The Wright Brothers' Airplane Compared to Insect Flight Design

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Abstract

The Wright brothers' activities in inventing the airplane are set forth. They include library research, conscious imagining of a solution to flight's demands, kite experiments, communication with experts, glider experiments, experiments with a wind tunnel, and propeller design. Then the aerodynamics of insect flight is considered, demonstrating their superb sophistication. It is concluded that since human flight was in fact the result of such a high degree of intelligent planning, certainly the Creator's design is even more directly obvious in the origin of insect flight.

Introduction

This year, 2003, marks the one hundredth anniversary of powered, controlled, manned flight. It is probably commonly believed that the invention of the airplane by the Wright brothers was the result of a couple of ordinary men (bicycle mechanics) tinkering around and somehow putting together a simple machine that managed to fly. In reality, however, their achievement was the result of a highly controlled scientific enterprise. Part I of this article provides an historical overview of the Wright brothers' accomplishment and Part II gives a description of the highly complex flight design features found in insects.

Part I: The Wright Brothers

The Process of the Invention of the Airplane

As far as we know, before 1903 no one in all of the history of mankind had ever succeeded in devising a heavier-than-air machine capable of carrying a man in sustained, powered, controlled flight. Before the Wright brothers' achievement the greatest minds had failed to conquer this frontier. After reading about Otto Lilienthal's gliding experiments in Germany, Wilbur and Orville Wright developed an interest in manned flight; and in the years 1896 through about 1899 they started reading everything they could on the subject. Through this research they learned much from the experiences of others (Kelly, 1989, pp. 46–48).

After realizing how much of a problem others had experienced in aircraft stability and that no one had succeeded in solving it, Orville devised a technique based on controlling the inclination of the wing tips. Then Wilbur devised another technique based on wing warping (Kelly, 1989, pp. 48–50). These inventions showed ingenuity on the part of the brothers. In August 1899 they built a biplane kite and conducted their own experiments on it. They found that they could control it by extra cords attached so as to enable them to warp the wings (Kelly, 1989, pp. 50–51). Thus, the brothers commenced a long process of scientific experimentation.

In May 1900, Wilbur Wright wrote a letter to Octave Chanute (who had experience in gliding), communicating his plans for experimenting with a man-carrying kite (Kelly, 1989, p. 52). This practice of communicating with experts in the field of study is an important part of the scientific method. In addition, it is in keeping with the Biblical wisdom of using a "multitude of counselors" (Proverbs 15:22).

Next the Wrights invented an elevator (a device for controlling the airplane's tilt up or down) superior to previous designs (Kelly, 1989, p. 54). Then they built and experimented with a man-carrying glider. First they worked with it as a kite, and then they actually flew it as a glider. These experiments, conducted in the fall of 1900 at Kitty Hawk, North Carolina, were highly successful (Kelly, 1989, pp. 64–66).

In 1901 the brothers returned to Kitty Hawk and continued their experiments with a larger glider. They began to change the camber of the wing. It is this camber, or height of the wing's curve, which determines the amount of lift that a wing can provide (Figure 1). Camber is actually the height of the wing divided by the distance from front to back. They then adjusted the camber to a ratio of 1 to 18, which improved the glider's performance. Also, during that year, by experimentation they learned more about the center of pressure on a curved surface (Kelly, 1989, p.71). During the latter months of 1901 the brothers built a wind-

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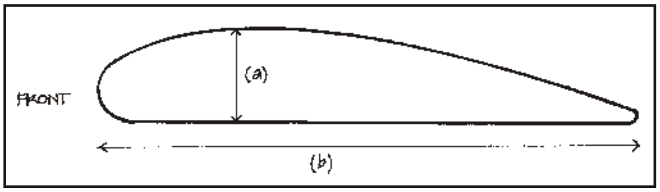

Figure 1. Camber ratio. Side view of wing. The camber of a wing is the ratio a/b seen here.

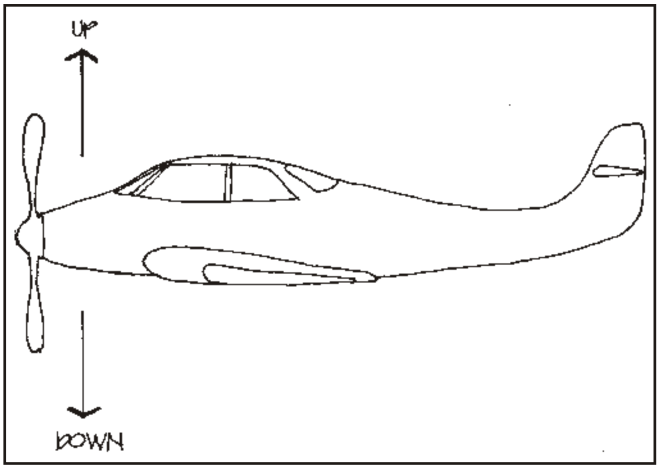

Figure 3. Side view of airplane illustrating "pitch", a vertical movement of the front of the plane.

tunnel and used it to test more than 200 types of wing surfaces (Kelly, 1989, p.76).

In 1902 the Wrights added a tail to the glider consisting of two vertical veins (Kelly, 1989, p.79). The success of these flights demonstrated that they were justified in disregarding the tables of air pressures used by their predecessors and building their gliders in accordance with the data obtained from their own wind-tunnel experiments (Kelly, 1989, p.80). This demonstrated the Wright's quest for and reliance upon empirical data rather than tradition and authority. This aspect of proper scientific research is also in accordance with the biblical admonition to "prove all things" (I Thess. 5:21).

Before the Wrights experimented with powered flight they built their own motor and devised a highly efficient propeller (Kelly, 1989, pp. 85–89). On December 17, 1903, the brothers finally made their historic first powered flight, followed by three others, each successively longer, that same day. According to Orville Wright:

> ...faith in our calculations and the design of the first machine, based upon our table of air pressures, obtained by months of careful laboratory work, and confidence in our system of control developed by three years of actual experiences in balancing gliders in the air, had convinced us that the machine was capable of lifting and maintaining itself in the air, and that, with a little practice, it could be safely flown (Kelly, 1989, p.99).

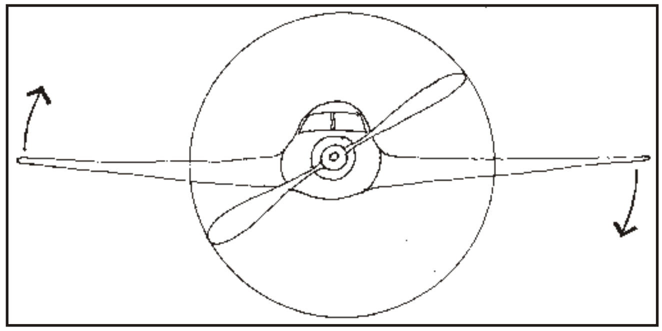

Figure 2. Front view of airplane illustrating "roll", a rotation of the plane about an axis from front to rear.

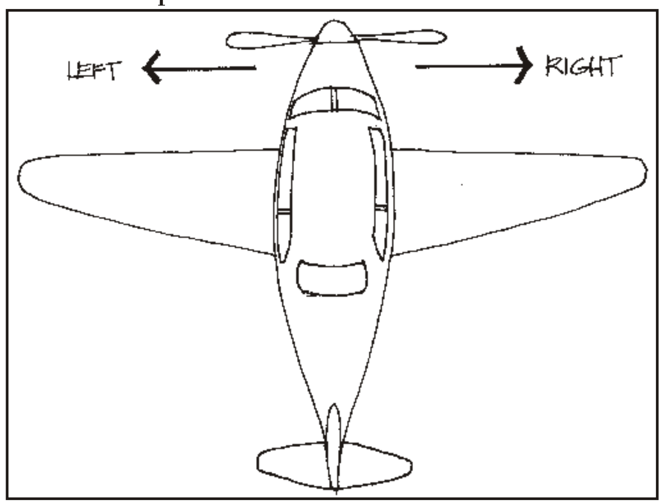

Figure 4. Top view of airplane illustrating "yaw", a horizontal movement of the front of the plane.

The Product

To produce a flying machine the Wright brothers skillfully brought together wings, propellers, an engine, and a pilot. These components had to be of a specific design and composition. In addition, it was essential to have control mechanisms. First of all, it was necessary to control the wings so that there would not be any rotation about a central axis running from the front to the rear of the airplane. This type of rotation is called "roll" (Figure 2). This control was accomplished by what the Wrights called "wing warping".

A second mechanism was necessary to control the movement of the plane's nose in a vertical dimension. This direction of movement is called "pitch" (Figure 3). Orville Wright was able to control pitch by designing an elevator (Wright, 1953, p. 14).

A third mechanism was necessary to control the plane's nose from moving right or left, a movement that is called "yaw" (Figure 4). The device used to control this movement was a vertical rudder in the rear of the plane which was originally controlled by being connected by wires to the cables that caused wing warping. Later this was changed so that the operator could control the rudder separately (Wright, 1953, p. 19).

This brief analysis of the use of design and controlling devices by the Wright brothers shows that they left little or nothing to "chance" in their labors. A study of insect flight will likewise show amazing evidence for design.

Part II: Insect Flight

More than 99.9% of all insect species exhibit flight (Dudley, 2000, p. 10). There are more than one million winged insect species described and they can be found "... in essentially all terrestrial ecosystems, and on all continental land masses, including Antarctica" (Dudley, 2000, p. 3).

Some insects are phenomenal fliers. Horseflies are said to be able to fly at speeds up to 30 mph (Dalton, 1975, p.26). Some dragonflies and hawkmoths can attain speeds of up to about 38 mph (Brackenbury, 1992, p. 118). The housefly can travel 250 body lengths per second, compared to 80 for diving swifts, and only 5 or 6 for humans (Brackenbury, 1992, p. 118). "Swarms of locusts occasionally make landfall in the Caribbean islands after being carried from breeding grounds in North Africa, several thousand miles to the east" (Brackenbury, 1992, p. 120). Monarch butterflies migrate 4,000 miles from Canada to Mexico (Brackenbury, 1992, p. 120). Acceleration rates of up to 9 times the force of gravity (g's) have been observed in some dragonflies and "acceleration at the transition from hovering to forward flight in hover flies and in bee flies reaches... up to 18 g's" (Brodsky, 1994, p. 71). "...[A]bout 23 million wingbeats were obtained in a tethered simulation of long-duration flight using a single *Drosophila melanogaster* (fruit fly)" (Dudley, 2000, p. 59). In order for insects to have such amazing capabilities, it is evident that they are, indeed, not the product of chance; but, in the words of the Psalmist, are "...fearfully and wonderfully made" (Psalm 139:14).

The flight of insects is very different from the flight of the Wright brothers' airplane. But the same basic features are present in both: a means of power (muscles instead of an engine), a means of translating that power into thrust (moving wings instead of a propeller), aerodynamic structures to provide lift (flexible wings instead of fixed wings), control mechanisms (for controlling flight in three dimensions), and control (an insect's nervous system instead of that of a human pilot).

Muscles, fuel, and oxygen

The Wright brothers' "Flyer" was powered by an engine which used fuel, burned in the presence of oxygen. The power for insect flight is provided by muscles which use a different kind of fuel, consumed with oxygen, also. Unlike vertebrate flying animals, insects have no muscles in their

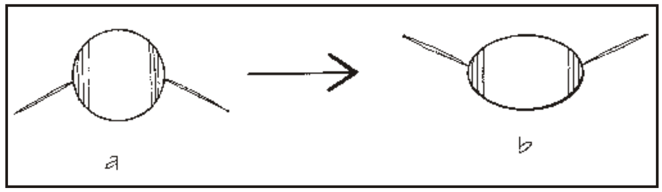

Figure 5. Simplified diagram of wing elevation through indirect dorsoventral muscle contraction. The wings at the left (a) are elevated by contraction of muscles (b).

wings (Dalton, 1975, p. 19). Their flight muscles are in the thorax. The base of each wing is attached to the thorax by an axillary apparatus, which includes sclerites, small bodies which act as fulcrums. In some cases the muscles pull directly on the wing base and sclerites (direct muscles), but in other cases the muscles pull on the thorax itself, changing its shape and causing it to pull on the wings (indirect muscles). The muscles function on both the down- and the upstroke. "Wing elevation in all insect orders is primarily attained through action of indirect dorsoventral muscles" (Dudley, 2000, p.44). As muscles connecting the interior dorsal and ventral aspects of the thorax are contracted, they pull these surfaces together, levering the wings upward (Figure 5). The muscles themselves are similar in insects and in birds; but insect muscles can generate far more force than those in birds or bats, since they can contract many more times per second, making them "...the most powerful muscle known in any animal" (Brackenbury, 1992, p. 36).

In insects, the fuel is either fats or carbohydrates. Fats are best for long distance flying, such as in locust migrations; while carbohydrates are best for fast, short distance flights, such as those made by bees. The fuel is delivered to the muscles by the blood (Brackenbury, 1992, p. 36). Flight muscle contraction not only enables insects to fly, it also accelerates the insect blood circulation, bringing fuel to the muscles more efficiently when it is most needed (Dudley, 2000, p. 163).

Insects need an enormous amount of oxygen when flying—up to 400 times the amount they need at rest (Brackenbury, 1992, p.43). "...[T]he thoracic muscles of insects in flight exhibit the highest known mass-specific rates of oxygen consumption for any locomotor tissue" (Dudley, 2000, p. 159). In insects, oxygen is not delivered to the muscles by the blood (as is the case in birds and bats), but through a system of air tubes (called tracheae) which bring in air from the outside through openings called spiracles. An insect can move its abdomen in such a way as to cause minute balloon-like sacs in certain regions of the tracheae to expand and act like a bellows, pumping air through the tubes (Brackenbury, 1992, p. 43). In addition, the thoracic muscle pumping during flight contributes to air flow through the tracheal system by compressing and expanding various tracheal tubes and tracheoles (the ends of tracheal tubes) (Dudley, 2000, p. 162). When the air sacs in some insects expand, the anterior spiracles open and the posterior spiracles shut. Then when the air sacs are compressed, the anterior spiracles close and the posterior spiracles open. The result is a one-way movement of air through the body, bringing in fresh air and expelling stale air (Brackenbury, 1992, p.43). Complex, coordinated systems, such as this one, are hardly what one would expect to develop by chance mutations and natural selection. At the tracheoles, oxygen leaves the respiratory system and enters into the muscle cells where it is needed. The thickness of the tracheole walls is important for the diffusion of oxygen through them. Dudley comments perceptively that "... structural design would appear in this instance to closely approximate the optimal value for effective oxygen transport" (Dudley, 2000, p. 161). Even a tiny detail, like the thickness of the tracheole wall, contributes to making insect flight feasible and appears to be the work of a Master Designer.

Wing movement

According to Dalton, insect wing movement in flying is more complex than that of birds (1975, p. 22). When a bird flaps its wings it changes their length by flexing and extending joints in the shoulder, elbow, and wrist. Insects cannot change the length of their wings, and in this respect are more similar to airplanes. But insects can deform the contour of their wings and rotate them about the longitudinal axis to a much greater degree than can birds (Dudley, 2000, p. 333). Torkel Weis-Fogh "...points out that as insects move their wings in an extremely complicated way, they produce fluctuating and unsteady airflow by means of a variety of novel aerodynamic mechanisms" (Dalton, 1975, p. 24). I think that such extreme complexity points to an extremely intelligent Designer. "[A]s soon as flapping starts and a flow of air passes around them, [the wings] change shape and become cambered into more efficient airfoils" (Dalton, 1975, p. 24). Brodsky lists four different wing deformations (1994, pp. 44–46). As the wing moves up and down it twists first one way, then the other. A fly's wing moves in an ellipse or a figure eight and this creates a "...current of air backward and downward, providing both lift and thrust" (Dalton, 1975, p. 25).

Some rates of wing beats for different insects in wing beats (up and down) per second are as follows: medium butterflies: 8–12, large dragonflies: 25–40, bumblebees: 130, houseflies: 200, honeybees: 225, mosquitos: 600, and gnats: 1,000 (Dalton, 1975, p. 26). As for the extremely high rate of wingbeat of gnats, Dalton reveals that:

> ...there are peculiar aerodynamic problems at these speeds that make the normal properties of airfoils change. In these conditions the insect is not flying in an aerodynamic sense at all, but rowing its way through the air....A very sophisticated method of propulsion indeed (p. 48).

Dragonflies can make their forward and rear wings beat in unison, completely out of phase, or anything in between, depending on their need. They can make such changes instantly while in flight (Brackenbury, 1992, p. 142). Dragonflies' four wings each functions independently, enabling these insects to perform complex maneuvers (Brackenbury, 1992, p. 115). Members of order Diptera (flies) also have independent movement of wings on opposite sides (they only have two wings), but the mechanism responsible for this is different from that in dragonflies (Brodsky, 1994, p. 186). These three common insects—gnats, dragonflies, and house flies—are phenomenal illustrations of God's handiwork.

We do not fully understand all that takes place in the insect body which contributes to flight. Dudley explains that this is because of a high number of interacting structures, such as the 16 muscles used to control a fly's wing, resulting in complex mechanics (2000, p. 50). Of course, all of human history (including the Wright brothers' achievement) teaches us that complex mechanics is the product of master mechanics.

Wing and Thorax Morphology

Insect wings are not modified limbs, as is the case in flying vertebrates. The wings consist of two thin layers of chitin, strengthened by a network of hollow veins (Dalton, 1975, p. 18). Wing strength and flexibility are essential to flight. These qualities come from "...polysaccharide chitin microfibers embedded in a protein matrix...[which makes it]... the finest zoological example of this mechanical design" (Dudley, 2000, p. 36). The wing's flexibility actually imparts considerable strength to it (Brackenbury, 1992, p.102). Dudley describes a gradient of wing stiffness from base to tip and also from leading edge to trailing edge (p. 55).

In addition, extra strength is imparted to insect wings by pleating. Pleating in insect wings not only enables them to be folded away but produces extra strength needed to resist the stresses of flight (Brackenbury, 1992, p. 85). Most insect wings only weigh a few millionths of a gram (Brackenbury, 1992, p. 82). The ratio of wing mass to body mass varies from 0.5% to 10% (Dudley, 2000, p. 55). It is important that insect wings are so light because when they are flapped so rapidly their inertia produces a great increase in resistance (Brackenbury, 1992, p. 82).

Other structural features which enhance wing performance include microscopic hairs (which prevent turbulent eddies from forming) (Brackenbury, 1992, p. 142); small vein-supporting brackets; spines; scales; and sensory structures (Dudley, 2000, p. 57). Finally, the hemolymph (insect blood) pumped through the wing veins apparently helps to keep the wings from drying out and becoming too fragile for flight. Anteriorly within the wings, circulation is caused by pressure induced by the heart; but posteriorly, circulation is caused by accessory pumping organs located at the base of the wings (Dudley, 2000, p. 53). So we see that even the complex wings themselves plus the structures required to produce their complex movements are apparently insufficient to produce flight. Additional organs are necessary, increasing the complexity of the entire flight system, and decreasing the already remote likelihood of its origin by chance.

In addition to complex wings, insects also have a specialized thorax to enable them to fly:

> The thorax of the insect, to which the wings are attached, is a complex of flight muscles and mechanisms so utterly sophisticated as to boggle an aircraft designer's imagination. The thorax enables an insect in flight to carry out just about any maneuver, to loop, swoop, climb vertically, fly upside down, sideways, backwards, to hover, and to vary between all of these in a fraction of a second (Dalton, 1975, p. 19).

The wings are attached to the thorax by a series of couplings which allow movement in any direction, much like a ball-and-socket joint (Dalton, 1975, p. 19). As already mentioned, within the thorax are sclerites — hard, small, peg-like outgrowths from the wall of the thorax which serve as a fulcrum for the movement of the wing and also as points of attachment for small muscles that alter the angle of attack of the wing during flight (Brackenbury, 1992, p. 16). There are also "...many elastic, rubber-like elements in the flexible wing base... to absorb the repeated shocks and reduce the frictional stresses..." (Brackenbury, 1992, p. 17). Extra chitin reinforces the wall of the thorax to help the wing pivot to withstand the stresses of rapid flapping (Brackenbury, 1992, p. 20). Since dragonflies use dorsoventral muscles for both upward and downward flapping, this causes additional stress on the thorax which is alleviated by an internal projection called an apodeme (Dudley, 2000, p. 49). If all of this complexity within the insect's thorax would boggle an aircraft designer's imagination, it must be the product of One with an even greater imagination.

Control Mechanisms

Attached to the sclerites, insects have small muscles that alter the angle of attack of the wing during flight (Brackenbury, 1992, p. 16). Flies have a total of eighteen such muscles (Dudley, 2000, p. 45). Locusts can use their flexible abdomens as a rudder (Brackenbury, 1992, p. 131). Some insects can turn in flight by extending a hind leg in the direction they wish to turn. This interferes with the motion of the hind wing on that side resulting in a turn in that direction since the opposite wing then produces a greater relative force (Brackenbury, 1992, p. 131). Some insects obtain aerodynamic control by structurally determined changes of the wing shape during flapping; but in dragonflies the wing shape is altered by a small muscle located at the wing base (Dudley, 2000, p. 61).

Control of Flight

"...[S]o advanced and automatic is the flight adjustment mechanism of most insects that they are incapable of falling from the air, enjoying a perfection of flying ability to make most pilots loop with envy" (Dalton, 1975, pp. 23–24). The nervous impulse to fly begins in the thoracic or abdominal ganglia "...and is regulated by a complex network of ganglial interneurons" (Dudley, 2000, p. 174). In one type of flight muscle (called synchronous) the neurons regulate the frequency and amplitude of contraction (Dudley, 2000, p. 172). The other type of insect muscle (called asynchronous) requires only one nervous impulse in order to contract over and over again (Dudley, 2000, p.175). This explains how some insects can attain such phenomenal wing beat rates as those previously mentioned. Such high rates of flapping would not be possible if the muscles had to contract and recover from each impulse. The nervous system enables flying insects to rapidly and continuously sense and correct any instability by a wide variety of compensatory, asymmetric wing motions (Dudley, 2000, p. 204).

The greatest sensory input is through the eyes. In all insects the region of the brain involved in vision is the largest. In dragonflies this region comprises about 80% of the total brain volume. Compound eyes provide much information to the insect, not only ahead, but substantially laterally, above, and below (Dudley, 2000, p. 205). It is apparent that the insect visual system must be able to rapidly evaluate the nature of the changing environment in order for flight to be controlled (Dudley, 2000, pp. 205–206). One reason for the success of insects in meeting this challenge is the fact that they are capable of resolving light impulses at a much higher frequency than even vertebrates — some flies and bees about ten times as fast (Dudley, 2000, p. 206).

Other sense organs are also involved in flight. Ocelli (simple eyes) are probably used in maintaining stable flight (Dudley, 2000, p. 213). All winged insects have a specialized structure (Johnston's organ), located in the second segment of each antenna, which monitors its bending during flight (Dudley, 2000, p. 213). "On wings, arrays of campaniform sensillae (dome-shaped mechanoreceptors) monitor the rate and extent of local bending" (Dudley, 2000, p. 215). Dragonflies have four beds of hairs between the head and body that send information to the brain about the orientation of the body (Dalton, 1975, p. 29).

Flies have a pair of halteres instead of a second pair of wings. These small knob-like structures oscillate at the same frequency as the wings, and are said to serve as gyroscopes (Dudley, 2000, p. 217).

In addition to having nervous control of flight, insects exhibit behavior which, though not itself flight, relates to flying. Some of these behaviors are quite complex, including placing the feet in the best position under the body, and orienting the body toward the wind in order to experience lift (Brackenbury, 1992, p. 45). Some species have elongated hind legs which they use to leap into flight (Brackenbury, 1992, p.46). Some jumping insects have additional structures to help them get air-borne:

> [M]any jumping insects... overcome the physiological deficiencies in their leg muscles by cranking up a spring that is then held ready to be released at high speed at the appropriate moment. They can thus catapult their bodies into the air at far greater speeds than could ever be achieved by muscle contraction. The principle is ingenious, and the hardware to make it work involves remarkable innovations of design (Brackenbury, 1992, p. 59).

Grasshoppers use a similar strategy with a stretch of elastic cuticle on the outside of the femur-tibia joint of the hind leg. When the cuticle has been fully stretched it is held by a catch until the moment when all the power is released at once (Brackenbury, 1992, p. 59). Our Creator has designed other "remarkable innovations" as well.

There is evidently much more to insect flight than just wing flapping. We see that sensing and rapidly and accurately responding to a wide variety of environmental stimuli through ingenious structures and complex behaviors takes place in these miniature organic machines we call insects, resulting in the marvels of flight that we can observe right in our back yards. What we see is far more sophisticated than not only the Wright brothers' airplane, but any airplane ever built by man's intelligence. "The heavens declare the glory of God..." (Psalm 19:1), but flying insects mightily declare His wisdom.

The Origin of Insect Flight

The following are quotations from previously cited sources regarding their views of the origin of insect flight:

> Assuming that the ability to fly arose somewhere between the Devonian and the Carboniferous, 20 million years of the evolutionary development of winged insects are shrouded in mystery (Brodsky, 1994, p. 79).
>
> Unfortunately, the evolutionary origins of flight in insects are not well known. Paleontological records of transitional forms are absent, and the likely selective forces acting on early winged morphologies can only be surmised, precluding any paleobiological interpretation of this major event in metazoan evolution (Dudley, 2000, p. 261).
>
> The paleontological history of winged insects starts from the Upper Carboniferous (Namurian). Namurian insects were represented by three clearly distinct groups (Brodsky, 1994, p. 88).
>
> We do not know how and when the three main lines of evolution of winged insects diverged... (Brodsky, 1994, p. 98).
>
> As impressive as insect diversity is today, even more remarkable is the fact that most major morphological innovations and indeed insect orders were present before the Mesozoic (245–265 million years ago)(Dudley, 2000, pp. 8–9).
>
> The dragonfly provides an excellent example of the perfection of ancient flight; they have changed very little from their ancestors... about 300 million years ago (Brodsky, 1994, p. 66).
>
> Odonata [dragonflies] is the oldest surviving order of flying insects, and... the aerial equipment of the dragonfly has remained essentially unchanged (Dalton, 1975, p. 28).

So not only do the complex, ordered flight systems of insects make foolish the notion that they are the product of mutations and natural selection; but the fossil record also offers no support for such a notion.

Conclusion

The Wright brothers' airplane was capable of flying because it had an intelligence controlling many specifically designed features which all had to be in place before it could fly. The anatomy of flying insects likewise meets all of the requirements for flight. It has been shown that each of these insect structures required for flight is a highly complex system (composed of specific materials). The logical conclusion is that insect flight is also the result of deliberate design. Furthermore, there is no evidence for a gradual evolution of insect flight. Indeed, without all of the above requirements being met, an insect could not experience flight. Even the evolutionist, Maynard Smith, agreed with this assessment when he is quoted as stating that flight control is "...a prerequisite for the initial evolution and subsequent elaboration of flight" (Dudley, 2000, pp. 203–204). If only one of the requirements for flight were satisfied, the insect would not fly, and even that particular innovation would be selected against because of the disadvantage involved in carrying around useless structures. The more requirements that might be satisfied, the greater would be the selective disadvantage, unless all were satisfied. The only logical solution is that these exceedingly complex flying insects would have to have been initially formed complete. This is clearly antithetical to evolution and supportive of creation. When one compares insect flight to human flight, the vast superiority of the former requires a vastly superior intelligence. Wherever there are people, flying insects exist, and their "message" of intelligent design is so clear that no man anywhere has an excuse for denying the existence of their Designer (see Romans 1:20).

Acknowledgments

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Lest We Forget

Precambrian Pollen in Hakatai Shale, Grand Canyon, Arizona

Pollen grains and spores from flowering plants and other vascular plants have been found in samples of Precambrian Hakatai Shale from the Grand Canyon of Arizona. For a review of earlier works, consult Howe, Williams, Matzko, and Lammerts (1986). We collected and processed our samples with reasonable care to avoid contamination.

Out-of-order microfossils have been recovered by non-CRS workers also, and reported in other journals. But all such Precambrian pollen papers have been widely rejected, neglected, or reinterpreted. This is largely because they conflict with the stratigraphic notion that pollen-bearing plants did not evolve until hundreds of millions of years after Pre-Cambrian sediments had accumulated. Generally all such reports are "written off" as instances in which microfossils somehow entered the formations long after the strata formed.

This is the first in a series of "Lest We Forget" memos in which various non-*CRSQ* discoveries of Precambrian vascular plant microfossils will be reviewed. It is hoped by this that: (1) some other workers will be encouraged to initiate analyses of more Precambrian sediments for possible pollen content, (2) non-creationist workers will feel obliged to exercise less dogmatism in defense of their stratigraphic long ages, (3) creationists who establish origins models will realize and recognize that rocks called Precambrian by uniformitarians contain plant fossils (even pollen grains)—a notion that Froede has successfully defended (1999), and (4) it will be generally admitted that pollen grains have been repeatedly extracted from Precambrian strata. Such pollen grains are at variance with the gratuitous assumptions that there was a vast Precambrian era, devoid of vegetation, and that vascular plants did not exist when strata called "Precambrian" were deposited.

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