A Course in

Basic Scientific English

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Longman

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

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

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—mathemati*cal*.

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

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.