take several balls of mass they will all be attracted to each other, and, in the absence of any other outside force, they will eventually all stick together. Thus, with this classical view, the cosmos could never have an outer bound, because the minute space was confined there would be no further mass to keep the universe stable, and eventually all the mass within the limits of the universe would attract and clump into one gigantic ball. However, observations of astronomers[7] have shown that things are quite the opposite, namely that, instead of the universe tending to collapse into one massive lump, it is expanding dramatically outwards in a manner that suggests, not an eternal universe, but one that was created—*in the beginning*.

Scientists are still struggling to reconcile quantum mechanics and the general theory of relativity into one universal law that would explain completely the physics of the universe in a single simple formula.[8] This unification law has not happened yet; the task is very difficult, and many scientists are working on it. Nevertheless, the physical ideas that appear clearly from the realm of the quantum and relativity laws establish that the universe appears to have been created from nothing but a spike of pure energy, emanating from the vacuum (*from the breath of God*)[9] and at a specific point in time (*in the beginning*). Classical physics could not conceive, nor explain, either of these two rather clearly stated Scriptural propositions. It is nice to see physicists catching up with the Word of God.

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7. The astronomer Edwin Hubble first observed the expanding universe in the 1920s. This expansion was actually predicted earlier in the General Theory of Relativity, but Einstein suppressed it by adding a negative energy term, since at the time he firmly believed in the eternal infinite universe of classical physics. He later called this his biggest mistake. Lately physicists are wondering whether such a negative energy does exist after all, but that would have to be the subject of another article!
8. Called the 'Theory of Everything' or TOE.
9. Please note 1 Timothy 6:16—light is a form of pure energy.

"After his kind"

Judith Evans

PLANTS WERE the first living organisms in God's work of creation. In Genesis 1:11 we read: "And God said, Let the earth bring forth grass, the herb yielding seed, and the fruit tree yielding fruit after his kind, whose seed is in itself, upon the earth". Compared with animals, plants are often thought of as simple organisms, and yet the secret life of plants is an incredible world that should leave us in awe of the Creator's wisdom.

This article seeks to explore some of those secrets that have enabled the plants to survive on this earth—providing beauty to the eye, being critical to the survival of all other life, and offering clear evidence of the purposeful design of a powerful Creator.

Colour and fragrance

"Consider the lilies of the field, how they grow; they toil not, neither do they spin: and yet I say unto you, That even Solomon in all his glory was not arrayed like one of these" (Mt. 6:28,29).

The sight of a field of flowers is a wonderful testament to the work of the Creator. Behind the beauty of the flowers, however, lies a complex world of chemicals. The colour of the petals is determined by the presence of two main families of pigments: the *carotenoids* and the *anthocyanins.* The crimsons, purples, blues and creamy whites, as well as some reds and yellows, are usually members of the anthocyanin family of pigments; the oranges as well as some of the other yellows and reds are carotenoids.

To create even more colours, the pigments bond together with other compounds, already in the petals. For example, *tannin* (the compound that leaves a brown stain on our tea cups) is also found in a variety of other plants. When it bonds to the anthocyanin pigment it gives a range of blueness in petals. In cornflowers it is the combination of anthocyanin with the metal element iron that gives the blue colour. On the other hand, in *Hydrangea* the petals are blue or red depending on the balance between aluminium and molybdenum. Finally, the amount of the pigment can determine the colour, the blue cornflower having only a small amount of anthocyanin, the deep purple cornflower having a concentration of anthocyanin around thirty to fifty times higher.

Many flowers have a beautiful scent. These are produced by around twenty different chemical groupings that make up the essential oils, the odours of the plant. The complexity of the plant odours has kept chemists who seek to analyse them busy for many centuries. Of course, not all the odours are pleasant, but most are quite unique. The starfish flower, *Stapelia*, from Africa smells like rotten meat to attract flies for pollination.

However, neither the colour nor the scent of the petals is there just for our pleasure. The colours and scents of plants directly influence the behaviour and movement of the animals on which they depend. Thus their main role is to attract the agents of pollination. So the pigments that produce the nearly white colours found in many flowers have no colour to our eyes but are clearly visible to the eyes of the bees and other insects that can see ultraviolet light. Butterflies are attracted to brightly coloured blossoms, moths and wasps prefer duller, more drab colours, whilst bats, flies and beetles are attracted chiefly by odour.

Good examples are to be found in the eighteen species of the *phlox* family that grow in the Americas. They demonstrate a strong correlation between the colour of the petals and the pollinator. In the tropical latitudes the scarlet flowers are hummingbird-pollinated, in the north the blue flowers are bee-pollinated, and those flowers pollinated by butterflies tend to be mauve or pink.

Plants also have ‘honey guides’, which act to guide pollinators to their reward once they have arrived at the flower. A yellow spot on the lip of a blue flower, or a series of dots on the petals, lead the pollinator to the nectar, the pollen and the sex organs of the flower. Again, some honey guides are only visible in ultraviolet light. Flowers that appear uniformly yellow to us in daylight appear quite different under ultraviolet light. The outer parts of the petals are bright, due to the presence of the carotenoid pigment, and attract the pollinator, whilst the anthocyanins at the centre act as the honey guide. Some flowers change colour with age, and this is found to be associated with a change in the amount of nectar.

Other amazing examples exist of the close relationships between plants and animals. The bee orchid relies on the male bee to pollinate it. Female bees and moths secrete a chemical called a *pheromone* to attract their males. So how does the bee orchid attract the male? It produces this chemical attractant and thus pretends it is a female bee. Evolution requires that this came about by pure chance, and evolutionists are unable to explain how pollination occurred beforehand.

The traveller’s palm of Madagascar is particularly spectacular and decorative. It produces a single vertical fan of huge leaves that can be very high, and its flowers have large chambers where the nectar is secreted. Its pollinator is a ruffed lemur, the size of a spaniel. On its arrival at the plant it finds a flower, pulls open with its hands the bracts that surround the petals, and then opens the flower with its teeth. For the two or three months that the palm flowers, the nectar is the main source of food for the lemur. No other insect, bird or reptile has the strength to open the bracts around the flower, or a tongue long enough to reach the nectar. Thus both palm and lemur are dependent on each other—a marvellous example of symbiosis. And yet how could the plant have survived if it evolved before the lemur?

Pollination and fertilisation

The genetic information essential for the continuation of each species is found in the seed, and the flower is the key to the complex process of producing the seed. As we have seen, the flower provides a source of food in the form of nectar to the pollinator. In return it uses the pollinator to distribute its pollen. However, in the case of some inconspicuous flowers, it is the wind that distributes the pollen.

Pollen grains are microscopic (ranging in size from twenty to 250 nanometres[1]), vary in shape, and are produced in enormous numbers. A single birch catkin can contain five-and-a-half million pollen grains. Pollen is the male sex cell of the flower, and is produced by the stamen, the male organ, comprised of the anther and the filament (see Figure 1 opposite). Inside the pollen grain are two nuclei, a pollen tube nucleus and the male nucleus that divides into two. The female organ, called the carpel, consists of three parts: an ovary containing an ovule, a thin pillar leading up from it called the style, and a sensitive pad at the top called the stigma.

Differences in the arrangement and details of the flowers are strong indicators as to whether

1. A nanometre is 10^{-9} metres, or one thousand millionth of a metre.

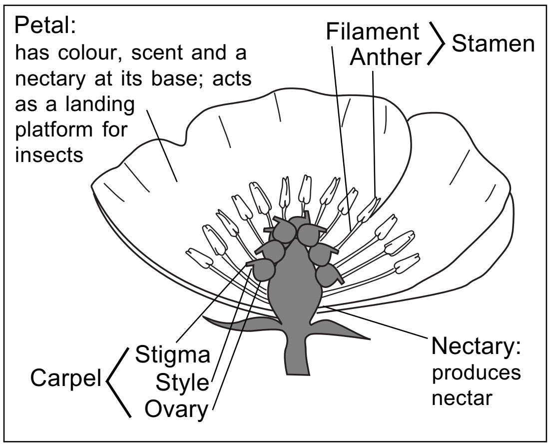

Figure 1: Parts of a flower

the flower is to be pollinated by the wind or by an animal. In both cases, however, the end result is the same. The aim is for the pollen grain to stick to the sugar-coated surface of the stigma. If conditions are favourable, the pollen grain then grows a tiny tube down the style. The two male nuclei then travel down the tube, behind the tube nucleus, which is controlling the growth of the tube, to the micropyle (see Figure 2 below). One of the male nuclei than fertilises the egg nucleus. More than one pollen grain may grow a pollen tube, but it is the male nucleus of the first pollen tube to reach the embryo sac that fertilises the egg. If an ovary has more than one ovule, each egg nucleus fuses with only one male nucleus.

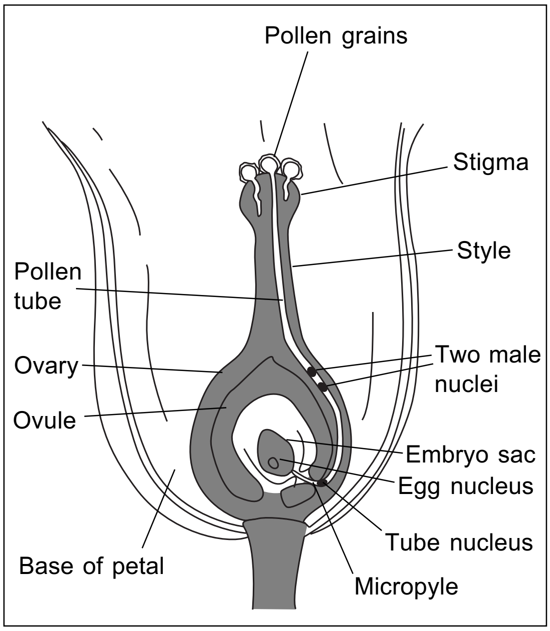

Figure 2: A male nucleus fertilising the egg nucleus

It is remarkable that a stigma will not react to pollen from another species. The stigma also distinguishes between a pollen grain that has been produced by the same flower and one from another individual of its own kind, in order to prevent self-fertilisation. Once the egg nucleus has been fertilised, it develops into the embryo, the seed, which will become the new plant. The other male nucleus fuses with two more nuclei in the embryo sac and forms the food store for the embryo to use while it grows. After fertilisation it is the ovary that develops into the fruit, and it is the number of fertilised ovules, therefore, that determines the number of seeds inside the fruit. All this wonderful process is anticipated by the words of the Creation record in Genesis quoted at the beginning of the article: “the herb yielding seed, and the fruit tree *yielding fruit after his kind*, whose seed is in itself, upon the earth” (1:11).

Seed production

Seeds take a variety of forms. They may be hook-covered, be equipped with parachutes or have a fruit enclosing them, and they display a huge range of sizes. For example, the coconuts from the coconut palm *Lodoicia* (in the Seychelles Islands) take up to six years to develop and have a mass of eighteen kilograms, whilst at the other extreme orchid seeds have a mass of less than one millionth of a gram.

The period between the formation of a seed and its germination is critical to the survival of plants. Firstly, plants need to disperse their seed. The most spectacular dispersal mechanism belongs to the squirting cucumber of the Mediterranean. The flowers develop into swollen cucumbers that swell until the pressure is so great that the seeds are propelled out through the hole left by the stem.

Survival to the next season or to the next generation then becomes of paramount importance. The abundance of seed-bearing plants in the world today, in contrast to the spore-bearing plants which were apparently once so dominant, is attributed to the ability of these plants to survive rapid climatic changes. The complexity of seed production, however, bears all the hallmarks of design by a Divine Creator.

Seed production is the basis of genetic diversity. The variation in the offspring of a plant confers an increase in the chances of survival. The seed also enables the plant to disperse itself. It is amazing that some seeds can remain viable typically for ten to fifty years, whilst a few credible estimates have put the age of some viable seeds at over 600 years.

For a seed to germinate it needs water, oxygen and the correct temperature. Some seeds germinate as soon as they are ripe, but others are able to delay germination, even under ideal growing conditions. The variety of survival strategies exhibited by seeds is awesome. Clover, for example, has a thick waxy seed coat, which means that some of the seeds will germinate immediately whilst others will be retarded. This enables the plant to spread out its germination over long periods, increasing the chances of at least some of the seeds germinating successfully.

Some plants need light for germination. The seeds of the foxglove, when swollen with water, can detect not only whether there is any light, but also how strong it is. This photocell-like capability means that the seed germinates only when there is bright, full sunlight in woodland clearings. In the case of the tomato plant, the seed is released within the succulent fruit, where the temperature is ideal and there is ample moisture and oxygen. However, the seed does not germinate until it is removed from the moisture of the tomato. This is usually after it has been through the digestive system of a consumer and is thus dispersed a long distance from the parent plant.

In some cases chemical inhibitors are present in the seed, which must be leached out or destroyed before germination can take place. Usually it is rainfall that leaches out the chemicals and leaves the ground wet enough to enable the newly germinated plants to survive. This is true for desert plants, where light rains are insufficient to leach out all the inhibitor and will not provide enough moisture to support new growth. Indeed, desert seeds can remain in the sand for decades waiting for the rain. In rose seeds the inhibitor is cyanide and in others it is ammonia. Winter annuals reduce the water content of their seeds while they are on the parent plant. After being subjected to some very cold conditions in their dried state they will not germinate until the temperature increases to a favourable level. Thus plants exhibit a wide range of complex mechanisms that enable them to detect environmental changes and allow them to survive in a wide variety of climates.

Growth

Once the seed has germinated the plant begins to grow. The giant bamboo can grow over one metre in a single day and so will achieve a height of thirty metres in fewer than three months. By contrast, a Sitka spruce that was found at the tree limit in the Arctic was estimated to be about a hundred years old and yet only measured twenty-eight centimetres in height. So growth is not a fixed quantity, but can vary greatly. The internal genetic program, which controls the shape and growth forms of plants, is incredibly flexible. As a plant grows, it develops a variety of organs, such as leaves, flowers, fruits and seeds. However, in addition to the internal program, there are at least five growth substances that help control day-to-day responses to the changes in the surrounding environment.

The complexity of these compounds is witnessed by the fact that it was not until the 1930s that one, called *auxin* (from the Greek word *auxein*, meaning 'to increase'), was discovered. In fact it was first isolated from a totally unexpected source, human urine. Auxins are produced in very small amounts, for instance at the tip of a seedling, and can move to other parts lower down the stem, where they affect the growth.

The effects of auxins vary enormously. The auxin produced in the tip inhibits the outgrowth of branches. So to make the side branches of conifers grow quickly and form bushy plants, instead of tall, slender ones, the leaf bud is removed from the plant (the so-called Christmas tree effect). By contrast, auxins can also have root-forming activity and are therefore commercially used as rooting powders when taking cuttings. Auxins can also trigger fruit formation without the need for pollination, which has also been used commercially.

Another important family of growth substances are the *gibberellins*. Over one hundred gibberellins have been discovered since they were first isolated in the late 1930s. They are so called because rice plants that were infected with the fungus *Gibberella* were found to grow very tall and thin compared with normal plants. Addition of gibberellin to a sugar beet plant can cause it to grow to great heights. Furthermore, gibberellin can mimic the effect of light on those seeds requiring light to germinate (see above).

Yet another class of growth substances called *cytokinins* (from *cyto*, meaning 'cell', and *kinein*, meaning 'movement' or 'growth') is particularly important in the development of the seed. It is responsible for stimulating the rapid production of new cells.

Another substance, *ethylene,* is surprising because it is a gas at room temperature. However, it is responsible for the well-known phenomenon that an overripe fruit, in a closed container, can cause the rest of the fruit to ripen more quickly. Only a small amount of ethylene is needed for this to occur. Another fascinating role of ethylene is its production in response to the stress that a seedling experiences when it is trying to force its way through the soil. Ethylene production causes the stem of the seedling to slow its growth upwards but expand its growth in thickness, thus giving the seedling the strength it needs to break through the soil and reach the light. This then leads us to the next question, Why do plants need to grow towards the light?

Photosynthesis

No discussion about plants would be complete without a mention of the process of photosynthesis, which enables plants to play their key role in the drama of life. "He [God] causeth the grass to grow for the cattle, and herb for the service of man: that He may bring forth food out of the earth" (Ps. 104:14).

The order of creation is witness to this. Plants can capture light and convert it into chemical energy. Chlorophyll, the pigment housed in the chloroplasts in the leaves of the plants, absorbs the blue and red wavelengths of light. Those wavelengths not absorbed are reflected or pass straight through the leaf and give it the characteristic green colour. The leaf actually contains other pigments, but these cannot usually be seen until the chlorophyll disappears from the leaf, especially during autumn. This is when the other pigments become more dominant and we see the beauty of the colours in the leaves, a reminder of God's promise to Noah that "summer and winter . . . shall not cease" (Gen. 8:22).

Light dislodges electrons from the pigment, forming tiny electric currents. These are then used by the plant to initiate a complicated sequence of chemical reactions. Very simply, the plant splits water into the elements hydrogen and oxygen and transfers the hydrogen to carbon dioxide molecules to make carbohydrates, such as sugars (like sucrose and glucose), starch and cellulose, the most common sources of foods and fuels available to all animals. The process also produces oxygen, which is essential for sustaining life on the earth. The burning of fuels with oxygen, within the cell, supplies the energy needs of all organisms.

The process of photosynthesis can be summarised by the following equation:

Carbon dioxide + water → glucose + oxygen

In his book, *Reaching for the Sun*, John King says:

> "There are lots of carbon dioxide and water molecules in the air, oceans, lakes, the soil, and inside living organisms, but the chances of any of them simply coming together in the right way to produce even a single molecule of glucose is extremely remote. Such a thing is not likely to have happened in the billions of years carbon dioxide and water have existed side by side on the earth. Yet, green plants form glucose . . . every daylight hour".

Indeed, the leaf itself is a further witness to the work of a Divine Creator. Its structure and shape make it ideally designed for its crucial function (see Figure 3). Being flat and thin allows a maximum surface area with minimum volume. The cells of the upper surface are transparent so that light can reach the palisade cells, the narrow cells where the chloroplasts are found. The contrasting arrangement of cells in the

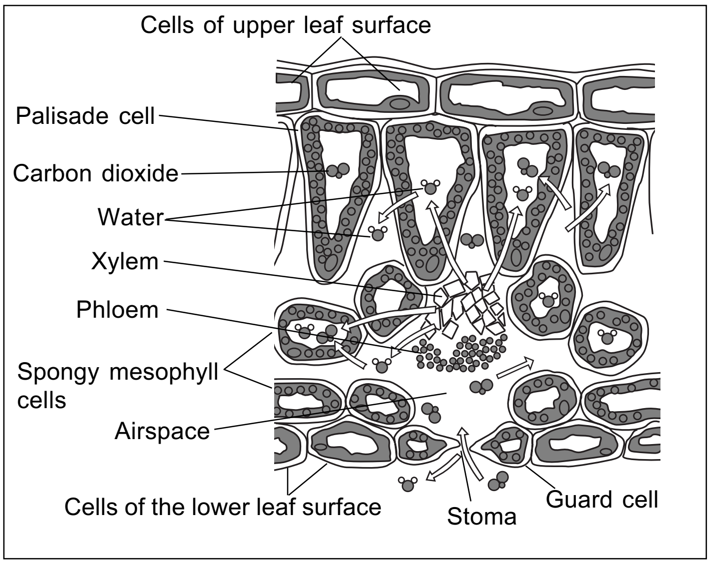

Figure 3: Leaf structure is designed for photosynthesis

palisade and spongy layers allows the leaf to use as much sunlight as possible. The leaves of some plants are also able to adjust their position to follow the sun as it moves across the sky. The thousands of stomata on the underside of the leaf, flanked by the guard cells, allow carbon dioxide to diffuse into the leaf, and oxygen to leave, as long as the plant is well supplied with water. Once the gases reach the palisade cells, together with the water carried to the leaf through the xylem tubes, photosynthesis takes place.

Some plants, such as cacti or the pineapple, have been designed in a very different way. Water loss is minimised by keeping the stomata shut all day and only opening them at night. This means that the leaf has a special chemical carbon dioxide pump, which can suck the gas more efficiently from the air and then release it behind closed stomata during the next day, into the cells where it is needed.

Summary

This article has only touched the surface in exploring the fascinating world of plants. Plants are indeed a witness to the wonders of creation, and yet are often neglected and taken for granted. Their ability to produce oxygen makes them the foundation of life on our planet. They are incredibly complex chemical factories, and have a phenomenal ability to survive in extreme conditions.

Truly, as Scripture records, "the earth brought forth grass, and herb yielding seed after his kind . . . and God saw that it was *good*".

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The Spirit of God—the basis of all things

Nigel Bernard

THIS ARTICLE concerns the Spirit of God and its relation to the heavens and the earth. The article begins by considering several key Scriptural passages that provide a foundation for our understanding of the Spirit. We then go on to see how the beliefs of the philosophers in Athens contradicted the Biblical view of the Spirit, and how Paul argued against them at Mars Hill. Then, having reflected upon the beliefs of such men as Isaac Newton and Brother Thomas, we consider the way in which the Bible view of the Spirit provides insight and a true perspective in the context of modern scientific theories and discoveries.

In the beginning

The Spirit of God is first mentioned in the very opening words of Genesis: "In the beginning God created the heaven and the earth. And the earth was without form, and void; and darkness was upon the face of the deep. And the Spirit of God moved upon the face of the waters" (vv. 1,2). The Hebrew word translated "moved" here occurs in two other places in Scripture. In Deuteronomy 32 it is translated "fluttereth": "As an eagle stirreth up her nest, *fluttereth* over her young, spreadeth abroad her wings, taketh them, beareth them on her wings . . ." (v. 11). In Jeremiah 23 it is rendered "shake": "Mine heart within me is broken because of the prophets; all my bones *shake*" (v. 9).

Strong says that the meaning of the Hebrew word is 'to brood'. This fits in well with the context of the eagle in Deuteronomy 32. From this it is often remarked that the movement of the Spirit upon the waters was a manifestation of the way God cared for His creation, even as a bird cares for her young. But in Jeremiah 23 the sense of 'shake' would seem to fit the context better. When a bird flutters or a bone shakes, the movement is not continuous in one direction, but rather switches rapidly back and forth. So in Genesis 1, perhaps, in addition to the sense of brooding, there is a sense in which the movement of the Spirit of God is depicted as being akin to a vibration or oscillation.

Jeremiah says of God: "He hath made the earth by His power" (10:12). The power of God is His Spirit. The angel Gabriel said to Mary: "The Holy Spirit shall come upon thee, and the power of