Chapter 18
The Scientific Method of Sir Karl Popper

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Sir Karl Popper, the Philosopher of Science

Sir Karl Popper was one of the most influential philosophers of science in the twentieth century and probably of all time. He proposed that a scientific theory could not be proved but could be disproved or falsified. He claimed that 'It must be possible for a scientific system to be refuted by experience. A theory that is not refutable by any conceivable event is non-scientific. Every "good" scientific theory is a prohibition: it

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forbids certain things to happen. The more a theory forbids, the better it is' (Popper 1963).

The theory that 'All tigers are carnivorous' is refuted or falsified by the observation of one vegetarian tiger.

The logical basis of scientific research is the method of bold conjectures and attempted refutations. The process can be described by the following oversimplified schema:

Problem ► Theory ► Experiment ► New Problem

His proposal that scientific studies should be based on rational analysis of existing theories and then submitted to severe tests by logical criticisms and experimental investigations is the basis of modern science.

A Biography of Karl Popper

The Austrian-British philosopher of science, Sir Karl Popper (1902–1994), was born in Vienna into a middle-class family. His father was a lawyer and his mother was a talented musician.

After the First World War, he attended the University of Vienna, reading mathematics, physics, psychology and physics. He graduated in 1928 and qualified as a secondary school teacher in mathematics.

In 1934, he published his first book, 'Logik der Forschung' (Logic of Scientific Research) a seminal study which established Popper's reputation as a philosopher (Popper 1959).

In December 1936, he accepted a lectureship at Canterbury College in Christchurch, New Zealand, and in January 1937, he and his wife left Austria for the Antipodes.

In New Zealand, he wrote 'The Poverty of Historicism' and the 2-volume 'The Open Society and its enemies'. He claimed these works were his contribution to the war effort. They were a powerful and critical, intellectual attack on totalitarian societies of both the Right and the Left. He stayed in New Zealand during the duration of the Second World War.

After the war, he obtained a Readership at the London School of Economics and Political Science. In the succeeding 23 years as Professor of Logic and Scientific Method, he had a worldwide impact in many fields from politics, science, philosophy, biology and sociology.

The Problem of Words and Their Meanings

In his autobiography 'The unended quest' Popper mentions a debate he had with his father about the Swedish dramatist Strindberg's autobiography where the writer was trying to extract the 'true' meanings of certain words. Popper continues:

> When I tried to press my objections that there was no such thing as a 'true' meaning, I was disturbed, indeed shocked that my father did not see the point. The issue seemed obvious to me. When we broke off, late at night I realized that I had failed to make much impact.
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> There was a real gulf between us on an issue of importance. I tried strongly to impress on myself that I must always remember the principle of never arguing about words and their meanings.
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> The quest for linguistic precision is analogous to the quest for certainty and both should be abandoned. It is always undesirable to make an effort to increase precision for its own sake since this leads to loss of clarity (Popper 1976).

It was the great merit of Popper to point out that 'science' starts with 'problems' and not with linguistic puzzles. It is the identification of the 'problem' that starts a research worker speculating as to how to arrive at a solution which will throw some light on the puzzle or question he is trying to answer. Without 'problems to resolve', without 'puzzles to elucidate' there is no science. Popper goes on to suggest that 'once we realize all scientific statements or hypotheses are guesses or conjectures and that the vast majority have turned to be eventually false, we can proceed to new ways of looking at scientific problems'.

In a famous passage, Karl Popper offers a way as how to handle this situation:

> Assume a young scientist meets a problem which he does not understand. What can he do? I suggest that even though he does not understand the problem, he can try to solve it and criticise his solution. Since he does not understand the problem, his solution will be a failure, a fact which will be brought out by criticism. In this way, a first step will be made towards pinpointing where the difficulty lies. This means precisely, that a first step will be made towards understanding the problem, for a problem is a difficulty and understanding a problem consists in finding out where the difficulty lies. And this can only be done by finding out why certain solutions do not work.
>
> So we learn to understand a problem by trying to solve it and by failing. When we have failed a hundred times, we may become even experts with respect to this particular problem. That is, if anybody proposes a solution we may see at once, whether there is any prospect of success for this proposal or the proposal will fail because of the difficulties which we know only too well from our own past failures (Popper 1972).

The question 'What kind of explanation may be satisfactory?' leads to the reply, 'An explanation in terms of testable theories and falsifiable universal laws and critical conditions'. An explanation of this kind will be the more satisfactory, the more highly testable these laws are thereby proceeding to better theories.

The Scientific Problem and Its Explanation

The aim of science is to find satisfactory explanations of whatever strikes us as being in need of an explanation. By explanation is meant a set of statements by which one describes the state of affairs to be explained, the 'explicandum'. The explanatory statement or 'explicans' is the object of our search and as a rule will not be known; thus, it will have to be discovered.

Thus a scientific explanation, the 'explicans', whenever it is a discovery will be the explanation of the known by the unknown.

The 'explicans', in order to be satisfactory must fulfil a number of conditions:

1. It must logically entail the 'explicandum', the problem.
2. The 'explicans' ought to be true, although in general it will not be known to be true. It must not be known to be false even after the most critical examination.
3. There must be independent evidence for the 'explicans'. In other words, it must be independent and avoid ad hoc or circular arguments.
   Consider the following dialogue:
   'Why is the sea so rough today ?'
   'Because Neptune is very angry'.
   'How doyou know Neptune is very angry ?'
   'Oh, don't you see how very rough the sea is !'
   The explanation is unsatisfactory because the only evidence for the 'explicans' is the 'explicandum', the problem itself.
4. In order that the 'explicans' should not be ad hoc, it must be rich in content. It must have a variety of testable consequences, which are different from the 'explicandum', the problem. It must lead to many 'Popper sequences' (Popper 1972).

Evolutionary Theory of Knowledge

On the 9th June 1989, Popper was asked to give his belated Inaugural Lecture at the London School of Economics (Popper 1999).

The title he chose was 'Towards an evolutionary theory of knowledge'. The lecture is relevant to all scientists or medical research workers who are grappling with problems involving studies in physics or biology. They are certainly relevant to the study of rheumatoid arthritis. He made the following points in describing the search for knowledge:

1. Knowledge has the character of expectations.
2. Expectations have usually the character of hypotheses, of conjectural or hypothetical knowledge: they are uncertain. And those who expect or who know may be quite unaware of this uncertainty.
3. Most kinds of knowledge are hypothetical or conjectural.

4. In spite of its uncertainty or its hypothetical character, much of our knowledge will be objectively true. It will correspond to the objective facts.
5. Therefore we must clearly distinguish between the truth of an expectation or a hypothesis and its certainty and therefore between the two ideas: the idea of truth and the idea of certainty.
6. There is much truth in our knowledge but little certainty. We must approach our hypotheses critically; we must test them as severely as we can, in order to find out whether they can be shown to be false after all.
7. Truth is objective: it is correspondence to the facts.
8. Certainty is rarely objective: it is usually no more than a feeling of trust, of conviction, although based on insufficient knowledge. Such feelings are dangerous since they are rarely well founded. They may turn us into hysterical fanatics who try to convince themselves of a certainty which they unconsciously know is not available.
9. The issue of social relativism is widely held, often by sociologists. Who study the ways of scientists and who think thereby they study science and scientific knowledge. Many of these sociologists do not believe in objective truth but think of truth as a sociological concept.
10. Some of them believe that truth is what the experts believe to be true. But in all science the experts are sometimes mistaken. Whenever there is a breakthrough, it means that the experts have been proved wrong. And that the facts, the objective facts were different from what the experts expected them to be.
11. It is our suppressed sense of our fallibility that is responsible for the despicable tendency to form cliques and go along with whatever seems to be fashionable. For I hold that science ought to strive for objective truth that depends only on the facts; on truth that is above human authority and above arbitration, and certainly above scientific fashions. Some sociologists fail to understand that this objectivity is a possibility towards which science should aim. Yet science has aimed at truth for at least for the last 2,500 years.

12. Philosophers and some scientists often assume that all our knowledge stems from our senses, from 'sense data' which our senses deliver. Some believe that the question: 'How do you know?' is in every case equivalent to the question 'What are the observations that entitle you to your assertion?' But seen from a biological point of view this kind of approach is a colossal mistake. For our senses tell us nothing without prior knowledge. This prior knowledge cannot in turn be the result of observation, it must the result of evolution by trial and error as a solution or an attempt at a solution of a problem.
13. Observations or data may lead in science to the abandonment of a scientific theory and thereby induce some of us to think up a new tentative theory – a new trial. But the new theory is our product, our thought, our invention and a new theory is only rarely thought by more than a few people, even when there are many who agree on the refutation of the old theory. The few are those who see the new problem. Seeing a new problem may well be the most difficult step in creating a new theory (Popper 1999).

Bacon, Hume and Popper

Sir Francis Bacon (1561–1626) proposed that science consists of making observations about natural phenomena which then lead to theories. Repeatable observations lead to theories by the mechanism of 'induction'. David Hume (1711–1776) claimed that because B follows A, today, we cannot make the prediction that the same will happen tomorrow. In other words, Bacon's method of 'induction' does not exist. Thus, the assumption A causes B is based on mere habit or belief and this severely undermined the belief in empiricism and empirical observations. Bertrand Russell claimed that 'The growth of unreason and romantic philosophies in the nineteenth and twentieth centuries is a natural sequel to Hume's destruction of empiricism' (Russell 1946).

Popper was a great critic of the Baconian myth that all science starts with observations and then slowly and cautiously proceeds to theories. It was the great merit of Popper to point out that 'science' starts with 'problems'. It is the identification of the 'problem' that starts a research worker speculating as to how to arrive at a solution which will throw some light on the puzzle or question he is trying to answer. Without 'problems to resolve', without 'puzzles to elucidate' there is no science. Popper goes on to suggest that 'once we realize all scientific statements or hypotheses are guesses or conjectures and that the vast majority have turned out to be false, the Baconian myth becomes irrelevant'. This leads to the realization that attempts to find the truth are not final, but open to improvement; that knowledge is conjectural, that it consists of guesses or hypotheses rather than final and certain truths. Criticism and critical discussion with the help of experiments are our only means of getting nearer to the truth. It thus leads to the tradition of bold conjectures and free criticisms, the tradition which created the rational and scientific attitude of Western civilization.

Popper insisted that 'The task of science is the search for truth, that is for true theories. Yet it is not the only aim of science. We want more than mere truth, what we are looking is for interesting and "deep" truth which has a high degree of explanatory power. What we are looking for is answers to our problems'.

Popper's Scientific Method

The fundamental procedure of the growth of knowledge remains that of conjecture and refutation, of the elimination of unfit explanations.

A scientific result cannot be justified. It can only be criticised and tested.

Theories about how knowledge grows involve methods of trial and error.

Here is a tetradic scheme for the description of the growth of knowledge:

$$P(1) \blacktriangleright TT \blacktriangleright EE \blacktriangleright P(2)$$

Popper proposed a powerful analytical method to investigate scientific problems. The process can be described by the following simple schematic outline of how to tackle a scientific problem.

We start from a simple scientific 'problem 1'(P1) and try to solve it by a 'tentative theory' (TT1) which may or may not be correct. The theory will then be subjected to 'error elimination' (EE1) either by logical criticism or experimental studies. As a result of these investigations, a new fact will appear, 'problem 2' (P2) which in turn will require a scientific explanation. This is a 'Popper sequence'.

If each 'Popper sequence' generates new facts, then the original problem becomes richer in that it has more questions to resolve, but at the same time, the investigation gets closer to the truth of the inquiry, to the centre of the problem. The new facts uncovered by this 'Second Popper Sequence' are different from the 'First Sequence' because they are related to the logical properties of the hypothesis or 'tentative theory' and the facts that follow from the 'error elimination' steps.

The tetradic schema is an attempt to show that the results of criticism, of 'error elimination' (EE) applied to a 'tentative theory' (TT) leads as a rule to the emergence of a 'new problem' (P2).

Problems, after they have been solved and their solutions examined, tend to beget problem-children, new problems, often of greater depth and even greater fertility than the old ones (Popper 1972).

The best tentative theories, and all theories are tentative, are those which give rise to the deepest and unexpected results.

If the new problem (P2) turns out to be merely the old problem (P1) in disguise, then we say that one theory only manages to shift the problem.

The decisive point is, of course always, how well does one theory solve our original problem. At any rate, one of the things we wish to achieve is to learn something new.

The Hippocratic Oath, Popper and Medicine

The centre piece of the 'Hippocratic oath' states: '…The regimen I shall adopt for the benefit of the patients according to my ability and judgement and not for their hurt or for any wrong' (Singer and Underwood 1962).

Popperian analysis of a scientific problem, such as rheumatoid arthritis, may provide new clues or ideas for treatment. However, it is only when the therapeutic proposals arising from Popperian analysis are actually provided to the patients that will we know if the scientific problem has been solved.

If no therapeutic benefits accrue to the rheumatoid arthritis patients from anti-*Proteus* treatment, then the hypothesis that these microbes are involved in this disease will have been disproved and the question of the origin of this condition will have to await new and better theories.

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