

## 1 The moon's gravity

## Speaking, Writing

Work in pairs. Why does the moon not fall down and hit the Earth? Talk together and then write a sentence to explain your ideas.

## 2 What keeps the moon up in the sky?

## Listening, Speaking

Listen and check your answer in 1. Was your explanation correct?

Now listen again and answer these questions.

1. How fast is the moon moving?
2. How much smaller than the Earth is the moon?
3. What point does the moon actually revolve around?
4. Which takes the moon longer – to revolve on its own axis or to rotate around the Earth? Why?
5. Is there really a dark side of the moon?

Check your answers in pairs, and then with the whole class.

## 3 Useful verbs

## Vocabulary

Match these verbs with their definitions.

agree	appear	call	consider	discover
disturb	establish	include	predict	rename

- a) to change the name of something
- b) to contain someone or something as a part
- c) to decide together

- d) to discover, prove or decide that something is true
- e) to find a place, fact or substance that no one knew about before
- f) to have a particular opinion about someone or something
- g) to make something move in a different way
- h) to say what you think will happen in the future
- i) to start to exist or be known about for the first time
- j) to use a particular name for something

## 4 Pluto

## Reading, Listening

**Fill the gaps in these sentences with the correct form of the verbs in 3. Be careful! Many of the verbs are passive forms.**

- a) Pluto was first (1)\_\_\_\_\_ in 1930, but astronomers had been looking for a planet beyond Neptune for more than thirty years before that.
- b) Calculations of the orbits of Neptune and Uranus made it appear that the gravity of another planet was (2)\_\_\_\_\_ their movement.
- c) In the 1970s it was (3)\_\_\_\_\_ that this was actually the result of a mistake in the calculation of the mass of Neptune.
- d) After Pluto was found and named, however, it was (4)\_\_\_\_\_ the ninth planet in the solar system for 76 years.
- e) In 2006, an international definition of a 'planet' was (5)\_\_\_\_\_ for the first time.
- f) Pluto, Eris, and the other inhabitants of the 'Kuiper Belt' beyond Neptune are now (6)\_\_\_\_\_ 'dwarf planets'.
- g) The theory that led to the discovery of Uranus in 1781 (and later of Neptune, in 1834) also (7)\_\_\_\_\_ that another planet should exist between Mars and Jupiter.
- h) They were all (8)\_\_\_\_\_ in the list of planets for fifty years.

- i) Nine more (9) \_\_\_\_\_ over the next few years, all of them very small and all located between the orbits of Mars and Jupiter.
- j) They were eventually (10) \_\_\_\_\_ 'asteroids' instead of planets.

**Now listen and check.**

5 Dwarf planets

Listening

**Listen again and arrange these in order of size.**

Ceres      Eris      Mercury      moon      Pluto

This worksheet is designed for one to two lessons, and will take about 90 minutes to complete. It is suitable for upper secondary school students in general, whether they are engaged in studying astronomy or not.

**1 The moon's gravity****Speaking, Writing****Aims**

- To engage the students' thinking about the topic
- To predict the content of the listening
- To write a short account of the students' own understanding

Make sure everyone has time to think of an explanation and write it down (briefly) before moving on.

**2 What keeps the moon up in the sky?****Listening, Speaking****Aims**

- To learn about the orbits and rotations of the moon and the Earth
- To listen for precise information

You will need to read the script out at least twice. On the first listening, students simply compare the content with their own ideas which they have written down.

After the first listening, ask the class to tell you what they got right and what information surprised them. Discuss and explain any points that come up. Then draw students' attention to the questions. Give them a moment to read the questions, then read the script a second time.

After the second listening, students work in pairs. They check that they agree about the answers to the questions that they heard. If you think the majority of students have still not completely understood, read the script a third time. If they are more confident, move directly on to going through the answers with the whole class. After they have heard the correct answers, students may want you to read the script one last time to make sure they now understand the

parts that they missed, or to enable them to ask questions about specific points of language.

### Key

1. Relative to the sun, the moon is moving at between 29 km/s and 31 km/s. Relative to the Earth it is moving at 1 km/s.
2. It is 50 times smaller by volume and 80 times smaller by mass.
3. It revolves around the mid-point (by mass) of the Earth/moon system, which is always within the Earth, but is not at the centre of it.
4. The moon takes exactly the same length of time to revolve on its axis as it does to rotate around the Earth (27 days 7<sup>3</sup>/<sub>4</sub> hours), because it is tidally locked to the Earth by the Earth's gravity.
5. One side of the moon is always dark – the side facing away from the sun. But as the moon spins on its own axis all parts of it move from light to darkness and then back to light. The same side of the moon always faces away from the Earth, however.

### Listening script

#### What keeps the moon up in the sky?

We know that in general 'what goes up must come down'. Everything normally falls down to Earth. So why doesn't the moon fall down out of the sky? What keeps it up there?

The moon looks completely still in the sky: but it's actually moving, very fast. In its orbit around the Earth, it's moving relative to us at just over one kilometre per second. The Earth itself, of course, is also moving around the sun at about 30 km/s, so the moon's speed relative to the sun varies from 29 km/s to 31 km/s.

It is the moon's movement relative to the Earth that keeps it from falling down out of the sky. Like everything else in the universe, the Earth and the moon are attracted towards one another by the force of gravity. As the moon is so much smaller than the Earth (about 1/50 of the volume and 1/80 of the mass) it is constantly "falling" towards the Earth. But at the same time it is moving past the Earth, so that by the time it falls to the level where the Earth is, it has also moved the same distance out to the side. As a result it also continuously turns so that it goes round and round the Earth. This is called an orbit.

In fact, the Earth is also attracted by the gravity of the moon. The moon and the Earth both revolve around a point between their centres. They don't just revolve around the centre of the Earth – the centre of rotation is nearer to the

moon than that. But as the Earth is so much bigger, the centre point is still inside the Earth.

The gravity of the moon also affects the Earth's rotation, and causes tides in the seas on Earth. Similarly, the gravity of the Earth has a (much greater) tidal influence on the moon, essentially causing the heaviest side of the moon always to face the Earth. As a result, the moon takes exactly the same length of time to rotate on its own axis as it takes to revolve around the Earth (27 Earth days and 7¾ hours). The other side of the moon is not dark – the sun shines on it just as much as it does on the side we can see – but it will never face towards the Earth.

### 3 Useful verbs

### Vocabulary

#### Aims

- To learn some useful vocabulary for talking about scientific knowledge and discoveries
- To prepare for the listening task

Students can do this individually or in pairs.

#### Key

a rename; b include; c agree; d establish; e discover; f consider; g disturb; h predict; i appear; j call

### 4 Pluto

### Reading, Listening

#### Aims

- To learn about the classification of heavenly bodies
- To understand the history of Pluto
- To listen for verb usage

Before students start on this, quickly revise basic verb forms with them, and make sure in particular that they understand the rules for forming the passive (any tense of the verb *to be* + past participle). Make sure they realise that they will usually have to change the words from exercise 3 before putting them into the gaps.

Once students have made an attempt at most of the questions, play the recording for them to check.

### Key

1 discovered; 2 disturbing; 3 established; 4 considered; 5 agreed; 6 called; 7 predicted; 8 included; 9 appeared; 10 renamed

### Listening script

#### Why is Pluto no longer a planet?

Pluto was first discovered in 1930, but astronomers had been looking for a planet beyond Neptune for more than thirty years before that. Calculations of the orbits of Neptune and Uranus made it appear that the gravity of another planet was disturbing their movement. In the 1970s it was established that this was actually the result of a mistake in the calculation of the mass of Neptune. After Pluto was found and named, however, it was considered the ninth planet in the solar system for 76 years.

Pluto is much smaller than the other planets (its diameter is less than  $\frac{2}{3}$  that of Mercury): in fact, it is much smaller than Earth's moon, and several other moons in the solar system. Since 2002, several other small bodies have been discovered orbiting beyond Neptune. One of them, Eris, discovered in 2005, is actually slightly larger than Pluto. In 2006, an international definition of a 'planet' was agreed for the first time. Pluto, Eris, and the other inhabitants of the 'Kuiper Belt' beyond Neptune are now called 'dwarf planets'.

But all of this has happened before. The theory that led to the discovery of Uranus in 1781 (and later of Neptune, in 1834) also predicted that another planet should exist between Mars and Jupiter. In 1801, Ceres was discovered there, and became the smallest of the known planets (it is less than half the size of Pluto). By 1807, three more new planets, Pallas, Juno and Vesta, had been discovered between Mars and Jupiter. They were all included in the list of planets for fifty years. But in 1845 Karl Ludwig Hencke found another, Astraea, and then another, Hebe, in 1847. Nine more appeared over the next few years, all of them very small and all located between the orbits of Mars and Jupiter. They were eventually renamed 'asteroids' instead of planets. More than 300,000 asteroids have now been discovered.

## 5 Dwarf planets

## Listening

### Aims

- To remember the relative sizes of smaller bodies in the solar system
- To check full understanding of details of the listening exercise

Read the script again and ask the students to put the five bodies in order of size. It will help to have named cut-out images (not to scale) which you can stick on the board and move around. Students can come to the board and move them: they will probably still disagree until they listen a third time. They need to understand the relative significance of phrases like 'much smaller' 'slightly larger' and 'half the size'. Keep playing the recording until they agree on the right order, and then draw their attention to these phrases in the script.

**Key**

From largest to smallest:

Mercury, moon, Eris, Pluto, Ceres.