What is Global Warming?!

By **Hayanon**
Translated by Y. Noda and Y. Kamide
Supervised by A. Mizuno

Monologue of a Mammoth

Hi. I am a mammoth. My genus existed from around 3 million years ago to 10,000 years ago. Do you know that remains of a frozen mammoth excavated in Siberia were displayed at the 2005 World Exposition in Aichi, Japan? To my delight, as many as about 7 million visitors came to see the display!

Although we resemble modern elephants, it is said that we were not their immediate ancestors. Some of our species were covered with long hair and were able to survive throughout the Ice Age.

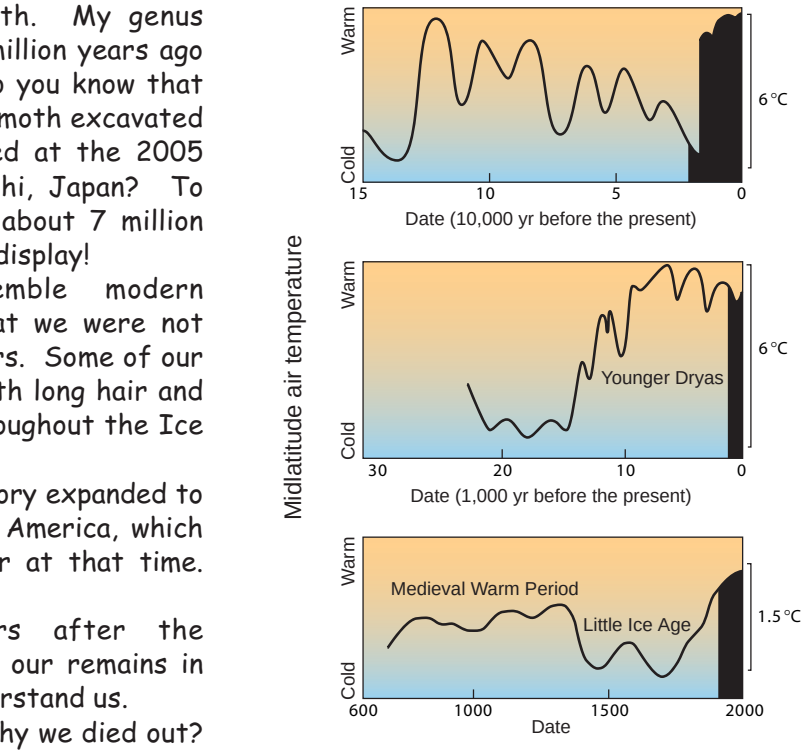
The mammoths' territory expanded to Europe, Asia, and North America, which were connected together at that time. Then we disappeared.

Thousands of years after the extinction, people found our remains in Siberia and came to understand us.

Do you ever wonder why we died out? There seem to be two possible reasons. One is that extinction is the result of global warming. Grasslands and ponds were replaced by coniferous forests due to the temperature rise after the Ice Age. The plants we lived on were gone.

I have heard that you, humans, are responsible for the acceleration of global warming by emitting more carbon dioxide and methane. I really hope that you will not suffer from food shortages like we did. Luckily, though, global warming can be minimized by your efforts and ingenuity.

People and mammoths coexisted in ancient days. Paintings of the mammoths on the cave walls in Europe are believed to date back to the Paleolithic era.
(http://www.grottederouffignac.fr/)



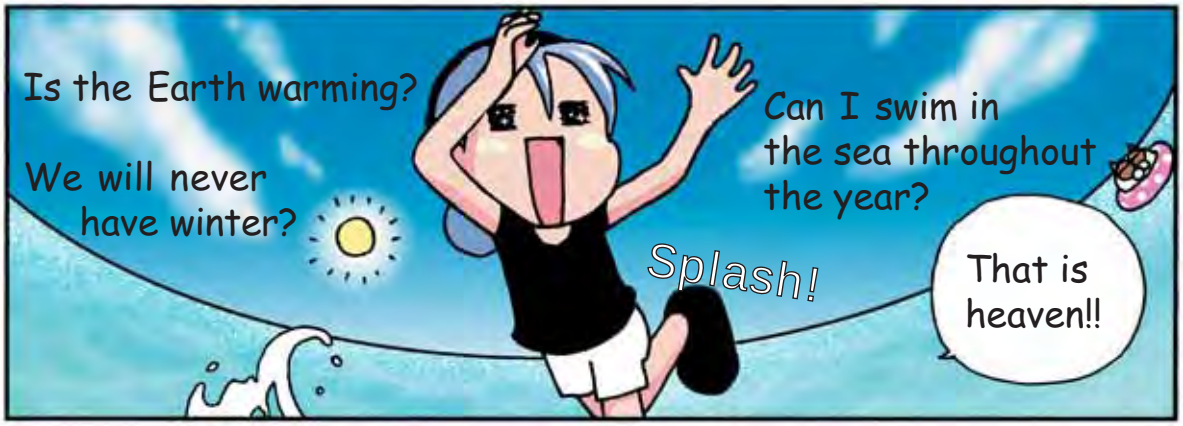
Climate Change (Adapted from "Webb, III, T. et al., in Global Change, Cambridge Univ. Press, 1985")

The other theory for our extinction is overhunting by humans. They sometimes act, driven only by their own desires, jumping over a line which should not be crossed. Please remember the value of all life on Earth and the preciousness of the Earth's environment.

The whole world needs to tackle the problem of global warming instead of pursuing their own interests in order to head off an irreversible crisis.

Also, if the globe keeps warming, my bed will be melted! That is really a problem. Now, I have talked enough. I am going back to sleep. Bye for now. Zzz ...

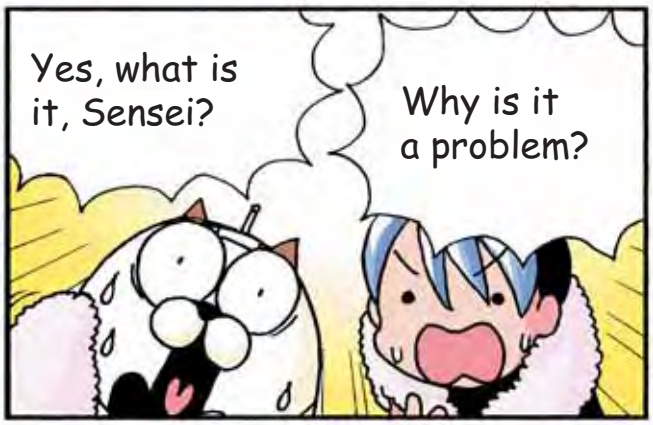

It is a rainy day today.
Our familiar friends, science lover Mol and her robotic dog Mirubo, are stuck in the house, doing nothing but watching TV.
STEL
Mom said summer is coming soon ...
... but why is it so cold?
I really miss the sunshine. Go away rain, and hurry up summer!
Now, we have a report on global warming ...
What?
Global warming?!


Is the Earth warming?
We will never have winter?
Splash!
Can I swim in the sea throughout the year?
That is heaven!!


I don't think so, Mol. Global warming must be something bad.
Why?
Everyone is happy in the warm weather.
They say it is a "problem."


We should ask Sensei!


Hi kids! Are you interested in global warming?
Pat


Yes, what is it, Sensei?
Why is it a problem?


That is not an easy question to answer.
Let's begin with thinking what will happen ...
... following global warming.

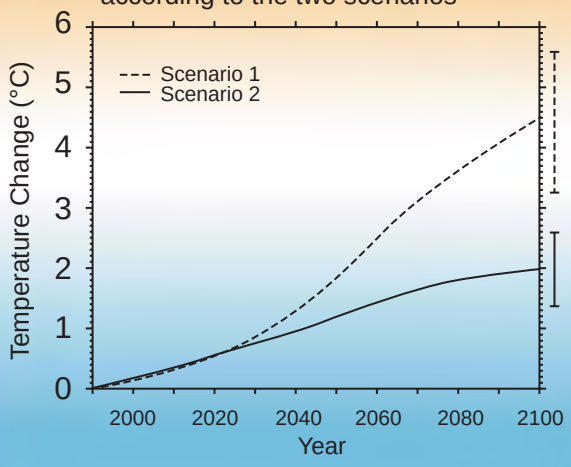
During the past 4.6 billion years, the Earth has gone through climate changes over and over. The Earth, a magma ocean at the beginning of its history, has alternately experienced ice ages and warm periods.

It is currently in the slow-paced warming period that started 20,000 years ago.

This is a simulation result, calculated by a supercomputer, on how global temperature will change over the next century.

It shows an increase of about 1 to 5 °C.

Global Temperature Change from 1990 to 2100, according to the two scenarios*



Modified from "Climate Change 2001: Contribution WG I to IPCC 3, J. T. Houghton et al. (eds.), Cambridge Univ. Press, 2001"

Is it only about 5 °C?

We can ignore such a slight change.

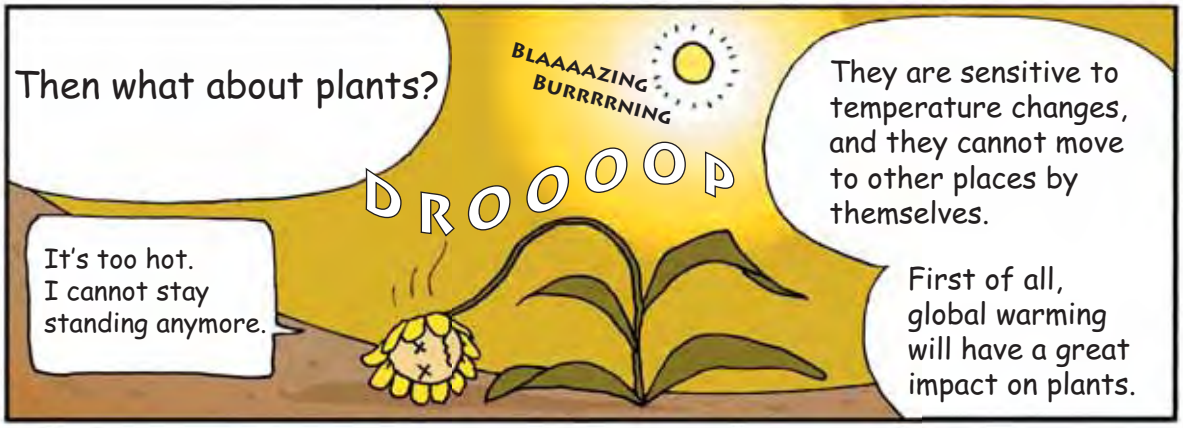
Actually, we could find ways to adjust ourselves to either extremely warm or cold weathers.

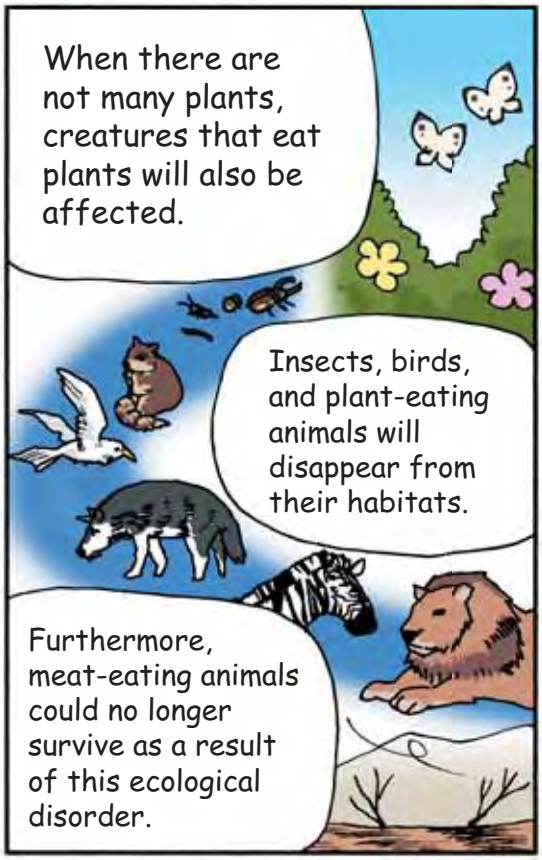
Other animals may migrate to comfortable places to live.

Move to ...

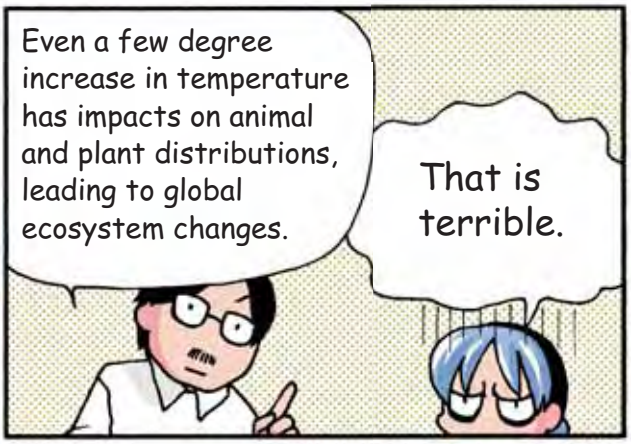
... a new world, folks.

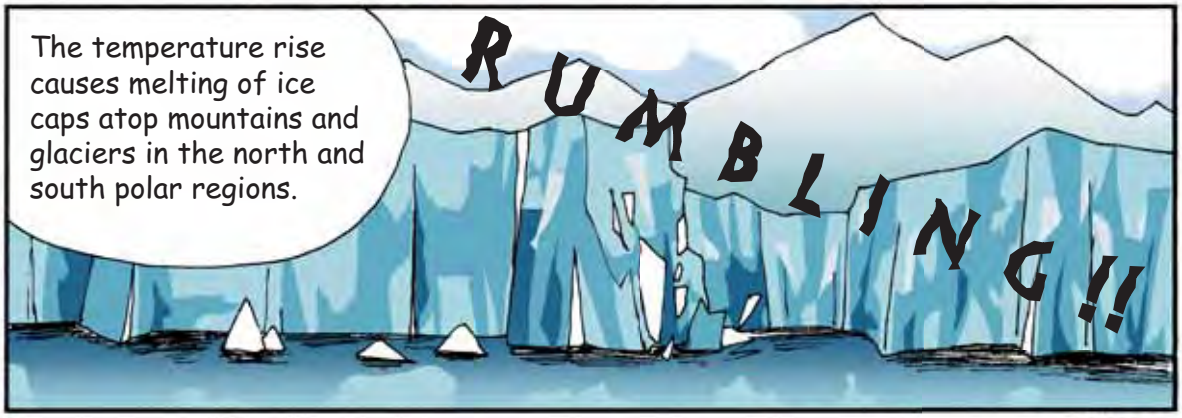
* Bars on the right show the range in the temperature in 2100 produced by two different models.
Scenario 1: A future world of rapid economic growth with technological emphasis on fossil fuel-intensive energies.
Scenario 2: A world with the introduction of clean and resouce-efficient technologies emphasizing environmental sustainability.

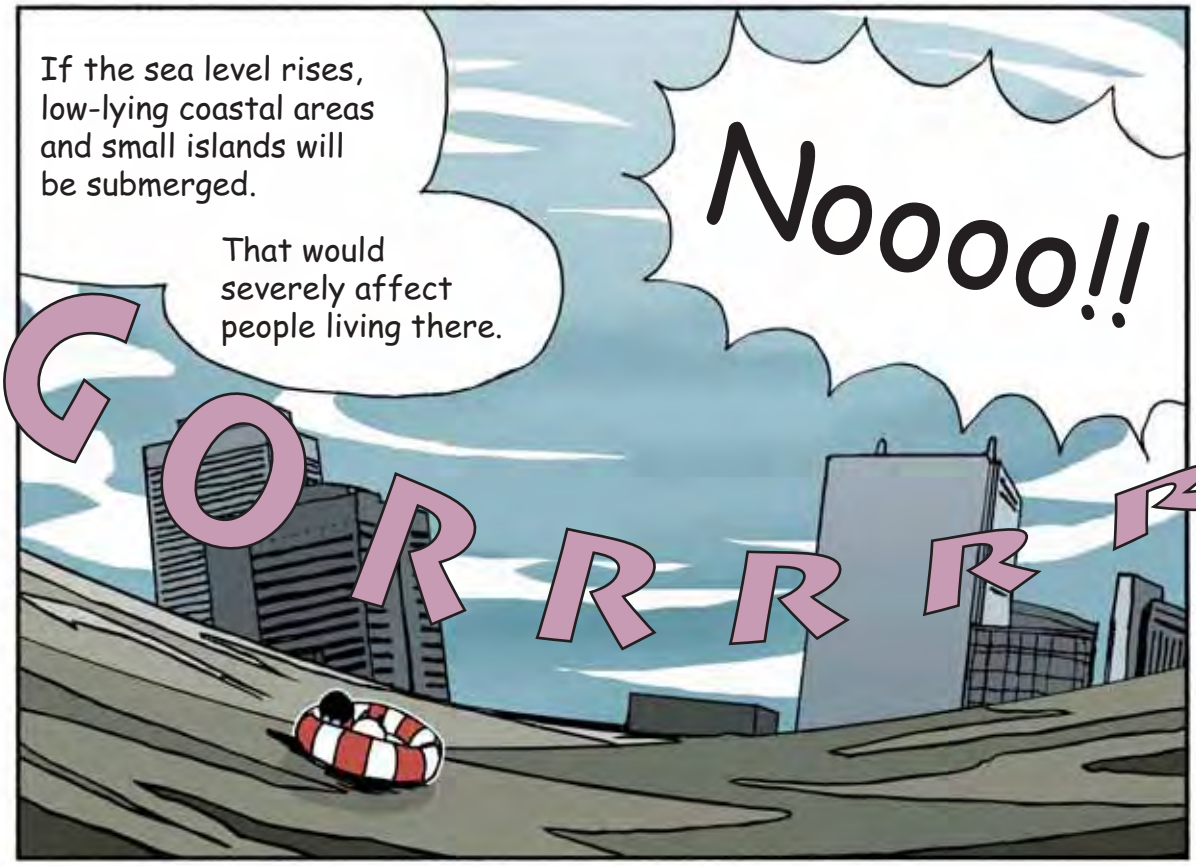

Then what about plants?
BLAAAAZING
BURRRRNING
DROOOOP
It's too hot.
I cannot stay standing anymore.
They are sensitive to temperature changes, and they cannot move to other places by themselves.
First of all, global warming will have a great impact on plants.

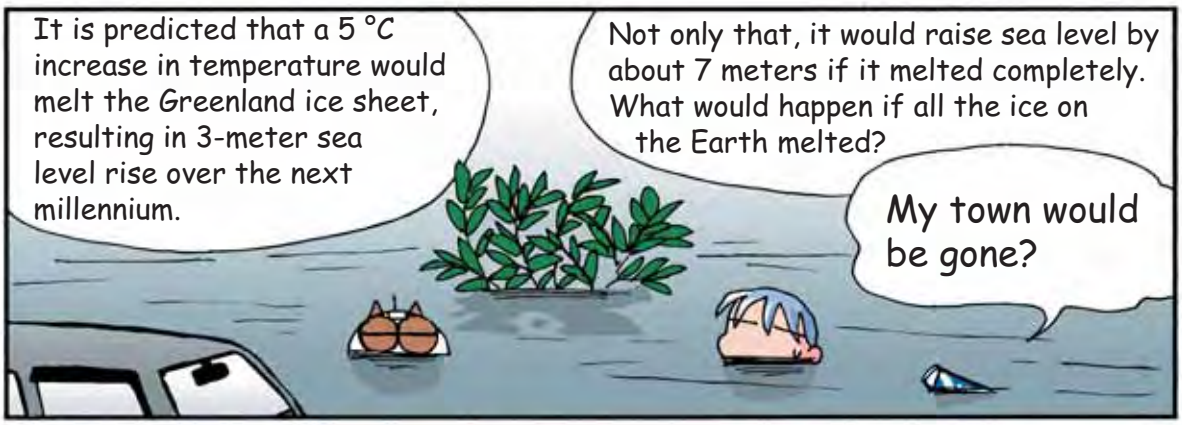

When there are not many plants, creatures that eat plants will also be affected.
Insects, birds, and plant-eating animals will disappear from their habitats.
Furthermore, meat-eating animals could no longer survive as a result of this ecological disorder.

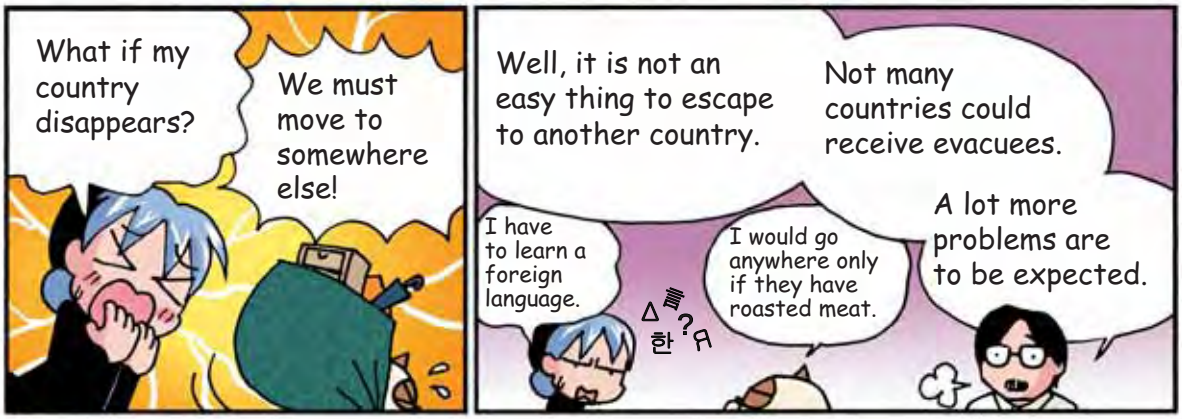

It is anticipated that we will face a serious shortage of agricultural foods.
This will impact livestock as well as crop harvests.

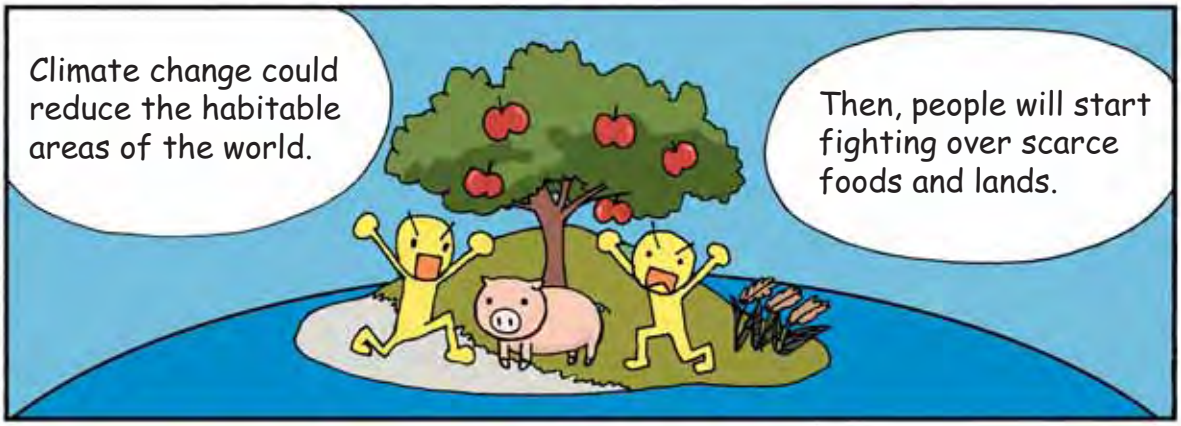

Even a few degree increase in temperature has impacts on animal and plant distributions, leading to global ecosystem changes.
That is terrible.

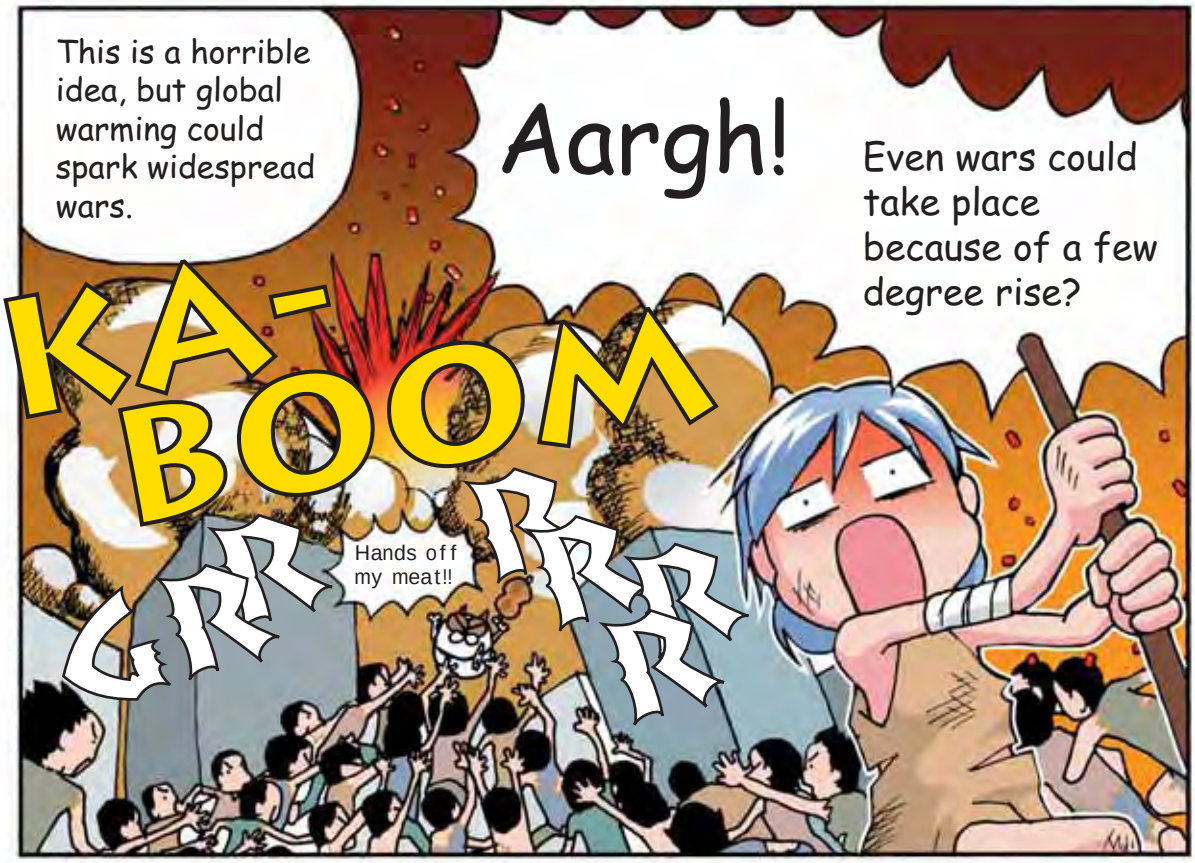

The temperature rise causes melting of ice caps atop mountains and glaciers in the north and south polar regions.
RUMBLING!!

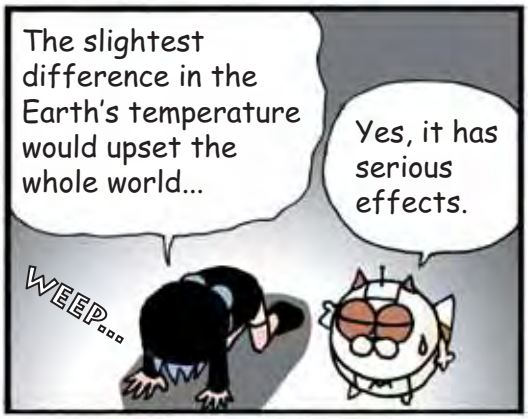

If the sea level rises, low-lying coastal areas and small islands will be submerged.
That would severely affect people living there.
Noooo!!
GORRRR


It is predicted that a 5 °C increase in temperature would melt the Greenland ice sheet, resulting in 3-meter sea level rise over the next millennium.
Not only that, it would raise sea level by about 7 meters if it melted completely. What would happen if all the ice on the Earth melted?
My town would be gone?

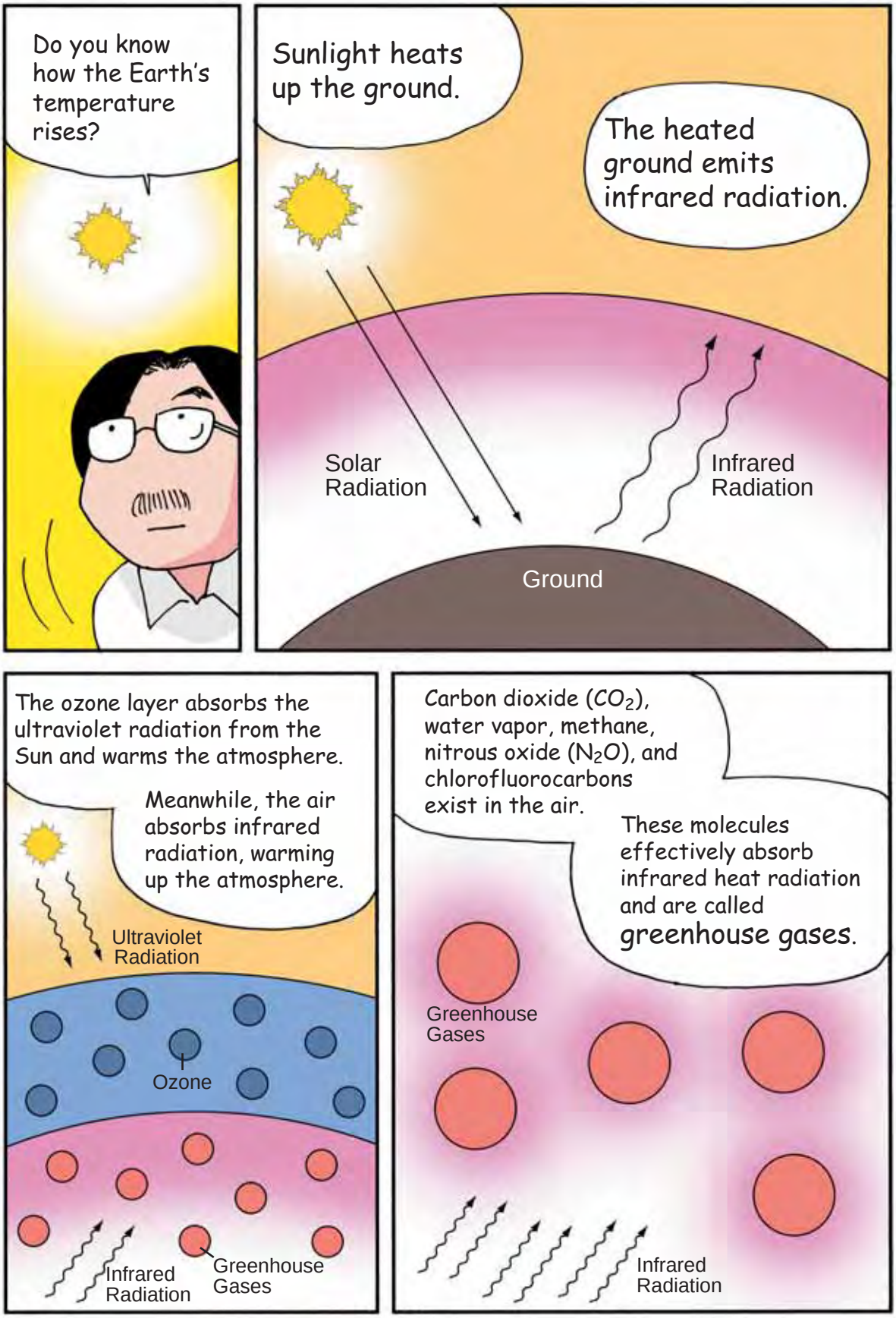

What if my country disappears?
We must move to somewhere else!
Well, it is not an easy thing to escape to another country.
Not many countries could receive evacuees.
A lot more problems are to be expected.
I have to learn a foreign language.
I would go anywhere only if they have roasted meat.
ㅿ?ㅁ
한


Climate change could reduce the habitable areas of the world.
Then, people will start fighting over scarce foods and lands.


This is a horrible idea, but global warming could spark widespread wars.
Aargh!
Even wars could take place because of a few degree rise?
KA-BOOM
GRR
Hands off my meat!!
RRR
RR


The slightest difference in the Earth's temperature would upset the whole world...
Yes, it has serious effects.
WEEP...

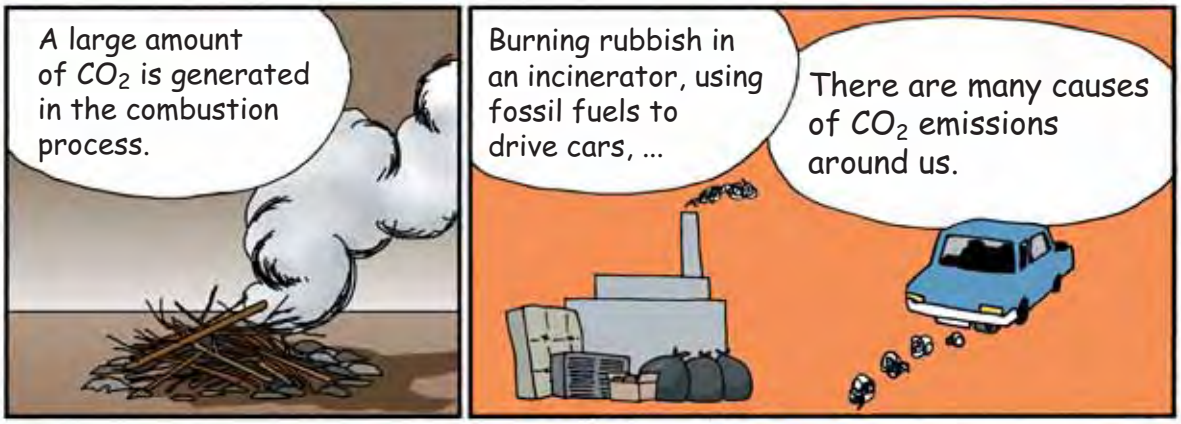

It is not time for tears.
We have to do something to stop global warming.
Let's begin with understanding its mechanism. Please explain it to us, Sensei.


Do you know how the Earth's temperature rises?
Sunlight heats up the ground.
The heated ground emits infrared radiation.
Solar Radiation
Infrared Radiation
Ground
The ozone layer absorbs the ultraviolet radiation from the Sun and warms the atmosphere.
Meanwhile, the air absorbs infrared radiation, warming up the atmosphere.
Ultraviolet Radiation
Ozone
Infrared Radiation
Greenhouse Gases
Carbon dioxide (CO_2), water vapor, methane, nitrous oxide (N_2O), and chlorofluorocarbons exist in the air.
These molecules effectively absorb infrared heat radiation and are called greenhouse gases.
Greenhouse Gases
Infrared Radiation

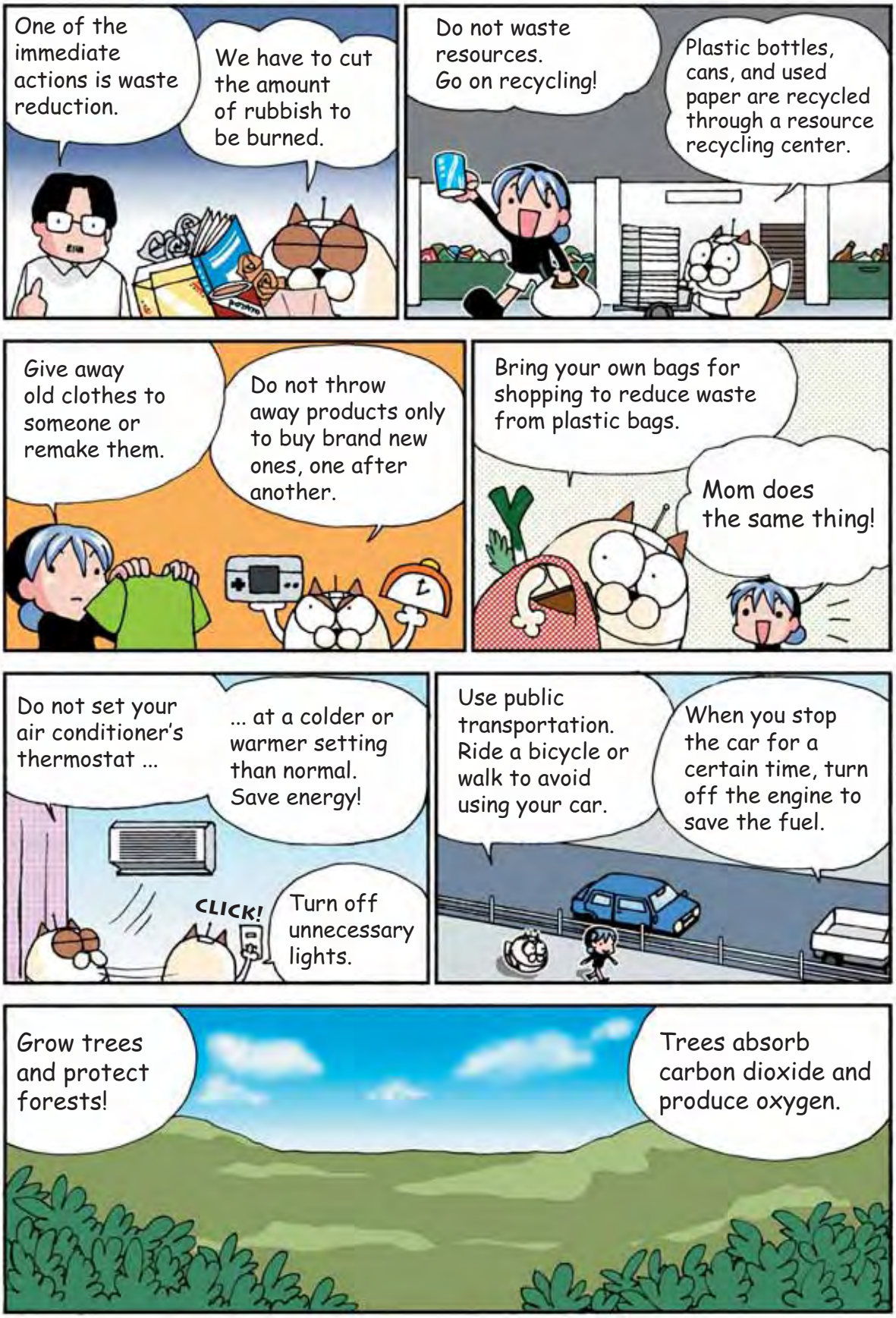

They are our enemies!!
Fight off greenhouse gases!
Listen, kids. Those gases play an important role in keeping our planet at comfortable temperature.
Without them, Earth would be a frozen, ice planet.
FREE ZING
Greenhouse gases form a "blanket" around the Earth and keep it warm.
The problem is an excessive increase of those gases.
Can you imagine how warm it is to be covered by many layers of blankets?
The Earth is acting just like that. It is becoming warmer and warmer inside the blankets.
The Sun's heat keeps coming, but the heat is trapped by blankets and cannot escape.
Oh, it is so hot!
STEEEAMING
I feel like I am in a greenhouse!

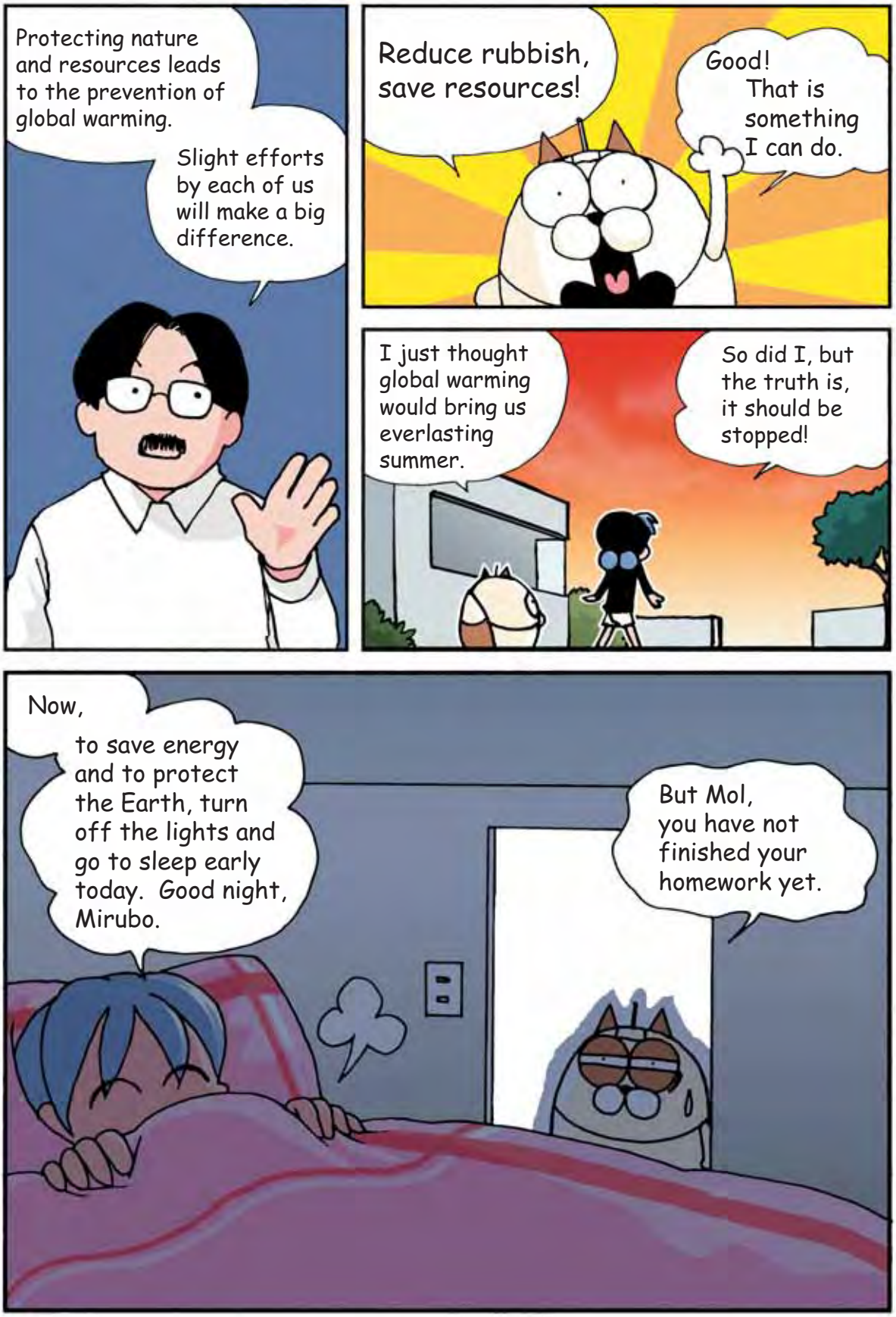

The Earth is getting warmer and warmer.
Remove the blanket, pleeease!
PUFF PUFF
What can I possibly do?!
Do you know any solution?


Many of greenhouse gases are emitted by human activities.
We have to try to reduce the human-originated gas emissions with our efforts and ingenuity.


A large amount of CO_2 is generated in the combustion process.
Burning rubbish in an incinerator, using fossil fuels to drive cars, ...
There are many causes of CO_2 emissions around us.


By reducing emissions, global warming can be prevented.
STOP
What exactly can be done?
Can we help stop such a big problem?


One of the immediate actions is waste reduction.
We have to cut the amount of rubbish to be burned.
Do not waste resources. Go on recycling!
Plastic bottles, cans, and used paper are recycled through a resource recycling center.
Give away old clothes to someone or remake them.
Do not throw away products only to buy brand new ones, one after another.
Bring your own bags for shopping to reduce waste from plastic bags.
Mom does the same thing!
Do not set your air conditioner's thermostat ...
... at a colder or warmer setting than normal. Save energy!
CLICK!
Turn off unnecessary lights.
Use public transportation. Ride a bicycle or walk to avoid using your car.
When you stop the car for a certain time, turn off the engine to save the fuel.
Grow trees and protect forests!
Trees absorb carbon dioxide and produce oxygen.


Protecting nature and resources leads to the prevention of global warming.
Slight efforts by each of us will make a big difference.
Reduce rubbish, save resources!
Good! That is something I can do.
I just thought global warming would bring us everlasting summer.
So did I, but the truth is, it should be stopped!
Now,
to save energy and to protect the Earth, turn off the lights and go to sleep early today. Good night, Mirubo.
But Mol, you have not finished your homework yet.

What is Global Warming?!


On TV and newspapers everyone talks about global warming. They say gasoline cars cause the problem and that the gasoline tax needs to be increased to stop it.


Gee, you are so smart, Mol! Greenhouse gases such as CO_2 and methane emitted from burning fossil fuels contribute a lot to global warming. Various measures are studied to cut those gases. The introduction of "environmental tax" on oil and coal is one of them.


When did the Earth start warming?


The Earth has gone through warm and cold climates in cycles that last thousands of years or tens of thousands of years since its birth about 4.6 billion years ago. The Earth is currently thought to be in a warm period, from the viewpoint of long-term climate changes.

However, greenhouse gas emissions including CO_2 have increased especially since the Industrial Revolution began around 1750. The recent warming trend reflects its impacts.


I know that the invention of the steam engine led to the rapid industrial development. Coal provided the power to drive the steam engines!

Thanks to inventions during this period, our life has become full of conveniences. Is that a cause of global warming?! We did not need the Industrial Revolution at all?!


Wait! I, and even TV, would not exist without those inventions.


Our present life has been established based on people's achievements of that time. They, however, never imagined we would face the crucial problem resulting from their inventions.

Chlorofluorocarbons (CFCs) are another example of what had provided us with convenience but later turned out to be harmful. CFCs, used in air conditioners, are found to destroy the ozone layer.

In 1898, a Swedish chemist S. Arrhenius suggested that CO_2 could cause global warming. The issue then began to be discussed at the U.S. Congress in the 1980s, and soon became of worldwide concern.


What will happen if the Earth keeps warming?


Scientists make predictions based on various scenarios. They say that the temperature will rise about 1 to 5 °C in the next 100 years.


Is that all?? We can ignore that.


No. Even though the rise would not be severe enough to directly kill animals, it could cause ecological disorder. Global warming could reduce crop yields as well as plants which animals depend on.

It would also cause sea levels to rise by melting glaciers. Most parts of low-lying islands like Maldives will be submerged. The occurrence of extreme weather events such as heat waves and typhoons is estimated to increase.


That is a big problem! What can we do to avoid that?


The whole world needs to tackle global warming together. An international conference is annually held to try to reduce greenhouse gas emissions.

Every one of us is also able to contribute to stopping the problem through energy saving. Setting your air conditioner's thermostat to a moderate temperature, or turning off the engine while parking, for example. Many small things make a great difference.


I have an idea! I will use a smokeless BBQ grill from now on. That could reduce CO_2 emissions.


Well, I do not know whether that works, maybe so ...

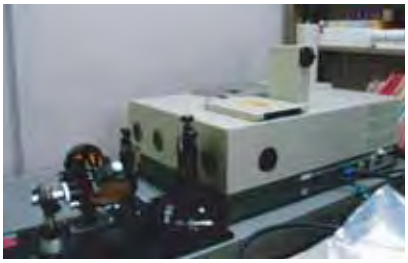
How to Measure Greenhouse Gases

Do you know that the content of greenhouse gases such as CO_2 and methane in the air is only a tiny bit? CO_2 accounts for 0.03% of the air, and the level of methane is only 1.7 ppm (parts per million). Because they have enormous impacts on climate changes despite their low content, an accurate measurement of those gases is essential.

In 1958, a U.S. scientist C. D. Keeling and his colleagues started measurement of CO_2 as the major greenhouse gas at an observatory on the top of an about 4,000 meter-high mountain called Mauna Loa in Hawaii.

A nondispersive infrared analyzer is used for the observation. This analyzer measures CO_2 concentration by making use of the gas's nature of absorbing infrared radiation. In more detail, infrared absorption intensities are measured alternately for two gas samples; one is the air sampled from the outside and the other is a reference gas whose CO_2 abundance is known. The CO_2 concentration is derived from the difference of the absorption intensities.

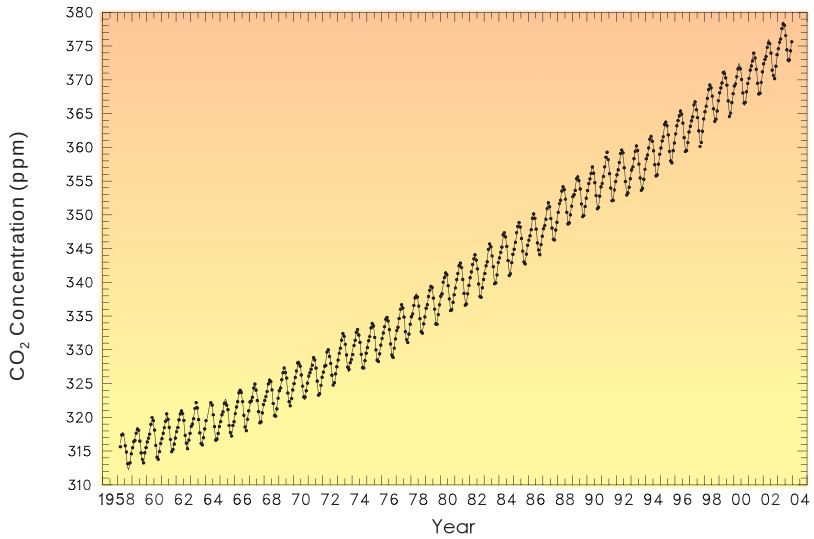
While the above method provides "in-situ" analysis of CO_2 concentration, "remote" data can be obtained using an instrument named Fourier Transform Infra-Red Spectrophotometer (FTIR). CO_2 in the atmosphere absorbs sunlight at some specific infrared wavelengths determined by the molecular structure of CO_2. Such a discrete absorption feature is called an absorption line. In the FTIR measurements from the ground, the spectrometer directly looks at the Sun, and the CO_2 concentration is derived from the intensity of the absorption lines.



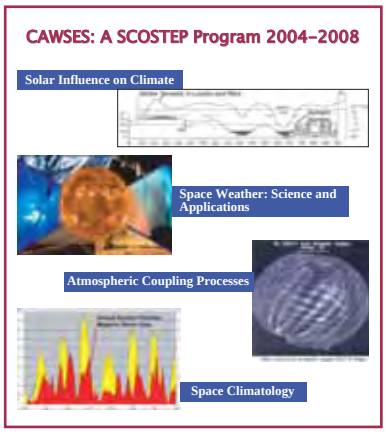
A compact FTIR measures atmospheric CO_2 concentration.

There is an ongoing project to make observations of greenhouse gases in the Earth's atmosphere from space! Satellite-borne FTIR is to obtain two types of infrared spectra. One is reflected by the Earth's surface after being radiated from the Sun, and the other is radiated from Earth itself.

With the aim of studying changes in the Earth's CO_2 concentration in a broader perspective, the GOSAT satellite of Japan and the U.S. OCO satellite carrying a diffraction-grating infrared spectrometer are scheduled for launch in 2007.



CO_2 Concentration Observed at Mauna Loa, Hawaii (Source: C. D. Keeling et al., Scripps Institution of Oceanography, University of California at San Diego)



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 Kids)

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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