corn (maize)
10. Dried chili pepper	11. Cocoa bean	12. Whole dried corn
13. Cracked dried corn	14. Pinto bean	15. Shelled pumpkin seed

VII. South Mexican and Central American Central:

Includes southern sections of Mexico, Guatemala, Honduras and Costa Rica.

Grains and Legumes

1. Maize, *Zea mays*
2. Common bean, *Phaseolus vulgaris*
3. Lima bean, *Phaseolus lunatus*

4. Tepary bean, *Phaseolus acutifolius*
5. Jack bean, *Canavalia ensiformis*
6. Grain amaranth, *Amaranthus paniculatus leucocarpus*

Melon Plants

1. Malabar gourd, *Cucurbita ficifolia*
2. Winter pumpkin, *Cucurbita moshata*
3. Chayote, *Sechium edule*

Fiber Plants

1. Upland cotton, *Gossypium hirsutum*
2. Bourbon cotton, *Gossypium purpurascens*
3. Chayote, *Sechium edule*

Miscellaneous

1. Sweetpotato, *Ipomea batatas*
2. Arrowroot, *Maranta arundinacea*
3. Pepper, *Capsicum annuum, C. frutescens*
4. Papaya, *Carica papaya*
5. Guava, *Psidium guayava*
6. Cashew, *Anacardium occidentale*
7. Wild black cherry, *Prunus serotina*
8. Cochenial, *Nopalea coccinellifera*
9. Cherry tomato, *Lycopersicum cerasiforme*
10. Cacao, *Theobroma cacao*
11. *Nicotiana rustica*

VIII. South American Center:

(62 plants listed) Three subcenters are found.
A. Peruvian, Ecuadorean, Bolivian Center: Comprised mainly of the high mountainous areas, formerly the center of the Megalithic or Pre-Inca civilization. Endemic plants of the Puna and Sierra high elevation districts included:

Root Tubers

1. Andean potato, *Solanum andigenum* (96 chromosomes)
2. Other endemic cultivated potato species. Fourteen or more species with chromosome numbers varying from 24 to 60.
3. Edible nasturtium, *Tropaeolum tuberosum*. Coastal regions of Peru and non-irrigated subtropical and tropical regions of Ecuador, Peru and Bolivia included:

Grains and Legumes

1. Starchy maize, *Zea mays amylacea*
2. Lima bean, *Phaseolus lunatus* (secondary center)
3. Common bean, *Phaseolus vulgaris* (secondary center)

Root Tubers

1. Edible canna, *Canna edulis*
2. Potato, *Solanum phureja* (24 chromosomes)

Vegetable Crops

1. Pepino, *Solanum muricatum*
2. Tomato, *Lycopersicum esculentum*
3. Ground cherry, *Physalis peruviana*
4. Pumpkin, *Cucurbita maxima*
5. Pepper, *Capsicum frutescens*

Fiber Plants

1. Egyptian cotton, *Gossypium barbadense*

Fruit and Miscellaneous

1. Passion flower, *Passiflora ligularis*
2. Guava, *Psidium guajava*
3. Heilborn, *Carica candamarcensis*
4. Quinine tree, *Cinchona calisaya*
5. Tobacco, *Nicotiana tabacum*

B. Chiloe Center (Island near the coast of southern Chile)

1. Common potato, *Solanum tubersum* (48 chromosomes)
2. Wild strawberry, *Fragaria chiloensis*

C. Brazilian-Paraguayan Center

1. Manioc, *Manihot utilissima*
2. Peanut, *Arachis hypogaea*
3. Rubber tree, *Hevea brasiliensis*
4. Pineapple, *Ananas comosa*
5. Brazil nut, *Bertholletia excelsa*
6. Cashew, *Anacardium occidentale*
7. Purple granadilla, *Passiflora edulis*

ASSIGNMENT/ TERM PAPER

1. Discuss the evolution of plant taxonomy or

2. Discuss the development of plant taxonomy