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The survival of mankind and human speciation in a complex astrobiological context

[1,2]I. Valentin Petrescu-Mag

[1] University of Agricultural Sciences and Veterinary Medicine, Cluj-Napoca, Romania, EU; [2] SC Bioflux SRL (Research Society), Cluj-Napoca, Romania, EU, zoobiomag2004@yahoo.com

Abstract. The migration of *Homo sapiens* in the outer space brings one of the most significant environmental transformations in the history of a species. The astronomic isolation barrier is certainly stronger than the known geographic isolation. The future human colonies will split into new races, subspecies and finally new species. The survival of human civilization depends in a large extent on spread of these colonies outside our solar system and outside Milky Way.
Key Words: *Homo sapiens*, survival, speciation, future.

Rezumat. Migrația speciei umane în spațiul cosmic aduce cu sine una dintre cele mai semnificative transformări ale mediului de viață în istoria unei specii. Izolarea astronomică este o barieră, cu siguranță, mult mai puternică decât izolarea geografică. Viitoarele colonii umane se vor distanța și separa în rase, subspecii și, in final, chiar specii distincte. Supraviețuirea civilizației umane va depinde în mare măsură de gradul de răspândire a acestor colonii în afara sistemului nostru solar și în afara Căii Lactee.
Cuvinte cheie: *Homo sapiens*, supraviețuire, speciație, viitor.

Introduction. The paper is a review on the survival of mankind (future issues) and human speciation (past, present and future). The aim of the study is to point out the most important problems threatening our existence and to summarize the possible solutions for survival in the near or far future. All these aspects are discussed in a complex astrobiological context; the migration of *Homo sapiens* in the outer space brings one of the most significant environment transformations in the history of a species.

Ida, Lucy and Ardi. Ida*, Darwinius masillae*, an early primate fossil that made a big splash last year (Franzen et al 2009), was a lemur-like primate that lived 47 million of years ago in an area that is now Messel, Germany. This fossil creature has been named Ida and it is a female as the name suggests. Lack of penis bone in Ida has confirmed that she was a female. Ida was not a fully-grown individual as her fossil contains a mix of adult and young teeth, suggesting that it was transitioning from a baby to adult. Ida has been found intact in her death position. Scientists have revealed that the last meal she had taken consisted of seed, leaves, and fruits because the contents of her stomach and gut have also been found intact. Researchers are also able to calculate her muscle size because some remnants of her skin and fur have been found outlining her body. Ida does not have claws but has hands, just like human beings have, with fingers and thumbs. She also has arms, which are flexible with short upper and lower extremities (all data from Franzen et al 2009). Authors considered Ida an important missing link in human evolution. However many scientists were skeptic and cited this event as „much hype and many errors" (Kay 2009), or „...the skeleton reveals little new information about ancient primates, much less human origins" (Gibonns 2009a). This discovery was a great succes of media and less of science (see the picture of the fossil in Figure 1).

Figure 1. The intact skeleton of *Darwinius masillae*.
Source: http://hubpages.com

Lucy (*Australopithecus afarensis*, see Figure 2) is the famous 3.2-million-year-old skeleton that revolutionized thinking about human origins (The Houston Museum of Natural History 2009). The nearly 40% complete skeleton of *Australopithecus afarensis* specimen was discovered in 1974, at Hadar, in the Awash Valley of Ethiopia's Afar Depression. The discovery of this hominid was significant as the skeleton shows evidence of small skull capacity akin to that of apes and of bipedal upright walk akin to that of humans, providing further evidence that bipedalism preceded increase in brain size in human evolution (Tomkins 1998; Johanson & White 1978).

a **b**

Figure 2.a) The fossil called *Australopithecus afarensis*; b) *Australopithecus afarensis* skull reconstruction, displayed at Museum of Man, San Diego, California (Source: http://en.wikipedia.org/wiki/Australopithecus_afarensis).

In 1994, a new hominid, *Ardipithecus kadabba* was found (Haile-Selassie 2001; Gibbons 2002), pushing back the earliest known hominid date to 4.4 million years ago. Details of this discovery were finally published in October 2009 when a new species of *Ardipithecus* was found.

Researchers have discovered the oldest known skeleton of a putative human ancestor: "Ardi" (*Ardipithecus ramidus*) (see Gibbons 2009bcd). Although the species had a brain and body the size of a chimpanzee, it did not knuckle-walk or swing through the trees like an ape. Instead, Ardi walked upright, with a big, stiff foot and short, wide pelvis (see Figs 3-6). *Ardipithecus ramidus* is about half a million years older than the earliest *Australopithecus afarensis* and it is a bit closer to the last common ancestor between living chimpanzees and humans. *Ardipithecus ramidus* is a younger sister species of *Ardipithecus kadabba*. According to Gibbons (2009b) three different hypotheses of early hominin evolution were drawn (see Figure 7).

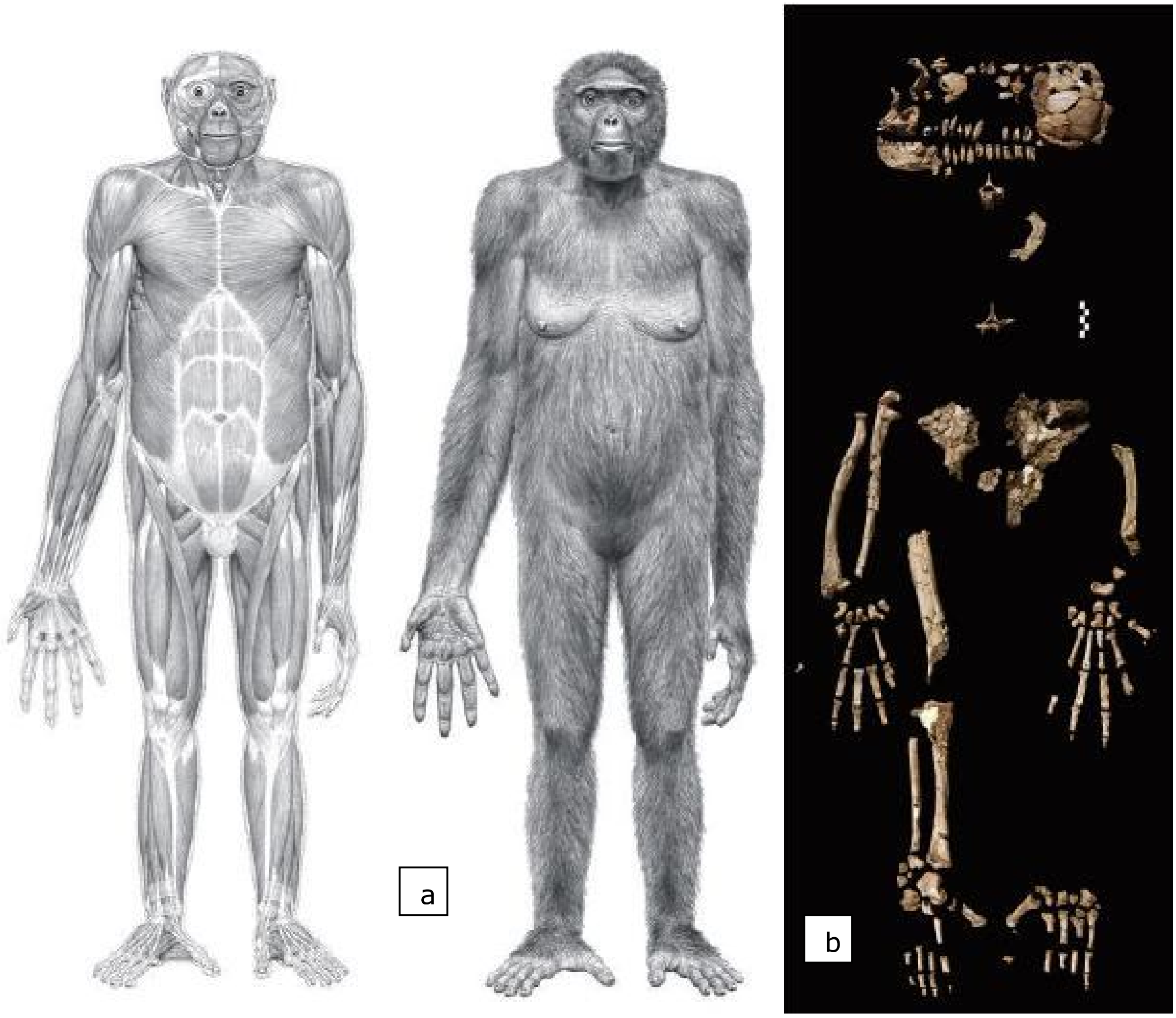

Figure 3. Two restorations of "Ardi" (a), a 45% complete skeleton (c) of *Ardipithecus ramidus*, published in Science (2009) (restorations by artist Jay Matternes; source http://scienceblogs.com).

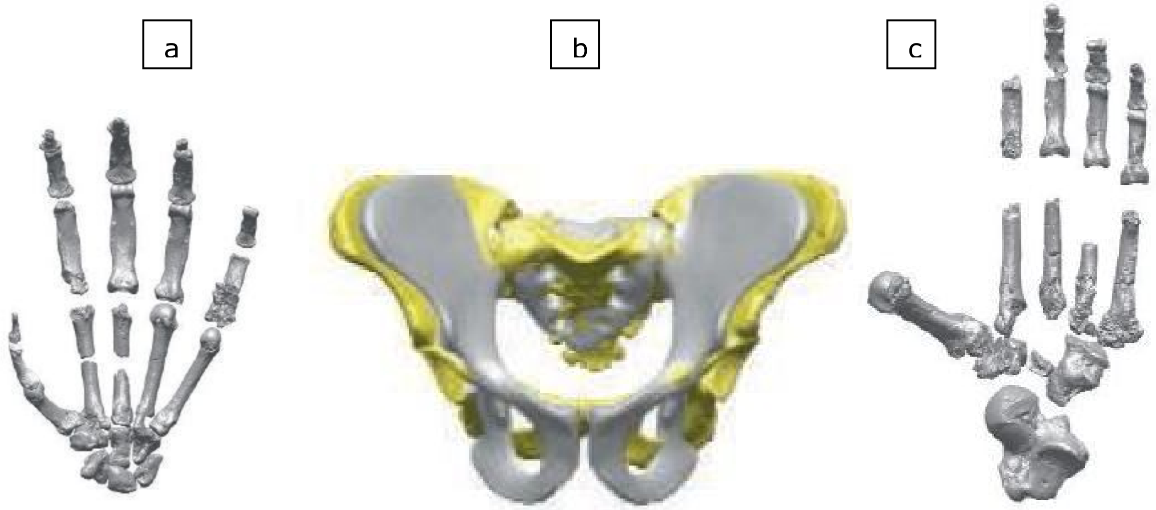

Figure 4. Restorations of Ardi’s skeleton, hand (a), pelvis (b) and foot (c), published in Science (2009) (restorations by artist Jay Matternes; source http://scienceblogs.com).

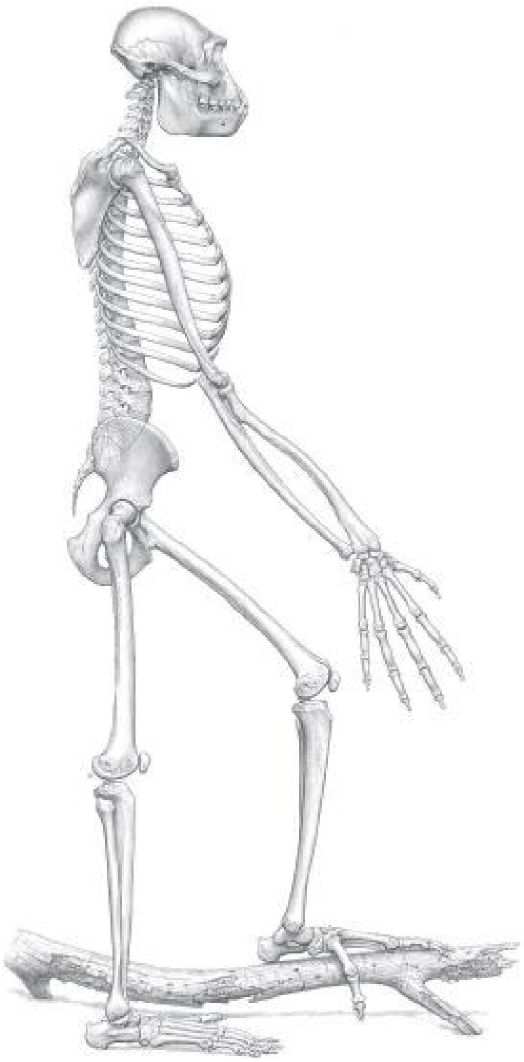

Figure 5. Restorations of Ardi’s skeleton, published in Science (2009) (restorations by artist Jay Matternes; source: http://scienceblogs.com)

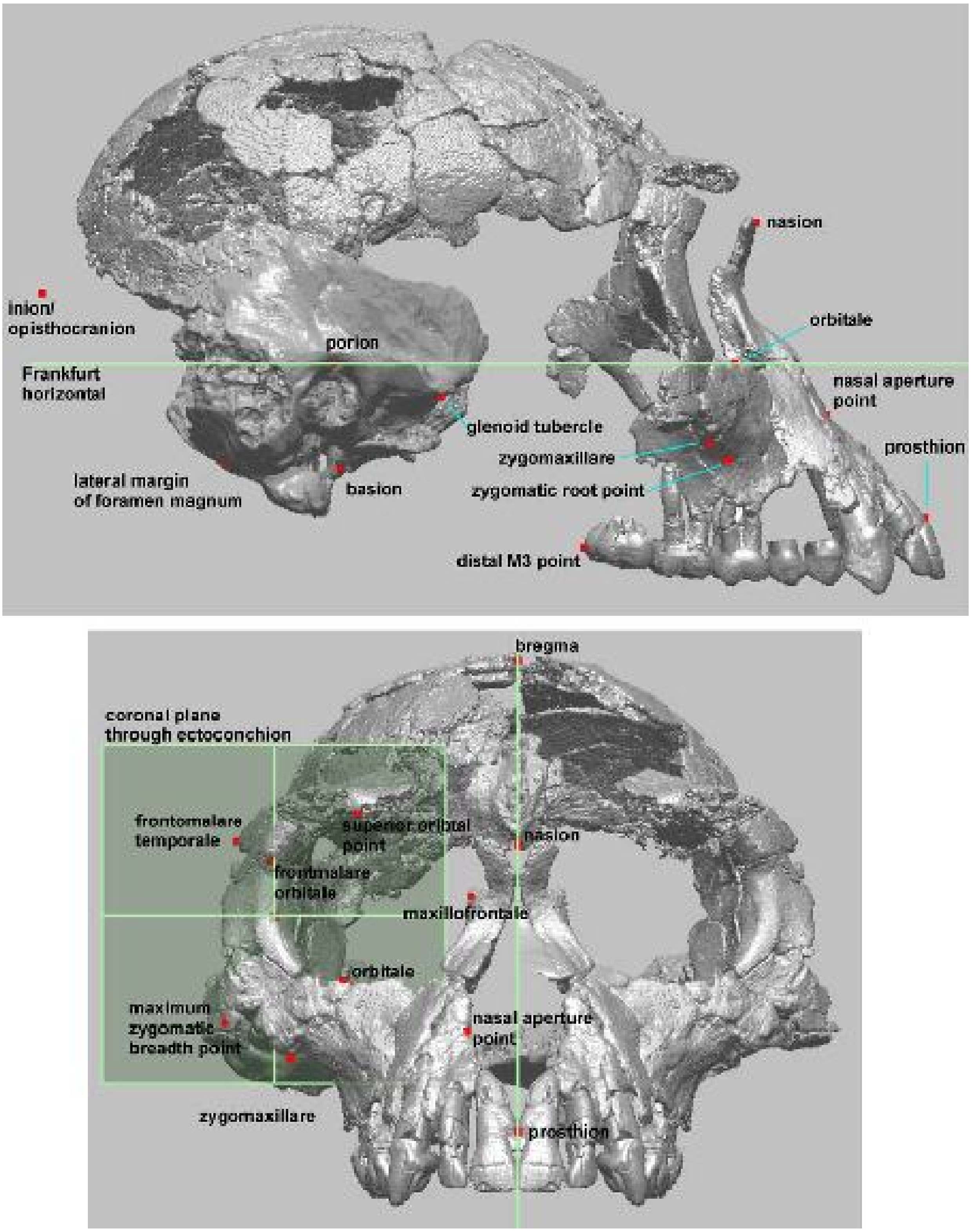

Figure 6. Skull of *Ardipithecus ramidus* assembled by Suwa et al (2009).

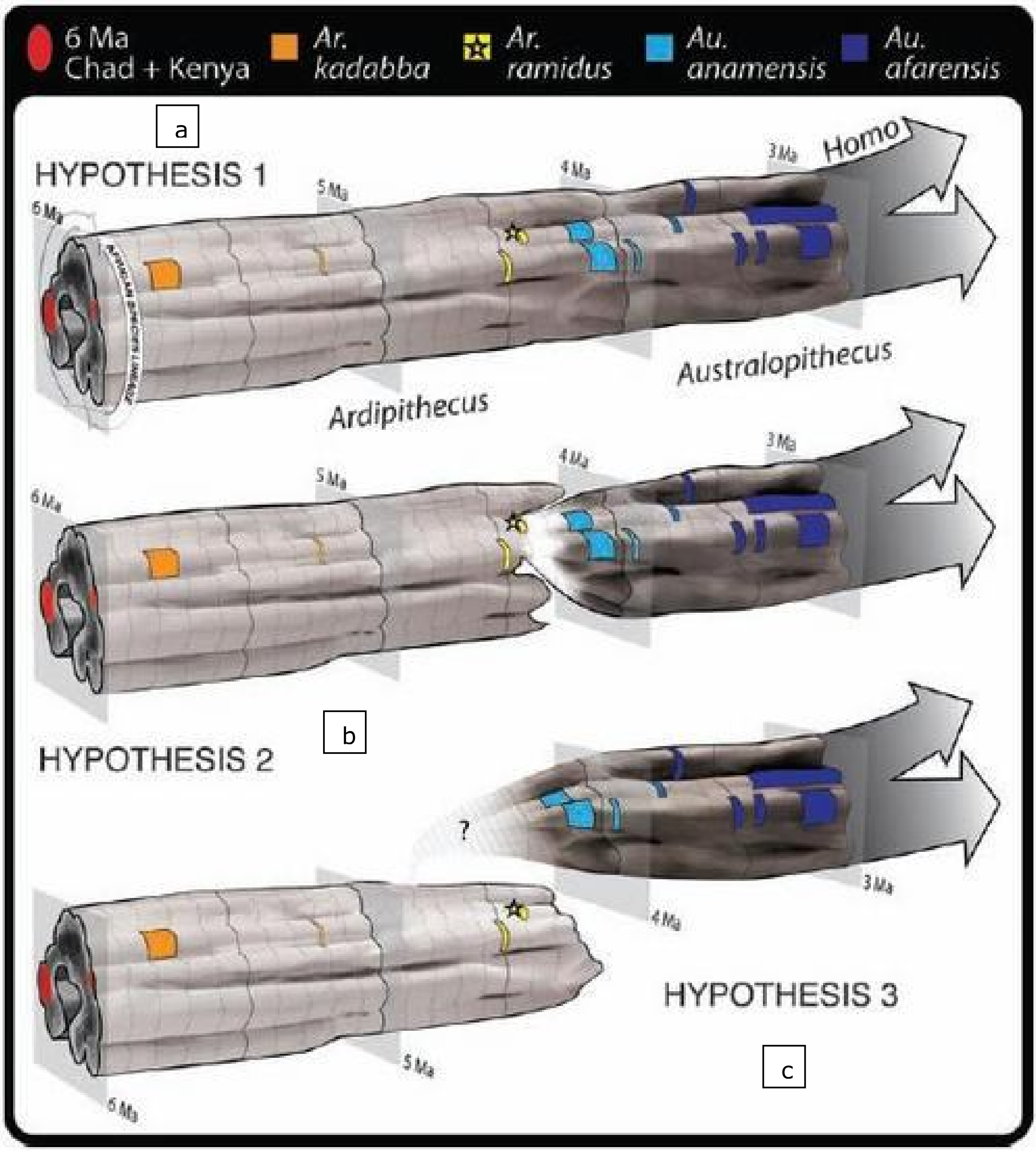

Figure 7. Three hypotheses of early hominin evolution. a)That there was a straight line of hominin evolution, each "species" being the phase or grade of one true natural species. b)A single line of hominin evolution with a speciation event in the same area in which the earliest *Australopithecus* split from *Ardipithecus ramidus*. c)*Ardpithecus ramidus* as one of the last members of a more archaic lineage which existed *after* a speciation event elsewhere in Africa that gave rise to the first *Australopithecus*. Published in Science (source: http://scienceblogs.com).

A Retrospective of Human Speciation. The major transformations of the environment, almost always, directly affected the human evolution (Bădărău 2007): the rising of the bipedal locomotion, an event dated 6-7 million of years ago (debatable after discovery of Ardi), the start of the encephalization and the making of the first tools (events which seemingly are contemporraneous) – 2.5-2.6 million of years, the development of the first *Homo* species with a "modern" aspect – this is *Homo ergaster* –

and the first migration of humans out of Africa – 1.8 million of years, the occurence of *Homo heidelbergensis,* the second migration of humans out of Africa and the following splitting of the previously mentioned species into *Homo neanderthalensis* in Europe and *Homo sapiens* in Africa – 600,000-130,000 years, the rising of *Homo sapiens* in Africa and the first migration of this species out of Africa – 200,000-80,000 years, the great, genetic bottleneck' event and the occurence of an imaginative and abstract mind in *Homo sapiens* – 80,000-70,000 years, the great migrations of *Homo sapiens* out of Africa – 50,000-20,000 years and the development of the neolithic ‚technical' man – 10,000-3,500 years (see in review, Bădărău 2007). A recent but provisory schema of hominin species distributed through time is available from Wikipedia (2009, see Figure 8).

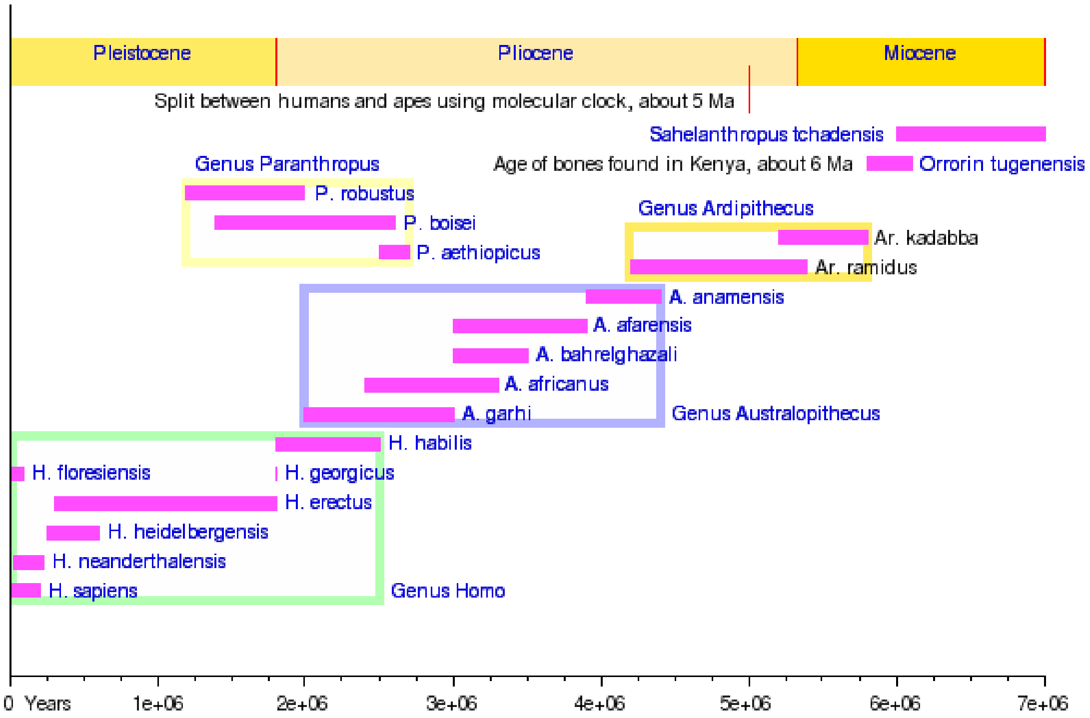

Figure 8. Hominin species distributed through time (1e+06 years = 1 × 10^6 years = 1 million years ago = 1 Ma; source: Wikipedia 2009).

The Geographic Isolation and the Three Great Human Races. In the last 5,000-7,000 of years, the geographic barrier split our species into three major races (presented in Figure 9): Negroid (or Africans), Caucasoid (or Europeans) and Mongoloid (or Asians). Nowadays, the globalization has broken the geographical barrier and a blend of Negroids, Caucasoids and Mongoloids (and interracial hybrids) can be found all over the world (Africa, Americas, Asia, Australia and Europe) due to the massive migration of populations.

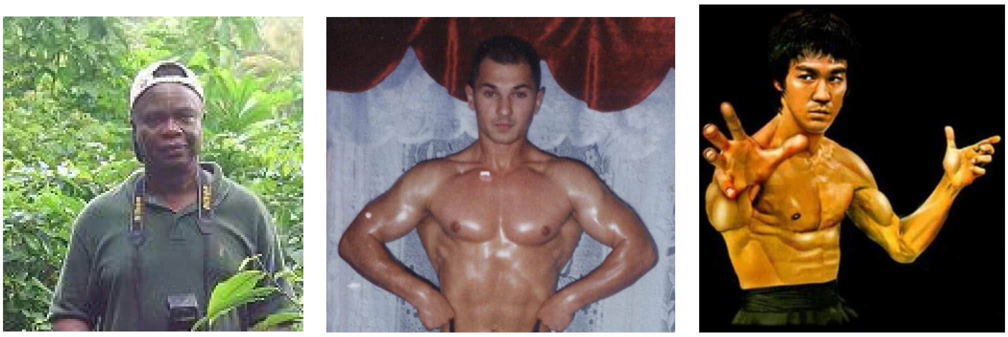

Figure 9. The three great human races: Negroid (left), Caucasoid (center) and Mongoloid (right).

In theoretical cases of perfect geographic isolation (absence of genetic recombination by genic flux and hybridation) the three races become three or more species in less than one million of years. Globalization prevented the split of human species into three ideal races (or other infraspecific taxa, subspecies and so on) and delayed speciation in the future. However, another type of isolation becomes imminent: astronomic isolation (that implies both spatial and temporal aspects).

A Future Speciation in Humans? Keys to Survival. In the last century *Homo sapiens* walked in outer space, trying to survive in a completely new environment. Although Moon was not sufficiently hospitable, man looks ahead to a new target: Mars, the Red Planet (Figure 10). The colonization of Mars is one of mankind's great plans. Even if this dream could be a failure, we have some alternatives, namely the colonization of certain satellites of Jupiter or Saturn (see Figs 11-12). Finding water on the Moon, on other moons, but also on Mars gives us great hope in this regard (Figure 14). Some artists have already imagined a red colony (Figure 13) (see also Zubrin 1996; Crossman & Zubrin 2002, 2005).

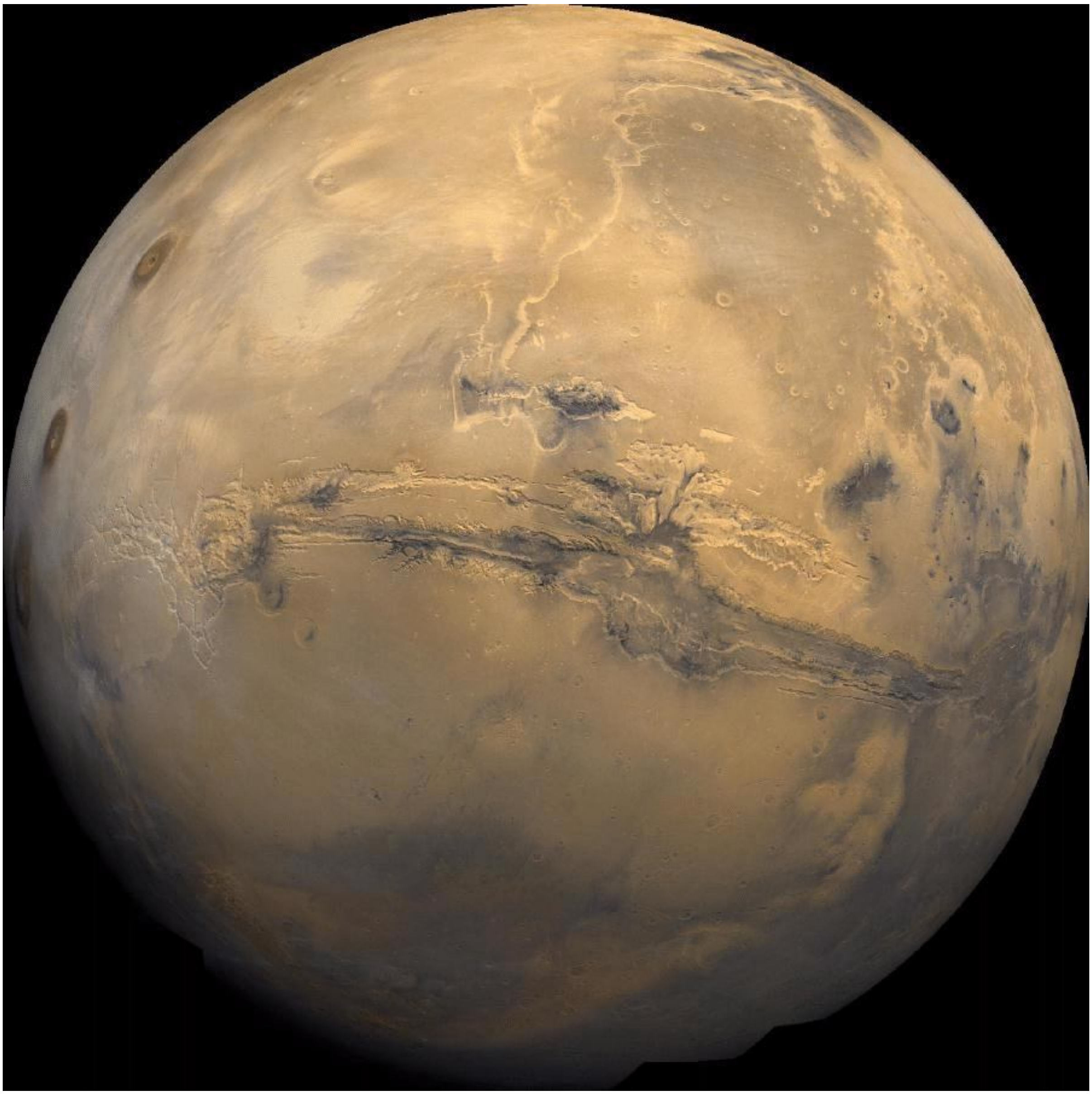

Figure 10. A Photoghaphy of Mars (Source: NASA – undated)

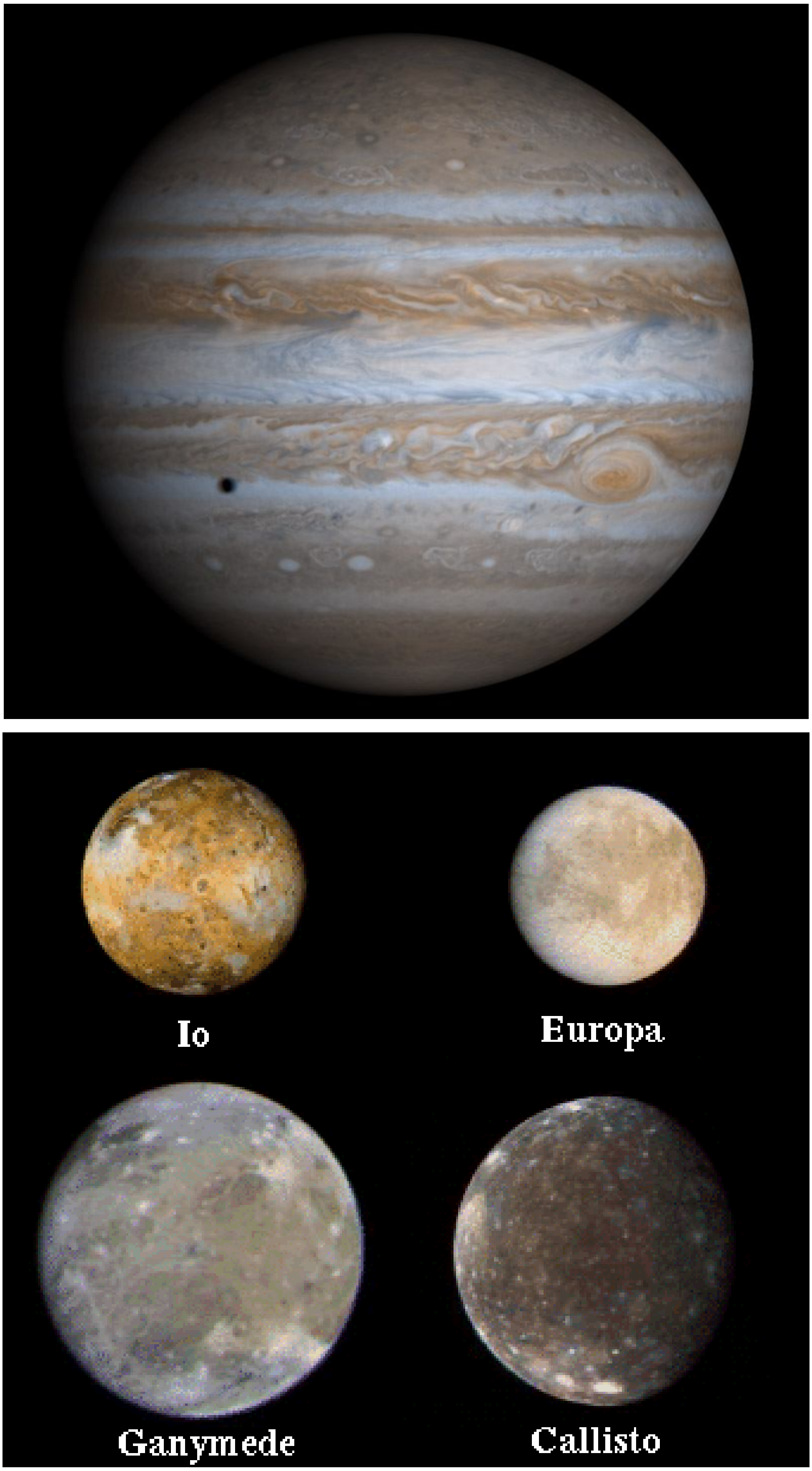

Figure 11. Jupiter and Galilean Moons. Sources:
http://nssdc.gsfc.nasa.gov/planetary/factsheet/joviansatfact.html
http://csep10.phys.utk.edu/astr161/lect/jovian_moons/

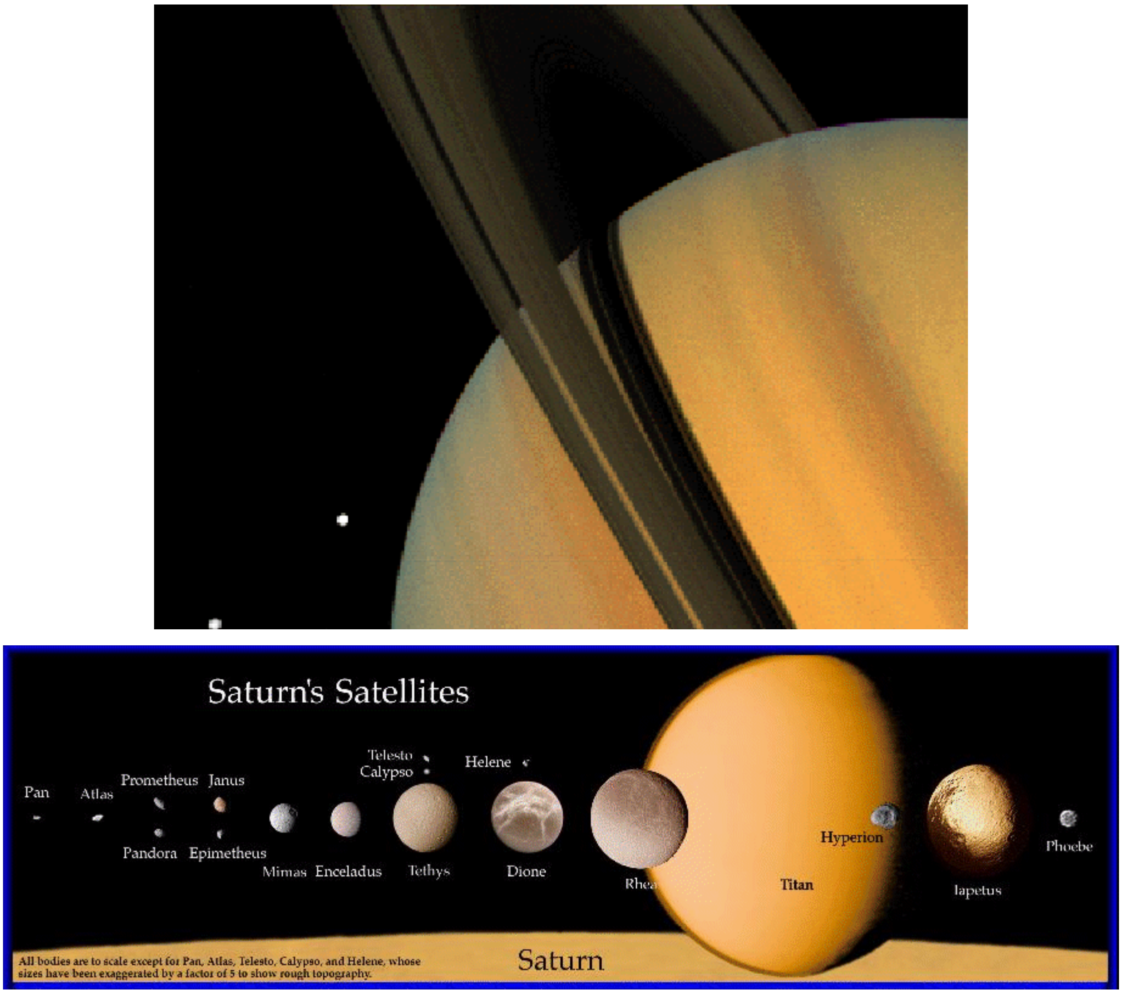

Figure 12. Saturn and its satellites. Source:
http://nssdc.gsfc.nasa.gov/planetary/factsheet/saturniansatfact.html

The Mars Joint Exploration Initiative (MEJI) is an agreement signed between United states' space agency, NASA, and Europe's space agency, ESA to join resources and expertise in order to continue the exploration of the planet Mars (BBC News 2009). The agreement was signed in Washington D.C. in October 2009. Discussions between NASA and ESA began in December 2008, driven by the ESA Ministerial Council's recommendation to seek international cooperation to complete the ExoMars mission and to prepare further Mars robotic exploration missions. At the same time, NASA was reassessing its Mars Exploration Program portfolio after the launch of its Mars Science Laboratory was delayed from 2009 to 2011. This provided NASA and ESA with an opportunity to increase cooperation and expand collective capabilities (NASA 2009; NASA & ESA 2009). The U.S. and Europe have taken the view that they can achieve more together scientifically at Mars if they combine their expertise. And with both parties' current Mars programmes also experiencing financial pressures, the shared approach means the exploration schedule of a mission every two years can be maintained (BBC News 2009). The executive board recommended NASA and ESA establish MEJI, spanning launch opportunities in 2016, 2018 and 2020, with landers and orbiters conducting astrobiological, geological, geophysical and other high-priority investigations, and leading to the return of soil and rock samples from Mars in the 2020's (Wikipedia 2009).

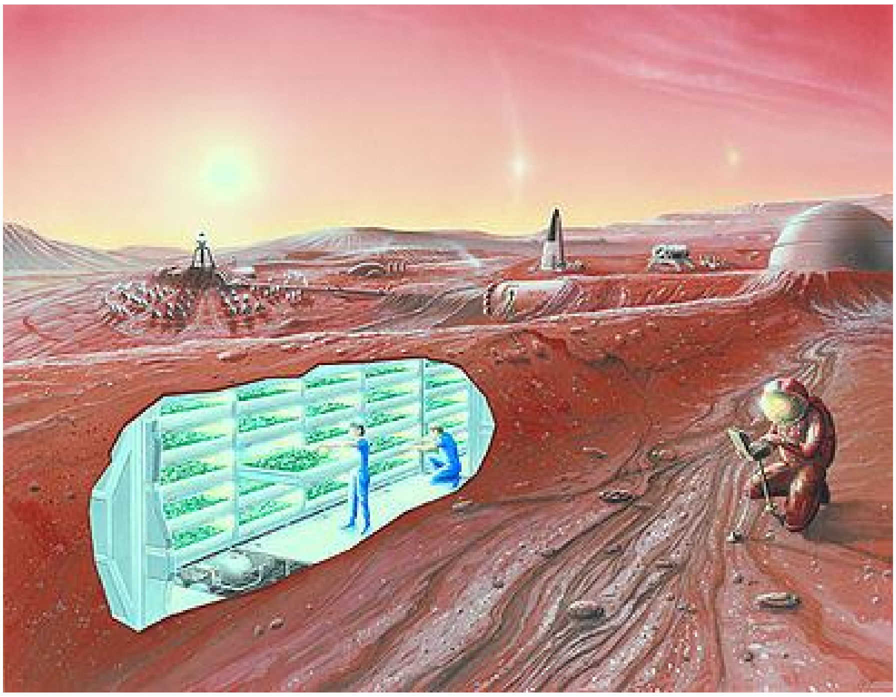

Figure 13. The early Martian Colony (source http://library.thinkquest.org) and an artist's conception of the colonization of Mars, with a cutaway showing part of the interior (NASA Ames 2005 – cited in Wikipedia 2009)

Colonization of other planets is not fiction but an imminent reality (see also Gagyi-Palffy & Stoian 2008). Probably, after Mars, Venus will follow, but also other natural satellites sufficiently warmed by the planet Jupiter. Then will follow the colonization of planets orbiting around nearby stars, such as the planets Gliese 581 b, c, d, or e (Bonfils et al 2005; Mayor et al 2009). Final escape from the limits of our solar system would mean for human civilization significant extension of its existence or delayed extinction (perhaps inevitable). Astronomic isolation can not be compared at all with geographic isolation. Due to the high spatial-temporal distances between the colonies and because of the lack of genic interchange, the human species will inevitably split into subspecies and even distinct species. Because of their new environments (food, pressure, gravitation, humidity, temperature, cosmic radiation, other sources of radiation), an adaptive radiation similar to the first terrestrial animals on Earth will follow on different terraformated planets. It is clear that the lifetime of the first immigrants will be, on average, at least 25% shorter than people on Earth (this is the price we will have to pay to live elsewhere in the universe). However, among the multitude of harmful mutations, some of them will also prove useful. These mutants will be the first sign of a successful colonization.

Figure 14. This image of a crater in near the Martian North Pole was taken by the High Resolution Stereo Camera on the Mars Express orbiter. It shows a large lake of water ice. The temperature when the image was taken was above the sublimation temperature of carbon dioxide ("dry") ice, so the material must be water ice. The lake is about 10 km (33,000 ft) across (source: http://www.astro.virginia.edu).

The Survival of Civilization. According to the present and vast literature, the future survival of civilization depends on a multitude the factors, some of them possible to avoid and others almost impossible to avoid. In Table 1 are presented the most important problems threatening our existence (including both economical-social aspects and environmental ones).

The increasing rate of population growth entails an increasing requirement for food and energy, resulting in more pressure on environmental goods. As the basic resources of the planet are inherently limited, the question arises how long such ever increasing demands can be sustained (Dordea & Coman 2007).

Table 1

Possible problems threatening our existence

No.	*Problem(s) threatening our existence*	*Theoretical solution(s)*
1.	The population's dinamics/food demand/energy demand (in the next century) (Dordea & Coman 2007; Hamaker 1982)	1.Increased production using modern but safe biotechnologies. 2.Good social and economical and administrative policies + legislation. 3.Can be self regulated instead, by feedback: increased mortality due to limited resources.
2.	Carbon dioxide/pollution/climatic changes (and their consequences) (Hamaker 1982; Petrescu 2002)	1.Good environmental policies. 2.Good social and economical and administrative policies + legislation. 3.Colonization of other planets (e.g., Mars).
3.	Investment money (the catastrophic consequences) (Hamaker 1982; Petrescu 2002)	1.Good social and economical and administrative policies + legislation. 2.Survival of the other human colonies.
4.	The next glaciation: a new Ice Age (Hamaker 1982; Petrescu 2002)	1.Terraforming some hot planets, such as Venus. 2.Warming artificially the Earth (intentional emissions into the atmosphere). 3.Using the hypothetical "worm holes", and/or 4.Escape into so called "parallel universes" (multidimensional universes).
5.	Distancing the Moon from Earth, disruption of Earth's axis of rotation (and their catastrophic consequences)	1.Colonization of other planets (e.g., Mars). 2. Step by step adaptation to the extreme environment.
6.	A Jovian nova	1.Colonization of other solar systems in Milky Way galaxy.
7.	Expansion of the Sun	1.Colonization of other planets (e.g., Mars).
8.	Transformation of the Sun into a White dwarf star (end of the Sun)	1.Colonization of other solar systems in Milky Way galaxy.
9.	A war between human colonies.	1.Peace policies and education.
10.	Extraterrestrial invasions	2.Peace policies or fight abilities.
11.	The collision of the Milky Way with Andromeda Nebula	1.Colonization of other solar systems outside Milky Way galaxy. 2.It may be that collision does not affect our solar system.
12.	Expansion and cooling of the universe (the Big Rip) (Caldwell et al 2003)	1.Using the hypothetical "worm holes" as time machine, and/or 2.Escape into so called "parallel universes" (multidimensional universes). 1+2: Surviving in a closed temporal cycle (see Figure 15)

In the last 10,000 of years, human population increased from some millions to over 6 billion and will reach about 10 billion perhaps as early as 2050. Some projections predict an increase to even 27 billion by 2150. Such a large population would be unsustainable, so that a limitation of population growth is imperatively necessary. The earth's carrying capacity, namely the maximum number of individuals that can be supported, on a long term, by the available resources of the planet is limited anyway. Expanding agricultural lands, by converting forests or pastures into farmlands, improving technologies for an intensive agriculture, using more productive varieties and breeds, expanding irrigation systems, better food storage and less distribution losses can enhance the earth's carrying capacity only temporarily, because it is essentially limited by the planet's size (Dordea & Coman 2007).

According to some projections, mankind will need 1.8 – 2.2 more planets of the size of our earth for satisfying humankind's demands by 2050. This is why it is necessary to assume more responsibility in managing resources of our "blue planet", in order to sustain future life (Dordea & Coman 2007).

The environmental policies will play an important rol in the future: carbon dioxide in special (Hamaker 1982), pollution in general (Petrescu 2002), special measures and studies for protected areas (Gagyi-Palffy 2007; Badea 2008; Hărșan & Petrescu-Mag 2008; Petrescu-Mag 2007), money investment – including what to be financed or not/what are the priorities (Hamaker 1982). All these depend on us.

However, there are some natural dangers, which can be only partly avoided. Such a danger is the next Ice Age. The present interglacial interval (which has now lasted for about 10,000 of years) represents a climatic regime that is relatively rare during the past million years, most of which has been occupied by colder, glacial regimes. Only during about 8% of the past 700,000 of years has the Earth experienced climates as warm, or warmer, than the present (NAS 1975, cited by Hamaker 1982). The penultimate interglacial age began about 125,000 years ago and lasted for approximately 10,000 of years. Similar interglaciar ages – each lasting aproximately 10,000 of years and each followed by a glaciar maximum – have occurred on the average every 100,000 of years during at least the past half of million of years (NAS 1975, cited by Hamaker 1982).

When will the present interglacial end? Few paleoclimatologists would dispute that the interglacials that have followed each of the terminations of the major glaciations have had durations of 10,000 of years. In each case, a period of considerably colder climate has followed immediately after the interglacial interval. Since about 10,000 years have passed since the onset of the present period of prominent warmth, the question naturally arises as to whether we are indeed on the brink of a period of colder climate (NAS 1975, cited by Hamaker 1982; Petrescu 2002).

Even if we look into the geological past, the question remains unsolved. If the end of the interglacial is episodic in character, we are moving toward a rather sudden climatic change of unknown timing. If on the other hand, these changes are more sinusoidal in character, than the climate should decline gradually over a period of thousands of years (NAS 1975, cited by Hamaker 1982; Petrescu 2002).

Another catastrophic event is the fact Moon is distancing from Earth. This will bring a disruption of Earth's axis of rotation and unpredictible consequences. Distancing of the Moon in relation with Terra is not a hypothesis, it s reality.

Other dangerous events are related to evolution of stars. Sun will expand (becoming a red giant), and probably Jupiter will become a nova (this, the second, is only a hypothesis). Both of them are catastrophic to life on Earth. However, until the end of the Sun, an earlier danger is estimated: the collision of the Milky Way with Andromeda Nebula. It is possible that the Sun to change its path without the solar system to be affected.

We will not discuss here aspects as extraterrestrial invasions and wars because they were already imagined in many science-fiction movies and documentaries. Also, literature is plenty of such subjects.

The 'Big Rip' is a cosmological hypothesis first published by Caldwell et al (2003) (see also Wikipedia 2009), about the ultimate fate of the universe, in which the matter of the universe, from stars and galaxies to atoms and subatomic particles, are progressively torn apart by the expansion of the universe at a certain time in the future. Theoretically, the scale factor of the universe becomes infinite at a finite time in the future.

The hypothesis, discussed by the same authors, relies crucially on the type of dark energy in the universe. The key value is the equation of state ω, the ratio between the dark energy pressure and its energy density. At $\omega < -1$, the universe will eventually be pulled apart. Such energy is called phantom energy, an extreme form of quintessence (more details in Wikipedia 2009).

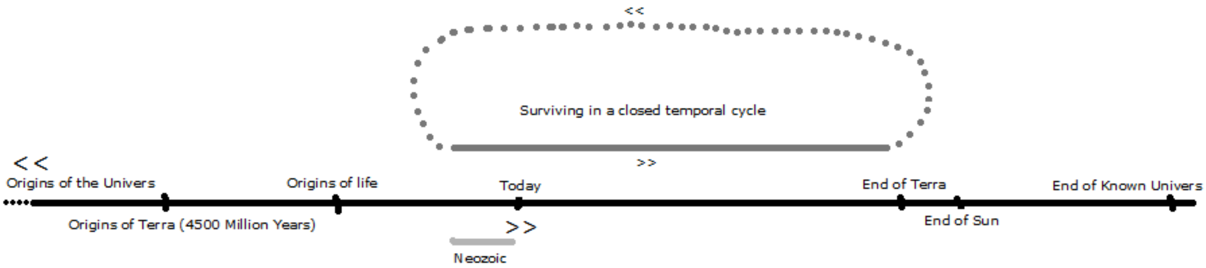

Figure 15. The survival of civilization into a closed temporal cycle (original)

In a "phantom" energy-dominated universe, the universe expands itself at an ever-increasing rate. This implies that the dimension of the observable universe is continually shrinking; the distance to the edge of the observable universe which is moving away at the light speed from any point gets ever closer. When the size of the observable universe is smaller than any particular structure, then no interaction can occur between the farthest parts of the structure, neither gravitational nor electromagnetic, and when they can no longer interact with each other in any way they will be "ripped apart". This model implies, also, that after a finite time there will be a final singularity, called the "Big Rip", in which all distances diverge to infinite values (see also Wikipedia 2009).

The authors of this hypothesis (Caldwell et al 2003) calculated the time from now to the end of the known universe for this form of energy to be the following:

$$t_{rip} - t_0 \approx \frac{2}{3|1+\omega|H_0\sqrt{1-\Omega_m}}$$

where ω is a measure of the repulsive force of Dark Energy, H_0 is Hubble's constant and Ω_m is the present-day value of the density of all the matter in the universe.

In their publication, they consider an example with ω = -1.5, H_0 = 70 km/s/MPsec and Ω_m = 0.3, in which case the end of the universe is estimated to take place over about 22 billion of years. However, this should be regarded as a hypothetical example only. Caldwell et al (2003) tell us that evidence indicates ω is very close to -1 in our universe, which makes ω the dominating term in that equation. The closer (1 + ω) is to zero, the closer the denominator is to zero and the more distant (in time) is the Big Rip event. If the value of ω were exactly equal to -1 then the Big Rip could not happen, regardless of the values of H_0 or Ω_m (Caldwell et al 2003; data from Wikipedia 2009).

In their scenario for a value as ω = -1.5, the galaxies would first be separated from each other. Approximately 60 million years before the end of the univers, gravity would be too weak to hold the Milky Way and other individual galaxies bound together. About three months before the end, the Solar system will be gravitationally unbound, and in the last minutes, stars and planets will be torn apart, and an instant before the end, atoms will be broken into subatomic particles (Caldwell et al 2003; Wikipedia 2009).

Final Remarks. The migration of *Homo sapiens* in the outer space brings one of the most significant environment transformations in the history of a species. The astronomic isolation barrier is certainly stronger than the known geographic isolation. The future human colonies will split into new races, subspecies and finally new species. The survival of civilization depends on spread of these colonies outside our solar system and outside Milky Way. However, the continuous expanding universe will bring the end of civilization. Lastly, our survival will depend on surpassing the "time barrier" using the hypothetical worm holes as „time machines". However, this theoretical solutions were presented here just to make us feel better; we hope because we are humans. Maybe this is the key solution of our existence.

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Author:
Ioan Valentin Petrescu-Mag, University of Agricultural Sciences and Veterinary Medicine, Cluj-Napoca, 3-5 Calea Mănăștur Street, Cluj-Napoca 400372, Cluj County, Romania, European Union.
Second adress: Bioflux SRL, 54 Ceahlău Street, Cluj-Napoca 400488, Cluj County, Romania, European Union.
E-mail: zoobiomag2004@yahoo.com
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