

Albert Einstein, Philosopher-Scientist, ed. P.A. Schlipp,  
Library of Living Philosophers, New York 1951, Tudor Publishing Co.  
Autobiography

- p. 9. Wonder. The development of the world of thought is in some sense a continuous light from wonder.  
Wonder at compass. No perceptible cause, push. Child of 4 or 5 years.  
Wonder of totally different kind at age of 12 over Euclid's elements. Lucidity and certainty.

p. 11 f. Epistemological credo.

"I see of the one side the totality of sense-experiences and, on the other, the totality of the concepts and propositions which are laid down in books. The relations between the concepts and propositions among themselves and each other are of a logical nature, and the business of logical thinking is strictly limited /13/ to the achievement of the connection between concepts and propositions among each other according to firmly laid down rules, which are the concern of logic. The concepts and the propositions get "meaning," viz. "content", only through their connection with sense experiences. The connection of the latter with the former is purely intuitive, not itself of a logical nature. The degree of certainty with which this connection, viz., intuitive combination, can be undertaken, and nothing else, differentiates empty phantasy from scientific "truth." The system of concepts is a creation of man together with the rules of syntax, which constitute the structure of the conceptual systems. Although the conceptual systems are logically entirely arbitrary, they are bound by the aim to permit the most nearly possible certain (intuitive) and complete coordination with the totality of sense-experiences; secondly they aim at greatest possible sparsity of their logically independent elements (basic concepts and axioms), i.e., undefined concepts and underived (postulated) propositions.

"A proposition is correct if, within a logical system, it is deduced according to the accepted logical rules. A system has truth content according to the certainty and completeness of its coordination-possibility to the totality of experience. A correct proposition borrows its "truth" from the truth-content of the system to which it belongs.

"... Hume saw clearly that certain concepts, as for example that of causality, cannot be deduced from the material of experience by logical methods. Kant, thoroughly convinced of the indispensability of certain concepts, took them -- just as they are selected [? by scientists ?] -- to be the necessary premises of every kind of thinking and differentiated them from concepts of empirical origin. I am convinced, however, that this differentiation is erroneous, i.e., that it does not do justice to the problem in a natural way. All concepts, even those closest to experience, are from the point of view of logic freely chosen conventions, just as is the case with concept of causality, with which this problematic concerned itself in the first instance."

## Education &amp; Insight

p. 15. "At the age of 12-16 I familiarized myself with the elements of mathematics together with the principles of the differential and integral calculus. In doing so I had the good fortune of hitting up [upon] books which were not too particular in their logical rigor, but which made up for this by permitting the main thoughts to stand out clearly and synoptically. This ..... I also had the good fortune of getting to know the essential results and methods of the entire field of the natural sciences in an excellent popular exposition, which limited itself almost throughout to qualitative aspects (Bernstein's "People's Books on Natural Science," 5 or 6 vols)

Turned from math's because split into specialties each of which could take up a life time.

"This was obviously due to the fact that my intuition was not strong enough in the field of mathematics in order to differentiate clearly the fundamentally important, that which is really basic, from the rest of the more or less dispensable erudition."

p. 17 "In this field [physics], however, I soon learned to scent out that which was able to lead to fundamentals and to turn aside from everything else, from the multitude of things which clutter up the mind and divert it from the essential."

Complaint about obligatory cramming of all sorts of stuff.

"It is, in fact, nothing short of a miracle that the modern methods of instruction have not yet entirely strangled the holy curiosity of inquiry; for this delicate little plant, aside from stimulation, stands mainly in need of freedom; without this it goes to wreck and ruin without fail. It is a very grave mistake to think that the enjoyment of seeing and searching can be promoted by means of coercion and a sense of duty."

## Physics.

XIX th century based it on mechanics. Even Maxwell and Hertz did so, though in retrospect they appear as those who dethroned mechanics.

p. 21. "It was Ernst Mach who, in his History of Mechanics, shook this dogmatic faith; this book exercised a profound influence upon me in this regard while I was a student. I see mach's greatness in his incorruptible skepticism and independence; in my younger years, however, Mach's epistemological position also influenced me very greatly, a position which today appears to me to be essentially untenable. For he did not place in the correct light the essentially constructive and speculative nature of thought and more especially of scientific thought; in consequence of which he condemned theory on precisely those points where its constructive-speculative character unconcealably comes to light, as for example in the kinetic ~~theory of~~ atomic theory."

## Basis for Critique of Physical Theory.

p. 21 f "The first point of view is obvious: the theory must not contradict empirical facts. However evident this demand may be in the first ~~ixskanz~~ place appear, its application turns out to be quite delicate. For it is often, perhaps even always, possible to adhere to a general theoretical foundation by securing the adaptation of the theory /23/ to the facts by means of artificial additional assumptions."

p. 23 "The second point of view is not concerned with the relation to the material of observation but with the premises of the theory itself, with what may briefly but vaguely be characterized as the "naturalness" or "logical simplicity" of the premises (of the basic concepts and of the relations between these which are taken as a basis). This point of view, an exact formulation of which meets with great difficulties, has played an important rôle in the selection and evaluation of theories since time immemorial. The problem here is not simply one of a kind of enumeration of the logically independent premises (if anything like this were at all unequivocally possible), but that of a kind of reciprocal weighing of incommensurable qualities. Furthermore, among theories of equally "simple" foundation that one is to be taken as superior which most sharply delimits the qualities of the system in the abstract (i.e., contains the most definite claims). Of the realm of theories I need not speak here, inasmuch as we are confining ourselves to such theories whose object is the totality of all physical appearances. The second point of view may briefly be characterized as concerning itself with the "inner perfection" of a theory, whereas the first point of view refers to the "external confirmation." The following I reckon as also belonging to the "inner perfection" of a theory: We prize a theory more highly if, from the logical standpoint, it is not the result of an arbitrary choice among theories which, among themselves, are of equal value and analogously constructed.

"The meager precision of the assertions contained in the last two paragraphs I shall not attempt to excuse by lack of sufficient printing space at my disposal, but confess here with that I am not, without more ado [immediately], and perhaps not at all, capable to replace these hints by more precise definitions. I believe, however, that a sharper formulation would be possible. In any case it turns out that among the "augurs" there usually is agreement in judging the "inner perfection" of the/25/ theories and even more so concerning the "degree" of "external confirmation"."

p. 33. Impressiveness of a Theory.

"A theory is the more impressive, the greater the simplicity of its premises is, the more different kinds of things it relates, and the more extended is its area of applicability. Therefore the deep impression made on me which classical thermodynamics made upon me. It is the only physical theory of universal content concerning which I am convinced that, within the framework of the applicability of its basic concepts, it will never be overthrown (for the special attention of those who are skeptics on principle)."

p. 49 Philosophic Prejudice.

"The antipathy of these scholars (Ostwald, Mach) towards atomic theory can indubitably be traced back to their positivistic philosophical attitude. This is an interesting example of the fact that even scholars of audacious spirit and fine instinct can be obstructed in the interpretation of facts by philosophical prejudices. The prejudice -- which has by no means died out in the meantime -- consists in the faith that facts by themselves can and should yield scientific knowledge without free conceptual construction. Such a misconception is possible only because one does not easily become aware of the free choice of such concepts, which, through verification and long usage, appear to be immediately connected with the empirical material."

Critique of Mechanics. 25 ff. (as basis of physics)

p. 29: Newtonian preference for inertial systems compared to preference for vertical in theory devised by people acquainted with only small area of earth's surface and who never saw stars.

p. 55. Rods and clocks.

"One has to understand clearly what the spatial co-ordinates and the temporal duration of events meant in physics. The physical interpretation of the spatial co-ordinates presupposed a fixed body of reference, which, moreover, had to be in a more or less definite state of motion (inertial system). In a given inertial system the co-ordinates meant the results of certain measurements with rigid (stationary) rods. (One should always be conscious of the fact that the presupposition of the existence in principle of rigid rods is a presupposition suggested by approximate experience, but which is, in principle, arbitrary.) With such an interpretation of the spatial co-ordinates the question of the validity of Euclidean geometry becomes a problem of physics."

p. 59 "... One is struck [by the fact] that the theory (except for the four-dimensional space) introduces two kinds of things physical things, i.e., (1) measuring rods and clocks, (2) all other things, e.g., the electro-magnetic field, the material point, etc. This, in a certain sense, is inconsistent; strictly speaking measuring rods and clocks would have to be represented as solutions of the basic equations (objects consisting of moving atomic configurations), not, as it were, as theoretically self-sufficient entities. However, the procedure justifies itself because it was clear from the very beginning that the postulates of the theory are not strong enough to deduce from them sufficiently complete equations to base upon such a foundation complete equations for physical events sufficiently free from arbitrariness, in order to base upon such a foundation a theory of measuring rods and clocks. If one did not wish to forego a physical interpretation of the co-ordinates in general (something which, in itself, would be possible), it was better to permit such inconsistency /62/ -- with the obligation, however, of eliminating it at a later stage of the theory. But one must not legalize the mentioned sin so far as to imagine that intervals are physical entities of a special type, intrinsically different from other physical variables ("reducing physics to geometry," etc.)

p. 53: Need of Formal Principle

"By and by I despaired of the possibility of discovering the true laws by means of constructive efforts based on known facts. The longer and the more despairingly I tried, the more I came to the conviction that only the discovery of a universal formal principle could lead us to assured results. The example I saw before me was thermodynamics. The general principle was there given in the principle: the laws of nature are such that it is impossible to construct a perpetuum mobile (of the first and second kind)."

p. 57 "The universal principle of the special theory of relativity is contained in the postulate: The laws of physics are invariant with respect to the Lorentz-transformations.... This is the restricting principle for natural laws, comparable to the restricting principle of the non-existence of the perpetuum mobile which underliethermodynamics."

p. 69 General theory. "Natural laws are to be expressed by equations which are covariant under the group of continuous coordinate transformations." E. Notes that this is restrictive and heuristic inasmuch as one begins from the simplest  $g_{\alpha\beta}$  equations. Perhaps any law could be reformulated to satisfy covariance.