Computer Simulation of Evolution: Genetic and “Memetic” Ways

Vladimir F.Levchenko, Vladimir V.Menshutkin

I.M.Sechenov Institute of Evolutionary Physiology and Biochemistry, St. Petersburg,
194223, Russia. Fax: +7 812 5523219, e-mail: lew@iephb.nw.ru, vvm@emi.nw.ru,
http://www.iephb.nw.ru/labs/lab38/

Abstract
Experience of evolutionary simulation is described in the article. The first presented program simulates the macroevolution of *Chordata* animals inside the space with different environments. Darwinian regulations of mutating and competition were set at the initial program version, but the model shows this is not enough to explain known particularities of biological evolution. Another model demonstrates that the evolutionary stability of species is a consequence of prohibitions on some types of evolutionary modifications. Our new simulation uses alike principles as the above but this model concerns the evolution of the human ethno-populations. The central feature, which distinguishes the man evolution from other cases, is that the interaction between man-populations and environment is controlled by human culture.
Keywords: simulation, evolution, informational processes, meme, cultural transmission.

1 Introduction. About This Simulation Method

Any living organism represents good example of anticipatory system: in every moment of time it attempts to forecast own future in order to survive. Within a framework of such philosophy, the biosphere evolution is consequence of functioning of the biosphere to provide permanent self-preserving, and this functioning is anticipatory one. From this, investigation of evolution, including computer simulation, can give some insight about universal ways of development for any anticipatory systems.

The biological evolution is very long-time process, which can't be studied directly. In fact, the simulation is one of few ways of evolutionary investigations. The attempts to simulate the biological evolutionary processes were already undertaken several times by different scientists. Usually, some macro-regularity (for example, the knowledge about dynamics of growing for real evolutionary trees - Fink, 1986) is used to build such models. Our approach is different: we try to obtain macro-laws of behavior for some ensemble of individuals (e.g. populations), setting different properties of these individuals and their surroundings. In particular, we assign the regulations of interactions between individuals and preset rules of mutations for some of the properties. After that we start our “evolutionary computer game”. At first sight, as the number of individuals is large the quantity of theoretically possible states for all system is very big and therefore such approach can't help for understanding of real evolution. But this is not the case here. The situation looks like ideal gas, when there is no need to monitor the behavior of every molecule if we attempt to study universal macro-laws, which describe all molecular ensemble. To discover some common laws of biological evolution, regulating properties of environment and species populations was the purpose of our simulation (Levchenko, 1993, 2004).

In order to make sure that model is correct it is necessary to compare the results of simulation with known materials. If they are similar to modeled ones then one can hope that other results of the simulation describe some new regularity. We aspired to use such approach as much as it is possible.

It is important to note that although the final states of simulated system can be theoretically predicted for every realization but practically this is impossible because the behavior of components of the system is very intricate. Moreover, one must as a rule make very large quantity of calculations in order to accomplish any such prediction. This is one of reasons why it is not possible to guess beforehand common laws of behavior of all system. In order to find out these laws it is necessary to make many experiments with different initial parameters and compare the results. Obviously, the possibility to carry out great number of evolutionary experiments under different conditions (what we are not able to accomplish in real nature!), demonstrate unique capacity of simulation methods.

The factors, which can influence evolution, are very numerous in reality. Simulation models described below were developed to investigate evolutionary regularities in macro scale. We did not try to predict the appearing of concrete forms, our aim was to clear up general laws of the evolutionary processes, for example, changes of rapidity of formation of new species under different modeled parameters. Therefore, only certain ecological properties of populations as well as general principles of interactions between them (including Darwinian) are considered in our models.

It is significant that biological terminology, which is used to describe the results of modeling, is metaphorical one. This is partly due to the fact that classical biological terminology is based on the conception of biological classification, which doesn't suppose gradual species evolution: any species can arise or perish but not evolve. Such "**paradigm of stationarity**" hampers any discussions about macro- and micro-evolution (i.e. evolution at the species level). In fact, it could be more correctly to discuss genetic drift and gradual evolutionary changes of phenotypes but unfortunately the corresponding biological evolutionary terminology is not enough developed yet (Alimov, Levchenko, Starobogatov, 1998; Levchenko, 1993, 2002; Starobogatov, Levchenko, 1993).

2 Simulation Model of Macro-Evolutionary process

2.1 The Description of the Model

The idea to simulate evolution of some biological groups as well as first programs for that were proposed by Vladimir Menshutkin at the beginning of 80th (Menshutkin, Aschepkova, 1988). The simulation program, which joins previous approaches, was developed on the end of 80s; it was written by us in Fortran language and named "**Macrophylon**" (Levchenko, Menshutkin, 1987). Several additions to this model were made further after some experiments give unexpected effects (see below and Levchenko, Menshutkin, Tsendina, 1988). Later, Kirill Essin converts the program to C language for IBM/PC. One of loadable versions of the program may be found in http://www.evol.nw.ru/lew/macrophylon/macrophylon.htm .

The program functions by cycle. The properties of each simulated population may be being changed at every cycle. The model has 12 different "environments" which are called **licenses**; some of licenses can be free at either moment of the time (such approach has allowed us to propose also the license-symbiotic conception for the ecosystem evolution - see Starobogatov, Levchenko, 1993; Levchenko, 1997, 2004). Each license has up to 10 sub-environments (regions), every of which may be inhabited by only one species population. Thus, every license can contain populations of one or several species. In order to rough estimate the size of population we use the quantity of its copies in license. Not difficult to see that maximal amount of different simulated populations may achieve 120.

Any population of the model is described by means of 25 different characteristics – **features** (they are represented by special array in the program). Every feature has several gradations - **properties** and therefore any population has combination of 25 some properties. Examples of features: size (properties are here the following: from 0.5 M to 1 M, from 1 M to 2 M, from 2 M to 5 M), type of upper and lower extremities, type of nourishment. The total amount of all possible properties is 100 in the model.

With some probability, **mutations** produce changes in the set of properties of population (not more than one change per property during one cycle). In the view of biology it is more correctly to call these modeled mutations as macro-mutations because they produce quite considerable modifications of phenotypes (see about macro-evolution Grant, 1985; Rensch, 1960). The modifications lead to the changes of survival possibilities of populations in licenses. Special array determines the set of possible mutations. For example: A <-> B <-> C, where A, B, C are properties within some feature; the transition from A to C isn't impossible, it is necessary to make two steps: A ->B, then B -> C. The mutation frequency can be varied in every experiment.

The properties, which cannot exist simultaneously, are called **incompatible properties**. For example: if skull does not exist, then any mutation of tooth cannot occur. Mutants, which appear with incompatible combinations of properties, are being eliminated from further simulation.

Each property is characterized by its **adaptive value,** which is ranked between 0 and 10 for every license. Special table was constructed for this purposes; it is based upon general biological considerations. For example: the adaptive value for gills in aquatic licenses is equal to 10, but it is 0 on land. The possibility to survive or, in other words, **fitness** of population in every license is the sum of corresponding adaptive values for all 25 properties. Fitness can range from 25 (minimum) to 250 (maximum); if the value of one of any properties is equal to 0, then fitness value is set to zero. That means the population can't live in the license.

Migration of any population from one license to another may occur if its fitness is higher there. For this to occur, one of the following conditions must be met: either new license is free and migrating population gains higher fitness than in currently occupied license, or fitness of migrating population is higher than fitness of one of populations, which already exist in license (then native population is replaced by migrant). We may also regulate the number of attempts for migration if several of them were unsuccessful because the license was occupied. Moreover, some additional barriers for migrations between licenses can be introduced to the model as well.

Simulation of **competition** is one of the main segments of the simulation. Those populations, which have the lowest fitness in a license, are being replaced by populations, which have the highest fitness in this license, at every cycle.

After many experiments with above model we have arrived at an idea to introduce additional parameters in order to regulate the level of competition. These parameters give a possibility to simulate what we call as "**soft competition**" when we permit **coexistence** of several populations with different fitness in license. The difference is not higher usually than one - two tens of percents of average fitness for the license.

At last, in order to simulate the predator-prey interactions, several licenses were defined which have to be occupied entirely by predators. Predators can eliminate some "weak" and easy prey (fitness of prey is not enough to resist predators) without even migrating into prey's licenses. However, if there is no prey, fitness values of predators diminish significantly (Levchenko, Menshutkin, Tsendina, 1988).

Very simplified functional scheme of the "Macrophylon" algorithm is presented in the Figure 1. Even initial version of the program was very complicated; it contained large number of arrays, loops, logical ramifications and more than thousand of operators.

At the beginning of simulation we place one population in one of licenses. Every cycle of the model involves the following operations: mutations, elimination of populations with incompatible properties, calculation of fitness values for all populations in all licenses, migrations (when it is possible), simulation of competition in every license, colonization of unoccupied parts of licenses, simulation of predator-prey interactions (when it is possible), recording of properties of all populations and other current parameters on hard disc, return to the beginning of cycle.

The model, hence, simulates certain classical basic evolutionary phenomena: mutation, elimination of non-viable individuals, migration and colonization processes, competitive exclusion of some species population by another species populations.

Our model has demonstrated also very important role of interactions between populations: the form of evolutionary trees depends primarily on the level of competition, not mutations. Therefore, additional parameters to examine this effect were introduced (see below and Levchenko, Menshutkin, Tsendina, 1988; Levchenko, 1993, 2004).

The total time of some experiments was to several tens of minutes (we used PDP-11 and later Pentium-I). This circumstance was one of principal restrictions, which didn't permit to complicate the program.

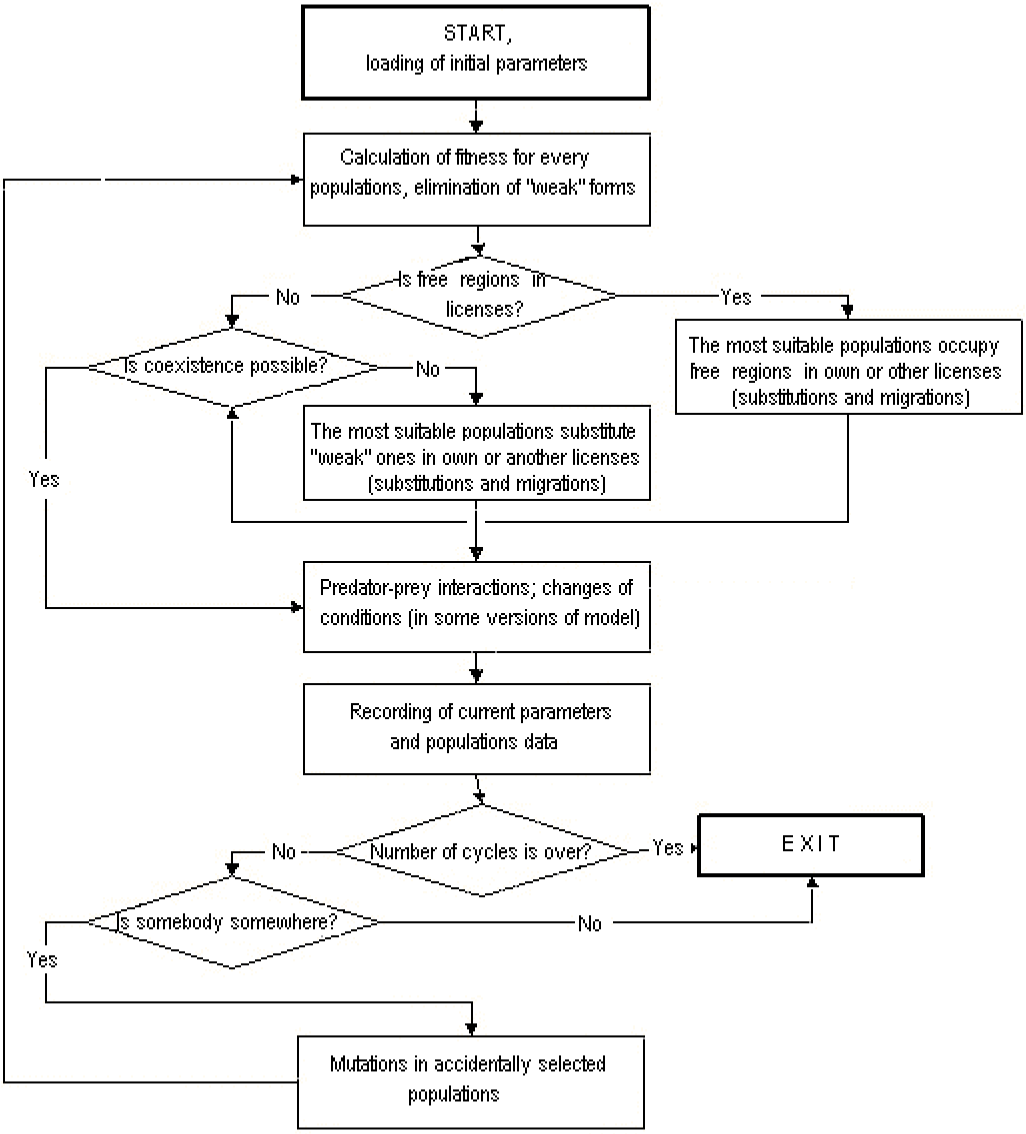
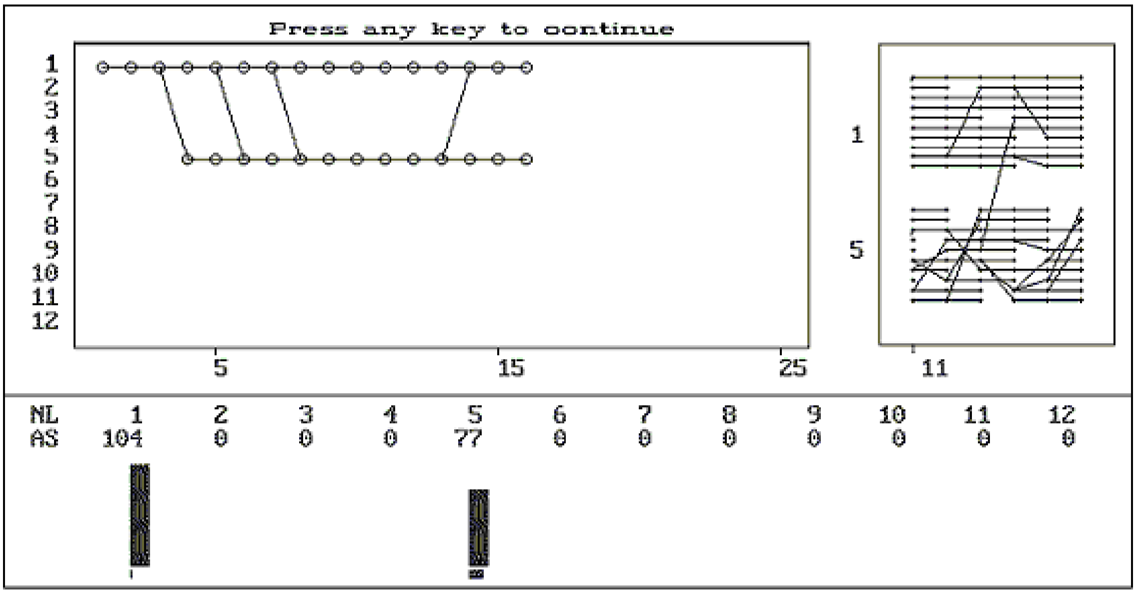


Figure 1. Simplified functional diagram of “Macrophylon” simulation model. Every main program cycle is being begun from “Calculation of fitness…” and is being finished at “Mutation…”. Other explanations are given in text of the article.

2.2 Some Results of the Macro-Evolution Simulation

In order to have a possibility to compare the results of simulation with biological data, we selected the phylum *Chordata* and began simulation experiments from *Lanceolatus* (lancelet) form. Single population of lancelet was placed to a sea-water license. Modeled mutations were in general agreement with the principal changes in adaptive properties: important changes in size, modification of types of nourishment and respiration, etc. The estimated time, which was necessary in reality to undergo such adaptive changes, is about 0.5 – 2 million years. This means, that here we have to talk about macro-mutations. The 12 licenses of this simulation were the following: 1 – 4 for different plankton and benthos sea-water forms, 5 – 7 for fresh-water forms, 8 – 9 for *Amphibia* forms, 10 – 12 for terrestrial forms (about any details see Levchenko, Menshutkin, Tsendina, 1988).



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NL    1    2    3    4    5    6    7    8    9   10   11   12
AS  104    0    0    0   77    0    0    0    0    0    0    0
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Figure 2. The example of macro-evolution simulation (screen photo by Kirill Essin). At the left part vertically - the numbers of licenses, at the center area - horizontal lines represent not empty licenses, diagonal lines mean migrations of new evolutionary forms between licenses 1 (sea-water) and 5 (fresh-water). The numerals 5, 15, 25 across are the numbers of cycles. At the right area - the same events in licenses 1 and 5 in details after 11 cycles. Lines represent fragments of evolutionary trees disposed horizontally. Bifurcation can happen after appearance of mutant; when a population is being competitively eliminated then the corresponding line is interrupted. At the bottom of the picture - the average fitness values (AS) in different licenses (NL).

Macro-mutations, migrations and competition took place at each cycle (see Figure 1); one program run is covering the period of 200 - 300 million years (several hundreds of cycles). Such duration corresponds to period of evolution of *Chordata* including the appearing of *Primates*. One of examples of the outputs is shown on Figure 2, where evolutionary events are given on two different scales. Time of work of simulation program for the case represented in the picture achieves about one minute.

Simulation studies of macro-evolution have demonstrated certain unexpected effects which, nevertheless, follow from Darwinian theory (this wasn't obviously at the beginning of investigations). For example, our results have shown that "re-immigration of descendants" is quite significant factor in evolution - see Figure 3.

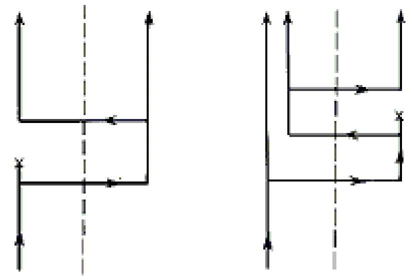

Figure 3. The example of evolutionary trees: re-immigration of descendants leads to elimination of parent forms. Across - the different licenses, the time is upward, **x** means elimination of population by another one.

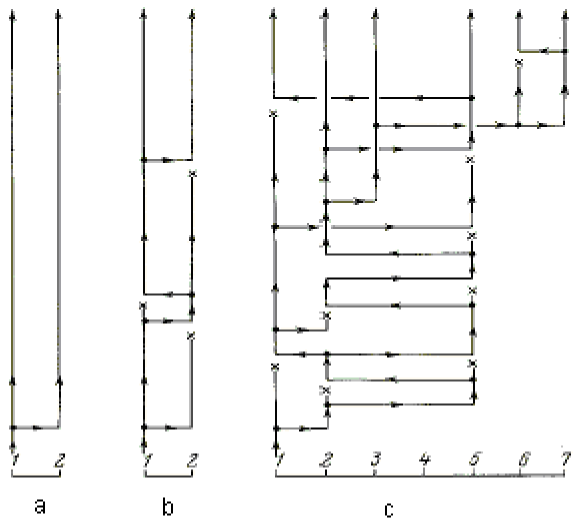

Figure 4. Example of evolutionary trees: a – “hard” competition, b – “middle” level of competition, c – “soft” competition. The numbers of licenses are across, the time is upward, **x** means elimination of population by another population.

Another interesting and new results were obtained in experiments concerning variations of parameters for competitive interactions. We have found that hard competition provokes such situation when specialization processes predominate over processes of infill of free licenses - see Figure 4. Not difficult to see that in the case of hard competition, the lateral branches of evolutionary trees grow slowly. The increase of frequency of mutations promotes only strengthening of this tendency.

If the environmental conditions are changed then “**specialists”**, which have arisen as a result of hard competition (at the left), perish because of they are not able to give new evolutionary forms and migrate to other licenses. The “**generalists**“ (Rautian, 1988), which arisen under conditions of soft competition, give new forms after environment have changed (Levchenko, Menshutkin, Tsendina, 1988; Levchenko, 1993, 2004). Such forms may colonize other licenses (at the right).

As simulation contains all data about modeled populations, we can compare "true" evolutionary trees with different their reconstructions when data isn't complete (i.e. some of the population properties are excluded from descriptions of species). The cluster analysis reconstructions demonstrate that frequent migrations between close licenses (see Figures 3 and 4) are not being usually taken into account and, hence, these reconstructions give frequently incorrect images of evolution (Levchenko, 1993).

Above we said that model uses basic mechanisms discussed in different evolutionary theories, including classical theory of Charles Darwin (1872): mutations, migrations between regions with different environments, competition when more suitable survives. Some of outputs of this simulation coincide with what is known in evolutionary biology and this convinces of accuracy of the model and our understanding of evolutionary mechanisms. Some of such results are presented below:

1) The probability of evolutionary returning to an initial form is very low; evolution is non-reversible;

2) The appearance of concrete biological form isn't predetermined; this is result of complicated combination of random events;

3) Nevertheless, some characteristics of evolutionary process in the scale of all system of licenses (speed of growth of evolutionary trees, speed of filling of licenses etc) depend principally on only several main parameters, in particular, level of competition and intensity of mutations. This suggests an idea to some predestination of life evolution in the biosphere scale (Levchenko, 1992, 2004);

4) Highly specialized forms ("specialists") don't evolve usually to new biological forms (Alimov, Levchenko, Starobogatov, 1997; Levchenko, 1993, 1999);

5) Evolution has irregular character (Eldredge, Gould, 1972) even if conditions are invariable.

But it follows that other unexpected outcomes of simulation (see above) can be considered as highly probable hypotheses. As the aim of this article is not to present our separated models in details we shall not describe here other particular results. It is more interesting and important that model of macro-evolution confirms the correctness of Charles Darwin approach, but – it is significant – not all suppositions of Darwinists, for example about dominating role of intensity of mutations (see above and Grant, 1985). The understanding of that allows us to choose more confidently directions and methods of further evolutionary investigations, as well as helps to clear up how different evolutionary tendencies are interconnected with each other.

2.3 The Development of the Model Toward Ecosystem Studies

In the described above model the ecological relationship, which have very important significance in real evolution (Capra, 1996; Gore, 1993; Levchenko, 1993, 2004; Maturana, Varela, 1980; Rautian, 1988; Starobogatov, Levchenko, 1993), are not enough considered. To investigate more these effects, the special simulation program was elaborated (Levchenko, 1993). The main principles of its construction were the same as for the above model but the species populations are abstract here, i.e. here aren't implied either known biological forms. Moreover, there are only two systems of licenses: for "animals" and for "plants" (consumer-resource model). Such simple ecosystem "construction" looks like complicated lichen in some aspects (Odum, 1975). If the flows of matters constitute closed circulation in this ecosystem then it is living. If the circulation is disturbed (for example because of some evolutionary variations of populations) then the ecosystem may collapse and perishes. The experiments have given the following interesting result: the ecosystem is surviving long time under evolutionary changes of populations, only if some of the directions of evolution are prohibited. Otherwise, the populations of parasitic forms arise and they demolish finally the system because the circulation of matter is being disrupted. One can suppose, therefore, that the basic populations of existing stable ecosystems are not able to produce new evolutionary forms under usual conditions (Levchenko, 1993, 2004; Menshutkin, Levchenko, 1988).

3 Simple Simulation Model of Human Civilization Evolution

3.1 The Description of the Model

Our new simulation model uses similar principles as in the above models but it concerns the evolution of human populations. The program was written in Visual Basic language using some ideas from our previous works (Menshutkin, Aschepkova, 1988; Levchenko, Menshutkin, 1987; Levchenko, Menshutkin, Tsendina, 1988; Menshutkin, Levchenko, 1988) and new monograph of Vladimir Levchenko (2004). Of course, the opinions and views of many biologists, who worked in the field of biological and human evolution, were considered (Capra, 1996; Gore, 1993; Gorshkov, 1994; Gumilyov, 1990; Maturana, Varela, 1980; Rindoš, 1985; Rosen, 1991; Vernadsky, 1989; Zherihin, 1987).

In reality every human sub-population (more exactly - **ethno-population**, see Levchenko, 2003, 2004) is conjoined with some complex of surrounding conditions in which it can successfully live. Central particularity, which distinguishes the man evolution from classical biological one, is that the interaction between human-populations and environment is controlled by human culture (complex of mental and material means for self-preserving of the ethnos - see Levchenko, 2004). Modifications of these interactions are coordinated with cultural changes, which may occur, for example, because of **cultural transmission** (Brody, 2001; Gore, 1993). The "meme language" (Dawkins, 1976) gives a chance to discuss "cultural mutations" and cultural transmission: **meme** (from "memory") is some analog of gene, which was introduced for description of cultural information.

As in the cases of above models we tried to use such mechanisms and parameters, which can be explained in the language of evolutionary ecology. Here are some analogies for mutations (but of memes), migrations of ethno-populations between licenses, competition interactions of ethno-populations etc. In order to describe cultural transmission, additional special parameter was introduced: probability of meme transmission between different cultures. In biological language such meme exchange can be interpreted as what is called "horizontal transfer of information" (this mechanism at genetic level is being discussed by biologists during long time for viruses and sometimes more developed organisms). Moreover, we used also the parameter of **live time** of ethno-populations; this time can't be more than 1000 years by estimation of prominent Russian historian Lev Gumilyov (1990). We were obligated to use this evaluation as some fact to simplify the model.

We assigned as **meme-mutations** in this model the appearance of new discoveries and technical inventions in human culture. Of course, these are "macro-meme-mutations" in fact. They can promote survival and development for ethnos-populations. The nature of human knowledge is such that every new discovery and invention is possible only after some ensemble of previous discoveries already exists (for example, many physical laws were found only after energy conservation law was formulated). Therefore the special oriented graphs of known important discoveries and inventions were built; the graphs permit only certain variants for the meme-mutations. Obviously, concrete "itineraries" of discoveries for every simulation experiment were different, but in any case the arithmetic was somewhere at first steps, while nuclear physics - at the ending. The probability of mutations for any ethno-population grows since its "young age" to "maturity" and then the probability is being decreased to "old age". Besides, the probability can be regulated by special parameter, which is named as **passionarity** (from "passion"). L.Gumilyov (1990) proposed this term to explain explosions of ethno-development: passionarity provokes human activity in creative spheres.

The scientific discoveries can lead to technical progress and, thus, to the intensification of using of surroundings resources. The model considers the technical development twice: as additional possibility to development of ethno-population (growth, expansion to other regions) and as source of new environmental pollutions (Gorshkov, 1994).

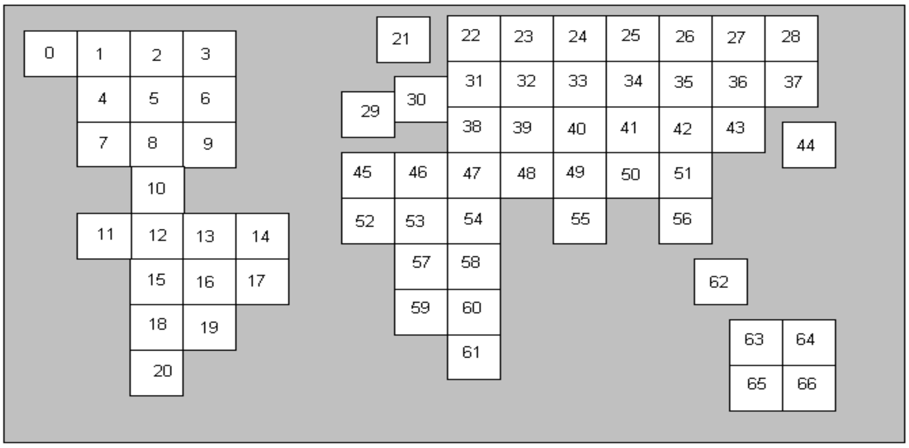

Figure 5. "Cell-map" of Earth territories, which was used in the simulation.

The natural habitats in the model are defined by simplified cell-map of Earth - see Figure 5. The migration of ethno-population is possible to neighboring cell if it contains necessary natural resources (different for every concrete ethno-population), and if it has not big level of pollutions (the number of ethno-population decreases along spending of resources and increasing of pollutions). Of course, difficult environments are considered also, some of them, for example Antarctica, are excluded from this simulation in order to simplify the model (Figure 5). Besides, one of the following conditions has to be satisfied: 1) new cell is free, or 2) fitness of migrating population is more than fitness of population, which is already living in the cell. The **probability of migration** can be regulated by special parameter. When a population colonizes some cell and when native habitants are there eliminated, their useful cultural attainments are being transmitted to the colonizer population. At last, there are some additional rules, for example: only when the corresponding means of travel are invented (e.g., ships, aircrafts) then migration to distant cell becomes to be possible.

Informational exchange between different ethno-populations can be also regulated: not all discoveries can be transmitted right away after their beginnings. There is some probability for that. This exchange can promote the increasing of survival. Before elaboration of radio and Internet the informational exchange was allowed only for neighboring cells.

3.2 Some Preliminary Results and Discussion

The experiments with the model are not finished and general construction of computer program as well as some its fragments are still being modified. Therefore, only some simple results are presented below.

The Figure 6 and 7 gives the pictures of development of human civilization for different parameters of the model. The first one illustrates the case of “calm” changes, when passionarity, probability of migrations and informational exchange have such values to get the image, which looks like known from human history until the middle of XX century. One can see that settlement of new regions is going quite slow (about 3000 years), resources are being spent not too fast and therefore the environmental conditions are not disturbed along almost all simulated period.

The Figure 7 gives the image of fast changes because of passionarity and probability of migrations are large. This leads not only to acceleration of scientific and technical development during some epochs but also to resources depletion and essential worsening of environment. One of consequences of that is the following: evident oscillations of the population number are taking place along evolution. Self-restoration of environment is one of reasons of the oscillations; the process look like the situation of so called “punctuated equilibria” (Eldredge, Gould, 1972; Zherikhin, 1987). Increasing in the number happens either after occupation of new territories or after using of important technical inventions (for example, of nuclear energy on the last steps of the simulation). It is interesting that large oscillations of number and of ethno-diversity hamper scientific and technical development, so this suggests an idea to some optimal rapidity of variations of environment and features of human sub-populations.

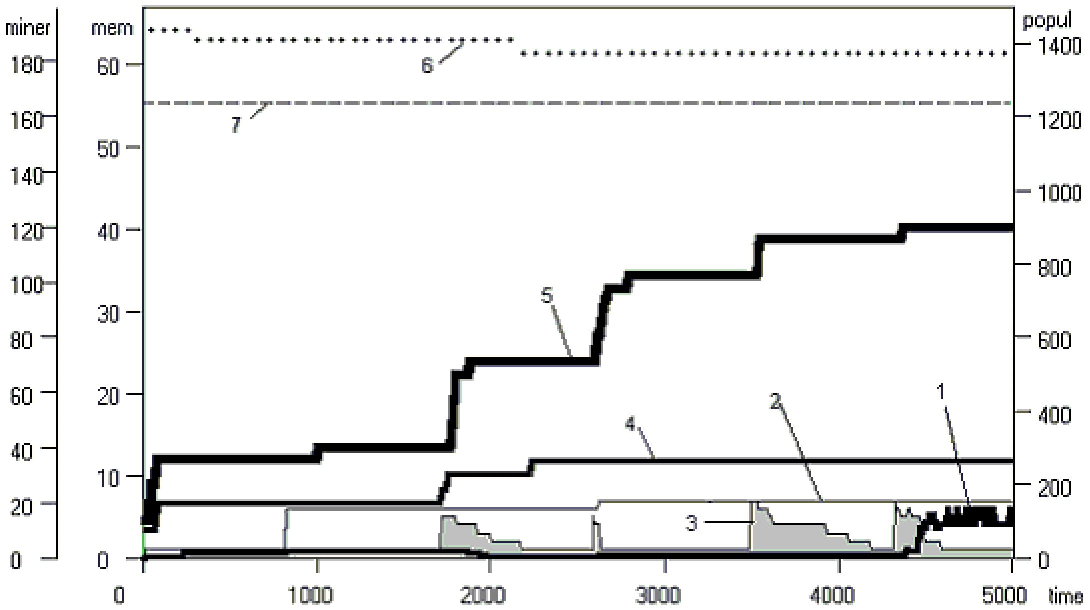

Figure 6. The evolution of human civilization under conditions of slow scientific and technical development. At the left part vertically – "miner" - mineral resources in some abstract units, "mem" - quantity of "macro-memes"; at the right part vertically - number of people in abstract units (numerals give sum of numbers of all man sub-populations in simulation). 1 - the number of all people on the Earth, 2 - number of cells with habitants, 3 - ethno-diversity, 4 - the quantity of scientific discoveries (scientific "macro-memes"), 5 - the quantity of technical inventions (technical "macro-memes"), 6 - coal and other mineral resources, 7 - oil and gas resources.

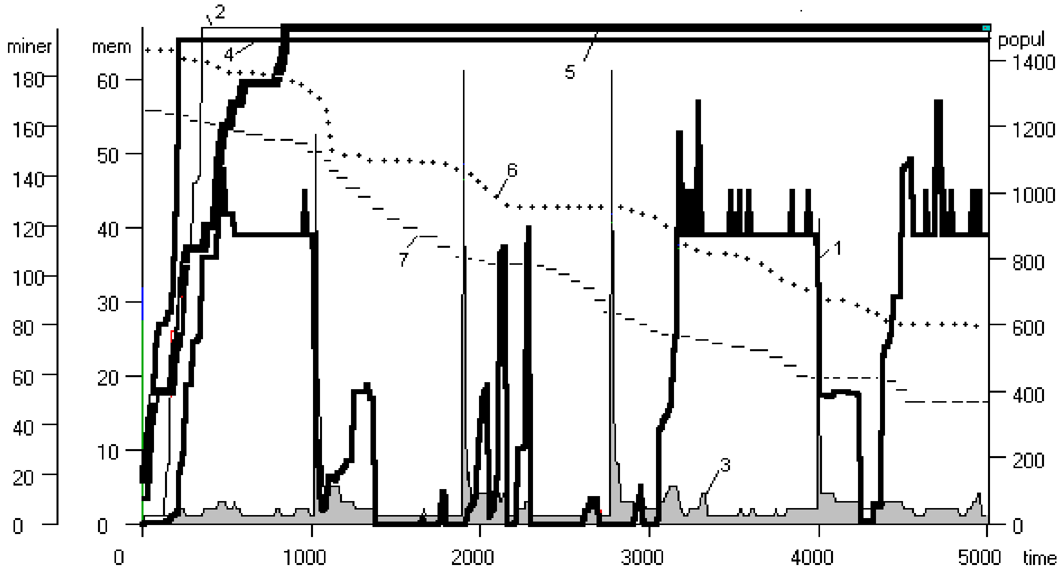

Figure 7. The evolution of human civilization under conditions of fast scientific and technical development. Notations are the same as in the Figure 6.

It is important to note that any results of the simulation have probabilistic nature because generator of random numbers is used, in particular in order to simulate mutations. This means (as well as in the case of simulation of biological evolution - see part 2) that it is necessary to make many program launchings to get reliable conclusions. Every realization gives own "human history" including final human population number. In the Figure 8 one can see these numbers for different realizations and for several sets of parameters. All diagrams demonstrate bimodal character what resembles the behavior of complicated systems with bifurcations and probably with anticipatory properties (Nikolis, Prigogin, 1977).

It is interesting also that the people migrations in every realization are geographically different and we can see along simulated evolution some transient structures of “states” and “nations”. This looks like “diffusive chaos” (Dubois, 1998) after some types of bifurcations happened. Although any single realization can't help to describe or predict concrete ways of human history, nevertheless it is possible to formulate some general regularities of the human development.

Firstly obviously, that intensive way of the civilization development leads usually to fast exhaustion of planetary resources and as result to the decrease of the human population number, not to mention destruction of environment. Although the social phenomena was not simulated here but not difficult to arrive at a conclusion that so called "technocratic" paradigm, which implies self-regulation of development, isn't satisfactory when we begin to take into consideration the interests of concrete people and living nature. Humanity needs seemingly another paradigm of development when just man controls technology but not conversely.

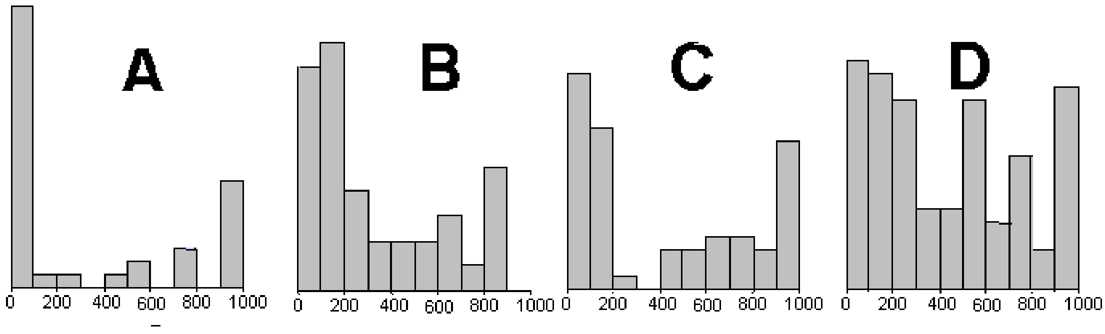

Figure 8. Final human population numbers in different cases of the simulated conditions. Every diagram gives set of results which were obtained for several realizations with identical initial parameters: A - fast evolutionary changes, B - technical development is restricted, C - migrations are restricted, D - technical development and migrations are restricted.

Secondly, one can see that some outputs of last simulation model look like results for biological evolution but with corresponding corrections of terminology. For example, the ethno-diversity as well as biodiversity is important factors of survival along evolution. In other words, some known regularities of biological evolution, including given at the end of part 2.2, which are based on the gene mutations, can be translated into the language for the case of evolution on the basis of the meme mutations. May be, we meet here with some general rules of evolution - this is quite natural inference (Levchenko, 2004; Menshutkin, 1995; Menshutkin, Natochin, Chernigovskaya, 1992). Then, if to understand the perfection of rules of behavior as one of the outcomes of cognition, not difficult to see that evolution on the basis of genetic changes is "pre-intelligent" way of that. Of course, more late mechanisms of informational exchange by means of memes give new substantial possibilities for cognitive activity.

One more of common conclusions, which can be also gotten from outcomes of above simulations, concerns important role of evolutionary restrictions, including cultural ones. If they define such directions of evolution when "symbiotic" interrelations of human sub-populations and environment are maintained, then the evolution is going along "calm" way. But if the restrictions are absent or insufficient then we come to situation, which looks like the ecosystem collapse (part 2.3). On the other hand, strong restrictions are hampering evolutionary process and, thus, reduce adaptive possibilities what isn't good in evolutionary context. All this suggests an idea to some optimal sets of parameters (e.g. level of above restrictions, probability of migrations and cultural mutations) have to exist to provide maximal rapidity of scientific and technical progress. At that, the same rapidity can be provided by different sets of parameters i.e. in the framework of different cultures.

Very intense informational exchange, which we can see on the last steps of the human history (when radio and Internet have arisen), catalyzes processes of generating of new memes. In particular, the exchange promotes discussions about future of humanity and, thus, contributes to creation of new paradigms of human development. The control of own future implies anticipatory activity, so one can suppose that acceleration of informational exchange leads to the appearance of new form of life organization on the planet.

4 Conclusions

Our experience demonstrates that the "computer game" method can be unique instrument for evolutionary investigations especially if to take into consideration that we are not able to observe real evolution in living matter. The experiments allow us to understand better some important factors, which can influence the development of life in the planet. Among them there are, for example, soft competition, descendant re-immigration, some evolutionary restrictions and other factors, which were discussed in the article. The development of computer technologies gives surely new possibility for this field of evolutionary studies.

Acknowledgment

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