Basic English for Science and Technology

by
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PRINTED IN JAPAN

近年において、国家間の相互依存関係がますます緊密化しつつある国際社会の中で、わが国は実に様々な分野にわたって大きな役割を果たすようになってきました。とりわけ、先端技術を駆使する理科系の分野においては、世界のリーダーの仲間入りをして以来、依然としてその座を維持し続けています。

本書は、このような社会情勢の中で、大学生の皆さんの英語テキストとして、書かれたものです。文体は平易でわかりやすく、内容も目先のできごとをジャーナリスティックに追うのではなく、より根本的で普遍的な、『スペース・シャトル』から、『太陽系への冒険旅行』、『コンピューターの功罪』、『長寿は特権』、『人体のしくみ』、『衛星が宇宙を飛行できるのは?』などに至るまで、バラエティーに富み皆さんの知的好奇心を刺激するようなテーマをとくに選んであります。また、本文各ページの右側には、本文中の重要単語・熟語のよりわかりやすい英語への言い換え、日本語での説明があり、英語のリーディングそのものをより楽しんでもらえるように工夫してあります。さらに、各章末の問題は、英検対策になることをも十分に考慮したテキストとなっています。

本当の読解力とは、一つ一つのテーマを暖めることによって生まれます. どうか、内容を楽しんでいただき、その結果として皆さんが英語により親しみを感じ、 読解力を伸ばすことができるならば、著者としてこれに勝る喜びはありません。

本書執筆にあたり、佐々木政子博士(東海大学総合科学技術研究所教授)を初めとして、Garold Murray 先生、Lewis Malamed 先生、Rosalind Whalley 先生、Paul Daniels 先生(東海大学外国語教育センター講師)から貴重なコメント、暖かい励ましのお言葉を頂戴いたしました。この場をお借りし、心より御礼申しあげます。また、東海大学における私共の教え子、生路茂太、園 華児、近藤雄介、坂本淳子、那須祐介、長崎伸一、山田 圭、各諸君、さらに Marjorie Faudree-Meluch (米国オハイオ州クリーブランド在住)、そして藤牧家の喜久子、望、友にも感謝の気持ちを捧げたいと思います。

最後に,本書の計画段階から執筆終了に至るまで,大らかにそして暖かく御指導いただきました英宝社編集部長,宇治正夫氏に衷心より深く感謝申しあげます.

マイケル・C・フォードリー 藤牧 新

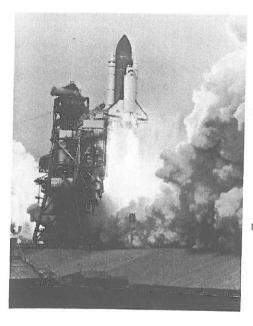
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1. Space Shuttle: Today is Lift-off Day!

スペースシャトル――今日は打上げの日

This chapter tells about the space shuttle's journey: from lift-off to orbit in space. It also describes some things about living in the zero gravity of space. Vocabulary helps the reader with the English of the space shuttle parts.



Today is lift-off day at the NASA Kennedy Space Center. The space 5 shuttle sits on the launch pad ready to take off. We can see the large orange tank that carries liquid hydrogen (H₂) and oxygen (O₂). This is called the "external fuel tank". Also we can see the

15 two white rockets, called the "solid rocket boosters". These send it into space. Before lift-off the astronauts are in their seats looking up to the nose of this giant spaceship.

The countdown has begun. "... 10, 9, 8, 7..." Six seconds before takeoff, the shuttle starts to shake and make noise, much like an earthquake. This is when over two million liters of liquid hydrogen and oxygen go to the three main engines. One second later, all the main engines light up. The shuttle comes alive.

- 6 launch pad: place where the space shuttle lifts off
- 7 take off = lift-off; blast off
- 9- liquid hydrogen 「液体水素」
- 11 liquid oxygen 「液体酸素」
- 13 external (adj.)「外側 の」↔ internal (adj.) 「内側の」 fuel tank 「燃料タンク」
- 15 solid rocket booster 「固体ロケットブー スター」
- 16 **astronaut** (*n*.) = people who go to space
- 20 **shake** (v.) 「振動する」
- 21 earthquake (n.) 「地震」
- 22 two million = 2,000,000
- 23 main engines: the three large engines of the space shuttle

The computers check if the engines are working properly. "...5, 4, 3, 2, 1..." Next, the two white rockets light up. Each of these rockets has 500,000 kg of solid fuel. We see smoke and fire as the shuttle goes up into the 5 sky. We have lift-off!

One minute after lift-off, the astronauts feel maximum force. This is called "Max-Q". "Max-Q" is at 3Gs, or three times Earth's gravity. So if you weigh 70 kg, you suddenly weigh 210 kg.

Then, two minutes after lift-off, the shuttle's speed is 4,800 km/hr and it is riding 48 km above the Earth. At this time, the two white rockets are jettisoned from the shuttle, and drop back to Earth. These "solid rocket boosters" are reusable. They are found in the ocean by radar. Ships bring the two rockets back to the Kennedy Space Center so they can be used again.

Six minutes after lift-off, the sky turns from blue to black. This is because there is no air high above the Earth. Soon we see pens, books, and paper floating inside the shuttle. We have zero gravity! Now we're in space!

Later, at an altitude of 110 km above the Earth, the empty orange tank drops away and falls back to Earth. It is non-reusable. It burns up in the Earth's atmosphere.

Next, the OMS (Orbital Maneuvering System) engines are turned on to put the shuttle into orbit. The OMS engines are smaller than the main engines. The shuttle orbits the Earth at 28,000 km/hr. This speed is nearly 10 times faster than a bullet from a gun, but yet, the crew is safe.

During orbit, the shuttle carries out its mission. For example, satellites are put into space. The Hubble Space Telescope and space stations may need work. Universities do zero gravity research experiments. People walk in space if needed.

If you look out the window, you may see a spectacular sunrise. Every day, or 24 hours, the astronauts see 16 sun-

- 3 **500,000 kg:** In English, "five hundred thousand kilograms"
- 3- solid fuel 「固体燃料」
- 7 **force** (n.) 「物理的な力」
- 11 **4,800 km/hr:** In English, "four thousand eight hundred kilometers per hour"
- 12 **jettison** (v.) 「分離する」
- 14 **reusable** (*adj.*) = can be used many times
- 19 float (v.) 「浮く」
- 20 zero gravity「無重カー
- 21 **altitude** (*n*.) = distance above the Earth (km)
- 22 **empty** (*adj*.) = nothing inside
- 23 non-reusable (adj.) = can only be used once burn up (v.)「燃え続ける」
 atmosphere (n.) = air around the Earth
- 24 OMS engine (n.)「軌 道制御エンジン」 maneuver (v.)「操る」
- 25 orbit (n.)「軌道」
- 28 **crew** (n.): people in the space shuttle; the astronauts
- 29 **mission** (n.) = work;
- 30 satellite (n.)「衛星」
- 32 experiment (n.) 「(科学の)実験」
- 34 **spectacular** (*adj*.) = beautiful
- 35 sunrise (n.) 「日の出」

rises and sunsets as they go around the Earth.

How is life in space? Living in zero gravity is much different from living on Earth. Everything floats.

First, there are no beds to sleep in. Some astronauts choose special sleeping compartments. Others just float or hold onto something. A special type of tape called "Velcro" is used to stop things from moving around inside the shuttle.

Eating, of course, is different. Foods are in paste form so they don't float away. Salt and pepper are used in liquid form. The shuttle does not carry water. Water and electricity are made from hydrogen and oxygen. Straws are used to drink the water.

After eating, cleaning up is very important. Dishes are disposable. Spoons and hands are cleaned with wet disinfectant paper towels. People are careful so food doesn't float inside the space shuttle.

Before bed, the astronauts don't take a shower or bath. They use the wet disinfectant towels to clean themselves.

When the astronauts finish their work in space, they return back to our home, the Earth.

1 sunset (n.) 「日没」

- 7 Velcro (n.) 「マジックテープ, ナイロン製の目のあらい縄と 鈎で, 互いに付着する面ファスナー」
- 9 **paste** (*adj*.)「ペースト; 糊」
- 15 **disposable** (adj.) = can be thrown away 15- **disinfectant** (adj.) 「殺菌効果のある」

Comprehension Questions

i i i		
	1.	What are the "solid rocket boosters"? They are
		a) part of the main engines
		b) the rockets of the OMS engines
		c) two white rockets
		d) the big orange tanks that carry hydrogen and oxygen
	2.	What is "Max-Q"? The astronauts feel
		a) minimum force before lift-off, it is at 3Gs
		b) maximum force before lift-off, it is at 3Gs
		c) minimum force after lift-off, it is at 3Gs
		d) maximum force after lift-off, it is at 3Gs
	3.	The OMS (Orbital Maneuvering System) engines
		a) put the shuttle into orbit
		b) are powerful engines used during lift-off
		c) are larger than the main engines
		d) are used when the astronauts want to go to the Moon or other planets
	4.	Which is true? The astronauts in the space shuttle
		a) drink water from a glass
		b) take a bath every night
		c) clean themselves using wet disinfectant paper towels
		d) cannot wash themselves because there is no shower

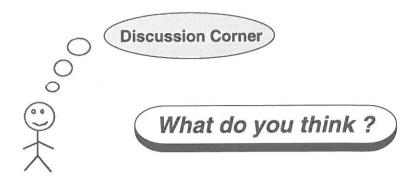
5. What is the main idea of the entire writing?

a) It tells us about living in space.

- b) It tells us about the NASA Kennedy Space Center.
- c) It tells us about going to space and living in space.
- d) It tells us about problems in going to space.

Building Sentences

the "solid rocket	lifts off when the two p boosters" light up. Eac	owerful white rockets called ch (1).
1 fuel 4 rockets	2 of these	3 has 500,000 kg
4 Tockets	5 of solid	
2. As the space shutt	tle goes higher, the (2)	no air high above the Earth.
1 blue to	2 because there is	3 sky
4 turns from	5 black	,
3. The OMS (Orbita Earth. The OMS e	al Maneuvering Systemengines are smaller than	engines (3) around the the main engines.
3. The OMS (Orbita Earth. The OMS e	al Maneuvering Systemengines are smaller than	engines (3) around the the main engines.
Earth. The OMS 6	engines are smaller than	the main engines.
Earth. The OMS of 1 to put 4 the shuttle	engines are smaller than 2 orbit	the main engines. 3 into
Earth. The OMS of 1 to put 4 the shuttle	engines are smaller than 2 orbit 5 are used	the main engines. 3 into



Answer the questions. Then share your answers with other students by speaking.

1. What would you like about living in space? What wouldn't you like? Please write three things for each and why.

1) 2)

3)

2. Would you like be an astronaut in the space shuttle? If you have a bachelor's degree in science (理学士) and three years' work experience, you can apply (応募する). The job name is "mission specialist". If you are chosen, you will spend two years in training. In this training, you will 1) study science subjects, and 2) do zero gravity training. Would you like to try? Please write "Yes" or "No" and "Why".

Find a partner. Ask your partner questions 1 and 2. Then switch.

2. When You Wish Upon a Star . . .

星に願いを・・・

This chapter tells about the life cycles of stars and how they shine so brightly. Vocabulary helps the reader with the English of different types of stars and nuclear fusion reactions inside stars.



If you drive along an Arizona desert highway on a clear, moonless night, you can see thousands, or perhaps, millions of stars. Looking up, you can see our galaxy, the "Milky Way", across the whole sky. This was the same desert sky that people of the Old American West saw. These were the

Native Americans, people looking for gold, gun-slinging cowboys, and of course, outlaws.

Just as people do, stars have life cycles. They are born, and live their lives. How is a star born? Stars are born in clouds of "interstellar" gas and dust called "nebulas". Gas and dust then come together from gravity. The star gets bigger and hotter. Eventually, the temperature reaches about 15,000,000°C. The star begins to glow brightly. Stars come in many colors: red, orange, yellow, blue, and white. Our sun is a yellow type star and will shine for millions or perhaps, billions of years.

- 2 desert (n.)「砂漠」
- 4 moonless night = a night when you can't see the moon
- 5- thousands . . . millions = many
- 8 **galaxy** (n.) = a large group of stars



9 **"Milky Way"** 「天の川」

- 15- gun-slinging cowboys = cowboys who carry and use guns
- 16 **outlaw** (*n*.) = "bad guys"
- 19 interstellar gas 「恒星間のガス」 nebula (n.) 「星雲」
- 20 **gravity** (n.)「重力」 「引力」
- 21 **eventually** (adv.) = finally
- 22 15,000,000°C: In English: "fifteen million degrees Celsius" glow (ν.) = shine

How do stars glow so beautifully in the night sky? It is by "nuclear fusion". "Nuclear fusion" is atoms coming together and releasing energy. In a star's core, or center, hydrogen (H) forms into helium (He). A possible reaction 5 is:

$$_{1}^{2}H + _{1}^{2}H \longrightarrow _{2}^{3}He + _{0}^{1}n + Energy$$

where hydrogen and helium are "chemical elements", and the "¹n" is a neutron. For, "¹H", the top number "2" is the total number of protons and neutrons, or "atomic weight".

The bottom number "1" is called the "atomic number", or number of protons. Different elements have different atomic numbers. Hydrogen (H) has an atomic number of 1; helium (He) has an atomic number of 2; carbon (C), 6; oxygen (O), 8; and so on.

In a star, "nuclear fusion" changes the elements, releasing energy. The hydrogen in the star's core burns for many years.

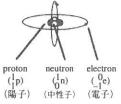
When there is little hydrogen left in a star, the star is at the end of its life. It expands and glows a red color. This is called a "red giant". All stars small, medium, and large, turn into red giants. However, smaller stars change into "small red giants" and larger stars grow into "large red giants". When there is no hydrogen left in the red giant, the star dies.

When a star dies, it collapses. How much mass a star has when it dies determines what it becomes.

Small stars about the size of our sun become "white dwarfs". These stars glow with a white hot light. They are very dense; one teaspoonful weighs the same as a moun30 tain the size of Mt. Fuji!

A medium or a large star will explode into a beautiful "supernova". How does one form? Gravity collapses the star into neutrons. The outer layers explode out into space.

2 nuclear fusion 「核融合」 atom (n.)「原子」

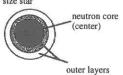


- 3 releasing (adj.) 「解放する」 core (n.)「核」
- 4 hydrogen (H) (n.)
 「水素」
 helium (He) (n.)
 「ヘリウム」
 reaction (fusion) (n.)
 「(核融合) 反応」
- 7 chemical elements 「元素」
- 8 neutron (n.)「中性子」
- 9 proton (n.) 「陽子」 atomic weight 「原子量」
- 10 atomic number 「原子番号」
- 13 **carbon** (C) (n.) 「炭素」
- 14 **oxygen (O)** (n.) 「酸素」
- 19 **expand** (v.) = gets bigger and bigger
- 25 collapse (v.)「崩壊する」

how much mass = kg 29 dense (adj.) 「密集し

- た」
 : has a high density;
- (kg/m³) 31 **explode** (v.)
- 「爆発する」 32 supernova (n.) 「超新星」
- 33 outer layers:

Medium or Large



If closer to Earth, a supernova can be seen in the daytime. But supernovas close to Earth are very rare.

After the supernova, medium size stars contract into "neutron stars". Like white dwarfs, neutron stars are also very dense. They do not glow and cannot be seen with the eye. "Neutron stars" give off radio waves. Sometimes these radio waves come in pulses, i.e., on-off-on-off, etc. This type of neutron star that goes on and off has a special name: "pulsar".

After the supernova, the largest stars turn into "black holes". Black holes give off x-rays. Black holes, scientists believe, can eat space dust, planets, and even other stars. Much knowledge about black holes is still a mystery...

- 2 rare (adj.) = very few; hard to find
- 3 contract (v.) = to get smaller
- 4 **neutron stars** = a star made of neutrons
- 6 give off radio waves: radio waves「電波」 come out of neutron stars
- 9 **pulsar** (*n*.) 「パルサー」
- 10- **black hole** (*n*.) 「ブラックホール |
- 11 give off x-rays: x-rays「放射線」 come out of black holes

Comprehension Questions

1. For ²H, the "2" is ______, and the "1" is ______.

- a) "atomic protons"; "atomic neutrons"
- b) "atomic number"; "atomic weight"
- c) "atomic weight"; "atomic number"
- d) "atomic electrons"; "atomic fusion"

2. What is the main idea of paragraph number five?

- a) When there is little hydrogen left in a star, the star is at the beginning of its life.
- b) It tells us about "blue giant" stars.
- c) When there is lots of hydrogen in the star, it turns into a "red giant".
- d) It tells us about "red giant" stars.

3. Which is true?

- a) Small stars about the size of our sun become black holes.
- b) The largest stars turn into "white dwarfs".
- c) After the supernova, medium size stars contract into "red giants".
- d) A medium or a large star will form into a beautiful "supernova".

4. In the last two paragraphs, which is true?

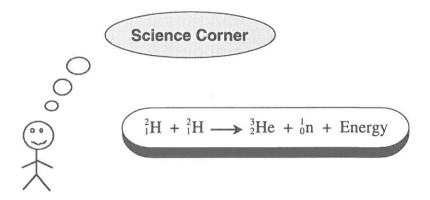
- a) Neutron stars give off x-rays; black holes give off radio waves.
- b) Neutron stars give off radio waves; black holes give off x-rays.
- c) Neutron stars give off sound waves; black holes give off light waves.
- d) Neutron stars give off radio waves; black holes give off sound waves.

5. What is the main idea of the entire writing?

- a) It tells us about life cycles of different size stars.
- b) It tells us about black holes in our "Milky Way" galaxy.
- c) It tells us about parts of the atom.
- d) It tells us about "red giant" stars.

Building Sentences

1. Stars are born (1). This takes million	ns of years.
1 gas and dust	2 gravity	3 come
4 together by	5 when	
2. Stars have their lig	tht from "nuclear fusion	on". (2).
1 is atoms	2 energy	3 "nuclear fusion"
4 and releasing	5 coming togethe	er
. (3), it grows into	a "red giant" type sta	ar.
1 the star	2 there is	3 when
4 little	5 hydrogen left in	1
	supernova. This happ changes into a neutron	ens at the end of a star's life star or a black hole.
1 into	2 large size	3 a beautiful
		. 34 O F ADMICINA OF THE STATE



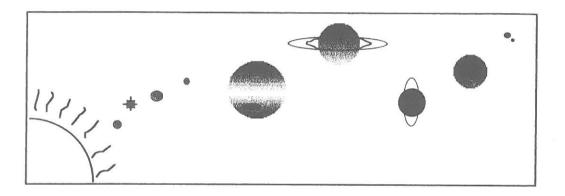
Write the correct answer in each blank. Three answers will not be used.

- 1. Hydrogen (H) and helium (He) are "_____".
- 2. "¹n" is a(n) "______".
- 3. The number "3" in " ${}_{2}^{3}$ He" is the _____.
- 4. The number "2" in " ³₂He" is the ______.
- 5. " ¹²C" (carbon-12) has a(n) _____.
 - (a) number of protons and neutrons
 - (b) number of protons
 - (c) number of neutrons
 - (d) neutron
 - (e) proton
 - (f) atomic number of 12 and an atomic weight of 6
 - (g) atomic number of 6 and an atomic weight of 12
 - (h) chemical elements

3. Adventure to the Planets of Our Solar System

太陽系への冒険旅行

This chapter tells about the different planets of our solar system, from Mercury to the distant Pluto. It also gives information about what makes each planet special. Vocabulary helps the reader with the English of the planets' names, and features.

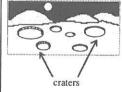


Our solar system has nine planets that orbit the Sun. Let's take a tour and go to each stop.

We begin with Mercury, which is the closest planet to our Sun. Mercury looks like our Moon with its many craters. It is the fastest moving planet, orbiting the Sun in just 88 days. But Mercury rotates very slow, so one side is always in sunlight. This side is very hot, while the night-time side is very cold. Mercury is made of orange and brown rock.

The next planet we arrive at is beautiful Venus, named after the Roman goddess of love. Venus is called "the evening star" because you can see it shining a beautiful white color at night. In addition, it is the brightest planet, and also brighter than all the stars in the sky. Because of its thick clouds, Venus is the hottest planet as well with a

1 solar system「太陽系」 planet (n.)「惑星」 orbit (v.) = goes around;「軌道」 3 Mercury (n.)「水星」 4 look like「似る」 4- craters (n.):



6 rotate (v_{\cdot}) = turn



10 Venus (n.) 「金星」 10- named after the Roman goddess of Love「(古代)ローマ の愛の女神の名前」 15 thick (adj.) 「厚い」 ↔ thin (adj.) 「薄い」 temperature of 480°C. The atmosphere on Venus is mostly carbon dioxide (CO₂).

Our home is the third planet, which we call the "Earth". As seen from space, Earth is a blue color with white 5 clouds and you can see the green and brown land. Earth holds life including animals, fish, plants, and of course, we humans. How can life survive on Earth? Earth has oxygen (O₂) and liquid water. The temperature on Earth is not too hot and not too cold for life.

The "Red Planet", Mars, is the next stop after Earth. Long ago, there were rivers and lakes here. But now, Mars is mostly a dry desert of red rock and sand. Mars has the highest mountain in the solar system, the volcano Olympus Mons. It stands 2.5 times as high as the tallest 15 mountain on Earth, Mt. Everest.

The four planets beyond Mars are called "gas giants". A "gas giant" is different from the Earth. First, a "gas giant" has a solid core, or center. Then it has a deep ocean covering the land. And they all have a thick atmosphere.

The first gas giant we arrive at is Jupiter. Jupiter is the fifth planet from the Sun and the largest planet in our solar system. It has a diameter 11 times that of Earth. Jupiter is famous for its giant storm, or typhoon, the "Great Red Spot". The "Great Red Spot" may be more than 400 years 25 old.

Beyond Jupiter is the beautiful "Ringed Planet", Saturn. The rings of Saturn can be seen from telescopes here on Earth. However, the rings have a thickness of only about 16 km. The planet itself is the second largest planet 30 in our solar system and has yellow, white, and brown stripes.

Farther out in space, 2.7 million km from the Sun, is Uranus. The seventh planet from our Sun, Uranus is a light-green color. It is unique because its axis is tipped 98 35 degrees from the vertical.

- 1 temperature (n.) [温度] "480°C": In English, "four hundred and eighty degrees Celsius" atmosphere(n.) = air,or gas around a planet 2 carbon dioxide (CO₂) (n.)「二酸化炭素」 4 Earth (n.): the planet we live on 8 oxygen $(O_2)(n.)$ 「酸素」 liquid water (n.) 「(液状の)水」 10 Mars (n.) 「火星」 11 lakes (n.) 「湖」 12 desert (n.) 「砂漠」 sand (n.) [砂] 13 volcano (n.) 「火山」 14 2.5 times [2.5 倍] 16 beyond (prep.) = after 17 gas giant: a type of planet thick atmosphere 厚い大気 deep ocean 深い海 solid center 20 Jupiter (n.)「木星」 22 diameter 11 times that of Earth 「直径
- は地球の11倍」 23- Great Red Spot:



27 Saturn (n.) 「土星」 ring (n.): Saturn rings

telescopes (n.) 「望遠

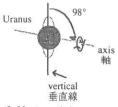
- 28 thickness (n.) 「厚さ」
- 31 stripe (n.) 「縞」
- 33 Uranus (n.)「天王星」
- 34 unique (adj.) = only
- 34- "... axis is tipped 98 degrees from the vertical.":

The farthest gas giant from the Sun, however, is Neptune. It is true that Neptune looks similar to Earth. This is because Neptune is a beautiful blue planet with wisping white clouds. Like Jupiter, Neptune has a giant storm. This giant storm is called the "Great Dark Spot". The

⁵ This giant storm is called the "Great Dark Spot". The Great Dark Spot is made of hydrocarbons.

Finally, we reach the mysterious planet Pluto and it's small moon, Charon. From the Hubble telescope, Pluto looks red; Charon is gray. Pluto's surface is frozen meth10 ane (CH₄), while Charon's is water ice. Of course, Pluto and Charon are very cold places.

Beyond Pluto is an ice cloud, called the "Kuiper Belt". Scientists believe comets are born there.



2 Neptune (n.) 「海王星」 looks similar to = looks like

5 Great Dark Spot =



- 6 hydrocarbon (n.) 「炭化水素」
- 7 mysterious (adj.) 「不思議な」 Pluto (n.)「冥王星」
- 8 **Charon** (n.)「Pluto の 衛星 (カローン)」
- 9 surface (n.)「表面」
- 9- **frozen methane** 「冷凍のメタン」
- 10 water ice 「氷」
- 12 ice cloud「氷の雲」
- 13 comet (n.) 「彗星」

Comprehension Questions

1. Venus is the _

- a) "evening star", smallest, and brightest planet
- b) "evening star", closest to the Sun, and hottest planet
- c) "evening star", brightest, and hottest planet
- d) "night star", brightest, and hottest planet

2. In paragraph number four, how does life survive on Earth?

- a) The temperature is right, and Earth has oxygen and carbon dioxide.
- b) The temperature is right, and Earth has oxygen and liquid water.
- c) The temperature is right, and Earth has only oxygen and ice.
- d) The temperature is hot, and Earth has nitrogen and liquid water.

3. What are the gas giants, Jupiter, Saturn, Uranus, and Neptune famous for ? (in order)

- a) Great Red Spot; 98° from vertical; beautiful rings; Great Dark Spot
- b) Great Dark Spot; 98° from vertical; beautiful rings; Great Red Spot
- c) Great Dark Spot; beautiful rings; 98° from vertical; Great Red Spot
- d) Great Red Spot; beautiful rings; 98° from vertical; Great Dark Spot

4. What is true about the farthest planet Pluto?

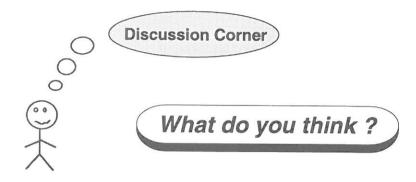
- a) It is red and its surface is mostly water ice.
- b) It is red and its surface is mostly methane (CH₄).
- c) It is the farthest planet and has two large satellites, Charon and Kuiper.
- d) It is a gas giant.

5. What is the main idea of the entire writing?

- a) It gives us basic information about planets, asteroids, and satellites.
- b) It tells about the planets of our solar system.
- c) It gives us basic information about possible life on other planets.
- d) It tells about rocket travel to other planets in our solar system.

Building Sentences

1.	Our (1). In order they are: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto. (Pluto is sometimes nearer than Neptune.) The first four worlds, Mercury, Venus, Earth, and Mars,						
			o, have rocky surfaces.				
	1 that orbit		solar system	3 has nine			
	4 planets	5	the Sun				
2.	Mars, known as the "F	Red	Planet" since ancient	times, (2) Earth.			
	1 from	2	has red colored	3 that can			
	4 deserts	5	be seen				
3.	The planets beyond M	lars	are the "gas giants":	Jupiter, Saturn, Ura-			
	nus, and Neptune. (3) and have a different structure—a solid core surrounded by a deep ocean and a thick atmosphere.						
	1 these "gas giants"	2	thon	3 the other			
			are larger	5 the other			
	4 planets	3	are larger				
4.	Pluto (4) eccentric, or irregular, orbit.						
		^	NI	2 in approximate			
	1 closer		Neptune, because	3 is sometimes			
	4 of its	5	to the Sun than				



Answer the questions. Then share your answers with other students by speaking.

1. What is your favorite planet? Then write three reasons why.

1) 2) 3)

2. Traveling to other planets takes many months or years. If you go to your favorite planet, what would you like to take with you on your trip? Write at least three things.

1)

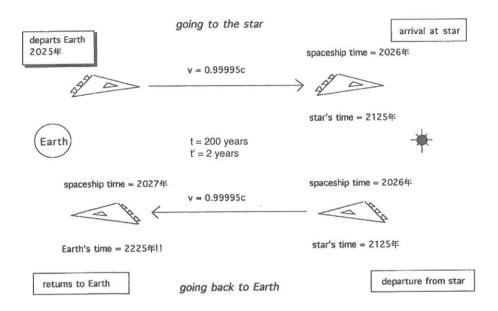
2)

3)

Find a partner. Ask your partner questions 1 and 2. Then switch.

4. Moving at the Speed of Light: We've Only Just Begun いよいよ始動した光速度移動

Other stars are so far away, it seems impossible to go there. But this chapter tells about how a "time machine" can help us travel to distant stars. Vocabulary helps the reader with the English of time travel, the speed of light, and spaceship speed.



Have you ever wondered what it would be like to travel to a distant star system in another galaxy? Would there be life there? Would they be like us? We know the many stars, galaxies, and nebulas that sparkle in the night sky are far away from our Earth. For example, the closest star to Earth, Proxima Centuri, is a distant 4.3 light years away. This means it would take 4.3 years travel at the speed of light, $c = 3.0 \times 10^8$ m/s, to get there. Other stars and galaxies are even farther. Therefore, if we are to travel to the distant stars, we need to travel at speeds near the speed of light.

- 2 galaxy (n.)「銀河」
- 4 nebula (n.)「星雲」
- 6 light year 「光年」 :the distance light travels in one year, 9.46 × 10¹² km; In English: "nine point four six times ten to the twelfth kilometers"
- 8 speed of light (c)
 「光速度」
 : The speed of light is a constant.
 constant (adj.) 「定数」
 c = 3.0 × 10⁸ m/s: In
 English, "c equals
 three point zero times
 ten to the eighth meters
 per second"

First of all, what is light? Light comes in many beautiful colors. Light is the radiant energy of photons. Radiant energy comes in waves at the speed of light. Research has shown that very small particles such as protons, neutrons, and quarks cannot travel at c. They can get close to it at 0.8c or 0.9c. But what about larger objects such as people and spaceships?

In 1905, Albert Einstein wrote his "Time Dilation

$$t' = t\sqrt{1 - \frac{v^2}{C^2}}$$

t prime is equal to t times the square root of one minus quantity: v squared over c squared.

Theory", which says that time changes at speeds above about 0.1c. Here, t is the normal time, t' is the time in the spaceship, v is the velocity of the spaceship, and c is the speed of light. "Time dilation" may help us travel to distant stars and galaxies, which are hundreds and thousands of light years from Earth.

How does time dilation work? Time dilation makes your time in the spaceship, t', less than the actual time, t. It is like a time machine—you travel to the future. For example, let's say the year is 2025. You go to a distant star which is t = 100 light years from Earth at a velocity of v = 0.99995c. Does it take you 100 years to get there? The answer is "No". Time dilation says you get there a lot faster in:

t' = 100 years
$$\sqrt{1 - \frac{(0.99995c)^2}{c^2}}$$
 = 1 year

which equals only one years time, arriving in the year 2026. But the time on the star will be t equal to 100 years later, or the year 2125!

Then you return to Earth at the same speed, v = 0.99995c. In the spaceship, it takes one more year, so

- 2 radiant (adj.) = bright 「輝く」
 photon (n.) 「光子」
 4 particle (n.) 「微分子」
 proton (n.) 「プロトン;陽子」
 neutrons (n.)
- 5 quarks (n.) 「クオー ク」

8- Time Dilation

- Theory
 「(物理) 時間膨張;
 (アインシュタインの相対性理論)」
 If you go at speeds
 more than 0.1c, time in
 the spaceship goes
 slower than normal
 time. So when you
 stop, you traveled to
 the future.
- 12 velocity (n.) = speed
- 17 **actual** (*adj.*) 「実際の」
- 21 0.99995c (n.) = In English: "zero point nine-ninenine-nine-five c".
- 24 "t prime is equal to 100 years times the square root of one minus quantity: zero point nine-nine-ninenine-five c squared over c squared".

when you arrive back to Earth, you will be in the year 2027. But Earth will be at the year 2225, 200 years into the future! Yes, it's true, time dilation can help us reach the distant stars and galaxies in less time. But when we return to Earth, it will be far into the future. Because of this, it is better for families to travel together.

Now, spaceships can go about 0.0002c, so a lot more research needs to be done. First, we need more powerful engines on our spacecraft. Also we need to design a space10 ship so it can be protected from the many small particles that could damage the ship at high speeds. In addition, Einstein stated as speed increases the ship gets heavier.

Some may think it seems impossible to go to other stars. But human history has shown us time and time again that seemingly impossible things have been made possible - with hard work - and the light of hope.

- 10 many small particles (in space): for example, space dust and rocks
- 12 increase (ν.) = (speed) go faster decrease (ν.) = go slower

Comprehension Questions

1. On the trip mentioned in paragraph number five, why is it better for families to travel together?

- a) The trip will take 200 years, so your great-grandchildren will return to Earth.
- b) The trip will take 2 years, but you will still be in the year 2025.
- c) When you return to Earth, it will be far into the past, 200 years before.
- d) When you return to Earth, it will be far into the future, the year 2225.

2. Which is true?

- a) The speed of light, c is equal to 3.0×10^6 m/s.
- b) Now, spaceships can go about 0.0002c.
- c) At speeds greater than about 0.01c, time also changes.
- d) "t' "is the normal time and "t" is the spaceship time.

3. Which is true?

- a) Einstein said as we go faster, the spaceship gets heavier.
- b) We can already travel at the speed of light.
- c) Einstein said as we go faster, the spaceship gets lighter.
- d) Einstein said as we go slower, the spaceship gets heavier.

4. What is the point of the last paragraph?

- a) It is impossible to go to other stars.
- b) Human history has shown us spaceships have traveled at the speed of light.
- c) Many things are possible with hard work and hope.
- d) Human history has shown us that time can change in spaceships.

5. What is the main idea of the entire writing?

- a) It tells us we can travel to the future by going to distant stars.
- b) Objects can never go faster than the speed of light.
- c) "Time dilation" makes objects go slower and we can travel to the past.
- d) It tells us that "time dilation" can help us go to different stars and galaxies.