Karl Popper – Conjectures and Refutations (Extract: pp. 33-58)

Section I

- Popper's question is "when should a theory be ranked as scientific" or "is there a criterion for the scientific character or status of a theory".
- This is *not* the same question as "when is a theory true (or acceptable)" but seeks to distinguish science from pseudo-science, knowing that science often errs and that pseudo-science may occasionally stumble on the truth.
- Popper wasn't satisfied by the usual answer – that science was distinguished from pseudo-science or "metaphysics" by its (essentially inductive) empirical method, proceeding from observation or experiment. Instead, Popper formulated his problem as distinguishing between genuinely empirical and non- or pseudo-empirical methods; those (eg. astrology) that, while employing observation, don't come up to scientific standards.
- It wasn't astrology that caught Popper's attention (back in 1919) but the new and often wild theories abounding after the collapse of the Austro-Hungarian Empire. Of those that interested Popper, Einstein's relativity theory was the most important by far, but he was also interested in (1) Marx's theory of history (2) Freud's psycho-analysis and (3) Alfred Adler's "individual psychology".
- There was a lot of nonsense talked about all 4 theories, but Popper was fortunate in learning of Eddington's eclipse observations that provided the first confirmation of Einstein's theory of gravitation and which had a lasting impact on Popper's intellectual development. He also co-operated with Adler in his clinical work.
- In the summer of 1919, Popper became increasingly dissatisfied with the 3 numbered theories, feeling dubious about their scientific status. He wondered why they were so different from physical theories, such as Newton's or Einstein's.
- Popper points out that few at the time would have believed in the *truth* of Einstein's theory of gravitation, which shows that it wasn't doubts about the truth of the other theories that bothered him. Nor was it that mathematical physics was more *exact* or *measurable*. It was rather that the other 3 theories had more in common with astrology than astronomy; more like ancient myths than science.
- Admirers of these theories were impressed by the following factors: (a) *explanatory power* – almost everything within their fields, resulting in an intellectual conversion or revelation of hidden truths, (b) the world was full of *verifications* of the theories – confirming instances were everywhere. Those who failed to see the truth just didn't want to see it, whether from repression or class interest.
- Popper thought the most characteristic feature was the stream of confirmations. Marxists saw confirmation in whatever they read or did *not* read in the papers. Freudian analysts saw their theories constantly verified in clinical observation. One particular occasion particularly impressed Popper about Adler – a case that didn't seem to be Adlerian, but which Adler managed to explain without having seen the child. How had he done so? Because of his 1,000-fold experience, now made 1,001!
- The point of the above remark is that earlier observations may have been no sounder than this one, this each being interpreted in the light of the others, yet

counting as a new confirmation. All that was confirmed was that any case could be interpreted in the light of the theory – whether Adler's or Freud's.

- Popper gives an example – of a child either nearly killed or saved by / from drowning, the action of the man responsible being understood as repressed or sublimated desire and shared inferiority. Any human action could be interpreted in the light of either theory and, far from considering this a strength of the theories, as did their supporters, Popper came to see this as a weakness.
- Things are different with Einstein's theory. Popper describes the light-bending predictions of the theory by checking the displacement of stars in a constellation seen at night and during an eclipse.
- The impressive thing about such an experiment is the *risk*. If the effect is absent, the theory is *refuted*. The theory is *incompatible* with certain possible observations. The result is *surprising* from a pre-Einstein perspective (though half the result can be deduced from the classical theory if assumed ballistic). This is the opposite of the Adler-Freud situation, where hardly any human behaviour was inconsistent with either theory.
- This led Popper in 1919/20 to the following (re-)formulation:
  1. It is easy to find confirmations or verifications of any theory just by looking for them.
  2. Confirmations should be counted only if they result from risky predictions – if we would have expected in the absence of the theory a result that would have refuted it.
  3. Every good scientific theory prohibits certain things; the more, the better it is.
  4. Theories irrefutable by any conceivable observation are non-scientific. Irrefutability is a vice not a virtue.
  5. Every genuine test of a theory is an attempt to refute or falsify it. There are degrees of testability – some theories take more risks and are more exposed to falsification.
  6. Confirming evidence ("corroborating evidence") should only be counted when it's a genuine test of the theory; if it was a serious but unsuccessful attempt to falsify the theory.
  7. Admirers may always retain belief in testable but falsified testable theories by introducing ad hoc auxiliary assumptions or re-interpretations. This is at the cost of at least lowering the scientific status of the theory. Popper later describes this rescuing operation as a *conventionalist twist* or *stratagem*.
- In sum, the criterion of the scientific status of a theory is its falsifiability or refutability or testability.

Section II

- Popper points out that Einstein's theory did satisfy the falsifiability criterion. Even though the accuracy of the instruments used in the "eclipse" test precluded complete assurance, there was clearly a possibility of refutation.
- Astrology does not pass the test. Practitioners are so impressed by confirming evidence that they ignore unfavourable evidence. Vagueness in prediction allows any situation to be explained as conformable to them, whereas more precise prognostications would have led to refutation. Escaping falsifiability destroys testability.
- Marxist history adopted a soothsaying practise. Initially, it was testable, but falsified (as Popper demonstrated in *Open Society* 15:iii) – but instead of

accepting this, Marxists reinterpreted into agreement both theory and evidence, making the theory irrefutable and destroying its much advertised claim to scientific status.

- There's not conceivable human behaviour that will refute either psycho-analytic theory. This doesn't mean that Fred and Adler weren't seeing things correctly – Popper thinks they had much to say of importance that will one day form part of a testable psychological science. However, clinical observations believed by analysts to confirm their theory cannot do so any more than so astrological data. No stronger scientific claim can be made for Freud's epic of Ego, Super-ego and Id than for the works of Homer. The theories describe facts, but in the manner of myths and while containing interesting psychological suggestions, these are not in testable form.
- Popper remarks in a footnote that clinical, like all, observations are interpretations in the light of theory (Popper covers this further in §iv, ff) and thus are apt to seem to support theory. Real support can only be found from attempted refutations. Criteria of refutation have to be laid down beforehand, and it must be agreed which observed situations will count as refuting the theory. Popper asks what observation would refute psycho-analysis itself? These haven't been agreed by analysts and there are certain concepts, such as ambivalence, that make this almost impossible to do so. Popper asks how the expectations of the analyst and proposed interpretations affect the response of the patient. He had coined the term *Oedipus Effect* (noting that the chain of events leading to Oedipus's parricide was initiated by the oracle's prediction of that event) to refer to the effect of a theory on the events it predicts or describes. Freud had noted, surprisingly without worry, that the analyst's suggestions could embed themselves in the patient's dreams.
- Very nearly all scientific theories arise from myths, Popper thinks, so a myth may contain important anticipations of scientific theories. He suggests (1) Empedocles' evolution (2) Parmenides' unchanging universe (parallel to Einstein's 4-space in which nothing ever happens and all is predetermined). So unscientific theories are neither worthless nor meaningless; but, they cannot claim to be backed by scientific evidence in the scientific sense, though may easily be in some sense backed by observation.
- Popper gives the example of astrology having been rejected by Aristotle and other rationalists down to Newton's day – but for the wrong reason, that it alleged sublunary influence of the planets. Newton's theory of the lunar cause of the tides effectively comes from the astrological stable, which explains Newton's reluctance to propound it and Galileo's refusal to consider it.
- Thus, Popper's proposal of falsifiability neither addressed neither problems of meaningfulness or significance nor of truth or acceptability. He attempted to draw a line between systems of statements of the empirical sciences, on the one hand, and those of metaphysics, religion or pseudo-science on the other: the problem of demarcation, to which the criterion of falsifiability is a solution as it demands possible conflict with conceivable observations for ranking as science.

Section III

- Popper now grants that his criterion of demarcation is far from obvious, since its significance remained widely unrecognised. In 1920, Popper thought it trivial – though it solved a worrying intellectual problem and had important practical – political – consequences. However, he didn't realise its full philosophical

significance, and thought that publishing it was absurd, since the problem must surely already have agitated many philosophers and scientists into reaching this obvious solution already. That this wasn't the case, Popper learnt from the reception of Wittgenstein's work, so Popper published it 13 years later as a critique of Wittgenstein's *criterion of meaningfulness*.

- Wittgenstein had tried to show in the *Tractatus* (6.53, 6.54, 5) that all philosophical or metaphysical propositions were non-propositions or pseudo-propositions – senseless or meaningless. All meaningful propositions were supposed to be truth functions of elementary atomic propositions describing atomic facts that can in principle be ascertained by observation. Meaningful propositions were fully reducible to elementary propositions –n simple statements describing states of affairs in principle capable of being established or rejected by observation. Defining an observation statement as something that *may* be observed, then every proposition must, according to the *Tractatus*, be a truth-function of observation statements, deducible from them. All other apparent propositions are meaningless pseudo-propositions, nonsensical gibberish.
- Wittgenstein used this idea to characterise science as against philosophy – the totality of true propositions is the total natural science (*Tractatus* 4.11). Propositions belonging to science are those deducible from and verified by *true* observation statements. Were we to know all true observation statements, we'd know all that natural science can assert.
- This is a crude verifiability criterion of demarcation – Popper refines it as follows: "The statements which may possibly fall within the province of science are those which may possibly be verified by observation statements and coincide with the class of *all* genuine or meaningful statements". Verifiability, meaningfulness and scientific character coincide.
- Popper claimed never to have been interested with the merely verbal pseudo-problem of meaning, only in the problem of demarcation, Popper's interest in which immediately led him to see that Wittgenstein's verifiability criterion of meaning was also a criterion of demarcation, and that as such it was totally inadequate even if its dubious concept of meaning was set aside. Wittgenstein's criterion of demarcation – verifiability or deducibility from observation statements – is both too narrow and too wide; it excludes almost everything characteristic of science while effectively failing to exclude astrology. No scientific theory can be deduced from observation statements or be described as a truth-function of them.
- Popper pointed out all this to the Vienna Circle and summarised his ideas in an unpublished book read by some of them – including Carnap who accepted the ideas and incorporated them in his paper *On Protocol-Sentences*, calling it *Procedure B*, in contrast to Neurath's *Procedure A*. Popper later incorporated this book into *Logic of Scientific Discovery* and in 1933 wrote a 2-page paper which was misunderstood by the Vienna Circle as proposing to replace a verificationist theory of *meaning* by a falsificationist one! Popper's protests that he was trying to solve the problem of demarcation rather than the pseudo-problem of meaning were unavailing.
- While the verificationist theory of meaning was at least clear, Popper claimed responsibility by his criticism for the confusion that now reigns. Criticism of Popper's *alleged* views is widespread and successful, but Popper claims never to have encountered criticisms of his *actual* views. However, testability is widely seen as a criterion of demarcation.

- Popper points out a difference with respect to negation between meaning and testability. Negations of meaningless statements (eg. Wittgenstein's favourite "Socrates is identical") are also meaningless (and similarly for *meaningful* statements), but the negations of testable or falsifiable statements need not be testable[1] (as Popper pointed out in *Logic*, and later so did his critics[2]).
- Popper has a useful footnote on the claim that falsification of a natural law is as impossible as its verification. He says he raised and replied to this objection in Logic. Popper claims that the objection confuses two levels of analysis and draws a parallel with mathematical proofs never being demonstrable because in checking them we can never be sure not to have missed a mistake. (1) On the first level there is an asymmetry, because one observation (the perihelion of mercury) can falsify (Kepler's Laws), though no number of singular statements can verify. Attempts to minimise this asymmetry only lead to confusion[3]. (2) On the second level, we can doubt any statement – even the simplest observation – and can agree that every statement is uncertain because it requires interpretation in the light of theories. This doesn't affect the asymmetry but is important. Popper notes that most people who dissected the heart before Harvey observed the wrong things, what they expected to see, and that there's no such thing as an observation safe from the dangers of misinterpretation, which is one reason why induction fails. The empirical basis consists in a mixture of theories of lower degrees of universality[4] ("reproducible effects"). However, the fact remains that whatever basis the investigator, at his peril, assumes, he can test his theory only by trying to refute it.

Section IV

- Popper thinks the problem of demarcation is the key to most of the fundamental problems in the philosophy of science. He will list some of these later, but can only discuss the *problem of induction* at length. It took Popper 5 years to realise the connection between demarcation and induction.
- Popper approached the problem of induction through Hume[5], who he thought was correct in showing that induction cannot be logically justified. Hume claims that there are no logical arguments that allow us to conclude that instances of which we have had no experience will resemble those of which we have. Even after observing frequent constant conjunction, we have no reason to make any inference concerning objects of which we have had no experience (Popper quotes from *Treatise* I.III.vi&xii, as well as from *Enquiry* iv:II and *Abstract*). If we say that experience teaches that us that constantly conjoined objects continue to be so conjoined, Hume repeats his question, asking why from this experience we form conclusions beyond the past inferences of which we have had experience. Justification of induction by experience must lead to infinite regress, so theories

[1] An example would be useful, as this is important and linked to the charge that there's a symmetry between verifiability and falsifiability which are linked by negation. Have a look in *Logic*. Presumably the Raven paradox comes in the picture here somewhere!
[2] Popper is uniformly conscious of his critics as adversaries in a way contrary to any philosophers I've come across before.
[3] So, isn't the falsification of a claim just the verification of its negation. Isn't Popper saying that we can't verify L, but we can verify L* = ¬L?
[4] What does Popper mean by "lower" and the connection with "reproducible effects"?
[5] Review and expand my "Hume on Future resembling the Past" essay, and review *Treatise*.

can never be inferred from observation statements or be rationally justified by them.

- Popper found Hume's refutation of inductive inference clear and conclusive, but disliked his psychological interpretation of induction in terms of custom and habit. While it has often been noted that Hume's explanation isn't philosophically satisfactory, as a theory it is certainly *psychological* rather than philosophical, since it tries to give a causal explanation of a psychological fact – that we believe in laws – by asserting that this fact is due to (constantly conjoined with) custom or habit. This is still unsatisfactory, because this psychological fact is itself the custom or habit of believing in laws or regularities, and we're simply explaining one habit in terms of another. However, we can reformulate Hume's theory in a more satisfactory manner when we realise that "custom" is used not only to describe regular behaviour but to theorise about its origin. So, like other habits, our habit of believing in laws is the product of frequent repetition – of the observation of the constant conjunction of things of one kind with those of another.
- This ordinary language genetico-psychological theory is thus hardly as revolutionary as Hume supposed, and is part of common sense. Even so, Popper felt Hume was mistaken, and that the psychological theory is refutable on purely logical grounds, additionally thinking it defective in at least three empirical areas:
  a) **The typical result of repetition**: eg. the piano, are that ultimately execution is possible without attention, becoming unconscious or "physiological". Prior to learning to ride a bike, we initially usefully decide to steer in the direction we're falling, but after practice we forget this rule, having no further use for it. Even if there are unconscious expectations, they only become conscious if something goes wrong ("hearing" the tick of the stopped clock). Hence, Popper concludes that repetition, far from creating a conscious expectation of law-like succession may begin with conscious belief, but destroy it by making it superfluous.
  b) **The genesis of habits**: these don't usually originate in repetition. Feeding and walking begin before habit is possible and deserve to be called customs only after repetition has played its part.
  c) **The character of the "believing in a law" experiences**: this is not quite the same as behaviour that betrays an expectation of a law-like succession of events, though sufficiently similar for joint consideration. Only in exceptional situations does such behaviour result from mere repetition of sense impressions (the stopped clock). Even Hume admitted that a single striking observation may be sufficient to create a belief or expectation, but tries to explain this away as the result of inductive habit formed from long repetitive sequences experienced in an earlier period of life. This is unsuccessful on account of unfavourable facts observed in young animals and babies. The example given is of puppies sensibly learning to abhor cigarette smoke after one sniff.
- Popper points out that it's not just that the empirical facts don't support Hume, but that there are purely logical objections to his psychological theory. Hume's central theory is that of *repetition*, which is based on *similarity* or *resemblance*. However, this idea is used uncritically, for we're led to think of special cases such as water drops hollowing the stone or clock ticks. The general case, on the other hand, is of repetition-for-us based on similarity-for-us; we must *interpret* situations as repetitions. The clever puppies showed by their response that they expected the

noxious smell to follow cues on the second occasion. The situation was a repetition-for-them because the anticipated its similarity to the previous occasion.

- This has a purely logical basis. The kind of repetition Hume envisages can never be perfect – the cases are only of similarity and are repetitions only from a certain perspective, as repetitions have a different effect on a spider from on Popper. So, for logical reasons there must always be a system of expectations, assumptions or interests. Since this arises *before* repetition, it cannot be the *result* of repetition.
- Consequently, we must replace the idea of events *being* similar by that of them being *interpreted* as similar. But, if this is so, Hume's theory leads to infinite regress in a way similar to that recognised by Hume himself and used to explode the logical theory of induction. We wish to explain behaviour as recognising or interpreting a situation as a repetition of another. We cannot explain this by reference to earlier repetitions once we realise these are also repetitions-for-them, for the same situation repeats – how to *recognise* or *interpret* a situation as a repetition of another.
- Popper summarises: similarity-for-us is the product of possibly inadequate interpretations and possibly unfulfilled expectations. It is therefore impossible to follow Hume and explain expectations as arising from many repetitions, for even the first repetition-for-us must be based on similarity-for-us, and therefore on expectations, which is just what we want to explain. Hence, Hume's psychological theory involves infinite regress.
- Popper felt Hume hadn't accepted his own logical analysis. Having refuted the logical idea of induction, he had to explain how as a matter of psychological fact we obtain our knowledge is induction is rationally unjustifiable. There are two possibilities:
  1. By non-inductive procedures, allowing Hume to retain a form of rationalism.
  2. By repetition and induction – by a logically invalid and unjustifiable procedure, so that all apparent knowledge is mere belief based on habit. This would make even scientific knowledge irrational so that rationalism[6] is absurd and must be given up.

  Popper doesn't discuss attempts to defend induction by saying that, though it is logically invalid if by "logic" we mean deductive logic, it is not irrational by its own standards since every rational man applies it as a matter of fact. Popper thinks it was Hume's great achievement to break the uncritical identification of matters of fact with the question of justification or validity.
- Popper thinks Hume never seriously considered (1), but, having ejected the logical theory of induction, he allowed it in again by repetition in the guise of a psychological theory. Popper reverses Hume, by explaining repetition-for-us as arising from our propensity to expect and search for regularities. We actively impose regularities on the world, trying to discover similarities in it and interpreting it in the light of laws of our own invention. Without waiting for premises, we jump to conclusions, which may be discarded later if observation shows them to be wrong.
- This is Popper's theory of trial and error, *conjectures and refutations*. It explains why attempts to force interpretations on the world are logically prior to the observation of similarities. Logic implies that this applies to science also, with scientific theories being inventions rather than digests of observations. The latter are rarely chance, but made with the intention of obtaining a decisive refutation.

[6] What does Popper mean by rationalism?

Section V

- It is still widely held that science proceeds from observation to theory, and Popper has been considered insincere in pretending to doubt what nobody in his senses can doubt. However, it's absurd to suppose we can observe in the absence of theory. While we might profitably collect beetles, we cannot just collect observations and bequeath them to the Royal Society. We can't just ask people to "observe" – we have to tell them *what* to observe because observation is always selective, requiring a chosen object, a definite task, an interest, a point of view and a problem. Describing the observation requires a descriptive language, including property-words, and it presupposes similarity and classification, which in turn presupposes interests, points of view and problems. Objects change according to whether the animal is hungry or an escaping meal. Objects can be classified and become similar or dissimilar *only* in relation to needs and interests. This applies just as much to the theoretical interests and special problems, conjectures and anticipations and background theories – the horizon of expectations – of *scientists*.
- The priority problem of hypotheses and observation is as soluble as that of the chicken and the egg – an earlier kind of hypothesis (or egg) came first. Any hypothesis is preceded by the observations it is designed to explain, but these presupposed a framework of expectations or theories. Observations that gave rise to a hypothesis did so because they couldn't be explained within the existing framework. This regress isn't infinite, but terminates in unconscious *inborn* expectations.
- Popper agrees that a theory of inborn *ideas* is absurd, but every organism has inborn *reactions* or *responses*, including to impending events. These expectations need not be conscious – new-borns "expect" to be fed, protected and loved. Because of the close connection between expectation and knowledge, we can speak of inborn knowledge, though this isn't valid a priori – since the new-born may be abandoned to starvation.
- The expectations are genetically or psychologically a priori of observation. One of the major expectations – indeed needs – is that of finding regularities. This corresponds to Kant's "law of causality", believed by him to be a priori valid, but failing to distinguish between psychological response and valid belief. Popper doesn't think Kant's mistake to be that crude, since the expectation of regularities is not only *psychologically* a priori but *logically* so, for reasons just rehearsed and despite the previously noted possibilities of disappointment that show that the expectations are not logically valid.
- So Kant isn't far from the truth, and the errors in his response to Hume are subtle, but in trying to show how knowledge is possible, he proposed a theory that "showed" that the quest must necessarily succeed, which is plainly false. Popper thinks Kant was correct in saying that our intellect doesn't derive laws from nature but imposes them on nature, but was wrong in thinking the imposition successful, or the laws necessarily true. Popper notes that Kant thought that Newton's dynamics was valid a priori, and thinks that this (since it guarantees success) makes it difficult to see how knowledge such as Newton's should be so hard to come by[7]. Nature resists and forces us to discard our laws as refuted; though, Popper wryly notes, if we live we may try again.

[7] He fails to point out, oddly, that Newton's laws are, in the light of Einstein, false.

- Popper provides a thought experiment of an "induction machine" which, when placed in a simplified world, may learn and formulate by repetition laws of succession that hold in its world. He has no doubt this can be achieved[8] – but if so, isn't his theory refutes, for if this machine can learn by induction, why can't we? Popper thinks the mistake in the argument is failing to see that in constructing the machine, we provide its world – rules of similarity and guides for the kinds of laws to be "discovered". The machine has "inborn" selection principles, problems of similarity having been solved for it by its makers who have interpreted its world for it.

Section VI

- Our propensity to impose regularity on nature results in *dogmatic* thinking and behaviour, where we expect to find regularities even where there are none[9], ignoring as "background noise" things that don't fit in, sticking to inadequate expectations that ought to be abandoned. Popper thinks such dogmatism is both necessary and useful, in allowing us to approach a good theory by stages; too ready acceptance of defeat would make us miss the opportunity to know that we were very nearly right.
- A dogmatic attitude is symptomatic of strong belief, in contrast to the critical attitude, symptomatic of weaker belief, that's willing to modify its tenets, admit doubts and demands tests. According to Hume & popular opinion, the stronger beliefs should follow long repetition and grow with experience, being "greater in less primitive persons"[10]. However, Popper notes that strong belief is more common in children and "primitives", with their pleasure in the imposition of rites and repetitions as such, whereas increasing experience can create an attitude of caution and criticism[11].
- Popper finds parallels with the dogmatic attitudes of neurotics, in whom the interpretation of the world in terms of a personal set pattern developed in childhood is maintained into adulthood, with everything interpreted in its light. This contrasts with the critical attitude which, while sharing with the dogmatic attitude the willingness to take up a schema of expectations, but is also willing to modify or abandon it. Popper opines that most neuroses are due to the arrested development of the critical attitude, maybe due to some former injury resulting in the need for certainty. Popper claims to have found links between the psychology of knowledge and other areas of psychology usually considered unconnected. His ideas on induction having originated in a conjecture about the origins of Western polyphony, though we are spared this story.

Section VII

- Popper now returns to the philosophy of science from the logical analysis of Hume's psychological theory, pointing out the relevance of the distinction between the critical and dogmatic attitudes to his central problem. The dogmatic

[8] This sounds suspiciously like a neural network.
[9] This is beginning to have the flavour of myth-making that Popper was so critical of in Freud, Adler and Marx.
[10] It's not clear how this transition in the argument is to be made. While children are supposed not to have experienced long repetitions, why should this be denied to "primitives"?
[11] This arises from a regularity of sorts – of regularly being shown the folly of jumping to conclusions!

attitude is unsurprisingly connected to verification and pseudo-science while the critical attitude is connected to science and falsification. The former is more primitive than, and prior to, the latter – it is a pre-scientific attitude. The critical attitude is superimposed on the dogmatic, since it must be directed against dogmatic beliefs which it needs for its raw material.

- Science begins with the criticism of myths and magical techniques & practices, not with the collection of observations or the invention of experiments. Both the scientific and pre-scientific traditions pass on their theories, but the former is distinguished by also passing on its critical attitude to them, as a challenge to discuss and improve. Popper claims the critical tradition as Hellenic, traced back to Thales.
- Popper claims this critical attitude of free discussion of theories aiming at uncovering their weaknesses to improve them as the reasonable, rational attitude, making use of observation in the interest of argument. The Greeks' discovery of the critical method led to the false hope of certain solutions to the old problems – establishing certainty, *proving* and *justifying* theories. This was a residue of the old dogmatism, as nothing outside of mathematics and logic can be proved, and the demand for rational proof in science indicated a failure to separate broad rationality from narrow certainty.
- Logic is essential to the critical process, not for *proof* but to show the remote *implications* of theories for effective criticism. Hume was correct to say that we cannot validly infer our theories from known truths – observations – and concluded that our beliefs were therefore irrational – again correct if "belief" means our inability to doubt our natural laws and the constancy of natural regularities, which has a physiological rather than rational basis. However, he is wrong if "belief" is taken as a *tentative* acceptance combined with a willingness to revise theories that fail to pass our tests. It isn't even irrational to rely on well-tested theories for practical purposes, as no more rational course of action is available.
- If we've made it our task to adjust ourselves as best we can to our world and take best advantage of its opportunities, explaining it where possible with the help of laws and theories, then there's no more rational procedure than that of trial and error, conjectures and refutations. We boldly propose theories, try our best to show them erroneous and accept them tentatively if we can't prove them wrong.
- All laws and theories are tentative, conjectural and hypothetical – even those we can't doubt any longer. Until a theory is refuted, we don't know how it must be modified. Popper notes that the daily rising and setting of the sun – despite being established by induction beyond reasonable doubt – was falsified by the land of the frozen sea and *midnight* sun (Thule, discovered by Pytheas of Massalia, branded a liar for his pains).
- The method of trial and error isn't identical to the scientific or critical approach, as it is applied by the amoeba as well as by Einstein. Popper thinks the difference lies not in the *trials* but in the constructive attitude towards errors, which the scientist tries to uncover in order to refute his theories, using the most searching arguments and experimental tests his theories and ingenuity permit him to design.
- The critical attitude is the conscious attempt to make our theories suffer in our stead in the struggle for the survival of the fittest, while a more dogmatic approach would eliminate our theories by eliminating us. Popper means truth, rather than utility, by "fittest". He doesn't think this procedure is in need of any further rational justification.

Section VIII

- Popper now turns to the logic of science. Much of his criticism of the psychology of experience can be ignored for these purposes since his criticism of the logical problems of induction is independent of it. We need retain just two points: (1) the criterion of demarcation is testability or falsifiability and (2) Hume's logical criticism of induction.
- Popper thinks there's an obvious connection between the two problems of demarcation and induction or scientific method. He believes that many scientists cling to induction because they think this is what characterises the scientific method and that this is all that separated science from pseudo-science; that only the inductive method can provide a satisfactory criterion of demarcation. Popper quotes Max Born's *Natural Philosophy of Cause and Chance* as an example of this view. According to Born, induction allows us to generalise a number of observations into a general rule and whereas everyday life has no definite criterion for the validity of induction, science has worked out a code for its application. Popper points out that Born provides no details of the contents of this inductive code, but stresses that there's no logical argument for its acceptance – it's a matter of faith, and so Popper is willing to call it a metaphysical principle. The reason for this is that he feels unable to persuade the astrologers and other pseudo-scientists to accept the same inductive criteria he does; hence, he thinks that induction is a demarcation criterion.
- Popper says it's obvious that there is no rule of "valid induction", not even a metaphysical one, since no rule can guarantee that a generalisation inferred from true observations, however often repeated, is true. Even Born himself didn't believe in the truth of Newtonian dynamics, despite its inductive support. According to Popper, the success of science doesn't depend on induction, but on luck, ingenuity and the purely deductive rules of critical argument.
- Popper summarises his position as follows:
    1. Induction is a myth, being a fact neither of psychology, ordinary life or scientific procedure.
    2. Science actually operates with conjectures, sometimes jumping to a conclusion after a single observation (as Hume and Born note).
    3. Repeated observations and experiments *test* hypotheses, acting as attempted refutations.
    4. Belief in induction is strengthened by the false assumption that it is the only criterion of demarcation.
    5. Conceptions of inductive method and criteria of verifiability imply a faulty demarcation.
    6. The above is unaffected by saying induction makes theories *probable* rather than *certain*.

Section IX

- It may not be immediately obvious that the solution to the problem of demarcation provides a solution to the problem of induction. The latter problem can be formulated (after Born) as that no experiment can have an infinite number of repetitions, so statements of a law – B depends on A – always transcend

experience. Even so, the statements of law are made all the time, sometimes from scanty material. Popper summarises the genesis of the problem as:

a) Hume's discovery that laws transcend experience and so cannot be justified by observation or experiment.
b) Science uses and proposes laws all the time, sometimes based on few observed instances.
c) *The principle of empiricism* – that in science only observation and experiment may decide on the acceptance or rejection of scientific statements, including laws and theories.

These three principles seem to clash, and so form the *logical problem of induction*. Born gives up (c), as Kant and Russell had done, in favour of a metaphysical principle, which isn't formulated, is vaguely described and of which Popper has never seen an even vaguely promising formulation.

- However, Popper claims that (a) to (c) do *not* clash, which we see as soon as we recognise the *tentative* nature of the acceptance by science of a law. Popper accepts the position he calls *hypotheticism* – that all laws or theories are conjectures or tentative hypotheses, and that we can discard a theory in the light of new evidence without discarding the old evidence that led us to accept it.
- The principle of empiricism (c) is preserved since the fate of a theory is decided by tests, being accepted while it withstands the severest tests we can design, but rejected if it can't. It is never inferred from the empirical evidence and there is neither logical nor psychological induction. Only the falsity of a theory can be inferred from the empirical evidence, and the inference is purely deductive. Hume's demonstration that we cannot infer a theory from observation statements doesn't affect the possibility of these refuting it. This solves the alleged clash between our three principles, and with it the problem of induction.

Section X

- Popper has a quick moan about philosophers' reluctance to have a problem solved. Wittgenstein held that genuine philosophical problems don't exist, and therefore cannot be solved, while others have too much respect for them and think them insoluble. The latter are shocked to think that there might be a simple, neat and lucid solution to an age-old problem; if there *is* a solution, it must be deep or complicated. Popper is still awaiting a simple, neat and lucid criticism of his position in *Logic*.
- One can invent *new* problems of induction[12], but Popper hasn't seen any re-formulations[13] of the problem that can't be easily solved by use of Popper's original solution. He considers some re-formulations[14]:
    1. How do we jump from observation statement to theory? While Popper thinks this appears a psychological rather than philosophical question, he also thinks we can address it without invoking psychology. The jump isn't from an observation statement but from a problem situation. The theory must *explain* the observations that created the problem by allowing us to *deduce* [15]them from the theory (augmented by other accepted theories and initial conditions).

[12] Investigate the interplay, if any, between Popper and Goodman. FFF just seems to have one dismissive comment in the Preface to the 1973 3rd Edition.
[13] These are just re-formulations of the old problem, rather than new ones?
[14] It's not quite clear to me whether Popper considers these new problems or just re-formulations.
[15] Note that observation statements are deduced from the theory, not vice versa.

Our question appears unanswered, because many possible theories both good and bad remain. So our initial question was with respect to a jump to a *good* theory. Popper's answer, however, is that we jump to *any* theory and then test it to find its quality – we repeatedly apply the critical method, eliminating bad theories and inventing new ones; it's hard, but there's no alternative.

2. Other original problem of induction was its justification. If you solve this problem by saying inductive inference is always invalid and so not justifiable, how is the method of trial and error justified? Popper's reply is that his method is one of eliminating false theories by observation statements, and the justification for this is the purely logical relationship of deducibility, which allows us to assert the falsity of universal statements (laws) on the grounds of the truth of singular ones (observations).
3. Why do we prefer non-falsified statements to falsified ones? From a pragmatic perspective, the problem doesn't arise[16], because false theories often serve well enough – formulae used in engineering or navigation are used with confidence by people who know them to be false, because they are good enough approximations and easy to handle. Popper's answer is that we search for truth – even though we can never be sure we've found it – so we prefer the non-falsified ones, which may yet be true, to the falsified which may not. Also, we don't prefer *any* non-falsified theory, only that which is better that its competitors. In the light of criticism, it's better at solving our problems, better tested and of which we conjecture that it will better withstand future trials.
4. Why is it *reasonable* to expect the future to be like the past? This has been taken as a fair question and that the answer should make it plain why such a belief is reasonable. Popper's view is that it is reasonable to think that the future will *differ* from the past in many vital respects. Since we've no better assumption to work from, it's reasonable to act on the basis that the future will be like the past, and that well-tested laws will continue to hold. However, it's also reasonable to think that some of the laws relied on may prove unreliable (as in the case of the midnight sun). Popper thinks that, to judge from past experience and general scientific knowledge, the future *won't* be like the past in most of the ways that those who think it will expect – water will sometimes not quench thirst and air will choke those who breathe it[17].

   It's only an apparent solution to say that the future will resemble the past in the sense that the laws of nature will not change, because this is begging the question, for we can only speak of a law of nature in the context of what we believe to be an unchanging regularity, and if we find this regularity not to be unchanging, we no longer count it as a law of nature. Popper agrees that the fact that we search for laws of nature indicates that we hope to find them and believe there are such things, but our belief in any particular law cannot be safer than our unsuccessful critical attempts to refute it.

- Those who think of the problem in terms of the *reasonableness* of our beliefs are correct to be dissatisfied with the post-Humean sceptical despair of reason, the view that belief in science and in primitive magical practises are on a par, since both are a matter of accepting a "total ideology", a convention or a tradition based on faith. Popper thinks we need to watch out in formulating the problem, with Hume, as one of the reasonableness of our beliefs. Instead, we have three problems, solutions to all of which Popper has provided:

[16] Ie. We *don't* prefer non-falsified theories. I thinks there's an equivocation over "preference" here.
[17] Popper needs to explain these suggestions more carefully.

1. The problem of demarcation; how to *distinguish* science from primitive magic
2. The problem of the rationality of the scientific or critical *procedure*, and the role of observation within it; and
3. The problem of the rationality of our acceptance of theories for scientific and practical purpose.

- Popper also thinks we need be careful to distinguish between (a) the problem of the reasonableness of the scientific procedure and tentative acceptance of the theories resulting from this procedure and (b) the problem of the rationality of the belief that such a procedure will be *successful*. The latter is reasonable because unavoidable, there being no alternative, but it is theoretically unjustifiable as Popper showed in §V. Popper claims that if we could show on logical grounds that the scientific quest was likely to succeed, how would we explain how such success has historically been so rare[18]?
- We can also put the problem of induction in terms of probability. If t is a theory and e the evidence, we can ask for P(t,e) – the probability of t, given e. It is then thought that the problem of induction is to construct a *calculus of probability* to enable us to determine the probability of any theory relative to empirical evidence e, and then to show that P(t,e) increases as supporting evidence accumulates, reaching high values, or at least exceeding 0.5.
- Popper had explained in *Logic* why he thought this approach to the problem is fundamentally mistaken, making the distinction between *probability* and *degree of corroboration* ("confirmation" has been subject to such abuse that Popper has surrendered the term to the verificationists). Popper thinks we must beware of uncritically assuming that degree of corroboration must be a probability in the axiomatic sense of Keynes, Jeffreys and Popper himself.
- In *Logic*, Popper had explained why we're interested in theories with a high degree of corroboration, but also why it's mistaken to conclude that we're interested in *highly probable* theories. Popper had showed that the probability of a statement is inversely proportional to the statement's information content and explanatory power. So, every interesting statement must have a low probability, and, vice versa, a statement of high probability[19] is scientifically uninteresting because it says little and has no explanatory power. While we seek theories with high degrees of corroboration, scientists don't seek highly probable theories but explanations – that is, powerful and improbable theories. It is characteristic of verificationism to take the opposite view. Finding that you cannot verify a theory or make it certain by induction, the verificationist may turn to probability as ersatz certainty in the hope that induction may at least yield that much.
- Popper has a footnote on the calculus of corroboration, in which he defines: $C(t,e) = E(t,e)\,(1 + P(t)P(t,e))$, where $E(t,e) = (P(e,t) - P(e)) / (P(e,t) + P(e))$ is a non-additive measure of the explanatory power of t with respect to e. C(t,e) isn't a probability since it ranges from –1 (t refuted by e) and $C(t,t) < +1$. C(t,t) is the degree of corroborability, degree of testability, or *content* of t. Popper doubts whether a complete formalisation of the idea of corroboration is possible, and has since simplified the definition to: $C(t,e) = (P(e,t) - P(e))/(P(e,t) - P(et) + P(e))$[20].

[18] Is Popper not too negative about what is seen as one of the triumphs of human civilisation?

[19] This is slightly perverse. He's talking about a priori probability – but an inverse square law much used has a high probability of success in its next application. It's not quite clear what we mean by saying that a theory is "highly probable".

[20] This all seems vaguely Batesian, and it'd be nice to see whether these formulae are derived, or are simply conjectures.