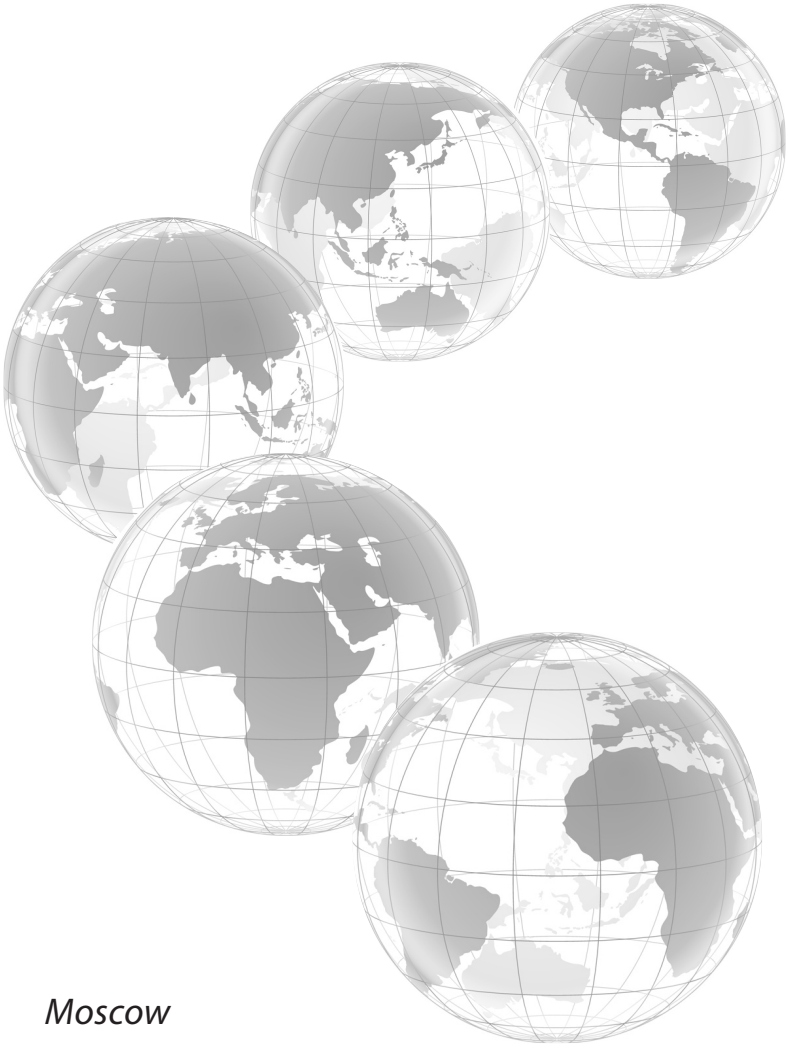
INTERNATIONAL SCIENTIFIC AND EDUCATIONAL JOURNAL

PARTNERSHIP OF CIVILIZATIONS

№ 1-2/2013



Moscow

THE EDITORIAL BOARD
A.I. Ageev
(Editor-in-Chief for "The Partnership of Civilizations" Journal)
T.T. Timofeev
(Deputy Chief Editor)
S. Farah
(Deputy Chief Editor)

O.P. Yermilina
(Executive Editor)
N.M. Guseinova
(Literary Editor)
Yu.V. Dorovskaya
(English translation)
B.D. Shulgin
(Design, Layout)
Yu.V. Strelnikova
(Proofreader)
I.P. Yershova
(Printing Manager)
V.M. Kokuev
(Internet Projects)
N.A. Piskunova
(Subscription Department)

Opinions of the authors of published material do not always reflect the views of the scientific and editorial board and team. The editors bear no responsibility for the accuracy of the information contained in advertisements.
The editors reserve the right not to enter into correspondence with authors. Submitted materials will not be returned.
Any use of materials published in «The Partnership of Civilizations» journal is subject to written consent of the editors.

All inquiries about e-subscription to "The Partnership of Civilizations" journal should be addressed to: (495) 234 4693; e-mail: Piskunova@inesnet.ru (the reference should be made to e-subscription to "The Partnership of Civilizations" journal)

Editors' address:
Office 4, bld. 1, 6/1, Sretensky Blvd., Moscow, 101000, Russia
Tel./fax: (495) 234 4693

© P. Sorokin — N. Kondratieff International Institute
T. 2, № 1-2(5)
Frequency of appearance — 4 times a year.
Number of copies 1,000
Free price

THE PUBLISHERS
- Pitirim Sorokin-Nikolai Kondratieff International Institute;
- Institute for Economic Strategies;
- MGIMO-University Center for Partnership of Civilizations;
- Center for Civilization Studies of the Institute of Europe RAS;
- International Futures Studies Academy;
- Lebanese-Russian House;
- Organization for Promoting Global Civilization (China).

THE SCIENTIFIC EDITORIAL BOARD FOR THE PARTNERSHIP OF CIVILIZATIONS JOURNAL
Yakovets, Yuri Vladimirovich — Professor, RANS Academician, President of the Pitirim Sorokin — Nikolai Kondratieff International Institute (Chairman of the Board)
Ageev, Alexander Ivanovich — Professor, RANS Academician, Editor-in-Chief of the journal, President of the International Futures Studies Academy (Deputy Chairman of the Board)
Farah Suheil — Professor at the Lebanese University, RAS and RANS Academician (Deputy Chairman of the Board)
Bolshakov, Boris Yevgenievich — Professor, RANS member, Head of the School of Sustainable Development
Valiev, Khussain Khasenovich — Professor, member of the Parliament of the Republic of Kazakhstan
Vinokurova, Uliana Alexeevna — Professor, RANS Academician, Prorector of the Arctic State University of Arts and Culture
Glaziev, Sergey Yurievich — RAS Academician, RF Counselor to the President
Zapesotsky, Alexander Sergeevich — RAS corresponding member, RAE Academician, Rector of the Saint Petersburg Humanitarian University of Trade Unions
Kuzyk, Boris Nikolaevich — RAS Academician, Director of the Institute for Economic Strategies
Malitikov, Yefim Mikhailovich — Professor of Chicago and Denver University (USA), President of the International Association "Znanie" ("Knowledge")
Mathews Robin — Professor at Kingston University (UK)
Maurice Aymard — Professor, Higher School of Humanities and Social Sciences, General Secretary of the UNESCO International Council for Philosophy and Humanistic Studies
Popov, Veniamin Viktorovich — Professor, Director of the Centre for Partnership of Civilizations of the Institute for International Research at Moscow State Institute for International Relations (University) under the RF Ministry of Foreign Affairs
Petrosyan, Valery Samsonovich — Distinguished Professor of the Moscow State University, RANS Academician
Timofeev, Timur Timofeevich — RAS corresponding member, Director of the Center for Civilization Studies of the Institute of Europe RAS
Zhang Shaohua — foreign member of RANS, chairman of the Organization for promoting global civilization (China)
Chistilin, Dmitry Konstantinovich — RANS foreign member, President of the Simon Kuznets International Institute for Self-Organization and Development (Ukraine)
Shmelev, Nikolai Petrovich — RAS Academician, Director of the Institute of Europe RAS

Vernadsky

Opening Remarks of the Editor-in-Chief

People are often compared to a candle, sun, star, river, ocean, etc. They do so out of a desire to find an appropriate starting point in trying to measure the scale of the individual. But there are individuals who are themselves perfect. Vladimir I. Vernadsky is among those few.

Sometimes the development of science and human thought in general is imagined as a stream or as a leapfrog game, where the followers stand on the shoulders of predecessors, involuntarily writing them off to the archive. Such idea is not always true. A more accurate description seems the description in terms of mountains and landscapes. Tops, peaks — that is what essential, what sets the tone both to space, and time, and imagination, and memory.

Vernadsky is the top, the requirement of its cognition is constant in the requirements for a real scientific search, real education, real culture, and real civic consciousness. About such peaks it was once said from the stand by philosopher: «He should be read standing…».

Vernadsky, as the mouth of the powerful river and the beginning of the great sea, embraces many strands, ways of human thought. This continuity and organic scientific inheritance in Vernadsky is framed by teachers, students and colleagues of V.I. Vernadsky who had also their predecessors, successors, and colleagues. Thus, in St. Petersburg University the teacher of the future Academician was V. Dokuchaev whose own research genealogy goes back to A. Butlerov, I. Mechnikov, D. Mendeleev. When Vernadsky was 20, V. Dokuchaev in the doctoral dissertation defended the foundations of the landscapes doctrine. If it existed the Nobel Prize in 1900, for the world scientific sensation about natural zoning, relationship of animated and inanimate nature, V. Dokuchaev, would no doubt have become its winner. When Vernadsky was more than 60 years, he identified the shells (geospheres) of the Earth differing by physical and chemical, thermodynamic properties, and created in the USSR Academy of Sciences the Division of Living Matter. It is easy to see the deep continuity between the efforts of Dokuchaev and Vernadsky. For solutions in the radioactive elements close to Vernadsky's approaches his international and national colleagues have received the Nobel Prize. And Vernadsky saw the award in its own name when alive.

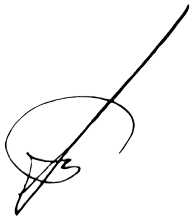
Vernadsky's research school alumni — outstanding geologists and physicists, science managers and innovative breakthroughs, and governmental officials. Especially it is necessary to recall his son George, one of the founders of the American school of Russian historiography. George's grandfather in 1858, several years before the birth of V. Vernadsky, published the first in Russia, «Essay on the History of Political Economy,» and one of the first in Russia researches on geopolitics. And even earlier ancestor was among the Cossacks the circle of Bohdan Khmelnytsky. Thus, by horizontal and vertical of genetic and intellectual relationships it was formed phenomenon of the great scientist. The 150th anniversary from the day and many generations before his birth absorbed the unusually capacious and richly equipped history of human thought with the history of human thought, research and public service, and selfless devotion.

From his ancestors and from his father, Actual State Councilor, which was a very high status in the «table of ranks» of the Russian Empire, V.I. Vernadsky inherited a bright life position: he is a member of the zemstvo movement, a member of the Central Committee of the Constitutional Democratic Party and the State Council, the founder of a number of institutions and high-level commissions still operating.

Vernadsky is not the only scientist whom stumbled over the tsunami of mass and selective terror and tectonic social shifts of the first half of the twentieth century. But, perhaps, he is the only one with such a track record, it would seem clear the «execution», who not only survived, but who worked, created, kept and saved — the science, other people (scientists, officers), the honor of scientist and citizen. And this very fact allows us to talk about the time of his life not so widely, as is often the case in the debate. Something very important is still hidden from us in how to live with dignity in any times, including such as «executions are going

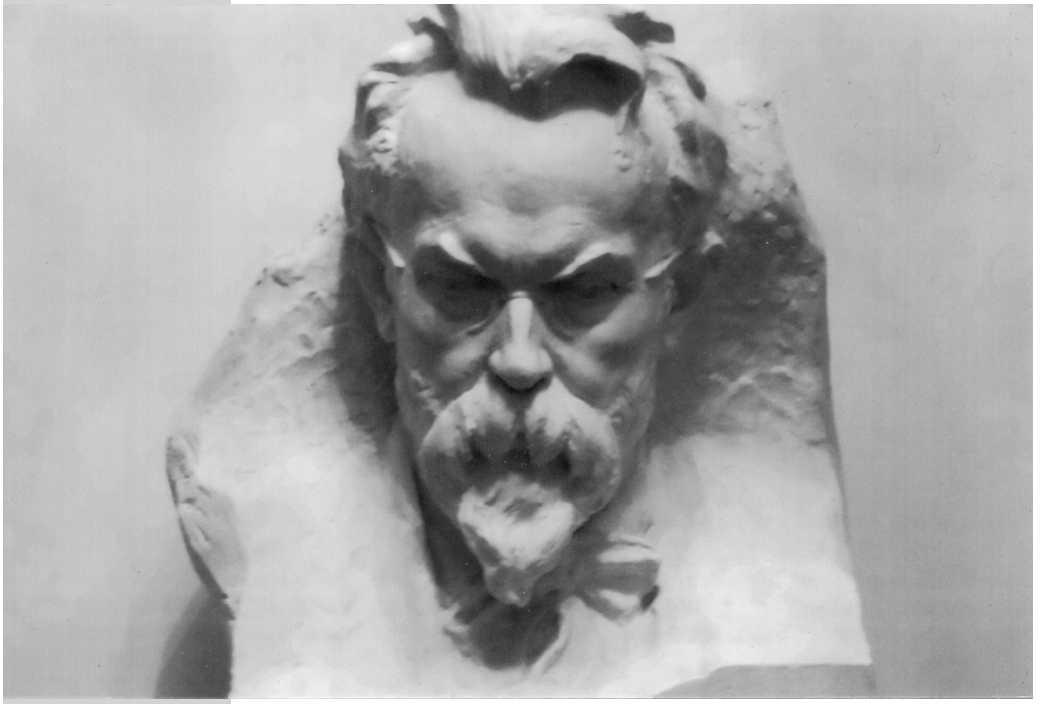
constantly, at the local Chekas hooligans, robbers are dominated» or when «new barbarism» is spreading like an epidemic in science.

Over the decades of his diverse activities Vernadsky presented to science, many industries, including nuclear, to the states — Russian, Ukrainian, Kazakhstan, to the world his powerful ideas and the energy of his personality. Vernadsky by the power of his thought and personality became the generator of evolution of the noospheric force, the end result of its evolution is «still hidden from us.»



A.*I.Ageev,* Editor-in-Chief For
"The Partnership of Civilizations"
Journal, Professor, RANS Academician

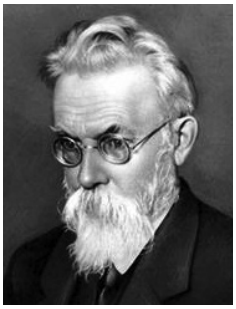
Contents



Vladimir Vernadsky a Genious of the World Science

Vladimir Vernadsky — a Genius of the World Science

Vladimir Ivanovich Vernadsky is a great Russian scientist-encyclopedist, who recast many branches of knowledge, laid the cornerstones of the evolving noosphere and the scientific revolution of the 21st century.



Yu. V. Yakovets,
President of the Pitirim Sorokin — Nikolai Kondratieff International Institute, Dr. Sc. (Economics), Professor, RANS Academician

"His sincere life Vladimir Vernadsky dedicated to science for Human and in the cause of Human. He was able to see the Earth from space for half a century before the first space flight, he descried ... the continents and oceans, rocks and living things, human, minerals, atoms and molecules, he saw that "a human for the first time becomes a geological force that changes the face of our planet… Its comprehensive mind ... reminds us of Aristotle, Leonardo da Vinci, Lomonosov, Buffon, and Humboldt."

A.L. Yanshin, Vice-President of the USSR Academy of Sciences

V.I. Vernadsky developed and enriched a body of Earth Sciences, created a number of new branches of natural science. *"V.I. Vernadsky has not just enriched the vast body of knowledge that is now termed the Earth sciences, but so transformed their theoretical basis, that without his theory of the biosphere and biochemical processes, the role of living matter in the life of our planet, these sciences cannot be imagined today. He understood the relationship between geology, mineralogy, crystallography, hydrogeology, hydrochemistry, soil science, geography, biology and all of them with physics and chemistry deeper than anyone else, being aware of the necessity of such their interaction. He, more than anyone else, saw the problems comprehensively and globally... The writings of Vernadsky laid the foundation of many new research directions and new sciences — genetic, mineralogy, radiogeology, hydrogeochemistry and biogeochemistry, the doctrine of the noosphere and the planetary role of living matter."*

S.R. Mikulinsky,
USSR AS corresponding member

Vernadsky laid the foundations of the nuclear science, predicted the great importance and a concurrent great danger of nuclear energy to human development:

"We are approaching great breakthrough in the life of humanity, which cannot be compared with those previously experienced. Time is not that far when human will get nuclear power in his hands, a source of such power that will enable him to build his life as he wants ... Will human be able to use this power and to direct it for good and not for self-destruction? Is he mature enough to be able to use the power that would inevitably be given to him by science?

V.I. Vernadsky 1922

V.I. Vernadsky created the doctrine of the biosphere and the inevitability of its transition to the noosphere - the sphere of reason.

"Humanity taken as a whole becomes a powerful biological force. The issue of the realignment of the biosphere in the interests of freely thinking humanity as a unitary whole comes before it, and its thought and work... The noosphere is a new geological phenomenon on our

planet, its where human for the first time ever becomes a major geological force. He can and must realign the area of his life through his labor and thought, realign drastically compared to what it was before."

V.I. Vernadsky, 1943

The doctrine of the noosphere is the fundamental basis of global sustainable development, establishment of the humanistically noospheric civilization in the 21st century.

V.I. Vernadsky deeply studied the history of science, a theory of the dynamics of scientific knowledge, and the explosion of scientific creativity, has shown the key role of science in the biosphere- noosphere transition and the modern state system.

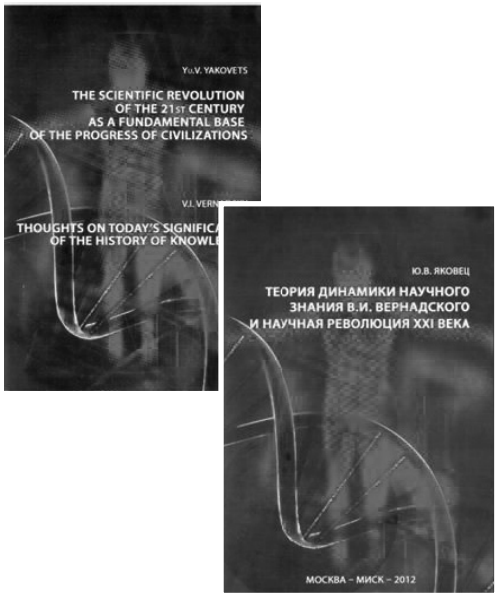
"We are approaching a new era of humanity and life on our planet in general, when the exact scientific thought as a planetary power comes to the fore, penetrates, changing the whole spiritual life of human societies, it covers and modifies the technology of life, creativity, philosophical thought, and religious life ... "

V.I. Vernadsky

The irregularity is incident to the course of scientific thought, periods of acceleration and deceleration… "Explosions of scientific creativity repeating down the centuries, indicate that the periods repeat down the centuries when richly endowed personalities are accumulated in one or several generations, in one or many countries, the ones who create a force that changes the biosphere. "

V.I. Vernadsky

The theory of the dynamics of scientific knowledge and the scientific explosion of creativity is the basis of the scientific revolution of the 21st century, the establishment of a new paradigm.



The greatness of the academic heritage of V.I. Vernadsky and his importance to the present was revealed by Professor S.P. Kapitsa and Chairman of the RAS Commission on Academic Heritage of V.I. Vernadsky Academician E.M. Galimov in the television series "Obvious but Incredible," March 12, 2011

"The salience of Vernadsky and his teachings is in the amazing, I would say, duration of its sounding. Vernadsky is not so much a researcher as a philosopher, natural scientist, and naturalist. He was able to generalize and see in what was arising in life and in science, that continuation of the future that people had not yet seen."

E.M. Galimov, RAS Academician,
Chairman of the RAS Commission
on Academic Heritage of V.I. Vernadsky

"Vernadsky laid the foundations of the industrial radiochemistry in our country when it was not yet on such scale, as it was required in the nuclear project. And here, in my opinion, the role of his followers is very large ... His program for the extraction of radium from natural waters is alive. This has also given much to radiochemistry, for the ability to deal with such substances. "

S.P. Kapitsa, Professor,
Honorary Vice-President of the RANS

V.I. Vernadsky was the founder and the first president of the Academy of Sciences of Ukraine, elected member of the Czechoslovak Academy of Sciences (1926), the French Academy of Sciences (1928), a member of many scientific societies. His teaching has got world-wide recognition.

The Theory of Dynamics of Vernadsky's Science and the Scientific Revolution of the 21st Century

*Thoughts on Today's Significance of the History of Knowledge**

Report at the meeting of the USSR Academy of Sciences Commission on the History of Knowledge, October 14, 1926

V.I. Vernadsky

I

The time we experience is an amazing time in the history of humanity. One has to look similar to it in the distant centuries of the past. This is a time of intense realignment of our scientific worldview, a profound change in the picture of the world.

The ideas about the world around that humanity of the West has entered into the 20th century, despite all the achievements of natural science, mathematics, historical sciences, technologies, which can characterize so vividly the 19th century, were essentially a result of a gradual and steady development of the principles and constructions of a new era, being prepared in the 16th and clearly spilled over into the 17th century, when even earlier achievements of Copernicus and the path made by Columbus, new mathematics, new philosophy, radical breaking of ideas about organization and position of human in the world told finally on the scientific efforts.

The 20th century brings with ever-increasing intensity already fundamental changes in the understanding of the world of the new time. This is a change of another magnitude than those created in the last century. They are similar to those which were contributed by philosophy, science and technology in the early 17th century to the worldview of the Middle Ages.

It is possible that we are experiencing an even more change. Perhaps, such experiencing turn of scientific thinking is more

** The report is reprinted from: V.I. Vernadsky. Works on the Universal History of Science. M.: Nauka, 1988 p. 213*

like the old crisis of spiritual life, the one that occurred two and a half thousand years ago, in the 6th and the nearest centuries B. C., when the great Hellenic science was created, technology flourished and for the first time a philosophical thought took familiar forms close to us in the Mediterranean cultural center, and in the religious quest, in the mysteries, the utmost deep intuition took place, the search for the meaning of existence.

The rise, sudden and bright, of the Hellenic genius appeared not once in the 19th century and in the earlier centuries, as a great miracle until it has been identified the movement of thought of the preceding time.

In the distance of the centuries other the same drastic realignments of spiritual consciousness of human, expanding his horizons and grasping of the world around by his thought, are opened up before us. In the ever-growing depth of the centuries with a high probability we should assume a many time repetition of the same creative constructive rises, turns in the beating of the mind, in the growth of understanding of ourselves and the world around us.

Before the duration of humanity life those two and a half thousand years are inconsiderable — eighty — ninety generations in which we can now trace three sharp rises of scientific consciousness. We can already now scientifically research into several — at least seven or eight thousands of generations, and we know about the existence of a thinking human being for hundreds of thousands of years.

In this distance of times the same process of growing of human mind was going. It went according to the same laws it goes now, as we see everywhere that the present is a logical manifestation of the past regardless of how far it is from us. We cognize the past through the present.

The existence in the past of the same great turns in thinking, which now unfolds before us, is undoubtful. It is enough to imagine the consequences of such great discoveries of human genius as the discovery of fire, agriculture or metals as instruments of life.

We are witnessing now the evolving phenomenon, only occasionally observed in the history of humanity, once encountered in hundreds of years, but not the only, but one of many that have already occurred.

For the historian of knowledge the modern moment is of the same interest and has the same meaning as a celestial phenomenon for an astronomer that repeats once in hundreds of years; it has even a greater significance because in the short — in terms of cosmos — humanity life, human can not observe evolution of the cosmos, he can only restore it with a greater or lesser success in his cosmogonies. The humanity lives in one of the stages of a changing cosmos; it observes the repetition of astronomical phenomena only to the extent of one stage: only a small part of the cycle of changing phenomenon is available to him. On the contrary, in the evolution of scientific thought of humanity the changing stages may be observed, cover empirically the whole area of changing phenomena entirely.

II

For the naturalist, when he covers any natural phenomenon, it inevitably takes the form of laws. To think scientifically means introducing a complex natural phenomenon within these forms. The

repetition of phenomena in time is one of the most striking manifestations of the regularity.

In those cases where, as in the historical sciences, such repetition is independent of human will, the observation of the cycle of events coming again to the historical arena, acquires a particular, absolutely exclusive significance.

I hardly make a mistake if I accept as inevitable and not requiring any evidence for a naturalist-empiricist position as inextricably linked with all his worldview and his way of work the belief that everything in the world around us, to which only he can come up with a scientific analysis or scientific synthesis, all equally fits into the framework of regularity. A naturalist-empiricist can not make any distinction between any natural phenomenon to which he is an observer whether it happens on the earth or in the heavens, in the material medium or in the manifestations of energy, i.e. in the transfer of states, in negligible volume of a molecule, atom, electron or proton, in the vast space of the nebula, which is alien to our world, or inside the human himself, in the creation of his spiritual manifestations thinkable out of space. His approach to all these phenomena will be essentially the same.

They will inevitably be natural phenomena for him.

While there are fundamental differences from other natural phenomena in the phenomena of the spiritual life of humanity, he will not see such difference as long as they obey his empirical generalizations. They will reveal, if the remainder will remain not obeying the laws of empirical knowledge. No other scientific approach to the study of natural processes for the naturalist exists

Without solving thus the issue of the identity or the difference in essence of spiritual manifestations of human life and other natural phenomena covered by sure scientific knowledge, a research scientist into the progress of scientific thought can still state that much of the spiritual work of humanity fits into the same unshakable «laws of nature», which he is seeking for and finds in his research work; and it can be reduced to his usual accuracies.

This is revealed by enormous influence of the development of scientific human thought on the phenomena of animated or dead nature, independent of human. Scientific human thought powerfully changes the nature. Nowhere seems it is seen as dramatically as in the history of chemical elements in the crust, as in the structure of the biosphere. Established throughout the geological time, set in its equilibrium biosphere begins to change ever stronger and deeper under the influence of scientific thought of humanity. The newly emerged geological factor — scientific thought — changes the phenomena of life, geological processes, energy of the planet. Obviously, this aspect of the scientific thought of human is a natural phenomenon. As such, it can not appear randomness to a naturalist-empiricist, it necessarily appears in his mental vision an integral part of the whole, which, as he adamantly knows, everything is subject to number and measure, covered by his empirical generalizations. In this picture of nature, scientifically built, the work of scientific thought should also have its manifestation in the same form and the same way as all other natural phenomena are included in it, small and grandiose. However, the scientific thought is included in natural

phenomena not only by such its reflected manifestation.

It has the features in itself peculiar to natural phenomena only.

First of all, it is seen in that certain *speed of movement* is characteristic of the course of scientific thought, that it changes conforming to the laws of nature over time, and it is observed a change of periods of its fading and periods of strengthening.

III

It is this period of strengthening of the scientific creativity we observe in our time, the third time in the last three millennia.

During all these periods there are common or typical features associated with extraordinary rapidity of scientific creativity, opening the fields of study untouched by earlier scientific thought. Scientific efforts of these periods have a vivid creative rather than destructive nature. The new is constructed and created; it often uses the old processed to the end for its creation. Usually it turns out unexpectedly to the contemporaries, that the new elements have already been concealed and prepared in the old. Often once and suddenly this old appears in a new guise, the old is illuminated at once. This is the usual vivid expression of our impressions of what is happening. It is very characteristic. This is the image of creation, but not destruction, the image unseen to us before, but apparently naturally going process, waited for its manifestation its completion.

Such a course of scientific consciousness is always observed throughout the history of thought. It is a more intense and covers a large area in the watershed periods. It is always typical of it the creation of new and maintaining previously achieved.

We the other day have experienced this by a particular example when in the picture of our world ideas about the disintegration of atom and destruction of matter in the processes of nature has penetrated as a shooting flow.

Yet none of the old was destroyed: Everything is illuminated by new understanding.

And now, when the area of new phenomena and new achievements of scientific creativity embraced our scientific efforts on a larger scale, we do not feel the chaos and destruction, at least temporarily. We live in times of arduous, continuous creation, the pace of which is increasing.

The main and decisive factor in this creation is the discovery of new and new phenomena, new areas of observation and experience accompanied by a huge influx of new empirical facts, previously unknown shape. A rapid growth of new in new areas extinguishes in our mind's eye the significance of the old.

This torrent of new, faster progress in scientific achievements when in a few decades it is achieved something that is usually created in centuries or millennia is obviously a manifestation of a force associated with the spiritual creative energy of human. If any analogy is required for our mind between this natural process, by which millions of people usually pass by not noticing it, this analogy may be an explosion.

You can talk about the *explosion of scientific creativity,* going in strong and persistent, not destroying framework previously created.

In order to make it more convenient to study these explosions of scientific creativity in the ordinary course of natural processes for naturalist, it is necessary to express them differently, reduce them to

common phenomena of material environment or energy inherent to them. Spiritual creative energy of human is not included here. Scientific thought in itself does not exist; it is created by a human living individual; it is his manifestation. In the world only individuals really exist who create and express a scientific thought, express a scientific creativity — spiritual energy. Weightlessness values created by them — scientific thought and scientific discovery — in the future change the way previously mentioned the course of processes of biosphere, the nature surrounding us.

Explosions of scientific creativity, repeated through centuries, indicate therefore, that through the centuries periods are repeated when it is accumulated in one or a few generations, in one or many countries richly endowed individuals, those whose minds create a force that changes the biosphere. Their nascence is a real fact that is the utmost closely associated with the structure of human as expressed in the aspect of natural phenomena. Social and political conditions that allow expression of their spiritual content get significance only subject to its existence.

These conditions can not cause the nascence of such persons themselves. For we know that such persons in the general mass of humanity are always a rare occurrence, not always taking place. Almost more than centuries should be waited after the deceased ones the new people emerge who are able to catch the thread left by the deceased.

It is very possible that in order to identify the periods themselves of scientific creativity it is necessary the concurrence of the two phenomena: the nascence of richly endowed people, their concentration in closer generations, and social, political and living conditions favorable for their manifestation.

However, the principal is the nascence of talented people and generations. In essence, this fact causes the possibility of the explosion of scientific creativity; nothing can be, failing it. Even if there were such concentrations of talents in a few generations in the interim periods, but not spilled over into the explosions of scientific creativity due to adverse conditions, the existence of such fluctuations of talent levels in the generations change should, however, be primarily to ensure that there will be explosions of creativity.

I can not dwell on here on somehow full analysis of these phenomena. I just want to mention all the known facts. Everywhere and always in the history of all sciences, we see a period when throughout of one, two, three generations talented people appear at the same time, raise to great heights a given area of the spiritual life of humanity, and then do not have their replacements. Sometimes we must wait long for the reappearance of minds of their peers or talents of their peers, sometimes they do not appear. We see it, for example, in ancient Greece in the history of art, literature, philosophy, where the greatest geniuses of all historical Hellenic life were concentrated within the space of a few decades; we see such empty periods, for example, in the 18th century in the French polite literature after the blossom in the 16th – 17th and the 19th centuries; we see the accumulation of the great French mathematicians in the late 18th and early 19th century and the break in generation earlier and later. We experienced the creation of the great Russian literature with a concurrent advent of the first-class writers.

Such temporary concentration of talented personalities in a few generations,

and their absence in many intermediate times — sometimes centuries — is a common characteristic phenomenon of the spiritual manifestations of humanity. It is sharp and pronounced in the history of scientific thought.

We still do not know why, how and what makes the nascence of talented people, the instruments of scientific thought, and their accumulation in close generations, and a lack in others. We must take them for a property of our race, a manifestation of its nature.

This is the same natural process, subject to a scientific investigation of a naturalist as what is the impact of scientific thought on the surrounding animated and dead nature, its change of energy biosphere.

In both cases, the scientific creative thought both in the mechanism causing it — the nascence of its talented creators and its manifestations — its change of energy of the planet, enters into an indissoluble connection, entirely in the complex processes of biosphere, sciences about nature, in the area of their research methods.

For the naturalist-empiricist it is an axiom, inseparably linked with his whole thought and with the form of his scientific work, that such manifestations can not be accidental, but just as subject to weight and measure as the movement of celestial bodies or the course of chemical reactions.

In his efforts he can not but finding a mechanism that connects them with the others.

IV

In essence, this task is just for that scientific discipline, which is the object of our work. This is a task of the history of knowledge, research into progress in time of scientific thinking and scientific quest.

The importance of this discipline becomes crucial, when a grandiose natural phenomenon evolves in front of us, involving us too and which is part of its domain.

It appears to me that it is a phenomenon we are destined to experience now that we live in a special era, are on the crest of a blast wave of scientific creativity. Peering into it and studying it, we can not but enter with thought into the future, can not but think about further identification of the phenomenon in human life that we observe. We see that we have entered into a special period of scientific creativity.

It is distinguished by the fact that concurrently all basic features of the picture of space scientifically built are fundamentally changing by all lines of science.

A feature of our time is not that such changes are taking place — a historian of science may find their individual manifestations, usually deafened by further course of scientific thought, many times in the past decades — it is important that they all appear at once, simultaneously. This causes the out-of-the-ordinary effect that they begin to produce both in our thinking, and its reflection in the world around us.

In essence, it is now, by its inevitable future implications for human life, probably the biggest phenomenon that occurs on our planet — the one that would have to draw our special attention and should direct all our will to clearing of its progress.

Our ideas about matter, energy, time, space radically change, completely new concepts of the same basic significance are created -concepts totally absent in all

previous scientific world views. We often do not find direct analogies in the past to these new concepts. These are electrons different from atoms building matter, but not the atoms of energy; these are quanta. The history of penetration of quanta in our scientific buildings is a curious phenomenon in the history of thought, because neither the creator of this idea, Max Planck, nor ever-increasing number of accepting quantum scientists could and can give it a clear expression in the images of our understanding of the world. Creation of a symbol of quanta without the possibility to express it in a clear, logically incontestable geometric image, and, especially, its triumphant march in the modern scientific creative work, is one of the most interesting events in the history of scientific thought, the study of which, perhaps, will allow coming closer to identifying the laws of the socalled scientific intuition.

Now, apparently, we are approaching new darings, perhaps, not less radically changing our thinking. We come to build a world without matter. And so our matter which is for us a set of atoms, completely and essentially different from that which was thought about by for example Galileo, Descartes, Newton. For the atoms of matter of our ideas, almost not include material particles, «empty» spaces in which insignificant centers of influence float, different from the emptiness — and we know nothing about the «emptiness» of the atom — are fundamentally different from those atoms, which the great minds had the idea about and who created the world outlook of our time. Logical analysis of new concepts leads to the irreducible to the whole controversies. They will become even greater if it proves impossible to express by the language and concepts of classical mechanics and even at all in the general form of moving particles the structure of atoms, if indeed the way first so successfully laid by D. Thomson, E. Rutherford,

N. Bohr (the analogy of the atom, admittedly, is obviously in outward appearance, with the planetary system) will be completely inadequate to explain the phenomena revealed by our experience and our observation. Replacing the geometric image of the atom with a new symbol, like a quantum, will put even more sharply brink of a new outlook on the future from ideas about the world since young people of my generation.

Such conception would be the more important that our thoughts irresistibly and consistently will use the atoms as a prototype, irreducible to movement, to identify all the other fine patterns, which will require us to build a picture of physical and chemical phenomena.

At the same time in our scientific worldview, in its very essence, another irreducible representation of the movement has already entered — the doctrine of symmetry. It is in it as an extraneous inclusion, not associated with other models of the world and matter created by physicists and mathematicians. Meanwhile, the empirical basis of the study of symmetry is one of the most solid achievements of science. Its profound significance was foreseen by Louis Pasteur and Pierre Curie, a theory of the solid state of matter — crystallography — is based on it, it irresistibly seizes chemistry and mineralogy, but it is stands now not only outside the sphere of our world picture, it is not affected by philosophical thought, and no those consequences and the applications are identified that follow from it and that will inevi-

tably lead to the scientific picture of the universe alien to the past centuries.

Much more attention excites a theory of relativity, which leads to a completely new picture of the world, drastically changing the prevailing its Newtonian construction until now. A radical change in the scientific concept of time and disappearance of the universal gravitation as a special force or forms of energy from the world picture — if they finally enter into the general consciousness, and they do — will put the same impassable boundary between our understanding of the structure of cosmos and ideas of the 19th century, which was put by this generalization of Isaac Newton at his time between scientific new and ancient or medieval world view. It has to hear very often that the victory of the theory of relativity will not introduce big changes in the scientific activity than were made by other major scientific achievements of the 19th century, such as for example, the doctrine of energy.

One can hardly agree with this. Those discoveries did not violate the framework of our basic physical concepts, but the theory of relativity, fundamentally changing the Newtonian models of the world, introduces us in the new world of ideas; all the consequences of this step, we can not even imagine now. We know that Newton's ideas about force, acting «instantaneously» at a distance, broke all the world view of scientists of the 17th and 18th centuries. It took several, about three, generations so that they are finally entered into the general consciousness, and a great role in this victory of the Newtonian ideas was played not by their logical force, but an element of a public nature — their introduction to school, raising a child in the spirit of these incomprehensible to empirical knowledge representations. Also, the generation grew accustomed from childhood to account for the fact that for people, whose thought was more independent, seemed absurd. Now, in a quarter of a millennium, we are so accustomed to them that it is difficult for us to move away from them into the world of ideas of Albert Einstein. I think, however, that Einstein's ideas could be easier understood vitally by the opponents of Isaac Newton; in fact they are less distant from them than from us. A refusal from the Newtonian ideas is no less sharp turn in the course of scientific thinking than their adoption was. It puts a line between the two world views as the victory of Isaac Newton put such line for the world view of new centuries and the Middle Ages.

To some extent this is a return to the threads of seeking truth, left at this turn in the 17th century.

Against the background of profound changes in ideas not less radical change of the foundations of chemistry associated with the identification of the atom and the chemical element and with an introduction to the scientific outlook of concepts about the dependence of the existence of chemical element on the time and the presence of isotopes in its medium, is going on. And here we grab the threads of ancient quests left in the 17th — 18th centuries and belonging to scientific worldview of the Middle Ages alien to the 17th -19th centuries. Enormous creative efforts of this run of life of humanity separated from us by centuries tell brightly on such particulars, the significance of which is only now become clear to us due to the achievements of the history of art and history of philosophy.

Not only chemistry changes, but thanks to new ideas about a chemical element the observed picture of the starry heaven begins to open to us phenomena unsuspected before. It is enough now to remember only the existence of the gaseous mass in the world, the density of which are ten thousand times greater than the density of water, whereas the terrestrial matter in the heaviest of its representatives, in platinum or iridium, only 20–22 times heavier than water. Astronomy is undergoing the fermentation of ideas which, in its multi-millennial history recalls, and could be compared by scale only with it, to the change that was made in its content when Galileo directed at the beginning of the 17th century in Padua and in Florence the first telescope in the solar system. But now the area of changing concepts covers not less deeply the entire Cosmos accessible to our mind's eye rather than one system of the Sun and the Earth.

V

The turning point in the scientific world view, now specified, has involved the area of physical- chemical sciences. In contrast to what had been observed in the 17th and 18th centuries, sciences mathematical and biological under the tremendous growth in the 19th century do not contribute to our scientific world view changes causing a radical reversal compared to the world outlook of the last century.

But in other areas of knowledge — in the understanding of the position of human in the structure of the world being scientifically created — it is observed now a huge leap of scientific creativity, while going concurrently with the growth of physical-chemical sciences.

In vain human would try to build scientifically the world, renouncing himself, and trying to find some, regardless of the nature, understanding of the world. This task is beyond his powers; it is also essentially an illusion and can be compared with classical examples of such illusions as the quests for perpetuum mobile, the philosopher's stone, and squaring of the circle. Science does not exist separately f1rom human and it is his creation the same as it is his creation a word, without which there can be no science. Finding the accuracies and laws in the world around him, human inevitably brings them to himself, to his word and to his mind. In truth scientifically expressed there is always a reflection of — may be extremely large — spiritual personality of human, his mind.

The naturalist-empiricist must always reckon with this; for him, with his methods of seeking truth, another world that is not associated with the reflection of the human mind, even if it exists, is not available. In philosophy, in connection with this a naturalist is necessarily a realist, for him, his scientific picture of the world is something really existing.

He might admit the possibility that such a reflection of the human mind, and consequently, the human personality, in the world being scientifically built, in general is not a chance; and is inevitably so far not a coincidence a more accessibility to his scientific creative efforts closer to the source of mind, natural phenomena, which are all the phenomena connected with human life. Always the human sciences are closer moved to him; the human personality can penetrate into them deeper than into scientific disciplines studying Cosmos.

Changes occurring in this part of the picture of the world, so even deeper and stronger tell on human life.

Two large new developments of scientific thought are observed in the 20th century in this field of knowledge.

First, for the first time the human consciousness becomes aware of *an extreme ancientry of human culture*, in particular, ancient manifestation of scientific thought on our planet.

The age of the earth, under its climate conditions, not different from modern is measured by a billion or billions of years; in the last ten-thousandths parts of this planetary time a scientific human thought had undoubtedly already existed.

Second, for the first time all the flows of spiritual creativity of human merge into a single whole before that going in the low dependence on each other, and sometimes quite independently.

The turning point in the scientific understanding of Cosmos, indicated earlier, thus coincides with concurrently going the utmost profound changes in human sciences. On the one hand, these sciences are aligned with the natural sciences, on the other, their object completely changes.

With each passing day a more and more ancientry of material remainders of the past of humanity opens up, which portrays its spiritual life in such periods, the researchers of the last century had not thought of; in that time and in manifestations of spiritual creativity preserved and survived to our time — in language, in the ancient legends in particular — realities are opened that seemed improbable in the historical criticism of the recent past.

A phenomenon occurs unexpected for a rationalist-scientist of humanities who relied on the mind as something completely self-sufficient, but an ordinary phenomenon for a naturalistempiricist. Logically probable conclusion often turns unrealistic, and vice versa a phenomenon taken place in reality, turns more complicated than it seemed to mind. Ideal constructions of the mind fall to pieces and logically unbelievable become an empirical fact.

One of the most powerful instruments of growth of historical knowledge, the creation of the 17th — 19th centuries — historical criticism and the veracity of its findings require amendments based on empirical data the mind can not foresee; the natural process may, as it turns out, fundamentally alter the achievement of historical criticism.

At the same time the history is aligned with the biological sciences. At every step the biological basis of the historical process begins to reveal itself, the effect of pre-human past of humanity not suspected before and apparently not taken into account adequately until now; in language and thought, in all its system and its every day life the utmost close threads that connect him with his utmost remote ancestors appears to us.

The community of laws for different manifestations of knowledge — historical ideological sciences — comes forward brighter and brighter. For instance, it is strongly felt and is sought for in the fact that we now have to deal — in one of the historical sciences, the history of knowledge and scientific thought. The appearance in bunches and concentration in certain generations of minds that can create a revolution in scientific quests of humanity, and consequently, in the energy of the biosphere, is not a coincidence and probably is associated with the deepest biological features of Homo sapiens.

The unified history of humanity shaped in the new form in the 20th century may be viewed as the manifestation of the same unexpectedly ancient and complex history in the modern manifestation of human, the world history in an unprecedented coverage, synthesizing into the integral whole the work of all human civilizations. Previously, concepts and ideas about the past of humanity were concentrated in the European history closely connected with the Mediterranean center of culture. This European history seemed universal. Already throughout the 19th century the continuing efforts to realign these ideas not meeting the real phenomenon were pursued. It can be considered now that such limited study of the past is over. The historical process is recognized as uniform for all Homo sapiens, and therefore, on the one hand, connection of historical knowledge with the biological knowledge is taken roots, and on the other — the reversal is going on in the structure of historical knowledge, unprecedented in strength and consequences in their past existence.

Thus, in the physical-chemical sciences and human sciences, historical, the reversal of creativity is going concurrently, exceptional by its force and magnitude. It is in the very beginning.

It seems to a naturalist-empiricist a spontaneous and naturally historical, nonrandom and can not be stopped by any disaster. Its roots are hidden deep in the system of nature incomprehensible to our mind, in its unchanging order.

We do not see anywhere in this system, as far as we study the evolution of the living over the geological time, turns and returns to the old, do not see any stops. Human emerged not accidentally, connected with the previous creatures before him and he performs not accidental work in the chemical processes of the biosphere not by chance.

The turn in the history of thought, now running, is independent of human will and can not be changed either by his desires or by any of his manifestations of life, public and social. It certainly is rooted in his past.

A new run of explosion of scientific creativity must inevitably reach its natural limit, as inevitable as the comet moves toward it.

VI

These greatest movements of scientific thought inevitably already tell on all spiritual structure of humanity. They are also told on his life, his ideals, and his everyday life. A new growth of philosophical thought is inevitably connected with it, which some have already indicated as started, and a new rise of religious art.

The historian of thought, the historian of science should look closely with deepest attention in such times to what is going on. He can learn this way to understand the past and, perhaps, foresee the future.

But this does not end his activities.

At such moments of explosion of scientific creativity scientific study into the past of scientific thought acquires another, more topical significance.

We notice now a huge revival in the history of knowledge, growing efforts in this area. It is revealed in a rapid increase in the scientific literature on the history of science, in the creation of special centers of its study — special institutions, scientific societies and journals devoted to it. In ordinary scientific work the historical point of view may be manifested more frequently than before.

This is partly due to the importance that the present moment has for the historian of scientific thought, involuntarily exciting a thought of each scientist idea in the said direction.

But this growth is also explained by the other: that in radical reversal of concepts and understandings of what is happening, in a mass creation of new ideas and pursuits, the aspiration to link them with the past is inevitable. Often such historical study is the only opportunity of their rapid penetration into the scientific thought and the only form of critical evaluation allowing distinguishing valuable and permanent in the vast material of this kind created by human thought. A significant part of this material is of a transient value and will disappear quickly. The sooner you can understand it, the faster the movement of our thought will be, the growth of a new scientific outlook. Such selection of scientific and significant can be made more accurately and rapidly in its historical study.

The scientific organization has not yet applied to new stages of science. But we can already see the sprouts of its future in the physical-chemical sciences. They are weak yet, but it is the beginning. At the symposiums of the American scientists, in international discussions of the Faraday Society in London, in the reviews of scientific journals a historical aspect appears more and more brighter in discussions of the most burning, les derniers cris, scientific issues.

The history of science is, and such moments, a tool of achieving new.

This is its meaning, however, as always incidental to it. The scientific study of the past, including scientific thought, always leads to the introduction of new in human consciousness. But in moments of the reversal in scientific consciousness of humanity thus and only thus the new opened can be a tremendous spiritual value in human life.

This burning interest in the history of science, in addition to it significance, as search for truth, we can not and should not forget in our Commission, the only center of this scientific discipline in our country.

The Scientific Revolution of the 21st Century as a Fundamental Base of the Progress of Civilizations

Yu. V. Yakovets,
President of the Pitirim Sorokin — Nikolai Kondratieff International Institute, Dr. Sc. (Economics), Professor, RANS Academician

1. Four Gulfs of the Global Crisis of Science.

The world science in the late 20th — early 21st century is experiencing a deep financial crisis, the like of which has never been observed for several centuries. The main signs of this crisis may be formulated as four deepening gulfs in the dynamics of the world knowledge.

The first gulf: the speed and depth of changes in society and nature are far ahead than consciousness of the essence and implications of these changes by the world science. The prevailing industrial scientific paradigm reflects the regularities and trends of the industrial world civilization completing its life cycle. But the post-industrial, humanistic-noospheric civilization is coming replacing it. Science received a powerful development effort in the industrial society has turned out to be unable either to foresee the rising ninth wave of global crises or to show the reliable guides to move towards the post-industrial civilization. The prevailing science loses its primary function of the «looking forward» in the stormy sea of changes that increases the risks in choosing a strategic course by the leaders of humanity. As the pace and radical changes grow, this gulf expands threatening by global catastrophes.

The second gulf — between science and society: the weakening of the ability of science to foresee crises and changes and to show the effective way of movement to the future has led to a drop in the prestige of science, weakening of attention to the scientific knowledge of society, by the government and business, explosion

of seemingly long gone in the past anti-scientific false teachings and beliefs. Faith typical for the industrial age in the limitless possibilities of science gave way to skepticism about its achievements, a lack of confidence in its abilities. From the beloved firstborn science is turning into all persecuted stepson. The power — at the national and international levels — and business leaders less and less listen to the voice in formulating strategic decisions that determines their not far horizon, increases the gulf between science and society. The gap weakens them both.

The third gulf: a discrepancy between the growing investment in science and its results. Between growing from year to year as a whole over the world and most countries investments in science (they have reached, according to the World Bank, 2.21% of world GDP, for countries with high income 2.47%, USA — 2.67%, Japan –3.45%) and the number of epochal scientific discoveries and major inventions similar to those that were observed during the scientific revolution of the late 19th — early 20th centuries. This gap is explained by the fact that the prevailing current industrial scientific paradigm has largely exhausted its creative potential, and the post-industrial paradigm at the establishment stage has not yet received the necessary support and achieved not to fullest its creative potential.

The fourth gulf: super concentration of scientific potential in rich countries of the «golden billion» practically the minimum level in poor countries where most of the world population resides. This can be seen from Table 1.

In the countries of the «golden billion» where 16% of the world population resides a half of the researchers is concentrated, 80% of R&D costs; 74% of patent applications from residents, it not a wonder that they get 98% of income from royalties and license sales, the bulk of the world technological quasi-rent. At the same time countries with low income science and technology and innovation potential is negligibly small, where 15% of the world population resides, the assimilation of achievements of scientific and technological revolutions

Table 1. *The Distribution of Scientific Potential by Countries with Different Income Levels*

Country Groups	Population Size, 2008		Number of Researchers		R&D Costs		Applications for Patents from Residents		Proceeds from Sale of Licenses	
	Mln. People	% of world	Thous. people	% of world	Bln. USD	% of world	thous.	% of world	Bln. USD	% of world
World	6697	100	8505	100	1337.5	100	988.5	100	181.3	100
Countries with income: High	1069	16.0	4220	49.6	1068.9	79.9	796.6	74.5	177.4	97.8
Above average	949	14.2	1180	13.9	68.4	5.1	40.9	4.1	2.3	1.2
Below average	3703	55.3	1774	20.9	101.8	7.6	134.1	13.6	1.4	0.7
Lower	978	14.6	594	7.0	…	…	…	…	…	…

Source: World Development Indicators 2010. Washington: The World Bank, 2010. p. 342.

of the 21st century and doomed to poverty, backwardness. Gross national income per capita in 2008 in low-income countries was 76 times lower according to the current exchange rate and 30 times lower by purchasing power parity than in high-income countries.

Thus, the world science being in the state of deep crisis at the final stage of its industrial cycle happens to be unable to effectively perform its essential functions — the cognitive, creative and predictive. And this is just at a time when civilization has entered into the era of radical changes, chaotic fluctuations.

2. The End of the Century of Science or a New Scientific Revolution?

Several years ago American science journalist John Horgan, after interviewing a number of prominent scientists, including Nobel laureates, concluded that that all the major scientific discoveries had been made and that all that remained was the working out of minor details, the end of the century of science comes[1].

In fact, the global crisis of science is not the end of the century of science but the crisis of the industrial scientific paradigm prevailed for more than two centuries that largely does not meet the requirements of development of society in the 21st century and is a forerunner of the postindustrial paradigm. Its establishment will be the main content of the scientific revolution of the second quarter of the 21st century.

This is a naturally determined process. The accumulation of knowledge is not smooth and continuous. It occurs under the regularities of cyclic-genetic dynamics. Along with the change of historical epochs a change of general scientific paradigms occurs — the amount of knowledge that underpins strategic decisions and actions. Such change is accompanied by crisis of the passing paradigm and the rise of new, innovative updating of the accumulated amount of knowledge. At the same time a set of the leading area of knowledge and centers of scientific creativity change. The general trend, from age to age, the role of scientific knowledge increases in addressing the increasingly complex challenges humanity faces to be solved with the will of the epochal and basic innovations. This is more so correct for the 21st century when it stands to overcome the cluster of global crises and to build a post-industrial, humanistic-noospheric integral society.

The school of the Russian cyclism rejects the point of the end of the century of science and foresees the completion of the modern crisis of knowledge by a new scientific revolution, the peak of which will likely be in the second quarter of the 21st century.

3. Will the New Scientific Revolution be Great?

The history of scientific knowledge, investigated in depth in his time by V.I. Vernadsky[2] and John Bernal[3] distinguishes several general scientific revolutions. I distinguish four scientific turns over the past five millennia.

The first of them occurred in the 3rd millennium B. C., when the accumulated amount of knowledge made possible to create sophisticated irrigation systems, to build the pyramids, palaces, religious buildings in the valleys of the great historic rivers (Nile, Tigris and Euphrates, the Indus) and

at the crossroads of sea trade routes (Minoan civilization on Crete). This became the basis of the technological revolution, many times increased the labor productivity.

The second scientific revolution began in the second half of the last millennium B. C., when in ancient Greece it was completed a science building by abstract and fundamental knowledge, established system of sciences still existing, Plato's Academy founded, Aristotle's Lyceum, Library of Alexandria, numerous schools of philosophers. This scientific revolution may be viewed indeed as Great because it laid the foundations of scientific knowledge at the millennia ahead.

The next scientific revolution refers to the period of the 15th–17th centuries, when due to the great geographical and scientific discoveries the picture of the world radically changed. John Bernal not without reason called this revolution Great. The explosion of scientific creativity had its epicenter in Europe. It became the fundamental base of the industrial revolution, establishment of the industrial world civilization.

Scientific revolution took place in the period of maturity of the industrial world civilization and was adequate to its content. There were assimilated electricity, liquid and gaseous fuels, development of air space began. Since the end of the 19th century the recent revolution in science evolved in natural sciences opening the way to knowledge and use of atomic energy and space exploration. Many discoveries were made in biology, medicine, science of society. However, despite the significance of these discoveries, it could hardly be called this Revolution Great: it took place within and on the basis of the industrial universal scientific paradigm.

Since the end of the 20th century it becomes increasingly clear that this paradigm has largely exhausted its creative and prognostic potential. The time of new «universal scientific revolution» is coming which may be viewed as Great.

What is the basis of such a bold statement, and in respect of the coming scientific revolution?

First, the first half of this century is a change of historical epochs: the decline of industrial and establishment of post-industrial, integral by its nature, world civilization, change of the fourth generation of local civilizations with the fifth more differentiated; transition from the second (millennium and a half) historical super cycle in the dynamics of the global civilization to the third. All the components of the genotype of civilization: nature of demographic dynamics, energy-ecological, technological and economic modes of production, architecture of geopolitical world order, socio-cultural system are radically changing. Such avalanche of radical changes does not fit into the «Procrustean bed» of the industrial scientific paradigm. The rapidly changing world requires the updating of the entire system of knowledge. The magnitude of changes defines the nature of scientific revolution.

Second, the growing gap between the rate of changes in society and its relationship with nature, their too late and incomplete awareness is the source of many erroneous strategic decisions and a phenomenon which Alvin Toffler called «future shock» — a fear of the future that leads to an inadequate response to new challenges and threats. This has the potentially to call into question the very existence of the species Homo Sapiens. The scientific revolution must clean the Augean stables of accumu-

lated knowledge, free them from the outdated dogmas and fill with new knowledge adequate to the modern age. It is in power by the great scientific revolution only.

Third, the building of science by its architecture, the ratio of elements that reflect the priorities of the passing era, in many respects does not meet the priorities of the new era. A grand transformation of the whole knowledge of science is coming, change of leaders that is only possible as a result of the great scientific revolution. The leadership goes to the social sciences, sciences about life and ecology.

Finally, the *fourth,* while the new architecture of science is only beginning to be built, its foundations had already been laid by outstanding Russian and foreign scientists of the last century, which are far ahead of their time. The new building is not built on sand, not on the fluctuation of random insights, but on the granite foundation of profoundly elaborated theories that makes it possible already now to identify the main outlines of the coming scientific revolution, the post-industrial scientific paradigm.

4. The Main Outlines of the Coming Scientific Revolution.

The main outlines of the coming scientific revolution can already be seen.

First, it will be accompanied by the *rise of science,* overcoming its crisis and enhancing the prestige as the foundation of a knowledge-based society. Young talents will be attracted by science, and the government and businessmen will not save money for researches into new problems.

Second, the content and result of the revolution will be the *establishment of interdisciplinary scientific paradigm* that is adequate to the realities of the 21st century, post-industrial civilization and serves as a reliable guide in dealing with any problems and resolving knots of contradictions.

Third, humanization of science will evolve. The priority will be given to the human sciences, medicine, social sciences and humanities. This will help prevent the spread of dangerous diseases, support active life of people under conditions of increasing longevity, prevent and overcome the devastating crises and conflicts, degradation of the moral foundations of society.

Fourth, noospherization of science is ahead, the priority of research into problems of interaction between society and nature, and their harmonious co-evolution, formation of environmental sciences system at the boundary between natural and social sciences, bringing environmental issues to the forefront in life of society and in scientific thought.

Since the second half of the 20th century as a result of the rapid jump of the productive forces, the invention of nuclear weapons and other weapons of mass destruction the reason has become not only geological but also the climate power. But concurrently species Homo Sapiens have found itself on the brink of self-destruction, according to Pitirim Sorokin — self-cremation in the flames of a thermonuclear war. In the 21st century many types of nonrenewable minerals, primarily fossil fuels will be mainly exhausted, now provide 82% of energy consumption. There is a growing shortage of fresh water, fertile land, tropical forests are felled rapidly — «green lungs» of the planet. It is becoming more and more likely a global ecological catastrophe. But science still can not give

an unambiguous answer to the question: what will happen to humanity the overall warming and the flooding of many coastal cities and countries — or a new ice age? Unusually cold winter of 2009–2010 and hot summer in 2010 have added doubts to science.

Fifth, a complicated process of demilitarization of science is ahead. In the industrial age, human genius has increasingly served to the Moloch of war. The state and corporations generously fueled military researches, the best minds were employed there. It is expected to refocus them on the priority humanitarian and environmental problems, the states should first of all take care of it.

5. The Fundamental Base of the Technological Turn and Progress of Civilizations

The revolution in science becomes the primary source and the driving force of the ninth wave of the epochal and basic innovations[4] that expect us in the first half of the 21st century and will transform the face of the world. The result of these innovations, a global technology revolution will not only be the formation of the post-industrial, technological mode of production of its first stage — the sixth technological order, noospheric energy-ecological modes of production and consumption, but also the establishment of an integral economic and sociocultural system, a multi-polar world order based on the partnership of civilizations and transition to a new whorl of the spiral of historical development — to a integral civilization. These epochal innovations can be realized only with goal-directed activity of the humanity and its leaders, with the defining role of science in shaping the future of society, ways and mechanisms of movement to it. Without it, the chaos of the transitional period will be increasing; the threat of global catastrophe will be growing.

Science is the core of the *synthesis of the three revolutions — scientific, educational and information* as the basis for a radical transformation of society. Science gives a new vision of the world at the next turn of the helix of historical development of society and its interaction with nature, defines the aims of the movement and ways to achieve them. Education is meant for a timely equipping with such new vision of the prevailing generation now and above all — the next generation of the 20s of the 21st century to whom the burden and responsibility of the adoption and implementation of strategic decisions will pass for three decades. The modern information revolution using the Internet, television and other sources of information should help accelerate the rapid assimilation and dissemination of a new paradigm among the present and future generations, improve professional competency, stepping up the transforming activity of hundreds of millions of people. This requires the humanization of information flows, turning them to science and education. An example can be the bilingual science education portal «New Paradigm» (www.newparadigm.ru) created by the Sorokin — Kondratieff International Institute, with more than a dozen and a half of sites on the topical issues of the formation of a new paradigm of social sciences. Similar portals should be created for other branches of knowledge. The Institute in association with the Saint Petersburg State University has proposed the creation

under the auspices of UNESCO the Internet portal «World Scientific Heritage». Three sites have been implemented to this end — «Nikolai Kondratieff,» «Pitirim Sorokin», and «Leonid Kantorovich.» We hope that the UNESCO will respond to this initiative.

The major direction of the coming global scientific revolution will be surmounting the polarization of scientific potential that has reached the extreme limit. It is almost entirely concentrated in the U. S., Western Europe, Japan, China, Russia, and India, the majority of countries and civilizations are devoid of scientific forces that can serve as a basis for the modern transformation and modernization of society.

It will be required the development and implementation under the leadership of the UNESCO a long-term strategy of partnership of civilizations in the field of science. Considerable efforts and resources are necessary of the vanguard nations and civilizations so that to overcome the excessive polarization of a scientific- technological potential and help strengthening it in the lagging countries, failing which it is impossible to bridge the gulf reached critical limits between the «golden billion» and the poorest countries and civilizations.

Thus, the scientific revolution of the 21st century underlies the technological turn, the wave of epochal and basic innovations, transition of the world civilization to a new whorl of historical helix.

6. The Role of Russia in the Scientific Revolution of the 21st Century.

Will Russia be able to join the leaders of the coming scientific revolution, despite the crises shaking it? There are considerable grounds for a positive answer to this key question to the fates of Russian science

First, it is the Russian scientists already in the first half of 20 century, laid the cornerstones of the post-industrial scientific paradigm. In the field of social sciences — Pitirim Sorokin, Nikolai Kondratieff, Alexander Bogdanov, Nikolai Berdyaev, Wassily Leontieff. In the field of environmental sciences — Vladimir Vernadsky, Alexander Chizhevsky, Nikolai Vavilov, Nikita Moisseyev. In the field of life sciences — Ilya Mechnikov, Ivan Pavlov. In the field of astronomy, physics, mathematics — Alexander Friedman, Pyotr Kapitsa, Lev Landau, Leonid Kantorovich, Jaures Alferov and many others. The ideas of these pioneers have been received by the world scientific thought and demanded in the 21st century.

Second, the utmost deep civilizational crisis of the 90s in Russia gave impetus to a new explosion of scientific creativity. Relying on the powerful shoulders of its great predecessors, the modern Russian scientific schools develop the ideas of the post-industrial paradigm of social and ecological sciences. This is particularly true of schools of Russian cyclism, civilization, noosphere, integral macroforecasting, philosophy of economy.

The results of the efforts of these scientific schools are a 7-volume fundamental work «Civilizations: Theory, History, Dialogue and the Future»[5], a three-volume book «The Philosophy of Economy»[6]. Russian and Kazakhstan scientists under the leadership of the P. Sorokin — N. Kondratieff International Institute elaborated and published in 10 parts, and presented at the Roundtable within the 64th session of the UN General Assembly on 27.10.2009, the Global Forecast «Future of Civiliza-

tions» for 2050 and recommendations to the partnership strategy of civilizations[7]. This ambitious project has become the evidence of the intellectual leadership of Russia in foreseeing the future of civilizations on the basis of the post-industrial scientific paradigm.

Third, Deep and devastating crisis the Russian science pushes to the search for fundamentally new ideas and approaches. According to the World Bank indicators, the number of researchers in Russia accounts for 6% of their total number in the world, and R&D costs — only 1% of the world; the number of patent applications from residents — 2.8% of the world, and Russia's share of royalties and license revenues — 0.24% only of the world and in the export of high technologies –0.33% only. This indicates a disregard of the government and corporations for science and its low efficiency.

It particularly tells on natural and technical sciences, material and technical base of which is utmost outdated. Industry and corporate science is destroyed, most of the engineering schools are liquidated, which once topped the world. There is a growing aging of scientific personnel — and in fact the scientific revolution is made by daring young talents.

If these trends continue under the inertia-based scenario, then over the next decade, the scientific potential of Russia will be irretrievably undercut, leading to a further decline of the competitiveness of domestic products, and its ousting from the domestic and foreign markets.

However, it is yet realistic an optimistic, innovative-breakthrough scenario, if the positions of supporters of the new paradigm strengthen in the scientific community and they get a real and considerable support from the government and corporations that will become a jumping-off place for tackling the crisis, assimilation of epochal and basic innovations, inclusion of the country into the world leaders in some areas of the formation of a new paradigm. In the field of social and ecological sciences this prospect is clearly visible. But this would require that the current leaders of the state and businesses should become aware of the dead-end movement by the inertia-based path, turn to science, formulate and implement a long-term strategy which will be able to bring Russia to the number of the leaders in a number of areas of the scientific revolution of the 21st century.

References

1. *Anchishkin AI.* Science-Technology-Economy. 2nd edition. M.: Ekonomika, 1986.
2. *Bell D.* The Coming Post-Industrial Society. A Venture in Social Forecasting. M.: Akademia, 1999.
3. The Future of the World Economics. Report of the United Nations Expert Group headed by Leontieff W. M: Mezdunarodnie Otnoshenia, 1979.
4. *Glaziev S.Yu.* A Theory of Long-Term Techno-Economic Development. M: Vladar, 1993.
5. *Horgan J.* The End of Science. M.: Nauka, 2003.
6. *Kondratieff N.D.* The Long Cycles of Conjuncture and a Theory of Foresight. M: Ekonomika, 2002.
7. *Kuhn, Thomas.* The Structure of Scientific Revolutions. M.: Gaia, 1997.
8. *Kuzyk B.N., Yakovets Yu.V.* Civilizations: Theory, History, Dialogue, and the

Future. Vols. 1–7, M.: INES, 2006–2010.
9. *Leskov L.V.* Will the 21st Century Receive Us Foresight in Dialogues. M: SKII, 2009.
10. *Mensch G.* Das Technologische Patt: Innovationen Uberwinden die Depression. Frankfurt-am-Main, 1975.
11. *Moisseyev N.N.* Parting with the Prostate. M.: Agraf, 1998.
12. *Moisseyev N.N.* The Fate of Civilization. The Path of Reason. M.: MNEPU, 1998.
13. *Schumpeter Joseph.* Business Cycles. Vol. 1,2. N. Y. 1939.
14. *Sorokin P.A.* The Basic Trends of Our Time. M.: Nauka, 1997.
15. *Sorokin P.A.* Social and Cultural Dynamics. M.: 2006.
16. The Global Forecast «Future of Civilizations» to 2050. Part 1–9. M: SKII, 2008–2009
17. *Toffler A.* The Third Wave. M.: AST, 2001.
18. *Toynbee A.*, Civilization on Trial. M.-SPb: Progress, Kultura, 1999.
19. *Vernadsky V.I.* Scientific Thought as a Planetary Phenomenon. Moscow: Nauka, 1991.
20. *Vernadsky V.I.* Works on the Universal History of Science. M.: Nauka, 1988.
21. *Yakovets Yu.V.* Cycles. Crises. Forecasts. M.: Nauka, 1999.
22. *Yakovets Yu.V.* Epochal Innovationsof the 21th Century. M.:SKII, 2009.
23. *Yakovets Yu.V.* Globalization and Interaction of Civilizations, 2nd ed., M.: Ekonomika, 2003.
24. *Yakovets Yu.V.* Global Economic Transformations of the 21st Century. M.: Ekonomika, 2010.
25. *Yakovets Yu.V.* The Great Scientific Revolution of the 21st Century. M.: SKII, 2010.
26. *Yakovets Yu.V.* The Past and the Future of Civilizations. The Edwin Mell Press, 2000.
27. Yakovets Yu.V., Kuzyk B.N. Response to the Challenges of the 21st Century — Establishment of the Integral Civilization. M.: INES 2009.
28. 2010 World Development Indicators. Washington: World Bank, 2010.
29. www.kuzyk.ru
30. www.newparadigm.ru

Notes

1. *Horgan John.* The End of Science: Facing the Limits of Science in the Twilight of the Scientific Age.Spb.: Amphora-Evrika, 2001
2. *Vernadsky V.I.* Works on the Universal History of Science. M.: Nauka, 1988.
3. *Bernal John.* Science in History M.: Inostrannaya Literatura, 1956.
4. *Yakovets Yu.V.* The Epochal Innovations of the 20th Century. M.: SKII, 2004.
5. *Kuzyk B.N., Yakovets Yu.V.* Civilizations: Theoru, History, Dialogue and the Future. Volume 1–7. M.: INES. 2006, 2008, 2010 (www.kuzyk.ru)
6. *Ossipov Yu.V.* The Philosophy of Economy. Textbook. M.: MSU. 2003.
7. Global Forecast «Future of Civilizations» for 2050. Parts 1–10, M.:SKII, 2008, 2009 (www.globfuture.newparadigm.ru).

The Strategy for Surmounting a Civilizational Crisis

Prospects for Overcoming Civilizational Crisis and Entering the Path of Global Sustainable Development

Yu. V. Yakovets,
President of the Pitirim Sorokin — Nikolai Kondratieff International Institute, Dr. Sc. (Economics), Professor, RANS Academician

Introduction. Vision 2050: A View from Russia

Instead of the peace and prosperity expected after the "cold war" the beginning of the 21st century has brought an abrupt wave of crises and upheavals, disappointments and sufferings. This put to a nonplus not only politicians, statesmen and business leaders, but also scientists who are to see far ahead and highlight the strategic perspectives.

The international team of scientists who prepared this report, includes representatives of the modern Russian scientific schools (Russian cyclicism, civilizational, noospheric, socio-demographic, integral macro-forecasting) and their foreign associates. Their views are represented in dozens of monographs, in the Global Forecast "Future of Civilizations" for 2050 (published in 10 parts and represented at the UN headquarters on 27.10.2009), report "A Long-term Strategy for Global Sustainable Development Based on Partnership of Civilizations", which was represented at the UN headquarters on 28.06.2011 and the UN Conference on Sustainable Development Rio +20 (13–17.06.2012 in Rio de Janeiro).

Building on the previous work, we decided to prepare a draft report to be discussed at the Conference within the Moscow

Economic Forum and the Astana Economic Forum, to publish in Russian and English, and submit to the participants of the Summit "G-20" (St. Petersburg, 05–07.09.2013).

This paper addresses the main points of this report.

Part 1. Civilizational Crisis: Diagnosis, Structure and Prospects for Overcoming

1.1. DIAGNOSIS OF THE GLOBAL CRISIS OF THE 1ST QUARTER OF THE 21ST CENTURY

Treatment of the disease starts with a diagnosis. However, there is still no reliable diagnosis for a cluster of global crises of the 1st quarter of the 21st century. This is not accidental and is explained, first, that it is not an economic crisis that is regularly repeated once every decade and not even only the crisis phase of the Kondratieff long cycle this is a *civilizational crisis* unequalled for more than two centuries. Second, because the industrial scientific paradigm itself is in the state of crisis, losing creative and predictive power.

We diagnose a cluster of global crises of the 1st quarter of the 21st century as a civilizational crisis, caused by the change of super-long civilizational cycles: the decline of the industrial world civilization, a change of generations of local civilizations, the end of the second historical super-cycle in the dynamics of the global civilization.

Such diagnosis allows, *first,* to understand the depth and duration of the crisis period, covering a quarter of the century. *Second,* to reveal the structure of the crisis, transforming all the components of the genotype of civilizations: natural-ecological, socio-demographic, technological, economic, geopolitical and socio-cultural. *Third,* to determine the ways and priorities to surmount crisis more reliably, balanced and concurrent transformation of all components of civilizational genotype based on partnership of civilizations and states, social strata and generations. This approach offers a historical perspective and musters the strength to pass through the crisis phase with less losses and upheavals.

1.2. FOUNDATIONS OF THE STRATEGY TO OVERCOME THE CRISIS

Studying the history of civilization shows that the crises of civilizations are not infinite. They end either by a shift of civilization on the wave of epochal innovations into a qualitatively new state, or leaving the historical arena.

The result of epochal innovations of the second quarter of the 21st century, in our opinion, will be the establishment of the integral, humanistically noospheric world civilization with the genotype adequate to it in the vanguard countries, the formation of the more differential and active fifth generation of local civilizations, interacting on the principles of dialogue and partnership.

A long transitional period is full of risks and surprises, including most catastrophic. To withstand these tests, the global community must develop and implement consistently a long-term, scientifically founded strategy to overcome the crisis of civilization and entering the path of global sustainable development.

There is no it so far. Global development is becoming increasingly unstable.

The international team of scientists developed and offered at the Conference

RIO+20 its version of a long-term strategy for entering the path of global sustainable development. It is based on the following key points:

— the depth and duration of civilizational transformations require developing a long-term global strategy to overcome crises and entering the path of sustainable development;

— there is a need for balanced and synchronized strategies for transformation of all the components of the genotype of civilizations;

— it is necessary to ensure the convergence of the level of socio-economic and technological development of countries and civilizations;

— the implementation of the strategy should be based on the institutions and mechanisms of innovation and socio-political partnership between civilizations and states, social strata and generations.

1.3. THE SYSTEM OF LONG-TERM STRATEGY GOALS

In determining the long-term goals of sustainable development and building of the tree of global strategy one should be based that the elements of the future already exist in the present, they need to be maintained and developed.

The tree of the strategy goals include: general goal — securing the transition to an integral, humanistically noospheric world civilization based on a wave of epochal innovations; the system of the first-level goals transforming all the components of the genotype of civilization, overcoming the economic and food crises, establishment of the noospheric energy-ecological mode of production and consumption, and the transition to a model of the demographic growth, overcoming depopulation and optimization of migration flows; an innovative breakthrough, dissemination of the achievements of the scientific and technological revolution of the 21st century and the sixth technological order; the transition from a decaying industrial economic system to the integral system, socially, ecologically, and innovation-oriented, the eradication of poverty in the world; the rise of science and increase in the creativity of education, revival of high culture and humanistically noospheric morality. These transformations should be targeted, balanced and synchronized. This is the advantage of a global strategy.

Part 2. The Transformation Strategy for the Elements of Sustainable Development

2.1. ON THE PATH TO THE NOOSPHERIC ENERGY-ECOLOGICAL MODE OF PRODUCTION AND CONSUMPTION AND “GREEN” ECONOMY

In the first quarter of the 21st century, the world is ridden by the global energy-ecological crisis, manifesting itself in the growth of the deficit and rise in prices for fossil fuels, increase in the greenhouse gas emissions.

The crisis can be overcome by the evolving of the noospheric energy-ecological mode of production and consumption, its main features include:

— energy efficiency, refusal from the energy-wasteful technologies in production and households;

— Decrease in the rate of growth in energy consumption from 1.9% in 1990–2009 to 0.2–0.4% in 2040s while overcoming the excessive gap between high- and low-income countries from 13.3 times by the

consumption of energy per capita and 39.6 times for the electric energy consumed;

— increase in the completeness of extraction and complex processing of fossil fuels (which takes 81% of the world balance of power consumption), the development of alternative sources of energy (quantum gas, tar sands, etc.);

— increase in the share of renewable, clean energy sources (solar, wind, biofuels, etc.);

— reduction of the share of greenhouse gas emissions, which grew in 1990–2008 by 2% per year;

— international regulation of dynamics of world energy prices.

The formation of "green" economy would promote the solution of these strategic objectives as well as the full evaluation of the cost of reproduction of natural resources and environmental damage, a more equitable distribution of natural resource rent, which is 4% of the global GDP, and full compensation for environmental damage.

To achieve these strategic objectives, in accordance with the proposals of President of Kazakhstan Nursultan Nazarbayev, it will be required to develop a long-term strategy for sustainable energy-ecological development and its adoption at the Summit RIO+25 at the World EXPO 2017 in Astana.

2.2. PROSPECTS FOR OVERCOMING THE FOOD CRISIS ON THE BASIS OF A NEW "GREEN" REVOLUTION

The long-term trend of an outrunning growth of food compared to the increase in population was replaced at the beginning of the 21st century with a global food crisis, the growing number of starving and its rapid rise in prices. Hopes to solve the problems with genetically modified foods fall short. With the growth of the population the area of agricultural land does not increase.

The global food crisis could be resolved on the basis of:

— optimization of the structure of food consumption, overcoming hunger in the world due to multiple increase in the productivity of the agricultural labor;

— an increase in food production in the world by 2050 1.7–1.8 times against 2010;

— support and planetary spreading of a new "green revolution", providing increased food production in a controlled environment;

— the establishment of the global food fund, including the insurance fund for natural disasters;

— international regulation of price changes in the world food market;

— Development and adoption of a long-term global food strategy at the "green" summit to ensure the eradication of hunger in the world in the coming decades.

2.3. SOCIO-DEMOGRAPHIC CRISIS AND PROSPECTS FOR ITS SURMOUNTING

In the postwar decades there were reached the population growth rates record in the history. But from the last quarter of the 20th century it prevailed the tendency of the population growth rates to fall (1.18% in 2005–2010), which, according to the UN projection will continue in the future (0.34% in 2045–2050.). An increasing number of countries and civilizations are being ridden by depopulation, and from the last quarter of the 21st century it will become a global trend. The aging of population intensifies a share of working-age and in-

novatively active population will be decreasing. A demographic factor from the economic growth engine is becoming its limiter.

It deepens simultaneously socio-demographic polarization. At an average annual growth rate in 2010–2020 in the world of 1% it will be in sub-Saharan Africa 2.4%, Latin America 1.6%, South Asia 1.3%, while in the Euro area 0.1%, Japan 0.3%, and Russia 0.2%. The structure of the world population is changing. The gap in public health spending per capita between the countries with high and low income is 18 times in 2010 in the current prices and 6.4 times in PPP terms.

There are growing signs of migration crisis, uncontrolled resettlement, increasing share of the population with the strengthening of civilizational contradictions in recipient countries. Accumulated migration reached 213.4 million people in 2010, including those in high-income countries 131.9 million.

It is necessary to change the vector of global demographic policy. While in the 2nd half of the 20th century it was aimed at controlling population growth, family planning, then it is now in most countries, it is aimed at promoting the birthrate, involving of senior people in production, and optimization of migration flows. It is necessary, using the rich countries, to reduce motivations for emigration and simultaneously normalize the situation with migrants in the recipient countries.

The UN with the involvement of scientists will need to develop a new, differentiated by countries and civilizations, socio-demographic strategy, in order to discuss it at a special summit, and take into account when determining a social element in sustainable development strategy.

2.4. TECHNOLOGICAL CRISIS AND STRATEGY OF INNOVATION BREAKTHROUGH

Growing in the future limitations to the economic growth from the natural-ecological and socio-demographic factors can be overcome only through the development and dissemination of fundamentally new resource-saving technologies. However, the industrial technology mode of production, ensuring a step increase in labor productivity is largely exhausted its growth potential.

The global crisis induces a growth in the number of scientific discoveries and major inventions, that is a prerequisite for a wave of epochal and basic innovations, evolvement of the scientific and technological revolution in the 2nd quarter of the century, the result of which is the formation of a new technological mode of production, its first stage — the sixth technological mode of production. China joins the leaders of the technological breakthrough, where for 2000–2010 the number of applications from residents for patents increased 11.7 times, while in high-income countries it decreased by 7.5%, and the average annual growth rate of labor productivity in China during 2005–2010 was 8.8% (the average in the world 2% in high-income countries 0.7%). The gap in the labor productivity level between countries with high and low incomes was 12.7 times in 2006.

The main objectives of a long-term strategy of innovation and technological breakthrough are:

— to create conditions for accelerated development of a new technological revolution and raising the growth rates of labor productivity;

— Humanization, ecologization and demilitarization of the technological progress, concentration of the results for solving energy-ecological, food, social issues while reducing the military-technological orientation;

— increased government support for base innovations;

— reducing in 2–3 times the gap in technological development between vanguard and lagging countries and civilizations, increasing the UN role in addressing these challenges;

— strengthening the role of the technological component of sustainable development and identification in the UN system organization responsible for coordinating these activities.

2.5. TRANSFORMATION OF ECONOMIC SYSTEM AND GLOBALIZATION

With unchallenged achievements of the market-capitalist system in the past in the recent decades the signs of its decline manifest themselves increasingly brighter. This is reflected in the trends of:

— the fall in the economic growth, in becoming destructive economic crises more frequent and their aggravation;

— forming a virtual "bubble economy", extracting resources from reproduction and accumulation for speculative gaming on stock exchanges;

— deformation of the structure of the economy, excessive swelling of market services area to the detriment of material production, especially agriculture and industry, the de-industrialization of economy;

— increasing speculative fluctuations of key macroeconomic indicators, first of all, in world prices, more and more distortedly reflecting the level and dynamics of the international value;

— injustice in income distribution between countries, social strata and generations of people, the gap in the production of GNI per capita between countries with high and low income reached 73.4 times in 2010 at the current prices and 28.6 times by PPP. The unemployment has risen sharply especially among the youth.

There is a need to develop a long-term strategy for economic development and partnership, aimed at:

— the establishment and spread of the integral economic system — socially, economically and innovatively-oriented;

— improving equity in the distribution of income among civilizations, states, social strata and generations;

— strengthening the national and international regulation of economic processes in the interests of the majority of the population, the development of effective mechanisms of market regulation at both regional and national, and global levels;

— eradication of poverty in the world, creation of international institutions and mechanisms for solution of this problem.

The establishment of an integral economic system is impossible without changing the model of globalization. By itself, the process of globalization is naturally determined and progressive. However, under the prevailing neoliberal model from the end of the 20th century the process of globalization is in the interest and under the control of transnational corporations and international financial centers, accompanied by increasing spontaneous and turbulent dynamics of the global economy, the growing gap between rich and poor nations and civilizations.

The formation of a new model of globalization implies:

— strengthening the regulation of the primary areas and processes from the UN and the international economic institutions (IMF, World Bank, WTO, etc.) with the transformation of the nature of their activities on democratic principles;

— the adoption and implementation of a global law, including the antitrust laws;

— a long-term strategy to overcome extreme economic polarization, raising the economic development level of the lagging countries, the implementation of the principles of equity and partnership in agricultural ties.

2.6. ON THE PATH TO THE MULTIPOLAR WORLD ORDER BASED ON THE PRINCIPLES OF DIALOGUE AND PARTNERSHIP AMONG CIVILIZATIONS

At the end of the 20th century with the end of the "cold war" it is ended the post-war bipolar architecture of the world order. An attempt to build the unipolar world dominated by one superpower has happened to be unsuccessful. In the long view, they will have to choose between two models of the world order: a return to the bipolar world, led by the two superpowers (U. S. and China), or the formation of the multipolar world order on the principles of dialogue and partnership among civilizations, their potential for conflict and confrontation in the transition period, by the model of S. Huntington.

While the 20th century was the century of states, the number of which was increasing rapidly and now exceeds two hundred — from dwarfs to giants — then in the 21st century 12 local civilizations of the fifth generation are becoming the major players in the geopolitical arena, the nature of the relations between them (confrontation and conflict or dialogue and partnership) determines the fate of humanity. Recognition of their equality and increasing all-round partnership in response to the challenges of the 21st century is a part of the geopolitical strategy to overcome the crisis of civilization and entering the path of global sustainable development.

The central tasks of geopolitical partnership of civilizations for sustainable development are:

— development and launching the institutions and mechanisms for dialogue and partnership among civilizations and states in response to the challenges of the new century, the identification and resolution of global emergencies through the joint efforts;

— preventing the rise of conflicts, a new arms race and international terrorism, eliminating its root causes, deliberate demilitarization of economy and society, weakening the influence of NATO and other military blocs;

— creating the conditions for the formation and implementation of socio-political partnership, civilizations, states, social strata and generations, and increased governmental and intergovernmental regulation in crisis situations.

2.7. DECAYING OF SENSATE AND ESTABLISHMENT OF THE INTEGRAL SOCIO-CULTURAL SYSTEM

From the second half of the 20th century it is picking up the tendency of crisis and decaying of the sensate socio-cultural system prevailed in the West for five centuries, noted by Pitirim Sorokin. This finds expression in the crisis of science and education, culture and morality, decline in spiritual and civilizational values.

At the same time there appear signs of the nascent integral socio-cultural system with the underlying processes of the rise of science, increase in the creativity of lifelong education, revival of high culture and humanistically noospheric morality, formation of new humanism. These processes require an active support of the states, UNESCO and other international organizations and global civil society.

The central link of the long-term strategy of socio-cultural development and partnership among civilizations is a synthesis of scientific, educational and information revolutions of the 21st century.

The scientific revolution will help to overcome the crisis of scientific knowledge, to assimilate and disseminate a new scientific paradigm adequate to the realities of the 21st century, to elevate the role of science at national and global levels, to implement the principles of the noospheric civilization formulated by Vladimir Vernadsky and Nikita Moiseyev.

The essence of the recent revolution in education is in the assimilation and transfer to new generations of the achievements of the scientific revolution, a new world view, enhancing creativity and innovativeness of education.

A synthesis of scientific and educational revolution with the new stage of the information revolution will allow accelerating many times and ensure the completeness of the assimilation of new knowledge and skills to the next generations.

The most important condition for the development and dissemination of the integral socio-cultural system is a revival of spiritual and civilizational values, overcoming moral degradation, the revival of humanism, preservation and enrichment of the world's cultural heritage, partnership of world religions in strengthening the moral foundations of the family and society.

Part 3. Local Civilizations on the Path to Sustainable Development

3.1. FEATURES AND PROSPECTS FOR DEVELOPMENT AND INTERACTION OF LOCAL CIVILIZATIONS OF THE FIFTH GENERATION

From the end of the 20th century it is going the transition from the fourth generation of local civilizations (with the dominance of the West) that prevailed for five centuries to the more differentiated, diverse and active fifth generation, which includes three civilizations of Europe (Western European, Eastern European, and Eurasian), three civilizations of America and Oceania budded off from the Western civilization of America and Oceania (Northern American, Latin American, Oceanic) and six ancient civilizations of Asia and Africa (Indian, Chinese, Japanese, Buddhist, Muslim and African — Sub-Saharan Africa). One can also talk about the Arctic civilization, including the northern parts of the Eurasian, Western European and Northern American civilizations, but has no independent geopolitical core.

By the middle of the 21st century it is possible differentiation fairly motley composition of the Muslim civilization into Arabic, Persian, Euro-Muslim, Afro-Muslim, Hindu-Muslim and Far Eastern Muslim.

It changes the structure of the leaders of the generation of local civilizations. The former leaders — Northern American, Western European and Oceanic — become a stronghold of the conservation of the industrial civilization. It becomes

the leaders of the movement to an integral civilization Chinese, Indian and Latin American civilizations. It becomes true the prophecy of Pitirim Sorokin and Arnold Toynbee –the shifting of the center of the creative activity of civilization to the East. African, Muslim as well as Eurasian and Eastern European civilizations are in the state of protracted crisis.

3.2. CIVILIZATIONS OF EUROPE

The Eurasian and East European civilizations are ridden with protracted deep civilizational crisis from the 1990s. From the end of the first decade of the 21st century the western European civilization also found itself in the state of crisis. The main signs of the crisis of civilization:

— the decline in population growth and the spread of depopulation. According to the UN medium variant forecast the level of depopulation in the years 2045–2050 in Europe as a whole will be — 0.26%, including Eastern Europe — 0.57% (Russia — 0.57%, Ukraine — 0.67%, 0.95% in Bulgaria), southern Europe — 0 19%) (Portugal — 0.39%, Serbia-0.30%), Western Europe — 0.22% (Germany-0.56%, the Netherlands — 0.11%). In Northern Europe, depopulation will involve the Baltic republics, Denmark and Finland;

— increase in the deficit of energy and other natural resources in most countries of Western and Eastern European civilizations, the gradual exhaustion of the best fields in the countries of the Eurasian civilization;

— technological degradation and the growing gap of the Eastern European and Eurasian civilizations from the vanguard countries;

— neoliberal economic reforms in the Eurasian and Eastern European civilizations led to the deformation of the structure of the economy, formation of the oligarchic-comprador economy, drastic economic polarization of the population.

Integrated into the European Union the Western European civilization was among the world leaders. However, the absorption of the Eastern European civilization in the 90s and anti-Keynesian crisis management policy of the European Union and the IMF have led to a profound long crisis, especially in southern Europe, a sharp increase in the unemployment, exacerbation of socio-political contradictions, a lower level of living.

Russia, despite high growth rates in 2000–2008, has not succeeded in overcoming the civilizational crisis of the 1990s and implementing innovative modernization of economy.

In the 2020s, the crisis of the European civilizations will be mainly overcome, but the negative demographic dynamics, the protracted economic crisis and neoliberal nature of economic policy will slow the economic growth. Under the inertia-based scenario it will be 2.4–2.6% for the period 2010–2050, under the innovation-breakthrough scenario it will go up to 2.8–3.5%.

The outlooks of the Eurasian civilization are ambiguous. The demographic situation develops unfavorably, the decline in population and the number of the active working age. The technological trends of degradation and deformation of the structure of economy have not been overcome. The state has no scientifically founded long-term strategy and mechanism for its implementation, and the neoliberal approaches have not been overcome.

If this trend continues in the future, the trend of the disintegration of the Eurasian civilization and the fall of its role in a geo-civilizational space will continue and establishes. But with the development and implementation of a long-term strategy of innovative breakthrough it is possible to overcome the negative trends, the revival of the Eurasian civilization in the new format. This will allowing coming closer to the vanguard group of countries and civilizations, but it is unlikely to enter them in the long term, there are too large losses incurred for a quarter of the century of the civilization crisis.

Europe's share in the world population decreased from 21.7% in 1950 to 10.6% in 2010 and 7.6% in 2050, the average age of the population will rise from 29.7 to 46.6 years and 21% exceed the average world indicator. The share of the European civilizations in world GDP declined from 42.8% in 1950 to 28.2% in 2000 and by 2050 will fall, probably up to 15–17%. So the decline of Europe, which in the 19th century reigned supreme in the world, this is not a figure of speech of Oswald Spengler, but the very real historical perspective under the adverse scenario.

3.3. CIVILIZATIONS OF AMERICA AND OCEANIA

The starting positions of the civilization group of America and Oceania are more favorable than of the European civilizations. The population growth remains, though declining: in Latin America — 1.12% in 2005–2010 and 0.10% in 2045–2050, 0.96 and 0.37% in North America, 1.04 and 0.59% in Oceania. These civilizations are well endowed with energy and other natural resources, as a result of "shale revolution" the U. S. from the 2030s may become private energy resources exporters (in 2009, net imports of energy will be 22%, and in Canada, net exports 53%, in Latin America 31%, in Australia, 137%). In North America and Australia a high technological level of economy, Brazil and Mexico rapidly increase the rates. Production of GNI by PPP per capita in 2010 in the U. S. is 3.2 times higher than the world average, in Canada — 6.6%, Australia — 41%, Latin America — 99% of the world average.

However, controversies are growing in this group of civilizations. The U.S. economy is largely based on the growing debt of more than 15 trillion U. S dollars. Market capitalization of companies in 2006 in the U. S. reached 148% of GDP, in Canada — 134%, Australia — 140%, Latin America — 52%. The U.S. became a hotbed of the global financial crisis of 2008–2009. Intensive in-migration to the United States and Australia are changing the ethnic structure of the population.

Based on accumulated experience, the North American civilization can maintain a relatively high rate of economic growth in the long term, although we cannot exclude the fall of the rate of growth in the U. S. under the adverse scenario. Latin America (especially Brazil) will most likely be developing at a rate higher than the world average on the up wave of the civilization cycle in 2020–2040.

The share of American and Oceanic civilizations in the world population has increased from 13.9% in 1950 to 14.5% in 2010 and will decrease to 13.5% by 2050. The share in the global GDP fell from 39% in 1950 to 31.7% in 2010 and is unlikely to exceed 20–22% by 2050. In any case, this group of civilizations would unlikely have enough reasons to claim the global leadership.

3.4. CIVILIZATIONS OF ASIA AND AFRICA

In the industrial age, the once prosperous and leading in the world civilizations of Asia and Africa have found themselves under the heel of the Western European civilization, and degraded both by population, and especially by the share in the world GDP and in terms of technology. The share of Asia (excluding Japan) dropped in the world population from 65.2% (with Japan 68.2%), in 1820 to 51.4% in 1950 (with Japan 54.7%), in the world GDP from 54.6% (59.4%) to 15.4% (18.4%). Japan suffered particularly large losses: its share in the population from 27.3% in 1700 decreased to 14.2% in 1950, in GDP — from 24.4% to 6.8%. Africa's share of world population dropped from 10.1% in 1700 to 7% in 1950, in GDP — from 6.9 to 3.8%.

In the last quarter of the 20th century as a result of the national liberation revolutions and the collapse of the colonial system of imperialism it is taking shape the reversal in trends. The first breakthrough was made by Japan, its share in world GDP rose from 3% in 1950 to 7.8% in 1978, but then decreased to 7.1% in 2001; the share in the population rose from 3% to 3.3%, but then decreased to 2.1%. The breakthrough was made through the technological and human factors, but at the end of the century the potential of the breakthrough was largely exhausted, the aging of population intensified, depopulation begins.

The Chinese civilization experiencing a renaissance became an undisputed global leader in terms of the economic growth in the last third of the century. Its share in the world GDP rose from 4.6% in 1973 to 12.3% in 2001, the average annual GDP growth rate is 6.72%. In the 2030s, China could surpass the U. S. in terms of GDP volume. It is the world leader in the establishment of the integral civilization, in terms of scientific and technological progress rates. However, in the long term the growth of economy will be limited by a demographic factor (entering from the 40s the stage of depopulation, growth in shortage of labor) and natural-ecological factor. Despite strenuous efforts to develop the sixth technological order the growth of economy in the long term will consolidate at 5–6%, but it will still exceed the world average.

In the last decades India also shows high rates of economic growth (5.17% in 1973–2001). Its share of world GDP increased from 3.1% in 1973 to 5.4% in 2001, the share in the world population grew from 14.4% in 1950 to 16.6% in 2001, and over the next decades, India will become the first nation in the world by population. There are no limitations by labor force, but the low standard of living and weak, scientific-technical and technological potential. Therefore it is unlikely that India will be able to maintain high rates of economic growth for a long time, but they will be higher than the world average.

The Buddhist civilization is diverse by its structure. The Republic of Korea is one of the world leaders in technological and economic development; economy of Vietnam and Thailand is growing fast. However, Myanmar (Burma), Laos, Cambodia, Mongolia are at the low level and do not have the prospects for surmounting the underdevelopment without external assistance.

The Muslim civilization is even more diverse. Along with the rich and high-tech countries of the Persian Gulf, Turkey, Indonesia, Malaysia are fast gaining momentum, there are a large number of countries

here at the middle level of development (Iran, Iraq) and there are a lot of laggards (especially Afghanistan). Civilization is shaken by internal strife and conflicts, but it has a high rate of population growth, is well endowed with labor resources and has not bad prospects for growth, increasing the share in the world population and GDP. However, it is possible that by the middle of the 21st century, it is differentiated into 5–6 civilizations (Arabic, Persian, Euro-Muslim, Afro-Muslim, Hindu-Muslim, and Pacific-Muslim). This process can go painfully and accompanied by escalation of conflicts.

The African civilization is in a deep crisis, growing poverty with the record rates of population growth. This turns the African civilization in the most conflict and lagging area of modern geopolitical space.

In the future, Asia's share in the world population will decline from 61.3% in 2010 to 57.2% in 2050, Africa's share will increase from 15.0 to 21.8%, so that three-quarters of population in the world in general belong to this group of civilizations. The share in the world GDP grows rapidly, in the next 15–20 years it will become prevailing. We could assume that this civilization in the future will determine the fate of the global civilization, humanity. But now it is the most vulnerable and polarized, conflict- and international terrorism affected part of the global civilization. This is where you should first perfect the mechanism for dialogue and partnership among civilizations.

3.5. A LONG-TERM FORECAST OF ECONOMIC GROWTH RATES OF CIVILIZATIONS

In Paris, in November 2012 it was published the OECD forecast "Looking to 2060: A Global Vision of Long-Term Growth". The forecast presents estimates of economic growth rates in the period 2011–2030 and 2030–2060 for 34 countries of the OECD and 8 countries of "G-20", non-OECD countries (Argentina, Brazil, China, Indonesia, India, Russia, Saudi Arabia, and South Africa). In Table 1 it is grouped the forecast data for the world as a whole, the OECD and non-OECD and in the context of civilization — by 12 civilizations of the fifth generation.

The OECD experts believe that in 2011–2030 global economic growth rates will rise from 3.5 in 1995–2011 to 3.7%, but then in the years 2030–2060 they will decline to 2.3%.

The OECD forecast has outlined significant changes in the territorial structure of economy, especially in 2011–2030 *(Table 2).* The share of 34 countries in the OECD will decline from 64% in 2011 to 49% in 2030 and 42% in 2060, the share of non-OECD countries will rise from 35% in 2011 to 51% in 2050, but the following 30 years — only to 58%. Under the stabilization of the share of China (28%) and Russia's share drop from 3.6 in 2011 to 3.1 in 2030 and 2.4 in 2060, Brazil from 3.1 in 2030 to 2.8 in 2060, with the increasing India's share from 7% in 2011 to 11% in 2030 and 18% in 2060–2.6 times for 50 years.

For the next 30 years it is anticipated a significant fall in the rate of growth in non-OECD countries more than double — from 5.9 to 2.8%, under a smaller decline in the OECD countries (from 2.2 to 1.8% — 18%). With the most significant drop in the rate of growth is taking shape in Russia (from 3% to 1.3% — 2.3 times), China (from 6.6 to 2.3% — 2.9 times), Poland (2, 6 to 1% — 2.6 times), Brazil (from 4.1 to 2% — more than twice), and the Republic of Korea (from 2.7 to 1% — 2.7 times).

Table 1. *Economic Growth Rates under the OECD Forecast, %*
GDP Growth rates at PPP in Constant Prices

Civilizations and leading countries	1995–2011	2011–2030	2030–2060	2011–2060
World	3.5	3.7	2.3	2.9
OECD countries	2.2	2.2	1.8	2.0
Non-OECD countries	6.7	5.9	2.8	3.9
CIVILIZATIONS OF EUROPE				
Germany	1.4	1.3	1.0	1.1
UK	2.3	1.9	2.2	2.1
France	1.7	2.0	1.4	1.6
Italy	1.0	1.3	1.5	1.4
Poland	4.3	2.6	1.0	1.6
Russia	9.1	3.0	1.3	1.9
CIVILIZATIONS OF AMERICA AND OCEANIA				
USA	2.5	2.3	2.0	2.1
Canada	2.6	2.1	2.3	2.2
Brazil	3.3	4.1	2.0	3.8
Mexico	2.6	3.4	2.7	3.0
Argentina	3.8	3.6	2.2	2.7
Australia	3.3	2.1	2.2	2.8
CIVILIZATIONS OF ASIA AND AFRICA				
Japan	0.9	1.2	1.4	1.3
China	10.0	6.6	2.3	4.0
India	7.5	6.7	4.0	5.1
Republic of Korea	4.6	2.7	1.0	1.6
Saudi Arabia	4.2	4.5	1.9	2.9
Indonesia	4.4	5.3	2.4	4.1
RSA	3.4	3.9	2.5	3.0

Table 2. *Dynamics of territorial structure of world GDP under the OECD forecast,%*

	2011	2030	2060
OECD countries	64	49	42
USA	23	18	16
Japan	7	4	3
Eurozone	17	12	9
Other OECD countries	17	15	14
Non-OECD countries	35	51	58
China	17	28	28
India	7	11	18
Other non-OECD countries	11	12	12
Including			
Russia	3.6	3.1	2.4
Brazil	2.8	3.1	2.8

This forecast of the economic growth rates appears fairly disputable, especially in terms of civilizational change of cycles. For 2011–2025 it falls the down wave of the industrial civilization cycle and the 5th Kondratieff cycle that determines the decline in economic growth rates against the previous fifteen years. However, from about the 20s it can be expected the reverse in trends as a result of the shift to the next up wave of the next civilizational and 6th Kondratieff cycle, which will express itself in the increase in the rate of growth in spite of a number of demographic constraints (decrease in population growth and the number of employed) and natural-ecological (exhaustion of certain mineral resources, shortage of fresh water, growth of environmental costs). One should not expect a return to record growth of 1950–1973 (4.9% p.a.), but it is quite real the average annual GDP growth of 3–3.5%, and not 2.3%, as projected by the OECD.

Part 4. Scientific Foundations, Institutions and Mechanisms for Implementing a Long-term strategy for Sustainable Development

4.1. SCIENTIFIC FOUNDATIONS OF A LONG-TERM STRATEGY

In the transition period it accelerates many times and grows complex the rates of changes and transformations. This requires from the states and international organizations (and first of all from the UN system) a far vision, profound scientific approach and strategic thinking. Only on this basis it can be formed an innovative partnership of science, education, government and business, social and political partnership of civilizations, states, social forces and generations, provided a recovery from the crisis by strengthening of governmental and international regulation of the utmost complex processes of change of civilizational cycles.

However, in the last quarter of the century, it is observed an increasing separation of the power from the advanced science — both at national and at international levels, which is contrary to the principles of the noosphere. Neoliberal approaches have made a major contribution to the development of the crises, actively supported by multinationals that seek to get out of control of the power and civil society. And in science itself, it is observed crisis, a weakening of the creative and prognostic potential of scientific schools being guided by the outdated industrial scientific paradigm.

In the report "Resilient People. Resilient Planet: A Future Worth Choosing" (2012) of the United Nations Secretary-General's High-level Panel on Global Sustainability it is noted the need for greater involvement of science to justify political decisions and retaining scientists to the UN activities. The recommendations of the 6th Civilization Forum within the United Nations Conference on Sustainable Development propose concrete steps in this direction: to establish the World Science Council under the UN Secretary-General; formation of scientific and expert councils under the UN organizations and other international organizations; formation of an international institute of global forecasting and strategic planning. The international team of scientists formed by SKII and INES has developed a long-term Forecast "The Future of Civilizations" for 2050, and the report to RIO+20 Confer-

ence "Foundations of a Long-term Strategy for Global Sustainable Development Based on Partnership of Civilizations", is preparing a report for the Summit in RIO +2- in St. Petersburg.

A theoretical basis of crisis recovery is laid by N. Kondratieff, P. Sorokin, J. Schumpeter, G. Mensch; scientific basis for sustainable development strategy — by V. Vernadsky and N. Moiseyev. These scientific bases are further developed and adapted to the conditions of the 21st century. It is time for the system of power to turn to the advanced science.

4.2. INSTITUTIONS TO IMPLEMENT SUSTAINABLE DEVELOPMENT STRATEGIES

Even the best and most scientifically founded strategy for recovery from crisis and entering the path of global sustainable development will remain the board of good intentions, unless it is based on real and effective institutions and mechanisms for the implementation of this strategy.

The globalization process, the formation of a planetary civilizational space includes not only economy, but also the information flows, the humanitarian sphere. It extends to the sphere of management and regulation of the functioning and development of all the humanity, global civilization, all the components of the genotype of civilization. In this area gradually from the wars and violence the center of gravity moves to democratic practices, resolution of contradictions inevitably arising in the global mega-system through dialogue and consensus, with the prospect of the increasing elements of partnership in response to common challenges and critical situations.

The outlines of gradually emerging global institutions include the following key elements.

1. *Summits of Heads of States* and governments of all or nearly all states to discuss and address major strategic issues. It is a kind of planetary councils, initiated by the United Nations or a group of leading powers, although there is taking shape some regularity (RIO, RIO+10, RIO+20). The competence of summits is not yet regulated, accumulating experience, which will require the generalization and legal regulation.

Summits of "G- 8" meet annually (represent the leaders of 4 civilizations) and "G-20".

2. *The UN system in* combination of central, functional and regional organizations. Its functions are defined by the UN Charter and require a transformation with respect to the conditions of the 21st century. The UN operates on democratic principles, but it has some authoritarian features. It appears that in the long term the UN may transform into the World Confederation of Nations and Civilizations (the European Union is an experimental site for testing such mechanism of confederation).

3. *Institute for Global Law* in the diversity of its constituent elements (administrative, civil, ecological, criminal, etc.) judicial authorities supporting such law is also in the state of formation, only some of its elements are identified so far.

4. *Institutes of global civil society* designed to represent the interests of different social groups and to exercise control of society over the activities of government authorities is also at the initial stage of formation. It is represented by many non-governmental organizations.

4.3. MECHANISMS FOR THE IMPLEMENTATION OF THE STRATEGY

It is also necessary to develop effective mechanisms for implementing a long-term strategy, which may include the following key elements.

1. *Forecasting, strategic planning and programming* of global development, cooperation between states and civilizations. Only on the basis of scientifically founded strategies it is possible, in a historically short period of time, to overcome the period of change of civilizational cycles, reducing the growing polarization of countries and civilizations. This requires the development of long-term scientifically founded projections of global development and production on such basis a long-term global strategy to overcome the crisis of civilization and entering the path of global sustainable development (a kind of a global anti-crisis program), strengthening the strategic function of the UN system. It seems necessary to embark upon the development of a long-term strategy for global sustainable development for 2030 and the strategy on the elements of the civilizational genotype and sustainable development so that to discuss this package of the strategy by Summit RIO+25.

2. *Financial support* for the implementation of global strategies and programs on the basis of global specialized funds with stable sources of formation and use of rental income.

3. *Mechanism of monetary and price controls* to avoid speculative fluctuations in world prices, undermining the stability of the global economy, the rationale for the formation of monetary, financial and legal sources, to overcome the "bubble economy."

4. *Staffing* for sustainable global development by establishing a system of training, retraining and advanced training of employees working in this sphere of institutions, public examinations for candidates for the offices of international officials.

5. *Monitoring and information support* for the implementation of the strategy and programs to ensure the transparency and reliability of data on global processes, to create a reliable and complete information base for the functioning of institutions and mechanisms for the implementation of the strategy.

Conclusion

Currently, the global community has faced with a difficult and fateful choice: how to overcome the civilizational crisis causing a heavy damage, to enter the path of global sustainable development, preservation and enrichment of potential accumulated by humanity for thousands years.

The force of inertia, fear of radical changes is pushing the leaders of states and international organizations to the path of a partial improvement, conservation of the moribund, but very profitable system for the rich countries, transnational corporations and world financial centers. This leads to the overcoming of its agony and increase of the sufferings of the majority of humanity. This is a dead end, but it prevails so far.

Another, innovative-breakthrough strategy is in the course on radical transformations, establishment of the integral, humanistically noospheric civilization based on the wave of epochal innovations. This path frightening by its terra incogni-

ta and high risks is not yet received by the conservative ruling and business elites. However, the structure of the elite is changing with the change of generations, and the crisis encourages taking risk and radical transformations, changing the face of the planet, and is eventually in the establishment of a positive scenario of the noosphere. It is this path the international team of scientists offers, its main points are outlined above.

Let us hope that the world leaders will defer to the recommendations of scientists.

References

1. Global Forecast "Future of Civilizations" for 2050. Part 1–10. M: SKII, 2008–2009. www.globfuture.newparadigm.ru.
2. The Foundations of a Long-Term Strategy for Global Sustainable Development. Report of the International Team of Scientists to the Conference RIO+20. M: SKII, 2011 (www.glob-strategy.newparadigm.ru).
3. Yakovets Yu.V. The Past and the Future of Civilizations. Lampeter: The Edwin Mellen Press, 2000.
4. *Yakovets Yu.V.* Globalization and Interaction of Civilizations. M: Ekonomika, 2003.
5. *Kuzyk B.N., Yakovets Yu.V.* Civilizations: Theory, History, Dialogue, and the Future. Vols 1,2,6. M: INES, 2006,2009.
6. *Glaziev S.Yu*. The Strategy of the Faster Growth of Russia under the Global Crisis. M: Ekonomika, 2010.
7. *Yakovets Yu.V.* Global Economic Transformations of the 21st Century. M: Ekonomika, 2011.
8. Resilient People. Resilient Planet: A Future Worth Choosing. Report of the United Nations Secretary-General's High-level Panel on Global Sustainability (The Partnership of Civilizations No. 4, 2012).
9. Sadovnichy V.A., Akaev A.A., etc. Modeling and Forecasting of the World Development. M.: MGU, 2012.
10. 2020 World Development Indicators. Washington: the World Bank, 2012.
11. World Population Prospects. The 2008 Revision. N. Y.: UN, 2008.

Presentation of Coursebooks, Monographs, Projects

Methology of Modeling and Forecasting of the World Dynamics

Extant Methods of the World System Modeling: Capabilities and Limitations

Askar Akaev *— Dr.Sc. (Engineering), Professor, RAS foreign member*
V.A. Sadovnichy *— Dr.Sc. (Physics and Mathematics), Professor, RAS Academician*

Mathematical modeling of the world dynamics goes back to the papers of a prominent American scientist Jay Forrester to the famous Club of Rome in the late 1960s and early 1970s, devoted to the application of system dynamics models for long-term ecological and economic forecasting (Forrester, 1978). The main question that interested the Club of Rome that time was to determine the sustainability of economic model that prevailed in the West after World War II. This model assumed the dynamic growth and unlimited expansion with the use of resource-intensive technologies. Forrester's reports showed that the continuation of resource-intensive growth strategy in the face of unprecedented population growth occurred in this period would inevitably lead either to an acute shortage of resources in the world, or to a catastrophic environmental pollution, which could cause a global environmental crisis.

FORRESTER'S MODEL

Jay Forrester, a professor at Massachusetts Institute of Technology, is the founder of system dynamics models. He developed an apparatus of "system dynamics" which allows computer modeling of different scenarios of development in the dynamics of complex

systems. The apparatus was based on the achievements of systems theory and computer modeling using the language of ordinary differential equations (ODE). J. Forrester, on the request of the Club of Rome which was established in 1968 on the initiative of the largest Italian public figure and businessman Aurelio Peccei, created first mathematical models of the world dynamics "World1" and "World2" (1971–1972) which put the beginning of global processes modeling. In 1971, J. Forrester published the first results of computer modeling of the world dynamics in the book "World Dynamics" (Moscow, Nauka 1978) which has become popular and in which he for the first time an attempt to describe the basic processes of economy, demographics, growth, environmental pollution, their interaction and conditionality on a planetary scale was made.

First of all, J. Forrester identified the most significant global processes. That time they were the following: 1) rapid increase in population; 2) industrialization and industrial growth associated with it which caused the environmental pollution; 3) food shortage; 4) increase in waste of production; 5) shortage of natural resources. Thus, the World-System, by Forrester, consists of the following main subsystems: population, capital assets (capital), agricultural funds, non-renewable natural resources, pollution of the environment.

Consequently, the world dynamics can be described by five major global variables as time-dependent functions: 1) N — world population; 2) K — fixed assets (capital); 3) X — share of assets in agriculture; 4) R — amount of non-renewable natural resources 5) Z — number of environmental pollution. J. Forrester believed that the influence of key variables N, K, R, X and Z to each other affects mainly through natural processes of interaction and supporting factors, such as, for example, increasing the difficulty of extraction of non-renewable resources as their depletion. In addition to these variables, J. Forrester introduced another concept — the quality of life which is in the nature of the indicator of system functioning. Quality of life Q is defined a priori as a product of four unitary factors:

$$Q = Q_C\, Q_F\, Q_N\, Q_Z \quad (1.1)$$

where $Q_C\, Q_F$ is dependence of life quality accordingly with material standard of living *(C)* and food *(F)*; $Q_N\, Q_Z$ reflect the influence of factors N and Z on quality of life as correspondent functional dependencies.

For the construction of simulation models that describe the dynamics of World-system there are used ordinary differential equations of the same type of the first order in the following form:

$$\frac{dy_i}{dt} = f_i^+ - f_i^-, \qquad i = \overline{1,n} \quad (1.2)$$

where, f_i^+ is a right side of equation which includes all the factors that cause the growth of the variable y_i, and f_i^- includes all of the factors that cause the decrease of the variable. It is also assumed that the summands on the right side could be represented as a product of functions that depend only on factors F_j which, in their turn, are functions of the main variables y_i. For example,

$$f^+ = \phi^+(F_1, F_2, \ldots F_m) = \phi^+(F_1)\, \phi^+(F_2) \ldots \phi^+(F_m), \quad (1.3)$$

where $F_j = \psi_j(y_{j1}, y_{j2}, \ldots y_{jl})$, $j = \overline{1,m}$, and $m<n$, $l<n$. It follows that the number of factors must be less than the basic variables, and

each factor does not depend on all major variables, but only a part on them. These restrictions were necessary in order to simplify the task of modeling.

Thus, there is a system of ordinary differential equations ODE (1.2) with right sides of the form (1.3). In order to solve this system of ordinary differential equations of the first order it is necessary to specify initial conditions at a particular time.

$$t = T_0 \; . \; y_{i|t=T_0} = y_{i0} \qquad (1.4)$$

These conditions together with the ODE (1.2) define the Cauchy problem. Under certain conditions, there exists a unique solution to this problem. Consequently, the task of the initial conditions (1.4) determines definitely the World-system dynamics. In connection with this the model of Forrester had been criticized as "mechanistic", referring to the lack of flexibility and controllability.

J. Forrester's model of the world dynamics has, correspondingly, five ordinary differential equations describing five global variables. In general, they are five non-linear ordinary differential equations. J. Forrester conducted calculations on this mathematical model for the time interval from 1900 to 2100. 1970 was taken for reference, since the data were compared with available statistics on the time interval of 1900–1970. This made it possible, first, to debug and verify the model itself, and second, to pull up poorly known model parameters. And from the 1970 calculations are purely prognostic. Of course, the chosen forecasting horizon up to 2100 does not allow speaking about an acceptable reliability and accuracy of the forecast beyond XX-th century, because this model does not directly take into account technical progress which plays the key role for long-term development. And for 130 years, the technological structure has changed three times (Glazyev, 1993), that has a significant impact on the age-old path of environmental and economic development. However, for such a model, J. Forrester did not set the problem of accurate prediction; the purpose of modeling was to identify trends in the development of system and its qualitative characteristics. In the essence, this is a model of industrial economy dynamics. In whole a scenario analysis of the model revealed threat of a crisis in the relationship between humanity and nature in the XXI century and showed the existence of "global balance" on the assumption of self-restriction and resource problems solving. J. Forrester considered that the only way to avoid a crisis connected with exponential growth is the transition to a global balance, where the system variables are located on the stationary values and do not change. In principle, it is impossible to complete full stabilization in the framework of Forester's model, since resources can only decrease over time. However, for other variables an output to stationary values may be reached, albeit for limited time periods.

MODIFICATIONS OF THE FORRESTER'S MODEL. A MODEL "WORLD 3"

The Club of Rome has supported a number of further projects on global modeling and study of the interdependence of various processes of the world dynamics. Direct continuation of Forrester's model was a model "World^3" developed by his talented disciple Dennis Meadows and internation-

al research group. In the "World³" model there was held a disaggregation of variables while saving five major subsystems (like J. Forrester did). The truth is that in the latest version of model "World³" there has been added sixth subsystem — "Management". In addition, D. Meadows introduced into this model a large number of interconnections, about 3 times exceeding the number of them used by J. Forrester. As a result, the system was constructed from 12 non-linear ordinary differential equations for the basic variables. Calculations on the model "World³" showed that, despite the great detailization, its predictions were qualitatively and quantitatively very similar to the results obtained by the model "World 2". In the model "World 3" there have failed attempts to overcome any of the major drawbacks of the base Forrester's model. The fact is that the unnecessary complication of the model without its drastic improvement has only led to the fact that the identification of system parameters has become even more difficult, because they trebled while the amount of objective statistical data remained extremely low.

However, the results obtained by using the "World 3" model and published in 1972 in the book "Limits to Growth", which was the first official report of the Club of Rome, had a noticeable response in the world and had a significant impact on the universal understanding of world development. In this book there were firstly expressed warnings about serious threats that may arise on the way to sustainable human development due to reduced supplies of energy and other natural resources, and also as a result of intense environmental pollution. These findings had great resonance in the world; the results of them increased the attention to environmental issues and widespread introduction of energy- and resourse-saving technologies of production. Responsible political leaders realized the danger of saving the old economic model and attempted to move to a new economy based on knowledge.

However, there was also strong criticism from different points of view. According to experts' opinions, the model of the world dynamics by Forrester-Meadows was too mechanical, it did not take into account regional structure of the World-system, there occured discrepancies with the theories of economic growth, the impact of social and technological innovation was not considered. Indeed, Forrester-Meadows model allows only searching for the scenario that would prevent the crisis cituation, by computer modeling of a number of successive scenarios with increasing restrictions on the intensity of resource consumption and environmental pollution. This model does not solve the problem of management the processes affecting the development of the global dynamics.

D. Meadows and his colleagues for nearly forty years continuously studied physical limits to growth imposed by the depletion of natural resources and limited ability of Earth's biosphere to absorb industrial and agricultural pollution. The results accumulated during this time are published in the book (Meadows, Randers, Meadows, 2008) which again confirms its science-based conclusion that the trends of modern economic and industrial development are the way leading to global ecological crisis. However, they also convincingly show the possibilities for humanity to shift to sustainable development of mankind with-

out stopping of economic development and reducing the standard of living in developed countries.

MESAROVIC-PESTEL MODEL

In the project "Strategy for Survival" M. Mesarovic and E. Pestel (Mesarovic, Pestel 1974) formulated a problem of constructing a model of the world dynamics based on the theory of multi-level hierarchical systems and reflecting the process of human interaction with the environment, as well as a complex of economic, social and political relationships in society. This model supposed to be manageable and had to include decision-making process conducted by a person. And most importantly, the world was proposed to be viewed not as a homogenous whole, but as a system of interacting regions with different levels of development and socio-economic structure.

In the Mesarovic-Pestel model, all countries were divided into 10 regions according to their socio-economic structure and level of development. Each region was described by a system of special sub-models with the same structure. Communication between regions was realized through import, export and migration. The main submodels were submodels economy, demography and energetics. Feedbacks between individual submodels were usually absent. This led to a rigid version of definition of endogenous variables for sub-models that use the calculations of other submodels as input information. In these submodels a number of parameters remained uncertain. Management was implemented through a choice of scenario by assigning values to uncertain parameters. The scenario was chosen by decision maker (DM) — a person who conducts computer modeling.

Models of Forrester-Meadows and Mesarovic-Pestel were among the major global models of the first wave. The main characteristics of these models are presented in the *Table 1*.

As a result of forecast calculations according to Mesarovic-Pestel model, it was shown that the world is facing not a global catastrophe (about the middle of XXI century as it follows fron the results of the model "World 3"), but a series of regional disasters which will begin much earlier and for many different reasons for different regions. Thus, they see the future of mankind in various protracted regional crises — environmental, energy, food, raw materials, and demographic ones. The effects of regional disasters will be felt around the world, and avoidance of global catastrophe can only be achieved by agreed efforts of international community — that was the conclusion of Mesarovic-Pestel. They argued that such crises can gradually cover the entire planet, if the international community will not take efforts to achieve a balanced development of all parts of the World-system. So Mesarovic and Pestel called their concept of world development as "organic growth". Therefore, the undoubted advantage of this model is the division of the World-system by interacting regions, as well as specialization and focus of sub-models on the solution of specific problems.

THE DEVELOPMENT OF GLOBAL MODELING IN THE USSR

Soviet scientists from the very beginning took an active part in the work of the Club of Rome, joined the research on global modeling and became essentially the leaders of the second wave of research on global modeling. The work was carried

Table 1.1 *Mathematical models for Global Development (1970s, the first wave)*

Authors Organization, institution	Levels of World-system The basic variables	Theory and Principles	The final models	Publications
Forrester, J., the founder of the construction of the system dynamics mathematical models. Massachusetts Institute of Technology (MIT), USA	WORLD-SYSTEM N — number of population K — physical capital X — share of capital in agriculture R — amount of non-renewable resources Z — amount of environmental pollutions	Theory and principles of the modern dynamics Mathematical models of the global dynamics $\begin{cases} \frac{dy_i}{dt} = f_i^+ - f_i^-, i=1,n; \\ y_i(t=T_0) = y_{i0}; n=5 \end{cases}$	World 1 (1971) World 2 (1972) On the instructions of the Club of Rome	The World dynamics. Moscow, Nauka, 1978 (English version — 1971)
Meadows D., **Randers J.** MIT, USA The Club of Rome	WORLD-SYSTEM Subsystem "Management" was added Disaggregation of variables was held	Detalization and specification of Forrester's model Mathematical model: a system of 12 nonlinear ODE	World 3 The official report of the Club of Rome	Limits to Growth, 30 Year Update. Moscow, Akademkniga, 2008 (English version — 1972)
Mesarovich M. (USA) **Pestel E.** (West Germany) The Club of Rome	WORLD-SYSTEM Division into 10 interacting regions Each region is described by a system of submodels	The theory of multi-level hierarchical systems Management and decision-making theory	Submodels of economy, demography and energetics based on structural differential equations	Mankind at the Turning Point. — Second report to the Club of Rome. 1974

out widely by Scientific Research Institute for System Studies of the RAS under the leadership of D.M. Gvishiani and by Computing Centre of the Russian Academy of Sciences under the leadership of academician N.N. Moiseev. The key innovation in these researches was the introduction of control parameters and studying of the possibilities of global processes management. There was proved the existence of controls that allow moving, lessening or even avoidance of the negative effects of global development *(Gelovani, Egorov et al, 1975)*. However, a high sensitivity of global models to the null hypothesis, the basic statistical information *(Gelovani, Britkov, 1979)* was also shown. Hence the conclusion that the possibility of application of mathematical methods of management and optimization has limited practical use for this kind of macro models. Therefore, further development of global modeling in the USSR went on the path of improvement of tools of computer support for decision-making processes and information management in the framework of modified Forrester-Meadows model. The concrete results of these studies culminated in well-known "Nuclear winter" model created under the direction of N.N. Moiseev

(Moiseev, Alexandrov, Tarko, 1985) and the report "On the threshold of the third millennium (global problems and processes of the USSR)" prepared under the direction of V.A. Gelovani. More detailed information of all this can be found in the article *(Dubovsky, 2010).*

First, the model of the world dynamics with management was proposed by V.A. Egorov *(Egorov, 1980).* His idea was to create new industries for recycling and recovery of resources to clean up the environment from pollution and re-cultivation of lands. Then it was possible to manage the processes of natural resources use, pollution, food production areas by the direction of required amount of capital in these industries. Naturally, this requires a redistribution of capital which can be optimized by a certain criteria. In mathematical model, the idea of managing a variable is implemented by adding to the right side of a proper ODE (2) an additional term containing as a factor a share of capital that is submitted to a new industry, serving subsystem. The latter serves as a control parameter. If we set all control parameters as a function of time, they will define a certain scenario of the World-system development. Next, we solve the problem of optimal management for a given criterion.

The group of V.M. Matrosov created a detailed and modified model of Forrester and Meadows with management of V.A. Egorov *(Matrosov, Izmodenova-Matrosova, 2005).* The distinctive feature of this model consisted in the fact that it did not set a problem of optimization according to some criterion. Moreover, the laws of variation of control parameters were rigidly defined and, in addition, the functional connections between the control parameters and the main variables of the model were introduced. Modification of Forrester's model was, in particular, in the use of more accurate equations describing system variables. For example, the economy sector was described by the neoclassical production function which expresses the dynamics of GDP and consideres the movement of capital, demographic dynamics and scientific and technical progress. Within the framework of derived model stationary solutions were found and their stability was proved. The disadvantages of this model include the complication of modification, making its identification problematic.

The main characteristics of global models of the second wave developed in the USSR are presented in the *Table 2.*

THE MAIN DIRECTIONS OF GLOBAL MODELING IMPROVEMENT

The next wave of interest to the issues of forecasting the future was born in the 1990 in connection with the approach of the third millennium and natural desire to look into a new century, a new millennium. During this period, a number of studies in which the authors tried to make sense of the results of rapid XX century, with its two world wars, the unprecedented development of scientific and technological progress and the demographic explosion, as well as to imagine world development in the XXI century were performed. As a result, a number of futurological prediction and science fiction occured, which had no direct relation to the global modeling.

By the way, the global modeling itself in the 90's of the last century has sharply decelerated, although for the studying of various aspects of the global dynam-

Table 2. *Global modeling and sustainable development with management (USSR — Russian Federation)*

Authors and writing teams Organization, institution	Theory and Principles	Models	Publications
Academician Gvishiani D.M., Gepovani V.A., Britkov V.B., Dubovsky S.V. et al. All-Union Research Institute for Systems Studies	The key innovation is the introduction of management and exploring of global processes management possibilities	1. Improvement of Forrester's model and the instruments of computer supporting 2. World-system and 9 regions	Report: On the threshold of the third millennium (global problems and processes of development in the USSR) — 1984
Academician Moiseev N.N., Alexandrov V.V., Tarko A.M. Computing Centre of the Russian Academy of Sciences	The noosphere doctrine System analysis Mathematical models of climate and global biogeochemical cycles	1. Global model of biosphere 2. Model of "Nuclear winter"	Man and the Biosphere. — Moscow, Nauka, 1985.
Prof. Egorov V.A. and a group of colleagues Keldysh Institute of Applied Mathematics RAS	The applying of optimal management theory to the global dynamics processes was first proposed	Mathematical model of the global dynamics with control parameters	Mathematical models of the global development. — L: Gidrometeoizdat, 1980.
Academician Matrosov V.M. and a group of colleagues RAS SB	Sustainable development Replacement of individual standard DE on the structural DE	Modified Forrester-Meadows model with Egorov's management	The noosphere doctrine, global modeling and sustainable development. — Moscow: Academia, 2005.

ics all around the world there were many research institutions and laboratories. A huge number of people were engaged in this work. However, the gradual complication of models led to the fact that they ceased to express the true cause-and-effect patterns. The majority of experts agree that sophisticated models developed in the 1980's did not justify their expectations, because they didn't make it possible to predict the actual development of economic processes. S. Kapitza *(Kapitza, 2008, p. 24)* cited in this context one remark of an American economist and Nobel Prize winner Herbert Simon that "forty years of experience in modeling complex systems on computers that are getting more and more rapid taught us that the brute force does not lead to the royal path of understanding of such systems… thus, modeling requires appeal to the basic principles that will lead us to the resolution of this paradox".

In recent years, the world has witnessed a new upsurge of activity in the field of geo-physical, ecological and socio-economic forecasting of the future. This is due to the aggravation of environmental and energy problems of mankind. Food problem also can significantly worsen together with considerable population growth. Unfortunately, the environmental load of humanity continues to grow, despite the advances in technology and the efforts of non-governmental organizations. The situation is complicated by the

fact that humanity has gone beyond reasonable limits and finds itself in the area of unsustainable development.

Thus, at the turn of the centuries an extremely important and urgent task of ensuring sustainable development throughout all mankind has clearly shaped *(Meadows, Randers, Meadows, 2008).* Achieving sustainable economic growth makes the development of long-term forecasts, allowing forming the long-term goals and strategies to achieve them not only possible, but postulate it as a necessary condition. It should be noted that socio-economic forecasts are carried out in different time frames — from short-term (one year), medium-term (from one to five years) to long-term (from five to 30–50 years).

If the purpose of short-term models is forecasting aimed at opportunistic activity, and medium-term models are to select a development policy in the near future, the long-term models are designed to investigate the conditions of sustained economic growth. Long-term models are primarily models of growth theory in the sense that they are an instrument for the study of future state of society according to its development strategy.

In recent years we have witnessed the emergence of serious scientific forecasts designed for three decades, and even for a half-century perspective, for example, forecasts of "PricewaterhouseCoopers" Corporation — *"The World in 2050" (The world in 2050, 2006*) and "Goldman Sachs" — *"Dreaming with BRICs: the path to 2050" (Wilson, Purushothaman, 2003).* However, as a rule, such forecasts are within the powers of only large interdisciplinary research teams. In many countries of the world forecast for decades, and even for 30–50 years are now developed. In such prognostic and similar projects of recent time very simplified models were used, which are unlikely to meet the modern requirements. For example, in the construction of mathematical models describing the dynamics of the socio-economic development the neoclassical model of growth by Solow, based on the traditional production function of Cobb-Douglas is used:

$$Y = AK^{\alpha}L^{1-\alpha}, \quad (1.5)$$

where K is physical capital, L — labour force, A — technical progress or total productivity of factors, α — share of income that results from the growth of capital expenditures. Under the technical progress Solow understands not only new technologies, but also a new level of knowledge and skills of the labor force, new materials, and new forms of organization of production. However, the development of human capital is better taken into account in models of endogenous economic growth, a simplified version of which was used in the model of "PricewaterhouseCoopers" corporation. It should be noted that most of the global models of the first and second generations used different versions of neoclassical growth model of Solow to describe a block of economic dynamics.

The main drawback of described model is that it is based on supply-side economics. Consequently, the model ignores a factor of solvent demand and comes only from the expected dynamics of production factors. However, the era of supply-side economics has passed for long time together with neoclassical economic theory. An era of economic demand, the Keynesian era, is coming again. It follows that the new dynamic macro models of the economy are to be built with the account of a joint ac-

tion of long-term equilibrium growth and cyclical fluctuations around it determined by supply and demand. This is the main direction for the improvement of currently used mathematical macro models of socio-economic development dynamics.

The interaction of cyclical fluctuations and growth trend are the very things that reveal a bifurcation point, where the economic system becomes unstable and could plunge into a crisis recession *(Akayev, 2008)*. Thus, considering the joint interaction of cyclical fluctuations and growth allows predicting the timing of the crisis, whereas the traditional model only described trend trajectory and could not predict the crisis and recession. The latter was regarded by critics as the main shortcoming of global models of the first and second generations.

As for the deep cyclical crises repeated every 30–40 years and associated with the change of technological structure, the change of great Kondratieff cycles, for their forecasting it is necessary to synchronize long-term models with real Kondratieff cycles either globally or within the national economy. This allows safe and relatively accurate setting of forecasting horizon which is determined by the duration of the next great Kondratieff cycle and measured in 30–40 years. It is also important that in this period of time one and the same technological system is operating; this guarantees the stability of characteristics of technological progress and, therefore, the constancy of production function parameters (1.5). The fact is that the parameters of production function, first, are different even for countries at similar levels of economic development, and secondly, they are different at different stages of development in the same country. So the synchronization of economic growth model with great Kondratieff cycle simplifies the problem of identifying the parameters. In the models of Forrester-Meadows and Mesarovic-Pestel, the hypothesis of the constancy of these parameters on the long time period of about 1000 years were taken; this certainly does not hold, because two technological structures are laid in this period of time, and each of them has its own parameter values. This in many respects explains the low accuracy of these models which becomes unacceptable for high horizons of modeling — forecasting.

One of the main drawbacks of first generation global models was the description of selected global processes by differential equations of the same type and standard form (1.2), they did not take into account the internal properties and mechanisms of processes development. J. Forrester, D. Meadows and their followers described the right sides of equations (1.3) as it was appropriate in econometrics — on the base of existing statistical data rows processing, which in most cases were very scant. This explains the low accuracy of global modeling results of the first wave. In this regard, in the development of global models of second generation a special emphasis was laid on structural models describng the internal mechanisms of the impact of factors that determine the development dynamics of key global processes and the World-system as a whole.

Structural models of global processes are based on appropriate scientific theories revealing the nature of these processes, the causal relationships within them. Obvious examples are global models of interaction between mankind and biosphere of the Earth, developed under the direc-

tion of Academician N.N. Moiseev *(Moiseev, Alexandrova, Tarko, 1985).* An integral part of these models is climate model based on the achievements of classical science: fluid dynamics, thermo-dynamics and calculus mathematics. It is important that climate model allowed identifying changes in climatic characteristics arising due to anthropogenic factors. Thanks to this the model for the first time in 1983 provided an analysis of climatic consequences of a hypothetical nuclear war and to see how climatic parameters change a year after the nuclear disaster, how nuclear night gradually occurs and gets clarified. Of course, drawing Forrester's equations of the form (1.2) wouldn't make it possible to achieve something like this.

Therefore, one of the most important areas of improvement models of global processes is the usage of structural models as the most reliable and accurate. Structural models are already widely used in demographic and economic forecasting; it will be shown in this paper. It should be noted that structural models of socio-economic processes are fundamentally different from the structural models of physical phenomena. In contrast to physical phenomena, socio-economic processes are usually self-organizing, self-developing, i.e. they are themselves involved in the programming of their behavior. For such systems modeling it is not enough to describe the internal structure of its elements interaction, we should still provide for the emergence of new properties of self-organization and self-development, which can not be derived from the properties of the individual parts of the system *(Golanskiy, 1983).*

True, this specific of socio-economic processes is not always taken into account when modeling. For example, the model of Forrester — Meadows, created in the form of interaction between subsystems feedback contour, ignored the integral characteristics of social system reducing them to a simple sum of the properties of subsystems components. The authors of the second forecasting model prepared for the Club of Rome — M. Mesarovich and E. Pestel — pointed at this drawback of Forester — Meadows model. The realization of sub-systems principle, proceeding from the interests of the whole, requires the construction of a multi-level hierarchical model, and this is precisely what the named authors did not succeed in.

2. Hierarchical dynamic modeling of the world dynamics

The undertaken above analysis of existing models and approaches to the modeling and forecasting of global development indicates the presence of hitherto unsolved problems and urgency of creating a hierarchical system of mathematical models to describe the macro trends and cycles of global and regional dynamics. In this system of modeling it is appropriate to allocate three interconnected hierarchical levels:

- modeling of the general trends of the world as a whole system;
- modeling of regional dynamics peculiarities; and the global dynamics is the result of regional cooperation and contradictions;
- modeling of socio-economic dynamics of individual countries in the context of world and regional development.

Accordingly, the composition of models should be formed:

• At the first level of modeling there is dynamic model of the World-system as a whole, intended for analysis of trends in the world development.

• At the second level of modeling there are models of regional dynamics intended for a more detailed description of global socio-economic changes with the uneven development of individual countries and regions.

• The results of the study of macro processes on the first and second levels of modeling set the external conditions and restraints for modeling at the third level which is the level of individual countries.

• At the third level of modeling there are models of particular countries intended for the analysis and prediction of their development in the context of the existing limitations and scenarios formed on the first and second levels of modeling.

Models of each level should be designed in order to enable concretization and expansion of their capabilities for solving particular problems. Thus, the models should have a "core" which describes the most important, basic processes related to each level of modeling and also to allow completing the "core" with individual blocks for more detailed description of particular phenomena and processes.

Three most important directions of improvement of global modeling were identified and formulated above. All of them are summarized in the *Table 3* for illustrative purposes.

Separately, it should be said about the importance of taking into account the cyclical processes in the global dynamics associated with uneven development of technology and innovation.

The world economic crisis that began in 2008 and was caused by the problems that have arisen in the U. S. financial sector, has led to a slowdown in many developed and developing economies of the world. The U.S. economy entered into a phase of prolonged instability and experienced a deep recession. A real threat of a new wave of economic recession remains. This situation portends new crises and long-term depression in the world economy in the coming decade.

All this has once again reminded the politicians, economists and businessmen about the uneven, cyclical nature of market economy development and the need to take drastic measures to identify a new

Table 3. *Basic directions of improvement of mathematical modeling of global processes.*

Directions of improvement	What is achieved
Use of socio-economic and geopolitical development patterns arising from the theory of great Kondratieff cycles	Reliable forecasting horizon about 30–40 years
Consideration of the impact of short-term cyclical fluctuations (self-oscillations) on the trend path of long-term development for the identification of critical phenomena	This allows determination of the bifurcation point and the point of failure into the crisis economic recession
Using of structural differential equations to describe the global processes by their deducing from the laws and mechanisms of relevant processes passing	This provides high accuracy and reliability, simplifies mathematical models

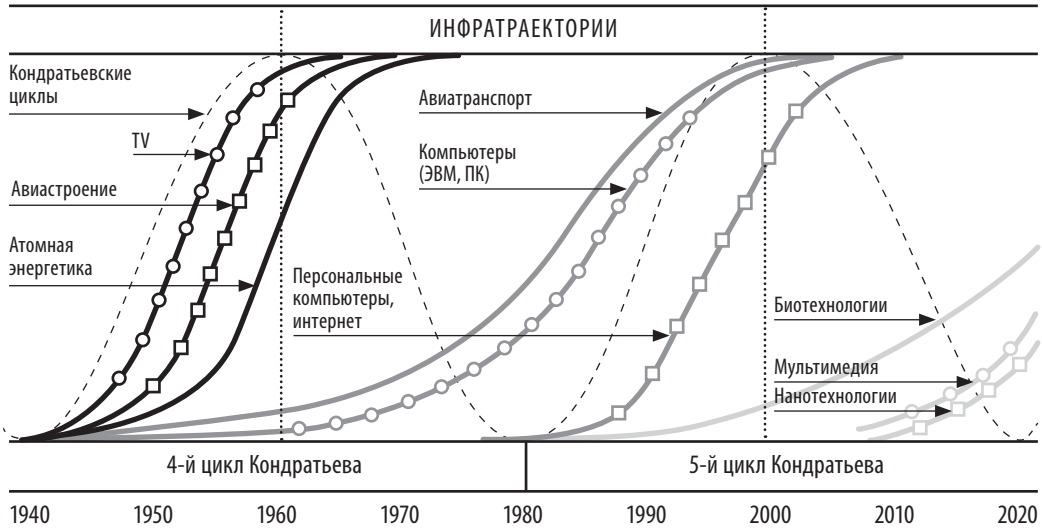
generation of basic technologies and the introduction of various innovations based on them, in order to overcome, painlessly as possible, the impending crisis and depression. In this regard, many researchers *(Glazyev, 2010; Klinov, 2010)* turned their eyes to the coming great Kondratieff cycle, uprising of which will probably be held in the 2020–2040, and they already make forecasts about its parameters and key basic technologies.

In 1912, the great economist of the twentieth century, Joseph Schumpeter, pointed out that the main driving forces of economic development are scientific and technical innovations. He wrote *(Schumpeter, 1982)* that when the innovation that is being introduced into the economy, we have the so-called "vortex of creative destruction" that undermines the balance of old economic system, causing retirement of old technologies, obsolete organizational structures and the emergence of new industries, new institutional capabilities, resulting in an unprecedented dynamism of economic development. Innovations are increasingly acting as a locomotive of economic development, determining its effectiveness and productivity of labour force. Innovations as a process are supported by the investments and related institutions, without which the mechanism to implement them does not work. Investments without innovations are meaningless and sometimes even harmful, because they mean investing in the reproduction of obsolete goods, products and technologies.

Scientific and technological progress in general, and the process of innovation, as it is now widely recognized, develops unevenly over time, namely — cyclically. This results in cyclical fluctuations of economic activity. Long-wave oscillations opened by the prominent Russian economist Nikolay Kondratieff *(Kondratieff, 2002)* were in the focus of researchers in the XXth century. Studying in the 1920s laws of the world economy phenomena, he discovered long cycles of economic conditions around a half-century duration which become called "great Kondratieff cycles". He fully justified the natural connection between "upward" stages of these cycles and waves of technical invention and their practical application in the form of innovation.

J. Shumpeter developed Kondratieff's doctrine of great cycles of conjuncture and elaborated an innovative theory of long waves, integrating it into the overall innovative theory of economic development *(Schumpeter, 1939).* Schumpeter considered cyclical movement of production as a form of deviation from the equilibrium which the economic system always seeks for. Spontaneous clots of innovation cause radical changes in the economy that lead it away from the primordial equilibrium path. The system never returns to its previous equilibrium. A new cycle begins during the next depression on a new level of equilibrium. According to Schumpeter, the change of equilibrium levels determines the long-term trajectory of economic development in which the economic system stays in dynamic equilibrium. Since the theory of great Kondratieff cycles plays a key role in Schumpeter's innovation theory of economic development, as well as the fact that Schumpeter considered it as a cornerstone of his theory, it would be fair to call the latter in the future the "innovative-cyclical theory of economic development by Schumpeter-Kondratieff".

Figure 1. *The diffusion of innovations along the cycle raise of Kondratieff's economic activity*



Most recently, M. Hirooka *(Hirooka, 2006)* showed on the base of processing and analysis of a large array of empirical data the close correlation of innovations and great Kondratieff cycles, and first confirmed that the diffusion of innovations is strictly synchronized with the upward wave of Kondratieff cycle and reaches its maturity in the highest cycle peak, as it is shown in the *Figure 1*. And different basic innovations, thanks to the action of self-organization, form a cluster and appear as a group on the stage of depression. This phenomenon was discovered by Gerhard Mensch *(Mensch, 1979)* who called it "a triggering effect of depression". In other words, depression forces companies to seek opportunities for survival, and the process of innovation can provide them, that is, depression starts the process of innovation. Clusters of basic technologies lead to emergence of new industries and, in turn, launch the next great Kondratieff cycle. Due to synergetic effect of innovations interaction within the cluster, they produce a powerful cumulative growth of economy; that is why they are the main driver of economic development.

Certain innovations extend beyond one Kondratieff cycle to the next one *(see Figure 1)*, contributing to the emergence of new infrastructures and networks, creating a longer trajectory of development which M. Hirooka called an infra-trajectory (for example, computers, aviation, biotechnology, etc.). Those innovations are called main (stem); they first spread in order to create new markets, but then their potential expand to form a new infrastructure in the economy. Infra-trajectories also form a sharply defined clusters, each of such clusters has a backbone main innovation. For example, in the current fifth Kondratieff cycle computer technologies act in this capacity.

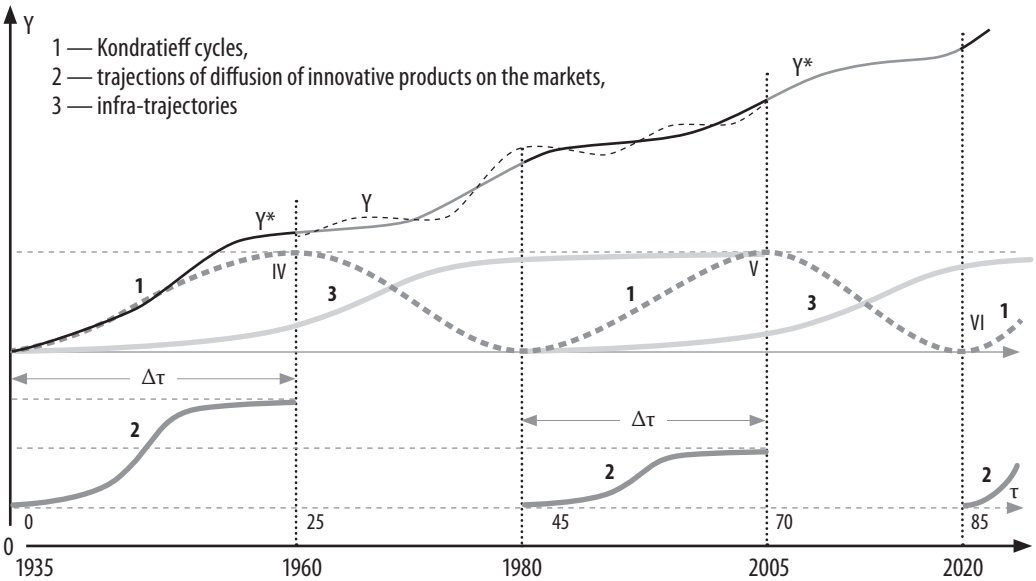
Proceeding from the new innovative paradigm established by M. Hirooka,

knowing of current infra-trajectories which are defined by main innovations of previous Kondratieff cycle, as well as the trajectories of basic innovations of the current Kondratieff cycle, we can build a predictive trajectory of dynamics of innovation and economic development, as it is shown graphically in the *Figure 1.2.* This is achieved by the summation of total value added generated by the basic innovation in the current Kondratieff cycle, and the value added created by institutional changes and a restoration phenomenon caused by infra-trajectories. The GDP trajectory has a characteristic stepped form, and, as Schumpeter argued, each step is best described by logistic curve which is a consequence of changes in economic conjuncture in accordance with the phases of great Kondratieff cycle. *Figure1.2.* presents the period of time that includes the fourth (IV) and fifth (V) Kondratieff cycles. Reliable forecasting could be extended at least until 2040, that is — the top of the sixth (VI) Kondratieff cycle peak.

The described above process of innovation and cyclical development of market economics has been formalized and described in the paper *(Akayev, Hirooka, 2009).*

In the 80s of the last century, after a global economic crisis, a heightened attention was given to the study of theory and practical applications of great Kondratieff cycles and there was a great number of works on this subject, including the development of mathematical models. However, mathematical models of that time were aimed at a qualitative analysis of cyclical fluctuations, at the definition of their key parameters such as cycle duration, the characteristic points, etc. One of the first mathematical models of Kondratieff's long wave was

Figure 1.2 *Graphical scheme of the construction of the trajectory of total output Y (GDP)*



proposed in the work of S.M. Menshikov and L.A. Klimenko *(Menshikov, Klimenko, 1984)*. It was a system of first order differential equations with delays. The model naturally generates oscillations similar to those of the economic conjuncture in Kondratieff cycles. It also allows very rough estimation of cycle duration and the turning points of the long waves. Dubovsky S.V. developed a more sophisticated model *(Dubovsky, 1995)* in which the cyclical development is embedded in the model of economic growth. In this model, GDP dynamics is described by the differential equation derived from the neoclassical growth model of Solow, and is completed with the investment model, respective to the technological cycles generating Kondratieff cycles. Dubovsky model also allows carrying out a qualitative analysis of differential equations solution and more precise identifying the periods of long waves corresponding to great Kondratieff cycles, as well as characteristic point related to the rise and fall of Kondratieff cycle.

An important task is to continue these studies in order to describe quantitatively the mechanism of innovation and cycle economic development by Kondratieff-Schumpeter, as well as, apart from the qualitative analysis of the impact of cyclical fluctuations on the long-term growth, to be able to calculate the trajectory of GDP, to evaluate the cycle duration and to predict the times of crisis recession in the economy.

The main objects in the emerging system of hierarchical modeling — forecasting are economy, demography, scientific and technological progress, natural resources and ecology. They determine the order parameters — those slow variables under the behavior of which the rest will adjust. The key parameters of order in the world history were and remain the number of population (N), available resources (R), the level of technology (A) and education (E), as well as national income (Y) depending on them. The following chapters there will provide specific implementation of described in this section program of the improvement of global mathematical modeling.

Dear readers! In order to subscribe to the electronic version of the International sscientific and educational journal "Partnership of Civilizations", please send your request to the e-mail: piskunova@inesnet.ru, putting in the subject line SUBSCRIPTION TO THE ELECTRONIC VERSION OF THE JOURNAL "PARTNERSHIP OF CIVILIZATIONS" FOR 2013 YEAR.

In reply to your request, you will be forwarded an invoice. After the payment proceeded, the journal "Partnership of Civilizations" will be delivered to your e-mail box.

Issues of the journal "PC" are delivered by e-mail in one file (.pdf), in accordance with the schedule of edition. In case there are plenty of pictures in one issue, it will be delivered in one or several letters (.zip) weighting each not more than 5 Mb.

RATES

Personal subscription

Year	Price per the issue, US dollars.	Rate of annual subscription, US dollars.
2013	30,00	120,00*

You can also order previous issues of the journal "Partnership of Civilizations" for 2012 year.

Corporate subscription

Address dispatch of the electronic version of the journal by e-mail.

For 5-9 subscribers to the electronic version of the journal "PC" the discount is 10%.

For 10-29 subscribers to the electronic version of the journal "PC" the discount is 20%.

For 30-50 subscribers to the electronic version of the journal "PC" the discount is 40%.

* In 2013 year the schedule of the journal "PC" edition is 4 issues per year (issues №1 and №2 of the journal "PC" are combined in 2013 year)