# Prime Elements
# of Ordinary Matter, Dark Matter & Dark Energy

## Beyond Standard Model & String Theory

Vladimir B. Ginzburg

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*Prime Elements of Ordinary Matter, Dark Matter & Dark Energy: Beyond Standard Model & String Theory*



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My special thanks go to the members of my family: to my beautiful granddaughter Alexandra, who learned about spirals at the age of two; to my daughter Ellen, with whom I brainstormed some ideas related to the vortex theory, including the role of Nothingness, and who edited my three previous books on this subject; to my son Gene, who provided a digital presentation of all illustrations for this book, and also designed the covers of all my books; to my brother Paul who patiently followed my research in this field and provided me with his valuable comments and corrections, and, finally, to my wife Tanya, whose moral support, advice, and assistance in editing this book were invaluable.

Vladimir B. Ginzburg.

Dr. Ginzburg has ventured to find the simple principles hiding behind the diversities of macrocosm (the Universe) and microcosm (the world of elementary particles). His idea of combining the two spiral trails, toryx and helyx, into one basic unit has everlastingly fascinated me like a simple but beautiful tapestry. I can feel how deeply he has respect for not only well-known scientists but less-known ones whose studies were no less wonderful than theirs. I firmly believe this book is one of the greatest achievements in all science.

Nobuyuki Kanai
Osaka, Japan.

Like Newton who once wrote: "I have seen further, it is by standing upon the shoulders of giants," Dr. V.B. Ginzburg admitted that the great scientists of all times had directly or indirectly influenced the development of his ideas. Thus, in the book *Prime Elements of Ordinary Matter, Dark Matter & Dark Energy*, he systematically traced out with amazing precision and lucidity the five phases of vortex theory from the ancient past to this postmodern age.

As you read the first twelve chapters, you will find yourself walking in the intellectual history for each page comes alive as it beautifully narrates the luminaries of science and mathematics in anecdotal rendering and not without sense of humor. You will also be continuously enlightened by his technical expertise. Such rare combination, dramatically replicate Einstein creative imagination when you interactively reflect his original contribution to the vortex theory called "Three-Dimensional Spiral String Theory (3D-SST)" in the last four chapters. It explains and solves most of mysteries, dilemmas and impasse of modern science and it outlines the Grand Unification of forces via a mathematical model which Einstein found elusive in his later years.

Without any hyperbolic exaggeration, his novel ideas are indeed worthy of a Nobel Prize for one of the totally unexpected outcomes of his 3D-SST is the equilibrium of polarization and unification which clearly define a common purpose for mankind at the core of the Universe.

PERIANDER A. ESPLANA
http://www.esplana.com.

*I found this to be a marvelous book. The historical anecdotes bring the science alive, and the science has enough detail for a person to try out all sorts of interesting ideas.*

Cynthia Kolb Whitney,
Editor, Galilean Electrodynamics.

***Prime Elements of Ordinary Matter, Dark Matter & Dark Energy*** serves as a singular textbook on the history of scientific and mathematical ideas—an excellent complement to Roger Penrose's highly acclaimed but more conventional *The Road to Reality*. In this book readers encounter many of the most brilliant minds and colorful personalities who have significantly contributed to the evolution of scientific knowledge, including those, such as Emmanuel Swedenborg and Walter Russell, who are rarely, if ever, mentioned in traditional books. The encounter with various scientific geniuses, often on a human level, makes this book highly engrossing.

In addition, this book also serves as a lucid exposition of the author's original mathematical formulation of the vortex theory and its applications based on his discovery of the toryx, and his formulation of the Three-Dimensional Spiral String Theory, which is his version of the grand unified field theory. At the heart of his elegant formulation there is his profound philosophical insight into the nature of reality, especially the inversive relation between nothingness and thingness, coupled with his thorough knowledge of physics and mathematics. Vladimir Ginzburg is a highly absorbing storyteller as well as a brilliantly original scientist. On every page the reader will experience the special glow found only when an author truly loves his subject. Throughout this book the author shares his deep love of science and invites readers to an exhilarating scientific exploration which excites him to no end. This is unquestionably one of the most enjoyable contemporary science books that also provides genuine substance.

Yasuhiko Genku Kimura,
Founder and Chairman, Vision in Action,
Author of *Think Kosmically Act Globally*
and *The Book of Balance.*

*Let me know all the intricacies of the Pythagorean Theorem, and I will tell you how the universe works.*

Author of this book.

# Contents

# PREFACE

Scientific theories do not last forever. Most of them are usually abandoned and replaced by more advanced theories. A few lucky older theories continued to survive for a while, but only as particular cases of more general theories, as was with Newtonian mechanics after Albert Einstein proposed his general theory of relativity. There is, however, one theory, known as the *vortex theory* that stubbornly refused to either go into oblivion or to become a particular case of a more advanced concept. Introduced at the dawn of science almost 2600 years ago, it had passed through five phases of accumulation of its strength by absorbing the discoveries made during the Greek civilization, the Copernicus Revolution, the age of electromagnetism, the atomic age, and the information age.

During the first four phases (see Chapters 1 through 12 of this book), the development of the vortex theory followed the same misfortunate pattern. Each time, this theory managed to bring attention of a new generation of brilliant scientists, who were enchanted by a deep physical meaning of its basic concept. But, although they employed the latest advances in science, none of them was able to produce a mathematical tool making the vortex theory practically usable. Consequently, the wonderful theory repeatedly faded away and stayed underground waiting for another chance to come back.

The 20$^{th}$ century was a wrong time for reintroducing the vortex theory. During that time physicists utilized the latest achievements of quantum mechanics and theory of relativity to develop their best jewels, standard model and string theory. In this environment the vortex theory had absolutely no chance for any success. But by the end of the 20$^{th}$ century, the conditions in physics had suddenly changed. Although the standard model still remained the best tool accurately predicting the results of numerous experiments, its predictions proved to be applicable only to a small fraction of matter contained in the universe. Out of the scope of the model were newly predicted dark matter and dark energy that occupy from 95 to 99% of the universe. The string theory turned out to be much less successful than the standard model, failing so far even to predict some basic physical phenomena.

It is possible to see what is holding back the development of contemporary theories of physics. These theories utilize superficial spacetime structures of prime elements having no analogy in nature. In the standard model, the prime elements are represented by mathematical points having neither space nor time. The string theory remedies the problem; it uses vibrating strings with spacetime attributes, but it goes too far by making the strings multi-dimensional. Consequently, both theories have difficulties of adopting their predictions to our three-dimensional world. Unlike the prime elements of contemporary physics, the prime elements of the vortex theory are in a form of three-dimensional spirals commonly found in nature. But, the vortex theory works properly only with very specific three-dimensional spirals.

In 1993 I discovered a unique spacetime spiral element, called the *toryx*. The toryx is a particular case of a multiple-level dynamic spiral with a poetic name *helicola* that describes the paths of all moving celestial bodies in our universe. The ability of the toryx to be turned inside out made it perfect for modeling the polarized prime elements of matter. At about the same time I discovered a close offspring of the toryx called the *helyx* that turned out to be ideal for modeling the polarized prime elements of the radiation particles. The space-time properties of the toryx and the helyx are governed by eight fundamental equations that can be viewed as their genetic codes. This discovery led me to the development of a new version of the vortex theory called *Three-Dimensional Spiral String Theory* (3D-SST).

Outlined in Chapters 13 through 16, 3D-SST absorbs many valuable aspects of current theories. Among them are the Heisenberg's uncertainty principle, the concept of maximum velocity in the universe, the relativistic character of mass, the concept of quarks, the idea of strong and superstrong (color) forces, the quantum energy states of atomic electrons, etc. At the same time, 3D-SST modifies and further extends these ideas by outlining the process of the polarization of Nothingness, the consequent formation of the prime elements of the universe, the unified character of subluminal and superluminal velocities, the unity between negative and positive infinities, the concept of cyclic absorption and release of energy by the elementary particles, the relativistic character of electric charge, the unified nature of strong, superstrong, gravitational, and electric forces, and the unified structure of the prime elements of the entire universe, including ordinary matter described by the conventional physics and also exotic dark matter and dark energy.

As any new theory, 3D-SST includes several ideas that some scientists may find controversial. To avoid any confusion, the author separated the parts of the theory that are based on prudent conventional assumptions from the parts that required some speculative propositions.

***Acknowledgements***

This book is primarily about the great scientists of all times. Directly or indirectly, they all affected the development of my ideas, and if some of these ideas have any merit, the credit must go to these studious servants of science. I am also grateful to several contemporary scientists for making their valuable and stimulating comments on my novel ideas. Among them are: Professor Carlo Rovelli (Department of Physics and Astronomy of the University of Pittsburgh), Professor Gregory M. Townsend (Department of Physics of the University of Akron), Professor Clifford Taubes (Department of Mathematics, Harvard University), who made encouraging comments on my idea of multiple-level Universe.

Several American physicists made valuable comments on my model simulating strong and electric forces between thin rings with evenly distributed electric charges. Among them are: Professor Rudolph Hwa (Department of Physics, University of Oregon), Dr. Blair M. Smith (Innovative Nuclear Space Power and Propulsion Institute, University of Florida), Professor Edward F. Redish (Department of Physics, University of Maryland), Professor David F. Measday (Department of Physics and Astronomy, University of British Columbia, Canada), Dr. Eric Carlson (Department of Physics, Wake Forest University), and Professor Warren Siegel (Department of Physics and Astronomy, Stony Brook University).

Thanks to the recommendations made by Dr. Akhlesh Lakhtakia (Department of Engineering and Mechanics, the

Pennsylvania State University), I was able to publish the first three papers describing my version of the vortex theory. My latest five papers on this subject were published with the assistance provided by Dr. Harold Fox (Editor of *The Journal of New Energy*), Yasuhiko Genku Kimura (Publisher and Editor-in-Chief of *VIA, The Journal of Integral Thinking for Visionary Action*). I appreciate very much my interesting discussions with Marvin Solit, Director of Foundations for New Directions, and his ideas about possible space orientations of toryces. I am very grateful to Dr. Cynthia Kolb Whitney (Editor of the Journal *Galilean Electrodynamics*) for reading the first edition of this book and giving me very valuable suggestions.

I am especially grateful to Mr. Nobuyuki Kanai from Osaka, Japan who followed my research on spirals for the last several years. He impressed me by his deep knowledge of history of science. After reading the manuscript of this book, he proposed to make many corrections that certainly improved the quality of the book. Let me finish the introduction to this book with the words of two great visionaries of the 20$^{th}$ century.

> *That the man calls matter, or substance, has no existence whatsoever. So-called matter is but waves of the motion of light, electrically divided into opposed pairs, then electrically conditioned and patterned into what we call various substances of matter. Briefly put, matter is the motion of light, and motion is not substance. It only appears to be. Take motion away and there would not be even the appearance of substance..*
>
> Walter Russell.

> *. . . we can not rest satisfied until the deeper unity between the gravitational and electric properties of the world is apparent . . .*
>
> Sir Arthur Eddington.

Their prophetic words resonate with the essential aspects of this book.

Vladimir B. Ginzburg

# CHAPTER 1

# A STORY OF THE PYTHAGOREAN THEOREM

We begin our story from a brief visit to the world of four ancient civilizations: Sumer, Babylon, Egypt, and Greece. The Sumerian, Babylonian and Egyptian civilizations were much older than the Greek civilization. Their people developed a practical geometry that was essential for their existence. But at the start of the 6$^{th}$ century BC, the center of the civilization was about to shift to Greece. This historic shift coincided with a revolutionary transformation of practical geometry into science. And as any revolution in the history of humanity, this dramatic event was associated with the name of one outstanding individual; this time the unusual man was Thales of Miletus.

## A CLEVER MERCHANT

Thales of Miletus was born in 625 BC in the city of Miletus located in the west coast what is nowadays Turkey. Miletus was a colony of Greece, or Hellas, as it was then called. Greek history goes back to around 2000 BC, when a group of illiterate, Indo-Europeans migrated from the northern Balkans into Eastern Mediterranean. During the next twelve centuries they established between six and seven hundred Greek city-states. The Greeks spoke inter-communicable dialects of one Indo-Germanic language. For writing, they used the Phoenician alphabet, adding vowels. They preferred to call themselves *Hellenes*.

Before the birth of Thales, the Greek independent city-states spread all over the islands and peninsulas of the Aegean Sea (Fig. 1.1). The Greeks also founded the independent city-states in their colonies located from the entry to the Black Sea along an extensive sea shoreline of Asia Minor, and in many of the off shore islands, including Cyprus, Crete and Samos. Several independent city-states were located in South Italy and Sicily, including Crotona, Tarentum, Elea, and Syracuse, but many of its most important city-states were situated in a relatively compact area around the Gulf of Corinth. Chief among them were Athens in Attica, and Sparta on the Peloponnesus.

Besides their common language, the Greeks were bonded by the legacy of the eighth-century BC Ionian poet Homer, the author of the *Iliad* and the *Odyssey*. For many generations of Greeks, these works manifested an ideal blend of manly prowess and religious beliefs. These ideals were vividly sculptured as the twelve gods and goddesses in the Pantheon built atop Mount Olympus in Macedonia. Remarkably, these sculptures resembled nothing else, but an ordinary Greek family elevated to a divine status. The spirit of these ideals stimulated creative works in architecture, art, and music, and also drew many people to participate in festivals and sport competitions. The famous Olympian Games had been founded in 776 BC at Elis on Peloponnesian peninsula.

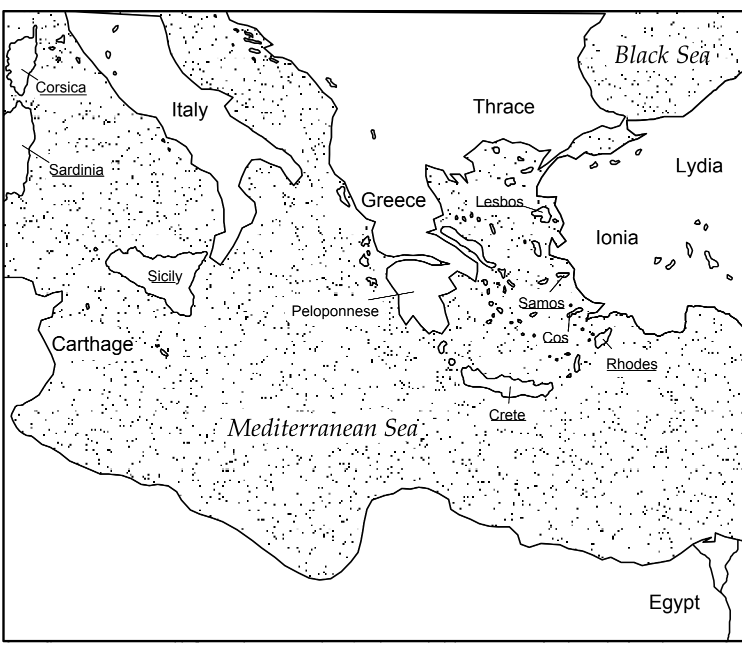


**Figure 1.1.** Map of the ancient Greece.

Contrary to the free spirit among inhabitants of the Greek city-state, their form of government during Thales time was tyranny, when the power of making laws was vested in a single man. Actually, it was a new form of government in Greece. In earlier centuries, Greece was more democratic. The councils, made of groups of landlords and oligarchs, ruled its city-states. With time, however, this system deteriorated and led to a discontent because of natural tendency of the aristocrats to run the government to their advantage at the expense of less powerful people. In many city-states, ambitious men used this discontent as a pretext to evict the oligarchs and grab the power. Interestingly, most of the tyrants were aristocrats themselves, but they expediently appealed to the commoners in their quest for power. Fortunately, not all the tyrants were repressive, and some of them ruled fairly and wisely. Nonetheless, it was still a dictatorship, resented by many upper class Greeks and some upcoming Greek philosophers.

There are no records indicating any effect of tyrannical rule on the Thales career. Initially, he became known as a successful merchant and also for his interest in magnets. He believed that "the magnet has a soul because it moves the iron." Many of his accomplishments came to us in the form of tales. In all these tales, a common theme was how he used the observations and reasoning to find a solution to a problem. One of the objects of his study was olive oil that was commonly used in Greece during his times. He wondered why the trees had not been producing olives for several years in a row. After studying the weather in the past, he discovered the weather pattern that was favorable to the ripening of the olives, and predicted a good crop in the upcoming season. Now he was ready to implement the results of his study. He bought up all the olive presses from the olive growers who were discouraged by many years of bad crops. When the big crop came the following year, Thales had made a fortune by being a sole owner of the oil presses.

Another famous tale, told by Aesop, shows how Thales followed the logic of a smart donkey. Thales used the donkeys to transport the salt from a salt mine that he owned. Instinctively, one of his donkeys learned that if he will stay longer in the water while crossing the river, then it would be much easier to carry his freight. Thales was certainly disappointed that a part of his payload had been dissolved. He asked himself a question "What would make donkey more tired after staying longer in the water?" So, the next time he replaced the salt in the saddle bags with sponges, and the donkey dropped his happy habit.

## THE CRADLES OF CIVILIZATION

Thales traveled extensively to Mesopotamia and Egypt, the two regions in which civilization had began to flourish many thousands of years before his trips there. Mesopotamia (Fig. 1.2) spread over a very vast region of Near East, and its early people were mostly migrating hunters-gatherers. This kind of occupation required them to have some knowledge of math, mostly counting. The earliest direct evidence of counting by the ancient people dates back as far as 35,000 years before our time.

Around 8000 BC, some dramatic changes took place in some areas of Mesopotamia known as the *Fertile Crescent*, including parts of modern Israel, Southern Turkey, and the Tigris-Euphrates Valley of Iraq. People who lived there learned how to make living by farming their lands. Now, without a need to migrate in pursuing the animals, they started living in the same place independent of the time of the year. The new living style, however, required different skills. They had to know how to divide the land, how to irrigate their fields, when to do planting and collect the crop, how to store the harvest and ration food. As their towns grew, they needed the government to provide them with common services, and, most importantly, to protect them against the marauders and foreign invaders. These developments forced both the people and their governments to learn how to perform their duties more efficiently. Counting alone would no longer suffice. They now needed the skills to do the four basic arithmetic functions: addition, subtraction, multiplication, and division.

Initially, the villagers used tokens, small baked clay objects, to keep track of their belongings. Some tokens with special shapes represented a specific number, while the others indicated a certain number of animals or jars of wine. Transferring the brittle clay tokens from one place to another was an enormous task that was eventually alleviated by the Sumerians who lived in the southern half of modern Iraq and included the cities of Ur, Larsa, Uruk, and

Eridu. The Sumerians simply impressed the shapes of the tokens on the surface of clay tablets that were convenient to transport. The numbers could now be expressed with written symbols. The written number system was born!

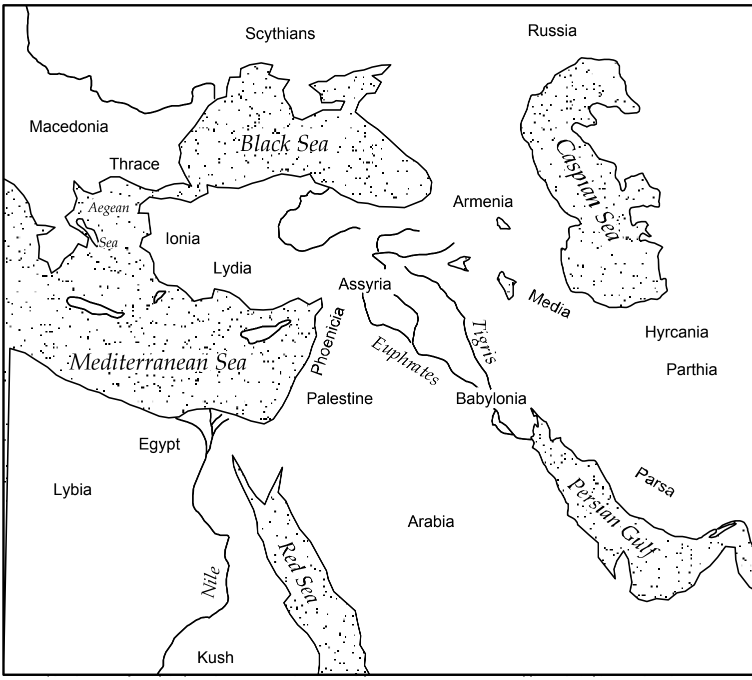


**Figure 1.2.** Map of Mesopotamia.

The Sumerians used a special number system that employed a combination of symbols for both 10 and 60. Their system allowed them to express both whole and fractional numbers. We use a similar system today, when we divide an hour into 60 minutes and a minute into 60 seconds. There are some indications that some sort of tally of the solar year began in Mesopotamia about 5740 BC. By 2000 BC, the Sumerians were using a calendar with a year divided into twelve months and thirty days in each month, with a total of 360 in one year. Their circle was also divided into 360 degrees, in the same way as we do it nowadays. Besides their great achievements in the development of math, the historians also credited Sumerians as the originators of writing in Western Asia.

Their civilization, however, had ended abruptly in 1763 BC, when king of Babylon Hammurabi defeated the Sumerian king Rem-Sin of Larsa. This year was a beginning of the 1200-year history of Babylonia. The Babylonians made a great head start by adopting both the writing and mathematics of the Sumerians. Later, they combined both together, making them capable of writing algebraic quadratic and cubic equations in the form: $ax^2 + bx + c = 0$ and $ax^3 + bx^2 + cx + d = 0$, where $a$, $b$, and $c$ are constants. They discovered the rule for finding the roots of quadratic equations, and also the roots of some cubic equations. The Babylonians also succeeded in geometry, and were familiar with several relations between the sides of the triangles, including the right triangle.

The great Egyptian civilization took its roots on the territory, expanded along the Nile River in Northern Africa. By about 4000 BC, people began establishing there permanent farming communities. Notably, this time coincided with the beginning of Copper Age. Initially, the settlements grew in the Upper and Lower Egypt as two independent kingdoms. A credit for their unification belongs to Menes, the king of Upper Egypt, who in 3100 BC united the two kingdoms and began the great line of pharaohs. Two hundreds years later his successors began building the pyramids. Khufu began construction of his Great Pyramid in 2560 BC. The mighty Egyptian empire had lasted for approximately 2600 years. It ended in 525 BC, when a son of Cyrus, the Great King of Persia, defeated the last Egyptian pharaoh.

Although there were many similarities between the way the upper class people were treated in Egypt and Mesopotamia, the lower castes were certainly treated differently in these two places. In Egypt, they were mostly the infantry and a vast labor force of slaves, but in Mesopotamia, the lower caste consisted of merchants, who conducted a flourishing trade as freemen well before 2000 BC. A notable example is of how differently they treated the Jews. The Egyptian rulers used the Jews as the slave laborers for the construction of their pyramids, and, as vividly described in the Bible, gave them a hard time before letting them go. Contrarily to that, the captured Jews enjoyed full rights in Babylonia. In 537 BC Cyrus allowed them to return back to their homeland. Along with all their belongings, they carried the gold and silver looted from the temple, which Cyrus returned to them, along with an imperial stipend for constructing a new house of worship that was destroyed during invasion of Israel by Babylon about fifty years earlier.

The Egyptians developed their math during the first half of the third millennium B.C. Because Egypt was almost contemporary to Sumer, the Sumerians certainly influenced the development of both writing and math in Egypt. Similarly to the Sumerians, the geometry served the Egyptians as a very practical tool. Annual flooding of the Nile River required continuous upgrading of the measurements of the plots owned by the farmers. The Egyptians paid great attention to the accuracy of these measurements, because of very strict laws that were setup to prevent encroaching into neighboring farmlands. They considered breaking these laws as the greatest sin punishable even in the afterlife. The Egyptians developed their own number system that was somewhat different than Sumerian's. They could solve problems of elementary algebra and compute areas of regular shapes, including triangles and trapezoids. In the process of proceeding with their huge construction projects, they further advanced math, enabling them to calculate the volumes of cylinders and pyramids.

## THALES IN BABYLON

By the time when Thales traveled abroad, both Egypt and Mesopotamia had passed the zenith of their creativity, but they still had sufficient amount of wealth to provide enjoyable life to their privileged class. A glamorous city of Babylon was the first destination of his journey. The main focus of this city was a temple with its divine overlord and official caste of calendar makers, surveyors, architects, and irrigation engineers. Babylon has prospered during cruel fighting between major powers of Near East that, besides Babylonia, included Assyria, Media and Lydia. In 615 BC, the Median king Cyaxares jointly with the Babylonians defeated Assyria and demolished completely its main city Nineveh. Thales was about ten at that time and, certainly, could not know that his name will be associated with destiny of this region thirty years later.

Cyaxares expansionistic campaign led him in 591 BC to Lydia, a rich and aggressive nation that controlled the land trade routes to Europe, the sea passage from Black Sea to the Aegean Sea, and the Greek city-states of the Ionian coast. On May 28, 585 BC, after almost six years of inconclusive and exhausting fighting, the two armies were standing one against another to start what was supposed to be a decisive battle. Nature, however, had something else in mind. In the middle of the day, the sky darkened. It was a solar eclipse, which had been predicted many years earlier by Thales, based on his studies of impressive records of the Babylonian stargazers. Unaware of the upcoming event, the soldiers took it as sign of the gods' displeasure, and both sides walked away from the battlefield. This event made Thales famous far beyond the boundaries of his native land.

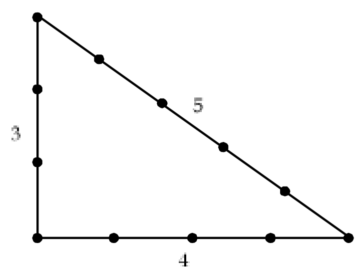


**Figure 1.3**. Making a right triangle with a string.

Besides his studies of astronomy, Thales also learned in Babylon the use of the circle and its divisions for measuring angles and directions. He was impressed by the simple methods of using a rope to make the perfect right angle (Fig. 1.3). Mark twelve equally distant spaces on the rope with the knots. Divide the rope into three sections: a section 3 with three spaces, a section 4 with four spaces and section 5 with five spaces. Connect two free ends of the rope together. Stretch out section 4 and attach its ends to a flat surface. Grab the knot between sections 3 and 5 and pull both these sections away from section 4 until the entire rope is completely stretched out. The rope now will be in a form of a triangle having a perfect right angle between sections 3 and 4. This type of triangle became known as a *right triangle*. Besides the above example of the right triangle with the sides related by the ratios 3:4:5, the Babylonians were familiar with fourteen more right triangles, including those with the sides related by the ratios 5:12:13, 8:15:17, and 7:24:25. Notably, the Babylonians discovered that the square of the longest side of the right triangle is equal to the sum of the squares of the two remaining sides as shown below:

$$3^2 + 4^2 = 5^2 \ (9 + 16 = 25),$$
$$5^2 + 12^2 = 13^2 \ (25 + 144 = 169),$$
$$8^2 + 15^2 = 17^2 \ (64 + 225 = 289),$$
$$7^2 + 24^2 = 25^2 \ (49 + 576 = 625), \text{ etc.}$$

Thus, the Babylonians came very close to the formulation of what became known to us as the *Pythagorean Theorem*.

## THALES IN EGYPT

A story goes that in Egypt Thales surprised and even frightened his guides by telling them the exact height of the Great Pyramid of Cheops. At the time of his visit, the pyramid was about 2000 years old, and the guides knew only the dimensions of the pyramid's square base that was 252 paces (1 pace = 3 feet) along each side. The height of the pyramid was certainly known to its builders, but by the present dynasty was well forgotten. Thales claimed that the height of the Great Pyramid was 160 paces. How did he know that?

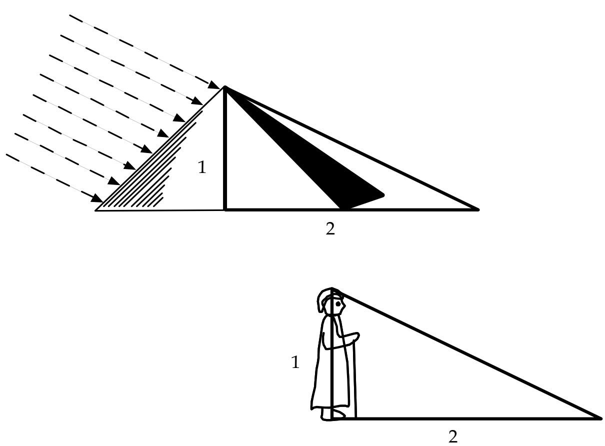


**Figure 1.4.** Sun's casting shadows in late afternoon.

Surprisingly, the Greek merchant learned how to measure the pyramid's height by studying the old Egyptian rules of proportion. Since the dawn of their civilizations, the Egyptians used proportion in astronomical observations, the works of art, and designing the buildings. They certainly applied this concept when building the pyramids in the desert at Giza. Thales made one step further. He saw proportion not only in an object itself, but also in a relation between the height of the object and its shadow. When looking during a sunny day at the shadow of the Great Pyramid and its own shadow, he noticed that the lengths of both these shadows changed in the same proportion during sunrise. But his inquisitive thoughts did not stop there. Where everyone saw only the objects and their shadows, Thales saw the abstract right triangles in which the short sides were formed by the heights of the objects and their shadows, while the long sides were formed by the sections of the sunrays, connecting the tops of the objects with the tops of their shades (Fig. 1.4).

Since, Thales thought, the sunrays glided over the tops of both the Great Pyramid and his head at the same angle, these right triangles are *similar* to their sides and must be proportionate to each other. Therefore, if he knows the relation between his height and his shadow, then he will be able to find the height of the Great Pyramid by measuring the length of its shadow. This is exactly what Thales did. To simplify his task, he probably made his measurements in late afternoon when his shadow was twice as long as his height, making a proportion 2:1. He then measured the length of the shadow of the Great Pyramid from the center of the pyramid. It turned out to be 320 paces. By applying the proportion 2:1, Thales discovered that the height of the Great Pyramid was 160 paces.

Eventually, the news about Thales' prediction reached the priests in the Egyptian Temple of Thoth, prompting them to make a more thorough search for the old records related to the time of construction of the Great Pyramid. The records that the priests had eventually discovered verified that 160 paces was indeed a correct height. Together with his prediction of the eclipse, the prediction of the height of the Great Pyramid made Thales extremely famous. But most importantly, it demonstrated that a *prediction was possible*, a revolutionary concept during his time.

## THE FIRST STEPS OF SCIENCE

After returning back to Miletus, Thales summarized the results of his studies and observations made in Babylon and Egypt. In Miletus, he established the first Greek center for learning, the Ionian School, and shared his knowledge with everyone who wanted to learn. His followers and many other Greeks held him in great esteem and considered him one of the seven wise men of Greece. He became first man known in the history of science to make specific mathematical discoveries, but his most important contribution was a new method of thinking.

Both the Babylonians and the Egyptians used mathematics to solve the everyday problems, such as calculating the dates and measuring the areas of their farm plots. For them, for instance, a line and a rectangle were the real patterns drawn on the sand. But nobody could draw these patterns very accurately. So, to solve this problem, Thales made a revolutionary step by moving away from the concrete objects in the physical world to accepting ideal mental objects. He, however, did not stop there. After abstracting the objects of mathematics, he used logic to deduce his conclusions. The end result of his efforts was a remarkable concept of theorems and proofs that gave to the world the first *theoretical geometry*. Fortunately for the humanity, his ideas fell into a fertile soil and were further developed by several gifted Greek philosophers, and the first in line was Pythagoras of Samos.

## "DIVINE" PYTHAGORAS

In ancient Greece, there was probably no other philosopher whose name was associated with so much praise and controversy. An outstanding contributor to the development of science, who applied strict logic to prove his point of view, he was, at the same time, a very superstitious man. The main causes of his misfortunes were the outside forces beyond his control, but his own misjudgments and cruelty certainly contributed to his tragic death and widespread prosecutions of his followers. Pythagoras was born in 560 BC in the Greek island of Samos, separated by a narrow strait from city of Miletus, the home of Thales. His father was Greek, but his mother was probably Phoenician. Pythagoras was born when Thales was still alive. Their lives overlapped for about ten years, and he probably became one of Thales' young students. Incidentally, Pythagoras lived during the same period as two other great thinkers: Confucius in China and Buddha in India.

As a young man Pythagoras settled in Babylon, where for 20 years he studied and taught astronomy, mathematics and astrology. Impressed by an extraordinary life and the teachings of Thales, he also traveled extensively in Egypt, and, by some accounts, went as far as to India. This explains the origin of his mystical ideas, including number magic and reincarnation that were typical of the East. Eventually, his travel routes expanded to all the known parts of the Mediterranean world. After seeing the approaching ships gradually appearing over the horizon, he concluded that the surface of the water was not flat, so the earth must be round. His logic forced him to pose a question: "What is the shape of other celestial bodies?" Both the moon and the sun appeared as circular discs, but Pythagoras now easily envisioned them also round as the Earth. So must be all heavenly bodies. The answer appealed to him even more, because he considered the sphere as a perfect geometrical form. Historians rightfully credited Pythagoras as the first person to promote this idea.

Pythagoras, who followed the footsteps of Thales so zealously, had certainly expected to be treated at least in the same way upon his return to Samos. It did not happen. It seemed like nobody was eager to learn about his ideas. Although greatly disappointed, he responded to this cool reception with a clever solution. He found a poor young man and offered him a deal. The young man will receive three oboli for every lesson in math that he fully understood. It was certainly an attractive proposition to a person who could now sit in a shade and make more money than in whole day's work in the hot sun. The deal worked, and the boy eventually became so much interested in math that he eventually began paying money back to Pythagoras to continue his lessons when his teacher was about to go broke.

In spite of his initial success, Pythagoras did not become a great teacher in his native island. Unlike Thales, whose life was not noticeably affected by the politics of his city-state, Pythagoras could hardly stand the harsh policies of the local tyrant Polycrates. To make things worse, the neighboring Persian Empire demanded heavy tribute. This was certainly not the most favorable atmosphere for an ambitious young man who saw his future in discovery of secrets of nature. In about 530 BC, Pythagoras left Samos. His destination was Croton, a little island at the tip of southern Italy that was a part of the Greek colony.

## The Pythagorean Secret Society

In Croton, Pythagoras founded a religious and philosophical Secret Society devoted to exploring the mysteries of number. The society immediately began to make a great impact on political views, circulated in the Greek cities of southern Italy. It was a religious order with initiations and rites and purifications that were common in other mystery cults of that time. It was not a "brotherhood" (as it has often been called), but a community of families. Both men and women could become the members of the society, and they shared all their simple belongings. The community was ultra-conservative and authoritarian. Some historians consider it as the model for the ideal society, described at length by Plato in the *Republic*.

Pythagoras accepted the Indian idea of reincarnation that the souls of both people and animals passed into other bodies after death. He considered himself the reincarnated soul of Euphorbus, a Trojan hero. Because of these beliefs, Pythagoras himself and the members of his Secret Society were strict vegetarians and wore no garments made of wool. Beans were also on a black list, as they form gases in the digestive track and look like genitalia. In his school, Pythagoras combined religious rituals with mathematical instructions. The approximately three hundred of his students were sworn by great oath to keep in secrecy all the discoveries made by their master. There was a cult of personality of Pythagoras, and an argument between the members was frequently resolved by referring to him: "He himself said it."

Although similar to many other secret societies of that time, there was one principal trait that made the Pythagorean society different. Pythagoras taught that a person can find its greatest purification in knowledge, and the knowledge meant mathematics. Following his hierarchical principles, Pythagoras divided his disciples into two groups, the *άκουσματικοί*, or *listeners*, and the *μαθηματικοί*, or those who had attained an advanced degree of