PROLOGUE

A TALE THAT BEGINS ON THE MOON

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* DRAMA CLUB! WANTED: CLUB MEMBERS!

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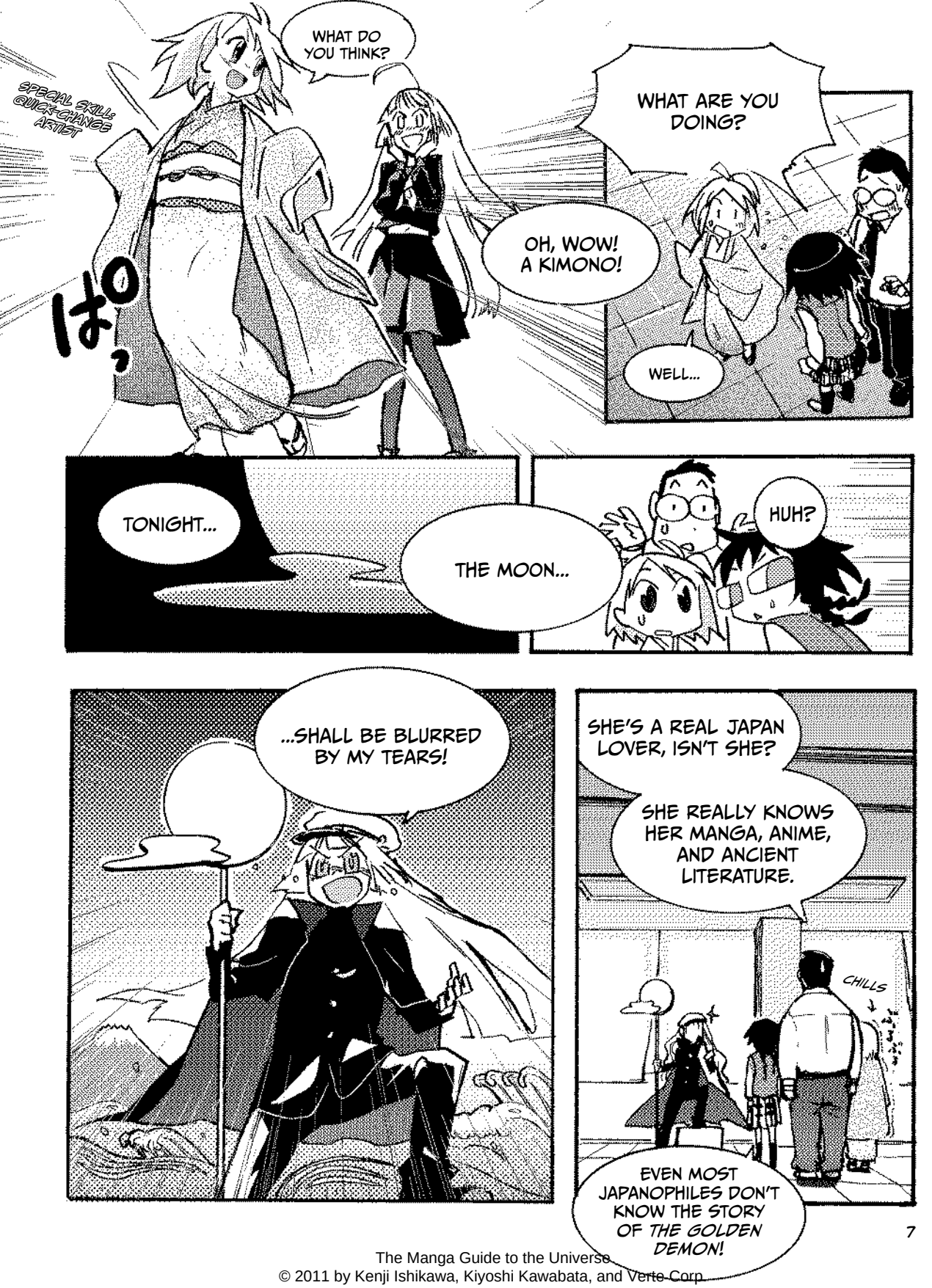

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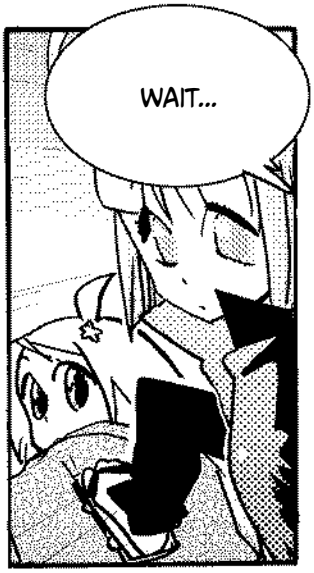

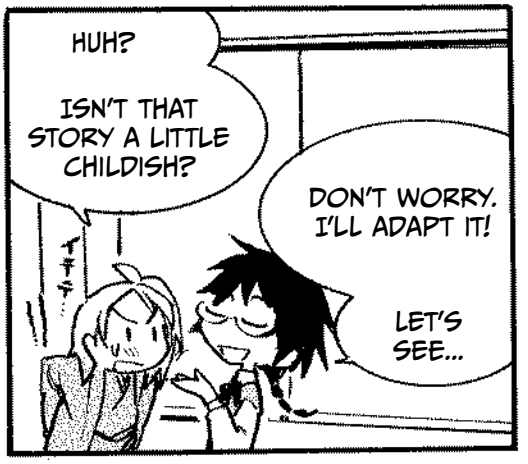

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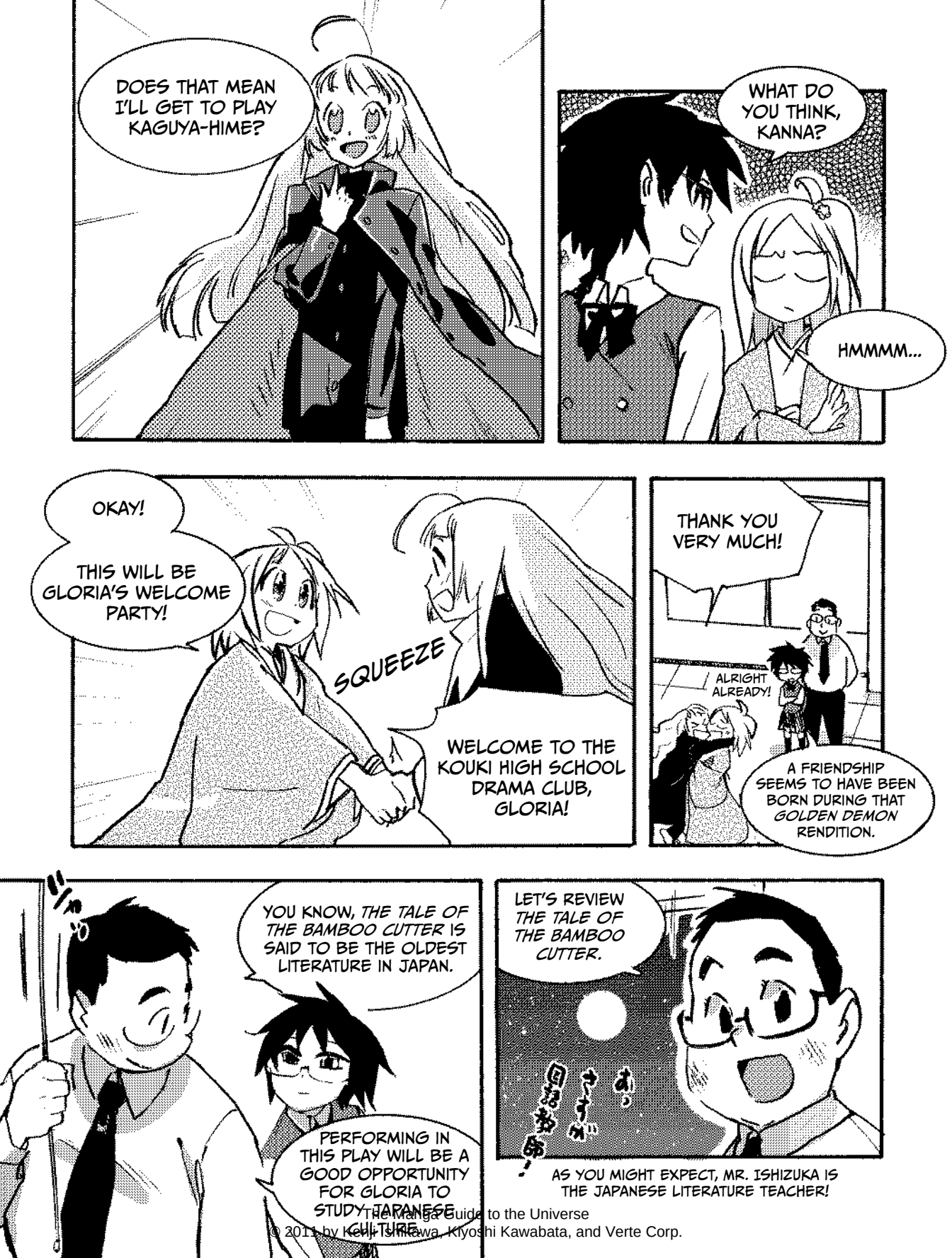

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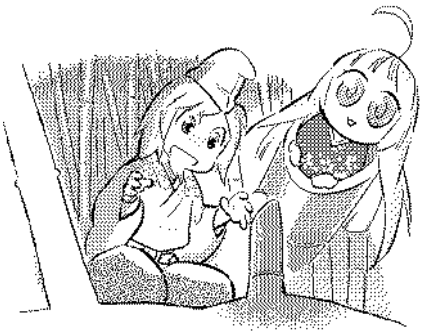
THE STORY OF KAGUYA-HIME

Long, long ago, an elderly bamboo cutter was walking through a grove when he came upon a mysterious glowing stalk of bamboo. When he cut it open, he found a tiny girl inside—so tiny that she fit in the palm of his hand. Thinking that the gods had taken pity on him and his wife, an old childless couple, he decided to bring her home so that he and his wife could raise her as their own child.

From that day forward, whenever the old man cut down a stalk of bamboo, he found a piece of gold inside. Little by little, he became very wealthy. The girl grew up quickly, and in just three months she grew into a kind and loving daughter.



HOW'D SHE GROW UP SO FAST?

IT'S A FAIRY TALE, DUH...

The girl, who was named Kaguya-hime, was so exceptionally beautiful that word of her beauty reached even the faraway capital. Many suitors called on her, but she wasn't interested in any of them.

However, five of these men were unable to ignore her beauty, and they asked for her hand in marriage.

As the condition for accepting a marriage proposal, Kaguya-hime asked each of her suitors to bring back a rare treasure that was impossible to find. Naturally, no one succeeded.

WHAT WERE THE TREASURES?

OH, THINGS LIKE A SHINING MULTICOLORED JEWEL FROM A DRAGON'S NECK, YOU KNOW...

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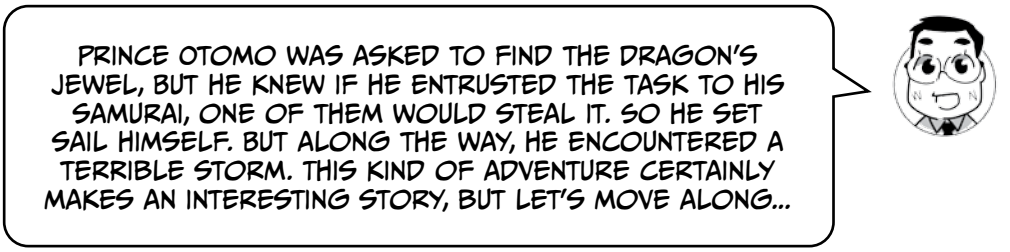
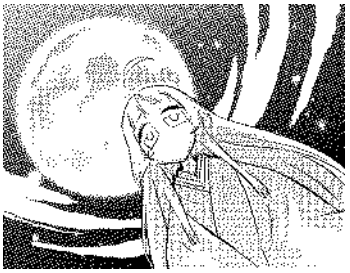
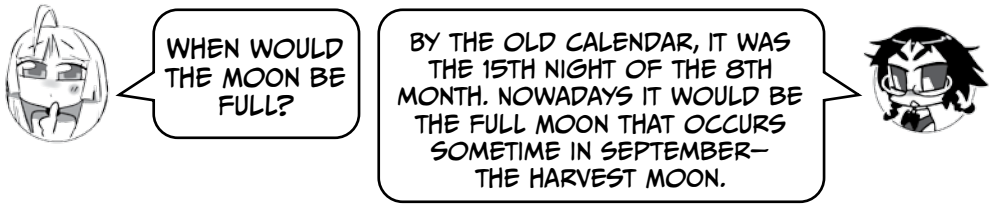


Kaguya-hime also caught the eye of the emperor—but he too was rejected. As the years passed, Kaguya-hime became more and more pensive whenever she gazed at the Moon, and as the autumnal full Moon approached, she would often burst into tears. The old bamboo cutter was very worried. When he asked her what was wrong, she replied, "I am not from this world! I come from the capital of the Moon, and I must return there when the Moon is full."



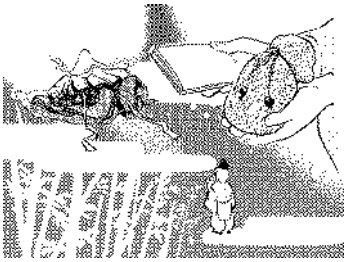


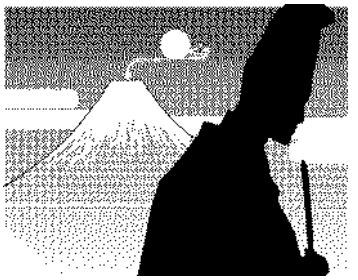
Hearing of this, the emperor tried to capture Kaguya-hime for himself before she could return to the Moon. He surrounded her house with soldiers, but then soldiers from the Moon came down and defeated them.

Before leaving for the Moon, Kaguya-hime gave the old bamboo cutter a letter and an elixir of immortality to give to the Emperor. Then the Moon's emissaries put the celestial maiden's feathered robe on her shoulders, and all of her memories of Earth disappeared. She returned to the Moon, pulled upward by an invisible force.

The Emperor read her letter but decided that he didn't want to live forever if he couldn't see her again. So he ordered his men to burn the elixir on top of the highest mountain in the country—the one that was closest to the Moon.

From then on, the mountain where the elixir was burned became known as Mt. Fuji, from the Japanese word for *immortality* (*fushi*).





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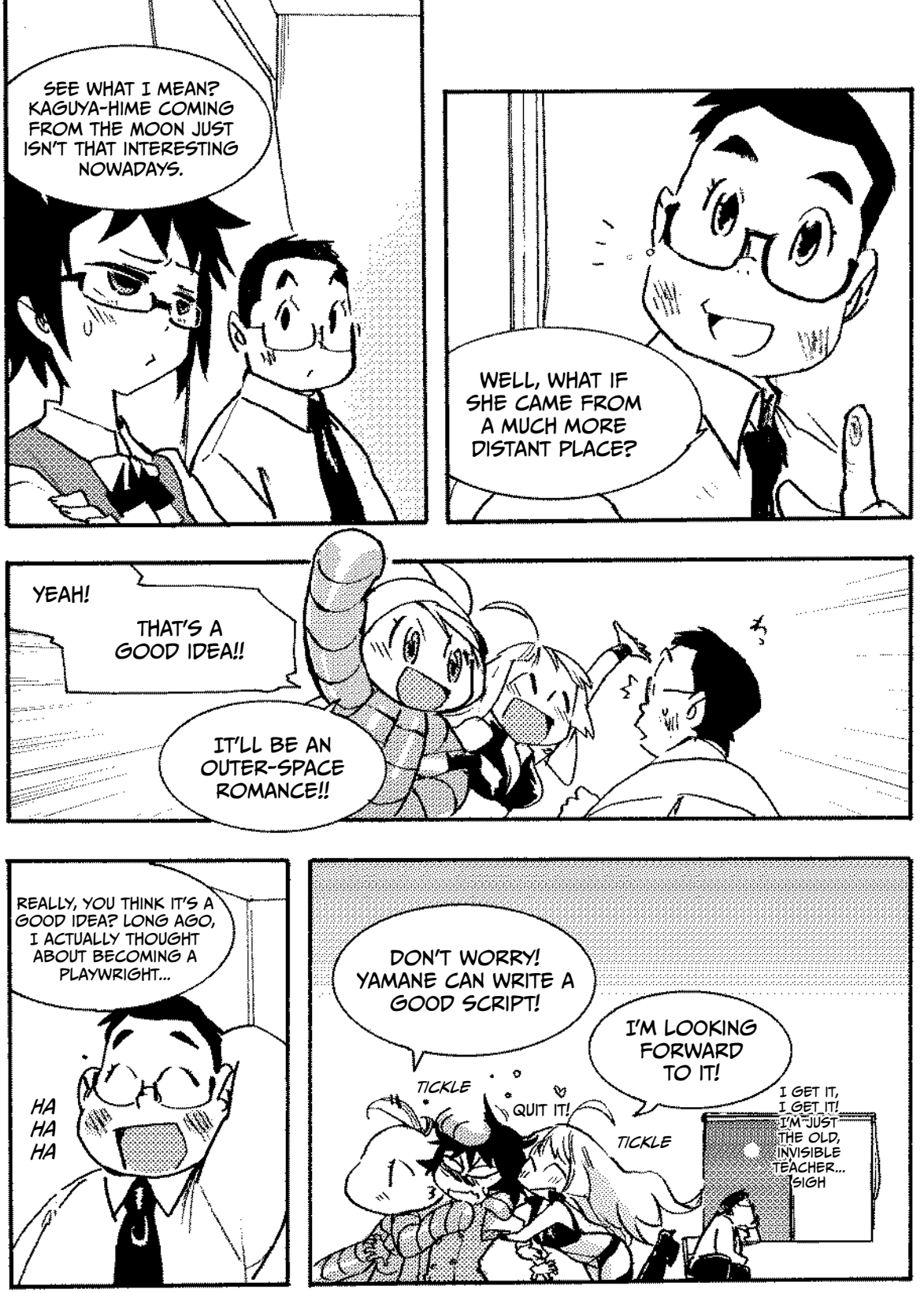

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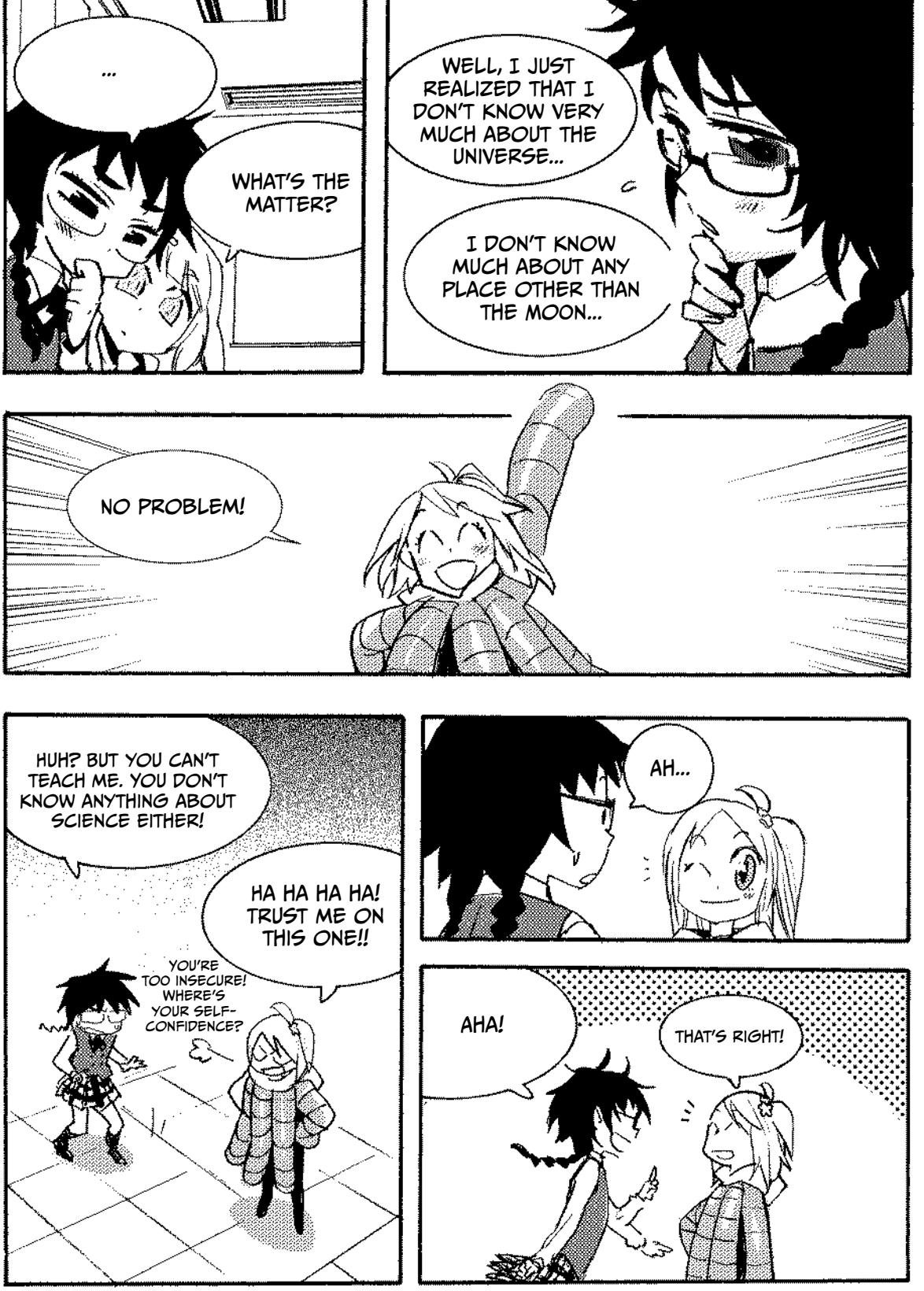

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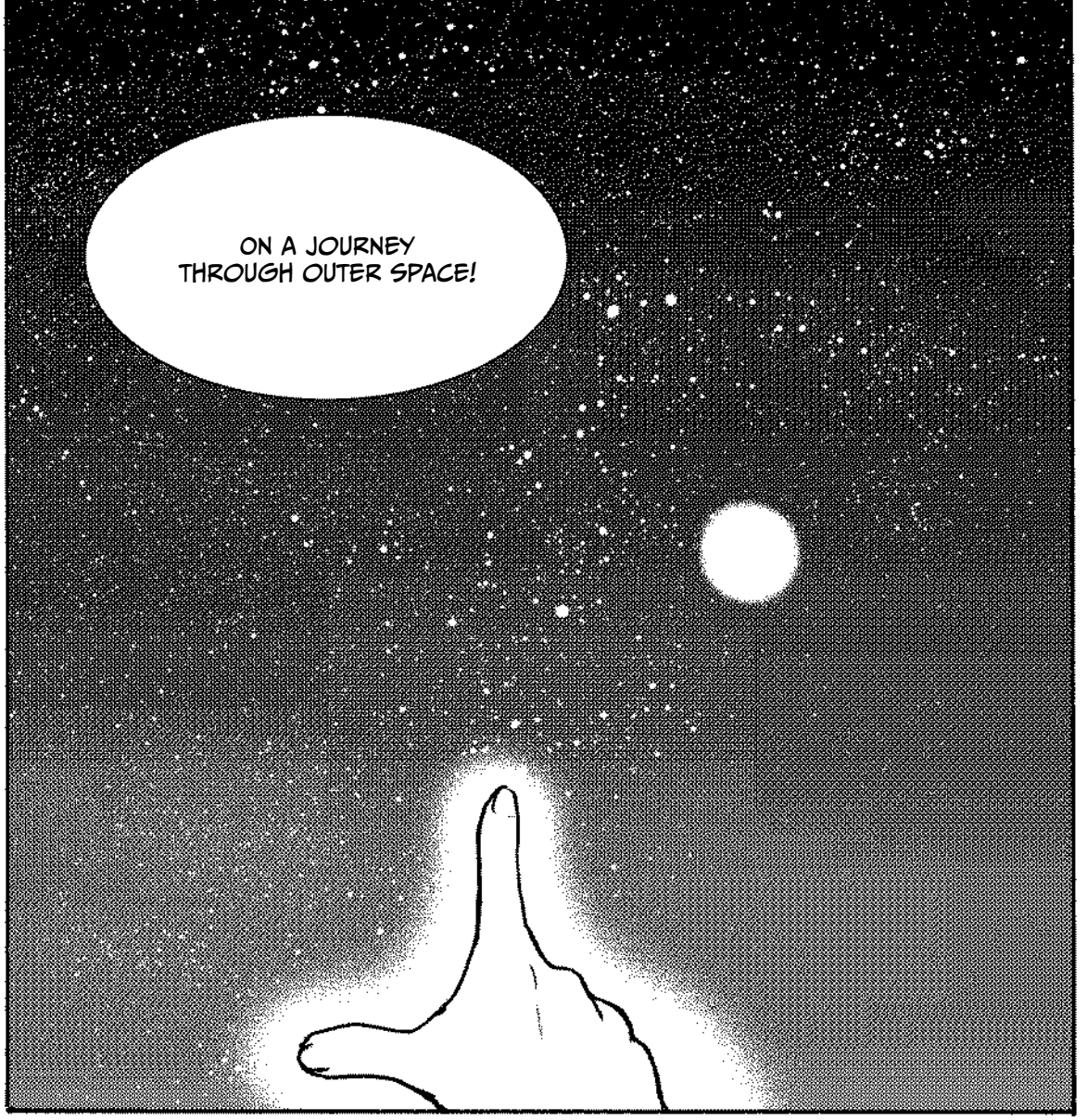

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How did ancient Japanese people know that the Moon was a celestial body like Earth?

The Tale of the Bamboo Cutter is an ancient Japanese fairy tale known to almost everyone in Japan. *The Tale of Genji*, written approximately 1,000 years ago, mentioned that the first fairy tale ever told was about an old bamboo cutter. However, it is rather surprising that the ancient Japanese believed that there was a city on the Moon where people lived.

For a long time, mankind believed that the universe was a small amount of space that wrapped around the world in which they lived. Maps from ancient times showed celestial bodies such as the Sun, Moon, and stars as tiny entities affixed to the surface of a shell that surrounded Earth. But in a universe like that, Kaguya-hime's story doesn't make sense. The people who created her story had a different view of the universe, in which the Moon was another world where people lived. Let's look at some other views of the universe from ancient times.

ANCIENT INDIA'S VIEW OF THE UNIVERSE

In ancient India, people believed in a turtle that rode on top of an enormous coiled snake and that elephants stood on the turtle's back to support a hemispherical Earth. The Sun was thought to appear and disappear as it revolved around the highest mountain, which stood at the center of the world. (This is Mt. Sumeru, which likely represented the Himalayas.) The Moon, which was the lamp belonging to the night watchman on this mountain, was thought to wax and wane depending on the direction the watchman was facing.

Ancient India's view of the universe

ANCIENT EGYPT'S VIEW OF THE UNIVERSE

In ancient Egypt, people believed that Nut, goddess of the sky, was supported by Shu, god of the air. Nut was said to be a symbol of the Nile River, and daytime and nighttime occurred when the Sun god Ra went back and forth across the river by boat every day. The Moon and stars were though to be suspended from Nut's body.

Ancient Egypt's view of the universe

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ANCIENT BABYLONIA'S VIEW OF THE UNIVERSE

The Babylonians thought that the Moon and stars were affixed to an enormous arched ceiling called the *celestial sphere*. The celestial sphere was supported by Mt. Ararat, and the Sun moved from east to west across its inner surface.

Ancient Babylonia's view of the universe

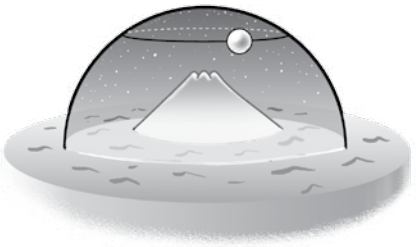
IN CHINA, WHERE ASTRONOMY WAS ORIGINALLY DEVELOPED

In contrast to these imaginary universes, people in ancient China and Greece tried to develop models of the universe scientifically. It was in China that astronomy was first developed.

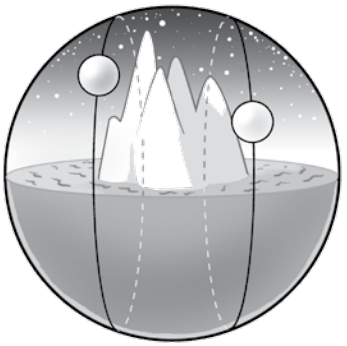
In China, several cosmologies were conceived approximately 2,000 to 2,400 years ago, based on observations of the heavens. Two such cosmologies were called Gai Tian and Hun Tian.

Gai Tian described a dome-shaped sky, like a cap, over a hemispherical Earth. This was surrounded by water (the ocean) and rotated once a day from east to west around the north pole. The Sun also traced a circle in the sky, and the size of that circle varied with the seasons.

Hun Tian, whose name means *the entire sky*, expanded upon the concept of Gai Tian to try to more accurately represent the movements of the celestial bodies. The celestial sphere enveloped everything like an eggshell rather than just capping it like a dome, and the variation in the constellations according to the seasons was explained by the notion that the north pole shifted, rather than always remaining directly overhead.



Gai Tian:
A cosmology positing a hemispherical dome over Earth



Hun Tian:
A spherical cosmology

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IN ANCIENT GREECE, WHERE THE SIZE OF EARTH WAS CALCULATED

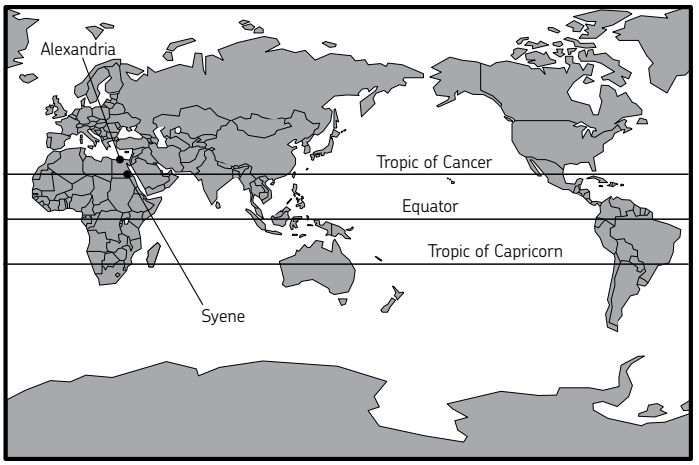
The ancient Greeks tried to explain the shape of the universe by using the logical thinking that permeates modern mathematics and physics. One of their greatest achievements was the discovery that Earth is a spherical body floating in space. The ancient Greeks were also the first to calculate the size of Earth.

Eratosthenes (who lived from about 276 BC to 195 BC) was a Greek scholar who was active in Egypt during the Hellenistic period. He calculated the size of Earth using the following method.

ERATOSTHENES' CALCULATION METHOD

Eratosthenes discovered an account that said that a rod standing vertically at midday on the summer solstice in Syene (in the southern part of Egypt) did not cast a shadow. It seemed that this phenomenon could only occur south of the Tropic of Cancer, when the Sun appeared at the zenith (directly overhead).

The astonished scholar wondered what would happen in Alexandria, in the northern part of Egypt, and he immediately performed the experiment under the same conditions. The result was that the shadow of the rod remained visible. Eratosthenes concluded from this evidence that Earth is a sphere, a theory that was being discussed among some scholars at the time.



The Tropics and the Equator

Eratosthenes also used his observations to try to measure the size of Earth. First, he measured the length of the rod's shadow. He calculated that in Alexandria at the same time on the same day, the Sun's rays arrived from a direction that was offset from the vertical by 7.2 degrees.

Next, he had a man walk from Alexandria to Syene and determined from the man's stride that the distance was 5,000 stadia (an ancient unit of measurement), or

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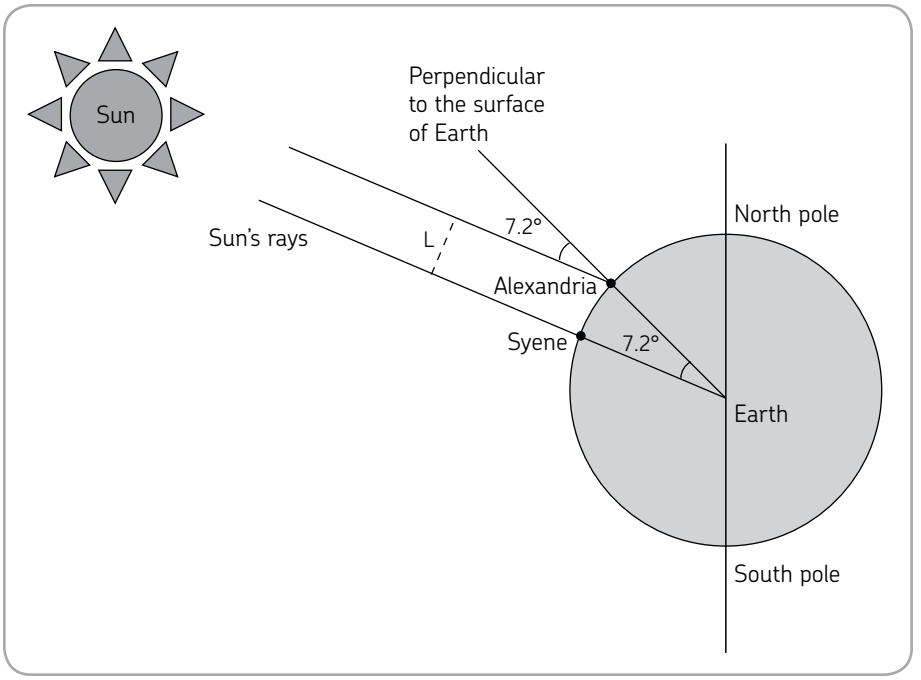
approximately 925 km (575 miles). Then he used the following formula to determine the circumference of Earth.

$$575 \text{ miles } (925 \text{ km}) \times \frac{360°}{7.2°} = 28{,}750 \text{ miles } (46{,}250 \text{ km})$$

Although we now know that the circumference of Earth is 40,000 km (24,855 miles), Eratosthenes' calculation is remarkably close.



Eratosthenes' calculation method

Another version of the story says that Eratosthenes got his idea by seeing the Sun's rays reach the bottom of a well rather than observing the shadow cast by a rod. Nevertheless, it is generally accepted that he calculated Earth's circumference as being approximately 25,000 miles, which is roughly accurate.

IF EARTH IS ROUND, THE MOON MUST BE ROUND TOO

It is quite reasonable to suppose that scholars like Eratosthenes were not the only ones to realize that Earth was round. Certain phenomena—such as the fact that you cannot see beyond the horizon, or that the top of the sail always appears first when a ship is approaching—were obvious to people whose lives were closely related to the sea, and these occurrences are inconceivable on a flat surface.

Ancient Greece, where Eratosthenes lived, was a maritime nation bordered by the Ionian and Aegean Seas and located not far from the Mediterranean Sea. For that reason alone, many seafaring Greeks may have sensed that the world might be round.

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On the other hand, when people with good eyesight observe light striking the Moon they should easily see that its surface is spherical rather than flat. For example, if you look at an enlarged photograph, there are clearly gradations at the outer edge and the waxing or waning border line. This wouldn't happen if the Moon were flat.

Now, let's return to the story of Kaguya-hime.

Japan is an island country, surrounded by the sea. This means that even in ancient times, some Japanese people probably recognized the existence of the curved horizon and from that concluded that Earth was round.

The round Earth

For example, when European missionaries traveled to Japan in the 16th century, they tried to introduce their scientific knowledge to the feudal lords they found there. One item they presented as a display of their knowledge was a globe. However, contrary to the expectations of the Europeans, most Japanese people did not show surprise at the suggestion that the world was a sphere.

The Moon has been appreciated by the Japanese since ancient times.

The fact that Japanese people have gazed at and felt affection for the Moon since ancient times is also apparent from folklore, such as the story of the Moon Rabbit. And although Otsukimi (moon-viewing) festivals seem to have originated in China, the custom of appreciating the Moon is said to have existed in Japan since the *Jōmon* period (approximately 14,000 BC to 400 BC). Most likely, it would have been recognized then that the Moon was a sphere.

If Earth—like the Moon—is round and floats in space, then the idea that people should live on both Earth and the Moon is a natural conclusion. Therefore, it's not surprising that this idea appears in the tale of Kaguya-hime.

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IS EARTH THE CENTER OF THE UNIVERSE?

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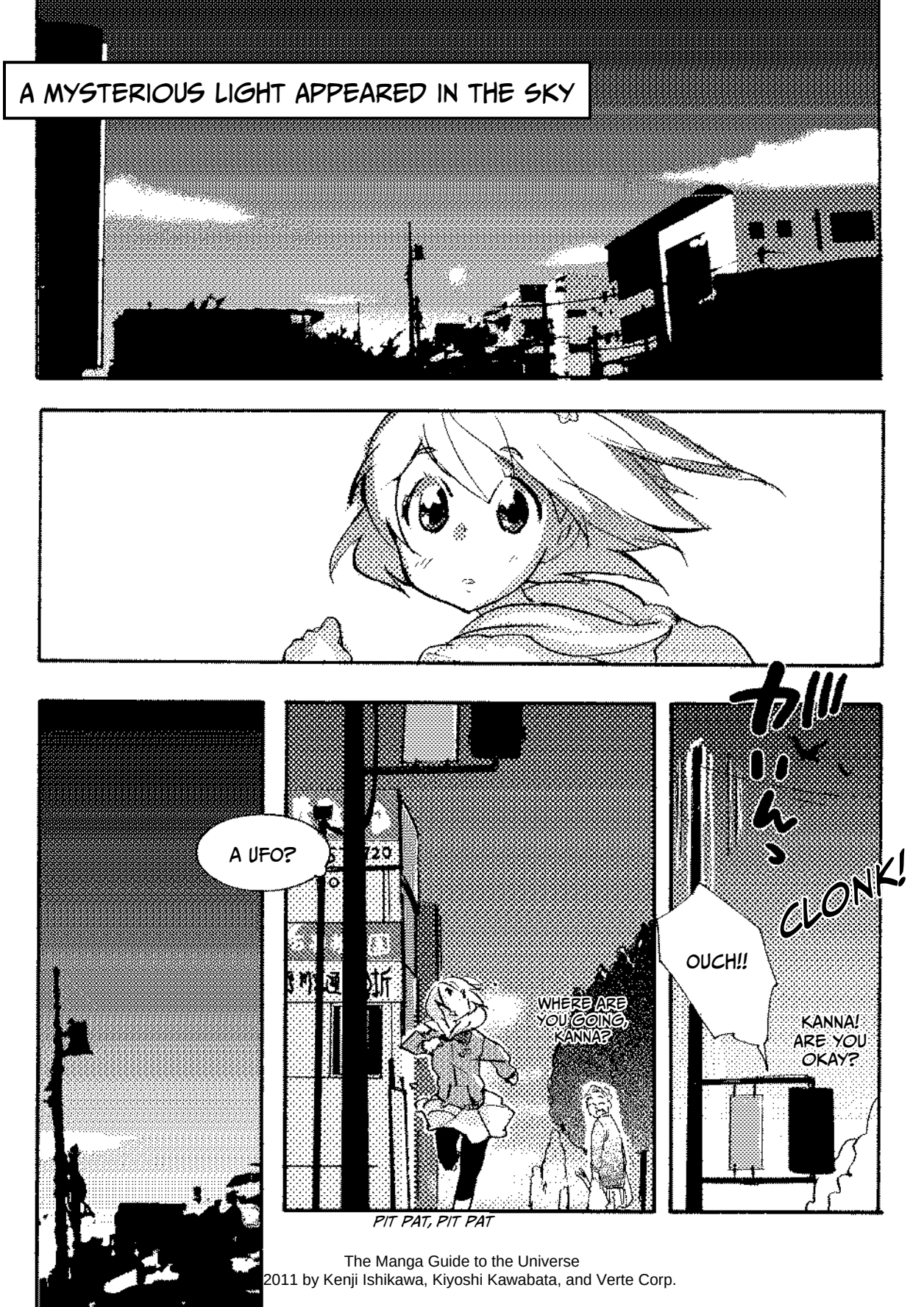

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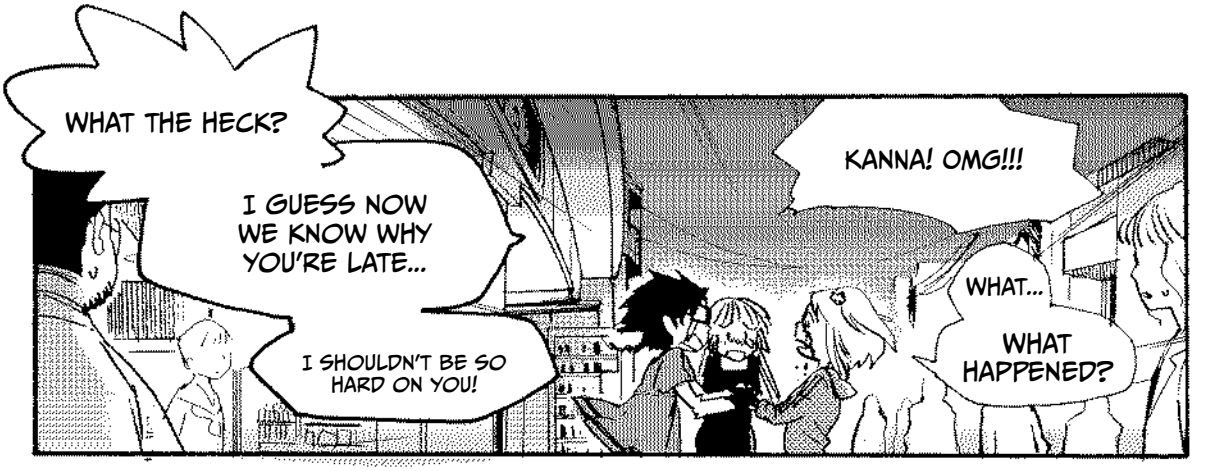
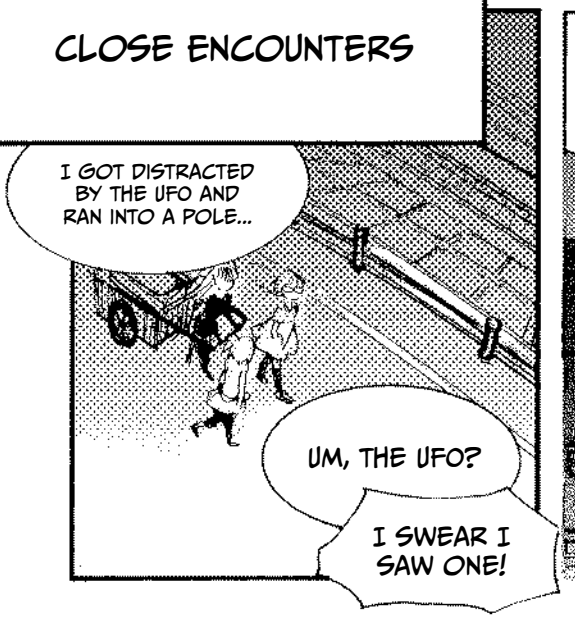
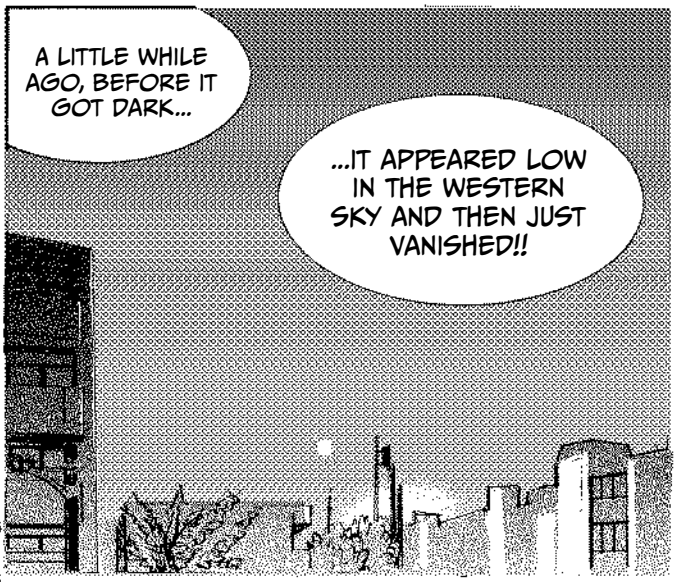
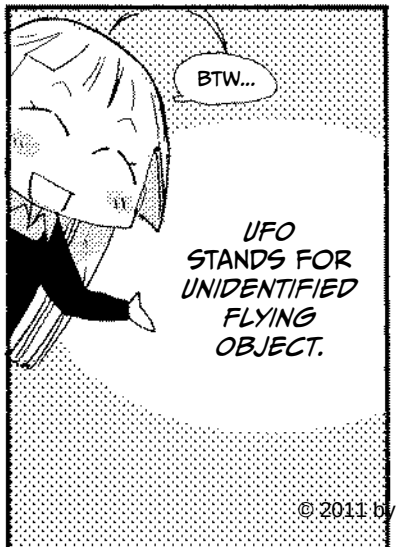
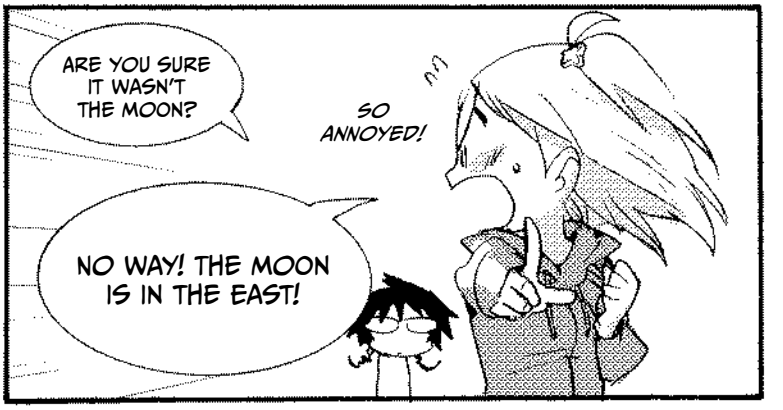


CLOSE ENCOUNTERS









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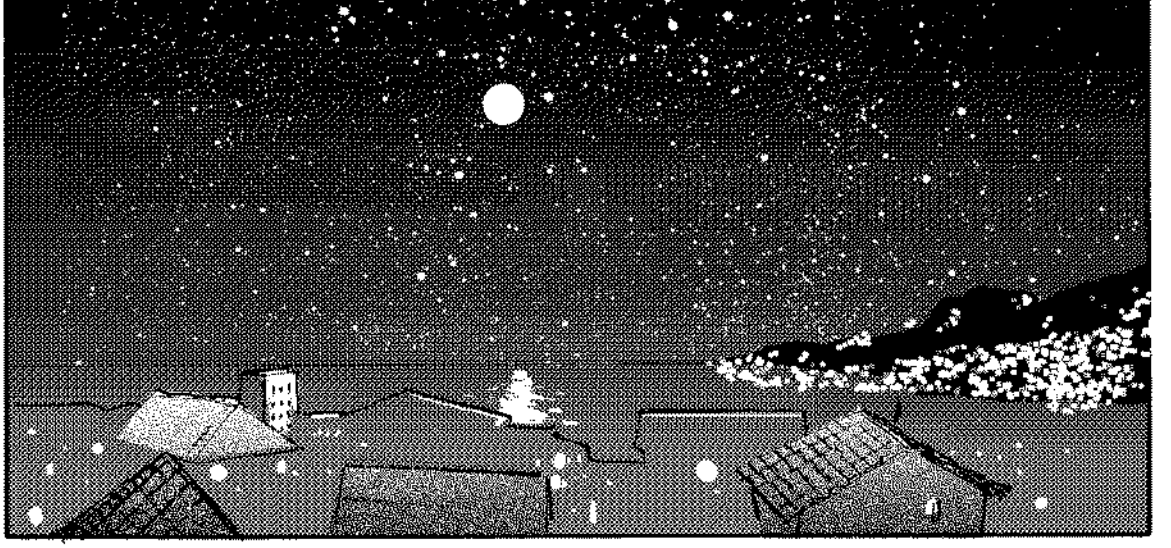

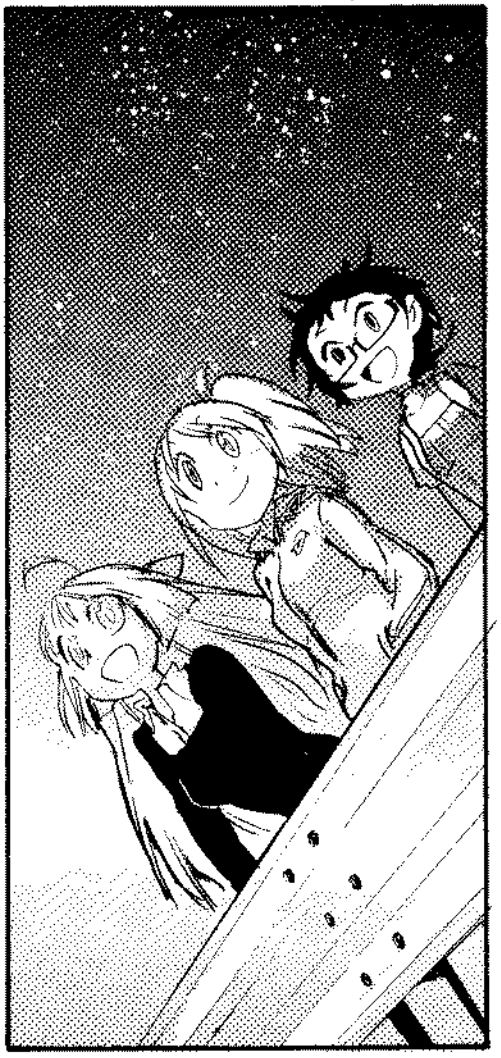

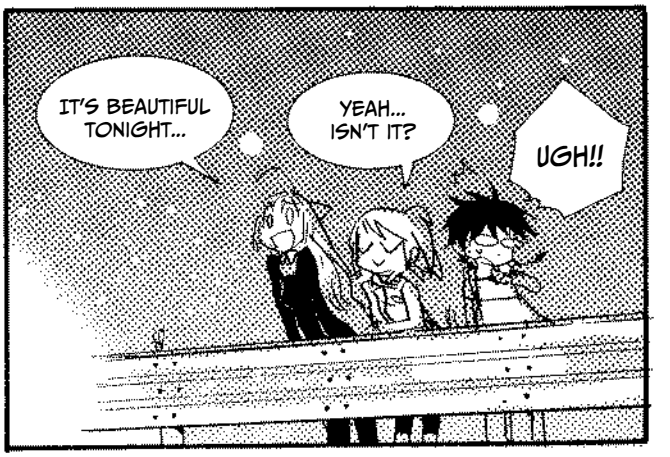

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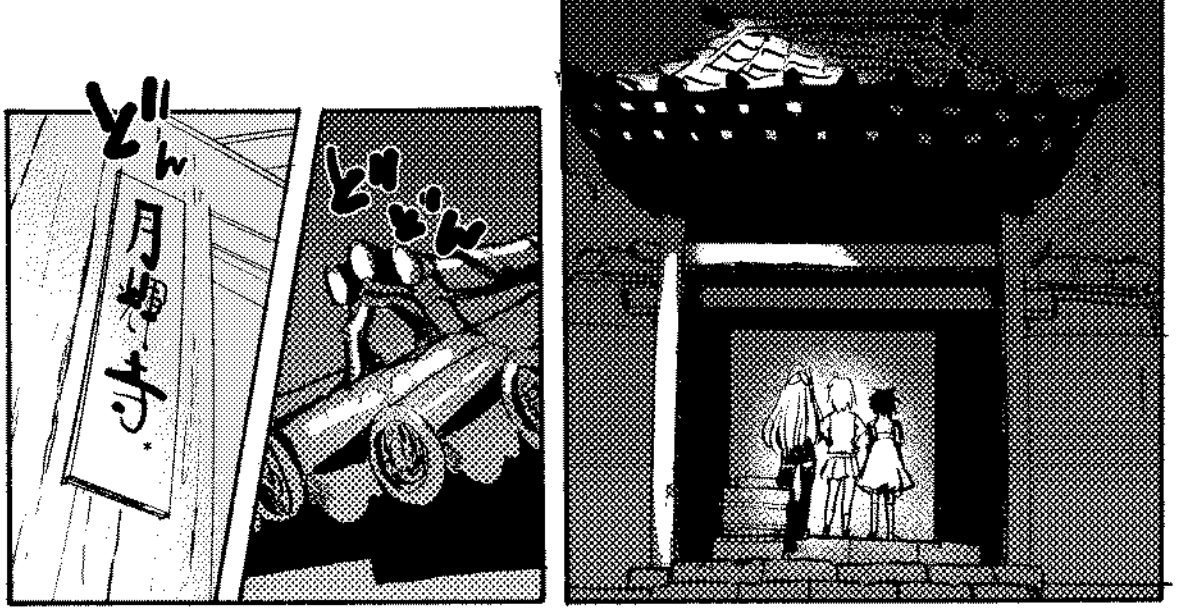
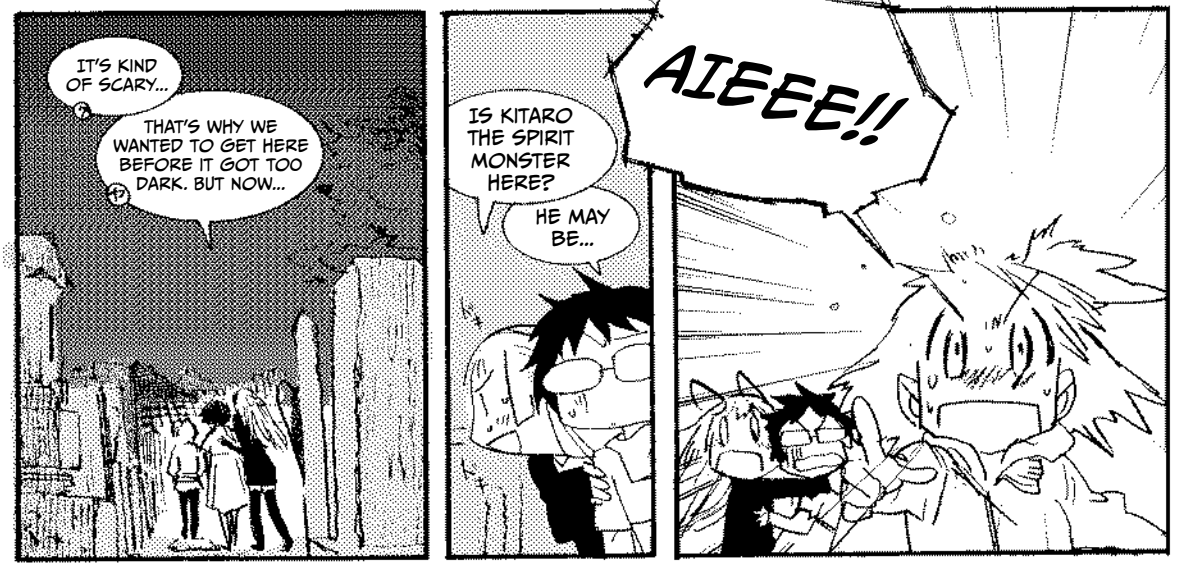


* GEKKOJI: TEMPLE OF THE MOONLIGHT



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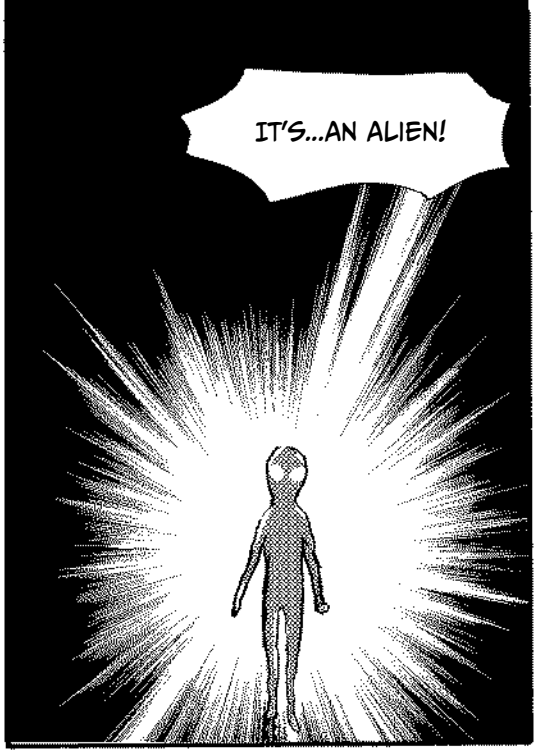

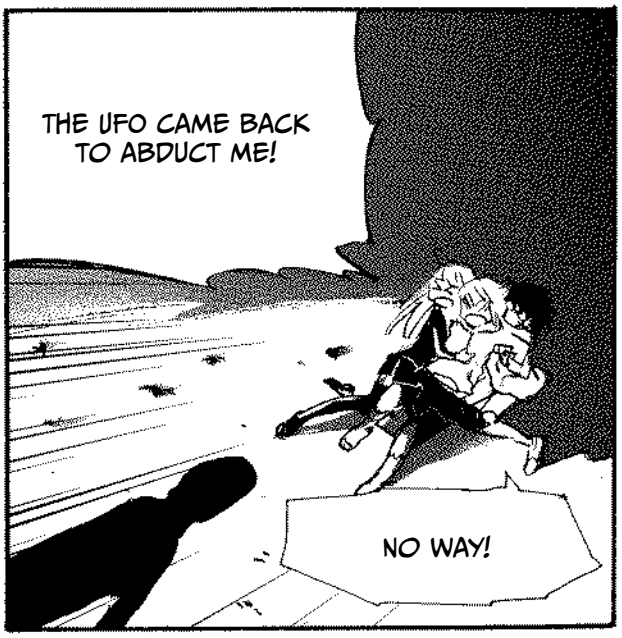

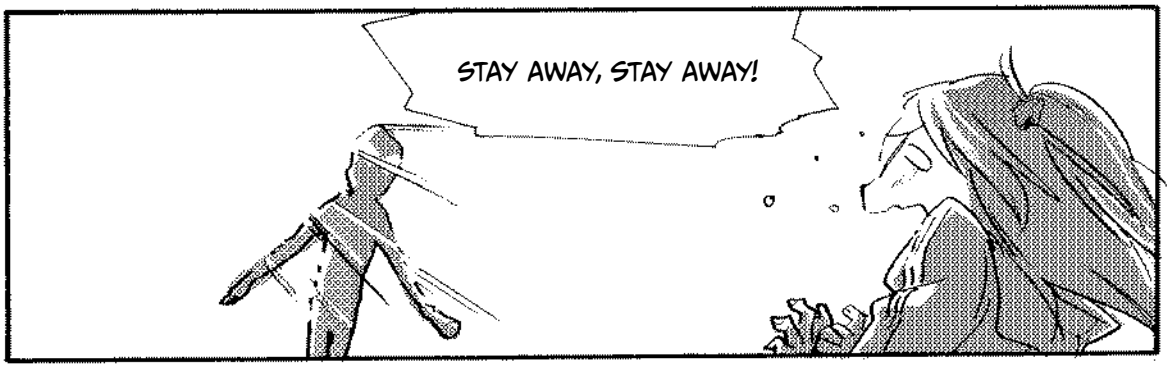

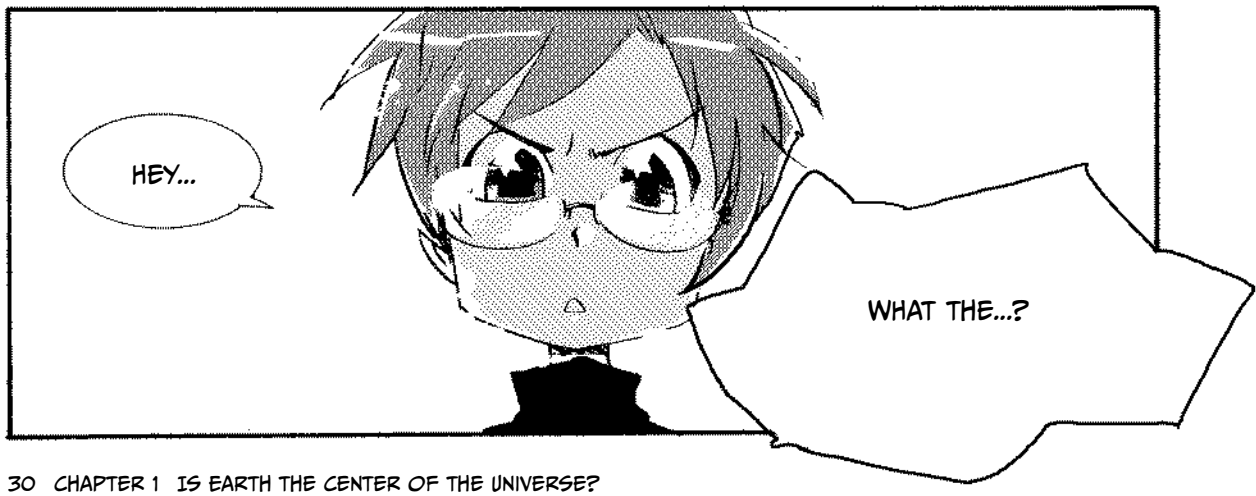

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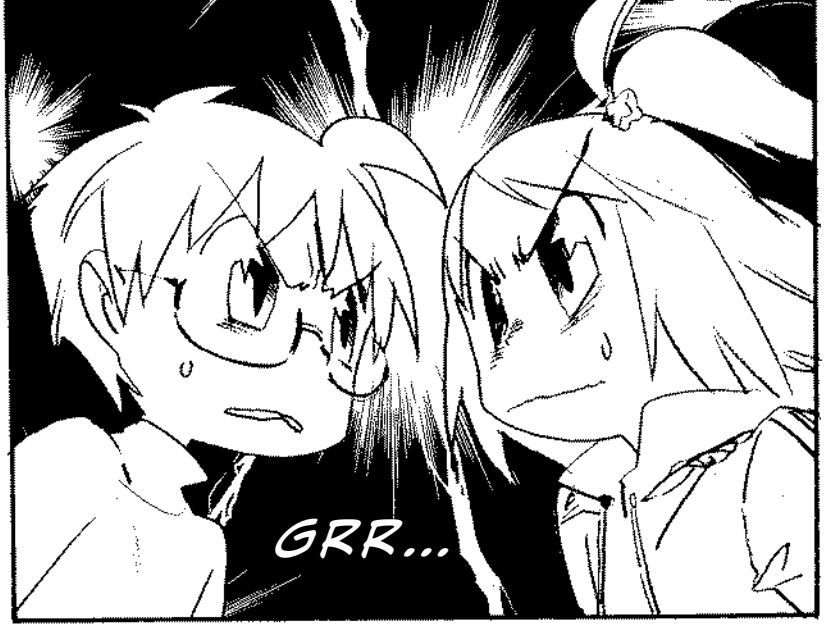
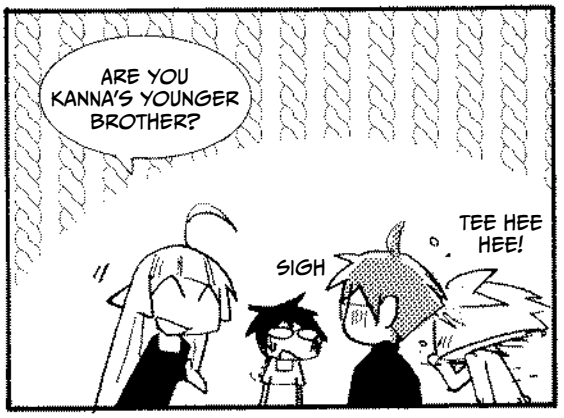
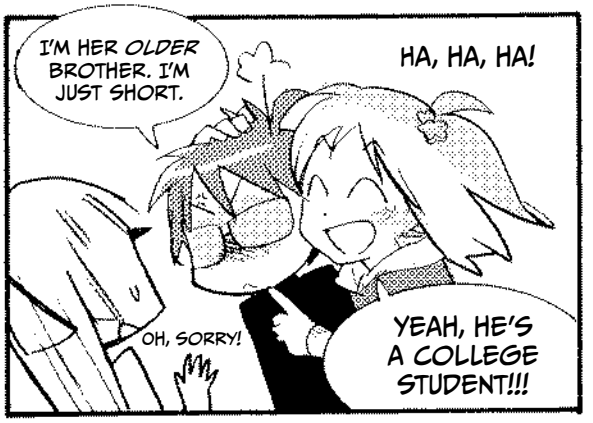
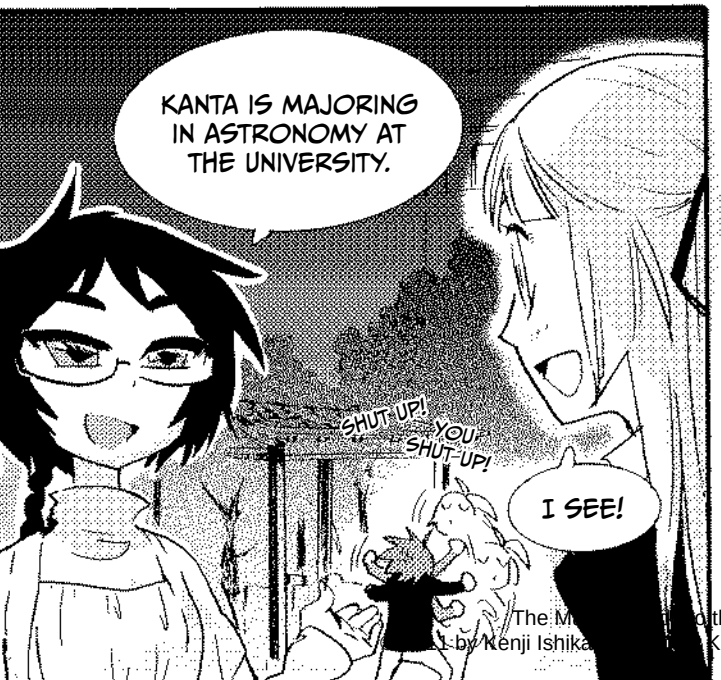
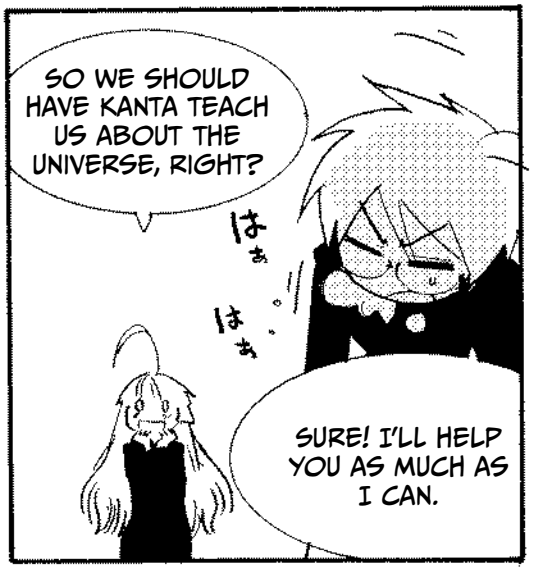

GRR...

UH OH...


ARE YOU KANNA'S YOUNGER BROTHER?
SIGH
TEE HEE HEE!


I'M HER *OLDER* BROTHER. I'M JUST SHORT.
HA, HA, HA!
OH, SORRY!
YEAH, HE'S A COLLEGE STUDENT!!!


KANTA IS MAJORING IN ASTRONOMY AT THE UNIVERSITY.
SHUT UP!
YOU SHUT UP!
I SEE!


SO WE SHOULD HAVE KANTA TEACH US ABOUT THE UNIVERSE, RIGHT?
はぁ
はぁ
SURE! I'LL HELP YOU AS MUCH AS I CAN.

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A: A SHINING LIGHT WAS VISIBLE AT A LOW POSITION IN THE WESTERN SKY AT APPROXIMATELY 5:30 IN THE EVENING.

B: THAT SHINING LIGHT IS A UFO BEING FLOWN BY ALIENS.

STATEMENT *A* IS AN OBSERVATION, AND *B* IS AN INFERENCE BASED ON IT.

PERHAPS THAT INFERENCE IS CORRECT, BUT IT ALSO MAY BE INCORRECT.

LET'S TRY TO VERIFY IT, THEN!

HE'S REALLY SWEET TO HELP US LIKE THIS.

FIRST, MISS KANNA...

CAN YOU DRAW A DIAGRAM SHOWING HOW THE SUN, EARTH, AND MOON ARE RELATED?

YES, SIR!

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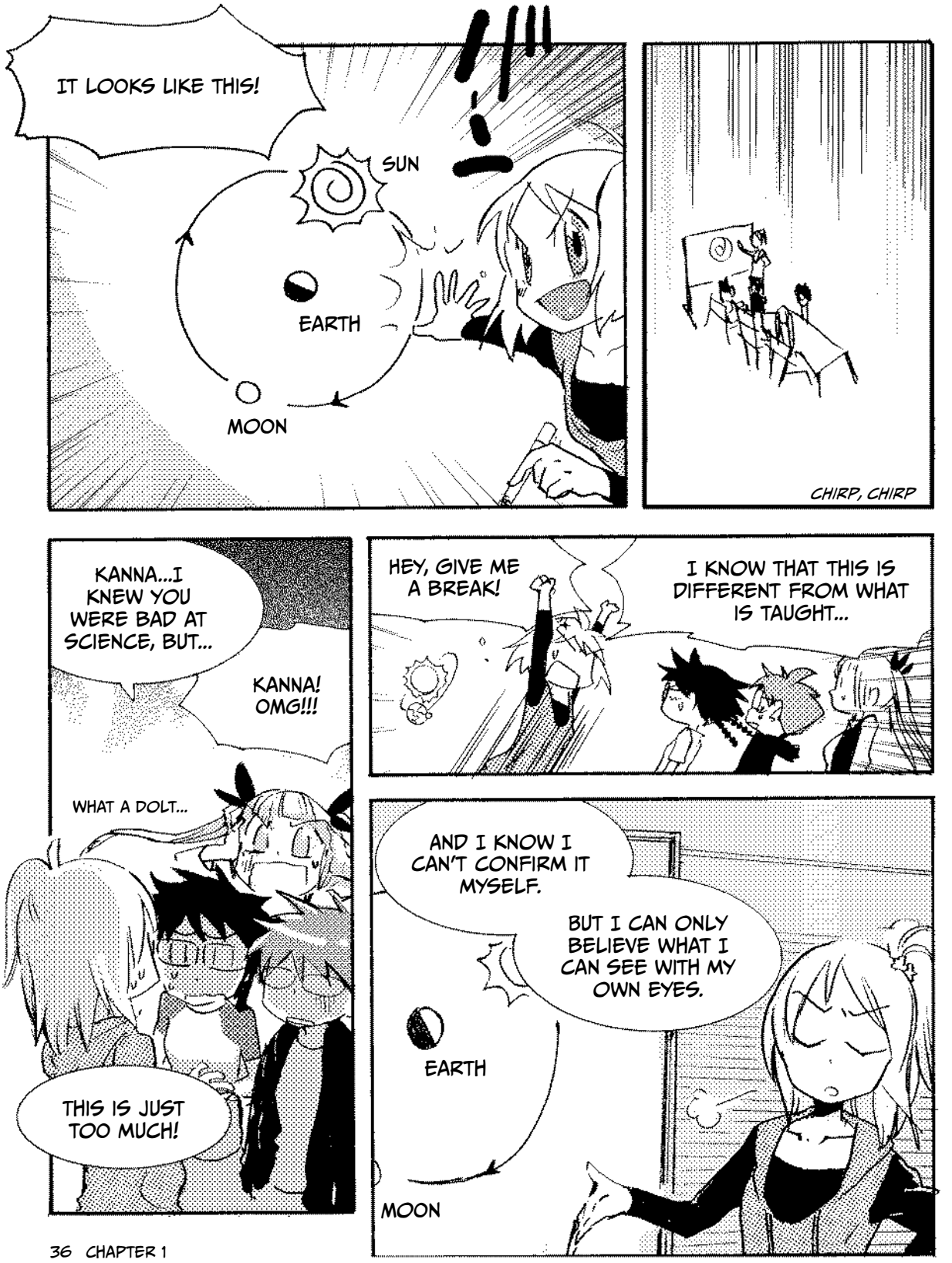

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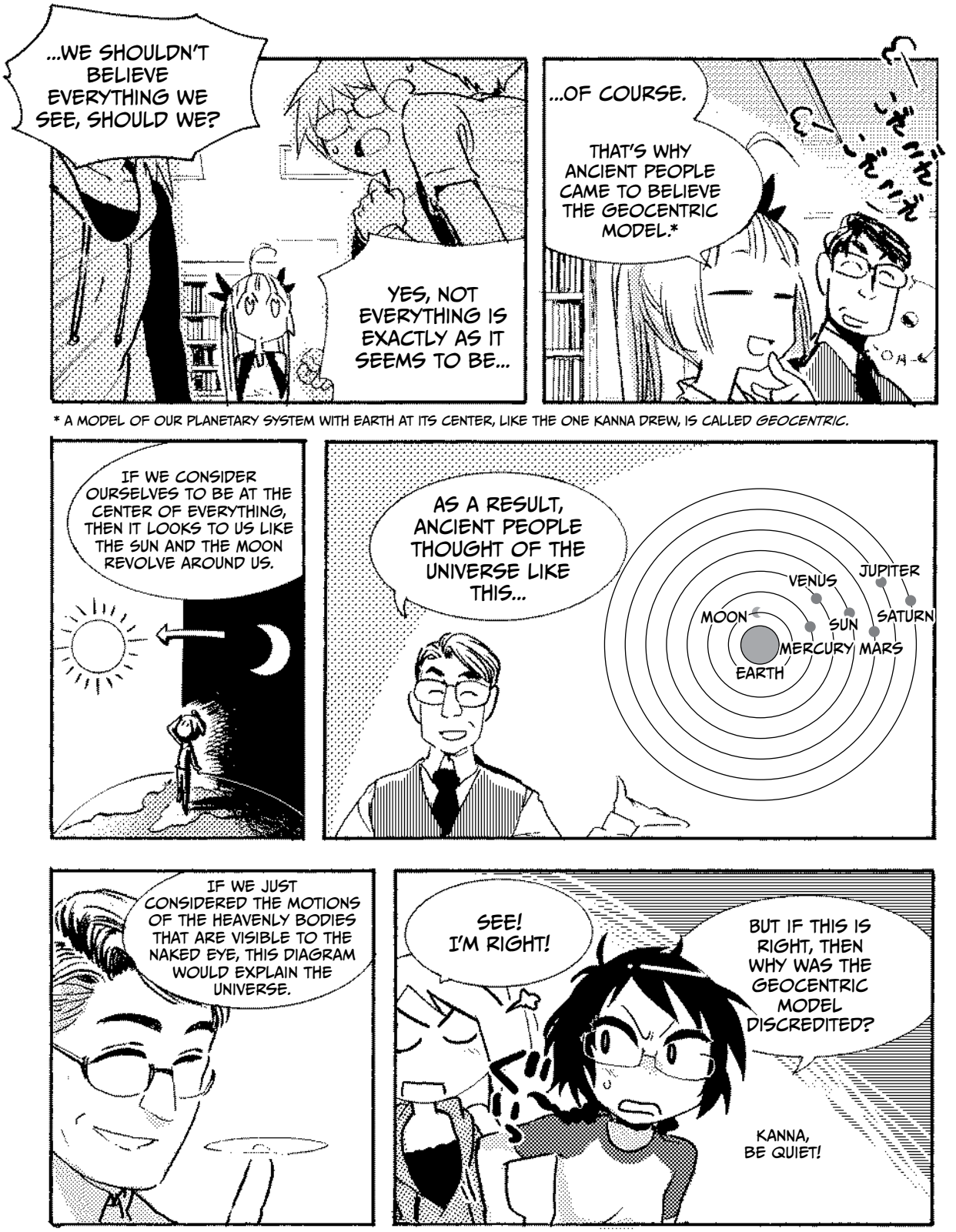

* A MODEL OF OUR PLANETARY SYSTEM WITH EARTH AT ITS CENTER, LIKE THE ONE KANNA DREW, IS CALLED *GEOCENTRIC*.

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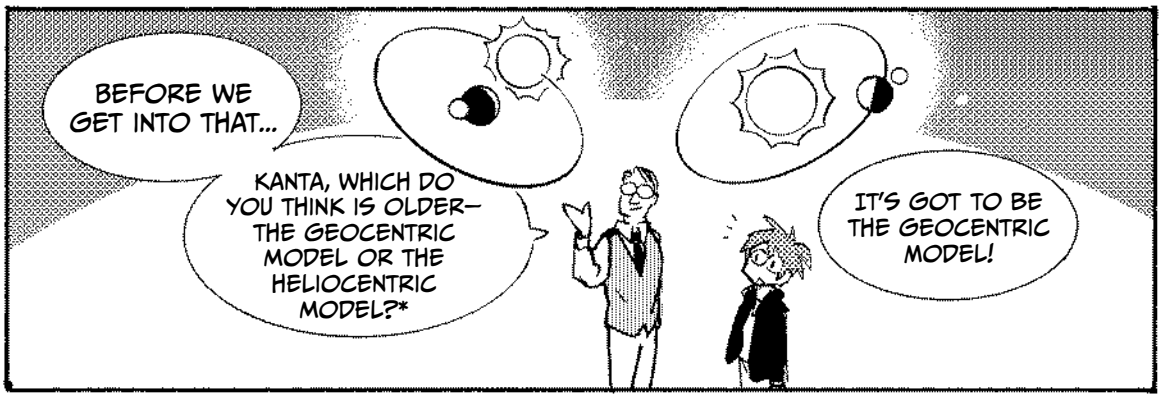
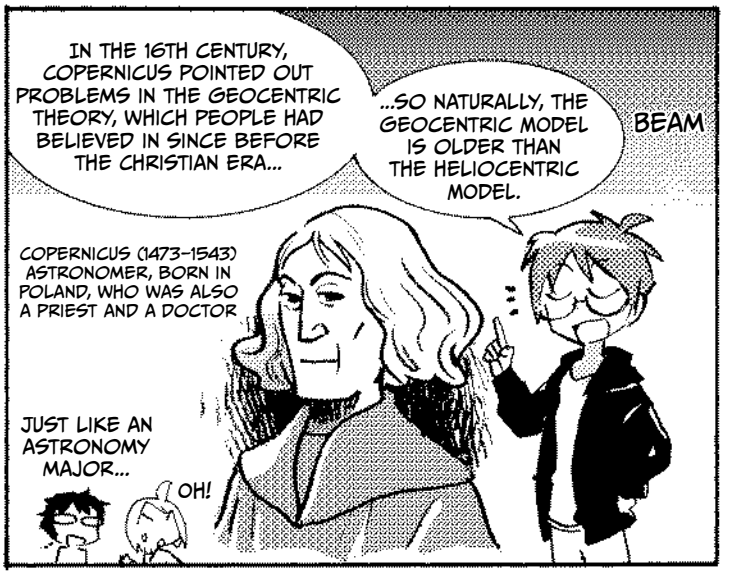
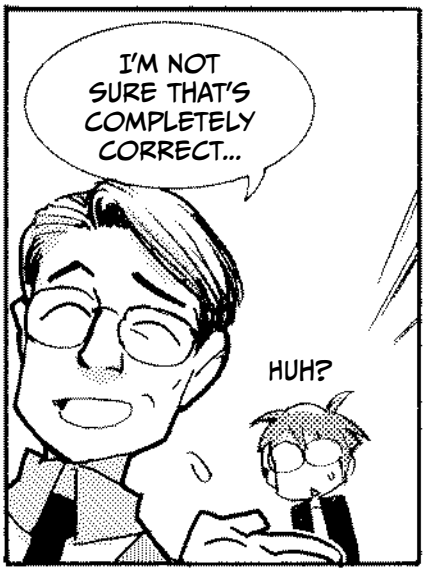
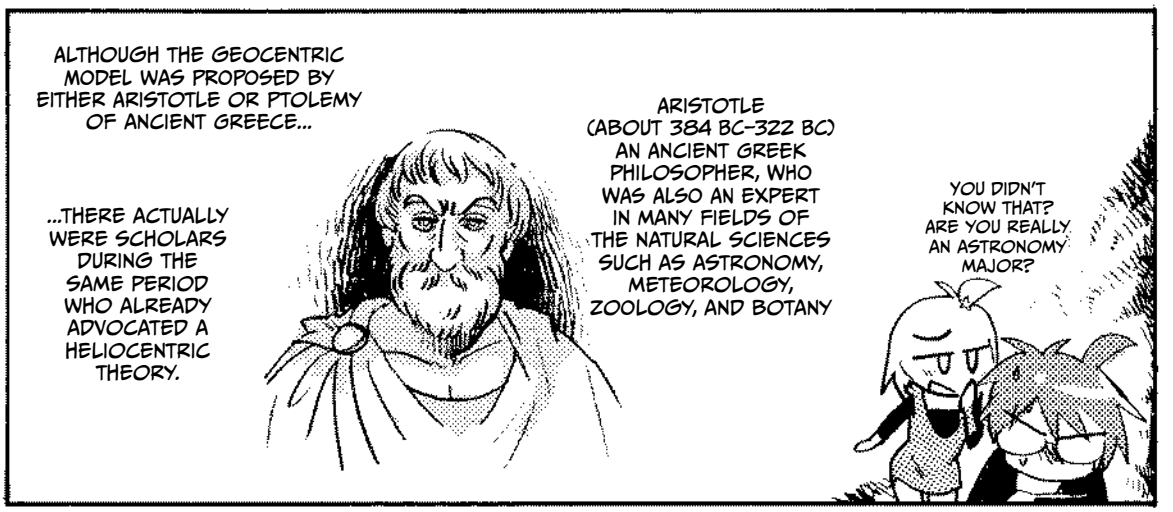


* A *HELIOCENTRIC* MODEL OF OUR PLANETARY SYSTEM HAS THE SUN AT ITS CENTER.







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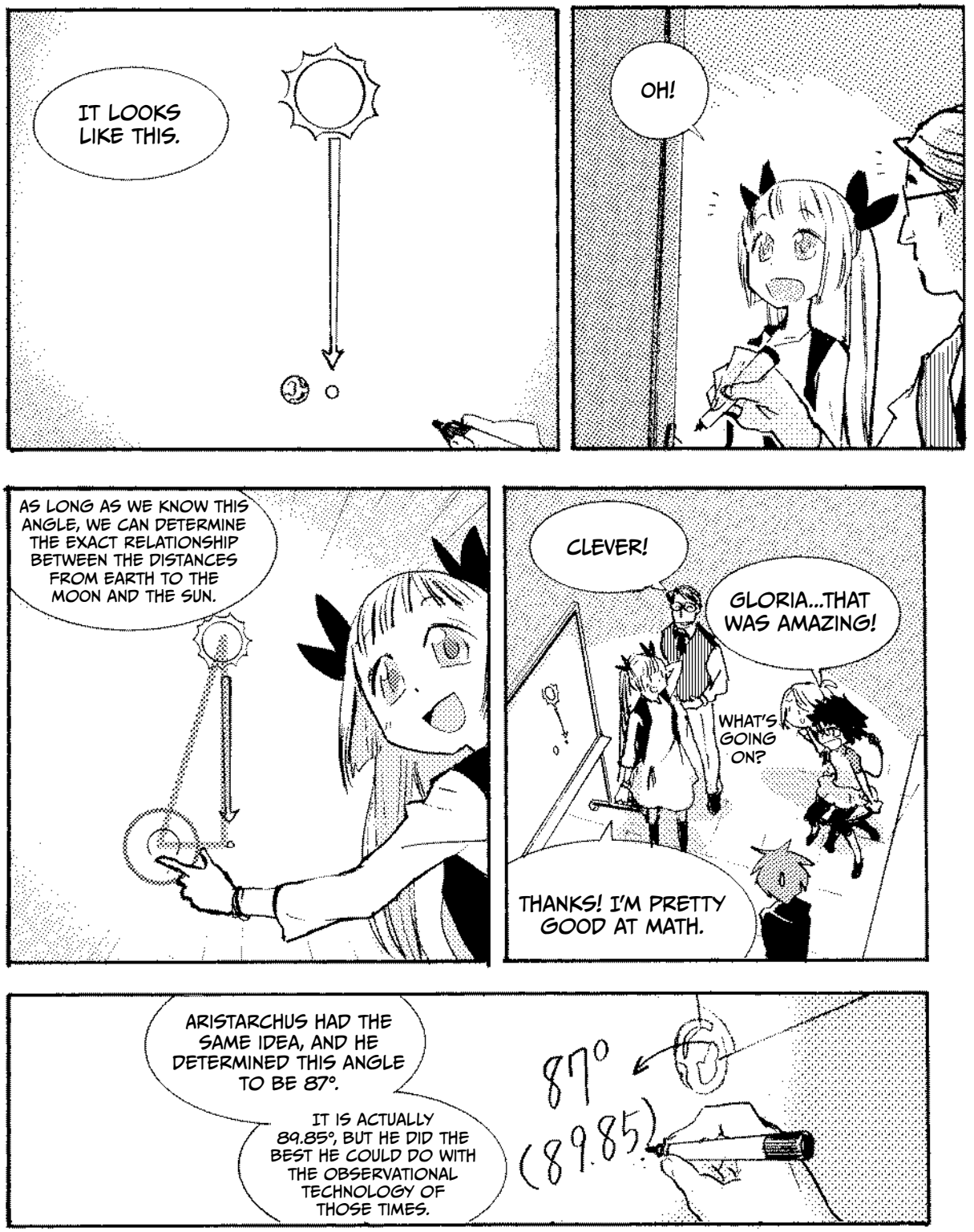

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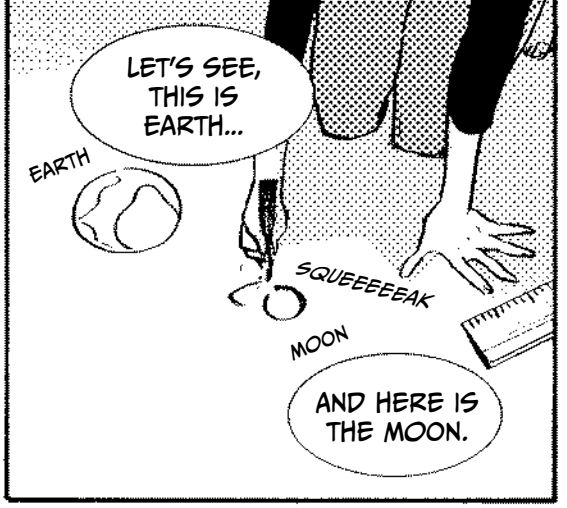

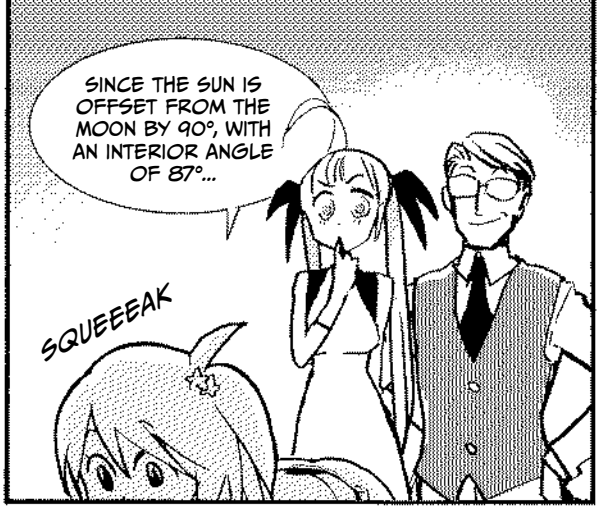

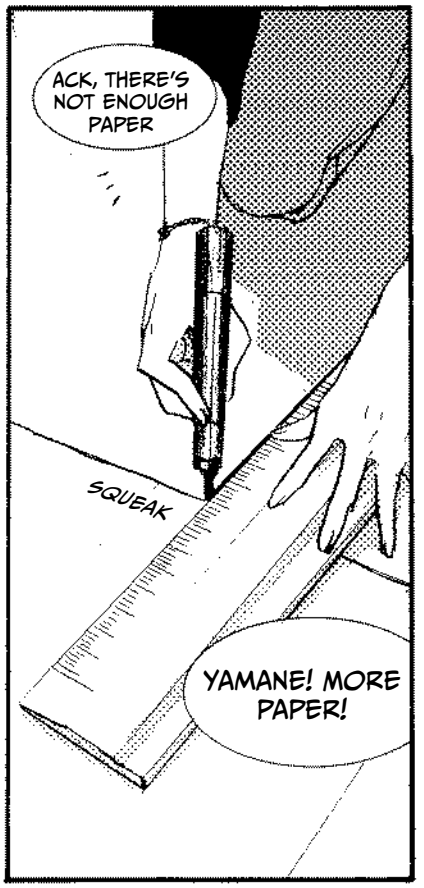

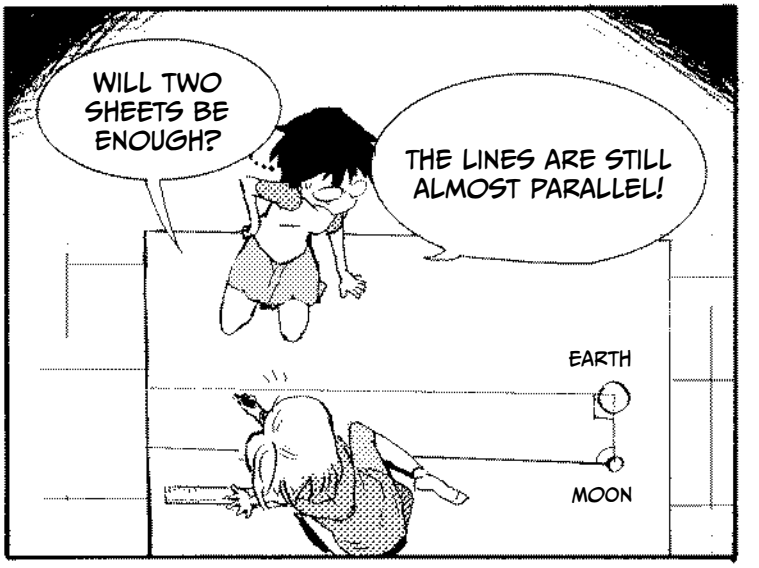

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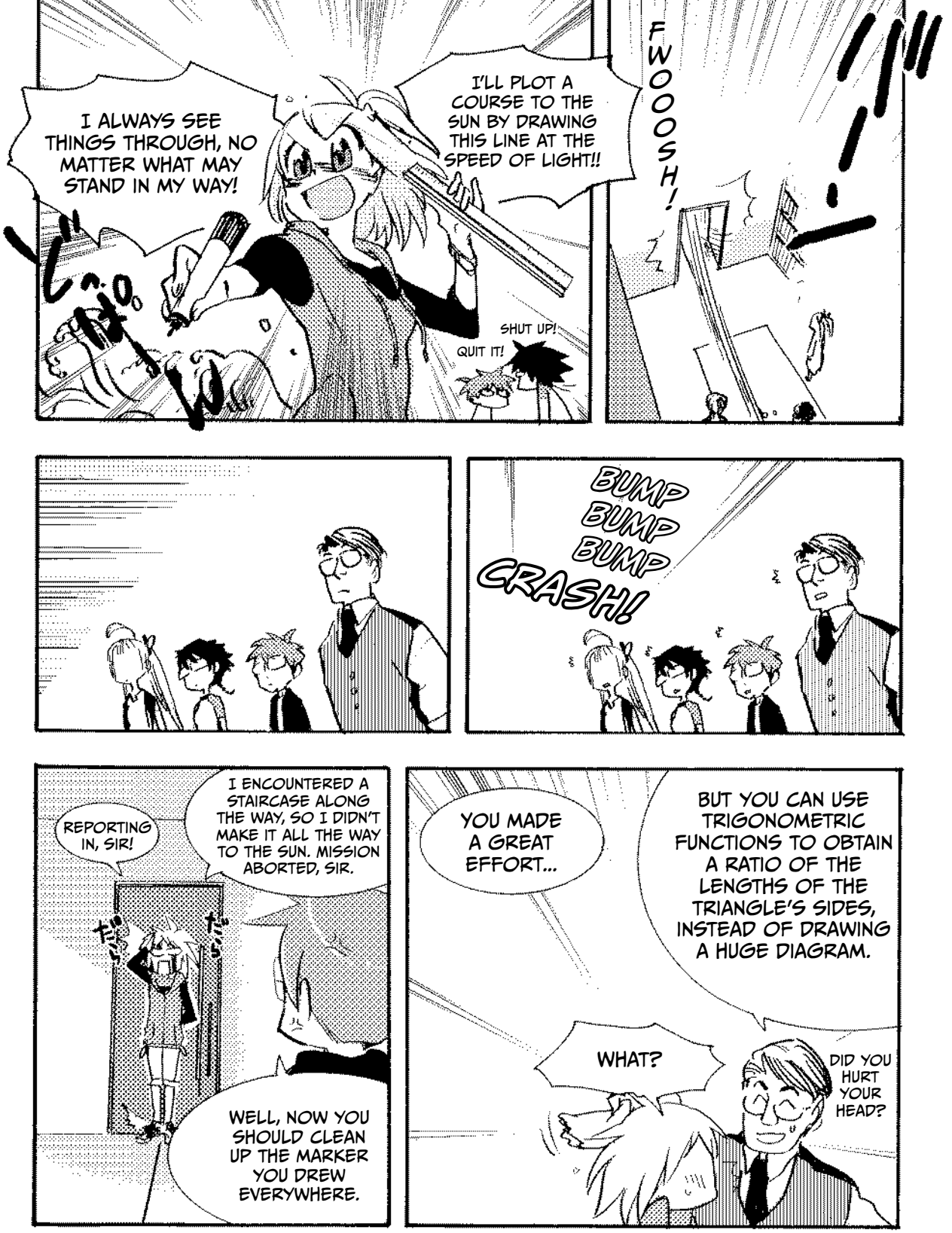

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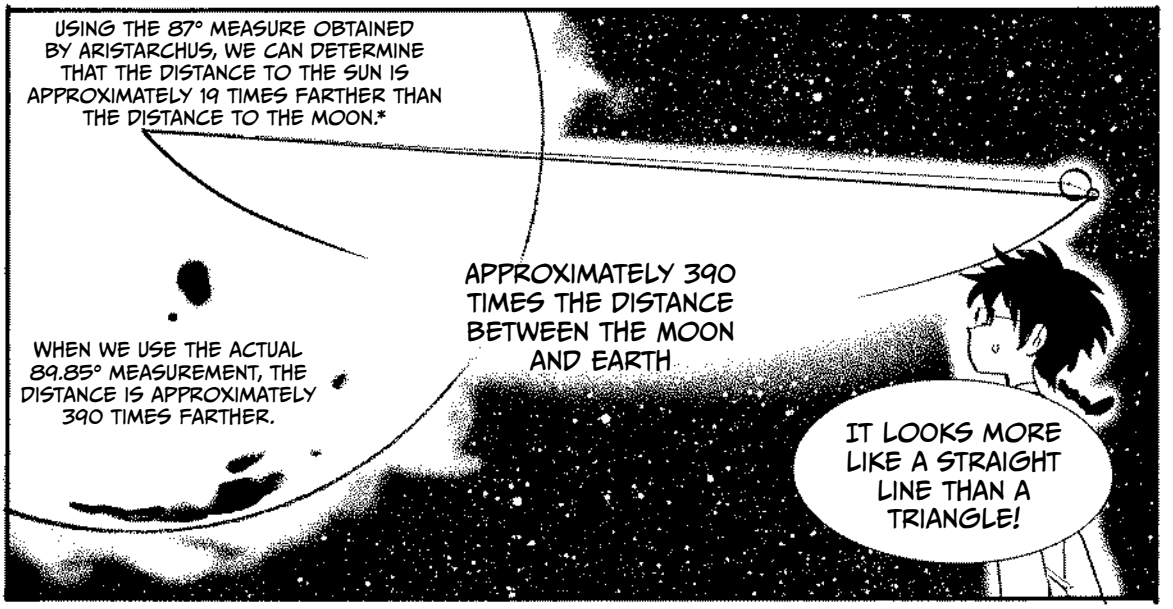
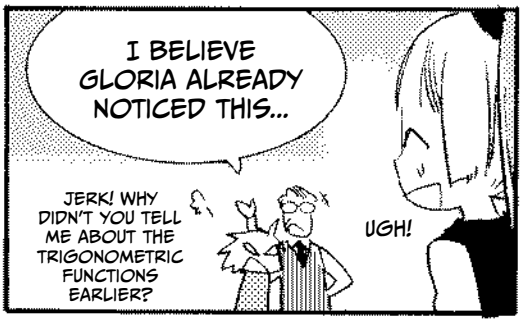
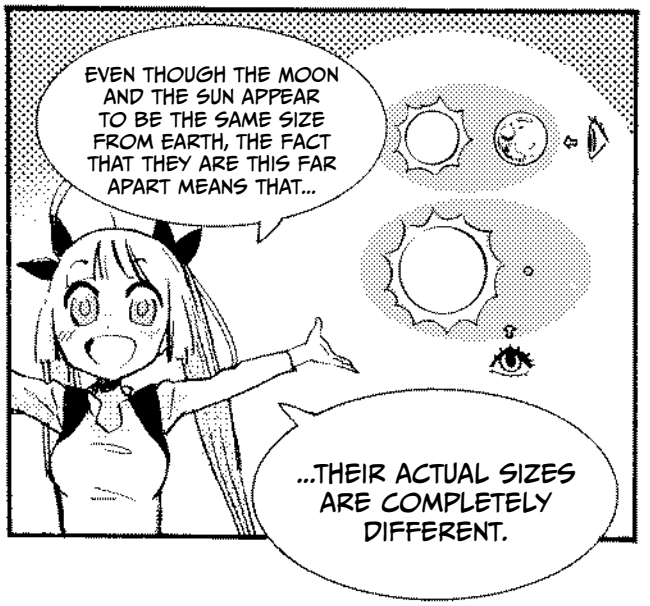
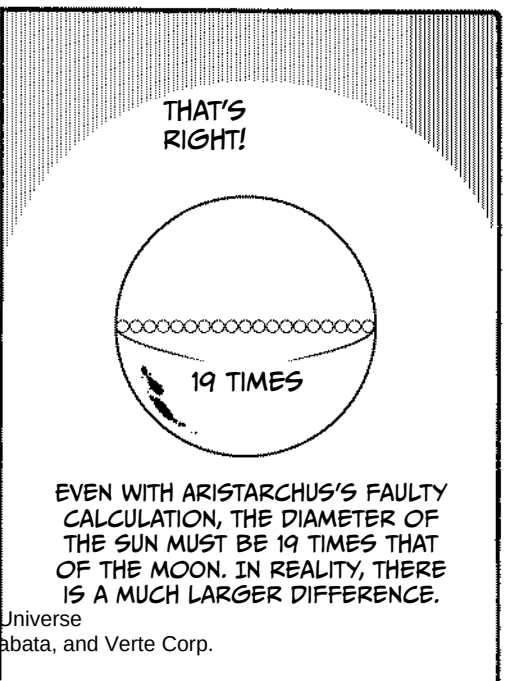


* THE TANGENT FUNCTION DESCRIBES THE RATIO OF OPPOSITE-TO-ADJACENT SIDES OF A RIGHT TRIANGLE (tan87° = 19).







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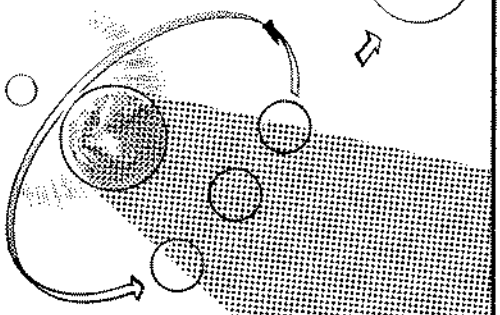
ARISTARCHUS ALSO NOTICED THAT A LUNAR ECLIPSE WAS CAUSED BY THE MOON ENTERING THE SHADOW OF EARTH.



THEN, BY EXAMINING THE SIZE OF THAT SHADOW, HE CONCLUDED THAT THE DIAMETER OF THE MOON WAS APPROXIMATELY 1/3 THE DIAMETER OF EARTH.

AS A RESULT, WE KNOW THAT THE DIAMETER OF THE SUN IS MORE THAN SIX TIMES THE DIAMETER OF EARTH.

SO IF THE SUN AND EARTH WERE MADE OF THE SAME MATERIAL, HOW WOULD THEIR MASSES DIFFER?

WE SHOULD CUBE THE RADIUS, LIKE WE DO WHEN WE'RE OBTAINING THE VOLUME...

$6^3 = 216$

SO IT'S ABOUT 200 TIMES HEAVIER?

ACTUALLY, IT'S 330,000 TIMES HEAVIER!

EARTH × 330,000

BUT EVEN 200 TIMES HEAVIER IS A BIG DIFFERENCE, ISN'T IT?

IF THE GEOCENTRIC THEORY WERE CORRECT, IT WOULD BE STRANGE FOR SUCH A LARGE SUN TO MAKE ONE CIRCUIT AROUND EARTH EVERY DAY.

1 DAY

THAT'S ODD!

THAT'S THE PART THAT ARISTARCHUS HAD A PROBLEM WITH.

IT MAY EVEN BE IMPOSSIBLE!

BUT WHY DID PEOPLE CONTINUE TO SUPPORT THE GEOCENTRIC THEORY, WHEN THEY KNEW THE SUN WAS SO BIG?

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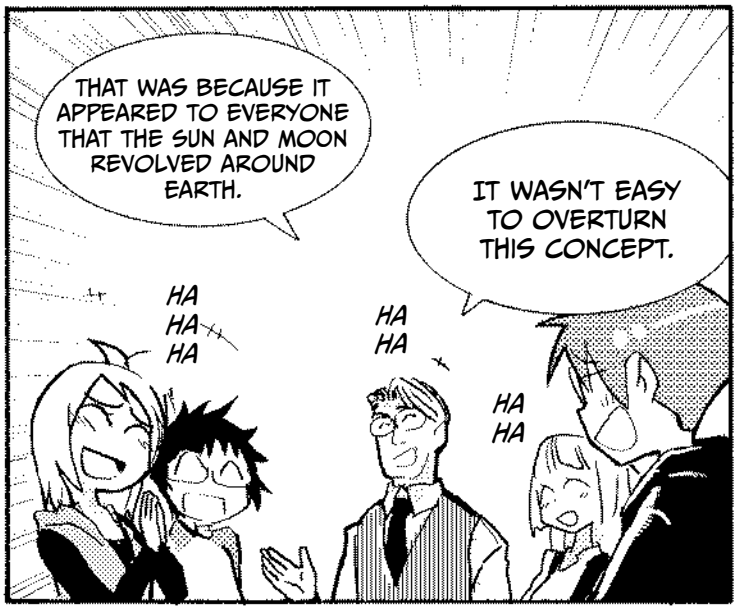

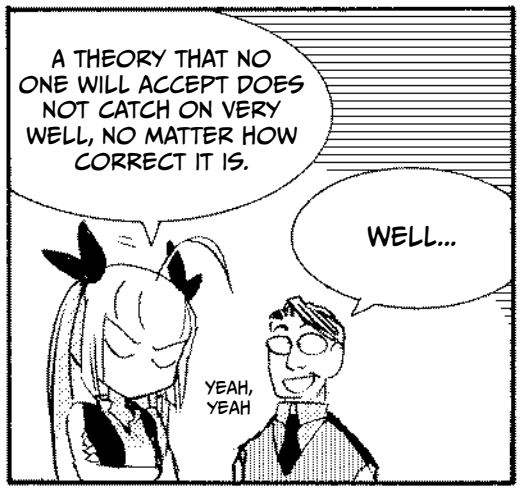

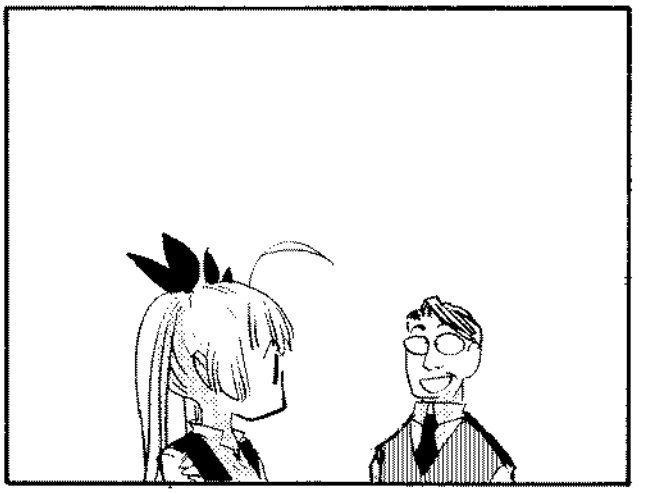

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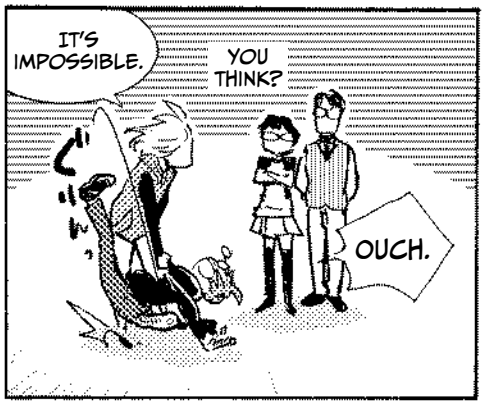

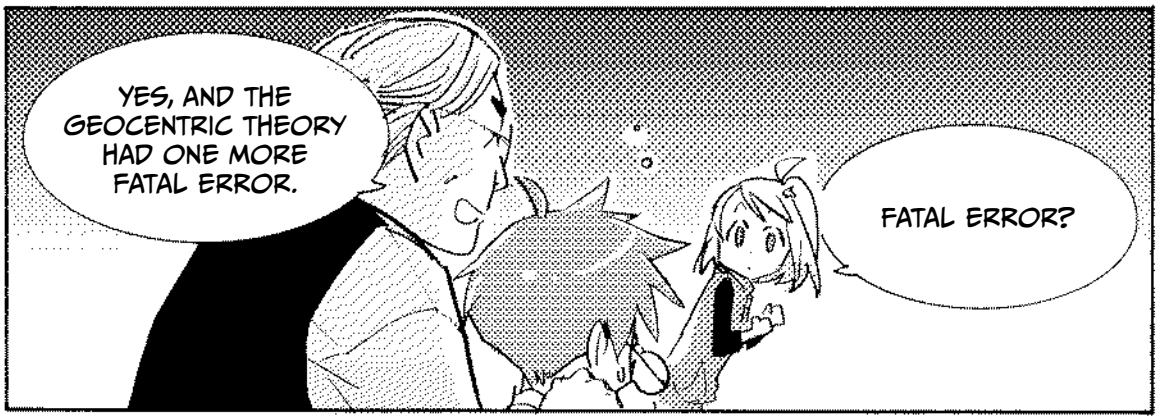

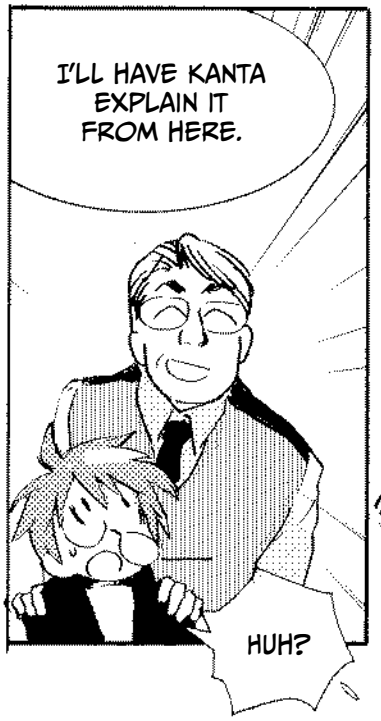

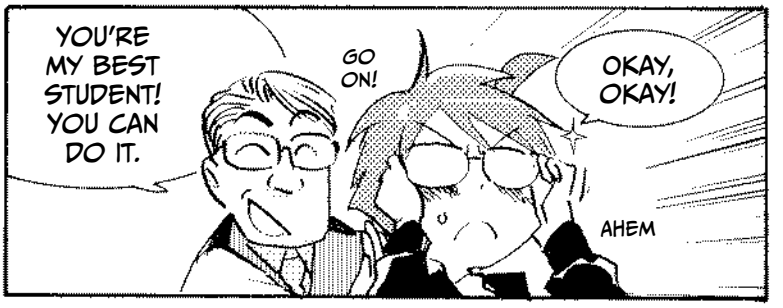

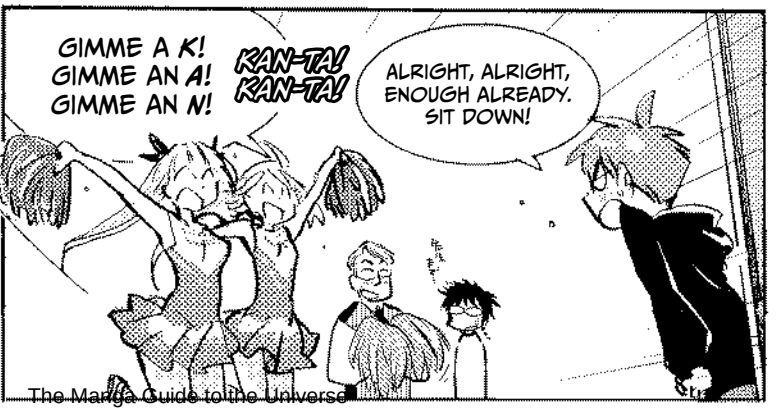

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