

INDUCTION, ANCIENT AND MODERN.

THE growth of the inductive sciences is one of the notes of modern research. The very word science, once appropriated to deductive or *a priori* knowledge, is now claimed as the exclusive property of inductive or *a posteriori* knowledge. Some of our modern treatises on Logic give far more space to inductive than to deductive Logic, and regard it as far more important. Observation and experiment take a prominence in modern systems that was quite unknown to the ancients. The laws of right observation and trustworthy experiment are examined and sifted with a carefulness of detail and a strictness of inquiry to which Aristotle and St. Thomas were wholly strangers. Laws and canons are laid down for their employment; the methods which are to regulate them are represented as the very groundwork of philosophy. The once cherished principles of the *Dictum de omni et nullo* and the *a priori* laws of thought are relegated to an unhonored obscurity. This change dates from Bacon and Locke. It does not concern us to trace its origin or the cause of its development. It is enough to say that as men turned their thoughts from laws received upon authority to those which were framed as the result of human experience, or indeed, as all authority began to be regarded as built up from below, rather than as coming down from above, it was but natural that the new constructive process should assume an importance it had never enjoyed before, and that unquestioning obedience to prevailing laws should be exchanged for a very critical inquiry into the validity and source of those laws. And when the new school of theology and philosophy had decided that they came from below, rather than from above, that they were the elected representatives of the people, rather than the appointed vicegerents of God, that they were true because everywhere of force, and not everywhere of force because true, it was but right and proper that their election should be challenged by the scientific inquirer, and that their authority should be subjected to the most approved principles of impartial and unbiased research.

Has the change been one which has strengthened truth, or one which has induced new and plausible forms of error? The answer to this question requires a very careful distinction between the various fields of knowledge. As regards things of a purely material nature and the laws that govern them, it cannot be denied that

we owe an enormous debt to the Baconian induction and its further development by subsequent writers. Nearly all our modern discoveries are due to it, and to the stimulus that it has given to the physical and mechanical sciences,—not merely to botany, chemistry, zoology; not merely to the sciences that deal with light, heat, and motion, but in the loftier tenets of medicine, hygiene, astronomy, history, ethnology, philology,—the new method has given an impulse to human activity that has changed the whole face of the world. The rapid growth of large cities, colonization, the decline in the warlike and the increase in the commercial spirit, the lower rate of mortality by reason of sanitary improvements and of the advance of medical knowledge, the decrease in crimes of violence and in lawless oppression of the poor, and many other changes, which amount to an unseen and gradual revolution, are in a great measure due to the development of the inductive method.

Yet in all this there is a counterbalancing loss which must not be overlooked. Even in the material development the gain is not unmixed; large cities have their disadvantages, and these of no mean order; the growth of a commercial spirit involves the danger of the growth of a selfish and a narrow spirit; the improvements in hygiene and medicine keep alive those who would in old times have died off in their sickly youth, and their unhealthy offspring hand on a weakly constitution in their turn to the next generation; if lawlessness has diminished, there is, on the other hand, a lower morality in the modern city than in the villages of former times, and the social critic may well be puzzled, as he weighs the advantages against the disadvantages, to say whether the effect of our material advance has on the whole been for the better or for the worse.

But there is another aspect under which we have to regard it. We have to ask whether the inductive spirit, as it is called, is calculated, on the whole, to strengthen or relax man's grasp of truth, whether the temper that has been introduced really promotes man's rational development, whether it increases or diminishes the number of important and practical principles possessed by him for the regulation of his conduct and the direction of his life to its true end, whether it is a temper that places him in his proper relation to God and teaches him the true end of his existence. We have to inquire, moreover, whether it is favorable or unfavorable to Revelation and to supernatural truth, whether its methods are suitable means to be employed by one who is looking out to discover what religion it is to which God has given His divine sanction, and outside of which all else are false and self-contradictory.

These questions will be very differently answered by those without and those within the Catholic Church. The latter, while they acknowledge the services, the enormous services rendered by the methods of modern inductive research, cannot but recognize their danger when once they are allowed to claim the almost exclusive possession of the field of truth. It is the discrediting of *a priori* truth, the knocking out of sight of the true basis of certitude, the abolition of all absolute certainty resulting from the domination of this new spirit, that alarms the Catholic. He dreads a deluge of the stream which, within proper limits and in moderate amount, would fertilize and refresh the face of the earth.

We have, therefore, to consider the relation of the ancient and modern induction, and how far we ought to give in to the claims of the latter to be the dominant method of modern logic. We will begin by glancing at the question historically, in order that we may see if there is in our two great authorities, Aristotle and St. Thomas, any recognition of modern induction and the methods by which it is safeguarded. We will then carefully examine the distinction between the induction of ancient and that of modern times, and lay down the laws and canons which regulate the one and the other. This portion of our inquiry is no unimportant one, and one, too, beset with difficulties. We have to steer our course between the Scylla of a narrow and blind indifference to the value of the new discovery, and the Charybdis of a too great devotion to a hungry monster that seeks to swallow up all truth in its rapid and all-devouring vortex.

Induction in its widest sense is, according to Aristotle, a process by which we mount up from the particular to the universal.<sup>1</sup> This may be done in three different ways.

1. The particulars may be the *occasion* which enables us to recognize a universal *a priori* law. They put before us in concrete form two ideas, the identity of which we might not have been able to recognize in the abstract. If we tell a man ignorant of Euclid that the exterior angle of every plane triangle is exactly equal to the two interior and remote angles, he does not instinctively recognize the truth of our statement. But if we draw first one triangle and then another, and prove it to him mathematically, he is able to mount up to the universal law. Even a single instance is sufficient to make it plain to him when once he sees that the proof is independent of the kind of triangle of which there is question, and that it holds good whether the triangle be equiangular, isosceles or scalene, obtuse-angled or right-angled or acute-angled. This, however, is scarcely induction in the strict mean-

<sup>1</sup> Ππαγωγή ή από τών καθ' έκαστον επί πà καθόλου έξόδος. Ar. Tom. I. 12.

ing of the word, for the argument is rather *through* and *from* the particular instance or instances to the universal.

Induction in its strict sense is based upon the particulars, and argues *from* them, not *through* them. It is any process by which we are enabled to affirm or deny respecting the universal subject something that we have already attained or denied of the several particulars contained under it. It naturally is divided into two different kinds, which furnish us with the second and third of the various meanings of the word.

1. Complete induction, in which all the particulars are enumerated.

2. Incomplete induction, in which only a portion of the particulars are enumerated, but from this portion a conclusion is drawn which covers those not enumerated.

Complete induction, is the exact reverse of the deductive process; as in the latter we argue from the universal subject to each and all of the particulars contained under it, so in the former we argue from each and all of the particulars to the universal subject. Aristotle defines it as *proving the major term of the middle by means of the minor*, as opposed to deductive inference, which proves the major of the minor by means of the middle. For instance :

Saul, David, and Solomon were men of remarkable achievements. But Saul, David, and Solomon were all the kings of the whole of Palestine, therefore all the kings of the whole of Palestine were men of remarkable achievements ; or,

Nettles, pellitories, figs, mulberries have flowers with a single perianth. But nettles, pellitories, figs, and mulberries are all the flowers belonging to the order *urticeæ*, therefore all the plants in the order *urticeæ* have flowers with a single perianth.

In these syllogisms the names of the individuals or of the lowest species are the minor term, inasmuch as they come under the class to which they immediately belong ; and though collectively they are identical with it in extension, yet they have a certain inferiority to it because it is always possible that some pert historical or botanical or other discovery might add another to the list of kings who ruled over the whole of Palestine, or to the *urticeæ* plants, or to any other enumeration of particulars coming under a universal. Hence in an inductive argument middle and minor change places, or rather that which is *minor* in point of possible extension stands as the *middle* term, because in actual extension it is the equal of the middle term, which, in this kind of argument, humbly resigns its rights and takes the place of the minor term of the syllogism.

Is the inductive syllogism a legitimate one? We must look at the import of the proposition. The import of a proposition is,

that it states the existence of such a connection between the two objects of thought, that in whatever individuals you find the one you will find the other. When we apply this test to the major premiss, we find it to be a true proposition. Wherever Saul, etc., are found as objects of thought, there one shall also find remarkable achievements. But it is not similarly applicable to the minor; it is not true that wherever we find possible kings of all Israel, there we shall find Saul, etc.; it is only true in the case of the actual kings as known to us. This weak point comes out when we fix our attention on the copula. All the kings of the whole of Palestine *were* Saul, David, and Solomon, means not that the ideas of Saul, David and Solomon are present wherever the idea of king of the whole of Palestine is present as an object of thought, but merely that in point of fact the class of all the kings of the whole of Palestine is made up of these individuals. This is not the logical meaning of the copula, and at once creates the opposition between the syllogism and induction of which Aristotle speaks, and the anomaly which he mentions respecting the middle term. This, moreover, accounts for the further anomaly of a universal conclusion in figure 3, although this anomaly may be avoided by transposing the terms of the minor premiss.

Is complete induction of any practical usefulness? Yes, it has the same function as deduction. It renders implicit knowledge explicit. We are enabled to realize what we had not realized before, to trace a universal law where we had not previously suspected one. It brings out some universal characteristic of a class, or teaches us to recognize those who are bound together as members of that class, by the possession in common of a peculiarity which before we had only recognized as belonging to the individuals. It is true that this sort of induction *per enumerationem simplicem* does not establish any connection by way of cause and effect between the common property and the common class. It may be a matter of chance that all the kings who ruled the whole of Palestine were distinguished men, or that all the *urticeæ* have a single perianth. But it is, at all events, a suggestive fact, and leads us to question ourselves whether there must not have been some reason why the kings in question had remarkable gifts or the flowers one perianth only.

For instance, if we go into the room of a friend, and find his library consists of ten books and ten only, and on examining them find that they are, one and all, books describing travels in China or Japan, a complete induction enables us to lay down the proposition:

All our friend's books are books of travels in China and Japan.  
This suggests to us a train of thought that would never have

arisen if we had confined ourselves to the isolated fact respecting the nature of each book. Looking at them one by one, our thoughts are directed merely to the character of each and to the individual facts narrated in it. Looking at them together, we begin to think that our friend must either have been travelling in Japan or China or that he is intending to go there, or that he must have friends in one or the other of those countries, or that he is proposing to write an article on the subject, or that for some reason or other he must have a special interest in China and in Japan.

Or, to take a historical instance: We are studying Roman history, and as we read the history of the early emperors we are disgusted at the low standard of morality prevalent among them, the cruelty, the ambition, the lust that attach to their names. We find Julius Cæsar engrossed by an insensate and unscrupulous ambition; Augustus, a man of pleasure; while the rest were among the vilest of manhood. This leads us to reflect, and the result of our reflection is to observe that when the empire had passed out of the hands of the Cæsars there was decided improvement. We also notice that the first two emperors were superior to the four who succeeded them, and we embody our reflection in an inductive syllogism:

Julius Cæsar, Augustus, Tiberius, Caligula, Domitian, Nero were men whose lives were marked by selfishness and crime;

All the Cæsars who ruled the Roman Empire were Julius Cæsar, Augustus, Tiberius, Caligula, Domitian, Nero:

Therefore all the Cæsars who ruled the Roman Empire were men whose lives were marked by selfishness and crime.

The conclusion of this syllogism naturally leads us to ask whether there must not be some influence tending to deteriorate the character in the position of emperor of Rome, and further, whether that influence is a universal one, or is limited to this family, whose members appear to have been specially affected by it. This gives occasion to an interesting train of thought, which would never have been suggested had we not mentally gone through our process of complete induction.

The weak point of a complete induction is that in so many cases we are not perfectly sure that it is complete. We fancy that we have not overlooked any one of the particulars, whence we argue to the universal law, while all the time there is one that for some reason has escaped our notice, and perhaps this very one is fatal to the universality of our law. In the case of the Roman emperors it is always possible that there might have intervened between the reign of one emperor and the next recorded a short space of time during which there reigned some emperor whom historians never knew of, or for some reason or other passed over in silence. We may practically feel certain that this is not the case, but we never

can have that perfect certainty that leaves no room for any possible doubt. Or, to take a more practical case. Let us suppose chemists arguing a century ago about the then known metals:

Iron, copper, silver, gold, lead, zinc, tin, mercury, antimony, bismuth, nickel, platinum and aluminium are all heavier than water;

Iron, copper, silver, gold, lead, etc., are all the metals;

Therefore all the metals are heavier than water.

Here would be a complete induction of the metals then known, but nevertheless the conclusion would be false. Since that time potassium, sodium, and lithium have been pronounced to be metals, and all these are lighter than water.

Of course there are some cases where an enumeration is perfectly secure of completeness, *e g.*, if we argue that January, February, etc., have all twenty-eight days or more, we cannot be wrong in concluding that *all* the months of the year have twenty-eight days or more. From the fact that Sunday, Monday, Tuesday, etc., are named after some heathen deity, we conclude that all the days of the week derive their names from heathen deities. But this is merely accidental and comparatively rare.

2. We now come to incomplete or material induction.

Incomplete induction is recognized by Aristotle, though he does not say very much respecting it. It comes under his definition of induction as "a process from particulars to universals," and the instance he gives is an instance of material and complete induction.

Pilots, charioteers, etc., who know their business are most skilful.

Therefore, generally, all who know their business are most skilful.

Further, he describes it as more persuasive and clearer, and more capable of being arrived at by perception and within the reach of the masses, while the syllogism is more forcible and clearer as an answer to gainsayers.

Here it is evident that he is speaking of an argument from a limited number of instances to the whole class. He describes the object of induction as being to *persuade* rather than to *convince*; as being *clearer* in the eyes of ordinary men, inasmuch as it appeals to their sensible experience; as more within their reach, since it is an argument that all can appreciate; whereas the argument that starts from first principles implies a grasp of such principles, and this is comparatively rare among the mass of men. Yet it has not the compelling force of deductive reasoning inasmuch as it can always be evaded; it is not in itself so clear as the syllogism; it does not hit home with the same irresistible force as the argument that makes its unbroken way from the first principles that none can deny to the conclusion which we seek to establish. All this is exactly applicable to material induction, and would have little or no force if he were speaking of formal or complete induction.

The example, moreover, that he gives is so incomplete as scarcely to deserve the name of induction at all. He merely takes two instances of the arts, and from them at once draws the conclusion that in all the arts science and success are inseparable. Possibly he chooses this extreme instance to show how very imperfect an induction may be sufficient to establish a general law where that law has the constant and universal testimony of mankind in its favor; and that men need only to be reminded of the law by the instances adduced rather than to be taught any fresh truth from an examination of the invariable coexistence of the two objects of thought which the instances exhibited as invariably united.

But Aristotle's brief reference to induction is a remarkable contrast to the elaborate treatment of it by modern writers on logic. St. Thomas, and the scholastic logicians generally, are equally concise in their discussion of it. Even the Catholic logicians of the present day pass it over in a few paragraphs or a few pages, which are devoted in part to an attack on Baconian induction and to an assertion that induction has no force unless it can be reduced to syllogistic form. Sir W. Hamilton, Mansel, and the Scottish school of philosophers are at one with the schoolmen and modern Catholic writers in their jealousy of the intrusion of induction, and, though they do not agree with them in advocating the necessity of reducing it to the form of the syllogism, yet they would assign to it a very subordinate place in a treatise on logic. It is the modern school of experimentalists, of whom John Stuart Mill is the illustrious leader, who put forward induction as "the main question of the science of logic, the question that includes all others." This suggests to us these questions:

1. How far does material induction come into logic at all?
2. Is it true that all induction must be capable of being reduced to a syllogistic form in order to be valid?
3. Is the neglect of induction by modern Catholic writers to be praised or blamed?

We are speaking here of *material* or *incomplete* induction, and unless we warn our readers to the contrary, we shall continue to use it in this sense to the end of our present chapter.

Induction, says Cardinal Zigliara, has no force whatever apart from the syllogism. Incomplete induction, says Tongiorgi, is not a form of argument different from the syllogism. Induction, says Mendive (*Logica*, p. 224), is a true form of reasoning, and it pertains to the essence of reasoning that it should be a true syllogism. Induction, says Liberatore (*Logic*, p. 90), does not differ in its essence, but only in the form it takes, from the syllogism. Yet we have seen that when reduced to syllogistic form it breaks the rules of the syllogism and uses the copula in an altogether differ-

ent meaning. How, then, are we to solve the difficulty? As usual, we have to examine carefully into our use of terms. *Syllogism* is an ambiguous term. There is the *deductive* syllogism, with its figures and moods, such as we have described them above, and which is subject to and based upon the *dictum de omni et nullo*. Whatever may be affirmed or denied of a universal subject, may be affirmed or denied of each and all the individuals that are included under that subject. In this sense induction is outside the syllogism, and any attempt to reduce it to syllogistic form at once exhibits a violation of syllogistic laws. But besides the deductive syllogism the word syllogism is used in a wider sense for any process of reasoning based on a more general principle, viz., wherever two objects of thought are identical with a third, they are also identical with each other. This principle includes not only the deductive syllogism, but the inductive syllogism also.

Induction, therefore, comes into logic as reducible to syllogistic form, but not to the form of the deductive syllogism. This is true of both complete and incomplete induction when we argue :

James I. and II., Charles I. and II. were headstrong monarchs ;  
James I. and II., Charles I and II. were all the monarchs of the Stuart dynasty ;

Therefore all the monarchs of the Stuart dynasty were headstrong.

We violate one of the rules of the third figure by our universal conclusion. We use the copula, not for the necessary coexistence of two objects of thought, since it is conceivable that a future Stuart might arise and falsify our minor, but for the fact which is true in the concrete. Our argument, moreover, refuses to obey the authority of the *dictum de omni et nullo*, and is therefore no true form of the inductive syllogism.

But our argument is a perfectly valid syllogism in that it is in accordance with the principles of identity we have just given; it is in accordance with the laws of thought and is perfectly logical. But is this true of *incomplete induction*? For instance: We argue from the fact that we have observed on a number of separate days to all possible days in the year. We have noticed that all the days when there has been a gradual fall in the barometer have been followed by rain, and we state the result of our observation in the following premisses :

January 18, March 4, April 7, October 19, were succeeded by rainy weather ;

January 18, March 4, April 7, October 19, were days on which there was a fall of the barometer ;

Therefore all the days on which there is a fall of the barometer are days followed by rainy weather.

In order that the conclusion may hold good in strict logic, we must be able to assert that January 18, March 4, April 7, October 19, are all the days when there was a fall in the barometer, and this is obviously ridiculous. But may we not put our minor in another form, and say :

What is true of January 18, March 4, April 7, October 19, is true of all days when the barometer falls ;

Rain near at hand is true of January 18, March 4, April 7, October 19, therefore, rain near at hand is true of all the days on which the barometer falls. Everything, therefore, depends on the representative character of January 18, March 4, April 7, October 19. If they have nothing in common save this one feature of the fall of the barometer which can be connected with the coming change in the weather, then no one can deny that there must be some sort of connection between a fall in the barometer and rainy weather near at hand, which will justify us in predicting of days on which the barometer falls that they will be succeeded by rain.

But before we enter on an investigation of this point, there is a previous question. Does it concern us as logicians to investigate it at all ? Is it within our scope to examine into the various instances in order to sift their value as evidence ? Has not the logician to assume his principles as true, supposing always that they contain nothing which violates the laws of the human mind and of right reason, or is he to employ the various methods of observation and experiment by which the truth of all *a posteriori* and synthetical propositions have to be tested ? If these lie outside the province of logic, the moderns are not only one-sided and unfair in giving so large a space to induction, but are all wrong in their very conception of the task they have to perform.

This question can only be satisfactorily answered by reminding the reader of the distinction between *formal* and *material* (or applied) logic. Formal logic simply takes its premisses for granted as long as they do not sin against any law of thought or contradict any proposition of the truth of which we are absolutely certain. Applied logic steps outside this comparatively narrow field, and asks what the terms are which regulate our admission into the mind of any proposition as a part of our mental furniture. Formal logic, therefore, has nothing to do with the conditions under which we can arrive at universal propositions other than those to which we are compelled by the nature of the mind itself. It has nothing to do with those propositions which we are led to regard as true by reason of what we witness in the external world, and which depend upon laws learned by observation and not rooted in as *a priori* conditions of thought. It has nothing to do with arriving at those *a posteriori* truths.

*Observation* and *experiment*, therefore, are wholly outside the province of formal logic. The only question is, whether they have any claim to consideration under the head of applied logic; whether as means of adding to the propositions that we regard as *certain* and adopt as such, they should be examined into, and the results to which they lead tested. As to their other qualifications for admission into the mind, this depends on a further question. Do the various methods which were first inaugurated by Bacon and subsequently developed by those who have followed in his steps give us certainty at all, and if so, what sort of certainty?

Probably no one in his senses will deny that external observation can give us certainty. That the sun will rise to-morrow morning, that a stone thrown into the air will fall to earth again, are as certain as anything can be that does not depend on the inner laws that regulate all being. But such a certainty is, strictly speaking, always a practical or hypothetical, never an essential or absolute certainty. It is within the bounds of absolute possibility. But some unknown comet might intervene between the earth and the sun during the coming night, or, some undiscovered and mysterious influence might whisk away our stone to the moon, not to mention the further possibility of Divine interference by what we call a miracle.

But in the case of *a priori* laws no miracle can intervene, no possible hypothesis can set them aside. God Himself cannot make five out of two and two, or prevent things equal to the same thing from being equal to one another, or cause the exterior angle of any plane triangle to be less than either of the interior and opposite angles. It is beyond the utmost limit of Divine omnipotence to bring about either of these, because they are in themselves contradictory, and would, if they could be realized, make God a liar. These *a priori* laws are not merely laws of thought and of human reason, but of being and of the Divine nature. They are based upon the nature of God Himself, and thus on Eternal and Immutable Truth.

Not so the physical laws at which we arrive by observation and experiment. God could reverse them all to-morrow, if He chose. He does, from time to time, intervene and hinder their efficacy. They are not founded on the Divine nature, but in the Divine enactment. They are, therefore, liable to exceptions, and this is why we say that they have only a hypothetical or conditional certainty.

But they have another source of weakness. Not only can God set them aside at any moment if He pleases, but we are not *absolutely* certain that they exist at all. All that we call physical laws

are but magnificent hypotheses. We have not the means of arriving at any absolute certainty when once we depart from those laws which are stamped on all being, and therefore on the human intellect, which are the very conditions under which we think, because the conditions under which all things, even God Himself, necessarily exist. When we come to laws that are purely *a posteriori*, we never can say more than that they are generalizations from experience, that they explain all the facts known to us, and that they satisfy every test we can apply to them. Such is the law of gravity, the undulatory theory of light, the laws of attraction and distance, etc. All this gives us physical certainty respecting them, but this is utterly inferior to absolute certainty. It is the attainment of physical certainty which is regulated by the various methods that have come in since the time of Bacon, and it cannot be denied that these methods were an object of comparative indifference and neglect to scholastic and Aristotelian philosophy. The pre-Reformation world did not recognize the importance of those modern discoveries and inventions which have revolutionized the world since the days of Bacon. With the Aristotelian philosophy dominant, the steam-engine, gas, the electric light, steam-looms, sewing-machines, and all the mechanical substitutes for human labor would either not have existed at all, or never arrived at their present perfection. The *a priori* method had no room for hypothesis, and hypothesis is the fertile mother of physical research and discovery. Whether all those have really fostered human progress, whether they have made men stronger, healthier, more honest, virtuous, and happy, is a point which does not concern us. We have already wandered too far away from the question before us, which is this: Are we to admit into logic, in its wider sense, what are called the *inductive methods*, and which are elaborated with wonderful skill and ability by John Stuart Mill?

Among the functions of natural or applied logic, one of the most important is to distinguish between certitude and probability, and also to separate the various kinds of certitude one from the other. But when once we have passed from the highest kind of certitude to a lower level, from metaphysical to physical certitude, it does not belong to the logician to elaborate with minute care the various conditions necessary for attaining to the latter. It would be misleading for him to dwell on them with too much detail; it would have a tendency to raise in the estimation of mankind the laws that are based on them to an equality with the *a priori* laws; to exalt hypothesis into law, to lead men to confound practical with absolute certainty, to obliterate the distinction between the eternal, the immutable, and the transitory, the contingent, the mutable. Yet in spite of all this, they cannot be passed over, and ought not

to be passed over unnoticed, in the present day. They are too important a factor in the present condition of human society to admit of our neglecting them; they are weapons which have been forged by what is called the march of human intellect, and it would be suicidal to deny their value and their efficacy. Besides, we ought to master them in order to protest against their abuse. We must give them their due in order that they may not usurp the whole field of human science. Mill and his followers drag down all the *a priori* laws to the level of the *a posteriori*, or rather deny the existence of *a priori* laws at all. This is the fatal result of the departure from the old scholastic method, which began at the "Reformation," and has been carried farther, day by day. But, *fas est et ab hoste doceri*; and the various methods set forth in detail by Mill have, in their own proper limits, a most important function to perform, and are of constant application to our everyday life.

We have now to return to our consideration of the premises which assert the representative nature of the instances on which we are going to base our law. Our methods are to give us the means of ascertaining this. They are to decide for us whether what is true of the instances under our consideration is true of all instances, real or possible; or, at least, they are to settle the question for us as far as it is possible in the nature of things to arrive at any certainty respecting it.

Our premisses then asserted that what was true of January 14th, etc., is true of all days on which the barometer falls, and the value of our argument depends on our being able to establish this proposition. What is necessary to prove it satisfactorily is to show that these days had nothing in common which could possibly be connected with the approach of rainy weather, save a certain heaviness in the air indicated by the fall in the barometer. If this could be ascertained beyond a doubt, then we should have a perfect physical certainty that there was a connection of cause and effect between the heaviness in the air and the subsequent rain. But in point of fact we never can be sure that there are not other characteristics common to these days which might be the source of the phenomenon of rain. To be absolutely certain would require a knowledge of the inner nature of things, which even the greatest scientist does not possess. All that we can say is, that we are unable to detect any common characteristic in the days in question which would account for the subsequent rain, save only the heaviness in the air and the consequent fall of the barometer, and therefore the connection between the rain and the heaviness in the air is at most but a strong probability.

Here, then, we have a case of the first of Mr. Mill's experimental methods, the *Method of Agreement*. We cannot do better than formulate it in his own words: If two or more instances of the phenomenon under investigation have only one circumstance in common, the circumstance in which alone all the instances agree is the cause (or effect) of the given phenomenon.

Our readers will observe that in this law Mr. Mill goes beyond the requirements we have given above, and exacts not only the presence of no common circumstance which could account for the result save one, but absolutely the presence of no common circumstance at all save one alone. To establish this will be still more impossible, therefore we can derive from the employment of this method nothing more than a strong probability. There are no two phenomena in the world which have not one common circumstance.

But there is another method which comes in to supplement the former. Let us suppose that we find a day exactly corresponding to one of the days aforementioned in every circumstance save one, viz., the weight of the air. In all else they are exactly alike. When we examine the rain record of the year we find that on the day when the air was heavy rain followed, and on the day when it was light fine weather came after it. Here too we should again have perfect physical certainty, if only we could find two days corresponding exactly in every possible circumstance save one. There would be no doubt whatever as to the connection of the circumstance with the result that was present when the circumstance in question was present, absent when the circumstance was absent. But here, too, it is impossible to find any two such days; there must of necessity be a dozen points of difference between the two. All that we can have is a certain amount of correspondence, and the absence of any points of difference which seem likely to be connected with the result, save the single circumstance which is conspicuous for its presence in the one case and for its absence in the other. Here, therefore, we are again limited to a probable connection and can get no further.

In this case we have an instance of the *Method of Difference*; we will again give it in Mr. Mill's own words:

"If an instance in which the phenomenon under investigation occurs and another in which it does not occur have every circumstance in common save one, that one occurring only in the former, the circumstance in which alone the two instances differ, is the effect, or the cause, or an indispensable part of the cause of the phenomenon."

But this second method, as Mr. Mill very pertinently remarks, is applicable rather to experiment than to observation, that is, to

cases where we can artificially vary the antecedents instead of having to receive them ready made. We will, therefore, take another instance, which will moreover have the advantage of illustrating other methods of inductive research which cannot be so easily applied to the case of the weather.

We will take a familiar and very practical case: We have of late from time to time risen with a headache in the morning for which we cannot account. Somehow we fancy it must be connected with some sort of digestive disarrangement and that this disarrangement is the result of some food that we have taken and that does not suit our stomach. One day it occurs to us that our headache always follows upon a special dish, and that possibly this might be its cause. We therefore take note of what we have for dinner, and after a little experience we discover that in most cases when we have eaten of jugged hare for dinner, we have had a headache the next morning. We set to work to test the connection by means of the methods of agreement and difference. First of all, we take a number of days when our dinner has been as varied as possible; on one day we have taken soup, on another day not; on one day we have had beef for the chief dish, on another mutton, on another veal, and on another pork. On one day we have drunk port wine, on another sherry, on another hock, on another champagne, on another claret, on another nothing but water. On one day we have partaken of pastry, on another not; on one day cheese, on another not, and so on *ad indefinitum*, varying our dinner in every possible way on the days of trial. But on all these days there has been the common element of jugged hare, and on each of them there has been a headache following. Here we have a good instance of the method of agreement.

But we cannot be certain that there may not have been some other cause for our headache which happened to coincide with the jugged hare. We may have been rather tired on the evenings in question, or, perhaps, a little more thirsty than usual, and the port wine may have been more attractive than on other days. So we proceed to a further experiment. On two given days we take the same amount of exercise, and order exactly the same dinner, drink the same amount of wine and go to bed at the same hour. The only difference between these two days is that on the former we make jugged hare an item in our bill of fare, and on the other omit it. The result is that the former day is followed by a severe headache, whereas after the latter we rise fresh and ready for business.

Here we have the method of difference. At first the experiment seems decisive, but it is not so. It may be the mere addition of

quantity involved in the presence of the jugged hare that is the cause of the headache, or perchance on the day we ate of it the wind was in the east, or our stomach was already out of order, or some unwonted worry had befallen us. We, therefore, are still in the region of probabilities. Can we ever escape from them? We can do a good deal towards it by means of a third method, which is often extremely useful.

We resolve on a new experiment. We determine that we will try the effect of eating on one day a very small portion of jugged hare at our dinner, on another of having a good deal more, on another of making it the chief part of our dinner, and on another of having no other meat dish at all. The result is that we find that the severity of our headache is exactly or almost exactly proportioned to the amount of jugged hare eaten on the previous evening; a small quantity produced a very slight headache, a large quantity a more serious one, while on the morning following the day when we ate nothing else than hare we were so wretchedly ill that we were unable to attend to our ordinary business. Here is what is generally known as the *method of concomitant variations*.

Whatever phenomenon varies in any manner whenever another phenomenon varies in some particular manner, is either a cause or an effect of that phenomenon, or is connected with it through some fact of causation.

We are now approaching certainty, but there is nevertheless a possible element of uncertainty arising from the chance of the varying headache having been owing to circumstances which by a curious coincidence happened to produce it, with a severity which quite by accident was in proportion to the amount of jugged hare eaten for dinner. We are still in the region of probabilities, and we look round for a final method to try and assure the truth of our inference.

We have for years been studying the effects of various sorts of food and drink, as well as of walking, hard study, riding, boating, etc., on our constitution. Long experience has taught us the effect of each of these. Beef and mutton make us rather heavy the next morning, so does port wine; champagne makes us rise well contented with ourselves, plum pudding produces indigestion; walking, riding, cricket, and boating produce different kinds of bodily fatigue; severe mental labor, a curious feeling of oppression on the top of our head, and so on. On some particular morning we take stock of our bodily condition, and its various constituent symptoms. We are able to trace each and all of them to some familiar antecedent—all except the headache—we can trace in our present state of body the result of most of the circumstances of the previous day, the mental and bodily labor, the various kinds

of food, the amount of sleep, each has its familiar result—all save the jugged hare. Hence we subduct from the various results all those we can trace to known causes, and (neglecting minor details) we have left on the one hand the headache and on the other the jugged hare. Surely, then, this result unaccounted for must spring from the cause not yet taken into consideration. This method, which can often be employed with great advantage, is called the method of residues. Mr. Mill formulates it into the following law:

Deduct from any phenomenon such part as is known by previous induction to be the effect of certain antecedents, and the residue of the phenomenon is the effect of the remaining antecedent.

Does this give us perfect physical certainty? Most decidedly not, if one take it by itself. Our attribution of effect *a* to cause *A*, of *b* to *B*, etc., is at best only a probable argument, and even if it is all correct, we cannot be sure that we have exhausted either consequents or possible antecedents. At most this method only contributes its share to the ever-increasing stream of probability which is gradually developing itself into the resistless river of practical certainty.

But when all these methods are united together, surely then we have certainty; not metaphysical certainty, but at least practical and physical certainty. Surely we can go beyond the mere tentative assertion of a hypothesis to the firm conviction of a well-grounded law which certainly connects together the circumstances we are considering as cause and effect, or at least as in some way connected together by a final and stable law of causation.

Here we enter on a wider topic which would be out of place in the present paper. To those who still hold to *a priori* truths, to the school of Aristotle and St. Thomas, there opens out an endless vista of causes and effects, descending from God, the first cause, to every detail of His works, each connected together by a law which He has decreed, but which He may at any time set aside at His good pleasure, and which He has set aside from time to time by what we call a miracle.

But to the modern school of sensationalists, to Mill and Bain, cause and effect are words which have no meaning. *Cause* is but an invariable, unconditional antecedent, and effect an invariable, unconditional consequent. In them, if they were logical, there would be no certainty about the future, for what possible reason is there why it should resemble the past? Because it has always done so? The very supposition is a contradiction in terms, for the future is still unborn. All that experience has taught them is that one portion of the past has hitherto resembled another, that there has always been an unbroken uniformity of succession in the series

of antecedents and consequents. But of the future as such we never have had and never can have any experience, and our conjectures respecting it are, if we logically follow to their conclusions the theories of Mr. Mill and his school, the merest guess-work, an arrow shot into the air without any sort of ground for believing that it will hit the mark.

Our conclusion, therefore, is that these methods are a most valuable contribution, if not to logic, strictly so called, yet to the course of human discovery and scientific research. The Catholic philosopher learns from Aristotle and St. Thomas the *a priori* law, one of the first principles of all knowledge, that every effect must have a cause. He knows that this law extends not merely to effects following as particular applications of some *a priori* law which becomes known to us as soon as a single instance of it is presented before us and grasped by our intelligence, as in the case of the deductions and inferences of mathematics, but also to effects following from what is also rightly called a law, inasmuch as it is a general principle, under which a vast number of particulars are ranged, but is nevertheless arrived at by generalization from a vast number of particular instances. In the one case, as in the other, the universal law of causation holds. In the one case cause is joined to effect in virtue of the inner nature of things; in the other simply because the will of God has so disposed the arrangements of the universe that He has created. In the one case experience makes known to us a law which is already imprinted on our intelligence; in the other experience makes known to us a law which is stamped upon the world outside, but only becomes a part of our mental furniture when we have carefully weighed and sifted a number of individual instances of its operation. In the one case the methods of induction are rarely, if ever, of any practical use; in the other they are simply invaluable.

We are now in a position to assign their true place to the inductive methods of which Bacon was the harbinger and Mr. John Stuart Mill and his school the prophets and apostles.

1. They certainly can claim a place in material logic, even if not in formal. To ignore them and to hurry over material induction with a passing remark that it must be virtually complete, *i.e.*, must include a number of instances sufficient to afford a reasonable basis of certitude, is scarcely prudent in the face of the development of scientific research. Catholics would not be so easily taken in by the hasty generalizations of the modern scientist if they had the use of these methods and the kind of certainty to be derived from them at their fingers' ends. It is no use to allege the authority of Aristotle and St. Thomas in disparagement of them. If Aristotle and St. Thomas had lived in the present day they would have

taken the lead in regulating the methods of scientific research, just as in their own day they laid down the principles of deductive argument. The eager questioning of nature was in their day a thing unheard of, and any elaborate setting forth of the methods to be pursued was then superfluous and unnecessary.

2. These inductive methods can never give us *absolute* certainty, but they can give us *physical* certainty. They cannot give us absolute certainty because the laws they reveal to us are reversible at the will of their maker; they can give us physical certainty for the simple reason that the human mind is so constructed as to be able to test without any reasonable doubt, on a combination of arguments of which it may be that no single and individual one is sufficient to carry conviction to the mind of a reasonable man, but a number of them combined is enough and more than enough to make him perfectly sure of the conclusion to which they one and all concurrently point.

3. We must always be on our guard against allowing ourselves to be persuaded into a conviction of the truth of some general hypothesis when the concurrent evidence is not sufficient of itself to produce conviction. We must remember Aristotle's admirable distinction between deduction and induction, that the one is more forcible, the other more persuasive and clear, and within the reach of ordinary men.

4. We have too often seen the intellectual convictions of scientific men shaken by the brilliant guesses which induction suggests, and which they regarded as justifying them in discarding the belief that they had previously held to be true. Very slow and cautious should we be in allowing any law arrived at by a process of pure induction to set aside any conviction that seems to be based upon a higher and more certain mode of argument. Of course there are occasional instances, as the so-often quoted case of Galileo; but for one such instance there have been hundreds in which some premature hypothesis has been allowed to weaken the grasp on *a priori* truth, to be in its turn discarded for some equally premature successor, sitting in its turn for a brief period on the usurped throne of truth.