

HIDDEN MARRIAGES & PHANTOM PREGNANCIES

Taxonomy is one of the oldest professions. Hunter gatherers would have been the first people to distinguish animals from plants; the former ran-away and needed hunting, while the latter were literally rooted to the spot and merely needed gathering. This division of living things reflects the means whereby they obtain their nutrition. Plants can obtain the energy for synthesising the proteins, oils and carbohydrates that make up their bodies from sunlight. This remarkable ability to photosynthesise is due to the presence of the molecule chlorophyll.

In plants the chlorophyll is confined to small sub-cellular organelles called chloroplasts. It was discovered in the 1960s that these organelles also contained their own strands of DNA. This DNA is organised in the same way as a bacterial genome, and led to the remarkable idea that chloroplasts are in fact evolved from once free-living photosynthetic bacteria. Photosynthetic bacteria (Cyanobacteria or Blue-green algae) are still common, and are found in a wide variety of habitats. The earliest fossils of photosynthetic bacteria date from 3,500 million years ago.

When you look at seaweeds in a rock pool it is apparent that these algae fall into three groups by their colour, namely: brown green and red seaweed. Although in physical appearance they all appear to have much the same level of organisation they do in fact have very different evolutionary histories. It was long known that their storage products and chlorophyll types differed, but it has only recently been shown from studies of DNA sequences that the date at which they split into the three colour lineages goes back some 1,000 million years. More surprising still is the notion that all land plants (from mosses to giant Sequoias) are derived from the green algae alone. Thus there are in fact three distinct Plant Kingdoms, a brown, green and red kingdom.

When botanists first began to divide the plant kingdom into recognisable parts they separated the spore producing plants from seed plants. In fact in Shakespeare's day fern-seeds were considered invisible! Animal reproduction could be understood because either within an egg or a mother's body could be seen an embryonic animal that would gradually develop after birth into a fully grown adult. In seed plants a similar embryonic state could be seen inside the seed. Thus it was assumed that sexual reproduction had presumably occurred to initiate the formation of the embryo in the seed. With spore plants (Algae, Mosses, Liverworts and Ferns) on the other hand it was not clear where or how sexual reproduction had occurred. Because of this these plants were classified as having 'Hidden Marriage' or **Cryptogamy**. Flowering plants on the other hand were classified as **Phanerogams** because they had 'Obvious marriage'.

In 1849 the German botanist Wilhelm Hofmeister published a remarkable work in which he accurately illustrated the entire process of reproduction in mosses, ferns, gymnosperms and angiosperms. The quality of his drawings were amazing for the time, and have been referred to as "*Magnificent beyond all that has been achieved before or since in descriptive botany*" a claim probably still true today.

He found that in all these plant groups the organism displayed a return, twice repeated, to the single cell as the starting point in each case of a new phase of development. For this double life-cycle he coined the term **Alternation of Generations**. It was only later shown that the number of chromosomes was halved at one of these single celled phases, when the spore was produced, and brought back to its full complement when the gametes fused at fertilisation. Thus Hofmeister was able to show that there existed an intimate relationship, differing only in degree, from mosses, through ferns, horsetails and gymnosperms to angiosperms. The discovery that spore plants and seed plants, which had once seemed so distinct, merely differed in the degree to which these two generations displayed themselves was a monumental discovery. For the first time it was clear that all plants formed a genetic continuum in developmental plan. This discovery was of profound importance in setting the scene for Darwin's publication on his theory of Evolution just 8 years later.

A moss plant has just one set of chromosomes. At its apex in spring it produces single-celled gametes. The female gametes, or egg-cells, are contained in minute flasks while the male gametes are flagellated, and swim through water droplets that collect on the moss plant apex. When a male gamete fuses with an egg cell a double set of chromosomes is generated. This single cell now develops parasitically on top of the moss plant to form a slender stalk with a swollen capsule at its end (this is equivalent to the oak tree). This capsule produces single-celled spores by meiotic divisions that halve the number of chromosomes. When released, these spores are borne on wind currents to new habitats where they germinate and grow into a new moss plant.



A pine tree has two sets of chromosomes. It develops female cones in which a meiotic division produces a spore which grows into an embryo-sac, a multi-cellular organism with just one set of chromosomes (this is equivalent to the moss plant). Within the embryo-sac some nuclei are contained in minute flask-like chambers and are egg-cells. The tree also develops male cones in which meiotic divisions produce spores which grow into 3-celled pollen grains (again this is equivalent to a moss plant). These pollen grains are released and carried by wind currents to the female cones, where a pollen-tube grows from the pollen grain. One of the nuclei in the pollen grain is a male gamete and when fully grown, this gamete is released from the pollen tube and fuses with an egg-cell. When the male gamete fuses with the egg cell a double set of chromosomes is generated. This single-cell now grows into an embryonic pine tree, with root and seedling leaves and a terminal bud. When the seed finally germinates growth of this embryo is resumed, and the seedling eventually turns into a fully-grown tree.

Thus essentially these two plants show the same cycle of generations, only differing in the degree to which they are expressed.

The *Ginkgo* is a gymnosperm (lit. 'Naked Seed') and not an angiosperm (lit. 'Hidden seeds'). This is because it does not form a flower but merely has a cone. Why should this be important? Angiosperms differ from gymnosperms in another more important reproductive character, namely that the seed is produced after fertilisation, whilst a gymnosperm seed is produced before fertilisation. When a *Ginkgo* sheds its seeds in autumn many may not be fertilised, even though they have been pollinated. This is because the male gamete is present inside the seed, but has still not been released from the 'pollen-plant' that grew from the pollen grain. It is only some 6 months after pollination that the gamete is finally released so that it can fuse with the egg-cell. Likewise Pine cones are pollinated in their first spring, but the release of the male-gamete, and its fusion with the egg-cell, doesn't occur until the second spring. The pollen plant thus lives for a whole year inside the developing seed of the Pine tree before releasing the male gamete. But this can lead to a waste of resources, because all gymnosperms are prone to **phantom pregnancies**. The seeds are grown whether or not pollination has occurred. Thus every seed in a pine cone will develop whether or not it has been pollinated, and as a result the un-pollinated seeds have a big store of food but no embryo growing within them.

Angiosperms have evolved the remarkable ability to only grow a seed if they have been pollinated and successfully fertilised. This is achieved by a process of double-fertilisation. The embryo-sac of angiosperms is tiny, with just 8 cells. Just before the male-gamete enters the embryo-sac it divides into two equal cells by mitosis. One of these fuses with the egg cell to make the embryo, while the second fuses with two other nuclei to make the endosperm - the food supply in the seed for the developing embryo. Thus only when an embryo is present does a seed grow. We can see this on any flowering plant where some flowers fall without developing fruits.

Why do land plants have this rather bizarre alternation of generations? The answer is in another question: How would an oak tree send its male gamete to another oak tree 200 metres away? The answer is it encloses it in a small capsule – the pollen grain. This grain's sole function is to carry the gamete to the stigma of a female flower and grow a pollen tube down to the embryo-sac and release the male gamete right next door to the female gamete. Without this 'gamete-carrier' land plants could never have left the sea.

All seaweeds reproduce by spores. Green seaweeds universally exhibit the alternation of generations, as do many red seaweeds but very few brown seaweeds. In fact many brown seaweeds, such as the typical wracks (*Fucus* sp.) of our Irish coastline, reproduce in the same way as animals. In spring they release egg-cells and sperm into the water, and these fuse to create zygotes that attach themselves to rocks and grow into new adult plants. Mosses and ferns are somewhat restricted by their gametes. Their male gametes are released into water droplets and must swim to the egg-cells. Thus both mosses and ferns are plants of wet habitats. Many can complete this vital part of the life cycle in a wet season, but for others it means they must live in shady habitats or adjacent to water bodies. Like amphibians they must return to water to breed. As with the evolution of the reptilian or bird-egg or internal gestation of the mammalian foetus, conquest of the land requires an ability to isolate gametes from the environment. The embryo-sac, as exemplified by the seed that develops from it, represents the plant kingdom's answer to reproduction on dry land.

So, give new respect to green seaweeds, they are the mother of all land-plants, and perhaps feel a touch of sorrow that brown seaweeds and red seaweeds never made it out of the water. If they ever do so in the future, they will find that being a land-plant is a very crowded environment, quite unlike that into which the first green plants would have launched themselves 400 million years ago.