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Emotions permeate human life. Recent findings in neuroscience and psychology suggest that evolution has equipped us with complex emotional mechanisms that not only enrich our inner experience, but also help us to decide quickly and accurately, form social bonds and lay the foundations for our morality. Moreover, the gulf between emotions and reason – so often confirmed in the long history of philosophy – today seems smaller than ever: emotions are by no means irrational.

These problems were discussed during the 15th Kraków Methodological Conference, *The Emotional Brain. From the Humanities to Neuroscience and Back Again*, held on May 19-20, 2011 in Kraków, and honored by the participation of many leading neuroscientists and philosophers. Naturally, this was not the only event organized by the Copernicus Center in 2011: there were numerous other conferences and seminars. We have also undertaken a number of educational activities, such as the series of lectures entitled *Science and Religion*. In addition, Copernicus Center Press has published 13 books, including the first Polish translation of Newton's *Principia mathematica*. Most importantly, the research activities of the Copernicus Center have taken new forms in 2011, both in scope and intensity. In particular, we are happy to report the launch of the research project "The Limits of Scientific Explanation", sponsored by the

John Templeton Foundation, and initially timetabled for three years. The details of the aforementioned events, as well as the Center's other activities, are provided in the annual report in this volume.

We have also included six essays documenting our intellectual journeys. They address various problems, from the question of whether mathematics is poetry, through investigating the mechanisms of meta-scientific revolution, drawing lessons from the rise and fall of theories of everything, inquiring into the relation between memory and imagination, taking up the question of the normativity of language, to the exposition of Russian thought on the relationship between science and theology.

It is with many positive emotions that we look back at what has happened, but even more so when we think of the future. These emotions bring about our eagerness to apply reason in the sphere where science and philosophy meet.

Bartosz Brożek

Essays »

Is Mathematics Poetry?[1]

Michael Heller

I will begin with something trivial – a syllogism that haunts first-year students:

All men are mortal.
Adam is a man.

Anyone with an analytically-oriented mind should conclude that:

Adam is mortal.

However, let a poet examine the example and he will look in another direction. The logical conclusion is obvious and hence it is uninteresting. Death is the real drama of human existence and syllogism is too poor a means to convey the inevitability of the drama. Yet the drama of death may be expressed, for instance, in the following way:

Preoccupied with killing,
it does the job awkwardly,
without system or skill.
As though each of us were its first kill.

When the drama cannot be overcome, it should be domesticated:

Whoever claims that it's omnipotent
is himself living proof
that it's not.

1 This paper is an edited transcript of a talk delivered by the Author on the occasion of receiving *honoris causa* degree at the Warsaw University of Technology. Translated by Bartosz Brożek.

There's no life
that couldn't be immortal
if only for a moment.

Death
always arrives by that very moment too late.

In vain it tugs at the knob
of the invisible door.
As far as you've come
can't be undone.[2]

How much more did Wisława Szymborska convey in the quoted passages than is expressed by the dull Aristotelian syllogism? Nevertheless, the syllogism does have something of the inevitability of death:

If p, then q,
p.
Therefore q.

Where does the necessity of the consequence come from? Isn't it possible that not-*q*? Szymborska could have expressed her insights in thousands of ways; a syllogism must end with one and only one conclusion. This is the poetry of consequence. Stars may burn out, all poems may be forgotten, heaven and earth may be long gone, but the syllogism's conclusion will still be valid.

Of course, the syllogism is a primitive form of the poetry of consequence. Let us have a look at a more subtle example.

Euclid proved that there is an infinite amount of prime numbers; he proved it, that is he formulated a deductive argument (a 'chain of consequences') which ended with the sentence "There are infinitely many prime numbers". Until today, the

2 Translated by S. Baranczak and C. Cavanagh.

distribution of prime numbers in the set of natural numbers remains a mystery. Numerical experiments have proved that the further one goes along the sequence of natural numbers, the less frequently prime numbers occur. Despite that, there are an infinite number of them. In 1737 Leonard Euler established a connection between the occurrences of prime numbers and a certain function, which looked deceptively simple, but turned out to be full of 'mathematical content'. The complexity of the function was recognized by Bernhard Riemann in a lecture delivered on the occasion of his acceptance to the Berlin Academy of Sciences. It was 1859, the year of the first edition of Charles Darwin's *The Origin of Species*. Since then, Riemann zeta function remains the source of numerous mathematical problems and an object of fascination for many mathematicians.[3]

Let us have a closer look at it. It looks quite ordinary, as do many mathematical formulas:

$$\zeta(s) = \sum_{n=1}^{\infty} \frac{1}{n^s},$$

where *n* is a natural number, and $s = \sigma + i\tau$ a complex number with the real part greater than 1.[4] Even if looked at with a trained mathematical eye, the function seems anything but unusual; however, when the deductive machinery is applied, surprising facts are uncovered. Already Riemann in his original contribution put forward a hypothesis that the zeros of zeta function are situated on the line $\sigma = 1/2$. Despite numerous, tireless attempts, the hypothesis remains unproven. Whoever provides the proof is entitled to a one million dollar prize. For many years

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3 I refer the Reader to an intriguing book by Krzysztof Maślanka, *Liczba i kwant*, OBI, Kraków 2004.

4 The relationship between the occurrences of prime numbers in the sequence of natural numbers and the zeta function is the following: $\zeta(z) = \prod_{n=1}^{\infty} \frac{1}{1-p_n^{-s}}$, where p_n is the *n-th* prime number in the sequence of natural numbers.

computers have been used to test Riemann's hypothesis. By September 2004, 910 billion initial zeros of the zeta function, as well as several billion distant zeros (in the proximity of the zero numbered 10^{23}) have been checked. Riemann's hypothesis has survived all of these tests – no counterexample has been found. But this is no proof for mathematicians[5]; a proof must make use of the 'miracle of consequence', not 'finger counting', even if the 'fingers' belong to supercomputers.

The Riemann zeta function has many surprising properties, and still new, even more surprising ones, are uncovered. It is not only mathematicians who are surprised. In the 1970s it was established that the zeroes of the zeta function are distributed according to the same probability function that describes the energy levels of large atomic nuclei. How does the zeta function have knowledge of the construction of atomic nuclei? Or *vice versa*: how do the atomic nuclei know of the zeta function? The function is pure mathematics, uncontaminated by any experience. Are we dealing here with matters fundamental to our understanding of both mathematics and physics?

Let us, however, leave this intriguing problem. Quite possibly, it is too early to follow this lead. It is more reasonable to come back to something which we may grasp better.

In 1975 Sergei Mikhailovitch Voronin, who died prematurely in 1998, proved a theorem known as the theorem on the universality of the zeta function.

Let us consider a strip in a complex plane:

$$P = \{s \in \mathbf{C} : \tfrac{1}{2} < Re(s) < 1\}$$

and a compact set *U* in *P*, such that the complement of *U* is connected in *P* (i.e., *P* has no 'holes'). Let $f : U \to P$ be a continuous function on U, holomorphic on the interior of *U* and having

5 Of course, a discovery of a single counterexample would constitute a proof that the hypothesis is false.

no zeros in *U*. Voronin's theorem says that for any $\epsilon > 0$ there exists a value $t = t(\epsilon)$, such that:

$$\zeta(s + it) - f(s)| < \epsilon,$$

for any s∈U.

Therefore, the theorem says that if a function *f* represents a sufficiently regular curve, which does not take the value zero in the domain in which it is determined, the curve may be approximated to any given accuracy by the Riemann zeta function by displacing *U* along the imaginary axis.

If this does not sound poetic enough, let us imagine that we have handwritten the poem of Szymborska's above, connecting the letters in such a way that the inscription is a regular curve. Voronin's theorem says that – if we displace the domain *U* appropriately – the zeta function will 'recreate' the poem (with any given accuracy). It turns out that in order to recreate the poem we would need to move the domain *U* quite far along the imaginary axis: so far that the computational power of today's, and perhaps even future computers, is too small to get us there. This does not change the fact, however, that Szymborska's poem is there!

One may protest: this is not Szymborska's poem here, but only the shape of the curve that was used to write it. But what is a poem if not a shape, which we somehow recognize? Ultimately, computers – which are capable of so many things – can only recognize shapes of zero and one, nothing more.

We encounter here a deep philosophical problem. Is there something besides form or shape? Isn't what we call content only a condensation of form? It is also a form of poetry that the Riemann function leads us as far as to consider such problems. And Szymborska was only a pretext here: instead of using her poem, we could have begun with Euclid's *Elements* or Shakespeare's *Collected Works*. We would only need to move even further along the imaginary axis.

If anyone still doubts whether mathematics is poetry, let him write a poem, an ode, anything... which would contain all the works of the world's poetry and all scientific treaties. If the ideal of poetry is the simplicity of form and the abundance of content, no Shakespeare has ever written a piece more beautiful than the Riemann function.

Wait! Haven't we gone too far? Strictly speaking, the zeta function contains only all possible shapes. By manipulating the parameters *s* and *t* we can recreate any sufficiently regular curve. Is it so surprising? I insist, nonetheless, that mathematics is poetry, and poetry of the highest standards.

Poetry tries to express the Inexpressible with recourse to metaphors, the loosening of grammar rules, the unexpected contrasting of meaning. Mathematics seems prosaic, since in the form of simple theorems it can express relations whose truth is guaranteed by the chain of controllable consequences. But it also has the means to express – like poetry – things that cannot be expressed in a language other than mathematical. Let us think of theorems which speak of 'going to infinity'; of existential theorems which say that something exists, although we cannot construct it; of structures – like Riemann function – which contain unimaginably rich content. In this I see the poetic side of mathematics.

However, there is a difference between what we traditionally call poetry and the poetry of mathematics. The most poetic aspect of mathematics is that it operates with strict consequences. If it failed in one place only, everything would turn into kitsch and amount to nothing more than a pile of nonsense. Michelangelo is credited with saying that in every block of marble he saw a statue, as plain as though it stood before him, and he only had to hew away the rough walls that imprisoned the lovely apparition to reveal it to other eyes. But works of art are imperfect: one unwise correction does not make them worthless, only a bit worse; and one never knows whether any work could not be better. The poetry of mathematics is perfect: if we have a proof we know it should be as it is.

From Epistemology to Doxalogy[1]

Józef Życiński

1. The Rise of the Doxatic Philosophy of Science

In epistemological analyses of modern science the Aristotelian distinction between the certain "episteme" and the hypothetical "doxa" was implicitly accepted. In the theory of knowledge presented in the "Posterior Analytics," the Stagirite claimed that simple "episteme" contains universal and necessary truths which describe the essence of things, and explain them causally.[2] This concept was turned to in medieval times when science was defined as "cognitio certa essentiae rerum per causas," — certain cognition of the essence of things through their causes. The Baconian "New Organon," by attempting to connect the principles of the Aristotelian "Organon" with the new rules of methodological empiricism, continued to draw on the image of science as a pursuit of essences on an empirical basis.

The epistemetic theory of science, i.e., the theory considering science as a counterpart of "episteme" containing ultimate truths, has many times been a subject of individual criticism. With the turn of the 19th and 20th centuries, such critics were E. Boutroux, P. Duhem and H. Poincaré, but the metascientific reflection of that period was clearly dominated by cumulativism

1 This article was previously published in: Joseph M. Życiński, *The Structure of Metascientific Revolution. An Essay on the Growth of Modern Science*, Pachart Publishing House, Tucson 1988, Chapter Seven, pp. 175-204.

2 *Posterior Analytics*, I, 2,6,8,13,17,31,33: II, 3,19; Cf. *Nicomachean Ethics*, VI, 3,5,6; *Metaphysics*, 1,2,5,6; XI, 4.1061 b 30.

that interpreted the growth of science in terms of the cumulative appearance of theories and the discovery of laws which, like Newtonian laws and Maxwellian equations, were supposed to be certain and immune to future corrections. For this reason the Pearsonian "Grammar of Science" was at the time far more popular than the incisive critical analyses of Duhem or Bergson. The optimistic theses of this approach that were developed by some logical positivists were accepted by many scientists and philosophers with no less reverence than the works of Aristotle were treated by the Averroists. The belief in the epistemetic character of science inspired various versions of anti-doxatic research programs. In the 1930's this epistemetic attitude was expressed in, for instance, H. Reichenbach's comments when he compared Carnap with Descartes on the principle of their shared "quest for an absolutely certain basis for science".[3] That such anti-doxatic elements became prominent in the research programs of our century was largely due to psychological factors which emerged as a reaction to the unprecedented development of both natural and formal sciences. Logic, believed thus far to be a perfect and closed system of rules, had revealed its intrinsic complexity after analyses undertaken by Boole, de Morgan and Peirce. Once mathematicians became introduced to Cantor's paradise, where postulates unquestioned by anyone respecting Euclid's authority could now be questioned, they developed ambitious research programs concerning problems previously unnoticed in earlier mathematics. The technological successes of natural sciences have been taken to demonstrate their epistemological superiority.

Having presented the Newtonian-Maxwellian patterns of scientific certainty, many scientists believed that in time

3 H. Reichenbach, *Logistic Empiricism in Germany*, "J. of Philos." 1936, vol. 33, no. 6, pp. 141-160.

all scientific statements would acquire a similar status. In this context it seemed quite natural to formulate prognoses of an approaching end of science after which all nontrivial issues would have been solved and scientists left only with trivial problems such as more accurate calculating of physical constants. Lorentz, who exclaimed that he would have been happier to have died a few years earlier before the facts forecasting the scientific revolution were known, illustrates how deeply the ideas of quasi-Aristotelian theory of knowledge were embedded in the conscience of 19th century scientists. From the perspective of the changes that have occurred in contemporary physics, it is not easy to accept the fact that even in the 1880s, M. Planck had been advised not to study physics since that discipline was believed to be approaching an end. Such advice, however, seemed to have been psychologically natural from the perspective of the 19th-century opinions on the growth of science. Finally, after centuries of useless terminological acrobatics, breakthrough discoveries toppling the opinions of the authorities of the past had been made; therefore, one could optimistically hope that from now on the development of science would just follow automatically if only the principles of scientific epistemology and unfailing methodological rules were applied.

The emergence of the Special Theory of Relativity shattered the illusion that science would end, but did not lead to the abandonment of anti-doxatic ideats. On the contrary, it was suggested that the profound changes in the physical description of the world were a sign of the immanent epistemological excellence of science. Upon accepting the notion that 19th century epistemological concepts were inadequate and too simple, action was taken which was to lead in the philosophy of mathematics and the philosophy of physics to a breakthrough corresponding to the Einstein-Planck breakthrough in physics.

Programs leading to an epistemological revolution were developed simultaneously in various centers; their results turned out later to be of paramount interest to mathematicians and physicists alike. The label ″revolutionary″ has been attached equally to logistic, formalist and intuitionist propositions. In the last case it was evident from the moment that the intuitionist research program began that in the apparent revolution the main role was to have been played by Ockham's razor, eliminating some hitherto developed branches of mathematics. Some of Brouwer's revolutionary ideas had been quoted 50 years later by Bourbakists as historical curiosities where amputation was believed to be the main vehicle for progress.

A successful realisation of either the formalist or the logistic research programs would undoubtedly have been a sign of revolution in mathematics. The discovery that ambitious research programs could not be fulfilled turned out to be the actual revolution in this field. A similar situation prevailed in the epistemology of natural sciences where the breakthrough discovery resided in stating the impossibility of realizing the breakthrough program of unifying science as developed by logical positivism. These two discoveries contributed to a rejection of all idealized epistemological patterns that various versions of positivism had presented as archetypes of scientific and mathematical knowledge. In this manner shocking theorems, quite contrary to those expected, were finally discovered in logic. These theorems point to the necessity of accepting certain limitations and clearly demonstrate how unrealistic earlier research programs were. The Platonic-Aristotelian opposition between ″episteme″ and ″doxa″ turned out to be a simplified dichotomic division in the domain where more sophisticated differentiations between different types of ″doxa″ had been necessary. If one adheres to this scheme and treats the set of propositions constituting ″doxa″

as a complement to the set of theorems belonging to "episteme", one has to agree that the metascientific revolution of our century has led to the transformation of epistemology into doxalogy.

In the first positivism of Comte as well as in the third positivism of the Vienna Circle, physico-mathematical knowledge was understood to correspond to "episteme". In these approaches, metaphysics and theology were to introduce doxatic semi-knowledge of poetic and expressive character. The lofty contrast made 50 years ago between the objective truth of science and the emotional expression of poetry and metaphysics is now but a relic of a bygone philosophy of science while in the cautious analyses of the contemporary philosophy of science it is suggested that even the verisimilitude concepts do not have to bear any relation to truth understood classically. In less pessimistic appraisals that take into consideration the consequences of the limitative theorems, attention is paid to the continuity of the cognitive research programs developed both by followers of Aristotelian philosophy and adherents of Tarski's concept of truth.[4] Yet, while within different schools of Aristotelian philosophy attempts had concentrated on defining a set of ultimate unquestionable truths, in the contemporary approaches the notion of semantic truth plays the role "of an ideal limit which can never be reached but which we try to approximate by gradually widening the set of provable sentences".[5]

As a result of the replacement of the epistemetic ideal of science by the doxatic one, some contemporary philosophers of knowledge propose an epistemology essentially different from positivistic epistemology and try to re-establish the cognitive functions of myth and poetry. In such approaches, metaphysics, literature or poetry become important means of discovering

4 Cf. A. Tarski, *Truth and proof*, "Sc. Amer." 1969, no. 220, pp. 63-77.

5 *Ibidem*.

reality and the elements of poetry, fiction and myth are taken to be elements unavoidably present also in scientific research programs.[6] The acceptance of the existence of the extra-scientific components in scientific cognition does not imply blurring the differences between science and poetry. Such differences are evident and only those authors who accept such broad definitions of poetry or myth that within their easy-going terminology even computer programs could be accepted as a form of poetry question them. Changes that have occurred in epistemology as a result of the metascientific revolution do not substantiate any prophetic prognoses concerning the future scientific paradigm which could combine the effectiveness of strict scientific formulations with poetic meditation on the mystery of the universe. If one, however, takes into account the similarities between scientific theories and interpreted formal systems, one should still maintain considerable criticism when assessing the objective value of scientific cognition. In such cognition, the traditional approach has been expressed in aiming at the discovery of the basic principles from which, as from the axioms in formal systems, propositions describing given physical states could be derived deductively. Dreams of an axiomatic set of laws of nature forming a deductive, consistent and complete system have became unrealistic after the limitative theorems were discovered. It follows from these theorems that there cannot be a universal description of nature performed in one consistent and closed language since every formal language which is at least as rich as arithmetic must contain meaningful propositions which cannot be considered to be either true or false. If one accepts the intuitively justified thesis that every exact science must contain the axioms of arithmetic, one has to abandon any hope of a

6 H. DeLong, *A Profile of Mathematical Logic*, Addison Wesley, Reading, MA 1970, p. 227.

scientific Turing machine which, on the premises of the basic principles of science, could deduce answers to any well-posed question. Hopes of elaborating a new language of science free from the burden of arithmetic and leading to complete systems are as optimistic as pre-Gödelian programs, and as unfounded. One conclusion, however, seems to be justified, namely, that the limitations of rich formal systems imply parting from many epistemological postulates accepted earlier in the philosophy of science.

The thesis that connects the breakdown of optimistic epistemology with the metascientific revolution would seem to be controversial, as many authors have critically judged the value of human cognition long before the limitative theorems were proven and before idealized concepts as to the role of verifiability in science had been abandoned. Undoubtedly, such criticism has been expressed to a varying degree in the reflections of the Stoics and Skeptics, in the Cartesian theory of methodological doubting or in the philosophy of Hume or Kant. The actual content, however, as well as the justifications of such criticism make classical critiques of cognition very different from the approach of modern epistemology. In past philosophical interpretations, statements concerning the fallacies and limitations of cognition followed either from the basic assumption accepted in a given philosophical systems or from presumptions introduced implicitly by representatives of such systems. If one accepts the tenets of irrationalism or skepticism already at the point of departure, it is easy to generate common-sense arguments to support the supremacy of intuition over intellect or to confirm the elusiveness of sense data. The logical preconditions which led to the discovery of limits of scientific cognition in contemporary philosophy of science are completely different. The limitative theorems are not a result of a psychological weariness of formalistic methods in logic but have resulted from the application of precisely such methods. In Hume's or Kant's critique of knowledge one can find many basic assumptions to be unsubstantiated and arbitrary. After a suitable modification of such assumptions one is able to avoid a far-reaching critique of our cognition. On the other hand, considerable effort has gone into finding counter-examples where the limitative theorems of Church, Gödel and Skolem would not apply. The demonstrated examples of such formulas, however, are so trivial or artificial that one cannot attach to them any cognitive value. This follows from the observation that such examples have been formulated within poor logical systems that do not contain arithmetic and it is hard to connect any hope of obtaining adequate significant theories with such systems.

The last point seems to disclose another interesting regularity confirming the earlier formulated conclusions: only poor or inadequate systems appear to be devoid of limitations, while rich and developed ones contain multifarious limitations. This epistemologically pessimistic regularity was described in a poem by the well-known Polish logician T. Kotarbiński. A poetic fish, when meditating on the ontological structure of the realm of water, notices: The depth is always followed by darkness; what is shallow, is always clear.

A similar regularity may be indicated in the framework of the natural sciences. During the early stages of the development of these sciences, such as the stage of macrocosm physics, one could devise strong postulates with unlimited accuracy in measuring all observables of the system, or one could aim at eliminating speculative explanations according to the principle: I frame no hypotheses. The emergence of quantum physics made it necessary, however, to depart from commonsense ideas and from the postulate of unlimited accuracy in measuring conjugate parameters. The emergence of relativistic cosmology uncovered the unrealistic character of earlier epistemological postulates by demonstrating that it is possible to analyze scientifically processes which due to event horizon shall never be available for observation, and it would be mere dogmatism to "a priori" reject the so-called pathological models, i.e., models in which basic cosmological assumptions are questioned. In this particular field the cautious traditional epistemology had to be abandoned, again, not as a result of any preconceived aversion to given methodological rules but rather as a result of a research practice inconsistent with the patterns of epistemetic theories. Hence, while earlier attempts at identifying epistemology with doxalogy had been either an expression of external criticism or have followed as a consequence of arbitrary assumptions, the situation is radically different at the present stage of metascientific reflection. Here the critique is an immanent one and the role of philosophers of science is first of all to give a synthetic description of the changes which have occurred in the field of research in mathematics and physics.

In the context presented above, there are good reasons to attach a higher value to conclusions following the critique of cognition implied by modern research practices than to some of the conclusions contained in Kant's "Critique of Pure Reason".[7] It is precisely the significance of profound changes in the epistemological layer of science which provides us with an additional factor permitting statements of the metascientific revolution to be formulated.

2. An Anarchistic Theory of Scientific Revolution

One of the illusions commonly encountered in the process of the growth of science is expressed in expecting breakthrough

7 *Ibidem*, p. 223.

discoveries after which everything would be essentially different. According to optimistic prognoses, breakthrough discoveries should open a radically new stage of scientific evolution in which, owing to the emergence of new investigation techniques and man's intellectual creativity, all the earlier difficulties would be finally eliminated. At the metascientific level this illusion led to attempts at unequivocally defining the structure and mechanisms of the evolution of science. In criticizing similar attempts, I would like to argue that, after the discovery of difficulties and limitations of inductivist, deductivist, or elitist theories of science, all hopes that the structure of scientific revolutions can be described in a single universal theory have to be abandoned. Such expectations are still upheld only in highly idealized approaches where simplicity becomes more important than adequacy.

Any realistic image of the evolution of science should take into account its internal logic, empirical background and external socio-cultural dependences. The omissions of any of those factors must necessarily lead to patching up the history of science. Such patching up is nowadays particularly evident in discussions about the structure of scientific revolutions. The conviction that shifts of scientific paradigms occur with identical regularities, despite the centuries that divide them, is an evident example of a peculiar belief in the permanence of mechanisms governing the growth of science. If one were to develop a theory of the oncoming decline of royal families valid for historical science in the same manner, the unavoidable question would emerge as to, why should the pattern defining the decline of the Hohenzollerns also be valid for the Piast or Romanov dynasties. A quasi-historicist attempt at rationally setting the order of succession of the line of emperors would no doubt be a demonstration of the epistemological optimism of its authors, however, the coincidence of such a theory with the actual royal succession would strongly suggest that, in a given interpretative historiosophy, retrodictions were applied instead of predictions. In the currently advanced theories of scientific revolutions it is precisely retrodictions that play the main role. It is for this reason that such theories differ so much one from another, for in retrospective explanations there is always a wide margin for choosing arbitrary sets of facts as representative for the growth of science.

The history of science is methodology-laden; as a consequence the set of characteristics defining the way scientific revolutions occur is also dependent on the methodological assumptions adopted. In this context we face a vicious circle, as support of the adequacy of a given methodology is drawn from the history of science while the description of the evolution of science strongly depends on the choice of metascientific assumptions. Clearly, different methodologies do not lead to entirely different historiographic descriptions, nevertheless a divergence of opinions is apparent even when attempting to answer the question of how many scientific revolutions can be distinguished in the course of the evolution of knowledge up-to-day. If in ancient Rome some twenty centuries before Thomas Kuhn someone had written a work "De structura revolutionum in scientia", his description of how Egyptian-Babylonian science turned into Hellenic science might perhaps have included factors quite different from those believed to be relevant when seen from the vantage point of contemporary revolution theories. From the perspective of knowledge in 50 B.C. it would perhaps be reasonable to claim that the revolution leading to the acceptance of Greek standards of science consisted in introducing theoretical aspects in place of hitherto purely pragmatic problems and in developing a set of theorems featuring a high degree of consistence, abstraction and comprehensiveness. If these features were to be accepted as the necessary consequences of any revolution, the Copernican-Galilean scientific program would have to be seen as counter-revolutionary, for before the rise of Newtonian physics its properties were quite the opposite of those just mentioned. As a result of connections with metaphysics, Aristotelian physics implied by Ptolemaic astronomy had a degree of abstraction higher even than that of modern physics; it also presented a more consistent and wholesome image of the world, and was less pragmatically-oriented than the observation and apparatus-dependent physics of Galileo. The degree to which statements of "shifts of paradigms" are an idealization is illustrated, for example, by the fact that in the 2330 scientific articles written over the period 1543 – 1678, as covered by statistics, only 7.7 % of the authors clearly supported program of Copernicus and Galileo.

Rather than proclaiming the shifts of paradigms it would be better to talk of the creeping of several micro-paradigms competing in the same time, for apart from astronomy where Tycho Brahe's model was a serious alternative to the heliostatic proposal of Copernicus and Galileo, in chemistry and biology, patterns of interpretation bearing no influence of the Galilean theory were maintained during a long time. Taking this into account one should pay more attention to the process of scientific micro-revolutions leading to new research programs and accounting for the epistemological specification of individual disciplines. It is significant that the course of the metascientific revolution in the philosophy of mathematics took a completely different course than the revolution in the epistemology of the natural sciences. Breakthrough discoveries in mathematics had not been proceded by an increase in the number of anomalies but followed the attempts at defining the foundations of mathematics. Moreover, no claim could be made that this revolution led to incommensurable changes in the basic concepts of the integer or set, although one cannot deny that important changes in the meaning of certain terms (e.g., the infinitesimals in non-standard analysis) did in fact follow in certain branches of mathematics.

The recent attempts at formulating a universal theory of scientific revolutions really strive at disclosing the mechanism of physical revolution. To a good approximation they describe the structure of the Einsteinian and Newtonian revolutions, whereby significant changes in the scientific perception of the universe occurred due to the development of physics conceived in the modern meaning of this term. To attempt, however, to specify the character of future scientific revolutions from experiences drawn from the two above-mentioned revolutions would, at best, demonstrate interpretative optimism. Even if one does not share the views of the forthcoming end of physics, there is no ground to believe that profound changes in the theoretical interpretation of the world should be connected with discoveries in the domain of physics. A possibility that breakthrough discoveries of the future may occur in biology, psychology or axiology cannot be excluded. With respect to these disciplines, any attempts to apply the concepts developed in the up-to-date analyses of scientific revolutions would be nonsensical. For instance, what could be today taken as a sign of an anomaly in psychology, axiology or ethics? If one were to take all the unexplained problems in these disciplines to be anomalies, then all the three disciplines are mainly a collection of anomalies at the present stage of their development.

Among the attempts at elaborating a universal theory of all scientific revolutions one should distinguish between two basically different types of interpretations. In the first of them, the laws of revolutions are described in the sociology of science, in the other, such laws are claimed to be the result of the internal rationality of science. In the first sociological and elitist approach to the behavior of scientific communities is considered to be more important than the objective content of scientific theories; mob psychology and sociologically conditioned interpretative conversions turn out to be more significant than the explanatory power or heuristic values of the theories appraised. Sociological theories of scientific revolutions result from a strong belief in the permanence of social mechanisms. It is precisely such mechanisms that decisively influence the course of the revolution. In the course of time, the ideas of rationality, methodological principles and the meaning of given terms evolve, while the most basic principles ruling the society of scientists remain unchanged thus enforcing identity of the most basic structures of scientific revolutions.

Such a belief in the priority of the laws of sociology over the logic of science is an epistemologically interesting demonstration of a fascination with social sciences. This fascination consists in yet another manifestation of the cognitive optimism of the elitist theory of scientific revolutions, since the laws of sociology, which are of a statistical nature, are bestowed with the property of being unequivocal determinants of the outcome of the revolution. Certain sophisticated versions of the theory may turn out to be unfalsifiable. If one of the elitist interpreters were to offer, for instance, that Gödel's incompleteness theorem is a manifestation of his subconscious inferiority complex, whereby Gödel living in Vienna just at the time Freud did, would have been familiar with the psychoanalytic theory of complexes, then such an interpretation is unfalsifiable. At the same time this interpretation would be of absolutely no relevance to logical appraisals of Gödel's theorem, for psychological preconditionings can at best constitute the context of a discovery but not the context of its justification. Psychological prejudices with respect to the implications of Gödel's theorem could have inspired various forms of criticism of this theorem. For its logical appraisal, however, the only interesting criticism was what followed deductively from justified logical premises.

A similar situation is apparent at the time of a scientific revolution. Psycho-sociological factors can then delay the reception of some ideats or unreasonably promote others, but to ascribe to such factors a decisive role is an expression of irrational belief in the power of sociology. When one observes the transition from Newtonian to Einsteinian physics it is hard to believe that any sociological factors could have made the society of the scientists of the early 20th century reject the internal logic of the development of science and introduce, e.g., the physics of ancient Egypt in place of the theory of relativity. It is equally difficult to imagine that any conditioning could make contemporary biologists adopt the biology of Lysenko combined with the geology of Velikovsky, except for a few self-made propagationists of home-made biology.

With respect to most elitist theories of scientific revolutions it is possible to devise falsifying counterexamples. For instance, if within such a theory one accepts both the elitist criterion of the acceptance of particular interpretations and the thesis that in the new paradigms the corresponding explanations are incommensurable with respect to the explanations of the old paradigms, then we cannot avoid questioning whether a general consensus of the scientific communities could not lead to the acceptance of a paradigm in which basic interpretations are commensurable with the theories accepted before the shift of paradigms. Whatever answer is given, either the thesis of the predominance of elitist-sociological factors in scientific revolutions or the dogma of incommensurability would have to be abandoned.

It is much more difficult to appraise theories of scientific revolutions in which the decisive factor governing the growth of science is to be the internal rationality of scientific knowledge. The weighty argument against attempts at developing a single algorithm of the development of science valid for all scientific revolutions concerns the question of whether such attempts are not a demonstration of neo-Hegelian rationalism in the philosophy of science. Hegel, thoroughly convinced of the rationality of science, had proven in an "a priori" manner that no planetoid objects could exist between Mars and Jupiter at the time when the existence of the Ceres planetoid had been confirmed observationally in exactly that region. A neo-Hegelian attempt at extending a single metascientific theory to cover all scientific revolutions will yield either a set of generalities describing merely phenomena implied in the very concept of a revolution or an attempt at a fact-disregarding speculation whose falsification is made difficult by the lack of exact data concerning past scientific revolutions.

The criticism of neo-Hegelian rationalism in the philosophy of science may be taken as an expression of interpretative minimalism, because the whole evolution of science results from the possibility of placing individual events under general laws. One should note, however, that the status of such laws in the natural sciences is quite different from that in the history of science. The belief in a unique algorithm that governs the evolution of science and is independent of time is as optimistic and unfounded as the Marxian belief in the ability to devise a single theory of a proletarian revolution valid in every country. The internal rationality of science is compatible with several variants of its development at breakthrough periods. The transition between Newtonian and relativistic physics could have followed an entirely different scheme. This transition could have been connected by lengthy intermediate stages; theories more complicated than Einstein's, taking, for instance, the role of spin and torsion into account, could have been developed, or, after a dynamic growth of quantum mechanics, a version of Grand Unified Theory could have been proposed instead of the General Theory of Relativity. In view of the several possibilities of rational evolution, any attempt at defining a unique mechanism of scientific revolutions seems to be a relic of reductionist rationalism. During the initial stage of the development of science such ideas inspired metaphysical research programs leading to attempts at explaining the whole complexity of the world's structure by recourse to one or a few elements functioning as "arche." Within the science of the 19th century, similar rationalist reductionism was expressed in striving for an explanation of all processes in terms of mechanics. After the fall of mechanism these ideats crept into the field of metascientific investigations. In some metascientific programs developed during our century, one may find metascientific versions of the Laplacean demon. While mechanics prevailed, the Laplacean demon was expected to be able to predict all the future states of the universe, provided that he knew the initial conditions and the laws of the system's evolution. Within the metascientific reductionism of our century similar attempts at predicting unequivocally the evolution of science were based on the knowledge of its current state and the inescapable mechanisms that determined the manner of its development.

Metascientific reductionism, just like the mechanistic reductionism of the 19th century, was found to be far too optimistic and untenable a viewpoint. Relics of this optimism have continued to live on as a presumption that it is possible to elaborate a unique theory to explain the nature of all scientific revolutions. Such a standpoint cannot avoid the objection of begging the question. An expression of groundless optimism and uncritical rationalism seems to be the opinion that one is entitled to extrapolate the regularities observed during the last few centuries to all breakthrough situations in the process of the development of science. Is such extrapolation not a case of supporting the belief in a metascientific Laplacean demon? There is no objective foundation for believing optimistically that the complicated process of the evolution of science could be represented by a plain model. If science evolves in a manner non-representable by simple models, then our attempt at developing a unique theory of all scientific revolutions is as Utopian as the attempts to work out a unified science that were undertaken in the 1930s.

There are many reasons for believing in a complex nonlinear evolution of science. A salient feature of relativistic physics is that in the formalism of scientific theories one can find well-defined limitations in the applicability of these theories. Einstein's general relativity cannot thus be applied to densities greater than 19^{94} g/cm^3. In quantum mechanics one cannot talk of distances less than 10^{-33} cm. The theories themselves contain implicit statements concerning the limits of their applicability, a feature absent from earlier scientific theories. A similar situation prevails in formal sciences where the limitative theorems provide the limits of the logical discourse. A clear description of such limitations radically changes the status of the so-called anomalies; the role of these anomalies is stressed in all theories of scientific revolutions. The fact that infinite temperatures appear when we apply Einstein's equations to the description of super-dense states of the universe is not an anomaly in the proper sense of this term. The infinite values of the parameters indicate only that the theory has been applied to the wrong domain and that a new theory describing processes close to the singularity is needed. The formulation of such a theory would undoubtedly represent a revolution in physics, since two previously separate disciplines, cosmology and quantum theory, would thus be joined. No reason is apparent, however, for claiming "a priori" that in order to accept such a theory of quantum cosmology a "conversion effect" is needed. Theoretical works on quantum cosmology which have been under way for several years now offer many rational criteria to assess the new theory that is sought. It would then be a demonstration of dogmatic sociologism to expect that irrational factors of an authoritarian-psychological character should predominantly influence the possible reception of such a theory.

The above critique of attempts at developing a universal theory of scientific revolutions does not imply that I am questioning the value of rational reconstructions of given revolutions or that of comparative analyses describing correlations observed between consecutive revolutions. In this critique I only question the possibility of presenting a model of revolution which could be accepted as an adequate model of all scientific revolutions without being trivial from the informational point of view because of the generality of its statements. The inability to develop such a model results from the fact that the complicated process of the growth of science cannot be represented by a single set of non-trivial algorithms.

From the analysis of the evolution of systems developed in Thorn's theory of catastrophes, one sees how strict are the relationships between the course of evolution and the number of factors determining the growth of the systems. According to this theory, if the evolution of a system is determined by no more than four different factors, there are seven structurally stable possibilities for the discontinuous evolution of the system. At a slight growth of the number of determining factors there follows a rapid increase in the number of possible variants of evolution and any attempt at a closer specification of the direction of changes becomes quite hopeless. In this context, any attempt at developing a unique non-trivial model of scientific revolutions expresses epistemological optimism far greater than that which in the medieval times led to the search for the philosophers' stone.

The factor that inspired the search for a unique universal theory of scientific revolutions was the conviction that at breakthrough points in the growth of science a decisive role was played by one type of predictions, whether rational or sociological, while the remaining factors could be reduced to zero. This belief was undoubtedly an expression of metascientific optimism. The trouble is that the actual evolution of science does not always seem to follow optimistic wishful thinking.

3. Open Science in the Open Universe

The transition from the epistemetic to the doxatic concept of science is a very significant stage for metascientific reflection. On the level of scientific research, however, one should not attach catastrophic consequences to the breakdown of epistemetic programs. In the process of the factual growth of science, progressive scientific research programs are far more important than the advance of idealized metascientific standards. Such programs have been formulated and developed independently of the attempts at submitting science to simple and universal metascientific schemes.

When viewed from today's perspective, philosophical reflections on the nature of scientific knowledge are often merely historical records of statements which are now judged to have been quite surrealistic. The works of Joseph Agassi and

Imre Lakatos provide us with interesting compilations of metascientific touch-ups which often occured in the past.[8] Despite unavoidable changes in the metascientific image of science, in scientific research programs one can still find some ideats occurring independently of local discontinuities caused by scientific revolutions. One such ideat is the broadly understood ideat of rationality, different variants of which appear at different stages of the development of science. An ontological interpretation of this ideat had been provided already by Anaxagoras in his maxim: "Reason rules the world." This belief in the rationality of the world has led to attempts at developing explanations which would be intersubjectively meaningful and subject to criticism rather than left to the fantasy of poets or to the occult, untestable knowledge of shamans and magicians.

Another important ideat which expresses metascientific rationalism was cognoscibilism representing the conviction that it is possible to know the world by means available to man. If at the cradle of Greek thought the notion had been unanimously accepted that our mind supplied us with delusions only, that is, with experiment that provided an interplay of semblances while reality itself remained for ever a great mystery to the human mind, then our present scientific civilisation would perhaps not have differed too much from the primitive cultures described with such sentiment by Feyerabend. Plato himself, when developing his theory of anamnesis, had struggled with the dilemma of whether the belief in the cognition of the world was not a delusion and whether, as today in Monod's interpretations, the universe was not merely a medley left to the guidance of necessity and chance. Plato's ontological assumptions made human

8 See, e.g., J. Agassi, *Science and Society. Studies in the Sociology of Science*, D.Reidel, Dordrecht 1981; I. Lakatos, *History of science and Its rational Reconstructions*, [in:] *idem*, *Philosophical Papers*, vol. 1, eds. J. Worrall, G. Currie, Cambridge University Press, Cambridge 1978, pp. 102 - 138.

cognition dependent on the recollections of experiences to which human souls were to be submitted in the objective world of truth before descending to earth.

In order not to resort to the highly speculative theory of ideas, Aristotle in the "Posterior Analytics" stressed the role of axioms which could be distinguished on the basis of our infallible intuitions and accepted as a foundation for syllogistic reasoning. Although the Platonic-Aristotelian justifications of the ideat of cognoscibilism had finally turned out to be either false or groundless, the ideat itself played a decisive role as a component of the hard core of several radically different research programs. The role it has played in the process of the development of science can only be compared to the role of the ideat of methodological positivism which has turned out to be a decisive one in forming the principles of methodology of modern science. The latter ideat, by postulating that in scientific reasoning one should refer only to immanent natural factors definable in terms of the natural sciences, had been decisive in making science epistemologically pure and in relieving it of extrascientific intrusion as had been practiced during its earlier stages. The ideat of methodological positivism developed by P. S. Laplace turned out to be far more effective in the process of the growth of science than all the remaining ideats proposed later by the sciencefascinated doctrinal positivists.

The main ideat of the period of the meta-scientific revolution is the ideat of the existence of the multifarious limitations in science that are proven on the basis of premises supplied by science itself. The discovery of such limitations does not imply any antiscientific or anti-rational consequences, just as the discovery that man depends on laws of nature does not justify the introduction of pan-deterministic interpretations. Since the discovery of strict laws of nature limiting any free play of processes had proven to be a fundamental condition for developing science, in a similar manner, the discovery of insurmountable limits to the scientific discourse is a breakthrough development at the level of metascientific reflection. Together with demonstrating the effectiveness of scientific procedures that define the limits of their own applicability, these discoveries show the fallacy of the ideats of scientific totalitarianism where the slogan: "No salvation outside science" had been promoted.

The discovery that there is no golden path for scientists and that even in mathematics truth is reached through conjectures, trials and errors, does not entitle anyone to conclude the growth of science has reached an impasse. Clear-cut prognoses that scientific progress must cease since it cannot continue indefinitely find no justification in the philosophy of science. Decrease in the rate of institutional progress should not be identified with the lack of substantial progress. The growth of scientific theories is not a simple derivative of institutional and management support and is far more complicated than the simplifying framework of sociologism would allow. Awareness of the limitations of science does not exclude the possibility of making new discoveries which will turn the attention of scientists to completely new problems. The presently known fact that undecidable questions exist in logical systems does not preclude the existence of "unaskable" questions, i.e. issues which in principle cannot be questioned at the present stage of research development and which will become objects of future scientific investigations.

It is yet a matter of the distant future to accurately assess the consequences of the meta-scientific discoveries of the recent period. Gödel's theorems, for instance, inspired many exciting discussions that referred even to ontological problems, the mind-body issue included.[9] Their epistemological implications have still been a subject of radically different appraisals. Attempts at equating the epistemological status of mathematics and natural sciences as well as those of treating physical theories as a formal calculus augmented by semantic rules of interpretations have been assessed in mutually opposed terms. Despite similar controversies, the fact remains that quantum theories can be treated either as pure formalism or as interpreted systems. It is a fact that in the research practice of formal sciences a closed set of axioms and rules of transformations from which logical consequences are derived have been accepted as basic elements of various theories. In the natural sciences a similar scheme of constructing scientific theories has been suggested only in methodological frameworks of deductivism; however, even there, the introduced basic assumptions depend strictly upon the available empirical data known before a theory is elaborated. In turn, differences between logic and physics should not gloss over the fact that differentiations between biology and physics are no less than between the formal and natural sciences. Despite such differences both biology and physics are classified as natural sciences even though any attempts at axiomatizing biology would be today grotesque.

A characteristic feature of the development of science was the combining into one unit issues believed earlier to be devoid of any intrinsic relationship. In this context, a breakthrough was made by Galileo who extended the laws of earthly physics over the supralunar world believed by the Aristotelians to be a world of unchanging perfect structures. The same unification methodology led Newtonian physics to discover the laws of dynamics and enabled post-Newtonian physics to discover the

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9 See, for instance, P. Slezak, *Gödel Theorem and the Mind*, "BJPS" 1982, no. 33, pp. 41-52 and the bibliography indicated there.

ever-extending unity of seemingly unrelated phenomena. The 19th century Maxwellian discovery that electricity, magnetism and optic phenomena could be connected, has been continued in our century by the Einstein connection of space-time and gravity and by the unification of weak and electromagnetic interactions in the Salam-Weinberg theory. One of the most exciting problems of contemporary physics is the search for the Grand Unification. One should not delude oneself into believing that a solution for the current problems in the form of a successful Grand Unified Theory will end the quest for unification. Just as Copernicus could not have foreseen the issue of the unification of different interactions, and as Newton did not ask about the consequences of bombarding black holes with tachyons, no more are we able, at the present stage of research, to even formulate the new issues which may arise at levels of reality unknown to present science.

The heuristic value of the ideats of unification does not imply, however, a positive view towards all attempts at unification. Searches for a single formula applicable to all phenomena, characteristic for magic, have also been a unification of a kind, as were those variants of reductionism in which all the unknown processes were to be explained in the category of newly discovered phenomena. Within a framework of such an ideology, Descartes tried to present the human organism as an array of pumps while his modern successors seek explanations of mental processes by referring to the operation of computers. Over the past century, reductionist research programs underwent evident degeneration at least twice. In the 19th century the reductionist ideology broke down in the mechanistic research program when it turned out that it was impossible to explain all processes through particles of matter and their laws of motion. In the 20th century, reductionism in mathematics had to succumb to the fact that it was impossible to fulfill the program of logicism whereby all mathematics was supposed to be reduced to a small number of axioms and transformation rules.

The degeneration of these two programs leads to a natural question concerning the status of reductionism in ontology. The simplest reductionist system in this domain is materialistic monism. Within this system the ontological structures of the differentiated reality comprising, among others, physical, psychic and cultural phenomena, are explained by reference to the thesis of the omni-materialistic character of all phenomena and to the laws determining the evolution of matter. Such a system could have passed scrutiny as a complete and consistent one at the times of Greek atomists when the relatively small set of formulated issues was explained by reference to the motion of atoms in a vacuum, thus offering explanations of atmospheric phenomena, psychic processes, the origin of dreams, etc. As knowledge grew and the set of issues to be dealt with expanded, one had to resort to the supplementary assumptions in order to find answers to questions unanswerable on the basis of earlier premises. The failure of mechanicism and of logicism provide grounds for questioning the optimistic suppositions that reductionist monism may turn out to be a closed and consistent system in which all philosophical issues can be solved.

An alternative with respect to the above concept is the antireductionist theory of the open universe that was developed, among others, by K. R. Popper. The author of "The Open Universe" while supporting the concept of the essential incompleteness of all science, counters reduction by the notion of emergence. The term "emergent" denotes evolutionary processes which are essentially unpredictable, i.e., cannot be treated as natural consequences of earlier processes.[10] In the process of the development of the open universe, states emerge which cannot be explained by reference to earlier states and to universal laws of evolution. In this indeterministic universe, therefore, one is unable to reduce biology to physics, psychology to biology, or principles of logic to psychic processes. Instead of totalitarian laws embracing all processes, in the Popperian open world one obtains a plurality of levels and laws. This emergent universe is "partly causal, partly probabilistic, and partly open";[11] and it is impossible to defend the optimistic ideats of reductionism in such a world.

While the growth of physics led to the fall of mechanistic reductionism, the development in the philosophy of science provided degeneration of the reductionist research program in the domain of epistemology. Before the metascientific revolution, various attempts were undertaken to ground physical-mathematical knowledge on undeniable foundations of protocol sentences, operational procedures and self-evident axioms. Within the framework of the contemporary philosophy of science such attempts seem to disclose cognitive optimism similar to the optimism of Florence Nightingale who believed that one must study statistics to understand divine thoughts. We do realize that the element of divine perfection can be found neither in statistics nor in lofty metascientific research programs. Illusive and exalted declarations implied by the latter have been replaced by moderate proposals of the present methodological pluralism. The concept of scientific theories, observational-theoretical distinctions, the role of personal-subjective elements in science are approached today in an essentially different manner because of the metascientific revolution which chal-

10 K.R. Popper, *The Open Universe. An Argument for Indeterminism*, Rowman and Littlefield, Totowa 1982.

11 *Ibidem*, p. 130.

lenged the epistemetic theory of science. After the ambitious but unrealistic programs of the 1920s and after the metascientific chaos characteristic of the 1950s and 1960s one can substantiate at the present time many metascientific assertions which were either controversial or iconoclastic in the past.[12] Many conclusions accepted as commonplace in the present post-revolutionary period seemed unthinkable to the authors of the 19th century. There remain still, however, many fundamental questions, especially in the philosophy of mathematics, which have no satisfactory answers at the present time.

Past experiences associated with the attempts to define the foundations of knowledge caution us against a happy ending for epistemology. The maturation process of ideas is much more complicated than some uncritical admirers of science wish to admit. Besides pressing problems which remain veiled by doubt and mystery, there exists also a large set of problems which are not perceived at the present stage in the development of knowledge. From the beginning of man's existence, the human organism required oxygen to function normally, but the theoretical description of the nature of oxygen only became possible in the 18th century. Although man had earlier reacted to the lack of oxygen in caves and to the presence of ozone after storms, the questions relating to the cause of these changes observed for a long time went beyond the limits of his imagination and conceptual schemes. In the realistic ontology of the stone age, the problem of gases invisible to the eyes seemed similar to the problem of invisible nymphs. In Thales' time, the appearance of simple electrical effects was already noted, but 24 centuries had to pass until they were interpreted in Maxwell's electrodynamics. For long centuries man searched for the alchemist's stone that

12 Cf. *The Structure of Scientific Theories*, ed. F. Suppe, University of Illinois Press, Urbana-IL 1977, p. 730.

would transform one substance into another. After the rise of quantum physics, the theoretical possibility of such transformations was recognized, but the procedure itself is too costly and much more complicated than was believed.

The opinion of Einstein that equations are wiser than their authors was often confirmed in the process of the development of science. When conflicts arose between the logical consequences of accepted principles and the human sense of psychologically conditioned irrationality, very often the progress of science was followed by profound revisions of the latter. The regularity of similar processes suggests that the future progress of science may necessitate profound transformations in the set of presumptions which seem to be natural and justified from the standpoint of the present theory of knowledge. One of the important features of the metamorphoses in the structure of science is the replacement of common sense scientific concepts by abstract ideas which transcend the realm of patterns of Platonic-Pythagorean interpretations. "Modern physics," as W. Heisenberg argues, "has definitely decided in favour of Plato".[13] To appraise the reliability of this opinion we have to notice that a physicist accepting radical empiricist epistemology would have today every good reason to consider statements concerning the existence of the effects of gravitation or of the meson field to be as much mystical as the statements concerning the music of celestial spheres or the world of Plato's ideas. The deep changes in theoretical physics justify the conclusion that the fundamental principles of this physics are more akin to the philosophical intuitions of Plato than to the empiricist dreams of Otto Neurath.

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13 W. Heisenberg, *Natural Law and the Structure of Matter*, [in:] *Frontiers of Modern Scientific Philosophy and Humanism*, Elsevier, Amsterdam 1966, pp. 26-42.

Among the new daring theories, distant from the spirit of bygone empiricism, one may, for example, find a theory claiming that quarks may turn out to be the elements of an infinite set of elementary particles to which one could not attribute properties of matter.[14] In that case quarks influencing physical processes would remain mathematical rather than physical objects. Even if we do not accept similar strong assumptions we have to admit that, for instance, the notion of an isolated elementary particle results from an idealization in which the effects of the interaction between particles and vacuum are disregarded. Because of these interactions each elementary particle is accompanied by a set of virtual particles, and it is not the bare particles but the particles surrounded by a cloud of virtual particles which are considered real.

The question of the existence that may be attributed to virtual particles is another complicated issue. The virtual mesons should not be regarded as a subset of the real mesons, at least for the reason that it would lead to the violation of the conservation laws in the domain of micro-phenomena. Virtual particles cannot be directly observed in those phenomena on the basis of which we may discover the presence of "real" particles. In the so-called Feynman's diagrams the virtual particles are never denoted by external lines. These particles, however, are in a sense real since without referring to them it would be impossible to interpret numerous phenomena in quantum mechanics. The reality of the particles is implied by mathematical formalism of the theories, though the empirical data as well as the human imaginative potential turn out to be limited.

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14 R. Hagedorn, *What Happened to our Elementary Particles*, [in:] *Physical Reality and Mathematical Description,* D.Reidel, Dordrecht, 1974, p. 109.

4. Summary and Conclusions

Open science reached its stage of maturity in the open universe of human knowledge because of the abandonment of narrow epistemological-methodological framework.[15] There are still many controversial questions concerning not only the future but also the past of science. The adherents of Bachelardian differentiation between prescientific theories presented by the 17th century and scientific post-Newtonian theories confront strong opposition by the advocates of Koyré-Lardreau approach. The latter argue that aiming at truth is an essential constituent of science and, consequently, Aristotle is no less a scientist than Einstein.[16] In such an approach it is easy to equalize astrology and chemistry since in both of them the aiming-at-truth appears an immanent factor. On the other hand, such treatment does not seem unacceptable if one only considers the differences between present theoretical physics and the physics of the end of the 18th century when almost all experimental physicists were pragmatically involved electricians.[17]

The period of 150 years which passed since 1834, when A. Ampère published "An Essay on the Philosophy of Science", appears to be an epoch of the deepest metamorphoses in the theory of human knowledge. For many scientists the discovery of these metamorphoses was a Damascene conversion experience in which they ascertained that their earlier belief in irrefutable, secure and unquestionable knowledge resembled belief

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15 Cf. J.R. Ravetz, *Criticism of Science*, [in:] *Science, Technology and Society*, London 1977, p. 84.

16 See, for instance, F. Aubral, X.Delcourt, *Contra la nouvelle philosophie*, Gallimard, Paris 1977.

17 Cf. A.R. Hall, *The Scientific Revolution: 1500-1800. The Formation of the Modern Scientific Attitude*, Uniwersytet Michigan, London 1962, chapt. XII.

in the Loch Ness monster.[18] Although no metascientific Santa Claus is able to fulfill earlier dreams of epistemological rationalism, we can at least recognize in these dreams symptoms of "Kinderkrankheit" in metascientific research programs. Their failure resulted either from unrealistic figures on the nature of science or from dreamlike attempts at extrapolating one theory of scientific revolutions on the entire history of science.

Modern science emerged in its mature form when the universal principles of Newton's dynamics were extended to all physical processes. In the 20th, century philosophy of science a similar attempt was undertaken on the metascientific level; its adherents aimed at universal methodological and epistemological principles which could be applied to all domains of scientific research. The metascientific revolution disclosed the illusionary character of similar attempts. I have tried to demonstrate in this book that in various fields of scientific investigations different epistemological principles and demonstrative procedures are needed; there are domains in which deductivist guesses play a positive heuristic role, and domains in which inductivist generalizations are necessary. The complex structure of science cannot be, however, subordinate either to the inductivist or to deductivist philosophy of science, because in scientific research, rational and empirical elements interact with psycho-social determinants in a manner that does not fit any idealized universal principles. In trying to explain the nature of these interactions in my theory of the so-called presumptions, I developed some ideas proposed by Polanyi and Bridgman. My acceptance of unavoidable psycho-social elements in science does not lead, however, to radical interpretations of cognitive sociology in which the content of scientific theories is to be

18 Cf. M. Ruse, *The New Dualism: Res Philosophica and Res Historica*, [in:] *Nature Animated*, ed. M. Ruse, D. Reidel, Dordrecht 1983, pp. 6, 13.

determined primarily by psychosocial factors. Unfalsifiable, all-explaining variants of such interpretations resemble in many aspects medieval astrological and alchemical theories which were supposed to disclose the hidden essence of the world.

While in the Kuhnian theory of scientific revolution the social-elitist determinants are accentuated, in the metascientific revolution the basic role is played by rational arguments and critical appraisal. Owing to critical reflection upon Einstein's physics, it became evident that simple metascientific principles of earlier empiricism can be no longer defended. Owing to rational reflection upon the foundations of mathematics and properties of logical systems, the unrealistic character of Hilbertian formalism was discovered. Neither the decline of logicism nor acceptance of the limitative theorems depended on a kind approval of leading scientific centers; no "conversion effect" was needed to acknowledge chains of deductive inferences or to assert that common sense epistemology cannot be applied to quantum mechanics. The metascientific revolution was based not on arbitrary decisions of influential scientists, but on breakthrough discoveries which had to be accepted because of their internal logic. The revolution was the necessary consequence of these discoveries because metascientific principles appropriate for 19th century science can be no longer applied to science after Einstein, Planck, Gödel and Hawking.

When Kant developed his critique of metaphysics in the 18th century, he still believed in the certainty of Newtonian physics. Discoveries at the beginning of our century revealed the groundlessness of this belief. After the metascientific revolution we must accept the fallibilist vision of physics in which conjectural and approximate "doxa" prevails. The revolution resulted in discarding the simple vision of unified and certain science, when it disclosed that the intrinsic structure of science is much more sophisticated and complex than the chimerical structure imagined by authors who claimed that there is no depth in science. Contrary to such claims, crucial discoveries in the philosophy of science led to the disclosure of hidden structures of science. The essence of these structures cannot be explained by taking into consideration only empirical, or rational, or psycho-social elements. Different scientific disciplines exhibit essentially different intrinsic structures, and for this reason no non-trivial methodology can be universally applied. For the same reason, it is impossible to present a simple description of the structure of the metascientific revolution. The revolution was based on various factors, intellectual as well as cultural, and assumed different shapes in different domains of research. In the domain of metascientific research there were no Bolsheviks imposing all-embracing principles of revolution as well as there was no single action transforming momentarily pre-revolutionary enchantment by science into contemporary criticism of science. The radical revision of previous scientific standards did not fit to one universal pattern, but depended on a variety of scientific discoveries which appeared inconsistent with former standards.

Radical changes in our views on the essence of science and the mechanisms of scientific growth facilitate conjectures about a new scientific paradigm in which "the fatal estrangement" between nature and culture is to be avoided. Similar yearnings towards a humanized science depend more on social-cultural preferences prevailing in the post-positivist epoch than on substantiated rational premises. Critical analysis discloses, however, that up to this time both these elements play important role in the evolution of science. I tried to present an evidence in this book that real science cannot be reduced either to its rational components, accentuated by Carnap and Popper, or to social-cultural elements, emphasized by contemporary adherents of radical cognitive sociology. If simplifying metascientific schemes are discarded, we can treat science neither as an opium for the enlightened nor as one of many ideologies accepted in contemporary society.

The abandonment of illusionary views on the perfection of scientific knowledge seems to be a very important intellectual attainment of the post-positivist philosophy of science. Its awareness yields neither the rejection of science nor cognitive pessimism; it leads only to a realistic assertion that the role of ″doxa″ in human knowledge is much more important than it had been recognized by infatuated admirers of ″episteme″. Avoiding the easy fascinations of the past, we may affirm the fundamental doctrine of the meta-scientific revolution — the doctrine that ″genus humanus transcendentalibus et incertitudine vivet,″ the human species lives on transcendentals and on (doxatic) uncertainty.

Criteria of Science, Cosmology, and Lessons of History[1]

Helge Kragh

1. Introduction

Ever since the age of Galileo, at the beginning of the Scientific Revolution, science has expanded in both breadth and depth, conquering one area after the other. The development of the scientific enterprise has not occurred at a uniform growth rate, of course, but it has nonetheless been remarkably successful, progressing cognitively as well as socially and institutionally. Today, some 400 years after Galileo first demonstrated the inadequacy of the Aristotelian cosmos and the advantages of the Copernican alternative, we may wonder if there are any limits at all to scientific inquiry. Will science at some future stage enable us to understand everything? Is scientific explanation limitless? These are big questions and not really the topic of this essay, but I shall nevertheless introduce it by some general reflections on the limits of science, divided in four points.

(i) When it comes to the question of the limits of science, it is useful to distinguish between *knowledge* and *explanation*. After all, we may have scientific knowledge about things, even understand them on a phenomenological or instrumentalistic level, and yet be unable to provide them with an explanation. Indeed, the history of science is one long series of temporary disharmonies between phenomenal and explanatory knowledge.

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1 This publication was made possible through the support of a grant from the John Templeton Foundation.

Early radioactivity is one example of an unexplained phenomenon that nonetheless was investigated in great detail and with great success. Another example is superconductivity, which was discovered in 1911 but only explained on a microphysical basis with the BCS (Bardeen-Cooper-Schrieffer) theory dating from 1957.

(ii) The question of scientific explanation obviously depends on our chosen criteria for what constitutes an acceptable *explanation*.[2] These criteria are not provided by nature, but by the scientific community. With an appropriate change of the criteria scientists may be able to explain phenomena that previously seemed inexplicable. This point is particularly well illustrated by the anthropic principle, which provides explanations for a variety of phenomena – from the neutron-proton mass difference to the age of the universe – that cannot be explained on the basis of standard physics and cosmology. But are anthropic explanations proper explanations at all? As well known, this is a matter of considerable debate and a main reason why the anthropic principle is controversial.[3]

(iii) Implicitly or explicitly, the question of the limits of science refers to the problem of the *domain* of science, that is, the territory of reality to which science applies. Are there phenomena or concepts that lie outside the realm of science, or can science legitimately be applied to *all* aspects of reality? According to hard-core reductionists the latter is the case. Thus, Frank Tipler

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2 The philosophical literature on scientific and other explanations is extensive. Relevant works include R. Nozick, *Philosophical Explanations*, Harvard University Press, Cambridge-MA 1981; P. Achinstein, *The Nature of Explanation*, Oxford University Press, Oxford 1983; and *Explanation: Styles of Explanation in Science*, ed. J. Cornwell, Oxford University Press, Oxford 2004.

3 See, for example, R.J. Deltete, *What Does the Anthropic Principle Explain?*, "Perspectives on Science" 1993, no. 1, pp. 285-305.

is by his own admission an "uncompromising reductionist," implying that "everything, including human beings, can be completely described by physics."[4] Generally, within the tradition of positivism the tendency has been to define reality as just those phenomena or concepts that are accessible to scientific analysis.

However, it is possible that the world that can be observed in principle (and hence be subject to scientific analysis) is only part of a larger non-physical world to which we have no empirical access and which therefore transcends the domain of science as ordinarily understood. For example, this is what has been argued within a non-theistic context by Milton Munitz, a distinguished philosopher of cosmological thought. According to him, there is a dimension of existence, which he calls "Boundless Existence," that transcends the existence of the physical universe. This Boundless Existence is not in space and time, it has no structure, and it can only be characterized – if characterized at all – in negative terms. "Boundless Existence," Munitz says, "is so totally unique ... that all similarities with anything in our ordinary experience must fall short and be inadequate."[5]

(iv) There are questions of a conceptual nature about which we do not even know whether they are meaningful or not – or, if they are meaningful, whether they belong to the domain of science. To indicate the type of these questions, a brief reference to two problems may suffice. First, there is the much discussed question of realized or actual infinities, of whether or not there can be an infinite number of objects in the universe.

4 F.J. Tipler, *The Physics of Immortality: Modern Cosmology, God, and the Renaissance of the Dead*, Doubleday, New York 1994, p. 352.

5 M.K. Munitz, *Cosmic Understanding: Philosophy and Science of the Universe*, Princeton University Press, Princeton 1986, p. 235; see also M.K. Munitz, The Question of Reality, Princeton University Press, Princeton 1990.

The problem has become an issue in the standard inflationary model of the flat universe, but it was also discussed in relation to the earlier steady state model according to which space was infinite and uniformly populated with matter. While many modern cosmologists are perfectly happy with actual infinities, others deny their scientific legitimacy and consider the question to be metaphysical.[6] The point is that we do not really know whether or not it makes scientific sense. It makes mathematical and philosophical sense, but will it ever be answered scientifically?

If infinity is one of those frightening concepts on the border between physics and metaphysics, so is the concept of *nothingness* or absolute void. This is another speculation with a rich and fascinating history that recently has become relevant to science, not least after the discovery of the dark energy revealed by the acceleration of the cosmic expansion. Dark energy is generally identified with the vacuum energy density as given by the cosmological constant. However, whether or not this turns out to be true, the modern quantum vacuum is entirely different from absolute nothingness.

As far as I can see, there cannot possibly be a scientific answer to what nothingness is, and yet it does not therefore follow that the concept is meaningless.[7] Such a conclusion presupposes a rather narrow positivistic perspective.

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6 See G.F.R. Ellis, U. Kirchner, W.R. Stoeger, *Multiverses and Physical Cosmology*, "Monthly Notices of the Royal Astronomical Society" 2004, no. 347, pp. 921-936. On the disturbing infinities appearing in steady state cosmology, see R. Schlegel, *The Problem of Infinite Matter in Steady-State Cosmology*, "Philosophy of Science" 1965, no. 32, pp. 21-31.

7 A useful overview is presented in: R. Sorensen, *Nothingness*, [in:] *The Stanford Encyclopedia of Philosophy*, ed. E.N. Zalta, Stanford University, Stanford 2003, <http://plato.stanford.edu/entries/nothingness>; see also B. Rundle, *Why there is Something Rather than Nothing*, Oxford University Press, Oxford 2004. For the history of the concepts of vacuum and nothing-

In this essay I look at a fundamental question in the philosophy of science, namely, the defining criteria of what constitutes scientific activity from a cognitive point of view. Another and largely equivalent version of this question is the demarcation problem, that is, how to distinguish between science and non- or pseudoscience. Why is astronomy recognized as a science, when astrology and gastronomy are not? However, I shall not deal with these questions in a general and abstract way, but instead illustrate some of them by means of a couple of examples from the more recent history of cosmology. I focus on two cases, the one being the controversy related to the steady state theory in the 1950s and the other the still ongoing controversy over the anthropic multiverse. Although separated in time by half a century, in some respects they are surprisingly similar and suited for comparison.

One remarkable feature shared by the two cases is the role played by philosophical considerations among the scientists themselves – philosophy *in* rather than *of* science.[8] The history of cosmology, and the history of science more generally, demonstrates that on the fundamental level philosophy is not extraneous to science but part and parcel of it. I suggest that Freeman Dyson was quite wrong when he stated, in a rare mood of positivism, that, "philosophy is nothing but empty words if it is not capable of being tested by experiments."[9] As will become clear, the views of science associated with Karl Popper's critical

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ness, see H. Genz, *Nothingness: The Science of Empty Space*, Basic Books, New York 1999.

8 On the concept of "philosophy in science" and some of the problems related to it, see M. Heller, *How Is Philosophy in Science Possible?*, [in:] *Philosophy in Science*, eds. B. Brożek, J. Maczka, W.P. Grygiel, Copernicus Center Press, Kraków 2011, pp. 13-24.

9 F. Dyson, *Infinite in All Directions*, Perennial, New York 2004, p. 96. A balanced argument for the value of philosophy in cosmological research

philosophy played an important role in both controversies. For this reason, I deal particularly with these views and Popper's emphasis on testability and falsifiability as defining criteria for science also in the area of physical cosmology. In the last section I offer some reflections on the use and misuse of historical analogies in the evaluation of scientific theories, a problem that turned up in both of the cosmological controversies.

2. Testability in the physical sciences

Few modern philosophers of science believe that science can be defined methodologically in any simple way and, at the same time, reflect the actual historical course of science.[10] There is no generally accepted, more or less invariant formulation that encapsulates the essence of science and its rich variation. All the same, there are undoubtedly *some* criteria of science and theory choice that almost all scientists agree upon and have accepted for at least two centuries. Thomas Kuhn suggested five such standard criteria of evaluation, which he took to be (1) accuracy; (2) consistency, internal as well as external; (3) broadness in scope; (4) simplicity; (5) fruitfulness.[11] Although Kuhn did not mention testability as a separate criterion, it was part of the first one, according to which there must be "consequences deducible from a theory [that] should be in demonstrated agreement with the results of existing experiments and observations." Kuhn did not specifically refer to predictions, except that he included them under the notion of "fruitfulness."

is given in E. McMullin, *Is Philosophy Relevant to Cosmology?*, "American Philosophical Quarterly" 1981, no. 18, pp. 177-189.

10 This section relies on material discussed more fully in a paper on *Testability and Epistemic Shifts in Modern Cosmology* submitted to "Studies in History and Philosophy of Modern Physics".

11 See T. S. Kuhn, *The Essential Tension: Selected Studies in Scientific Tradition and Change*, University of Chicago Press, Chicago 1977, pp. 321-322.

Most philosophers of science, including Kuhn himself, are aware, that the mentioned criteria may contradict each other in concrete situations and that a relative weighing may therefore be needed. But then the system cannot fully or uniquely determine an evaluation in a concrete case. In the context of modern cosmology Kuhn's criteria have been discussed by George Ellis, who points out that although they are all desirable they are not of equal relevance and may even lead to conflicts, that is, to opposing conclusions with regard to theory choice.[12] Still, Ellis (and most other cosmologists) finds the first of Kuhn's criteria to be the one that in particular characterizes a scientific theory and demarcates it from other theories. In short, empirical testability is more than just one criterion out of many. Nearly all scientists consider this epistemic value an indispensable criterion for a theory being scientific: a theory which is cut off from confrontation with empirical data just does not belong to the realm of science.

As an example, consider Einstein, who in the period from about 1905 to 1925 moved from a cautious empiricist position *à la* Mach to an almost full-blown rationalism. In his Herbert Spencer lecture of 1933 he famously stated that "we can discover by means of pure mathematical considerations the concepts and the laws ..., which furnish they key to the understanding of natural phenomena. ... In a certain sense, therefore, I hold it true that pure thought can grasp reality, as the ancients dreamed."[13]

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12 G.F.R. Ellis, *Issues in the Philosophy of Cosmology*, [in:] *Philosophy of Physics*, eds. J. Butterfield, J. Earman, North-Holland, Amsterdam 2007, pp. 1183-1286.

13 A. Einstein, *Ideas and Opinions*, Three Rivers Press, New York 1982. On Einstein's philosophy of science, see, for example, J. Shelton, *The Role of Observation and Simplicity in Einstein's Epistemology*, "Studies in History and Philosophy of science" 1988, no. 19, pp. 103-118, and J. D. Norton, *"Nature is the Realization of the Simplest Conceivable Mathematical Ideas":*

But in between these two expressions of his rationalist credo, there was the no less important sentence: "Experience remains, of course, the sole criterion of the physical utility of a mathematical construction." As late as 1950, commenting on his latest attempt at a generalized theory of gravitation, he readily admitted that "Experience alone can decide on truth."[14] According to Einstein, while in the creative or constructive phase of a scientific theory empirical considerations might be wholly absent, such considerations were at the very heart of the context of justification.

While testability is universally admitted as a necessary (but not, of course, sufficient) condition for a theory being scientific, in practice the concept can be interpreted in ways that are so different that the consensus may tend to become rhetorical only and of little practical consequence. The following list of interpretive questions is not complete, but it gives an idea of what physicists sometimes disagree about when it comes to testing of theories:

1. Actual testability (with present instrument technologies or those of a foreseeable future) is obviously preferable. But should it be required that a theory is actually testable, or will testability in principle – perhaps in the form of a thought experiment – suffice?
2. Should a theory result in precise and directly testable predictions, or will indirect testability do? For example, if a fundamental theory T results in several successfully confirmed predictions $P_1, P_2, \ldots, P_n$, can prediction P_{n+1} be considered to have passed a test even if it is not actually tested?[15]

Einstein and the Canon of Mathematical Simplicity, "Studies in History and Philosophy of Modern Physics" 2000, no. 31, pp. 135-170.

14 A. Einstein, *On the Generalized Theory of Gravitation*, "Scientific American" 1950, no. 182(4), pp. 13-17, on p. 17.

15 It is sometimes argued that there are reasons to believe in untestable predictions if they follow from a well-established theory with empirical success.

3. Will a real test have to be empirical, by comparing consequences of the theory with experiments or observations, or do mathematical consistency checks also count as sufficient (theoretical) tests?
4. Another kind of non-empirical testing is by way of thought experiments or arguments of the *reductio ad absurdum* type that played an important role in the controversy over the steady state theory. A cosmological model may lead to consequences that are either contradictory or unacceptably bizarre. How should such arguments enter the overall evaluation picture?
5. At what time in the development of a theory or research programme can one reasonably demand testability? Even if a theory is not presently testable, perhaps it will be so in a future version, such as there are many examples of in the history of science.
6. How should (lack of) testability be weighed in relation to (lack of) other epistemic desiderata? E.g., is an easily testable theory with a poor explanatory record always to be preferred over a non-testable theory with great explanatory power? Or what if the testable theory is overly complicated, and the non-testable one is mathematically unique and a paragon of simplicity?
7. Should predictions of novel phenomena be counted as more important than pre- or postdictions of already known

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On this account the existence of other universes is "tested" by the successfully tested background theories, in this case quantum mechanics and inflation theory. See, for example, M. Tegmark, *The Mathematical Universe*, "Foundations of Physics" 2008, no. 38, pp. 101-150. On a different note, string theorists have suggested that the theory of superstrings has passed an empirical test because it includes gravitation without being designed to do so. E. Witten, *Magic, Mystery, and Matrix*, "Notices of the AMS" 1998, no. 45, 1124-1129.

phenomena? This is a question on which philosophers are divided and where the historical evidence is ambiguous.

3. A historical case: The steady state theory

The steady state theory of the universe, proposed by Fred Hoyle, Hermann Bondi and Thomas Gold in 1948, aroused a great deal of philosophical interest, in part because of the theory's controversial claim of continual creation of matter and more generally because of its appeal to philosophy and methods of science. For example, Bondi and Gold argued that the new steady state theory was preferable from a methodological point of view, as it was simpler, more direct, and more predictive than the cosmological theories based on general relativity. The latter class of theories, they said, was "utterly unsatisfactory" since it covered a whole spectrum of theories that could only be confronted with the observed universe if supplied with more or less arbitrary assumptions and parameters: "In general relativity a very wide range of models is available and the comparisons [between theory and observation] merely attempt to find which of these models fits the facts best. The number of free parameters is so much larger than the number of observational points that a fit certainly exists and not even all the parameters can be fixed."[16] Relativistic cosmology sorely lacked the deductive character of the steady state theory, which uniquely led to a number of predictions, such as the mean density of matter, the curvature of space, and the average age of galaxies. According to Bondi and Gold, the predictions were crucially based on what they called the perfect cosmological principle (PCP), namely, the postulate that there is neither a privileged place nor a privileged

16 H. Bondi, T. Gold, *The Steady-State Theory of the Expanding Universe*, "Monthly Notices of the Royal Astronomical Society" 1948, no. 108, pp. 252-270, on p. 269 and p. 262.

time in the universe. Thus, the PCP is a temporal extension of the ordinary cosmological principle (CP).

Whether in the Bondi-Gold or the Hoyle version, the steady state theory was critically discussed by many philosophers and philosophically minded astronomers and physicists.[17] To the first category belonged Adolf Grünbaum, Mario Bunge, Milton Munitz, Norwood Russell Hanson, and Rom Harré, and to the latter Herbert Dingle, Gerald Whitrow, William McCrea, and William Bonnor. We witness in this discussion an instructive case of philosophy in science, an unusual dialogue between professional philosophers and the spontaneous philosophy of practicing scientists.

Much of the methodological discussion in the 1950s and 1960s focused on the criteria on which to judge the scientific nature of the steady state theory, or of cosmology in general. To give just a couple of examples, Dingle found the cosmological principle – whether in its original CP or the "perfect" PCP form – to be plainly unscientific because it was a priori and hence in principle inviolable.[18] According to Bunge and some other critics, the steady state theory was nothing but "science-fiction cosmology" because it rested on the ad hoc assump-

17 On the philosophical foundation of steady state cosmology and the discussion of its scientific status, see Y. Balashov, *Uniformitarianism in Cosmology: Background and Philosophical Implications of the Steady-State Theory*, "Studies in History and Philosophy of Science" 1994, no. 25, pp. 933-958, and H. Kragh, *Cosmology and Controversy: The Historical Development of Two Theories of the Universe*, Princeton University Press, Princeton 1996.

18 H. Dingle, *Cosmology and Science*, [in:] *The Universe*, eds. G. Piel *et al.*, Simon and Schuster, New York 1956, pp. 131-138. The misguided claim that the cosmological principle is a priori has more recently been made by the German philosopher Kurt Hübner, according to whom cosmological models rest on a priori constructions that are essentially independent of observations. K. Hübner, *Critique of Scientific Reason*, University of Chicago Press, Chicago 1985, pp. 150-152.

tion of continual creation of matter.[19] On the other hand, and contrary to the later multiverse controversy, testability was not at the heart of the discussion. Both parties accepted that a cosmological theory must be observationally testable, but they rated this epistemic value somewhat differently and did not draw the same conclusions from it.

In 1954 Bondi and Whitrow engaged in an interesting public debate concerning the scientific status of physical cosmology. Whitrow, stressing the unique domain of cosmology, argued that it was not truly scientific and probably never would be so. It would remain, he thought, a borderland subject between science and philosophy. Bondi, on the other hand, suggested that the hallmark of science was falsifiability of theories and that on this criterion cosmology was indeed a science. "Every advocate of any [cosmological] theory will always be found to stress especially the supposedly excellent agreement between the forecasts of his theory and the sparse observational results," he admitted. And yet,

> The acceptance of the possibility of experimental and observational disproof of any theory is as universal and undisputed in cosmology as in any other science, and, though the possibility of logical disproof is not denied in cosmology, it is not denied in any other science either. By this test, the cardinal test of any science, modern cosmology must be regarded as a science. ... I consider universal acceptance of the possibility of experimental disproof of any claim an absolute test of what constitutes a science.[20]

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19 M. Bunge, *Cosmology and Magic*, "The Monist" 1962, no. 47, pp. 116-141.

20 G.J. Whitrow, H. Bondi, *Is Physical Cosmology a Science?*, "British Journal for the Philosophy of Science" 1954, no. 4, pp. 271-283, on p. 279 and p. 282. For the Bondi-Whitrow discussion, see also H. Kragh, *Cosmology and Controversy*, *op. cit.*, pp. 233-237.

Although not mentioning Karl Popper by name, Bondi was clearly defending a main methodological point in Popperian philosophy which he much admired. Whitrow, who was also well acquainted with Popper's views, did not disagree, although he warned that falsifiability should not be considered a final and absolute criterion: "The important role of disproof in science, which has been so cogently argued by K. R. Popper, is intimately related to the self-correcting tendency of science and this, in my view, is another aspect of the pursuit of unanimity."[21]

Although Popperian criteria of science played a considerable role during the cosmological controversy, and were highlighted by the steady state proponents in particular, they were rarely an issue of dispute. By and large, criteria of a Popperian kind were accepted also by many cosmologists favouring an evolving universe governed by the laws of general relativity. One of them was the British astronomer George McVittie, who was strongly opposed to the steady state theory and other theories he suspected were based on a priori principles. He described the philosophical foundation of the Bondi-Gold theory as "Karl Popper's dictum that a scientific theory can never be proved to be true but, instead, that certain theories can be proved to be false by an appeal to observation." While he considered the dictum to be a "probably unimpeachable doctrine," he parodied Bondi's use of it. If one followed Bondi's vulgar version of Popper's philosophy, "we should be justified in inventing a theory of gravitation which would prove that the orbit of every planet was necessarily a circle. The theory would be most vulnerable to observation and could, indeed, be immediately shot down."[22]

21 G.J. Whitrow, H. Bondi, *Is Physical Cosmology a Science?*, *op. cit.*, p. 280.

22 G.C. McVittie, *Rationalism versus Empiricism in Cosmology*, "Science" 1961, no. 133, 1231-1236, on p. 1231. McVittie belonged to what he called the "observational school" in cosmology. See J.-M. Sánchez-Ron, *George McVittie,*

4. A modern case: The anthropic multiverse

Like the earlier controversy over the steady state cosmological model, the present discussion of the multiverse hypothesis deals to a large extent with philosophical issues and the borderline between science and philosophy.[23] Both cases are about foundational issues that cannot be answered simply by observation and calculation. Among those issues are: Does the theory belong to science proper, or is it rather a philosophical speculation? If it disagrees with established standards of science, should these standards perhaps be changed? What are the basic criteria for deciding whether a theory is true or false? The discussion in 2008 between Bernard Carr and George Ellis concerning the multiverse, taking place in the journal *Astronomy & Geophysics*, can be seen as a modern analogue of the 1954 Bondi-Whitrow discussion about the scientific nature of physical cosmology.[24]

However, although the two cosmological controversies have enough in common to make a comparison meaningful, there are also some dissimilarities. As mentioned, in the case of the steady state theory there was a great deal of interest from the side of the philosophers, who were key players in the debate.

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the Uncompromising Empiricist, [in:] *The Universe of General Relativity*, eds. A. J. Kox, Jean Eisenstaedt, Birkhäuser, Boston 2005, pp. 189-222.

23 The central source in the multiverse debate is *Universe or Multiverse*, ed. B. Carr, Cambridge University Press, Cambridge 2007. See also H. Kragh, *Higher Speculations: Grand Theories and Failed Revolutions in Physics and Cosmology*, Oxford University Press, Oxford 2011, where further references are given. More popular accounts of the multiverse (in one or more of its several versions) include L. Susskind, *The Cosmic Landscape: String Theory and the Illusion of Intelligent Design*, Little, Brown and Company, New York 2006, and A. Vilenkin, *Many Worlds in One: The Search for other Universes*, Hill and Wang, New York 2006.

24 See B. Carr, G.F.R. Ellis, *Universe or Multiverse?*, "Astronomy & Geophysics" 2008, no. 49, pp. 2.29-2.37.

Strangely, a corresponding interest is largely absent in the case of the multiverse debate, where the philosophically related questions are predominantly discussed by the physicists themselves. Another difference is that the overarching question of the multiverse hypothesis is whether or not it is testable by ordinary observational means. Does it result in predictions of such a kind that, should they turn out to be wrong, the hypothesis must be wrong as well? In this respect the cases of the steady state and the multiverse are quite different: whereas the first was eminently falsifiable – and was in fact falsified – the multiverse fares very badly in terms of falsifiability. As has often been pointed out, it explains a lot but predicts almost nothing.

The current discussion concerning the multiverse involves two major questions of obvious relevance to the philosophy of and in science:

(i) Has cosmology become truly and exclusively scientific, in the sense that philosophical considerations no longer play a legitimate role? If so, has it achieved this remarkable status by changing the rules of science?

(ii) Which people or groups have the "right" to define these rules of science and thus to decide whether or not a particularly theory discussed by the scientists is in fact scientific?

It is far from clear whether some of the recent developments, such as multiverse cosmology and aspects of so-called physical eschatology, belong primarily to science or philosophy. The idea of many universes, traditionally a subject of philosophical speculation, is now claimed to have been appropriated by the physical sciences. Is this yet another conquest of the ever-victorious physics, at the expense of philosophy? According to Max Tegmark, this is indeed the case. "The borderline between physics and philosophy has shifted quite dramatically in the last century," he comments. "Parallel universes are now absorbed by that moving boundary. It's included within physics rather than metaphysics."[25] However, sceptics disagree.

One problem with the multiverse hypothesis is that the excessive amount of universes seems to allow almost any physical state of affairs – if not in our universe, then in some other. This, together with the unobservability of the other universes, tends to make the multiverse unacceptable from Popperian-like points of view. According to Popper's philosophy, a scientific theory must be falsifiable and therefore set constraints to the results of possible observations: "Every 'good' scientific theory is a prohibition: it forbids certain things to happen," as he said in a lecture of 1953.[26] At least in some versions, multiverse cosmology suffers from an extreme lack of prohibitiveness.

Some physicists advocating the multiverse and anthropic reasoning have questioned whether there is any need for external norms of science of a philosophical nature, these norms being Popperian or something else. "If scientists need to change the borders of their own field of research," says the French cosmologist Aurélien Barrau, "it would be hard to justify a philosophical prescription preventing them from doing so."[27] Leonard Susskind, the leading advocate of the string-based landscape multiverse theory, agrees with Barrau that normative prescriptions are unnecessary and may even be harmful. He suggests that only the scientists themselves, or perhaps their scientific communities, can decide by means of their practices what is and what is not science: "It would be very foolish to throw away the right answer on the basis that it doesn't conform to some criteria

25 Quoted in C. Seife, *Physics Enters the Twilight Zone,* "Science" 2004, no. 305, p. 465.

26 K.R. Popper, *Conjectures and Refutations*, Routledge, New York 1963, p. 48.

27 A. Barrau, *Physics in the Universe,* "Cern Courier" 2007 (20 November, online edition).

for what is or isn't science."[28] Susskind is particularly dissatisfied with the falsification criterion and what he calls the "overzealous Popperism" advocated by the "Popperazi" following Popper's philosophy. "Throughout my long experience as a scientist," he says, "I have heard unfalsifiability hurled at so many important ideas that I am inclined to think that no idea can have great merit unless it has drawn this criticism. ... Good scientific methodology is not an abstract set of rules dictated by philosophers."[29]

It needs to be pointed out that the Barrau-Susskind argument is deeply problematic and hardly tenable. Not only is it circular reasoning to define science as what scientists do, it also presupposes that all scientists have roughly the same ideas of what constitutes science, which is definitely not the case. Not even within such a relatively small field as theoretical cosmology is there any consensus. Subjects that scientists find interesting and discuss at conferences or write articles about in peer-reviewed journals do not automatically belong to the realm of science. Moreover, it makes no sense to speak of a "right answer" without appealing, explicitly or implicitly, to some criteria of science. To conclude that a theory is either valid or invalid necessarily involves certain standards of scientific validity. These standards need not be part of a rigid philosophical system ("dictated by philosophers"), nor do they have to be explicitly formulated, but it is hard to see how they can be avoided. Nature herself does not provide us with the criteria for when an answer is right.

5. Karl Popper and modern cosmology

As already indicated, Popper's philosophy of science has played, and continues to play, an important role in methodo-

28 Quoted in G. Brumfiel, *Outrageous Fortune*, "Nature" 2006, no. 358, p. 363.

29 L. Susskind, *The Cosmic Landscape*, *op. cit.*, pp. 193-195; see also H. Kragh, *Higher Speculations, op. cit.*, pp. 280-285.

logical debates concerning cosmology. According to a study by Benjamin Sovacool, astronomers and cosmologists often invoke Popper's ideas as a guide for constructing and evaluating theories, although they rarely reveal a deeper familiarity with these ideas.[30] The first time Popperianism entered the scene of cosmology was in the 1950s, in connection with the steady state theory and Bondi's explicit use of standards based on Popper's philosophy of science. In a discussion of modern cosmology from 1960, he summarized Popper's view as follows: "The purpose of a theory is to make forecasts that can be checked against observation and experiment. A scientific theory is one that it is in principle possible to disprove by empirical means. It is this supremacy of empirical disproof that distinguishes science from other human activities. ... A scientific theory, to be useful, must be testable and vulnerable."[31]

The leading theoretical physicist and cosmologist Lee Smolin is no less a "Popperazo" than Bondi was. As Bondi used Popper's philosophy to criticize the big bang theory, so Smolin uses it to dismiss most versions of multiverse cosmology. "According to Popper," he says, "a theory is falsifiable if one can derive from it unambiguous predictions for practical experiments, such that – were contrary results seen – at least one premise of the theory would have been proven not true. ... Confirmation of a prediction of a theory does not show that the theory is true, but falsification of a prediction can show it is false."[32]

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30 B. Sovacool, *Falsification and Demarcation in Astronomy and Cosmology*, "Bulletin of Science, Technology & Society" 2005, no. 25, pp. 53-62.

31 H. Bondi, *The Steady-State Theory of the Universe*, [in:] *Rival Theories of Cosmology*, eds. H. Bondi *et al.*, Oxford University Press, London 1960, pp. 12-21, on p. 12.

32 L. Smolin, *Scientific Alternatives to the Anthropic Principle,* [in:] *Universe or Multiverse?*, ed. B. Carr, Cambridge University Press, Cambridge 2007, pp. 323-366, on pp. 323-324. Emphasis added. For Smolin as a self-declared

In regard of the considerable impact of Popper's thoughts, it is remarkable that physical cosmology is hardly mentioned at all in his main works. Yet a closer look reveals that cosmology does turn up in his books and papers, most explicitly in a lecture given in 1982 in Alpbach, Austria. Calling cosmology "the most philosophically important of all the sciences," at this occasion he praised the by then defunct Bondi-Gold-Hoyle theory as "a very fine and promising theory," not because it was true but because it was testable and had in fact been falsified. As a result of measurements based on methods of radio astronomy, "it seems to have been refuted in favour of the (older) big bang theory of expansion."[33] Popper did not mention the cosmic microwave background radiation or other evidence (such as the measured amount of helium in the universe) that had laid the steady state theory in the grave.

Although references to Popper's philosophy of science often appear in modern cosmology, it is probably fair to say that few of the physicists and astronomers have actually read him. Most seem to rely on what they have been told or happen to know from the secondary literature. This results in discussions that are sometimes simplistic and based on misunderstandings. What cosmologists (and other scientists) discuss is most often naïve falsificationism rather than the sophisticated versions of authentic Popperianism.[34] Popper's views, including his awareness that falsifiability cannot stand alone as a demarcation criterion, were far from the caricatures one can sometimes meet in the science literature. It should be recalled that his philosophy

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"Popperazo," see L. Smolin, *The Trouble with Physics*, Penguin Books, London 2008, p. 369.

33 K.R. Popper, *In Search of a Better World: Lectures and Essays from Thirty Years*, Routledge, London 1994, pp. 58-60.

34 As pointed out in M. Heller, *Ultimate Explanations of the Universe*, Springer-Verlag, Berlin 2009, pp. 88-89.

was normative and that he did not claim that the associated standards reflected the actual practice of scientists. Moreover, he never held that falsifiability is a sufficient condition for a theory being scientific, but only that it is a necessary condition. Although somewhat ambiguous with regard to the relationship between his methodological rules and scientific practice, he admitted that strict falsifiability does not belong to the real world of science:

> In point of fact, no conclusive disproof of a theory can ever be produced; for it is always possible to say that the experimental results are not reliable, or that the discrepancies which are asserted to exist between the experimental results and the theory are only apparent and that they will disappear with the advance of our understanding. ... If you insist on strict proof (or strict disproof) in the empirical sciences, you will never benefit from experience, and never learn from it how wrong you are.[35]

Contrary to what many scientists believe, Popper did not assign any absolute value to the criterion of falsifiability and did not consider it a *definition* of science. He recognized that the distinction between metaphysics and science is often blurred. "What was a metaphysical idea yesterday can become a testable theory tomorrow," he wrote.[36] Far from elevating falsificationism to an inviolable principle, he suggested that it is itself fallible and that

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35 K.R. Popper, *The Logic of Scientific Discovery*, Basic Books, New York 1959, p. 50. In a note appended to the English edition, Popper remarked that "I have been constantly misinterpreted as upholding a criterion (and moreover one of *meaning* rather than of *demarcation*) based upon a doctrine of 'complete' or 'conclusive' falsifiability."

36 K.R. Popper, *Replies to my Critics*, [in:] *The Philosophy of Karl Popper*, ed. P.A. Schilpp, Open Court Publishing House, La Salle, IL 1974, pp. 961-1200, on p. 981.

it may be rational to keep even an admittedly wrong theory alive for some time:

> There is a legitimate place for dogmatism, though a very limited place. He who gives up his theory too easily in the face of apparent refutations will never discover the possibilities inherent in his theory. *There is room in science for debate*: for attack and therefore also for defence. Only if we try to defend them can we learn all the different possibilities inherent in our theories. As always, science is conjecture. You have to conjecture when to stop defending a favourite theory, and when to try a new one.[37]

This is indeed a view far from the strict or naïve falsificationism often discussed by scientists either for or against Popper. It is a view closer to the one associated with philosophers of science such as Imre Lakatos and Thomas Kuhn.

6. The role of historical analogies

Just like scientists use methodological and other philosophical arguments in evaluating the value of a fundamental scientific theory, sometimes they use (or misuse) arguments relating to the history of science. The typical way of doing this is by supporting an argument of a philosophical kind by means of concrete historical cases in the form of exemplars. That is, history is used analogically. The standard formula is this: Since, in a certain historical case, the epistemic value *x* proved successful, a modern theory should preferably incorporate *x*; or, conversely, if values of the kind *y* have proved a blind alley in the past, they should be avoided in a modern theory. The values or prescriptions *x* and *y* will usually be those associated with either well known successes or failures in the history of science. Often it is enough to associate them with the great authorities of the past.

37 K.R. Popper, *Replies to my Critics*, *op.cit.*, p. 984. Popper's emphasis.

Historical analogy arguments of this kind are quite common in controversies and in discussions of theories of a foundational nature. Einstein often relied on historical exemplars when he wanted to illustrate and give support to his favourite deductivist methodology of science, such as he did in the semi-popular book *The Evolution of Physics*.[38] During the cosmological controversy in the 1950s, some physicists and astronomers used Galileo's supposed empiricism as a weapon against what they considered rationalistic and a priori tendencies in the steady state theory. McVittie associated this theory with Aristotle's dogmatic world system (!) and the empirical cosmology based on general relativity with Galileo's physics. Dingle similarly claimed that the perfect cosmological principle has "precisely the same nature as perfectly circular orbits and immutable heavens" and that "it is largely identical with the Aristotelian principle of celestial regions."[39] It was and still is common to refer to the epicycles of ancient astronomy when scientists want to criticize a theory for being complicated and ad hoc.

In other cases the references to history are not to concrete events or persons, but of the "history suggests" type where the record of some general idea in past science is used to evaluate the methodological basis of a modern theory. For example, string theory notoriously lacks connection to experiment and is, according to some critics, largely justified by the dubious idea that fundamental physics must be mathematically beautiful. One of the critics, Daniel Friedan, says: "History suggests that it is unwise to extrapolate to fundamental principles of nature from the mathematical forms used by theoretical physics in any

38 For an analysis of Einstein's attitude to and use of the history of science, see H. Kragh, *Einstein on the History and Nature of Science*, [in:] *The Way through Science and Philosophy*, eds. H.B. Andersen *et al.*, College Publications, London 2006, pp. 99-118.

39 H. Dingle, *Cosmology and Science, op. cit.*, p. 137.

particular epoch of its history, no matter how impressive their success. ... Mathematical beauty in physics cannot be appreciated until after it has proved useful."[40]

Again, although the anthropic principle does not lead to precise predictions, it may be justified by referring to historical cases in which a theory has been highly successful in spite of its limited predictivity. The prime example of such a theory is Darwinian evolution, which is sometimes referred to in the debate over the standards to be used in fundamental physics and cosmology. "One is reminded of Darwin's theory, which is a powerful explanatory tool even though some question its predictive power," says Craig Hogan. "Anthropic arguments are vulnerable in the same way to 'Just So' storytelling but may nevertheless form an important part of cosmological theory."[41]

One historical case that occurs surprisingly often in the universe-or-multiverse discussion is Kepler's geometrical model of the heliocentric universe as expounded in his *Mysterium Cosmographicum* from 1596. When multiverse proponents refer to Kepler's model, it is invariably as a negative exemplar, to illustrate that the universe is probably not uniquely described by the mathematical solutions to the equations of physics. According to Steven Weinberg, "We may just have to resign ourselves to a retreat, just as Newton had to give up Kepler's hope of a calculation of the relative sizes of planetary orbits from first principles."[42] Frank Wilczek uses the same case to argue for the same conclusion: "In the development of Copernican-Newtonian celestial mechanics, attractive a priori ideas about the perfect shape of

40 D. Friedan, *A Tentative Theory of Large Distance Physics*, "Journal of High Energy Physics" 2003, no. 10, p. 063.

41 C.J. Hogan, *Why the Universe Is Just So*, "Reviews of Modern Physics" 2000, no. 72, pp. 1149-1161, on p. 1160.

42 S. Weinberg, *Living in the Multiverse*, [in:] *Universe or Multiverse*, *op. cit.*, pp. 29-42, on p. 39.

planetary orbits (Ptolemy) and their origin in pure geometry (Kepler) had to be sacrificed."[43] On the other hand, Kepler may also be used as a positive exemplar (and Galileo as a negative exemplar), as Martin Rees does in his argument for the multiverse: "Kepler discovered that planets moved in ellipses, not circles. Galileo was upset by this. ... The parallel is obvious. ... A bias in favour of 'simple' cosmologies may be as short-sighted as was Galileo's infatuation with circles."[44]

My last example of the questionable use of history of science comes from Carr, who suggests that critics of the multiverse are on the wrong side of history. Throughout the history of cosmology, the universe has always been conceived as bigger and bigger, he claims, so why be satisfied with a single universe instead of a whole lot of them? Carr's argument may have some rhetorical force, but it is poor from both the perspective of history and from a logical point of view. At any rate, here it is:

> Throughout the history of science, the universe has always gotten bigger. We've gone from geocentric to galactocentric. Then in the 1920s there was this huge shift when we realized that our galaxy wasn't the universe. I just see this as one more step in the progression. Every time this expansion has occurred, the more conservative scientists have said, 'This isn't science.' This is the same process repeating itself.[45]

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43 F. Wilczek, *Enlightenment, Knowledge, Ignorance, Temptation*, [in:] B. Carr, *Universe or Multiverse*, *op. cit.*, pp. 43-53, on p. 50.

44 M. Rees, *Explaining the Universe*, [in:] J. Cornwell, *Explanation*, *op. cit.*, pp. 39-66, on p. 63.

45 Quoted in T. Folger, *Science's Alternative to an Intelligent Creator: The Multiverse Theory*, "Discover Magazine" 2008 (online version). In fact, the universe has not "always gotten bigger." Kepler's universe was much smaller than Copernicus's, and Kant's universe of the 1750s was much bigger than the Milky Way universe a century later.

This is not the place for discussing the role of history of science in scientific or philosophical arguments, but it needs to be pointed out that in general one should be very cautious with reasoning based on historical analogies and extrapolations from historical trends. Historical arguments and analogies have a legitimate function in the evaluation of current science.[46] We cannot avoid being guided by the past, and it would be silly to disregard the historical record when thinking about the present and the future. On the other hand, such guidance should be based on historical insight and not, as is often the case, on arbitrary selections from a folk version of history. Generally speaking, the history of science is so diverse and complex that it is very difficult to draw from it lessons of operational value for modern science. In 1956, in connection with the controversy over the steady state theory, Gold reflected on the lessons of history of science with regard to the methodology of cosmology and other sciences. He considered history to be an unreliable guide:

> Analogies drawn from the history of science are frequently claimed to be a guide [to progress] in science; but, as with forecasting the next game of roulette, the existence of the best analogy to the present is no guide whatever to the future. The most valuable lesson to be learned from the history of scientific progress is how misleading and strangling such analogies have been, and how success has come to those who ignored them.[47]

Of course, scientists should not ignore history. They can and should use the rich treasure of resources hidden in the history

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46 L. Darden, *Viewing the History of Science as Compiled Hindsight*, "AI Magazine" 1987, no. 8(2), pp. 33-41; H. Kragh, *An Introduction to the Historiography of Science*, Cambridge University Press, Cambridge 1987, pp. 150-158.

47 T. Gold, *Cosmology*, "Vistas in Astronomy" 1956, no. 2, pp. 1721-1726, on p. 1722.

of science, but they must do it with proper caution and professional insight.

Some Remarks on Plato's Aporia of Memory and Imagination

Jacek Dębiec

1. The Beginnings

Memory has intrigued philosophers since Antiquity. For Plato, it was through *anamnesis* (or recollection), an exploration of one's own memory that an individual was able to gain insight into important truths. For this reason, Plato's epistemology was inherently linked to his concept of memory. Had memory been unreliable, truth would remain inaccessible or distorted. In his dialogue *Theatetus* which explores the nature of knowledge, Plato introduces the problem of remembering in the metaphor of the block of wax:

> Imagine [...] that our minds contain a block of wax [...]. Let us call it the gift of the Muses' mother, Memory, and say that whenever we wish to remember something we see or hear or conceive in our own minds, we hold this wax under the perceptions or ideas and imprint them on it as we might stamp the impression of a seal ring. Whatever is so imprinted we remember and know so long as the image remains; whatever is rubbed out or has not succeeded in leaving an impression we have forgotten and do not know.[1]

According to Plato, the presumed substrate of memory, some undefined capacity or the mind or soul, passively receives impressions. Characteristics of this substrate account for individual differences in learning and remembering — depending

1 Plato, *Theatetus,* 191c-e, [in:] *idem, The Collected Dialogues,* eds. E. Hamilton, H. Cairns, Princeton University Press, Princeton, NJ 2002.

whether a slab of wax is larger or smaller, pure or muddy, harder or softer, memory imprints are made quicker or slower, and last longer or shorter, respectively.[2] Memories conceived as impressions or imprints are unchangeable and persist until their substrate is affected. In other words, the only change that may happen to the original memory is its fading or decay.

The concept of memory as an impression sealed by past experiences was further developed by Aristotle. In his short treatise *On Memory,* the philosopher from Stagira reemphasizes Plato's views, stating that 'the object of memory is the past'.[3] In addition, Aristotle discusses the relations between affections (passions) and remembering, and observes that very intense affections may impair memory formation:

> [...] in those who are strongly moved owing to passion [...] no memory is formed; just as no impression would be formed if the movement of the seal were to impinge on running water [....].[4]

The metaphor of an imprinted block of wax inspired, influenced and at times troubled Western thinkers for centuries. As Paul Ricouer remarks in his *Memory, History, Forgetting*:

> This hypothesis — or better, admission — of the imprint has, over the course of the history of ideas produced a procession of difficulties that have continued to overwhelm not only the theory of memory, but also the theory of history, under another name — the trace.[5]

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2 Cf. ibidem, 194e-195.

3 Aristotle, *On Memory,* 25 [in:] *idem, The Complete Works,* ed. J. Barnes, Princeton University Press, Princeton, NJ 1995.

4 Ibidem, 450b, 1-5.

5 P. Ricoeur, *Memory, History, Forgetting,* tr. K. Blamey, D. Pellauer, Chicago University Press, Chicago, Il 2006, p. 13.

However, Ricoeur notes that Plato's concept of memory as a source of knowledge should be considered in relation to his concept of imagination. Indeed, while seeking an answer to the question of how false opinions were possible, Plato discusses the role of imagination in remembering. In *Philebus,* he further develops his theory of remembering and replaces the metaphor of the block of wax with the one of the book:

> It seems to me that [...] our soul is like a book [...]. It appears to me that the conjunction of memory with sensations, together with the feelings consequent upon memory and sensation, may said as it were to write words in our souls. And when this experience writes what is true, the result is that true opinion and true assertions spring up in us, while when the internal scribe that I have suggested writes what is false we get the opposite sort of opinions and assertions.[6]

The very nature of memory formation mechanisms enables the creation of false or distorted memories. According to Plato, any errors or distortions in our remembered knowledge occur during initial encoding or acquisition. Depending on their relation to the original experience, memories are characterized either by likeness to it (*eikastike*) or by a mere semblance (*phantasma*).[7] Therefore, memory content or image may be formed either through 'the making of likeness' or 'the making of semblance'.[8] Although, Plato proposes the existence of two independent memory or image-making mechanisms to explain the possibility of false judgments, he does not further develop his views. For our consideration, it is important to note that Plato did not exclude the possibility of a modification or a change of the original impression before it was finally imprinted. The forma-

6 Plato, *Philebus,* 38e-39, [in:] *idem, The Collected Dialogues, op. cit.*

7 *Idem, Sophist,* 235d-236b, [in:] *idem, The Collected Dialogues, op. cit.*

8 *Ibidem,* 236c.

tion of memories is not an entirely passive process. Imagination contributes to the way we remember and recall things.

The tension between preservative and creative aspects of memories recognized in Antiquity and first conceptualized in writing by Plato determined the theoretical framework within which memories were explored and studied. According to Ricouer, the Ancient Greek *aporia* of memory and imagination delineated "two rival *topoi* [...] from which we can never completely extricate ourselves".[9]

2. To Preserve and to Reconstruct

Ideas about the preservative and the creative aspects of memory have emerged under different labels throughout the history of Western civilization. An emphasis on either the preservative or the creative characteristic depended on the context and the particular subject of investigation. One of the best examples of the presence of Plato's *aporia* in twentieth century psychology can be found in the works of Sigmund Freud and Frederic Bartlett. The views of Freud are often contrasted with or even opposed to the ideas of Bartlett.[10] Whereas the former is regarded as the proponent of the reproductive theory of memory (recollections are reproductions of original experiences), the latter is known for his reconstructive theory of memory. According to Freud, who studied the impact of early childhood traumas on the later psychological and social functioning of his patients, memories constituted unchangeable traces. In *The Interpretation of Dreams,* commenting on his clinical observations and the works

9 P. Ricoeur, *op.cit.,* p. 7.

10 Cf. J. Ost, A. Costall, *Misremembering Bartlett: A Study in Serial Reproduction,* "British Journal of Psychology" 2002, no. 93, pp. 243-255.

of his predecessors, especially the Belgian philosopher Joseph Delboeuf, Freud notices:

> The way in which the memory behaves in dreams is undoubtedly of the greatest importance for any theory of memory in general. It teaches us that 'nothing which we have once mentally possessed can be entirely lost' (Scholz); or as Delboeuf puts it 'every impression, even the most insignificant, leaves an unalterable trace indefinitely capable of coming out into the open'.[11]

At the opposite pole, Frederick Bartlett, who investigated the social processes of remembering by telling his subjects self-created stories and then testing their recollections of these stories, formulated his reconstructive theory of memory. For Bartlett:

> Remembering is not the re-excitation of innumerable fixed, lifeless and fragmentary traces. It is an imaginative reconstruction, or con struction, built out of the relation of our attitude towards a whole active mass of organized past reactions or experiences and to a little outstanding detail which commonly appears in image or language form. It is thus hardly ever really exact...[12]

The reproductive and reconstructive theories demonstrate that observable phenomena provide support for opposing views. Memories appear to be both persistent, unalterable traces of the original experience, as well as imaginative reconstructions of the learning event influenced by the context of their recall. The tension between the preservative and the creative seems to be inherent in the very nature of memory. There must be some-

11 S. Freud, *The Interpretation of Dreams,* tr. R. Robertson, Oxford University Press, Oxford 2008.

12 F.C. Bartlett, *Remembering: A Study in Experimental and Social Psychology,* Cambridge University Press, Cambridge 1932, p. 213.

thing inherent in memory formation mechanisms that allows this preservation, as well as creation.

3. Memories are in the Brain

Systematic experimental research of memory and remembering started at the end of the 19th century. One of its pioneers, the German psychologist Hermann Ebbinghaus, studied learning and forgetting. Ebbinghaus observed that forgetting of newly learned information occurs in an exponential manner. In other words, the longer the newly acquired memories are retained the more resistant they are to the detrimental influence of the passage of time. Ebbinghaus' observation inspired further research and lead to the formulation of the memory consolidation theory. Memory consolidation theory echoes Plato's ideas of memory as an impression or imprint. It posits that newly learned information is initially labile and susceptible to inferences and that through presumed consolidation processes it becomes stabilized into persistent memory trace. Identification of molecular pathways leading to the formation of long term memories in neural circuits allowed formulation of a cellular version of the consolidation theory which explains learning processes in terms of underlying changes to the synapses between neurons. Memories, as understood within the framework of consolidation theory, become resistant to disruption once consolidated and may persist all through the life of an individual. As James McGaugh wrote in his review article *Memory — a Century of Consolidation:*

> At the beginning of this new millennium, the consolidation hypothesis still guides research investigating the time-dependent

involvement of neural systems and cellular processes enabling lasting memory.[13]

Despite the apparent success of consolidation theory, some experimental studies in the late 1960s and early 1970s suggested otherwise, reporting that well consolidated memories when recalled become susceptible to alterations.[14] Further research provided compelling evidence for the lability of activated memories.[15] These findings lead to the formulation of the memory reconsolidation theory. Memory reconsolidation theory proposes that biological substrates of memories re-activated by retrieval or recall become labile and need to be restored or re-consolidated. At the cellular level, reconsolidation processes resemble memory consolidation and involve many molecular pathways subserving the initial encoding of newly acquired information. Reconsolidation is believed to allow the modification of existing memories in the context of new experience. Existing memories may be updated, weakened or strengthened. For example, stress mediators such as norepinephrine enhance encoding, as well as the reconsolidation of memories making them last throughout the life of an individual. However, if stress levels are too high, the same neuromodulator (norepinephrine) may prevent learning and memory formation. Although, on a phenomenal level memories may appear either as unalterable traces or as imaginative reconstructions, their underlying biological substrate and mechanism are the same.

13 J.L. McGaugh, *Memory – a Century of Consolidation*, "Science" 2000, vol. 287, pp. 248-251.

14 Cf. D.J. Lewis, *Psychobiology of Active and Inactive Memory,* "Psychobiological Bulletin" 1979, no. 86, pp. 1054-1083.

15 Cf. Y. Dudai, *Reconsolidation: The Advantage of Being Refocused*, "Current Opinions in Neurobiology" 2006, no. 16, pp. 174-178; K. Nader, E.O. Einarsson, *Memory Reconsolidation: An Update,* "Annals of the New York Academy of Sciences" 2010, no. 1191, pp. 27-41.

The metaphor of the block of wax implies that the presupposed function of memory is to maintain impressions or imprints of the past. Indeed, as Aristotle puts it: 'memory relates to what is past'.[16] However, the investigation of memories as a biological phenomenon refocuses the discussion. In their very origin, memories evolved as tools increasing chances of survival. In fact, a considerable amount of research provides evidence that fear and stress are a major facilitator of memory processes. [17]Cristina Alberini goes even one step further and points at the involvement of stress molecules in learning processes, and suggests that long-term memory stems from cellular changes that are a survival response to stress.[18] Even if the formation of a new memory is initiated by an original learning experience, the same memory is subject to alterations allowing better adaptation to the future. Putting memories in their evolutionary context sheds light on their paradoxes. Interestingly, Plato recognized that anamnesis, recalling the truths encoded in memories, was central in transforming the life of an individual. However, in general, Plato's views on memories were still unidirectional and relied on an image of passive imprints of the past. The aporia of preservative and creative aspects of memory shows that Plato himself saw the cracks in this image. Memory is of the past and for the present, and the future.

16 Aristotle, *On Memory,* 10 [in:] *idem, The Complete Works, op.cit.*

17 Cf. J. Dębiec, J.E. LeDoux, *Fear and the Brain*, "Social Research" 2004, no. 7, pp. 807-818; C. Sandi, *Effects of Chronic Stress on Memory and Neuroplasticity: Animal Studies,* [in:] *The Handbook of Stress. Neuropsychological Effects on the Brain,* ed. C.D. Conrad, Wiley, Blackwell, MA 2011

18 Views presented by the author during her public talk on July 7th, 2011 at the New York University Langone Medical Center.

Normativity of Meaning from the Usage-Based Perspective

Aeddan Shaw

Introduction

It almost seems a truism to state that there are many faces to normativity and that each has a rich and chequered history. The debate over the normativity of meaning is one such aspect and can ultimately be traced back to Plato and Aristotle, with Plato's theory of forms countered by Aristotle's view of the social aspect of language. Whereas Plato saw language as something innate, Aristotle held that 'every sentence has meaning, not as being the natural means by which a physical faculty is realized, but, as we have said, by convention.'[1] For well over 2000 years, the debate has swung back and forth between the two poles of nativism and socially constructed meaning (to give them their somewhat more up to date labels), with the last 50 years belonging firmly to the nativist camp as championed by Noam Chomsky. Recent findings in linguistics, anthropology, neuroscience and philosophy, however, suggest that much of the nativist position rests on false premises and that it is time to once again rethink our view of language and its accompanying philosophy.

This article will examine the following hypotheses concerning the debate over the normativity of meaning. The first hypothesis is that current paradigms for understanding the normativity of meaning have been undermined because the

1 Aristotle, *On Interpretation*, section 1, part 4 (taken from the MIT online edition.)

linguistic model upon which they are based (generally a version of the nativist view expounded by Chomsky) increasingly seems to be incomplete. Recent findings from linguists such as Tomasello and Everett challenge the nativist view that language is innate and, this paper will argue, have important consequences for the philosophical debate concerning the normativity of meaning. This is of particular importance as the myriad contemporary debates concerning meaning, normativity and content still utilise an outdated, formal view of language which has lost much of its rationale. Research from Tomasello[2] and others[3] confirms these hypotheses and is, arguably, preceded by Wittgenstein's late linguistic philosophy and his intuition that meaning is use.

The second hypothesis is that language is ultimately normative but this normativity is culturally and linguistically bound. Traditionally, the normativity of language has been ascribed to either an extrinsic or intrinsic source or it was even held that it is non-normative. The picture that emerges from a usage based conception of meaning, however, indicates that, depending on the perspective one adopts, one can see language from any of these three positions. This is something which I would tentatively term the aspect theory of the normativity of language. The contemporary problem with the normativity debate is that, since all languages are subject to a 'universal grammar', they are therefore subject to one of these three positions only, the result depending on what one regards as the main elements of a formally understood language. However, once one embraces the usage-based theory and rejects inborn grammar and fixed meanings, one can easily see that the three

2 see M. Tomasello, *Constructing a language: A usage-based theory of language acquisition*, Harvard University Press, Cambridge 2003.

3 see D. Everett, L*anguage. The Cultural Tool*, Profile Books, London 2012.

views are just different perspectives of the same phenomenon, one that escapes an easy conceptualization.

By way of a methodological coda, normative is understood here as providing a reason for a particular action. Therefore, language is understood to be normative in the sense that it does more than simply provide a description of human actions: it drives and determines them. To quote Lance and Hawthorne, when we assert a claim about meaning 'one is simply asserting that a word or sentence should be used in a certain way'.

There are currently three main positions in the normativity of meaning debate which will be explored in turn before the paper turn [two turns – one too many] to an examination of what the usage based approach can afford us.

Position One: Language is non-normative.

The non-normative view, simply put, is that there is no normativity in language. As advocated by Hattiangadi, it is rightly rejected by Brożek[4] on the grounds that it conflates personal and impersonal obligations and, furthermore, on the basis of practical realizability. In the case of the latter, Hattiangadi believes that it is 'impossible for a person *x* to follow the rule "person *x* should apply 'rich' only to rich persons" under all circumstances', an idea which, on the contrary, seems eminently achievable.

A linguistic system functions, at least partially, on the basis of shared conceptions of meaning and value. If someone were to use a word in a manner for which it is not intended then, logically, one uses it with a different meaning. One could, for example, envisage a situation in which person x describes a man begging for money on the street as 'rich' but then the

4 Cf. B. Brożek, *The Normativity of Meaning*, [in:] *The Many Faces of Normativity*, eds. J. Stelmach, B. Brożek, Copernicus Center Press, Kraków 2012 (forthcoming).

meaning of either the term 'rich' or the utterance as a whole is radically different – for example, ironic ('oh yes, he is really rich') or perhaps spiritual ('he is poor in material terms but rich in spirit'). Either way, it is clear that we are considering a very different meaning and Hattiangadi seems to conflate connotational meaning with the denotational. As if this were not enough, Hattiangadi also seems to understand normative as making a given course of action somehow akin to a compulsion, that the speaker is forced to use a term in a given way. We can, of course, use words incorrectly but then there will be normative consequences – we have used it incorrectly and thus one can expect some kind of 'linguistic punishment'. As Brożek puts it:

> I may not follow a legal rule because of some other considerations or even a desire, but this does not change the fact that by not following it I break it. Similarly, when I apply a word incorrectly (because I have a desire or even a reason to do so), I break a meaning rule. An example of a meaning rule is "A person *x* should apply 'rich' only to rich persons", and not "If a person *x* has a reason to do so, or merely wishes so, *x* should apply 'rich' only to rich persons.[5]

Thus the argument from non-normativity seems to be unconvincing. Words can be used with multiple meanings but they can also be used correctly and incorrectly. To utilise the analogy of language as a cultural tool, Hattiangadi seems to suggest that there is no need to use a whisk (the word) to beat eggs (the 'meaning') when one is making a cake (the normative consequences). Of course, I could choose to use the whisk for a number of tasks: as a doorstop, for example, or to stir my soup. I may even do this with some success but the fact remains that to use the whisk correctly, I should be using it to beat those eggs.

5 *Ibidem*.

However, there is a lingering sense that, perhaps, meaning could be non-normative and the key is to be found in the interplay between meaning and use. Let us consider, for example, unique, culturally bounds terms such as *koshatnik*, which designated 'a dealer in stolen cats' during the Soviet era. This would seem to support the *meaning engendered normativity* view: first you have a norm and then you have meaning and thus the meaning is extrinsic. Whilst interesting, this example offers more than just a unique custom and the meaning of a lexical item from a given cultural environment: it also says something about the concept of normativity within that culture too. The term *koshatnik* originally referred to someone who loved cats very much – a cat-lover if you will. At some point the term was used to describe someone who dealt in stolen cats – perhaps an ironic use of the same term – but in a manner which undermines the x = y relationship which one would expect from a normative relationship. Indeed, this non-normative relationship seems typical of Soviet and post-Soviet countries. Polish has an untranslatable term, *kombinowanie*, where the attitude to normativity is partially shaped by the language. This Polish term embraces a number of meanings with no clear equivalents in English. A rough paraphrase of the term could be 'to arrange things so that they are as beneficial as possible, disregarding the legality of the actions and generally viewed in a positive and sometimes negative manner'. The use of this term and its relative popularity has resulted in a much more flexible attitude towards rule following than in, for example, Germany – here we have a word and its meaning having a normative impact at a societal level. The word came to life in the post war period in Poland, where resources were scarce and a great deal of imagination was required in order to secure the necessary goods for survival and to avoid the constraints of the authorities. Closely related to Zinoviev's idea of the *homo sovieticus,* the term embodies the experiences of a former Eastern bloc country and has led to deeper consequences – regarding the law as something to be subverted and overcome. Totalitarian regimes have a considerable impact on language, meaning and their ties, whether real or imagined, from the euphemistic 'ethnic cleansing' of the former Yugoslavia of 20 years ago to the Doublespeak of Orwell.

This is a situation example which readers of *Through the Looking Glass* will be familiar with:

> "I don't know what you mean by 'glory,'" Alice said. Humpty Dumpty smiled contemptuously.
> "Of course you don't—till I tell you. I meant 'there's a nice knock-down argument for you!'"
> "But 'glory' doesn't mean 'a nice knock-down argument'," Alice objected.
> "When I use a word," Humpty Dumpty said, in rather a scornful tone, "it means just what I choose it to mean—neither more nor less."

What Humpty Dumpty suggests is a kind of tyranny of use – there is no fixed meaning, only use alone triumphs and, to a certain extent, this is correct since without novel uses of a term, we can have no new meanings. Thus, from a given perspective, it would seem that meaning could be non-normative. Let us now turn to the extrinsic position.

Position Two: The normativity of meaning is extrinsic.

The extrinsically normative view posits that meaning acquires its normative element from an external source (such as morality or prudence). As advocated by Boghossian[6], language

6 Cf. P. Boghossian, *Is Meaning Normative?*, [in:] *Philosophy-Science-Scientific Philosophy*, eds. Ch. Nimtz, A. Beckermann, Mentis, Paderborn

cannot supply this normativity as it is only hypothetical as opposed to, for example, moral rules which might be considered categorical. Brożek terms this 'locally conventional' and this means that 'one is free to follow or not follow any particular meaning rule'[7] whereas, for Boghossian, this is not the case with legal or ethical precepts. Upon examination, this does not bear closer scrutiny: whereas one can surely choose to follow the conventions of a language or not i.e. one can choose to play the game of a given language or not, if one wishes to be understood then one must abide by the rules. By analogy, if we play by the rules of society then we do not need to be punished by the law.

There is undoubtedly an extrinsic factor at play in the normativity of meaning – Wittgenstein's intuition, that meaning is use, would initially seem to suggest an external source for linguistic normativity, that of linguistic conventions within a speech community. This is a view supported by others, including Jacob:

> Meaning consists in a pattern of agreement between members of a community. This is what it takes to be part of a linguistic community: an individual belongs to a community if his or her uses of words coincide with the uses of others.[8]

Jacob augments this, after Dretske, in highlighting how the normative consequences of certain words are pre-packaged:

> On many occasions, if x and y are human and if x kills y, then some normative consequences follow. If x killed y intentionally and with no mitigating circumstances, then x ought to be sanctioned. Notice the contrast between the relations expressed

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2004, pp. 205-218.

7 Cf. B. Brożek, *The Normativity of Meaning*, *op. cit*.

8 P. Jacob, *Is Meaning Intrinsically Normative?*, [in:] *Argument & Analyse*, eds. C.U. Moulines, K.G. Niebergall, Mentis, Paderborn 2002, p. 189.

> respectively by the verb 'kill' and by the verb 'murder'. Whatever the circumstances, if x murdered y, then x ought to be sanctioned. Legal and moral norms are built into the very existence of murders. Legal and moral norms are constitutive of murders.[9]

What could be the source of such normativity? The language of Easter Island, Pascuense, has an evocative term which is '*tingo*' – to borrow things from your neighbour one by one until he has nothing left. At some point in the island's past, presumably someone did this very thing and another enterprising islander coined the term: here we have an apparent extrinsic source (a cultural more or norm) supplying a linguistic term and a meaning which is unique to the language and culture. As Everett notes, 'Languages are structured by cultures and the limitations of human cognition and the pressures of finding solutions to the communication problems common to all humans'[10]. This intuition, however, is one which the nativist position struggles to deal with: if all languages possess a universal grammar, then languages cannot have such a relationship.

Yet we should be careful not to ascribe external factors, such as culture, too dominant a role since, at least in some cases, language would also seem to have a normative element. Let us now turn to the view from the intrinsic camp.

Position Three: The normativity of meaning is intrinsic.

The notion that meaning is intrinsic and derived from grammar owes much to Russell and 20th century linguistic philosophy. Russell himself said that 'the study of grammar, in my opinion, is capable of throwing far more light on philosoph-

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9 *Ibidem*, pp. 190-191.

10 D. Everett, *Language. The Cultural Tool*, *op. cit*., p. 47.

ical questions than is commonly supposed by philosophers'[11] and, arguably, the same could be said of the implications of the study of grammar on normativity. As advocated by Whiting, meaning is given by language itself, through its grammatical rules. This has traditionally been regarded as constituting a part of a Universal Grammar, a logical underpinning of all natural languages. If we consider Hattiangadi's example of the word 'rich' then, as Whiting puts it:

> I ought to apply the term to a person only if she is rich does not seem contingent upon (say) my desire to speak truthfully. If that desire changes, and I apply the term to a poor person, it remains the case that I am not applying it as it should be applied, but rather incorrectly.[12]

This much seems clear – certain words have more 'weight' than others – and connotation cannot be overlooked in any considerations of meaning. This is supported by Lance and Hawthorne and their assertion that the very speech act of making a meaning claim is itself normative, that saying what something means is *prescribing*'[13]. Yet the intrinsic argument, whilst sound, rests on a shaky foundation and a static conception of language which is outdated. Tomasello convincingly illustrates how our grammatical systems are the products of the process of *grammaticalization* and thus of a kind of *post hoc* construction of a normative grammatical system. He offers a useful example in the form of *gonna* which has emerged from the verb *going to* in English:

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11 B. Russell, *Principles of Mathematics*, Routledge Classics, London 2009, p.42.

12 D. Whiting, *The Normativity of Meaning Defended*, "Analysis" 2007, vol. 67, no. 2, 2007, p. 135.

13 M. Lance, J. Hawthorne, T*he Grammar of Meaning. Normative and Semantic Discourse*, Cambridge University Press, Cambridge 1997, p. 2.

> The original use of *going* was as a verb for movement, often in combination with the preposition *to* to indicate the destination (*I'm going to the store*), but sometimes also to indicate an intended action that the *going to* enabled (*Why are you going to London? I'm going to see my bride*). This later became *I'm gonna VERB*, with *gonna* indicating not just the intention to do something in the future, but futurity only (with no movement or intention necessary; on this change see Bybee, 2002). Givón's (1979) well-known characterization of this process is: today's morphology is yesterday's syntax.[14]

This can (and does) supply reasons for action (if everyone ignores linguistic rules then they cease to function and if everyone ignores the 'correct' meanings for terms then they lose their power, their motivational force) i.e. if we say rich signifies someone with a lot of money, we are obliged to assign the meaning rich to all people who have the property of being rich. However, if we consider Chomsky's famous example of 'Colorless *green* ideas sleep *furiously*', we can 'unpack' a meaning from this nonsensical sentence not because of generative grammar but because we are used to such patterns. This post hoc linguistic pattern detection does not generate meaning in itself, in the way that use does, but rather seeks to lay a pattern of meaning over the top of a meaningless sentence. For generative grammar to work, I would argue, it should be able to supply meaning, to be truly generative. Thus there is a role which is played by language itself, but it is strongly limited and ultimately determined by the culture in which it is embedded. A culture which has a very literal sense of its language will arguably have a strong intrinsically normative relationship between meaning and use; one in which this connection has withered, will not.

14 M. Tomasello, *Constructing a language...*, *op. cit.*, p. 14.

Where Whiting and the intrinsic camp falter is their inability to explain language change: if the term = meaning relationship is something which is inherent, pre-packaged as it were, then how can meanings change over time? One need only glance at a copy of Shakespeare to see how words have evolved – nice meant variously 'foolish' and 'trivial' to the Bard rather than the meaning that we currently utilise. From another perspective, as Everett puts it, we have the issue of words whose meaning seems to conflict with their initial sense such as the fact that a boxing 'ring' is square. An intrinsic account struggles to explain such terms but, in the words of Everett,

> From the perspective of culture, however, they make perfect sense. All meanings, literal, colloquial, figurative and so on, are produced by culture for its purposes... Each one has a history of gradual adaptation from the original functions of its parts to the new functions of the whole. The idea that they are paradoxes seems to derive from a misunderstanding of Plato's notion that there is a fixed, real, and true meaning of a word. But that is not how it works at all. Word and phrase meanings are based on historical accident and cultural preferences.[15]

Thus all of the existing approaches have some difficulties in explaining both the source of linguistic normativity and, indeed, whether it exists at all. The adoption of a different view of language, however, can be fruitful in addressing all of these issues.

Position Four: The usage-based perspective.

As we have seen, much of the fault of current paradigms lies in the conception of language which underpins them. To recap, this amounts to two main issues: firstly, a static, fixed

15 D. Everett, *Language. The Cultural Tool*, *op. cit.*, p. 130.

conception of meaning and, secondly, the idea that a universal grammar somehow underpins all languages and, therefore, every language has an equivalent grammatical superstructure (i.e. that the modal verb *might* in English has a direct equivalent in other languages). Put simply, the nativist position seems to be essentially the wrong way round. As Tomasello forcefully argues:

> The Generative Grammar hypothesis focuses only on grammar and claims that the human species has evolved during its phylogeny a genetically based universal grammar. The theory is unconcerned with the symbolic dimensions of human linguistic communication. The usage-based view—or at least the version of it espoused here—is precisely the opposite. In this view, the human use of symbols is primary, with the most likely evolutionary scenario being that the human species evolved skills enabling the use of linguistic symbols phylogenetically. But the emergence of grammar is a cultural-historical affair—probably originating quite recently in human evolution—involving no additional genetic events concerning language per se.[16]

Grammar is thus in no sense 'hard wired' and, much in the same way that Darwin's finches evolved different beaks to exploit different food sources, it would seem that we have developed different languages and means of communication to suit differing contexts: this analogy is a useful one – the end result is the same (to feed in the case of the finch, to communicate in the case of the human) but the means to do so is adapted to fit the environment in which it is to be used. Small wonder then that lexical differences exist, whether it be the famed and much disputed Inuit words for snow or the remarkable 27 different words for moustache used by Albanians. It is no surprise either,

16 M. Tomasello, *Constructing a language...*, *op. cit.*, p. 9.

although rather more controversial, that different grammars have developed as well – the Piraha people lack anything like a past or future tense since they regard anything which has not been experienced directly by the speaker to be without value. It would also seem that different languages have different normative structures at work and, indeed, that some have possessed differing sources of normativity in their histories.

Everett[17] has a convincing metaphor of hunting with a bow and arrow. Most cultures in the world have developed some form of archery equipment, often independently. Does this mean that there is some kind of universal archery hardwiring in our brains? Or perhaps an archery instinct a la Pinker? Everett convincingly argues that it is rather a product of our problem solving apparatus and often the best solution to the problem of how to catch something which is faster than you – and thus, by analogy, our languages often have many similarities due to their applications and usage but this does not presuppose that they are either identical or derived from a particular gene.

Language as a cultural tool possesses both explanatory and descriptive power: the idea that meaning is generated by use encompasses both positions and also helps to explain how a language may be intrinsically, extrinsically or non-normative. The normativity of meaning question, when seen through the prism of language as a cultural tool, would seem to dissolve: after all, one does not invent or utilise a tool (word) that does not do the job for which it was intended (meaning) yet, at the same time, certain tools do become obsolete over time. What is more controversial is the idea that language use can affect the *normativity* of meaning – that the idea that the source of linguistic normativity can shift from the intrinsic to the extrinsic or even to cease to exist.

17 Cf. D. Everett, *Language. The Cultural Tool*, *op. cit.*, pp. 16-20.

Let us consider a concrete language, English, and a concrete example in the Third Commandment, 'Thou shalt not take the name of the Lord thy God in vain'. This was originally a strong prohibition with considerable normative consequences – the case of the Egyptian in the Book of Moses being a case in point, with the blasphemer being stoned to death as punishment. For the Puritans of New England, the use of a term had a certain normative meaning – to blaspheme meant time spent in the stocks. Depending on the perspective one adopts, this normative relationship could be either intrinsic (particularly given the reverence for the Word in colonial America) or extrinsic (the society had clear and defined punishments for blasphemy; this led to a normative relationship whereby people did not 'take the Lord's name in vain'). Over time, this was maintained (many of our 'light' exclamations such as 'gosh' are either corruptions of God) but the normative consequences softened somewhat. Today, at least for Christians, there are limited normative consequences for blasphemy – yet arguably the meaning of the prohibition has remained the same, resulting in a non-normative relationship. What has changed is the culture, the culture of use **and** the normativity of the meaning. Normativity, like languages and flowers, can flourish, wither and die. A statement can have normative consequences for some speech communities but not for others, be intrinsically normative in some and extrinsically in others. What is certain, however, is that it is a relationship ultimately bound up with use - objections of the Putnam Twin Worlds type, namely that usage is not enough to determine meaning, remain unconvincing: the discovery that XYZ is chemically different to H^2O would merely result in a change in use.

Concluding remarks

Let us briefly restate here the aspect theory of the normativity of meaning. Previous attempts to untangle the normativity of meaning have come unravelled as a result of their dependence on an outmoded conception of language. Relying on a fixed conception of meaning and a 'shared universal grammar' for all languages makes the choice of whether the normativity of language is intrinsic, extrinsic or absent largely arbitrary. The aspect theory, however, rests on an altogether more solid yet dynamic foundation of language use and reveals that different languages enjoy differing sources of normativity as a result.

It is worth highlighting what the implications may be from this new view of language. Firstly, since the source of the normativity of meaning within a language may vary, we need to examine what this might mean for languages as a whole. Secondly, and more broadly, it seems that many of our fundamental notions in linguistic philosophy need to be overhauled and reconsidered in light of the usage based view of language. Finally, a further conclusion is that learning a language is not a matter of learning the symbolic representations of a shared universal grammar but rather acquiring an intricate web of meanings and nuances. As Tomasello puts it:

> Because they are learned imitatively from others, linguistic symbols are understood by their users *intersubjectively* in the sense that users know their interlocutors share the convention (that is, everyone is potentially both a producer and a comprehender and they all know this.[18]

This is perhaps the most far reaching of all of the consequences of this view of language, requiring a fundamental rethink of the

18 M. Tomasello, *Constructing a language...*, *op. cit.*, p. 12.

presuppositions which underpin not only our linguistics, philosophy and cognitive science but also their practical applications.

The Issue of Knowledge and Faith in the Russian Academic Milieu from the 19th to the 21st Century[1]

Teresa Obolevitch

The subject of the relationship between knowledge and faith has been raised in Eastern Christian thought from the Early Church Fathers onwards. Over the centuries, the issue has assumed various forms every now and then. Initially (in early Christian apologists) the question was mainly the relation of "pagan" philosophy to the Revelation (the famous Tertullian's *Athens and Jerusalem*), afterwards (in the so-called golden age of patristics marked by the teachings of e.g. Cappadocian Fathers) the philosophers deliberated on the role of the rational inquiries over the fundamentals of faith, which resulted in the development of theology, and since modern times the thinkers have pondered on the issue of the relationship between science and faith or between scientific and theological knowledge. All the aforementioned aspects of the subject generally identified as "knowledge versus faith" were examined by Russian theologians and philosophers as well – especially by the lecturers of the ecclesiastical academies and seminaries from the 19th century until the present time.

1. Revelation and philosophy

Russian universities, differently from the Western ones, did not have theological faculties. The role of the latter was

1 This publication was made possible through the support of a grant from the John Templeton Foundation.

fulfilled by ecclesiastical academies (existing in Moscow, Saint Petersburg, Kiev and Kazan) which prepared the elites of the Russian Orthodox Church (seminaries, being the equivalent of *gymnasia*, were the earlier educational stage). At the beginning[2] at the ecclesiastical academies (the first of which was founded in 1804) the attitude to philosophy was distrustful and sceptical. In accordance with the 1814 act, 10 hours a week were granted for lectures in philosophy.[3] Nevertheless – according to the evidence given by one of the nineteenth-century historians – it was understood as a discipline whose aim was "experiencing the weakness and helplessness of the human reason in searching for the truth unaided, without the light of Revelation given from above."[4] This is why the only presented viewpoints were the ones consistent with the "true reason" of the Holy Scripture. At the same time, Plato was set as a model – as "the main pillar of philosophy," with the stipulation that "he should be studied from the original sources, since the philosopher's thought has been distorted by the hermeneutists."[5] Philosophy was perceived

2 Additionally, it should be mentioned that in the 17th and 18th centuries at higher education establishments – the Kiev-Mohyla Academy in Kiev and Slavic Greek Latin Academy in Moscow (where philosophy was taught since 1634 and 1687 respectively) the language of tuition was Latin, and western thomistic coursebooks were used in order to prepare the future clergymen to fight Catholicism and the Union of Brest. Later, the scholastic texts were replaced with the coursebooks written in the Protestant spirit and based on Wolff's thought.

3 See В. Заев, *Реформы духовных академий в XIX – начале XX в. I. Первая реформа духовных академий 1808-1814 гг.*, "Труди Київської Духовної Академії" 2008, no. 8, pp. 279-282, 287, 297-298, 307-308.

4 Cit. after: Г. Шпет, *Очерк развития русской философии*, [in:] *Очерки истории русской философии*, eds. Б.В. Емельянов, К.Н. Любутина, Издательство Уральского университета, Свердловск 1991, p. 371.

5 Л.Е. Шапошников, *Православие и философия: границы взаимодействия*, "Вече. Альманах русской философии и культуры" 2002, no. 13, p. 45.

merely as *ancilla theologiae*; metaphysics, history of philosophy, psychology, logics and ethics taught at the academies were supposed only to "complement the theological vision of the world."[6] It is characteristic that since 1817 the issues of religious and secular education lay within the competence of one dicastery – The Ministry of spiritual issues and national education, one of the aims of which was "establishing in the Russian society the salutary harmony between *faith, knowledge and authority* (*sic*! – T.O.), or, in other words, between the Christian piety, the enlightenment of the minds and citizens' existence."[7] As a result, not only the ecclesiastical academies stayed aloof from philosophy, but also the secular universities as well.[8]

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6 Cf. Н.А. Куценко, *Профессиональная философия в России первой половины – середины XIX века: процесс становления и виднейшие представители*, ИФ РАН, Москва 2008, p. 33; Б.В. Емельянов, *Цензурная судьба русской философии первой половины XIX века*, "Известия Уральского государственного университета", 2010, no. 1(73), pp. 101-102; Н.К. Гаврюшин, *Русское богословие. Очерки и портреты*, Нижегородская духовная семинария, Нижний Новгород 2011, pp. 21-23.

7 Cit. after: Г. Шпет, *Очерк развития русской философии*, *op. cit.*, p. 443.

8 Such subordinationist approach to secular sciences brought about serious detriment to Kazan University, whose "reformer," M.A. Magnitsky called philosophy the source of disbelief and heresy, invoking the Epistle of Paul to the Colossians (2:8) where it was defined as "vain deceit." In the university edifice there was an inscription stating the misery of the human reason in the face of faith. The outlines of the lectures were subject to censorship. Thus – as Gustav Shpet states – "some of the professors began to give lectures in their subjects in an accusatory tone, while others searched for confirmation of the fundamentals of the Holy Scripture in them. The professor of mathematics found the manifestation of Divine wisdom in a right-angled triangle, the professor of anatomy – in the build of the human body. Certain sciences ceased to be taught, e.g. geology, because all its theories stood in contradiction with the Holy Scripture." (Г. Шпет, *Очерк развития русской философии*, *op. cit.*, pp. 451-452). The reputation of Kazan University was later restored by Nikolai Lobachevsky who developed non-Euclidean geometry.

Gradually, more comprehensive coursebooks finally appeared, and their authors – the lecturers – initiated the development of the original, "professional" philosophical thought in Russia, the so-called academic philosophy which anticipated the oncoming movement of the slavophiles and university philosophy. The professors of the Academies ceased to use Latin and began to teach in Russian. The initiator of the Russianisation in education was, among others, the professor of Academy in Kiev Ivan Skvortsov (1795-1863), who wrote:

> The Academy needs philosophy in its entirety. It is the necessity of time, and without it the tutor of the Church will not have reverence among his disciples.[9]

Another noteworthy person is the professor of Saint Petersburg Theological Academy, Fyodor Sidonsky (1805-1873), whose *Introduction to philosophy* (1833) was considered to be the most outstanding book on philosophy of the first decades of the 19th century. Sidonsky boldly promoted the view about the autonomy of philosophy and its independence from any authority figures. Simultaneously, he also expressed the opinion that philosophical cognition is less complete than theological cognition, although theology requires rational reflection. According to him, "Faith is necessary for the reason by assisting it, and reason is necessary

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Another wave of deprivation of philosophy at the universities occurred at the times of Minister Shirinsky-Shikhmatov, who used to say: "The benefit of philosophy has not been proven, while the detriment caused by it is quite possible." In 1850, on the command of the minister, the departments of philosophy at the universities were closed up. However, at the time the role of the philosophical centres (facilitating, among others, the reception of German idealism) was taken over by the ecclesiastical academies.

9 Cit. after: Н.А. Куценко, *Профессиональная философия в России...*, *op. cit.*, pp. 91-92; cf. also: *idem*, *Протоиерей Иоанн Скворцов и Киевская духовно-академическая школа*, [in:] *Философия религии: альманах* 2006–2007, ed. В.К. Шохин, Наука, Москва 2007, pp. 393-398.

for the faith to develop it and it makes lucid our human awareness of the Divine sphere."[10] Sidonsky's successor in the philosophy department was Vasily Karpov (1798-1867), the translator of Plato into Russian and the advocate of the so-called transcendental synthesis – the postulate of expressing the whole reality, both the empirical and the supernatural one, in a single universal philosophical system (this ideal would be realised later by, among others, Vladimir Solovyov in his doctrine of integral knowledge). The exponents of the academic philosophy expressed views which should be considered theistic. In their reasoning, instead of the religious notion of God, they often employed its philosophical equivalents, such as "the absolute," "the absolute being," "the unconditional being," "the infinite being" etc., describing the aspect of God that can be the object of rational reflection[11] and thus retaining the moment of inexpressibility, apophasis, in Him. Philosophy itself was then understood as "the study of being in its relation to what is unconditional."[12]

In the academic milieu, philosophy as *ancilla theologiae* performed the function of the apology of the revealed truth, of "the justification of the forefathers' faith"[13] and was employed to polemicise with atheistic or agnostic thought.[14] For instance,

10 Ф.Ф. Сидонский, *Введение в науку философии*; cit. after: Л. Е. Шапошников, *Православие и философия: границы взаимодействия*, *op. cit.*, pp. 48-49.

11 Cf. И.В. Цвык, *Проблема истины в русской духовно-академической философии*, "Вестник Московского университета. Серия 7: Философия" 2004, no. 2, pp. 14-15.

12 Г.Д. Панков, *Апологетика философии в контексте апологетики богооткровенной веры в православно-академической мысли*, [in:] *Колізії синтезу філософії і релігії в історії вітчизняної філософії (до 180-річчя Памфіла Юркевича та 130-річчя Семена Франка)*, eds. Г. Аляєв et al., АСМІ, Полтава 2007, p. 24.

13 V. Solovyov will return to this idea later.

14 However, voices criticizing philosophy even as the servant of theology appeared as late as in the second half of the 19th century. For instance, in 1884 the journal "Вера и разум" (*Faith and Reason*) issued by Kharkiv diocese, published a text whose author protested against the positive evalua-

the professor of dogmatics at Moscow Ecclesiastical Academy, Filaret Gumilevskij (1805-1866) taught at his lectures that the aim of philosophy is to

> to demonstrate how a mystery of Revelation, although it cannot be approached on the principles of reason, does not contradict its theoretical and practical needs. On the contrary, it aids them. "It heals any infirmity of reason caused by sin."[15]

Let us quote the opinion of M.A. Ostroumov, who wrote in his philosophy coursebook for students that "religious faith will show philosophy the ways of its studies, and philosophy will strengthen and clarify the faith, it will detach faith from misconceptions and superstitions."[16]

As can be seen, in the ecclesiastical-academic milieu, philosophy was generally treated as a field which was auxiliary or even ancillary to Revelation. It can be interpreted as a discipline searching for the understanding of the fundamentals of faith – in the spirit of Augustinian-Anselmian idea of *fides quaerens intellectum*. Russian philosophy eventually obtained autonomy in the works of the slavophiles and their opponents – occidentalists, especially among the thinkers of the Silver Age.[17] Nevertheless, the so-called academic philosophy bore great

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tion of philosophy carried out by the professor of the Moscow ecclesiastical academy, Victor Kudryavcev-Platonov. Another author, K. Istomin polemized with Solovyov's attempt of rationalization of the truth of faith (see А.А. Ермичев, *История русской философии в журнале "Вера и разум"*, "Вестник Русской Христианской Гуманитарной Академии" 2008, vol. 9(2), p. 150).

15 G. Florovsky, *Ways of Russian Theology*, trans. by R.L. Nicholas, <http://www.myriobiblos.gr/texts/english/florovsky_ways_chap5.html>.

16 Cit. after: Л.Е. Шапошников, *Православие и философия: границы взаимодействия*, *op. cit.*, p. 70.

17 Many of them, e.g. Vladimir Solovyov, and also Vasily Rozanov, Fr. Pavel Florensky or Fr. Sergei Bulgakov will later be accused – not without reason – of heterodoxy and sometimes even of heresy.

significance for the reception and the gradual development of the Russian tradition of philosophising that will retain the religious orientation present in the above-mentioned professors of ecclesiastical academies.

2. Scientific and natural apologetics

In the 19th century Orthodox thinkers had to confront one more intensely developing field of study, namely natural sciences. The biggest challenge of the time was biology,[18] and specifically the theory of evolution. The figure considered to be the precursor of the reflection over the issue of the relations between science and faith is Mikhail Lomonosov (1711-1765),[19] a scientist comprehensively educated in natural science and humanities, and the author of religious poems. In the milieu of the ecclesiastical educational institutions – academies and seminaries – science initially did not receive much attention; it was ignored, like philosophy used to be. The students of the seminaries were only acquainted with practical information concerning agriculture that could be useful in the pastoral work of a village parish priest. Later, the departments of mathematics and natural sciences were created, but they did not exist for a long time. Due to the reservations put forward by the over-procurator of the Holy Synod, Count Dmitri Tolstoy who insisted that in the academies only theology should be taught, natural sciences were removed from the curriculum. The 1868 bill of the Ministry of Internal Affairs provided for teaching the physical and

18 Physical theories, such as Copernicanism, have never been subjected to condemnation in Eastern Orthodox Church, and what is more, this theory was taught even at Kiev-Mohyla Academy. One of the authors writing about the teachings of Copernicus and Galileo with approval was, among others, Hryhorii Skovoroda (1722-1794).

19 See А.В. Солдатов, *Наука и религия в русской религиозной философии*, "Вестник Русской Христианской Гуманитарной Академии" 2007, vol. 8(2), pp. 142-143.

mathematical sciences only in the Academy in Saint Petersburg, but this project was not accomplished. In 1869 the authorities went as far as to close down the departments of physics and mathematics in the academies. Only due to the efforts of the vice-chancellor of Moscow Ecclesiastical Academy, Aleksander Gorsky,[20] supported by the Archbishop of Kamchatka Innokentii, the "substitute" department of scientific and natural apologetics was created on 12th October 1870. The former lecturers of physics and cosmography acquainted students with the fundamental natural phenomena and scientific theories, but they did it only for apologetic purposes.[21]

The awareness that one of the reasons for the conflict between faith and reason was the ignorance of the "over-zealous" apologists of Christianity, who, "having the best intentions, usually possessed only a very superficial knowledge about science and nature"[22] enforced the revision of the curriculum in the ecclesiastical academies. At the same time, it was emphasized – like it was done as far back as by the early Christian writers, e.g. St. Augustine – that reason comes from God, and thus the attacks on knowledge (including science) in fact imply questioning the Divine intention. The professor of Moscow Ecclesiastical Academy, Sergei Glagolev (1865-1937), called this tradition of combining the "classical rationality" with the Orthodox theology "the school of believing reason," making reference to the analogous expression of a slavophile Ivan Kireyevsky. The lecturers of

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20 Cf. Д.Ф. Голубинский, *Участие протоиерея А.В. Горского в деле учреждения при Московской Духовной Академии кафедры естественно-научной апологетики*, "Богословский вестник" 1900, vol. 3(11), pp. 467-474.

21 В. Заев, *Реформы духовных академий в XIX – начале XX в. I. Первая реформа духовных академий 1808-1814 гг.*, "Труди Київської Духовної Академії" 2008, no. 9, pp. 350-352.

22 П.С. Страхов, *Богословие и естествознание (К вопросу о задачах естественно-научной апологетики*), "Богословский вестник" 1908, vol. 1(2), p. 258.

the new discipline were supposed "not only to convince, but also to teach – obviously not the fundamentals of science in their entire range and content, since it is unfeasible with the use of the means of apologetics, but to *teach to believe* – first scientifically, then religiously."[23] In order to achieve it, they taught about the existence of God on the basis of His works (thus acquainting the students with teleological and cosmological arguments). At the same time, the professors were supposed to demonstrate the insufficiency of the "scientific faith," understood as the conviction about the rightness of the scientific doctrines, which – contrary to the invariable, irrefutable, or using modern language unfalsifiable dogmas of faith[24] – have barely the character of working hypotheses[25] and not the ultimate explanations of the Universe. Abandoning the strategy of isolation or the conflict between science and religion in favour of the co-operation between them was to facilitate – in the opinion of scientific and natural apologists – to realise the grand, noble purpose of comprehending God and the universe created by Him. At the same time, there was a call for creating "Christian" or, to be more specific, "Orthodox" philosophy which would raise the question about the relation of reason and faith in the spirit of the Eastern Orthodox Church.[26]

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23 *Ibidem*, p. 262.

24 It must be emphasized that the Eastern Orthodox Church rejects the thesis about the evolution of dogmas. See e.g. Епископ Василий (Родзянко), *Теория распада вселенной и вера отцов. Каппадокийское богословие – ключ к апологетике нашего времени. Апологетика XXI века*, Москва: Паломник 1996, <http://bishop-basil.org/russian/works/book/part1.shtml>.

25 The status of a hypothesis was ascribed, among others, to Darwin's theory on the origin of species developed at the time.

26 Cf. И.С. Вевюрко, *Научная рациональность и православное богословие в трудах мыслителей русских духовных школ начала XX века*, <www.bogoslov.ru/text/287359.html>.

It ought to be emphasized that mathematics and natural sciences were taught not only in the academies, but also in the seminaries[27] (which provided secondary education after all), but only to a limited extent, on an incomparably lower level than in *gymnasia* preparing for studies at the university. Professor V. Javorsky in the journal "Богословский вестник" deplored the fact that the lecturers of the physical and mathematical sciences have at their disposal only 3 hours of algebra per week in the first year, 3 hours of geometry per week both in the second and the third year, and 3 hours of physics in the fourth year. After 1867, due to further reforms, natural history, trigonometry, and astronomy were removed from the curriculum, and remaining subjects were limited to the minimum. Javorsky also complained about the lack of practice, the lack of the requirement for written assignments, and poor equipment of the laboratories, necessary for performing the experiments and exemplary lessons. As a result, a seminary graduate – the future village parish priest – had difficulty explaining even the most common physical phenomena which he encountered in his pastoral work, for instance the meteorological phenomena. And really,

> The alumnus of the seminary (...) is supposed to be a fighter in the world... In order to be worthy of his status, he ought to possess the sufficient level of intellectual development... As an apologist of faith, a priest must know natural sciences. A theologian often happens to touch the fundamentals of the natural sciences. Young theologians almost from the very beginning hear and know that the lack of faith and the negative tendencies of the contemporary world must be fought using their own tools... Therefore, the fighters must be given these tools....[28]

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27 The equivalent of the lower seminaries in Western countries.

28 В. Яворский, *Кафедра "физико-математических наук" в духовных семинариях (Несколько слов и мыслей по поводу ожидаемой реформы духовно-учебных*

As it can be seen, some of the exponents of the Eastern Orthodox Church were conscious of the significance of the secular education for the clergy, although they first of all emphasized the apologetical purpose of studying mathematical and natural sciences, directed at the defence of the fundamentals of faith in the face of positivism, materialism and atheism. Academy professors also interpreted particular scientific theories in the spirit of harmony between faith and reason which they called for, even though that ″concordance″ often existed at the expense of not abiding by the competence of science, and subordinating its facts to the unbending dogmas of Christianity.

Let us remind two standpoints of the search for the agreement between science and religion present in academic philosophy. The professor of philosophy, Victor Kudryavcev (1828-1891) wrote, that the settlement of the question about the origin of the Universe belongs to natural sciences (astronomy, geology, paleontology and biology), adding that science does not entirely exhaust the subject, as it only explores the empirical world.[29] At the same time, Kudryavcev was inclined to acknowledge Darwin's theory as a plausible explanation of the origins of human species. Another lecturer of scientific and natural apologetics, Dimitri Golubinsky (1832-1903, the son of an exponent of academic philosophy, Fyodor Golubinsky) taught that ″science ought to be conscious – personified by its lecturers – of its helplessness about certain issues,″ at the same time adding a controversial thesis that ″numerous phenomena of visible nature cannot be ultimately explained barely in terms of nature, just the opposite, one should acknowledge the supernatural

заведений), ″Богословский вестник″ 1902, vol. 2(7/8), pp. 573-574.

29 Cf. В.Д. Кудрявцев, *Регрессивная и прогрессивная теория происхождения мира*, ″Богословский вестник″ 1892, vol. 1(1), pp. 19-20.

action of the almighty Creator."[30] The statement about the limitation of science, as well as emphasizing the Divine action in the world does not evoke controversy, however, the methodologically misformulated assertion about the impossibility of scientific explanation of the empirical world within the world itself, immediately violates the independence of science and reduces it to the role of an auxiliary discipline, subordinate to theology.

Both the theologians – quite properly – indicated the insufficiency of the scientific explanation, but they differed in the evaluation of scientific facts, and specifically Darwin's theory. Contrary to V. Kudryavcev, who recognized the cognitive significance of science, D. Golubinsky seemed to be satisfied with the claim that "science does not contradict religion," thus employing, so to say, the principle of decontradictification, and in the conflictual situation he decidedly rejected the theories which seemed to undermine the fundamentals of faith. Due to this, he described "the views of the Darwinists" as "nonsensical," "unreasonable," "unproved" and "unsupported," thus violating the autonomy and the cognitive value of science. As he was writing:

> To certain detailed questions concerning the creation of the world, it is safer to reply in the following manner: This we do not know.[31]

Apophatism – not only religious, but also scientific one – was, for Golubinsky and many other scientific and natural apologists, the best and the most reliable strategy in debatable issues. The mysteriousness of the "exceptionally intricate" subject matter which the work of creating the world is, hindered the progress towards making attempts to confront the positive scientific discoveries.

30 Д.Ф. Голубинский, *Открытое письмо к N.N. по поводу вопросов о сотворении мира*, "Богословский вестник" 1895, vol. 3(8), pp. 202-203.

31 *Ibidem*, p. 207.

Some authors, for instance Sergey Glagolev mentioned above, sought purpose of scientific and natural apologetics in the scientific justification of the fundamentals of faith.[32] It is obvious, that it is an undertaking which is doomed to failure, since it violates the fields of interest of science and religion. The exponents of the new discipline not always guided themselves with appropriate methodology in their experiments. As a result, apologetics practised in such manner disregarded scientific facts and set science in the background, and that is why the assurances about initiating the dialogue between science and religion remained within the sphere of wishful thinking.

3. The issue of the relationship between science and religion in the 20th century

After the 1917 revolution, the question of the relationship of science and faith became an especially urgent problem in the USSR, since the communist propaganda relied exactly on the scientific facts. This is why numerous clergymen of the Eastern Orthodox Church reattempted the apology of faith from the accusation of inconsistency with the discoveries of the positive science. The problem in question was the subject of deliberation of Nikolai Fyoletov (1891-1943), the author of posthumously published *Outline of Christian apologetics*, in which the theologian investigated such issues as the origin of the Universe and the man, the problem of miracles, natural laws etc. from Christian perspective, and also of father Luka (Voyno-Yasenetsky, 1877-1961, the author of works *Science and religion* and *Spirit, Soul and body*).

32 See О. Мумриков, *Естественно-научная апологетика как целостная дисциплина: общий обзор*, "Вестник Православного Свято-Тихоновского богословского института. IV: Педагогика. Психология" 2009, vol. 4(15), p. 28.

The works which deserve special attention are the publications of the Russian emigrant theologians working in Paris: Vassily Zienkovsky (1881-1962), Vladimir Lossky (1903-1958) and Georges Florovsky (1893-1979). Zienkovsky devotes the first part of his *Apologetics* to the relations of the Christian faith and the contemporary scientific knowledge. The author emphasizes that the conflict between faith and reason occurs only in the situation of the isolation of the latter from the tradition of the Church. It is not clear whether it means that scientific cognition ought to be – according to Zienkovsky – subordinated to the doctrine of the Church. For Zienkovsky, on one hand, writes about the autonomy of science:

> Eastern Orthodox faith creates wide space for *exploring* nature. (...) The freedom of research is the essential condition of scientific work.[33]

On the other hand, the author expresses the opinion about the superiority of theological cognition over the scientific one: "We are conscious of our duty and right of exploring and explaining the natural phenomenon in the light of Christ."[34] Why? Out of the simple reason that Zienkovsky taught that science explores the results of Divine action, and thus indirectly leads to superior religious cognition.

> The problem of God's presence in the world concerns the sphere to which both theology and science aspire, since it is about God's action *in the world* that reveals itself as much by religious contemplation as through scientific research. (...) Indeed, science explores nature as if God's participation in the life of the world never and nowhere became apparent. However, while science does not

33 В.В. Зеньковский, *Основы христианской философии* [*Basics of Christian Philosophy*], vol. 1, Канон, Москва 1997, pp. 88-89.

34 *Ibidem*, p. 101.

> sense the perplexity of such attitude, for Christian theology it is obviously a dead end. (…) Exploring nature must essentially lead to the *metaphysics* of the world (…).[35]

According to Zienkovsky, the search for the relationship between science and religion, the exploration of the empirical and the extra-empirical is characteristic for the Russian thought in a unique way.[36]

As far as the conflict between science and religion is concerned, Zienkovsky admits priority and rightness to the fundamentals of faith, writing about the hypothetical character of science. And it is this hypotheticality which hinders making attempts of an explicit, definite and complete settlement of the fundamentals of faith and the scientific facts:

> If some statements of the contemporary knowledge can in no way correspond with the Christian doctrine of faith, there is nothing tragic for either side. Scientific ideas and generalisations are continuously *im Werden*, certain hypotheses are replaced by others, certain ideas give way to another ones.[37]

Thus, Zienkovsky shuns the methodologically erroneous position of concordism which was characteristic to numerous

35 В.В. Зеньковский, *Об участии Бога в жизни мира*, [in:] *idem*, *Собрание сочинений*, vol. 2: *О православии и религиозной культуре*, Русский путь, Москва 2008, pp. 345, 350, 356. Cf. *idem*, *Основы христианской философии*, vol. 1, *op. cit.*, p. 64: "Whatever we would discover in the world, we discover owing to the Divine presence in the world. (…) Any cognition 'the relation to the Absolute'."

36 Cf. В.В. Зеньковский, *О мнимом материализме русской науки и философии*, in: *idem*, *Собрание сочинений*, vol. 1: *О русской философии и литературе*, Русский путь, Москва 2008, pp. 316-317.

37 В.В. Зеньковский, *Основы христианской философии*, vol. 1, *op. cit.*, p. 89. Cf. *idem*, *Апологетика* [*Apologetics*], <http://www.klikovo.ru/db/book/msg/4132>: "Science, in its progress, must either replace some hypotheses by another ones, or modify them to such extent that in fact they become new ones. (…) However, the text of the Bible remains unchanged."

exponents of Russian thought at the turn of the 20th century, although he does not avoid the temptation of subordinating science to religion.

As opposed to Zienkovsky, Vladimir Lossky was not occupied with the issue of the relationship between science and religion as such. The question of scientific cognition appears marginally in his works, in connection with the subject of apophatism, the key issue for the Eastern Orthodox Church. This Orthodox theologian elaborated on the motive (already present in the academic philosophy) of the limitation of human cognition (including the scientific cognition concerning the exploration of nature) on the basis of the texts by the Church Fathers. He wrote:

> For St. Basil, not the divine essence alone but also created essences could not be expressed in concepts. (...) There will always remain an "irrational residue" which escapes analysis and which cannot be expressed in concepts; it is the unknowable depth of things, that which constitutes their true, indefinable essence.[38]

Lossky – like other Paris theologians: Vassily Zienkovsky mentioned above or Georges Florovsky[39] – by no means rejected the possibility of getting to know the world and God, but he emphasized that it concerns only the Divine actions – powers, energies and not His essence. Those energies are present in the world, thus exploring the mysteries of nature is an indirect way to knowing the Creator.

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38 V. Lossky, *The mystical Theology of the Eastern Church*, transl. by members of the Fellowship of St. Alban and St. Sergius, St Vladimir's Seminary Press, Crestwood-New York 1976, p. 33. Cf. К.В. Преображенская, *Богословие и мистика в творчестве Владимира Лосского*, Издательство СПбГУ, Санкт-Петербург 2008, pp. 34-35.

39 Cf. G. Florovsky, *The Idea of Creation in Christian Philosophy*, "Eastern Churches Quarterly" 1949, no. 8(2), pp. 53-77.

At present (after the Church has left the underground) the issue of the relationship between faith and science is one of the most widely discussed, both in the Russian academic milieu (the theological, philosophical and scientific ones), and in the press and other mass media. Numerous conferences, panel discussions, and debates on this subject are organised in various contexts, among others the methodological, biblical or philosophical ones.[40] Also the hierarchs of the Eastern Orthodox Church take part in the discussion over this issue.[41] It is noteworthy that some of the scholars, defending the faith (sometimes from the alleged menace constituted by science), quote – in accordance with the rule *consensus patrum* ("the consensus of the Fathers"), still valid in the Eastern Orthodox Church – particular opinions of the early Christian authors on e.g. the origin of man (usually in the spirit of creationism). Other, more open and discerning thinkers teach that "the consensus of the Fathers" should be looked for "not in the exterior phrases but in *what concerns the spirit* – the appropriate attitude to the interpretation of certain passages of the Holy Scripture"[42], rejecting the literal exegesis of the Bible and studying natural sciences. According to the author of the above citation "some of the contemporary apologists (...) attacking the 'secular science' instead of utilizing it for

40 I am going to mention two well-known contemporary textbooks of scientific and natural apologetics: Е. Порфирьев, *Православная естественно-научная апологетика*, Краснодар 2006; А.И. Осипов, *Путь Разума в поисках истины* (several editions), Москва (both the authors defend the position of creationism).

41 See e.g. Metropolitan Filaret of Minsk and Slutsk, *God and Physical Cosmology*, "Faith and Philosophy. Journal of the Society of Christian Philosophers" 2005, vol. 22, no. 5, pp. 521-527.

42 О. Мумриков, *Церковь и естественнонаучные картины мира: проблемы рецепции*, <http://www.mpda.ru/site_pub/129001.html>. See also Special Issue of the journal "Vstrecha" (*Встреча*) 2005, no. 3(21), edited by the students of the Moscow Theological Academy.

the benefit of the Church where it is useful, act in an extremely unreasonable manner."[43]

The standpoints concerning the relationship between science and faith are exceptionally varied – from the extreme concordism on one hand to the extreme separatism on the other, through numerous more or less successful attempts of a dialogue or of subordinating the scientific cognition to the religious one. Nevertheless, the sole fact of wide interest in the problem discussed here allows to cherish hope that a comprehensive and impartial quest for the answers to significant questions vexing the contemporaries as well, will be continued.

43 О. Мумриков, *Церковь и естественнонаучные картины мира*..., *op. cit.*

Annual Report »

The Copernicus Center in 2011

The year 2011 saw the further intensification and consolidation of the undertakings of the Copernicus Center. Below, we present an overview of the key areas in the Center's activity, with details provided in a separate booklet.

1. Research

Within the Copernicus Center for Interdisciplinary Studies there are 9 research groups. The *Copernican Group*, led by Professor Michał Kokowski, concentrates on the life and achievements of Nicholas Copernicus against the backdrop of his times, the analysis of Copernicus' achievements from both scientific and cultural perspectives, the reflection on the genesis and reception of Copernicus' achievements, as well as the detailed analysis of the theories formulated by the advocates of Copernicanism (Gallileo, Kepler). The *Science and Religion* group (head: Rev. Dr. Zbigniew Liana), investigates the relationship between science and religion in the 20th century, the problem of 'science-faith' in the life and work of John Paul II, the history of the relationship between science and religion, the relationship between technology and religion, the relationship between science and religion in Russian philosophy, epistemological and ontological questions in the context of the relationship between science and religion, and the problematics of symbolism in patristic thought. The *Philosophy and Cosmology* group, led by Professor Marek Szydłowski, focuses on the axiology of modern cosmology, the temporality of modern cosmology, the philosophical assumptions in cosmology, the study of the boundaries of physics and cosmology, the conceptual foundations and philosophical aspects of complex systems, cosmobiology, the beginning of the Universe in modern cosmology, the notion of multiverse in modern cosmology, as well as Feynman's notion of quantum gravity. The research interests of the team *Mathematical Structures of the Universe* (head: Professor Andrzej Woszczyna) include interpretational issues in the applications of noncommutative geometry to physics, mathematical formulations of gravitational physics, the theory of structure formation in the Universe, and computer algebra systems with application to general relativity. The team *History of Mathematics: People – Ideas – Philosophical Aspects*, led by Professor Wiesław Wójcik, investigates the history of Polish mathematics, the conceptions of the unity of mathematics, the philosophical foundations of mathematics, the changeability of the notion of 'mathematics', the evolution and meaning of the mathematical 'basic concepts', as well as differences among, and the sources of, ancient, modern and contemporary mathematics. The *Neuroscience* research team (head: Professor Jerzy Vetulani), carries out research connected with experimental work on the functioning of the human brain as well as the question of its interpretation and methodological connection with cognitive neuroscience. The *Analytical Metaphysics* team, led by Professor Tomasz Placek, focuses on causality theories in the classical and probabilistic versions, determinism in nature, possible-worlds structures in connection to space-time structures, and metaphysical implications of some physical results such as Bell's theorems. The *History of Science and Philosophy of Nature* research team (head: Rev. Professor Janusz Mączka) investigates the basic ideas of the Polish philosophy of science in the first half of the 20th century, the peculiarities of this philosophical movement, as well as engages in the publication of pre-war manuscripts concerning the philosophy of science. Finally, the *Biological*

Foundations of Law and Ethics research team, led by Professor Bartosz Brożek, concentrates on such problems as ethics and neuroscience, law and neuroscience, the concept of normativity, conceptual schemes in law and ethics, the evolutionary model of ethics and law, evolutionary theory in social sciences, and the methodology of social sciences.

Altogether, in 2011, the members of the research teams have published 20 books of a monographic nature and collections of essays, as well as over 80 papers affiliated with the Copernicus Center.

2. Publications

In 2011, the Copernicus Center, in collaboration with Konsorcjum Akademickie Publishing House, published thirteen books under the imprint of Copernicus Center Press. Apart from the first Polish translation of Newton's *Principia Mathematica*, translated by Jarosław Wawrzycki, these were: Michel Heller, *Filozofia przypadku. Kosmiczna fuga z preludium i codą* (Philosophy of Chance. A Cosmic Fugue with a Prelude and a Coda); Józef Życiński, *Świat matematyki i jej materialnych cieni* (The World of Mathematics and Its Material Shadows), *Oblicza racjonalności. Wokół myśli Michała Hellera* (The Faces of Rationality. Themes from the Philosophy of Michael Heller), edited by Bartosz Brożek, Janusz Mączka, Wojciech P. Grygiel, and Mateusz L. Hohol; *Philosophy in Science. Methods and Applications*, edited by Bartosz Brożek, Janusz Mączka, and Wojciech P. Grygiel; Tadeusz Pabjan, *Eksperymentalna metafizyka. Johna S. Bella filozofia mechaniki kwantowej* (Experimental Metaphysics. John S. Bell's Philosophy of Quantum Mechanics); Maria Piesko, *Nieobliczalna obliczalność* (Uncomputable Computability); Stanisław Krajewski, *Czy matematyka jest nauką humanistyczną?* (Is Mathematics a Part of the Humanities?);

Dowody ontologiczne. W 900. rocznicę śmierci św. Anzelma (Ontological Arguments. On the 900th Anniversary of St. Anselm's Death), edited by Stanisław Wszołek; *Czy nauka zastąpi religię?* (Will Science Replace Religion?), edited by Bartosz Brożek and Janusz Mączka; *Ewolucja życia i ewolucja wszechświata* (The Evolution of Life And the Evolution of the Universe), edited by Janusz Mączka and Paweł Polak; *Studies in the Philosophy of Law 6: The Normativity of Law*, edited by Jerzy Stelmach and Bartosz Brożek; *Studies in the Philosophy of Law 7: Game Theory and the Law*, edited by Jerzy Stelmach and Wojciech Załuski.

In addition, the Center continues to publish two periodicals in cooperation with the Center for Interdisciplinary Studies (OBI): *Zagadnienia Filozoficzne w Nauce* and *Semina Scientiarum*.

3. Education

In 2011, the Copernicus Center, in cooperation with the University of Information Technology and Management in Rzeszów and Tischner European University in Kraków, organized 8 open lectures in Polish, within the series *Science and Religion* (continuation). The lectures were transmitted online via the Copernicus Center's website. Also, on May 19, 2011, the *2011 Copernicus Center Lecture*, entitled *Our Emotional Brains*, was delivered by Professor Joseph LeDoux.

4. Conferences

The main academic events organized by the Copernicus Center in 2011 included the 13th Kraków Methodological Conference, *The Emotional Brain. From the Humanities to Neuroscience and Back Again* (Kraków, May 19-20, 2011), the international conference *Church's Thesis: Logic, Mind and Nature* (Kraków, June 3-5, 2011), as well as the international seminar *Language–Logic–Theology* (Kraków, December 9-10, 2011).

The 15th Kraków Methodological Conference, *The Emotional Brain. From the Humanities to Neuroscience and Back Again*, was devoted to the problem of emotions, considered both from neuroscientific and philosophical perspectives. The participants tried to address such questions as: Can both disciplines – the humanities and neuroscience – enrich and educate each other and close the gap between the *Geisteswissenschaften* and *Naturwissenschaften*? Or perhaps it is neuroscience that will dominate the reflection over the human emotional life? Or maybe it will stay as it is: two separate disciplines, two separate methods, with no real point of contact? The honorary guest of the conference was Professor Joseph LeDoux (New York University), and other participants included: Yadin Dudai, Nico Frijda, Regina Sullivan, Jacek Dębiec, Dominika Dudek, Janusz Rybakowski, Jerzy Vetulani, Elizabeth Phelps, James Russell, Paul Whalen, Bram Heerebout, Didier Grandjean, Wojciech Załuski, Bartosz Brożek and Wojciech Grygiel.

The conference *Church's Thesis: Logic, Mind and Nature* was organized within the *Studia Logica* conference series *Trends in Logic*. The conference focused on a thesis formulated for the first time in 1935 by the American mathematician Alonzo Church and called – after Stephen Kleene – Church's Thesis. It is a proposition which identifies an intuitive notion of an effectively computable function with the notion of a recursive function. An identification of a fuzzy philosophical notion on the one hand, and a strict formal one on the other, turned out to be fruitful but troublesome. The acceptance of the thesis led to a negative answer to Hilbert's *Entscheindungsproblem*, but the thesis itself has never been proved. Many important logicians and philosophers have ventured to solve the numerous problems connected to the thesis, and various lines of research have shown that it has many incarnations and constitutes an interdisciplinary issue. The title of the conference referred to the works of Georg Kreisel, who formulated three versions of Church's Thesis, pertaining to machine-, human-, and physical-computability. The plenary speakers of the conference were: Jack Copeland (University of Canterbury), Marie Duží (VSB-Technical University of Ostrava), Yuri Gurevich (Microsoft), Petr Hájek (Academy of Sciences of the Czech Republic), Pavel Materna (Academy of Sciences of the Czech Republic), David McCarty (Indiana University), Wilfried Sieg (Carnegie Mellon University), Oron Shagrir (Hebrew University of Jerusalem), Stewart Shapiro (Ohio State University), Jan Woleński (Jagiellonian University), Ryszard Wójcicki (Institute of Philosophy and Sociology of the Polish Academy of Sciences), and Konrad Zdanowski (Institute of Mathematics of the Polish Academy of Sciences).

The international seminar *Language–Logic–Theology*, organized within the *Limits of Scientific Explanation* research project, sponsored by the John Templeton Foundation (see below), set out to analyze the language and logic of theological discourse. On typical accounts, only selected linguistic and logical aspects of theology are discussed, such as the problem of analogical terms or the so-called 'proofs' of God's existence. However, as any discourse, the theological one may be subject to more thorough formal scrutiny: it seems potentially fruitful to engage in the analysis of the structure of theological theories, the relationship between theology as a theory and other theories (e.g., science or philosophy), the problem of what kind of logic is suitable to reconstruct theological discourse, the question of the semantic values in theology, etc. In addressing such problems the seminar's participants have followed in the footsteps of the members of the Kraków Circle (J. Bocheński, J. Salamucha, J.F.

Drewnowski), who in the 1930s initiated research in the formal reconstruction of religious discourse. The seminar's participants included: Dominique Lambert, Jan Szczurek, Kim Solin, Roland Cazalis, Pavel Materna, Bartosz Brożek, Adam Olszewski, Wojciech Grygiel, Jan Woleński, Marie Duží and Wiesław Wójcik.

In addition, in 2011 the Copernicus Center organized or co-organized other conferences and seminars, including: the *Copernicus Center Colloquium #3* (Kraków, February 26, 2011), the seminar *Meanings of Biological Plasticity* (Kraków, October 19, 2011), the conference *Dzieło niedokończone... Wokół myśli abp. Józefa Życińskiego* (The Unfinished Quest: Contributions to Science and Religion by Józef Życiński) (Kraków, October 21, 2011), the seminar *Filozofia w nauce* (Philosophy in Science) (Kraków, October 22, 2011), the workshop *Generalized position and momentum operators: generalized indeterminacy relations* (Warsaw, October 30 – November 2, 2011), the seminar *Racjonalność teologii* (Rationality of Theology) (Kraków, November 24, 2011), the conference *Czy świat jest matematyczny? Wokół Myśli Michała Hellera* (Is the World Mathematical? Themes from Michael Heller's Philosophy) (Kraków, December 10-11, 2011), the seminar *Oblicza normatywności* (The Faces of Normativity) (Kraków, December 12, 2011), the seminar *Is an articulation between Science and Faith possible? An example: the life of Georges Lemaître, priest, friend of Einstein and father of Big Bang cosmology* (Kraków, December 15, 2011).

5. The Limits of Scientific Explanation

In September 2011, the John Templeton Foundation awarded a prestigious grant to a team of researchers from the Copernicus Center for Interdisciplinary Studies, to carry out a three-year research project entitled *The Limits of Scientific*

Explanation. This is the first major research grant sponsored by the Templeton Foundation in Central and Eastern Europe.

The research goal of the project is to look at the limits of scientific explanation from different perspectives and in different domains (cosmology, cognitive science, normative sciences, theology). The limits of scientific method will be analyzed 'from within', i.e. how it operates in its respective applications, and 'from outside', i.e. from the metascientific, philosophical and theological perspectives. To do so, a unique methodology developed in the Kraków school will be applied, one that combines tracing philosophical issues in science, a good command of the philosophy of science and formal methods, solid knowledge of the history of science and a multidisciplinary approach. This analysis is conducted in close contact with the standard research in the respective scientific disciplines. The broad area of analysis should enable the formulation of new insights and ground-breaking theories as to the limits of scientific explanation and the mechanisms of incorporating the achievements of science into philosophical and theological theories. The second goal of the project is educational with both graduate and postgraduate courses being offered. The third goal of the project is dissemination. This includes the establishment of an internet portal enriched with free material, public lectures, seminars and conferences, as well as the publication of book monographs, collections of essays and articles in peer-reviewed journals.