CHAPTER XIII

Transition to Induction

Section 1. Having now discussed Terms, Propositions, Immediate and Mediate Inferences, and investigated the conditions of formal truth or consistency, we have next to consider the conditions of material truth: whether (or how far) it is possible to arrive at propositions that accurately represent the course of nature or of human life. Hitherto we have dealt with no sort of proof that gives any such assurance. A valid syllogism guarantees the truth of its conclusion, provided the premises be true: but what of the premises? The relation between the premises of a valid syllogism and its conclusion is the same as the relation between the antecedent and consequent of a hypothetical proposition. If A is B, C is D: grant that A is B, and it follows that C is D; and, similarly, grant the premises of a syllogism, and the conclusion follows. Again, grant that C is not D, and it follows that A is not B; and, similarly, if the conclusion of a valid syllogism be false, it follows that one, or other, or both of the premises must be false. But, once more, grant that C is D, and it does not follow that A is B; so neither, if the conclusion of a syllogism be true, does it follow that the premises are. For example:–

Sociology is an exact science;
Mathematics is a branch of Sociology:
.'. Mathematics is an exact science.
Mathematics is an exact science;
Sociology is a branch of Mathematics:
.'. Sociology is an exact science.

the conclusion is true although the premises are absurd. Or again:–

Here the major premise is true, but the minor is false, and the conclusion is false. In both cases, however, whether the conclusion be true or false, it equally follows from the premises, if there is any cogency in Barbara. The explanation of this is, that Barbara has only formal cogency; and that whether the conclusion of that, or any other valid mood, shall be true according to fact and

experience, depends upon how the form is filled up. How to establish the premises, then, is a most important problem; and it still remains to be solved.

Section 2. We may begin by recalling the distinction between the denotation and connotation of a general term: the denotation comprising the things or events which the term is a name for; the connotation comprising the common qualities on account of which these things are called by the same name. Obviously, there are very few general terms whose denotation is exhaustively known; since the denotation of a general term comprises all the things that have its connotation, or that ever have had, or that ever will have it, whether they exist here, or in Australia, or in the Moon, or in the utmost stars. No one has examined all men, all mammoths, all crystals, all falling bodies, all cases of fever, all revolutions, all stars–nor even all planets, since from time to time new ones are discerned. We have names for animals that existed long before there were men to observe them, and of which we know only a few bones, the remains of multitudinous species; and for others that may continue to exist when men have disappeared from the earth. If, indeed, we definitely limit the time, or place, or quantity of matter to be explored, we may sometimes learn, within the given limits, all that there is to know: as all the bones of a particular animal, or the list of English monarchs hitherto, or the names of all the members of the House of Commons at the present time. Such cases, however, do not invalidate the above logical truth that few general terms are exhaustively known in their denotation; for the very fact of assigning limits of time and place impairs the generality of a term. The bones of a certain animal may be all examined, but not the bones of all animals, nor even of one species. The English monarchs that have reigned hitherto may be known, but there may be many still to reign.

The general terms, then, with which Logic is chiefly concerned, the names of Causes and Kinds, such as gravitation, diseases, social events, minerals, plants and animals, stand for some facts that are, or have been, known, and for a great many other similar ones that have not been, and never will be, known. The use of a general term depends not upon our direct knowledge of everything comprised in its denotation, but upon our readiness to apply it to

anything that has its connotation, whether we have seen the thing or not, and even though we never can perceive it; as when a man talks freely of the ichthyosaurus, or of the central heat of planets, or of atoms and ether.

Hence Universal Propositions, which consist of general terms, deceive us, if we suppose that their predicates are directly known to be related to all the facts denoted by their subjects. In exceptional cases, in which the denotation of a subject is intentionally limited, such exhaustive direct knowledge may be possible; as that "all the bones of a certain animal consist of phosphate of lime," or that every member of the present Parliament wears a silk hat. But what predication is possible concerning the hats of all members of Parliament from the beginning? Ordinarily, then, whilst the relation of predicate to subject has been observed in some cases, in much the greater number of cases our belief about it depends upon something besides observation, or may be said (in a certain sense) to be taken on trust.

'All rabbits are herbivorous': why do we believe that? We may have seen a few wild rabbits feeding: or have kept tame ones, and tried experiments with their diet; or have read of their habits in a book of Natural History; or have studied the anatomy and physiology of the digestive system in many sorts of animals: but with whatever care we add testimony and scientific method to our own observation, it still remains true that the rabbits observed by ourselves and others are few in comparison with those that live, have lived and will live. Similarly of any other universal proposition; that it 'goes beyond the evidence' of direct observation plainly follows from the fact that the general terms, of which such propositions consist, are never exhaustively known in their denotation. What right have we then to state Universal Propositions? That is the problem of Inductive Logic.

Section 3. Universal Propositions, of course, cannot always be proved by syllogisms; because to prove a universal proposition by a syllogism, its premises must be universal propositions; and, then, these must be proved by others. This process may sometimes go a little way, thus: All men are mortal, because All animals are; and All animals are mortal, because All composite bodies are subject to

dissolution. Were there no limit to such sorites, proof would always involve a regressus ad infinitum, for which life is too short; but, in fact, prosyllogisms soon fail us.

Clearly, the form of the Syllogism must itself be misleading if the universal proposition is so: if we think that premises prove the conclusion because they themselves have been established by detailed observation, we are mistaken. The consideration of any example will show this. Suppose any one to argue:

All ruminants are herbivorous;
Camels are ruminants:
∴. Camels are herbivorous.

Have we, then, examined all ruminants? If so, we must have examined all camels, and cannot need a syllogism to prove their herbivorous nature: instead of the major premise proving the conclusion, the proof of the conclusion must then be part of the proof of the major premise. But if we have not examined all ruminants, having omitted most giraffes, most deer, most oxen, etc., how do we know that the unexamined (say, some camels) are not exceptional? Camels are vicious enough to be carnivorous; and indeed it is said that Bactrian camels will eat flesh rather than starve, though of course their habit is herbivorous.

Or, again, it is sometimes urged that–_All empires decay:
∴. Britain will decay.

This is manifestly a prediction: at present Britain flourishes, and shows no signs of decay. Yet a knowledge of its decay seems necessary, to justify any one in asserting the given premise. If it is a question whether Britain will decay, to attempt (while several empires still flourish) to settle the matter by asserting that all empires decay, seems to be 'a begging of the question.' But although this latter case is a manifest prediction, it does not really differ from the former one; for the proof that camels are herbivorous has no limits in time. If valid, it shows not only that they are, but also that they will be, herbivorous.
Hence, to resort to a dilemma, it may be urged: If all the facts of the major premise of any syllogism have been examined, the

syllogism is needless; and if some of them have not been examined, it is a petitio principii. But either all have been examined, or some have not. Therefore; the syllogism is either useless or fallacious.

Section 4. A way of escape from this dilemma is provided by distinguishing between the formal and material aspects of the syllogism considered as a means of proof. It begs the question formally, but not materially; that is to say, if it be a question whether camels are herbivorous, and to decide it we are told that 'all ruminants are,' laying stress upon the 'all,' as if all had been examined, though in fact camels have not been, then the question as to camels is begged. The form of a universal proposition is then offered as evidence, when in fact the evidence has not been universally ascertained. But if in urging that 'all ruminants are herbivorous' no more is meant than that so many other ruminants of different species are known to be herbivorous, and that the ruminant stomach is so well adapted to a coarse vegetable diet, that the same habit may be expected in other ruminants, such as camels, the argument then rests upon material evidence without unfairly implying the case in question. Now the nature of the material evidence is plainly this, that the resemblance of camels to deer, oxen, etc., in chewing the cud, justifies us in believing that they have a further resemblance in feeding on herbs; in other words, we assume that resemblance is a ground of inference. Another way of putting this difficulty which we have just been discussing, with regard to syllogistic evidence, is to urge that by the Laws of Syllogism a conclusion must never go beyond the premises, and that therefore no progress in knowledge can ever be established, except by direct observation. Now, taking the syllogism formally, this is true: if the conclusion go beyond the premises, there must be either four terms, or illicit process of the major or minor term. But, taking it materially, the conclusion may cover facts which were not in view when the major premise was laid down; facts of which we predicate something not as the result of direct observation, but because they resemble in a certain way those facts which had been shown to carry the predicate when the major premise was formed.

'What sort of resemblance is a sufficient ground of inference?' is,

therefore, the important question alike in material Deduction and in Induction; and in endeavouring to answer it we shall find that the surest ground of inference is resemblance of causation. For example, it is due to causation that ruminants are herbivorous. Their instincts make them crop the herb, and their stomachs enable them easily to digest it; and in these characters camels are like the other ruminants.

Section 5. In ch. ix, Section 3, the Dictum de omni et nullo was stated: 'Whatever may be predicated of a term distributed may be predicated of anything that can be identified with that term.' Nothing was there said (as nothing was needed) of the relations that might be implied in the predication. But now that it comes to the ultimate validity of predication, we must be clear as to what these relations are; and it will also be convenient to speak no longer of terms, as in Formal Logic, but of the things denoted. What relations, then, can be determined between concrete facts or phenomena (physical or mental) with the greatest certainty of general truth; and what axioms are there that sanction mediate inferences concerning those relations?

In his Logic (B. II. c. 2, Section 3) Mill gives as the axiom of syllogistic reasoning, instead of the Dictum: "A thing which co-exists with another thing, which other co-exists with a third thing, also co-exists with that third thing." Thus the peculiar properties of Socrates co-exist with the attributes of man, which co-exist with mortality: therefore, Socrates is mortal. But, again, he says that the ground of the syllogism is Induction; that man is mortal is an induction. And, further, the ground of Induction is causation; the law of causation is the ultimate major premise of every sound induction. Now causation is the principle of the succession of phenomena: how, then, can the syllogism rest on an axiom concerning co-existence? On reflection, too, it must appear that 'Man is mortal' predicates causation: the human constitution issues in death.

The explanation of this inconsistency may perhaps be found in the history of Mill's work. Books I. and II. were written in 1831; but being unable at that time to explain Induction, he did not write Book III. until 1837-8. Then, no doubt, he revised the earlier

Books, but not enough to bring his theory of the syllogism into complete agreement with the theory of Induction; so that the axiom of co-existence was allowed to stand.

Mill also introduced the doctrine of Natural Kinds as a ground of Induction supplementary, at least provisionally, to causation; and to reasoning about Kinds, or Substance and Attribute, his axiom of co-existence is really adapted. Kinds are groups of things that agree amongst themselves and differ from all others in a multitude of qualities: these qualities co-exist, or co-inhere, with a high degree of constancy; so that where some are found others may be inferred. Their co-inherence is not to be considered an ultimate fact; for, "since everything which occurs is determined by laws of causation and collocations of the original causes, it follows that the co-existences observable amongst effects cannot themselves be the subject of any similar set of laws distinct from laws of causation" (B. III. c. 5, Section 9). According to the theory of evolution (worked out since Mill wrote), Kinds–that is, species of plants, animals and minerals–with their qualities are all due to causation. Still, as we can rarely, or never, trace the causes with any fullness or precision, a great deal of our reasoning, as, e.g., about men and camels, does in fact trust to the relative permanence of natural Kinds as defined by co-inhering attributes.

To see this more clearly, we should consider that causation and natural Kinds are not at present separable; propositions about causation in concrete phenomena (as distinct from abstract 'forces') always involve the assumption of Kinds. For example–'Water rusts iron,' or the oxygen of water combines with iron immersed in it to form rust: this statement of causation assumes that water, oxygen, iron, and iron-rust are known Kinds. On the other hand, the constitution of every concrete thing, and manifestly of every organised body, is always undergoing change, that is, causation, upon which fact its properties depend.
How, then, can we frame principles of mediate reasoning, about such things? So far as we consider them as Kinds, it is enough to say: Whatever can be identified as a specimen of a known substance or Kind has the properties of that Kind. So far as we consider them as in the relation of causation, we may say: Whatever relation of events can be identified with the relation of

cause and effect is constant. And these principles may be
generalised thus: Whatever is constantly related to a phenomenon
(cause or Kind), determined by certain characters, is related in the
same way to any phenomenon, that has the same characters.
Taking this as axiom of the syllogism materially treated, we see
that herbivorousness, being constantly related to ruminants, is
constantly related to camels; mortality to man and, therefore, to
Socrates; rusting to the immersion of iron in water generally and,
therefore, to this piece of iron. Nota notae, nota rei ipsius is
another statement of the same principle; still another is Mill's
axiom, "Whatever has a mark has what it is a mark of." A mark is
anything (A) that is never found without something else (B)–a
phenomenon constantly related to another phenomenon–so that
wherever A is found, B may be expected: human nature is a mark
of mortality.

Section 6. The Syllogism has sometimes been discarded by those
who have only seen that, as formally stated, it is either useless or
fallacious: but those who also perceive its material grounds retain
and defend it. In fact, great advantages are gained by stating an
argument as a formal syllogism. For, in the first place, we can then
examine separately the three conditions on which the validity of
the argument depends:

(1) Are the Premises so connected that, if they are true, the
Conclusion follows? This depends upon the formal principles of
chap. x.

(2) Is the Minor Premise true? This question can only arise when
the minor premise is a real proposition; and then it may be very
difficult to answer. Water rusts iron; but is the metal we are now
dealing with a fair specimen of iron? Few people, comparatively,
know how to determine whether diamonds, or even gold or silver
coins, are genuine. That Camels are ruminants is now a verbal
proposition to a Zoologist, but not to the rest of us; and to the
Zoologist the ascertaining of the relation in which camels stand to
such ruminants as oxen and deer, was not a matter of analysing
words but of dissecting specimens. What a long controversy as to
whether the human race constitutes a Family of the Primates! That
'the British Empire is an empire' affords no matter for doubt or

inquiry; but how difficult to judge whether the British Empire resembles Assyria, Egypt, Rome, Spain in those characters and circumstances that caused their downfall!

(3) Is the Major Premise true? Are all ruminants herbivorous? If there be any exceptions to the rule, camels are likely enough to be among the exceptions. And here the need of Inductive Logic is most conspicuous: how can we prove our premises when they are universal propositions? Universal propositions, however, are also involved in proving the minor premise: to prove a thing to be iron, we must know the constant reactions of iron.

A second advantage of the syllogism is, that it makes us fully aware of what an inference implies. An inference must have some grounds, or else it is a mere prejudice; but whatever the grounds, if sufficient in a particular case, they must be sufficient for all similar cases, they must admit of being generalised; and to generalise the grounds of the inference, is nothing else than to state the major premise. If the evidence is sufficient to justify the argument that camels are herbivorous because they are ruminants, it must also justify the major premise, All ruminants are herbivorous; for else the inference cannot really depend merely upon the fact of ruminating. To state our evidence syllogistically, then, must be possible, if the evidence is mediate and of a logical kind; and to state it in this formal way, as depending on the truth of a general principle (the major premise), increases our sense of responsibility for the inference that is thus seen to imply so much; and if any negative instances lie within our knowledge, we are the more likely to remember them. The use of syllogisms therefore tends to strengthen our reasonings.

A third advantage is, that to formulate an accurate generalisation may be useful to others: it is indeed part of the systematic procedure of science. The memoranda of our major premises, or reasons for believing anything, may be referred to by others, and either confirmed or refuted. When such a memorandum is used for further inferences, these inferences are said, in the language of Formal Logic, to be drawn from it, as if the conclusion were contained in our knowledge of the major premise; but, considering the limited extent of the material evidence, it is better to say that

the inference is drawn according to the memorandum or major premise, since the grounds of the major premise and of the conclusion are in fact the same (Mill: Logic, B. II. c. 3). Inductive proofs may be stated in Syllogisms, and inductive inferences are drawn according to the Law of Causation.

Section 7. To assume that resemblance is a ground of inference, and that substance and attribute, or cause and effect, are phenomena constantly related, implies belief in the Uniformity of Nature. The Uniformity of Nature cannot be defined, and is therefore liable to be misunderstood. In many ways Nature seems not to be uniform: there is great variety in the sizes, shapes, colours and all other properties of things: bodies falling in the open air–pebbles, slates, feathers–descend in different lines and at different rates; the wind and weather are proverbially uncertain; the course of trade or of politics, is full of surprises. Yet common maxims, even when absurd, testify to a popular belief that the relations of things are constant: the doctrine of St. Swithin and the rhyme beginning 'Evening red and morning grey,' show that the weather is held to be not wholly unpredictable; as to human affairs, it is said that 'a green Yule makes a fat churchyard,' that 'trade follows the flag,' and that 'history repeats itself'; and Superstition knows that witches cannot enter a stable-door if a horse-shoe is nailed over it, and that the devil cannot cross a threshold inscribed with a perfect pentagram. But the surest proof of a belief in the uniformity of nature is given by the conduct of men and animals; by that adherence to habit, custom and tradition, to which in quiet times they chiefly owe their safety, but which would daily disappoint and destroy them, if it were not generally true that things may be found where they have been left and that in similar circumstances there are similar events.

Now this general belief, seldom distinctly conceived, for the most part quite unconscious (as a principle), merely implied in what men do, is also the foundation of all the Sciences; which are entirely occupied in seeking the Laws (that is, the Uniformities) of Nature. As the uniformity of nature cannot be defined, it cannot be proved; the most convincing evidence in its favour is the steady progress made by Science whilst trusting in it. Nevertheless, what is important is not the comprehensive but indeterminate notion of

Uniformity so much as a number of First Principles, which may be distinguished in it as follows:

(1) The Principles of Contradiction and Excluded Middle (ch. vi. Section 3) declare that in a given relation to a given phenomenon any two or more other phenomena are incompatible (B is not A and a); whilst the given phenomenon either stands related to another phenomenon or not (B is either A or a). It is not only a matter of Logic but of fact that, if a leaf is green, it is not under the same conditions red or blue, and that if it is not green it is some other colour.

(2) Certain Axioms of Mediate Evidence: as, in Mathematics, 'that magnitudes equal to the same magnitude are equal to one another'; and, in Logic, the Dictum or its material equivalent.

(3) That all Times and all Spaces are commensurable; although in certain relations of space (as pi) the unit of measurement must be infinitely small. If Time really trotted with one man and galloped with another, as it seems to; if space really swelled in places, as De Quincey dreamed that it did; life could not be regulated, experience could not be compared and science would be impossible. The Mathematical Axioms would then never be applicable to space or time, or to the objects or processes that fill them.

(4) The Persistence of Matter and Energy: the physical principle that, in all changes of the universe, the quantities of Matter and Energy (actual and potential, so-called) remain the same. For example, as to matter, although dew is found on the grass at morning without any apparent cause, and although a candle seems to burn away to a scrap of blackened wick, yet every one knows that the dew has been condensed from vapour in the air, and that the candle has only turned into gas and smoke. As to energy, although a stone thrown up to the housetop and resting there has lost actual energy, it has gained such a position that the slightest touch may bring it to the earth again in the same time as it took to travel upwards; so on the house-top it is said to have potential energy. When a boiler works an engine, every time the piston is thrust forward (mechanical energy), an equivalent in heat

(molecular energy) is lost. But for the elucidation of these principles, readers must refer to treatises of Chemistry and Physics.

(5) Causation, a special form of the foregoing principles of the persistence of matter and energy, we shall discuss in the next chapter. It is not to be conceived of as anything occult or noumenal, but merely as a special mode of the uniformity of Nature or experience.

(6) Certain Uniformities of Co-existence; but for want of a general principle of Co-existence, corresponding to Causation (the principle of Succession), we can only classify these uniformities as follows:

(a) The Geometrical; as that, in a four-sided figure, if the opposite angles are equal, the opposite sides are equal and parallel.–Countless similar uniformities of co-existence are disclosed by Geometry. The co-existent facts do not cause one another, nor are they jointly caused by something else; they are mutually involved: such is the nature of space.

(b) Universal co-inherences among the properties of concrete things.–The chief example is the co-inherence of gravity with inertia in all material bodies. There is, I believe, no other entirely satisfactory case; but some good approximations to such uniformity are known to physical science.

(c) Co-existence due to Causation; such as the positions of objects in space at any time.–The houses of a town are where they are, because they were put there; and they remain in their place as long as no other causes arise strong enough to remove or destroy them. Similarly, the relative positions of rocks in geological strata, and of trees in a forest, are due to causes.

(d) The co-inherence of properties in Natural Kinds; which we call the constitution, defining characters, or specific nature of such things.–Oxygen, platinum, sulphur and the other elements; water, common salt, alcohol and other compounds; the various species of plants and animals: all these are known to us as different groups of co-inherent properties. It may be conjectured that these groupings

of properties are also due to causation, and sometimes the causes can be traced: but very often the causes are still unknown; and, until resolved into their causes, they must be taken as necessary data in the investigation of nature. Laws of the co-inherence of the properties of Kinds do not, like laws of causation, admit of methodical proof upon their own principles, but only by constancy in experience and statistical probability (c. xix, Section 4).

(e) There are also a few cases in which properties co-exist in an unaccountable way, without being co-extensive with any one species, genus, or order: as most metals are whitish, and scarlet flowers are wanting in fragrance. (On this Section 7, see Venn's Empirical Logic, c. 4.)

Section 8. Inasmuch as Axioms of Uniformity are ultimate truths, they cannot be deduced; and inasmuch as they are universal, no proof by experience can ever be adequate. The grounds of our belief in them seem to be these:

(1) Every inference takes for granted an order of Nature corresponding with it; and every attempt to explain the origin of anything assumes that it is the transformation of something else: so that uniformity of order and conservation of matter and energy are necessary presuppositions of reasoning.

(2) On the rise of philosophic reflection, these tacit presuppositions are first taken as dogmas, and later as postulates of scientific generalisation, and of the architectonic unification of science. Here they are indispensable.

(3) The presuppositions or postulates are, in some measure, verifiable in practical life and in scientific demonstration, and the better verifiable as our methods become more exact.

(4) There is a cause of this belief that cannot be said to contain any evidence for it, namely, the desire to find in Nature a foundation for confidence in our own power to foresee and to control events.