Swales, J. (1971). *Writing scientific English.* London: Nelson.

Unit 8 Experimental and explanatory descriptions

Descriptive work plays a large part in most kinds of scientific writing. This unit analyzes and gives practice in some of the most important types of scientific description. These are:

descriptions of experiments
descriptions of how things work
descriptions of how things are produced
descriptions of how things were discovered or invented

Experimental descriptions

It is not the job of this book to say anything about how experiments should be organised and conducted. However, it can have something to say about how the language used to describe experiments can be organised. In previous units many of the structures commonly used in this kind of writing have already been practised. Now it is time to look more closely at the organisation of individual sentences into paragraphs

Study this passage:

Turn a gas-jar upside down and a wooden splint is burnt under it for about a quarter of a minute. I close the jar with a cover and then we put it the right way up on the bench. Next you remove the cover, 2 cm of lime-water is quickly added. Replace the cover and we shake the jar.

This is part of a description of an experiment to show that CO_2 is formed when wood burns. Although the individual sentences are grammatically correct, it is not a good description. (Why?)

The subject-form should not be changed unnecessarily.

Decide which subject-form you are going to use before beginning a description. Here are the five possibilities:

(a) Imperative	*Turn a gas-jar upside down.*
(b) Passive	*A gas-jar is turned upside down.*
(c) First person singular	*I turn a gas-jar upside down.*
(d) First person plural	*We turn a gas-jar upside down.*
(e) Second person plural	*You turn a gas-jar upside down.*

Although all five forms are possible (a) and (b) are better choices than the others. (c) is usually thought to be too personal. (d) should be used only if the experiment has actually been done by two or more people. (e) is best used for writing instructions, but not descriptions.

Here is the passage rewritten in subject form (a):

Turn a gas-jar upside down and burn a wooden splint under it for about a quarter of a minute. Close the jar with a cover and then put it the right way up on the bench. Next remove the cover and quickly add 2 cm of lime-water. Replace the cover and shake the jar.

○ **Exercise 1** Rewrite the passage using subject-form (b).

∧ **Exercise 2** Rewrite at least one of these grammatically correct descriptions, organizing them better.

The preparation of water-gas

You soak a small quantity of asbestos wool in water. The asbestos wool is then pushed to the bottom of a heat-resistant test-tube. Then I fill half of the test-tube with small pieces of charcoal. The test-tube is closed with a holed cork. We push a piece of tubing through the cork and an apparatus is set up for collecting the gas over the water. Heat the part of the test-tube containing the charcoal and you collect the gas.

Title: ....

We tie a thread to a metal object which is then suspended from a spring-balance. When the object hangs freely I note the reading on the balance. A graduated cylinder is taken and you then fill it with water up to a convenient point. Place the object in the water in such a way that you cover it completely. Ensure that it hangs vertically and does not come into contact with the walls of the cylinder. We then note the new reading on the spring-balance and the new level in the cylinder.

Now read this description carefully:

A clear glass capillary tube is fixed vertically in a beaker. The beaker contained a liquid which wets glass, such as water or petrol. The liquid rose up the tube and reaches a certain height which depended on the nature of the liquid and the diameter of the tube. With a given liquid, the amount of rise is proportional to the narrowness of the tube. The thickness of the walls of the tube had no effect on the phenomenon. The surface of the liquid at the top of the column was concave to the air.

Again this description is badly organized. (Why?)

The narrative tense should never be changed unnecessarily.

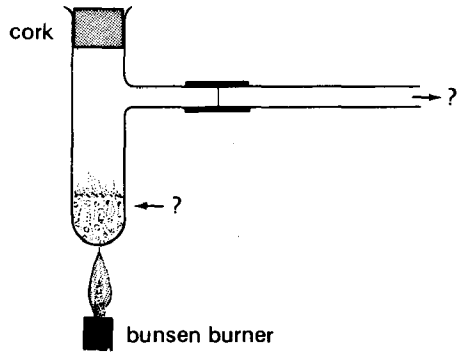
The narrative tense is the tense used to describe the series of operations carried out in the experiment. The narrative tense should be either the Past Simple or the Present Simple, never both in the same description. (However, the special uses of the Present Perfect (Unit 7) should not be forgotten.) But remember that even if the Past Simple is used for the narrative, general statements, such as *water wets glass*, must still be in the Present Simple.

○ **Exercise 3(a)** Rewrite the description of Capillary Elevation, organising the tenses. (Choose either Present or Past as narrative.)

□ **Exercise 3(b)** Write a description of Capillary Depression (i.e., what happens to a liquid which does not wet glass, such as mercury.)

△ **Exercise 4** Turn this description into the passive using the Past Tense as narrative. (Remember that this does not mean that *all* the verbs should be in the past passive.)

Take a beaker of water and heat it over a burner. Record its temperature every minute. The temperature rises steadily until it reaches 100° but after that it remains constant. Now mark the side of the beaker to indicate the water level. Leave the beaker to boil for several minutes and again record the level. Notice that some of the water has disappeared. The water is changing into water vapour (water vapour from boiling water is called steam). We deduce that the heat being supplied to the boiling water is being used up in the process of turning water into steam. Heat absorbed in this way is known as latent heat.



△ **Exercise 5(a)** Describe a simple experiment which can be done with the kind of apparatus shown on the last page.

□ **Exercise 5(b)** Describe an experiment which can be done with a more elaborate and complicated version of the apparatus on page 100.

In Unit 4 we saw that most adverbs go immediately before the past participle:

The phosphorus is carefully dried.
Tables are usually made of wood.

Now notice that in ordinary spoken English we usually find:

Then the light is turned on.
First the water level goes down.
Now the answer can be given.

But in technical written English:

The circuit is then completed.
The water level is first depressed.
The answer can now be given.

A second difference between technical and non-technical writing is that when people write technically they tend to use verbs of Latin origin rather than phrasal verbs* (that is verbs + particles like *take off* or *push down*). Phrasal verbs and Latin verbs belong to different styles. It is therefore better in any one description to keep mainly to one type of verb. Here are a few of many examples of saying (approximately) the same thing:

Technical 'Latin' verbs	*Less technical phrasal verbs*
ignite	*set fire/light to*
insert	*push in*
depress	*push down*
consume	*use up*

(continued)

* As this book is not primarily concerned with improving comprehension and building up vocabulary, phrasal verbs are only mentioned in passing. Getting students to produce them naturally and correctly is not an easy matter, because phrasal and prepositional verbs fall into a large number of grammatical sub-classes. However, they would certainly be included in any advanced course, or any course aimed at developing spoken technical English.

Technical 'Latin' verbs	*Less technical phrasal verbs*
equalize	*make up*
occupy	*fill up*
extinguish	*put a fire/light out; go out*
add	*put in*
remove	*take off/away*
invert	*turn upside down*
place	*put*

(If you look at Exercise 6, you will see how some of these verbs are used; others should be used in Exercise 7.)

The third aspect of the organization of descriptions is rather more difficult because it is a problem of style. Try and avoid putting a 'technical' clause or sentence next to a 'babyish' clause or sentence. Here are three examples of how *not* to write:

The heat lost by a solid is equal to // how much hotter the water and the container have got.

If we do some experiments and some sums we will find that // the velocity V of sound in a given gas is proportional to the square root of the absolute temperature T.

If you set a light to a pile of papers, the paper catches fire and bright hot flames eat across the sheets until all the paper has been burnt up. // In such a process a certain amount of energy in the form of both heat and light is emitted.

The (//) shows that there is a break in style. If possible, try not to have such breaks of style in your own descriptive writing.

Exercise 6 Look at this experimental description and cross out the alternatives which you think are more babyish, more informal or more likely to be used when speaking rather than writing.

A small { bit / piece } of phosphorous is carefully dried and { placed / put } on a crucible lid inside a bell-jar { It is then ignited / Then it is set on fire } with a warm glass rod and a stopper is { inserted / pushed in } The phosphorous burns producing { clouds / dense white fumes } of phosphorous pentoxide which react with the water. The water level is first depressed as the air { becomes warm / gets hot } but { eventually / in the end } it rises as the oxygen is used up { As you must make sure that the pressure left over is normal / In order to restore the pressure of the remaining gas to normal } water is now poured into the trough until the water levels are made equal. Approximately one-fifth of the bell-jar { is now occupied with water / now has water in it } showing that one-fifth of the air { is consumed / is used up } when phosphorous burns.

Exercise 7 Here is an informal description of an experiment. Rewrite it in formal scientific English.

An experiment to show that carbon dioxide and water are formed when a hydrocarbon burns in air

Set a candle alight and carefully put an upside-down gas-jar over it until the flame goes out. Then take the gas-jar off and put some lime-water in it. Put a cover over the jar and shake it about. The lime-water will turn milky. This shows that there is some carbon dioxide inside. Then let the flame of the candle burn against a cool surface. You will see some drops of a liquid. Put some copper sulphate powder into this liquid and you will see that it turns blue. This shows that the liquid is water.

The last few pages have given practice in writing technical descriptions using the passive. Importance has been given to this kind of writing because it is more difficult. It should not be thought, however, that the passive is always better. Other subject-forms are acceptable as long as they are used consistently.

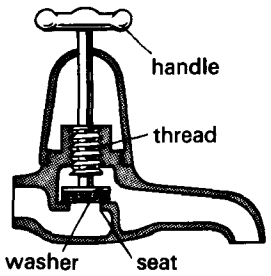
Descriptions of how things work

This type of description usually requires a diagram. A diagram makes the explanation easier to follow. A diagram can also be used to avoid the problem of vocabulary. Sometimes you will not know the name for a part of a machine or a piece of apparatus. Never mind! Draw a diagram and label the parts you do not know *A*, *B*, *C*, etc.

Read this explanatory description carefully:

A water tap is a device for turning on and off a flow of water. Its most important parts are a rod with a handle on the top and a washer which is fixed to the bottom of the rod. The metal parts of a water tap are usually made of brass because brass resists corrosion. The washer is made of a flexible material such as rubber or plastic.

A Water Tap



When the handle is turned the rod either rises or descends because of the spiral thread. The column descends until the washer fits firmly in its 'seat'. (This position is shown in the diagram.) The tap is now closed and no water can flow out of the pipe.

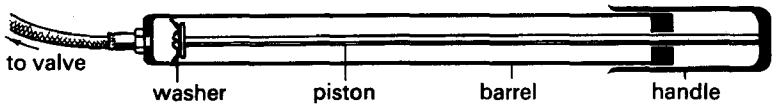
○ **Exercise 8(a)** Cross out the wrong alternatives. (*S* = sentence)

1 This description consists of 1/2/8 paragraphs.
2 The first paragraph describes a tap/explains how it works.
3 The second paragraph describes a tap/explains how it works.
4 Each paragraph contains 1/3/4/6 sentences.
5 The first sentence (*S*1) is/is not a definition.
6 *S*2 describes the main moving parts of a tap/the main fixed parts.
7 *S*3 explains why brass resists corrosion/why brass is used.
8 *S*4 explains/does not explain why rubber is often used for a washer.
9 *S*5 begins with a subordinate clause/a main clause.
10 *S*6 explains/does not explain why the column goes down.
11 *S*7/*S*8 links the description to the diagram.
12 *S*7 must come before *S*8/it doesn't matter which sentence comes first.

○ **Exercise 8(b)** Write a description of how a water tap works, choosing only five of the eight sentences given in the original passage. In other words, decide which are the five most important sentences and write them out.

○ **Exercise 9** Write a continuous description of how a bicycle pump works choosing one of the given alternatives each time. Your description should therefore contain nine sentences arranged as a passage of continuous English.

A Bicycle Pump



1 A bicycle pump is a device { for forcing water through a narrow tube. / for extracting air from tyres. / for moving air against a pressure difference.

2 It { can / cannot / might } work without the valve in the bicycle tyre.

3 { Essentially, / Firstly, / Importantly, } it consists of a hollow barrel, a piston with a handle, and a leather washer at the end of the piston.

4 If the piston is left at the bottom of the barrel the pressure is approximately equal { that of the atmosphere. / to that of the atmosphere. / to that of the atmospheric.

5 When the piston is drawn sharply upwards the air below the piston rises, thus causing the pressure { to fall / to rise / to remain constant.

6 Atmospheric pressure then pushes the sides of the leather washer { away from / against / through } the barrel, allowing air from outside to enter.

7 When the handle is pushed down the air pressure below the piston { is rising. / rose. / rises.

8 This pressure forces the sides of the soft leather washer against the sides of the barrel, { stopping air from entering. / stopping air from escaping. / allowing air to escape.

9 The air is then pumped { through the tyre-valve into the tyre. / through the tyre into the tyre-valve. / by the tyre-valve into the tyre.

Notice that three of the nine sentences end with an *-ing* clause:

5 .... *the piston rises, thus causing .....*
6 .... *pushes .... the barrel, allowing air from outside to enter.*
8 .... *forces .... the barrel, stopping air .....*

Finally, here is an example from the last section:

The phosphorous burns, producing dense white fumes of phosphorous pentoxide.

These are *-ing* clauses of result:

x happens, causing *y* to happen.

Such *-ing* clauses are particularly useful in descriptions of how things work, because with them we can avoid describing a series of events using a series of 'ands':

x happens, and *y* happens, and then *z* happens.

A typical sentence structure is subordinate clause + main clause + *-ing* clause. (5) is an example of this:

(a) (subordinate clause)	*When the piston is drawn sharply upwards,*
(b) (main clause)	*the air below the piston rises,*
(c) (*-ing* clause)	*thus causing the pressure to fall.*

○ **Exercise 10** Here are the mixed-up parts of ten (a) + (b) + (c) sentences of this type. Join them together correctly. The first one has been done.

(a)

When the piston is drawn sharply upwards,
When the oven rises in temperature,
As the oven cools,
When the mixture is ignited,
If a bubble of air is introduced into a barometer,
If one end of a metal bridge is fixed to the ground,
When water is heated from 0° C,
If there is a good head of water,
As a rivet cools,
When plates of copper and zinc are placed in dilute sulphuric acid,

(b)

the zinc reacts with the acid,
it pushes the mercury down,

the invar rod is pulled back,
the gas is re-admitted,
the air below the piston rises,
it contracts,
the combustion forces down the cylinder,
the turbine will rotate at high speed,
the other usually rests on a roller,
it contracts,

(c)

thus producing energy.
making the instrument inaccurate.
reaching its maximum density at 4° C.
so cutting off the gas.
drawing the two plates together.
causing the crankshaft to turn.
thus generating large quantities of electricity.
raising the temperature.
thus allowing the bridge to alter its length.
thus causing the pressure to fall.

As some of these (c) clauses show, the 'result' nature of the *-ing* clause can be emphasized by putting *so, thus* or *thereby* at the beginning.

◺ **Exercise 11** Complete as many of these sentences as you can, by writing main clauses of your own.

1 ...., causing the water to condense.
2 ...., thus causing the bell to ring.
3 ...., producing a spark.
4 ...., thereby showing that the solution is acidic.
5 ...., causing the vehicle to lose speed.
6 ...., thus controlling the speed of the engine.
7 ...., indicating that a chemical change has taken place.
8 ...., so breaking the current.
9 ...., thereby forcing the rocket into the air.
10 ...., showing that the water molecules pass across the membrane into the sugar solution.

△ **Exercise 12** Write a simple explanatory description of one of the following (diagrams may be used):

1 a bunsen burner	3 a bus	5 a fountain pen
2 a burette	4 an electric switch	6 a thermometer

□ **Exercise 13** Write a more detailed description of how one of the following works (diagrams should be used):

1 an electric bell
2 one type of galvanometer
3 a telescope
4 a thermostat
5 a thermos flask
6 a wind-mill

How things are produced

We now come to explanations of industrial processes; how substances are purified, how minerals are extracted, how metals and alloys are produced, how objects and materials are manufactured.

Study this description:

Sulphur extraction by the Frasch process

In some parts of the world sulphur deposits lie too deep to be mined in the ordinary way. However, in about 1900 an American engineer called Herman Frasch developed a process for the extraction of this deep-lying sulphur. The Frasch process depends on the fact that the melting point of sulphur is only a little above the boiling point of water. The process consists of three basic operations. First, large amounts of water are super-heated; in other words, the water is heated under pressure to above its normal boiling point. Secondly, this super-heated water is pumped down the well so that it melts the sulphur. Finally, the molten sulphur is pumped to the surface.

△ **Exercise 14** The description contains seven sentences. (*S* = sentence) Complete the following analysis:

*S*1 A statement of the problem of sulphur extraction .....
*S*2 A statement of when the problem .....
*S*3 A description of the basic principle .....
*S*4 A statement that there are only three .....
*S*5 A description of the first .....
*S*6 A description of the .....
*S*7 A description .....

We have seen that the description of sulphur extraction is organized into two main parts: a brief scientific and historical introduction, and a summary of the main operations. The description is also organized in another way:

In some parts of the world (*sulphur deposits lie too deep*) to be mined in the ordinary way. However, in about 1900 an American engineer called (*Herman Frasch developed a process*) for the extraction of (*this deep-lying sulphur*). (*The Frasch process*) depends on the fact that the boiling point of sulphur is only a little above the boiling point of water. The process consists of three basic operations. First, (*large amounts of water are super-heated*); in other words, the water is heated under pressure to above its normal boiling point. Secondly, (*this super-heated water*) is pumped down the well so that it (*melts the sulphur*). Finally, (*this molten sulphur*) is pumped to the surface.

As the arrows show, some of the sentences are linked together by what might be called 'key-phrases'. Important information given in one sentence is referred to again in a later sentence. However, in the later sentence the information is put in a less central position. This is shown below:

Central position	**Non-central position**
(The verb phrase carries the information)	(The noun phrase carries the information)
*S*1 *Sulphur deposits lie too deep*	*S*2 *This deep-lying sulphur*
*S*3 *Herman Frasch developed a process*	*S*4 *The Frasch process*
*S*5 *Large amounts of water are super-heated*	*S*6 *This super-heated water*
*S*6 *So that it melts the sulphur*	*S*7 *This molten sulphur*

(Notice also the use of *this* to refer back to something already mentioned.)

The use of such 'key-phrases' can do quite a lot to improve a foreigner's written English. This is because 'key-phrases' make descriptions easier to understand, while, at the same time, they avoid repeating the same information in exactly the same way. And these two problems of being clear and not repeating yourself are particularly difficult if English is not your first language.

○ **Exercise 15** Complete this passage. Remember 'key-phrasing.' (Each .... signifies one word.)

Copper is usually extracted from an ore called copper pyrites. Copper ..... are minerals containing a considerable proportion of copper sulphides. The ..... process is known as smelting. Basically, this ..... consists of heating the ..... in a furnace through which a stream of air is blown. The ..... melts the ore while the oxygen in the ..... combines with the unwanted elements and removes them. For example, the ..... combine with the oxygen to form sulphur dioxide. Because .... is a gas it can easily be removed from the ..... .

○ **Exercise 16(a)** Rewrite the following passage using the verbs below. Use each verb once only.

Pig iron .... from iron ores such as iron carbonate. The extraction process .... as smelting. First, the ore .... with coke and crushed limestone. This mixture .... into a blast furnace. As the mixture falls into the furnace it .... a blast of hot air which fires the coke and .... the temperature of the mixture to about 1800° C. As the coke .... some of it .... with the oxygen in the air to form carbon monoxide. This, in turn, ... with the iron to form oxide-free iron and carbon dioxide. Some of the other impurities, such as sulphur, ... by combining chemically with the limestone.

burns	*is extracted*
combines	*is then fed*
meets	*is known*
raises	*is mixed*
reacts	*are removed*

△ **Exercise 16(b)** Fill in the first column of 'key-phrases'

the extraction process
the ore
this mixture
the air (to form ....)
This, (in turn ....)

In the above passage there are two sentences of the structure:

x + verb .... y + *to* + verb + z (where *to* = *in order to*)

One is: *This, in turn, reacts with the iron to form oxide-free iron and carbon dioxide.*

What is the other?

Now compare these two sentences:

(a) *Impurities are eliminated by passing the liquid through a filter.*
(b) *The liquid is passed through a filter in order to eliminate impurities.*

(a) and (b) are two different ways of saying similar things. But they are not saying the same thing. Remember that the subject is a 'strong' position in a sentence. Therefore, a different subject will produce a slightly different description. (a) for instance is principally about *impurities*, while (b) is principally about *the liquid.* In this way it is not difficult to see that:

(a) explains how the impurities are eliminated.
(b) explains why the liquid is passed through the filter.

Now compare:

(c) *CO is formed by combining the burning coke with oxygen.*
(d) *The burning coke combines with the oxygen to form CO.*

Is (c) or (d) the better way of describing part of the iron-smelting process?

As the main purpose of iron-smelting is not to produce *CO*, (d) is a much better descriptive statement. In (c) too much importance is given to how *CO* is formed.

Sentences like (b) and (d) are often called statements of purpose.

○ **Exercise 17** Read this description:

The Treatment of water

Modern methods of treating water usually involve three stages. First, impurities are allowed to settle to the bottom by storing the water in reservoirs. This settling period also kills about 90% of the bacteria. Then the smaller solids and more of the bacteria are removed by filtering the water through sand and gravel. Finally, most of the remaining bacteria are killed by adding a minute proportion of chlorine to the water.

This description is not really satisfactory because too much importance is given to impurities, bacteria, etc., and not enough to water. (Consider the title of the passage.) More emphasis should have been given to what was done to the water and why.

Rewrite the description, using statements of purpose; in other words, *water* should be in the 'strong' subject position.

□ **Exercise 18** Write organized outline-plans for descriptions of two of the following. Then turn one of the plans into a descriptive passage.

1 Coal-mining
2 The refining of mineral oil
3 The production of textiles
4 Glass-making
5 The manufacture of paper
6 Making steel in a Bessemer converter
7 Generating electricity from a hydro-electric plant
8 The manufacture of fertilizers

How things were discovered or invented

Read this explanatory description:

The discovery of the velocity of light

In 1676 Römer discovered that light travels at a determined speed. His discovery was based on the fact that a few years previously other astronomers had identified the satellite of the planet Jupiter. It had also been discovered that each satellite took a certain time to make one circuit of the planet. Römer observed the precise time that one of these moons was in a given position in relation to the planet. For six months he noted that this position was reached progressively a little later each day. After six months he found that the satellite reached the predetermined position just over 16 minutes later than six months previously. For the following six months the times became progressively shorter. Römer explained this phenomenon in the following way. In six months the earth travels exactly half its orbit round the sun. Hence the shortest times were recorded when the earth was nearest Jupiter and the longest when the earth was farthest away, the maximum difference being 2 × 93 million miles (twice the distance from the earth to the sun). Therefore, the light had travelled an extra 186 million miles and it had taken approximately 16 minutes to do so. Römer thus calculated that the velocity of light is just under 190,000 miles a second.

In many ways descriptions of inventions and discoveries follow the same principles of organization as other kinds of description. However, the use of tenses is likely to be more of a problem. So, answer these questions:

(a) What is the main narrative tense used in the passage?
(b) Which four verbs are in the Past Perfect?

(c) Can you give reasons for using this tense?
(d) Which three verbs are in the Present Simple?
(e) Why are they in the Present Simple?

Notice that this kind of structure:

Römer { *discovered* / *observed* / *noted* / *found* / *calculated* } *that .....*

is more frequently used in describing inventions and discoveries than in most other types of scientific writing. (Why?)

It should also be noted that some of the 'rules' for indirect speech do not apply to scientific and technical English. Compare:

(a) *500 years ago many people thought that the earth was flat.*
(b) *300 years ago Newton stated that white light is composite.*
(c) *Römer discovered that light travels at a determinate speed.*

The last two example-sentences contain general truths. Such true general statements usually remain in the Present Simple even in indirect speech.

△ **Exercise 19(a)** Draw a diagram illustrating Römer's reasoning.

△ **Exercise 19(b)** Write definitions of the following:

1 light
2 a light
3 velocity
4 a mile
5 an orbit
6 a satellite

□ **Exercise 20** *Either* explain how the speed of sound can be measured, *or* describe any one invention or discovery you know about.