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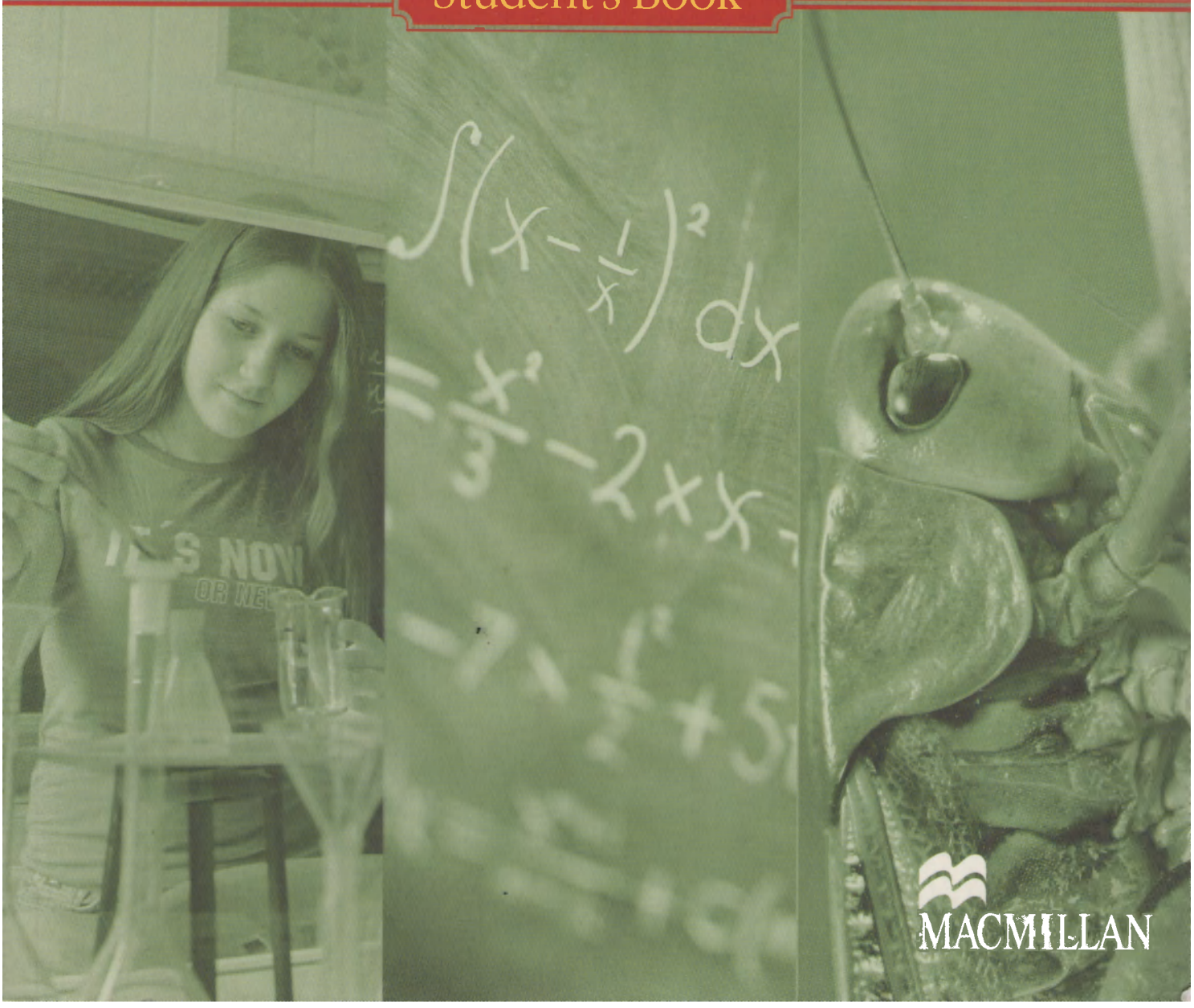
MACMILLAN
Guide to Science

Student's Book



MACMILLAN

Contents

Дорогие друзья!

Представляем вам учебно-методический комплект (УМК) ***«Macmillan Guide to Science»***, который поможет вам приобрести навыки владения английским языком в естественно-научной области.

Курс адресован учащимся старших классов общеобразовательных учреждений и колледжей, увлекающимся естественными науками, а также студентам младших курсов естественно-научных факультетов высших учебных заведений.

Тема курса - история знаменитых открытий и вклад известных учёных в научный прогресс человечества. Курс сочетает изучение английского языка с учебным материалом естественнонаучных дисциплин. Коммуникативная направленность курса делает его особенно актуальным, так как в современном мире именно владение коммуникативными навыками позволит вам активно общаться с иностранными коллегами, легко вступать в международные научные сообщества и становиться полноценными участниками международных проектов.

В Книге для учащихся четыре раздела. Каждый раздел посвящён одной из четырёх естественнонаучных дисциплин - биологии, химии, математике и физике, и включает в себя пять уроков (Unit). Первый урок каждого раздела неизменно состоит из краткого исторического обзора данной дисциплины и текста, который позволяет представить уровень и значимость данной науки в наши дни. Следующие четыре урока каждого раздела посвящены наиболее крупным научным открытиям в данной области. В целом в книге 21 урок - в 21 уроке рассказывается о российских учёных, ставших Нобелевскими лауреатами, и о Российской академии наук.

Каждый урок включает в себя два текста (Reading), сопровождаемых аудиозаписями (Listening). Аудиотексты, озвученные носителями языка, относятся к различным стилям речи и позволят вам получить навыки аудирования, необходимые для понимания как научных докладов, так и разговорной речи. Кроме того, каждый урок содержит упражнения на расширение и закрепление активной лексики - как общего, так и специального плана (Vocabulary), и на проверку понимания прочитанного (Comprehension).

Особенно хотелось бы отметить упражнения и материалы, нацеленные на развитие навыков устной (Speaking) и письменной (Writing) речи. Освоив материал курса, вы сможете вести дискуссии, проводить презентации, составлять доклады и отчёты, писать письма, статьи, эссе, сочинения. Глоссарий (Glossary) слов и терминов, который вы найдет в конце книги, поможет вам при работе с курсом.

Надеемся, что УМК ***«Macmillan Guide to Science»*** будет вам интересен и полезен.

Авторы УМК «Macmillan Guide to Science»

Unit 1

Before you read

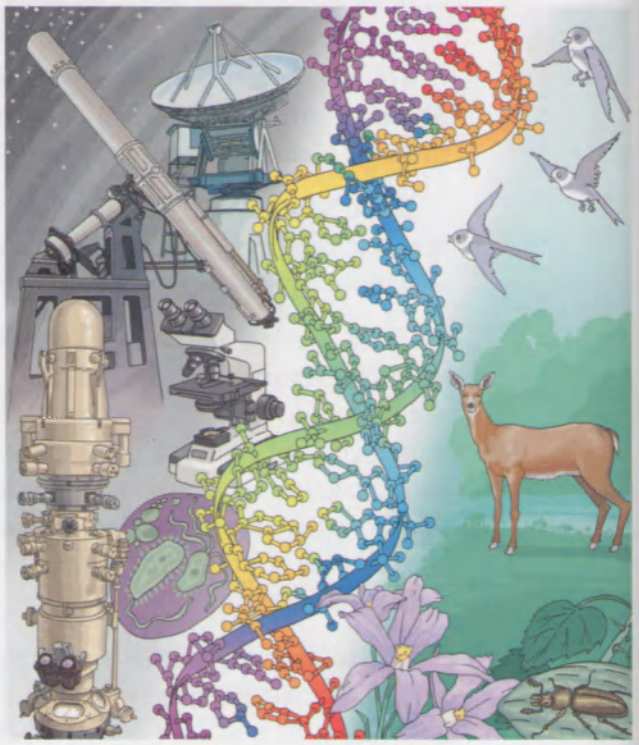
Discuss these questions with your partner.

- What can you see around you that is living?
- What can you see that is not living?
- What can living things do that non-living things can't?
- Can you classify living things?

A Vocabulary

Match these words with their definitions.

1 life cycle	A characteristic
2 observation	B from birth to death
3 property	C develop an idea
4 successor	D what you see
5 formulate	E sb who follows
6 pollen	F a fine yellow powder found in flowers
7 contribution	G sth given to help progress
8 foundation	H what is passed down from one generation to the next
9 treat	I give medical help
10 classify	J process according to which only the strongest species survive
11 inheritance	K academic
12 natural selection	L put into groups
13 field	M basic idea
14 principle	N academic area
15 advance	O improvement
16 scholar	P basis
17 genetics	Q the study of how characteristics are passed from one generation to another



Reading 1

Biology

An introduction

Biology means *the study of life* and it is the science which investigates all living things. For as long as people have looked at the world around them, people have studied biology. Even in the days before recorded history, people knew and passed on information about plants and animals. Prehistoric people survived by learning which plants were good to eat and which could be used for medicine. Farming would not have developed if they had not begun to understand which animals could produce food like milk and eggs.

In the past, more than 2000 years ago, people in the Middle East understood the part that insects and pollen played in the life cycle of plants. The ancient Egyptians studied the life cycle of insects and were particularly interested in the changes they went through as they grew from larvae to adult insects. The ancient Mesopotamians even kept animals in what were the earliest zoological gardens. The ancient Greeks, too, were greatly interested in understanding the world around

them. Aristotle recorded his observations of plants and animals, and his successor, Theophrastus, wrote the first books on plant life, which made a very important contribution to the study of botany.

After the fall of the Roman Empire, the centre of the scientific world moved to the Middle East. The Arab scholar Al-Jahiz wrote the *Book of Animals* in the 9th century. He was just one of a great number of Arabic, Persian and Turkish scientists who set out the foundations for the modern science of biology. Later still, in Europe, particularly in Germany, scholars such as Albertus Magnus discussed the properties of life. Magnus wrote seven books on plants and twenty-six on animals.

Modern biology really began in the 17th century. At that time, Anton van Leeuwenhoek, in Holland, invented the microscope and William Harvey, in England, described the circulation of blood. The microscope allowed scientists to discover bacteria, leading to an understanding of the causes of disease, while new knowledge about how the human body works allowed others to find more effective ways of treating illnesses. All this new knowledge needed to be put into order and in the 18th century the Swedish scientist Carl Linnaeus classified all living things into the biological families we know and use today.

In the middle of the 19th century, unnoticed by anyone else, the Austrian monk Gregor Mendel, created his Laws of Inheritance, beginning the study of genetics that is such an important part of biology today. At the same time, while travelling around the world, Charles Darwin was formulating the central principle of modern biology – natural selection as the basis of evolution.

It is hard to believe, but the nature of viruses has become apparent only within the last half of the 20th century and the first step on this path of discovery was taken by the Russian botanist Dmitry Ivanovsky in 1892.

In the 20th century, biologists began to recognise how plants and animals live and pass on their genetically coded information to the next generation. Since then, partly because of developments in computer technology, there have been great advances in the field of biology; it is an area of ever-growing knowledge.

Pronunciation guide

Albertus Magnus /əl'be'təs 'mægnəs/
Al-Jahiz /el 'gʌhəz/
Aristotle /ærɪ'stɔtˀl/
Carl Linnaeus /kɑ:'l lɪ'nɪəs/
van Leeuwenhoek /væn 'leɪvənhuk/
Mesopotamian /mesəpə'tæmɪən/
Theophrastus /θɪə'fræstəs/

B Comprehension

Read the text and decide if the following statements are true or false.

1 The earliest people must have known about plants or they would have died. T ☐ F ☐
2 The Egyptians were interested in changing the way insects lived. T ☐ F ☐
3 Europeans learnt all they knew about biology from the Middle East. T ☐ F ☐
4 The microscope allowed biologists to treat illnesses. T ☐ F ☐
5 Darwin's theory was one of the most important in biology. T ☐ F ☐
6 The study of biology hasn't changed at all over the centuries. T ☐ F ☐

Before you listen

Discuss these questions with your partner.

→ *Do you know what a germ is?*
→ What can you say about their size and shape?
→ What do you know about the classification of germs?

C Listening

Listen to this lesson about germs. Circle the correct word or phrase to make true statements.

1 The teacher believes people **rightly / mistakenly / rarely** think all germs are bad.
2 Germs don't live on **microbes / animals / people**.
3 **Some / all / few** germs are responsible for illnesses.
4 There are four basic types of **fungi / protozoa / germ**.
5 Germs are **only round / mostly long and thin / different shapes**.

Before you read

Discuss these questions with your partner.

- What careers in biology can you think of?
- Do you like any of them? Which ones and why?
- Are there any areas of biology that you do not find interesting?
- What areas of biology do you consider the most important for human society nowadays? Why?

D Vocabulary

Complete the sentences below with words from the box.

mammal	threatened
species	adapt
cell	diseases
environment	crops
composition	building blocks

1 Unfortunately, the growth of cities often means wildlife is ..... with extinction.

2 A ..... is an animal that feeds its babies milk.

3 Farmers that grow ..... like cereals and vegetables normally have to work very hard.

4 The smallest, basic structural and functional unit of life is a ..... .

5 Serious illnesses are known as ..... .

6 What something is made of is its ..... .

7 It's amazing how animals can ..... to changes in their living conditions.

8 There are many different ..... of butterfly.

9 Humankind's actions have often had a negative effect on the ..... .

10 The most basic parts of something can be called ..... .

Reading 2

Biology today

Dear Students,

I am writing this letter to welcome all of you who are about to begin your first year course in Biology here at the university. You might think it is a little early for me to ask you to think about what you will do when you leave here in three years' time. However, our science, like any other, has so many different areas it is impossible for you to study them all. The first thing you will need to think about is specialising. This letter is to offer you some suggestions to think about for your future.

As you know, there are four main areas of biology that we shall concentrate on in the coming years. Biology can be divided into zoology, the study of animal life, and botany, the study of plant life. We shall also study molecular biology, the study of how the building blocks of living things, the cells, work. Another topic of interest is genetics, how biological information is passed on from one

generation to the next: that is, inheritance. You should specialise, but you will also need to know about all of these four areas of study. Plants and animals do not live separately from each other; all living things are made up of cells and one of the things genetics tells us is how plants and animals adapt to the conditions around them.

So what about after the course is over and you have graduated in Biology? Can you have a career in biology? For those who choose to specialise in genetics or molecular biology there are important career opportunities in medicine. At the present time, there is a great deal of research going on in gene therapy where biologists are working with doctors and chemists to find new ways of treating diseases. Other biologists are looking at ways of changing the genetic composition of the plants we grow for food; of making them more able to fight diseases and at the same time produce more food.

We are experiencing a period of climatic change too, and this is having an effect on the way animals and plants live. The science of ecology is becoming more and more important; biologists who specialise in zoology are working in many parts of the world. Some are working to protect species like the tiger, which are seriously threatened by climate change. Others are investigating wildlife from the smallest insects to the largest mammals, trying to understand how they all live together. Botanists are looking at the effect new types of food crops have on the environment and how changes in that area can affect our general health. There is even a new area of biology called astrobiology, which is looking at the possibilities of life on other planets – but perhaps that is something for the more distant future.

Whatever you specialise in, as long as there is life on this (or any other) planet, there is work for a biologist.

Good luck and enjoy your studies!

Jean Shearer

Professor of Biology

Pronunciation guide

career /kəˈrɪəʳ/
climatic /klaɪˈmætɪk/
gene /dʒiːn/
genetics /dʒəˈnetɪks/
inheritance /mˈherɪtəns/
molecular /məˈlekjuləʳ/
species /spiːʃiːz/

E Comprehension

Read the text and answer the questions in your own words.

1 What four areas can biology be divided into?

2 If you are interested in cells, which area should you study?

3 How can zoologists help animals in the wild?

4 In what way can botanists protect people and the environment?

5 What is astrobiology?

Before you listen

Discuss these questions with your partner.

→ What do you know about climate change?

→ How do you imagine plants and animals are affected by global climates becoming warmer?

F Listening

Listen to part of a TV programme about climate change. Then decide if the following statements are true or false.

1 The report suggests there are reasons for hope as well as worry. T ☐ F ☐

2 In the past, ice ages and droughts killed off all life. T ☐ F ☐

3 Temperatures are rising at five degrees every century. T ☐ F ☐

4 Some plants and animals move as climates become warmer. T ☐ F ☐

5 There are mountain animals that will die if temperatures rise. T ☐ F ☐

G Speaking

Discuss these questions with your partner.

- How important do you feel the study of biology is for our world today?
- Would you prefer not to study it? Why?
- Are there any areas of biology which you think are more important than others?

Task

Prepare a short presentation to answer the question: 'What is biology?'

Use the information in both texts.

Talk about:

- what the study of biology includes
- the four main areas of biology
- where biologists work
- what biology informs us about

First complete these notes. Use them in your presentation.

Biology: The study of ..... .

There are four main areas:

..... is about ..... .

..... is about ..... .

Molecular biology is about ..... .

..... is about inheritance.

Biologists work in ..... ,

..... and ..... .

In conclusion, biology is about ..... .

Remember to:

- read the texts again
- select information that is relevant
- add examples where you can

Speaking tips

- ✔ Speak from notes.
- ✔ Don't write out everything you plan to say; use key words.
- ✔ Introduce each new idea clearly.

H Writing

Write a letter to your tutor telling him or her which areas of Biology you would like to specialise in and why. Use these notes to help you.

Dear Mr / Mrs **(tutor's surname),**

Writing to tell you choices I have made

Specialise in: **(one or two of the main areas)**

Reasons for choosing: interested in **(plants / animals / laboratory work / latest ideas / your own ideas)**

Possible career choices: what I hope to do when I graduate **(medicine / ecology / agriculture / your own idea)**

Offer to meet and discuss choices: I would like your advice and hope we can ...

Yours sincerely,

(your full name: first name + surname)

Write 100-140 words.

Unit 2

Before you read

Discuss these questions with your partner.

- What is a microscope?
- What can you do with one?
- What kind of scientist uses a microscope?
- What other tools/equipment do biologists use?

A Vocabulary

Choose the correct definition of these words.

1 state	**A** deny **B** say **C** suggest
2 weaken	**A** reduce **B** increase **C** add
3 decaying	**A** breaking down **B** growing **C** sleeping
4 trap	**A** free **B** imprison **C** move
5 maggot	**A** egg of a fly **B** larva of a fly **C** small fly
6 jar	**A** ceramic plate **B** plastic cup **C** glass pot
7 disprove	**A** prove wrong **B** don't prove **C** not approve
8 microorganism	**A** germ **B** small animal **C** little plant
9 vacuum	**A** a full space **B** an empty space **C** a space with gas

Reading 1

Germ theory

In the past, germ theory was something that caused a lot of discussion and disagreement. Germ theory, the idea that microorganisms or germs were the cause of many diseases, was something that took biologists and the medical profession a long time to accept. Long before the invention of the microscope, biologists were uncertain about the existence of microorganisms, forms of life too small to be seen with the naked eye. Biologists knew that small life forms existed, but could not say where they came from. The accepted scientific theory was what was known as spontaneous generation (abiogenesis). Quite simply, this stated that living things appeared from nowhere, as if out of nothing, for no reason. According to scientists this happened in things that were decaying: that is, in what remained of things that were dead. Spontaneous generation could take place in a dead animal, for example, when the animal's flesh decayed into maggots. These maggots would then grow into flies or other insects. Mud or dead plants were other places where new life could come into existence.

Near the end of the 17th century the Italian scientist Francesco Redi proved that maggots come from eggs that flies lay in the flesh of dead animals. He carried out one of the first modern scientific experiments in this area. He put meat into three jars. One jar he kept tightly closed so that air could not enter. Another he covered with cloth and the third he left open to the air. Maggots appeared, but only in the open jar. However, belief in spontaneous generation was not destroyed by his experiment and almost 100 years later, the Englishman John Needham carried out a similar experiment. First, he boiled the meat to kill any living organisms that were already there. He kept the air from outside out of his jar and not maggots but microorganisms or germs grew in it. Needham argued that this proved that life could be generated spontaneously from dead material. However, he did not know they were present in the air already in the jar. When Lazzaro Spallanzani in Italy repeated Needham's experiment but removed the air from the jar creating a vacuum with the result that nothing grew on the meat, people argued that he only had proved that spontaneous generation could not take place without air.

The invention of the microscope did little to weaken the belief in spontaneous generation. The microscope opened up a new world of microorganisms to biologists but they could not explain where they came from and so claimed it was by spontaneous generation.

It was not until the middle of the 19th century that the French biochemist, Louis Pasteur, proved to the world that microorganisms were present in the air and that the idea of spontaneous generation had no place in biology. Pasteur changed Redi's experiment so that the jar was 's'-shaped at the opening. This let the air in, but trapped any microorganisms in the 's' bend. The meat in Pasteur's jars did not generate microorganisms. Only when Pasteur moved the jar, allowing the meat to touch the microorganisms in the trap, did microorganisms start to grow. In this way he showed that growth only occurred when there was contact with the air. This time the scientist's conclusions could not be ignored. The idea of spontaneous generation was finally disproved and from that time on biologists have recognised that microorganisms are present in the air.

Pronunciation guide

abiogenesis /eɪbaɪəʊˈdʒenəsɪs/
germ /dʒɜːm/
Lazzaro Spallanzani /lɑːzəro spələnˈtʃɑːnɪ/
Louis Pasteur /luɪ ˈpɑːstɜː/
Needham /niːdəm/
spontaneous /spɔnteɪnɪəs/

B Comprehension

Read the text and answer the questions in your own words.

1 Where did biologists believe living things came from before the days of the microscope?

2 What was original about Redi's experiment?

3 What did people say about Spallanzani's experiment?

4 What effect did the microscope have on belief in spontaneous generation?

5 How did Pasteur change Redi's experiment?

Before you listen

Discuss these questions with your partner.

- How many mammals can you name? Name as many mammals as you can.
- How many insects can you name?
- Can you name living things that you can only see under a microscope?
- What do you know about protozoa such as amoebas?

C Listening

Listen to this class discussion about protozoa and correct the following statements.

1 The word protozoa means microorganisms.

2 One of protozoa's ecological functions is to produce bacteria.

3 Paramecium have a simple internal organisation and a fixed shape.

4 All protozoa are parasites and live in humans or animals.

5 Protozoa can only feed by taking in nutrients through the cell mouth.

Before you read

Discuss these questions with your partner.

- Are germs dangerous?
- How can we get rid of germs?
- What dangerous diseases from the past are now rare?

D Vocabulary

a. Match these words with their definitions.

1 application	A give liquid through a needle
2 harm	B getting better
3 inject	C hurt
4 recovery	D use
5 sample	E passing a disease from one person or animal to another
6 vaccine	F ability to avoid illness
7 immunise	G medicine that prevents disease
8 resistance	H protect from illness
9 infecting	I something taken to make tests on

b. Match the words to make phrases.

1 become	A vaccines
2 go	B out a vaccination programme
3 make	C of a disease
4 develop	D known as
5 die	E a recovery
6 carry	F bad

Reading 2

Louis Pasteur

Pasteur (1822-1895) began his scientific career as a chemist, but it is because of his applications of germ theory to the prevention of disease that he became known as 'The Father of Microbiology'. Pasteur did not create germ theory, but he proved it to be correct. Once he had achieved this, he set about finding ways to prevent germs, the microorganisms present in the air, from infecting food and people.

He completed his famous experiment proving that microorganisms were present in the air while working for a wine company. He was trying to discover why wine sometimes went bad as it was being made. Once he had found the cause – microorganisms – he began to develop the process which carries his name – pasteurisation. It was perfectly possible to kill all the microorganisms in food by boiling it, a process known as sterilisation, but this damaged the taste and the quality of the food. Pasteur's process killed not all, but most, of the microorganisms, with the result that the food needed to be kept cool and eaten or drunk within a limited time. Most importantly, the quality of the food was not harmed by the process. Much of the food we eat today is pasteurised.

His next achievement was to build on the discovery of the British scientist Edward Jenner. Many years earlier, Jenner had discovered a way of giving people resistance to the deadly disease smallpox, by

injecting them with a similar disease that was found among cows. The process became known as vaccination. Pasteur applied germ theory to his work and looked at samples of blood taken from healthy and infected animals. He grew bacteria in his laboratory and used it to infect animals. By chance, some of these germs failed to grow well in his laboratory; these weak germs were then used to infect some chickens. Although the chickens suffered at first, they made a complete recovery and could not be infected again. In this way, he discovered a way of increasing resistance to disease. Pasteur developed vaccines for many serious diseases including cholera and anthrax. At that time, these illnesses were certain death for anyone who caught them.

Pasteur's discoveries revolutionised work on infectious diseases. Pasteur's vaccines were different from Jenner's in one important way. Jenner found a weak form of smallpox and transferred it to humans. Pasteur weakened the disease in a laboratory and immunised people with that weakened form. His success allowed a colleague to develop the first vaccine for rabies, which Pasteur used to save the life of a nine-year-old boy. By this act, Pasteur's position as a hero was assured.

Thanks to the work of Pasteur, we now live longer, our food stays fresh longer and we are less likely to die of disease. Indeed, smallpox is no longer found anywhere in the world, due to a huge vaccination programme carried out in the 20th century. This could never have happened without the scientific achievements of The Father of Microbiology.

Pronunciation guide

anthrax /ænθræks/
cholera /ˈkɒlərə/
pasteurisation /ˌpɑːstəraɪˈzeɪʃən/
vaccine /ˈvæksiːn/

E Comprehension

Read the text and choose the correct answer.

1 Pasteur used his work on pasteurisation to
- **A** move his specialisation to microbiology.
- **B** find ways to protect food and people from infection.
- **C** make a theory of germs.
- **D** prevent microorganisms being in the air.

2 Pasteurisation
- **A** kills only dangerous microorganisms.
- **B** works for a limited time.
- **C** doesn't work with wine.
- **D** kills all the microorganisms.

3 Pasteur's vaccinated animals
- **A** recovered from the disease.
- **B** died from the disease.
- **C** didn't suffer from the disease.
- **D** didn't catch the disease.

4 Pasteur became a hero when
- **A** he invented pasteurisation.
- **B** a vaccine saved a boy's life.
- **C** he discovered vaccines.
- **D** a colleague developed a rabies vaccine.

5 Because of Pasteur,
- **A** we eat less tasty food.
- **B** there are no germs anymore.
- **C** many serious diseases are rare.
- **D** we don't need to keep food cool.

Before you listen

Discuss these questions with your partner.

- What vaccinations have you had?
- Do you know of any diseases for which we cannot be immunised?
- What vaccines would you like to see developed?

F Listening

Listen to the extract from a lecture about immunisation. Then listen again and fill in the gaps in the tapescript.

Historically, being immunised against diseases is a relatively new thing but that doesn't mean the idea hadn't been thought of before. If we go as far back as 429 BC, the historian Thucydides noted that after a **(1)** ..... plague in Athens, those who survived did not become infected again. This was at a time before there was even recognition of such things as **(2)** ..... and viruses.
Nowadays, we take it for granted that we will be vaccinated and avoid diseases like polio but how many of us actually stop to ask ourselves what is behind the **(3)** ..... we have? How does vaccination work? Basically, it is the process by which a person is exposed, that is, made open to an agent so

that his or her immune system develops against that agent. The immune system makes antibodies which fight against infection. Once the human immune system is exposed to a disease, it is able to act against any future infection. Vaccination exposes a person to an immunogen – something which helps develop immunity – in a controlled way by using a **(4)** ..... dose so he or she doesn't become ill while being immunised.

The good thing about a vaccination programme is that it can limit the spread of a disease among a population, reducing the risk for people who have not been vaccinated so we have something which is known as herd **(5)**..... . That means when the number of non-immune people has dropped to a certain level, the disease will disappear from the whole population. This is how nowadays we have achieved the elimination of many diseases.

G Speaking

Discuss these questions with your partner.

- → How do you think Redi's work helped Pasteur?
- → How do you think Jenner's work helped Pasteur?
- → Do we need vaccination? Are there any negative aspects to it?

Task

In groups, discuss the work of Louis Pasteur.

Talk about:

- germ theory
- vaccination
- effects of his work today

First complete these notes. Use them in your presentation.

Pasteur proved that microorganisms were present ..... . He improved on Redi's experiment.

Pasteur built on Jenner's work. He developed vaccines for serious ..... .

Pasteur's work means we are more ..... and our ..... is safer.

Remember to:

- plan what you are going to say
- give examples

Speaking tips

- ✔ Emphasise important points by repeating the idea, not the words.
- ✔ Speak clearly and slowly.
- ✔ Make sure everyone speaks using phrases like: What do you think, (name)? Would you like to add to that, (name)?

H Writing

Write a short report explaining what people used to believe about the origins of living creatures.

Write about:

- → spontaneous generation
- → how living things were created
- → how deeply people believed this
- → what proved the idea wrong

Read text I again and use these notes to write four paragraphs.

PARAGRAPH 1

Introduction Spontaneous generation: What is it? Why do you think people believed it?
Vocabulary: microorganisms, belief, fact

PARAGRAPH 2

Where did this happen? What did people see happening? What helped the idea to survive?
Vocabulary: decaying, proof, appearance

PARAGRAPH 3

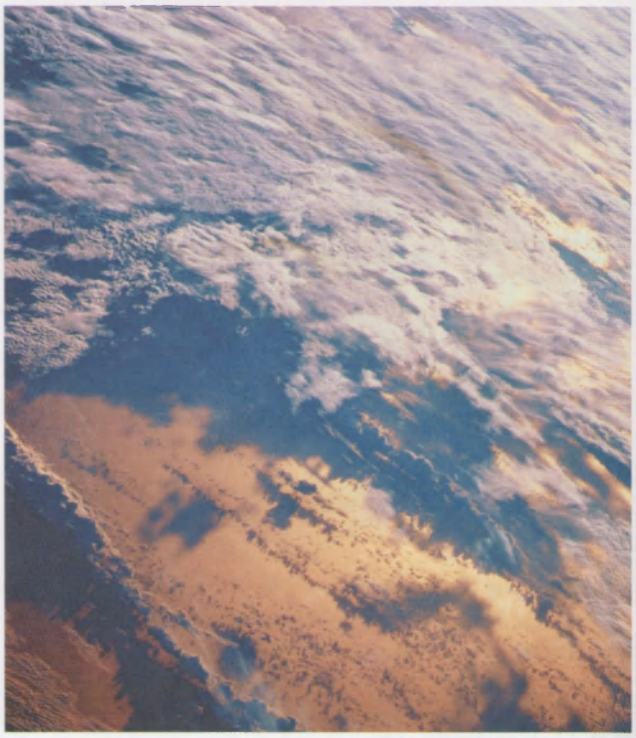
What experiments took place? Why were they not all believed? Which was the most successful? Why?
Vocabulary: deeply, air, present

PARAGRAPH 4

Conclusion Spontaneous generaration finaly disproved. Experiments gave proof.
Vocabulary: scientific, conclusions, disproved

Write 200-250 words.

Unit 3



Before you read

Discuss these questions with your partner.

- What different forms of life exist on Earth?
- What effect do human beings have on the planet?
- How do you see the future of our planet?
- Suggest some measures to improve it.

A Vocabulary

Complete the definitions below with words from the box.

coin	evolve
extinct	impact
inhabit	layer
approximately	permanent
predict	

1 To ..... means to live in a particular place.

2 A(n) ..... animal or plant no longer exists.

3 To ..... means to change physically over a long period of time.

4 A(n) ..... is an effect.

5 To ..... a term means to use a word or phrase that no one has used before.

6 A(n) ..... is a covering.

7 ..... means lasting forever.

8 ..... means not exactly.

9 Scientists often ..... global change will destroy our Earth.

Reading 1

The biosphere

The biosphere is the layer of the Earth in which all life exists. The term *biosphere* was coined in 1875 by the geologist, Eduard Suess, but it was Vladimir Vernadsky who recognised its ecological importance in 1929. He believed that all living organisms together with their environments make up the biosphere. These environments include the air (the atmosphere), land (the geosphere), rocks (the lithosphere) and water (the hydrosphere). The exact thickness of the biosphere on Earth is difficult to calculate, but most scientists would agree that it is from about 5000 metres above sea level to around 9000 metres below sea level. Thus, there is a 14-kilometre zone within which life exists.

The biosphere is important because it is all of life. Without the biosphere, Earth would be a lifeless planet like all the others in our solar system. Also, the biosphere could not exist without water. Water is essential for all living organisms on Earth and has played a very important role in the evolution of life on our planet. Life on Earth began approximately 3.5 billion years ago in the oceans. At that time, Earth was very different from what it is today.

The earliest forms of life were very simple organisms similar to modern bacteria. Over millions of years, more complex organisms evolved and in time, many different forms of life began to inhabit the land, the sky and the oceans. They all depended on each other to survive. The biosphere is like a ladder. This ladder is known as the food chain, and all life depends on the first step of the ladder which is made up of plants. Animals eat the plants; bigger animals eat the smaller animals, and so on. In this way, all organisms are closely connected to their environment.

The biosphere is what keeps us alive. It gives us our food, water and the air that we breathe. Everything we need in order to grow and survive comes directly from the biosphere, so it is important to protect it; however, humans have not always done that. Humans have had a huge impact on the biosphere. Sometimes this has been good, but at other times it has been very destructive. The growing human population on Earth means there is less room for other species and by destroying their habitats we have made many types of plants and animals extinct.

As scientists learn more about our world, they can help us to understand the biosphere, how it evolved, and even try to predict how the biosphere will respond to global change and human activities. Scientists are very concerned about the future, particularly how people will affect the environment in harmful ways. It is very important to try to prevent any permanent damage, or we will destroy ourselves.

Pronunciation guide

biosphere /ˈbaɪəʊsfɪə/
Eduard Suess /ˈedwəd sus/
environment /ɪnˈvaɪrənmənt/
geosphere /ˈdʒɪɔsfɪə/

B Comprehension

a. Read the text and decide if the following statements are true or false.

1 The biosphere is made up of all living things and their environments. T ☐ F ☐

2 The biosphere is a 5 km layer around the Earth. T ☐ F ☐

3 The first living creatures on Earth were in the seas. T ☐ F ☐

4 The only thing the biosphere provides us with is food. T ☐ F ☐

5 Many types of plants and animals have disappeared. T ☐ F ☐

6 Scientists can already predict the future of the biosphere. T ☐ F ☐

b. Read the text and answer the following questions.

1 What is the biosphere?

2 Why is it so important?

3 What layers does it consist of?

4 What is a food chain?

5 What effect do we have on our planet?

Before you listen

Discuss these questions with your partner.

1 What is extinction?

2 Give examples of extinct animals.

3 Do you know of any animals that are in danger of becoming extinct?

4 How can they be saved?

C Listening

Listen to the discussion between a teacher and some students about extinction. Then listen again and fill in the gaps in the sentences.

1 The Tasmanian tiger looked like a dog with a ..... head.

2 It was called a tiger because it had ..... on its body.

3 The ..... who arrived in Tasmania killed it.

4 The Tasmanian tiger was a very..... animal.

5 The last one died in ..... – in a zoo.

6 The Tasmanian tiger was declared extinct in..... .

Before you read

Discuss these questions with your partner.

- Are you interested in science?
- What sort of discoveries would you like to make?
- What do you imagine the world will be like in 50 years' time?

D Vocabulary

Complete the sentences below with words from the box.

source	deposits
commission	contribution
boundary	doctrine
ore	required
crust	

1 Vernadsky's particular beliefs led him to develop his unique ..... .

2 Rich mineral ..... were found in the area.

3 Uranium ..... is mined in Australia.

4 Vernadsky's development of the idea of the biosphere was an important ..... to science.

5 Oil is a..... of energy.

6 A..... was organised to look into the position of the mine.

7 The ..... between the two spheres has been defined.

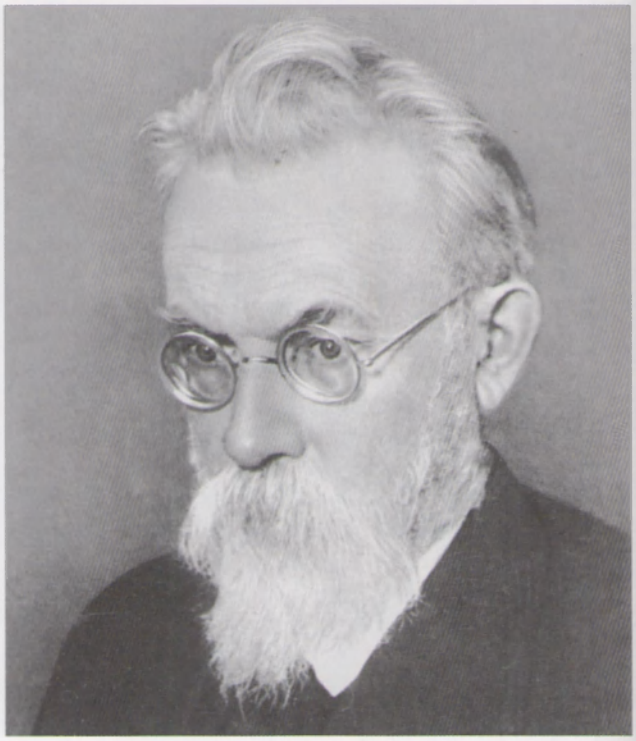
8 In the Earth's ..... there are many minerals.

9 What are the conditions ..... for a better future?

Reading 2

Vladimir Vernadsky

Vladimir Ivanovich Vernadsky was a Russian scientist who was born on 12th March, 1863 in St Petersburg. His most important contributions to science were the development of the ideas of the biosphere (from the Greek word *bios* meaning *life*) and the noosphere (from the Greek word *noos* meaning *mind*).



He graduated from the Physics and Mathematics Department of St Petersburg University in 1885. From 1890 to 1911 he taught mineralogy and crystallography at the University of Moscow. In 1912 he was made a full member of the Russian Academy of Sciences where he was actively involved for 33 years, until his death in Moscow on 6th January, 1945.

Through his work in mineralogy, Vernadsky became interested in the distribution of chemical elements in the Earth's crust, hydrosphere and atmosphere – the field known as geochemistry. Vernadsky published many papers on the geochemistry of various elements, including the geochemistry of radioactive compounds.

Vernadsky was one of the first scientists to suggest the possibility of using radioactive elements as sources of energy, and he organised a special commission to look for uranium ores in Russia. In 1916, the first uranium deposits were discovered. But Vernadsky was aware of the danger of putting atomic energy into the hands of man. He said that scientists carried the huge responsibility of making sure their discoveries did not lead to destruction.

However, Vernadsky is probably best known for his development of the idea of the biosphere of the Earth and his ideas on the evolution of the biosphere into the noosphere.

He defined the boundaries of the biosphere by showing that the biosphere includes all the hydrosphere, part of the troposphere – the lowest layer of the atmosphere where most weather changes take place – and the upper part of the Earth's crust down to a depth of two or three kilometres, in short, everywhere that life exists. For Vernadsky, the biosphere had existed since the very beginning of the Earth's history and it was constantly evolving. Our present living world is the product of a long and complex evolution of the biosphere.

Vernadsky believed that the technological activities of mankind were a stage in this evolution. He believed that human reason and combined scientific efforts could overcome the negative results of technology and could lead to a safe future for everyone. This positive evolutionary stage of the biosphere of the Earth is for him the *noosphere*, the sphere of reason.

In his paper, *Several Words on the Noosphere* (1944, the last paper he published before his death), Vernadsky outlined the conditions that were required for the creation of the noosphere: equality for all people and an end to wars, poverty and hunger. Today, Vernadsky's vision of the world is more important than ever before.

Pronunciation guide

crystallography /krɪstə'lɔgrəfɪ/
geochemistry /dʒɪɔ'kemɪstrɪ/
mineralogy /mɪnə'rælədʒɪ/
noosphere /'nəʊɔsfɪə/
uranium ores /jʊ'reɪnɪəm ɔ:z/

E Comprehension

Read the text and choose the correct answer.

1 Vladimir Vernadsky taught at
- **A** St Petersburg University.
- **B** Moscow University.
- **C** the Russian Academy of Sciences.
- **D** both St Petersburg and Moscow University.

2 Vernadsky's work in mineralogy led to
- **A** his work in publishing.
- **B** discovery of the Earth's hydrosphere.
- **C** his interest in geochemistry.
- **D** a new field of geochemistry.

3 He was one of the first to suggest using
- **A** atomic energy.
- **B** minerals.
- **C** the biosphere.
- **D** various elements.

4 The biosphere is the layer of Earth where
- **A** only minerals are found.
- **B** living things are found.
- **C** only the troposphere is.
- **D** its history began.

5 According to Vernadsky,
- **A** the noosphere is in the atmosphere.
- **B** the biosphere developed from the noosphere.
- **C** the biosphere creates a negative environment.
- **D** the noosphere would create a better world.

Work in pairs. Make three questions on the text for your partner to answer. Then change roles.

Before you listen

Discuss these questions with your partner.

- → What do you know about uranium?
- → Do you think atomic and nuclear power are safe? Why / Why not?
- → Do you know any other radioactive elements?
- → Give examples of their application.

F Listening

Listen to the class discussion about uranium. Then decide if the following statements are true or false.

1 Uranium has been in the Earth's crust for a very long time. T ☐ F ☐

2 Uranium entered a star that had exploded. T ☐ F ☐

3 Uranium is lighter than oxygen. T ☐ F ☐

4 Uranium is a source of energy. T ☐ F ☐

5 A small amount of uranium can produce a great deal of oil. T ☐ F ☐

6 Less carbon dioxide enters the atmosphere when we use nuclear power. T ☐ F ☐

G Speaking

Discuss these questions with your partner.

- What do you understand by the term *biosphere*?
- In what sorts of different environments can life exist?
- Think about humanity. How do we affect our environment?

Task

Discuss with your partner the idea of the biosphere and a noosphere. Do you believe it is possible for Earth to develop a noosphere? Say what you think and find out if your partner agrees or disagrees with you.

Talk about:

- what the term *biosphere* means
- which environments are contained within it
- the importance of the food chain
- human impact on the biosphere
- the importance of the biosphere
- what the noosphere is

Read texts 1 and 2 again and use these notes to help you.

Meaning: biosphere comes from the words ..... and ..... .

The biosphere has four environments:

air, known as the ..... .

land, known as the ..... .

rocks, known as the ..... .

water, known as the ..... .

The food chain is important because..... .

Human impact: effect on plants and animals

The biosphere is important because..... .

The development of the noosphere is (im)possible because ..... .

Remember to:

- read the texts carefully
- locate the information you need
- keep your information in a logical order
- discuss all parts of the question
- take part fully in the discussion
- ask for your partner's opinions and ideas

Speaking tips

✔ Briefly introduce your topic.

✔ Use terms such as 'in addition', 'according to', and 'furthermore' to connect your ideas.

H Writing

Write an article for your school magazine explaining what the biosphere is, who developed its meaning, and why it is important that we protect it. Use these notes to help you.

PARAGRAPH 1

Introduction Briefly explain what the term *biosphere* means.
Vocabulary: Greek meaning, sphere of life

PARAGRAPH 2

Write about Vernadsky and his role in the development of the idea of a biosphere. Include information about the different environments in the Earth's biosphere.
Vocabulary: geochemistry, evolution, boundaries, hydrosphere, troposphere, Earth's crust

PARAGRAPH 3

Write about the impact of human beings on the biosphere. Give examples of both good and bad effects.
Vocabulary: technology, scientific effort, human reason

PARAGRAPH 4

Conclusion What do you think will happen to the biosphere in the future? Can it develop into a noosphere, as Vernadsky had hoped?

Write 200-250 words.

Unit 4

Before you read

Discuss these questions with your partner.

- Can you draw a cell and label its parts?
- What part contains hereditary information?
- Have you ever seen a cell under the microscope?
- Do you remember your impressions?

A Vocabulary

Complete the sentences below with words from the box.

- chromosomes
- multi-celled
- protoplasm
- lifespan
- nerve
- determined
- single-celled
- tissues
- nucleus
- muscle
- stem cell

1 ..... are found in cells and pass on information.

2 Bacteria are ..... organisms.

3 ..... organisms consist of more than one cell.

4 Cells of the same structure and function that are grouped together form ..... .

5 ..... is the jelly-like mass that fills a cell.

6 The cell's hereditary material is stored in its ..... .

7 The natural ..... of a pig is 10-12 years.

8 The ..... tissue stretches or tightens to move the body.

9 The purpose of the ..... cell is to transmit nerve impulses.

10 Every single cell in the body is born by a ..... .

11 Gender is ..... by the presence or absence of certain chromosomes.

Reading 1

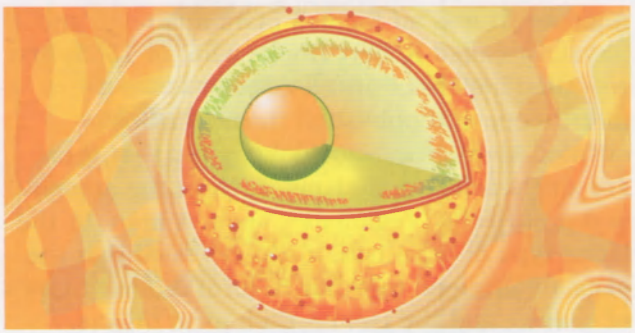
Cells

A cell is a tiny unit which constitutes the core of all living things: human, animal, plant or microbe. It was an English mathematician and physicist called Robert Hooke who, in 1665, first recorded his observations of cells under a microscope and published them in a book entitled *Micrographia*. Hooke noted that there are single-celled organisms, such as the amoeba, and multi-celled organisms, such as man. In the latter type of organism, it was revealed that the cells are grouped together to form different types of tissues, and the tissues then form organs.

The structure of a cell appears very simple. It is a jelly-like mass, called protoplasm, enclosed by a wall, with a central nucleus. Although research continued into the structure and function of cells, it was not until the late 19th century that a process of staining and fixing tissues was developed. This made it possible for scientists to preserve the cells for more detailed observation under a microscope. It was then discovered that new cells are formed by the division of old ones, and that each cell has its own lifespan. In other words, a cell is born (created), feeds, produces waste, grows, splits to create new cells or disintegrates and dies. Each cell has a specific function and specific characteristics, for example, muscle cells stretch and nerve cells carry information.

Stem cells are central to this infrastructure. These cells provide a remarkable repair system for the body, as they are able to develop into any type of cell. They can continue to redivide as often as possible to replace damaged or dying cells. The cells created from the division of a stem cell can remain stem cells, or become any of the other specific cells (blood cells, brain cells or other) in the organism. The key to the division process lies in the nucleus. The nucleus splits into two identical parts in the shape of rods or threads, which break away in opposite directions and form new nuclei. At this point the cell itself divides and two new cells are born.

The rods or threads are called chromosomes. Each chromosome is made up of links of protoplasm called genes joined together in a chain. It is the genes that determine the essence of each cell and its particular characteristics. The number of chromosomes found in a particular organism always remains the same, but it will vary depending on the species; human beings have 48, for example, and sugar cane over 200.



Pronunciation guide

amoeba /əˈmiːbə/
chromosome /krəʊməsəʊm/
microbe /maɪkrəʊb/
microscope /maɪkrəskəʊp/
nucleus /njuːklɪəs/

B Comprehension

Read the text and answer the questions in your own words.

1 How do organs form in multi-celled organisms?

2 What stages/processes does a cell's lifespan include?

3 Why are stem cells important?

4 What happens to the two identical *threads* or *rods* the nucleus splits up into?

5 What are chromosomes?

Before you listen

Discuss these questions with your partner.

→ What do you know about genetic engineering?

→ Do you think it is safe?

C Listening

Listen to two students discussing their homework. Then answer the questions by writing one or two words in each gap.

1 They will both write a report for their ..... class.

2 The boy may write about ..... .

3 It is now possible for scientists to change information in ..... .

4 ..... watermelons have been produced by scientists in their labs.

5 Scientists can use this new technology to produce more ..... .

6 Plants can be genetically engineered to make ..... .

Before you read

Discuss these questions with your partner.

- Do you have plants at home? Do you have a kitchen garden?
- What do you know about selection of plants?
- Have you ever conducted an experiment?

D Vocabulary

Match these words with their definitions.

1 blend	A changed
2 altered	B children
3 hypotheses	C combine
4 ratio	D theories
5 offspring	E relative amount
6 successive	F element
7 particle	G think of
8 trace	H find
9 come up with	I following

Reading 2

Gregor Mendel

Gregor Mendel was born on 20th July, 1822, and died on 6th January, 1884. He was a biologist and botanist whose scientific research showed that inheritance proceeds according to certain scientific laws.

Mendel was a brilliant student and his family encouraged him to study, but they were very poor so Mendel entered a monastery in 1843. There he taught Mathematics, Physics and Greek to high school students. Eight years later, in 1851, the monastery sent him to the University of Vienna where he was able to continue his education. In 1853, he returned to the monastery and began teaching and researching again.

Mendel's theories of heredity based on his work with pea plants are well known to students of

Biology. But his findings were so different from the accepted views on heredity at the time that his work was ignored until long after his death. His paper, *Experiments in Plant Hybridisation*, in which he described how traits were inherited, has become one of the most influential publications in the history of science.

Mendel was the first person to trace the characteristics of successive generations of an organism. In Mendel's day, a number of hypotheses had been suggested to explain heredity. The most popular one was the so-called *blending theory*. According to this theory, inherited traits blended from generation to generation. For instance, a red rose crossed with a white rose would, over time, produce a pink rose. Another theory put forward by Charles Darwin was called *pangenesis*. This stated that there were hereditary particles in our bodies, and that these particles were affected by our actions. The altered particles could be inherited by the next generation. These theories were disproved by Mendel.

The first thing he noticed when he began his experiments was that traits were inherited in

certain numerical ratios. This observation led him to come up with the idea of the dominance of genes and he tested it in peas. For seven years he crossed thousands of plants to prove the Laws of Inheritance. From his experiments, Mendel developed the basic laws of heredity. Those laws are the following: that traits do not combine, but are passed whole from generation to generation (which disproved the blending theory and Darwin's theory); each member of the parental generation passes on only half of its hereditary information to each offspring (with certain traits dominant over others); and different offspring of the same parents receive different sets of hereditary information.

Mendel's research formed the beginnings of the modern science of genetics. Genetic theory has had a huge impact on our lives. Many diseases, for example haemophilia, are known to be inherited, and family histories can be traced to determine the probability of passing on a hereditary disease. Scientists can now design plants that are easier to grow, or which can produce more food. This practical side of the results of Mendel's research is being used to improve the way we live.

Pronunciation guide

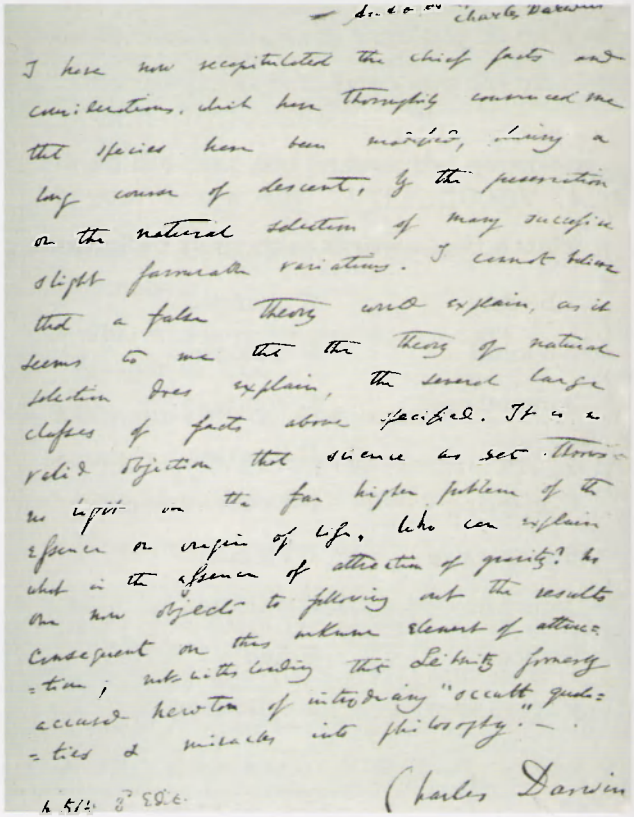
haemophilia /hiːməˈfɪlɪə/
hybridisation /ˌhaɪbrɪdaɪˈzeɪʃən/
pangenesis /pænˈdʒenəsɪs/
ratio /reɪʃəʊ/
Vienna /vɪˈenə/

E Comprehension

Read the text and choose the best title for each paragraph. There is one title which you do not need to use.

PARAGRAPH 1 .....
PARAGRAPH 2 .....
PARAGRAPH 3 .....
PARAGRAPH 4 .....
PARAGRAPH 5 .....
PARAGRAPH 6 .....

A The experiment
B His studies
C Genetics today
D A modern science
E An important paper
F Different theories
G Gregor Mendel, the scientist


I have now recapitulated the chief facts and considerations, which have thoroughly convinced me that species have been modified, during a long course of descent, by the preservation or the natural selection of many successive slight favourable variations. I cannot believe that a false theory would explain, as it seems to me that the theory of natural selection does explain, the several large classes of facts above specified. It is a valid objection that science as yet throws no light on the far higher problem of the essence or origin of life. Who can explain what is the essence of the attraction of gravity? No one now objects to following out the results consequent on this unknown element of attraction; notwithstanding that Leibnitz formerly accused Newton of introducing "occult qualities & miracles into philosophy."

Charles Darwin

Before you listen

Discuss these questions with your partner.

- What does evolution mean?
- Do you know anything about Charles Darwin?
- What do you know about natural selection?

F Listening

Listen to a talk about Darwin. Then decide if the following sentences are true or false, according to the speaker.

1 Darwin wrote two famous books. T ☐ F ☐
2 Darwin's theory was very popular in his time. T ☐ F ☐
3 Differences between fossils and modern animals helped him form the Theory of Evolution. T ☐ F ☐

4 Natural selection meant the healthiest specimens would survive. T ☐ F ☐

5 An adaptation was inherited and decreased an organism's chances of survival. T ☐ F ☐

G Speaking

Discuss these questions with your partner.

→ How are characteristics passed on from generation to generation?

→ How does modern science change this? Why?

Task

Prepare a short presentation on the topic: 'Theories of inheritance'. Use the information in both texts.

Talk about:

- Mendel's theory
- Mendel's experiment
- theories that were disproved
- cells, chromosomes and genes

First complete these notes. Use them in your presentation.

Mendel's theory: Mendel stated that ..... .

Mendel's experiment: Mendel conducted experiments on ..... .

Disproved theories: The theories that Mendel disproved were ..... and ..... .

What are cells? How is genetic information passed on?

Remember to:

- read the texts carefully
- underline the parts containing the information you need
- use your own words; do not copy everything from the texts
- stick to the point

Speaking tips

✔ Refer to your notes.

✔ Do not read out a long monologue.

✔ Express yourself clearly and concisely.

H Writing

Write a letter to a science museum applying for a part-time job. Use these notes to help you.

Dear **(Sir/Madam)**,

Writing to apply for a job:

I am writing to apply for the position of

.....

.....

Why you would be suitable: interested in science **(physics / mathematics / biology / your own ideas)**:

I believe I would be suitable for the position because .....

.....

Intend to study Science at university:

It is my intention to study Science at university, and I believe this will .....

.....

Previous work experience: **(laboratory / library / your own ideas)**

I **(have)** worked in a ..... for ..... years/months.

Say you are available for an interview:

I am available for an interview .....

.....

Yours faithfully,

(your full name: first name + surname)

Write 100-140 words.

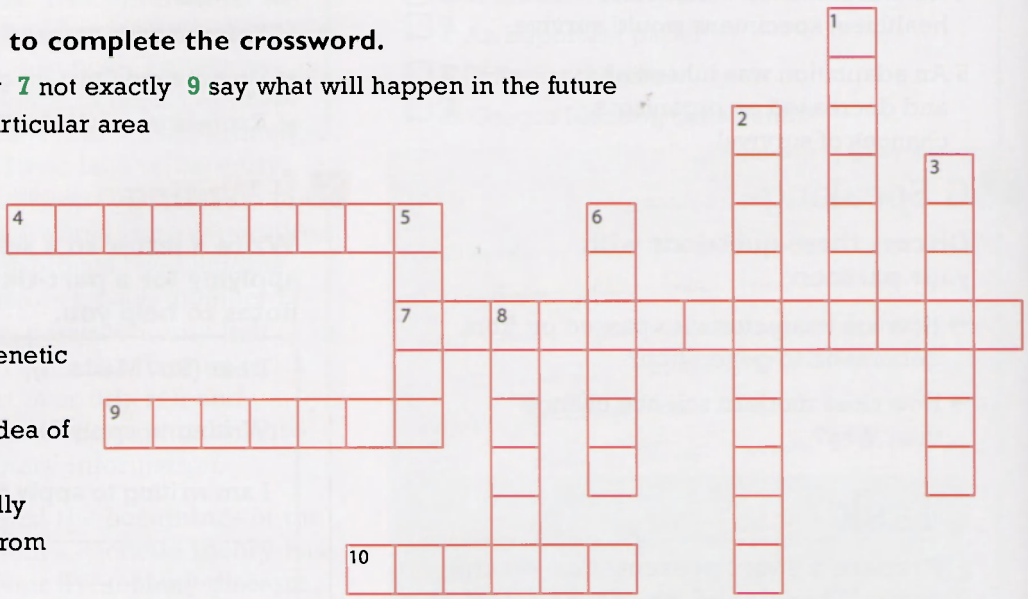
Revision vocabulary Units 1 to 4

A Use the clues to complete the crossword.

Across: 4 forever 7 not exactly 9 say what will happen in the future 10 one particular area

Down

1 live in
2 threadlike structure with genetic information
3 give a general idea of
5 characteristic
6 develop gradually
8 yellow powder from flowers



B Circle the correct answer.

1 The life ..... of insects starts when they are larva.
A cycle B field C vacuum

2 In the 18th century living things were ..... into biological families.
A treated B stated C classified

3 The biological information passed on to us from the previous generation is our ..... .
A inheritance B observation C principle

4 Charles Darwin is famous for ..... the idea of natural selection.
A disproving B adapting C formulating

5 It was really small – a ..... .
A pollen B microorganism C crop

6 They'll take a ..... of your blood for testing.
A sample B injection C vaccine

7 He was immunised to have ..... to diseases.
A recovery B application C resistance

C Complete the sentences with these phrases.

- coined a term
- came up with
- Earth's crust
- dominant gene
- have an impact
- threatened species
- uranium ore
- chemical elements

1 Mendel ..... a theory.
2 Suess ..... . It was *biosphere*.
3 The panda is a ..... but efforts are being made to save it.
4 ..... is found in the ground.
5 When cells are making flowers, the ..... will decide what colour they are.
6 The outer layer is the ..... .
7 You can find ..... in the atmosphere.
8 Usually advances in science ..... on our lives.

D Complete the sentences with words derived from the words in red.

1 The scientist recorded his..... during the experiments. **observe**
2 Vernadsky was interested in the ..... of various elements in the atmosphere, hydrosphere, etc. **distribute**
3 Pasteur's ..... of germ theory to preventing disease led to pasteurisation. **apply**
4 Mendel followed the characteristics of an organism through..... generations. **succession**
5 Fortunately the patient made a quick ..... . **recover**

Unit 5

Before you read

Discuss these questions with your partner.

- What do you know about heredity?
- What characteristics do you have in common with people in your family?

A Vocabulary

Complete the sentences below with words from the box.

striking	strand
substance	bound
breakthrough	revealed
compound	organic base
coils	pattern

1 What is the chemical ..... used in paint?

2 A sprung seat is made up of ..... of strong wire.

3 An important discovery that helps us find a solution is called a ..... .

4 A long length of something is a ..... .

5 We can find a ..... if we watch something and see if it acts in similar ways over a period of time.

6 It was quite ..... how different the children were.

7 The sheets of paper were ..... together by string.

8 Mendel's discoveries ..... the secret of heredity.

9 A combination of two or more elements or parts is called a ..... .

10 A(n) ..... is an organic compound which acts as a base.

Reading 1

The discovery of the structure and function of DNA

Look around you and you will see people of all different shapes and sizes, hair and eye colour. However, despite the differences that seem so striking, if you compare the genes of any two human beings they will be 99.9% the same. This similarity means we belong to the same species while the 0.1% difference makes us individuals and means we are different from each other.

What exactly is a gene? To answer that we have to look at the chromosomes inside the nucleus of a cell. We get 23 of these from our mothers and 23 from our fathers. Found in almost every cell in the body, these chromosomes consist of long strands of the chemical called deoxyribonucleic acid which is known as DNA. Each cell contains about two metres and if you put all the strands together they could travel to the Moon and back many times.

Scientists have known that DNA exists since 1869 when the Swiss scientist Johann Friedrich

Miescher noticed something he had not seen before in the nuclei of cells. He called it 'nuelein'. It was more than 70 years later that scientists examined his theory.

It was two researchers at Cambridge University, England, who, in 1953, finally revealed the secret of DNA and its role in the pattern of life. James Watson, an American zoologist, and Francis Crick, an English biologist, had already discovered that DNA was made up of sugar and phosphates in the form of a chain. The whole structure was bound together by four compounds called guanine, adenine, thymine and cytosine. Each of these four nucleotides, as they were known, had a different organic base. They knew that guanine and adenine were the larger of the four, and that thymine and cytosine were the smaller; what they did not know was how they all fitted together.

Returning from London one day, Watson hit on the idea of experimenting with different pairs. The two men made cardboard models of the four nucleotides and then tried systematically fitting them together. Watson later described their breakthrough in this way: 'Suddenly I became aware that an adenine-thymine pair was identical in shape to a guanine-cytosine pair'. Thus the men had discovered the relationship between the organic bases, and could see how each of these pairs of nucleotides formed a single rung on the so-called DNA ladder (DNA is shaped like a long ladder that is twisted into a spiral; this structure is known as the double helix). The discovery was the key to a much better understanding of the process of heredity.

There may be millions of these DNA ladder rungs linked to form hundreds of thousands of coils which in turn make up the structure of a single DNA molecule. In order for a cell to divide, all these coils have to be unwound. Then all the new nucleotides have to be linked in the right order and joined together by enzymes (enzymes are chemicals which we can find in all living organisms; they cause changes to take place). The entire process has to take place at great speed; in fact, in the time it takes for a cell to divide. Since bacteria cells split and form new cells in less than 20 minutes, this would mean that the DNA helix has to unwind very fast (several hundred turns a second) and a new chain has to be formed at the rate of several thousand nucleotides a second. At such a speed, a car engine would blow apart.

Pronunciation guide

adenine /'ædəni:n/
cytosine /'saɪtəʊsi:n/
deoxyribonucleic /di:ɔksɪˌraɪbəʊnju'kli:ɪk/
enzymes /'enzaɪmz/
guanine /'gwɑ:ni:n/
thymine /'θaɪˢmi:n/

B Comprehension

Read the text and decide if the following statements are true or false.

1 A particular species shares almost all its genes. T ☐ F ☐
2 We get equal numbers of chromosomes from our parents. T ☐ F ☐
3 Friedrich Miescher immediately revealed the importance of DNA. T ☐ F ☐
4 The four compounds of DNA are not the same size. T ☐ F ☐
5 Watson and Crick did the computer modelling for nucleotide bases. T ☐ F ☐
6 A new helix chain is assembled at a comparatively slow speed. T ☐ F ☐

Before you listen

Discuss the following with your partner.

→ How is DNA useful to different people in different occupations?
→ Talk about: archaeologists, doctors, the police

C Listening

Listen to a talk. Then complete the information about DNA.

1 Each strand has about ..... billion letters of coding.
2 We inherit the information from our ..... .
3 DNA will be useful in the future for ..... care .
4 The Y chromosome comes from our ..... .
5 Archaeologists use DNA found in people's ..... .
6 The police get information from DNA found at a ..... .

Before you read

Discuss these questions with your partner.

- Do you know anything about genetic engineering?
- Do you buy genetically modified food?
- Would you like to clone something or someone?
- Have you read any books - scientific or fiction - about cloning?
- Are there any films where the issue of human cloning comes up?
- Is cloning a matter of technology, ethics or politics?

D Vocabulary

Match these words with their synonyms and antonyms.

Words

1 endanger
2 extract
3 unique
4 extinction
5 replica
6 particular
7 identical
8 create
9 latest
10 brilliant
11 improve
12 move ahead

Synonyms

A copy
B special
C take out
D threaten
E death
F exclusive
G recent
H make better
I progress
J same
K intelligent
L make

Antonyms

a survival
b original
c protect
d insert
e general
f common
g fall behind
h destroy
i different
j stupid
k make worse
l old

Reading 2

Cloning

It used to be only in science fiction that the existence of a race of identical creatures could be imagined: a group of people with exactly the same hair colour, the same features and the same height. However, now this dream – or nightmare – could actually become reality. In theory, the process of creating replicas of any living being seems quite simple. First, a body cell, which contains the specific genes of a living organism, splits in two. The resulting new cells, each containing the same genes, then grow into two new, identical organisms. This process is known as cloning, and it can be applied to humans, animals, insects and plants.

Early experiments with cloning took place using the tadpoles of frogs. In 1968, Dr J.B. Gurdon of Oxford University, England, took an unfertilised frog's egg from a frog – let us call it frog number 1 – and destroyed its nucleus. This meant that he had removed all the genetic information which related to this frog. He then inserted a new nucleus extracted from a cell from another frog –

frog number 2. The tadpole which developed from the egg produced by frog number 1 was identical to frog number 2, not to frog number 1! It was not until 1996, however, in Scotland, that a group of British researchers led by Ian Wilmut achieved the successful cloning of an adult animal. The result was Dolly, who has taken her place in the history books as the first lamb to be cloned from the DNA of an adult sheep.

Following the birth of Dolly, both scientists and ordinary people have begun to think about the possibilities of cloning. The latest technology now means that we can remove body cells from the best of our race, the brilliant scientist, the musical genius, the child prodigy, and ensure that the same genes are reproduced in as many babies as we wish. However, cloning does not mean copying. The process actually takes its name from the Greek word *clon* which means a twig. A twig has the same genetic information as the tree it comes from, but the two look very different. In the same way, a clone shares the same genes as its donor, but its behaviour and characteristics will be different: personality will always be unique.

Science has provided us with knowledge which seems to have unlimited possibilities. We can not only make *designer* human beings, but we can also use cloning to improve health. For example, scientists predict that in the future, pigs with organs that could be used in human transplants, could be cloned. Cloning could also enable us to learn more about the embryo and how organisms develop. Cloning could put an end to the risk of extinction of the endangered species on our planet; if animals can be cloned, they need never die out.

However, the process is very controversial. Some people have asked whether a cloned individual would really be a human; would it have a soul? Would there be relationships and responsibilities between donors and clones? What would be the position of the children of donors in relation to clones? These people are concerned that cloning, or genetic engineering, would interfere with the laws of religion or nature. Others are concerned that it might lead to attempts to alter the features of a particular race and result in a new kind of ethnic cleansing. The fact is that the new opportunities offered by science have always meant that we are faced with new ethical questions. These questions need to be discussed and evaluated before we move ahead.

Pronunciation guide

cloning /kləʊnɪŋ/
embryo /'embrɪəʊ/
replicas /'replɪkəz/
unfertilised /ʌn'fɜ:təlaɪzd/

E Comprehension

a. Read the text and choose the best title for each paragraph. There is one title, which you do not need to use.

CLONING OF LIVING BEINGS

BENEFITS OF CLONING

COPYING AND CLONING

MORE DISADVANTAGES

ETHICAL PROBLEMS

POSSIBLE FUTURE

b. Answer the following questions.

1 When did the first attempt to create a clone take place? What happened?

2 Who's Dolly? Why is she famous?

3 In what ways is cloning different from copying?

4 Give one example of how cloning could be beneficial to humans.

5 What are the disadvantages of cloning from an ethical point of view?

c. Work in pairs. Think of at least one more question to the text your partner should answer. Then change roles.

Before you listen

Discuss these questions with your partner.

→ What does research involve?

→ What kind of person would be good at research in your opinion?

F Listening

Listen to a talk about the scientist Rosalind Franklin and choose the correct answer.

1 Perhaps Franklin didn't receive the recognition she deserved because
- **A** she was the only woman.
- **B** women were treated differently in the past.
- **C** she was only one of the people working on DNA.

2 Franklin's particular skills were
- **A** being a researcher.
- **B** interpretation and explanation of scientific results.
- **C** photographing crystals and explaining the photos.

3 Franklin's photo revealed
- **A** a new technique of crystallography.
- **B** the basic helix structure.
- **C** the atoms in a crystal.

4 Watson was interested in the photo because
- **A** the structure of DNA had never been seen before.
- **B** it could be reproduced.
- **C** he wanted to identify the double-helix.

5 Today Franklin is
- **A** regarded by all as a genius.
- **B** recognised as the most important contributor to DNA.
- **C** somebody whose role in DNA research is clear.

G Speaking

Give a two-minute presentation on the benefits and problems of human being cloning. First read text 2 again and make notes on the following:

- → What is cloning?
- → How is cloning done?
- → benefits: medicine, saving of endangered species
- → problems: donors and clones, children of donors, religion, ethnic cleansing

Remember to:

- use key words for your notes, not complete sentences
- glance at your notes regularly

Speaking tips

- ✔ Speak in a clear voice.
- ✔ Maintain eye contact with your audience.

H Writing

Write an essay about the key events that led to the discovery of the structure and function of DNA and explain the possible applications of these findings in today's world.

Remember to:

- read the texts again
- select information that is relevant

Include some of these useful phrases in your writing:

To begin with, ...

Research began with ...

Later on, ...

In addition to that, ...

However, / On the other hand, ...

Finally / In conclusion

PARAGRAPH 1

Introduction
What is DNA?

PARAGRAPH 2

Information about the scientists and their work (Miescher, Watson, Crick, Wilmut).

PARAGRAPH 3

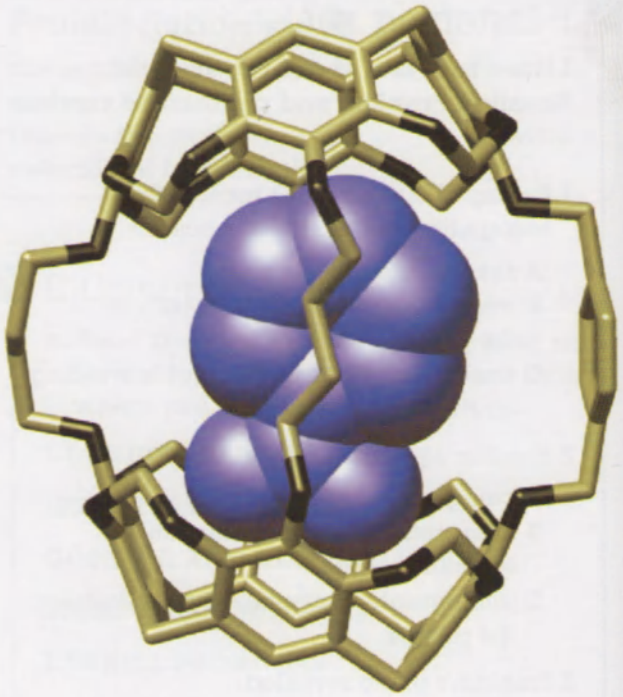
Cloning (benefits & problems)

PARAGRAPH 4

Conclusion

Write 200-250 words.

Unit 6



Before you read

Discuss these questions with your partner.

- Can you name any famous chemists?
- What are they famous for?
- Where do chemists work?
- What equipment do they use?

A Vocabulary

Complete the sentences below with words from the box.

conservation of mass	matter
combustion	quantity
accurate	breakthrough
alchemists	properties

1 It is a fact that substances cannot change their ..... .

2 ..... means that no matter how a substance is changed, what it is made up of will always stay the same.

3 When scientists make a ..... they succeed after trying very hard.

4 Without oxygen there cannot be ..... – things cannot burn.

5 ..... is what physical objects are made of.

6 All classifications in chemistry need to be ..... .

7 ..... believed that they could turn iron into gold.

8 Mendeleev's table classifies the elements found in nature according to their ..... .

Reading 1

Chemistry

An introduction

Chemistry is often said to be the central science, as it connects all other sciences. While mathematicians calculate the world, physicists explain it and biologists say what lives in it, chemistry looks at everything in the world and explains how it is made and what it can do.

Chemistry began with fire. Burning changes things and ancient man must have wondered what happened to the wood he burnt. It was by burning things that ancient man discovered iron and glass, combining different substances in the fire and seeing how they combined. Once gold was found, the false science of alchemy was born. People believed they could change ordinary metals like iron into gold. Though the idea was wrong, the alchemists discovered many of the chemical processes that are in use today.

The origin of modern chemistry comes from the work of Antoine Lavoisier, an 18th century Frenchman who was executed in 1794 during the French Revolution. He formulated the idea of the conservation of mass: that is, even though

substances can be changed, their quantity of mass remains the same always. Although Lavoisier was the first to publish his ideas, in Russia, Mikhail Vasilyevich Lomonosov had reached the same conclusions some years earlier. Both men were interested in the nature of combustion – what happens when things burn – and this was the first breakthrough in our understanding of chemistry.

The second great development in chemistry came later and concerned the nature of matter itself: how it was made up and what its parts were. In the early part of the 19th century, the British scientist, John Dalton stated that all matter was made up of atoms of different elements and that these could not be broken down into smaller parts. We know now that atoms exist and that they do have parts which can be broken down, but at the time his ideas divided chemists into those who accepted his ideas and those who did not. There was a whole century of research to be done before the work of Marie Curie on radioactivity and of Ernest Rutherford and Niels Bohr on atomic structure finally proved that Dalton was correct after all.

Even while chemists were divided on atomism, it became necessary for someone to make sense of the growing list of elements that were being discovered. That someone was Dmitri Mendeleev. He took Dalton's theory of atomism and arranged the elements by their atomic weight and by their chemical properties. So accurate was his classification of the elements, that he was able to predict the properties of undiscovered ones to fill the gaps in the table. Mendeleev's table is one of the most useful and important generalisations of chemistry and of all science.

These three developments give us the definition of chemistry. It is the science of the composition, structure and properties of substances and how they can be transformed.

Pronunciation guide

alchemy /ˈælkəmɪ/
Antoine Lavoisier /ˈæntwən lævuɑːzɜ/
Marie Curie /məri ˈkjuərɪ/
Rutherford /ˈrʌðəfəd/

B Comprehension

Give a title to each paragraph. Read the text again and complete the summary. Use words from the text.

Chemistry is the science which **(1)** ..... all other sciences. Through chemistry, we can study how things are made and what they can do.
Alchemists discovered a lot of chemical **(2)** ..... before chemistry developed properly. There are three main areas of study in modern chemistry. The first is about how **(3)** ..... change when something happens to them. The second is about how things are made, and looks at the atomic **(4)** ..... of elements. The third is to look at the **(5)** ..... of elements.

Before you listen

Discuss these questions with your partner.

- What is the difference between an element and a compound?
- What is the difference between a liquid, a solid and a gas? Name as many as you can.

C Listening

Listen to a chemist talking about chemical processes. Then listen again and complete these notes. Choose from the words in the box. There are more words in the box than you need.

■ solid ■ elements ■ liquid ■ bond
■ materials ■ compound ■ process
■ form ■ atoms ■ gas

For example, two **(1)** ..... : hydrogen and oxygen. Hydrogen has the atomic number **(2)** ..... and oxygen **(3)** ..... .

Two molecules of hydrogen and one of oxygen = one **(4)** ..... .

Water can change its **(5)** ..... but is still H_2O. Some chemical processes appear complicated as they have different **(6)** ..... bonding in different quantities.

Before you read

Discuss these questions with your partner.

- What do chemists produce?
- Why do doctors need chemists?
- Do you think chemists can do anything to help pollution?

D Vocabulary

Match these words and phrases with their definitions.

1 preservation	A to take out of
2 oil refining	B watch carefully
3 waste	C something added to give taste
4 flavouring	D process that keeps something in the same condition
5 meet the standard	E very small strands
6 monitor	F produce
7 cure	G making oil purer
8 manufacture	H unwanted part of production process
9 fibre	I be of the right level
10 extract	J make healthy

Reading 2

Chemistry today

Careers in chemistry: what can you do with a degree in Chemistry?

This leaflet has been written to help you decide about your future. You have studied Chemistry at university and have decided that you want to continue working in the science. What career opportunities are available? There are two main areas where your knowledge of chemistry will be called upon: medicine and industry.

Medicine

Many chemists work in medicine. In fact, it is probable that our hospitals and doctors could not

operate without the support they get from chemists. Chemists are the people who carry out the research and develop new medicines. All over the country, chemists are working on new cures for diseases. There is always more work to be done on antibiotics. Bacteria develop resistance to these drugs and biochemists need to be constantly testing how well these medicines are working as well as looking at new antibiotics to replace the old ones. There are many illnesses which have no cure at the present time and a great deal of research is going on, looking for new and better treatments for cancer, HIV/AIDS and malaria.

There are career opportunities within hospitals, too. Doctors need the support of chemists analysing samples from patients, conducting tests and measuring how well patients are responding to treatment. One quickly developing area is in the testing and recording of DNA samples.

Industry

Chemists work in the food industry, creating chemical flavourings and preservatives to improve the quality of what we eat or to help keep it fresher for longer. Other people work in quality

control, sampling and testing the food products to make sure that they meet the standards we expect them to have. In recent years, the European Union has revised its standards for quality and health in all food products sold in the EU, including both those made there and imported. Chemists have their part to play in monitoring these products as well as in developing new methods of meeting these standards.

Another very important industry that our knowledge of chemistry has created is the oil refining industry. Oil is taken out of the ground and put through a chemical process which turns it into many different products. From oil, we can make not only petrol, but also plastics, synthetic fibres, paint and gases for fuel and other uses. A major concern in the industry today is the pollution resulting from these processes. Industries are trying to reduce the impact of this by wasting less and by extracting more from the waste products of the manufacturing process. Chemists are working to filter harmful waste, preventing it from going into the atmosphere.

Almost all other industries depend in some way on the work of chemists. Chemistry has given us a huge range of plastics and colourings. In fact, there is a chemical process involved in everything we make. The whole manufacturing process needs to be designed, managed and tested for safety by chemists.

Other choices

Career opportunities for chemists also exist in journalism, the law and education.

Pronunciation guide

antibiotic /æntɪbaɪˈɒtɪk/

HIV/AIDS /ˌeɪtʃaɪviːˈ/ /eɪdz/

malaria /məˈleərɪə/

E Comprehension

Read the text and answer the questions in your own words.

1 How do chemists help to treat and cure diseases?

2 How can chemists support doctors working in hospitals?

3 What do chemists do to make sure we have good quality food?

4 What part do chemists play in the production of plastics?

5 How are chemists working to reduce pollution?

Before you listen

Discuss this question with your partner.

→ How is life today different from life last century when medical drugs weren't available?

F Listening

Listen to a chemist talking about his job. Then answer the questions.

1 What kind of a business does he work for?

2 How long does it take to test a new compound?

3 Where does he spend his time working?

4 Can he usually predict the result of his experiments?

5 What percentage of his experiments fail?

G Speaking

Discuss these questions with your partner.

- What are the main branches of modern chemistry?
- Do you know any recent inventions in the field of chemistry?
- Would you like to work as a chemist? Why / Why not?
- Would you say it was one of the best jobs available? Give your reasons.

Task

Working in a group, discuss the opportunities for chemists in today's economy. Use the information in text 2 and any ideas of your own.

Talk about:

- where chemists work
- what they do
- what they are responsible for

First complete these notes. Use them in your discussion.

Career opportunities working in chemistry

Main work areas:

Medicine

Research, development and testing: .....

Offer support to doctors: .....

sampling and recording (esp. DNA)

Industry

Developing new products: food .....

Designing and organising chemical processes for industry

Monitoring and improving processes (food production, pollution control)

Conclusion

Remember to:

- read the text again
- add any ideas of your own
- explain the general idea and then give details
- allow everybody to speak

Speaking tips

- ✔ You could choose a secretary to keep notes of what you discuss and inform you of any points you forget.
- ✔ Make sure everyone is given plenty of opportunity to speak. The secretary could check this too.

H Writing

Write a short essay with the title: 'What is chemistry and what does it study?'

Read text 1 again and use these notes to write four paragraphs.

PARAGRAPH 1

Introduction (how the essay is organised)
- What do chemists do?
- What are they interested in?
- What are the main areas of the science?

Vocabulary: To begin with, chemists, chemistry, etc

PARAGRAPH 2

Chemistry studies matter, how matter is made, what happens when matter changes

Vocabulary: moreover, matter, materials, structure, transform

PARAGRAPH 3

three important areas in chemistry:
- transformation – how chemical changes occur
- atomic structure – how materials are made and how they are different from each other
- elements of matter – what they are and what their properties are, classified by Mendeleev

Vocabulary: furthermore, atom, elements, properties

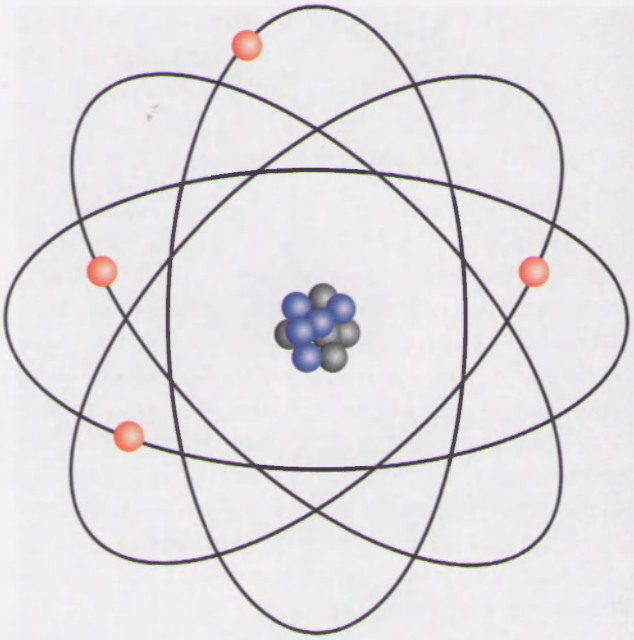
PARAGRAPH 4

Conclusion (summarise ideas)

Vocabulary: finally, to sum up, generally, science

Write 200-250 words.

Unit 7



Before you read

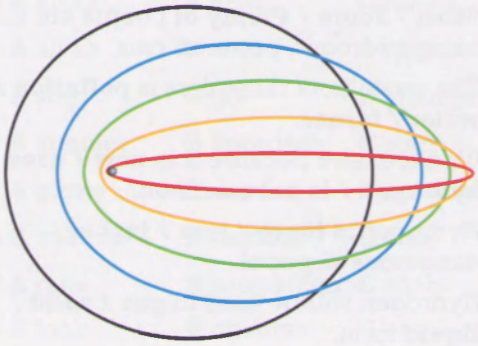
Discuss these questions with your partner.

- In chemistry and physics, what is an atom?
- What is smaller than an atom?
- What happens if you split an atom?

A Vocabulary

Match these words with their definitions.

1 subatomic	A part of an atom which has no charge
2 electron	B two or more atoms
3 neutron	C smaller than an atom
4 molecule	D part of an atom that has a negative charge
5 proton	E a theory developed by physicists to explain the atom
6 quantum mechanics	F part of an atom which has a positive charge
7 carbon	G pulled together
8 attracted	H a chemical element
9 helium	I a chemical element that is lighter than air
10 universe	J the whole cosmos



Reading 1

The atom

The ancient Greeks coined the term *atomos*, meaning the smallest possible separation of matter. In ancient times, both the Greeks and Indians had philosophised about the existence of the atom but, as mentioned in unit 6, it was first hypothesised scientifically by the British chemist John Dalton (1766-1844) in the early years of the 19th century, when he suggested it was the smallest particle that could exist. Since then, smaller subatomic particles have been discovered and the part they play as the basic building blocks of the universe is clear. We now know that atoms are made up of differing numbers of electrons, neutrons and protons, and these too are made up of even smaller particles.

Dalton's theory about atoms was not immediately accepted by chemists, though one reason for this was Dalton's well-known carelessness in experimental procedures. However, we know now that Dalton was correct in almost everything he said in his theory of the atom. He described an atom, even though he had never seen one, as a particle that cannot change its nature. It could, he observed, combine with the atoms of other chemical elements to create a compound. Almost a century later the first subatomic particles were discovered. By the 1930s, physicists were working

with new ideas which allowed them to investigate the parts of the atom in great detail. In turn, these developments helped them to develop quantum mechanics – the basis of both modern chemistry and physics.

In chemistry, the atom is the smallest part of an element that can still be recognised. An example will explain best of all. Each element is identified by the number of protons it has. An atom of carbon has six protons. Those six protons without the neutrons and electrons, or the electrons without the other subatomic particles are simply subatomic particles; they are not carbon. A carbon atom can be combined with two atoms of oxygen to give the compound carbon dioxide, or CO_2. It is this difference in the number of subatomic particles that makes one atom different from another.

Subatomic particles also have another purpose. If there is the same number of electrons and protons in the atom, then the atom will be electronically neutral. A difference between the two means the atom has an electrical charge, in other words, it produces electricity. This electricity means the electrons can become attracted to each other. In this way, atoms can bond together to form molecules, and when enough molecules are joined together we have matter that we can see.

The most recent theories of the origins of the universe say that all the atoms in the universe were formed in the first few minutes of the universe coming into existence. The most common element is the simplest, hydrogen, which has the atomic number 1. Seventy-five per cent of all atoms are hydrogen atoms. The next most simple is the next most common, helium, atomic number 2 making twenty-four per cent of all atoms. All the other atoms add up to just one per cent of everything that exists in the universe.

Pronunciation guide

carbon dioxide /kˈɑːbən ˈdaɪɔksaɪd/
hydrogen /haɪdrədʒən/
hypothesise /haɪˈpɔθəsaɪz/
molecule /mɔlɪkjuːl/
neutron /njuːtrɔn/
philosophise /fɪˈlɔsəfaɪz/

B Comprehension

Read the text and choose the correct answer.

1 Dalton believed the atom to be
- **A** an element.
- **B** made of smaller particles.
- **C** the smallest possible particle.
- **D** his own idea.

2 Dalton's theories were
- **A** generally accepted.
- **B** not tested very carefully.
- **C** accepted at once.
- **D** not correct.

3 The number of protons in an element
- **A** is the same as the number of electrons.
- **B** is always six.
- **C** never changes.
- **D** characterises the element.

4 Electrons help
- **A** protons to form elements.
- **B** atoms to be neutral.
- **C** molecules to become atoms.
- **D** atoms to form molecules.

5 Hydrogen is
- **A** the simplest atom there is.
- **B** present in all atoms.
- **C** the oldest atom.
- **D** as common as helium.

Before you listen

Discuss these questions with your partner.

→ What fuels do people use to make power?
→ Where does petrol come from?

C Listening

Listen to the conversation. Then for each statement below, circle the correct word or phrase.

1 **Most / Some / Plenty of** people are already using hydrogen-powered cars.
2 The waste from these cars is **pollution / water / fumes**.
3 It's expensive because it **is new / uses hydrogen / is not common**.
4 Hydrogen is **more / less / just as** dangerous as petrol.
5 Hydrogen will be used in **gas / solid / liquid** form.

Before you read

Discuss these questions with your partner.

- What do you need to make a fire?
- What happens to water at 100°C?
- How do we create ice, water and steam? How can steam be turned back into water?

D Vocabulary

Choose the correct answer A, B or C from the list below.

1 With an air ..... you can take air out of a container.

2 Another word for a space, empty or not is a ..... .

3 A(n) ..... is a substance that increases the strength of hydronium if put in water.

4 A(n) ..... is a substance that increases the strength of hydroxide ions if put in water.

5 To make a(n) ..... means you had a try.

6 Somebody's ..... is the way they do something.

7 When a light ..... , it shines softly.

8 The jar can hold a large ..... of liquid.

9 As the pressure increases, the danger of explosion increases in ..... .

10 Scientists carry out experiments and ..... how matter changes its form.

1	**A** pump	**B** mixer	**C** fan
2	**A** jar	**B** chamber	**C** vacuum
3	**A** alkali	**B** acid	**C** litmus
4	**A** alkali	**B** acid	**C** litmus
5	**A** start	**B** go	**C** attempt
6	**A** attempt	**B** approach	**C** start
7	**A** glows	**B** dazzles	**C** sparkles
8	**A** volume	**B** number	**C** size
9	**A** ratio	**B** proportion	**C** share
10	**A** look	**B** observe	**C** see

Reading 2

Robert Boyle

My dear Ilooke,

Your letter arrived yesterday. I think you are right to write a book of memories of your scientific work. I am delighted that you have asked me to remind you of your time as my assistant.

I asked you once to make an air pump for me. It was then a new idea and allowed me to create a vacuum by drawing out the air from a glass jar. It was then that my experiments began. Perhaps this is something I will be remembered for, but I did not follow the scientific methods of the time. The traditional way to prove a fact was to argue it logically, and the conclusion must be the truth. Unfortunately, it was not always so. My approach was to observe what actually happened.

I placed a number of different objects into the vacuum chamber. One of them was a burning

candle. The flame immediately went out. Another was a piece of coal, still glowing red from the fire. Once in the chamber it stopped glowing. If the air was put back in, and the coal was still hot, it would begin to glow again. From these observations I concluded that air was necessary for combustion to take place; nothing could burn without air. On another occasion, I placed my watch into the jar. I could hear it ticking as I drew the air out. Astonishingly, as the air was taken out of the chamber, the ticking became quieter. My conclusion: sound travels through air. If there is no air, sound cannot be heard.

As the air pump is actually taking something out of the jar, I thought, then that air must be made of something. My conclusion was that a gas is made up of very small particles. I reached this conclusion by observing the pressure in the vacuum jar. As the volume of gas is reduced, so the pressure increases in proportion. This is universally true and as you know, is now known as Boyle's Law.

The work I did led me to the conclusion that chemistry is the science of the composition of substances. We chemists are here to try to understand how materials are made. In my opinion, an element is the one substance which cannot be broken down any further. We can discover what elements are in compounds. When investigating these compounds, I discovered a way of testing them to find out if they are acid or alkali. I call it the litmus test.

I realise that there is much more for us to learn. I know that we can learn about the chemistry of the human body by observing how animals' bodies behave in a vacuum. It is not work that I have attempted. It would mean I would have to kill the animals and dissect them afterwards to make my observations. I still cannot bring myself to kill an animal, let alone cut it up afterwards. This is work others will have to do.

Best wishes,

Boyle

Pronunciation guide

alkali /ˈælkəlaɪ/

litmus /ˈlɪtməs/

vacuum /ˈvækjuəm/

E Comprehension

Read the text and decide if the following statements are true or false.

1 Boyle reached conclusions after observation. T ☐ F ☐

2 He found air needed to be present to allow combustion. T ☐ F ☐

3 The pressure in the jar never changed. T ☐ F ☐

4 He believed chemistry was all about combustion. T ☐ F ☐

5 He observed animals in a vacuum. T ☐ F ☐

Before you listen

Discuss these questions with your partner.

→ How do you know a medicine is safe?

→ How do people test medicines?

F Listening

Listen to the extract from a talk by a scientist about the safety testing of medicines. Then listen again and fill in the notes.

One tenth of animals used in UK medical research, are used to test the **(1)** ..... of medicines.

The authorities may not carry out a safety study if identical results are **(2)** ..... .

The liver or the **(3)** ..... could be badly affected by new medicines.

Safety testing is used for new chemicals and **(4)** ..... used in food.

Therefore, tests are for healthy people and people receiving **(5)** ..... care.

G Speaking

Discuss these questions with your partner.

→ What important discoveries have chemists made? Think about medicine, vaccines and industry.

→ What practical uses have these discoveries had?

Task

Prepare a short presentation on Robert Boyle's achievements.

Talk about:

- his experiments on: burning, sound
- his conclusions on: gases, pressure
- his approach to science

First complete these notes. Use them in your presentation.

Experiment to look at burning in a vacuum.
Candle went out.
Therefore, ...

Experiment to look at sound in a vacuum:
Sound reduced.
Therefore, ...

Observations on vacuum:
..... . Boyle's Law

Approach to science:
..... from what happened.
Believe what he saw, not what he wants to believe.

Remember to:

- introduce each point
- give clear examples
- let the audience know when you have finished

Speaking tips

✔ Make your notes as short as possible.
✔ Speak from memory – don't read.
✔ If you make a mistake, go back and correct it.

H Writing

Write an article for a student magazine with the title: 'Interesting facts about the atom'.

Read text I again and make notes under these headings:

History of discovery
.....
.....
.....
.....

Parts of the atom
.....
.....
.....
.....

What the parts do
.....
.....
.....
.....

How many atoms
.....
.....
.....
.....

Use the headings in your article. Write four paragraphs. Use some of these words and phrases:

- at first
- smallest particle(s)
- a number of
- electrically charged
- bond
- molecule
- hydrogen

Remember to make your article as interesting as possible!

Write 200-250 words.

Unit 8

Before you read

Discuss these questions with your partner.

- Do you know whether metals become lighter or heavier when burnt?
- What do you think causes this change?

A Vocabulary

Complete the definitions below with words from the box.

released	reaction
state	concept
distinguished	demonstrate
flammable	contribute
trace	dominant

1 To ..... means to show.

2 A ..... is the condition of something at a particular time.

3 A ..... is a process in which a chemical change happens.

4 Somebody ..... is well regarded in their field.

5 A ..... is an idea.

6 To be ..... is to be set free.

7 ..... matter is matter that can burn.

8 To ..... means to help somebody or something be successful.

9 To ..... something back means to discover how it developed.

10 Something that is ..... is very important, successful or powerful.

Reading 1

The Law of Conservation of Mass

The Law of Conservation of Mass is one of the most important concepts in chemistry. The law states that matter can neither be created nor destroyed. This means that in any chemical reaction, the mass of the reacting substances at the start of the reaction will be the same as the mass of the products at the end of the reaction. Matter can change its form in a reaction, for example from a liquid state to a gas, but the mass will remain the same.

The Law of Conservation of Mass is also known as the Lomonosov-Lavoisier Law because, as we saw in unit 6, both of these scientists contributed to its development. Lomonosov first described the law in a letter to a friend and then published his ideas in a dissertation dated 1760. Lavoisier reached the same conclusions much later, in 1789, and was the first to formulate the law in clear scientific terms. For this reason the law takes its name from both these brilliant men.

The idea of conservation of mass, however, can be traced back as far as ancient Greece. In the 5th century BC, Anaxagoras, a philosopher and

scientist, said that nothing comes into existence or is destroyed and that everything is a mixture of pre-existing things. Over the course of history, many other distinguished scientists also expressed their views on the conservation of mass.

The dominant theory in the 18th century was the *phlogiston theory*. According to this theory, all flammable materials (that is, materials that can burn) contain a substance called phlogiston, which is released during the burning process. That means that when flammable materials burn, the new substance, without phlogiston, should weigh less than the original substance. But this theory was wrong. Experiments showed that some metals actually increased in weight when they burnt. Lomonosov's experiment in 1756 demonstrated that the increase in weight was due to air. Many years later, Lavoisier proved that oxygen was required for combustion (burning); without it, the mass of burnt matter remained the same.

The Law of Conservation of Mass was not discovered in the usual scientific way. Lavoisier did not reach his conclusions by generalising from a large number of similar cases because, at that time, there was not enough scientific information for him to do so. Instead, Lavoisier assumed that his theory was true and then he set about proving it. His belief was justified because he did indeed prove the Law of Conservation of Mass.

The fact that the total amount of matter in chemical reactions is always conserved and never disappears even though the matter may be in an altered form, is not only important for science, but also for other fields of human knowledge, particularly philosophy. It has led us to think about the nature of existence, and where we truly come from.

Pronunciation guide

Anaxagoras /ənəˈksægərəs/
distinguished /dɪˈstɪŋgwɪʃt/
flammable /ˈflæməbəl/
phlogiston /flɒˈdʒɪstən/
substance /ˈsʌbstəns/

B Comprehension

Read the text. Match the questions below about the Law of Conservation of Mass with the paragraphs. There is one question which you do not need to use.

PARAGRAPH 1 .....
PARAGRAPH 2 .....
PARAGRAPH 3 .....
PARAGRAPH 4 .....
PARAGRAPH 5 .....
PARAGRAPH 6 .....

A How was it discovered?
B Which theory did it replace?
C Can we create or destroy matter?
D What is the name of the law?
E What has it made us consider?
F What is mass?
G How long ago had other philosophers thought about it?

Before you listen

Discuss these questions with your partner.

→ How important is it to study the past?
→ Do you know of any philosopher-scientists from the past?

C Listening

Listen to a class discussion about some famous people from the past. Then tick the statements that are true.

1 In ancient times there were no strict separations between philosophy and science. ☐
2 Thales rightly believed water was the basis of all composition in nature. ☐
3 Thales' importance lies in his use of science rather than mythology. ☐
4 Empedocles' theory of the four elements included earth and water. ☐
5 Anaxagoras agreed with Empedocles' theory. ☐
6 Anaxagoras also claimed things kept the same form. ☐

Before you read

Discuss these questions with your partner.

- Can you say what the chemical composition of water is?
- Do you know what part oxygen plays in breathing and what part it plays in combustion?

D Vocabulary

Choose the correct answer.

1 The word *propose* means
- **A** observe
- **B** accept
- **C** suggest

2 The word *absorb* means
- **A** take in
- **B** remove
- **C** lose

3 The word *compose* means
- **A** dry
- **B** make
- **C** boil

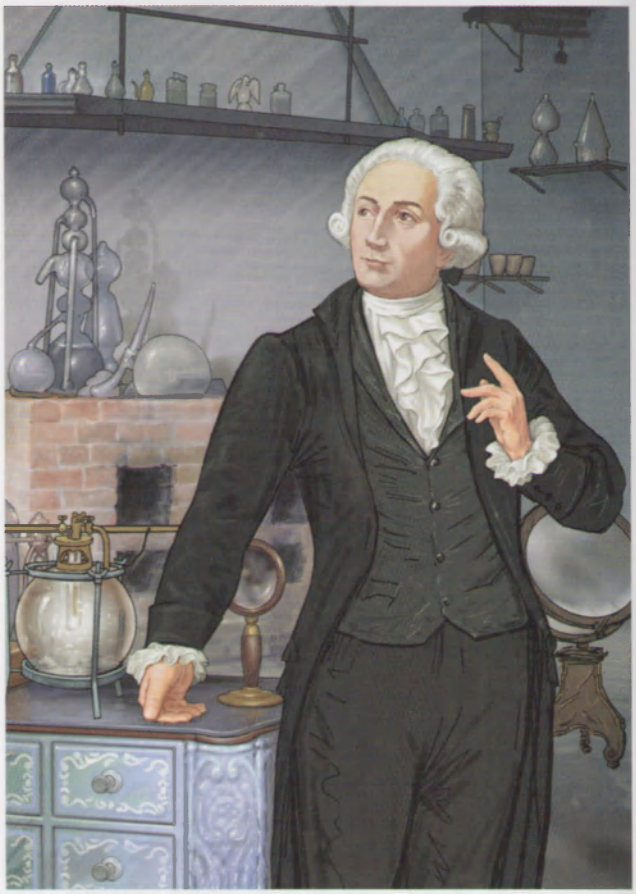
4 The word *reflect* means
- **A** show
- **B** prevent
- **C** help

5 The word *mechanism* means
- **A** workings
- **B** parts
- **C** machinery

6 The word *respiration* means
- **A** breathing in
- **B** breathing out
- **C** breathing in and out

7 The phrase *in line with* means
- **A** wishing to do something
- **B** be different from
- **C** according to

8 The word *contain* means
- **A** to have inside
- **B** to protect
- **C** to create



Reading 2

Antoine Lavoisier

(1) .....

Lavoisier discovered oxygen and its role in combustion and respiration (breathing); he disproved the phlogiston theory which was popular at the time; he drew up a list of 33 elements or substances that could not be broken down further and formed the basis of the modern-day list of elements. Added to that, he proposed the Law of Conservation of Mass.

(2) .....

His father was a lawyer, and in line with his family's wishes, Lavoisier completed a law degree, but his main interest was in science. In 1764, at the age of 21, he published his first paper on chemistry, and in 1768 when he was just 25 years old he was made a member of the French Academy of Sciences, one of the most important scientific institutions in the world.

(3) .....

Lavoisier, too, was fascinated by combustion and disagreed with the phlogiston theory, which he set out to disprove. He did this by carefully weighing the reacting materials and the products that were made in a chemical reaction. This was a very important step in the development of chemistry, and is now known as quantitative chemistry, that is, chemistry that involves accurate measuring. In order to accurately measure changes in mass that happened during his experiments, Lavoisier developed a balance that could weigh to 0.0005g. Measurement was important because Lavoisier strongly believed that matter was conserved through any reaction and this belief led to the development of the Law of Conservation of Mass.

(4) .....

Through this, he discovered that it did not support the phlogiston theory because after burning, the mass of the material was greater than it had been at the start. If the elements had really contained phlogiston and lost it during the reaction, they should have weighed less, not more. Further experiments were required to find out what was happening in these reactions, and Lavoisier discovered that air was absorbed as these elements burnt. He realised that something (later identified as oxygen) was taken in during combustion rather than being given out (the phlogiston theory).

(5) .....

One of these was that respiration was caused by chemical reactions with oxygen in the air. By carefully composing and decomposing water, he discovered that it is made up of oxygen and hydrogen. He gave names to elements which reflected their functions. For example, he came up with the name *oxygen* because it means *acid-former*, and that is what oxygen does. This system of chemical nomenclature is still largely in use today.

Pronunciation guide

fascinate /fæsɪneɪt/
nomenclature /nəʊˈmeŋklətʃə/
quantitative /kwɔntɪtətɪv/

E Comprehension

Read the text and then use the sentences below to complete the text. There is one sentence which you do not need to use.

A Many scientists of the day were studying combustion, and the mechanisms of this process.

B Lavoisier was born into a wealthy and aristocratic family.

C Known as 'The Father of Modern Chemistry', Antoine Lavoisier (1743-1794) made many important contributions to science.

D The method of quantitative chemistry helped him to understand many chemical processes.

E Thus it appeared that oxygen was one of the most important elements.

F He examined his idea of the conservation of mass by studying the combustion of phosphorous and sulphur.

Before you listen

Discuss these questions with your partner.

→ Do you know how scientists name different elements?

→ Which languages do most scientific words come from?

→ If you discovered an element, what would you name it?

F Listening

Listen to a teacher explaining how chemical elements got their names to a class of high school students. Then choose the correct answer.

1 Chlorine comes from a word meaning
- **A** silver
- **B** fair
- **C** green

2 An element that can be seen in the dark is
- **A** platinum
- **B** phosphorus
- **C** oxygen

3 Four elements were named after a village in
- **A** Sweden
- **B** Russia
- **C** France

4 Iridium received its name from
- **A** mythology
- **B** a range of colours
- **C** a rainbow

5 The name for gold and its chemical symbol
- **A** are from two different languages.
- **B** are both taken from mythology.
- **C** mean the same thing.

G Speaking

Task

Discuss with your partner which you think are the most important scientific discoveries of the past. Say what you think and find out if your partner agrees or disagrees with you.

Talk about:

- the contributions of ancient scientists
- the work of Lomonosov
- the work of Lavoisier

Read texts 1 and 2 again and use these notes to help you.

Ancient scientists: Names? Theories?

Lomonosov: Ideas / Concepts?

Lavoisier: Discoveries?

Remember to:

- use some of your own ideas
- explain things clearly
- consider your partner's opinion

Speaking tips

✔ Remember it is a two-way discussion.

✔ Ask questions to check you have understood.

✔ Don't interrupt your partner too often.

Helpful phrases:

→ To begin with, I would suggest ...

→ Would you go along with that?

→ No, I rather think that ...

→ Well, you certainly have a point, but ...

→ Yes, I see where you're coming from.

→ Don't you also think ... ?

→ That's absolutely right.

→ May I just break in there?

→ What about ... ?

→ Last but not least ...

H Writing

Write a short essay to answer this question: 'What are the main differences between the phlogiston theory and the Law of Conservation of Mass?'

Read texts 1 and 2 again and use these notes to write four paragraphs.

PARAGRAPH 1

Introduction Name the two concepts. Say when (18th century) and where (Europe) they were being discussed.

Vocabulary: During the ... , a subject of much discussion ...

PARAGRAPH 2

The phlogiston theory. Its main ideas about mass.

Vocabulary: flammable, release, lighter

PARAGRAPH 3

The Law of Conservation of Mass. The main idea behind it (matter is neither created or destroyed). The people who worked to prove it (Lomonosov, Lavoisier).

Vocabulary: quantitative chemistry, mass of the material, combustion, oxygen

PARAGRAPH 4

Conclusion The progress of science through experimentation (phlogiston theory versus the conservation of mass).

Vocabulary: experiments brought about ...

Write 200-250 words.

Revision vocabulary Units 5 to 8

A1 Find the word or phrase in each group that does not fit.

1 DNA	nucleus, strand, interpreter, filter
2 chemistry	conservation of mass, matter, combustion, helix
3 atom	electron, X-ray, neutron, proton
4 Law of Conservation of Mass	matter, flavouring, chemical reaction, mass of the product
5 elements	hydrogen, alkali, carbon, helium

A2 Now write five sentences using one word from each category.

B Read the clues to help you find eight words in the wordsearch connected with chemistry and physics.

d	w	m	e	c	h	a	n	i	s	m	c	b	a
k	i	d	g	c	e	x	s	t	r	e	o	q	b
v	k	s	w	r	b	e	w	s	b	j	n	n	s
u	v	w	c	b	i	d	g	u	e	d	s	k	o
u	n	i	v	e	r	s	e	b	c	s	u	v	r
s	v	t	u	k	i	t	w	s	b	u	m	u	b
m	o	l	e	c	u	l	e	t	k	b	p	d	e
e	l	z	z	u	j	h	i	a	u	a	t	s	b
l	u	u	j	h	e	z	u	n	b	t	i	o	a
g	m	e	x	t	r	e	w	c	a	o	o	e	r
r	e	t	a	i	l	e	r	e	v	m	n	p	g
t	r	e	l	i	t	m	u	s	i	i	i	i	a
g	c	a	u	c	t	i	o	n	s	c	g	o	i
w	r	b	j	g	c	e	x	d	g	c	e	d	n

1 the workings of a process
2 space, Earth, the cosmos
3 smaller than an atom
4 two or more atoms
5 the amount that something can hold
6 a kind of paper that shows if something is acidic or not
7 take in liquid for example
8 matter or material

C Circle the correct answer.

1 The scientists made a remarkable ..... and solved the problem.
A breakthrough
B search
C monitor

2 In the Science class, the students were asked to ..... a frog.
A break
B dissect
C manage

3 Another word for amount is ..... .
A waste
B state
C quantity

4 If something follows a..... then it acts in a similar way over a period of time.
A concept
B proportion
C pattern

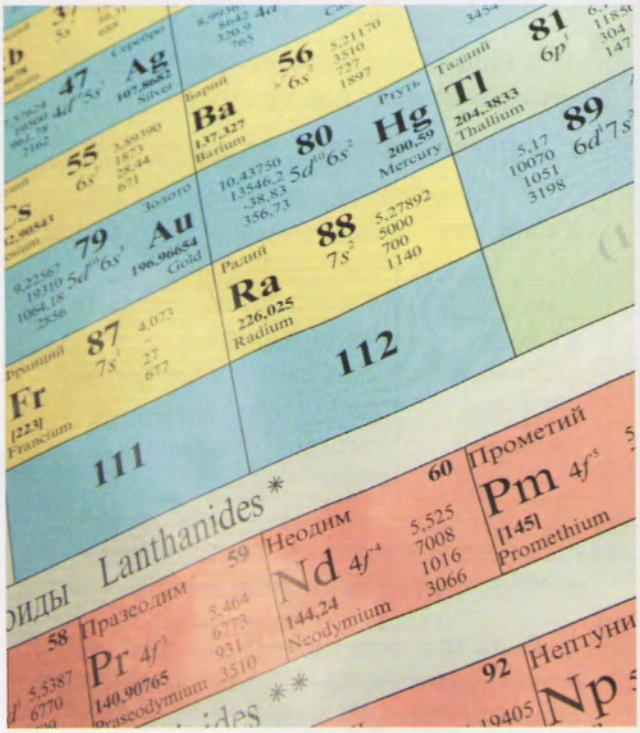
5 A..... is a part.
A component
B preservative
C ratio

6 She attended a(n) ..... to meet other scientists and discuss her theory.
A conference
B seminar
C experiment

7 The air ..... removed the air.
A pump
B chamber
C vacuum

8 To ..... means to make or build.
A attract
B construct
C attempt

Unit 9



Before you read

Discuss these questions with your partner.

- Do you think chemistry is a difficult subject? Give reasons.
- Which chemical elements have you heard of?
- Can you explain what the periodic table is used for?

A Vocabulary

Circle the correct word in the definitions below.

1 If you are **curious / strange / odd**, you want to find out information about something.

2 When a **proper / strict / formal** attempt is made, it is done officially.

3 If something occurs **gradually / suddenly / rarely**, it happens over some time.

4 When two things **relate / interact / determine**, they react to one another.

5 The word **specific / detailed / thorough** means exact.

6 If there is **reappearance / occurrence / repetition**, the same thing is done many times.

7 A **shell / nucleus / atom** is the hard outer part of something that protects what is inside.

8 If somebody **predicts / notices / impresses** something, they say what they think will happen in the future.

9 If you are **discovered / based / impressed** by someone, you admire them.

Reading 1

The periodicity of elements

The history of the periodicity of elements began with the first ideas concerning substances and particles. It had been noticed by the earliest thinkers that things (different substances) are different from each other, and that each can be reduced to very small parts of itself (the beginnings of the atomic theory).

Over the course of history, more and more elements were discovered, and scientists were naturally curious about the relationships between them. Lavoisier divided the elements known in the 1700s into four classes, the first formal attempt at grouping the elements. In 1869, unknown to each other, Julius Meyer and Dmitri Mendeleev devised periodic tables in which the elements were arranged by atomic weight. However, on the basis of his table, Mendeleev was able to do something that Meyer could not; he predicted the properties of elements that had not been discovered yet. Chemists were highly impressed when these elements were later discovered.

Mendeleev noticed that when all the elements were arranged in order of their atomic weight, a certain repetition of properties was obvious. He had organised the chemical elements according to their atomic weights because he believed that the properties of the elements would gradually change as the atomic weight increased, but in composing his periodic table, he found that the properties of the elements suddenly changed at very clear stages, or periods. To show where the changes were happening, Mendeleev grouped the elements in a table that had both rows and columns.

The modern periodic table of elements is based on Mendeleev's, but instead of being arranged by atomic weight, the modern table is arranged by atomic number (the number of protons in the nucleus of the atom). Rows in the periodic table are known as periods. The chemical properties of the elements in each period slowly change, but at the end of each row, a sudden change in these properties is observed. The columns in the periodic table are known as groups. Elements within the same group have many similar properties.

The periodicity that Mendeleev discovered is directly related to the arrangement of an atom's electrons around its nucleus. Electrons are located in specific electron shells (in simple terms this means that the electrons make a kind of shell around the nucleus of the atom) and each shell can contain only a certain number of electrons. The first shell can hold two electrons, the second shell can hold up to eight electrons, and so on. For example, neon has ten electrons, two in the first shell, and eight in the second shell. Next is sodium, with eleven electrons, and here is one of the places in the table where a sudden change occurs. Sodium has three shells because it has eleven electrons, two in the first shell, eight in the second, and one in the third. This extra shell is the reason for the big change in chemical properties. It is the electrons in the outer shell that determine the chemical properties of the elements because it is these atoms which interact with other atoms.

Pronunciation guide

Julius Meyer /dʒuːlɪəs ˈmaɪə/
periodicity /pɪərɪɔˈdɪsətɪ/
sodium /səʊdɪəm/

B Comprehension

Read the text and decide if the following statements are true or false.

1 Substances are the smallest parts of matter. T ☐ F ☐
2 Two scientists created periodic tables in the same year. T ☐ F ☐
3 Modern periodic tables use atomic weight. T ☐ F ☐
4 Protons are found in shells. T ☐ F ☐
5 Sometimes we can find ten electrons in the second shell. T ☐ F ☐
6 The chemical make-up of an element depends on the outer shell. T ☐ F ☐

Before you listen

Discuss these questions with your partner.

→ Are chemical experiments interesting? Why?
→ Which kind do you enjoy the most?
→ Do you know the English names for any laboratory equipment?

C Listening

Listen to the conversation between a Chemistry teacher and a class of students. Then listen again and choose the best answer A, B or C.

1 To ensure safety in a lab students should
A have short hair.
B wear special shoes.
C protect their clothes and eyes.

2 If somebody spills a chemical on their skin, they
A will definitely need a first aid kit.
B should place it under cold, running water.
C should use the emergency cupboard.

3 Check chemical labels twice because
A it's easy to choose the wrong one.
B the names are basically numbers.
C the formulae depend on letters.

4 Dangerous substances
A are only bases and acids.
B can burn you.
C are easier to spill.

5 Another rule in the lab is
A avoid running unless necessary.
B the teacher must present all experiments alone.
C clean and tidy up at the end of class.

Before you read

Discuss these questions with your partner.

- Do you know of any famous people who had to struggle to succeed?
- What did they achieve?
- Do you think you could be so strong?

D Vocabulary

Complete the sentences below with words from the box.

hardship	enroll
resign	appoint
confirmed	resulted
solution	expand
density	uniform

1 They are going to ..... a new professor in the Chemistry department.

2 Many famous people in the past suffered a lot of ..... to achieve their goals.

3 The experiment proved that the gases had a ..... reaction, that is the same reaction.

4 Most schools expect you to ..... before you begin your studies.

5 The..... of a substance is how thick and compact it is.

6 If metal is heated you will see it ..... .

7 It was a ..... made up of water and salt.

8 If somebody is unhappy in their job, they may..... .

9 The experiment in the lab ..... in a huge explosion.

10 The outcome of the experiment ..... his theory.

Reading 2

Dmitri Mendeleev

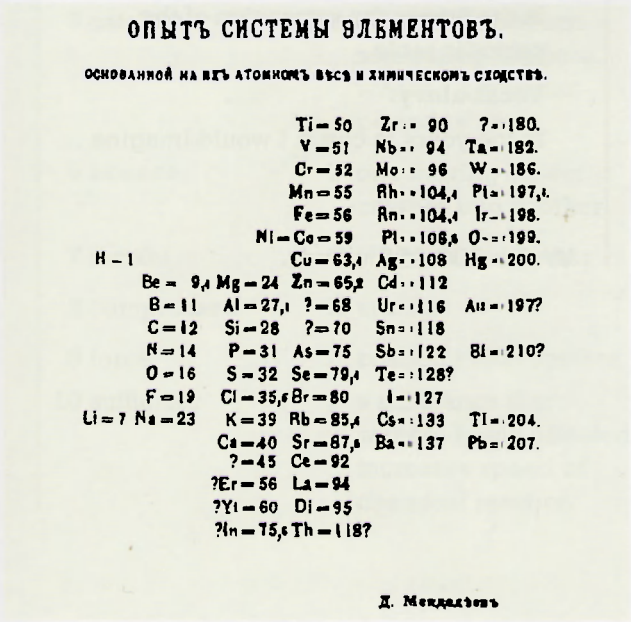
Dmitri Ivanovich Mendeleev was born in Tobolsk, in Siberia, on 7th February, 1834. As a child he showed a great interest in Mathematics and Physics and was a talented student. Despite the hardships experienced by his family while he was growing up, his mother was determined to see him educated and to help him achieve his dreams. After the family moved to St Petersburg, she managed to enrol him as a student science teacher on a full scholarship. Despite many more problems, Mendeleev earned his degrees and eventually, in 1863, was appointed Professor of Chemistry at the Technological Institute and the University of St Petersburg.

Probably his greatest scientific achievement was the discovery of the periodic law and the development of the periodic table of elements. He left gaps in his table for undiscovered elements and predicted the properties of the elements that would fit these gaps. His predictions were confirmed when, during his lifetime, three predicted elements; gallium,

germanium and scandium, which he had named eka-aluminium, eka-silicon and eka-boron respectively, were discovered. These discoveries gave him great respect among members of the scientific community.

However, Mendeleev made other important contributions to science. He was involved in many areas including hydrodynamics, agricultural chemistry, mineral recovery, meteorology and chemical technology. One particular contribution involved solutions. He spent a lot of time studying how the nature of solutions could be determined, adding greatly to our understanding in that field. In addition, he was involved in physical chemistry, looking at the expansion of liquids because of heat. He spent time in Paris with Henri Victor Regnault studying the densities of gases and came up with a formula to explain how gases are uniform when expanding; in other studies he defined the absolute boiling point of a substance. His studies of gases at high and low pressures moreover, allowed him to develop an accurate barometer and while working for the Russian navy, he came up with pyrocollodion, a smokeless powder based on nitrocellulose. The list of his achievements is endless!

Despite his international reputation as one of the world's most important scientists, the Tsar at the time did not approve of Mendeleev's politics, resulting in his resignation from the University of St Petersburg in 1900. He died on 20th January, 1907, from pneumonia.



ОПЫТЪ СИСТЕМЫ ЭЛЕМЕНТОВЪ.

ОСНОВАННОЙ НА ВѢСѢ АТОМНОМЪ ВѢСѢ И ХИМИЧЕСКОМЪ СХОДСТВѢ.

		Ti=50	Zr=90	?=180.	
		V=51	Nb=94	Ta=182.	
		Cr=52	Mo=96	W=186.	
		Mn=55	Rh=104,4	Pt=197,4.	
		Fe=56	Ru=104,4	Ir=198.	
		Ni=Co=59	Pl=106,6	O=199.	
H=1		Cu=63,4	Ag=108	Hg=200.	
	Be=9,4	Mg=24	Zn=65,2	Cd=112	
	B=11	Al=27,1	?=68	Ur=116	Au=197?
	C=12	Si=28	?=70	Sn=118	
	N=14	P=31	As=75	Sb=122	Bi=210?
	O=16	S=32	Se=79,4	Te=128?	
	F=19	Cl=35,6	Br=80	I=127	
Li=7	Na=23	K=39	Rb=85,4	Cs=133	Tl=204.
		Ca=40	Sr=87,6	Ba=137	Pb=207.
		?=45	Ce=92		
		?Er=56	La=94		
		?Yt=60	Di=95		
		?In=75,6	Th=118?		

Д. Менделѣевъ

Pronunciation guide

eka-boron /ekəbɔːrɒn/
germanium /dʒɜːˈmeɪnɪəm/
nitrocellulose /naɪtrəʊˈseljʊləʊs/
pneumonia /njuˈməʊnɪə/
pyrocollodion /ˌpaɪrəʊkəˈləʊdɪən/
Regnault /reˈnɔː/

E Comprehension

Read the text and answer the questions in your own words.

1 What position did Mendeleev achieve at the University of St Petersburg?

2 Why did Mendeleev leave gaps in the periodic table of elements?

3 How were Mendeleev's predictions proven correct?

4 What contribution did Mendeleev make in the area of solutions?

5 What did Mendeleev's formula concerning gases explain?

Before you listen

Discuss these questions with your partner.

→ What do you know about atoms and electrons?

→ What do you know about chemical reactions?

F Listening

Listen to a teacher explaining to a class how electrons work. Then complete each sentence with one word.

1 Mendeleev didn't know about ..... .

2 The periodic table arranged by Mendeleev was based on atomic ..... .

3 Electrons are located in ..... around the nucleus of an atom.

4 Valence electrons determine the ..... properties of an element.

5 Lithium and ..... have only one valence electron.

6 Lithium and boron have ..... electron shells.

G Speaking

Discuss these questions with your partner.

- → Besides the nucleus and electrons, what else is found in an atom?
- → Do you think scientists will discover any more elements?

Task

Prepare a short presentation to answer the question: 'What is the periodic table?' Use the information in both texts.

Talk about:

- who devised the periodic table
- what is contained in the periodic table
- the role of electrons
- how the modern periodic table works

First complete these notes. Use them in your presentation.

Periodic table: An arrangement of.....

.....

The first periodic table proposed by

.....

was based on .....

Electrons determine .....

The modern periodic table is arranged

.....

Remember to:

- read the texts very carefully
- make sure you understand the scientific processes
- try to use your own examples and explain them clearly

Speaking tips

- ✔ Use time markers such as 'firstly', 'next' and 'then'.
- ✔ Don't speak too quickly; take your time.
- ✔ Refer to your notes.

H Writing

Write a magazine article for your school magazine about the history of the periodicity of elements. Use these notes to help you.

PARAGRAPH 1

Introduction

Briefly explain what periodicity is, and where the concepts of electrons and atoms were first developed.

Vocabulary:

In ancient times ... , during the 18th century ...

PARAGRAPH 2

Write about the work of Mendeleev; arrangement by atomic weight.

Vocabulary:

organised according to ... , grouped by ...

PARAGRAPH 3

The role of electrons; how electrons are the basis of the modern periodic table.

Vocabulary:

the function of ... , is based on ...

PARAGRAPH 4

Conclusion

If you think new elements will be discovered in the future; the expansion of the periodic table.

Vocabulary:

In the years to come, I would imagine ...

Write 200-250 words.

Unit 10

Before you read

Discuss these questions with your partner.

- Do you know how chemical reactions occur?
- What conditions are important to the speed of the reaction?
- Can any conditions be altered during the reaction?
- What are the three different states of matter?

A Vocabulary

Match these words with their definitions.

1 rate	A decay
2 consumed	B spring back like a ball
3 rot	C moment
4 collide	D as if eaten up
5 catalyst	E the speed at which something happens within a particular period of time
6 bounce	F one moving object crashes into another
7 instant	G strength and power
8 compressed	H enough
9 force	I pushed hard together
10 sufficient	J a substance that without being affected increases speed of chemical reaction

Reading 1

Chemical kinetics

Chemical kinetics is the study of rates of chemical reactions. In the world around us billions of chemical reactions occur; some are incredibly slow while others are amazingly fast. It can take years for wood to rot, while the lighting of a match takes just an instant. Chemical kinetics attempts to understand the factors that control the rates of chemical reactions. These factors are concentration, pressure, surface area, the nature of the reacting substances, temperature and catalysts.

In general, increasing the concentration of the reacting substances increases the reaction rate. This is because molecules must collide in order to react. The more concentrated the reacting substances, the more molecules there will be in any given volume, and therefore, the greater the number of molecular collisions.

If the substances involved in the reaction are gases, pressure will have an effect on reaction rate. Solids and liquids can not be compressed, but gases can, so pressure acts as a kind of concentration for gases. The volume of a gas decreases as the pressure increases. For a given amount of gas,

increasing the pressure means we are forcing the same number of gas molecules to occupy a smaller volume. In the smaller volume, the molecules will collide more often, which means there will be a greater number of successful collisions in a given period of time. Reaction rate increases with pressure.

If a chemical reaction takes place at a boundary between two states (gas, liquid or solid), the surface area will affect the reaction rate. Only the molecules at the surface area are available to react, so increasing the surface area increases the number of molecules that are able to react, and this leads to a higher reaction rate.

Some substances are naturally more reactive than others. For example, if the metals magnesium, zinc and copper are dropped into hydrochloric acid in separate test tubes, three very different results are obtained. The magnesium is consumed within seconds, the zinc is consumed but takes much longer, and the copper shows no reaction. Therefore, magnesium is more reactive than zinc and copper.

Temperature affects the rate of a chemical reaction in two ways. Firstly, molecules move faster in a hot system than in a cold one, so they will collide more often if they are moving faster. Secondly, increasing the temperature increases reaction rate through its effect on the collision energy (known as activation energy) of the molecules. Molecules must collide with sufficient force in order to combine and produce a chemical reaction. Higher temperatures give molecules the energy to collide forcefully. If they collide with less than a certain amount of energy, they simply bounce off of each other unchanged.

Finally, a catalyst is a substance that increases the rate of a chemical reaction without being consumed in the reaction. It increases the reaction rate by reducing the activation energy, that is, the minimum amount of energy that the reacting molecules must have in order to react.

Pronunciation guide

catalyst /kætəlɪst/
hydrochloric /haɪdrəʊklɒrɪk/
magnesium /mæ gniːzɪəm/

B Comprehension

Read the text and choose the correct answer.

1 The rate of a chemical reaction
- **A** depends on different factors.
- **B** is very fast for metals.
- **C** is always the same.

2 In order for a chemical reaction to occur
- **A** the volume of a gas must increase.
- **B** solids must be compressed.
- **C** molecules must collide.

3 Higher concentrations of reacting substances will lead to
- **A** more chemical reactions.
- **B** increased pressure.
- **C** reactive products.

4 The metal zinc
- **A** is more reactive than magnesium.
- **B** reacts more slowly than magnesium.
- **C** is less reactive than copper.

5 Higher temperature can make molecules
- **A** travel faster with no increase in energy.
- **B** travel at the same speed, but with more energy.
- **C** travel faster, and with more energy.

Before you listen

Discuss these questions with your partner.

→ What is salt made up of?

→ What state does salt exist in?

C Listening

Listen to two students talking about chemical reactions. Then listen again and decide if the following statements are true or false.

1 A chemical reaction begins with reactants. T ☐ F ☐

2 Weight is released in a chemical reaction. T ☐ F ☐

3 Salt is a metal. T ☐ F ☐

4 Sodium and chlorine are solids. T ☐ F ☐

5 In a chemical reaction combined substances make new ones. T ☐ F ☐

Before you read

Discuss these questions with your partner.

- What is a chain made up of?
- What do you think a chain reaction is?

D Vocabulary

Complete the sentences below with words from the box.

thermal explosion	expertise
by-product	field
analysis	external
transformation	phenomenon
primary	sequence
reactive	additional

1 A(n) ..... is what is produced as a secondary result of a process.

2 ..... means outer.

3 A(n) ..... is an area where a particular force has an effect.

4 ..... means added to.

5 ..... is the process of examining something in order to understand it.

6 A(n) ..... is a series of events, one after the other.

7 A(n) ..... is a complicated chemical process involving heating which leads to exploding.

8 A(n) ..... is any state or process understood according to the senses rather than by reasoning.

9 Repairing the nuclear reactor is our ..... concern at the moment.

10 The surgeon's medical ..... saved the man's life.

11 Not all chemical substances are ..... .

12 How is the ..... of wood into ash explained?

Reading 2

Nikolay Semyonov

Nikolay Semyonov, a physicist and chemist, and a leader of the Soviet nuclear weapons programme, was born on 15th April, 1896, and died on 25th September, 1986 in Moscow. His primary scientific contributions are related to the quantitative theory of chemical chain reactions, the theory of thermal explosion, and the burning of gaseous mixtures.

He was a Physics graduate of Petrograd (St Petersburg) University, and in 1920 he was put in charge of the electron phenomena laboratory of the Physico-Technical Institute in Petrograd. It was at this time, while working with Pyotr Kapitsa, that he discovered a way to measure the magnetic field of an atomic nucleus. In 1931, he became Director of the Institute of Chemical Physics of the USSR Academy of Sciences, and from 1944 he was a professor at the Moscow State University.

For his work on the mechanism of chemical transformation, he was awarded the 1956 Nobel Prize for Chemistry. Semyonov's work on the mechanism of chemical transformation includes an important analysis of the application of the chain theory (a sequence of reactions where a reactive product or by-product causes additional reactions) to different reactions, particularly combustion processes.

In chemistry and physics, a chain reaction is a reaction that, once started, continues without further outside influence. Proper conditions for a chain reaction depend not only on various external factors, such as temperature, but also on the quantity and shape of the substance in the reaction. A chain reaction can be of various types, but nuclear chain reactions are the best known, and it was in this particular area that Semyonov contributed his expertise to the nuclear weapons programme. He also made valuable contributions to the field of molecular physics and electron phenomena.

Semyonov published his work in three important books. The first was *Chemistry of the Electron*, published in 1927. This was followed by *Chemical Kinetics and Chain Reactions* in 1934, which was the first book in the USSR to propose a theory of chain reactions in chemistry. Further studies in chemical kinetics led to the publication, in 1954, of *Some Problems of Chemical Kinetics and Reactivity*, which was translated into many languages.

Semyonov received many awards and honours in his lifetime, including five Orders of Lenin. He was a member of the Chemical Society in London, Foreign Member of the Royal Society and Foreign Member of the American, Indian, German, and Hungarian Academies of Sciences. He held honorary doctorates from the University of Oxford and Brussels University.

Pronunciation guide

chain reaction /tʃeɪn rɪˈækʃən/
gaseous /gæsɪəs/
laboratory /ləˈbɒrətəˈrɪ/
phenomena /fəˈnɒmɪnə/
thermal explosion /θɜːˈməl ɪksˈpləʊʒən/

E Comprehension

Read the text and choose the best title for each paragraph. There is one title which you do not need to use.

PARAGRAPH 1 .....
PARAGRAPH 2 .....
PARAGRAPH 3 .....
PARAGRAPH 4 .....
PARAGRAPH 5 .....
PARAGRAPH 6 .....

A Scientific career
B Lifetime recognition
C Basic facts
D Famous author
E The highest honour
F The combustion process
G Explanation of a scientific process

Before you listen

Discuss these questions with your partner.

→ How much do you know about atomic science?
→ What do you think of it?

F Listening

Listen to a lecture on atomic and nuclear energy and keep notes. Then answer the questions in your own words.

.....
.....
.....
.....
.....
.....
.....
.....
.....
.....

1 Where is energy contained?

2 What is nuclear fission?

3 What is used to split an atom?

4 What is nuclear fusion?

5 When a uranium atom is split into two, what particles are released?

6 How could a *nuclear winter* affect life on Earth?

G Speaking

Task

Discuss with your partner the dangers of nuclear war. Say what you think and find out if your partner agrees or disagrees with you.

Talk about:

- the main idea behind nuclear energy
- nuclear fission
- nuclear fusion
- the future

Read texts 1 and 2 again and your notes from listening exercise F. Use the following notes as well to help you.

The main idea: chemical kinetics and chain reactions

Nuclear fusion: what happens?

The future: what might happen?

Remember to:

- try to use your own examples
- explain yourself clearly
- listen to your partner

Speaking tips

✔ Use expressions such as 'I agree / disagree', 'In my opinion'.

✔ Invite your partner to speak by asking 'What do you think?'

✔ Don't say everything at once – remember, it is a discussion not a lecture.

H Writing

Write a report on the topic: 'Factors affecting chemical reaction rates.'

Read texts 1 and 2 again and use these notes to write six sections. Use the title headings below for your sections.

REPORT:
Factors affecting reaction rates

By: (Your name)

Date: (The date)

INTRODUCTION
Say what the report is about, and briefly list the areas you will discuss.

SECTION 1
Concentration **Vocabulary**: collide

SECTION 2
Pressure **Vocabulary**: compress, force

SECTION 3
Surface area **Vocabulary**: reaction rate, molecules

SECTION 4
Reactivity **Vocabulary**: metals, consumed

SECTION 5
Temperature **Vocabulary**: hot system, activation energy, bounce off

SECTION 6
Catalysts **Vocabulary**: increase rate, minimum energy

CONCLUSION
Sum up by giving an outline of the six main areas.

Write 200-300 words.

Unit 11

Before you read

Discuss these questions with your partner.

- What does physics study?
- How old is the science of physics?
- Can you name any famous physicists?

A Vocabulary

Choose the correct answer A, B or C.

1 Scientists use ..... to make measurements.

A calculations
B estimations
C equations

2 The molecules are in ..... .

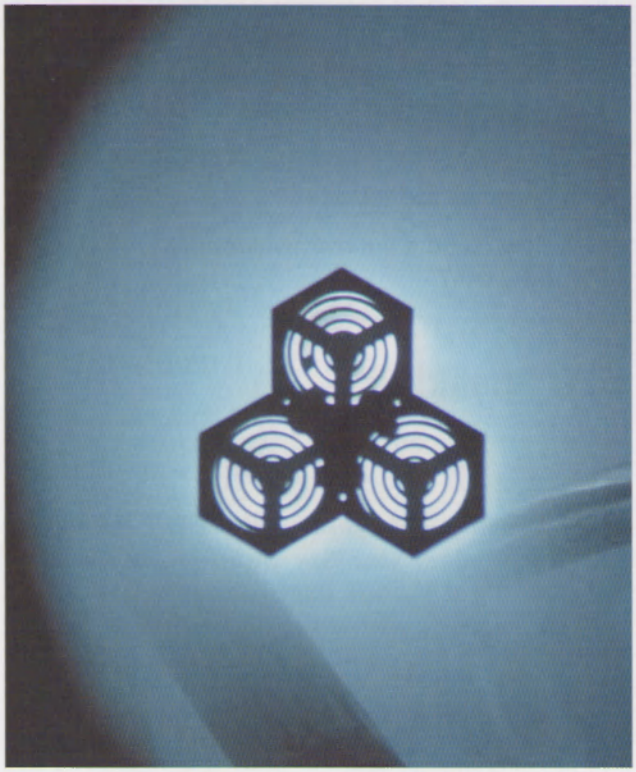
A movement
B motion
C activity

3 A(n) ..... is a mathematical statement that shows two expressions are equal.

A estimation
B calculation
C equation

4 A machine is a mechanical ..... .

A gadget
B device
C appliance



Reading 1

Physics

An introduction

Ever since humankind first looked at the stars moving about the sky, they have wondered how and why they do that. People have always wondered why things behave the way they do. For thousands of years people have been asking questions like why things fall to the ground, not away from it. Why are some types of stone hard and others soft? Why does the Sun come up in the east and go down in the west? These are all questions that physics can answer.

In the beginning, people answered questions like these in philosophical or religious ways. In early descriptions of the world, philosophers such as Aristotle reported what they believed to be true, rather than what they saw to be true. Others, however, such as astronomers from India, Egypt and China, or the Greek thinker, Archimedes, were able to use calculations to predict the movements of the Sun and the Moon or to describe and build machines.

The works of Eastern scholars reached Europe in the 12th and 13th centuries. There were studies of planetary motion by Indian astronomers, the theories of light from Buddhist and Persian thinkers and especially the work of the Persian philosopher Nasir al-Din al-Tusi on the planetary system. Eventually, these ideas pushed Europe into a scientific revolution. Galileo laid the foundations for this with his work on dynamics, that is, how things move. Nicolas Copernicus and then Johannes Kepler described the solar system with the Sun at its centre. Later, building on their work, Isaac Newton set out his Laws of Motion and modern physics was born.

The next great area of investigation was electricity and in the 19th century Michael Faraday first demonstrated an electromagnetic motor. Later, it was improved by James Clerk Maxwell, whose equations were also used to describe light. In proving Maxwell's equations, Heinrich Hertz discovered radio waves and Wilhelm von Rontgen, X-rays. Maxwell's work was also the starting point for Einstein's Theory of Relativity. At the same time, other scientists were working on thermodynamics, that is, the study of changes of heat in matter. Physicists such as Robert Boyle, James Prescott Joule and many others set out the theories that allow us today to make use of engines and other mechanical devices. Rontgen's discovery of X-rays and the work of Pierre and Marie Curie on radioactivity led to the development of the science of nuclear physics.

In the first half of the 20th century, developments in physics were concerned with the structure of atoms. The parts of the atom were identified – its nucleus, protons and electrons. Eventually in the 1940s, scientists in the USA were able to split a nucleus and the result was the world's first nuclear explosion. Also at that time, scientists such as Max Planck were looking at the relationship between matter and wave motion. The field of quantum mechanics, which explains not only how atomic particles move, but how the universe does, came into being. Without physics to describe the way things behave, we would have none of the technology and machinery we take for granted today.

Pronunciation guide

Buddhist /budɪst/
Copernicus /kəʊˈpɜːnɪkəs/
Joule /dʒuːl/
Nasir al-Din al-Tusi /nɑːsɪr el dɪn el tusɪ/
Persian /pɜːʒən/
Rontgen /rɜːntgən/
thermodynamics /θɜːˈməʊdaɪnæmɪks/

B Comprehension

Read the text and choose the best title for each paragraph. There is one title which you do not need to use.

PARAGRAPH 1 .....
PARAGRAPH 2 .....
PARAGRAPH 3 .....
PARAGRAPH 4 .....
PARAGRAPH 5 .....

A Early ideas about physics
B Mechanical devices
C Ideas that created the modern world
D What we can learn from physics
E Atomic physics
F The origins of modern physics

Before you listen

Discuss these questions with your partner.

→ Have people always believed that the Earth goes round the Sun?
→ Why do you think people would doubt this?

C Listening

Listen to a radio programme about Copernicus. Then listen again and complete these notes.

Copernicus provided a heliocentric **(1)** ..... theory of the solar system.

People used to believe the Sun went round the **(2)** ..... .

Copernicus led the way for science to **(3)** ..... existing theories.

Copernicus held that the Earth is not the centre of the **(4)** ..... .

He also explained the phenomenon of **(5)** ..... and gave the correct order of the planets.

Before you read

Discuss these questions with your partner.

- What is lightning?
- When do you see it?
- Which travels faster, sound or light?

D Vocabulary

a. Match these words with their definitions.

1 dark matter	A carry out
2 survey	B show
3 reveal	C to increase in speed
4 spark	D investigation
5 accelerate	E quick flash
6 three-dimensional	F best
7 leading	G having height, width and depth
8 perform	H hypothetical, invisible material which does not take in or give out light

b. Complete the sentences below with words from the box.

dark matter	leading
accelerate	perform
three-dimensional	survey
spark	reveal

1 The scientist wanted to ..... a dangerous experiment in the laboratory.

2 You have to wear these ..... glasses to watch this film.

3 He's a ..... heart surgeon; the operation is bound to be successful.

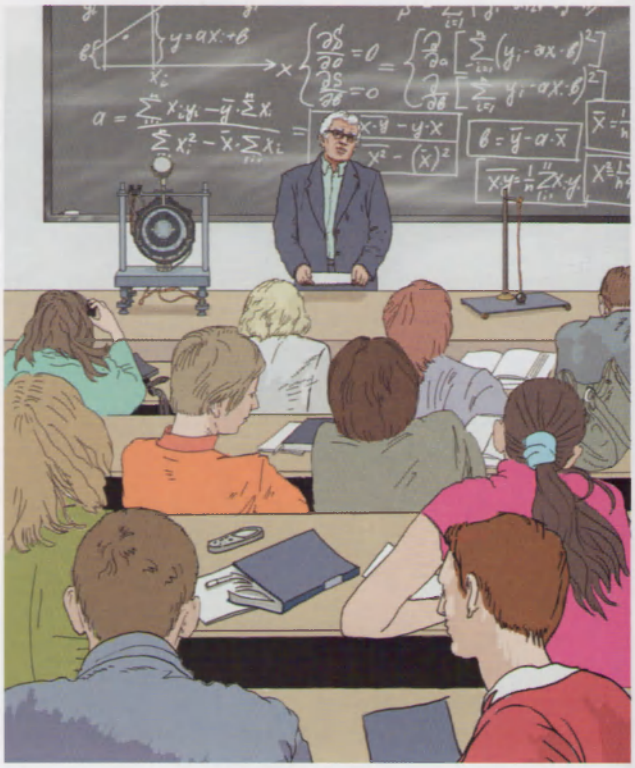
4 Usually trains ..... after pulling out from the station.

5 The company carried out a very interesting ..... the results of which were published in the newspaper.

6 Rub the two stones together until there is a ..... .

7 What do you know about .....? It's difficult to explain.

8 He's innocent and I'll do whatever it takes to ..... the truth.



Reading 2

Physics – the new science fiction

A speech by Professor Martin Brimble, who is retiring from his post as Professor of Physics at the University of Solihull after more than 30 years has revealed not what we know about the universe, but what we still don't know.

Science reporter Bob Hatton reports.

You would expect that after 30 years as Professor of Physics at one of the country's leading research centres, Professor Brimble would know quite a lot about the way the universe works. So what was most surprising was his detailed survey of the great unsolved problems facing physicists today.

For simplicity, he divided his talk into three parts. First, he talked about those things which happen in the world – and they happen every day – but for which there is no scientific explanation. He wasn't talking about ghosts or magic, naturally, but there are events which physicists have observed and which their theories and experiments have not yet been able to explain. Then, there are theories and ideas

which scientists haven't been able to prove right or wrong because no one has been able to perform an experiment to test the theory. And as if that weren't enough, there are ideas which they know work and the science is right, but they are still waiting for the technology to be invented.

Well, what happens that can't be explained? One phenomenon is ball lightning. This is said to be just like ordinary lightning, but instead of being a spark jumping from point A to B, it forms a ball of light, about the size of a basketball. Scientists have been trying to explain it since 1904, but without success. Their efforts have been unsuccessful partly because of the fact that some physicists don't even believe the phenomenon exists. Another such phenomenon is the accelerating universe. Physicists know that everything in the universe is moving away from everything else faster and faster. They've even measured the acceleration. But what they don't know is why it's happening. One idea is that it's something to do with dark matter, but that's another problem. Because it is dark matter, we can't see it and many physicists will say they don't even know where to look for it – if it exists at all. The truth is there just isn't enough matter in the universe to keep it in one piece. Research is going ahead, but answers may take a long time to come.

Some things cannot be tested because they're just too big to test. These are ideas that sound like science fiction, but are actually theories that may be true because other theories could be wrong. For example, time travel: some say it's possible, but to do it, would need more energy than there is in the universe.

And we'll have to wait for a three-dimensional microchip to be made before we can build the fastest possible computer. So according to Professor Brimble we've got a lot to look forward to in the future!

Pronunciation guide

microchip /maɪkrəʊtʃɪp/
Solihull /səʊlɪhæl/

E Comprehension

Read the text and decide if the following statements are true or false.

1 Professor Brimble spoke about how much physics has taught us. T ☐ F ☐

2 The universe is moving fast in one direction. T ☐ F ☐

3 There are theories in physics which have not been tested. T ☐ F ☐

4 Some physicists say there is no such thing as ball lightning. T ☐ F ☐

5 Physicists are very close to finding dark matter. T ☐ F ☐

Before you listen

Discuss these questions with your partner.

→ What do you know about the Big Bang?

→ Does it seem like a good explanation to you for the creation of the universe?

F Listening

Listen to a teacher and a student discussing her project about the Big Bang. Then listen again and answer the questions.

1 When did the Big Bang occur?

2 In what two ways is the phrase Big Bang used?

3 In which direction is all matter moving nowadays?

4 At one time, in the distant past in what form was all matter?

5 What chain of events did the Big Bang set off?

6 After the Big Bang, why did hydrogen atoms fuse together?

7 Can you describe the beginnings of simple galaxies?

G Speaking

Discuss these questions with your partner.

- What do you find the most fascinating about physics?
- Which areas would you like to know more about?

Task

Discuss with your partner whether you think physics will be able to find answers to the unsolved problems in text 2. Say what you think and find out if your partner agrees or disagrees with you.

Talk about:

- ball lightning
- the accelerating universe
- time travel

Read text 2 again and use these notes to help you.

Ball lightning: Prove it is real? Possible causes (electromagnetism and air temperature?)

Accelerating universe: Find dark matter, find another possibility, check measurements

Time travel: New source of energy, impossible for philosophical / religious reasons, theory is wrong

Test theories? Find new theories?

Remember to:

- explain your ideas
- give reasons for your ideas
- listen to other points of view

Speaking tips

- ✔ Ask questions to find out reasons.
- ✔ Give your partner time to speak.
- ✔ Be prepared to change your mind.
- ✔ Useful words and phrases: primarily; without a doubt; it cannot be denied; quite probably; there's a slight possibility; highly unlikely; would you agree?; I'd have to disagree with you there.

H Writing

Write a short essay to answer this question:

'What are the main differences in theories of physics before and after the scientific revolution?'

Read text 1 again and use these notes to write four paragraphs.

PARAGRAPH 1

Introduction Scientific revolution changed way of looking at the world. First describe way of thinking before science. Then look at what modern scientists have achieved.

Vocabulary: first, then, explain, reasons

PARAGRAPH 2

Ancient world. Thinkers affected by religion and superstition. Believed ideas without analysing them. Others found proof in calculation and observation. Some found right answers for wrong reasons. Thinkers described world they lived in.

Vocabulary: philosophy, religion, mathematics, ideas moved slowly, description

PARAGRAPH 3

Modern world more open to change. Accept what they see, not what they want to see. Modern physicists had advantage of knowing about mistakes of the past. Scientists look for answers to problems. Aim is to improve the world.

Vocabulary: proof, building on ideas, development

PARAGRAPH 4

Conclusion Same in need for observation and proof. Different in acceptance of belief and wish to change world.

Vocabulary: finally, summary, analysis, belief

Write 200-250 words.

Unit 12

Before you read

Discuss these questions with your partner.

- What household appliances use electricity?
- Where does electricity come from?
- What does a magnet do?

A Vocabulary

Choose the correct word to complete the sentences.

1 ..... is something through which electricity can pass.

2 An electrical ..... supplies power in our home.

3 The electromagnetic field ..... a force on the particles.

4 To ..... power you need a way to control electricity.

5 Normally, electricity is carried through homes by ..... .

6 Is 6 o'clock a ..... time for your meeting?

1	**A** A conductor	**B** A magnet	**C** Static
2	**A** bulb	**B** current	**C** particle
3	**A** put	**B** exerted	**C** applied
4	**A** attract	**B** exert	**C** generate
5	**A** wires	**B** charges	**C** forces
6	**A** comfortable	**B** fitting	**C** convenient

Reading 1

Electricity and magnetism

Electromagnetism is everywhere. It is a field that exists throughout space. When particles are electrically charged, the electromagnetic field exerts a force on them. These particles then move and exert a force on the electromagnetic field. By generating these fields when and where we want them and by controlling these forces we have electricity. This gives us the power we use in the modern world. All our TVs, phones, street lights and cars depend on electromagnetism.

So what is electromagnetism? Actually, it is two things, but they are so closely connected that it is convenient for us to think of them as one, as two sides of the same coin. There are two types of field: electric and magnetic. Electrically-charged particles result in an electric field, static electricity. When there is a conductor, a material which will allow electric field to pass through it, then we can create an electric current. In our homes, the conductors are the wires that run through our house to the

light bulbs or the TV. A magnetic field results from the motion of an electric current and is used to generate the electricity we use.

In the 19th century, James Clerk Maxwell, the Scottish physicist, produced the equations that proved the two forces acted as one. One effect of this was for physicists all over the world to hurry back to their libraries and laboratories to rewrite the theories on the motion of objects. Maxwell's equations showed that what physicists had believed for centuries was in fact not correct. It was not until Einstein, in the 20th century, that the theory of motion was put right – at least for now.

How do we know the two things are one? Well, sailors had known for centuries that lightning affected the magnetic compasses on their ships. No one, however, made the connection between lightning and electricity until Benjamin Franklin, the American politician and scientist, flew a kite in a thunderstorm to attract the lightning. In other parts of the world, physicists were experimenting with magnets and electricity. Most passed a current across a magnetic needle and watched it move. The Frenchman, Andre Marie Ampère eventually applied mathematics to electromagnetism. It is from his work that we have our modern understanding of electromagnetism.

One piece of the jigsaw remained. No one had discovered a way of generating electricity. True, there were batteries, Alessandro Volta invented the Voltaic pile in 1800, but it was of limited use. Certainly no battery could provide enough electrical power to operate a machine. For that the world would have to wait for Michael Faraday to find a way of creating an electrical current, when and where it was needed.

Pronunciation guide

Ampère /æmpeə/

Voltaic Pile /vɔlˈteɪɪk paɪl/

B Comprehension

Read the text and choose the correct answer.

1 We can make electricity by
- **A** exerting a force.
- **B** creating electromagnetic fields.
- **C** charging particles.
- **D** moving particles.

2 Electrical and magnetic fields
- **A** are opposites.
- **B** are two very different things.
- **C** are very closely related.
- **D** need a conductor.

3 Maxwell's equations
- **A** corrected the theory of motion.
- **B** caused scientists to rethink.
- **C** rewrote older theories.
- **D** have completely ensured the theory of motion now.

4 Our modern knowledge of electromagnetism comes from
- **A** Ampere.
- **B** lightning.
- **C** Benjamin Franklin.
- **D** experiments with magnets.

5 The electric battery
- **A** could operate a machine.
- **B** could create an electric current.
- **C** was invented by Faraday.
- **D** was invented in 1800.

Before you listen

Discuss these questions with your partner.

→ Can you think of some different ways of generating electricity?

→ What are the advantages and disadvantages of each?

C Listening

Listen to the extract from a lecture on generating electricity. Then listen again and complete the table.

Ways of generating electricity		
	Advantages	**Disadvantages**
Fuel		
	1	2 .....
Nuclear power		
	3	4 .....
Hydroelectricity		
	5	6 .....
Wind power		
	7	8 .....

Before you read

Discuss these questions with your partner.

→ What do you think is the most important invention

A of all time?

B in the last century?

C in the last 20 years?

D Vocabulary

a. Match these words with their definitions.

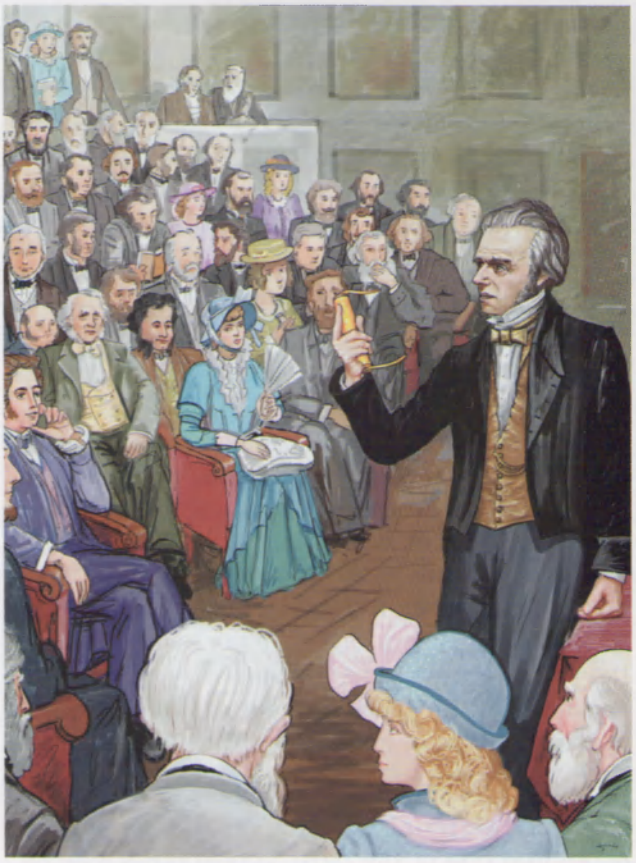
1 loop	A not proud
2 entirely	B round shape
3 device	C machine
4 modest	D completely
5 coach	E vehicle pulled by horse
6 status	F revolve, go round
7 rotate	G position

b. Match the words to make phrases.

1 receive	A experiments
2 attend	B a job
3 offer	C electricity
4 be	D on a tour
5 go	E to work
6 carry out	F an education
7 set	G of something
8 build	H lectures
9 generate	I a device
10 make use	J low born

c. Match the adjectives to the nouns.

1 leading	A motor
2 scientific	B current
3 electrical	C field
4 electrical	D physicist
5 magnetic	E community



Reading 2

Michael Faraday

Faraday (1791-1867) was unusual among famous men in the 19th century. His family did not have a high status in Victorian society. He was born in London to a poor family. He received little more than a primary school education, but educated himself. He did not have the support and encouragement of famous teachers. Instead, he worked making and repairing the covers of books in the daytime and attending public lectures at the Royal Institution in the evenings.

One series of lectures was given by Humphrey Davy, one of the leading physicists of the time, and Faraday wrote to him, hoping to become accepted into the scientific community. Davy wrote back, recommending that Faraday continue to be a bookbinder. Faraday's chance came soon after that. Davy injured his eyes in an explosion in his laboratory, and offered Faraday a job as his secretary. The years which followed were not entirely happy ones for

Faraday. He was not considered to be a gentleman, his family were too low born for that. Even when he went with Davy on a tour of Europe, Faraday had to wash Davy's clothes, eat with the servants and ride on the roof of the coach rather than inside it. For a time, Faraday thought about giving up science altogether.

Now, however, Faraday had time to carry out experiments at the Royal Institution of Great Britain, though he was still Davy's assistant. Davy tried and failed to make an electric motor and discussed his failure with his assistant. Faraday set to work, and produced what he called a homopolar motor. It was simply a wire, rotating around a magnet when an electric current from a battery was applied. It seems though that somehow Faraday upset Davy, who had recently been honoured by Queen Victoria. The following years saw Faraday working on Davy's experiments with glass. Whatever Faraday did, Davy seemed determined to prevent him from succeeding with electricity.

In 1829 Davy died, and soon after Faraday began the series of experiments that would make him one of the most important scientists of all time. He managed to build a device which moved a magnet through a loop of wire. This motion of the magnet through the wire created an electric current. He demonstrated that a changing magnetic field produces an electrical field. He was helped by James Clerk Maxwell to state the process mathematically (maths had always been Faraday's weakness), and this is now known as Faraday's Law of Induction. It is one of the foundations of electromagnetism and of modern technology. Later, Faraday built the first dynamo, a way of generating electricity. What Faraday did was to discover a way both of making electricity and of making use of it. Without his discoveries we would not be able to enjoy the modern lifestyle that we have now.

Although now famous, Faraday remained modest. He was offered honours by the Queen, but refused to accept them. Nearly 150 years after his death, however, he was honoured in another way. Between 1991 and 2001 his face appeared on a Bank of England £20 note.

Pronunciation guide

dynamo /ˈdaɪnəməʊ/
encouragement /mˈkʌrɪdʒmənt/
homopolar /həʊməʊˈpəʊlə/
honoured /ɔːnəd/
Humphrey /hʌmfrɪ/
injure /mdʒə/
Law of Induction /lɔːfəv ɪnˈdʌkʃən/

E Comprehension

Read the text and answer the questions in your own words.

1 How did Faraday get his education?
2 What was Faraday's second job?
3 Why did Faraday experiment with glass?
4 How did Maxwell assist Faraday?
5 How were Faraday's achievements recognised?

Before you listen

Discuss these questions with your partner.

→ How does a candle work?
→ How does a torch work?
→ How does an electric light work?

F Listening

Listen to the conversation and fill in the gaps in the notes.

1 A hairdryer works with ..... .
2 The electric ..... operates a fan.
3 The electric ..... warms the heating element.
4 Air is ..... the element.
5 A..... controls the heat in the element.

G Speaking

Discuss these questions with your partner.

→ Can you live without

A TV?

B a CD player?

C a fridge?

Task

Discuss with your partner the following topic. 'How would life be different without electricity?'

Talk about:

- things we use electricity for (lighting, cooking, refrigeration, your ideas)
- things we don't need electricity for (play games, reading/writing, do sports, your ideas)
- places that use electricity (homes, hospitals, factories, your ideas)
- luxury items that use electricity (TV, music, video games, your ideas)

Remember to:

- say what you think
  I (don't) think/feel/believe (that); in my opinion; as far as I'm concerned
- give your reasons
  I say this because, due to, because of
- agree/disagree politely
  Quite right. I'm not sure I agree ...

Speaking tips

✔ Ask questions.

✔ Let your partner finish their sentences.

✔ Ask for explanations if you don't understand.

H Writing

Write a short essay to answer this question: 'How did Faraday's personal life affect his scientific work?'

First read text 2 again and look at these notes. Then plan your essay.

PARAGRAPH 1

Early life:

poor family, not educated at school, worked with books

Vocabulary:

family background, bookbinder, no encouragement

PARAGRAPH 2

Entry into science:

evening lectures, wrote to famous scientist, assistant

Vocabulary:

Royal Institution, scientific community, secretary

PARAGRAPH 3

Relationships:

not a gentleman, treated like a servant, unhappy, problem with Davy

Vocabulary:

status, unhappy, think about

PARAGRAPH 4

Private life:

modest, hard-working, refused honours

Vocabulary:

discoveries, honours, banknote

Write 200-250 words.

Revision vocabulary Units 9 to 12

A Use the words in the box to complete the sentences.

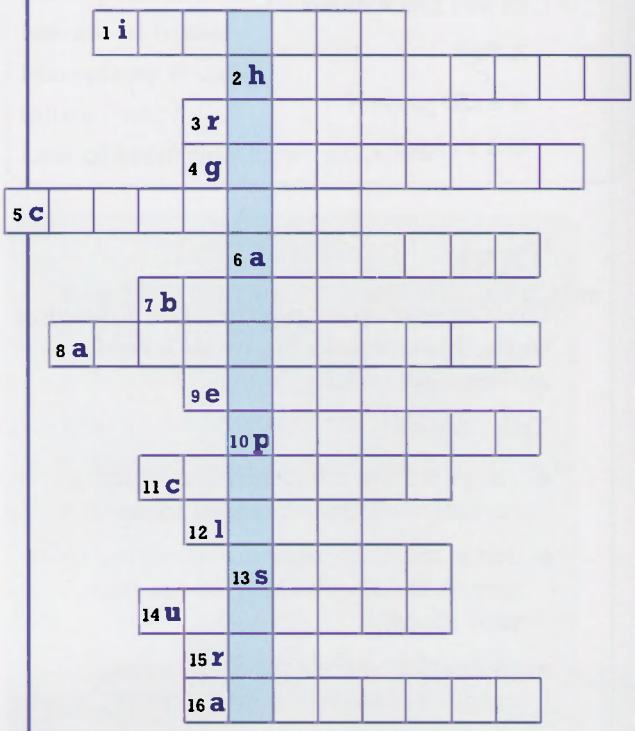
conductor	enroll
expand	convenient
specific	resign
catalyst	calculations
repetition	devise

1 Metal is an example of a good ..... – something through which electricity can pass.
2 To plan and make is to ..... .
3 If you are ..... , you are exact.
4 When writing an essay, try to avoid ..... of vocabulary.
5 When you sign up or join a school, you ..... .
6 The bus stop is right outside our front gate; that's very ..... .
7 Materials such as metal, when they are heated, they ..... .
8 A ..... is a substance that increases the speed of chemical reactions.
9 If you decide you want to leave your job, you ..... .
10 I need to make some ..... before I ask the bank for a loan.

B The words in green are in the wrong sentences. Put each word into the correct sentence.

1 To **rotate** power you need to be able to control electricity.
2 A **device** is produced as the secondary result of a process.
3 A mathematical statement showing two expressions are equal is a(n) **by-product.**
4 Electricity passes around buildings through **dark matter.**
5 Light is not absorbed or emitted by **wires.**
6 **Compressed** means having height, width and depth.
7 To **generate** means to turn around on an axis.
8 A(n) **equation** is a series of events.
9 The material was **three-dimensional** as it had been pushed tightly together.
10 This is the **sequence** we are going to use to carry out the experiment.

C1 Use the clues to complete the crossword and find the hidden expression.



1 immediate
2 two magnetic ends being the same
3 make known, show
4 if it happens over a period of time, it happens .....
5 as if eaten up
6 give a job, a position to somebody
7 we put it in a lamp
8 accomplishment.
9 to apply (force for example)
10 do, carry out
11 crash, hit
12 a circle
13 a flash
14 being the same
15 decay
16 the process of examining something to understand it.

C2 What does the hidden expression mean?

Unit 13

Before you read

Discuss these questions with your partner.

- What did early people commonly believe about the relationship between the Earth, the Sun and the other planets?
- Is it important for scientists to discover laws about the physical world? Why / Why not?

A Vocabulary

Match these words with their definitions.

1 elliptical	A suppose, speculate
2 orbit	B talk or write more about something
3 expand on	C a statement describing a phenomenon in science which is true at all times
4 the heavens	D having the Sun as the centre
5 inertia	E a *path* around another object
6 gravity	F effect
7 geocentric	G having the Earth as the centre
8 heliocentric	H the sky
9 hypothesise	I oval or egg-shaped
10 revolve	J what makes things fall
11 law	K law of physics according to which a body tends to maintain its speed & direction
12 impact	L move around

Reading 1

The Law of Universal Gravitation

In ancient times, people believed that the Earth was the centre of the solar system and tried to understand and explain the movement of the Sun, the Moon, the stars and the planets around the Earth. As scientific knowledge and technology improved over time, this idea (called the *geocentric* theory, from the ancient Greek words meaning *Earth-centred*) lost favour and new theories about the solar system were put forward.

Tycho Brahe (1546-1601) and Galileo (1564-1642) made accurate measurements of the heavens, which were the basis for later theories. Nicolas Copernicus (1473-1543) believed that the Earth was not the centre of the solar system but

just another planet revolving around the Sun, which itself never moved. This type of theory was called *heliocentric*. Johannes Kepler (1571-1630), an assistant to Brahe, used Brahe's measurements to support Copernicus' heliocentric theory. This led to his discovery of three laws relating to planetary movement, including the fact that the planets move in elliptical orbits around the Sun.

It was left to Isaac Newton to expand on these theories by testing and proving Kepler's laws. By observing things around him, Newton realised several things. One was that objects can be in one place, without moving. This is called *inertia*. Then, if the object moved, it moved toward another object. The phenomenon causing this *pull* of one object towards another was the force of gravity (or *little g*). Newton found that the mass of the two objects and the distance between them determined the *strength* of the force of gravity and developed an equation which expressed this relationship.

Continuing to test and expand his findings, Newton hypothesised that this relationship existed not only between objects on the Earth but also objects in space. This led in 1687 to Newton's *Philosophiae Naturalis Principia Mathematica (Mathematical Principles of Natural Philosophy*, usually called *Principia*) in which he wrote about his historic discovery of the Law of Universal Gravitation (or *big G*). By calling his discovery a *law*, it meant that the relationships he had discovered were true everywhere and in all cases.

Newton's discovery had a huge impact on scientific thinking for centuries afterwards. In fact, his findings were not improved upon until 1905, when Albert Einstein introduced his Special Theory of Relativity.

Pronunciation guide

Galileo /gælɪ'leɪəʊ/
geocentric /dʒiːəʊ'sentrɪk/
inertia /ɪ'nɜːʃə/
Philosophiae Naturalis /fɪlɔ'sɔfɪə nætʊrælɪs/
Principia Mathematica /prɪn'sɪpɪə mæθe'mætɪkə/
Tycho Brahe /taɪkɔ brɑː/

B Comprehension

Read the text and choose the correct title for each paragraph. There is one title which you do not need to use.

PARAGRAPH 1 .....
PARAGRAPH 2 .....
PARAGRAPH 3 .....
PARAGRAPH 4 .....
PARAGRAPH 5 .....

A Newton's discovery
B Early theories of heliocentrism
C The strength of Newton's Law
D Geocentrism
E Newton's observations
F Einstein's theories

Before you listen

Discuss these questions with your partner.

→ Does all research lead to important discoveries? Explain your answer.
→ What role does the work of earlier researchers play in scientific discoveries?

C Listening

You will hear five students talking about famous scientists. Match each statement with the speaker. There is one statement which you do not need to use.

SPEAKER 1 .....
SPEAKER 2 .....
SPEAKER 3 .....
SPEAKER 4 .....
SPEAKER 5 .....

A He believed in a combination of the geocentric and heliocentric theories.
B He used scientific methods to explain planetary motion.
C He believed in the heliocentric theory.
D He believed nothing was accidental.
E He believed in the geocentric theory.
F He was the first to measure the movement of the stars.

Before you read

Discuss these questions with your partner.

- Do you know anything about the scientist Isaac Newton?
- Is it a good idea for scientists to tell others about their research results? Why / Why not?

D Vocabulary

The words in green are all in the wrong sentences. Put the words into the correct sentences.

1 My uncle worried so much about his work that he had a **mint**. .....

2 Our class visited the **estate** and we saw how money is made. .....

3 That crystal vase is very **calculus** and will easily break. .....

4 The branch of mathematics that is concerned with limits and with the differentiation and integration of functions is called a **delay** .....

5 The **telescope** had a huge old castle and beautiful gardens. .....

6 A **nervous breakdown** has a large convex lens so that you can see things which are far away. .....

7 There was a **fragile** so we were late. .....

Reading 2

Isaac Newton

Isaac Newton was born on Christmas Day 1642, according to the calendar which was used in England at that time, or, according to the modern calendar, 4th January, 1643. His father was a wealthy farmer in the north of England, and the owner of a large estate which included the family home, called Woolsthorpe. Unfortunately, his father had died several months before Newton was born, so he never knew him. When he was two, his mother married again and moved to another village, leaving him behind to be brought up by his grandmother.

When his stepfather died some years later, Newton's mother returned to Woolsthorpe, together with the three children from her second marriage. Even though Newton's family was wealthy, his mother did not want him to go to school. Instead, she wanted him to learn to be a farmer and to take care of the family's estate. Newton did not like farming and was not very good at it. Eventually, he was allowed to return to school and then to attend university, although he had to work to earn money to cover at least some of his expenses.

Despite the fact that Newton was studying Law at Cambridge, where the ideas of Aristotle were greatly respected, he became more interested in modern philosophers like Rene Descartes, Thomas Hobbes and Robert Boyle and also explored the ideas of Nicolas Copernicus, Galileo and Johannes Kepler. At some point, he became interested in mathematics, including the work of Euclid and Descartes, which eventually resulted in Newton's invention of calculus. In the field of optics, he made important discoveries about light and colour theory, as well as building the first reflecting telescope. He was also involved in alchemy, religion and, of course, physics,

where his discovery of the laws of planetary motion and gravity were great advances and also served as the basis for later work, such as Albert Einstein's. He was also interested in politics, serving as a Member of Parliament and in other governmental positions.

Throughout his life, Newton was a fragile, sensitive person, who did not take well to criticism. In fact, he often delayed publishing his work because he was afraid of being criticised, which led to many problems later on. He suffered two nervous breakdowns and finally stopped doing research. However, he remained active by working for the government as Warden, and later Master, of the Royal Mint, where his efforts produced important results. He was made a knight by Queen Anne in 1705.

Newton died on 20th March, 1727. The epitaph for his tomb, which is in London's Westminster Abbey, was written by the poet, Alexander Pope:

Nature and nature's laws lay hid in night;

God said 'Let Newton be!' and all was light.

Pronunciation guide

calculus /kælkjuləs/
Descartes /deɪkɑːt/
epitaph /epɪtɑːf/
Euclid /juːklɪd/
fragile /frædʒaɪl/
telescope /telɪskəʊp/
Westminster Abbey /westmɪnstə ˈæbɪ/
Woolsthorpe /wulsθɔːp/

E Comprehension

Read the text and choose the correct answer.

1 As a young child, Newton
- **A** lived on a small farm.
- **B** lived at Woolsthorpe with his grandmother.
- **C** lived with his parents.
- **D** lived with his mother and her new husband.

2 Newton's mother
- **A** took him with her when she remarried.
- **B** wanted him to go to school.
- **C** thought he should be a farmer.
- **D** covered all costs of his education.

3 Newton was originally studying to be
- **A** a physicist.
- **B** a philosopher.
- **C** a mathematician.
- **D** a lawyer.

4 Newton was not particularly influenced by
- **A** the ideas of Aristotle.
- **B** the ideas of Descartes.
- **C** the ideas of Copernicus.
- **D** the ideas of Euclid.

5 Newton had problems in his later life because
- **A** he was so famous.
- **B** he was afraid of criticism.
- **C** he published his work.
- **D** he stopped doing research.

Before you listen

Discuss these questions with your partner.

→ Can you explain why we see colours?

→ Do you know the famous story of how Newton discovered gravity?

F Listening

You will hear part of a radio programme about great scientists. Listen and fill in the notes.

Optics is the branch of physics that studies the physical **(1)** ..... of light known as optics.

Newton claimed that a prism could **(2)** ..... white light into a spectrum of colours.

A second prism and lens could recompose the multi-coloured spectrum into **(3)** ..... light.

Newton said **(4)** ..... with coloured light caused us to see colours.

Newton believed light is made up of particles connected to **(5)** ..... .

Newton's calculations said gravity kept the Moon in **(6)** ..... .

G Speaking

Discuss these questions with your partner.

→ Do you agree that Newton was one of the most important scientists in world history? Why / Why not?

→ What areas of science was Newton's contribution crucial to?

Task

Read text 1 again and give a two-minute presentation on the Law of Universal Gravitation.

Talk about:

- the geocentric theory
- heliocentric theories
- Newton and his theory of gravity

First complete these notes. Use them in your presentation.

To begin with, we need to discuss what was believed in ancient times. The geocentric theory held .....
.....
.....
.....

Later theories were based on .....
and the theories said .....
.....
.....
.....

Isaac Newton added to these theories by .....
.....
.....
.....

Newton's theories are still important because .....
.....
.....
.....
.....

Remember to:

- present the facts in chronological order
- use the full names of the scientists when referring to them for the first time

Speaking tips

✔ If you don't know a word, explain what you mean using other words you know.

✔ Don't speak too quickly. It isn't a conversation and the class may not catch everything you say.

H Writing

You have been asked to write a newspaper article about Isaac Newton. Write the article, giving biographical information and an explanation of his many achievements.

For your research take notes from texts 1 and 2 and exercise F listening.

Use this plan:

Title (think of an eye-catching title)

PARAGRAPH 1

Explain who you're writing about and why.

PARAGRAPH 2

Give an overview of Newton's life.

PARAGRAPHS 3 AND 4

Give examples of his theories and how he arrived at the conclusions.

PARAGRAPH 5

Sum up by briefly restating his life and achievements and say what kind of impression Newton made on you.

Write 200-250 words.

Unit 14

Before you read

Discuss these questions with your partner.

- Have you heard of quantum mechanics?
- What are atoms made up of?

A Vocabulary

Complete the sentences below with words from the box.

evidence	tiny
back up	adequately
duality	radiates
distinct	

1 There was a(n) ..... amount of energy - it was separate from any other.

2 There has to be ..... to prove a theory.

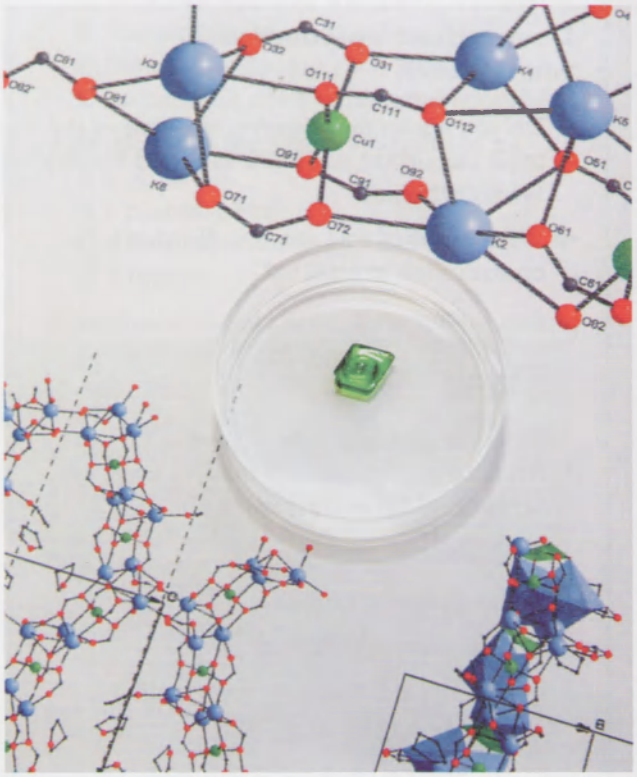
3 Atoms are not just small. They're ..... !

4 If energy is given off, we say it ..... .

5 You will need to ..... your theory with some kind of proof.

6 I think I have argued my point quite ..... .

7 Some properties being best explained by wave theory and others by particle theory is known as ..... .



Reading 1

Quantum mechanics

Quantum mechanics is the branch of physics that explains the behaviour of the tiniest matter such as atoms, molecules and nuclei. **(1)** ..... Thanks to the ideas it put forward, scientists managed to explain all the new experimental evidence of the time that could not be explained by classical physics (also known as *Newtonian physics*, after Isaac Newton).

(2) ..... A few years later, Isaac Newton suggested that light was made up of tiny particles. Both of these theories were backed up by experiments. But neither theory could adequately explain on its own all of the phenomena associated with light.

Nearly two hundred years later, in 1900, Max Planck assumed that hot things send out energy in packets, and he named these packets *quanta* (singular: quantum). **(3)** ..... In 1905, Albert Einstein published a paper based on

Planck's work to explain the photoelectric effect, and called the energy packets of light *photons*. According to this theory, when light shines on a metal surface, the photons in the light can carry enough energy to hit an electron in an atom in the metal and knock the electron out of the atom.

In 1920, while working on the idea that a moving particle had the property of a wave and thus could have a wavelength (that is, that there was a specific length to the waves of light), Niels Bohr decided to find the wavelength of an electron moving around the nucleus of an atom. He found that an electron could have a stable orbit, which means that the electron in orbit is not radiating energy. He also found that an electron absorbed or radiated a certain distinct amount of energy only when moved to another stable orbit. **(4)** .....

It appears that quanta were being used by scientists to explain all sorts of phenomena that they could not explain before. However, the scientific community was divided on whether light was a wave or a particle because it behaved as both in different experiments. So they began to think of light as both a particle and a wave. **(5)**..... This concept is true for both matter (such as electrons) and energy (such as light). We can only conclude that light is somehow both a wave and a particle, or it is something else that we cannot quite understand and which physicists of the future will be able to explain.

In the final analysis, quantum mechanics explained two very important things: why atoms were stable and why atoms absorbed or released energy in certain ways.

Pronunciation guide

Christian Huygens /krɪstjən 'haɪgən/
Einstein /'aɪnstaɪn/
Newtonian /nju'təʊnɪən/
nuclei /nju:klɪaɪ/
photoelectric /fəʊtəʊɪ'lektrɪk/
quantum /kwɔntəm/
wavelength /'weɪvleŋθ/

B Comprehension

Read the text and complete with the missing sentences below. There is one sentence which you do not need to use.

A Quanta were the modern answer to Newton's theories.

B Electrons could not inhabit the space between orbits.

C Quantum mechanics is used for understanding the behaviour of systems at atomic length scales and smaller.

D The foundations of quantum mechanics were laid in the late 1600s, when Christian Huygens proposed that light was made up of waves.

E Then Albert Einstein began to wonder if light also delivered its energy in packets.

F This is now known as the wave-particle duality concept.

Before you listen

Discuss these questions with your partner.

→ What physical phenomena are made up of waves?

→ What things are we able to do because of these waves?

C Listening

Listen to a teacher and a student discussing the photoelectric effect. Then complete each sentence with one word.

1 When light shines on a ..... surface, electrons can be released.

2 Isaac Newton and Albert Einstein both believed that light was made of ..... .

3 The role of science is to find out the ..... .

4 In experiments with the photoelectric effect the..... agreed with Einstein's predictions .

5 Einstein didn't win the Nobel Prize for his ..... of Relativity.

6 From different points of view,..... can be a particle or a wave.

Before you read

Discuss these questions with your partner.

- Do you know what Bohr's model of the atom is?
- Can you explain it?

D Vocabulary

a. Match the words to make phrases.

1 stable	A properties
2 quantized	B chain reaction
3 wave-particle	C states
4 dual	D bomb
5 atomic	E atom
6 fission	F duality

b. Match these words with their definitions.

1 spectral line	A used about things that have two parts
2 in essence	B using new methods or achieving new results
3 groundbreaking	C basically
4 dual	D used about ideas or beliefs that disagree with each other and cannot be both
5 contradictory	E win
6 complementarity	F light or dark band of particular wavelength, used to identify substances
7 gain	G a basic principle of quantum theory according to which a system may have either particle-like or wave-like properties
8 significant	H important

Reading 2

Niels Bohr

Niels Bohr was born in Copenhagen in 1885, and died there in 1962. He was one of the most distinguished physicists of all time. He is best known for the development of the Bohr model of the atom, his theory explaining the existence of spectral lines, and the principle of complementarity. His work won him the 1922 Nobel Prize in Physics.

His interest in science began at an early age because his father was a professor of physiology. Specialising in Mathematics and Physics during his final years of school, Bohr continued these studies at university. He received his Master's degree from the University of Copenhagen in 1909 and his PhD in 1911. Later that same year, he went to England where he worked with Sir Joseph Thomson (who had discovered the electron), and Ernest Rutherford (who had put forward the concept of a nucleus within the atom).

He worked on the structure of the atom using quantum ideas from Max Planck and Albert Einstein. In Bohr's model of the atom there is a nucleus, and electrons move around the nucleus in stable states (also known as orbits or energy

levels) without radiating energy. When an electron moves from one state to another, only very specific amounts of energy are lost or gained. If the atom gains energy, the electron jumps to a level further from the nucleus; if it loses energy, it drops to a level closer to the nucleus. Whenever energy is lost or gained, a line in a spectrum is produced. This model is now known as a quantized atom, from the term *quantum* introduced by Planck to describe small packets of energy.

In 1927, Bohr put forward his principle of complementarity, which refers to effects such as wave-particle duality. Bohr's principle was the most groundbreaking scientific concept of the 20th century. In essence, the principle states that things may have dual or contradictory properties, but we can only experience one property at a time. For example, we can think of an electron as a wave or as a particle, but we cannot think of it as both at the same time, even though it may actually be both at once.

In 1920, Bohr had been appointed director of the Institute of Theoretical Physics and he continued to work there throughout the 1920s and 1930s. However, during the German occupation in World War II, due to his having a Jewish mother, it was necessary for Bohr to avoid arrest by the police. He therefore escaped to Sweden. From there, he travelled to England and then to America, where he became involved in the Atomic Energy Project which aimed to build the first atomic bomb. He made a significant contribution by discovering that only uranium-235 could produce the fission chain reaction required for an atomic explosion. However, he was concerned about the political problems that the development of atomic weapons could cause, and supported the idea of sharing the new technology with other countries, particularly the USSR.

Niels Bohr held many important positions, and was honoured by many important scientific institutions. He was President of the Royal Danish Academy of Sciences, and a member of many other famous Academies. Bohr was awarded honorary doctorates by the world's greatest universities. Interestingly, Bohr's son also became a physicist and won the Nobel Prize for Physics in 1975.

Pronunciation guide

Copenhagen /ˌkəʊpənˈheɪgən/
fission /ˈfɪʃən/
quantized /ˈkwɔntaɪzd/

E Comprehension

Read the text and choose the correct answer.

1 Bohr went to England
- **A** in 1909.
- **B** to receive his PhD.
- **C** to work with Planck and Einstein.
- **D** and worked with two famous scientists.

2 A quantized atom does not
- **A** have electrons moving in stable states.
- **B** produce a spectrum.
- **C** have electrons moving, radiating energy.
- **D** have a nucleus.

3 Bohr's principle says
- **A** properties can only be experienced separately.
- **B** electrons are definitely waves and particles.
- **C** properties can only disagree.
- **D** an electron is actually a particle.

4 Bohr thought atomic weapons
- **A** should be supported whatever the circumstances.
- **B** could only be developed in cooperation with the USSR.
- **C** should be developed in cooperation with the USSR.
- **D** should make a significant contribution to politics.

5 Niels Bohr
- **A** had a successful son.
- **B** won the Nobel prize in 1922 and 1975.
- **C** was president of many academies.
- **D** worked for many important scientific institutions.

Before you listen

Discuss these questions with your partner.

→ Do you know what a prism is?

→ Do you know how a prism works?

F Listening

Listen to a teacher explaining spectral lines to a class of physics students. Then listen again and decide if the following statements are true or false.

1 Atoms inside electrons produce light. T ☐ F ☐

2 Elements that glow produce all the colours. T ☐ F ☐

3 Spectral lines are unique for each element. T ☐ F ☐

4 Stars are too far away to be tested through spectroscopy. T ☐ F ☐

5 A large number of atoms together will produce many lines. T ☐ F ☐

G Speaking

Task

Prepare a short presentation about the history of quantum mechanics and the people who contributed to its development.

Talk about:

- why it was necessary
- how it got its name
- what answers it gave
- what it didn't explain

Read texts 1 and 2 again and use these notes to help you.

New experimental evidence: needed to be explained

Naming: Max Planck

Answers provided: Einstein and Bohr's work

Still a mystery: wave-particle duality

Remember to:

- read the texts carefully and underline the information you need
- present your ideas in a logical order
- be concise

Speaking tips

✔ Use words like 'firstly', 'secondly' and 'finally'.

✔ Try to look at your audience as you are speaking to them.

H Writing

Write a composition to answer the question: 'How did quantum physics develop?'

Read texts 1 and 2 again and use these notes to write four paragraphs.

PARAGRAPH 1

Introduction Say what quantum physics deals with (atoms, electrons, etc).

Vocabulary: It is used to ...

PARAGRAPH 2

The first scientists to work on or use the theory: Max Planck (quanta); Albert Einstein (photons).

Vocabulary: At the beginning of the 20th century, ...

PARAGRAPH 3

The scientist who used quantum mechanics the most in his work: Niels Bohr (model of the atom, complementarity, spectral lines).

Vocabulary: One very important figure was ...

PARAGRAPH 4

Conclusion The two important concepts it explained (stability and energy levels); what it didn't give an answer to (wave-particle duality).

Vocabulary: In conclusion, ...

Write 200-250 words.

Unit 15

Before you read

Discuss these questions with your partner.

- Why do scientists want to test and prove theories?
- Do you think there are general laws which can explain the physical universe? Why / Why not?

A Vocabulary

Find a synonym in the box for the words or phrases in green in the sentences. Then check your answers in the text.

an eclipse	apparent	notion
multi-dimensional		bend
obstacles	eager	curved

1 In science fiction films, space travel is often talked about as being **more than one dimension** since it involves both time and space. .....

2 When there is **the phenomenon of the Sun being covered by the Moon**, it is observed by millions of people. .....

3 The scientist was very **keen** to test her theory. .....

4 The heliocentric theory was a(n) **idea** that many people did not want to accept. .....

5 Unfortunately, he met many **difficulties** in his research. .....

6 Light can **turn**. .....

7 It was **obvious** to scientists that more research was needed. .....

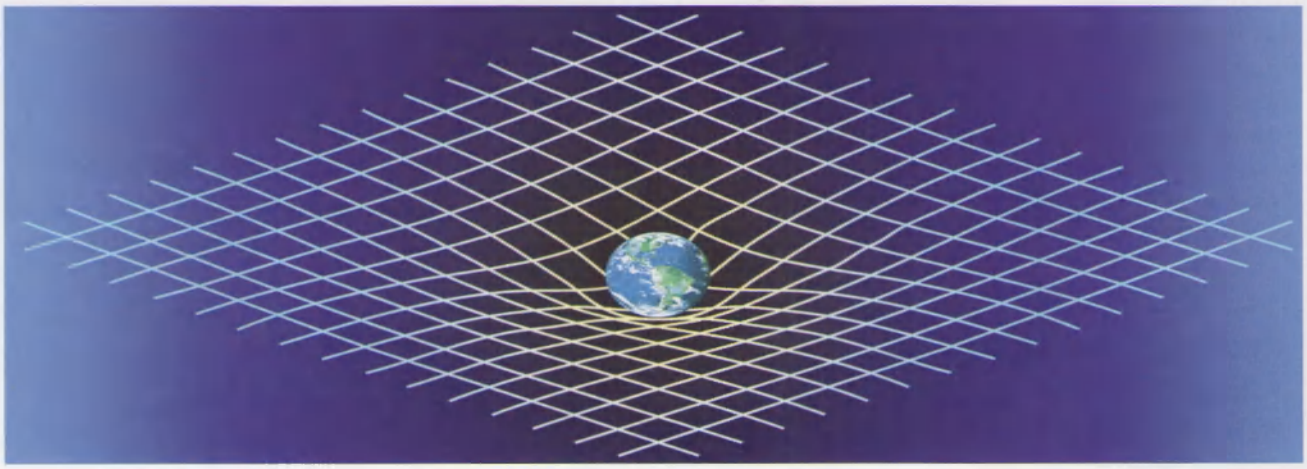
8 The line was **rounded**. .....

Reading 1

The General Theory of Relativity

Isaac Newton's discovery of the Law of Universal Gravitation would seem to have definitively answered the question of planetary movement. And yet, it became apparent to scientists that a number of phenomena which they observed did not agree with those they expected to see based on Newton's predictions.

One of the differences was the orbit of the planet Mercury, which did not quite match the orbit predicted by Newton's theory. Another problem resulted from James Clerk Maxwell's theory of electromagnetism (about 1870), which indicated that space was filled with matter that moved and was not empty and motionless, as Newton had believed. Finally, there was a problem with



Newton's claim that light travelled at a constant speed, whether the observer was moving toward or away from it or not.

These questions captured the interest of a brilliant young physics student, Albert Einstein.

Einstein's first attempt to solve the problem was his 1905 paper on *The Special Theory of Relativity*, a concept which had been noted by Galileo in 1632. In this work, Einstein found that time and space are relative, not constant. This means that time and space are different depending on where the observer is. This was proved by an experiment involving two clocks: one was put on an aeroplane which travelled around the world and the other remained at the starting point on the ground. When the first one returned, it was running slower than the one which had been left behind, exactly as Einstein had predicted.

Einstein continued to expand on this theory, and in 1916 presented a paper on a new theory, *The General Theory of Relativity*, which took into account the effect of gravitation on space and time. It involved the notion of space time, a multi-dimensional phenomenon which is constantly moving and bending as it meets obstacles in its path. Everything in the universe is part of this space time and is carried along with it. Furthermore, gravity is not a force which moves things, but rather it is an *element* which illustrates curved space and time.

Einstein's theory was based on geometrical calculations and principles and had to be proved by scientific testing in the natural world, which many scientists were eager to do. In 1919, during a solar eclipse, a British team working in two different locations measured the light of several stars. They found that the light from these stars was actually bent, just as Einstein's theory had predicted. Needless to say, Einstein immediately became internationally famous. Scientists continued to apply Einstein's equations to other natural phenomena, all with positive results.

Pronunciation guide

eclipse /ɪklɪps/

Mercury /mɜːkjʊrɪ/

B Comprehension

Read the text and decide if the following statements are true or false.

1 The orbit of the planet Mercury led scientists to question Newton's Law of Universal Gravitation. T ☐ F ☐

2 Maxwell agreed with Newton that space was empty and motionless. T ☐ F ☐

3 Einstein was the first scientist to talk about the notion of relativity. T ☐ F ☐

4 According to Einstein, gravity is not a force which moves matter. T ☐ F ☐

5 Einstein's theories were never proved by scientific testing. T ☐ F ☐

Before you listen

Discuss these questions with your partner.

→ Are scientists influenced by the work of earlier scientists? Explain your view.

→ 'Discovery is just a different way of looking at something.' Do you agree or disagree with this statement? Explain why.

C Listening

You will hear five famous scientists talking about research involving relativity. Match each statement with the speaker. There is one statement which you do not need to use.

SPEAKER 1.....

SPEAKER 2.....

SPEAKER 3.....

SPEAKER 4.....

SPEAKER 5.....

A He discovered one of the first principles of relativity.

B His work led to the discovery of the Theory of Relativity.

C He discovered the two theories of relativity.

D He disagreed with the Theory of Relativity.

E He supported the Theory of Relativity.

F He tested the Theory of Relativity.

Before you read

Discuss these questions with your partner.

- What do you know about Albert Einstein's life?
- What do you think Einstein is particularly famous for?

D Vocabulary

Match these words with their definitions.

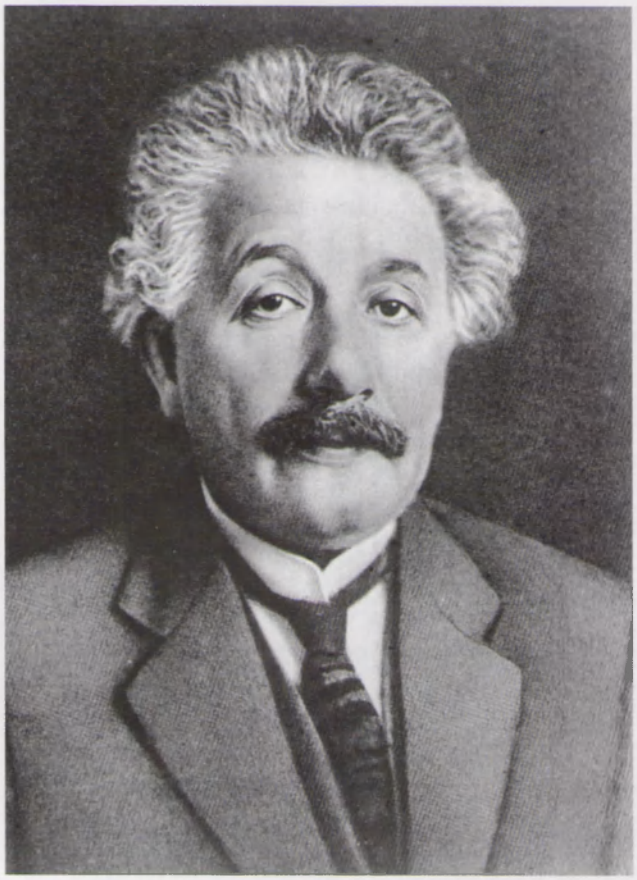
1 acknowledged	A a legal document which protects an inventor's rights to his/her invention
2 long-standing	B bombs, etc for killing large numbers of people
3 patent	C changed
4 dedicated	D recognised
5 overturned	E existing for many years
6 weapons of mass destruction	F committed to
7 expose	G somebody who is against war
8 admission	H entry
9 pacifist	I make open to

Reading 2

Albert Einstein

Albert Einstein is widely acknowledged to be one of the greatest physicists of all time. Born in Ulm, Germany in 1879, his family soon moved to Munich, where he lived until he was 15. He attended the Luitpold Gymnasium and in 1894, wrote his first scientific work, *The Investigation of the State of Aether in Magnetic Fields*.

Einstein's family moved to Italy in the same year, but he stayed behind to finish school. However, one year later, he left school without telling his parents and went to Italy to be with them. Shortly afterwards, he applied for admission to the Swiss Polytechnic Institute but was not accepted; he had not done well in the non-science part of the test. He later attended the Swiss Federal Polytechnic



School in Zurich, from which he received a degree and so was qualified to teach Physics and Mathematics. Unfortunately, however, he was not able to get a teaching position but with the help of his old classmate and friend, Marcel Grossman, was able to get a job in the Swiss Patent Office in 1902. In 1903, Einstein married his former classmate, Mileva Marie. They had three children – a daughter and two sons.

While Einstein was working at the Patent Office, he began to examine different problems in physics and came up with some remarkable discoveries. In 1905 he published three papers, one of which was about his Special Theory of Relativity, a concept which completely overturned Isaac Newton's long-standing Law of Universal Gravitation.

In the following years, Einstein and his family moved from one European capital to another. In each city he held teaching positions at local universities or in scientific institutions. He continued researching a number of different questions and published papers which had a great impact on the field of physics, including his work on the concept of relativity, which led to his Theory

of General Relativity in 1915. He paid his price for creativity, however, and due to the great stress he was under, he became seriously ill in 1917.

When Einstein's General Theory of Relativity was proved to be true by British researchers in 1919, he became world famous. He received the 1921 Nobel Prize for Physics in recognition of his work (in 1905) on the photoelectric effect (when electrons are produced if matter is exposed to electromagnetic radiation, for example, in X-rays), which had been thoroughly tested and widely accepted.

Einstein was very active in politics. He moved to the US from Europe just before the start of World War II, and advised the American President Franklin Roosevelt to start building an atomic bomb before the Nazis produced one. However, he later said that had he realised the Nazis would not produce an atomic bomb, he would never have advised Roosevelt in this way. He never personally worked on the bomb. In fact, he was against war and weapons of mass destruction. All his life Einstein had been a pacifist, only recognising the need to fight against the Nazis when it became apparent that they had to be stopped. After the war, he dedicated himself to working for nuclear disarmament.

Einstein believed that we should never stop questioning things and keep searching for answers about the natural world. On 18th April, 1955 he died of heart failure.

Pronunciation guide

Aether /iːθə/
Luitpold /luɪtpɔld/
Munich /mjuːnɪk/
pacifist /pæsɪfɪst/
Zurich /zuərɪk/

E Comprehension

Read the text and choose the correct answer.

1 Einstein left Munich in
- **A** 1879.
- **B** 1894.
- **C** 1895.
- **D** 1902.

2 After completing his education at the Swiss Federal Polytechnic School, Einstein
- **A** was not accepted at the Swiss Polytechnic Institute.
- **B** got a job teaching Physics and Mathematics.
- **C** got a job working with his friend, Marcel Grossman.
- **D** got a job working at the Swiss Patent Office.

3 After the publication of his 1905 papers, Einstein
- **A** became an international celebrity.
- **B** stopped working on the Theory of Relativity.
- **C** continued working on the Theory of Relativity.
- **D** spent his time teaching rather than doing research.

4 Einstein became an international celebrity
- **A** when his theories were proven to be true.
- **B** when he discovered the General Theory of Relativity.
- **C** when he discovered the Special Theory of Relativity.
- **D** when he won the Nobel Prize.

5 Einstein received the 1921 Nobel Prize
- **A** because of his discovery of relativity.
- **B** because his theories overturned Newton's Law.
- **C** because of his earlier work.
- **D** because of his contributions to world peace.

6 Einstein's attitude to war could be described as
- **A** tolerant in certain situations.
- **B** totally opposed.
- **C** supportive.
- **D** undecided.

Before you listen

Discuss these questions with your partner.

→ Do you know anything about Einstein's childhood?

→ Do you know what his hobby was?

F Listening

Listen to part of a radio interview with a historian talking about Einstein. Then complete each sentence with a word or short phrase.

1 Einstein made his first scientific discovery when he was ..... years old.

2 He realised that something was causing the needle of the compass ..... in a certain way.

3 He taught himself ..... at the age of 12.

4 Einstein tried to get information about the speed of ..... by looking into a ..... .

5 Recent research shows that there is no ..... in the belief that Einstein had a learning difficulty.

G Speaking

Discuss these questions with your partner.

→ Which area of Einstein's work do you think is most important? Why?

→ Do you agree with Einstein's statement that we should never stop questioning and looking for answers? Why / Why not?

Task

In a group have a discussion about Einstein's life.

Talk about:

- his early life (childhood interest in science, education)
- his discoveries (special and general relativity)
- why they were important (showed that accepted theories like Newton's were not true; provided scientists with important new theories and directions for future research)
- his interest in world peace

Remember to:

- make sure as a group you consider all points
- take everyone's point of view into account

Speaking tips

✔ Don't try to talk about too many things.

✔ Pick one or two facts you know well and give examples so people will understand them.

✔ Speak loudly enough so the whole group can hear you.

H Writing

A letter from Einstein

Imagine you are Albert Einstein in 1919. Write a letter to your old friend and colleague, Marcel Grossman on the day that Sir Arthur Eddington proved your General Theory of Relativity by measuring the way light was bent during a solar eclipse. Use these notes to help you.

PARAGRAPH 1

Why you are writing: after years of study and research, theory originally written in 1915 proved.

PARAGRAPH 2

Background information: up until now, Sun's light too bright to measure, so not able to prove theory. During solar eclipse, British scientists observed and measured light in two places, found the Sun's light bent exactly as theory predicted.

PARAGRAPH 3

How you feel: too much attention, don't like being followed around by reporters, want to get on with your work.

Include some of these words and phrases: history was made today, most important day of my life, finally, everyone says, don't really like

Write 100-140 words.

Unit 16

Before you read

Discuss these questions with your partner.

- Why do people study Maths?
- When do you use it?

A Vocabulary

a. Match these words with their definitions.

1 division	A a system of figures or symbols representing numbers
2 knot	B a written sign in maths or music, for example, which represents an operation, an element, relation, etc
3 set up	C a record of money spent or received
4 numeral	D a separation
5 symbol	E make ready for operation
6 tally	F a symbol representing a number
7 notation	G tie, bond

b. The words in green are all in the wrong sentences. Put the words into the correct sentences.

1 If you keep a **division**, you have a system to note how much has been spent. .....

2 The Roman **knots** are still used as numbers nowadays. .....

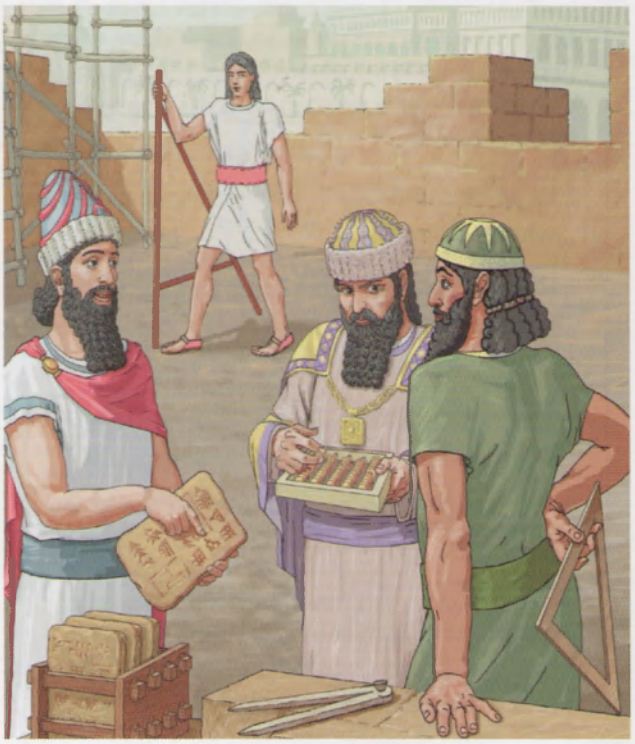
3 There is a **set up** between science and art subjects. .....

4 In maths we use **numerals** to show what kind of problem we are solving. .....

5 ..... **Symbols** in maths are things like numbers.

6 Some people tie **notation** to remember something. .....

7 She **tally** an experiment. .....



Reading 1

Mathematics

An introduction

The English word *mathematics* tells us something about the influence the Ancient Greeks had on our knowledge. The word comes from the Greek for science, learning and knowledge. It is usually shortened to maths in British English and to math in the USA.

Mathematics developed from a series of ideas, each new idea building on earlier ones. Each new idea became more complex as mathematicians tried to explain how things in the world relate to one another. The first idea to have developed was certainly that of number. People needed to count their belongings. As society developed, numbers became more and more important for business dealings and taxation and it became especially important to be able to record numbers. A wide variety of systems for recording numbers developed in different parts of the world. One example is the tallies that were used by the Incas in South America. They used pieces of string of different lengths and by tying knots in different places along the string, they were able to keep tax

records and business accounts throughout their land.

With writing, different ways of recording numbers developed in different countries, too. Roman numerals are a well-known example. In this system I is one and X is ten, so IX is one before ten, that is nine, and XI is eleven. It was not until the 16th century that the system of mathematical notation that we use today finally developed. It is a system that uses Arabic numerals (1, 2, 3 and so on) with a set of symbols + (plus), – (minus), = (equals) for example, along with letters, many of which are taken from the Greek alphabet. It is a system which is used by all mathematicians all over the world. In fact, it has been said that mathematics is one of only two genuinely international languages; the other one is music.

Whether or not mathematics is a science is still a matter of opinion in the mathematical community. Some say no, it is not because it does not pass the test of being a pure science. We know that one plus one is two because that is how we count. No one can set up an experiment to prove that one plus one is two without counting. Therefore, because it cannot be proved by experiment, mathematics is not a science. Others say yes, it is, because science is the search for knowledge and that is what mathematics does. Therefore, mathematics is a science.

Whatever your point of view, there is no doubt that mathematics is applied to all sciences. Many of the most important developments in fields such as physics or engineering have led to further developments in mathematics. The argument over whether mathematics is a science or not appears to be unimportant when you realise that it is impossible to separate mathematics from science or science from mathematics. Many universities recognise this. In many places of learning there are divisions of study, often called Mathematics and Science. The unbreakable connection between mathematics and all other sciences is recognised by the very way in which we study them.

Pronunciation guide

equal /iːkwəl/
minus /maɪnəs/
plus /plʌs/

B Comprehension

Read the text and decide if the following statements are true or false.

1 Mathematics developed in complexity due to a need to understand the relationships between things. T ☐ F ☐

2 The Incas were the first to come up with a number system. T ☐ F ☐

3 Mathematics is an *international language* because it uses Arabic numerals. T ☐ F ☐

4 Opinions are divided over whether mathematics is truly scientific. T ☐ F ☐

5 The development of mathematics is dependent on other sciences. T ☐ F ☐

Before you listen

Discuss these questions with your partner.

→ What is an abacus?

→ What is a calculator?

→ How do you prefer to do arithmetic?

C Listening

Listen to the extract from a radio programme about number systems. Then listen again and choose the correct answer.

1 The Arabic system
- **A** is a decimal system.
- **B** causes difficulties.
- **C** is only for multiplication.

2 The decimal system
- **A** is based only on hundreds.
- **B** can express any figures simply.
- **C** is complicated.

3 Roman numerals
- **A** can be divided easily.
- **B** are useful for complex maths.
- **C** can't be easily multiplied.

4 In Roman numerals C means
- **A** two hundred.
- **B** fifty.
- **C** one hundred.

Before you read

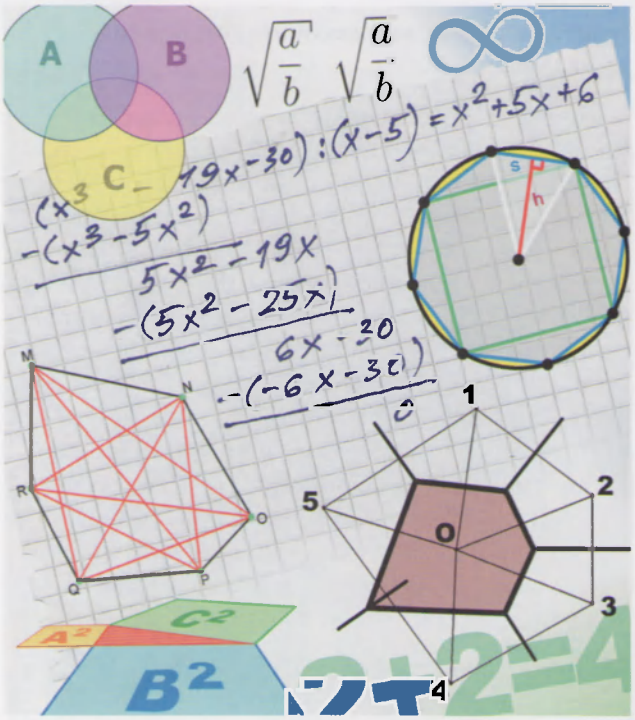
Discuss these questions with your partner.

- Do you know the names of any important people connected with Mathematics in history?
- What types of problems do you do in Mathematics at school?

D Vocabulary

Match these words with their definitions.

1 natural number	A the proof that something is mathematically true
2 integer	B a number larger than zero
3 operation	C any number (positive or negative) or zero
4 function	D a way numbers combine together
5 right angle	E the relationship between argument and result in calculus
6 square	F the result of combining numbers
7 sum	G an angle of 90 degrees
8 satellite navigation system	H system in orbit around the Earth for directions
9 theorem	I the product of two equal terms
10 axiom	J principle



Reading 2

Mathematics

What mathematicians study can be summed up as relating to four major fields. They look at quantities – how much or how many. There is also the study of structure – how things are arranged together and the relationship between the parts. Then there is the study of space, where mathematicians are interested in the shape of things. Finally, there is change and how things move, over time or through space.

Quantity is mostly concerned with numbers. Mathematicians are interested in both natural numbers and integers. Natural numbers are those which are greater than zero, while integers may be zero itself or more or less than zero. There are four ways these may combine together; these are called operations. In arithmetic, we know the operations as addition (+), subtraction (-), division (÷) and multiplication (x). For a fuller, more philosophical understanding of number and the operations that can be applied to them, mathematicians look to Number Theory.

The study of the structure of things is said to have begun with the Greek mathematician, Pythagoras, who lived from 582 to 507 BC. Every

mathematician has to learn his most famous theorem. A theorem is a proof of mathematical truth. Pythagoras showed us that in a right-angled triangle, the square of the side of the hypotenuse is equal to the sum of the squares of the other two sides. The hypotenuse is the longest side of such a triangle and that length, multiplied by itself is the same as the length of one side multiplied by itself and added to the other side multiplied by itself. Mathematicians find it easier to write this as: $a^2+b^2=c^2$, (a squared plus b squared equals c squared) where c is the hypotenuse. It is Pythagoras' Theorem which gives us algebra, a branch of mathematics that originated in the Arab world.

Another Greek mathematician laid the foundations for our understanding of space. More than 200 years after Pythagoras, Euclid used a small set of axioms to prove more theorems. This, we know today as geometry. He saw the world in three dimensions - height, width and length. Developments in other sciences, most notably in physics, have led mathematicians to add to Euclid's work. Since Einstein, mathematicians have added a fourth dimension, time, to Euclid's three. By combining space with number we have developed the trigonometry used in making maps both on paper and in satellite navigation systems.

From algebra and geometry comes calculus. This is the most important tool that mathematicians have to describe change, for example, if you calculate the speed of a moving car or analyse the way the population of a city changes over time. The most significant area of calculus is function, which is concerned with the relationship between argument and result. Indeed, the field of functional analysis has its most important application in quantum mechanics, which gives us the basis for our study of physics and chemistry today.

There is more to maths than this. For example, pure maths involves a more creative approach to the science. An important field of study is statistics which uses Probability Theory, the mathematical study of chance, to predict results and analyse information. Many statisticians would say that they are not mathematicians, but analysts. However, without maths, statisticians would all agree, there would be no statistics at all.

Pronunciation guide

algebra /ældʒɪbrə/
geometry /dʒɪˈɔmətrɪ/
hypotenuse /haɪˈpɔtənjuːz/
integer /ˈɪntɪdʒə/
Pythagoras /paɪˈθægərəs/
satellite /ˈsætəlaɪt/
trigonometry /trɪgəˈnɔmətrɪ/

E Comprehension

Read the text and complete the summary. Use words from the text.

A Maths studies four areas: quantities, structure, space and **(1)** ..... .

B Natural numbers are larger than **(2)** ..... but **(3)** ..... can be zero.

C **(4)** ..... was a Greek mathematician who made the famous theorem $a^2=b^2+c^2$ which helps us find the size of a **(5)** ..... .

D Algebra came from **(6)** ..... countries.

E With **(7)** ..... Euclid helped us understand **(8)** ..... .

F Trigonometry combines space with **(9)** ..... .

G Calculus describes **(10)** ..... and used in quantum mechanics allows us to study physics and **(11)** ..... .

H Statistics predicts results and analyses **(12)** ..... .

Before you listen

Discuss these questions with your partner.

→ How do you use mathematics outside the classroom?

→ How is mathematics involved in cooking?

F Listening

Listen to these people talking about mathematics in everyday life. Then listen again and match the activity to the area of mathematics.

There is one activity which you do not need to use.

1 estimating sizes	A algebra
2 the arrangement of parts	B arithmetic
3 avoiding collisions	C geometry
4 paying for goods	D Probability Theory
5 calculating wages	E trigonometry
6 predicting lottery numbers	

G Speaking

Discuss these questions with your partner.

→ What different areas of mathematics are there?

→ How did some ancient Greek thinkers contribute towards mathematics?

Task

Prepare a short presentation on the four main areas of mathematical study.

Talk about:

- what the areas are
- what they focus on
- what mathematical developments are practised in different areas
- how they might be of use in the real world

Read the texts again and use these notes to help you.

INTRODUCTION

Four areas. What are they? What does each one focus on?

POINTS 1-4

Number, Structure, Space, Change: for each area give details and an example of its usefulness.

CONCLUSION

Sum up, restate the introduction. Point out that there are other areas of interest too.

Remember to:

- outline what you will say
- make your points clearly
- let the audience know you have finished

Speaking tips

✔ Speak from notes.

✔ Choose simple examples.

✔ Make eye contact with your audience.

H Writing

Write a short essay to answer this question: 'Mathematics is the science of numbers. Discuss.'

Read text I again and use these notes to write four paragraphs.

PARAGRAPH 1

Introduction Say what you will write about. Maths about numbers, but also more. Maths called a science, but opinion is divided. (Do not answer the question yet.)
Vocabulary: concerned with, referred to, matter of opinion

PARAGRAPH 2

Maths developed from numbers. Counting, recording. Different systems, for the same maths, eg Incas, Romans. Knowledge of numbers gave more knowledge.
Vocabulary: firstly, number systems, society, development

PARAGRAPH 3

Development of maths gave method. Two points of view: maths a science, because about learning, maths not a science because not able to test. Normally called a science because is involved in all other sciences.
Vocabulary: experiment, knowledge, scientific, therefore

PARAGRAPH 4

Conclusion Maths about numbers, but only part of maths. Maths may / may not be science, but in practice part of every science. Maths is the science of numbers.
Vocabulary: in conclusion, important, in addition

Write 200-250 words.

Revision vocabulary Units 13 to 16

A Match the words and phrases with their meanings.

Isaac Newton

1 fragile	A the tendency of a body to maintain its speed and direction
2 calculus	B the natural force of attraction exerted by the Earth on objects on or near its surface
3 impact	C easily broken
4 inertia	D branch of mathematics concerned with limits, differentiation and integration of functions
5 gravity	E effect

Albert Einstein

1 pacifist	A arms which can kill many people
2 weapons of mass destruction	B something that prevents
3 notion	C somebody who doesn't believe in war
4 multi-dimensional	D involving time and space
5 bend	E idea
6 obstacle	F curve

Niels Bohr

1 spectral line	A basically
2 in essence	B in disagreement
3 groundbreaking	C light or dark band of particular wavelength, used for identifying substances
4 contradictory	D revolutionary
5 complementarity	E a principle according to which things cannot be studied as having contradictory properties at the same time

B Use the words in the box to replace the words in blue.

patent	numerals	operations
theorem	symbols	integers

1 Mathematicians are interested in natural numbers and **numbers which are zero itself or more or less than zero.**

2 A **legal document to protect an inventor's rights** ensures nobody steals the invention.

3 In maths you use **systems to combine numbers together in different ways.**

4 We use **these marks** to indicate addition, subtraction, multiplication or division.

5 **Statements or rules** are used in mathematics.

6 We still use Roman **numbers** nowadays.

C Find ten words or phrases in this word search using the clues.

d	r	i	g	h	t	a	n	g	l	e	n	b
k	i	d	g	r	a	d	i	a	t	e	a	q
v	k	i	w	r	b	e	w	r	b	j	t	n
u	v	s	c	b	i	e	g	c	d	a	u	k
d	r	t	j	r	g	v	m	e	c	p	r	v
s	l	i	u	a	x	i	o	m	b	p	a	u
o	a	n	p	v	n	d	r	r	k	a	l	d
e	u	c	z	u	j	e	b	z	a	r	n	s
l	z	t	j	h	e	n	i	n	b	e	u	o
e	c	b	i	a	r	c	t	b	a	n	m	e
r	e	t	a	i	l	e	r	s	v	t	b	p
e	c	l	i	p	s	e	w	b	l	d	e	i
g	c	a	d	u	a	l	i	t	y	s	r	o

Clues

1 principle
2 an angle of 90 degrees
3 a number larger than zero
4 a path round a planet for example
5 obviously separate from others
6 proof
7 to give off energy
8 when for example, the Moon covers the Sun
9 obvious
10 the quality of some things of having contradictory properties

Unit 17

Before you read

Discuss these questions with your partner.

- What is algebra?
- Can you think of any ways that we use it in our everyday lives?

A Vocabulary

a. Match these words and phrases with their definitions.

1 linear algebra	A money gained or lost
2 reunion	B rewriting
3 matrices	C linear equations
4 profit and loss	D coming back together
5 transposing	E arrangement of mathematical elements
6 operators	F what goes into something and what comes out
7 input and output	G signs used in maths

b. Match the words to make phrases.

1 arithmetical	A quantities
2 unknown	B spaces
3 abstract	C system
4 vector	D algebra

Reading 1

Algebra

Algebra originated in the Middle East. Earlier than 1000 BC, the Babylonians developed an arithmetical system for solving problems that could be written algebraically. This was in advance of other systems, notably that of the Ancient Egyptians, who were able to solve the same problems, but did so by using geometry. The word *algebra* comes from Arabic and translates into English as *reunion*. It describes a system of mathematics which performs calculations by firstly rewriting, that is, transposing them, and then reducing them to their simplest form.

Algebra is the branch of mathematics which studies the structure of things, the relationship between things and quantity. It looks different from arithmetic when it is written. Arithmetic uses numbers and the four operators (plus, minus, multiply and divide). Algebra uses symbols, usually letters, and the operators. Actually, it is not very different from arithmetic;

what can be done in algebra can be done in arithmetic. There are good mathematical reasons, however, why algebra is used instead of arithmetic.

Firstly, by not using numbers, mathematicians are able to set out arithmetical laws. In this way they are able to understand the system of numbers more clearly. Secondly, by using algebra, mathematicians are able to perform calculations where unknown quantities are involved. This unknown is usually represented by *x*. Solutions can then be applied not just to the immediate problem, but to all problems of the same nature by the use of a formula. A common algebraic problem to solve in school exams would be, for example: *find x where 3x + 8 = 14*. A third reason for the use of algebra rather than arithmetic is that it allows calculations which involve change in the relationship between what goes into the problem and what comes out of it, that is, between input and output. It is an algebraic formula which allows a business to calculate its potential profit (or loss) over any period of time.

It is possible to classify algebra by dividing it into four areas. Firstly, there is elementary algebra in which symbols (such as x and y, or a and b) are used to denote numbers. In this area, the rules that control the mathematical expressions and equations using these symbols are studied. Then, there is abstract or modern algebra in which mathematical systems consisting of a set of elements and several rules (axioms) for the interaction of the elements and the operations are defined and researched. Thirdly, there is linear algebra (linear equations) in which linear transformations and vector spaces, including matrices, are studied. Finally, there is universal algebra in which the ideas common to all algebraic structures are studied.

Like all branches of mathematics, algebra has developed because we need it to solve our problems. By avoiding the use of numbers we are able to generalise both the problem and the solution.

Pronunciation guide

equation /ɪkweɪʃən/
linear /lɪnɪə/
matrices /meɪtrɪsi:z/

B Comprehension

Read the text and decide if the following statements are true or false.

1 Algebra is a mathematical system which rewrites a problem making it as simple as possible. T ☐ F ☐
2 Written down, algebra differs to arithmetic in the operators it uses. T ☐ F ☐
3 Algebra has some advantages to offer the mathematician. T ☐ F ☐
4 Algebraic formulae are primarily of use in businesses. T ☐ F ☐
5 Universal algebra combines all the structures from the other three areas. T ☐ F ☐

Before you listen

Discuss these questions with your partner.

→ Do you do arithmetic, algebra and geometry at school?
→ If so, which do you like best, and why?

C Listening

Listen to a teacher talking to a class. Then listen again and complete the sentences.

1 Algebra is a branch of mathematics that uses mathematical ..... to describe variables.
2 In a mathematical statement, letters are often used to represent a(n) ..... which is not fixed.
3 A(n) ..... is a mathematical statement containing letters or symbols to represent numbers.
4 A term is a number or a(n) ..... of a number and one or more variables.
5 An expression is a collection of numbers, variables and ..... , positive or negative, of operations that make mathematical and logical sense.

Before you read

Discuss these questions with your partner.

- What is the job of an engineer?
- Why does an engineer need to know maths?

D Vocabulary

Complete the sentences below with words and phrases from the box.

- accumulation of quantities
- methodology
- differential calculus
- vast
- tangent
- coordinate
- sake
- infinitesimal
- integral calculus
- vital
- latter
- chord
- distinction

1 A line segment joining two points on a curve is a ..... .

2 A..... is a line or surface that touches another.

3 The area of maths used to determine areas, volumes and lengths is called ..... .

4 The area of maths relating to changes in variable is called ..... .

5 If something is close to zero it is ..... .

6 You need to eat well for the ..... of your health.

7 There is a ..... amount of knowledge to learn in sciences.

8 There are two theories – one from ancient times and a modern one. The....., the modern one, is widely accepted now.

9 She claimed the ..... of having solved the equation.

10 A..... is a number that identifies a position relative to a straight line.

11 ..... is the system of methods followed in an area of study.

12 ..... measures areas under a curve, distance travelled, or volume displaced.

13 If something is ..... , it is of the utmost importance.

Reading 2

Gottfried Leibniz*

Gottfried Leibniz was born and lived most of his life in Germany. He made visits to both Paris and London, for the sake of learning and study, but spent the vast majority of his working life as an employee of German royalty, as a philosopher, engineer and mathematician. It is for the latter that he is best remembered. His greatest achievement was as an inventor of calculus, the system of notation which is still in use today. Leibniz is remembered as *an* inventor, not *the* inventor of calculus. In England, Isaac Newton claimed the distinction, and was later to accuse Leibniz of plagiarism, that is, stealing somebody else's ideas but stating that they are original. Modern-day historians however, regard Leibniz as having arrived at his conclusions independently of Newton. They point out that there are important differences in the writings of both men. Newton, it must be said, was very protective of his achievements and jealous of others' success. It is important to mention that Leibniz published

his writings on calculus three years before Newton published his most important work.

Leibniz was the first to use function to represent geometric concepts. Among other terms, Leibniz used what is now everyday language in mathematics to describe these concepts. Words such as *tangent* and *chord*, were first used by Leibniz. He also saw that linear equations in algebra could be arranged into matrices. It was in this significant piece of work on calculus that he introduced mathematics and the world to the word *coordinate*. He also made important advances in algebra and logic in ways that still today, three hundred years later, have an impact on mathematics.

Leibniz' importance for modern mathematics can be understood through his work. He was especially interested in infinitesimal calculus. This is an area of calculus developed from geometry and algebra. It is divided into two parts. There is differential calculus, which is concerned with measuring rates of change of quantities. And there is integral calculus, which studies the accumulation of quantities. That is, Leibniz was looking at ways of measuring the speed and the distance travelled, for example. Today, calculations of this type are used not only in mathematics but in every branch of science and in many fields which apply a scientific methodology, such as economics and statistics.

Despite the disagreements between Leibniz and Newton, modern mathematicians recognise each of them as being vital to the development of modern mathematics. Newton was certainly the first to apply calculus to the problems of physics. In mathematics itself, it is to Leibniz that we look for our system of writing equations and for the language we use to refer to the concepts. While both reached their understanding without the benefit of reading each other's work, it remains a fact that Leibniz was first to publish.

*Leibniz is also sometimes spelt Leibnitz, although Leibniz is more common.

Pronunciation guide

Gottfried Leibniz /gɒtfriːd ˈlaɪbnɪts/

infinitesimal /ɪnfɪnɪˈtesɪməl/

plagiarism /pleɪdʒərɪzəm/

E Comprehension

Read the text and answer the questions in your own words.

1 For what contribution to mathematics is Leibniz best remembered?
2 Who was Leibniz' main rival? About what did they disagree?
3 Which important geometrical terms did Leibniz invent?
4 What other areas of work also use Leibniz' calculus?
5 Who is considered more important for the development of modern mathematics?

Before you listen

Discuss this question with your partner.

→ Can you remember what a matrix is? Tell your partner what you remember.

F Listening

Listen to the extract from a lecture about matrices. Then listen again and tick the statements which are true.

1 A matrix is a table of abstract quantities that can be added or multiplied. ☐
2 No form of matrix was used in prehistoric times. ☐
3 Matrices can be added, multiplied, and decomposed in different ways. ☐
4 The horizontal lines in a matrix are the columns. ☐
5 A matrix with *m* rows and *n* columns is known as an *m*-by-*n* matrix. ☐

G Speaking

Discuss these questions with your partner.

→ Who do you think made the most important contribution to calculus?

→ What was that contribution?

Task

In a group, discuss the disagreement between Leibniz and Newton.

Talk about:

- invention of calculus
- worked independently
- who published first
- Newton's jealousy
- each man's contribution

First read text 2 again and look at these notes. Then use them in your presentation.

INVENTION:

both active at same time

INDEPENDENT:

Leibniz in Germany (visit to England), Newton in England

PUBLISH:

Leibniz first

NEWTON:

protective, accused Leibniz

CONTRIBUTION:

Leibniz notation, Newton physics

Remember to:

- give examples and your own opinion

Speaking tips

✔ Look at the group, not your notes.

✔ Let your group know when you have finished.

H Writing

Imagine you have started an advanced algebra course at school or university. Write a letter to a friend telling him/her what you have learnt about it so far.

First read text 1 again and then complete the table.

Brief history of algebra	
What algebra is and the four areas of algebra	
How algebra is useful	

Dear **(first name)**,

PARAGRAPH 1

Hi! You asked me to tell you all about my studies. Last week we learnt about the history of algebra ...

PARAGRAPH 2

Now I'll briefly explain exactly what algebra is and tell you what the different areas ...

PARAGRAPH 3

Finaly you may wonder why we use algebra. Actually, it's very useful ...

Best wishes,

(your first name)

Write 150-200 words.

Unit 18

Before you read

Discuss these questions with your partner.

- What do you think the word geometry means?
- Do you know any other words associated with geometry?
- What are some ways geometry is used every day?
- What do you know about Euclid?

A Vocabulary

Match these words with their definitions.

1 spatial	A	a way of drawing things so that they look real
2 roots	B	relating to physical space
3 perspective	C	beginning
4 concentric	D	with a common centre
5 intersect	E	limited
6 deduction	F	a conclusion
7 finite	G	to cut across
8 radius	H	a free two-dimensional shape
9 plane	I	a straight line from the centre to the edge of a circle

Reading 1

Geometry

Geometry (from the Greek *geometria*, *the Earth's measure*) has its roots in the ancient world, where people used basic techniques to solve everyday problems involving measurement and spatial relationships. The Indus Valley Civilisation, for example, had an advanced level of geometrical knowledge – they had weights in definite geometrical shapes and they made carvings with concentric and intersecting circles and triangles. Gradually, over the centuries, geometrical concepts became more generalised and people began to use geometry to solve more difficult, abstract problems.

However, even though people in those times knew that certain relationships existed between things, they did not have a scientific means of proving how or why. That changed during the Classical Period of the ancient Greek civilisation (490 BC-323 BC). Because the ancient Greeks were interested in philosophy and wanted to understand the world around them, they developed a system of logical thinking (or *deduction*) to help them discover the truth. This methodology resulted in the discovery of many important geometrical theorems and principles and in the proving of other geometrical principles that had been known by earlier civilisations. For example, the Greek mathematician Pythagoras was the first person that we know of to have proved the theorem $a^2 + b^2 = c^2$.

Some of the most significant Greek contributions occurred later, during the Hellenistic Period (323 BC-31 BC). Euclid, a Greek living in Egypt, wrote *Elements*, in which, among other things, he defined

basic geometrical terms and stated five basic axioms which could be deduced by logical reasoning. These axioms or postulates, were: 1. Two points determine a straight line. 2. A line segment extended infinitely in both directions produces a straight line. 3. A circle is determined by a centre and distance. 4. All right angles are equal to one another. 5. If a straight line intersecting two straight lines forms interior angles on the same side and those angles combined are less than 180 degrees, the two straight lines if continued, will intersect each other on that side. This is also referred to as the parallel postulate. The type of geometry based on his ideas is called Euclidean geometry, a type that we still know, use and study today.

With the decline of Greek civilisation, there was little interest in geometry until the 7th century AD, when Islamic mathematicians were active in the field. Ibrahim ibn Sinan and Abu Sahl al-Quhi continued the work of the Greeks, while others used geometry to solve problems in other fields, such as optics, astronomy, timekeeping and map-making. Omar Khayyam's comments on problems in Euclid's work eventually led to the development of non-Euclidean geometry in the 19th century.

During the 17th and 18th centuries, Europeans once again began to take an interest in geometry. They studied Greek and Islamic texts which had been forgotten about, and this led to important developments. Rene Descartes and Pierre de Fermat, each working alone, created analytic geometry, which made it possible to measure curved lines. Girard Desargues created projective geometry, a system used by artists to plan the perspective of a painting. In the 19th century, Carl Friedrich Gauss, Janos Bolyai and Nikolai Ivanovich Lobachevsky, each working alone, created non-Euclidean geometry. Their work influenced later researchers, including Albert Einstein.

Pronunciation guide

Abu Sahl al-Quhi /ˈæbu ˈsʌhˀl el ˈkuhɪ/
Girard Desargues /ʒɪˈrɑːʳ deˈzɑːʳg/
Hellenistic /heleˈnɪstɪk/
interior /ɪnˈtɪrɪə/
Janos Bolyai /ˈdʒænəs ˈbɔlɪaɪ/
postulate /ˈpɔstjulət/
spatial /ˈspeɪʃəl/

B Comprehension

Read the text and choose the correct answer.

1 Geometry was first used to solve
- **A** common problems.
- **B** abstract problems.

2 During the Classical Period of Greek civilisation,
- **A** the way problems were solved changed.
- **B** people were only interested in geometry.

3 The Greeks made important advances in geometry
- **A** only during the Classical Period.
- **B** during both the Classical and Hellenistic Periods.

4 After the decline of Greek civilisation,
- **A** mathematicians used geometry to solve other kinds of problems.
- **B** nothing new was discovered.

5 Between the 17th and 19th centuries, European thinkers
- **A** ignored the Greeks' ideas about geometry.
- **B** created new types of geometry.

Before you listen

Discuss these questions with your partner.

→ What relationship does geometry have to art?
→ Which looks bigger: something that is closer to us or something that is far away? Why?
→ How many dimensions are there?

C Listening

Listen to a conversation between two friends. Then complete the sentences with a word or short phrase.

1 The boy is learning about ..... geometry.
2 Artists paint on a flat, one- ..... surface.
3 Objects that are nearer to us look ..... than objects that are further away.
4 Desargues invented a way to understand ..... .
5 Desargues' theorem said when two triangles are in perspective the corresponding sides lie on the same ..... .

Before you read

Discuss these questions with your partner.

- What developments in geometry do you know about that occurred during the Renaissance (c 15th -17th centuries AD)?
- What differences and what similarities can you think of between maths and philosophy?

D Vocabulary

Find a synonym in the box for the words or phrases in green in the sentences. Then check your answers in the text.

knowledgeable	tutor
prosperity	synthetic geometry
goal	advance
on the continent	analytic geometry
harsh	

1 The country was going through a time of **successfulness.** .....

2 The climate was **very cold and unpleasant.** .....

3 Her **aim** in life was to become a philosopher. .....

4 He lived **in Europe, not Britain.** .....

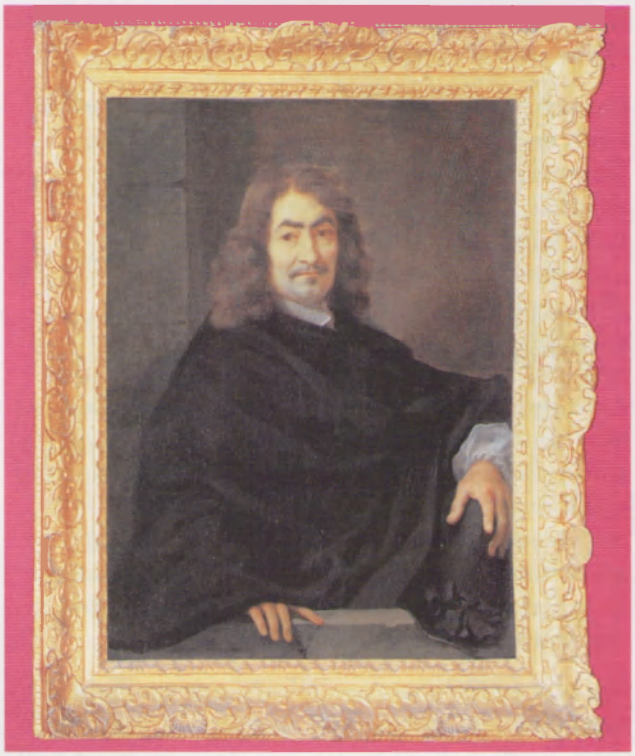
5 She studied **a kind of geometry that used theorems and observations to reach conclusions.** .....

6 He taught **a kind of geometry involving curves and understanding them.** .....

7 She is very **well-educated;** she always beats me at Trivial Pursuit. .....

8 Computer technology is expected to **develop** immensely in the next couple of years. .....

9 She wants to find a Maths teacher to **teach** her children at home. .....



Reading 2

René Descartes

Rene Descartes was born in France on 31st March, 1596, at a time of major change in the world. The great wars which had been going on throughout Europe had finally ended, creating an atmosphere of peace and stability which encouraged creative thinking, experimentation and the questioning of old beliefs and ways. After the fall of Constantinople in 1453, Greek and Islamic texts had been rediscovered and read by learned men around Europe. Ideas of the great Renaissance artists and thinkers had quickly spread across the continent. What is more, with the discovery of the New World by Columbus in 1492, a period of exploration, expansion and prosperity had begun.

After completing his education at the Jesuit College and the University of Poitiers, both in France, Descartes began to work on his goal of presenting a new way of looking at philosophy and mathematics. Although his first essays were probably written earlier than 1628, the year he moved to Holland, he was not well known until 1637, when a collection of his essays appeared and attracted the interest of the scientific world.

His great work *Discourse on the Method* was one of the essays included in this collection.

Descartes was knowledgeable about the work of Plato and Aristotle, as well as that of earlier European philosophers like Augustine and Aquinas. Descartes' goal was to reach true knowledge about things by applying mathematical methodology to find answers to philosophical questions. Starting with the principle that the only thing he could be sure of was that he himself existed (*Cogito, ergo sum* meaning, *I think, therefore I am*), he reached his own conclusions about God and the physical world. Because his ideas were very different from traditional ideas of his time, he was often criticised by religious leaders. His work had a great influence on later philosophers, including Benedict de Spinoza, Blaise Pascal, John Locke and Immanuel Kant.

Another of his goals was to advance the field of mathematics, particularly geometry. Until that time, Euclidean geometry was the type most well known. Also known as synthetic geometry, Euclidean geometry uses theorems and observations to reach conclusions.

Building on the work of the ancient Greek, Apollonius of Perga (262-190 BC), Descartes realised that it would be useful and important to be able to measure curved lines in addition to straight ones. This led to his invention of the Cartesian coordinate system, a way of algebraically measuring curves and understanding things about them. This was the start of analytic geometry (also called *coordinate geometry* and *Cartesian geometry*) and eventually led to the invention of calculus. In addition to his work in philosophy and geometry, Descartes contributed to algebra, optics and even physiology and psychology.

Descartes became one of the most important figures of his time. Queen Christina of Sweden invited Descartes to tutor her, which he did. However, he became ill in Sweden, possibly because he was not used to the cold, harsh climate, and died on 11th February, 1650. To honour him for his many contributions, people call him the 'Founder of Modern Philosophy' and the 'Father of Modern Mathematics'.

Pronunciation guide

Aquinas /əˈkwaɪnəs/
Cartesian /kɑːˈtiːzɪən/
Constantinople /ˌkɒnstæntɪˈnəʊpəl/
Jesuit /ˈdʒezjuɪt/
Poitiers /ˈpwɑːtɪeɪ/
psychology /saɪˈkɒlədʒɪ/
Renaissance /rɪˈneɪsəns/

E Comprehension

Read the text and decide if the following statements are true or false.

1 Descartes' time was one of major changes. T ☐ F ☐
2 Descartes aimed to invent a new branch of mathematics and philosophy. T ☐ F ☐
3 Descartes had not been influenced by earlier philosophers. T ☐ F ☐
4 Descartes' ideas often did not meet with the approval of church authorities. T ☐ F ☐
5 Descartes' major contribution was to calculus. T ☐ F ☐

Before you listen

Discuss these questions with your partner.

→ How do archaeologists know whether ancient civilisations used geometry?
→ What are some things ancient civilisations used geometry for?
→ What is a compass used for?
→ What is a magnetic compass used for?

F Listening

You will hear part of a talk about the history of mathematics. Listen and choose the correct answer.

1 The ancient Egyptians
A didn't know a lot about geometry.
B built small structures.
C were quite knowledgeable regarding geometrical ideas.

2 The Chinese
- **A** may have had geometrical measurement systems.
- **B** certainly didn't have geometrical measurement systems.
- **C** had advanced measurement systems.

3 A recovered object ancients used for measuring
- **A** was probably worn on the hand.
- **B** was found in the sea.
- **C** may have been a kind of compass.

4 Ancient people from India may have
- **A** known a lot about astronomy.
- **B** taught the Greeks astronomy.
- **C** measured the seas.

5 Most ancient civilisations used geometry
- **A** in their architecture.
- **B** in some way.
- **C** to plan their cities.

G Speaking

Discuss these questions with your partner.

→ What was the world like when Descartes was born?

→ Who was Descartes influenced by?

→ Why was Descartes' methodology special?

Task

Discuss Descartes' achievements with your partner.

Talk about:

- his goals - to reach true knowledge by using mathematical methodology to find answers to philosophical questions
- his contributions – philosophy, Cartesian coordinates, analytic geometry, algebra, optics, physiology and psychology
- conclusion – his death, honours he had earned

Remember to:

- revise maths terminology
- use it correctly

Speaking tips

✔ Listen to your partner's views.

✔ Talk only about important points.

✔ Organise your points logically.

✔ Use past tenses.

H Writing

Write a short essay on 'The history of geometry'. Use these notes to help you.

Read text I again and underline the important points.

PARAGRAPH 1

Introduction One-two sentences to say what you are writing about.
Vocabulary: long history, dates back to ancient times, has changed a lot since then

PARAGRAPH 2

Ancient world.
Vocabulary: In the beginning, was used to solve general, everyday problems, measurements for building (give 1-2 examples), not scientific, contributions of the Greeks – understand the physical world, logical thinking discovery of many important theorems, proof of older theorems for the first time (give an example), Euclidean geometry – still used today

PARAGRAPH 3

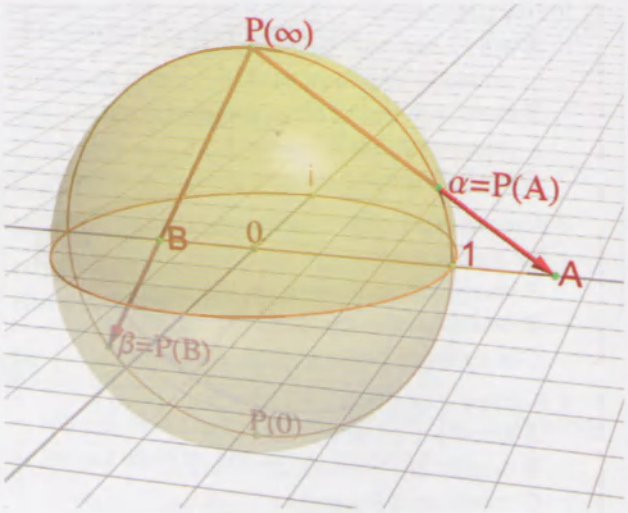
Geometry after the Greeks.
Vocabulary: Centuries later, Islamic mathematicians built on Greek ideas ... applied them to other fields (give examples), Europeans became interested in 17^{th}-18^{th} centuries – new advances, new fields of geometry (give 1-2 examples)

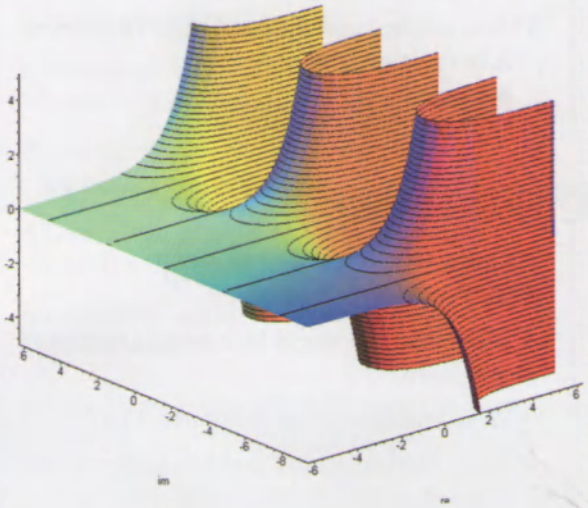
PARAGRAPH 4

Conclusion
Vocabulary: It can be concluded that ... today people still use geometry every day: engineering, construction, city planning, art (paintings/drawings and decorations/ jewellery, etc)

Write 200-250 words.

Unit 19





Before you read

Discuss these questions with your partner.

- What do you know about calculus?
- Can you think of a problem calculus could be used to solve?

A Vocabulary

Complete the definitions below with words from the box.

slope	approximation
embrace	acceleration
diverse	indispensable
sphere	cube
rectangle	

1 If something is a(n) ..... , it isn't exact.

2 An increase in speed is called ..... .

3 If something is ..... , you can't manage without it.

4 If you ..... an idea, you accept it.

5 A ..... is a three-dimensional, square shape.

6 Something which is ..... is different or of many kinds.

7 If you place two squares side by side, you form a(n) ..... .

8 A ..... is a three-dimensional surface, all the points of which are the same distance from a fixed point.

9 A ..... is also known as a fall.

Reading 1

Calculus

Calculus is the branch of mathematics that deals with the rates of change of quantities as well as the length, area and volume of objects. It grew out of geometry and algebra. There are two divisions of calculus – differential calculus and integral calculus. Differential calculus is the form concerned with the rate of change of quantities. This can be illustrated by slopes of curves. Integral calculus is used to study length, area and volume.

The earliest examples of a form of calculus date back to the ancient Greeks, with Eudoxus developing a mathematical method to work out area and volume. Other important contributions were made by the famous scientist and mathematician, Archimedes. In India, over the

course of many years – from 500 AD to the 14th century – calculus was studied by a number of mathematicians. In fact, the first text on calculus was written in India. However, it was not until the end of the 1600s that calculus was taken up in Europe. There was much scientific activity at the time, and calculus was able to answer many questions, particularly in the field of physics. Many great mathematicians of the time embraced calculus and furthered its development, including Rene Descartes and Pierre de Fermat, but the most important contributions were made by Gottfried Leibniz and Isaac Newton. Newton was the first to use calculus in his studies of physics and Leibniz developed many of the symbols that we use in calculus.

The starting point of calculus is the idea that you can use an approximation and keep increasing the accuracy until an exact answer is found. An example of this would be to calculate the volume or area of a sphere by using shapes such as rectangles or cubes that become increasingly smaller until the exact volume or area is determined. In calculus, this final result is called a limit.

Differential calculus describes processes that are *in flux* – which means they are constantly changing. Examples of this are temperature variations or the speed of a moving object. By using differential calculus, it is possible to determine the rate at which the temperature changes and the rate of acceleration of the moving body. Integral calculus begins with a known rate of change and, working backwards, finds certain values. For example, if you know the rate of acceleration of a car, you can find out its speed at a given point.

Today, both forms are used in every area of science and knowledge. Fields as diverse as engineering, medicine, business and economics make use of calculus. Calculus is such an indispensable tool that it is applied whenever we have a problem that can be solved by mathematics.

Pronunciation guide

Archimedes /ɑːkɪˈmiːdiːz/
embrace /ɪmˈbreɪs/
Eudoxus /juˈdɒksəs/
indispensable /ɪndɪˈspensəbˀl/

B Comprehension

Read the text and decide if the following statements are true or false.

1 Calculus and geometry led to the development of algebra. T ☐ F ☐
2 India was using calculus before Europe. T ☐ F ☐
3 In the 17th century, calculus was applied to physics. T ☐ F ☐
4 Integral calculus can calculate the rate at which a population increases. T ☐ F ☐
5 Differential calculus has to do with systems that are undergoing change. T ☐ F ☐

Before you listen

Discuss these questions with your partner.

→ Do you know who coined the term *calculus*?
→ Can you think of another word that comes from the word *calculus*?

C Listening

Listen to a teacher and students discussing some of the history of calculus. Then answer the questions in your own words.

1 What was the original meaning of the word *calculus*?
2 Who named the branch of mathematics known as *calculus*?
3 Why did Newton name it *the science of fluxions*?
4 What did Newton accuse Leibniz of doing?
5 Leibniz and Newton had different starting points in their work on calculus – what were they?

Before you read

Discuss these questions with your partner.

- Who do you think were the greatest mathematicians in history?
- Which kinds of mathematics were they involved in?
- What do you know about Pierre de Fermat?

D Vocabulary

a. Match these words with their definitions.

1 devotion	A don't pay attention to
2 astounding	B somebody working in the same field
3 councillor	C top judge
4 fellow	D amazing
5 neglect	E commitment
6 chief magistrate	F member of an administrative body

b. Complete the sentences below with words from the box.

- devotion
- astounding
- fellow
- neglect
- councillor

1 She shows great ..... to her family.

2 Please don't..... to pay the phone bill.

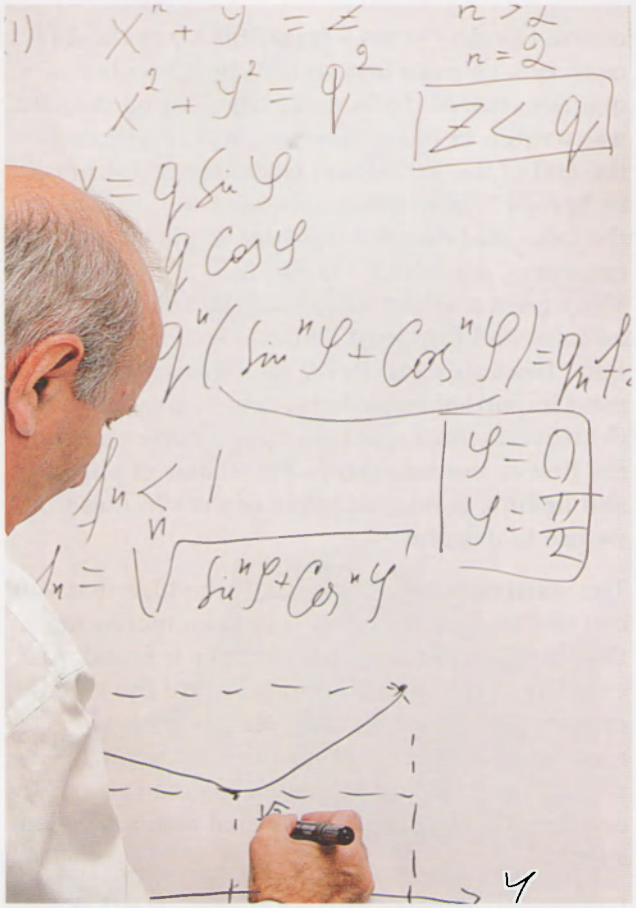
3 Meet Peter. He's a(n) ..... film enthusiast! We love watching films!

4 What a(n) ..... speech he gave at the conference. It was amazing!

5 He's been a town ..... for over five years now.

c. Match the words to make phrases.

1 practise	A theory
2 criminal	B coordinates
3 remarkable	C law
4 number	D geometry
5 probability	E achievements
6 Cartesian	F court
7 analytic	G recognition
8 receive	H theory



Reading 2

Pierre de Fermat

Pierre de Fermat was born in Toulouse, France on 17th August, 1601, and died on 12th January, 1665. He came from a wealthy family, and he studied law in Orleans. After graduating, he began to practise law and later he became a councillor in parliament. By 1652, he had become the chief magistrate of the criminal court – a very important and highly respected position.

In 17th century France, magistrates spent large amounts of time on their own. It was during this time that de Fermat worked in the field of mathematics. In fact, his devotion to this science was so great that he spent as much free time as he could working on mathematical problems and solutions. Although de Fermat published very little in his lifetime, he is still considered to be one of the greatest mathematicians of all time. His achievements in mathematics are quite astounding.

De Fermat's most important work was done in the development of modern number theory, which was one of his favourite areas of mathematics, and which had an important impact on the study of calculus. Sir Isaac Newton said that his own invention of calculus – differential calculus in particular – was based in large part on the work of de Fermat, who had done his studies on calculus well before Isaac Newton and Gottfried Leibniz were born. In 1654, Blaise Pascal wrote a letter to de Fermat asking about the latter's views on probability. Thus began a correspondence that became the foundation of Probability Theory, with de Fermat and Pascal considered to be the founders of this theory. Rene Descartes is famous for his invention of Cartesian coordinates and his important work *La Geometrie*. De Fermat had independently come up with his own three-dimensional analytic geometry, which was more complicated and advanced than Descartes'; Descartes' work became more popular, however, because its notation was more convenient. Today, both scientists are seen as the fathers of analytic geometry.

De Fermat also made contributions in the field of optics, formulating a law on the way light travels. His methods were so advanced that many of his results were not proved for a century after his death, and de Fermat's Last Theorem took more than three hundred years to prove. De Fermat rarely provided his proofs, that is, evidence or procedures for reaching conclusions, to explain how he got his answers. In his letters to fellow mathematicians, he stated theorems but neglected the proofs, which was very annoying for them. Since he never wanted anything to be published (as he considered mathematics to be his hobby), there was nowhere for scholars to check his claims and consequently during his lifetime, he received very little recognition as a mathematician. If the people he wrote to had not saved his papers and letters, we may never have heard of de Fermat and his remarkable achievements.

Pronunciation guide

magistrate /ˈmædʒɪstreɪt/

Orleans /ɔːˈliːənz/

Toulouse /tuːluːz/

E Comprehension

Read the text and choose the correct answer.

1 Despite having little of his work published while alive, de Fermat
- **A** had a successful career in law.
- **B** is seen as a great mathematician.
- **C** held an important position.

2 De Fermat's work on modern numbers
- **A** was influenced by Newton's work.
- **B** helped him develop a branch of calculus.
- **C** had an effect on calculus.

3 Pascal and de Fermat
- **A** are recognised as the fathers of Probabality Theory.
- **B** communicated about analytical geometry.
- **C** produced work more advanced than Descartes'.

4 De Fermat's methods and results
- **A** were never proven in his lifetime.
- **B** were ahead of their time.
- **C** suffered as he never provided proof.

5 We know about de Fermat's work nowadays because
- **A** his work was published.
- **B** learned people researched his claims.
- **C** he left behind a correspondence.

Before you listen

Discuss these questions with your partner.

- → What do you know about de Fermat's Last Theorem?
- → Do mathematical puzzles interest you?
- → What do *squared* and *cubed* mean?

F Listening

Listen to a teacher talking to a class about Fermat's Last Theorem. Then complete the sentences below.

1 Fermat's Last Theorem was the world's most puzzling ..... problem.

2 Fermat left no ..... of the proof he had found.

3 Fermat claimed there was no solution for any equation beyond the ..... .

4 Proof is a line of reasoning that consists of many ..... .

5 Andrew Wiles published a proof to the Last Theorem in ..... .

G Speaking

Discuss these questions with your partner.

→ Is calculus only useful in mathematics and sciences such as physics?

→ How can calculus be used in other branches of knowledge?

Task

Prepare a short presentation to answer the question: 'What is calculus?' Use the information in text 1.

Talk about:

- what calculus deals with
- the two divisions of calculus
- who developed calculus
- how it is used today

First, complete these notes. Use them in your presentation.

Calculus: The study of ..... .

There are two divisions of calculus:

.....

Calculus is about rates of .....

..... .

Integral calculus is about .....

..... .

Two mathematicians made the biggest contributions:

Isaac Newton, who mainly dealt with .....

..... .

Gottfried Leibniz, who mainly dealt with

..... .

Some modern-day applications are .....

..... .

Remember to:

- use simple examples that everyone can understand
- speak slowly and clearly

Speaking tips

✔ Speak to your audience, not your notes.

✔ Pause between sections.

✔ Speak calmly, but not too softly.

H Writing

Write a composition on the topic: 'The greatest mathematical puzzle of them all.' Use the information from text 2 as well as your notes from exercise F. You can listen to the class discussion again if you want to take notes. There is a plan here to guide you.

PARAGRAPH 1

Introduction Say what this puzzle is, and give a very brief outline of its history (include information about how long it took to solve it).
Vocabulary: Briefly ... / in brief ...

PARAGRAPH 2

Discuss what de Fermat claimed to have discovered (the proof for a difficult equation); say where he wrote this claim.
Vocabulary: Basically the theorem was ...

PARAGRAPH 3

Say why mathematicians were so fascinated by the problem (it looked simple, but was very difficult; they believed that de Fermat had found the proof, so they wanted to find it too).
Vocabulary: Despite appearing ...
Appearances were deceptive because ...

PARAGRAPH 4

Conclusion Say when it was solved, and who solved it. Say something about the fact that de Fermat's proof has not been discovered yet.
Vocabulary: After his death ... . Not until ...

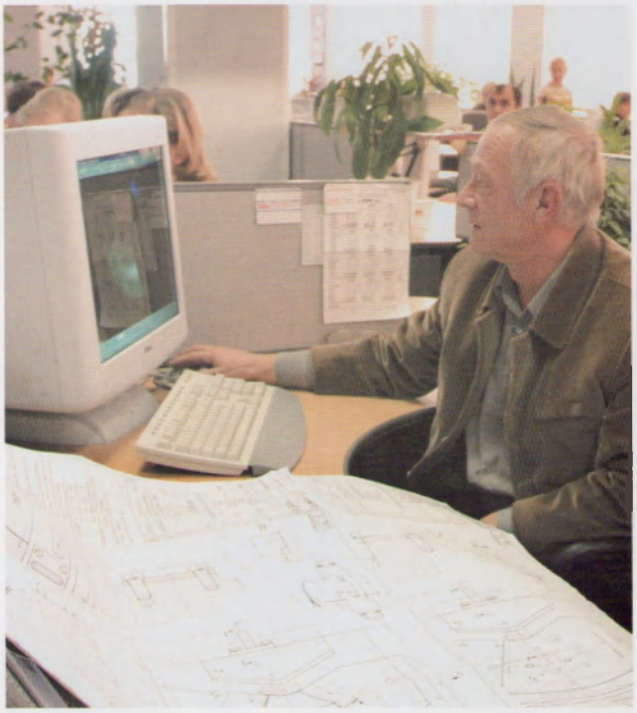
Write 200-250 words.

Unit 20

Before you read

Discuss these questions with your partner.

- In what fields do you think mathematics is useful?
- How many kinds of mathematics can you think of?



A Vocabulary

a. Match these words with their definitions.

1 enable	A to make something easier to do or understand
2 arise	B to make better
3 refine	C to allow
4 exclude	D to occur
5 simplify	E to leave out
6 adjustments	F understandable
7 comprehensible	G small changes

b. Match the words to make phrases.

1 applied	A of mathematics
2 branch	B developments
3 mathematical	C variety
4 final	D mathematics
5 second	E terms
6 knowledgeable	F model
7 real	G solution
8 major	H stage
9 mathematical	I life
10 wide	J mathematician

Reading 1

Applied mathematics

Most of the major developments in mathematics were the result of trying to solve a particular problem. When faced with a problem, people would ask themselves 'How can we do this?' 'What's the best way of doing that?' Thus, mathematics arose. Today, we have many different branches of mathematics, all of which can be used to answer questions like the ones above.

When mathematics is used to solve problems in other related areas of life, it is known as applied mathematics. Mathematics is *applied*, that is, used, to provide us with answers and solutions. It is used in numerous ways. A few examples are numerical analysis, engineering and programming. In these and other areas, applied mathematics takes problems from real life, and gives us successful and creative tools for solving them. Often, the first step when using applied mathematics is to create a mathematical model. This is a description of the problem in mathematical terms. This model is then studied to obtain exact or approximate solutions. If the solution is exact, the model is applied to the problem; if it is approximate, the model is refined until it is exact. Then, the conclusions are

interpreted and explained in comprehensible terms. Often the model is changed to be more realistic or to include more features of the problem. Thus, the modelling process may involve many adjustments. The second stage is the final solution to the problems mathematically formulated in the first stage. Mathematics is used or *applied* to other fields to solve problems in these fields.

It is often not clear which mathematical tools will be useful in the study of a new problem, for example, algebra or differential calculus. For this reason, applied mathematicians need to be well trained in a range of mathematical areas so they will have a wide variety of mathematical tools available to them. They must not only be skilled mathematicians but must also be knowledgeable in the specific area to which mathematics is being applied. For example, in dealing with business and industry, a knowledge of economics is necessary. In this way, a good applied mathematician can then create and interpret appropriate models. A good applied mathematician must therefore be knowledgeable in both mathematics and the field of application in order to successfully deal with a problem.

When it comes to creating models, the mathematician will make choices about which factors to include and which to exclude. The goal is to produce a model that is realistic enough to reflect the main aspects of the problem being studied, but simple enough to be treated mathematically.

Sometimes the mathematician has to either simplify this model so it can be analysed, or devise new mathematical methods that will allow the model to be analysed. The modelling process may involve a sequence of models of increasing complexity. Problems sometimes lead to new mathematical methods, and existing mathematical methods often lead to a new understanding of the problems.

Mathematics in its most useful, practical form becomes a tool with which we can improve our world. That is exactly what applied mathematics is and what it does.

Pronunciation guide

adjustments /əˈdʒʌstmənts/
approximate /əˈprɒksɪmət/
numerous /ˈnjuːmərəs/

B Comprehension

Read the text. Then put the events (A-F) below in the correct order, from first to last, to show the procedure for using applied mathematics.

EVENT 1 ..... **A** The revised model is applied.
EVENT 2 ..... **B** The model is adjusted.
EVENT 3 ..... **C** A mathematical model is created.
EVENT 4 ..... **D** A problem arises.
EVENT 5 ..... **E** A solution is found.
EVENT 6 ..... **F** Approximate solutions are obtained.

Before you listen

Discuss these questions with your partner.

→ Does applied mathematics sound interesting to you? Why? Why not?
→ Would you like to study it at university? Why? / Why not?

C Listening

Listen to a course director giving some information to a group of potential maths students. Then decide if the following statements are true or false.

1 Mathematics is an expanding area with good job prospects. T ☐ F ☐
2 The difference between pure and applied mathematics lies in the content of the studies. T ☐ F ☐
3 An applied mathematician finds answers to questions raised by mathematics. T ☐ F ☐
4 A pure mathematician's answers take the form of general propositions with exact, formal proof. T ☐ F ☐
5 The two kinds of mathematics can come to the same conclusions. T ☐ F ☐

Before you read

Discuss these questions with your partner.

- Do you think a scientist should have an all-round education?
- What benefits could scientists derive from involvement in other fields apart from science?

D Vocabulary

Complete the definitions below with words from the box.

cybernetics	collaborative
insight	tend
draw on	elect
via	established
imitate	aspect

1 A feature or a side of something is a(n) ..... .

2 To ..... means to copy.

3 The field of ..... studies people and machines' practices and procedures to understand where they differ.

4 If work is ..... , it is done by cooperating.

5 ..... means by the use of.

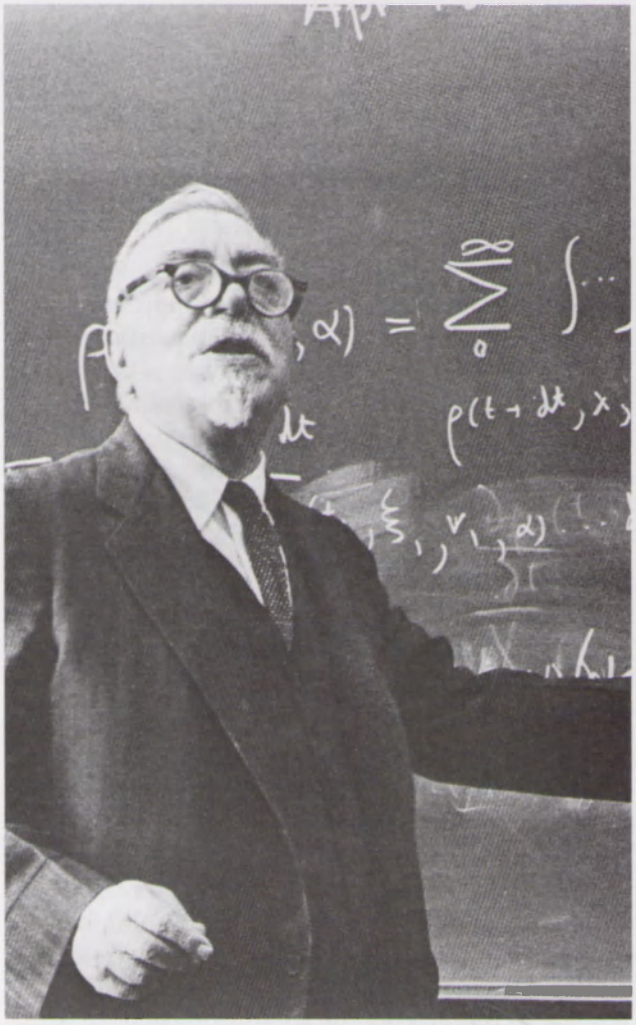
6 If you have ..... into something, you have special understanding.

7 To ..... means to choose, perhaps for a position of responsibility.

8 If you ..... something, you make use of a resource.

9 When you ..... to do something, it is a habit you have.

10 If something is ....., it is made certain.



Reading 2

Norbert Wiener

Norbert Wiener, the famous applied mathematician, was born in 1894 in the USA and died in Stockholm, Sweden, in 1964. His father was a professor of Slavonic languages at Harvard. Norbert was a very intelligent child and his father was determined to make him a famous scholar. This is indeed what he became, being awarded a PhD by Harvard at the age of 18. He also studied Philosophy, Logic and Mathematics at Cambridge and Gottingen.

His first important position was that of Instructor of Mathematics at MIT (Massachusetts Institute of Technology) in 1919, followed by that of Assistant Professor in 1929 and of Professor in 1931. Two years later, in 1933, he was elected to the National Academy of Sciences (USA), from which

he resigned in 1941. In 1940 he started to work on a research project at MIT on anti-aircraft devices, a project which played an important part in his development of the science of cybernetics.

The idea of cybernetics came to Wiener when he began to consider the ways in which machines and human minds work. This led to the development of the idea of cybernetics, which is the study of the ways humans and machines process information, in order to understand their differences. It often refers to machines that imitate human behaviour. The term was coined from the Greek *kubernetike* which means *the art of the steersman* (the skill of a captain when controlling the ship). This idea made it possible to turn early computers into machines that imitate human ways of thinking, particularly in terms of control (via negative feedback) and communication (via the transmission of information).

Norbert Wiener was also deeply attracted to mathematical physics. This interest originated in the collaborative work that he did with Max Born in 1926 on quantum mechanics. But Wiener's interests were not limited to logic, mathematics, cybernetics or mathematical physics alone, as he was also familiar with every aspect of philosophy. In fact, he was awarded his doctorate for a study on mathematical logic that was based on his studies in philosophy. In addition to that, in a very different field, he wrote two short stories and a novel. Wiener also published an autobiography in two parts: *Ex-Prodigy: My Childhood and Youth* and *I Am a Mathematician*.

Norbert Wiener was an amazing mathematician, who was gifted with philosophical insight. In an age when scientists tended, and still tend, to specialise in their own very specific fields, this man was interested and involved in many different disciplines. Due to this, he was able to draw on many resources in his varied research, thus making him an incredibly successful *applied* scientist. Wiener was one of the most original and significant contemporary scientists and his reputation was securely established in the new sciences such as cybernetics, theory of information and biophysics.

Pronunciation guide

cybernetics /saɪbəˈnetɪks/
via /vaɪə/

E Comprehension

Read the text and choose the correct answer.

1 Norbert Wiener's father
- **A** was awarded a PhD.
- **B** taught intelligent children.
- **C** was a language instructor.

2 Norbert Wiener began to think seriously about cybernetics
- **A** when he was at MIT.
- **B** when he was a science instructor.
- **C** after he resigned.

3 An example of cybernetics in action would be
- **A** a television
- **B** a computer
- **C** a ship

4 Wiener wrote a book about
- **A** himself
- **B** childhood
- **C** philosophy

5 According to the text, most scientists
- **A** know a lot about many different subjects.
- **B** are familiar with applied science.
- **C** deal with certain fields only.

Before you listen

Discuss these questions with your partner.

- How important have computers become in the modern world?
- Do you use a computer?
- What do you use it for?

F Listening

Listen to a teacher talking about a famous mathematician. Then listen again and correct the statements which are wrong.

1 Wiener enjoyed the fine arts.

2 Wiener was only ever taught at home.

3 Wiener got his undergraduate degree at the age of 18.

4 Wiener's working life was 50 years long.

5 Only a few cyber terms have been coined.

G Speaking

Discuss these questions with your partner.

→ When you think of a scientist, what image comes to mind?

→ Do you think scientists are unusual in any way? If yes, in what way?

Task

Discuss with your partner the advantages and disadvantages of computers. Say what you think and find out if your partner agrees or disagrees with you.

Talk about:

- what computers can do
- what computers can't do
- advantages of having/using a computer
- disadvantages of having/using a computer

Remember to:

- listen to your partner
- support your point of view with examples
- ask for your partner's opinion

Speaking tips

✔ Use expressions such as 'In my opinion', 'I strongly believe', 'As far as I'm concerned' to express your view.

✔ Ask questions such as 'What do you mean?' to clarify meaning.

✔ If you have to interrupt, say 'I'm sorry to interrupt, but … '.

H Writing

Write a letter to your friend telling him or her all about your university course in applied maths / cybernetics. Use these notes, your own ideas and information from texts 1 & 2 and exercise C to help you.

Hi **(friend's name),**

PARAGRAPH 1

Opening remarks:

Ask how your friend is. Apologise for taking so long to write back. Say how you are and what you have been doing.

PARAGRAPHS 2 AND 3

Main body:

Tell your friend about your university and your studies. Tell him/her what degree you are doing (applied mathematics / cybernetics).

Explain what applied mathematics is and how it differs from pure maths.

Explain what cybernetics is.

PARAGRAPH 4

Closing remarks:

Invite your friend to visit you for a few days. Say you are looking forward to seeing him/her.

Sign off (Bye for now, All the best, Love, etc)

(your first name)

Write 100-140 words.

Unit 21

Before you read

Discuss these questions with your partner.

- Is it important to study physics, chemistry and biology? Why / Why not?
- How do scientists in your country get support to conduct their research?

A Vocabulary

Find a synonym in the box for the words or phrases in green in the sentences below.

establish	reform
expedition	atlas
naturalist	headquarters
prestigious	supervise

1 The researchers need to **start** a new laboratory. .....

2 A scientist's job is often considered **to have respect and give you influence.** .....

3 There is a need for **improvements** in our society. .....

4 The **journey to explore and do scientific research** was made in 1872. .....

5 Look up this city in the **book of maps.** .....

6 Could you **manage** the people on this project? .....

7 He's a **person who studies animals and plants.** .....

8 The **central office** can be found in Moscow. .....

Reading 1

The Russian Academy of Sciences (RAS)

In 1724, Peter the Great established the Academy of Sciences as part of his push for reform to strengthen Russia. He wished to make the country as economically and politically independent as possible and he was aware of how important scientific thought, along with education and culture, was to this. However, unlike other foreign organisations at that time, the Academy was a state institution, which Peter intended should offer scientists from any country the opportunity to do their research in complete freedom, as well as providing the opportunity for students to study under these famous people. The Academy officially opened in 1725.

Over the next three decades, work was done in many fields, among them, work on electricity and magnetism theory. Research enabled the development of mining, metallurgy, and other branches of Russian industry. Work was done in geodesy and cartography and 1745 saw the first atlas of Russia created.

From its earliest days, the Academy carried out mathematical research, which added greatly to the development of calculus, hydrodynamics, mechanics, optics, astronomy, and made discoveries in various fields, such as chemistry, physics and geology. In addition, expeditions in 1733-1742 and 1760-1770 helped contribute to the discovery of Russia's natural resources.

The 19th century was a time of many more contributions from the Academy. The Academy's

naturalists were involved in voyages of discovery, including that of F.F. Bellingshausen and M.P. Lazarev in 1820, when Antarctica was discovered. In the fields of mathematics and physics, progress was furthered by N.I. Lobachevsky and his theory of non-Euclidean geometry as well as by P.L. Chebyshev who made progress in the field of probability, statistics and Number Theory. Other notable achievements were the invention of the radio, the creation of the periodic table of the chemical elements, the discovery of viruses and the cell mechanisms of immunity. In the 1890s and early 1900s, I.P. Pavlov carried out experiments which resulted in the discovery of classical conditioning or conditioned reflexes. Clearly, throughout the 18th and 19th centuries and into the 20th century, the Russian Academy led the way in Russian science.

In 1925, the name of the Academy changed to the Academy of Sciences of the USSR. One of the achievements of the Academy was to help set up scientific research centres in all Soviet republics. The Academy also gave scientists the opportunity to work and study in different parts of the USSR and abroad. In 1934, its headquarters were moved to Moscow. At that time, it had 25 member institutions. The Academy continued to grow, reaching a high point of 260 member institutions. In 1991, after the breakup of the USSR, the Academy's name was changed to the Russian Academy of Sciences (RAS).

Today, the RAS supervises the research of a large group of institutions within Russia which focus on different research areas, including philosophy, botany, anthropology, palaeontology and archaeology as well as nuclear physics, astrophysics, mathematics, computer engineering and many others. A special Internet system, called the Russian Space Science Internet (RSSI), which links over 3000 members, has also been set up.

Becoming a member of the RAS is not easy. Only scientific researchers who have done outstanding work or who have great potential are chosen to become members.

Last but not least, the RAS gives awards to members who have made significant discoveries. Its highest award is the Lomonosov Medal, named after the outstanding Russian scientist, writer and polymath of the 18th century. Many RAS award winners have later gone on to be awarded prestigious Nobel Prizes.

Pronunciation guide

geodesy /dʒiːˈɔɒdesɪ/

hydrodynamics /ˌhaɪdrɔdaɪˈnæmɪks/

metallurgy /meˈtælədʒɪ/

B Comprehension

Read the text and decide if the following statements are true or false.

1 Peter the Great set up educational and cultural centres. T ☐ F ☐

2 The Academy was unusual in not being a private interest. T ☐ F ☐

3 The 19th century was a time of numerous expeditions to find Antarctica. T ☐ F ☐

4 In the 20th century, the Academy changed name several times and moved its central office. T ☐ F ☐

5 Nowadays, members are obliged to communicate via the Internet. T ☐ F ☐

Before you listen

Discuss these questions with your partner.

→ What do scientists do?

→ Do you think it is difficult to be a scientist? Why / Why not?

→ Would you like to be a scientist? Why / Why not?

C Listening

You will hear part of a talk about a famous Russian physicist. Listen and complete the sentences.

1 As a child, Dr Landau was a mathematical ..... .

2 He became a university student when he was ..... years old.

3 Dr Landau worked both in Russia and ..... .

4 Dr Landau won the Nobel Prize in ..... .

5 One of the Moon's..... is named after him.

Before you read

Discuss this question with your partner.

→ Do you think it is a good idea to award prizes to scientists for their work? Why / Why not?

D Vocabulary

Match these words with their definitions.

1 superfluidity	A being able to transmit electrical current without resistance at very low or high temperatures
2 laser	B something which does not follow the normal pattern
3 violence	C material that can transmit electricity but not as well as metal
4 exception	D branch of electronics involving devices dealing with electromagnetic radiation
5 semiconductor	E characteristic of matter which can flow endlessly without resistance
6 heterostructure	F when there is just one boundary between material that can transmit electricity
7 optoelectronics	G angry physical force
8 superconductor	H device that produces intense, concentrated beam of light

Reading 2

Russian Nobel Prize winners in Physics and Chemistry

Because of its long history of supporting scientific research and education, Russia has produced a number of internationally recognised leaders in physics and chemistry.

The Russian Academy of Sciences (or the USSR Academy of Sciences, as it was called before 1991), played a major part in all their careers. With one exception, all were members of the Academy, carrying out their research and publishing their findings with the Academy's support.

1956 In 1956, Nikolay N. Semyonov was the first Russian to receive a Nobel Prize for Chemistry for his research into the mechanism of chemical reactions. He was trained as a physicist and chemist. During his career, working alone or with other distinguished scientists like Pyotr L. Kapitsa, he made many important discoveries and contributions to chemistry and physics. In 1931, Semyonov became the first director of the Institute of Chemical Physics of the Academy and was also one of the founders of the Moscow Institute of Physics and Technology (MIPT).

1958 The collaboration of Pavel A. Cherenkov, Igor Y. Tamm and Ilya M. Frank resulted in the discovery and description of the Cherenkov-Vavilov effect, a phenomenon which is very important in nuclear physics. For their work they received the Nobel Prize in 1958. All three of the scientists were professors at universities and the Academy's institutes and greatly influenced future generations of scientists.

1962 After receiving his doctoral degree from Leningrad University at the exceptionally young age of 19, Lev D. Landau went on to study abroad. When he returned to Russia, he became head of two of the Academy's institutes. Like Semyonov,

he was also involved in founding the MIPT. He received the Nobel Prize for Physics in 1962, for his phenomenological theory of superfluidity in helium.

1964 Nikolay G. Basov and Aleksandr M. Prokhorov worked together on a project which led to the development of the laser and their receiving the 1964 Nobel Prize. Both worked at the Lebedev Institute of Physics (Basov was the Director from 1973-1988) and also taught at universities. Even though Prokhorov never became a member of the Academy, the Academy's General Physics Institute was renamed the A.M. Prokhorov General Physics Institute in his honour.

1978 Pyotr L. Kapitsa went to England after he had completed his studies at Petrograd Polytechnic Institute. He studied at Cambridge and also worked on various projects there. He returned to Russia in 1934 and continued his career there. He was also one of the founders of the MIPT. In addition, Kapitsa was a member of the Soviet National Committee of the Pugwash movement, a group of international scientists who wanted to use science for the good of humankind and not for violence and war. Kapitsa won the Nobel Prize for Physics in 1978, for his work on low-temperature physics.

2000 Zhores I. Alferov has been active in physics since graduating from the Electrotechnical Institute in Leningrad. He received the Nobel Prize for Physics in 2000, for the development of the semiconductor heterostructures used in high-speed electronics and optoelectronics.

2003 More recently, Russian Nobel Prize winners in 2003 were Vitaly L. Ginsburg and Alexei A. Abrikosov. Ginsburg, who holds a doctoral degree from Moscow State University, became the director of the Academy's Physics Institute after Igor Tamm. Ginsburg was influenced by Landau, with whom he had worked, and by Tamm, who had been his teacher. Alexei Abrikosov was educated at Moscow State University. He worked at the Landau Institute for Theoretical Physics for over 20 years (1965-1988) and also taught at Moscow State University during that time. They received the Nobel Prize for Physics for pioneering contributions to the theory of superconductors and superfluids.

Pronunciation guide

helium /hi:lɪəm/

heterostructures /hetərəʊ'strʌktʃəz/

superfluidity /su:pəflu ɪdətɪ/

E Comprehension

Read the text and answer the questions in your own words.

1 How many Nobel Prize winners were members of the Academy?

2 Which scientists were among those who founded the Moscow Institute of Physics and Technology?

3 Which scientists, apart from Lev Landau, had things or places named after them?

4 Which scientists left the country to further their studies?

5 Who was the director of the Academy's Physics Institute before Vitaly Ginsburg?

Before you listen

Discuss these questions with your partner.

→ What does the Nobel Prize represent?

→ Why do you think it's such a prestigious award?

F Listening

Listen to an interview where a commentator is talking about the Nobel Prize. Then answer the questions.

1 According to Bradford, what is the greatest reward for winning a Nobel Prize?
- **A** the money
- **B** the medal
- **C** the certificate
- **D** the honour

2 How are people nominated for the Prizes?
- **A** Alfred Nobel chooses them.
- **B** The committee chooses one of their friends.
- **C** Institutions suggest people who have done outstanding work.
- **D** They are voted for.

3 Why did Alfred Nobel decide to set up the Nobel Prizes?
- **A** He didn't know what to do with his money.

B He wanted to do some good with his money.
C He wanted to help scientists only.
D He wanted to show people how rich he was.

4 How much money did Alfred Nobel give to set up the Prizes?
A more than $400,000
B more than $400,000,000
C more than $40,000
D more than $4,000,000

5 Which is true about the Nobel Prize winners?
A Most of them are women.
B Most of them are men.
C They must be European.
D They must be young.

6 There is NO Nobel Prize for
A literature
B physics
C peace
D mathematics

G Speaking

Discuss these questions with your partner.

→ What are some of the goals of the Russian Academy of Sciences?

→ Has the Academy of Sciences been successful in achieving its goals? Give examples to support your view.

Task

Give a two-minute summary of the history, goals and achievements of the Russian Academy of Sciences. Use the information in both texts.

Talk about:

- the history of the RAS – when founded / where / by whom; growth throughout USSR; work now continued by the RAS
- goals of the RAS – support scientific research; share knowledge with others, etc
- examples of the Academy's success – talk about one or two of the Nobel Prize winners: name / prize won and year / scientific achievements / education / where he worked / something special about him

Remember to:

- maintain eye contact with your audience
- glance at your notes, don't read from them
- take your time

Speaking tip

✔ Focus on important information.

H Writing

Write an article on the history of the Nobel Prize and give some examples of scientists who have won it. Read text 2 again and listen to exercise F again if necessary. Use this plan to help you.

PARAGRAPH 1

Explain what the Nobel prize is and give a brief history of it.

PARAGRAPH 2/3

Give two or three examples of Russian scientists who have won the Nobel Prize for physics and chemistry and explain why they won it. Which achievement do you consider to be the most important one? Why?

PARAGRAPH 4

Sum up by saying what the prize represents and that many Russian scientists have been proud receivers.

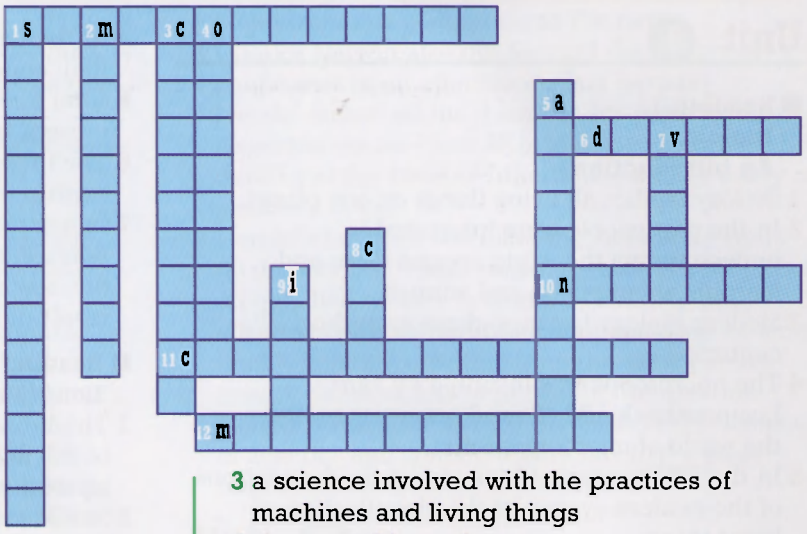
Use a formal register (no short forms).

Use conjunctions (eg furthermore, however, because of, etc).

Write 200-250 words.

Revision vocabulary Units 17 to 21

A Use the clues to complete the crossword.



Across

1 material that can transmit electricity but not as well as metal
6 a laser is a ..... that produces a beam of light
10 not pay attention to
11 something which can be understood
12 a system of rules and procedures followed in a field of study

Down

1 material that can transmit electricity without resistance at very low or high temperatures
2 the science and technology of metals
3 a science involved with the practices of machines and living things
4 signs used in maths
5 amazing
7 the most important
8 a three-dimensional, square shape
9 ..... and output

B Complete the sentences with words from the box.

matrices	infinitesimal
spatial	goal
acceleration	vast
approximation	palaeontology
coordinate	tangent

1 Leibniz realised linear equations in algebra could be arranged into ..... .
2 One kind of line that touches another is a ..... .
3 ..... means being close to zero.
4 A ..... amount of knowledge exists in the sciences.
5 Geometry helps people solve ..... problems – those which relate to physical space.
6 A ..... is a number that identifies a position relative to a straight line.
7 If you have a ..... , you need to work hard to achieve it.
8 It was (a)n ..... , it wasn't exact.
9 The rate of ..... was very fast.
10 She studies ..... – the forms of life in prehistoric times.

C Circle the correct answer.

1 ..... is a branch of electronics involving devices for electromagnetic radiation.
A Optoelectronics **B** Cartography **C** Hydrodynamics

2 ..... is the quality of matter which allows it to flow easily even at temperatures close to zero.
A Geodesy **B** Superfluidity **C** Prosperity

3 Work that is done jointly is ..... .
A transversal **B** collaborative **C** indispensable

4 A person who studies plants and animals is a ..... .
A councillor **B** chief magistrate **C** naturalist

5 A ..... job gives you respect and influence.
A prestigious **B** diverse **C** established

6 ..... in a drawing makes it look real.
A Aspect **B** Perspective **C** Culture

7 ..... calculus is the area of maths used to determine areas, volumes and lengths.
A Differential **B** Integral **C** Chord

8 You can make a(n) ..... or a loss.
A adjustment **B** exception **C** profit

Translation Work

Unit 1

Reading 1

Biology

An introduction

1 Biology studies all living things on our planet.
2 In the past people were interested in understanding the world around them and learning about plants and animals.
3 Modern biology began to develop in the 17th century.
4 The microscope was invented by van Leeuwenhoek and allowed scientists to discover the world of microorganisms.
5 In the 18th century, Linnaeus set the foundations of the modern system of the classification of living things.
6 The Laws of Inheritance and the principle of natural selection were formulated in the 19th century.
7 Nowadays our knowledge in the area of biology is increasing rapidly due to computer technology.

Reading 2

Biology today

1 Nowadays biology has so many different areas that it is impossible for one person to study them all.
2 Students should study the four main areas of Biology: zoology, botany, molecular biology and genetics.
3 Genetics studies inheritance and how living things adapt to their surroundings.
4 There are plenty of career opportunities for those with a degree in Biology.
5 Medicine needs talented scientists to carry out research in areas such as gene therapy and virus infections.
6 The world is experiencing a period of climatic change and it is the work of scientists to predict the consequences of this.
7 Ecology studies the environment and the way plants, animals and humans live together and affect each other.

Unit 2

Reading 1

Germ theory

1 Many biologists in the past did not believe in the existence of microorganisms because they were too small to be seen with the naked eye.
2 After germ theory had been accepted by doctors and biologists, the next question arose: where did germs come from?
3 The theory of spontaneous generation (abiogenesis) was very popular among scientists.
4 At the end of the 17th century, the Italian scientist Redi conducted some experiments with maggots.
5 John Needham did not know that germs were present in the air.
6 The invention of the microscope did not help to explain the appearance of microorganisms.
7 In a series of carefully planned experiments, Louis Pasteur showed that microorganisms were not contained in food but were generated as a result of food coming into contact with the air.

Reading 2

Louis Pasteur

1 The French chemist Louis Pasteur devoted his life to solving practical problems in industry, agriculture and medicine.
2 Sterilisation killed all the microorganisms but spoilt the taste and quality of the food.
3 Pasteurisation did not destroy all the microorganisms but it did not spoil the taste of food.
4 Edward Jenner, an English doctor, discovered a way of protecting people against smallpox by injecting them with cowpox. The process became known as vaccination.
5 Pasteur applied germ theory to Jenner's discovery and developed vaccines for other serious diseases.
6 Among Louis Pasteur s discoveries are the pasteurisation process and ways of preventing diseases such as anthrax, cholera and rabies.
7 Nowadays, Pasteur's discoveries affect all our lives: we eat pasteurised food and we carry out vaccination programmes regularly.

Unit 3

Reading 1

The biosphere

1 All living organisms, together with their environments, make up the biosphere.
2 The thickness of Earth's biosphere is approximately 14 km.
3 Life evolved in the oceans 3.5 billion years ago.
4 Scientists think that simple organisms like bacteria were among the first inhabitants of the Earth.
5 All organisms in the biosphere depend upon each other; the food chain is an example of such dependence.
6 Humans have affected the biosphere immensely, both positively and negatively.
7 Scientists study the biosphere and try to predict further changes and prevent permanent damage.

Reading 2

Vladimir Vernadsky

1 The Russian scientist Vladimir Vernadsky made a very important contribution to science when he developed the idea of the biosphere.
2 Vernadsky taught mineralogy and crystallography at the University of Moscow and became interested in geochemistry.
3 Vernadsky understood the possibility of using radioactive elements, but he also warned people that these elements were very dangerous.
4 The first uranium deposits were discovered in Russia in 1916 through Vernadsky's efforts.
5 For Vernadsky, the biosphere had existed since the very beginning of the Earth's history and it was constantly evolving.
6 Vernadsky believed that human reason, activity and scientific thought could lead to the evolution of the biosphere into the noosphere, the sphere of reason.
7 Vernadsky outlined the conditions that were required for the creation of the noosphere: equality for all people and an end to war, poverty and hunger.

Unit 4

Reading 1

Cells

1 The smallest unit of living matter that can exist by itself is the cell.
2 Robert Hooke, an English mathematician and physicist, was the first to see cells under a microscope and noted that there are single-celled and multi-celled organisms.
3 In multi-celled organisms, cells similar in form and structure are usually grouped together into different types of tissue.
4 A cell contains a nucleus; this is found in the protoplasm, which is enclosed by a wall.
5 Every cell goes through the same stages of a life cycle: it is born, feeds, grows, splits to create new cells and dies.
6 Stem cells are cells that have the remarkable potential to develop into many different cell types in the body. They can continue to redivide as often as possible to replace damaged or dying cells.
7 Genes are the *units of heredity* found in chromosomes, which are found in the nucleus.

Reading 2

Gregor Mendel

1 Mendel, who was a brilliant but poor student, entered a monastery in order to study.
2 Mendel was sent to University of Vienna by the monastery, in order for him to continue his education.
3 According to blending theory, inherited traits blend from one generation to the next.
4 Charles Darwin also put forward the theory of pangenesis in an effort to explain heredity.
5 Mendel described his theory in his paper *Experiments on Plant Hybridisation*, in which he developed the Laws of Inheritance known today as Mendel's Laws.
6 Mendel's Laws are the following: hereditary traits do not mix but remain separate; each parent passes on only half of their hereditary factors to each offspring (with certain traits dominant over others); finally, different offspring from the same parents receive different sets of hereditary information.
7 Mendel's research formed the basis of the science of genetics and genetic theory has had a great impact on our lives.

Unit 5

Reading 1

The discovery of the structure and function of DNA

1 A human being takes 23 chromosomes from his or her mother and another 23 from his or her father.
2 Chromosomes include strands of the chemical called deoxyribonucleic acid (DNA).
3 In the 19th century the Swiss scientist, Johann Friedrich Miescher noticed an unknown chemical in the nuclei of cells, which he called *nuclein*.
4 James Watson and Francis Crick discovered that DNA was made up of sugar and phosphates in the form of a chain which was bound together by four nucleotides called guanine, adenine, thymine and cytosine.
5 The DNA chain looks like a long ladder that has been twisted into a spiral and is known as the double helix.
6 Watson and Crick discovered how each pair of nucleotides formed a single rung on the so-called DNA ladder.
7 When stretched out, the DNA in one human cell is approximately two metres long.

Reading 2

Cloning

1 Cloning is the process of growing two or more identical organisms from one cell.
2 Early successful experiments with cloning, using the tadpoles of frogs, took place in 1968.
3 The technique of tadpole cloning consisted of transplanting a frog's DNA, contained in the nucleus of a body cell, into an egg cell whose own genetic material had been removed.
4 Cloning does not mean copying: a clone shares the same genes as its donor, but its behaviour and characteristics will be different.

5 The technology of cloning is of value to science, medicine, agriculture and industry.
6 Cloning could be beneficial to humans. For example, we could use cloning to improve health; we could learn more about how organisms develop and we could put an end to the risk of extinction of endangered species.
7 The practical applications of cloning are financially promising but many ethical questions remain.

Unit 6

Reading 1

Chemistry
An introduction

1 Chemistry is said to be the central science, as it connects all other sciences.
2 Alchemists discovered many of the chemical processes while trying to change ordinary metals into gold.
3 The origin of modern chemistry comes from the work of the 18th century French scientist Antoine Lavoisier who formulated the idea of the conservation of mass.
4 Although Lavoisier was the first to publish this idea, the Russian scientist Mikhail Lomonosov had reached the same conclusions some years earlier than Lavoisier.
5 In the 19th century the British scientist John Dalton stated that all matter was made up of atoms and that these could not be broken down into smaller parts.
6 The Russian scientist Dmitri Mendeleev arranged all the known elements by their atomic weight and chemical properties thus creating the Periodic Table.
7 Chemistry is the science that deals with the properties, composition and structure of substances.

Reading 2

Chemistry today

1 There are many areas of science and industry where the knowledge of chemistry is called upon.
2 In medicine, chemists work on new cures for diseases, develop new antibiotics and carry out other important research.
3 Chemists work in the food industry; they monitor quality of food products to make sure that they meet certain standards, for instance.
4 Nowadays, some chemical processes are involved in nearly every industry.
5 Knowledge of chemistry was fundamental to the development of the oil refining industry.
6 Oil, taken out of the ground and put through a chemical process, could be turned into many different products.
7 One of the major tasks of chemists today is to reduce the impact of pollutants on our environment.

Unit 7

Reading 1

The atom

1 The term *atom* is Greek in origin and means 'the smallest particle of a chemical element'.
2 The first scientific hypothesis about the atomic structure of matter was put forward by the British chemist John Dalton.
3 Dalton considered the atom to be a small particle that could combine with the atoms of other chemical elements in order to form compounds.
4 In modern scientific usage the atom is considered to be composed of smaller particles such as electrons, neutrons and protons.
5 By the 1930s quantum mechanics had been developed and it became the basis of modern chemistry and physics.
6 Atoms differ from one another in the number of subatomic particles they contain.
7 An electrical charge causes electrons to attract. In this way, atoms can bond together to form molecules.

Reading 2

Robert Boyle

1 Robert Boyle, an Irish scientist noted for his work in chemistry and physics, is best known for the formulation of Boyle's Law.
2 The air pump allowed Boyle to create a vacuum in a glass jar.
3 A burning candle and a piece of coal stopped burning when placed in a vacuum, leading Boyle to the conclusion that air was necessary for combustion to take place.
4 He also came to the conclusion that sound travels through air and cannot be heard in vacuum.
5 Observing the change of pressure in a vacuum, Boyle suggested that even gas was made up of very small particles.
6 As the volume of gas is reduced, its pressure increases in proportion.
7 While investigating some compounds, Boyle discovered a way of testing them to find out if they were acid or alkali.

Unit 8

Reading 1

The Law of Conservation of Mass

1 According to the Law of Conservation of Mass, the mass of the reacting substances at the start of the reaction will be the same as the mass of the products at the end of the reaction.

2 Lomonosov first described the Law of Conservation of Mass and published his ideas later, in 1760.
3 Lavoisier formulated his conclusions into a scientific theory in 1789.
4 The idea of conservation of mass itself was not actually new. In the 5th century BC, the Greek philosopher Anaxagoras said that nothing comes into existence or is destroyed and that everything is a mixture of pre-existing things.
5 Experiments showed that some metals increased in weight when they burned.
6 Lavoisier proved that oxygen was required for combustion to take place.
7 The fact that matter in a chemical reaction can change its form, but always conserves its mass, was very important not only to science but to philosophy, too.

Reading 2

Antoine Lavoisier

1 Antoine Lavoisier made a great contribution to the science of chemistry: he discovered oxygen, disproved the phlogiston theory and formulated the Law of Conservation of Mass.
2 Lavoisier discovered oxygen and its role in combustion and respiration.
3 Lavoisier, whose father wanted him to be a lawyer, belonged to a wealthy aristocratic family.
4 At the age of 25 Lavoisier was made a member of the French Academy of Sciences.
5 Lavoisier assumed that matter was conserved through any chemical reaction and he set about proving it.
6 Lavoisier developed a very precise balance and weighed the reacting materials and the products that were made.
7 Lavoisier placed chemistry on a solid foundation by experimenting with the weight of substances involved in chemical reactions.

Unit 9

Reading 1

The periodicity of elements

1 With the development of science, scientists discovered more and more elements.
2 The first formal attempt to group the elements was made by Lavoisier in the 1700s.
3 The Russian scientist Dmitri Mendeleev created a periodic table where the elements were arranged according to their atomic weight.
4 Mendeleev predicted that empty spaces between elements in the periodic table would be filled after the discovery of new elements.
5 Mendeleev predicted the physical and chemical properties of elements that had not been discovered yet.
6 The number of protons in the nucleus of an atom is known as the atomic number, and the modern table is arranged by atomic number.
7 The numbers in each period that is, row in the periodic table, correspond to the number of electrons contained in the outermost electron shell of an atom of a specific element.

Reading 2

Dmitri Mendeleev

1 Dmitri Ivanovich Mendeleev was born in 1834 to a large family – his mother gave birth to 14 children.
2 In 1863, Mendeleev was appointed Professor of Chemistry at the Technological Institute and the University of St Petersburg.
3 The periodic table was Mendeleev's greatest achievement. He was even able to predict the existence of elements that had not been discovered yet.
4 Mendeleev was involved in many areas including hydrodynamics, agricultural chemistry, meteorology and chemical technology.
5 Mendeleev defined the absolute boiling point of a substance (the critical temperature).
6 He spent a lot of time studying solutions, adding greatly to our understanding of them.
7 His studies of gases at high and low pressures allowed him to develop an accurate barometer.

Unit 10

Reading 1

Chemical kinetics

1 The study of reaction rates and reaction mechanisms is known as chemical kinetics.
2 The rate of a reaction depends on the concentration of the reacting substances, the temperature, the presence of catalysts and the nature of the reactants.
3 A change in the concentrations of the substances will change the number of molecular collisions.
4 If the substances involved in the reaction are gases, pressure will have an effect on reaction rate. Reaction rate increases with pressure.
5 Increasing the surface area where a chemical reaction takes place, increases the reaction rate.
6 An increase in temperature generally increases the rate of reaction.
7 A catalyst is a substance that influences the rate of the reaction.

Reading 2

Nikolay Semyonov

1 Nikolay Semyonov was a Soviet physicist and chemist who, together with Sir Cyril Hinshelwood, was awarded the 1956 Nobel Prize for Chemistry for research into chemical kinetics.

2 Semyonov had a successful career and became a Professor at the Moscow State University and Director of the Institute of Chemical Physics of the USSR Academy of Sciences.
3 Semyonov conducted research into the mechanisms of chemical chain reactions.
4 A chain reaction is a reaction that, once started, continues without further outside influence.
5 A chain reaction can be of various types, but nuclear chain reactions are the best known.
6 Semyonov contributed much to the study of chemical chain reactions, the theory of thermal explosions and the burning of gaseous mixtures.
7 Professor Semyonov received many awards and honours from foreign universities and scientific societies.

Unit 11

Reading 1

Physics
An introduction

1 A lot of questions which used to be asked, such as why does the Sun come up in the east or why does it go down in the west, have been answered by physics.
2 The idea that the Sun was the centre of the universe pushed Europe into a scientific revolution.
3 Isaac Newton, building on Copernicus' and Kepler's work, set out his Laws of Motion and modern physics was born.
4 Thermodynamics is the study of changes of heat in matter.
5 James Maxwell's equations were used to describe light.
6 The discovery of X-rays and the work of Marie Curie on radioactivity led to nuclear physics.
7 Successful experiments in the 1940s resulted in the splitting of a nucleus and led to the world's first nuclear explosion.

Reading 2

Physics – the new science fiction

1 Professor Brimble indicated that we still did not know much about the universe.
2 Brimble mainly talked about things that happened in the world every day for which there was no scientific explanation.
3 There were theories and ideas which scientists could not prove because it was very hard to test them.
4 There exist some theories which are definitely correct, but which are still waiting for new technologies to develop before they can be applied.
5 Ball lightning is a mysterious phenomenon which has not been explained yet.
6 Physicists have discovered that the universe is expanding at an accelerated rate but they do not know why this is happening.
7 To explain phenomena they had observed in the universe scientists had to assume the existence of what is called dark matter.

Unit 12

Reading 1

Electricity and magnetism

1 Electromagnetic fields exist throughout space.
2 An electromagnetic field exerts a force on electrically charged particles.
3 An electromagnetic field is used to generate electricity, which home appliances depend on for operation.
4 It is widely known that Andre Marie Ampere was the first to apply mathematics to electromagnetism.
5 The electrical batteries invented by Alessandro Volta were of limited use and could not provide enough electrical power to operate a machine.
6 The discovery of electromagnetism enabled scientists to create TVs, phones and electrical motors.
7 Maxwell's equations showed that what physicists had believed in for centuries was wrong.

Reading 2

Michael Faraday

1 Michael Faraday came from a poor family; because he could not get a good school education he educated himself.
2 Faraday had to work so hard to support himself that he even thought about giving up science at one point.
3 When Faraday worked as Humphrey Davy's assistant he built a homopolar motor.
4 Because mathematics had always been Faraday's weak point, he worked together with Maxwell.
5 Faraday managed to build a device which moved a magnet through the loops of wire, thus creating an electric current.
6 Faraday's Law of Induction is the foundation of electromagnetism and modern technologies.
7 Faraday discovered a way both of making electricity and of making use of it.

Unit 13

Reading 1

The Law of Universal Gravitation

1 The belief in ancient times that the Earth was the centre of the solar system led to incorrect theories.

2 The fact that planets move in elliptical orbits around the Sun was explained by Copernicus' heliocentric theory.
3 Johannes Kepler tested and proved Copernicus' heliocentric theory.
4 It was Isaac Newton who, while observing things around him, realised that objects could be in one place without moving. He called this phenomenon inertia.
5 The force of gravity is the attraction of one object towards another. It is determined by the mass of the two objects and the distance between them.
6 The Law of Universal Gravitation is true everywhere and in all cases, not only on Earth but also in space.
7 The discovery of the Laws of Gravitation had a strong influence on scientific thinking for centuries.

Reading 2

Isaac Newton

1 Newton's mother wanted him to be a farmer but he was not very good at it.
2 While studying Law at Cambridge, Newton became interested in modern philosophy.
3 Newton's interest in mathematics eventually resulted in the invention of calculus.
4 While working in the field of optics, Isaac Newton made some important discoveries about light and colour and built the first reflecting telescope.
5 The laws of planetary motion and the Law of Universal Gravitation discovered by Newton were of paramount importance. Later they were used by Albert Einstein in his scientific work.
6 It is interesting to note that Newton was involved in politics as well. He was even a Member of Parliament.
7 Newton is known to have been intolerant to criticism. His intolerance caused many conflicts and finally he stopped doing research.

Unit 14

Reading 1

Quantum mechanics

1 As had been suggested by Newton, experiments proved the idea of light being made up of tiny particles.
2 In 1900, Max Planck assumed that hot bodies radiated energy in packets called *quanta*.
3 The theory of photoelectric effect explains how photons can knock an electron out of an atom.
4 It has been found that the electrons in atoms can absorb and radiate a certain amount of energy only when moved from one stable orbit to another. In a stable orbit, electrons do not radiate energy.
5 Light is considered to be both a particle and a wave at the same time.
6 Quantum mechanics explains why atoms are stable and why they absorb or release energy only in certain ways.
7 Scientists have used quantum mechanics to explain a number of phenomena that could not be explained before.

Reading 2

Niels Bohr

1 Niels Bohr is best known as one of the founders of quantum mechanics and spectroscopy and as a scientist who suggested his own model of the atom.
2 Bohr's father was a professor of physiology so Niels became interested in science while he was still very young.
3 In England, Bohr worked with famous scientists such as Sir Joseph Thomson, who discovered the electron, and Ernest Rutherford, who conceived the notion of a nucleus within the atom.
4 The discovery that only uranium-235 could produce the fission chain reaction was a significant contribution towards building the first atomic bomb.
5 It is important to mention that Bohr supported the idea of sharing new technologies with other countries, including the USSR.
6 The world's greatest universities awarded him honorary doctorates.
7 Bohr created the theory of spectral lines and formulated the principle of complementarity, which refers to a wave-particle duality.

Unit 15

Reading 1

The General Theory of Relativity

1 Newton claimed that light travels at a constant speed regardless of the observer moving toward or away from the radiating source.
2 Albert Einstein tried to solve the problem of light in his paper *The Special Theory of Relativity*.
3 Einstein found that time and space are not constant but relative.
4 Einstein's theory was proved experimentally by means of two clocks. The clock that was put on a flying aeroplane ran slower than the one that had been left on the ground.
5 During a solar eclipse it was found that the light coming from stars was bent. This discovery brought international fame to Einstein.
6 Einstein assumed that gravity was not a force but an illustration of curved space and time.
7 Many scientists used Einstein's equations to describe other phenomena and got positive results.

Reading 2

Albert Einstein

1 Albert Einstein is known as one of the greatest physicists of all time.
2 While still at Luitpold Gymnasium, Einstein wrote his first scientific work *The Investigation of The State of Aether in Magnetic Fields*.
3 Einstein was qualified to teach Physics and Mathematics but could not get a teaching position then.
4 While working at the Patent Office, he began to do research in the field of physics and made some outstanding discoveries.
5 Einstein's Theory of Relativity caused an upheaval in the scientific world as it completely overturned the long-standing Law of Universal Gravitation.
6 The Nobel Prize for Physics was given to Einstein in 1921 for his work on the photoelectric effect. He proved that when matter was exposed to electromagnetic radiation, electrons were produced.
7 Einstein never worked on the atomic bomb because he had always been against war and weapons of mass destruction.

Unit 16

Reading 1

Mathematics
An introduction

1 The word *mathematics* comes from Greek and means *science*, *learning* and *knowledge*.
2 As society developed, it became necessary for people to be able to count their belongings, so numbers became significant.
3 Several systems for recording numbers developed in different parts of the world. One example is the tallies that were used by Incas: they tied knots along a string to keep tax records.
4 The idea of number was the first to have been developed in mathematics. Since then mathematics has developed immensely becoming much more complex.
5 Nowadays, Arabic numbers are used by mathematicians all over the world.
6 Whether or not mathematics is a science has been debated for years. However, since mathematics is applied to all sciences, this debate is of no real importance.
7 It is said that mathematics is as international a language as music is.

Reading 2

Mathematics

1 The great Greek scientist Pythagoras proved that in a right-angled triangle, the square of the side of the hypotenuse is equal to the sum of the squares of the other two sides.
2 The proof of a mathematical truth is called a theorem.
3 There are four operations that are used in arithmetic: addition, subtraction, multiplication and division.
4 A branch of mathematics that originated in the Arab world is called algebra.
5 We see the things around us in three dimensions: height, width and length. That is why Euclidean geometry is three-dimensional. Einstein added time as the fourth dimension.
6 Calculus uses functions that set the relationship between argument and result.
7 Probability Theory is the mathematical study of chance and is used to predict the results of tests and to analyse information.

Unit 17

Reading 1

Algebra

1 The branch of mathematics which studies the structure of things, the relationship between things and their quantitative characteristics, is called algebra. It uses symbols, usually letters, and operators.
2 To understand the system of numbers more clearly, mathematicians stopped using numbers.
3 The advantage of not using numbers is the generalisation of both the problems and the solutions.
4 Algebra is divided into four areas: elementary, abstract or modern, linear and universal.
5 Linear algebra studies linear transformations and vector spaces including matrices.
6 The ideas common to all algebraic structures are studied in universal algebra.
7 By using algebra, people are able to perform calculations with unknown quantities.

Reading 2

Gottfried Leibniz

1 Gottfried Leibniz is said to be the inventor of calculus.
2 He published his works on calculus three years before Newton did.
3 It is important to mention that Leibniz was the first to use words such as *tangent* and *chord*.
4 Leibniz was the first to introduce a system for writing equations and the modern mathematical language.
5 Leibniz's work in the field of infinitesimal calculus is of paramount importance.
6 Differential calculus is concerned with measuring the rates of change of quantities, while integral calculus studies the accumulation of quantities.

7 It was Gottfried Leibniz who made the most important contribution to calculus and who ascertained that linear equations in algebra could be arranged into matrices.

Unit 18

Reading 1

Geometry

1 The roots of geometry go back to ancient times when people tried to solve practical problems, using geometrical knowledge. They measured weight for example, by using definite geometrical shapes such as the cone, the cylinder and the cube.
2 The ancient Greeks wanted to find the truth about the world around them and developed a system of logical thinking called *deduction*.
3 It has been proved that even earlier civilisations knew about some geometrical principles and theorems.
4 Euclid, a Greek living in Egypt, defined basic geometrical terms and five basic axioms. Thus, Euclidean geometry, which is still successfully used today, was born.
5 It is a well-known fact that you can join any two points with a straight line.
6 In the 17th and 18th centuries analytic geometry was created and it became possible to measure curved lines.
7 Non-Euclidean geometry was founded by Lobachevsky, Gauss and Bolyai in the 19th century.

Reading 2

René Descartes

1 René Descartes was born at a time when the great wars in Europe had ended and the peaceful atmosphere encouraged creative thinking and the questioning of old beliefs.
2 In the middle of the 15th century the ideas of the great Greek and Islamic thinkers spread around Europe.
3 Descartes began to work both in the field of mathematics and philosophy after completing his education.
4 He tried to find answers to philosophical questions by applying mathematical methodology.
5 The only thing Descartes was sure of was that he himself existed.
6 Religious leaders criticised Descartes for his ideas, which were very different from traditional ones.
7 Descartes realised the importance of measuring curved lines and created the Cartesian coordinate system.

Unit 19

Reading 1

Calculus

1 The branch of mathematics that deals with the rates of change of quantities, the length, area and volume of objects is called calculus.
2 Length, area and volume are studied by integral calculus while differential calculus describes processes that are in flux.
3 It is interesting to note that the first forms of calculus were used by the ancient Greeks to measure area and volume.
4 Newton was the first to use calculus in his studies of physics.
5 Calculus has proven to be an indispensable tool in medicine, engineering, economics and business.
6 Thanks to integral calculus, it is possible to calculate the speed of a car at any given moment if you know its acceleration rate.
7 You can use differential calculus to calculate the rate at which temperature changes as well as the acceleration of a moving body.

Reading 2

Pierre de Fermat

1 Pierre de Fermat started his career practising law and even became the chief magistrate of the criminal court, which was a highly respected position.
2 Fermat achieved astounding results in the field of mathematics. However, he did not receive much recognition during his lifetime.
3 Fermat's ideas in mathematics were so advanced that it took more than three hundred years to prove his last theorem.
4 The way Pierre de Fermat presented his work was quite annoying for fellow mathematicians as he stated the theorems but neglected the proofs.
5 Fermat formulated a law on the way light travels thus making a great contribution to optics.
6 Fermat independently came up with a three-dimensional analytic geometry, a system which was more complex than Descartes' Cartesian coordinates.
7 Fermat and Blaise Pascal are both considered to be the founders of Probability Theory.

Unit 20

Reading 1

Applied mathematics

1 People have always been faced with a lot of practical problems. Mathematics came into being as they tried to solve them.

2 One of the most remarkable achievements ever was the creation of applied mathematics, which provides us with answers and solutions to many different problems.
3 The first step when using applied mathematics is the creation of a mathematical model. This is a description of the problem in mathematical terms.
4 If there is an exact solution, the model is applied to the problem. However, if the solution is approximate, the model is refined until the solution is exact.
5 A mathematical model should be realistic enough to reflect the main aspects of the problem being studied, but simple enough to be treated mathematically.
6 Problems sometimes lead to new mathematical methods, and existing mathematical methods often lead to a new understanding of the problems.
7 To successfully deal with a problem, an applied mathematician needs to be skilled in mathematics as well as knowledgeable about the field to which mathematics is being applied.

■ Reading 2

Norbert Wiener

1 Norbert Wiener was a very gifted student and at the age of 18 he was awarded a PhD for a dissertation on mathematical logic.
2 In the 1940s, Wiener did research on anti-aircraft devices at Massachusetts Institute of Technology (USA), a project which played an important part in his development of the science of cybernetics.
3 The idea of cybernetics came to Wiener when he began to consider the ways in which machines and human minds work.
4 Cybernetics is the study of the ways living organisms and machines process information.
5 Wiener's works concern mainly logic and mathematics, cybernetics, mathematical physics and philosophical issues.
6 Due to his involvement in many different disciplines, Wiener was able to draw on many resources in his varied research, thus making him an incredibly successful *applied* scientist.
7 Creating a machine that imitates the human way of thinking was a remarkable achievement of the 20th century.

Unit 21

■ Reading 1

The Russian Academy of Sciences (RAS)

1 Founded in St Petersburg in 1724 by Peter the Great, the academy was opened in 1725 by his widow, Catherine I, under the name of the St Petersburg Academy of Sciences.
2 The Academy offered scientists from any country the opportunity to do their research in complete freedom.
3 From its earliest days, the Academy carried out mathematical research, which added greatly to the development of calculus, hydrodynamics, mechanics, optics, astronomy, and made discoveries in various fields, such as chemistry, physics and geology.
4 The 19th century was a period of numerous significant developments and discoveries; the members of the Academy played a leading role in developing science in Russia.
5 Among notable achievements were the invention of the radio, the creation of the periodic table of chemical elements, the discovery of viruses and the cell mechanisms of immunity.
6 Today, the Russian Academy of Sciences supervises the research of a large group of institutions within Russia which focus on different research areas.
7 The Space Research Institute of the Russian Academy of Sciences has set up a network, called the Russian Space Science Internet, which links over 3000 members.

■ Reading 2

Russian Nobel Prize winners in Physics and Chemistry

1 Nikolay Semyonov was the first Russian to receive a Nobel Prize for Chemistry in 1956 for his research into the mechanism of chemical reactions.
2 In 1958 Pavel Cherenkov, Igor Tamm and Ilya Frank won the Nobel Prize for Physics for discovering and describing the phenomenon known as the Cherenkov-Vavilov effect, a phenomenon which is very important in nuclear physics.
3 Lev Landau was awarded the Nobel Prize for Physics in 1962 for his theory of superfluidity in helium.
4 Nikolay Basov and Alexandr Prokhorov won the Nobel Prize for Physics in 1964 for their pioneering work in quantum electronics that led to the development of the laser.
5 For his fundamental inventions and discoveries in the area of low-temperature physics Pyotr Kapitsa was awarded the Nobel Prize in 1978.
6 Zhores Alferov received the Nobel Prize for Physics in 2000 for the development of the semiconductor heterostructures used in high-speed electronics and optoelectronics.
7 Vitaly Ginsburg and Alexei Abrikosov shared the Nobel Prize for Physics in 2003, which they received for pioneering contributions to the theory of superconductors and superfluids.

Glossary

A

abacus /æbəkəs/ счёты
abiogenesis /ˌeɪbaɪəʊˈdʒenəsɪs/ абиогенез (*самозарождение живых организмов, или возникновение живого из неживого*)
to absorb /əbˈzɔːb/ поглощать
to accelerate /əkˈseləreɪt/ ускорять
accelerating universe /əkˈseləreɪtɪŋ ˈjuːnɪvɜːs/ расширяющаяся Вселенная
account /əkˈaunt/ счёт; расчёт
acid /æsid/ кислота
to adapt / /ədæpt/ приспосабливать, адаптировать
to add /æd/ 1. прибавлять, присоединять (*к чему-либо*) 2. прибавлять, добавлять (*к сказанному*) 3. *мат.* складывать; прибавлять
adenine /ædəniːn/ аденин (*азотистое основание, входящее в состав ДНК*)
adjustment /ədʒʌstmənt/ коррекция, исправление
to advance /ədˈvɑːns/ 1. продвигаться вперёд 2. (*быстро*) развиваться, делать (*большие*) успехи
aether /iːθə/ эфир (*летучее вещество*)
to affect /əˈfekt/ влиять, воздействовать
AIDS (acquired immune deficiency syndrome) /eɪdz/ СПИД /əkwaɪəˈd ɪmjuːn dɪˈfɪʃnsɪ ˈsɪndrəum/ (*синдром приобретённого иммунодефицита*)
alkali /ælkəlaɪ/ щёлочь
to alter /ɔːltə/ изменять
amoeba (*мн. ч.* **amoebas, amoebae**) /əmiːbə/ амёба
angle /ˈæŋgᵊl/ угол
anthrax /ˈænθræks/ сибирская язва
applied mathematics /əplaɪd mæθəˈmætɪks/ прикладная математика
approximation /əprɔksɪˈmeɪʃᵊn/ приближённое значение
area /eərɪə/ 1. площадь, пространство; *мат.* площадь 2. область, зона, район 3. область, сфера деятельность
argument /ɑːgjumənt/ *мат.* аргумент, аргумент функции (*независимая переменная, от значений которой зависят значения функции*)
axiom /æksɪəm/ аксиома

B

balance /bæləns/ *зд.* весы
ball lightning /bɔːl ˈlaɪtnɪŋ/ шаровая молния
to bend /bend/ сгибать(ся)
biological family /baɪəlɔdʒɪkᵊl ˈfæmlɪ/ *биол.* семейство
to blend /blend/ смешивать(ся)
'blending theory' /blendɪŋ ˈθɪərɪ/ теория независимого наследования признаков
boiling point /bɔɪlɪŋ ˈpɔɪnt/ точка кипения
to bound together /baund təgeðə/ связывать; объединять
boundary /ˈaundᵊrɪ/ граница, предел
breakthrough /ˈbreɪkθruː/ достижение, открытие, победа, прорыв (*в развитии науки или технологии*)

C

to calculate /kælkjuleɪt/ вычислять
calculus (*мн. ч.* **calculi, calculuses**) /kælkjuləs/ *мат.* исчисление
cancer /kænsə/ рак
carbon /kɑːbən/ углерод
catalyst /kætəlɪst/ катализатор (*вещество, ускоряющее химическую реакцию, но само при этом не изменяющееся*)
cell /sel/ *биол.* клетка
chain reaction /tʃeɪn rɪˈækʃən/ цепная реакция
to charge /tʃɑːdʒ/ заряжать
chemical /kemɪkəl/ химическое соединение
chord /kɔːd/ *мат.* хорда (*прямолинейный отрезок, соединяющий две произвольно выбранные точки кривой*)
circle /sɜːkəl/ 1. круг; окружность 2. круг (*круг общения и т. п.*)
circulation of blood /seːkjuˈleɪʃən əv blʌd/ кровообращение
cloning /kləumŋ/ клонирование
coil /kɔɪᵊl/ виток
to coin a term /kɔɪn ə tɜːm/ вводить термин, создавать новый термин
to collide /kəlaɪd/ сталкиваться; соударяться
combustion /kəmˈbʌʃtən/ горение
complex organism /kɔmpleks ˈɔːgənɪzᵊm/ сложный организм, многоклеточный организм
complicated /kɔmplɪˈkeɪtɪd/ сложный
compound /kəmˈpaund/ *хим.* соединение
conclusion /kənkluːʒᵊn/ вывод, заключение
conditioned reflexes /kənˈdɪʃənd ˈriːfleksɪz/ условные рефлексы
conductor /kəndʌktə/ *физ.* проводник (*вещество с очень малым удельным сопротивлением, хорошо проводящее электрический ток благодаря наличию большого числа свободных электронов*)
cone /kəun/ конус
consequence /kɔnsɪkwəns/ (по)следствие, результат (*чего-либо*)
to constitute /kɔnstɪtjuːt/ составлять
to consume /kənˈsjuːm/ поглощать; потреблять, расходовать
copper /kɔpə/ медь
core /kɔː/ сердцевина; суть, сущность
creature /kriːtʃə/ создание, творение; живое существо
crop /krɔp/ сельскохозяйственная культура
to cross /krɔs/ 1. пересекать 2. *биол.* скрещивать
crust /krʌst/ корка (**Earth's crust** земная кора)
cube /kjuːb/ куб
cubed /kjuːbd/ *мат.* в кубе, в третьей степени, возведённый в куб
curve /kɜːv/ кривая
cytosine /saɪtəʊsiːn/ цитозин (*азотистое основание, входящее в состав ДНК*)

D

to damage /dæmədʒ/ повреждать, портить, наносить/причинять ущерб
to decay /dɪ'keɪ/ гнить, разлагаться
decimal system /desəməl 'sɪstəm/ десятичная система
deduction /dɪ'dʌkʃən/ логический вывод, дедукция; вывод, заключение
to denote /dɪ'nəut/ обозначать
density /densətɪ/ плотность
deposit /dɪ'pɔzɪt/ *зд.* месторождение (*угля, железной руды, газа и т. п.*); залежь
to destroy /dɪ'strɔɪ/ уничтожать, разрушать
destructive /dɪ'strʌktɪv/ разрушительный
device /dɪ'vaɪs/ устройство, приспособление; механизм; аппарат, прибор, машина
to devise /dɪ'vaɪz/ придумывать; изобретать
differential calculus /dɪfə'renʃəl 'kælkjuləs/ дифференциальное исчисление
disease /dɪ'zi:z/ болезнь
to disintegrate /dɪs'ɪntɪgreɪt/ разрушать(ся); распадаться; расщеплять
to disprove /dɪs'pru:v/ опровергать; доказывать ложность, ошибочность, несостоятельность (*чего-либо*)
to dissect /dɪ'sekt/ *мед.* анатомировать, вскрывать, препарировать
diverse /daɪ'vɜ:s/ разнообразный
to divide /dɪ'vaɪd/ 1. делить(ся); распределять(ся) 2. *мат.* делить; делиться нацело, без остатка
division /dɪ'vɪʒən/ 1. деление, разделение 2. *мат.* деление
DNA (deoxyribonucleic acid) /di:en'eɪ/ /ˌdi:ɔksɪraɪbəunju'kli:ɪk æsɪd/ ДНК (*дезоксирибонуклеиновая кислота*)
double helix /dʌbᵊl 'hi:lɪks/ двойная спираль, двойная спираль ДНК
to drop /drɔp/ падать; опускать(ся)
drug /drʌg/ лекарство
duality /dju'ælətɪ/ 1. раздвоенность, раздвоение 2. дуализм

E

electric current /ɪ'lektrɪk 'kʌrənt/ электрический ток
electric forces /ɪ'lektrɪk 'fɔ:sɪz/ электрические силы
electrical bulb /ɪ'lektrɪkᵊl bʌlb/ электрическая лампа, лампа накаливания
electrical charge /ɪ'lektrɪkᵊl tʃɑ:dʒ/ электрический заряд
electromagnetic field /ɪlektrəumæg'netɪk fi:ᵊld/ электромагнитное поле
electromagnetic motor /ɪlektrəumæg'netɪk məutə/ электродвигатель с постоянными магнитами, магнитоэлектрический двигатель
elliptical /ɪ'lɪptɪkᵊl/ эллиптический
to emerge /ɪ'mɜ:dʒ/ появляться; возникать (*о вопросе*)
endangered /ɪn'deɪndʒəd/ исчезающий; находящийся под угрозой исчезновения; вымирающий
engine /endʒɪn/ двигатель
environment /ɪn'vaɪrənmənt/ окружающая среда
enzyme /enzaɪm/ энзим, фермент (*белковые молекулы или их комплексы, ускоряющие химические реакции в живых системах*)
equal /i:kwəl/ равный; одинаковый (to equal *мат.* 1. приравнивать; ставить знак равенства 2. равняться)
equation /ɪ'kweɪʒən/ уравнение
to establish /ɪ'stæblɪʃ/ учреждать, основывать, устанавливать
to estimate /estɪmeɪt/ приблизительно оценивать, давать приближённую оценку
to evolve /ɪ'vɔlv/ эволюционировать, развиваться
to exclude /ɪk'sklu:d/ исключать
to expand /ɪk'spænd/ 1. расширять(ся); увеличивать(ся) в объёме, в размерах 2. развивать(ся)
explosion /ɪk'spləuʒᵊn/ взрыв
extinct /ɪk'stɪŋkt/ исчезнувший; вымерший

F

to fertilize /fɜ:təlaɪz/ *биол.* оплодотворять; опылять
fibre /faɪbə/ волокно
finite /faɪnaɪt/ ограниченный, имеющий предел; *мат.* конечный
fission /fɪʃᵊn/ *физ.* деление атомного ядра; расщепление атомного ядра
flammable /flæməbᵊl/ легковоспламеняющийся
flavour /fleɪvə/ 1. вкус 2. вкусовая добавка
flesh /fleʃ/ тело, плоть
flux /flʌks/ 1. поток 2. постоянное движение; постоянное изменение
fluxion /flʌkʃᵊn/ производная (*одно из основных понятий дифференциального исчисления, характеризующее скорость изменения функции*)
food chain /fu:d tʃeɪn/ цепь питания
force of gravity /fɔ:s əv 'grævətɪ/ сила гравитации
foundation /faundeɪʃᵊn/ основание, основа
fuel /fju:əl/ топливо
functional analysis /fʌŋkʃənᵊl ə'næləsɪz/ функциональный анализ

G

gadget /gædʒɪt/ штучка, игрушка; приспособление
gene therapy /dʒi:n 'θerəpɪ/ генная терапия
to generate /dʒenəreɪt/ генерировать, производить
generation /dʒenə'reɪʃᵊn/ поколение
genetic composition /dʒe'netɪk kɔmpə'zɪʃᵊn/ генетический состав
gene /dʒi:n/ ген
geocentric theory /dʒi:əu'sentrɪk 'θɪərɪ/ геоцентрическая теория
germ /dʒɜ:m/ бактерии, микробы, микроорганизмы
germ theory (of disease) /dʒɜ:m θɪərɪ / микробная теория инфекционных заболеваний
goal /gəul/ цель
gravity /grævətɪ/ тяготение, гравитация, гравитационное взаимодействие
guanine /gwɑ:ni:n/ гуанин (*азотистое основание, входящее в состав нуклеиновых кислот; одно из 4-х азотистых оснований, входящих в состав ДНК*)

H

habitat /hæbɪtæt/ среда обитания
haemophilia /hi:məfɪlɪə/ гемофилия (*наследственное заболевание, выражающееся в склонности к*

кровотечениям вследствие несвёртывания крови)
headquarter /ˌhedˈkwɔːtə/ штаб-квартира
helium /ˈhiːlɪəm/ гелий
helix /ˈhiːlɪks/ спираль
heredity /həˈredətɪ/ наследственность
heterostructure /ˌhetərəʊˈstrʌktʃə/ гетероструктура (*комбинация нескольких гетропереходов (контактов между двумя различными по химическому составу полупроводниками), применяемая в полупроводниковых лазерах, светоизлучающих диодах и т. п.*)
HIV (human immunodeficiency virus) /ˌeɪtʃaɪˈviː/ ВИЧ (*вирус иммунодефицита человека*)
homopolar motor /ˌhəʊməʊˈpəʊlə ˈməʊtə/ униполярный электродвигатель
household appliances /ˈhaushəuld əˈplaɪənsiːz/ бытовые приборы
hydrochloric acid /ˌhaɪdrəuklɔrɪk ˈæsɪd/ соляная кислота
hydrogen /ˈhaɪdrəudʒən/ водород
hypotenuse /haɪˈpɔtənjuːz/ гипотенуза
to hypothesize /haɪˈpɔθəsaɪz/ предполагать; выдвигать гипотезу

I

to immunise /ˈɪmjunaɪz/ иммунизировать, прививать от чего-либо
impact /ˈɪmpækt/ влияние
inertia /ɪˈnɜːʃə/ инерция
to infect /ɪnˈfekt/ заражать, инфицировать
infinitesimal calculus /ɪnfɪnɪˈtesɪməl ˈkælkjuləs/ анализ бесконечно малых величин
infinity /ɪnˈfɪnətɪ/ бесконечность
to inhabit /ɪnˈhæbɪt/ населять
inheritance /ɪnˈherɪtəns/ наследие
to inject /ɪnˈdʒekt/ делать укол
input /ˈɪnput/ 1. ввод (*данных, информации*) 2. вход
integer /ˈɪntɪdʒə/ целое число
integral calculus /ˈɪntɪgrəl ˈkelkjuləs/ интегральное исчисление
interior angle /ɪnˈtɪərɪə ˈæŋgᵊl/ внутренний угол
to intersect /ɪntəˈsekt/ пересекать
iron /ˈaɪən/ железо

J

jar /dʒɑː/ стеклянный сосуд
to join /dʒɔɪn/ присоединяться; вступать

K

to keep tax records /kiːp tæks ˈrekɔːdz/ вести учёт налогов

L

larva /ˈlɑːvə/ личинка
the Law of Conservation of Mass /ðə lɔːʳ əv kɔnsəˈveɪʃən əv mæs/ Закон сохранения массы
the Law of Induction /ðə lɔːʳ əv ɪnˈdʌkʃən/ Закон электромагнитной индукции
the Law of Universal Gravitation /ðə lɔːʳ əv juːnɪˈvɜːsəl grævɪteɪʃən/ Закон всемирного тяготения
the laws of motion /ðə lɔːz əv məuʃən/ законы Ньютона, законы движения
layer /ˈleɪə/ слой
lead /led/ свинец
life span /laɪf spæn/ продолжительность жизни
linear algebra /ˈlɪmə ˈældʒɪbrə/ линейная алгебра (*часть алгебры, изучающая векторы, векторные (линейные) пространства, линейные отображения и системы линейных уравнений*)
linear transformation /ˈlɪnɪə trænsfəˈmeɪʃən/ линейное преобразование
liquid /ˈlɪkwɪd/ жидкий
litmus /ˈlɪtməs/ лакмус (*красящее вещество, добываемое из некоторых лишайников; применяется как индикатор для определения реакции среды, имея красную окраску в кислой среде и синюю в щелочной*)
long-standing /lɔŋ ˈstændɪŋ/ *зд.* устоявшийся
loop of wire /luːp əv ˈwaɪə/ виток провода

M

maggot /ˈmægət/ личинка
magnetic needle /mægˈnetɪk ˈniːdᵊl/ магнитная стрелка (*напр. компаса*)
mammal /ˈmæmᵊl/ млекопитающее
mathematical notation /mæθəˈmætɪkᵊl nəuteɪʃən/ математическое обозначение; математическая запись
matrix (*мн. ч.* **matrices**) /ˈmeɪtrɪks/ матрица
matter /ˈmætə/ материя; вещество
to measure /ˈmeʒə/ измерять
mineral recovery /ˈmɪnᵊrᵊl rɪˈkʌvərɪ/ добыча полезных ископаемых
mint /mɪnt/ монетный двор
modelling process /ˈmɔdəlɪŋ ˈprəuses/ процесс моделирования
multi-celled organism /ˈmʌltɪ seld ˈɔːgəmzəm/ многоклеточный организм
multidimensional /ˈmʌltɪdaɪˈmenʃənᵊl/ многомерный
to multiply /ˈmʌltɪplaɪ/ умножать
muscle cell /ˈmʌsᵊl sel/ мышечная клетка

N

natural numbers /ˈnætʃərəl ˈnʌmbəz/ натуральные числа (*целые положительные числа 1, 2, 3... и т. д., образующие натуральный ряд*)
natural selection /ˈnætʃərəl səˈlekʃən/ естественный отбор
nerve cell /nɜːʳv sel/ нервная клетка
notion of space-time /ˈnəuʃən əv speɪs ən taɪm/ *физ.* понятие пространства-времени (*понятие, отображающее единство реального существования пространства и времени*)
nuclear disarmament /ˈnjuːklɪə dɪsɑːməmənt/ ядерное разоружение
nuclear fusion /ˈnjuːklɪə ˈfjuːʒən/ термоядерный синтез; слияние ядер
nucleotides /ˈnjuːklɪəˌtaɪdz/ нуклеотиды (*фосфорные эфиры*

нуклеозидов, состоящие из азотистого основания, углевода и одного или нескольких остатков фосфорной кислоты; играют важную роль в энергетических и информационных внутриклеточных процессах, являясь составными частями нуклеиновых кислот, коферментов и других биологически активных соединений)
nucleus (*мн. ч.* **nuclei**) /ˈnjuːklɪəs/ ядро
numeral /ˈnjuːmərəl/ цифра (**Arabic numerals** арабские цифры; **Roman numerals** римские цифры)

O

offspring /ɔfspruŋ/ потомок
oil /ɔɪˀl/ нефть
oil refining industry /ˈɔɪəl rɪˌfaɪnɪŋ ˈɪndəstrɪ/ нефтеперерабатывающая промышленность
operator /ɔpəˌreɪtə/ *мат.* оператор (*символ /знак операции*)
optics /ˈɔptɪks/ оптика
ore /ɔː/ руда
organic base /ɔːˈgænɪk beɪs/ органическое основание
origin /ɔrɪdʒɪn/ происхождение
output /ˈautput/ 1. вывод (*данных, информации*) 2. выход 3. выходная информация
oxygen /ɔksɪdʒən/ кислород

P

pangenesis /pænˈdʒenəsɪz/ пангенезис, пангенез (*выдвинутая Ч. Дарвином гипотеза наследственности, согласно которой признаки и свойства родителей передаются потомству посредством мельчайших зародышей, поступающих в половые клетки из всех других клеток организма; позднее сам Ч. Дарвин признал её неудовлетворительной*)
particle /pɑːtɪkˀl/ частица
patent office /peɪtənt ˈɔfɪs/ патентное бюро
pattern /pætən/ 1. образец, модель; шаблон, структура 2. характер; особенность
phenomenon (*мн. ч.* **phenomena**) /fəˈnɔmɪnən/ *мат.* явление, фенёмен
plagiarism /pleɪdʒərɪzˀm/ плагиат
plane /pleɪn/ *мат.* плоскость
pollen /pɔlən/ пыльца
pollution /pəˈluːʃən/ загрязнение
polygon /pɔlɪgən/ многоугольник
polymath /pɔlɪmæθ/ человек с энциклопедическими знаниями; эрудит
potassium /pəˈtæsɪəm/ калий
powder /paudə/ 1. порошок 2. порох
power /pauə/ 1. сила; мощность 2. энергия
to predict /prɪˈdɪkt/ предсказывать
preservative /prɪˈzɜːvətɪv/ консервант
to preserve /prɪ zɜːv/ сохранять; консервировать
pressure /preʃə/ давление
to prevent /prɪvent/ предотвращать
principle of complementarity /ˈprɪnsəpˀl əv kɔmplɪmentærətɪ/ принцип дополнительности
Probability Theory /prɔbəˈbɪlətɪ ˈθɪərɪ/ теория вероятностей (*в популярной литературе нередко используется неточный термин «теория вероятности»*)
progenitor /prəuˈdʒenɪtə/ предшественник
property /ˈprɔpətɪ/ 1. свойство; качество 2. собственность
protozoa /prəutəuˈzəuə/ простейшие животные организмы
pump /pʌmp/ насос
to put forward /put ˈfɔːʳwəd/ выдвигать, предлагать (*идею*)
put in charge /put in tʃɑːdʒ/ назначать ответственным

Q

quality /kwɔlətɪ/ качество
quantitative chemistry /kwɔntɪtətɪv ˈkemɪstrɪ/ количественная химия
quantity /ˈkwɔntətɪ/ количество
quantum mechanics /ˈkwɔntəm mɪˈkænɪks/ квантовая механика

R

rabies /reɪbiːz/ бешенство (*вирусная болезнь человека и животных*)
to radiate /reɪdɪeɪt/ излучать
radio wave /reɪdɪəu weɪv/ радиоволна
radioactivity /reɪdɪəu ækˈtɪvətɪ/ радиоактивность
radius /reɪdɪəs/ радиус
rate /reɪt/ скорость (**at the rate** со скоростью)
rectangle /rektæŋgˀl/ прямоугольник
rectangular /rekˈtæŋjulə/ прямоугольный
to reduce /rɪˈdjuːs/ сокращать(ся)
to refer to /rɪˈfɜː tu/ относиться к чему-либо
to refine /rɪˈfaɪn/ *зд.* усовершенствовать/построить более совершенную (*математическую модель*)
reflecting telescope /rɪflektɪŋ ˈtelɪskəup/ зеркальный телескоп
relative /relətɪv/ относительный
to release /rɪˈliːs/ 1. выпускать 2. освобождать
replica /replɪkə/ реплика, точная копия (*напр. генная реплика, т. е. точная копия гена*)
resistance /rɪˈzɪstəns/ устойчивость, сопротивляемость
respiration /respəreɪʃən/ дыхание
to reveal /rɪˈviːəl/ открывать, раскрывать; обнаруживать
to revolve /rɪˈvɔlv/ вращаться (*вокруг чего-либо*)
right-angled triangle /raɪt ˈæŋgˀld ˈtraɪæŋgˀl / прямоугольный треугольник
RNA (ribonucleic acid) /ɑːrenеɪ /raɪbəunjuːkleɪk ˈæsɪd/ РНК (*рибонуклеиновая кислота*)
rod /rɔd/ палочка
rot /rɔt/ гнилой
to rotate /rəuˈteɪt/ вращаться

S

satellite navigation system /sætəlaɪt nævɪˈgeɪʃən ˈsɪstəm/ спутниковая навигационная система
semiconductors /semɪkəndʌktəz/ полупроводники (*вещества, электрическая проводимость которых при комнатной температуре занимает промежуточное положение между проводимостью металлов и*

диэлектриков, причём с повышением температуры их проводимость резко возрастает)
sequence /'si:kwəns/ ряд, последовательность
shell /ʃel/ 1. оболочка 2. раковина
to shrink /ʃrɪŋk/ 1. уменьшаться 2. уменьшать, сокращать
to simplify /'sɪmplɪfaɪ/ упрощать, облегчать
single-celled organism /'sɪŋgᵊl seld 'ɔ:gənɪzəm/ одноклеточный организм
slope /sləup/ уклон, наклон
smallpox /'smɔ:lpɔks/ оспа
sodium /'səudɪəm/ натрий
solar eclipse /'səulə ɪ'klɪps/ солнечное затмение
solar system /'səulə 'sɪstəm/ солнечная система
solid /'sɔlɪd/ твёрдый
solution /sə'lu:ʃən/ раствор
source /sɔ:s/ источник
spatial /'speɪʃəl/ пространственный
species /'spi:ʃi:z/ *биол.* вид (*мн. ч.* также **species**)
spectral line /'spektrəl laɪn/ спектральная линия (*узкий участок спектра излучения, соответствующий определённой частоте (длине волны)*
to split up /splɪt ʌp/ расщеплять(ся)
spontaneous generation /spɔn'teɪnɪəs dʒenə'reɪʃən/ самозарождение
square root /skweə ru:t/ квадратный корень
squared /skweəd/ в квадрате, во второй степени
stable orbit /steɪbᵊl ɔ:bɪt/ стационарная орбита
static electricity /'stætɪk ɪlek'trɪsətɪ/ статическое электричество (*явление, при котором на поверхности и в объёме диэлектриков и полупроводников возникают и накапливаются свободные электрические заряды*)
stem cells /stem selz/ стволовые клетки
strand /strænd/ *биол.* цепь, нить
to stretch /stretʃ/ растягивать(ся)
subatomic particle /ˌsʌbə'tɔmɪk 'pɑ:tɪkᵊl/ элементарная частица
substance /'sʌbstəns/ вещество
to subtract /səb'trækt/ вычитать
successive generation /sək'sesɪv dʒenə'reɪʃən/ последующее поколение
successor /sək'sesə/ преемник
sum /sʌm/ сумма
superconductor /ˌsu:pəkən'dʌktə/ сверхпроводник (*вещество, переходящее в сверхпроводящее состояние при охлаждении его ниже определённой критической температуры*)
superfluidity /ˌsu:pəflu'ɪdətɪ/ сверхтекучесть (*особое состояние квантовой жидкости, при котором она способна протекать через узкие щели и капилляры без внутреннего трения*)
superstition /ˌsu:pə'stɪʃən/ предрассудок
surface /'sɜ:fɪs/ поверхность
to surround /sə'raund/ окружать
system of notation /'sɪstəm əv nəu'teɪʃən/ система обозначений

I

tadpole /'tædpəul/ головастик
to take into account /teɪk ɪntu ə'kaunt/ принимать во внимание, учитывать
tally /'tælɪ/ 1. итог, итоговый результат 2. палочка с зарубками или веревочка с узелками, обозначающими сумму долга
tangent /'tændʒənt/ 1. касательная 2. тангенс
theory of relativity /'θɪərɪ əv relə'tɪvətɪ/ теория относительности
thermodynamics /θɜ:məudaɪ'næmɪks/ термодинамика
three-dimensional microchip /θri: daɪ'menʃənəl 'maɪkrəutʃɪp/ трёхмерный микрочип
thymine /'θaɪəmi:n/ тимин (*азотистое основание, входящее в состав ДНК*)
tissue /'tɪʃu:/ *биол.* ткань
trait /treɪt/ признак; характерная черта, особенность
transformation /trænsfə'meɪʃən/ превращение
transmission of information /trænz'mɪʃən əv ɪnfə'meɪʃən/ передача информации
to transpose /træns'pəuz/ преобразовывать
transversal /trænz'vɜ:səl/ поперечный
triangle /'traɪæŋgᵊl/ треугольник
trigonometry /trɪgə'nɔmətrɪ/ тригонометрия
twig /twɪg/ веточка

U

universe /'ju:nɪvɜ:s/ Вселенная
to untwist /ʌn'twɪst/ разматывать(ся)
upheaval /ʌp'hi:vəl/ перен. переворот, потрясение (*в обществе*)

V

vacuum chamber /'vækjuəm 'tʃeɪmbə/ вакуумная камера
value /'vælju:/ величина; значение
variable /'veərɪəbᵊl/ переменная
vector space /'vektə speɪs/ векторное пространство, линейное пространство
vision /'vɪʒᵊn/ *зд.* концепция
volume /'vɔlju:m/ объём

W

wall /wɔ:l/ стенка; оболочка
waste /weɪst/ отходы
wave motion /weɪv 'məuʃən/ движение волны
wave particle duality /weɪv 'pɑ:tɪkᵊl dju'ælətɪ/ корпускулярно-волновой дуализм (*представление о природе элементарных частиц, в соответствии с которым они обладают свойствами и частиц, и волн*)
wavelength /'weɪvleŋθ/ длина волны
weapons of mass destruction /'wepənz əv mæs dɪ'strʌkʃən/ оружие массового поражения
width /wɪdθ/ ширина
wire /waɪə/ провод
wireless /'waɪələs/ беспроводной

X

X-rays /eksreiz/ рентгеновское излучение, рентгеновские лучи

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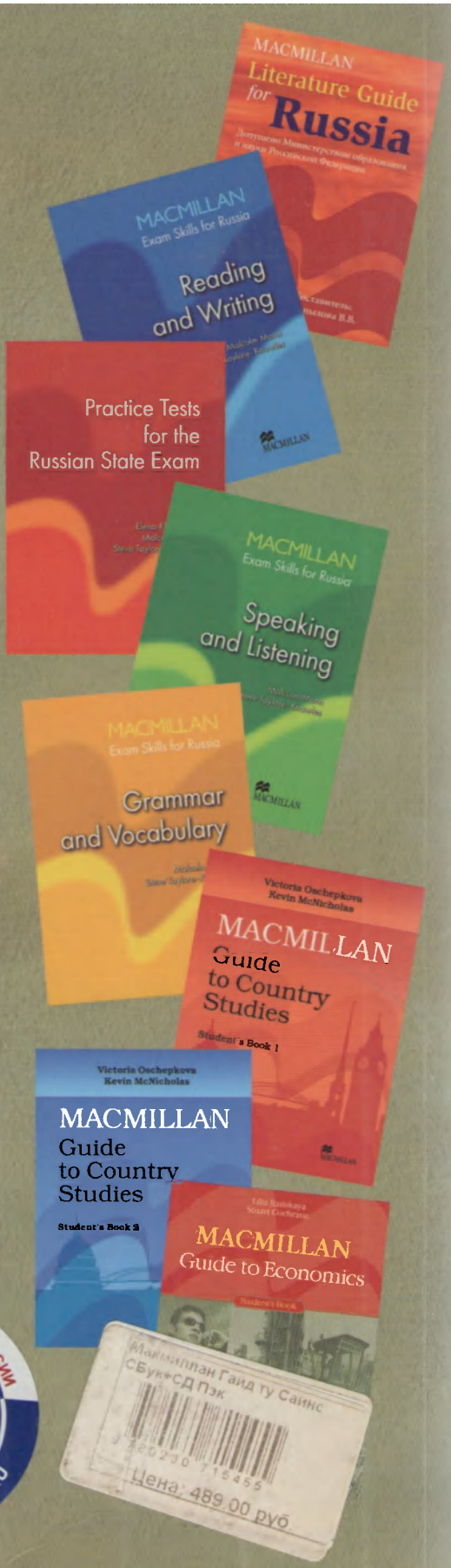
Guide to Science



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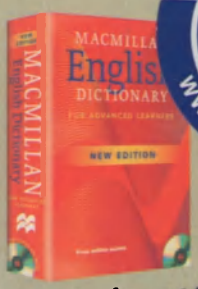

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