Chapter 17
Selected Theses on Science

Eugene S. Kryachko

A lifetime's worth of wisdom.
Steven D. Levitt.
(co-author of "Freakonomics"
[see, e.g., Humboldt Kosmos 99, 20 (2012)].

Only a lazy researcher[1] would not think and write about a recent reform of the National Academy of Sciences of Ukraine (Dezhina 2014). I do not, however, count myself among those. Below I offer my, slightly more advanced, perhaps naïve—as might seem to many, theses on science and its contexts. These are the results of my thoughts of a typical scientific "workhorse" with the experience of more than 40 years working in the field of science. They are based on my experience. I believe my theses do not require any specific knowledge for understanding. To some they may seem trivial.

[1]I avoid to use the word "scientist" (*uchenyi* in Russian—"the knowing one"). Lev Landau called himself a "proletarian of a mental work" and did not like the word "scientist" because as he claimed—"scientific" can only be a cat (Gorobets et al. 2009). More appropriate word here is the researcher. The term "scientist" was also alien for V. Vernadsky (by analogy with the office and commercial workers). He only accepted the term *workers of science* and considered himself as one of them (Vernadsky 2004, p. 17):

> these people in general accomplish a great deal, because it is among them that produce those who make their society a new one. These people, who do not fit into the present, create the future. They violate the aspirations of society for the average, impersonal. The more in the society of such people, the more diverse and stronger its culture.

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Introduction

While, the key goal of this story goes actually to the dictum of Aristotle that started his famous Book "Metaphysics" 350 BC (Aristotle 2014) (its primary name was "First Philosophy" and book was divided into fourteen books [usually named after the first thirteen letters of the Greek alphabet: Alpha, Alpha the Lesser, Beta, Gamma, Delta, Epsilon, Zeta, Eta, Theta, Iota, Kappa, Lambda, Mu, and Nu]): "All men by nature desire to know."

This statement illustrates men's aspiration to learn and to gain a new knowledge about the outer world, the Universe (see Fig. 17.1): from the unknown to the knowledge, that implies to learn or to accumulate the knowledge acquired. Per se, this is the science, its essence, aim, and tasks. Herewith, Weyl (1954) at the end of his lecture "Unity of Knowledge" at the Bicentennial Conference of Columbia University defined the main components of knowledge: "intuition, mind's ordinary act of seeing what is given to it, understanding and expression, thinking the possible, and the construction of symbols or measuring devices" (Weyl 1968, pp. 623–630). We will talk about this below.

Phenomena, Contemplation and Beyond

The true mystery of the world is the visible, not the invisible

Oscar Wilde

In school, we learned that science—if we were aware at that time of the meaning of this word: it was percepted either as arithmetic, physics, biology, or chemistry—is not a simple thing! On the one side, all that was not that easy. On the other, that was easy enough, if we were absorbed in studying of popular scientific journals. There were a lot of them in Russia (then Soviet Union) when I was at school: "Young Technician," "Technics of Youth," "Science is Power,"[2] "Science and Life," "Chemistry and Life," "Round the World," and they were published in large numbers. In contrast, when Alexander von Humboldt published "*Kosmos*" in the 1840s—the multi-volume series of intellectual and comprehensive treaties on nature and science—such widespread nature of science in the public sphere was not yet there. Nowadays, it is.[3]

[2]Since that time—journal is published since 1926—I remember that words "Knowledge itself is power" by Francis Bacon, which were on the cover page. See also citation to Section "Effectiveness and quality of Science: Expert Appraisal."

[3]Botting (1974) elaborates that *Kosmos* has important role for the Alexander von Humboldt Foundation, which has gathered over 25,000 scientists from more than 130 countries all over the world—in fact, in a sense, the scientific or Humboldt net, network—www.humboldt-foundation.de—naturally incorporated into the world scientific networks, such as the American Physical (aps.org) and Chemical Societies (acs.org), ResearchGate (www.researchgate.net), and the others.

Fig. 17.1 Mankind's eternal aspiration of puzzle: image. Eternal aspiration of humanity is driven by curiosity [A.D. Sakharov (1989) in his lecture "Science and Freedom" (Gorelik, 2004, 2014) noted, that "Our apelike ancestor, probably, was very curious creature. <…> Curiosity was the basis for fundamental science. It's still brings us practical results, which are often unexpected for us" (quote is translated from Russian). [Reproduced by permission from Newspaper "Den", 2011]

Let us turn to definitions. *Nature* is a world that surrounds us, the outer world for us, world beyond us, or Universe, if you wish. Nature (Universe) appears to us through the act of appearance—a phenomenon [as in Greek, word φαινόμενον (phainomenon), from the verb φαίνειν (phainein), means "to show, appear, shine, to be manifested, or manifest itself] or "experiences." The term "phenomenon" entered philosophy due to I. Kant (see Kant 1770, 1994). Each phenomenon, as inferred from its above definition as an act of appearance, is observable and can be detectable, either by means of human senses or measured by human-made instruments. The former manner of observations—perceptional contemplations, via sensations—is rather limited, simply for physical reasons.[4] As an example, our senses are incapable of telling us whether the Earth is revolving relative to its axis and around the Sun, about the nature of the forces keeping planets on their orbits, about electromagnetic fields, death, and so on.[5] The latter is also limited, though its limits are beyond those of the former. The Truth—Nature, Universe—is presumed to exist independently on any observation implying therefore, that a "real phenomenon," or object, is not identical to an "observed phenomenon" or subject.

[4]A trivial example: a toad enables to see only oblong objects (Heisenberg 1958, 1977).

[5]We've already learned about senses and their role in philosophy from Lenin's "Materialism and Empirio-criticism" where he defined matter as "Matter is the objective reality given to us in sensation." Some logical inconsistencies of this definition and its discrepancy with the principle of "Occam's razor," according to which, words which do not correspond to some observable matter, should not be used, are analyzed elsewhere. See, for example, http://nohead.narod.ru/dannaia0112.htm.

"Dark Universe" is a space show at the Hayden Planetarium, which was shown there by Mordecai-Mark Mac Low, a curator at the American Museum of Natural History, about the history of the Universe outside the Hayden Planetarium eight years ago, he says, when a schoolteacher approached him and said: "You don't really believe all this Big Bang stuff, do you?" Shades of those bumper stickers and billboards you see in some parts of the country: "Big Bang? You've got to be kidding—God." It also introduces a recent article "What You Can't See Is Even Cooler" by Dennis Overbye published in the International New York Times on October 31, 2013.

We understand phenomena or subject via perceptional contemplations, which is the first source of knowledge according to Kant (see Part II.I. Kant 1770, 1994). In this case, *a subject* is "given to us" and "appears." Further, we consider it by giving it a meaning. We imagine and cognize it.[6] As a result, notions arise. Thinking of *notion,* we understand a form of "thinking about subject, in general." Saying in other words, we cognize a phenomenon via application of our knowledge to the phenomenon. It is important to note that subjects of cognition are on their own irrespective of cognition, of contemplative and conceptual-logical forms, by means of which these subjects are perceived and conceived by us, by our consciousness (Asmus 1973). "Consequently, contemplation and notions—are the gist of our every cognition, as neither notions without relevant to them cognition, nor cognition without notions can not provide the knowledge" (see Part II.I. Kant 1770, 1994). *Knowledge*—is a consolidation of both, it's a representation of phenomenon, perceptionally contemplative and conceptual. When this representation becomes identical, then truth or "equivalence between knowledge and its subject" is reached (see Part II.III. Kant 1770, 1994).

Let's make a step aside. Reasoning logically, we may suggest an existence of thing, or an object, which is not-cognizable, which is not directly accessible to observation: "a thing that is not thought of as an object of the senses but rather as a thing-in-itself" (see Fig. 17.2). To some extent, they are opposite to "phenomena." Immanuel Kant has introduces a notion of "*noumenon,*" which is "Ding an sich" in German, and "thing-in-itself" or "thing per se" in English (Kant 1770, 1994). A rough English equivalent of "noumenon" is "something that is thought" or "the object of an act of thought," "a transcendent object." The concept of a noumenon, as Kant explained (Kant 1770, 1994), "is necessary to prevent sensible intuition from being extended to things-in-themselves, and thus to limit the objective validity of sensible knowledge" (Kant 1994). An unknowability of noumenon means, as Asmus (1973) emphasized is in the expansion and deepening of our knowledge, as it occurs in the subjective forms of sensibility and understanding, is cognition of only phenomena, not of things-in-itself. In this sense, according to Kant (1770), mathematics is not a reflection of objective reality and reliable only for us, as consistent with inherent for us forms of sensibility and understanding.

[6]Intellect, according to Kant, is the ability to cognize subject for perceptional contemplation. Science about rules of intellect is "a logic, within which mind deals with itself, only" (Kant 1770).

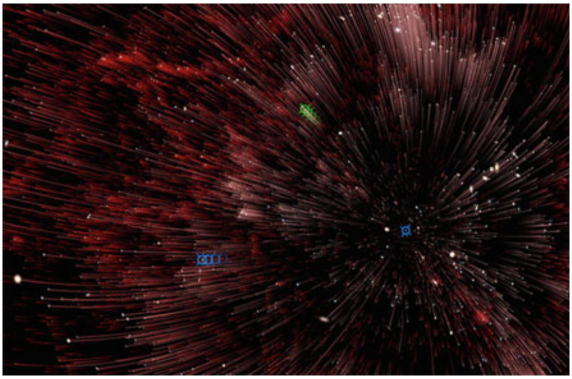

Fig. 17.2 Space show "Dark Universe." Reproduced by permission from American Museum of Natural History, 2013

Science: Definition

The word "science"[7] is rooted to the Latin "*scientia*" that means "knowledge." Science is a sphere of human activity directed to the creating a new knowledge of nature, man's process of discovering phenomena and understanding the relationships between them and their nature,[8] thus demonstrating the harmony, the unity of nature, by means of unraveling myriads of painstakingly collected data (Helferich 2004), and "obtaining knowledge about the actual character of physical reality" (Kafatos and Nadeau 2000), extracting information (Brillouin 1956) from phenomena, and explaining *why* and *how* they do manifest themselves these given ways; the mankind's aspiration, the approach to perceive the truth of the whole, if the latter does exist and achievable, perceptual (Connes et al. 2001), as the body of empirical knowledge (the knowledge obtained by means of experience) represented as some information.

The purpose of science is to achieve the truth on the way to a new knowledge. The truth, as Immanuel Kant wrote (see Part II.III. Kant 1770, 1994), is the correspondence of knowledge with its object. However, the key question is how to "find a universal and true criterion of the truth of all knowledge"?

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[7]Editors' note: The English word "science" became established in the 1830s as a translation of the German notion *Wissenschaft.*

[8]A bright example of "how understanding arises" was given by Carl Friedrich von Weizsäcker (Von Weizsäcker 1973, Footnote 7, p. 745): "In his simile of the cave, Plato describes people who are sitting in the cave and looking at the wall, there they only see the shadows of some things which are transported behind their backs. Then they are turned around or at least one of them is turned around completely in order to see the reality. Then he suddenly realizes how unimportant is the great art of the people, who have been sitting with him looking at the shadows. This is the art of predicting what shadow would follow the other one. They take the shadow to be the real thing. But this art is far surmounted by the understanding of one who sees the real thing. But then, he has seen only the things which are carried behind their backs in the cave. He goes into the outer world, and there he sees the shadows of things in the light of the sun, and he sees real things in the light of the sun, and then he may see the sun itself."

Science, of course, demonstrates the harmony and unity of nature. Science "obtains knowledge about the real nature of physical reality" (Connes et al. 2001) by means of solving myriads of thoroughly collected data (Helferich 2004), of extracting an information (Brillouin 1956) from the observation of phenomena. Science reflects the desire of mankind to comprehend the truth in general, if the latter exists, accessible and knowable (Connes et al. 2001) to comprehend the truth as a kind of "body" of empirical knowledge gained by observing the knowledge presented in the form of some information. Its driving force is as perennial question *why* from the sub-cortex of curiosity (Haas 2013) and mysteries of the surrounding world.[9]

Science is a way of understanding the world of phenomena through research, which aims to formulate the laws of this world using scientific induction (Bacon 1620; Popper 1963), and create a series of models with increasing predictive power in order to simulate the resulting image of picture of the reality, which displays, in appropriate terms, the world into the ourselves—so-called "*Language*." This is what gives meaning to Science (Jennings 2006):

> Scientists, it seemed clear, began with careful observations, cautiously proceeded to a tentative hypothesis, progressed to more secure but still provisional theories, and only in the end achieved, after a long process of verification, the security of permanent laws. Newton saw the apple fall, hypothesized that it had fallen at one speed rather than another for a reason, theorized that there might be an attraction between all bodies with mass, and then, at long last, arrived at a law of gravitation to explain everything. This "observation up" or "apple down" picture of how science works was so widespread that it defined what we mean by science: when Sherlock Holmes says that he never theorizes in advance of the facts, he is explaining why he can be called a scientific detective. Various thinkers poked holes in this picture, but generally their point was that, while the program was right, it was harder to do than it appeared. (Jennings 2008)

To achieve this goal, Science demands a language whose words are the means by which men convey information to one another—to paraphrase an old saying: "a look (observation) can be worth a thousand words"—and the method used to determine what is a "truth" … a criterion of truth (Pika 2012). Language of science must be understood to all scientists. So, mathematics[10] is such language—a sort of monism. Why? I think it all came from the Greeks. Kline (1982) wrote that "the Greeks discovered the power of the mind," which the man is endowed with, with

[9]In personal notes "Equinocial Regions of the New Continent during Years 1799–1804" (London 1814, Vol. 1, pp. 34–35) about his wanderings, Alexander v. Humboldt wrote: "The very nature of sublimely eloquent. Stars as they shine in the firmament, fill us with joy and ecstasy, and yet they are all moving in the orbit determined with mathematical precision."

[10]The word "mathematics" comes from the Greek μαθημα (máthēma), meaning language, "what is taught," i.e., "Science." That is why the attitude to mathematics as "the science of sciences," "the queen of sciences" (Loktev 2013).

"the mind, which, based on observation or experience, is able to discover truths" (Kline 1982, p. 19). Mathematics, in turn, united, and unified the whole science. Well, there is more on that below.

I've stated earlier that under processing observations and experiments as well as under constructing hypotheses and formulating the laws of nature, Science utilizes the scientific method of induction that states that "the observation of phenomenon *X* corresponding to hypothesis *Y*, increases the probability that the hypothesis *Y* is true." Therefore, the recipe of the scientific method is seen the following three points:

(1) First of all, we build a kind of intuitive hypothesis or assumption *Y*;
(2) then, we observe a number of phenomena, using man's sensory cognitive abilities and draw a conclusion that is based on the man's capacity to the abstract thought and strict laws of formal logic, and particularly, on the principle of induction;
(3) the latter corrects the hypothesis *Y* and converts it into the final hypothesis *Y′* that explains these and other observations. As a result, the hypothesis *Y* either is rejected or becomes the truth, i.e., the law. And, whether is actually that, strictly speaking (sic!—tautology), logic that governs the nature, the nature that acts by the laws we—the human mind—ascribe to it?

Actually, whether mathematics, as a continuation of the logic (Russell 1903), is that fount of rigor, "immutable truths in themselves and truths about the laws of nature?" (Kline 1982).

Paradoxically, the induction principle is self-contradictory itself, and it is contrary to our intuition. This fact has been formulated as a paradox of confirmation (Hempel 1943), the paradox of "black ravens" of Hempel is expressed in statement that "All ravens are black." Being far of a skeptic, I would not say so affirmatively that the Hempel paradox has yet been finally resolved, although the principle of induction could be replaced by Bayes' theorem (Bayes and Price 1763; Efron 2013).

Taking a pause, I note on one side that, to my mind, the paradoxes in science could shake the foundations of the theory of science in general and induce the paradigm shift that was introduced by Kuhn (1962) in his book "The Structure of Scientific Revolutions."[11] On the other side, if logical paradoxes arise, whether does that mean the logic we invoke for our cognition of nature, i.e., the logic that is the foundation of knowledge, and, hence, of the science, is flawed and should be replaced by a more suitable for these purposes?

[11]To complete this Section, I would like to illustrate it with the quotation from works of Osip Mandelstam (1972): "Contradictory views, or paradoxes, played a significant role in the history of science. Two kinds of views are in conflict, and the latter causes a further movement of science forward giving the development of this conflict."

Digitizing of Society and Science

All Things Are Numbers

[Everything is a number]

Pythagoras of Samos

… the Pythagoreans… took numbers to be the whole of reality, the elements of numbers to be the elements of all existing things, and the whole heaven to be a musical scale and a number

Aristotle, "Metaphysics"

Again, I recall my school days before the Millennium. Information at that time either dropped out with ink droplets from our pens (raise your hands, readers, who still remember them?) or resulted from a scratching of blackboard in the classroom by piece of chalk. I recall that at that time there still were working horses—"now they are a rather expensive entertainment and kind of unit" as Huseynov (2014) wrote on the pages of "Novaya Gazeta." Now, in the Millennium, novels are written in the SMS formats on smartphones (among other things, a very handy gadget to store, which, however, is losing to slate, if it is used without the mobile phone option). People use Instagram and post selfies, saying literally, at random, with no need that glossy magazines are crying: a man, living at this speed and within such a dense information environment that includes use of transport, loses his/her own personal informational self-space and starts to identify themselves with the face of the selfie kissed by "like" kind of informational bits and glances at the smartphone, as some kind of a his (her) body part.[12] The elders witnessed that in particular. They are "digitized" as $60(=XL)^{+}$.[13] Everything is cloned by means of 3D printer.[14] The information world has become confusing or, as they say in the quantum theory, due to Schrödinger, "entangled" ("Verschränkung"). It is sort of network, kind of "*cheloveinik*" (precisely in Russian meaning man-ant-hill (Zinoviev, 1997). Oxymoron!

The outlined picture is not, however, so depressive as it looks. Within the context of these Theses, science after millennium becomes livelier (Palagin 2014). Actually we live in a time of transition from informational to the knowledge-oriented society which is based on sophisticated informational technologies. These technologies provide the user with any possible level of solving problems of the highest complexity. These are the technologies which provide the rapid progress of modern civilization. However, I believe, this implies the end of science as a cognitive activity. Though in fact, if there exist some equations that describe everything or nearly all phenomena of nature, then, according to this point of view,

[12]The first place in Russian Web (Ru.net) is taken by search of the words "to download (watch, listen) for free"? (Zinoviev, 1997).

[13]Do you actually meet 70+, 80+, and so on somewhere? By the way, the author of these lines is still lingered in the "group" aged 60+.

[14]There appeared some information that 3D printers which can print food and for which "there is nothing impossible" are brought to Kiev. Thanks God, XL-printers that can breed babies in test tubes and get the smell of the earth after the rain have not yet been invented.

they can be solved. That is, in the other words, the truth is achieved. What remains then for Science? With this question mark, I would like to close this part.

Now, I think, it is the right place to return to the *Y* hypothesis. In the majority of cases, it has a physical content. In the other words, it is based on the conclusions borrowed from physics as one of the science areas itself and about which Ernest Rutherford, who treated himself as a physicist said (after was awarded with the Nobel Prize in Chemistry in 1908): "All science is either physics or stamp collecting." Whether it sounds quite ironically that the word "physics" originates from the Greek (Greek, again!) word "φυσιζ," meaning "nature," or precisely, "a study of nature" (Bayes and Price 1763)? A kind of monism, again. Within this context, the rejection by Newton of physical terms and the introduction of mathematized equations and transformation of the whole of physics into his "Mathematical Principles of Natural Philosophy" become clear.

Later on, this idea, the doctrine of logical empiricism—to unify, to mathematize science—was the key one in a so-called Vienna circle (see Stanford Encyclopedia of Philosophy, n.d.), where such famous scientists as Hans Hahn, Moritz Schlick, Philip Frank, and Rudolph Carnap tried to show that all science can be exclusively incorporated on the basis of mathematics and symbolic logic and, in this sense, computerized or "digitized," according to the Stanford Encyclopedia of Philosophy (2011). Carl Friedrich von Weizsäcker came up with the similar conclusion, little later, when in the mid-1950s suggested his own *Ur*-theory or the theory of *ur*-alternatives (archetypal objects) (von Weizsäcker 1971, 1992, 2006; Görnitz 1988; Lyre 1995). According to this theory, everything in the Universe, either matter or energy, is actually information. The main thesis of his theory is "*Energy is information.*" Von Weizsäcker called this approach "radical atomism." He defined the information of an event as the number of completely undecided binary alternatives that are decided by the occurrence of the event. Within the same theory, He postulated that an arbitrary object (matter) can be partitioned into the smaller composed pieces—Is there a limit to divisibility?—until all statements about it are reducible to binary inferences: "yes" or "no," "plus" or "minus," "be" or "not to be," "0" or "1," and so on, namely the Boolean algebra (see, e.g., Hansen, n.d.). To realize this view von Weizsäcker looking for the most elementary form that can be really there investigated the term of information. He states that information can be defined as the quantity of form. In fact, von Weizsäcker's *Ur*-theory is a form of digital physics or, more generally, the digital sciences, which roots at the "Vienna circle".[15] The basic postulate of *Ur*-theory is the existence of such mapping:

$$U\colon [\boldsymbol{H}] \to C^{2\otimes n} := \bigotimes_{n} C^2 \qquad (1)$$

[15]If to talk about the digitalized science, we can think of Neptune Planet, which was "discovered on the tip of a pen" by American astronomer Percival Lawrence Lowell (Liubarsky 1983) (thereby obscuring the role of numerous observations of the motion of the planets, which led to this "pen"), and, then, was "re-discovered" with the help of telescope.

between the quantum state vector $|\psi\rangle \in \boldsymbol{H}$, the Hilbert space of quantum states, C^2—Hilbert space of Boolean functions, or *ur*'s, i.e., f: $Z_2 \rightarrow Z_2$ where $Z_2 = \{0, 1\}$ is a bit (see, e.g., Nielsen and Chuang 2000; Kryachko 2011). The minimal *n*, for which the mapping (reflection) (1) is reversible, called the information content of the given quantum state, or the number of *ur* (von Weizsäcker 1971, 1985, 1992, 2006; Görnitz 1988; Lyre 1995). It is worth noting that for the photon, *n* is large and reaches about ≈1030, which is in line with the arguments of Eddington (1931) and of Dirac (1937).

Ur-theory of von Weizsäcker is one of the forms of so-called numerical physics, a part of the "pancomputationalism," which is based on assumptions that Universe is computable and, therefore, can be described with the use of information. Quantum Digital Physics was recently developed by Deutsch (2001), Zizzi (2003) and the others. In this regard, it is worth to mention the 2013th Nobel Prize in Chemistry awarded to Martin Karplus, Michael Levitt and Arieh Warshel "For the development of the multiscale models for complex chemical systems" (see, e.g., Kuzmin 2014). From the point of view of the Digital Physics, the entire Universe can be hypothetically observed as a huge quantum computer (Wolfram 2002; Schmidhuber, n.d., 't Hooft 1999; Lloyd 2006) that models its own future!

Science in the Modern Society: Change of Paradigm

For knowledge, too, is itself power

Sir Francis Bacon

In his work "Scientific Thought as Planetary Phenomenon," V. I. Vernadsky (1997), the first President of the National Academy of Science of Ukraine acclaimed that biosphere of the twentieth century becomes *noosphere* created, first of all, by the progress of science, scientific understanding and, based on it, the social labor. A. D. Sakharov shared this view of observing science as a part of civilization (Gorelik 2004), part of the Noosphere which notion was introduced by Vernadsky (2004). In his lecture "Science and Freedom," Sakharov (Gorelik 2004) concluding the results of the twentieth century, reminded that it was the century of world wars and genocide, but, nevertheless, called it a century of science that (Gorelik 2004):

1. On the "end-in-itself" basis carries out the desire of the mind to knowledge;
2. Becomes the main labor force, and;
3. Unites the mankind.

According to Marx and Engels (1969), science is a "general social knowledge," "general powers of the human head," and "general intellect." Science is permanently developed and during the first scientific and technological revolution becomes a labor force. With the beginning of the twentieth century, science united with the production: machinery, automatized production, use of computers. Further, we witnessed a unity of science and production via fusion of science and production through engineering and pipeline organization of production. At that particular time, science became the main production force that uses scientific knowledge to design and develop new technologies on the basis of science. The latter—which provide the production of more than 90% of the social product—presently replaced the traditional natural technologies. These are, in particular, nanotechnologies, called the technology of the twenty-first century, and development of new materials such as fullerenes and graphene. Distinction of science from the other types of human activity lies in that an important role the element of insight, creativity, genius, and search of an idea that alike the others play in science. However, science is not only a labor force. It is a form of social consciousness that reflects a reality, in a form of systematic knowledge that it exists regardless of the knowing man.

The contribution of the fundamental sciences is extremely important. And here, in my opinion, there appears a modern paradox which has globally changed the public consciousness. On the one hand, the fundamental science went into the status of the labor forces and, on the other hand, modern production, demanding "the implementation of scientific research and scientific approach, began increasingly resemble to science" (Turchin 2000). In the process of production—which creates the product of labor including both material goods and services in the case of material production and a new knowledge as in the case of science—the labor forces enter into industrial relations. The latter determine the distribution of wealth within the society that is necessary for its existence and development and for human needs fulfillment. The distribution depends on the work and carried out in accordance with the quantity and quality of labor. Product of science is a knowledge which is represented as a set of data, or information: the data gathered in articles, reviews, books, dissertations, reports, patents, and so on. Information becomes a "tool of trade" in science and "behaves as a commodity" (Arrow 2014). This, in turn, in my opinion, makes it much less idealistically attractive, as I would say, in comparison with what was science of the middle of the last century, when quantum mechanics was establishing and its ideas (and, of course, the information) were simply floating "in the air." In contrast to the product, which is sold once, information can be sold repeatedly (Arrow 2014).

Number of scientific journals, which are indexed by three citation databases on the WEB of Science Thomson Reuters (ISI)—Science Citation Index, Social Science Citation Index and Arts and Humanities Citation Index—and Scopus (Elsevier). The last database consists of information on ca. 31.234 peer-reviewed scientific journals, while Web of Science of about 19,538 items. 15,189 among them are indexed by both databases. Speed of increase of number of scientific publications is also discussed in Larsen and Ins (2010) and Lotka (1926).

At present, the entire population of the Earth reaching for about seven billion creates trillions of gigabytes[16] of data. Science creates most of them and creates in a format of information. Dimensions of the last information space, which could be called as “science capacity,” are shown in Fig. 17.3. The dimensions are impressive! Everything points on rapid science development. It is known that by the end of 2013, every 20 s new scientific article was published. And, do you remember of an Indian emperor Ashoka the Great who was reigning in India during III B.C. and who developed “The Secret Society of The Nine Unknown,” which was slightly reminding of modern scientific institute and which consisted of nine greatest Indian scientists and sages? Their task was to systematize all scientific knowledge and to present it in form of catalog, which was received from ancient sacred manuscripts as a result of observations and experiments. Each of “The Nine Unknown” wrote one volume, which was dedicated to one of the fields of science. Nine volumes! But if now we make a list of articles, which were published in the world we can see that in 1880 this number was 100 pages, in 1920–500, in 2013—11,000 that is about 1.5 million titles a year! According to the forecast of International Data Corporation (IDC), the amount of data developed and stored by the society will reach number of 40,000 Eb, which is 5200 Gb per capita by the year of 2020. 100 g of DNA would be enough to store all this information. This fact makes us truly believe in the future development of DNA-based computers. And, all these “tons” of information are only to satisfy a man’s trait to curiosity—recall the quotation from Aristotle’s “Metaphysics” that starts the present Theses—which will exist forever. However, as science is a main labor force, knowledge must be beneficial and should bring benefits. What are those criteria which are similar to those of assessing the quality of material goods, which can evaluate a quality of new knowledge? What do actually “quality of science” mean? Is it clear that the key criteria should be that which can assess the manner to treat a new knowledge as “beneficial”?

In society, there is a point of view that, in my opinion, does not logically infer at all from the “profitability” of knowledge. To specify, this viewpoint is that “benefit” directly correlates with citation of a given work in any its format: articles, reviews, or books containing this knowledge. The general point is that between three components—the article, perusal of it, from one side, and a new knowledge, from the other, resulted from this article—lays the process of reading and thinking, the process that is constantly changed and still absolutely unknown, as a “thing-in-itself.” Therefore, the following criteria of a “profit,” “marketability” of knowledge, and as a result, the criteria of appropriateness of a researcher lie at the heart, in scientometrics in particular:

[16]Bit is the main item of classical information in computational and digital communications. Epistemologically, this word comes from “bheid” meaning a “part” (Smirnov 2013). However, there is an opinion that this word came as a short form of “binary digit,” receiving only two logical values or states: either a “0” (logical value “false”) or “1” (logical value “true”).

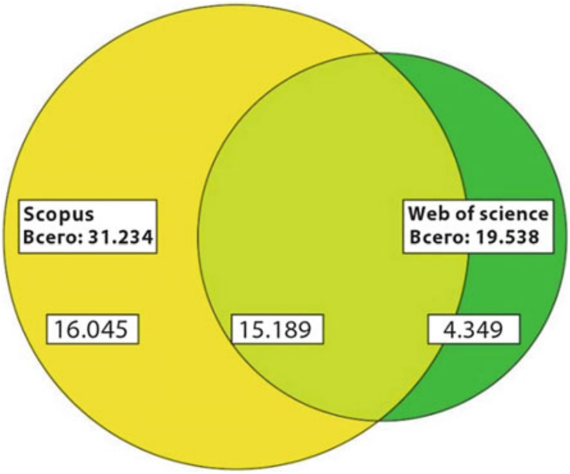

Fig. 17.3 Reproduction of the picture “Jump into the Future.” Reproduced from Zatsman (2012). *Source* Zatsman (2012)

1. Citation Index (CI) that illustrates a level of publishing in peer-reviewed journals with high impact factor, and;
2. Hirsch Index *h* (see, e.g., Hirsch 2005; dos Santos Rubem and de Moura 2015; Nature Physics 2013; Pyykko 2006; Khantermirov 2014), which is one of the most widespread criteria of impact of the scientific papers.

The following thoughts on these criteria rise immediately and naturally. First of all, it sounds paradoxical: If a new knowledge is the knowledge about the outer world, then its “commodity” is determined by this outer world, though, strictly speaking, the mentioned “worlds” are alike. Second, another conflict is whether these two criteria are sufficient to measure the effectiveness and quality of science carried out by given researches, and to address its funding issues. True, these criteria are, generally speaking, inadequate in the scientometrics, as it is known from a number of collisions in the literature (see, e.g., Sigmund and Wallin 2009). Herewith, Évariste Galois could have *h* equal to 2; Einstein’s general index *h* ranged somewhere between 4 and 5, which is lower the average $h \sim 10$–12 among PhD students. In conclusion, the following question arises: Whether quotation is seen as that particular criterion to determining the scientific work and its “marketability”?

The answer to this question will be given in the next section. However, the following facet of this answer is worth mentioning right here. Recall the Preamble of these Theses. The reform of the RAS was held after the Russian Academy of Sciences in 2012 set up the “evaluation process” based on 130 criteria, including an involvement in international cooperation, effectiveness of the work, commercial potential of research and development, resource availability, future-orientation, etc.

(Dezhina 2014). It was concluded that 290 of 297 Institutes of the RAS are effective, which has been considered as inadequateness of these criteria and, in general, the inapplicability of the "digitization" of Science.

Effectiveness and Quality of Science: Expert Appraisal

I do believe that, despite the fact that the problem of "digitizing" efficiency, quality and value of scientific work (Dezhina 2014; Russie.Nei.Visions 2014) is as old as science itself, its correct formulation lies in somewhat different plane. In fact, Science is a human activity aimed at production and creation of new knowledge on the way from ignorance of this phenomenon(s) to the truth. Therefore, the above criteria should be based primarily on understanding of how close this research is to the truth? According to Kant, "the question is to find the universal and true criterion of the truth for all knowledge" (Part II.III. Kant 1770, 1994). Relevance of closeness to the truth of a scientific production is definitely a subjective matter. None can force the authors of production (work) to refer to those works in which, in their opinion, the truth is not yet reached. I admit that this criterion does not require a standard bibliographic search of the number of references. Speaking generally, the correlation between the number of references to this work and its proximity criterion of truth remains poorly understood. Is there such a correlation at all?

And the other way round—we may assert the hypothesis that the proximity of a given work to the truth can be measured by a group of researchers working in the same area. This constitutes a so-called expert evaluation which was established itself as the most reliable and valid approach to the analysis of scientific activity (Van Raan 2005; Derrick et al. 2011; Mryglod et al. 2013).

This might sound rather naïve, but let consider any scientific work as an object, an element of the external world that we aim to cognize. We perceptionally contemplate the work, as well as a phenomenon, and develop its conceptual representation as well as about the phenomenon that it is modeling. Hence, the closer to the actual simulated phenomenon to the studied one, the closer this work to the truth. I assume my viewpoint is quite clear, even without mentioning Goethe: "It is a shame that the truth is so simple." Well, let us move then further on.

The main message of this section is the following: Alexander von Humboldt Foundation or any of its sub-organisms, such as Humboldt Clubs, for example, represents a sufficient and extremely convenient expert panel for assessment of the scientific work on the basis of the criterion of its proximity to the truth.

Conclusions

Agree with me, or criticize me

[Agree or criticize me]

Ya. B. [Zeldovich]

All people, by its nature, seek to serve the Science

(rephrasing Aristotle)

*Bow **[remains]*** as TV producers say. That is, findings, conclusions, and thinking around them. Seriously, I will agree: Theses are somewhat subjective and a bit ragged. I always suspected that my attitude toward science is kind of emotional. Consequently, it is illogical and partly kanterian, as, already, probably, noted by part of readers.

Since the time of the reform at Russian Academy of Sciences (2012), I read much about the philosophy of Science, Science of Science, Scientometrics, trying to understand where is the reason for reforms of RAS, which is the oldest institution in Russia and was established by Peter the First in 1724. And now, partly rethinking, I put it all in my thesis.

I cannot judge the quality of these theses outlined above. Although I think they are, firstly, shed light on Science from a slightly different angle, which is, in fact, a point of view. And, secondly, they are not so bad, as do not satisfy so-called incomprehensibility principle, introduced by Fraser (2013): "The intensity of attention multiplied by its span cannot exceed some fixed value." At least one of the Theses that are worth of attention is the following:

> If we assume that those criteria for assessing the scientific production of the RAS, which were mentioned in Section "Phenomena, Contemplation and [Beyond]", would be equivalent to criteria 1 and 2 of the Section "Digitizing of Society and Science", the reform of the Russian Academy of Sciences is unjustified, as these criteria do not correspond to the key performance criteria of science, which prioritizes the Kant "Truth and only Truth" (with a Capital Letter). The Latter cannot be measured with the citation and Hirsch indexes![17]

I regret that I couldn't tell more. Firstly, it is "About perpendiculars." Although in science person acts as an observer of the nature, of the Universe, cognizing its truth, he is its integral part, which is rather confused by nature itself. And, as Jean-Jacques Rousseau in his novel "Émile" (1762): "We do not know what our nature permits us to be." Second: "About the parallels." Theses, actually, began with a citation of Aristotelian "Metaphysics." You know, when in the I century BC Greek scholar Andronicus of Rhodes republished manuscripts of Aristotle and "Metaphysics," in particular, he joined in the last treatises of Aristotle, in which he addressed the issue of existence and knowledge, titled "The fact that after physics" (*ta meta ta physika*). That after (above) Physics—is metaphysics, is a method of

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[17]It is more than enough to think of *h*-index of Einstein and his work on the EPR paradox (Einstein et al. 1935).

philosophical inquiry, is not based on sensible intuition, and speculation on intellectual contemplation. In this regard, I remembered about my visit to Bonn in 2012, where I was among awarded with the research grant of the Alexander von Humboldt Foundation within the Forum in the "The New Desire for Metaphysics" (Bonn, October 24–28, 2012). I am sure, for "Workers of intellectual labor" as Landau, such conferences are vital. At this—I would like to put an end point.

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