Archimedes and the Door of Science Study Guide

Archimedes and the Door of Science by Jeanne Bendick

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Plot Summary

Archimedes and the Door of Science is a book written for primary school students on the life and discoveries of the great Greek mathematician and scientist Archimedes of Syracuse. The author encourages home educators to use the book and suggests that it can be used as part of a history, science or mathematics curriculum. It contains various examples of how to construct an experiment to illustrate one of Archimedes's discoveries and contains helpful illustrates for the student reader.

The book contains fourteen chapters. In Chapter 1, Who Was Archimedes, the author introduces the reader to Archimedes, a citizen of Greece who was born in Syracuse on the island of Sicily south of Italy in 287 B.C. His father was an astronomer and he had an elite education growing up. His mind constantly raced and he was always fascinated by technical problems. He is one of the giants of science and mathematics. He invented the sciences of mechanics, hydrostatics and prefigured important work in calculus, geometry, number theory, chemistry, and astronomy.

Chapter 2, The World of Archimedes, describes the historical setting for Archimedes's life and work, which involves explaining the culture of Syracuse and Greek culture generally, along with Archimedes education, surrounding geography and the extent of the known world. The author talks about the unique Greek approach to knowledge and their love of argument and abstract thought. We also learn that Archimedes was related to the King of Syracuse, a relationship that proves important later on.

In Chapter 3, Alexandria!, Archimedes also studied in Alexandria at the great library and museum there with many other important mathematicians and scientists. We also learn about Archimedes famous irrigation tool, the Archimedean Screw and we learn about his use of simple machines generally. Chapter 4, Archimedes and His Lever, discusses Archimedes famous use of levers, and his claim that he could move the world if he had a lever long enough. Chapter 5, Archimedes and King Hiero's Crown recounts the details of the famous 'Eureka!' story and Archimedes discovery of the idea of density. Chapter 6, Archimedes and Astronomy, Chapter 7, Archimedes and Mathematics, Chapter 8, The Measurement of a Circle and Chapter 9, Archimedes and Numbers discuss his contributions to astronomy, mathematics, circle measurement and numeration respectively. Chapter 10, Archimedes and Centers of Gravity discusses Archimedes's important insights into Centers of Gravity and Chapter 11, The Sphere and the Cylinder, discusses his favorite discovery and symbolic epitaph.

Chapter 12, The War Machines of Archimedes, discusses the war machines Archimedes built to defend Syracuse against Marcellus, the Roman General, and Chapter 13, The End of Archimedes discusses how Archimedes died at the hands of a Roman soldier three years after the siege of Syracuse began. Chapter 14, No End to Archimedes, recaps his everlasting discoveries.

Chapter 1, Who Was Archimedes?

Chapter 1, Who Was Archimedes? Summary and Analysis

Archimedes was born in Syracuse, Sicily in 287 B.C. and was a Greek citizen. An olive branch was placed on the door of his house to tell the people of Syracuse that their astronomer, Phidias, has been gifted with a sun. His birth was celebrated with two family parties, one on the fifty day to put him under the protection of the gods and on the tenth day where Phidias promised to his guests to raise his son as a good Greek citizen.

Archimedes has only a first name, no last or first name. It is not clear who he was named after. In those days, little was known about science if anything. Science, however, began because of him. He was unusual in various respects: his mind never stopped attempting to add to the knowledge of humanity. No problem bored him and he performed many experiments. He is responsible for many original ideas and scientific discoveries. He thought out many important issues from the beginning. As such, Archimedes was one of the great scientists in history.

He created the sciences of mechanics, hydrostatics, the laws of levers and pullers, buoyancy, specific gravity, the notion of an element, the Archimedean screw, a machine that measured eclipses and he created war machines. The only math he didn't write about was algebra, even foreshadowing calculus by discovering the math of changing rates. His most important contribution, however, was helping to introduce rigorous, logical thinking into science.

Chapter 2, The World of Archimedes

Chapter 2, The World of Archimedes Summary and Analysis

Sicily is an island of the toe of Italy; many European nations were no more than half-civilized tribes. No one knew that the Americas existed and below the civilized part of Egypt, there were only great deserts, below which were jungles full of savage barbarians called 'gorillas'. Great civilizations lied to the East, but it took a long time to get there. Very few forms of travel or communication existed and when they did, they were slow.

Greek ideas influenced the West for centuries after their empire collapsed, even to the presence day in science, law and art, even ethics. It is not clear why the Greeks were so different from the peoples that preceded them and were their contemporaries.

Syracuse was a large city and center of commerce, located near the center of the Mediterranean Sea. It was near Italy, Greece, and Africa. Most jobs in Syracuse had something to do with the sea. As a child, Archimedes must have spent a lot of time at the docks. Despite the fact that everyone was busy, many asked the big questions and argued about the answers.

Greek learning started as a child at home, at least for men. Children lived with women; his friends would have played ordinary child's games and he probably knew Aesop's Fables, learning about punishment when he was bad. But historians know little about Archimedes family specifically, save that his father, Phidias, was an astronomer, and that he was related to Hiero II, Syracuse's King. He started school at eight and managed his slaves; he avoided getting into trouble. Much of his early education involved learning how to think, not just the learning of facts. School was held in his teacher's house and learned to write on papyrus. He did geometry, grammar, and studied Homer on poetry and history, Aesop on fables, Solon on laws and many other things.

Greek citizens had to be well educated to play a role in Greek democracy in their city-state; he also had to serve in the military. He would have to learn military tactics and how to fight. Many would drop out to pursue standard professions but some boys stayed to learn more without a schoolmaster. These boys would focus on law, philosophy and ethics. The boys would also sometimes go to the theater.

Life was simpler then; people had less money but had fewer concerns. They walked where they wanted to go and had little furniture; their food was simple. Citizens had leisurely lives. Slaves did most work in Greek society.

Chapter 3, Alexandria!

Chapter 3, Alexandria! Summary and Analysis

When he finished school, Archimedes sailed for Alexandria in Egypt, which was then the greatest city in antiquity. The city was created by Alexander the Great in 332 B.C. His general Ptolemy ruled Egypt after his death and turned Alexandria into the most important Greek center for learning and art, constructing the greatest library in the world at that time, where Greeks learned for a millennium. Scientific research began here and all academics came to Alexandria.

Archimedes had trouble initially finding someone to take him to Alexandra; sailing in those days had great risks, as they had no compasses, charts or sea-faring clocks. Greek ships were primitive. But the Greek Empire was spread across the Mediterranean Sea and ships were the only connections between many areas. Archimedes probably set sail between age sixteen or seventeen.

When he would have arrived in Alexandria, he must have seen the great Pharos lighthouse, one of the Seven Wonders of the Ancient World. The Syracuse harbor could not match the majesty of the Alexandrian harbor. Ships from all over the known world would have been there, from Spain, Africa, Britain and even China.

In Alexandria, Archimedes studied mathematics at the school created by his predecessor Euclid, a Greek mathematician born in 330 B.C. and died in 275 B.C. His students continued to pursue his work and we possess his textbooks over two thousand years after he wrote them. He discovered many of the key geometrical axioms in his books The Elements. All geometry came from this book directly or indirect from two millennia. The Museum there produces Euclid, Archimedes and Apollonius, who shaped mathematics for thousands of years. Archimedes's teacher at the school was Conon of Samos, an early astronomer. And Archimedes studied so hard that he wouldn't leave the Museum for days. Students often had to copy books by hand to preserve them. He worked with his teacher and his friend, Eratosthenes, who later became head of the library.

During the year, the Egyptians often had trouble gathering water, which they could only collected a few months out of each year. Archimedes watched them collect water and invested the Archimedean screw to make things easier. The screw was placed in a cylinder and when placed in the water and turned with a crank, it would pull water out onto the field; Egyptian farmers still use the screw to irrigate. The Dutch use the screw to pull water from the land back into the sea. The screw is a simple machine, with a body, thread and axis. The screw also became the propeller on boats and airplanes.

Chapter 4, Archimedes and His Lever

Chapter 4, Archimedes and His Lever Summary and Analysis

Archimedes eventually went back to Syracuse but he still wanted to explore his ideas and did so in his study. He worked in the dirt, as papyrus was expensive and hard to change. He would even trace diagrams on his skin in the tub. He would often argue with King Hiero; they argued about whether pure mathematics was the most beautiful thing or whether practical things that all could understand were more beautiful. But mechanics could combine both, as it is the action of force on things and understanding these interactions through mathematics.

Archimedes one day argued to Hiero that any weight anywhere could be moved with the right force in the right amount. He could move the world with a lever, if only it were long enough. He then claimed that he could move a ship with three masts all by himself. Hiero took him up on his offer. He produced a helix contraption fixed to the dock with a screw. He moved the ship.

He moved the ship with a pulley, which is a complex sort of level. A screwdriver, for instance, is a lever, as it a crowbar and an oar. As long as you add force, you can make these things machines. Machines are any object we can use to make work easier by giving us mechanical advantage. They move objects by communicated information about force from the body to force against the object the machine is used against.

Work done on the machine is force, the work that needs to be done is resistance and a lever turns on a fulcrum. Together, these forces come together to move things. And levers come in first and second-class types. A first-class level is a seesaw and a second-class lever is a wheelbarrow. A third-class lever is a fishing rod. Each of them organize the combination of a fulcrum, the place where force is applied and where the resistance is. A pulley is also a lever of the second-class type.

All mechanical devices are composed of two kinds of machines - the level and the inclined plane like a wedge. The screw is an inclined plane that is twisted around a shaft. A wedge is the combination of two inclined planes.

Chapter 5, Archimedes and King Heiro's Crown

Chapter 5, Archimedes and King Heiro's Crown Summary and Analysis

Hiero was impressed by Archimedes's feat. One day he ordered a new gold crown, but it fit too comfortably on his head; he was worried that it contained silver. When Hiero confronted the goldsmith, he promised he wouldn't cheat the king. Hiero then asks Archimedes to figure out whether his crown is solid gold. Archimedes took the crown home and spent days staring at it, doing nothing else. He didn't bathe during this time until his slaves forced him into the water. Archimedes realized that he displaced a certain amount of water.

At that moment, he shouted and ran down the street yelling, "Eureka!" which means "I have found it!" After coming back, he filled a jar with water and put the crown in it, measuring how much water spilled out. Then he put the gold lump in, but less water came out. The crown took up more space than the gold, so it displaced more water. But since silver is lighter than gold, more silver is required to make it equal in weight. If the crown were only gold, it would have displaced the same amount of water, but if it had silver in it, it would be larger, displacing more water. And so Archimedes proved that Hiero had been cheated.

But his discovery was more significant. He discovered the idea of the density of gases, liquid and solids. And the weight of an object compared to its weight or volume of water is its specific gravity. The author then suggests the way that a student can learn the principle of density herself. The measurement Archimedes had done involved the creation of the first hydrometer.

Water's upward lifting force came to be called buoyancy and the author suggests an experiment for the student reader to understand buoyancy as well. She explains that an object floats only when it displaces the same amount of water that it weighs. Some things ink because they are heavier than the water they displace. A steel ball will sink, but a steel ball spread out into a boat will float because it displaces more water. This new field, known as hydrostatics, was invented by Archimedes and would not be added to until Blaise Pascal's discoveries eighteen hundred years later.

Chapter 6, Archimedes and Astronomy

Chapter 6, Archimedes and Astronomy Summary and Analysis

Astronomy preceded the Greeks but it was mostly practical. They could predict eclipses, tides, floods and so on. But the Greeks pursued astronomy for more abstract reasons; the starts and their motion were beautiful and disciplined, reflecting their values. Even their word for the heavens, 'cosmos' means 'orderly and harmonious arrangement'.

The Greeks knew that the light of the moon came from the reflection of the sun. Aristotle deduced the shape of the earth from the shadow it made on the moon. From an early age, Archimedes was interested in astronomy but they had few tools, not even telescopes. They had patients, curiosity and intellect, along with mathematics, sundials and a few compasses. They thought the sun revolved around the earth and thought the earth was the center of the universe. The stars were 'fixed' in the sky and they could only see five planets - Mercury, Venus, Mars, Jupiter and Saturn. Archimedes was said to have estimated the distances to these planets.

A fellow astronomer, Aristarchus, argued that the sun was the center of the universe and thought the universe was much larger than initially thought. Archimedes agreed with Aristarchus and thought the earth was very large. His friend Eratosthenes measured the circumference of the earth to near exact precision. Phidias thought that the sun was twelve times larger than the earth.

The Greeks had terrible trouble measuring the length of the year because of the differing periods of moon and sun. Archimedes is thought to have accurately deduced the length of the year using his machine. Some writers, like Cicero, were thought to have observed them two hundred years after the fact. The machine was a small series of concentric glass spheres meant to track the motion of the planets and is thought to be the first planetarium.

Chapter 7, Archimedes and Mathematics

Chapter 7, Archimedes and Mathematics Summary and Analysis

The term 'mathematics' in Greek, just means 'science'. And math was the subject Archimedes most enjoyed, working in every field of mathematics known to him. But he did not write textbooks; instead, he only wrote technical, brilliant essays for other mathematicians.

Archimedes wrote on arithmetic, trigonometry, laid the foundations down for calculus and focused most on geometry. These fields of mathematics are crucial for modern life - arithmetic for everyone, trigonometry for distances and direction, calculus, which makes space travel possible and geometric, which makes architecture possible. He also analyzed shapes like spheres, cylinders, cubes, cones, and their relationships to flat surfaces. He also analyzed semicircles, spirals, hyperbolas, parabolas and ellipses. He figured out how to calculate volume and all measurements of solids began with him.

Chapter 8, The Measurement of a Circle

Chapter 8, The Measurement of a Circle Summary and Analysis

Multiplying two times the radius of a circle time pi, 3.14159, gets you the circumference of a circle. Pi times that radius squared renders the area of the circle. But Archimedes figured out how to find the area of a circle without the formula. Until Archimedes, people found out the approximate area of a circle by drawing the largest square they could within a circle and then the smallest square outside of it. The area of the circle was somewhat in between the area of the two squares. It would also help with the circle.

Archimedes enclosed his circle with polygons, adding more sides until he reached ninety-six. The circumference he found with his polygons was always less than 22/7ths multiplied times the diameter and always more than 223/71sts the diameters. He also showed that a circle's area equaled the area of a right triangle with the circle's radius as one side and its circumference as the other. He also found that the ratio between a circle's area and its diameter squared is 11:14. He eventually generated pi as between 3.1408 and 3.1428, which is quite close to 3.14159. He also had a method of deriving square roots.

Chapter 9, Archimedes and Numbers

Chapter 9, Archimedes and Numbers Summary and Analysis

Historians know that Archimedes author two papers concerning arithmetic but one is lost. He had written it on the principles of counting or numeration. The Greeks had just derived a system of numeration and it was clumsy. Many believe that Archimedes and Apollonius used a decimal system.

His other paper, The Sand Reckoner, has been preserved. In the paper, Archimedes said that there were unimaginably large numbers and that anything could be measured with them with numbers to spare. There were an infinite number of numbers. He started his argument with the largest number in Greek - the myriad or 10,000. He multiplied it by itself and then continued from there, arguing at each step that the result was still a number.

Archimedes then generated the 'cattle problem' for his friends to show them how large numbers could be. However, some think that he did not write the problem because it was written in verse and he was not a poet.

Chapter 10, Archimedes and the Centers of Gravity

Chapter 10, Archimedes and the Centers of Gravity Summary and Analysis

Much is still unknown about gravity, but most of what we know came from Sir Isaac Newton in the 17th Century. But Greek scientists worked on gravity in their day. Archimedes thought a lot about balance and centers of gravity. When he demonstrated the idea of centers of gravity, he laid the groundwork for theoretical mechanics. An object's center of gravity is the point where an object's weight seems to center.

Archimedes wrote books on mechanics showing that centers of gravity are not always located at the centers of objects. Not everything balances in the middle. He found that weights that balance one another at equal distances have equal weight. This helps to make sense of the relationship between planets, starts and moons. The center of gravity of the earth is 20,000 miles from the moon.

The author then outlines a project in which students can demonstrate the principle of centers of gravity for themselves, a type of balancing mobile.

Chapter 11, The Sphere and the Cylinder

Chapter 11, The Sphere and the Cylinder Summary and Analysis

The most important work Archimedes did, in his opinion, was his work on spheres and cylinders, along with cones and pyramids. He also related flat objects like circles and triangles to their three-dimensional counterparts, like spheres and trapezoids. He found that taking a sphere and creating a cylinder as wide as the greatest circle of the sphere and which was as high as a sphere took up 1.5 times the space as the sphere. Archimedes wanted the image of a sphere within such a cylinder on his tomb.

Archimedes also developed a method for proving his solution to problems which mathematicians have considered important ever since. Basically, the method is to enumerate all possible solutions to the problems, eliminates unnecessary elements, and then rules them out one by one.

Chapter 12, The War Machines of Archimedes

Chapter 12, The War Machines of Archimedes Summary and Analysis

When King Hiero ruled Syracuse, life had both peace and prosperity, but war raged elsewhere. Rome and Carthage fought one another at this time; Carthage was a great city on the Mediterranean coast of Africa, with widespread colonies. It ruled the west of the Mediterranean and the Carthaginians were taking over Sicily. Yet Rome was growing more powerful as well, capturing the Greek city-states in Italy. Romans and Carthaginians agreed to trade within their own boundaries, but the Strait of Messina between Sicily and Italy proved impossible to divine. Hiero knew that they would one day fight over Syracuse, because of its proximity to the Strait. While the city was allied with Rome, Rome seemed overextended. Hiero and Archimedes often talked about this worry.

When Archimedes was old, he resisted Hiero's request to make war machines; he thought science should make men grow not cause them to die. But Hiero continued to press him, telling him that he would be serving science. Archimedes agreed, designing many devices, which Hiero kept in good shape. Hiero thought the city would need them one day and he was right; in 215 B.C. he died and his grandson Hieronymus became King, but he did not have power long. Hippocrates, a Carthaginian traitor, killed him and took over the city. He then severed the alliance between Rome and allied with Carthage. Then the Romans declared war on Syracuse, sending the general Marcellus (one of their greatest) to conquer.

Marcellus had sixty large ships with six rows of oars each. The war machine was enormous and the people were scared. Hippocrates was scared as well. But his soldiers knew how to work Archimedes's machines but he didn't know how they worked. Archimedes must have hated him but because he loved Syracuse, he helped Hippocrates and placed the machines in the city. The great Roman historian Plutarch recounted the battle.

He said that the people were frightened until Archimedes's machines went into action, hurling stones and missile weapons at the Romans. Huge poles emerged from walls to the ships, sinking them when let down from high. Sometimes the ships were lifted high in the air and shaken until the mariners were thrown out. Marcellus had to withdraw.

Marcellus and his men thought that they could dig under the walls, but Archimedes had anticipated this idea, produces shorter weapons and machines that could accommodate distance. When the Roman soldiers came near the wall, they were hit with darts and stones came down on their heads. Some Roman soldiers thought they were fighting gods.

Marcellus was not hurt but was frustrated that he was losing. Any lose rope would scare his soldiers, as they feared a trap beyond their imagination. Marcellus also knew Archimedes was beyond the machines, as he was so famous. It is also said of the battle, but not in Plutarch's account, that they used large polished pieces of metal to reflect sunlight onto the ships and set them on fire. But it is not clear whether this is true. Apparently, Archimedes quite enjoyed using his machines. Marcellus gave up the siege, instead blockading the city on the land and the sea.

Chapter 13, The End of Archimedes

Chapter 13, The End of Archimedes Summary and Analysis

Marcellus laid siege to Syracuse for three years. He also took over large parts of Sicily and killed Hippocrates along with eight thousand of his soldiers. Marcellus planned for Syracuse, noticing in 212 B.C. a wall and tower poorly guarded and had his men build ladders to scale the walls.

The Syracusans were too confident in Archimedes's machines and lost focus during the Feast to Diana; Roman troops entered the city without their knowing it. The soldiers sounded trumpets, letting lose in the city, creating panic. Marcellus was sad that such a beautiful city would be destroyed, since plundering was the right of soldiers. He told his men, however, to leave the citizens of Syracuse free and ordered them not to hurt Archimedes, because he wanted to meet him.

Archimedes didn't notice the siege because he was working on a problem. A Roman soldier commanded him to follow him to Marcellus. He then asked the soldier to leave him because he was working, telling him that he would come when he finished working. Then the soldier stepped on the drawing. Archimedes was furious, bringing his drawing stick down on the soldier's foot. In his rage, the soldier killed Archimedes with his sword. Marcellus had the soldier killed and mourned Archimedes. He found Archimedes's friends and relatives and helped produce a tomb and ceremony in his honor. The sphere within the cylinder was placed on his tomb.

Chapter 14, No End to Archimedes

Chapter 14, No End to Archimedes Summary and Analysis

Some people have minds that can grasp the great workings of the universe. Archimedes's mind was of this type. He started mechanics, hydrostatics, the study of buoyancy, the principle of specific gravity, level and pulley laws and the secret to measuring circles. He produced a method for mathematicians and many think of him as the greatest mathematician that ever lived.

Characters

Archimedes

Archimedes was one of the greatest scientists and mathematicians of all time. He created numerous sciences, like mechanics and hydrostatics, made contributions to astronomy, geometry, trigonometry, numeration, and prefigured some of the key insights of calculus. He was responsible for figuring out how to apply simple machines to any number of different uses, most notably to irrigating fields with the Archimedean Screw and defending Syracuse against the Romans with his war machines, some of which used levers to flip ships and polished metal to set other ships on fire.

Archimedes was born in Syracuse, Sicily in 287 B.C. and was a Greek citizen. His father, Phidias, was an astronomer as he would be. Archimedes was raised with an elite education and once he finished formal schooling, he left for Alexandria to study on his own with colleagues at the Museum and the famous Library of Alexandria.

When he returned to Syracuse, he made many discoveries that laid the foundations for many important advances in mathematics and science.

Archimedes created the sciences of mechanics and hydrostatics. He discovered the laws of levers and pullers, buoyancy, specific gravity, and the notion of an element. He produced effective war machines and the Archimedean screw, a machine that measured eclipses and he created war machines. The only math he didn't write about or contribute to was algebra, even foreshadowing calculus by discovering the math of changing rates. His most important contribution, however, was helping to introduce rigorous, logical thinking into science.

King Hiero II

King Hiero II was the King of Syracuse for most of Archimedes's life. He was also Archimedes's relative. King Hiero was a fairly good king, as kings go. He rarely harassed citizens and often focused on promoted Archimedes's achievements. He would consult Archimedes on various problems as well.

Archimedes and Hiero would discuss deep problems together; they also often debated about whether abstract subjects like mathematics were more beautiful than more practical subjects like mechanics. Hiero helped Archimedes to have his famous "Eureka!" moment when he asked Archimedes to determine whether his gold crown was made of pure gold or whether his goldsmith had ripped him off. And he was greatly impressed by Archimedes when Archimedes made good on his claim to be able to move a galley with a series of levers and pulleys.

For the most part, Hiero and Archimedes got along well, but their relationship became somewhat strained when Hiero asked Archimedes to help him build war machines. At

the time, Rome and Carthage were fighting a war; they had divided their territories to the boundary, which happened to be the Strait of Messina, quite close to Syracuse. Hiero suspected that one day either Carthage or Rome would attack Syracuse so he attempted to convince Archimedes to build war machines. Eventually Archimedes relented and built the machines, which Hiero kept in working order until his death. Afterwards, the machines were used to protect Syracuse for some time.

Phidias

Archimedes's father and an astronomer himself.

Apollonius

One of Archimedes's fellow astronomers and mathematicians in Alexandria.

Conon of Samos

Archimedes's teacher in Alexandria.

Erastosthenes

Archimedes's fellow astronomer who became head of the library and measured the circumference and tilt of the earth along with the size and distance of the sun and moon.

Hieronymus

Hiero II's grandson who took the Syracusan throne after Hiero died. His reign was short-lived when he was killed by the Cathaginian spy Hippocrates, who then took the throne.

Hippocrates

The Carthaginian usurper who murdered King Hieronymus and took the throne. He was king when Marcellus attacked Syracuse. Marcellus eventually killed him.

Marcellus

The famed Roman general who could not beat Archimedes's machines and respected him enormously.

Plutarch

The famed Roman historian from which much of our knowledge of Archimedes derives.

The Roman Soldier

A soldier in Marcellus's army charged with bringing Archimedes to Marcellus unharmed, but when Archimedes angered him, he stabbed and killed Archimedes with his sword.

Objects/Places

Syracuse

The Sicilian city where Archimedes was born, spent most of his life, and died.

Sicily

The island off the coast of Italy where Syracuse is located.

Italy

The European nation - not a nation in Archimedes's time - where Rome was seated; it is to the north of Sicily.

Rome

The capital city-state of the early Roman Empire in Archimedes's time.

Carthage

The North African city-state that was fighting with Rome during Archimedes's time.

The Strait of Messina

The strait between Sicily and Italy whose control was disputed between Carthage and Rome.

Alexandria

The Egyptian city where Archimedes studied; at the time, it had one of the Seven Wonders of the World, the Library of Alexandria and it also had the Museum, where Archimedes studied.

Ptolemy's Museum

The academy where Archimedes studied.

The Library of Alexandria

The great library of antiquity where Archimedes studied as a young man.

Archimedes's Tub

The tub where Archimedes had his famous "Eureka!" insight.

Archimedean Screw

Archimedes's invention that helped to irrigate fields.

Simple Machines

Levers and incline planes that could be used to accomplish many tasks alone and more when combined.

The Ship-Moving Helix

The device Archimedes used to move a galley all by himself.

King Hiero's Crown

The crown Hiero believed was not pure gold. When he asked Archimedes to prove this, Archimedes had his "Eureka!" moment soon afterward.

Buoyancy and Specific Gravity

Two principles of mechanics and hydrostatics Archimedes discovered.

The Length of the Year

Archimedes helped to calculate the length of the year accurately.

The Area of a Circle

Archimedes figured out how to calculate the area of a circle with a much higher degree of precision than had been achieved before.

Infinite Numbers

Archimedes showed that there was an infinite amount of numbers.

Centers of Gravity

The place where objects balance when held, Archimedes discovered many of their properties.

The Sphere and the Cylinder

The relation between the sphere and the cylinder was the discovery Archimedes regarded as his greatest, so great in fact that he wanted the sphere and cylinder diagram inscribed on his tomb. He got his wish.

Archimedes's War Machines

At the behest of King Hiero, Archimedes built war machines that one day helped to stave off a Roman invasion.

Archimedes's Writings

Archimedes wrote many articles and books recording his insights. We have many of these books today.

Themes

The Glory of Discovery

Archimedes was always fascinated by technical problems, even from an early age. And his interests were ecumenical, ranging from mechanics to pure mathematics along with many subjects in between. The thing that motivated him was a deep interest in discovery and the glory that derives from it. The best example of the glory of discovery can be found in the story behind Archimedes's Eureka!' moment. Archimedes has been charged by King Hiero II to discover whether his gold crown is made of pure gold or whether his goldsmith cheated him. He noticed that it was somewhat lighter than it was supposed to be.

Archimedes is given a piece of gold similar in weight to the crown and he initially cannot figure out how to test for silver in the crown. He spends days mostly staring at the crown and the gold lump, foregoing bathing and eating. When his slaves force him into the bathtub and he displaces water, he thinks to see how much water the gold lump and the crown displace. This will reveal the density of the crown versus the gold lump, allowing Archimedes to deduce whether the goldsmith cheated the king. When he realizes this he yells, "Eureka!" and jumps out of the tub to run down the street screaming with joy.

Another example is the way Archimedes died. He was so busy working on a problem that he didn't notice that the entire city of Syracuse was in a panic and was busy being conquered by the Romans. When a Roman soldier came to escort him to see General Marcellus he refused to budge from working on a problem, arguing that the answer was much more important than meeting a general. This insistence led to his death. He even died in the pursuit of discovery.

The Excitement of Mathematics

Mathematics was perhaps Archimedes's first love. The book illustrates this explicitly when it discusses the argument between Hiero and Archimedes about which realm of ideas was more beautiful, the abstract ideas of mathematics or more practical ideas that everyone could grasp.

One of Archimedes's most important discoveries was figuring out how to precisely calculate the area of a circle. Before Archimedes calculating the area of a circle was painstaking and inaccurate. To figure out the area, one had to draw the largest possible square that a circle could contain and the smallest possible square that could contain the circle, measure the area of both squares and then one knew only that the area of the circle was somewhere between these two measurements.

But Archimedes used polygons to surround the circle in the same way, calculating the range as he added sides, generating better and better measurements until he stopped

after using ninety-six sided polygons. He discovered the pi had a value between 3.1408 and 3.1428, very close to the genuine measure of 3.14159.

Archimedes loved mathematics so that he wanted one of his favorite mathematical discoveries on his tomb. He discovered one day that if one placed a cylinder around a sphere whose diameter was the same as the diameter of the sphere and the cylinder was as high as the sphere that the volume of the cylinder was 1.5 times the volume of the sphere, allowing the volumes of spheres to be accurately calculated. He was so excited by this discovery that he wanted the image of a sphere embedded within a cylinder inscribed on his tomb. And indeed, this occurred.

The Creation of Sciences

Archimedes is responsible for the creation of many sciences, particularly mechanics and hydrostatics. His work in hydrostatics began with his experiment with King Hiero's crown, which King Hiero believed had not been made out of pure gold as he was promised by his goldsmith. Archimedes was charged with deducing whether the king had been ripped off.

He realized that he could deduce whether the crown and an equivalently weighted gold lump had the same composition by seeing how much water they displaced. When the crown displaced more water, Archimedes knew that it took up more space, which meant that to weigh the same it must have an additional, lighter metal in its make-up. This proved that Hiero had been ripped off. But it also led Archimedes to discover one of the most important principles of hydrostatics, the principle of buoyancy.

In mechanics, his accomplishments began with the creation of the Archimedean Screw, which is still in use today. It was a lever wrapped around a shaft that was itself embedded within a hollow cylinder. It could be cranked in order to draw water from the Nile into the fields of farmers. And the screw is still used to this day. He was interested in the use of all sorts of simple machines. His interest in levers led to his famous claim that with a long enough lever he could move the world. He also impressed the city of Syracuse when he moved an entire ship with a lever.

Style

Perspective

The perspective of Archimedes and the Door of Science is that of an author and teacher, Jeanne Bendick. She presents Archimedes in an exciting and reverent light. But this perspective seems to be not merely Bendick's own but her attempt to write a book about a scientist and mathematician in ancient times that interests children. Normally, books bore children, and books about science, mathematics or ancient history are enough to put most students to sleep. Combining them in a single book is a big risk. As a result, Bendick must struggle to make the book as engaging as possible.

Bendick also teaches throughout the book with diagrams, examples and suggested projects. There are diagrams of Archimedes's shapes and his additions to geometry. She lists examples of simple machines and asks the reader to generate some of her own and she suggests that teachers have students build a mobile to further understand the nature of centers of gravity.

Bendick is clearly a woman excited about scientific discovery. She praises ancient Greek society for its interest in abstract knowledge. While she acknowledges the importance of practical knowledge, she seems to agree with Archimedes that there is something beautiful and noble in the pursuit of knowledge for its own sake. She never condemns Archimedes either, presenting him almost as a scientific saint. Sometimes she paints Archimedes as idiosyncratic and aloof, but there is no condemnation of these traits to be found.

Tone

The tone of Archimedes and the Door of Science is one of deep excitement, not only over Archimedes's life, but also over his discoveries. Much of the book is written with reverent words, suggesting that Archimedes might be the greatest mathematician of all time, or the tone will reflect Bendick's description of the Greek people as lovers of knowledge and argument. Even the chapter headings are excitedly titled, sometimes using exclamation points like the title of Chapter 3, "Alexandria!" The book's tone is intended to inspire a student with wonder at Archimedes's problems, thought process, discoveries and inventions.

The tone stays chipper and bright, even during the author's description of the siege of Syracuse and Archimedes's death at the hands of an angry Roman soldier. The book is at its most exciting when it covers Archimedes's war machines and how they kept the great Roman general Marcellus at bay for three long years. And it covers Archimedes's noble death, refusing to leave to see Marcellus with a soldier until he had finished working on a problem, leading the soldier to kill him. While there is some sadness, the author's description connotes a feeling that Archimedes died doing what he loved.

Sometimes the tone begins to sound like a textbook, however, particularly when the author suggests projects that students can do in order to learn about Archimedes's ideas or when she discusses the details of one of his mathematical ideas.

Structure

Archimedes and the Door of Science is an educational book written for school teachers or home educators interested in teaching their children about science, history and mathematics. As such, it is short and written with big letters. It contains many pictures and diagrams illustrated in simple ways, as is appropriate for younger students.

The book contains fourteen short chapters with titles intended to garner interest such as "Alexandria!" and "The End of Archimedes." Each chapter contains some amount of story line, some more than others, most discuss some important problem that Archimedes worked on an his solution and many contain little projects that a student can do in order to better understand Archimedes's ideas.

In Chapter 1, Who Was Archimedes?, the author introduces Archimedes and explains his dates, birthplace, family and societal structure. She explains that he is one of the giants of science and mathematics. In Chapter 2, The World of Archimedes, the author describes Archimedes's historical setting more broadly, including facts about Greek culture and Archimedes's education. Chapter 3, Alexandria!, explains Archimedes self-guided education in Alexandria at the famous library and museum there. In this chapter we also learn about Archimedes's first great invention, the Archimedean Screw. Chapter 4, Archimedes and His Lever, covers Archimedes's use of simple machines, Chapter 5, Archimedes and Hiero's Crown recounts his Eureka story and Chapters 6 through 11 discuss various other discoveries he made. Chapter 12 discusses the war machines he designed, Chapter 13 his death and Chapter 14 his legacy.

Quotes

"But many of the things you know about science began with Archimedes." (3)

"They asked and answered and argued. The Greeks argued about everything." (13)

"The farmers of Egypt as still using the Archimedean screw to irrigate their fields, after more than two thousand years." (36)

"That's what experimenting is—proving ideas with things, instead of with words or diagrams." (40)

"Had I but another earth on which to stand, my friend, I could move this earth itself." (41)

"Eureka!" (58)

"Archimedes Principle: A body that is submerged partly or wholly in a fluid is buoyed up by a force equal to the weight of the fluid it displaces." (68)

"Archimedes lived long before the decimal system was invented, but his figure for pi would have been between 3.1408 and 3.1428, which was pretty accurate! Pi is sometimes called the 'Archimedean number'." (91)

"Of all Archimedes' discoveries, this was his favorite: if you took a sphere, and made a cylinder whose base was the greatest circle of the sphere, and whose height was the diameter of the sphere, the cylinder would take up 1.5 times the space as a sphere and its volume would be 1.5 times as much. ... He thought the discovery was so important that he wanted this figure placed on his tomb." (108)

"Science is to me something to make men grow, not to destroy them." (113)

"And doubtless the rest of the Syracusans were but the body of Archimedes's designs, one soul moving and governing all." (121)

"And above all, let no one dare lay hand on the person of Archimedes, or on his house or his belongings. I long to meet this man, to sit down and talk with him, and to pay honor to a mind that dwarfs the thinking of most men." (126)

"Some people say he was the greatest mathematician of all time." (131)

Topics for Discussion

What did Archimedes consider to be his greatest discovery?

Why didn't Archimedes want to help King Hiero build war machines?

Name three sciences that Archimedes invented and explain how he invented them.

What event produced the problem that caused Archimedes to exclaim "Eureka!"?

How did Archimedes show there are infinite numbers?

How did Archimedes show the area of a circle?

Discuss the influence of Archimedes's work on modern science and mathematics.