Translated extract from

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Die genialsten Erfindungen der Natur
Bionik für Kinder

S. Fischer Verlag
Frankfurt am Main 2010
ISBN 978-3-396-85389-2

pp. 42-63

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Nature's Most Ingenious Inventions
Bionics for Children

Translated by Allison Brown

In the Beginning Was the Bird

Human beings have always dreamed of being able to fly through the air like a bird: to cover great distances easily and effortlessly, look down on the world from above, and be free and weightless: Haven't you ever imagined what it would be like if you could simply take off and fly?

But can birds really fly without exerting any effort? This chapter will tell you about the ideas of inventors and engineers for building airplanes and amazing flying machines patterned after nature. You will get to know animals and plants that were their models and read about what ideas are still alive today and what research projects might determine our future. One thing is certain: Up to now we humans have understood only a fraction of all there is to know about the astoundingly diverse and complex techniques of flying that exist in nature.

Leonardo da Vinci

One man who was particularly fascinated by observing nature was the Italian Leonardo da Vinci. "Da Vinci" was not his real name, but simply means "from Vinci," the city where Leonardo was born in 1452, that is, more than 500 years ago. Leonardo da Vinci was an extraordinarily curious person. He was a naturalist, painter, inventor, architect, and artist, and was also very interested in medicine. Since he had so many diverse interests and talents he is referred to as a "Renaissance man" or universal genius. That means that he was simply good at everything!

Leonardo da Vinci studierte schon vor mehr als 500 Jahren den menschlichen Bewegungsapparat.

Leonardo da Vinci studied human movement and the musculoskeletal system more than 500 years ago.

Leonardo examined things by drawing and painting them, as we know through his countless drawings that still exist today. This helped him develop a very good eye for detail and he recognized more precisely than most people how technical devices and living beings functioned. Leonardo was also well educated and he was familiar with all kinds of books and writings about the early inventions of others. Thus not everything he drew was really a new idea of his own. He compiled a lot of things he read in books and then elaborated on them by thinking of additional functions that these inventions could serve.

Leonardo da Vinci's most famous painting is the Mona Lisa, with her mysterious smile. But even more amazing are his detailed drawings of the human being: Da Vinci tried to understand the structure of the human body and the individual body parts and how they interacted and were interdependent. Muscles, proportions, facial expressions—he viewed all of this with the eyes of an illustrator in preparing his numerous sketches. He had already discovered that all movements and changes in posture result from the interplay of muscles, ligaments, connective tissue, and bones. Our bodies compensate immediately for every shifting of weight, no matter how small. This is a key foundation for our being able to stand erect in the first place. Surprisingly, da Vinci's very old drawings are so precise that they remain valid even today.

Patent trick

Leonardo da Vinci was also left-handed and he usually wrote using "mirror writing," from right to left. For one thing, that kept him from smearing the ink on the paper as he wrote with his left hand. For another, this made it harder for people to read his notes!

Hold a small mirror in front of the writing. In the mirror you can read the Italian expression for "mirror writing."

Five hundred years ago there was no such thing as a patent office. Leonardo might have used this special form of writing to prevent his inventions from being copied. He supposedly also incorporated small errors into his drawings, such as a falsely constructed cogwheel, so the device would not work if someone tried to copy his design. Only Leonardo knew what had to be taken into account when building his devices. In that way he made himself and his knowledge indispensable for the technical implementation of his ideas.

The first bionics researcher

Leonardo da Vinci spent a lot of time observing nature very carefully. His assistants often had to spend hours with him at a pond while he sat fascinated, watching the movements of dragonflies, beetles, and other animals, and examining now they lived.

Based on his observations, he concocted the most incredible devices. The wings of bats, for example, clearly inspired his impressive plans for a flying machine, since the form and structure of the wings clearly resemble each other.

The apparatus was to fly on the muscle strength of a single individual, according to da Vinci's plans. The pilot was supposed to use his arms and legs to pull and push on cords and posts at the same time so that the wings moved up and down. What do you think—did that work?

Let us look at an even earlier attempt by humans to lift off the ground by flapping wings up and down.

Icarus

According to a Greek myth, Daedalus and his son Icarus were the first people who tried to fly like the birds. Daedalus was an inventor. Together with his son Icarus, he was imprisoned on the island of Crete by the Greek king Minos, who wanted to prevent him from being able to

reveal to anyone the secrets of the inventions he made for the king. Daedalus wanted to flee. Because the island was totally surrounded by water, and the seas were monitored by the king, the only way to escape was by air. But how would that be possible? Daedalus collected birds' feathers and built wings, which he and his son strapped to their arms. The feathers were held together with cords and wax. Icarus found it all very interesting and played around with the wings while his father was building them. Daedalus scolded Icarus and impressed upon him not to fly either too high or too low.

The long, thin finger bones of the bat are incorporated into the wings of this flying device as wooden slats.

He was afraid that the feathers could get soaked from the sea foam, thus becoming too heavy if he flew too close to the water. On the other hand, the heat of the sun could melt the wax that held the feathers together, and the wings would fall apart if they flew too high. Therefore it was important to fly with great care in order to maintain the proper altitude. When they started their journey, the two of them flapped over the sea, passing several islands. According to legend, everyone who happened to see them could not believe their eyes. Flying humans! That was impossible!

After a while Icarus got carried away and started trying out new flying maneuvers, soaring ever higher, toward the sun. And then what Daedalus had been afraid of happened: the wax on

the wings melted and Icarus's wings fell apart while he was still in the air. He crashed down and drowned. Daedalus buried his son on an island, which was named after him: Ikaria. The sea that, according to the myth, they flew over is still called the Ikarian Sea.

Can a human being fly like a bird by flapping wings?

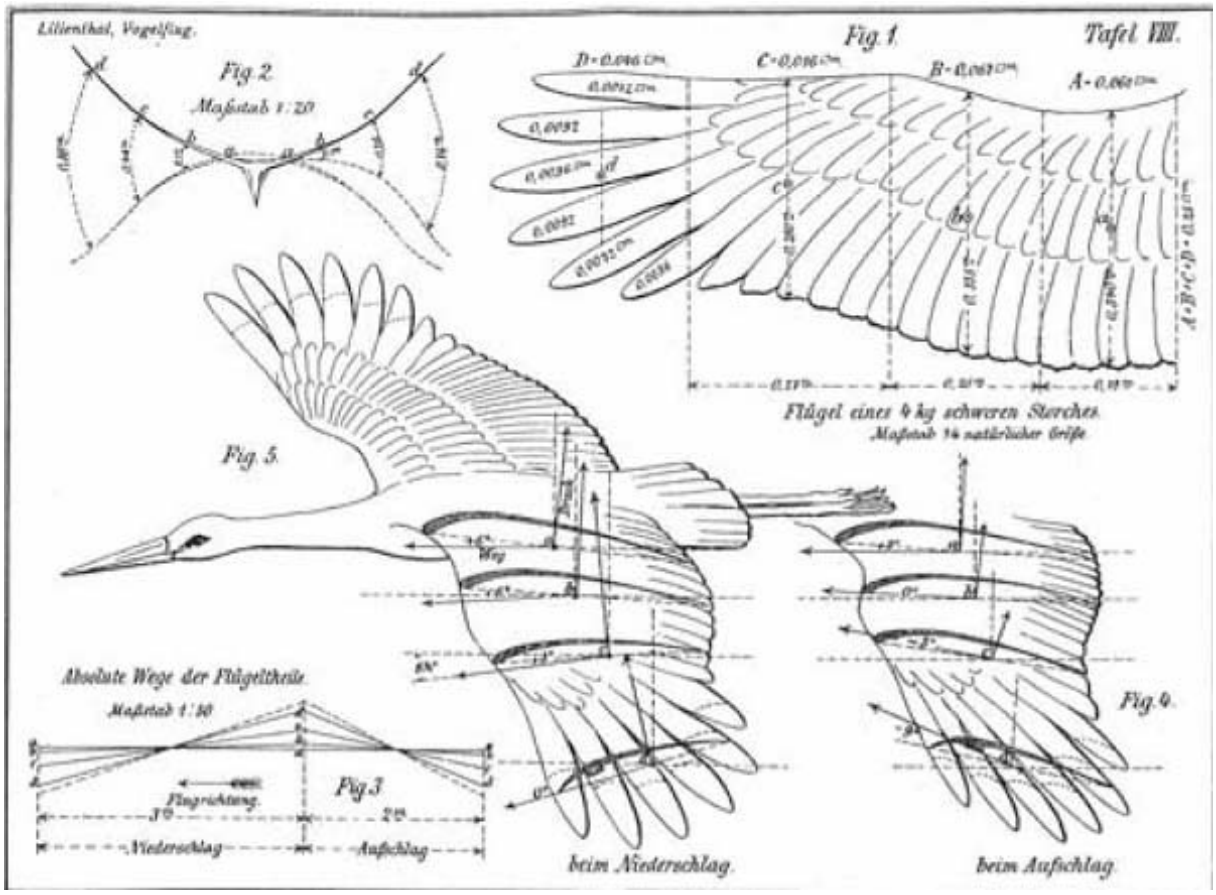
This story is a myth and no one knows how much of it is true. Do you think a person is strong enough to fly by flapping wings? Try for yourself! Stand erect and gently flap your arms up and down for about two minutes. While you are doing that, imagine you had large wings on your arms. How do your muscles feel after your "flight"? How long could you keep moving a pair of wings this way? Could you flap fast enough to achieve the speed needed for takeoff?

Warning: People cannot fly! Therefore, do not even try to take off flying—neither from a wall nor a tree. When doing this experiment, definitely keep both feet on the ground!

By the way: The original destination of their trip was Sicily, in Italy. Daedalus continued his journey there alone after his son's death. The islands of Crete and Sicily are almost 500 miles apart as the crow flies. It is impossible for someone to cover that distance flying on muscle power alone.

The Development of Modern Airplanes

Large distances are no problem at all for migratory birds, however. They often cover well over a thousand miles. In the winter they travel to warmer regions and then return in the summer. The stork is one example, which is why it was the inspiration behind the first aircraft.



Otto Lilienthal observed a stork's wings very closely and then began building flying devices that heralded in a new aviation age.

Aviation pioneer: Otto Lilienthal

Otto Lilienthal (1848–1896) was an avid aviator. He built many flying devices and got new ideas by observing closely how birds fly and the structure of their wings.

He was especially keen on the stork. He observed and described this bird as if it were a piece of technical aviation equipment. How long and wide were the wings? How large was the angle over which they flapped up and down? Exactly how were the wings structured? What different shapes of feathers were on the wings? Like Leonardo da Vinci, Lilienthal also wrote meticulous notes on everything and drew sketches.

The special shape of a wing, called an airfoil, provides for good lift.

After Lilienthal had studied the flight behavior of birds, he decided against a flapping or powered flight in designing his aircraft and chose rigid wings instead. This system paved the way to successful aviation and has remained in use to today. He did, however, incorporate a special trick he observed in birds into his plans: The profile of airplane wings corresponds to the side-view shape of a bird's wing. The airplane wing is somewhat thicker in the front than in the back and has an upward arch, just like a bird's wing. That was truly bionics at work!

Lilienthal built various different gliders and tried them out. After only a few trials he managed to fly farther than any human being before him. To stabilize the wings he built a vertical tail structure at the end of the plane fuselage. People were impressed by his successful flight attempts. There was always a big show whenever word spread that Lilienthal was about to take off in a glider from the so-called "flying hill" in Berlin that was created especially for his trials. Spectators, reporters, and photographers all gathered to admire and photograph the flights.

Otto Lilienthal crashed and died during one of these trials. That was in 1896, but his idea continues to live on.

Bird feathers

Bird feathers are light and pliable and yet stable enough that they don't break. In order for a bird that flies by means of flapping or powered flight to take off, the wings have to be somewhat elastic. The feathers allow for a very sophisticated kind of flight. During flight maneuvering the wings sometimes bend passively in certain directions.

So the idea of shaping the wing of airplanes like the wings of birds is more than a hundred years old. Most of today's airplanes also have rigid wings and an arch-shaped body.

After Lilienthal enjoyed great success with his glider planes, research began to find a suitable engine for airplanes. Austrian aviation pioneer Wilhelm Kress was one of the first to build a motor into an airplane. In 1901 he attempted to fly his powered aircraft, but the trial ended in a lake. The engine he used was much too heavy for the plane.

Winged seeds as a model: the Zanonia Glider

The winged seeds of the vine called Macrozanonia served as the model for Ignaz "Igo" Etrich's flying wing. It looked a lot like today's hang gliders, but it was shaped like a zanonia seed.

In the early twentieth century, Austrian pilot and airplane builder Igo Etrich developed a flying apparatus patterned after a winged, or flying, seed: the seed of the Macrozanonia macrocarpa plant, or simply zanonia. This plant entwines itself like a liana vine, climbing up jungle trees and growing a squash-like fruit. When the fruit ripens it breaks open like an oversized nut and releases hundreds of seeds with wings about 4 to 6 inches wide that disperse in the wind. These seeds have extraordinarily good gliding qualities and can sail several tenths of a mile. This is how the plant disperses its seeds in the environment. Igo Etrich built a "flying wing" that could glide magnificently, just like the flying seed. A flying wing is a fixed-wing aircraft without a tail or definite fuselage, much like a hang glider. However, it was almost impossible to steer Etrich's flying wing. When he built in a steering

mechanism, the flying qualities of his aircraft worsened. Today, airplanes comprised solely of wings are constructed primarily for military purposes, since they are hard to detect on radar.

The shape of the wing of the Etrich Rumpler Taube resembles that of a zanonia seed.

Later, Igo Etrich developed another familiar airplane, the form of which resembled a dove in flight. It was built by the aircraft and automobile builder, Edmund Rumpler, and is therefore known as the Rumpler Taube (*Taube* is German for dove). It was one of the first airplanes to be mass-produced. Because Igo Etrich did not have a patent for his airplane, anyone could copy his invention without paying any fees to him. More than forty companies based their new airplanes on the shape of the Taube and further developed Etrich's ideas.

Edmund Rumpler also built cars. On the one hand he was able to put his expertise in car motors to good use in airplane construction. But he was also one of the first engineers to transfer knowledge about aerodynamic effects on airplanes to automobiles. He built cars that were extremely streamlined for the times, such as the so-called *Tropfen* (German for drop), which was a car that looked like a drop of water on its side.

Winged seeds go everywhere

As you already learned in the first chapter, burrs and poppies use different techniques to disseminate their seeds.

But winged seeds dispersed by the wind are also very common in nature. You certainly are familiar with maple seeds, which spin in the air like helicopter rotor blades as they fall from the tree. That slows down the fall of the seed so the wind can carry it away.

Making a Helicopter

Make a helicopter that flies like a maple seed. You can simply trace the pattern for the winged seed on a piece of paper, but make it a bit bigger. Then cut out the pattern on the solid lines and fold along the dotted lines.

Fold back parts A and B and then fold up part C. Bend the two wings into a V-shape. Hold the flying device as high as possible and then let it fall.

Try experimenting with different wing positions. What happens if you fold the propeller further up or further down?

You can make this flyer in a variety of sizes and using different materials. Which one stays in the air the longest and thus could disseminate its seeds the farthest?

Can you think of other winged seeds that occur naturally? Draw them in your research notebook and try to describe how they fly.

Why an Airplane Flies

Over the last hundred years countless aviation and technology enthusiasts, such as the Wright brothers and other courageous aviation pioneers, have worked on making the dream of flying come true. They continued to develop the first airplanes further and further until they were ready for mass production. Today there are a wide variety of airplanes: jets, power gliders, passenger airplanes, gliders, supersonic airplanes, and many more. But how can an airplane fly, even though it is heavier than air?

Lift, etc.

A passenger plane can only take off if it reaches the necessary lift-off velocity. The runway has to be rather long so the plane engines have enough time to accelerate. In other words, the pilot has to really step on it!

Lilienthal's idea also plays an important role. The shape of airplane wings is called an airfoil; it is more curved on the top than on the underside and the wings are tilted slightly. Consequently, the air moving above the wing flows faster than the air below the wing. Air moving quickly over a curved surface creates a low pressure area. Since the pressure above the wing is lower than below it, the pressure gradient pushes the plane upwards, creating lift. The lift is what allows the plane to take off and stay in the air. A slightly higher pressure area develops below the wings. The faster a plane flies, the greater the lift. The lift is also influenced by the size of the wings, the angle between the wings and the airplane fuselage, and the altitude at which the plane is flying. Lift can also be produced with a wing that is not curved if it has the proper angle. The engines force the plane forward, creating thrust.

You can use a hand-launch glider to try out for yourself how much the lift is dependent on the speed of the plane. Small, inexpensive cardboard or Styrofoam airplanes are available in a toy store or you can make a paper airplane (instructions can be found on the Web or in books on the subject) in order to conduct an experiment that will illustrate the relationship between velocity and lift.

Test a Hand-Launch Glider

Hold the flyer up high and let it go. Does it fly on its own? Throw the flyer forward a little and measure how far it flies. Then throw the flyer forward as hard as you can. If you have a good flyer you can observe that it rises up on its own after you throw it. This happens due to the force of the lift. What is the maximum distance you can get your flyer to fly?

Bernoulli's Principle

Daniel Bernoulli was a Swiss mathematician and physicist who lived in the eighteenth century. He recognized that pressure is lowered where a liquid flows quickly. This also applies to flowing air. Bernoulli discovered this principle about 300 years ago.

It is easy to illustrate Bernoulli's principle through a simple experiment: Hold a strip of paper in front of your mouth and blow over the top of it. What happens?

The paper rises because the flow of air that you created by blowing works just the same way as the airflow when an airplane takes off. The pressure is lowered above the curved surface, causing the paper to lift up.

You can perform a similar experiment with a somewhat larger piece of thin cardboard. Fold it once in the middle and stand it up on a smooth surface such as a table. Have someone blow through this "roof" and ask him or her to get the roof to rise. Your assistant will be surprised because it won't work. The flow of air causes suction, pulling the cardboard down. Try it out yourself before you have someone else do it.

Whirling air

During a flight, strong air whirls develop at the wings of the airplane, because the low and high pressure areas at the end of the airfoils try to balance each other out. Additional whirls all around the entire wing are also very important for the lift, as they accelerate the air moving along the top of the wing and slow down the air on the underside. The air whirl that the airplane pulls along behind it is referred to by experts as a wake vortex or turbulence. They form behind the end of the two wings during the flight. Wake vortex turbulence creates a strong suction that can be very dangerous for airplanes coming up from behind, and must be avoided.

This kind of turbulence also has other disadvantages: It creates some of the flight noise and consumes energy. The noise is disturbing for people who live near airports or along flight routes. And the additional energy needed as a result of the turbulence costs the airlines money and wastes resources because the airplanes require more fuel. Engineers want to avoid both of these problems, so they are trying to find solutions. The most important goal is to bring sustainable improvements to aircraft technology and to save energy.