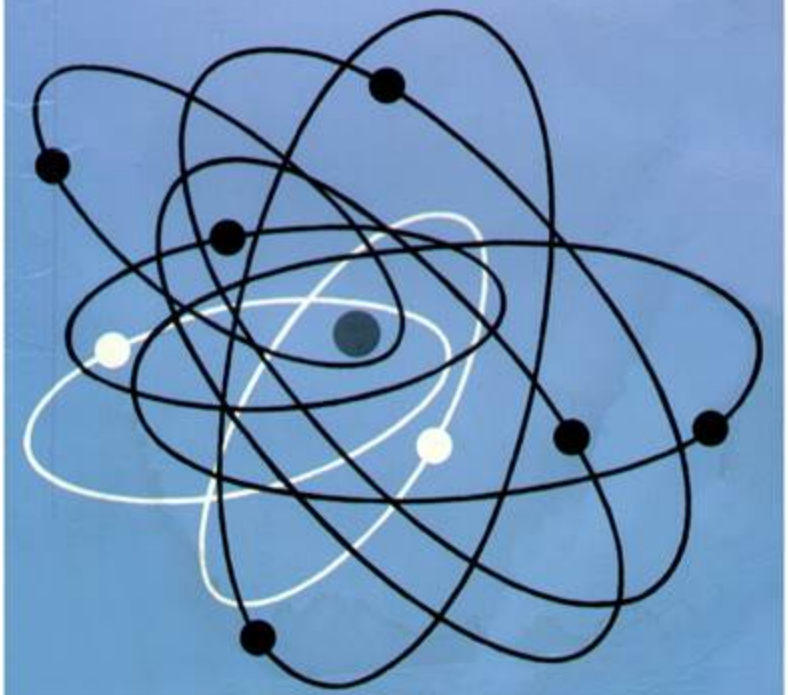
Students Book

A course in basic scientific English

J R Ewer & G Latorre



A Course in
Basic Scientific English

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Longman

Contents

Unit 1

THE SCIENTIFIC ATTITUDE

What is the nature of the scientific attitude, the attitude of the man or woman who studies and applies physics, biology, chemistry, geology, engineering, medicine or any other science?

We all know that science plays an important role in the societies in which we live. Many people believe, however, that our progress depends on two different aspects of science. The first of these is the application of the machines, products and systems of applied knowledge that scientists and technologists develop. Through technology, science improves the structure of society and helps man to gain increasing control over his environment. New fibres and drugs, faster and safer means of transport,[1] new systems of applied knowledge (psychiatry, operational research, etc.) are some examples of this aspect of science.

The second aspect is the application by all members of society, from the government official to the ordinary citizen, of the special methods of thought and action that scientists use in their work.

What are these special methods of thinking and acting? First of all, it seems that a successful scientist is full of curiosity—he wants to find out how and why the universe works. He usually directs his attention towards problems which he notices have no satisfactory explanation, and his curiosity makes him look for underlying relationships even if the data available seem to be unconnected. Moreover, he thinks he can improve the existing conditions, whether of pure or applied knowledge, and enjoys trying to solve the problems which this involves.

He is a good observer, accurate, patient and objective and applies persistent and logical thought to the observations he makes. He utilizes the facts he observes to the fullest extent. For example, trained observers obtain a very large amount of information about a star (e.g. distance, mass, velocity, size, etc.) mainly from the accurate analysis of the simple lines that appear in a spectrum.

He is sceptical—he does not accept statements which are not based on the most complete evidence available—and therefore rejects authority as the sole basis for truth. Scientists always check statements and make experiments carefully and objectively to verify them.

Furthermore, he is not only critical of the work of others, but also of his own, since he knows that man is the least reliable of scientific instruments and that a number of factors tend to disturb impartial and objective investigation (see Unit 8).

Lastly, he is highly imaginative since he often has to look for relationships in data which are not only complex but also frequently incomplete. Furthermore, he needs imagination if he wants to make hypotheses of how processes work and how events take place.

These seem to be some of the ways in which a successful scientist or technologist thinks and acts.

[1] *transportation* in U.S.A.

Comprehension

1 Name some sciences.
2 Name two ways in which science can help society to develop.
3 Give some examples of the ways in which science influences everyday life.
4 What elements of science can the ordinary citizen use in order to help his society to develop?
5 How can you describe a person who wants to find out how and why the universe works?
6 What is the role of curiosity in the work of a scientist?
7 Name some of the qualities of a good observer.
8 Give an example of how observed facts are utilized to the fullest.
9 How does a sceptical person act?
10 How does the scientist act towards (a) evidence presented by other people, (b) evidence which he presents in his own work?
11 What do you know about the data which the scientist often has to use? How does this affect his way of thinking?
12 For what other purposes does a scientist need imagination?

Word Study

WORD-BUILDING

A common way of making new words in English is by adding standard combinations of letters to existing words, either at the beginning (prefixes) or at the end (suffixes). By noting these carefully, you will find it is easy to make large increases in your recognition vocabulary.

1 The suffix *-ist*

A person who studies and applies	geology is a geolog*ist* biology is a biolog*ist* sociology is a .... is a chem*ist* anthropology is a .... is a psycholog*ist* archaeology is a .... is a ecolog*ist* agronomy is a .....

2 The suffix *-(i)an*

A person who studies and applies	mathematics is a mathematic*ian* statistics is a .... is an obstetric*ian*

But

A person who applies the study of	economics is an economist engineering is an engineer architecture is an architect medicine is a doctor[1]

[1] Usually *physician* in U.S.A.

3 The suffix *-ion*

This suffix converts a verb into the corresponding noun. The following are some examples which occur in our first passage:

VERB	NOUN
to act	act*ion*
to apply	applicat*ion*
to observe	observat*ion*

More examples of this suffix are given in the Word Study section of Unit 2.

EXERCISE (a) Form nouns from the following verbs:

to imagine; to attract; to direct; to construct; to connect; to relate; to fluctuate.

(b) Form verbs from the following nouns:

conversion; suggestion; production; definition; operation; reduction; population.

NOTE: to join—junction; to destroy—destruction; to query—question; to transmit—transmission.

4 The prefixes *in-* and *un-*

These prefixes are used to make an adjective negative, e.g. '*in*complete' (l. 45) means 'not complete'; '*un*connected' (l. 24) means 'not connected'.

EXERCISE (a) Using *in-*, make the following negative:

accurate; capable; direct; essential; frequent.

(b) Using *un-*, make the following negative:

able; stable; usual; critical; reliable; successful; imaginative; true.

Structure Study

SIMPLE PRESENT TENSE

The main structure in the passage is the Simple Present Tense. Remember that this tense is used:

(i) for actions in the present which happen usually, habitually or generally, e.g. 'He usually *directs* his attention towards problems which he notices have no satisfactory explanation' (ll. 20–21);

(ii) for stating general truths, e.g. 'science *plays* an important role in the societies in which we live' (ll. 4–5); or for stating scientific laws, e.g. Water *freezes* at 0°C.;

(iii) for describing processes in a general way, e.g. A scientist *observes* carefully, *applies* logical thought to his observations, *tries* to find relationships in data, etc.

EXERCISE (a) Fill in the blanks in the following and repeat aloud several times:

I make	accurate experiments	... check	the validity of statements
They ...		... check	
She ...		... checks	
The scientist ...		... check	
Scientists ...		... check	
We ...			
You ...			

I think	logically	... observes	accurately
He ...		... observe	
They ...		... observes	
We ...		... observe	
She ...		... observes	
You ...			

(b) Add as many verbs and appropriate complements as possible, chosen from the passage and the Word Study section, to the following subjects: the scientist, scientists, we,

e.g. The scientist USES
Scientists USE
We USE
reliable instruments

(c) Repeat Exercise (b) above using the same set of verbs and complements, but using new subjects chosen from the passage or the Word Study section, e.g. *Physicists* use reliable instruments.

The Negative The Simple Present Tense forms the negative by the use of *do not* or *does not* before the main verb, e.g.

I, you *do not*
He, she *does not* KNOW the importance of science.
We, they *do not*

EXERCISE (d) Fill in the blanks in the following and repeat aloud:

I do not accept	incomplete evidence
You ... not accept	unreliable information
We ... not accept	inaccurate statements
A scientist ... not accept	authority in science
They ... not accept	

(e) Repeat Exercise (a) above, using the negative.

The Interrogative The Simple Present Tense forms questions by the use of *do* or *does* before the subject of the main verb, e.g.

Do / *Does* / *Do* [I, you, he, she, we, they] KNOW the importance of science?

EXERCISE (f) Repeat Exercise (d) above, using the question form.

(g) Put the verbs in brackets into their correct forms:

1 A statistician (apply) mathematics in his work.
2 You (accept) incomplete evidence?
3 The evidence (seem) incomplete.
4 The government official (use) objective methods?
5 Trained observers usually (utilize) data to the fullest.
6 He always (try) to look for underlying relationships in collections of data.
7 A scientist always (think) logically?

SUBSTITUTION TABLES
Simple Present
Active

A Affirmatives

1	2	3	4	5	6	7
A scientist	often	uses	mathematics	in	his	work
A technologist		employs	complex instruments			
A researcher		needs	imagination			
An investigator			statistical methods			
They		use	new apparatus		their	
Scientists		employ				
You		need				
Researchers						

B Negatives

1	2	3	4
A physicist	does not	use	unreliable instruments
A biologist		employ	inaccurate observation
He		apply	unsuccessful techniques
An engineer			
Scientific workers	do not		
I			
We			
Biochemists			

C Questions

1	2	3	4	5	6
	a specialist				
	an agronomist		develop		instruments?
Does	he				
	a medical worker		require		techniques?
		some-times		new	
	mathematicians				
	geologists		need		methods?
Do	they				
	psychologists		use		ideas?

Discussion and Criticism

1 Do you think there are other special ways of thinking and acting, used by scientists? If so, comment and explain.

2 Do you think some of these ways are more important than others? If so, give reasons.

3 Do you know of any famous scientist whose work demonstrates some or all the qualities mentioned in the passage? Give details.

4 Try to say something about the work of some of the scientists mentioned in the Word Study section.

5 In what ways do other sciences affect the particular science you study yourself? Give examples.

6 Do you agree that it is important to train the non-scientist to think in a scientific way (ll. 14–17). Give good evidence for your point of view.

7 Do you agree that 'man is the least reliable of scientific instruments' (ll. 40–41)? Give examples.

8 Give a clear explanation of what you think the word 'authority' (l. 36) means.

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Unit 2

NUMBERS AND MATHEMATICS

It is said that mathematics is the base of all other sciences, and that arithmetic, the science of numbers, is the base of mathematics. Numbers consist of whole numbers (integers) which are formed by the digits 0, 1, 2, 3, 4, 5, 6, 7, 8 and 9 and by combinations of them. For example, 247—two hundred and forty seven[1]—is a number formed by three digits. Parts of numbers smaller than 1 are sometimes expressed in terms of fractions, but in scientific usage they are given as decimals. This is because it is easier to perform the various mathematical operations if decimals are used instead of fractions. The main operations are: to add, subtract, multiply and divide; to square, cube or raise to any other power; to take a square, cube or any other root and to find a ratio or proportion between pairs of numbers or a series of numbers. Thus, the decimal, or ten-scale, system is used for scientific purposes throughout the world, even in countries whose national systems of weights and measurements are based upon other scales. The other scale in general use nowadays is the binary, or two-scale, in which numbers are expressed by combinations of only two digits, 0 and 1. Thus, in the binary scale, 2 is expressed as 010, 3 is given as 011, 4 is represented as 100, etc. This scale is perfectly adapted to the 'off-on' pulses of electricity, so it is widely used in electronic computers: because of its simplicity it is often called 'the lazy schoolboy's dream'!

Other branches of mathematics such as algebra and geometry are also extensively used in many sciences and even in some areas of philosophy. More specialized extensions, such as probability theory and group theory, are now applied to an increasing range of activities, from economics and the design of experiments to war and politics. Finally, a knowledge of statistics is required by every type of scientist for the analysis of data. Moreover, even an elementary knowledge of this branch of mathematics is sufficient to enable the journalist to avoid misleading his readers, or the ordinary citizen to detect the attempts which are constantly made to deceive him.

Comprehension

1 What is the relationship of mathematics to the other sciences?

2 What is the science of numbers called?

3 Name a two-digit integer.

4 Name two ways of expressing parts of the number *one* (unity).

5 Name the common arithmetical operations. Using actual numbers, give examples of each.

6 What are the two number-systems commonly used throughout the world?

7 Give examples of numbers in the binary system.

8 What are the advantages of each system?

9 Name some other branches of mathematics.

[1] in American usage the *and* is omitted.

10 What branch of mathematics is very useful to the ordinary citizen? Why?

Word Study

SYNONYMS EXERCISE

Find words in the passage which mean approximately the same as:

entire (w...e); usually (f...y); in the place of (i...d of); system of measurement (s...e); widely (ex...y); be put to use in (be a...d to); lastly (f...y); kind, sort (t...e); simpler (e...r); cause someone to make a mistake by giving wrong or incomplete information (m...d); continually (c...y); discover, find out (d...t); action of trying to do something (a...t); a group of measurements, etc. arranged in an orderly way to form a whole (s...m).

WORD-BUILDING

1 The suffix *-ion* (*-ation, -ition*)

This suffix forms nouns from verbs with the meaning of: process or result of doing something. Thus *operation* (l. 10) means: process or result of operating. Other nouns formed in this way are: 'add*ition*' (process or result of adding) from (*to*) *add*, 'subt*raction*' from *subtract*, 'div*ision*' from *divide*, 'multipl*ication*' from *multiply*.

EXERCISE

Using *-ation*, make nouns from the following verbs: apply; adapt; specialize; compute; calculate; isolate; combine; explain; investigate.

2 The suffix *-ment*

This suffix forms nouns from the corresponding verbs, e.g. 'measure*ment*' (l.16) from the verb (*to*) *measure*.

EXERCISE

By adding *-ment*, form nouns from the following verbs: equip; move; adjust; establish; attach; improve; state.

3 The suffix *-ity*

This suffix forms nouns from the corresponding adjectives, e.g. 'activ*ity*' (l. 28) from the adjective *active*; 'probab*ility*' (l. 26) from *probable*, and 'simpl*icity*' (l. 23) from *simple*.

EXERCISE (a)

Form nouns from the following: alkaline; relative; potential; complex; equal; reliable; acid.

NOTE: the adjective *able* becomes 'ab*ility*'.

(b)

Applying the principle given in the Note above, make adjectives corresponding to the following nouns: availability; adaptability; stability; responsibility.

4 The prefix–suffix *-en*

This is used either as a prefix to adjectives (or occasionally nouns) to form a verb (e.g. '*en*able' (l. 32), '*en*large', etc.) or more commonly as a suffix, e.g. 'wid*en*' (from *wide*).

EXERCISE

By adding *-en*, form verbs from the following:

length; strength; tight; weak; loose; short; deep; height.

REVISION EXERCISE

Complete the following by choosing appropriate words from **1, 2, 3** and **4** above:

The main a...ity of the scientist is the i...ion and e...ion of the world around us. To en... him to do this he uses many different kinds of e...ment, and in order to make them more a...able to his purposes he frequently makes a...ments to them which lead to their i...ment. For example, he may s...en a part which is too weak, l...en one which is too short and t...en something which is too loose, and thus causes too much m...ment, so that the instrument does not have the necessary s...ity. So even the most specialized scientist needs to be an engineer, sometimes!

Structure Study

THE PASSIVE

The main structure used in this passage is the Passive of the tense used in Unit 1, i.e. the Simple Present. We use the Passive when we have little interest in or knowledge of, the doer of the action but are more interested in what happens to, or is done to, the person or thing thus affected.

You probably remember that the Passive is formed by the appropriate tense of the verb *to be* plus the Past Participle, e.g.

	THE ACTIVE	BECOMES IN THE PASSIVE	
People *use*	statistics	Statistics	USED
	mathematics	Mathematics *is*	
	imagination	Imagination	
	decimals	Decimals	
	computers	Computers *are*	
	chemicals	Chemicals	

c.f. 'Other branches of mathematics *are used* in many sciences' (ll. 24–25). The passive is used here because we are not at the moment concerned with *who* uses these branches.

Similarly: 'Attempts *are* constantly *made* to deceive the ordinary citizen' (ll. 34–35). We do not wish to specify at this point *who* makes these attempts.

EXERCISE (a)

Make the following sentences Passive, thus eliminating the unspecified doer of the action, and emphasizing the object, or the main verb:

1 People apply mathematics in many different activities. (Begin: Mathematics is ...).

2 People use the binary scale in electronic computers.

3 People form the square of a number by multiplying the number by itself. (Begin: The square of a number is ...).

4 In the binary scale, people express numbers by combinations of 0 and 1.

5 People usually use decimals rather than fractions for scientific purposes. (Begin: Decimals, rather than fractions ...).

6 People develop new products every day.

7 People call mathematics 'the language of science'.

8 People use the decimal system even in countries with non-decimalized systems of weights and measurements.

9 It is easier to perform mathematical operations with computers if we use the binary system instead of the decimal system.

10 People use electronic computers for many different purposes.

11 People often find relationships in incomplete data.

12 People make attempts to deceive the ordinary citizen.

NOTE: If the doer of the action has some importance (though less than the object), or is needed to complete the sense of the sentence, it is given, e.g. 'A knowledge of statistics is required *by every type of scientist*' (ll. 29–30).

Notice that there is a small problem of word-order in all but the most simple form of this type of sentence,

e.g. The scientific investigator applies logical and persistent thought to his problems (Active), becomes:

Logical and persistent thought is applied by the scientific investigator to his problems (Passive).

The order of words is thus: object—verb in the Passive—subject—rest of sentence.

(b) Make the following sentences Passive, mentioning the doer of the action but shifting the emphasis to the object:

1 A combination of the digits 0–9 forms integers.

2 Engineers require an advanced knowledge of algebra and geometry. (Begin: An advanced knowledge of ...)

3 Scientists, especially physicists and engineers, often use electronic computers.

4 Journalists, who seldom have a knowledge of statistics, frequently mislead the ordinary citizen.

5 Every day, applied scientists and technologists produce new drugs, fibres, chemicals and equipment. (Begin: Every day, new ...)

6 A combination of two elements forms a chemical compound.

7 The ordinary citizen often requires an elementary knowledge of statistics.

8 Economists also use mathematics.

9 Every type of scientist requires a knowledge of statistics.

10 Scientists use accurate systems of measurement.

11 Philosophers employ specialized extensions of mathematics.

12 Physicists also use probability theory.

(c) Make up sentences similar to the ones given in Exercises (a) and (b) above, using words learnt in this unit and Unit 1, and then change them from Active to Passive.

SUBSTITUTION TABLE

NOTE: Sentences must be made sensible by using an *appropriate* qualifying word from Column 3 in each case.

SIMPLE PRESENT PASSIVE

1	2	3	4	5	6	7	8	9
Logical thought					a scientist			
Patience					him			
Accurate observation	is	always usually often	used applied	by	an engineer	in	his	work
Computers	are	sometimes	employed		technologists		their	
New techniques		never			them			
Reliable instruments					statisticians			

Make the above (a) negative, (b) interrogative.

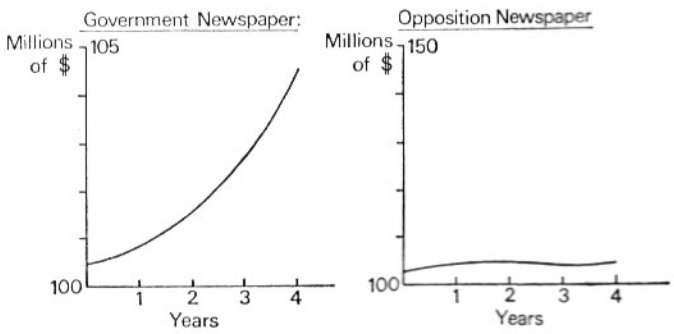
Discussion and Criticism

1 Try to explain the nature and use of: geometry; algebra; statistics; probability theory. Give actual examples where possible.

2 In what ways are any of the branches of mathematics mentioned in the passage connected with the science you study yourself? Give examples.

3 Try to (a) state, (b) prove: (i) an algebraic formula; (ii) a geometrical theorem; (iii) a physical, chemical or biological law.

4 Comment on the graphs below, which appeared in a Government and Opposition newspaper respectively just before a General Election. They represent the Government's spending on science during its 4 years of office.



5 How can mathematics be made more interesting, especially to children?

6 Find, and comment on, some examples of statistics used misleadingly by journalists and others (there are usually plenty in newspapers and magazines).

7 What kind of people or organizations deliberately try to deceive the ordinary citizen by using statistics wrongly? Why and how?

Unit 3

SCIENTIFIC METHOD AND THE METHODS OF SCIENCE

It is sometimes said that there is no such thing as the so-called 'scientific method'; there are only the methods used in science. Nevertheless, it seems clear that there is often a special sequence of procedures which is involved in the establishment of the working principles of science. This sequence is as follows: (1) a problem is recognized, and as much information as appears to be relevant is collected; (2) a solution (i.e. a hypothesis) is proposed and the consequences arising out of this solution are deduced; (3) these deductions are tested by experiment, and as a result the hypothesis is accepted, modified or discarded.

As an illustration of this we can consider the discovery of air-pressure. Over two thousand years ago, men discovered a method of raising water from one level to another by means of the vacuum pump. When, however, this machine passed into general use in the fifteenth and sixteenth centuries, it was discovered that, no matter how perfect the pump was, it was not possible to raise water vertically more than about 35 feet. Why? Galileo, amongst others, recognized the problem, but failed to solve it.

The problem was then attacked by Torricelli. Analogizing from the recently-discovered phenomenon of water-pressure (hydrostatic pressure), he postulated that a deep 'sea of air' surrounded the earth; it was, he thought, the pressure of this sea of air which pushed on the surface of the water and caused it to rise in the vaccum tube of a pump. A hypothesis, then, was formed. The next step was to deduce the consequences of the hypothesis. Torricelli reasoned that this 'air pressure' would be unable to push a liquid heavier than water as high as 35 feet, and that a column of mercury, for example, which weighed about 14 times more than water, would rise to only a fourteenth of the height of water, i.e. approximately 2.5 feet. He then tested this deduction by means of the experiment we all know, and found that the mercury column measured the height predicted. The experiment therefore supported the hypothesis. A further inference was drawn by Pascal, who reasoned that if this 'sea of air' existed, its pressure at the bottom (i.e. sea-level) would be greater than its pressure further up, and that therefore the height of the mercury column would decrease in proportion to the height above sea-level. He then carried the mercury tube to the top of a mountain and observed that the column fell steadily as the height increased, while another mercury column at the bottom of the mountain remained steady (an example of another of the methods of science, the controlled experiment). This further proof not only established Torricelli's hypothesis more securely, but also demonstrated that, in some aspects, air behaved like water; this, of course, stimulated further enquiry.

Comprehension

1 What does the establishment of the working laws of science often involve?

2 What does a scientist collect when he tries to establish a scientific law?

3 What is the next step in the process described above?

4 What does the scientist then deduce?

5 How does he proceed to verify these deductions?

6 What does he finally do with his original hypothesis?

7 Give an approximate date for the invention of the vacuum pump.

8 Is it possible to raise water from the bottom floor of a building to the roof 50 feet above, using a vacuum pump? Why?

9 What was Torricelli's theory about the height of the water in a vacuum tube?

10 What were his deductions concerning the effect of air pressure on a column of mercury?

11 What further inference was made by Pascal?

12 Why did he use *two* mercury tubes?

13 What were the three results of Pascal's experiment?

14 What do you think happened to the mercury column when it was carried down the mountain?

Word Study

EXERCISE

Using appropriate words chosen from the reading passage, fill in the blanks in the following:

The scientist or technologist uses many m...s when he tries to s... a problem. For instance, an engineer who wants to r... a l... from one l... to another has the choice of several different p...s. One of them is to use a p... which takes the air out of the pipe or t... along which he wants the l... to flow, thus creating a v.... Air p... then pushes on the lower s... of the l... and forces it up the pipe. This method is d...d in the petrol system of a car.[1]

OPPOSITES EXERCISE (a)

From the reading passage choose words which mean the opposite of the following:

shallow (d...p); to lower (to r...e); to rise (to f...l); high (l...w); to succeed (to f...l); to refuse or reject (to a...t); imperfect (p...t); irrelevant (r...t); to pull (to p...h); depth (h...t); horizontal (v...l); to increase (to d...e); seldom (o...n).

(b) Use the words given above in sentences, using the Present Tense and Present Tense Passive.

WORD-BUILDING

The suffix *-ize*[2]

This forms verbs from nouns and adjectives, and has the meaning: to cause to be or have, or: to subject to a process of, e.g.

[1] *gasoline* system (U.S.) [2] frequently spelt -ise

analogizing (l. 20) is equivalent to: subjecting (the problem) to a process of analogy.

EXERCISE

By adding *-ize*, form verbs from the following: standard; special; local; pressure; theory; sterile; popular; familiar; neutral; optimum.

NOTE: anal*yse*, from analysis; paral*yse*, from paralysis; mini*mize*, from minimum; maxim*ize*, from maximum; and *util*ize, from use.

In technical literature this suffix is sometimes used with the names of persons or places associated with certain processes, e.g. *macadamize* (road engineering), *pozzuolize* (geology and engineering), and *pasteurize* (food technology).

Structure Study

SIMPLE PAST TENSE

The main structure used in the passage of Unit 3 is the Simple Past Tense. You will probably remember that this is the tense normally used for describing actions which happened in the past and are now finished. With regular verbs the tense is formed by adding *-ed* or *-d* (if the infinitive already ends in *-e*) to the infinitive, e.g.

'Men discover*ed* a method of raising water' (ll. 12–13)

With other subjects, the verb is still in the same form, e.g.

I / You / We / They — discovered — a method, etc.

There are, however, a number of irregular verbs which are frequently encountered, and these have their own special forms of past tense and participle. A list of the most common is given in Appendix B, and should be revised now.

EXERCISE (a) Repeat the first exercise in the Word Study section above, putting the verbs into the Past Tense.

(b) Put the reading passage of Unit 1 (*The Scientific Attitude*) into the Past Tense.

The Negative

The Simple Past Tense, with both regular and irregular verbs forms the negative by the use of *did not* before the infinitive of the main verb; this is the same for all subjects, e.g.

Galileo / I / You / We / They — *did not* SOLVE the problem of the water-pump

The Interrogative

The Simple Past Tense forms questions by the use of *did* before the subject of the main verb, e.g.

Did [Pascal / I / you / we / they] TEST his inference by means of an experiment?

REVISION EXERCISE

Put the following sentences, which contain irregular verbs, into (i) the Simple Past Tense; (ii) Simple Past Negative; (iii) Simple Past Interrogative:

1 The liquid rises in the tube.
2 The pipes bend under the weight, and break.
3 The aircraft flies faster than sound.
4 The electric motor drives a pump.
5 The engineer takes a lot of measurements.
6 The scientist chooses between several procedures.
7 The hot-water system loses a lot of heat.
8 The lazy schoolboys make an electronic computer.
9 Later, they become famous scientists.
10 We give the results of the calculations in decimals.
11 The experiment takes a long time to carry out.
12 They draw many inferences from the hypothesis.
13 I find the ratio between the numbers.

THE PASSIVE OF THE SIMPLE PAST TENSE

This is used for the same purposes as the Simple Present Passive (see Structure Study section of Unit 2), except that it refers to the past, not the present. It is also formed in the same way, except that *is* and *are* are replaced by *was* and *were* respectively, e.g.

'It *was discovered* that it was impossible to raise water more than about 35 feet' (ll. 15–17)

The problem *was* then *attacked by* Torricelli. (l. 20)

EXERCISE

Put exercises (a) and (b) of the Structure Study section of Unit 2 into the Simple Past Passive.

SUBSTITUTION TABLE

Simple Past Tense

A Affirmatives

1	2	3	4
I	assembled	the electronic unit	last month
We	completed	the apparatus	several weeks ago
He (she)	obtained	a new measuring device	in 1964
They	built	the equipment	some time ago
The technicians	finished	the experimental model	at the end of 1963
Our research group	began work on	the prototype	a fortnight ago
An investigator	tested	a new system	at the beginning of last year

B Negatives

1	2	3	4
		find the ratio between the two quantities	
He (she)		obtain the right figures	
The investigators		make any mistakes	the last time the experiment was performed
The specialist	did not	give the results in decimals	
We		set up sufficient controls	
The student		see the implications of the problem	
They		write down all the data	
The researcher			

C Questions

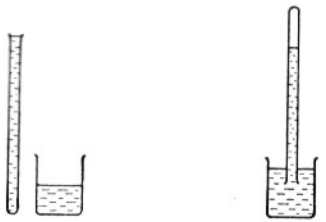
1	2	3	4
		understand the main problem	
	you	spoil a specimen	
	he	choose the most efficient procedure	
	the researchers		in last week's experiments?
Did	the technician	set up the apparatus correctly	
	they	draw the right conclusions	
	our team	test the new measuring device	
	the students	make any mistakes	

D Passives

1	2	3	4
	some new apparatus		
	a fresh approach		developed
	an interesting theory	was	employed
In the experiments we did last year	some complex instruments	were	tested
	several basic concepts		
	many different methods		

Additional Exercise (for irregular verbs): Put the sentences of Table B above into the Affirmative (i.e. Simple Past Affirmative).

Discussion and Criticism



From the simple diagrams given above, describe Torricelli's famous experiment in a clear and orderly way. This should include his method of forming a vacuum.

2 Draw a simple diagram, or series of diagrams, of an experiment you know. Exchange this with another student (or group): you then describe his experiment, while he explains yours.

3 Torricelli's experiment not only provided support for his hypothesis but also involved the invention of a basic scientific instrument, the barometer. What other basic instruments do you know? How do they work, and what are some of their uses?

4 In the description of scientific method (ll. 5–10), step 2 says 'a solution is proposed'. However, in practice it is common to find that several solutions seem to be equally possible (the multiple hypothesis). How would you proceed in such a case?

5 Given an example of scientific method used in the development of the science you study yourself.

6 Do you agree that there is no *one* scientific method? Give reasons and examples.

7 What do you think is meant by 'as much information as appears to be relevant is collected' (ll. 6–7)? What was the relevant information in Torricelli's case? (Note the developments in hydrostatics.)

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Unit 4

PURE AND APPLIED SCIENCE

As students of science you are probably sometimes puzzled by the terms 'pure' and 'applied' science. Are these two totally different activities, having little or no interconnection, as is often implied? Let us begin by examining what is done by each.

Pure science is primarily concerned with the development of theories (or, as they are frequently called, models) establishing relationships between the phenomena of the universe. When they are sufficiently validated, these theories (hypotheses, models) become the working laws or principles of science. In carrying out this work, the pure scientist usually disregards its application to practical affairs, confining his attention to explanations of how and why events occur. Hence, in physics, the equations describing the behaviour of fundamental particles, or in biology, the establishment of the life cycle of a particular species of insect living in a Polar environment, are said to be examples of pure science (basic research), having no apparent connection (for the moment) with technology, i.e. applied science.

Applied science, on the other hand, is directly concerned with the application of the working laws of pure science to the practical affairs of life, and to increasing man's control over his environment, thus leading to the development of new techniques, processes and machines. Such activities as investigating the strength and uses of materials, extending the findings of pure mathematics to improve the sampling procedures used in agriculture or the social sciences, and developing the potentialities of atomic energy, are all examples of the work of the applied scientist or technologist.

It is evident that many branches of applied science are practical extensions of purely theoretical or experimental work. Thus the study of radioactivity began as a piece of pure research, but its results are now applied in a great number of different ways—in cancer treatment in medicine, the development of fertilizers in agriculture, the study of metal-fatigue in engineering, in methods of estimating the ages of objects in anthropology and geology, etc. Conversely, work in applied science and technology frequently acts as a direct stimulus to the development of pure science. Such an interaction occurs, for example, when the technologist, in applying a particular concept of pure science to a practical problem, reveals a gap or limitation in the theoretical model, thus pointing the way for further basic research. Often a further interaction occurs, since the pure scientist is unable to undertake this further research until another technologist provides him with more highly-developed instruments.

It seems, then, that these two branches of science are mutually dependent and interacting, and that the so-called division between the pure scientist and the applied scientist is more apparent than real.

Comprehension

1 What is often implied by the terms 'pure' and 'applied' science?
2 What is the aim (object) of pure scientific investigation?
3 Name some examples of basic research.
4 How are the working laws of science established?
5 What is the work of an applied scientist?
6 Name some examples of applied science.
7 Name some applications of radioactivity.
8 Name some examples of the interaction of pure and applied science.
9 Give two other words meaning the same thing as hypothesis.

Word Study

EXERCISE

Complete the following sentences, choosing *one* of the four expressions in the brackets:

1 The results of research into radioactivity are applied in (electronic computers; sampling procedures; cancer treatment; pure science).

2 Many branches of applied research developed out of (the work of technologists; pieces of basic research; equations describing the behaviour of fundamental particles; new processes).

3 Pure science relates to (more highly-developed instruments; sampling procedures; solving practical problems; developing theories which explain the relationships between phenomena).

4 New kinds (types) of instruments are frequently essential for (developing basic research; improving fertilizers in agriculture; describing the life cycles of insects; finding the cube root of fractions).

5 Investigating the strength and uses of materials is an example of (the principles of pure science; technology; the interaction of basic and applied research; a theoretical model).

NOUNS AND THEIR ASSOCIATED VERBS

To use a language properly, it is important to know not only the names of things (nouns) but also the names for the actions that are associated with them (verbs): the actions are as important as the objects. Here is a list of the verbs connected with some important nouns appearing in this unit and also Units 1 and 2:

to obtain	evidence	to	invent	a machine
	knowledge		design	an instrument
	information		develop	a process
	results		modify	a technique

design, plan make, perform, conduct, carry out control time repeat	an experiment	develop suggest prove, validate disprove modify discard support put forward test	a theory a hypothesis

to — to

EXERCISE (a) Complete the following sentences with suitable verbs from the above tables:

1 A scientist must ... adequate evidence to ... a theory.

2 We must ... many experiments in order to ... a new process.

3 If an experiment is not successful, we must ... it.

4 An experiment must be carefully ...ed if we want it to ... a theory properly.

5 Technologists ... new machines to increase production.

6 If a series of carefully ...ed experiments dis... a hypothesis, we should ... it.

7 Engineers ... experiments to ... information about the strength of materials.

8 When new instruments are ...ed, the scientist is able to ... further experiments which frequently have the result of ...ing or ...ing well-established theories.

(b) What verbs are associated with the following nouns? (They all appear either in this unit or Units 1 and 2):

a problem; observations; research; a statement; relationships; mathematical operations.

WORD-BUILDING

1 The suffix *-al*. This forms adjectives from the corresponding nouns, e.g. 'practic*al*' (l. 11) from *practice*, 'theoretic*al*' (l. 29) from *theory*. Adjectives from the names of sciences ending in *-ics* also take this suffix, e.g. mathematics—mathemat*ical*.

NOTE: theory—theor*etical*; geometry—geometr*ical*; hypothesis—hypoth*etical*; techni*que*—techni*cal*; machine—mech*anical*; centre—centr*al*; air—a*erial*; cycle—cyc*lical*.

EXERCISE Form further adjectives from the following:

addition; condition; experiment; nature; neuter; operation; section; region; analysis; matter.

2 The prefix *inter-*. This is added to verbs and derivatives to give the extra meaning of: between, among, one with the other, e.g. *interconnection* (l. 3), *interaction* (l. 37).

EXERCISE (a) Form adjectives from the following:

dependent; related; national.

(b) Form verbs from the following, using the prefix *inter-* in all cases:

act; breed; change; connect.

Structure Study

THE *-ing* FORM (I)

The main structure used in the passage of Unit 4 is the *-ing* form of the verb. This is frequently used by scientific writers because of its conciseness and flexibility, and is employed in a number of different ways. Note the following examples:

(i) 'Are these two totally different types of activity, *having* ... no interconnection?' (l. 2)
'The equations *describing* the behaviour of fundamental particles.' (l. 12)
In both these cases the *-ing* form takes the place of a longer phrase with *which*, *who* or *that*. Thus in the first example *having* is equivalent to *which have*; in the second, *describing—which describe*.[1]

(ii) 'Such activities as *investigating* the strength ... of materials, *extending* the findings of pure mathematics ... and *developing* the potentialities of atomic energy ...' (ll. 22–26)
Here, the *-ing* form takes the place of the derived noun: *investigating = the investigation of*, *extending = the extension of*, etc.

(iii) 'These theories ... become the *working* laws of science.' (l. 8).
'These two branches of science are mutually dependent and *interacting*.' (l. 45–46)
In the above examples, the *-ing* structure is used as an adjective describing (which describes) the noun it is associated with.

(iv) 'Let us begin by *examining* what is done by each.' (l. 4).
'(Radioactivity is applied) in methods of *estimating* the ages of objects.' (l. 34)
Note that in these cases the *-ing* form follows a word like *by*, *of*, *with*, *from*, *in*, etc. (prepositions). Many nouns, verbs and adjectives are associated with prepositions that complete their meaning, and any verb following (which follows) these prepositions takes the *-ing* form.

(v) 'The technologist, in *applying* a particular concept of pure science ... reveals a ... limitation in the theoretical model.' (ll. 38–39).
Here the *-ing* form is used, in association with a preposition, in place of a longer phrase with a noun or verb. Thus in the example given above, *in applying* is equivalent to: during the process of the application of ...

[1] A slightly different case occurs in l. 11, where the verb '*confining*' refers to 'the pure scientist', and is equivalent to the phrase '*and confines*'.

NOTE: The *-ing* form is also used in two additional cases which are not illustrated in passage 4. These are:

(vi) As part of the Continuous (Progressive) Tenses,

(vii) After certain verbs, such as *avoid.*

These uses are illustrated in Units 6 and 7 respectively.

Focus your attention for the moment on the first two uses demonstrated above:

1 As a replacement of (replacing) a phrase with *who, which* or *that*

EXERCISE (a) Find further examples of this use in the passage.

(b) In the following sentences, replace the phrases in italics with the appropriate *-ing* form:

1 A person *who does* research in chemistry is called a research chemist.

2 The research scientist often comes across problems *that require* new types of instrument for their solution.

3 New types of instrument frequently lead to discoveries *which modify* the basic principles of science.

4 Scientists sometimes develop theories *which affect* other human activities such as morals or religion. (Do you agree that morals and religion are 'activities'?).

5 Technologists develop new techniques *which increase* man's control over his environment.

6 Theories *that describe* the nature of the universe are constantly revised by scientists.

7 The force *that holds* the solar system together is gravitation.

8 The total amount of chemical reactions *that take* place in a living organism is its metabolism.

9 Viruses are entities *that occupy* a position between living and non-living matter.

10 Scale models *that reproduce* the behaviour of flowing water are used in hydraulics research.

11 Some rockets use liquid fuels *that consist* of oxygen and kerosene.

12 Newton described the laws *that govern* the motion of falling bodies.

2 Replacing a noun

EXERCISE (a) Find further examples of this use in this passage and also in the passage of Unit 1 (*The Scientific Attitude*).

(b) In the following passage replace the word or phrase in italics by the appropriate *-ing* structure:
The work of the technologist is *the application of* the theories of

the research scientist, *the development of* new processes, *the invention of* new machines and *the extension of* the uses of techniques *which exist* already. It is often difficult to separate his work from some of the activities *which belong* to the pure scientist, such as *the design of experiments* and *the elaboration of* hypotheses.

Discussion and Criticism

1 How are the following sciences applied for technological purposes: geology; meteorology; chemistry; psychology? Give details.

2 Do you agree that many pieces of applied research began as pure science? (ll. 28–29) Give examples.

3 Name some materials used in engineering. Why is it important to test their strength?

4 Give any details you know about an inventor and his work, and if possible, about its connection with basic research.

5 Do you know any examples of an advance in the field of pure science which was dependent on the development of new instruments? (ll. 41–44).

6 Give examples of how the following are applied in the discipline you study yourself: radioactivity; statistics; optics; electricity; magnetism; psychology.

7 Do you agree with the conclusions of the last paragraph? (ll. 45–48). Give reasons for your answer.

8 Radio, television (TV) and films often give a favourable picture of the pure scientist, and an unfavourable one of the applied scientist (excluding doctors). Is this true in your own country? Why? Give your own opinion in the matter.

9 Give examples of man's increasing control over his environment.

Unit 5

(Revision of material appearing in Units 1–4)

'DIRECTED' RESEARCH?

A recent phenomenon in present-day science and technology is the increasing trend towards 'directed' or 'programmed' research; i.e. research whose scope and objectives are predetermined by private or government organizations rather than researchers themselves. Any scientist working for such organizations and investigating in a given field therefore tends to do so in accordance with a plan or programme designed beforehand.

At the beginning of the century, however, the situation was quite different. At that time there were no industrial research organizations in the modern sense: the laboratory unit consisted of a few scientists at the most, assisted by one or two technicians, often working with inadequate equipment in unsuitable rooms. Nevertheless, the scientist was free to choose any subject for investigation he liked, since there was no predetermined programme to which he had to conform.

As the century developed, the increasing magnitude and complexity of the problems to be solved and the growing interconnection of different disciplines made it impossible, in many cases, for the individual scientist to deal with the huge mass of new data, techniques and equipment that were required for carrying out research accurately and efficiently. The increasing scale and scope of the experiments needed to test new hypotheses and develop new techniques and industrial processes led to the setting up of research groups or teams using highly-complicated equipment in elaborately-designed laboratories. Owing to the large sums of money involved, it was then felt essential to direct these human and material resources into specific channels with clearly-defined objectives. In this way it was considered that the quickest and most practical results could be obtained. This, then, was programmed (programmatic) research.

One of the effects of this organized and standardized investigation is to cause the scientist to become increasingly involved in applied research (development), especially in the branches of science which seem most likely to have industrial applications. Since private industry and even government departments tend to concentrate on immediate results and show comparatively little interest in long-range investigations, there is a steady shift of scientists from the pure to the applied field, where there are more jobs available, frequently more highly-paid and with better technical facilities than jobs connected with pure research in a university.

Owing to the interdependence between pure and applied science (see Unit 4), it is easy to see that this system, if extended too far, carries considerable dangers for the future of science—and not only pure science, but applied science as well.

Comprehension

1 What is programmed research?

2 What differences in working conditions are there between the present-day scientist and scientists working at the beginning of the century?

3 Describe laboratory conditions at the beginning of the century.

4 What were the origins of programmed research?

5 Why is it difficult nowadays for the individual scientist to make significant contributions to science?

6 Mention one of the effects of organized research on the attitudes of scientists.

7 What is a common attitude of private industry and government departments towards scientific investigation?

8 What part does money play in the situation discussed in the passage?

9 How is the situation likely to affect the future of science?

10 Give another word meaning the same as 'applied science'.

11 Give two other words for 'directed' research.

Word Study Revision

EXERCISE (a) The reading passage contains numerous examples of suffixes and prefixes used in Units 1–4. Pick these out, and give the meaning of the prefix or suffix in each case.

(b) Give the opposites of: suitable; likely; frequent; limited; essential; able; efficient.

(c) In the following sentences, use a verb with *en* as a prefix or suffix to replace the expression in italics:

1 They *increase the length of* the pipe.

2 We *made* the road *wider*.

3 The engineers *increase the strength of* the bridge.

4 That government department plans to *make* its laboratories *larger*.

5 The tube was *made shorter*.

6 The high temperature had the effect of *making* the metal *softer*.

7 The softening of the metal had the effect of *making* the whole structure *weaker*.

(d) Add the appropriate suffixes to form the names of specialists in the following scientific disciplines: archaeology; obstetrics; ecology; agronomy; economics; physics; statistics.

(e) Using nouns formed from verbs given in the exercises in Unit 1, complete the following:

1 The po...ion of England is about 50,000,000.

2 Governments talk about a re...ion of nuclear armaments.
3 There is a close re...ion between pure and applied science.
4 The use of radio was responsible for a great increase in the speed of tr...ion of messages.
5 What are the main op...ions of arithmetic?
6 Many new devices were used in the co...ion of the latest type of computer.
7 Atmospheric pressure varies considerably, but these fl...ions can be recorded by means of a barograph.

(f) Using nouns formed in the appropriate exercise of Unit 2, complete the following:

1 The accurate me...ment of quantities is very important in science.
2 A good scientist is highly critical of his own st...ments.
3 Scientific instruments and machines frequently need ad...ment before they are used.
4 The de...ment of scientific e...ment is a specialized process.
5 Experimental methods often lead to the es...ment of working principles or laws.
6 One of the aims of programmatic research is the im...ment of industrial techniques.

(g) Give the opposites of: tight; to raise; deep; often; horizontal; regular; to increase.

Structure Study Revision

1 Simple Present Tense

EXERCISE (a) Make the following sentences interrogative:

1 She wants to know the answer to the problem.
2 He carries out experiments.
3 Some scientists use complex procedures.
4 He tests his theory very carefully.
5 Good laboratory conditions act as a stimulus to research.
6 The scientist applies persistent and logical thought to his problems.
7 The experiments reveal a limitation in the theoretical model.

(b) From the above sentences, choose appropriate ones only (i.e. that make sense) to put in the negative.

2 Simple Present Passive

EXERCISE (a) Put the following sentences into the passive (decide whether an agent with *by* is necessary or not):

1 People use mathematics in all branches of science.

2 People apply scientific methods in many everyday activities.
3 People obtain a great deal of useful knowledge from the study of nature.
4 People usually use the decimal system for scientific purposes.
5 People control experiments to obtain accurate results.
6 People obtain accurate results from controlled experiments.
7 Different kinds of people often make attempts to deceive the ordinary citizen.

(b) Put the following sentences into the passive (decide whether an agent with *by* is necessary or not):

1 Government departments apply programmed research on an increasing scale nowadays.
2 Specialized technicians develop modern scientific instruments.
3 The work of the technologist frequently helps the basic scientist.
4 Nowadays social scientists investigate an increasingly wide range of problems.
5 An electric pump raises the water.
6 Geologists use radioactivity as a means of dating rocks.
7 Scientists require very strong evidence before they accept a theory.

3 Simple Past Tense

EXERCISE (a) Put the following into the Simple Past Tense:

1 The bridge bends under its own weight.
2 The electric motor drives the pump.
3 The scientist chooses between several possible solutions.
4 The Torricelli experiment becomes famous.
5 The engineers find a new method of testing metal-fatigue.
6 The water in the pump rises.
7 The pressure falls slightly.

(b) Repeat the following paragraph, putting all the verbs into the Simple Past Tense:

The geochemist goes to sea in a ship equipped with special pipes. Technicians then push these pipes through thousands of feet of water until they strike the bottom (bed) of the ocean. Then they drive the pipes into the sea-bottom, and when they bring them up again they are full of mud. The geochemist takes it to his laboratory and examines it carefully. This mud gives him evidence about the constitution of the rocks of the earth.

4 Simple Past Passive

EXERCISE Put the sentences of **2**, Exercises (a) and (b) above into the Simple Past Passive.

5 The *-ing* form of the verb

EXERCISE (a) The reading passage gives various examples of the *-ing* form. Pick these out, and replace them, where possible, by another structure having the same meaning.

(b) Replace the phrases in italics by an *-ing* form:

1 Air *that pushes* on the surface of the water causes it to rise in a vacuum pump.

2 Liquids *which weigh* more than water rise less in a vacuum tube.

3 The pressure *that exists* at the bottom of the ocean is greater than that on the surface.

4 Experiments *which proved* the effects of air pressure were conducted by Torricelli and Pascal.

5 Numbers *that consist* of digits are called integers.

6 Statistics is a discipline *which affects* all the other sciences.

7 The technologist is concerned with *the development of* new processes and techniques.

Discussion and Criticism

1 Give examples of programmed research in any field.

2 Give examples of types of research which it is difficult for a single scientist, working alone, to carry out.

3 Describe any cases you know of an individual scientist contributing to the advance of science.

4 Why does private industry want immediate results for its research?

5 Explain the last paragraph of the passage. Why may programmed research become a danger to the future of applied research? What is your own opinion?

6 To what extent is research directed or programmed in your country? Give details.

7 Do you think any research should be directed? If so, what kinds, and to what degree? Give good reasons for your answers.

8 What are the arguments for and against allowing scientists complete freedom to do the research they want to do, rather than what the Government, or some other outside person or organization, consider to be important?

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