Introduction
Flight According to Principle

One very cold and windy morning on a North Carolina beach, a lonely group of men huddled on the sand near their pride and joy: a kitelike contraption, built of cloth and wood and outfitted with bicycle parts. On the count of three, with the motor turning and heavy wind gusting, one man started to run alongside and guide the craft; in an instant, the pilot lying on the wing steered the craft to flight a few feet above the ground. The aircraft wobbled forward in the air for no more than 12 seconds, and settled triumphantly back to the ground. To an outsider, it would seem like a modest achievement. But it was the first time in history that an aircraft propelled by a motor and controlled by a pilot had left the ground. It was a moment that Wilbur and Orville Wright had labored to achieve for nearly 5 years.

On December 17, 2003, the world will celebrate the 100th anniversary of the first flight of the Wright Flyer. Before 1903, some people had flown gliders without engines; some had piloted lighter-than-air craft like hot-air balloons. Now a pilot would have the power to fly an aircraft at will, over long distances. No one could know in 1903 how that power would change the world.

Today we are so used to seeing jets in the sky, we forget that people were not always able to fly like birds. Some early aviators thought that building wings like those of birds would be enough to accomplish flight. The Wright Brothers, on the other hand, knew that flying would not be so simple. They were willing to think and work—and scratch their heads in perplexity—and think and work again for years to accomplish that first flight:

"... I would hardly think today of making my first flight on a strange machine in a 27-mile wind . . . I look with amazement upon our audacity in attempting flights with a new and untried machine under such circumstances. Yet faith in our calculations and the design of the first machine, based upon our tables of air pressures, secured by months of careful laboratory work, and confidence in our system of control ... had convinced us that the machine was capable of lifting and maintaining itself in the air . . ."

— Orville Wright, from “How We Made the First Flight”

In the early days of aviation, flying was extremely dangerous. Many daredevils were killed trying out crazy new flying machines. Otto Lilienthal, the German hang glider and foremost authority on aeronautics, had just been killed in one of his gliders in 1896 when the Wrights started to become interested in the idea of a flying machine. When Wilbur heard about Lilienthal’s accident, he quickly read everything he could find about aircraft and wrote to the Smithsonian Institution for information on aeronautical research.
Lilienthal was a great influence on the brothers; he was not just a daredevil. He advocated using piloted gliders to learn about aerodynamics. He is considered to be the first person to design heavier-than-air aircraft carefully and deliberately. He developed many functioning gliders and was famous around the world. The brothers adopted his thoughtful approach to designing aircraft. Like Lilienthal, every time they made an innovation, it was well thought out.

“To invent an airplane is nothing. To build one is something. But to fly is everything.”
— Otto Lilienthal

The brothers were also lucky enough to be able to correspond with Octave Chanute, another very important pioneer and author of “Progress in Flying Machines,” published in 1894. Chanute was a civil engineer in his sixties when he began to study the problems of aviation. He designed and built gliders himself, so he had useful advice to offer the Wright Brothers. In fact, the correspondence between Chanute and the brothers shows many of the problems they had, and how they gradually solved them, one by one. Control of a flying aircraft was the most difficult problem to solve in the early days. Pilots often got hurt when their gliders did uncontrollable things.

When the brothers observed soaring birds, they noticed that birds change the shape of their wings as they glide. Wilbur Wright had an extremely important insight about aircraft: he realized that a flying machine had to be controllable in all three axes of its motion: roll, pitch, and yaw. He came up with a technique he called “wing-warping,” using a wing shaped like a long box that could flex its shape like a bird flexes its wing. Twisting the wings would change the direction of flight. In 1899, he and Orville constructed a 5-foot kite to test this idea. As predicted, when Wilbur used the control cables to twist the kite, it rolled left and right. Wilbur and Orville knew they were onto something.

In 1900, the brothers decided to build a large glider to test their theories about flying. Kitty Hawk, North Carolina was chosen as the test site because of its constant strong winds, sand for soft landings, and few trees. The glider was successfully flown as a kite, and on the last day of the “testing season,” there was finally enough wind to fly the aircraft as a piloted glider and demonstrate roll control through wing-warping.

In 1901, the brothers returned to Kitty Hawk with a new glider that they had built at their bicycle shop. Their new aircraft had the same basic design as the 1900 aircraft, but it was larger to provide more lift to carry a pilot in lighter winds. In fact, it was the largest glider ever built and weighed about 100 pounds without the pilot.

Even though the new glider had flown up to 300 feet in a single glide, it did not perform as well as the brothers had expected. It only developed one-third of the lift that was predicted by data from Otto Lilienthal, and the drag was greater than predicted. The brothers modified the curvature of the wing, but this only slightly improved the glider’s flight. Their test flights that year ended with a crash that rewarded Wilbur for his efforts with bruises and a black eye. At the end of 1901, the brothers were frustrated, and Wilbur remarked that humans would never learn to fly within the brothers’ lifetimes.

The brothers began to question the aerodynamic data from Lilienthal on which they were basing their designs. They came up with another extraordinary idea. They built their own wind tunnel, one of the first in the United States, and used it to test their models. They found that the previous data from Lilienthal were in error and that their own data more correctly described the way gliders flew.
In 1902, Wilbur and Orville returned to Kitty Hawk with a new aircraft based on their new data. This aircraft had about the same wing area as the 1901 aircraft, but its wings were long and thin and it had a new movable rudder at the rear. The movable rudder worked with the wing-warping to keep the nose of the aircraft pointed into the curved flight path. With this new aircraft, the brothers completed flights of over 650 feet. This machine was the first aircraft that had active controls for all three axes: roll, pitch, and yaw. At the end of 1902, the brothers knew that all they needed to do was develop a motor and propellers and they would have the first successful airplane.

The Wrights could not find a manufacturer who would meet their requirements for a lightweight engine with sufficient horsepower, so they built their own 12-horsepower engine in just 6 weeks. They also created the first working aircraft propellers. In September 1903, they returned to Kitty Hawk with their new powered aircraft. With the pilot and the motor, the 1903 aircraft weighed a little over 700 pounds. On December 17, 1903, the brothers finally made four successful flights. After more than 5 years of solving problem after problem, Wilbur and Orville Wright had conquered powered flight.

But the brothers' work didn't end there. The 1903 airplane was only the first, and crudest, working airplane. It was very difficult to fly, especially since it tended to pitch down nose first into the ground. It took quite a bit more time and effort to develop a fully controllable craft.

By the end of 1904, the Wrights were making flights of several minutes at Huffman Prairie in a new aircraft with a new 18-horsepower engine. The brothers tried to solve the pitch problem by adding 200 pounds of ballast to the airplane, but the craft was still hard to control and difficult for the engine to lift.

In 1905, the brothers decided to keep the same engine, but to redesign the airframe. They increased the size of the elevator and rudder, and moved them farther from the center of gravity of the craft, increasing the overall length from 18 to 28 feet. This increased the torque produced by these control surfaces and provided greater control of the aircraft. The airplane's weight was reduced to nearly that of the 1903 airplane. The brothers continued to use a catapult system, first tried in 1904, to aid with takeoff.

These improvements solved the last lingering problems. After 7 years of effort, the brothers had finally eliminated the pitching effect that had plagued the 1903 craft and built the first practical airplane. Little more than a decade later, in World War I, airmen and flying aces of many nations would embrace the airplane and entrust their lives to it.
The Wright Brothers were raised in Dayton, Ohio, a few years after the Civil War. Their parents were Susan Catharine Wright and Bishop Milton Wright, a minister in the United Brethren Church. Both parents were talented, college-educated scholars who loved to learn. The boys’ father was intellectual, and their mother was also mechanically gifted.

These qualities were inherited by the brothers and fostered by their life at home. Orville remarked, “We were lucky enough to grow up in an environment where there was always much encouragement to children to pursue intellectual interests; to investigate whatever aroused curiosity.” The older brother was thoughtful and quiet; the younger brother was playful and adventurous. The two became lifelong best friends, always confiding their thoughts and plans to each other.

His father said of Wilbur, “In memory and intellect, there was none like him. He systemized every thing. His wit was quick and keen. He could say or write anything he wanted to. He was not very talkative. His temper could hardly be stirred. He wrote much. He could deliver a fine speech, but was modest.”

Wilbur was an excellent student, but circumstances such as his mother’s illness and his own health prevented him from graduating from high school or attending college. But he and Orville found their own way in life anyway, using their imaginations and ingenuity.

Orville, the younger brother, was more mischievous than Wilbur. He was a little like Mark Twain’s Tom Sawyer; he was always coming up with a new scheme. He was adventurous and became a champion cyclist. While Wilbur would sit and read everything that fell into his hands, Orville was out in the world finding a lot of interesting things to get involved in.

The brothers had always liked mechanical things, especially the flying toys they had as children. When they were very young men, they built their own printing press using a tombstone and buggy parts and printed their own newspaper. At one point, Orville printed a newspaper called the 'Tattler' for a young classmate, the poet Paul Laurence Dunbar.

When the brothers discovered bicycles, they began repairing them and eventually opened the famous Wright Cycle Company repair shop, where they produced their own bicycle models, the Van Cleve and the St. Clair. The bicycle shop became the brothers’ workshop to build airplane parts—the parts that eventually flew on the first airplane.
When the brothers finally achieved their goal of powered flight, some people didn’t understand the meaning of what they had done. Some found it hard to believe that a couple of “bicycle mechanics” could have succeeded where other distinguished would-be flyers had failed. By 1908, Wilbur and Orville had convinced the public that they had attained the goal that so many had tried to reach.

At one point, Wilbur amazed onlookers on the ground by flying around the Statue of Liberty and following the Hudson River to Grant’s Tomb. This would be a shocking thing to see for the first time, if you’d only seen seagulls do it before. How brave and confident would you have to be to fly around the Statue of Liberty in your own homemade flying machine? The ambition, the curiosity, the studiousness, and not least, the bravery of the Wright Brothers were all needed to dare to fly.

Not long after the Wrights’ success, in 1912, Wilbur died of typhoid fever at age 45. Orville sold the Wright Company, built an aeronautics laboratory, and returned to inventing. He also stayed active in the public eye, promoting aeronautics. He served for 28 years on the National Advisory Committee for Aeronautics (NACA), which was the forerunner of the National Aeronautics and Space Administration (NASA).

In 1930, Orville received the first Daniel Guggenheim Medal. This award, awarded for “great achievements in aeronautics,” was established in 1928 by the Daniel Guggenheim Fund for the Promotion of Aeronautics. It is still awarded today to individuals for outstanding contributions. Orville Wright died in 1948 at the age of 76 in Dayton, Ohio.

Although neither had more than a high school education, the Wright Brothers were able to use the math and science they had learned to accomplish what is considered to be the most influential achievement of the 20th century. Some people even said that more education would have “ruined” the Wrights. However, Orville never agreed with that view. On the contrary, he said, a better scientific education would have helped them to do their work more easily.