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Review: Effect of global warming on plant evolution and diversity; lessons from the past and its potential recurrence in the future

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Abstract. *Setyawan AD. 2009. Effect of global warming on plant evolution and diversity; lessons from the past and its potential recurrence in the future. Nusantara Bioscience 1: 43-52.* Lessons from the past show that global warming and glaciation are repeated natural cycles; the trigger factor is not always the same. Still, global warming is always accompanied by elevated levels of CO2 and greenhouse gases in the atmosphere, which causes the other rising global temperatures. Present and destruction of various plants and other living things continue to happen from time to time. Every era has its own life form, as a mirror of global environmental conditions at the time. Biodiversity is not always the same between one period of global warming and the subsequent global warming or one period of glaciation with the next glaciation. However, new breeds always show traces of the evolution of their ancestors. Man is one of the agents of global warming that began with developing agricultural systems since 8,000 years ago. The impact of climate change due to global warming should continue to be wary of. Based on past experience, global warming is always followed by mass extinctions, but various life forms will still survive even though their shape is almost certainly not the same as before. Living organisms that can survive will evolve into new taxa different from their parental taxa. Humans who were present at that time probably were not men present at this time, given *Homo sapiens* may have been extinct for not being able to adapt or otherwise has evolved into a new man who may no longer show characteristics of human wisdom.

Keywords: global warming, evolution, diversity, new species.

Abstrak. *Setyawan AD. 2009. Pengaruh pemanasan global terhadap evolusi dan keanekaragaman tumbuhan; pelajaran dari masa lalu dan kemungkinan terulangnya kembali di masa depan. Nusantara Bioscience 1: 43-52.* Pelajaran dari masa lalu menunjukkan bahwa pemanasan global dan glasiasi merupakan siklus alamiah yang terus berulang; faktor pemicunya tidak selalu sama, namun pemanasan global selalu disertai peningkatan kadar CO_2 dan gas-gas rumah kaca lainnya di atmosfer yang menyebabkan meningkatnya suhu bumi. Hadir dan musnahnya berbagai tumbuhan dan makhluh hidup lainnya terus terjadi dari waktu ke waktu. Setiap jaman memiliki bentuk kehidupannya sendiri-sendiri, sebagai cermin kondisi lingkungan global pada saat itu. Keanekaragaman hayati tidak selalu sama antara masa pemanasan global yang satu dengan masa pemanasan global berikutnya; atau dari masa glasiasi yang satu dengan glasiasi berikutnya, meskipun keturunan-keturunan baru selalu menunjukkan jejak evolusi dari nenek moyangnya. Manusia merupakan salah satu agen pemanasan global yang dimulai dengan dikembangkannya sistem pertanian sejak 8000 tahun yang lalu. Dampak perubahan iklim akibat pemanasan global perlu terus diwaspadai. Berdasarkan pengalaman di masa lalu, pemanasan global selalu diikuti kepunahan massal, namun berbagai bentuk kehidupan tetap akan bertahan meskipun bentuknya hampir pasti tidak sama dengan yang ada sebelumnya. Makhluk hidup yang dapat bertahan akan berevolusi menjadi taksa baru yang berbeda dengan taksa tetuanya. Manusia yang hadir pada saat itu barangkali bukanlah manusia yang hadir saat ini, mengingat boleh jadi *Homo sapiens* telah punah karena tidak mampu beradaptasi atau sebaliknya telah berevolusi menjadi manusia baru yang barangkali tidak lagi menunjukkan ciri-ciri manusia bijaksana.

Kata kunci: pemanasan global, evolusi, keanekaragaman, jenis baru.

INTRODUCTION

Climate change is a study that has long been a topic in biology. The effect of climate change on the lives of living things has long been rooted in biological studies, long before the politicians pay attention to their impact on the environment. The study of the climate influence on changes in the distribution of living things has been done in Europe since England started the industrial revolution (around 1765). Grinnell (1917) describes, in detail, the influence of climate on the spread of many species, followed by Andrewartha and Birch (1954) and MacArthur (1972). These observations include various species of birds, butterflies, insects, herbs, and trees. Research which is mainly done is the change of the distribution of birds (Gudmundsson 1951; Harris 1964; Kalela 1949, 1952; Salomonsen 1948; Williamson 1975; Thomas and Lennon 1999), of butterflies (Ford 1945; Parmesan et al. 1999; Parmesan 2002, 2003), and of insects (Uvarov 1931; Dobzhansky 1943, 1947; Dennis 1993; Bale et al. 2002) to the north due to warmer summers and winters are less harsh, while the plants are relatively more limited and generally involves the spread of plants around the Arctic (Sturm et al. 2001; Stirling 2002; Smol et al. 2005) and tropical mountains (Pounds et al. 1999, 2005; Wilson et al. 2005). At present, the study of the impact of climate change on biota includes, among others, the single impact of extreme weather on ecosystems, changes in distribution and abundance, phenology, physiology, morphology, genetics, and behavior (Roy and Sparks 2000; Stefanescu et al. 2003; Root and Hughes 2005, Parmesan 2006).

Climate change, either global warming or glaciations, is a natural cycle that has continued since the earth's formation. Since the Precambrian period (600 million years ago; mya), there has been at least twice global warming and three times glaciations on a large scale. These changes are caused by many factors, including volcanic activity (Fischer 1984), falling of celestial body (Hildebrand et al. 1991), the separation of ancient continental (tectonic) (Strecker et al. 2007), and others. These changes are marked with the extreme and comprehensive change of temperature and gas composition and directly impact the lives, so the diversity of living things change continuously from time to time, either in the form of extinction due to failure in adaptation or the appearance of new taxa as the response to the evolution of these changes (Fishcer 1984).

Global warming results from an imbalance between the amounts of solar radiation energy received and released by the Earth, as it is restrained by the gases that lie between the earth's surface and the stratosphere, so the Earth's surface temperature rises. Greenhouse gases include water vapor, CO_2, CH_4, N_2O, CFCs, aerosols, etc. (Ramaswamy et al. 1992, 2001). These gases can result from natural events or human activities (anthropogenic). Agricultural and industrial activities are the primary source of anthropogenic global warming. Agriculture has donated greenhouse gases of CO_2 and CH_4 for thousands of years because of the conversion of forests to agricultural land on a large scale and the discovery of wet rice fields techniques (Yagi et al. 2000; Komiya et al. 2010). Industry donates CO2 and other greenhouse gases as the effect of fossil fuel use, i.e., coal and oil industries (IPCC 2001; Iijima et al. 2010).

This literature review aims to explain the connection of global warming with the adaptation and evolution of plants and its effect on the diversity and classification of plants. Nowadays, the study in this field is relatively still limited. However, climate change is an old phenomenon in the study of biology, the issues discussed are generally only associated with the impact on agriculture, health, and responses at the ecosystem level, mainly changes on biota and the environment due to a single extreme incident, such as El Nino of Southern Oscillation (ENSO) and North Atlantic Oscillation (NAO). Therefore, studies connecting global warming with evolution and classification, especially in plants, need to be done.

GLASSHOUSE GAS AND GLOBAL WARMING

Greenhouse gases. Greenhouse gases are forming in the atmosphere, either naturally or anthropogenic, that can absorb and re-emit infrared radiation at specific wavelengths. The Earth's surface, atmosphere, and clouds are emitted by the radiation. The primary greenhouse gases in the atmosphere are aqueous vapor (H_2O), carbon dioxide (CO_2), nitrogen oxide (N_2O), methane (CH_4), and ozone (O_3). Aqueous vapor and CO_2 contribute about 95% of the greenhouse effect, and the rest, about 5%, are contributed mainly by O_3, CH_4, N_2O, and chlorofluorocarbons (CFCs). Aqueous vapor is the most abundant gas in the troposphere, but because the amount is the relatively fixed and short residence of time, then the impact on global warming is negligible (Table 1). International agreements have been made to regulate greenhouse gas emissions. Montreal Protocol regulates the emissions of greenhouse gases which are entirely due to human activities, such as halocarbon, chlorine, and bromine. The Kyoto Protocol regulates greenhouse gas emissions of CO_2, N_2O, and CH_4, hexafluoride sulfur (SF6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) (IPCC 2001).

Greenhouse effect. Greenhouse gas is the main cause of the greenhouse effect, namely global warming as the effect of the rising of the earth's surface temperature. Greenhouse gases absorb infrared radiation emitted by the earth, atmosphere, and clouds. The main source of energy is solar radiation that is emitted in all directions. Greenhouse gases can absorb heat between the earth's surface and troposphere ("natural greenhouse effect") (Figure 1). Radiation greatly affects the temperature of the atmosphere at an altitude where it is emitted. In the troposphere, temperatures generally decrease with increasing altitude. Infrared radiation emitted at altitude with temperature of about -19°C, while the earth's surface is maintained at a higher temperature, approximately +14°C. the increasing levels of greenhouse gases lead to the increasing of impermeability of infrared radiation into the atmosphere, therefore the radiation has begun to occur at a higher altitude with a temperature lower than -19°C, resulting in increasing of infrared radiation followed by the rising of temperatures greater than +14°C ("*enhanced effect of greenhouse*"). This is generally a result of anthropogenic activities. The theory of the greenhouse effect was first proposed by Arrhenius in 1896. He estimated that the surface temperature will increase due to multiplying of CO_2 in the atmosphere (IPCC 2001; Loaiciga et al. 1996).

HUMAN ROLE IN GLOBAL WARMING

Pre industry. Agriculture has started 11,000 years ago in the fertile area of the eastern Mediterranean, later followed by Chinese and American Indians. This activity grew very rapidly, about 2000 years ago all the major food crop has been cultivated. Agricultural activities have begun donating CO_2 greenhouse gases since about 8000 years ago, with the conversion of natural forest to agricultural land on a large scale in Europe and China. The remains of the burned or decomposing trees release CO_2 into the atmosphere (Naik et al. 2007). Other greenhouse gases, CH_4, is produced by the agriculture supporting activities such as animal husbandry and burning of land for hunting, but the CH_4 in large numbers began to be donated about 5,000 years ago, since the discovery of wet fields

Table 1. Concentration and resident time of some greenhouse gases (Loaiciga *et al.* 1996).

Parameter	Greenhouse gases						
	H_2O (ppm)	**CO_2 (ppm)**	**CH_4 (ppm)**	**CFC-11 (ppt)**	**CFC-12 (ppt)**	**N_2O (ppb)**	**O_3[a] (ppb)**
Early industrialization (1750-1800)	3000	280	0,8	0	0	285	1-15[b]
1990	3000	353	1,72	280	484	310	10-100
Resident time	10-15 days	50-100 years	10 years	65 years	130 years	150 years	n.a.[c]

Note: ppm = part per million, ppb = part per billion, ppt = part per trillion; a = < 12 kn, b = approximate value, c = ozone produced continuously in the stratosphere via photolysis, n.a. = not applicable.

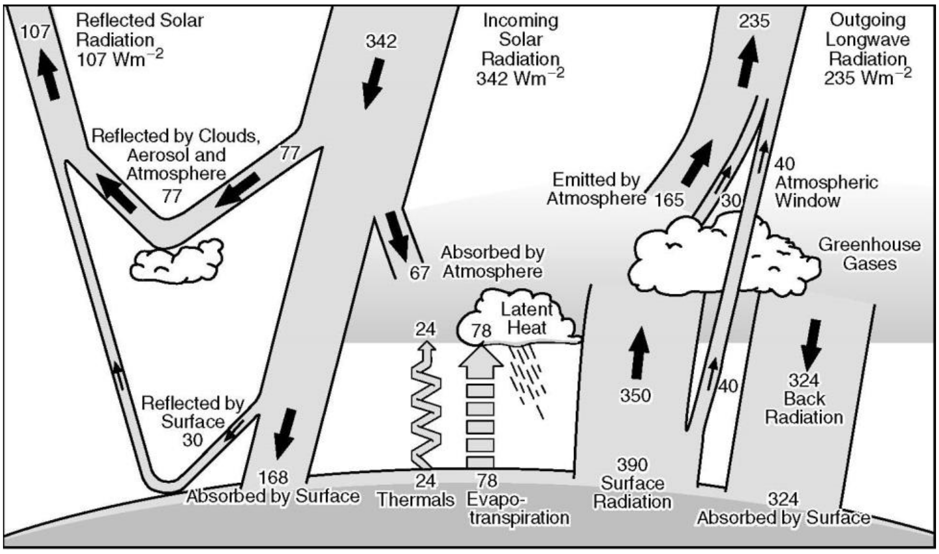

Figure 1. Average annual energy balance of the earth. Solar radiation entering Earth's atmosphere on average per year is 342 W/m^2, which were 107 W/m^2 directly reflected into space by clouds, atmospheric and earth surface. The remaining 235 W/m^2, mostly absorbed by the earth's surface (168 W/m^2) and a small portion absorbed by the atmosphere (67 W/m^2). The earth surface radiates energy back into the atmosphere in the form of infrared radiation (24 W/m^2), heat (78 W/m^2), water vapor and direct lost through the atmospheric "window". Finally, by 235 W/m^2 of radiation emitted back to space through the atmosphere (165 W/m^2), clouds (30 W/m^2) and the atmospheric "window" (40 W/m^2) (Kiehl and Trenberth 1997).

techniques in southern China. This technique led to the decomposition of organic materials by anaerobic bacteria and produce CH_4 (Zhang et al. 2008). This technique has spread to Southeast Asia and India since 3000 years ago. Its use was more widespread with the discovery of techniques of terraced rice fields in the hills of Southeast Asia since 1,000 years ago. Therefore, long before the industrial period, Europe and Asia have contributed to greenhouse gas (Ruddiman 2005).

Industrial period. The industrial revolution in England began in 1765 with the discovery of steam engine with coal fuel. This machine contributes the releasing of CO_2 and carbon black (aerosols) in the air, but an increased rate of CO_2 emissions to the air on a large scale began with the discovery of gasoline engine (1876) and diesel (1893) of petroleum fuel. Industrial activity not only produces CO_2 and CH_4, but also produces various kinds of other greenhouse gases as set forth in the Montreal Protocol and Kyoto Protocol. In addition, it is believed that in the future it will still be found and produced greenhouse gases which are new, including various types of aerosols which are difficult to quantify scientifically (Hansen et al. 1998; 2006).

CO_2 gas is the largest contributor of greenhouse gases. Since the industrial revolution, its levels in the atmosphere have increased up to 83 ppm, from 280 ppm (in 1800) to 363 ppm (in 1990) (Table 1.). If the level of CO_2 emissions in 1990 is not reduced, then the levels in 2100 will nearly be doubled from pre-industrial levels. The main sources of CO_2 are coal and petroleum. Coal remains a potential source of CO2 in the future, because the world's needs tend to rise higher than oil or gas (Loaiciga et al. 1996). Another source is the change of land use in tropical area and natural resources either in the ocean, biosphere, and land. Therefore, the reduction of fossil fuel consumption, which continuously grew by 1.2% per year since 1975, needs to be done. CO2 gas is the largest contributor of greenhouse gases up to now, although recent studies of some NASA researchers give opinion about a large number of the contribution of non-CO2 gases in global warming (Hansen and Sato 2001). The United States is the largest contributor to CO2 and up to now is not willing to implement the Kyoto Protocol.

Mitigation scenario. Contribution of greenhouse gases due to anthropogenic activities can have a positive or negative effect on global climate. Agriculture is the most influencing factor during interglaciations climate. During the pre-industrial, agricultural activities increased the temperature of the earth about 0.8°C, so the earth is warm enough for occupancy; because since 8,000 years ago glaciations cycles have begun which is marked by the emergence of ice domes in northern Canada. On the other hand, the rising temperatures about 0.6°C after the industrial revolution has raised the fears of global warming, where the increase of about 0.5°C occurred in the past three decades (Figure 2) (Hansen et al. 2000; Ruddiman 2005).

At this time, the trend of temperature rise due to greenhouse gases is 0.15 ± 0.05°C per decade, which is slightly lower than the scenario of "*business as usual*"

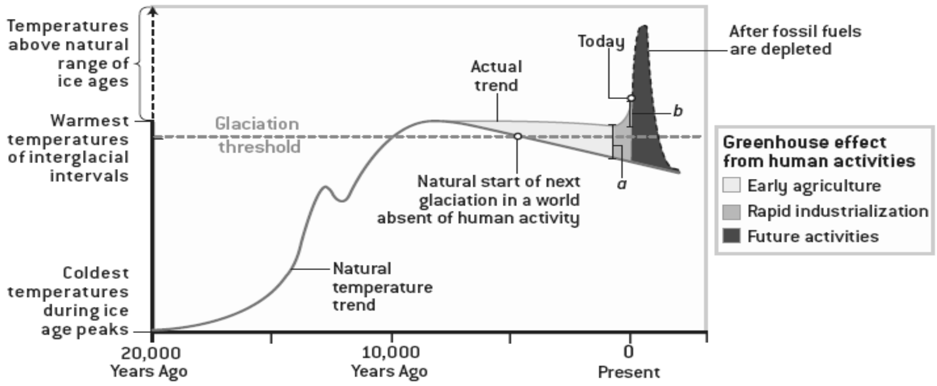

Figure 2. Effect of greenhouse gases from human activities that counteract glaciation began about 5,000 years ago. Early agricultural activity in pre-industrial produce greenhouse gases to offset the cooling of the earth's natural tendency (shaded), by heating the earth nearly around 0.8°C. Effects of early global warming (a) obscured when compared with 0.6°C warming (b) measured in the late 17th century due to rapid industrialization (black). After running out of fossil fuels and increases as the peak temperature of greenhouse gases, the Earth will cool down towards the next glaciation, which has been delayed for thousands of years (Ruddiman 2005).

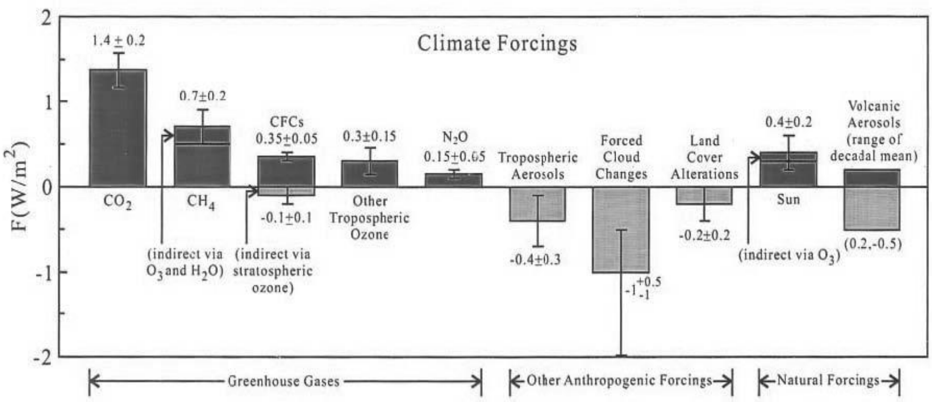

Figure 2. The estimated strength of the factors forming the climate between the years 1850-2000 (Hansen and Sato 2001).

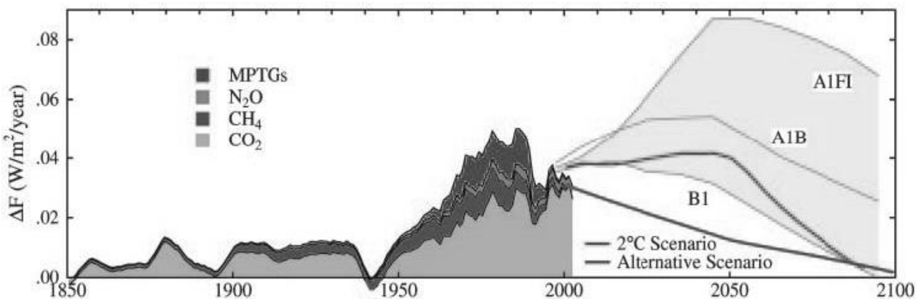

Figure 3. The growth rate of greenhouse gases (5-year mean) that affect climate change (1850-2000), and mitigation scenarios of global warming in the coming century (Hansen and Sato 2004).

namely CO_2 that is added at 1% per year. If this growth occurs continuously till the next century, then in 2100 the earth's temperature will be equal to the period of mid-Pliocene (2.75 mya), when the earth is around 2°C warmer than current temperature and sea level is 25 m higher than today. Studies in Greenland show that the temperature changes abruptly with an annual average of 5-8°C for 3 years happened in ancient times. Therefore it is necessary to attempt to limit the rate of global warming. The IPCC has several scenarios to inhibit the rate of global warming, including A1F1 scenario, A1B scenario, and B1 scenario. In the scenario of 2°C increase temperature, if emissions of CO_2 could be maintained at current levels, and the technology to reduce or capture emissions of CO_2 is found in the second quarter of this century, then in 2050 it is estimated that the temperature rise is only to 0.5°C, and in 2100, it can be stabilized again at the level as the beginning of the industrial revolution. To optimize this plan, the alternative scenario can also be made to keep the climate strength for the next 50 years is at 1 W/m2 or less and to keep the global warming of 0.75° C or less (Figure 3) (Hansen and Sato 2004).

IMPACT OF GLOBAL WARMING AT ANCIENT TIMES ON BIOLOGICAL EXTINCTION

Life in ancient times, from the Precambrian period until now, shows the presence of genetics radiation, genetic innovation, and mass extinction of taxa. Evolution is triggered by changes in conditions of nature, where the periodic climate changes from cold conditions (glaciation) to hot conditions (global warming). The factors that trigger climate change are not always the same. Fischer (1984) shows the correlation of various factors that cause the biology crisis and affect the evolution, namely the volcanism, the climate change, and the extinction of living things (Figure 4). The primeval experience proves that the change of CO_2 and O_2 levels greatly affect the biological extinction. Earth's CO_2 gas is

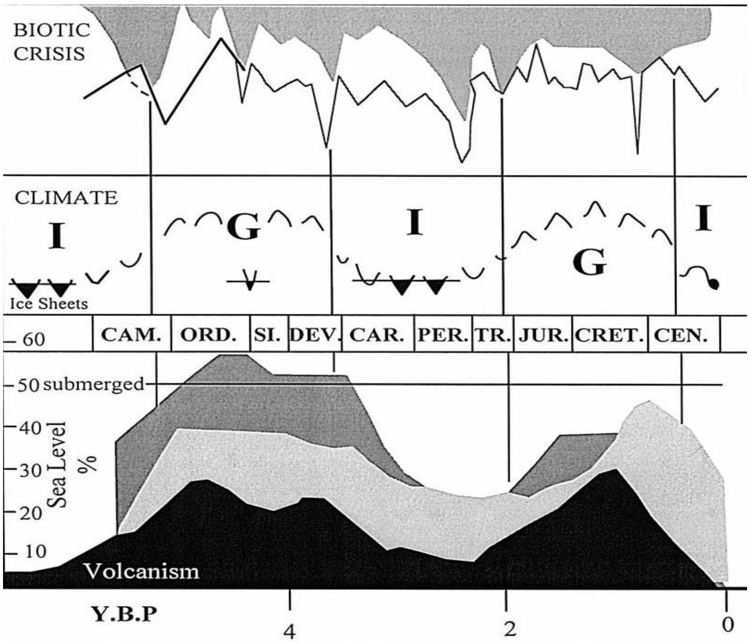

Figure 4. Periodic cycles of changing environmental conditions on the Precambrian period until now that indicate the relationship between volcanism, sea level, climatic conditions, and the extinction of living things (Fischer 1984).

EON	ERA		PERIOD	EPOCH	APPROX. TIME BOUNDARY	LIFE FORMS ORIGINATING
PHANEROZOIC	CENOZOIC	QUATERNARY SUB-ERA	PLEISTOGENE	Holocene (Recent)	10,000	
				Pleistocene	1,800,000	Human beings
		TERTIARY SUB-ERA	NEOGENE	Pliocene	5,300,000	Human-like apes
				Miocene	23,800,000	
			PALAEOGENE	Oligocene	33,700,000	True primates
				Eocene	54,800,000	Marine and carnivorous mammals
				Palaeocene	65,000,000	Hoofed mammals
	MESOZOIC		CRETACEOUS		142,000,000	Flowering plants, placental mammals
			JURASSIC		205,700,000	Birds
			TRIASSIC		248,200,000	Small dinosaurs, small mammals
			PERMIAN		290,000,000	Conifers, mammal-like reptiles
	PALAEOZOIC		CARBONIFEROUS		354,500,000	True reptiles, fern forests
			DEVONIAN		417,500,000	Land vertebrates, air-breathing insects
			SILURIAN		443,000,000	Vascular land plants
			ORDOVICIAN		495,000,000	Vertebrates
			CAMBRIAN		545,000,000	Hard-bodied invertebrates
PROTEROZOIC	NEOPROTEROZOIC				1,000,000,000	Soft-bodied invertebrates
	MESOPROTEROZOIC				1,600,000,000	Cells with distinct nuclei
	PALAEOPROTEROZOIC				2,500,000,000	
ARCHAEAN	LATE				3,000,000,000	Primitive unicellular organisms
	MIDDLE				3,500,000,000	
	EARLY				4,000,000,000	
PRISCOAN (HADEAN)					4,650,000,000	

Figure 5. Geologic time scale; Proterozoic, Archaean, and Priscoan (Hadean) commonly known as the Precambrian period (Microsoft Encarta 2003).

produced naturally through volcanic and tectonic activity, the release of hydrates gas and oxidation of organic material. The O_2 gas continued to be multiplied by the phytoplankton since 3.5 Ga) (Barnes 1999). To facilitate the understanding of time scales in ancient times, Figure 5 presents the geological time scale.

Paleozoic. Paleozoic era is started and ended with global warming, in the middle of it, there was an interspersing of glaciations in the short time. When approaching to the era change of Precambrian to Cambrian, there were the major changes including the breakup of Rodinia continent and very extensive glaciations and also the Cambrian explosion, namely the soft tissue biomineralization of various organisms produce vertebrate animals, so their tracks appear in the fossil. In the Cambrian period, the levels of O_2 and CO_2 in the atmosphere were respectively about 0.2 and 20 times of today's level, thus they greatly affected the respiration and the distribution of living things. In the era of mid-early Cambrian and early Ordovician, the lack of O_2 due to natural disasters in the ocean caused a massive extinction of trilobites (Barnes 1999). In boundary period of Ordovician and Silurian, it happened 200 million years of global warming, and it interspersed with cooling for 10 million years. This cooling occurred because of the decrease of CO_2 due to the separation of Antarctica from Gondwana. In the Ordovician era, CO_2 levels are estimated to be about 16 times today, while the O_2 content of about 15-20% of current time due to the spread of marsh plants producing coal. Levels of both significantly affect the average surface temperature, as well as CH_4 and aqueous vapor content. Climate in the late Paleozoic era was more diverse and complex. In the limit of Permo-Carboniferous era, glaciations occurred during 60 Ma, because of the decrease in CO_2 due to the formation of Pangea. In the Permian era, the continent of Pangea was very dry and dusty, had limited vegetation cover, but in some raised parts of the edge of the continental, the rainfall was very abundant (Barnes 1999). In Permo-Triassic boundary, there occurred global warming because of the release of CO_2 on large scales due to the eruption of volcano in Siberia. Global warming caused a mass extinction of about 85-95% species on earth, so it takes 5 million years in the early Triassic to recover from this devastation. Extinction is also driven by the occurrence of gas hydrate release and the oxidation of organic matter that also increase levels of CO_2 in the atmosphere, and the existence of ecological instability due to changes in habitat and annual climate fluctuations (Erwin 1993; Barnes 1999).

Mesozoic. In the Mesozoic era, global warming happened because of the opening of sea water circulation from the equator to the poles, the formation of broad shallow seas and warm and also the volcanic activity. In the early Jurassic period, the temperature range 5-10°C higher than at present. In the Cretaceous period, the temperature is getting hotter, where the level of CO_2 is almost 4 times today. At the end of the Mesozoic era, on the Cretaceous-Tertiary era boundary, an asteroid crashed in Chicxulub, Yucatan Peninsula, Mexico which cause climate change, acid rain, and a big fire, resulting in mass extinction of dinosaurs, ammonites, and other biotas. This great extinction gave adequate space for the development of new plants, Angiosperms, which its genetic innovation began to emerge in the early Cretaceous era (Prinn and Fegley 1987; Barnes 1999; Beerling et al. 2002).

Cenozoic. In the Cenozoic era, there was global warming that is followed by glaciations and by slow global warming until the temperature was as today. Global warming in the Paleocene-Eocene era boundary was caused by the release of hydrate gas. At that time, the earth's temperature was 2-4°C higher than the current temperature, and it caused mass extinction of benthos foraminifera, the plankton turned into calcareous, and the mammals began to emerge on mainland. Glaciations at the Eocene-Oligocene boundary were due to the decreasing levels of CO_2 in the atmosphere which were as the result of the formation of alpine region (Himalayas, Alps, Andes, and the Cordillera), and also the intermixture of warm and cold sea water circulation due to the opening of Drake Passage (between South America and Antarctica) and the closing of Panama isthmus. This led to the extinction of foraminifera plankton. In the late Neogene, the global cooling was widespread happened due to the continued freezing of Arctic region. The glaciations continued in the early Quaternary Holocene due to the melting of ice on a large scale in North America, besides the influence of the cycle of the sun's orbit (Barnes 1999; Thompson et al. 2006).

ADAPTATION AND EVOLUTION OF PLANT DUE TO GLOBAL WARMING

Increased levels of CO_2, CH_4 and other greenhouse gases in the atmosphere have an impact on climate change, among others: the increase of average global temperatures, the changing of rainfall patterns, and the increased frequency and intensity of extreme weather. This will affect the living things in the distribution, phenology, physiology, morphology, genetics, and behavior. Species that are able to adapt in the long run, likely will experience the evolution and speciation to form new species.

Changes in distribution and abundance. Global warming can also lead to invasion of species from tropical and sub tropical to temperate areas or from low land to high land. On Galindez Island, Antarctica, global warming led to increase in the rates of germination and seedling resistance of Deschampsia antarctica, so that between 1964-1990 its number increased rapidly from 500 to 12,030 individuals. In some places in the Alps, the observation in 1992-1993 shows that for decades biodiversity increased rapidly by 70% due to upward colonization. In Quelccaya, Andes, the decrease of ice dome causes the return of Distichia muscoides which was present in the region around 11,000 - 6,000 years ago when the temperature is 1.5-2.0°C warmer than today (Hughes 2000; IPCC 2001; Parmesan 2006; Thompson et al . 2006).

Changes in phenology. The time which promotes inflorescence determines the success of Angiosperms's reproduction. The phenology of plant species may change due to changes in rainfall and temperature. In the forest areas that are sensitive to the early arrival of rains in the spring, the vegetation changes will occur in line with changes in rainfall patterns. In North America, for many decades, the earlier time of inflorescence of Syringa vulgaris and Lonicera spp. (L. tatarica and L. korolkowii) has been gone forward in average of 2 and 3.8 days per decade. On the other hand, studies in Lapland, Sweden showed that temperature increases do not affect phenology of Saxifraga oppositifolia and Ranunculus nivalis, although a large number of other species are affected (IPCC 2001; Molau et al. 2005; Parmesan 2006).

Changes in physiology and morphology. The increase in temperature and CO_2 concentration directly affects photosynthesis, growth, and productivity of plants. In temperate areas, increased levels of CO_2 can be observed from the annual ring width line of cambium and wood biomass. Global warming since the mid-19th century led to the biomass of trees in temperate regions increased rapidly, for example, on *Pinus aristata* and *Populus* spp., Even in *Populus* spp. increased up to 33%. On the other hand, since the 1950's the average of wood biomass of tropical plants has begun to decline. Increased levels of CO_2 affect the density of stomata. Current plants have fewer stomata than herbarium specimens of the same species that were collected about 200 years ago, because the number of stomata openings is less, CO_2 for photosynthesis needs are met (Hughes 2000; IPCC 2001; Gielen and Ceulemans 2001).

Genetic differences and behavioral changes. In some species of plants, the success of fruit and seed formation is greatly influenced by the temperature at the reproduction period. Two cultivars of Prunus avium L., where one is able in adapting to the cold temperature and the other to warm temperatures show that rising temperatures reduce pollen germination of both, but increases the pollen tube growth. The microgamet ability of both in reaching the base of the stylus is different. At a temperature of 20°C, both microgamet populations are relatively similar, but at a temperature of 30°C, the cold cultivars microgamet populations decrease and at a temperature of 10°C, cultivars decrease slightly warm. Different genotypes respond differently to temperature during the reproductive period, in which the plants need time to adapt to changes in temperature (IPCC 2001; Hedhly et al. 2004).

PLANT DIVERSITY AND CLASSIFICATION CHANGES DUE TO GLOBAL WARMING

Taxa extinction due to global warming. The past time has proven that global warming is one of the main factors causing extinctions, and evolution should be done by taxa to survive. In the future, climate change is also expected to be the main factor of taxa extinction. Modeling study that includes 1,103 species of animals and plants in an area of 20% of the earth's land surface shows that in 2050 approximately 15-37% of species will extinct if global warming continues at current pace. Global warming causes climate homogenization in large areas and causing loss of habitat with a special climate (niche), therefore, it increases the invasion of alien species and wipes out many native species (Thomas 2004).

The formation of new taxa of Angiosperms. Global warming causing the extinction of taxa, on the other hand, encourages the development of new taxa through evolutionary process. Global warming in the Mesozoic era, which began in the early Jurassic to the temperature of 5-10°C higher than at this time and ended by the asteroid falls at the Cretaceous-Tertiary boundary, has caused the extinction of most of the gymnosperms which dominate the earth in those days, and allowed the development of new taxa of Angiosperms and its users, mammals. Early ancestor of Angiosperms has been present since 142 mya, but most have just started attending in the early Cretaceous period, especially in the Aptian era (122-125 mya). Most of Angiosperms which persisted up to now come from the upper Albian era (110-113 mya). Figure 6 shows the possibility of evolution of Angiosperms and their close relatives (Doyle and Donoghue 1988).

In the Cenomanian stage, Angiosperms diversity began to increase. In the Turonian and Senonian stage, Angiosperms is more abundant than ferns and gymnosperms. A number of modern Angiosperms familia from Cenomanian stage has the form of leaves and fruits very similar to modern taxa. In the Maastrichtian stage, a number of modern genera and families began to attend, such as *Nypa* (Arecaceae), *Ctenolophon* (Linaceae), Proteaceae, Myrtaceae, Ilex (Aquifoliaceae), Poaceae, Sapotaceae, Nothofagus (Fagaceae), or Sarcococca Pachysandra (Buxaceae), Ascurinu (Chloranthaceae), Anacolasia (Olacaceae), Alnus (Retulaceae), Guarea (Meliaceae), and Symplocos (Symplocaceae). Some of the modern family is expected to appear on Turonian stage (90-100 mya) and some orders are appeared on Cenomanian stage, some earlier. In the Paleocene period, there appeared Alyxia (Apocynaceae), Betula (Retulaceae), Barringtonia (Lecythidaceae), Brownlowia (Tiliaceae), Bombax (Bombacaceae), Crudia (Caesalpinaceae), and Liquidambar (Hamamelidaceae) and several other genera (Raven and Axelrod 1974).

Classification and phylogeny of ancient and modern Angiosperms. Ancient Angiosperms (primitive) that is still survive until now generally has been present at the beginning of the Cretaceous (110-90 mya), where Africa and South America is only 800 km and is still connected by volcanic islands, so the movement of species is still allowed, while Modern Angiosperms is generally present before the unification of Africa and Eurasia that occurred in the early Paleocene (about 63 mya). Ancient Angiosperms has evolved to adapt to various environmental conditions, until now the diversity, abundance, and has been spread over other plant groups.

The phylogenetic character of basal Angiosperms (ancient) and non-basal (modern) strongly influence the composition of its classification. The reproductive character of ancient Angiosperms can be traced by comparing among the Angiosperms members that present at this time, and compiling them in a proper phylogenetic among basal Angiosperms, so their origins history can be traced to about 130 mya, the year which Angiosperms began to emerge to replace gymnospemae and ferns domination (Table 2) (Friedman and Williams 2004).

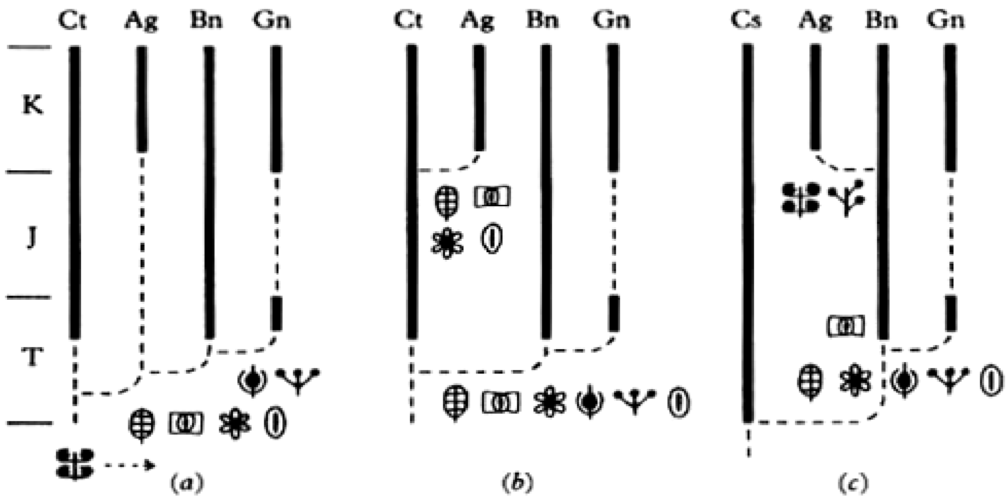

Figure 6. Evolution scenario Angiosperms and relatives; (a) is a close relative anthophyta Angiosperms other, (b) Angiosperms derived from *Caytonia*; (c) Angiosperms derived from Benettitales. T = Triassic, J = Jurassic, K = Cretaceous; Ct = *Caytonia*, Ag = angiospernae, Bn = Benettitales, Gn = Gnetales (Doyle and Donoghue 1988).

Table 2. Reproductive character of Angiosperm (Friedman and Williams 2004)

Character	Early Angiospermae (20th century)	Early Angiospermae (21st century)	Modern Angiospermae (kebanyakan)	*Zea mays* (monocot)	*Arabidopsis thaliana* (eudicot)
Pollen grains	2-cell	2-cell	2-cell	3-cell	3-cell
Composition of the female gametophyte when ripe	7-cell, 8-nuclei	4-cell, 4-nuclei	7-cell, 8-nuclei	7-cell, 8-nuclei	7-cell, 8-nuclei
Position of the cell cycle at fertilization of gametes	Unknown	G1	Unknown	G1	G2
Ploidy endosperm	3n	2n	3n	3n	3n
The pattern of endosperm development	Free nuclei or cellular	Cellular	Free nuclei	Free nuclei	Free nuclei

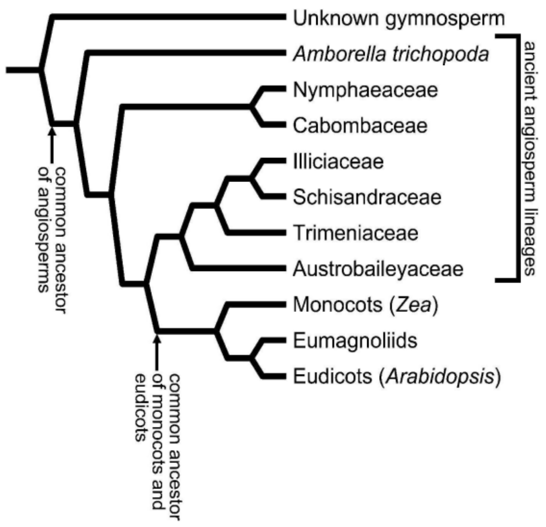

Figure 7. Angiosperms phylogeny based on recent molecular analysis. *Amborella*, Nymphaeales, and Karis Austrobaileyales have a more ancient lineage than monokot origin, eumagnoliid, and eudikot (Friedman and Williams 2004).

Throughout the 20th century, taxonomic experts agree that the character of ancient Angiosperms reproduction is represented by magnoliid, where all other Angiosperms is considered to be originated from it. But in 1999, a number of phylogenetic analyses showed that the *Amborella*, Nymphaeales, and Austrobaileyales develop a more basal part of other Angiosperms; and appeared before the ancestors, i.e., monocot, eudicot, and eumagnoliid, so it had an older lineage, and may still represent the biological character of the most ancient Angiosperms. All other Angiosperms, but those three, shares the properties of a common ancestor (Figure 7). This discovery answered the question of Darwin in 1903 on the mystery that the origin of flowering plants is confusing, so it is called "abominable mystery." The exact determination of phylogenetic line as the true picture of evolution will guide the preparation of appropriate systematic (Friedman and Williams 2004). The result of this evolution shows that the plant always tries to adapt to changing environmental conditions, including major changes due to global warming or glaciation, to create new types that are more dominant and much different than the parent (Walther et al. 2002; Thomas 2005).

CONCLUSION

Lessons from the past show that global warming and glaciation is a repeated natural cycle. The trigger factor is not always the same, but global warming is always accompanied by elevated levels of CO_2 in the atmosphere. The existence and the destruction of various plants, animals and other organisms continue to occur from time to time. Every era has its own life form, as a mirror showing that global environmental conditions are always changed. Biodiversity is not always the same between one period of global warming with the other period of global warming, or from one glaciation to the next glaciation, although new breeds always show traces of evolution of his ancestors. Therefore, the impacts of climate change which is caused by global warming need to be anthropogenically wary of. Even if global warming is still going on and is followed by mass extinction, it is believed that various forms of life will still be present on the earth, but such life forms is almost certainly different from the one at this moment. Living organisms which can survive are likely to evolve into new taxa that are different from existing taxa. Humans who were present at that time probably is not a man who is present at this time, because Homo sapiens may have been extinct for not being able to adapt or otherwise has evolved into a new man who may no longer shows characteristics of human wisdom.

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