What is the Ozone Hole?!

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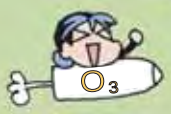
A Brief History of Ozone Layer Research

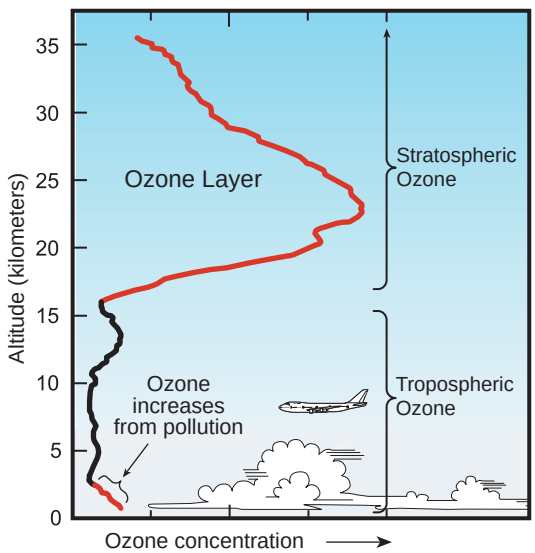


About 90% of the Earth's ozone is found in the stratosphere. Let's see briefly the history of stratospheric ozone: Who discovered it, and how?

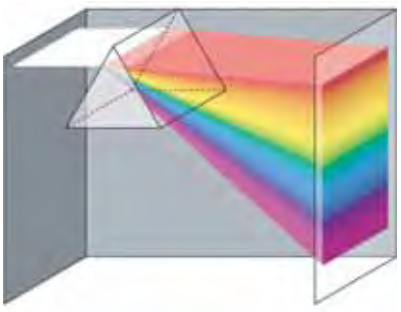
Sunlight is made up of different electromagnetic waves, ranging from short wavelength ultraviolet to long wavelength infrared. Do you think this is a difficult subject? Imagine a rainbow or a prism. You see different colors in a rainbow, and that indicates that sunlight contains various light waves.

In 1881, an Irish chemist W. N. Hartley found that ozone absorbs ultraviolet at wavelengths from 200 to 300 nanometers*. Fifteen years later, W. Huggins, an English astronomer, studied the spectra of the dog star Sirius and discovered ozone absorption of ultraviolet at wavelengths from 300 to 340 nanometers.

* A nanometer is one billionth of a meter.



The ozone layer lies about 15 - 40 km in altitude, although this height varies with latitude. <Courtesy of WMO Report "Scientific Assessment of Ozone Depletion 2002">



When a beam of sunlight passes through a prism, the rays of different wavelengths come out.

Hartley asked why ultraviolet rays are not detected in sunlight at the Earth's surface, although they exist just after being radiated from the Sun. He suggested that there was a large quantity of ozone up in the sky that absorbs ultraviolet radiation. An experiment with a balloon was carried out to confirm his idea, but the balloon did not get as high as the ozone layer.

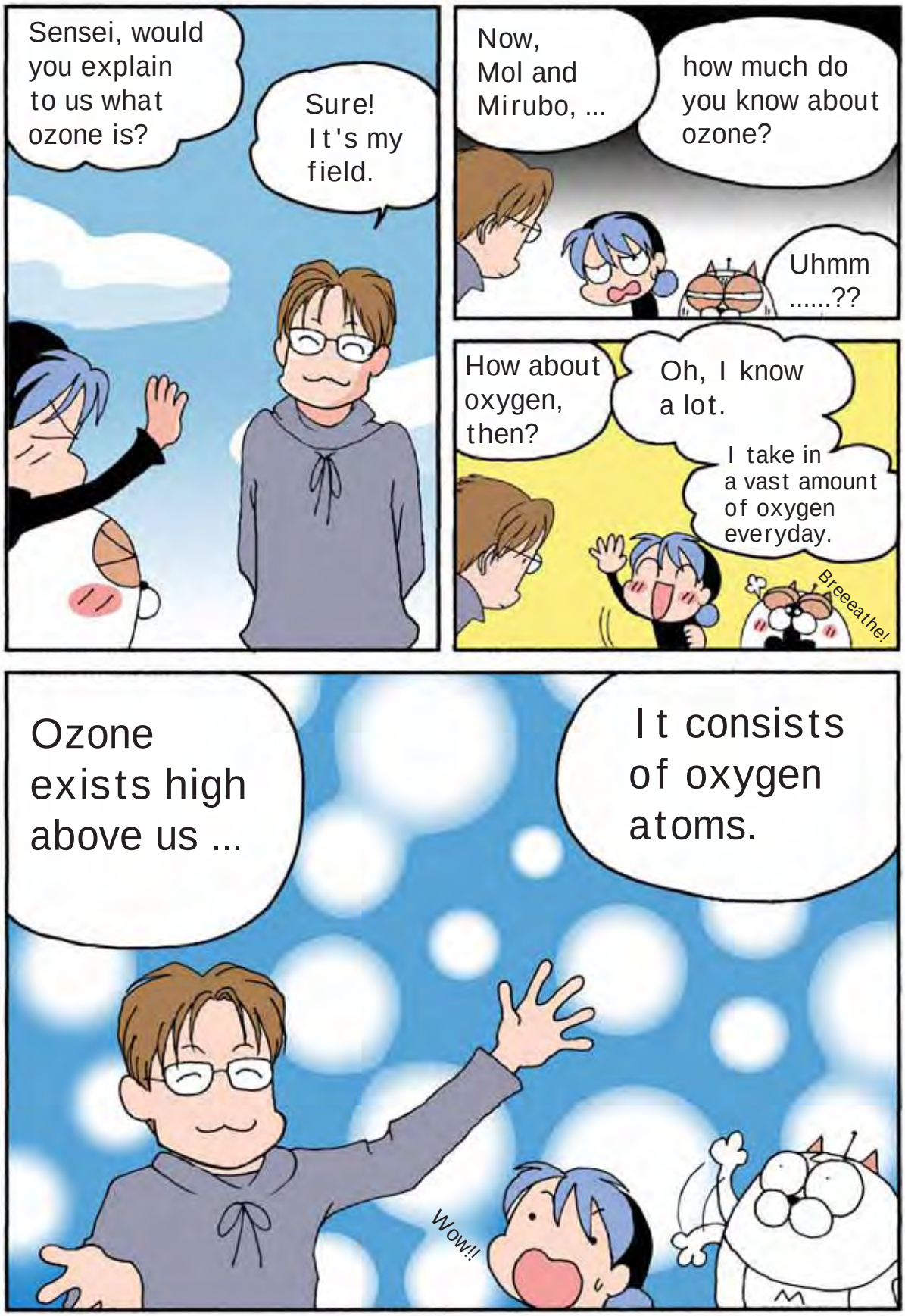
Finally in the 1940s, rocket observations showed the existence of stratospheric ozone. Unfortunately, Hartley had already passed away by then. Various research projects started following the finding to understand the ozone distribution, its birthplace, etc. Ozone observations began in Antarctica in 1957 as part of the International Geophysical Year. At that time, no one could predict that these observations would lead to the discovery of the ozone hole.

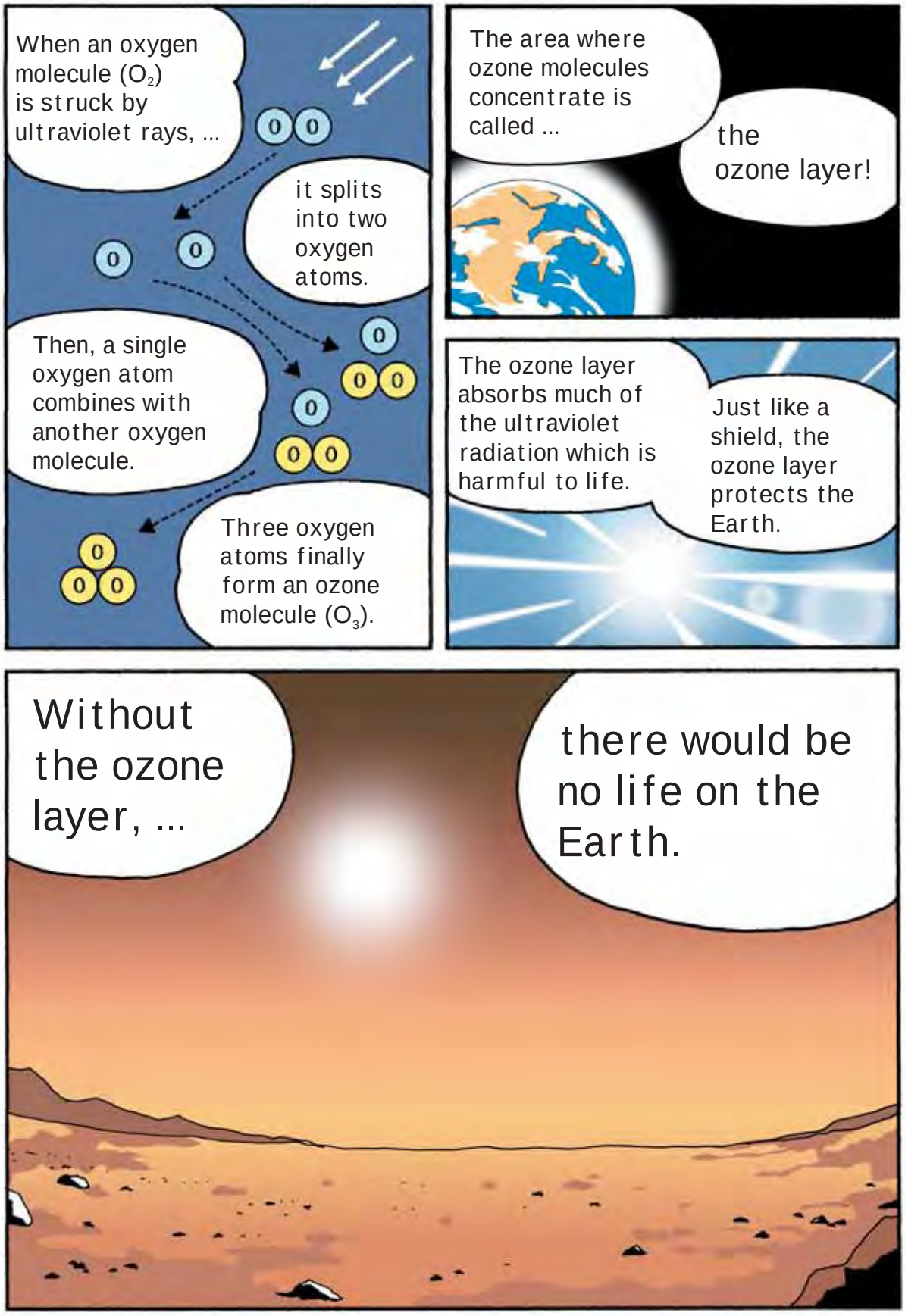
As research has progressed, people began to acknowledge that animal and plant life is protected by the ozone layer that absorbs harmful ultraviolet. Behind today's research lie the accomplishments of scientists like Hartley, who first studied the chemical, ozone.

We hope you readers share an adventure trip into ozone with our Mol and Mirubo!

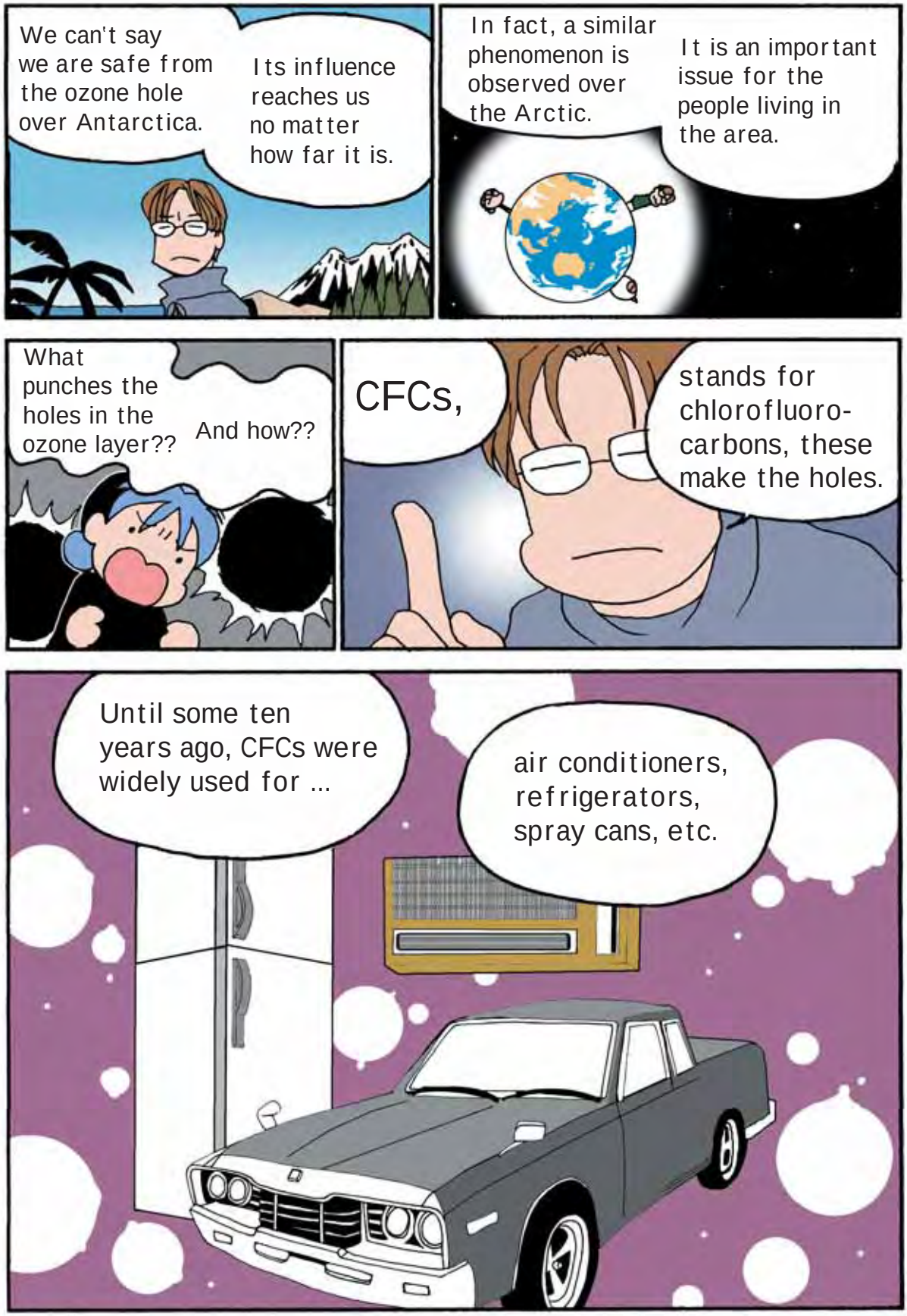

Here are science lover Mol and her robotic dog Mirubo ...
glancing at drifting clouds, lying on their backs in the meadow on a nice and warm day.
Mirubo, what do you think there is above the clouds?
Above the clouds? Hmm...
The sky should be up there.


Don't you have the slightest imagination?
I expect you to tell me something interesting.
She is at a rebellious age.
Boo-boo
Of course I have imagination.
It would be nice if there was a huge food court over the clouds.
Wait!
I remember ...
high above the clouds is the ozone layer.
I heard that before.
The ozone layer?
What is that?


Sensei, would you explain to us what ozone is?
Sure! It's my field.
Now, Mol and Mirubo, ...
how much do you know about ozone?
Uhmm .....??
How about oxygen, then?
Oh, I know a lot.
I take in a vast amount of oxygen everyday.
Breeeathe!
Ozone exists high above us ...
It consists of oxygen atoms.
Wow!!

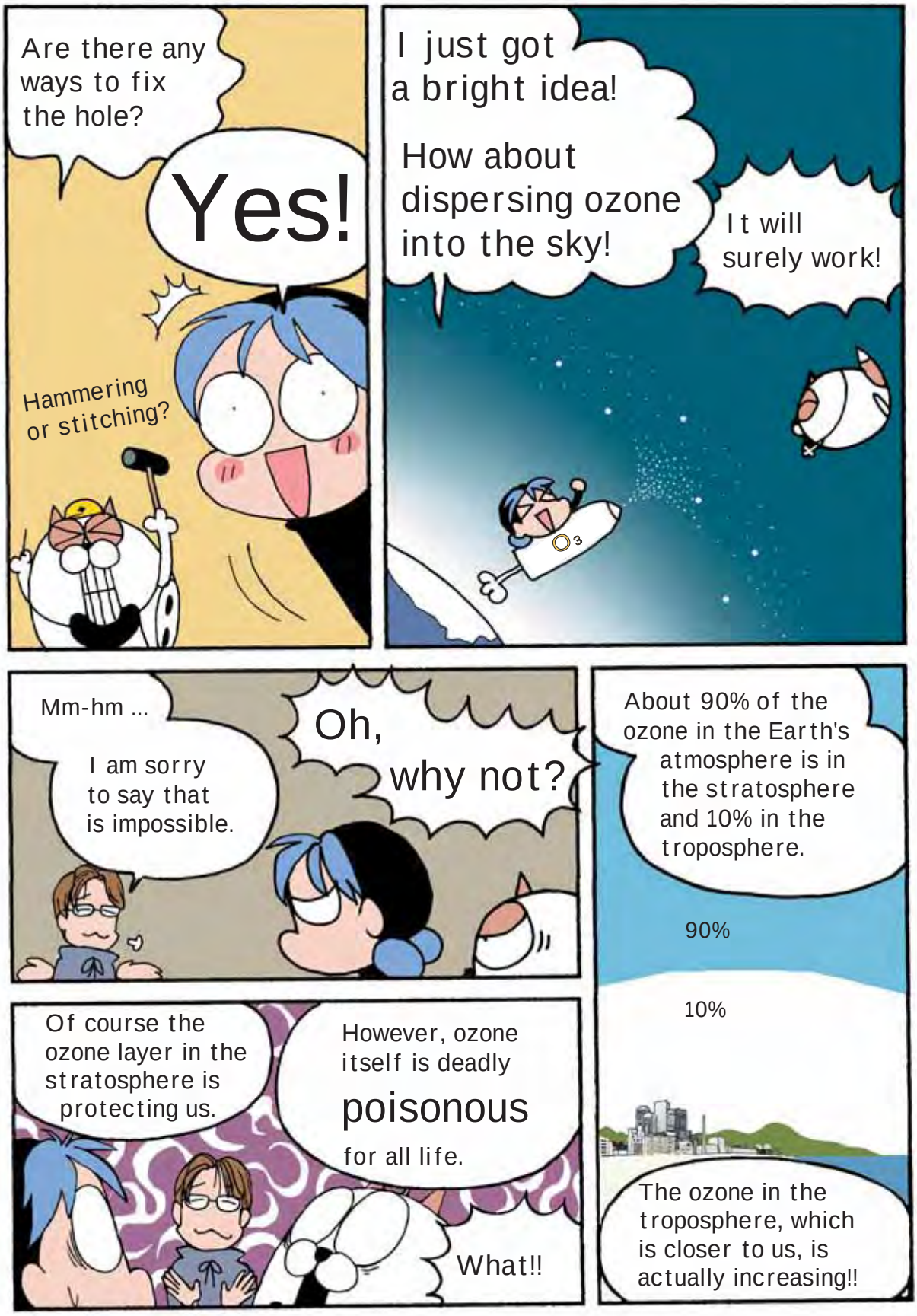

When an oxygen molecule (O_2) is struck by ultraviolet rays, ...
it splits into two oxygen atoms.
Then, a single oxygen atom combines with another oxygen molecule.
Three oxygen atoms finally form an ozone molecule (O_3).
The area where ozone molecules concentrate is called ...
the ozone layer!
The ozone layer absorbs much of the ultraviolet radiation which is harmful to life.
Just like a shield, the ozone layer protects the Earth.
Without the ozone layer, ...
there would be no life on the Earth.

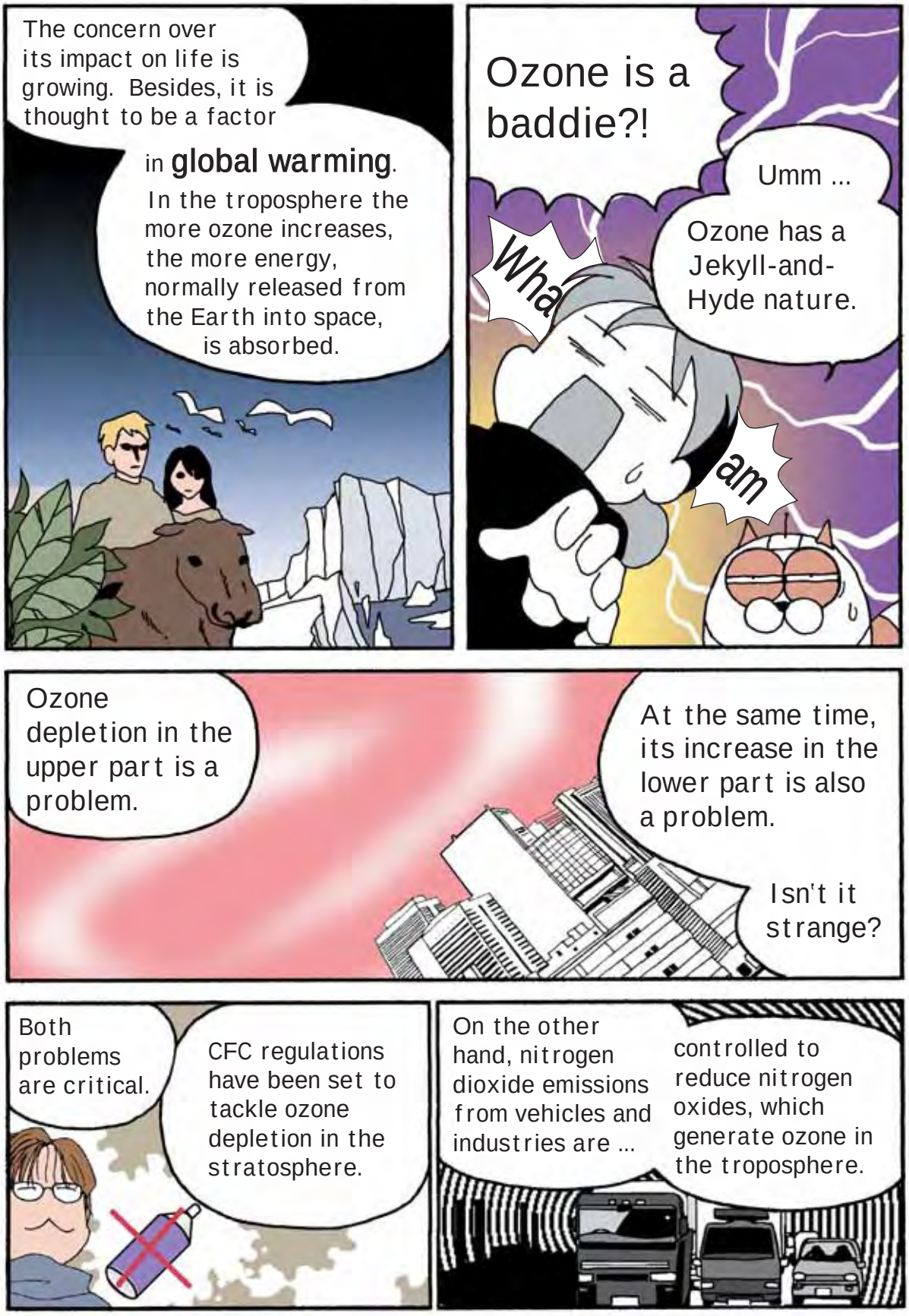

Waaahhh! Ultraviolet radiation is dangerous!
Calm down. We have the ozone layer protecting us.
No need to worry.
Hip, hip, hurray!
Let me remind you that there is a worry.
Whaaaat?!
In the 1980s, scientists found that ozone was being lost over Antarctica.
It looks like there is a hole in the ozone layer.
Antarctica
More ultraviolet radiation is coming through the hole??
That is a crisis!!
Wait.
The ozone hole exists over Antarctica, not Japan.
We are safe, anyway.
What a relief!
No!! Penguins will get sunburned!
Don't tell me you are serious.


We can't say we are safe from the ozone hole over Antarctica.
Its influence reaches us no matter how far it is.
In fact, a similar phenomenon is observed over the Arctic.
It is an important issue for the people living in the area.
What punches the holes in the ozone layer??
And how??
CFCs,
stands for chlorofluoro-carbons, these make the holes.
Until some ten years ago, CFCs were widely used for ...
air conditioners, refrigerators, spray cans, etc.


Now we know that CFCs emitted by human activities travel with the air flow and ascend to the stratosphere.
In the stratosphere they are destroying the ozone layer!
When this research result was released, it showed the need to set regulations for the use of CFCs.
However, we need air conditioners, refrigerators, etc.
Substitutes for CFCs
then began to be used for those appliances.
I doubt that the ozone loss will be stopped soon after people abandon CFCs.
Exactly.
CFCs are highly stable compounds and require a long time to decompose.


Noop! When will the ozone hole be stitched?
Or, will it never be filled in?
Recent research using a super computer shows that the ozone hole will close in 50 years.
50 years?! Does it take so long?!
Yes, and until that time, the ozone hole will continue to exist.
That is too bad.
All we can do is wait for the recovery of the ozone layer?!


Are there any ways to fix the hole?
Yes!
Hammering or stitching?
I just got a bright idea!
How about dispersing ozone into the sky!
It will surely work!
Mm-hm ...
I am sorry to say that is impossible.
Oh, why not?
About 90% of the ozone in the Earth's atmosphere is in the stratosphere and 10% in the troposphere.
90%
10%
Of course the ozone layer in the stratosphere is protecting us.
However, ozone itself is deadly poisonous for all life.
What!!
The ozone in the troposphere, which is closer to us, is actually increasing!!


The concern over its impact on life is growing. Besides, it is thought to be a factor in global warming.
In the troposphere the more ozone increases, the more energy, normally released from the Earth into space, is absorbed.
Ozone is a baddie?!
Umm ...
Ozone has a Jekyll-and-Hyde nature.
What
am
Ozone depletion in the upper part is a problem.
At the same time, its increase in the lower part is also a problem.
Isn't it strange?
Both problems are critical.
CFC regulations have been set to tackle ozone depletion in the stratosphere.
On the other hand, nitrogen dioxide emissions from vehicles and industries are ...
controlled to reduce nitrogen oxides, which generate ozone in the troposphere.


Studies are being carried out about stratospheric and tropospheric ozone.
Thus, countermeasures can be taken to prevent their condition from deteriorating.
I never realized that the ozone layer above the clouds keeps the Earth safe.
That is impressive!
It would be nice if 100 years from now people say, “There was an ozone hole a long time ago ...”
Yeah,
I hope that will happen.
Ha Ha Ha
Now, we have to protect the ozone layer in return.
Yes, let's think what we can do about that.

What is the Ozone Hole?!

Hello, Sensei! I recently read a news article about the ozone hole. Is it true that the ozone layer protects humans, animals, and plants?

Yes. The ozone layer covers the Earth and acts as a shield against ultraviolet radiation from the Sun. It is like an invisible but well-built shell.

Ultraviolet means nothing to a super high tech robot like me.

All right. How old do you think the ozone layer is?

Let me see ... I guess it had been formed long before the first human was born.

The Earth is about 4.6 billion years old. The ozone layer is believed to have been created about 400 million years ago.

Ozone had already existed before the age of dinosaurs, from 250 million to 65 million years ago. The ozone layer formed slowly over billions of years!

That's right! Thanks to the ozone layer, life on Earth was made possible. Without it, there would be no life. Mirubo, you are not the exception.

What will happen if ozone in the ozone layer decreases?

Well, more ultraviolet radiation would come to the Earth and may cause severe damage to life.

Ultraviolet radiation can cause sunburn. You will be charred, Mol.

Nooo!

It will be even worse. Ultraviolet radiation destroys DNA and increases the risk of skin cancer. It has also been shown that proteins in the eye's lens can be damaged by being exposed to excessive ultraviolet light, which will result in cataracts. A cataract causes cloudy or blurry vision.

Oh, I am very worried about the ozone layer. How is it surveyed? It lies so high above us.

Do you have an alien colleague to ask to observe the ozone layer from a UFO?

Not exactly, but something like it.

Really?? I was just kidding ...

We have satellites for observing the ozone layer from space. They are encircling the Earth and measuring ozone over Japan, Europe, Antarctica, etc.

Are there any other ways?

Yes. Ground observations give data of the status of ozone even at high altitudes. We use laser radars or other measures of detecting radio waves emitted by ozone. Instrument malfunctions can be corrected much easier on the ground than in space.

I got it! A repair shop should be set up in space for satellites and for myself. If there is, a space trip will become more comfortable for me.

Oh, keep to the point, Mirubo.

Magical Experiment on Ozone

I hope you have enjoyed the scientific adventure trip of Mol and Mirubo. We are currently facing two ozone problems. One is ozone depletion in the stratosphere causing the ozone hole. The other is an increase in tropospheric ozone, which is a component of photochemical smog. Now, I will show you a magical experiment for understanding more about ozone.

What I need is an orange I bought at a nearby supermarket and a glass flask like those you find in a laboratory of your school. Both are nothing special. First, peel the orange and drop a few pieces of the rind into a flask. Photo 1 was taken just after doing this. Do you say "nothing changes"? Be patient! About 30 seconds later, white smoke appears (see Photo 2)!! What happens in the flask, and what makes the white smoke?

Photo 1 Drop orange peels into the flask, and wait 30 seconds.

Photo 2 There is smoke without fire!

Before answering these questions, I will explain about photochemical smog. Have you seen distant mountains covered by whitish or brownish haze that stops you taking scenic photos for souvenirs? This haze, which happens more frequently in some big cities in the world, is closely related to smog (see Photo 3). Smog changes its color and thickness hour to hour, and its frequency varies by the time of day and even year. Such weather conditions as sunlight intensity, wind direction, etc. affect the occurrence of smog.

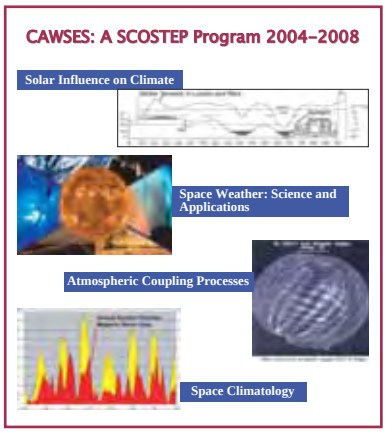
Smog is made of hydrocarbons and nitrogen dioxide emitted by industries or vehicles, and ozone. A complex set of chemical reactions involving hydrocarbons and ozone forms smog. Small particles are found in smog, and they scatter light. That is why the visibility of distant objects decreases. Smog can irritate your eyes and throat. It is also said to be harmful to all living things, for example, scorching leaves.

Now, let's get back to the point. There are no gimmicks or tricks in the magical experiment. Actually, I put a small amount of ozone into the flask in advance. Ozone is a colorless gas and cannot be seen as Photo 1 shows. Orange peel gives a chemical of the hydrocarbon family, limonene, which is a source of the invigorating scent we smell when we eat an orange. The chemical reaction between ozone and limonene created the smoke in the flask. This is a model of how smog is formed!

Photo 3 Smog in Seattle. A brownish haze hangs around above the horizon.

On the ground, hydrocarbons are emitted by industries and vehicles, and produce photochemical smog by reacting with ozone. Scientists around the world are working to understand its detailed mechanism.

WARNING: THIS EXPERIMENT IS POTENTIALLY DANGEROUS. DO NOT TRY TO PRACTICE IT WITHOUT PROPER SUPERVISION!



Climate and Weather of the Sun-Earth System (CAWSES)

CAWSES is an international program sponsored by SCOSTEP (Scientific Committee on Solar-Terrestrial Physics) and has been established with the aim of significantly enhancing our understanding of the space environment and its impacts on life and society. The main functions of CAWSES are to help coordinate international activities in observations, modeling and theory crucial to achieving this understanding, to involve scientists in both developed and developing countries, and to provide educational opportunities for students at all levels. The CAWSES office is located at Boston University, Boston, MA, USA. The four science Themes of CAWSES are shown in the figure.

http://www.bu.edu/cawses/
http://www.ngdc.noaa.gov/stp/SCOSTEP/scostep.html

Solar-Terrestrial Environment Laboratory (STEL), Nagoya University

STEL is operated under an inter-university cooperative system in Japan. Its purpose is to promote "research on the structure and dynamics of the solar-terrestrial system," in collaboration with a number of universities and institutions both in Japan and abroad. The Laboratory consists of four research Divisions: Atmospheric Environment, Ionospheric and Magnetospheric Environment, Heliospheric Environment, and Integrated Studies. The Geospace Research Center is also affiliated to the Laboratory to coordinate and promote joint research projects. At its seven Observatories/Stations, ground-based observations of various physical and chemical entities are conducted nationwide.

http://www.stelab.nagoya-u.ac.jp/

はやのん Hayanon

Graduated from the Department of Physics of Ryukyu University, Hayanon, a writer and cartoonist, has contributed a number of serials in popular magazines on the basis of her strong background in science and computer games. Her consistent writing style, expressing a love for science, is well accepted.

http://www.hayanon.jp/

子供の科学 Kodomo no Kagaku (Science for Children)

Kodomo no Kagaku, published by the Seibundo Shinkosha Publishing Co., Ltd. is a monthly magazine for juniors. Since the inaugural issue in 1924, the magazine has continuously promoted science education by providing various facets of science, from scientific phenomena in everyday life to cutting edge research topics.

http://www.seibundo.net/

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