Studying plant diversity - Plant classification

Organising our knowledge about biodiversity

One of Kew's most important roles is to catalogue the world's plant diversity. There is a huge number of flowering plants - an estimated 300,000 species. To begin to understand this amazing biodiversity it somehow has to be broken into manageable chunks.

While some of these species have not even been discovered or described, others we know in great detail. There is a vast amount of information that botanists, ecologists, chemists, farmers, doctors, cooks and craftspeople have learnt about plants, and we need a framework to organise this knowledge.

A plant classification acts as a type of database, in which the scientific plant names are the key to unlocking this information (see information sheet B2).

What is plant classification?

Classification is the process of grouping things together on the basis of the features they have in common. It is a way of summarising what we know – a kind of filing system. Anything can be classified (furniture, vehicles, emotions) but here we are referring to biological organisms and specifically plants.

The study of plant classification is known as taxonomy ('taxon' means 'group') and it is done by specialised botanists called 'taxonomists'.

The history of plant classification

The ability to classify objects and phenomena (feelings, weather, sounds etc.) is an important human survival skill that is almost certainly inborn. Our ability to distinguish food from poisons, friend from foe, useful substances from those of no value, is as vital today as it was in the Stone Age.

The earliest plant classifications were probably similar to those of present day folk cultures or tribal people. These classifications categorise plants according to their useful properties,

Kew **information** sheet **B1**

for example food, medicinal or magical value and timber strength.

The first written classifications still in existence are those of the Ancient Greek authors such as Theophrastus (d. 287 BC) and Dioscorides (c. 40 – c. 90 AD). Dioscorides' book *Materia Medica* was the first known herbal, and the only one for about 1000 years. Theophrastus provided a rudimentary plant classification based on the 500 or so plants in the botanic garden at Athens.

The scientific study of plant classification in Europe began properly in the 18th century. The Swedish botanist Carolus Linneaus (1707-78) is credited with establishing the naming system that we use today for all living organisms. He was also the first person to group organisms into a logical hierarchy, based on shared similarities. His plant classification was based solely on flower parts, and existed relatively unchallenged for over 200 years until it was eventually superseded by systems using more characters.

In the 19th century, the theories of evolution (Charles Darwin and Alfred Russel Wallace) and genetic inheritance (Gregor Mendel) led to a desire to produce a **phylogenetic classification** - one which reflects evolutionary changes.

Many of the classification systems proposed in the late 19th and early 20th centuries claimed to be phylogenetic. However, the botanists were only using characteristics that they could see (morphological features), and deciding which differences were important and which to ignore was purely speculative and based

ROYAL BOTANIC GARDENS KEW

Above: **A tiny portion of the world's plant diversity on display in Kew's Alpine House.**

on the prejudices of individuals. (How do you decide, for example, if the shape of petals is more significant than the number of stamens?) Also, as there can only be one truly phylogenetic system (i.e. the one which reflects the actual route of evolution), the many different systems proposed cannot all have been right!

There are now more modern approaches to classification. These aim to reduce or remove the botanist's own preference for certain characters (and therefore reduce bias). Importantly they are more experimental, hypothesis-testing and scientific. The ultimate aim is a classification system which accurately represents plant evolution. We are now close to achieving this with the new classification based on genetics.

Types of classification – and why botanical is best!

Classification can be an intuitive process which we tend to carry out automatically. Plants, for example, can be grouped according to their uses; 'fruit', 'vegetable', 'ornamental', 'timber', 'weed' etc. This type of classification is 'artificial' in that it tends to group plants that are completely unrelated. It can also reveal only one piece of information, namely the character on which the classification was based – in this case, how a plant is used.

Modern scientific plant classifications are very different from artificial classifications mainly because they serve a different purpose.

Botanical classification aims to be 'natural' in that it tries to express relatedness of plants. This type of phylogenetic classification aims to reflect evolutionary history, so the plants within a group can be considered to have a common ancestor. Although this may seem to be a pointless exercise when there are other more 'useful' ways of grouping plants, a classification based on relatedness has great power in that it is **predictive**. If you know the natural group to which a plant belongs you can immediately predict all sorts of other characters for it. If someone tells you they have a *Primula* in their garden you can immediately say that it will have a ring of petals (corolla) that is tubular at the base, that the stamens are opposite the petal lobes and that the stigma is capitate (head-like).

A recent example of the value of this predictiveness was the discovery of an AIDS drug in an Amazonian plant *Alexa*. A chemical called castanospermine was found in an Australian tree in the genus *Castanospermum*. Kew taxonomists, working from their classification of the family, were able to predict that this compound or very similar ones, would probably be found in *Alexa*, on the other side of the world. Fieldwork in Brazil followed by laboratory studies in the Jodrell Laboratory at Kew proved this to be the case.

How is it done?

To create a classification you need:

(1) the objects to be classified

(2) identifying features (characters) which can be used to group the objects

(3) a logical way of ordering the resulting groups.

The objects to be classified are obviously the plants, specimens of which are still being collected and new species still being discovered. Any classification system therefore has to be flexible to cope with new additions and discoveries.

The huge variety in plant form provides a very diverse range of identifying features or characters which can be used for grouping. One of the oldest and commonly used methods of grouping plants depends on physical characters, or **morphology**. These characters are mostly visible with the naked eye or a hand lens and many are used, including:

size, shape, number and arrangement of parts within a flower

arrangement of groups of flowers in an inflorescence

the way the anthers (pollen-containing structures) open

leaf shape, texture, pattern of veins, arrangement on stem

type and shape of fruit

plant habit (tree, climbing annual, aquatic perennial etc.)

sap colour

smell

These characters are also used in plant identification.

As well as these easy-to-see features, botanists also use other characters. Many structural features are only visible with a microscope, for example the shape of pollen grains and their surface sculpturing. With the correct treatment and staining, the chromosomes within plant cells, plus other cellular structures, can be seen under a microscope. Their shape and number can also be important distinguishing characters.

Biochemistry is also useful as some chemicals are only found in certain groups of plants. In many cases this indicates that members of the group are closely related. The most recent addition to botanists' methods of grouping plants is genetic analysis (see 'Plant genes and the new classification').

Plant genes and the new classification

A team led by scientists at Royal Botanic Gardens, Kew, have recently devised a new classification of flowering plant families, based entirely on differences between genes.

Genes are long strings of instructions for making proteins – the 'building blocks' of life. These instructions are coded by a four-letter alphabet (the DNA bases). Genes are passed down through generations, so if one of the 'letters' changes in a plant, all its offspring will inherit that change. These changes gradually accumulate, so they can be used to trace plant ancestry. Two species are more likely to be closely related (i.e. to have separated relatively recently in evolutionary time) if they show only a few differences in their gene sequences, than if the differences are larger.

The scientists chose three genes found in all plants, and 565 plant species to represent all the world's flowering plant families. For each plant, the three genes were sequenced, and the sequences (long lists of the letters of the DNA bases) were compared using computer analysis. The result was a huge 'family tree' of plants with branches showing how species have separated into natural groups.

This new classification of plant families represents evolutionary relationships better than any other before it.

Further information

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