Curriculum Units by Fellows of the Yale-New Haven Teachers Institute
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The Physics of Flight

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The idea of this unit is to fully integrate the physics of flight with literature, history, and multiculturalism. This unit is designed to teach fourth and fifth graders of diverse backgrounds about the wonders and history of flight by studying and taking into consideration the same factors that Orville and Wilbur Wright had to consider when they were first building their airplane. The students will be involved with many hands-on explorations of the four basic concepts of flight (weight, lift, thrust, and drag). (See figure i)

Through the unit, *The Physics of Flight* , students will take a more personalized look at how the advent of flying changed and inspired people. The students will be reading the novel *Dragonwings* by Laurence Yep which follows a young Chinese boy, Moonshadow, as he travels from China to San Francisco to live and work with his father. The boy's father, Windrider has an obsession with flight which leads to an eventual correspondence with Orville and Wilbur Wright. This book gives a very real account of being an immigrant in a country that does not necessarily welcome that presence, added to that, the skepticism that surrounds the boy and his father regarding their dreams of eventually flying. Students will be learning about this mass immigration of Chinese into California at the turn of the century as well as about Chinese culture. They will also be grappling with the concepts of immigration, a sense of belonging, and then relating this to their own lives.

The excitement of flying, though not as novel today as compared to the early 1900's, is not lost on any child. This natural enthusiasm to learn about the question, "How do airplanes fly?" that undoubtedly all children have asked at one point or another, will motivate students throughout the unit. By making this a fully interdisciplinary unit, there should be a way for all types of learners to feel connected to and inspired by the content of the unit.

Objectives

With so many time constraints and curriculum requirements, particularly in the area of literacy, now placed on the classroom teacher, many find it challenging to teach adequate and meaningful science and social studies units. This unit was designed with that need of the classroom teacher in mind. Also in mind is the necessity to

have students realize that nothing occurs in isolation, that all learning and living experiences happen in conjunction with many other factors.

The objectives for the unit are all aligned with the standards of New Haven Public Schools:

- Students will state and define the four principles of flight.
- Students will create and construct several different 'flying' mechanisms, observe and rate how the design affects how the mechanism flies.
- Students will develop their communication by recording data and observations in science journals, charts, tables, and graphs.
- Students will read the book *Dragonwings* by Laurence Yep, make predictions about what they will read and paraphrase what they have read.
- Students will examine what life is like for an immigrant in America.
- Students will compare and contrast their own culture and traditions to the Chinese traditions mentioned in the novel.

The main objective of the physics portion of this unit is to acquaint children with a somewhat simplistic version of flight. The culmination of the unit will be students building their own aircraft based on what they have learned about weight, lift, thrust, and drag. The students will conduct many experiments leading up to the construction of their own aircraft, beginning with kites (drawing from the character Windrider of Dragonwings who is a kite maker by trade), and moving to gliders. Students will experiment with the airfoil and how this wing design makes lift possible. As the students work with the airfoil, they will also conduct experiments designed to illustrate the principal of drag on an aircraft and how planes are designed to minimize this. Students will also examine the importance and sources of thrust in flight which, on an aircraft, comes from the jet engines located at the midpoint of the plane, and on a smaller planes comes from the propeller.

With this unit, there are many different ways in which to assess the students. To begin with, observation will be a very effective form of informal assessment. The teacher will observe the students' participation level with all whole-class activities, and also watch how each student interacts when working with a partner. It is important for the student to be able to communicate with her partner for her to complete the experiments. The students' science journals that they keep throughout the unit can also be used to assess their progress. In the journals the students will be keeping all of their observations and reflecting on those observations. This reflection should be a good indicator of the students' level of understanding of what they are doing and their

thought processes. At the end of each experiment, the teacher will assess what the students have created, paying less attention to the correct completion of the project and more attention to whether or not the students understand why their design worked or did not work.

How Do Planes Fly?

Almost all children are intrigued by planes and birds flying in the sky. At one time or another, they all want to fly, and so, in turn, are curious about how things fly. This fact makes this unit appealing to students because they have the chance to explore that question and to answer it themselves.

How Can a Heavy Plane Lift Off the Ground?

The Bernoulli Effect is the effect that is credited for lifting a plane off the ground. Daniel Bernoulli was a Swiss mathematician who first discovered it in 1783. Bernoulli noticed that as air moves, its pressure drops. This is true for air, water, or any other liquid. The faster the air moves, the more the pressure drops.

Planes fly because they are lifted off the ground by a force called "lift." Lift happens because the pressure is greater below the wing of the airplane than it is above the wing. Air pressure is lower when the air travels faster, and air pressure is higher when the air travels more slowly. This can happen because of the shape of the wing. The wing of an airplane is usually flat along the bottom and curved on the top, and tapers to a point at the back end of the wing. Since the top of the wing is curved, the air has further to travel than on the bottom of the wing. The same amount of air goes above the wing as below the wing, the air on top is spread out more and traveling faster, creating lower pressure above the wing. The air below the wing has a shorter distance to travel and travels more slowly, this air has a higher density, so this creates a higher pressure below the wing. When an airplane travels faster, the pressure difference becomes greater. In order for the plane to actually come off the ground and into flight, the lift force must be greater than the weight of the plane.

The only way for wings to lift a plane off the ground is if they are moving very quickly through the air. Gliders can achieve this same effect by flying downward and gaining speed. Gliders will also use upward air currents to gain some additional height. (See figure ii)

The 'angle of attack' is also important for lift to occur. The angle of attack is the angle at which the wing meets the airstream. At high speeds, the wing needs only about a 4 degree angle of attack to produce enough lift. As the planes travels more slowly, the angle must increase to produce enough lift to equal its weight. However, if the angle of the wing reaches 14 degrees, the wing stalls and the airplane descends. Stalling occurs when the airstream above the wing becomes turbulent and the wing loses lift. (See figure iii)

What Makes a Plane Move Forward?

Thrust is the force that moves the plane forward in the air. Thrust must overcome drag, the resistance of air, or the plane will not move. Thrust is typically measured in pounds or kilograms. Airplanes create thrust using propellers, jet engines, or rockets. For the purpose of the unit, rockets are not discussed with the students. Rocket engines are extremely powerful providing a tremendous amount of thrust, and large ones are often powered by liquid oxygen and ethyl alcohol.

When thrust is created by a propeller, it acts as a giant fan, pulling air past the plane. The blades of the

propeller slope at an angle and curve. The propeller spins and pushes some air backwards. Since the front of the blade is curved, it acts much like a wing, forcing the air to move faster over the front of the blade than behind it. With a lower pressure in front of the blade, combined with a backward flow behind the propeller, this is the thrust that moves the plane forward.

Jet engines are used on larger aircraft to create thrust and to overcome drag. Surprisingly, the main thrust involved with jet engines is not the air that is heated by combustion and pushed out through the jet engine, it is from the cooler air that bypasses the duct. At the front of the engine is a fan that rotates to suck air into the engine. Some of this air enters the compressor of the engine where the air then increases in pressure. Next, this high-pressure air enters the combustion chambers of the engine where the air is combined with kerosene and burns. This burning produces hot, high-pressure gas which is then passed through the turbines. The turbines are the part of the engine that drives the compressor near the front of the engine, and drives the fan at the very front of the engine. From the turbines, the hot high-pressure gas rushes out the backend of the jet engine with great force. This thrust of hot gases mixes with cool air that has bypassed the engine and together creates enormous thrust.

How Does Air Create 'Drag'?

Drag is what needs to be overcome by thrust in order for a plane to move through the air. Drag is the force that resists the motion of the plane moving through the air, that is, friction with the air. Friction is caused when two things rub together, in this case, it is the air rubbing against the surface of the airplane. Planes, birds, or anything else that moves through the air or water can be specially shaped to minimize drag, this shape is a "streamlined" shape. The idea of a streamlined shape is to have the air be able to flow around the plane as smoothly as possible. This can be seen by watching downhill skiers, whenever they have the chance to, they crouch down into a ball, making themselves as small as possible and therefore reducing drag. Pilots do the same thing, when they finish with takeoff, they retract the landing gear on the plane, they want to make the plane as small as possible so that the drag on the plane is reduced. If the landing gear of the plane remained extended during flight, the drag on them at cruising speeds would be so great that the landing gear would be ripped right off the plane. As the speed of a plane increases, so does the drag. The best streamlined shape is similar to a slim teardrop with the rounded end pointing in the direction that the plane is traveling and the pointed end at the back. This shape parts the air smoothly in the front, and the gentle tapering allows the air to come together again with the least amount of disturbance.

Incorporating Literacy and Multiculturalism

By reading the book *Dragonwings* the students will be able to get an historical and humanized perspective on flying. Yep's novel, a Newbury Honor Book, is an historical fiction book that tells a beautiful story and skillfully incorporates many literary elements which are a part of the fourth and fifth grade curriculums. Students will read the book in small groups. The focus of these groups will be to have the students use various skills in reading comprehension, problem solving, critical thinking, and making connections to their own lives.

Students will be using *Dragonwings* as a springboard into the multicultural aspect of the unit. They will be noticing the Chinese customs and comparing them to their own customs and traditions. Yep devotes a good deal of the novel to exploring the interactions, both good and bad, between American culture and Chinese

culture at the turn of the century. Students will compare and contrast this situation to the blending of cultures that happens daily in the students' lives. Students will also consider what would motivate people to leave their home and travel to a strange new land. This will encourage a sense of compassion and empathy on the part of the students.

Dragonwings: Getting off the Ground with literature

Dragonwings is set at the turn of the century and follows a young Chinese boy named Moonshadow, as he travels from China to San Francisco to live with his father. The father, a kite maker by trade, has been working in America for many years and is very intrigued by flight. The father, Windrider, initiates a correspondence with Orville and Wilbur Wright to further his own flying machine despite the criticism and skepticism of those around him. Through the letters that are written between these men, the reader gets a glimpse into the hard work and diligence that went into the first flight, as well as the science behind flying.

The Wright Brothers

On December 17, 1903 in North Carolina, Orville Wright proved to only five spectators that man could fly in his biplane *Flyer I.* Orville flew from Kill Devil Hill and over Kitty Hawk beach. This first flight lasted for twelve seconds but Orville had complete control of the plane. The *Flyer I* succeeded where its predecessors failed, thanks to its recently developed lightweight 12-horsepower gasoline engine. The original *Flyer* flew only four times and logged in 98 seconds of flight time. The plane was caught in a gust of wind and crashed on the beach.

Before the brothers had a successful flight, they experimented with gliders, often pulling them like giant kites. Thanks to the boys' business savvy, they were able to fund all of their experiments with different flying machines. With a friend, Orville began a printing business. Wilbur helped to establish and expand this small business. The boys then decided to start a bicycle and repair business when in the 1890's the new safety bicycle (a bicycle with the two wheels being the same size) became extremely popular in Europe and America. Building and repairing bicycles took up much of the brothers' time but Wilbur was not satisfied. Wilbur wanted to invent something of his own. Wilbur came across an article in a magazine about Otto Lilienthal, a German engineer who made gliders in which he could glide on. Wilbur read about Lilienthal's ideas and thought they would not work, Wilbur was correct, Lilienthal died when his glider crashed. This gave Wilbur an idea for an invention, he wanted to build a machine that would fly, would be controlled by a human pilot, and would run on its own power.

For three years the Wrights would go to Kitty Hawk to try their gliders. In 1902 they were successful and decided it was time for them to put an engine on their "heavier-than-air machine." The first attempt was on December 14, 1903 with Wilbur as pilot they were not successful. Three days later, on December 17, Orville flew the plane 37 yards. The plane made three more flights that day, the last flight was 260 yards with Wilbur as the captain.

Making the Trip from China to San Francisco

From around 1840 to 1900, approximately 2.4 million Chinese left their homes and crushing poverty to move to Southeast Asia and Peru, the Hawaiian Islands, Australia, the West Indies, Africa, and the United States of America. After the Opium War, the Chinese Government increased taxes, and when the peasants were unable to pay their taxes, their land was taken away from them. Some people tried to move to the cities but jobs were scarce. Hawaii was an obvious destination for the Chinese, and the islands needed workers for the sugar

plantations. By 1882, nearly half of all the plantation workers on the Hawaiian Islands were Chinese.

In 1848 gold was discovered at Sutter's Mill in California. Stories of *Gam Saan* , which means "Mountain of Gold" and was the term used by the Chinese when referring to California, enticed the Chinese to come to America to work for a few years in the gold mines and then return to China as rich men. Greater than half of the Chinese who came to the United States were from Guangdong, a province in South China, and the city of Canton. These people lived near the coast and were not afraid of the long and miserable voyage across the Pacific Ocean. It was almost always young men who left China, who did not plan to remain in the United States for long. The men would leave without their families but planned on returning so that they would die in their homeland.

Traveling to San Francisco was not an easy trip. By the 1870s steamships had taken over as the main way of crossing the ocean and the trip could be made in about a month's time. Before steamships, slow sailing ships would take two to three months to make the trip. The conditions were usually miserable, the ships would be crowded with men, the air was foul, and some of the immigrants were ill or seasick aboard the ship. The men would eat, sleep, and pass their time on straw mats and only occasionally were they permitted onto the deck of the ship. The trip to America was very expensive, about forty dollars. The average Chinese peasant earned about twenty to thirty dollars a year. For those who did not have money saved, there were two ways of paying for the trip. Money could be borrowed from money-lenders in the villages and could be paid back once the men arrived in the United States. Another way was to enter into a contract-labor agreement. By doing so, the Chinese man agreed to work for an American employer for a period of usually three to seven years. Every month the employer would deduct an amount of money from the wages until the immigrant's trip had been paid for. Both of these systems for paying were open to abuse. Many of the Chinese were swindled and ended up either working far beyond the number of years they were supposed to work or they paid about one-hundred dollars for the ticket.

The Chinese in America

At first, the Chinese were apprehensive to travel to America. However, by the 1850s the first group of men that had traveled to San Francisco began returning which was reassuring to the men who had remained in China. More encouraging was the fact that the men who returned brought riches with them that they had earned during their time in the United States.

Once the men overcame their apprehensions of making the voyage to San Francisco, made the long journey, and finally, with joy, arrived in the Golden Mountain they were greeted by the societies that had been formed to assist new arrivals. Clan societies protected families and district societies looked out for men from the same districts back in China. Eventually the numerous societies merged to form the Six Companies, a company for each of the districts from which most of the immigrants came. The Companies looked out for the welfare of the immigrants; one of their most important functions was to ship back to China the bones of any immigrant who had died, so that his remains could be honored in the traditional manner. The Six Companies were very powerful and controlled much of what happened to the Chinese immigrants. The Companies saw to it that those who had entered into a labor contract fulfilled the terms of the contract and that those who obtained their tickets based on credit paid back their debts in full. The Six Companies also prohibited any immigrant from returning to China before his debts were paid. This was made possible by an arrangement that was set up between the main steamship company and the Companies.

San Francisco had its very own Chinatown at the time, and was a home away from home for the immigrants. The Chinese men who worked in San Francisco could return to Chinatown in the evening to be joined on the

weekends and holidays by the men who worked in the mines, on the railroads, and farms. In Chinatown the language, the food, the pastimes, and the traditions were familiar and comforting. Chinatown also had its downfalls; it was overcrowded, its inhabitants were poor, and there were few women and children.

The Jobs of the Chinese in California

In the 1850s, California was ninety percent male and the Chinese took the jobs that were traditionally considered to be "women's work." The Chinese set up laundries, restaurants, and worked as cooks on mining camps or as domestic servants. Employers began to be enthusiastic about hiring the Chinese because of their industriousness and willingness to take jobs that others would be too dignified to take.

Founded in 1861, the Central Pacific Railroad became a major employer of Chinese labor. Employers were at first reluctant because they thought the strenuous nature of the job would be too much for their smaller body frame. Employers soon found that the Chinese were quite capable and of the ten thousand men who worked to build the Central Pacific, nine thousand of them were Chinese. Farmers who employed Chinese laborers found the same to be true about their diligence on the farm.

How the Chinese were Welcomed

The first group of Chinese did not make an attempt to Americanize since they did not plan on remaining in the United States for long. They were, however, welcomed as hardworking, honest, and meticulous. As popular as the Chinese were with employers, they were just as unpopular with white laborers who resented their success and accused them of taking away jobs from Americans. Many Californians began to assert that the Chinese were slaves. This assertion was extremely disturbing to the Californians considering that, in 1849 they had adopted a constitution prohibiting slavery, and a year later joined the Union as a nonslave state. Many people cried out for the expulsion of the Chinese from the state since they were perceived as a continual threat to the stability of California. The Chinese in California became a target for hostility, a ready scapegoat.

California legislature began to pass a series of bills against the Chinese. They were declared ineligible for citizenship; they were made to pay higher taxes; they were not protected by the law; they were required to send their children to separate schools although none were built; they were not allowed to marry white women. By 1882, discriminatory restrictions were put in place against the Chinese. In 1882 the Chinese Exclusion Act was passed that excluded any Chinese laborers from entering the United States. On November 30, 1885 Congress passed an act to prohibit contract labor. On May 5, 1892 the Geary Act was passed which extended the Chinese Exclusion Act of 1882 for another 10 years and also required the certificates of residence for Chinese living in the United States. In 1899 the United States declared an Open Door Policy toward China which increased feelings of goodwill toward the American government among the Chinese in both China and in the United States.

During this time, the Chinese found ways to get around the immigration restrictions. Some men became "paper merchants" since merchants could bring their families over. Chinese laundrymen, restaurant owners, gardeners, and cooks all tried to claim they were merchants. When the San Francisco earthquake occurred in 1906, almost all of the city's records were destroyed providing the Chinese an opportunity to claim that they were born in San Francisco, which would mean that they were automatically American citizens. Yet, the Chinese in America continued to face many hardships and opposition, and, over the years became more and more isolated from American culture.

Eventual End of Exclusion

By 1940, nearly fifty-two percent of the Chinese population in America was born in the United States making them American citizens. Gradually, this generation began to assimilate with American culture. When World War II began, the Chinese in the United States voiced their protest of the Japanese invasion of China and their support of the Allied forces. The war against Japan made the United States and China allies. The United States provided great amounts of military and financial assistance to the government of Generalissimo Chiang Kai-shek, the leader of the Republic of China. Generalissimo's wife toured the United States in 1943, hoping to win the repeal of the Chinese Exclusion Act. President Franklin D. Roosevelt saw the importance of China as an ally with America and supported the repeal and in 1943 Congress discussed and repealed the act.

Timeline: A Glance at Flight in History (31)

BC

- c.1000 The Greek myth of Icarus and Daedalus who fly with wings of wax and feathers.
- c.400 Kites invented by the Chinese.
- c.300 Carved wooden bird made, with an aerofoil section wing and tail fin.

AD

- c.1020 The "flying monk" Oliver of Malmesbury, leaps from the top of an abbey wearing a pair of wings, sustaining injuries from the glide.
- c.1300 Marco Polo witnesses man-carrying kites in China.
- 1783 Joseph and Etienne Montgolfier launch their first hot-air balloon.
- 1850s Sir George Cayley carries out gliding experiments. He is recognized as the father of modern aviation.
- 1890s German engineer Otto Lilienthal successfully tests a series of monoplanes and biplane gliders.
- December 17, 1903 Wright *Flyer* becomes the first aircraft to achieve sustained flight with a man on board.
- November 9, 1904 Wilbur Wright takes the *Flyer II* a distance of 2.75 miles (4.4 km.), the first flight lasting over five minutes.
- November 12, 1906 Brazilian pilot Alberto Santos-Dumont makes the first officially recognized world distance flight record.
- July 25, 1909 Louis Bleriot successfully flies over the English Channel.
- September 23, 1913 Roland Garros makes the first nonstop crossing of the Mediterranean Sea, 453 miles (730 km).
- May 1919 First transatlantic flight, by a US Navy NC-4.
- 1924 Two Douglas World Cruisers become the first aircraft to fly around the world. The trip took

from April 6 to September 28.
- May 20-21, 1927 Charles Lindbergh flies nonstop from New York to Paris, his speed averaged 107.5 mph (173 km/h).
- November 28-29, 1929 First flight over the South Pole. Flown by Bernt Balchen, with Richard Byrd in charge.
- August 27, 1939 Maiden flight of the Heinkel He 178, the world's first jet aircraft.
- October 14, 1947 Charles "Chuck" Yeager breaks the sound barrier at the speed of Mach 1.015.

Strategies

Every student brings his or her own unique background knowledge and life experiences to the classroom, as well as his or her own learning style. The integration of the different subjects and varied styles of lesson plans will help to meet the needs of the many different kinds of students that can be in any one class. Some students will be interested in and motivated by one aspect of the unit and not by others. The idea is that whichever subject area captivates a student, this will motivate him or her to take an interest in the other lessons and subjects. By teaching the subjects so closely to one another, the teacher will impress on the students that nothing can be learned in isolation and that everything is related. Once a student fully realizes and understands this, learning and acquiring new information will be an easier and more enjoyable process for him or her, regardless of what is being learned.

Taking Off with Flight Vocabulary

At the beginning of the unit, before delving into the material, it is important to activate the students' background knowledge and to create a foundation for them to work from for the remainder of the unit. The unit can be introduced by sharing with the students the objectives for the unit. Students are much more

efficient learners if they have an idea as to what they are to be learning, they need to know ahead of time that what they are doing is going to mean something to them. To find out where the students are regarding their knowledge of flight, begin with a whole-class discussion, asking the students who has flown on a plane before. Only a short discussion on their experiences on planes is needed. Proceed to construct a KWL chart with the class, helping out with prompts if needed:

K W L

What I Know What I Want to Know What I Learned

About airplanes How do airplanes fly? What I Learned section is filled as the unit progresses.

Orville and Wilbur Wright were the first to fly What made them build an airplane?

Once the students' minds are ready to begin thinking about the physics of flight, the teacher introduces important vocabulary words. This is necessary so that the class can have a common vocabulary, and so the teacher can be sure that the students are always aware of what is being discussed in the lessons.

Introduction of Dragonwings

When introducing the book, explain to the students that they will be learning about some people who were alive at the same time as the Wright Brothers, who have already been discussed in the construction of the KWL chart. Explain to them that Moonshadow and Windrider are Chinese and the two came to America to work. The students should be aware that they are reading this book to gain a different understanding of why people wanted to fly and how hard it was for that to become a reality. At this time, all the new and challenging words from the book do not need be introduced to the students. Some words and phrases should be discussed at this point. Students will be able to infer the meanings of many important vocabulary words through reading the story. For example, the students will realize on their own that an immigrant is someone who leaves their own country to live in another country. Allowing the students to construct their own understanding will be much more meaningful to them.

Beginning Flight Instruction

In order to capitalize on the students initial enthusiasm of the exploration of the question, 'How do airplanes fly?' it is important to get them working with hands on demonstrations and experiments almost immediately after the introductory lesson to the unit. Once the students have completed the first two columns of the KWL chart, they will be ready to delve into a simple experiment that will demonstrate how pressure of air drops as the air moves faster.

Illustrating the Bernoulli Effect

For this experiment the students can work in pairs. Each pair will have two ping pong balls each attached to its own piece of thread. Suspend the balls at equal height about ¾ of an inch apart. Give each pair a drinking straw and tell them to try to force the two ping pong balls apart by blowing through the straw as hard as they can. The students will find that by lining up the straw in between the two balls, the harder they blow, the closer the two balls will come together. Explain to the students that this happens because the harder they blow, the faster the air moves between the two balls, meaning the pressure here has dropped. Since the pressure between the two balls has dropped, the pressure on the outer sides is greater and pushes the balls together. This illustrates the Bernoulli Effect.

Another demonstration of the Bernoulli Effect requires a hairdryer and a ping pong ball. This is best done by the teacher as a demonstration to the whole class. Point the hairdryer upwards and float the ball on the draft from the hairdryer. The ball will always stay right in the middle because air moves the fastest at the center of the jet so the pressure here is low. The pressure surrounding the ball is higher and pushes the ball into the center.

Kites

Tying in with the novel, students will be building kites. Each child will have their own kite to decorate, assemble, and fly. The kites should be decorated in a traditional Chinese pattern such as a dragon or with two large eyes, before they are constructed (it may be possible to involve the art teacher for this particular project). The students will then fly the kites outdoors. Standing with their backs to the wind, the students may need to help a little by running with their kites. They should be led to notice that the kite is lifted upwards by the wind and that the stronger the wind is, the greater the force is that pushes the kite into the air. Some children may make an early connection that an aircraft needs great speed or great thrust to fly. They should be encouraged to verbalize this in the best way they can, using the children's language to help others to learn.

Airfoil and Plane Shape

This is a valuable foundation experiment for the children to do. Working with partners would be best for this activity. Students will make a paper wing by folding and bending a piece of paper to look like the cross-section of an airplane's wing with a flat bottom and a curved top. By attaching their 'wing' to two knitting needles using drinking straws and then anchoring the knitting needles in a block of clay, their 'wing' is ready for flight. Either a table fan or a hairdryer can be used to make air flow past the airfoil, the teacher will remind the students not to push the airfoil up by blowing air underneath it. The airfoil will slide up and down the knitting needles as it flies or stalls. Have the students try blocking the wind with a piece of cardboard or thin notebook. They will see that the wing falls. If the wing does not fall, they are blowing up from below.

Note: In all diagrams of airfoil and lift, the air is shown to be moving rather than the wing. This is for simplicity for explaining the experiments and concepts.

Perhaps the most difficult concept for the children to understand is the concept of drag. The way drag can be minimized is through streamlining the shape of an aircraft. When the air flows smoothly around the plane, drag is reduced. An experiment can be done to illustrate drag, however, this must be a teacher demonstration only and done only with the permission of the principal. Anchor a candle firmly in a candle holder or on a saucer with modeling clay. Light the candle and gently blow on the flame, but not enough to blow it out. Note that the flame bends in the same direction as the wind. That is because there is nothing there to disturb the airflow, and the air can move smoothly. Next time hold a piece of cardboard flat in front of the flame. By blowing toward the cardboard, air will curl around the cardboard and cause the flame to flicker toward the cardboard. The moving forward of the flame shows an air disturbance. An aircraft constructed with the same shape would have considerable air disturbance behind it. Air disturbance behind an aircraft is drag because it slows the aircraft down. Then bend the cardboard into a teardrop shape and secure the two ends. Center it in front of the flame with the rounded end away from the flame. By blowing on the cardboard this time, the students will see that the flame bends over smoothly, away from the cardboard. This shows that the cardboard has not upset the airflow very much and therefore has reduced drag.

Gliders and Paper Airplanes

Gliders, the simplest kind of winged aircraft, and paper airplanes have no source of power, or thrust. As soon as they are launched they begin to fall back toward the ground. In a typical manned glider, the pilot keeps flying by finding rising currents of warm air which lifts the glider. The pilot can control the glider using pedals connected to the rudder of the plane. The rudder is located on the back of the tail and swings left or right depending on where the pilot wants to go. The first person to build and test gliders was the English inventor, Sir George Cayley. In the early 1850's, he made the first glider to carry a person. The purpose of building and flying paper airplanes and gliders with the students is to begin to synthesize lift, weight, thrust, and drag since all these forces are in play with paper airplanes and gliders.

Each student can begin by making a basic paper airplane or their own version of a paper airplane. Students should launch the plane several times like this, recording their observations in a science journal. The students can then begin experimenting with bending the wings and cutting flaps in the wings for different effects which they will record in their journals. Another variable can be added by giving the students' a paperclip for their planes. The students can then begin to experiment with how the weight of a plane changes how it flies, and how even the placement of the weight on the plane (the front of the plane versus the back of the plane for example) changes how the plane flies.

Gliders can be easily and inexpensively purchased or made. They are usually made of light weight materials such as foam or balsa wood and cardboard. Depending on how many gliders have been purchased or made, students may work independently, in pairs, or in small groups. As the children launch the gliders, they should pay attention to the angle in which they point the gliders. The gliders should travel in a smooth curve. However, if the glider looks like it is diving, removing some of the weight from the nose of the glider will produce the desired results (purchased gliders usually come with some sort of weight at the front).

Propeller

An airplane propeller provides thrust in two different ways. It has curved blades which create high-pressure air behind the propeller and low pressure in front of the propeller. This pushes the propellers and the plane forward. Also, the spinning propeller pushes air backward which pushes the plane forward. By making a model propeller, the students will be able to see how the air is pushed backward as it turns. Making the propellers requires simply that the students construct two curved blades (construction paper, oak tag or cardboard will do) and have them spin smoothly. If this is not possible, a table fan can be used instead. Once the propellers are assembled or the fan is in place, suspend some ribbons or crepe paper from the edge of a table or doorframe and spin the propellers (or turn on the fan). The students will eventually notice in which direction they need to spin their propellers to make the ribbons flutter, and what happens to the ribbons when the propellers are spun in the opposite direction. Try turning the fan around to illustrate this concept, making sure to spend some time before the lesson begins discussing the shape of the blades of the fan.

Jet Engines

The first jet engines were created by Frank Whittle, an English engineer, in 1937. Whittle's jet engines never advanced beyond tests. The first jet engine-powered airplane to fly was the German Heinkel He 178 in 1939. The engine for this plane was designed by Hans Pabst von Ohain. Jet engines move the average airliner at 563 to 593 mph (900 to 950 km/h) which is almost the speed of sound. To allow the students to explore jet engines and to realize that there is more power generated from a jet engine than by any propeller plane, the students will work with concepts of escaping gases to produce thrust. It is also important for the students to make the connection that with thrust in flight, every action has an equal and opposite reaction. Introduce

Newton's Law that every action has an equal and opposite reaction, when the idea of thrust is first presented.

To explore how jet engines work to throw gas backwards and propel the plane forward, the students should work in pairs for this experiment. Each pair will need a balloon, a drinking straw, tape and a piece of thin string. By threading the string through the straw and attaching the string at both ends to the tops of chairs or tables, the students have created a track that the straw can move back and forth on. The balloon should be blown up and attached to the straw on the string, by letting the balloon go, the balloon will slide along the string. The jet balloons work in a similar way to a jet engine. Air being thrown out the back of the balloon pushes the balloon forward at high speeds. By changing how much the balloons are filled up, the students will be able to experiment with speed and distance. Student pairs can compete against one another, noting differences in how the balloons perform.

Powered Flight

This is where the students really have the opportunity to apply what they have learned about flight and create something that will fly with its own power source. Obviously, students will have some limitations, and will have to stick with a type of propeller plane. Remind students that a propeller plane needs a source of power to make the propellers turn. Students should work with their partners to brainstorm different ways to produce power using materials they can find around the classroom. Many students will eventually realize that they have, at one point or another, taken an elastic band, wound it up and watched it spin around with a fair amount of power. Allow the students to draw their models incorporating their source of power in their drawings. The students should then be given the materials they need to build the planes. Model airplane kits can be purchased inexpensively or the materials can be purchased from a model shop. The important part of this is to make sure that whatever the students are building has a source of power. If the classroom's budget is limited, purchasing one model for the classroom will be enough to show the students this kind of flight is possible for them to achieve.

Strategies for the Literary and Multicultural Elements

Incorporating the literature and the multicultural aspects should be done at the discretion of the teacher. While the physics portion of the unit can stand by itself without the reading of the novel or the exploration of the experiences of early Chinese immigrants, the students' understanding and appreciation of human flight would be greatly decreased with their absence.

Depending on the students' independent reading level, they should be assigned to read *Dragonwings* independently. The children should keep Reading Response Journals in which they write down brief summaries of what they have read and including their own reactions. Some children may need more direction or specification. Have the children write down three or more important things that happened in each chapter and tell them to relate one thing from their own lives to what they have read in each chapter. After a while, these children will begin to make connections between their own lives and the readings more automatically. Then in Guided Reading Groups, the teacher should go over the readings using this book as a means to teach the skills the children need. For the purpose of this unit, there is no regimented method to teach the book, it should be used to complement what is already being done during the literacy portion of the school day. It was stated above that the students should read *Dragonwings* independently, but it can also be read only while the students are in reading group, or even as a read aloud for the whole class.

Dragonwings Take Flight

When reading *Dragonwings* with the students, no matter which format is being used, special attention needs to be given to the sections of the book that talk about the creation of the flying machine that the two main characters are building. Chances are, almost all of the children at one time or another have thought about a way that they could make themselves fly. When the students reach the part in the book when Windrider first begins work on his flying machine, have the students imagine and draw their own flying machine. Remind them of some of the physics concepts that they have studied relating to flight, challenge them to use materials that they find around the house or that they could easily obtain.

In the novel the main character starts a correspondence with the Wright Brothers. Ensuring that the students know who the Wright Brothers are, have them write their own letters to Orville and Wilbur. A great extension would be for the students to write the next letter that would have appeared if the novel continued following the lives of Windrider and his son, Moonshadow. Allow ways for the children to connect with the struggle and the passion of these men. By allowing the children to work on their own designs of the paper airplanes and other projects involved with this unit, they will begin to get a sense of struggle, perseverance, and a desire to succeed on their own.

Learning about Chinese Immigration

In the back of the novel, Laurence Yep includes a brief note to the reader about the inspiration for Dragonwings as well as a quick history behind the story. This is a great place to begin when introducing the historical element of this unit. Yep explains that while the book is based on true historical facts, there are no actual historical figures that Windrider and Moonshadow are based on. Yep mentions how little is actually known about the thousands of men who came from China and poured into San Francisco hoping to make their fortune to bring their family back home in China out of poverty. The truth is, there is a limited amount of information on these men. An example of this is evident in the fact that almost every railroad track that was laid between Alaska and Texas was laid by a Chinese laborer, but on May 10, 1869, when the Central Pacific met the Union Pacific at Promontory Point, Utah, a gold spike was driven into the roadbeda photograph was taken of the event, and not a single Chinese man was in the picture. Today, there is no memorial for the thousands of Chinese who built the railroad while making a mere $31 a month.

To build a general understanding of Chinese culture as it existed in California during the middle to late 1800s, Guided Reading times should be laced with mini-lessons and facts about the way this group lived. While reading, have the students stop and reflect on the way the Chinese in the novel are interacting with each other and compare those interactions to how the Chinese in the story interact with the white Americans. The students will begin to see startling differences between these two interactions. The historical and cultural portion of the unit can be taught somewhat conversationally. Allowing the students the chance to notice and discuss the culture and the conditions of being Chinese in America will be much more meaningful to the students rather than providing them with endless history lessons covering the same subject. Prompt the students to think about how the struggle of Chinese men in America is like or dislike the struggle of other ethnic groups that have come to America. The students can be sent home to ask parents or grandparents how their own family came to reside in America. The students will most likely hear family stories about the hardships, perseverance, and motivation of their ancestors who helped to establish their family in this country. Have the students share some of the stories that they have uncovered, either in written form or orally, allowing the students to teach each other and learn about the different kinds of experiences that build their smaller community as well as the greater American society.

Lesson 1

Objective The students will identify, differentiate, and diagram the four principals of flight (weight, lift, thrust, and drag).

Materials

paper with a plane drawn on it

pencils

Procedure

Introduction: This lesson builds the foundation for the rest of the unit so it is important to make sure that the students see the point in this lesson, and that they come to understand these concepts based on finding answers to their own student generated questions. Begin by asking the students what they know about flight. Some students may have a great knowledge of flight already because of a passion and curiousity that they have been exploring, use these students to raise enthusiasm among the other students. At some point, one of the students will ask something along the lines of: *How does a big heavy plane fly?* This is where the four concepts can be introduced.

1. Weight is an obvious place to start. The students understand that the plane does weigh something, as do birds and other animals that fly. Explain that there needs to be a force to overcome this weight, and that force is called *lift* . At this point, the ping pong ball demonstration from the Strategies section of this unit can be shown to illustrate how a plane is actually pulled up by the way air moves. Another valuable demonstration at this time would also be the homemade airfoil also discussed in the Strategies section of this unit.
2. After a brief discussion of how lift counteracts weight, the students should arrive at the conclusion that a plane must be moving forward in order for it to fly. Introduce the term *thrust* and describe that as the force that moves an airplane forward. As a result of the plane moving through air, however, there is the final force called *drag* . Drag is air resistance acting on a moving plane. Explain to the students that is a bit like walking through water, it is hard to do, and the faster they try to move through the water, the more they have to work to overcome drag.
3. A good demonstration at this point is to take a candle (with the principal's permission and every possible safety precaution put in place) and place a piece of construction paper in front of the flame. Blow at the broad side of the paper and the students will notice that the flame dances around in all directions. Explain that this is drag, the air moves around in many directions behind the plane (the paper) and causes the plane to slow down or stop moving altogether. Then paperclip two sides of the paper together and stand it upright. Have the clipped end point to the flame and blow (gently) on the rounded side. The flame will now bend back gently. This indicates that there is very little drag because the air can move in a smooth path past the plane.
4. Give the students a piece of paper with a plane drawn on it. Have the students draw one arrow that points straight up, one that points straight down, one that points straight in front of the plane, and one that points directly out the front of the plane (as in figure i). Ask the students what they think the arrows might indicate. Most likely, one of the students will say that each arrow is

one of the four forces. Have the students label the drawing. Depending on the level of the class, this can be done whole class, or individualized with different amounts of assistance, some students may find that a peer can explain it to them more clearly.

Closure: Once the students have the diagram clearly labeled, have them differentiate among the different forces. Encourage them to put the definitions of each force into their own words.

Extension: Make paper airplanes with the students, allow differentiations in design, supply students with paperclips and translucent tape if needed. With a sensitive classroom scale, weigh the planes. Have the students try to fly the planes using different amounts of 'thrust.' Students will begin to see that the heavier a plane is, the more thrust is needed for the plane to glide. This is not a great way to examine all four forces in isolated action, but students will begin to understand that a certain amount of speed is needed for the plane to glide successfully, and that the angle of attack changes how well the plane will glide. The angle of attack changes the drag on a plane. If the plane is launched at a steep angle upward, a great deal of force is needed for any kind of a successful glide.

Lesson 2

Objective The students will work with a partner to construct a 'glider' with a straw, strips of paper, and translucent tape.

Materials

Each pair of students needs:

a plastic drinking straw
two strips of paper
four pieces of translucent tape
student science journals (any notebook or bound pages will work)
a glider for the teacher with two additional paper strips

Procedure

Introduction: Explain to the students that they will be constructing gliders out of some familiar materials. As a class, quickly brainstorm the different shapes that they have seen for gliders of the types or shapes they think would work the best for gliding. Stress that there is no correct or incorrect way of doing so but that they will need to record what they do and what they observe in their Science Journals. They will also need to test their design several times to make sure the results are consistent. Before the students begin, have a brief discussion reminding the students how to work well with a partner.

1. Distribute the materials following whatever procedure is set up in class for this.
2. The students should be sitting with their partners and can begin working as soon as they have all of their materials. Set an amount of time that they will be able to work on their own models and let the students know how much time they have.
3. Students will try many ways of fastening the strips of paper to the straw and may need additional strips of paper or additional pieces of tape, have some on hand for quick distribution. Observe the students as they work
4. The completed version of the glider should be the straw with a strip of paper in a loop taped to each end of the straw. Allow at least 15 minutes for the students to experiment with their own designs, write in their journals, and record their observations.
5. Once time for the students to work is up, have a few of the partners share with the class what they discovered about making and flying their own gliders. After this brief discussion, show the class a model of the glider that was built ahead of time with the two loops on either end of the straw. Tell the students that you would like to see how adding one and then two more loops will change how the glider works.
6. Create a chart where the observations can be recorded. The chart should have a spot to write down the distance traveled for each of three test runs for each of the glider designs (3 in total). Have one of the students fly the glider and the rest of the class make observations on exactly what the glider did. Then have the student fly the glider at least two more times and add to the observations as needed. Then add another loop of paper right in the center of the straw and repeat the flying tests in the same way as before. Then create a fourth loop of paper and adjust the glider so that there are four loops evenly spaced along the straw. Conduct the flight tests in the same manner as with the two other designs.

Closure: Now, as a class, compare and contrast how the three different glider designs worked. Encourage students to think about what was happening to the glider as more loops were added to the straw. Ask the students which design they thought worked the best and why.

Extension: If there is time, or at another time, give the students some additional materials and tell them to add on to their existing glider. Have them make observations in their journal to see how these additions change the way the glider works.

Lesson 3

Objective the students will create a 'propeller' given a piece of paper and a paper clip as well as their knowledge of how propellers move.

Materials

a table fan or standing fan
paper
scissors
paper clips
student Science Journals

Procedure

Introduction: Set a table fan in view of the classroom at the beginning of the lesson. For this lesson, the students should already understand about the four basic concepts of flight: weight, lift, thrust, and drag. Ask the students the different ways in which a plane can move forward through the air. They will give answers such as propellers and jet engines, both are correct. Ask the students to describe what a propeller looks like and how they think it works to move a plane. A student should, at some point, notice the fan and say that a propeller looks (and works) just like a fan with its rotating blades. Turn on the fan and make sure all the students get a chance to feel how the air is sucked in the back and pushed out the front, try to get the students to use these words themselves to describe how the fan is working.

1. Distribute a piece of paper, scissors, and a paper clip to each student (or to pairs of students). Tell the students they will be making their own propellers of sorts, that what they will be making should simulate the shape and spiraling action of a propeller but not necessarily be able to pull a plane forward.

2. Set a time and allow the students to work on their designs. Give them enough time to work on their designs, complete at least three test runs, and record their observations in their journals. There are several designs that will work. However, if none of the students create working propellers, have one already made to show the class to help them along. It should have two 'arms' reaching up, and one arm reaching down. Bend each arm at the top at a 90 degree angle, in opposite directions, attach the paper clip to the bottom arm. Hold the paper at the place where the two top arms are bent and let go, the devise should slowly spiral to the ground.
3. Once the students have the general shape of the propeller, have them begin experimenting by slightly twisting the arms at the top, or bending the edges in different ways, adding on or taking away paper clips.

Closure: Discuss what made the paper propellers spin as they floated to the earth. Also, discuss how a plane needs thrust to move through the air, and that a plane is actually pulled through the air rather than pushed. The propeller blades on a small plane move air in such a way that the air is pulled through the propellers and pushed out the back of them, the same way that a fan works.

Extension: Try to create a way to reduce friction enough on a small table fan so that it can actually be pulled along a table or the floor. Very smooth rolling wheels (such as inline skate wheels, or desk chair wheels) can be fastened to the bottom of the fan and place it on a table or the floor covered with some material that is smooth (a glossy paper or contact paper). The students will be able to see more clearly the action of pulling rather than pushing.

Glossary of Terms

Aerodynamics The science that deals with air and how aircraft fly.
Ailerons Movable controls fixed to the wings that are used to make an airplane bank.
Airflow The flow of air past a moving aircraft.
Airfoil A structure such as a wing, a tailplane or a propeller blade that develops lift when moving quickly through the air.
Airstream A current of moving air.
Angle of attack The angle at which the wing meets the airstream.
Banking When the pilot lowers one wing and raises the other during a turn.
Biplane A fixed-wing airplane with two sets of wings.
Buffeting A shaking and bumping of an airplane as it nears the speed of sound and is affected by shock waves.
Dihedral The angle at which wings or tailplanes are attached to the fuselage. It helps to keep the airplane stables.

Drag The air resistance acting on an airplane. Drag acts in the opposite direction to thrust.
Elevator A movable control attached to the tailplane that makes an airplane climb or descend.
Fin The fixed, vertical part of the tail unit that helps keep an airplane flying straight ahead.
Fuel injector In any engine, the part that sprays a mist of fuel into the combustion chamber. The resulting explosion moves a piston in a propeller engine, or provides a flaming exhaust in a jet engine.
Fuselage The body of an aircraft.
Glider An aircraft with no engine, deriving its lift from rising air currents.
Jet Type of engine that provides thrust by a powerful exhaust.
Kite A tethered glider that is lifted by the wind. A kite was the first heavier-than-air aircraft.
Lift A force that acts upward against gravity and makes it possible for airplanes to fly.
Monoplane A fixed-wing airplane with one set of wings.
Pitch Nose up-and-down motion, provided in flight by moving the elevators on a tailplane.
Propeller A set of blades driven by an engine that pull or push and airplane through the air.
Roll Side-to-side rocking motion of an aircraft, controlled by the ailerons mounted on each wing.
Rudder A movable control fixed to the fin that helps control direction.
Stalling This happens when a plane flies too slowly. Its wings are unable to produce enough lift and it loses height.
Tailplane The fixed, horizontal part of the tail unit that help to keep an airplane stable.
Thrust A force that pushes an airplane forward through the air.
V/STOL Vertical and/or short take off and landing.
Wing flap A hinged section of the wing that is lowered when landing and taking off to increase lift at low speed.
Yawing The aerodynamic term that describes an airplane's nose swinging from side to side.

Notes

1. Marshall Brain & Brian Adkins, "How Planes Fly," www.howstuffworks.com.

2. Steve Parker (1995), *What if...Airplanes?* , 16.

3. Brain and Adkins

4. Parker, 20-21.

5.Donald Lopez (1995), *The nature company discoveries library: Flight* , 23.

6. Parker, 20.

7. David Macaulay (1998), *The new way things work* , 107.

8. Lopez, 32-33.

9. Macaulay, 107.

10. Jefferis, 14-15.

11. Lopez, 22-23.

12. Theodore Rowland-Entwistle (1988), *Children of history: Wilbur and Orville Wright* , 20-28.

13. D. Ying-Hui Wu and J. Dao-Sheng Tung (1993), *Coming to America: The Chinese_American* experience, 27.

14. Frank Ching (1976), "The Asian Experience in the United States," *The immigrant experience in America,* 192

15. Roger Daniels (1990), *Coming to America: A history of immigration and ethnicity in American life* , 239.

16. Linda Perrin (1980), *Coming to America: Immigrants from the far east* , 11.

17. Ying-Hui Wu and Dao-Sheng Tung, 29.

18. Ying-Hui Wu and Dao-Sheng Tung, 32.

19. Perrin, 15-17.

20. Daniels, 242.

21. Perrin, 22-23.

22. Ying-Hui Wu and Dao-Sheng Tung, 34.

23. Perrin, 25-26.

24. Perrin, 28.

25. Ching, 194.

26. William L. Tung (1974), *The Chinese in America 1820-1973* , 17.

27. Tung, 21.

28. Ying-Hui Wu and Dao-Sheng Tung, 44.

29. Ying-Hui Wu and Dao-Sheng Tung, 48.

30. Ying-Hui Wu and Dao Sheng Tung, 54.

31. David Jefferis (1994), *Timelines flight: Fliers and flying machines* , 44-45.

32. J. Hann (1991), *How science works* , 86.

33. N. Ardley (1995), *How things work,* 101.

34. Andrew Haslam (1995), *Make it work! Flight* , 24-25.

35. Hann, 89.

36. Haslam, 22-23.

37. Haslam, 32-33.

38. Haslam, 42.

39. Haslam, 34-35.

Student Reading List

Ardley, N., Reader's Digest (1995). *How Things Work* . London, Dorling Kindersley Limited.

A book of activities to demonstrate different concepts in physics. Provides three different activities involving the concepts of flight.

Baker, W. & Haslam, A. (1994). *Make it work! Machines* . New York: Scholastic.

How to build 'things that go.' Shows how to create a working model of an airplane and other machines which can be used to explore how propellers work.

Breckenridge, J. (1993). *Simple physic experiments with everyday materials* . New York: Sterling.

Shows how to explore physics concepts using the materials that can be found around the home.

Graham, J. (2001). *Hands-on science: Forces and motion* . New York: Kingfisher.

Explores all kinds of forces and motion complete with colorful photographs.

Jefferis, D. (1994). *Timelines flight: Fliers and flying machines* . New York: Franklin Watts.

An excellent history of the flying machine complete with explanations about the technological and scientific advances that made flight and flight advancement possible.

Lafferty, P. (1992). *Eyewitness science: Force and motion* . New York: Dorling-Kindersley.

An explanation of how and why things move. Contains many colorful photographs with detailed captions.

Maestro, B. (1996). *Coming to America: The story of immigration* . New York: Scholastic Inc.

This children's picture book explores the evolving history of immigration in he United States.

Parker, S. (1995). *What if: Planes* . Connecticut: Copper Beech.

An entertaining look at flight asking all the questions that kids wonder about. Entertaining drawings to demonstrate what would happen if plane designs were altered.

Potter, J. (1995). *Science in seconds for kids* . New York: John Wiley.

A kid-friendly approach to learning scientific concepts.

Rowland-Entwistle, T. (1988). *Children of history: Wilbur and Orville Wright* . Freeport, Long Island: Marshall Cavendish Corporation.

The lives of the Wright brothers as they grew up through their flying years.

Yep, L. (1975). *Dragonwings* . New York: Scholastic.

A novel following a young Chinese boy and his father as they struggle to assimilate with American culture. They begin a correspondence with the Wright brothers and work to build their own flying machine.

Ying-Hui Wu, D. & Dao-Sheng Tung, J. (1993). *Coming to America: The Chinese-American experience.* Brookfield, Connecticut: The Millbrook Press.

Traces the history of Chinese immigration to the United States, discussing why they emigrated, their problems in a new land, and that contributions to American culture.

Teacher Reading List

Coppa, F.J. & Curran, T.J. (1976). *The Immigrant Experience in America.* Boston: Twayne Publishers.

A good discussion of the experiences of an Asian immigrant in America.

Daniels, R. (1990). *Coming to America: A history of immigration and ethnicity in*

American life. New York: HarperCollins Publishers.

A history of all the immigrants coming into America from 1500 to present.

Hann, J., Reader's Digest (1991). *How Science Works* . London: Dorling Kindersley Limited.

A book of physics activities including an explanation of the physics behind the activities.

Haslam, A. (1995). *Make it work! Flight* . New York: Scholastic.

An excellent guide to the exploration and demonstration activities in this unit. Activities are step by step and progress from the most basic elements of flight to fully powered flight by the end of the book.

Hoff, R. (1967). *America's Immigrant's: Adventures in eyewitness history.* New York: Henry Z. Walck, Inc.

A collection of stories from those who migrated to America during the nineteenth and twentieth centuries.

"How Planes Fly." HowStuffWorks (http://www.howstuffworks.com), by HowStuffWorks, Inc. 2002.

Lopez, D. (1995). *The nature company discoveries library: Flight* . Sydney: Time Life Books.

A complete look at flight. The book begins by studying animals that fly and examining how that led to human flight. Many colorful pictures.

Macaulay, D. (1998). *The new way things work.* Boston: Houghton Mifflin Company.

Text book style approach to covering physics concepts. Includes helpful illustrations of all the concepts.

Perrin, L. (1980). *Coming to America: Immigrants from the far east.* New York: Delacorte Press.

A close look at the history of Asian immigrants.

Tung, W.L. (1974). *The Chinese in America 1820-1973: A chronology and fact book.* New York, Oceana Publications, Inc.

A chronology of the Chinese in America from 1820 to 1973 with important documents included.

Yans-McLaughlin, V. (1990). *Immigration Reconsidered: History, sociology, and* politics. New York, Oxford University Press, Inc.

A collection of essays which challenge ethnocentric American or European perspectives on immigration.

List of Materials

Dragonwings by Laurence Yep (a class set is advised)

paper with a plane drawn on it

pencils

plastic drinking straws

strips of paper

translucent tape

student science journals (any notebook or bound pages will work)

a table fan or standing fan

scissors

paper clips

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