

ON PSYCHOLOGY AND METAPHYSICS.¹

BEING THE PHILOSOPHICAL FRAGMENTS OF BERNHARD
RIEMANN.

Nec mea dona tibi studio dispersa fideli
Intellecta prius quam sint, contemta relinquo.

Lucretius.

WITH every simple act of thinking, something permanent, substantial, enters our soul. This substantial somewhat appears to us as a unit but (in so far as it is the expression of something extended in space and time) it seems to contain an inner manifoldness; I therefore name it "mind-mass." All thinking is, accordingly, formation of new mind-masses.

Mind-masses entering the soul appear to us as ideas, the quality of the latter depending on the inner state of the former.

¹ Translated by C. J. Keyser from Bernhard Riemann's *Gesammelte Mathematische Werke*.

Editors' Note.—The profound purely scientific significance of Riemann's work in pure mathematics and mathematical physics has been long since recognised, and time is more and more disclosing the great philosophical import of portions of that same work, as, for example, of the famous *Habilitationschrift* on "The Hypotheses that Form the Foundations of Geometry." Riemann was indeed distinctly a *philosophical* mathematician. *Grundlage* (the foundations of things), more than anything else, fascinated his marvellous genius, and his greatest work was exploration among the *roots* of knowledge.

These "Fragments" contain all that Riemann has left us of his direct speculation in psychology and metaphysics. They are a rough and incomplete record of his thought, but for boldness and vigor they resemble very much some of his scientific productions. Some of his profoundest ideas have certainly not been duly exploited. In their German dress, they are to many people practically inaccessible, and to bring them more fully before the thinking public has been our purpose in presenting them to the English reader.

The psychological ideas which Riemann has here set forth bear clearly the im-

Forming mind-masses amalgamate, combine or compound themselves in definite degree, partly with each other, partly with older mind-masses. The manner and strength of these combinations depend on conditions which are but imperfectly recognised by Herbart and which I shall complete in the following. They depend chiefly upon the inner relationship of the mind-masses.

The soul is a compact of mind-masses combined in a most intimate and manifold manner. It grows constantly by accession of mind-masses, and upon these depend its development.

Mind-masses, once formed, are imperishable, their combinations are indissoluble; only the relative strength of these combinations is altered by the incoming of new mind-masses.

Mind-masses require for their continued existence no material support and produce upon the physical world no abiding effect. They stand, therefore, in no relation to any part of matter and have, accordingly, no position in space.

On the other hand every entrance, every nascence, every formation, of new mind-masses and all combinations of them require a material agent or support. All thinking occurs therefore in a definite place.

(Not the retention of our experience, it is only the thinking that strains; and the force expended, so far as we can estimate this, is proportional to the mental activity).

Every entering mind-mass excites all related mind-masses and this excitation is the more powerful the more insignificant the diversity of their inner states (quality).

This excitation is not restricted merely to the related mind-masses but extends itself mediately also to those cohering with them

press of the thought of his place and period, which was predominantly Herbartian, and of his own special mathematical and mechanical proclivities. Some readers may find the study of these pages difficult and perhaps even unprofitable. For like Riemann's purely philosophical ideas, which were influenced by Fechner, his psychology will, at least in its terminology, be found to be at variance in many points with the views and tendencies of the time. They have, however, a quite independent significance as throwing light upon Riemann's own intellectual development, and thus, apart from whatever intrinsic merit they may possess, form a valuable page in the history of the development of thought.

(i. e., to those combined with them in earlier processes of thought). If, therefore, part of the related mind-masses hang together among themselves, then these are not only immediately excited but also mediately and consequently in proportion more powerfully than the rest.

The reciprocal action of two simultaneously forming mind-masses is conditioned by a material process (*Vorgang*) between the places where the two are forming. Likewise from material causes all forming mind-masses enter into immediate reciprocal action with those formed just before; but all older mind-masses cohering with the latter are excited mediately to action and in measure so much the less the looser this coherence and the weaker the bond of union among themselves.

The simplest and most common manifestation of the activity of older mind-masses is Reproduction, which consists in the striving of the active mind-mass to engender one similar to itself. The formation of new mind-masses is based upon the common action partly of older mind-masses, partly of material causes, and these common agents are hindered or helped by the inner dissimilarity or similarity of the mind-masses they strive to generate.

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The form of the forming mind-mass (or the quality of the idea accompanying its formation) depends on the relative motion-form of the matter in which it is constructed, so that similar motion-forms of the matter condition similar forms of the mind-masses formed in it; and, conversely, like forms of mind-mass presuppose like forms of motion of the matter in which they have been formed.

All mind-masses simultaneously forming (in our cerebrospinal system) combine in consequence of a physical (chemico-electric) process between the places where they are forming.

Every mind-mass strives to produce a like-formed mind-mass and, accordingly, strives to produce that form of motion of the matter by which it was formed.

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The assumption of a soul as a unitary support of the permanent somewhat (the ideas) which is produced by the separate acts of the

soul-life is based (1) on the intimate coherence and the reciprocal interpenetration of all ideas. In order, however, to explain the combination of a definite new idea with others, the assumption of a unitary support is not alone sufficient; much more, the cause on account of which the idea enters into just these definite combinations, in this definite strength, must be sought in the idea with which it combines. But the assumption of a unitary support of all ideas in addition to these causes is superfluous.

We now apply these laws of mental processes, to which the explanation of our own inner consciousness leads, to explain the order and adaptation observed on the earth, i. e., to explain Being and historical development.

In order to explain our soul-life we had to assume that the mind-masses generated in our nerve-processes continue as parts of our soul, that their inner coherence persists unchanged and that they are subject to variation only in so far as they enter into combination with other mind-masses.

An immediate consequence of these principles of explanation is that the souls of organic beings, i. e., the compacts of mind-masses, arisen during life, continue to exist after death. (Their isolated persistence is not sufficient). But in order to explain the orderly development of organic nature in which the earlier collected experiences obviously serve as basis for the later creations, it is necessary to assume that these mind-masses enter into a greater compact of mind-masses, the Earth-Soul, and that these serve a higher soul-life according to the same laws as the mind-masses engendered in our nerve-processes observe in their service of our own soul-life.

As, for example, at the sight of a red surface the mind-masses, begotten in a multitude of distinct primitive fibers, combine into one single compact mind-mass, which appears at the same instant in our thought, so the mind-masses engendered in the different individuals in a plant-genus which from a climatically little diversified region of the earth enters into the earth-soul, combine into a single whole expression (*Gesammteindruck*). As the different sense-perceptions of the same object unite in our soul into one single

picture of the object, so will all plants of a given region of the earth give to the earth-soul a most minutely elaborated picture of the climatic and chemical conditions of such region. In this way it is made plain how from the earliest life of the earth the order and plan of later creations developed.

According to our principles of explanation the persistence of existing mind-masses requires no material support, but all combinations of them, at least all combinations of different varieties of mind-masses, can take place only by means of new mind-masses engendered in a common nerve-process.

For reasons that will be unfolded later, the substratum of mental activity must be sought only in ponderable matter.

Now it is indeed impossible to refer the rigid earth-crust and all ponderable masses above it to a common mental process, but the motions of these masses must be explained from other causes.

Accordingly there remains only the assumption that the ponderable masses within the rigid earth-crust are supporters of the soul-life of the earth.

Are they adapted to this end? What are the external conditions for the possibility of life? The common experiences relating to such life-processes as are accessible to observation must form the basis in this investigation; but only within the limit of our ability to explain them are we able to draw thence conclusions likewise applicable to other regions of phenomena.

The general experiences concerning the outer conditions of the process of life within the circuit of phenomena accessible to us, are:

1. The more highly and completely developed the life-process, the more the supporters of the latter require protection against outer disturbances tending to alter the relative position of the parts.
2. The known physical processes (*Stoffwechsel*) that serve as means to the thought-processes, are:
 - a. The absorption of elastic fluids by liquids.
 - b. Endosmosis.
 - c. The formation and resolution of chemical combinations.
 - d. Galvanic currents.

3. Organic matter has no discernible crystalline structure; it is partly solid (slightly brittle), partly gelatinous, partly liquids or elastic fluids but always porous, i. e., notably penetrable by elastic fluids.

4. Among the chemical elements only the four so-called organic elements are general supporters of the life-process, and of these, again, entirely definite combinations, the so-called organising combinations, are compound parts of the organic body (protein, cellulose, etc.).

5. Organic combinations persist only up to a definite upper limit of temperature, and only down to a certain lower limit can they be supporters of the life-process.

Changes in the relative position of the parts are effected in greater degree by mechanical forces, in less degree by variations of temperature, in still less degree by rays of light; accordingly, we may arrange the facts which together constitute our theorem, as follows:

1. The ability of the lower organisms to propagate by division. The gradually decreasing reproductive power in case of the higher animal organisms.

2. The parts of plants are the more sensitive to change of temperature, the intenser and the more highly developed the life-process in them. In the higher animal organisms, particularly in the most important parts, there prevails an almost constant temperature.

3. The parts of the nervous system that serve as seats for independent activity of thought, are protected as much as possible against all these influences.

The fact first stated is obviously grounded in this, viz., the relative position of the parts can be the more readily determined by processes within the matter, the less it can be determined by external circumstances. This freedom from external circumstances is found however within the earth's crust in far higher degree than has been attained by organic contrivances outside the crust.

Among the following facts, which we consider collectively, those grouped under (4) and (5) appear to contradict our assump-

tion ; they would do so in fact, if an absolute validity were assignable to the conditions we perceive for the possibility of a life-process and not merely a relative validity for our own circle of experience. Against the ascription to them of absolute validity there lie, however, the following objections :

1. In that case the whole of nature, with the single exception of the earth's surface, would have to be regarded as dead, for on all other heavenly bodies there prevail conditions of heat and temperature under which organic combinations could not exist.

2. It is absurd to assume that upon the rigid earth-crust the organic originated from the inorganic. In order to explain the nascence of the lowest organisms on the earth-crust, one must assume an already existing organising principle or a thought-process, under conditions that would render organic combinations impossible. We must accordingly assume that these conditions are valid only for the life-process in the actual state of the earth's surface, and only so far as we can explain them may we estimate the possibility of life-processes under other conditions.

Why then are only the four organic elements general supporters of the life-process ? The reason can be sought only in properties by which these four elements are distinguished from the rest.

1. Such a common property of these four elements is found herein, that of all stuffs they and their combinations are condensed with greatest difficulty and in fact up to the present time, even not at all.

2. Another common property of these elements is the great multiplicity of their combinations and their easy resolubility. This property might be as well the consequence as the cause of their appropriation to the life-processes.

That, however, the former property, difficulty of condensation, makes the four elements peculiarly fit to serve life-processes, is already partly explained immediately from the actual conditions of the life-process, that are grouped under (2) and (3), but yet more if we seek to assign to their causes the phenomena of condensation of gases to liquids and solids.

Zend-Avesta, a truly life-giving word¹ creating new life in knowledge as in faith! For how many a thought, which, once mighty indeed in the development of man, preserved in us through tradition only, all at once now rises again out of its seeming death, in purer form to new life, disclosing new life in nature! For how immeasurably unfolds before our eyes the life of nature, which hitherto manifested itself only on the surface of the earth, how unspeakably sublimer does it now appear than formerly! What was considered as the seat of mindless unconscious forces appears now as the workshop of the highest spiritual activity. In wondrous fashion is fulfilled what our great poet in prophetic trance depicted as the goal that hovered before the mind of the investigator.

As Fechner in his *Nanna* sought to show that plants have souls, so the point of departure of his contemplations in the *Zend-Avesta* is the doctrine that the stars have souls. The method he employs is not that of the abstraction of general laws by induction and the application and testing of these in the explanation of nature, it is analogy. He compares the earth with our own organism, which we know to be endowed with a soul. He searches out not merely in a one-sided way the similarities, but does equal justice to the dissimilarities, too, and so arrives at the conclusion that all the former show the earth to be a being with a soul, and that all the latter indicate that it is a being with a soul far higher than our own.

The convincing power of this representation lies in its all-sided elaboration in detail. The total impression of the picture unfolded before us of the life of the earth must tend to justify the view and supply what the single conclusions lack in rigor. This evidence rests essentially upon the intuitive apprehensibility of the picture, upon its exceeding susceptibility of being executed in detail. I should accordingly deem it unjust to Fechner's view, should I endeavor to give by extracts an account of his procedure. In the following discussion of Fechner's views I will abstract from the form in which they are presented and fix attention on their substance only, and will rely on the former method, that of the abstraction

¹ Cf. Fechner, *Zend-Avesta*, I, Preface.

of general laws by induction and their verification in the explanation of nature.

Let us ask first: Whence do we conclude that a thing has a soul (the occurrence in it of a persistent unitary thought-process)? Of our own possession of a soul we are immediately certain; in case of others (men and animals) we infer such possession from individual purpose-serving movements.

Wherever we trace well ordered adaptation of means to ends back to a cause, we seek this cause in a thought-process; we have no other explanation. But thinking itself I at least can regard as only a process in the interior of ponderable matter. The impossibility of explaining thinking as motion of matter in space is clear to every one after an unbiased analysis of the inner consciousness; yet the abstract possibility of such an explanation may be here conceded.

That adaptation of means to ends is observed upon the earth, no one will deny. Accordingly the question arises, where ought we to locate the thought-process which is the cause of this adaptation? We are here concerned only with conditioned ends (i. e., such as are restricted to limited times and spaces); unconditioned ends find their explanation in an eternal will (not engendered in a thought process). The only adaptation of means to ends, whose cause we perceive, is the adaptation of our own actions. It rises out of the willing of the end and reflection upon the means.

If now we find a body consisting of ponderable matter with a completely closed system of permanent end-and-means-combinations, then we may assume for the explanation of this adaptation an enduring thought-process in the same; and this hypothesis will be most probable if (1) the adaptations are not in parts of the body already closed, and (2) if no reason exists for seeking the cause of the adaptation in a greater whole to which the body belongs.

If we apply this to the adaptation observed in men, animals and plants, it results that one part of this adaptation is explained from a thought-process in the interior of these bodies, that another part, however, the adaptation of the organism, by a thought-process in a greater whole.

The grounds hereof are :

1. The adaptation of organic arrangements is not closed in the single organisms. The reasons for the arrangement of the human organism are obviously to be sought in the character of the whole surface of the earth, which includes organic nature.

2. Organic movements repeat themselves innumerable, partly in different contemporaneous individuals, partly in the life of one individual or of a family succession.

3. The organic arrangements receive on the one hand (i. e., in case of man and animals) in the life of the single individuals, and on the other (i. e., in case of plants and embryos) in the life of the single species, no continuous development. The cause of their adaptation is accordingly not to be sought in a simultaneously progressing thought-process.

After abstracting from these (organic) adaptations, there remains now in case of man and animals as is well known, and, according to Fechner's view, in case of plants, still a closed system of variable end-and-means interlocking relations (*in einander greifender veränderlicher Zweck- und Wirkungsbezüge*); and this adaptation is to be explained from a unitary thought-process in them. These consequences of our principles are confirmed by our inner consciousness. According to the same principles we must seek the cause of the adaptations observed in organisms in a unitary thought-process in the earth on the following grounds :

a. The end-and-means-relationship in the organic life of the earth does not break up into separate systems but is all comprehended in one. Accordingly it cannot be explained from several separate and distinct thought-processes in parts of the earth.

b. There is within the limits of our experience no reason to seek the causes of these adaptations in a greater whole. All organisms are designed only for life upon the earth. The state of the earth's crust accordingly contains all (external) reasons of its arrangement.

c. They are peculiar (individual). According to all that experience teaches we must assume that they are not repeated on other heavenly bodies.

d. Neither do they last during the life of the earth but rather in the course of this life there constantly appear new and more complete organisms. We must accordingly seek the cause in a thought-process simultaneously progressing to higher order.

From the standpoint of exact natural science, of the explanation of nature from causes, the assumption of an earth-soul is accordingly an hypothesis for the explanation of Being and of the historical development of the organic world.

"When the body of the lower soul dies," says Fechner, "the higher soul takes it up out of its life of contemplation into its life of reminiscence." The souls of perished creatures shall, therefore, form the elements of the soul-life of the earth.

The different thought-processes seem to differ chiefly in respect to their temporal rhythm. If plants have souls, then hours and days must be for them what seconds are for us. The corresponding period for the earth-soul, at least for its outward activity, possibly embraces many thousands of years. So far as the historical recollection of man extends, all movements of the earth-crust are to be explained from mechanical laws.

ANTINOMIES.

Thesis.

Finite, Representable.

Antithesis.

Infinite, System of Notions lying at the limit of the representable.

I.

Finite elements of Space and Time.

Continuity.

II.

Freedom, i. e., not the power absolutely to originate, but to pass judgment between two or more given possibilities.

Determinism.

In order that decision by arbitrary power may be possible in spite of completely definite laws of the action of ideas, one must assume that the psychic mechanism itself has, or at least in its development acquires, the peculiar property of inducing the necessity of these laws.

No one can, in case of affairs, abandon the conviction that the future is co-determined by his transactions.

III.

A God working in Time. (Government of the world).

A timeless, personal, omniscient, almighty, all-benevolent God (Providence).

IV.

Immortality.

A thing in and by itself endowed with transcendental freedom, radical evil, intelligible character and lying at the basis of our temporal appearance.

Freedom is very well compatible with sound lawfulness of the course of nature. But the concept of a timeless God is then untenable. But the restriction which omnipotence and omniscience suffer through freedom of the creature in the sense above determined, must be eliminated by the assumption of a temporally acting God, of a ruler of the hearts and destinies of men ; the concept of Providence must be supplemented and in part replaced by the notion of government of the world.

GENERAL RELATION OF THE CONCEPT SYSTEM OF THESIS AND ANTITHESIS.

The method applied by Newton to the grounding of the Infinitesimal Calculus, and which since the beginning of this century has been recognised by the best mathematicians as the only one that furnishes sure results, is the method of limits. The method consists in this, viz., instead of considering a continuous transition from one value of a quantity to another, from one position to another, or, speaking generally, from one determination of a concept to another, one considers in the first place a transition through a finite number of intervals and then allows the number of these intervals to increase so that the distances of two successive points of division all decrease infinitely.

The concept-systems of antithesis are concepts that are indeed thoroughly determined by negative predicates but are not positively representable.

Just because a precise and complete representation of these concept-systems is impossible, they are inaccessible to direct investigation and elaboration by our reflection. They may, however, be regarded as lying at the limit of the representable, i. e., we can form a concept-system lying within the representable, which passes over into the given system by simple change of magnitude ratio. By abstracting from the ratios of the quantities, the concept-system remains unchanged in case of transition to the limit. At the limit itself, however, some of the correlative concepts of the system lose their susceptibility of being represented, and those, indeed, that mediate the relation between other concepts.

THEORY OF KNOWLEDGE; OR, AN ATTEMPT AT A DOCTRINE OF
THE GROUND-NOTIONS OF MATHEMATICS AND PHYSICS AS
FOUNDATION FOR THE EXPLANATION OF NATURE.

Natural science is the attempt to comprehend nature by precise concepts.

According to the concepts by which we comprehend nature not only are observations completed at every instant but also future observations are pre-determined as necessary, or, in so far as the concept-system is not quite adequate therefor, they are predetermined as probable; these concepts determine what is "possible" (accordingly also what is "necessary," or the opposite of which is impossible), and the degree of the possibility ("the probability") of every separate event that is possible according to them, can be mathematically determined, if the event is sufficiently precise.

If what is necessary or probable according to these concepts occurs, then the latter are thereby confirmed and upon this confirmation by experience rests our confidence in them. If, however, something happens which according to them is not expected and which is therefore according to them impossible or improbable, then arises the problem so to complete them, or if necessary, to transform them, that according to the completed or ameliorated concept-system, what is observed ceases to be impossible or improbable. The completion or amelioration of the concept-system forms the "explanation" of the unexpected observation. By this process our

comprehension of nature becomes gradually always more complete and assured, but at the same time recedes even farther behind the surface of phenomena.

The history of the illuminating natural sciences, as far as we are able to trace it back, shows that this is in fact the way in which our knowledge of nature advances. The concept-systems on which these sciences are now based arose by gradual transformation of older concept-systems, and the reasons which incited to new modes of explanation may be always traced back to contradictions or improbabilities that emerged in the older modes of explanation.

The formation of new concepts, so far as it is accessible to observation, occurs therefore by that process.

Now it has been proved by Herbart that also those concepts serving to comprehend the world, whose origin we are unable to trace either in history or in our own development because of their imperceptible transmission to us along with speech, may all be derived from this source, in so far as they are more than mere forms of combinations of simple sensuous ideas, and that accordingly they need not be derived (as according to the Kantian categories) from a peculiar constitution of the inner soul, anterior to all experience.

This proof of their origin in the comprehension of what is given by sense-perception is therefore important for us because *only thereby their significance can be established in a manner adequate for natural science.*

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After the notion of things existing for themselves (*für sich bestehender Dinge*) has been formed, reflexion upon change, which contradicts the notion of existence for self, gives rise to the problem to maintain as far as possible this already proved notion. Out of this rises at the same time the notions of continuous change and of causality.

Only transition of a thing out of one state into another, without a leap being perceived, is observed. By way of supplementation, we may assume either that the transition occurs by a very great but finite number of imperceptible leaps or that the thing

passes over from the one state into the other through all intervals. The strongest reason for the latter conception lies in the necessity of maintaining as much as possible the already established notion of things existing for themselves. It is indeed impossible actually to imagine a transition through all intervals, a fact however, as already observed, that, taken narrowly, holds of all concepts.

According to the earlier formed and experientially proved notions of the existence of things, for themselves, it is concluded that a thing would remain what it is, were nothing else added. Herein lies the incitement to seek a cause for every change.

1. When is our conception of the world correct?

“When the coherence of our ideas corresponds to the coherence of things.”

The elements of our picture of the world are entirely different from the corresponding elements of the depicted real. The former are something within us; the latter something without. But the combinations of the elements in the picture must coincide with those of the elements in the depicted, if the picture is to be true. The truthfulness of the picture is independent of its niceness; neither does it depend on the question, whether the elements of the picture represent greater or smaller masses of the elements of the real. But the combinations must correspond to each other; an immediate effect of two elements upon each other must not be assumed in the picture, where in reality only mediate effect occurs. In this case the picture were false and in need of correction; if, on the other hand, an element of the picture is replaced by a group of finer elements, so that its properties result partly from simpler properties of the finer elements, partly also from their combinations, and become accordingly in part intelligible, then thereby is indeed increased our insight into the coherence of things, without, however, the earlier conception being declared false.

2. From what shall the coherence of things be found?

‘From the coherence of phenomena.’

The idea of sense-things in definite space and time relations is what is found by intentional reflection upon nature or what is *given* for such. As is well known, however, the *quality* of the characters

of sense-things, color, sound, tone, smell, taste, heat or cold, is something merely taken from our sensation, something not existing outside of us.

That by which the coherence of things must be known is accordingly quantitative relations, the space and time relation of sense-things and the intensity relations of the characters and their qualitative differences.

Knowledge of the coherence of things must result from reflection upon the observed coherence of these magnitudinal relations.

CAUSALITY.

1. What an agent strives to effect must be determined by the concept or idea of the agent, its action can depend on nothing else than its own nature (*Wesen*).

2. This requirement is satisfied when the agent strives to preserve or to restore itself.

3. Such an action is, however, not thinkable if the agent is a thing, a being (*Seiendes*), but only if it is a state or relation. If a striving to preserve or to restore something occurs, then also deviations from this something must be possible and indeed in different degrees; and in so far as this striving is opposed by other strivings the preservation or restoration is at most only approximate. But there are no degrees of being, a gradual difference of only states or relations being thinkable. Accordingly, if an agent strives to preserve or to restore itself, then it must be a state or relation.

4. Such an action of a state, it is self-evident, takes place only upon such things as are capable of a like state. Upon which of these things, however, it takes place and whether it takes place at all cannot be inferred from the idea (*Begriff*) of the agent.¹

¹ These propositions are valid only if the action (*Wirken*) is to be ascribed to a simple real cause (*Realgrund*).

If two things *a* and *b* by an external cause enter into combination, then a consequence *c* may be attached either to the combination, the state itself of being combined, or indeed to the change of their ranks. The simplest assumption is that the consequence *c* is attached to the state of being combined.

It is unnecessary to extend these considerations further. Their principle con-

Kant has rightly observed that by the resolution of the concept of a thing we can find neither that it exists nor that it is the cause of something else, and accordingly that the concepts of being and causality are not analytical but can be derived only from *experience*. When however he later feels himself obliged to assume that the notion of causality originates in a pre-experiential property of the cognising subject and therefore stamps it a mere rule of time-series, by which, in experience, with each observation as cause *any other* could be connected as effect, then is the child thrown out with the bath. (Indeed, we must derive the relations of causality from experience; but we must not fail to correct and to complete our conception of these facts of experience by reflection.)

The word hypothesis has now a somewhat different significance from that given it by Newton. We are now accustomed to understand by hypothesis all thoughts connected with the phenomena.

Newton was far from the crude thought that explanation of phenomena could be attained by abstraction.)

Newton: *Et haec de deo; de quo utique ex phaenomenis disserere ad philosophiam experimentalem pertinet. Rationem vero harum Gravitatis proprietatum ex phaenomenis nondum potui deducere, et Hypotheses non fingo. Quicquid enim ex Phaenomenis non deducitur, Hypothesis vocanda est.*

Arago, *Œuvres complètes*, T. 3, 505, says: *Une fois, une seule fois Laplace s'élança dans la région des conjectures. Sa conception ne fut alors rien moins qu'une cosmogonie.*

sists herein that we hold fast the law: "What an agent strives to effect must be determined by the idea of the agent," but that we do not apply this law as did Leibnitz or Spinoza to beings with a manifoldness of determinations but to real causes of the greatest possible simplicity.

We are accustomed in German to translate *actio* as well as *effectus* by effect (*Wirkung*). As the word occurs most frequently in the latter sense, there easily arises an obscurity when we use it for *actio*, as for example, in case of the usual translation of "*actio aequalis est reactioni*," "*principium actionis minimæ*." Kant sought to avoid the difficulty by adding in parenthesis beside effect, mutual action (*Wirkung, Wechselwirkung*) the Latin expression *actio, actio mutua*. We might venture to say: "Force is equal to the opposite force." "Law of least force expenditure." Since however we have in fact no simple expression for *agere*, an effort directed upon something else, we may be permitted to make use of foreign words.

Laplace to a question by Napoleon, why in his *Mécanique céleste* the name of God did not appear: *Sire, je n'avais pas besoin de cette hypothèse.*

The distinction which Newton makes between laws of motion or axioms and hypotheses seems to me untenable. The law of inertia is the hypothesis: If a material point were alone in the world and moved in space with a definite velocity, it would preserve this velocity constantly.