

# HOW WE LEARN

A SHORT PRIMER OF SCIENTIFIC  
METHOD FOR BOYS

BY

W. H. S. JONES, M.A.

Fellow and Lecturer of St Catharine's College  
Senior Classical Master at the Perse School  
Cambridge

Cambridge:  
at the University Press  
1916

## PREFACE

THIS little book is intended for the use of scholars of about sixteen, who for some terms at least have been trained to work out exercises in induction of the kind described and illustrated in the pamphlet *Scientific Method in Schools*. It sums up and systematizes, and to a certain extent develops, what they have been learning incidentally and partially. But it contains the very minimum that a pupil of sixteen should know, and it is suggested that the teacher would do well, before setting a section to be studied and learned at home, first to give an oral lesson expanding and illustrating the points treated in that section. The exercises at the end are intended to serve as written home work.

I hope that nobody will be offended at my intentional medley of trivial and important, of commonplace decisions and momentous discoveries. Such mixtures should not appear incongruous to anyone who remembers that "the method of discovery" is essentially one. My main object has been to impress upon the learner the unity of knowledge.

The teacher may find it useful if I append here a short list of problems that can be worked out by teacher and class together during the preparatory years before this primer is studied. The main characteristic of this work should be scientific thoroughness,

and the way of conducting it is described at some length in the pamphlet mentioned above. Some of these problems can be worked out by brighter and older pupils without help, but the teacher ought to be careful not to encourage unscientific habits by setting tasks above the powers of the class.

EXERCISES IN INDUCTION FOR PUPILS BETWEEN  
THE AGES OF 13 AND 16.

(1) Definitions of ordinary terms; e.g., *stupidity*, *hurry*, *piety*, *food*, *despair*, *sultriness*, *remorse*, *rapacity*, *statesman*, *quibble*, *pilgrim*, *drug*, *distress*, *instrument*, *hoard*, *harangue*.

(2) Grammar rules of various languages; e.g., the use of *which* and *who* in modern English; the difference between *le* and *lui* in French; the rules for the agreement of the relative in Latin; the use of the subjunctive in Latin to express indirect command; the rules for the agreement of the participle in French; the use of the supine in Latin.

(3) Historical commonplaces, e.g., the value of sea power; the value of strong government, even if tyrannical; the economic factor as a cause of wars; the dangers of absolute monarchy; oratory as a force in history; the factors most favourable to the growth of democracy.

(4) Mountain barriers as a protection from enemies; the origins of lakes; why towns have dwindled or disappeared; the effects of rivers upon the history of those dwelling in their basins; "the rule of the isthmus" in ancient times; the influence of large deserts upon surrounding countries.

(5) The law of levers; the law of pulleys; to find the centre of gravity of a disc, cube, etc.; the scientific meaning of "burning"; heat and expansion; elements combine in fixed proportions by weight (a working hypothesis formed from a few illustrations of the law); the effect of darkness upon plants.

(6) The marks generally left upon a man by his trade or profession (cobbler, farmer, fisherman, engineer, etc.); how to detect a smoker, a consumptive man, a short-sighted man, a man with a weak heart; the chief symptoms of common ailments.

I must thank Mr W. E. Johnson, Fellow of King's College, Professor R. L. Archer and Mr F. W. Westaway, for their great kindness in reading the proofs and correcting many errors and ambiguities.

W. H. S. J.

*September 1916.*

# CONTENTS

## CHAPTER I

	PAGE
INTRODUCTORY . . . . .	1

## CHAPTER II

WORDS AND THEIR MEANINGS . . . . .	8
------------------------------------	---

## CHAPTER III

SCIENTIFIC METHOD . . . . .	19
ADDITIONAL NOTE . . . . .	51

## APPENDIX

EXAMPLES OF INDUCTIVE REASONING DONE BY BOYS . . . . .	52
QUESTIONS . . . . .	60

# CHAPTER I

## INTRODUCTORY

### KNOWLEDGE AND SENSATION.

What is Truth? What is Knowledge? Philosophers and scientists have discussed these questions for well over two thousand years, but complete answers seem as remote as ever. There has, however, been great progress, particularly during the last three hundred years. The problems are not solved, but we see our way better, and realize that we are on the right road to the solution, even though it prove ultimately to be unattainable. It is with the certainties, the admitted facts, that this little book will deal. I wish to point out how each one of us can make his thoughts more accurate, and so express them that they may be accurately communicated to others.

Pause for a moment and try to examine the nature of your thoughts, the contents of your consciousness, the way in which your mind acts upon the sensations presented to it.

In your waking hours a continuous stream of impressions intrudes itself upon you, impressions of shape, colour, smell, taste, touch, sound—everything in fact

that is conveyed by the five senses—the meaning of which, in proportion to the activity of your brain, you try to make clear to yourself. If you are sleepy, inattentive or ill, the impressions are often unobserved. The remark is constantly heard, “I did not notice that.” But for the most part your mind is acting as an interpreter, explaining and arranging your sensations. You say to yourself:—

That is a horse.

The rain falls fast.

The church is round.

A bell is ringing.

These and similar statements are all interpretations of sense-impressions.

But the powers of the mind are not limited to present sensations and their interpretation. It can store up experience, a power we call *memory*, and so pass judgment on the past; it can also look forward and prophesy about the future.

There was a frost last week.

X. made fifty runs this afternoon.

Julius Caesar was a great Roman.

We shall go to London to-morrow.

There will be a shower soon.

A close examination reveals that the powers of the mind are conditioned by its past experience, in the light of which it works. This experience may be its own. It may, however, be the experience of other minds, passed on by one of the means we possess of transmitting thought. The character of Julius Caesar, for example, is known to us because we have accounts of him in writing, which preserve for us the thoughts of Caesar's contemporaries.

But even the simplest acts of thought about present sense-impressions imply experience. Let us take the sentence:—

That is an orange.

What are our sense-impressions? We see something yellow, that looks round. If that were all we might be uncertain whether it is an orange or a yellow ball. But if we handle the yellow thing we are enabled to come to a correct decision. Experience comes to our aid and tells us that balls do not “feel” quite so. Furthermore, the mere use of language, without which we cannot think to any great extent, implies experience. When I read, either to myself or aloud, the word *horse*, I immediately associate the sound with a kind of composite photograph in my mind which has been formed by a long succession of past sense-impressions, each one of which I have learnt to associate with the word. Kangaroos I have never seen, but the name suggests to me pictures and descriptions all of which appeal to my own sense-experience.

The material, then, with which mind works can be analysed into sense-impressions, which it interprets and stores up in what we call *experience*. Countless individuals have added to this stock of experience, and made it accessible to others by means of language, whether oral or written. The mind works by giving a meaning to these sense-impressions, by interpreting them, by explaining their relations one to another—in brief, by bringing order and system to what would otherwise be a meaningless chaos like the appearances in certain kinds of dreams.

This attention to order and system is the chief characteristic of knowledge or science. The scientist



aims at building out of the vast mass of human experience an orderly whole, with its parts duly and properly connected, an organized unity, a universe. So large is the material that few scientific men live long enough to do more than to arrange a very few facts, thus bringing nearer to completion a tiny portion of the huge building. But the workers are diligent and numerous. Bit by bit, little by little, the edifice progresses, and though we cannot yet see signs when, if ever, it will be completed, we must be content with the thought that each day registers an advance upon the preceding.

#### THOUGHTS ARE JUDGMENTS.

But we must return to our examination of thought. Whenever we interpret our sense-impressions, whenever, in fact, we really *think*, we are as it were pronouncing a verdict. A thought is a judgment:—

This tea is too sweet for me.

The train is on the move.

A cup is standing on the table.

All these sentences are expressions of a verdict, and represent a decision reached by the mind. Now a judgment of necessity implies two things between which a relation is declared to exist. The three sentences given above may thus be divided into their constituent parts:—

This tea | over-sweetness.

-The train\* | movement.

Cup | position on the table.

THE TESTING OF JUDGMENTS.

How can we be sure that the connections are rightly made, that the verdicts are true and the judgments correct?

In some cases we cannot prove the correctness at all. If I find the tea too sweet, no amount of argument, no demonstration that only one small lump was put into the cup, will induce me to alter my decision. I alone am a competent judge of my likes or dislikes. As to the motion of the train, I am ready to admit that my eyes may have deceived me, and if a number of bystanders deny my statement I shall probably acquiesce. Another person's judgment in such cases is, given equally good eyesight and equally good opportunities of observation, as likely to be correct as mine. Similarly in the case of the cup and the table. The evidence of better observers or a closer inspection on my own part may possibly lead me to conclude that it is not a cup but a mug, not a standing position but a lying position, not a table but a sideboard. These cases are simple, and not likely to cause any difficulty. But often the greatest care is necessary in testing a judgment. How to do so accurately we learn by studying logic and scientific method. We must now distinguish between them. Strictly speaking, logic deals with the rules to be observed during the process of reasoning. If certain assumptions are made, logic tells us what conclusion we can legitimately draw from them. It does not concern itself with the truth or falsity of the assumptions, but only with the proper way for thought to deal with any material that is put before it<sup>1</sup>.

<sup>1</sup> I use *logic* in the sense of *formal logic*.

Logic has no fault to find with the following argument:—

All butterflies have a thousand legs.

This creature is a butterfly.

Therefore this creature has a thousand legs.

The reasoning is quite valid, and logic does not grumble. But logic is far from contented if we say:—

All men have two legs.

This creature has two legs.

Therefore this creature is a man.

The creature may be a man, but the argument does not prove it. The reasoning is not valid, for although all men have two legs, all two-legged creatures are not necessarily men. Some are monkeys. Scientific method, on the other hand, although it makes use of logic, is not content, as logic is, to take statements for granted. It compares statements with reality. It examines butterflies, and shows by observation that they have not a thousand legs. It examines the creature with two legs, and by comparison and contrast shows that it is not a man but a gorilla. Scientific method, in fact, includes logic but goes beyond it by insisting that the judgments with which logic deals shall correspond to reality, the nature of which it tries to apprehend with ever-increasing clearness, using logic as one means to that end.

#### GRAMMAR.

It will be convenient here to pay a little attention to the meaning of the word *grammar*. Grammar is the science of words. Now it is by means of words, or language, that we express our thoughts or judgments. In so far as they both are concerned with thoughts

there is a close connection between grammar and logic. The fundamental parts of a sentence, the subject and predicate, correspond roughly to the two components which are united by our minds when we make judgments. There are other points in which logic and grammar correspond. But language, which is the subject of grammar, expresses not only our judgments but our feelings or emotions. Man is not entirely a rational creature, and his language often betrays the fact. Furthermore, language is at best an imperfect instrument, and the logical connection of our thoughts is often implied instead of being explicitly stated. You must remember that grammatical accuracy is merely conformity with the ways in which educated people use words; logical accuracy is conformity with the laws of valid reasoning. The sentences given above:—

All men have two legs;

This creature has two legs;

Therefore this creature is a man;

are all quite grammatical. You can parse and analyse them without finding any flaw. Logically, however, the argument is unsound. Remember, then, that grammar deals with words, logic with thoughts.

## CHAPTER II

### WORDS AND THEIR MEANINGS.

When a little child is learning to speak he at first attaches to a sound the vaguest of meanings. Any kind of building is, for him, *a house*; anything that causes pleasure is *nice*. As time goes on, sense-impressions are interpreted more accurately, and a more accurate use of words is the result. But perfect precision in the use of language is never attained by anybody; it is therefore all the more necessary for us consciously to exercise ourselves in fixing what meanings words suggest to our minds. There is especial need of care in dealing with words that denote abstractions, such as *justice, courage, wit, cruelty*, or with words that represent, not nature's classes (*horse, cat, butterfly*) but human inventions, e.g., *State, republic, politician, table, machine*. You must remember that the meaning which a person assigns to a word depends in no small degree upon his own experience. He cannot help associating with a word all that he has suffered or enjoyed from the person or thing denoted by it. If a boy's father be habitually unkind or cruel, that boy will also be tempted to associate the word *father* with unpleasant memories of harsh treatment. He must

therefore be continually on his guard against this tendency, and try to assimilate his notion of a father to that formed by the more fortunate majority of children. It is because words thus sum up the past experience of an individual that perfect uniformity of meaning is impossible. I often cannot avoid misunderstanding my neighbour because his use of words is not quite the same as my own. But however impossible it is always to understand fully what is said to us, we must never cease to make the effort. Above all, we must try to take away from the meanings we attach to words that which is peculiar to ourselves, being due to the singularities of our own experience. Otherwise we inevitably fall into confusion, error and futile disputes. How, then, is it possible to use words with greater precision? How do we learn to speak more accurately? I refer, of course, not to grammatical accuracy, but to that accuracy which consists in putting the right *labels* (I mean words) to the things around us. Linguistic accuracy generally accompanies accuracy of observation and of thought. As we learn to distinguish a thing from something else like it, we learn also to name that thing properly. As you learn about moths you want names to give to the different kinds, and as your knowledge increases you use these names with fewer mistakes. Correct classification, in fact, is of immense importance, being the foundation of scientific knowledge. Animals and things are nearly all capable of being grouped. Some groups exist naturally; others are artificial, *man-made*, and therefore far more irregular than the former. It is very difficult, for instance, to know exactly what is meant by a *Conservative*. Conservatives form an artificial group, and

the views of its members are not fixed, but are sure to differ, to some extent at least, from period to period. For this reason it is hard, if not impossible, to define Conservatives. The most that can be done is to state the general tendency of Conservative policy, to enumerate the characteristics which have been common to Conservatives of all periods.

#### DEFINITIONS.

Words denoting abstractions, or which have a vague or fluctuating meaning, such as *courage*, *republic*, *Liberals*, *Church*, always tend, in some minds at any rate, to become mere names unconnected with reality. So powerful is the spell exercised by words that we are inclined to think that we have only to be familiar with a name to be familiar also with the thing the name represents. The best corrective to this fallacy is the habit of framing definitions. As soon as we realize that a word is but a label, a convenient reminder of a person, thing or group, it becomes plain at once why it is important never to allow the connection between word and reality to be broken. Only some parts of reality, however, admit of true, logical definition. Individual persons and things cannot be defined, neither can certain of the most general kinds of reality. We cannot define *Napoleon*; neither can we define *being* or *substance*. Definitions are properly of species, which can be defined by taking the class above and then adding the special characteristics which distinguish the species we have in mind from the other species belonging to the same higher class, or *genus* as it is called. Thus portraits (*species*) are pictures

(genus) of real persons or animals (*specific characteristic*). I have used the words "class," "genus," "species," in their ordinary, everyday sense, but scientists use special names when referring to the classes of living things. Thus tigers are the species *Felis tigris*, of the genus *Felis*, of the family Felidae, of the order Carnivora, of the series Vertebrata. The classes are subdivided, and divisions tend to shade into their neighbours. In fact the classification is more a matter of convenience than of strictly scientific accuracy, and the great work of Charles Darwin was to show how a new species develops out of an old one. Nevertheless this method of classification enables us to define natural classes more easily and more accurately than any other.

It is now clear, I think, why only classes, and of these not the highest, can be defined. Only a class other than the highest can be equated with a part of a higher class possessing characteristic qualities which mark it off from the rest of that higher class.

A very good way of defining a class which is not biological is to examine carefully the synonyms of the word used to denote it. For example, suppose we wish to define *stupidity*. This word has many *synonyms*, or words meaning nearly the same thing. Very few, if any, synonyms have exactly the same meaning. The synonyms that suggest themselves are, among others, *foolishness*, *silliness*, *idiocy* and *dulness*. We see at once that there is a general similarity in the ideas these words call to our minds. They all suggest irrational conduct, or a condition of mind leading to such conduct. But irrational conduct exhibits many variations. We must try, by examining sentences in which the synonyms



are correctly used, to discover the special varieties of unreason they represent. We must further remember carefully that what we are in search of is not *our* notion of stupidity, silliness, and so on, but the meanings attached to these words by the generality of mankind. It will probably be decided that by silliness is meant unreason caused by weakness of intellect; idiocy is unreason that reminds one of the actions of certain kinds of madmen; foolishness is the unreason that results from allowing one's brain to be clouded by carelessness; dulness is failure to perceive what the ordinary, rational mind easily perceives. Stupidity is excess of dulness.

#### PRECISION OF SPEECH.

The habit of using words in precisely their right meanings is well worth cultivating, as it leads to accuracy of thought and lessens the risk of misunderstandings. It is one which can be formed only by very slow degrees, and this fact is one reason, perhaps the chief reason, why so few people acquire it. A long and wide experience, unceasing vigilance, close attention and acute observation are all necessary, and combined with these qualities there must be a strong desire to improve. To know the chief difficulties and dangers is of great use. We must learn to discriminate between synonyms, to discover the exact meanings attached to words by the best authors, to remember that some words have a technical sense, to realize that a great many words slowly but surely change their meanings, and that care is required in the use of metaphor. The last three points I will explain more fully.