COURSE CODE: PBB 111
COURSE TITLE: INTRODUCTION TO PLANT BIOLOGY AND BIOTECHNOLOGY
NUMBER OF UNITS: 3 Units
COURSE DURATION: Two lecture hours and two practical hours per week

COURSE LECTURER: **ODOLIGIE IMARHIAGBE**

**INTENDED LEARNING OUTCOMES**

At the completion of this course, students are expected to:

1. Understand the reason for classification of living organism,
2. Understand the characteristics and the evolutionary relationships among groups of plants.
3. Demonstrate hands-on practical on self-identification of plants using classification keys

**COURSE DETAILS:**

Week 8: classification of living organism
Week 9: kingdom concept
Week 10: taxonomic rank and possible evolutionary relationship among plants
Week 11: field studies.
Week 12: Revision

**RESOURCES**

**Course lecture Notes:**

**Books:** Botany for Degree Students - A. C. Dutta

Introduction to plant biology and biotechnology by G.O Anoliefo

**Project:** collection of living organism specimens for hands-on practical re-classification
.
• **Exams:**
• Final, comprehensive (according to university schedule): ~ 70% of final grade
**Assignments & Grading**
• **Academic Honesty:** All classwork should be done independently, unless explicitly stated otherwise on the assignment handout.
• You may discuss general solution strategies, but must write up the solutions yourself.
• If you discuss any problem with anyone else, you must write their name at the top of your assignment, labeling them "collaborators".
• **NO LATE HOMEWORKS ACCEPTED**
• Turn in what you have at the time it's due.
• Homework submission is due at the start of the next class.

• If you will be away, turn in the homework early.
• Late submission of assignments (projects) will not be accepted.

**1.0 Classification of living organisms**

In science, the practice of classifying organisms is called **taxonomy** (*Taxis* means arrangement and *nomos* means method). Organization of plants into groups in the earlier days of biology was probably motivated by the desire to adequately recognize them and determine which plants and animals could be useful sources of food, medicine, shelter, and tools. It has been shown that later during the renaissance period in Europe, the motivating factor became the desire to reveal the hidden order and harmony between different organisms as originally pre-planned by God. These different objectives for the study of the groups of organisms were exhibited in the way the organisms were classified.

There are literally millions of distinguishable kinds of organisms in existence, but none of them ever comes into being with an already attached label giving a name, evolutionary and ecological relationship with other organisms. The present day motivating factor for the grouping of organisms may still include the reasons used in the past. However it enables the present day biologist to perceive some order and to express different kinds of relationships among both living and fossil organisms. The science that governs the above submission is classification. Classification is very important for the following four reasons.

1. It aids memory; since it is nearly impossible to remember all the organisms in any particular group unless there are traits or characteristics that are peculiar to such groups and which would help us remember such organisms.

2. Classification systems greatly improve our perception powers. If it is known that a kind of organism can produce its own food once it is exposed to sunlight it would be easy to predict the broad group to which such an organism belongs.
3. Classification systems improve our ability to explain relationships among things. If among organisms, which produce their own food some can fix nitrogen and as such do not require input of nitrogen. Such an organism would be more related than just ability to produce their own food.
4. Classification provides relatively stable, unique and equivocal names for organisms. The plant *Chromolaena odorata* has the common name awolowo weed in Nigeria. Siam weed in other parts of the world. It would be difficult to identify the above plant with just the common names, since different parts of the world call it by different names.

It is therefore customary to identify an organism before trying to establish the relationship between it and others. All plants produce their own food and so are characteristically the same. It is however important to note that groups of plants have evolutionary and ecological relationships. The sweet potato is called *Ipomea batatas* (family: convolvulaceae). It is a perennial plant, which trails on the ground. It is an underground tuberous root. The Irish potato however is called *Solanum tuberosum* (family: Solanaceae). It is a highly branched annual and underground stem tuber. These two plants bear the name potato, but are however not related botanically. The banana and the plantain on the other hand look alike, produce fruits that also look alike and can even be found in the same ecological zones. The banana is the *Musa sapientum* while the plantain is *Musa paradisaca.* These two plants are herbaceous monocotyledonous plants, which belong to the same family called Musaceae.

There are many thousands of different types of plants, which vary very widely. It is not possible to study them unless they are arranged in a given order. It was De Candolle in 1886 that stated, "Science can make no real progress without a regular system of nomenclature"' the study, where plants are classified, named and identified is called **plant taxonomy** or **systematics botany**. Taxonomists group plants on the basis of anatomical, morphological, physiological and genetic similarities and it is the analysis of the similarities and differences that lead to the various taxonomic systems.

Carolus Linnaeus was credited with being the first to establish an acceptable form of classification of plants. His mode of classification employed the artificial system

## 2.0 System of Classification

### 2.1 The Artificial system

In this system plants are classified on the basis of their ultimate use e.g agricultural plants would be classified as grains, fruits, and timber plants. Ornamentals would be classified as herbs, green house and garden-perennial plants. The artificial system does not necessarily indicate relationship between plants. Linnaeus also classified plants based on their reproductive characteristics as in the numerical characteristics of flowers. These included the number of stamens, number and organization of carpels. According to his system, which is also called sexual system; plants were divided into 24 classes, including 23 of phanerogams and 1 of cryptogams. Phanerogams were further subdivided into groups with unisexual and bisexual flower. Plants with unisexual flowers were further classified as monoecious or diecious and hence the emphasis on stamens. Plants with bisexual flowers were classified based on whether the stamens were united with the carpels or free and whether the stamens were free or united. The work of Linnaeus laid the foundation for the consistent and extensive use of the binomial system of nomenclature. He divided each order into genera and each genus into species, quite like a first and a surname. Plants bear such names as *Citrus sinensis* (sweet orange) *Citrus paradisi* (grape fruit), *Citrus aurantifolia* (sour lime) and *Citrus limon* (lemon)

**2.2 The natural system**

This is the second system of classification where all the characters are considered in determining whether a plant is related to the other. In this system, plants are usually classified based on the similarities and differences in morphological and reproductive characters. The groupings start from the very large encompassing group to the small groups. The latter (i.e the small groups), in modern classification is the species (no singular or plural). The reproductive characters used in the natural system helped to create the evolutionary relationship between plants and thus are the important differences between different plants based on a detailed description of characters and a sequence of their evolution from simple to more complex types of plants in different periods.

The natural system divides the plant kingdom into two division viz; cryptograms or flowerless plants and the phanerograms or flowering plants. The phanerogram are subdivided into gymnosperms or the naked-seeded plants such as the cycad (*Cycas circinalis*), confer (*Pinus sylvesteris*) and the gnetale (*Gnetum gnemon*). The angiosperms or closed-seeded plants include plants like goat wee (*Ageratum conyzoides*), the cassava (*Manihot utissima*) and the lagos mahogany (*Khaya ivorensis*). Angiosperms are further sub-divided into two classes viz dicotyledons (e.g tomato-*Lycopersicon esculentum*) and monocotyledons (e.g *Oryza sativa*)

If we stretch the classification using the edible (Uselu-Benin beans-that is the name given to the popular beans bought at market very close to my university) as an example, we shall have it as a class-dicotyledon, order Fabaceae, genus-*Vigna* and species-*uguiculata*

**2.3 The phylogenetic based system**

This system is based on the evolutionary relationship of plants reflecting genetic relationship between plants and to establish their progenitors. This system employed the theories of the German botanists, Adolf Engler (1844-1930), and August Eichler (1883) who in presenting plant classification based on inherited relationships, further subdivided in to the monocotyledonae and dicotyledonaeae classes. The mono and dicotyledons were divided into orders and families.

**3.0 The Five Taxonomic Kingdoms of the living world**

Under the three domains are six kingdoms in taxonomy mentioned above, Classification has attempted to place the millions of living organisms in positions that reflect their evolutionary link with extinct ones. There is so much diversity of living things that biologists devised taxonomic means of placing these organisms into specific groups. R. H Whittaker, 1969, proposed the five kingdom classification. He based his criterion for classification on the following

**Complexity of cell structure: Prokaryotic cell and eukaryotic cells**

**Prokaryotes** refer to the smallest and simplest type of cells, without a true nucleus and no membrane-bound organelles. Bacteria fall under this category. Some characteristics:

- Small (1-10 μm)
- DNA circular, unbounded
- Genome consists of single chromosome.
- Asexual reproduction common, by mitosis.
- No general organelles
- Most forms are singular

**Eukaryotes** are more complex in structure, with nuclei and membrane-bound organelles. Some characteristics of eukaryotes are:

- Large (100 - 1000 μm)
- DNA in nucleus, bounded by membrane
- Genome consists of several chromosomes.
- Sexual reproduction common, by mitosis and meiosis
- Mitochondria and other organelles present
- Most forms are multicellular

The group includes Kingdom monera or prokaryotae, Protista or protoctista, fungi, plantae, and animalia

**Kingdom Monera**

Is composed of all the prokaryotic organisms in existence and is essentially the kingdom of bacteria. Monerans differ from all the other known organisms in that they are unicellular; lack the nuclear membrane as well as the other membrane-bound organelles. They inhibit virtually anywhere on earth, from the air, water, depth of oceans, hot places, polluted areas and very cold regions.

**The kingdom Protista**

Consist of single celled and colonial eukaryotic organism. It was introduced by the German biologist Ernst Haeckel in 1866 to classify micro-organisms which are neither animals nor plants. Since protists are quite irregular, this kingdom is the least understood and the genetic similarities between organisms in this kingdom are largely unknown. For example, some Protista can exhibit properties of both animals and plants. These organisms are mostly aquatic but some inhabit damp soil and decaying tree bark. The animal-like protists are called protozoa. The plant-like ones are called algae while the fungus-like ones are the watermolds

**The kingdom fungi**

Consist of multicellular eukaryotic organisms with cell walls made of chitin. These organisms are heterotrophic in nature, with absorptive nutrition such as the saprobes, which lives on dead matters and mutualists, which live in mutual beneficial symbiosis with other organism. Mushrooms and moulds belong in this kingdom. Originally, they were part of the plant kingdom but were re-categorised when they were discovered not to photosynthesise

**The kingdom Plantae**

The Kingdom plantae is also called as kingdom Metaphyta. The Kingdom plantae includes all types of eukaryotic, multicellular, photosynthetic plants found in this biosphere. Most of the organism in this kingdom is autotrophs, which synthesis their own food with the help of solar energy. There are very few species, which are both autotrophs and heterotrophs. The history of life on earth and the success of many organisms literally depend on the success of plants

**The kingdom Animalia**

Consist of multicellular eukaryotic organisms, which digest food outside the cells and then absorb the product.

## 4.0 The Three Domains

The domain is the broadest category, while species is the most specific category available. The taxon Domain was only introduced in 1990 by Carl Woese. The three domains are organized based on the difference between eukaryotes and prokaryotes. Today's living prokaryotes are extremely diverse and different from eukaryotes. This fact has been proven by molecular biological studies (e.g. of RNA structure) with modern technology. The three domains are as follows:

**4.1 Archea (Archeabacteria)** Archaea are prokaryotic cells, typically characterized by membrane lipids that are branched hydrocarbon chains attached to glycerol by ether linkages. The presence of these ether linkages in Archaea adds to their ability to withstand extreme temperatures and highly acidic conditions, but many archea live in mild environments. Halophiles, organisms that thrive in highly salty environments, and hyperthermophiles, organisms that thrive in extremely hot environments, are examples of Archaea. Archaea evolved many cell sizes, but all are relatively small. Their size ranges from 0.1 to 15 µ diameter and up to 200 µ long. They are about the size of bacteria or similar to the size of a mitochondrion in a eukaryotic cell. Members of the genus Thermoplasma are the smallest of the Archaea.

**4.2 Eubacteria** consists of more typical bacteria found in everyday life. Even though bacteria are prokaryotic cells just like Archaea, their membranes are made of unbranched fatty acid chains attached to glycerol by ester linkages. Cyanobacteria and mycoplasmas are two examples of bacteria. They characteristically do not have ether linkages like Archaea, and they are grouped into a different category—and hence a different domain. There is a great deal of diversity in this domain, and between that and horizontal gene transfer; it is next to impossible to determine how many species of bacteria exist on the planet.

**4.3 Eukaryote** Members of the domain Eukarya have membrane-bound organelles (including a nucleus containing genetic material) and are represented by four kingdoms: Plantae, Protista, Animalia, and Fung

Because of the exclusion of viruses from the three dormin system of classification, Stefan Luketa in 2012 proposed a five-domain system, adding Prionobiota (acellular and without nucleic acid) and Virusobiota (acellular but with nucleic acid) to the traditional three domains.

**5.0 The concept of Binomial nomenclature**

Binomial nomenclature is used to name an organism, where the first word beginning with a capital is the genus of the organism and the second word beginning with lower-case letter is the species of the organism. The name must be in italics and in Latin, which was the major language of arts and sciences in the 18th century. The scientific name can be also abbreviated, where the genus is shortened to only its first letter followed by a period. In our example, *Lepus europaeus* would become *L. europaeus*.

Taxonomy and binomial nomenclature are both specific methods of classifying an organism. They help to eliminate problems, such as mistaken identity and false assumptions, caused by common names. An example of the former is the fact that a North American robin is quite different from the English robin. An example of the latter is the comparison between crayfish and catfish, where one might believe that they both are fish when in fact, they are quite different.

Nomenclature is concerned with the assignment of names to taxonomic groups in agreement with published rules. To study for a test these are the best words to know taxonomist, biologist, chemist, geologist, unicellular, multi- cellular, bilateral symmetry, radial symmetry, chlorophyll, photosynthesis, respiration, reproduction, vertebrates, endoskeleton, exoskeleton, consumers, decomposers, heterotroph, autotroph, vascular, non-vascular. These are all part of classifying things.

**6.0 Taxonomic Rank**

All living organisms are classified into groups based on very basic, shared characteristics. Organisms within each group are then further divided into smaller groups. These smaller groups are based on more detailed similarities within each larger group. This grouping system makes it easier for scientists to study certain groups of organisms. Characteristics such as appearance, reproduction, mobility, and functionality are just a few ways in which living organisms are grouped together.

In his landmark publications, such as the *Systema Naturae*, Carl Linnaeus used a ranking scale limited to: kingdom, class, order, genus, species, and one rank below species. Today, nomenclature is regulated by the nomenclature codes. According to Art 3.1 of the International Code of Nomenclature for algae, fungi, and plants (ICN) the most important ranks of taxa are:

kingdom, division or phylum, class, order, family, genus, and species. According to Art 4.1 the secondary ranks of taxa are tribe, section, series, variety and form. There is an indeterminate number of ranks. The ICN explicitly mention

In biological classification, **taxonomic rank** is the relative level of a group of organisms (a taxon) in a taxonomic hierarchy. Examples of taxonomic ranks are:  kingdom, phylum, classes, order, families, genus, and species.  A given rank subsumes under it less general categories, that is, more specific descriptions of life forms. Above it, each rank is classified within more general categories of organisms and groups of organisms related to each other through inheritance of traits or features from common ancestors. The rank of any *species* and the description of its *genus* is basi*c*; which means that to identify a particular organism, it is usually not necessary to specify ranks other than these first two

**Kingdoms**

the most basic classification of living things is kingdoms. Currently there are five kingdoms. Living things are placed into certain kingdoms based on how they obtain their food, the types of cells that make up their body, and the number of cells they contain.

**Phylum**

The phylum is the next level following kingdom in the classification of living things. It is an attempt to find some kind of physical similarities among organisms within a kingdom. These physical similarities suggest that there is a common ancestry among those organisms in a particular phylum.

**Classes**

Classes are way to further divide organisms of a phylum. As you could probably guess, organisms of a class have even more in common than those in an entire phylum. Humans belong to the Mammal Class because we drink milk as a baby.

**Order**

Organisms in each class are further broken down into orders. A taxonomy key is used to determine to which order an organism belongs. A taxonomy key is nothing more than a checklist of characteristics that determines how organisms are grouped together.

**Families**

Orders are divided into families. Organisms within a family have more in common than with organisms in any classification level above it. Because they share so much in common, organisms of a family are said to be related to each other. Humans are in the Hominidae Family.

**Genus**

Genus is a way to describe the generic name for an organism. The genus classification is very specific so there are fewer organisms within each one. For this reason there are a lot of different genera among both animals and plants. When using taxonomy to name an organism, the genus is used to determine the first part of its two-part name.

**Species**

Species are as specific as you can get. It is the lowest and most strict level of classification of living things. The main criterion for an organism to be placed in a particular species is the ability to breed with other organisms of that same species. The species of an organism determines the second part of its two-part name.

Classifications of five species follow: the fruit fly so familiar in genetics laboratories (*Drosophila melanogaster*), humans (*Homo sapiens*), the peas used by Gregor Mendel in his discovery of genetics (*Pisum sativum*), the "fly agaric" mushroom *Amanita muscaria*, and the bacterium *Escherichia coli*. The eight major ranks are given in bold; a selection of minor ranks are given as well

**Table 1: Hierarchical classification of organism**

| | **Fruit fly** | **Human** | **Pea** | **Fly agaric** |
|---|---|---|---|---|
| **Domain** | Eukarya | Eukarya | Eukarya | Eukarya |
| **Kingdom** | Animalia | Animalia | Plantae | Fungi |
| **Phylum** or **Division** | Arthropoda | Chordata | Magnoliophyta (Tracheophyta) | Basidiomycota |
| Subphylum or subdivision | Hexapoda | Vertebrata | Magnoliophytina (Euphyllophytina) | Agaricomycotina |
| **Class** | Insecta | Mammalia | Magnoliopsida (Equisetopsida) | Agaricomycetes |
| Subclass | Pterygota | Theria | Rosidae (Magnoliidae) | Agaricomycetidae |
| Superorder | | Euarchontoglires | Rosanae | |
| **Order** | Diptera | Primates | Fabales | Agaricales |
| Suborder | Brachycera | Haplorrhini | Fabineae | Agaricineae |
| **Family** | Drosophilidae | Hominidae | Fabaceae | Amanitaceae |
| Subfamily | Drosophilinae | Homininae | Faboideae | Amanitoideae |
| **Genus** | *Drosophila* | *Homo* | *Pisum* | *Amanita* |
| **Species** | *D. melanogaster* | *H. sapiens* | *P. sativum* | *A. muscaria* |

**7.0 The concept of Angiosperm Phylogeny Group**

The Angiosperm Phylogeny Group, or APG, refers to an informal international group of systematic botanists who collaborate to establish a consensus on the taxonomy of flowering plants (angiosperms) that reflects new knowledge about plant relationships discovered through phylogenetic studies. In the past, classification systems were typically produced by an individual botanist or by a small group. The result was a large number of systems Different systems and their updates were generally favoured in different countries. Examples are the Engler system in continental Europe, the Bentham & Hooker system in Britain (particularly influential because it was used by Kew), the Takhtajan system in the former Soviet Union and countries within its sphere of influence and the Cronquist system in the United States. Before the availability of genetic evidence, the classification of angiosperms (also known as *flowering plants*, *Angiospermae*, *Anthophyta* or *Magnoliophyta*) was based on their morphology (particularly of their flower) and biochemistry (the kinds of chemical compounds in the plant).

After the 1980s, detailed genetic evidence analysed by phylogenetic methods became available and while confirming or clarifying some relationships in existing classification systems, it radically changed others. This genetic evidence created a rapid increase in knowledge that led to many proposed changes this produced a number of surprising results in terms of the relationships between groupings of plants, for instance the dicotyledons were not supported as a distinct group. At first there was a reluctance to develop a new system based entirely on a single gene. However, subsequent work continued to support these findings. These research studies involved an unprecedented collaboration between a very large numbers of scientists. Therefore, rather than naming all the individual contributors a decision was made to adopt the name Angiosperm Phylogeny Group classification, or APG for short. The first publication under this name was in 1998,[2] and attracted considerable media attention.[4] The intention was to provide a widely accepted and more stable point of reference for angiosperm classification. As of 2016, three revisions have been published, in 2003 (APG II), in 2009 (APG III) and in 2016 (APG IV), each superseding the previous system. In APG classification, above or parallel to the level of orders and families, the term **clades** is used more freely.