

Cantor and the future of the natural sciences

by Jonathan Tennenbaum

This speech was given at the Schiller Institute conference in Halle on May 6, and was translated from the German by Edward Carl. Dr. Tennenbaum is the director of the Fusion Energy Forum in Germany.

Max Planck once described, in a reminiscence, the spirit of the true natural scientist: "It is not logic, but the creative imagination, which enkindles a new discovery in the mind of the researcher moving forward in the dark . . . and without the imagination, fruitful new ideas cannot arise. For, if there is one thought that invigorates and uplifts us—amidst often painstaking, detailed work for the mind and body—that thought is, that in physics, we do not work for the present, for momentary success, but rather, so to speak, for Eternity."

We find that Planck's precise metaphor applies to Georg Cantor, since he worked "for Eternity" in the highest degree. In his discoveries, Cantor saw the first glow of a distant renaissance, which would be centered, in his words, on an "organic explanation of nature," in Leibniz's sense, which would replace the increasingly one-sided and inadequate, mechanistic natural science of his (and our own) day. Let us here vow to set into motion, on the threshold of the approaching century, this greatly desired renaissance!

As in the renaissance movements of the past, this means, first of all, to free the human mind from the chains of Aristotelianism—this time, we should hope, for good. And to this end, Georg Cantor placed a powerful weapon in our hand. With his discovery of the concept of transfinite orderings, he revived and vindicated the method of Plato, Nicolaus of Cusa, Kepler, and Leibniz at a crucial point—and indeed on the exact issue that has continued to be the subject of the most raving attacks of Aristotle and his followers for millennia.

What enraged Aristotle the most was Socrates' and Plato's assertion that beyond the objects of sense perception there are *real* existences, which Plato named Ideas, and which are the *causes* for the sense phenomena as well as of everything else; and that these Ideas are *not* merely characteristics or epiphenomena emitted out of the sense objects, but rather that an idea can only stem out of a higher Idea, and that the Ideas have their origin and continued existence in God. Aristotle objected violently to Plato's insistence, that Ideas must be understood as *separated* from their predicates.

This separation, this singularity, is exactly the region of human creativity, of the axiomatic changes whose existence Aristotle denied. Compared to this, Aristotle only knows abstractions, only formal generalizations of individual cases, but not true universals.¹

Cantor's development of the transfinite was a kind of "*experimentum crucis*." Already in its second term, Aleph 1, the series of transfinite "Aleph" magnitudes—which, as it seems, proceeds from the simplest concept of a lawful ordering, that is a precondition for comprehending the world—already transcends the bounds of everything which can be represented or communicated in terms of sense perception or imagination. The Aristotelians have long since jumped out of the windows, shrieking. For them, that which is not definable or describable through the categories of sense perception, is indeterminate, and completely incomprehensible to the human understanding, which, according to Aristotle, is limited to the finite.

Contrary to this, Cantor showed that the terms of the Aleph series, including in particular Aleph 1 (\aleph_1), are each specific, completely determined "thought-objects," each distinguishable from the other. At the same time, one ought not to imagine the Aleph transfinite as some sort of static, unchangeable objects of the Type of the objects of sense perception, but rather as reflections of the inner relationships of a self-developing negentropic universe. Aleph 1, for ex-

1. The metaphysics of Aristotle, like nearly everything else that stems from Aristotle, is a long-winded, obsessive attempt to annihilate Platonic ideas. One could even say further, that Aristotle wanted to *assassinate* the Ideas; for in his metaphysics, he aimed his most venomous attack on exactly that place within Plato's "Phaedo" dialogue, during Socrates' last conversation with his pupils before his execution, wherein he is talking about the soul's immortality. In so doing, Aristotle exposes his spiritual affinity with the same people who organized Socrates' trial and execution. This spiritually hostile state of affairs, directly opposed to Socrates and Plato, reminds us all the more of Judas's later betrayal, because of the fact that Aristotle belonged to the inner circle of Plato's Academy in Athens for so many years. (There is a further interesting aspect, which is that Galileo's mathematics teacher, the priest, Paolo Sarpi, as a pretended anti-Aristotelian, directed his main work against the doctrine of the immortality of the soul. As an agent of the Venetian oligarchy, Sarpi introduced the attempt to infiltrate the newly flowering Platonic natural sciences of the Renaissance and to bring them under their control.)

ample, in comparison to Aleph 0, represents an entirely different conceptual quality. Aleph 1 corresponds to the external bounding principle of all lawful orderings of simple mathematical functions, i.e., the *principle* of that which is comprehensible and lawful in the ordinary mathematical sense. Precisely for this reason, Aleph 1 doesn't belong to mathematics in the ordinary sense at all—here, again, loud shrieks are arising—for, mathematics is not able to give a comprehensive, final definition of what a “law”—i.e., what a mathematical function—really is.

Thus, from the domain of ordinary mathematics, which is of the thought-quality of “Aleph 0,” Aleph 1 cannot be reached at all. The concept of “lawfulness” and of lawful orderings, must, just as Riemann said in his habilitation dissertation, arise from *outside* mathematics, and, indeed, from that which many people today would call metaphysics, which, however, is actually nothing other than the entire core of physics.

With his Aleph series and developments linked to it, Cantor showed how an entire class of conceptions—which, until then, only a few great minds had mastered, and which were otherwise either anticipated in a vague, intuitive manner, or, in the case of the Aristotelians, rejected as “non-existent”—could be firmly established and integrated into the store of scientific and cultural knowledge. Therefore, the path is opened, as Cantor himself saw, to overcome the awful impoverishment of man's conceptual world, associated with the dominance of empiricism, positivism, and formalism. Only then does it become possible to successfully carry out the development of an “organic explanation of nature.”

Cantor's work concerning transfinite orderings leads to an *analysis situs* of the process of scientific hypothesis-formation. And, according to his own report, the study of Cantor, together with Riemann's habilitation paper, “On the Hypotheses Which Underlie Geometry,” gave Lyndon LaRouche the key to solving the central formal problems of physical economy—the elaboration of an intelligible representation of the “negentropic” growth of a growing human economy.

On the other hand, only LaRouche's approach to physical economy was wanting, in order to place the universal contributions of Cantor onto an unshakeable ontological foundation. With this, that creative process of formation of fruitful hypotheses—of which Max Planck spoke, and which the Aristotelians would rather banish from the world—that creative process becomes the direct, *measurable* subject of scientific thought.

Cantor's principal contribution

From what has been said, it should be clear that Cantor's chief contribution to future scientific and technological revolutions is not to be sought mainly in applications of the formal working-out of his theories—what one nowadays calls “mathematical structures”—to specific problems of physics.



Jonathan Tennenbaum (right) at a Schiller Institute meeting in Gdansk, Poland. Says Tennenbaum: “Cantor's most far-reaching contribution lies in the improved quality of scientific thinking, which a deep acquaintance with Cantor's own process of discovery can bring to this and future generations of scientists.”

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Indeed, the importance of the formal elaboration of scientific theories tends nowadays to be greatly exaggerated. It quite certainly was a driving idea of Cantor's to reach away from the mechanistic to an “organic explanation of nature,” wherein the formal, combinatorial, or structural aspects (which, for example, in microbiology, are considered to be the only things deemed “scientific”) are completely subordinate to the conceptual development. In other words: The ordering, the form of the reciprocal interrelations of higher ideas, is *not* a formal-logical one, but rather unfolds only out of their own intelligible inner essence. Accordingly, it is decisive for the future of the natural sciences in Cantor's sense, to allow the creative processes to speak *their own language*. The greatest enemies of creativity are formalism and its ugly sister, the Romantic movement.

I also believe that the greatest positive influence of Cantor's work upon the future of the natural sciences will not come from his mathematics, in the narrow sense, but rather, through his decisive contribution toward clarifying and widening the general concepts upon which the whole development of the natural sciences will be based. I would like to illustrate this point from a special viewpoint.

Providing human civilization does not go to ruin in a holocaust of barbarism, we can be sure that colonization of the Moon and the planets will be begun in the first decades

of the coming century. In that case, there will commence, within the physical economy of humankind, a new condition, for which no adequate historical parallel exists. The coming development will be of such a form, as can only be organized and understood on the basis of Cantorian ideas, of the type which constitute the kernel of LaRouche's physical economy. We are speaking of a coming period in which the growth of productive activity, in scale and intensity per capita and per arbitrary quantum of space-time, has no other goal and content than the perfection of the human spirit. The cycles of

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investment, of production and of consumption, will come to be seen exclusively from the standpoint of a *noetic thought process*, in which the entire population—as an aggregate of creative individuals—*acts*, through those cycles, upon itself and upon the Universe as a whole. In other words, the *value* of material production lies in the propagation and development of *ideas*, ideas of the quality of the increasing mastery of humankind over nature.

What steps into the foreground of the spiritual, cultural life of the participating population, in this process, is no longer the result of an individual scientific revolution, but rather a *series* of such revolutions, following one after the other, expressing the power or relative perfection of a higher hypothesis. The aggregate of human activity in space and time, all of human history, will then become a single laboratory by which to measure the relative truthfulness of our momentary level of culture, or in other words, to discover and stepwise to overcome the limits of our own thought processes.

Since this goal of the perfection of the Image of God embraces every single human being, as well as human civilization as a whole, the necessity arises, not only to develop the creative potential of every single human being to the fullest measure, but simultaneously to ensure that the creative contributions of *all* human beings—and not merely the contributions of a handful of isolated geniuses, but, in the future, of *billions* of creative personalities—shall be integrated into the practice and culture of the society, and transmitted, as a single, *intelligible idea*, to the individuals of further generations. How could it be possible that a single, communicable idea could enfold within itself billions of creative personali-

ties, as living singularities? The work of Georg Cantor gives us one crucial key to this.

Toward a new renaissance

Now, the form of economic development that we presently project for the epoch of the colonization of the Solar System is, of course, nothing other than the original design that Leibniz put forward in his essay "Society and Economy,"² as the fundamental principle of modern industrial society. Only the continued power of the oligarchy has hindered humanity up until now from realizing, to its full extent, the Leibnizian form of physical economy.

Precisely this idea inspired the pioneer-champions of the so-called American System of Political Economy, men such as Alexander Hamilton, Friedrich List, and Henry Carey. The same idea inspired the minds of the creators of Weimar Classicism, which, not accidentally, preceded the spectacular development of science and technology in Germany in the nineteenth and early twentieth centuries.

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I have already referred to the *noetic substance* of every physical economy, which in the epoch of Mars colonization will come to the fore more than ever. The development of an economy is determined by the *cultural ability and inclination* of the population for generating, propagating, and assimilating increasingly higher (i.e., more truthful) qualities of *ideas*. This means a shift in the spiritual center of gravity, away from an Aristotelian obsession with external objects of sense perception, and over to the realization, that truth is not to be found in an imaginary agreement between discrete mental images and the constellation of sense objects, but rather, within the moral perfection of the thinking subject. This perfection lies in the knowledge of the ordering of the higher ideas, which derives from the relation of our soul to God.

This, of course, is exactly the goal not only of Friedrich Schiller, with his program for the aesthetical education of Man, but also of a far-reaching network around Schiller and the Humboldt brothers, a goal certainly shared by Carl Gauss, as well as the young Beethoven. This was the goal of the Humboldt education reforms, with their accent upon classical philology; the revitalization of the German language, theater, and the art of poetry by Schiller and his circle; and the adoption and further development of the geometrical method of the Ecole Polytechnique in France.

All of these measures are linked together with a special comprehension of the function of language (in the broadest sense), which plays a crucial role in the later work of Rie-

2. For an English translation, see *Fidelio*, Fall 1992, p. 54.

mann and Cantor. As Wilhelm von Humboldt emphasized, the essence of a human language—in contradistinction to communication among animals or computers—lies within the *process* of generation of new concepts which are made *nameable* and *communicable* by the method of metaphor. Georg Cantor did exactly this with his Aleph series.

Underlying every language, there exists a universal metaphorical thought-principle, which Wilhelm von Humboldt saw in close connection with the *musicality* of the language. From this arises the question: What is the relationship between the various stages of development of a language, and between different languages, with regard to their ability for truthful hypothesis formation? Here we have a typical example of Cantor's conception of "power" or "cardinality" of an order-Type.

For example, if the use of the hypothesizing subjunctive mood is restricted, or the formation of metaphors is made more difficult, the Cantorian "power" of a language is diminished. On the other hand, Schiller and his allies strove for a powerful enhancement of the latter, as a decisive path toward a new renaissance.

I would like to shed light on these thoughts with a few examples.

The method of hypothesis

We take, first of all, an example that Lyndon LaRouche has frequently employed in the recent period: the determination of the meridian or the approximate circumference of the Earth by the Greek Eratosthenes. LaRouche stresses that Eratosthenes was able to measure the curvature of the Earth with his construction, without anyone having seen this curvature with their eyes. In fact, one could say that astronauts were the first ones in a position to directly see this curvature, 2,000 years later. LaRouche underscores that an Aristotelian would never be able to do what Eratosthenes did; for, to an Aristotelian, it would appear to be absolutely nonsensical and impossible to measure something which nobody has seen!

It is worthwhile to reflect upon one additional aspect of this. As one immediately recognizes, Eratosthenes' construction already presupposes the hypothesis of a spherical-shaped Earth and the geometry of the circle. Whence comes this hypothesis? Whoever considers the matter only superficially, might quickly answer: The hypothesis came from seeing that the Earth casts a circular shadow during eclipses.

Nevertheless, what did one see? Sense-impressions in and of themselves are nothing but a chaos; only the operation of *ideas* creates nameable forms out of sense-impressions—ideas, thus, which could never arise by themselves out of the pure chaos of sense impulses. (In contradiction to the opinion of the chaos theoreticians! Already after a few weeks, a normal baby has surpassed the stage of development of a chaos theoretician!)

As Herbart and Riemann after him emphasized, the most elementary concepts of science and of daily life in the course

of history themselves undergo a far-reaching evolution. For example, we are able to imagine a primitive stage of development of a human society—a tribe of anthropologists, for example—where the sight of a circle only awakens notions like "round thing" or "smoothly bordered thing" or "pretty object without corners." A donkey, on the other hand, sees in the Moon probably an apple stolen and eaten away by some celestial donkey! And so forth.

What I want to indicate by that, is the following: Only under the influence of the *higher idea* of a general ordering principle—that is, in a certain sense, an idea of Natural Law—can one arrive at the notion of the circle and sphere and, in particular, to the hypothesis of Eratosthenes, that a yet-unseen sphere defines the ordering principle for various measurements made on the Earth—measurements, that from the standpoint of a flat Earth, would constitute irreconcilable anomalies.

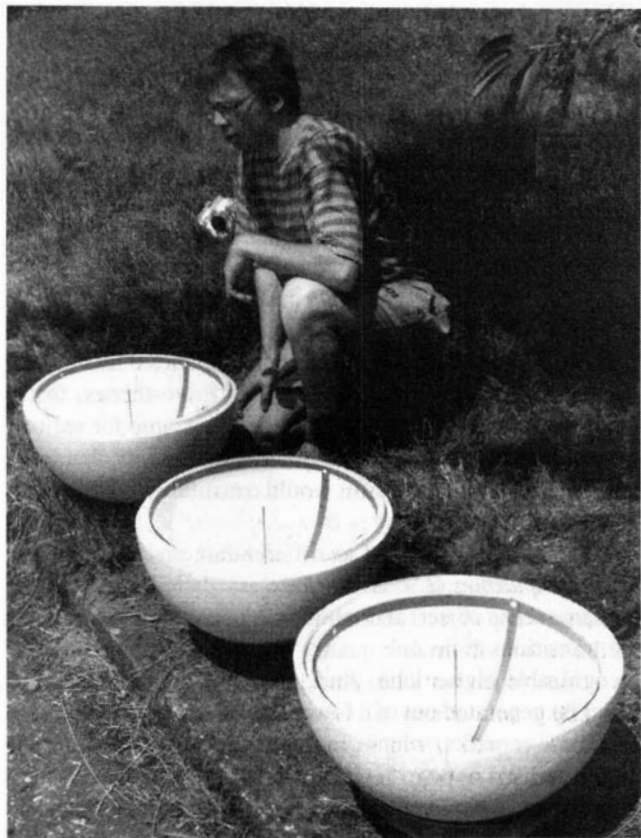
Cantor thus taught us to differentiate and to order the different *qualities* of ideas, that are associated with one and the same sense object, and, above all, to correctly understand the transitions from one quality to the next one owing to a recognizable higher idea. And, also, that a higher idea can never be generated out of a lower one.

These remarks, which, in the example of Eratosthenes, might perhaps appear trivial, turn out to have the greatest importance, when we consider the challenges faced by science today. The various, explosive anomalies of astrophysics, for example, point to a characteristic curvature of physical space-time, which we, of course, can neither see nor grasp with the currently existing representations and concepts of natural science.

Defeat the Aristotelian inquisition

A majority of the evils that we find in the natural sciences today lend themselves, with the help of Cantor's ideas, to being easily exposed, and their causes identified in an externally imposed Aristotelianism.

For example: the significance of the Periodic System of Dmitri Mendeleev. Our disastrous educational practice routinely communicates to students the impression, that the Periodic System were merely a formal scheme that Mendeleev had derived, by Aristotelian induction, out of the data concerning the chemical elements. What Mendeleev had actually done, as opposed to that, is to completely redefine the entire field of chemistry and physics, insofar as he introduced and proved something which no chemist had ever seen or experimentally shown in a test tube. After Mendeleev, the central subject of chemistry moved beyond the chemical elements as such, and, instead, shifted to the idea of a higher harmonic ordering-principle which determines, "from above," the characteristics of the individual elements and their mutual relationships. Thereby, Mendeleev confirmed and extended the central thesis of Johannes Kepler, which Kepler had first developed in his hypotheses concerning the



Replicating Eratosthenes' demonstration of the curvature of the Earth: A Schiller Institute researcher in Germany tests the spherical sundials that will be used to measure the Sun's angle from the zenith (see diagram, p. 43). The demonstration was performed successfully in Frankfurt and Milan on July 25 and in Copenhagen and Munich on July 26.

solar system. In my book about the "atomic women,"³ I have shown how the entire development of radioactivity and nuclear physics emerged out of this original idea of Kepler, mediated through Mendeleyev. Unfortunately, one must deplore the circumstance, that the practice of passing on such generative ideas to the younger generation has been virtually banished from our science education system.

The Aristotelian inquisition in the natural sciences is nowhere more blatant than in biology. There, the underlying prejudice makes itself ever more strongly felt, that the concept of "life" itself has no precise meaning, and, in the final analysis, must be considered to be "unscientific." For, who has seen "life"? As Aristotle would say, there are these and those concrete animals or plants which he had regarded as "living" because they eat, grow, or move; but "life" as an idea or principle does not exist in the real world. The molecular biologists of the present day confirm this: They have found

nothing among their molecules that corresponds to "life." However, when they attempt to derive the characteristics of living organisms from interactions of atoms and molecules—ideas of the quality of the Aristotelian sense perception—then they run into paradoxes and insurmountable difficulties.

Now, from a Cantorian standpoint, it is easy to understand this situation. Of course, there *is* a principle of life, whereby living organisms absolutely distinguish themselves from non-living matter! This principle had already been identified by Leonardo da Vinci and Luca Pacioli or even earlier, and connected with the characteristic harmonic ordering principle of the Golden Section. The problem consists in this: that this principle of life stands exactly in the same relation to the mechanistic notions of the molecular biologists, as Cantor's Aleph 1 is to the orderings of the power Aleph 0. (Or, of the circle to the inscribed polygons.) This means that any, however complicated, combination of mechanistic interpretations is still infinitely far away from being able to explain or even to characterize the "life" of a living organism. Thus, it appears to the molecular biologists, as if life either does not exist or is a mystery, only because they refuse to admit the corresponding higher idea into their minds!

It is similarly the case with the so-called "wave-particle paradox" of modern quantum theory. In his famous argument with Erwin Schrödinger, Niels Bohr overtly forbade the process of Platonic concept-generation. Bohr—who later converted to Taoism—publicly declared that physics should not be allowed to utilize any concepts that go beyond the categories of sense perception or related imagination. Whereas Man has known for more than 2,000 years—and, actually, since the beginning of civilization—that reality cannot be understood on the basis of such primitive types of ideas.

These examples show precisely the nature of the present-day dark age: The entire class of higher ideas, for example of the type of Cantor's transfinite, has been "forbidden." This was precisely the goal of the brutal persecution of Cantor by Kronecker and the friends of Helmholtz. Through the suppression of these ideas, the process of hypothesis formation has virtually come to a standstill, and scientists have become donkeys. This process of stupefying (or "dumbing down," as it is expressed in America nowadays) aims to destroy exactly that which Schiller and his fellow combatants wanted to achieve.

The process of lawful transformation

However, beyond this useful, and quite necessary, *negative* attack, we are able to do something even more interesting. We assume these two Types, Aleph 0 and Aleph 1, and the transition from Aleph 0 to Aleph 1, to be a characteristic type of singularity. Now we look at the entirety of anomalies of the various fields of knowledge, in order to see how they might be related eventually to this type of singularity. I do not mean this in the sense of statistical correlation, but rather in this way: that by means of a coherent hypothesis, they

3. Jonathan Tennenbaum, *Kernenergie: Die weibliche Technik* (Wiesbaden, Germany: Dr. Böttinger Verlag GmbH, 1994), reviewed in *EIR*, May 26, 1995.

might be brought into a relation of conceptual congruence or equivalence.

Take something quite fundamental: the concept of *change* itself. In present-day natural science, change is practically always thought of merely in a kinematic sense: to wit, the process of change of any system is supposed to be reducible to changes of position or other continuously variable parameters of the parts of the system. This kinematic bias leads people to think, that no other form of change could exist as a lawful process. As a result, the so-called quantum jumps and similar things present sheer, unsolvable paradoxes, which Bohr et al. indeed characterized as unintelligible *in principle*. Precisely this fixation on the banal-kinematic form of change constituted the great weakness of Einstein, the catastrophic error of his entire physics.

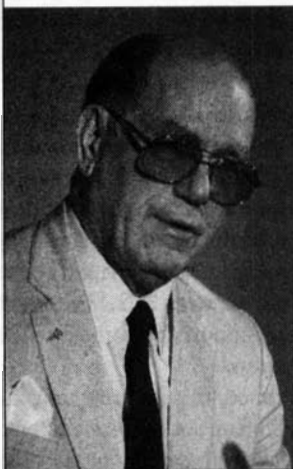
On the other hand, in an 1879 treatise "Über unendliche lineare Punktmannigfaltigkeiten" ("On Infinite Linear Point-Manifolds"), Cantor himself addressed himself to this problem. With clear reference to Riemann's dissertation on the hypotheses of geometry, Cantor remarks, that the assumption of a simple continuous space-time "has no intrinsically compelling reason; it must be seen as the result of a free act of our mental-constructive activity. The hypothesis of the continuity of space is therefore nothing other than the arbitrary assumption of a complete, one-to-one correspondence between the three-dimensional, purely arithmetical continu-

um (x, y, z) and the space which underlies the world of appearance."

Now Cantor's work shows us, and indeed proves, the existence of an entirely different form of lawful transformation, than the simple, banal-kinematic: namely, the Type of the transition from Aleph 0 to Aleph 1. The crucial thing is that, by virtue of the transfinite generating-principle itself, no intermediate link or continuous transition of the kinematic sort exists, but rather Aleph 1 is the necessary successor of Aleph 0, Aleph 0 the necessary predecessor to Aleph 1. This then draws our attention to the substance of our own mind, which signifies a change of the characteristics of action of a whole system, which is associated with an increase of the density of singularities in every interval of action. Precisely this is the characteristic form of change of a physical economy under the influence of scientific revolutions, and we believe that many anomalies of astrophysics and other fields will be able to be tackled anew, in a more fruitful manner, from this standpoint. This may open the path to a better understanding of the reality sometimes referred to by the idea of the "quantum field."

Thus, much work lies ahead of us. In 50 years will come the 200th anniversary of Georg Cantor's birthday, which some of us will perhaps also celebrate here in Halle. By that time, we hope to have harvested the first fruits of the renaissance foreseen by Cantor.

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