not fill the three-dimensional space completely, as we saw with the tree branching structure. In the body, the branching form allows the complementary vessel systems to exist within each other.

Similarly, with a tree, the branching structure ensures an appropriate surface to volume ratio, allowing the exchange of sufficient quantities of energy (sunlight), moisture etc. with the environment. Thus the physical structures of both the vessel system and the tree are suited to their purpose and correct functioning. It is surely a reasonable step to believe that a Designer intended their forms to be that way. The design argument applies not only to their biological components and functions, but to the physical, fractal forms required to achieve their purpose.

Conclusion

In summary, then, we have a world in which we see many beautiful natural forms. That world has an orderly structure, following a set of 'laws of nature'. The human mind has both a desire and an ability to understand the nature of this world. In describing the 'rules', beauty and economy are again evident. The physical structures are suited to their required functions. Each of these elements indicates the hand of a Creator God in the natural world. Taken together, they supply ample evidence for our belief in Him.

In addition, the aspects considered in this article show us something of the character of the Creator. He is a God of love, Who wishes us to share His joy in the world around us, to understand its laws and to exercise moral choice. Our appreciation of beauty, our desire for explanation and our ability to comprehend the world are all God-given characteristics. Let us use them wisely, bearing in mind God's words to Job: "Who marked off [the earth's] dimensions? Surely you know! Who stretched a measuring line across it?" (Job 38:5, NIV).

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The honeybee—an example of the Creator's genius

Eric Marshall

THERE ARE probably 800,000 species of insects,[1] but few, if any, have been so well studied as the honeybee. No doubt this is in part because of its value to man as a pollinator and as a source of honey. As a result we have a large body of information about the behaviour and biology of the honeybee.

Almost without exception, those who write about it accept and promote evolutionary ideas for the origin of its remarkable life cycle and habits. We believe that the complex structure of the honeybee colony, the interdependence of its members and its special relationship with a large range of insect-pollinated plants is much more reasonably seen as an outstanding example of the genius of the Creator.

Design is an activity that uses various means to achieve an end. In a complex situation, sophisticated machines may be made and particular strategies devised for their use. We see such purposeful complexity in the honeybee colony, firstly in its interaction with insect-pollinated plants that provide its food sources, and secondly in the way in which individuals operate to serve the colony's needs, even though the vast majority never live to see the benefit of their work.

1. *Microsoft Encarta 2000:* 'Insects'.

Some facts

It is helpful to remind ourselves briefly of some of the facts about honeybees. They are *social* insects, that is, they operate as a colony of many; typical numbers vary from 10,000 to 80,000. There are three types (or castes) of bees: the queen, the workers and the drones.

The **queen** is a fully sexually developed female, and is basically an egg-laying machine. She also secretes chemicals (called pheromones) that inform the colony, amongst other things, of her presence. She can live up to five years, and at peak times of egg laying will, because of appropriate feeding from the workers, produce many times her body weight of eggs daily. She is able to control whether the eggs she lays are fertilised or unfertilised. Fertilised eggs hatch to become, after larval and pupal stages of development, either other queens (infrequently) or workers. Unfertilised eggs become drones. There is usually only one laying queen at a time in a colony.

The **worker bee** is a sexually undeveloped female which, in certain cases, can produce a few eggs; these, being unfertilised, will hatch to become drones. She is, however, equipped with glands that enable her to produce secretions, often referred to as **bee milk** or **royal jelly**, which are fed to the larvae. She also has the ability to produce wax, which is used for comb building. Older worker bees also fly from the hive to collect water, nectar, pollen and propolis,[2] and are able to communicate to each other the location and quality of nectar and pollen sources. Workers form the vast majority of the bees in a colony, and are essential to its operation and survival. Workers in the summer live only for about six weeks, but those born in the autumn will survive up to six months, probably because they are not required to raise much brood, or to forage, over the winter. In the winter the colony clusters on combs filled with honey and pollen, worker bees flying only when weather permits. The quantity of honey that can be gathered by one hive in a good season in the United Kingdom can exceed 100 pounds. This is an astonishing performance, for it has been estimated that the bees' total flight path to produce one pound of honey is equivalent to three orbits of the earth!

The **drone** is a fully sexually developed male, whose only function seems to be to mate with a virgin queen. Drones, numbering a few hundred in a colony, are reared in spring and summer, and are expelled from the hive in August/September when their usefulness is past.

The production of workers and drones and, infrequently, of a new queen to replace an ageing one, ensures the survival of the colony. Increase in colony numbers occurs through the process of **swarming**. Under conditions of rapid colony growth promoted by abundance of nectar and pollen, which may fill the available brood rearing space, the workers construct special cells on the face of the comb and rear additional queens. As far as is known, the larvae that become queens would have become workers but for a changed feeding regime of abundant royal jelly[3] and increased honey supplies. It is thought that the increase in colony size causes a reduction in the distribution of **queen substance**, a pheromone secreted by the queen among the worker bees. This causes them to believe that the queen is either failing or dead and needs to be replaced.

This behaviour poses a severe challenge to evolutionists, because it is clear that the workers, with their short life spans, will individually never have previously experienced these conditions. Their ability to respond is there because they already have in place the instinctive detection mechanisms and the potential to produce queens at will by changed feeding. It seems completely unreasonable to suppose that such a mechanism could evolve gradually or as a consequence of being faced with the loss, apparent or actual, of the queen.

Comb building

The structure and construction of the comb that bees make to rear broods and to store honey and pollen is a marvel in itself. It is economical in its use of the material beeswax, and it is also structurally strong at the temperature of the hive (35°C). Anyone who has lifted a full frame of honey from a hive will readily appreciate this. Mathematicians (quoted by Huber, 1814) have calculated that comb cells are the proper shape to hold the greatest possible amount of honey with the least possible consumption of wax. It has also been estimated that a pound of wax can be built into 35,000 cells, capable of storing twenty-two pounds of honey, and that this pound

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2. Propolis is a resinous secretion of plants, for example on poplar buds. It has pharmacological properties for which it is collected and marketed. It may also contribute to hygiene in the hive.
3. Ronald Ribbands, *The Behaviour and Social Life of Honeybees* (1953), p. 247.

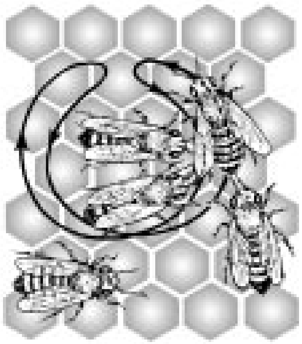

Figure 1

of wax would require the bees to consume about five pounds of honey to make it.[4]

Wax-producing bees cluster with others along the surface from which the finished comb will hang. The wax is produced as scales on the abdomen of bees, then masticated and placed in a ridge. The ridge is added to and modified in shape by bees using their mouth parts; so although the cell bases and walls start relatively thick they are thinned down until the wall thickness is only about 0.07 millimetres. Researchers speculate that the final thickness is controlled by the flexibility of the thinned wax. These thin flexible walls are strengthened by a thickened top, like a coping stone, which allows the bees to walk over the surface without damage to the walls. Honeybees build cells of two different sizes; the smaller size is used for rearing worker brood, the larger for rearing drone brood.

These remarkable skills, which result in a continuous comb without irregular spaces, are clear evidence of purposeful design. It is altogether missing the point to argue, as Darwin did, that "this perfection had arisen from a few simple instincts, by natural selection".[5] The miracle is the presence of the instincts *in combination*, to meet a need that the insects could never foresee before the event, as well as the worker bees being equipped with glands that produce wax from the sugars in the honey they ingest. It is this capability, amongst a myriad of others, built into workers, but not queens or drones, that should cause us to marvel at the Creator's genius.

There are other bees (and wasps) which build combs of different formations. For example, bumblebees build rounded pot-like cells, set on the floor of their usually subterranean nests. These are suited to their needs, and are just as valid as evidence of the immense variety in creation as of supposed steps in some speculative evolutionary chain. Indeed, there is no evidence that bumblebees, or other bees with what might be described as less advanced comb designs, are 'evolving' their comb designs, which might be expected if gradual improvement were a normal consequence of natural processes, as postulated by the scientists who promote evolution.

Communication and the 'bee dance'

Solitary insects have little need to communicate with each other, but social insects do. Some communication in the hive is by transfer of pheromones. This is marvellous in itself, but the greater marvel is the communication of information about the location of sources of nectar. Nectar is vital to the survival of the colony. If searching for it were a purely chance affair then the proportion of bees reaching a good source would be very small, especially if it were some distance away. However, bees do not need to fly randomly, because foraging bees are able to communicate the distance and direction of a source, as well as giving samples of collected nectar to other bees.

This is done by means of a dancing action on the surface of the comb. For sources of nectar up to 100 metres from the hive, the returned forager does a 'round dance' (Figure 1), which will simply alert others to a nectar source close by, the scent and quality of which they can sample from the forager. For sources beyond 100 metres the dance becomes a figure-of-eight pattern (Figure 2). The direction of the source relative to the direction of the sun from the hive is given by the angle between the vertical and the central line in the figure-of-eight (Figure 3). As the forager

4. *Ibid.*, pp. 201-2.
5. Cited by Ribbands, *ibid.*, p. 198.

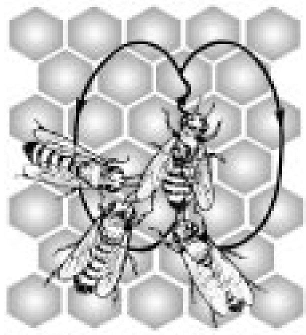

Figure 2

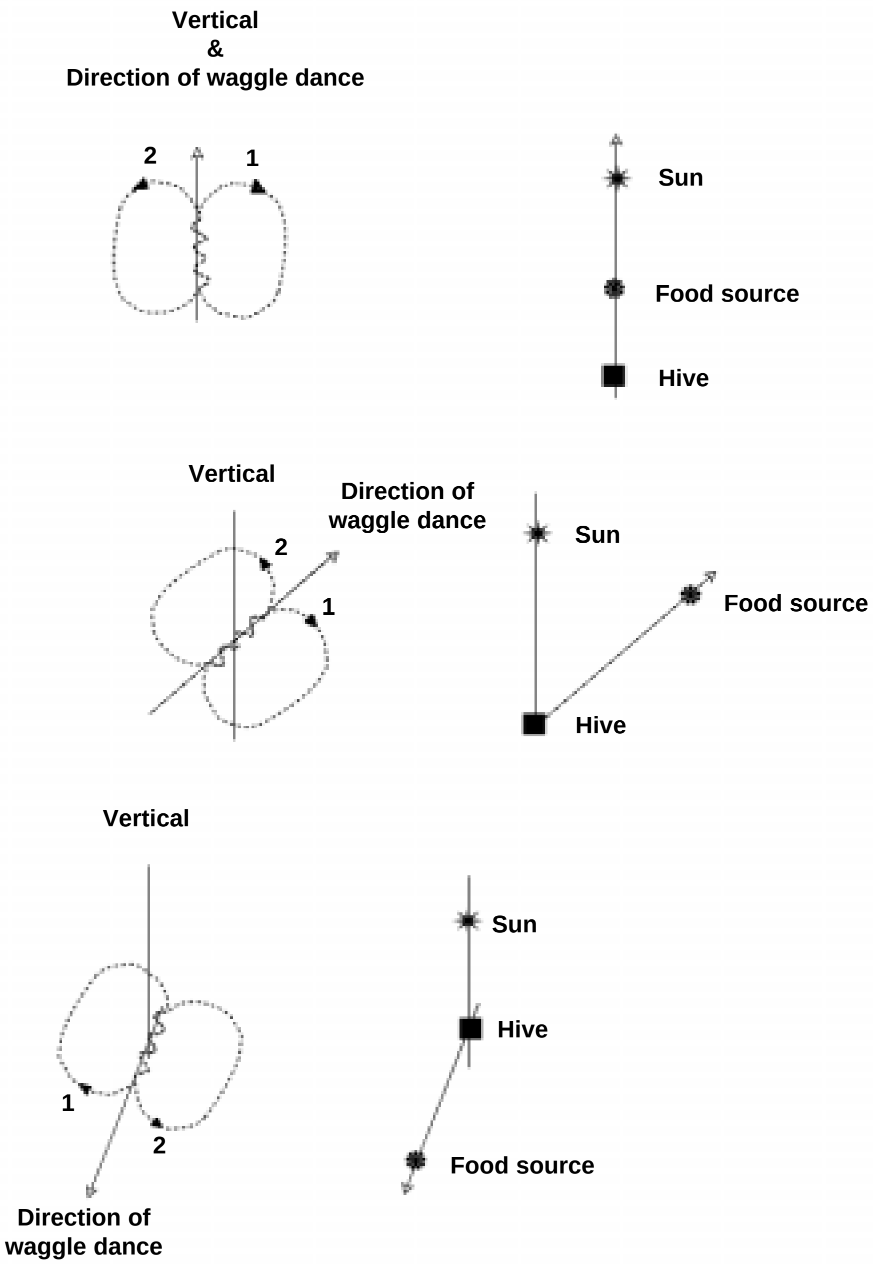

Figure 3: Illustrations of the honeybee waggle dance to show the direction of a food source

traverses the central part of the figure-of-eight she wags her tail. The duration of each wag-tail circuit, which takes only a few seconds, is related to the distance between the hive and the source of nectar; longer wag-tail dances indicate that the source is further away. Reliable distance information up to at least 4,500 metres is communicated.

Of course it is possible to observe bees dancing on the comb, but within the hive the dances are actually detected *in the dark* by the bees, who follow the dancing forager! It has also been discovered that during the wag-tail part of the dance the bee emits high frequency vibrations which are related to the distance of source from the hive.

Much has been written on this topic,[6] and it is fascinating. For our purposes we note that, for the worker honeybee to communicate, by its dancing, the data required for other bees to find the location of the nectar, it must:

- **detect the position of the sun—**the bee's compound eyes have plane-polarising filters which enable it to 'see' the sun even on cloudy days
- **measure the distance to the source from the hive—**it is thought that the bee can measure the energy expended during flying
- **possess good time sense and time memory—**to allow for the movement of the sun during the thirty to sixty minutes it is foraging. Also, it is known that some species of flowers produce nectar at specific times of the day, and that bees stop visiting while the nectar flow has ceased
- **detect scent**
- **recognise flowers by colour and shape—**bees are able to do this, and will only visit at the times of nectar secretion.

Some evidence also exists to suggest that bees can detect the earth's magnetic field, which can help them, together with a memory of the physical objects nearby, to identify their hive accurately.

All these remarkable skills are instinctive, built into the make-up of the honeybee. And, importantly, they all have to work in combination, surely requiring the hand of a master designer.

Nectar processing

The dance of the bee is remarkable enough, and ensures the best possible chance for the colony to collect nectar for storage. But nectar cannot be stored as it is. It is typically composed of eighty per cent water and twenty per cent sugars.[7] Such a sugar solution, at the temperature of the hive (35°C), would be an ideal nutrient solution for bacteria and moulds. Unprocessed, it would rapidly ferment and be of no use to the bees. It is here that the behaviour of the bees in the colony ensures that spoilage does not occur. Nectar brought by foragers is normally passed to other bees working in the hive, but in heavy flows it is put in cells for later manipulation. The colony bees expose droplets of nectar from their tongues to allow some evaporation of the water present.

More concentrated droplets are put into cells where further evaporation of water takes place. This happens because other bees are involved in circulating air throughout the hive to control the temperature and humidity. This is easily observed on a summer evening during a honey flow, when bees can be seen standing at the entrance of the hive and flapping their wings vigorously—the sound is distinctive, and satisfying to the beekeeper!

Why this effort to concentrate the nectar? Honey, which should contain more than eighty-per-cent sugars, is a bactericide, and, when capped with wax in a cell, will keep for years. But the reader might ask why bacterial, fungal or yeast action does not take effect while the honey is still diluted. Worker bees have glands that produce enzymes (biological catalysts). One of these, invertase, converts the sucrose to a mixture of glucose and fructose, which allows the bees to produce a much more concentrated solution of sugars than is possible with sucrose, glucose or fructose alone. This phenomenon, which only happens at the temperature in the hive, ensures a highly concentrated sugar solution.[8]

Another enzyme, glucose oxidase, reacts with glucose in dilute solutions to form gluconolactone

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6. K. von Frisch, *The Dance Language and Orientation of Bees* (Harvard Press, Cambridge [Mass.], 1962); *The Dancing Bees* (2nd edition, Methuen, London, 1966).
7. Ted Hooper, *Guide to Bees and Honey* (1976), p. 60.
8. At 30°C (the temperature of honeycombs in the hive) the solubility of glucose in a solution of fructose increases abruptly if the fructose concentration is raised above 1.5 grams per gram of water. The gram of water can then hold in solution, as well as the fructose, 1.2 grams of glucose. This is fifty per cent more than a dilute fructose solution can carry. This high glucose solubility does not operate at higher temperatures, nor at lower ones. Moreover, the sugar sucrose does not have this property of high solubility. See Eva Crane, *A Book of Honey* (1980), p. 18.

Did you know . . . ?

- Bees fly at 13-15 mph
- Honeybees visit 2 million flowers to make 1 lb of honey
- 5 lbs of honey is eaten by bees to produce 1 lb of beeswax
- One healthy hive contains 40-50,000 bees
- A bee's life span is only six weeks during honey production

Beeswax is used for . . .

- Making candles and ornaments
- Lubricating sewing needles and thread
- Making lip balm, cosmetics and medicinal creams
- Waterproofing shoes, fishline and clotheslines
- Making furniture polish and floor polish
- Lubricating doors, windows and tools

(gluconic acid) and hydrogen peroxide. It is this hydrogen peroxide which protects against bacterial spoilage of the dilute honey until the bees have raised its sugar content sufficiently to provide protection.[9] The hydrogen peroxide then breaks down into harmless water and oxygen. The fact that a similar system is used by the four species of honeybee, colony-forming bumblebees and stingless bees makes it no less remarkable. If such a process were being operated by man in a commercial factory, we would be amazed at the elegance of the chemical reactions used and praise the clever designer of the process. Here we believe is further evidence of the Creator's genius at work.

Interdependence of queen, worker and drone

The mutual dependence of the queen, worker and drone makes it very difficult to conceive how such an arrangement could ever have happened by chance processes. The queen is totally dependent on the provision made by the workers for her origin and continued existence. It seems that workers decide whether a fertilised egg will become a queen, because they control the feeding regime that determines this. Once hatched, the virgin queen is able to survive on the stores collected by the workers, but if she is ultimately to become a viable laying queen she must mate with one or more drones. Worker bees encourage drone production in early spring so that they are available if and when required. Once mated, the queen will lay eggs, but this depends on her being fed by the workers, mainly with bee-milk secreted from special glands which they uniquely possess.

However, the worker bees in contact with the queen groom her, in the process of which they

9. *Ibid.*, pp. 18-19.

collect and distribute secretions from the queen that actually modify their behaviour. Without this queen substance some workers' ovaries develop and others begin to rear more queens. It is clear at even the simplest level that all the members of the colony are interdependent. Additionally, the nectar and pollen collected and stored for later use are of no benefit to the workers who collect it. The value of these stores is that they allow *later* generations of bees to survive and carry the colony through the times when no nectar and pollen supplies are available. Those that collected it are by then long dead! It is this *long-term* benefit arising from *short-term* instinctive actions that bears the hallmark of design and challenges evolutionary explanations.

Honeybees as pollinators

Genesis 1:11 records: "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: and it was so". We are all familiar with flowering plants and trees. Flowering is part of the process by which seed is produced. The male part of the flower produces pollen, and the female part of the flower is, at the appropriate time, receptive to pollen, which sticks to it. This then travels down the pollen tube to the ovary, fertilising the ovules, which develop into seeds.[10]

Some plants, such as grasses and catkin-bearing trees (for example hazelnut), produce light, dry pollen that is transferred by wind—these plants are wind pollinated. Almost all other plants require some animal agent to transfer the pollen. In most cases insects are the agents, and bees are the most effective pollinators. They are especially important in commercial pollination, because hives can contain 20,000–40,000 bees available for pollination.

Bees need pollen to provide the protein in their diet, especially for the growing larvae. Plants that use insect pollination produce pollen with much higher protein levels than those that are wind pollinated. The worker honeybees' rear legs have 'pollen baskets' (corbiculae) into which they pack pollen that has collected on their hairy bodies. The other pairs of legs are used to comb pollen grains from their bodies and pass them to the rear legs for packing into the corbiculae. Although bees may visit flowers primarily for nectar, pollen will also adhere to their hairy bodies as they pass the anthers on the way to the nectaries of the plant.

Plants produce nectar to attract insects like bees so that pollination can occur. Many flowers are in fact rather colourful, and marked to direct bees to the nectaries. These markings are not always obvious to us because they are visible in the ultraviolet part of the electromagnetic spectrum. However, bees can see these ultraviolet colours and are able to remember the shapes and patterns they see.

Without doubt there is a close interdependence between plants and bees (and other insects) to ensure the survival of each. As one writer has said: "These intimate relationships in the microcosm of a flower—depending on the shape of the flower and the movement of a bee within it, on the bee's need to visit many flowers to fill her honey sac, and on recognition of colour and her memory for scent—provide the means by which many of the world's fruit and seed crops can be harvested and increased. Cross-pollination is essential for many of these crops, and in a number of others it may give yields that are higher, of better quality, or earlier (or all three) than those produced from self-pollination".[11]

This is clear testimony to a *designed* situation. Both plants and insects, depending upon each other, need to have come into existence concurrently, otherwise neither would have survived. Indeed, it is difficult to see why such plants and insects should have come into being at all, when other mechanisms of plant reproduction such as wind pollination and asexual vegetative methods (like runners on strawberries), were available and effective. It is interesting to note that some plants, for example species cyclamen, produce both types of pollen,[12] which are released at different times. This is particularly appropriate, for they often flower in situations and at times of the year when insect pollinators are scarce.

Conclusion

Vast amounts of research have been carried out on the honeybee; even Ronald Ribband's book *The Behaviour and Social Life of the Honey Bee*, published in 1953, cited nearly 700 references. Research continues and is published regularly. Although, almost without exception, researchers publish ideas in evolutionary terms, their

10. For a fuller description of this remarkable process, see "'After his kind'" in this Special Issue, p. 171.
11. Crane, *op. cit.*, p. 21-2.
12. Christopher Grey-Wilson, *Cyclamen* (1997), p. 38.

work has brought to light the amazing habits and skills of honeybees and their interdependence with insect-pollinated plants; indeed, the reliable production of some crops would be impossible without them. Readers who know of the UK National Lottery will be aware that it is a very unlikely event to guess correctly the random selection of six numbers out of forty-nine—millions fail in the attempt every week. The very much vaster selection of possibilities that have come together to produce a honeybee colony with its attendant supporting plant ecology must make the odds virtually impossible. We may safely see the remarkable capabilities of this little insect and its life history as fitting tributes to the genius of the Creator, Who has chosen to reveal Himself in the Bible. His words, we are assured, are "sweeter also than honey and the honeycomb" because "in keeping of them there is great reward" (Ps. 19:10,11).

The life is in the blood*

Mark Allfree

UNDER THE Law of Moses the children of Israel were expressly forbidden to eat blood. The penalty for anyone who transgressed this law was severe: "And whatsoever man there be of the house of Israel, or of the strangers that sojourn among you, that eateth any manner of blood; I will even set My face against that soul that eateth blood, and will cut him off from among his people" (Lev. 17:10). Clearly a very important principle was behind this prohibition. Whilst it may be said that such a law had good foundation purely on the basis of hygiene, this was not the reason why Israel were forbidden to eat blood. They were told why: "For the life of the flesh is in the blood: and I have given it to you upon the altar to make an atonement for your souls: for it is the blood that maketh an atonement for the soul" (v. 11).

The basis of this law was thus twofold: first, that "the life of the flesh is in the blood"; and second, that because of this God had chosen the blood to represent the means whereby atonement could be secured: "I have given it to you upon the altar to make an atonement for your souls". The discerning Israelite would thus learn from this commandment that for him to be accepted before God he had to dedicate his whole life to God, just as the blood of the animal was poured out; but also that his sins had to be blotted out through the atoning sacrifice of an innocent victim. This of course pointed forward to Christ, "In whom we have redemption through his blood, the forgiveness of sins, according to the riches of his grace" (Eph. 1:7).

The life of the flesh is in the blood

"The life of the flesh is in the blood", says the Scripture. Whilst this was intended to teach spiritual lessons to those with discernment, yet this statement has remarkable support in relatively modern scientific discovery. For many centuries people failed to realise the importance of the blood to the wellbeing of the human body. Even when it was discovered that the condition of the blood had an effect on health, the only practical idea they developed was to bleed patients to get rid of the 'bad blood'. This inevitably led to death in many cases, for, as we now know, loss of blood leads to death, whilst preservation of blood and transfusion leads to renewed life. No part of the body can contrive to live without the blood. All parts of the body depend upon the regular circulation of blood. If the supply of blood is inadequate death soon results.

The blood is distinct from all other parts of the body. It conveys nourishment to all the body tissues, and is the principal means by which tissues communicate with one another (for example, by hormones). It is certainly true of the blood more than of any other part of the body that "the life of all flesh is the blood thereof" (Lev. 17:14).

The Bible said this three thousand years ago. It is only within the past three hundred years that scientists have arrived at the same conclusion. Surely this should testify to scientists today that the Bible really is what it claims to be: the Word of the living God. Yet men still prefer to disregard the Bible's claims in favour of a theory which has no basis in fact: the theory of evolution. But we need look no further than the blood to see how unconvincing the theory of evolution really is. Blood is an amazing substance, which simply could not have evolved by chance. Consider the following evidence.

* First published Nov. 1992.