Icterus glabula	(Baltimore Oriole)
Quiscalus quiscala	(Common Grackle)
Molothrus ater	(Common Cowbird)
Richmondena cardinalis	(Cardinal)
Melospiza melodia	(Song Sparrow)
Buteo jamaicensis	(Red-tailed Hawk)
Circus cyanens	(Marsh Hawk)
Cathartes aura	(Turkey Vulture)
Colinus virginianus	(Bob-white Quail)
Zenaidura macroura	(Mourning Dove)
Tyto alba	(Barn Owl)
Bubo virginianus	(Great Horned Owl)
Chordeiles minor	(Common Nighthawk)
Archilochus colubris	(Ruby-throated Hummingbird)
Charadrius vociferus	(Killdeer)
MAMMALS	
Didelphis marsupialis	(Opossum)
Cryptotis prava	(Least Shrew)
Scalopus aquaticus	(Eastern Mole)
Procyon lotor	(Raccoon)
Taxideo taxus	(Badger)
Mephitis mephitis	(Striped Skunk)
Canis latrans	(Coyote)
Citellus tridecemlineatus	(Thirteen-lined Ground Squirrel)
Geomys bursarius	(Plains Pocket Gopher)
Dipodomys ordi	(Ord Kangaroo Rat)
Peromyscus maniculatus	(Deer Mouse)
Peromyscus leucopus	(White-footed Field Mouse)
Neotoma floridana	(Eastern Wood Rat)
Rattus norregicus	(Norway Rat)
Sigmodon hispidus	(Hispid Cotton Rat)
Dasyp usnovemcinctus	(Armadillo)
Lepus californicus	(Blacktail Jackrabbit)
Sylvilagus floridanus	(Eastern Cottontail)

ICE AGES: THE MYSTERY SOLVED?
PART I: THE INADEQUACY OF A UNIFORMITARIAN ICE AGE

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Abstract

The old astronomical theory of the ice ages, based on slight long-term changes in the earth's orbital geometry, is now believed to be the solution to the mystery of the ice ages. However, the changes in solar radiation are too small to cause an ice age, especially for the dominant eccentricity cycle. There are many problems with climate simulations, and research indicates it is practically impossible to initiate glaciation over Northeastern North America under uniformitarian conditions.

I) THE ASTRONOMICAL THEORY OF THE ICE AGES

A) Introduction

There are many theories of the ice age or ages, all of which have serious difficulties. However the astronomical theory of the ice ages has become popular recently. This theory states that ice ages resulted from differences in solar radiation due to cyclical variations in the geometry of the earth's orbit around the sun. These variations are: 1) changes in the eccentricity of the earth's orbit; 2) the precession of the equinoxes; and 3) changes in the tilt of the earth's axis. This theory is not new, but has existed over a hundred years. What is new, however, is its revival in the past 15 years due to statistical correlations with oxygen isotopes in deep-sea cores. Most earth scientists now believe that the long-standing mystery of the ice age has finally been solved. The purpose of this paper is to show in detail that the mystery remains unsolved within the uniformitarian framework.

B) Historical Development

1) EARLY ACCEPTANCE

The theory that long-term orbital variations have caused the ice ages is attributed to Milutin Milankovitch, a Yugoslavian meteorologist.[1, 2] However, several men before him believed that orbital variations caused the ice age. The astronomer, John Herschel, in 1830 was apparently the first to suggest that these variations might affect climate.[3] In 1842, Joseph Adhémar, a mathematician, published *Revolutions of the Sea*,[4] in which he theorized that the precession of the equinoxes was the mechanism for the ice ages in the hemisphere furthest away from the sun during winter. Parts of his theory were later proved wrong. James Croll elaborated on Adhémar's theory by including the eccentricity and obliquity cycles.[5] However, the latter concept was not well understood at that time. After detailed celestial mechanical calculations had been made by astronomers for all three orbital variations, Milankovitch derived the secular change in incoming solar radiation in the past for various latitudes. Consequently, he is credited with the theory, which is also called the Milankovitch theory or mechanism. As improvements in the orbital data of the planets became available, his calculations were updated several times. The recent calculations of Vernekar[6] and Berger[7-9] are the standard today. Berger is considered the most accurate because he used more terms in his series expansion equations, but Vernekar's results agree reasonably well with Berger's, especially for the past 400,000 years. (References to geological time or long ages in this paper are used for the sake of discussion and are not to be construed as belief in the uniformitarian, evolutionary time scale.)

Due to Milankovitch's influence in the 1920's, most European geologists accepted his theory by the 1940's. This was mainly due to apparent confirmation from the previous work of Penck and Bruckner on gravel terraces in the Alps.[10] They found four gravel terraces that they attributed to four ice ages, the timing of which seemed to fit the Milankovitch cycles. Penck and Bruckner's research was revised when others discovered more than one gravel deposit in each terrace. It is interesting that this new information conforms to the astronomical theory even better,[11] especially since no "absolute" dating was available at that time.

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2) DISILLUSIONMENT IN THE 1950'S AND 1960'S

Interest in the Milankovitch theory waned in the 1950's and 1960's due to many contradictions with the new radiocarbon dates from peat and other deposits found between layers of glacial till.[12] In addition, many meteorologists claimed that the radiational changes were too small to have caused ice sheets. Regardless, a few scientists clung to the theory because of the cyclical nature of both ice ages and the astronomical theory and because it is the only one that can be "tested" by geology.

3) MODERN REVIVAL IN THE 1970'S

The efforts of the few believers came to fruition during the 1970's after the advent of sophisticated scientific techniques applied to deep-sea cores. The Milankovitch theory was finally "confirmed" by matching oxygen isotope cycles in cores with the radiation cycles. The key paper was published in 1976 in *Science* by Hays, Imbrie, and Shackleton entitled: "Variations in the Earth's Orbit: Pacemaker of the Ice Ages."[13] An easy-to-read historical summary leading up to the "solution" can be found in the book *Ice Ages Solving the Mystery* by John Imbrie, one of the principal researchers, and Katherine Palmer Imbrie, his daughter.[14] "By the mid-1970's, scientists could state, with confidence, that the ice ages came and went over the past million years mainly because of changes in climate due to orbital eccentricity, axial tilt, and axial precession."[15]

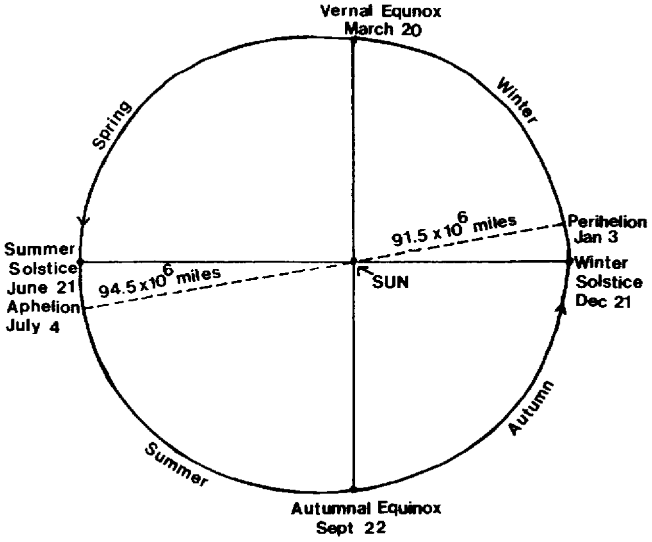

Figure 1. The current geometry of the earth's orbit around the sun. (Redrawn from Imbrie and Imbrie, 1979)

C) Orbital Variations

1) ECCENTRICITY

The earth's orbit around the sun is an ellipse (Figure 1) with a current eccentricity of .017 (zero is a perfect circle and one is a straight line). However, over geological time, the eccentricity varies from near zero to .06 with two major periods of approximately 413,000 and 100,000 years.[16] This variation is caused by the gravitational pull of the other planets in the solar system. Figure 2 shows the changes in the earth's eccentricity extrapolated backwards for two million years.

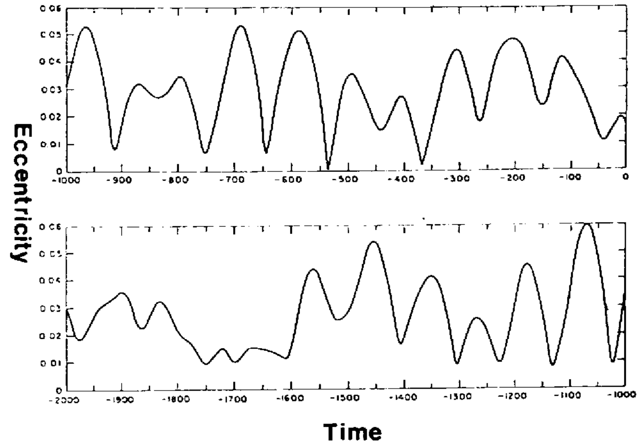

Figure 2. The variation in the earth's eccentricity for an assumed past two million years. Units are in thousands of years. (Vernekar, 1972)

2) PRECESSION OF THE EQUINOXES

A second variation in the earth's orbit is the precession of the equinoxes, also called the change in the longitude of the perihelion, which is the nearest approach of the earth to the sun. The precession of the equinoxes is actually the resultant of two forces acting on the earth's orbit. First, the equinoxes and solstices are forced to rotate clockwise along the earth's orbit due to the differential gravitational attraction of the poles and the earth's equatorial bulge by the sun and moon.[17] Second, the orbital ellipse itself rotates counterclockwise but at a much slower rate. Another way of viewing the precession of the equinoxes is to look at the earth from the position of the fixed stars. Over a long period of time, the axis of the earth's rotation wobbles like a spinning top (Figure 3). The period, which is defined as the time for one rotation of the vernal equinox to the same point on the orbit, is about 21,000 years.[18] Currently, perihelion occurs on January 3rd (Figure 1), and the Northern Hemisphere receives

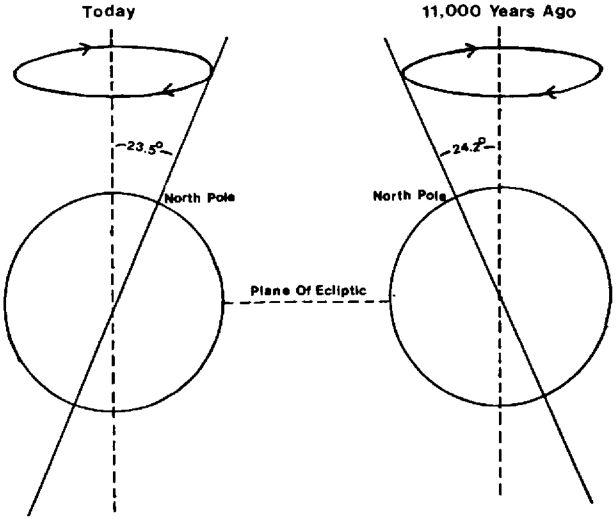

Figure 3. The change in the earth's axis as seen from the fixed stars between today and 11,000 years ago. Also included is the change in the tilt of the earth's axis. (Redrawn from Fodor, 1982)

slightly more solar radiation in winter than in summer. In about 11,000 years, the pattern will reverse (Figure 3), and the Northern Hemisphere will receive more radiation in summer. Figure 4 shows the variation of the precession extrapolated over the past two million years.[19] The amplitude of the change is not even, but is modulated by the eccentricity cycle, which also changes over time. Figure 4 is actually a graph of e · sin(w), where e is the eccentricity and w the longitude of perihelion as measured from the moving vernal equinox. In reality, the eccentricity mainly affects the radiation impinging on the earth through the precession cycle.[20, 21] If the orbit were circular, the precession would not change the radiation on the earth since in each season the earth would be the same distance from the sun When the eccentricity is large the precession cycle would have a relatively large radiational effect.

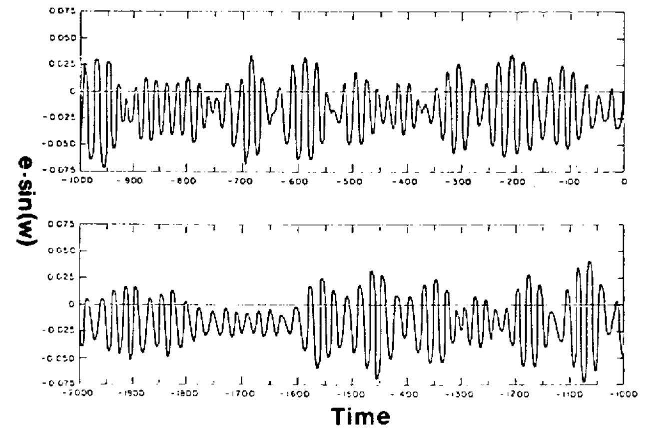

Figure 4. The variation of the precession of the equinoxes, modulated by the change in the eccentricity of the earth's orbit. Units are in thousands of years. (Vernekar, 1972)

3) THE EARTH'S TILT

The third long-term variation of the earth's orbital geometry is the change in the tilt of the earth's axis with respect to the orbital plane. This is also referred to as the change in the obliquity of the ecliptic. Currently, the tilt is 23.5°. Due to a wobble in the earth's axis, the tilt varies from 22.1° to 24.5° with a period of approximately 41,000 years.[22] Figure 3 shows the change in the tilt for one-half the precessional period. Figure 5 is a graph of the relatively regular variation of this orbital element calculated for the past two million years.

4) COMBINED RADIATIONAL CHANGES

The three orbital variations do not change the yearly amount of radiation received by the earth as a whole, except for a very small change due to the eccentricity. Nor do they change the yearly total falling in each hemisphere.[23] The Milankovitch mechanism changes the seasonal and latitudinal distribution of the solar energy. The tilt cycle redistributes the radiation latitudinally in each hemisphere. A decrease in the tilt from 23.5° to the minimum of 22.1° would cause less radiation north of 43°N, but is balanced by more radiation south of 43°N. The precession cycle affects the seasonal partition of solar radiation. A decrease in winter radiation is balanced by an increase during the summer and is opposite in the Northern and Southern Hemispheres.

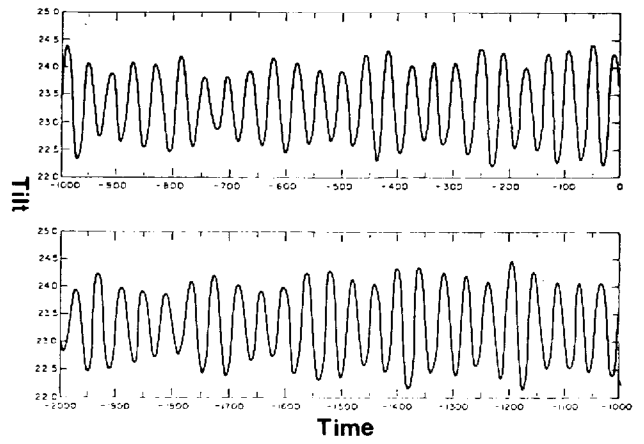

Figure 5. The variation in the tilt of the earth's axis for an assumed past two million years. Units are in thousands of years. (Vernekar, 1972)

Because of the possible combinations, there has been controversy over which latitude and season is the most important for causing an ice age. The astronomical theory is plastic enough that practically any ice age timing can be predicted: "Depending on the latitude and season considered most significant, grossly different climate records can be predicted from the same astronomical data."[24] Adhémar and Croll believed cool winters were the most favorable.[25] However, the summers would most likely be warmer and cause more melting than occurs today, which was a problem with their models. Milankovitch favored cool summers and warm winters with the most important latitude 65°N.[26] Kukla, a few years ago, felt autumn was the most significant season.[27] Most paleoclimatic researchers today side with Milankovitch.

Figure 6 shows the net change in solar radiation in langleys per day from the present as a function of latitude for the top of the atmosphere calculated from 160,000 years ago to 50,000 years into the future due to all three orbital variations combined.[28] A langley is the amount of radiation in calories absorbed on a square centimeter in one minute. Figure 6 is for the Northern Hemisphere caloric summer which corresponds to the Southern Hemisphere caloric winter. A caloric summer is defined as that half of the year where every day has more radiation than the other half, which is then the caloric winter. Figure 6 shows that the precession cycle with its approximate 21,000 year period predominates at low latitudes and is twice as strong as the tilt, which is concentrated at higher latitudes. The current average radiation at 65°N between April 1st and September 30th, which is close to the caloric summer, received at the top of the atmosphere is about 750 langleys/day.[29] Comparing this with the numerical value in Vernekar's monograph[30] of 17 langleys/day at 65°N, 25,000 years ago, before the peak of the last ice age, shows that the caloric summer radiation was only 2.3 percent less than today. The anomaly is greater north of 65°N, but much less to the south. Further examination of Figure 6 shows that the latitudinal distribution of above and below average radiation is complex. Sometimes below normal radia-

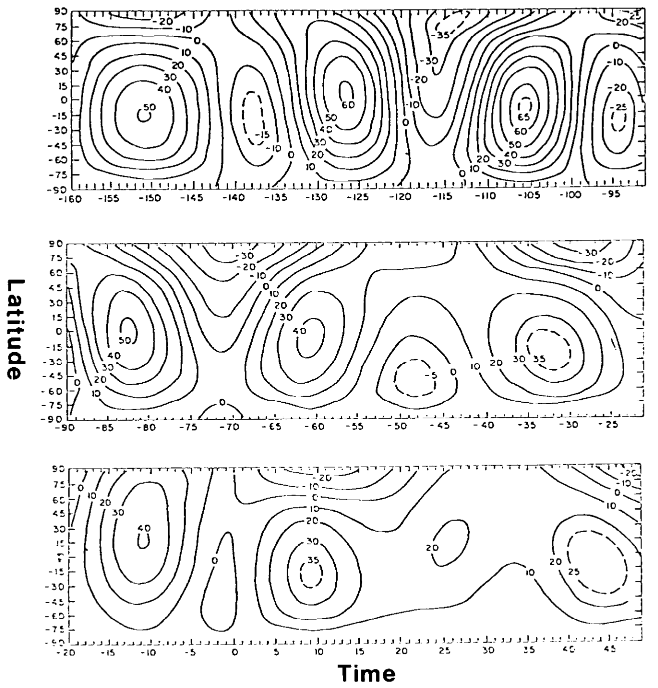

Figure 6. The net change in solar radiation in langleys per day received at the top of the atmosphere of the Northern Hemisphere caloric summer for an assumed time interval of 160,000 years in the past to 50,000 years in the future. Minus latitude is for the Southern Hemisphere. Units are in thousands of years. (Vernekar, 1972)

tion at higher latitudes occurs with above normal values at lower latitudes of the Northern Hemisphere, for example at about 30,000 and 150,000 years ago. At other times, the whole Northern Hemisphere is below normal, as at 70,000 and 115,000 years ago.

II) METEOROLOGICAL PROBLEMS WITH THE ASTRONOMICAL THEORY OF THE ICE AGES

A) Introduction

Is the recent jubilation in "solving the mystery" of the ice ages premature? Is the Milankovitch mechanism the solution to the mystery? Not all paleoclimatic researchers agree. Oerlemans recently said: "In spite of all efforts, however, the cause of the ice ages cannot be said to be known."[31] Pollard and others stated in 1980: "There is little agreement as yet on the dominant causes of the Quaternary ice ages . . ."[32] With these comments in mind from well-known scientists in the field, the author will take a deeper look at the solution. Meteorological problems of the astronomical theory will be discussed. Analysis problems of deep-sea cores will be dealt with later.

B) Changes in Radiation Small

Many scientists in the past have pointed out that the cyclical changes in radiation of the Milankovitch mechanism, especially at high latitudes, are too small to cause an ice age.[33-36] The 2.3 percent anomaly at 65°N, 25,000 years ago, becomes even less when the mid and high latitudes are considered as a whole, since the mid latitudes contain more area than the high latitudes. If the whole Northern Hemisphere is included, the summer anomaly will fall to less than one percent.[37] No matter what area is considered, the change in radiation really is small. Paltridge and Platt, radiation specialists, state: "Milankovitch's proposition that the variability is sufficient to explain certain changes of the extent of polar ice is questionable to say the least . . ."[38] In focusing on major problems in polar research, Washburn states, in referring to the Milankovitch theory: "Yet the mechanism and quantitative adequacy of the effect pose major difficulties . . ."[39]

It is difficult to know how a small radiation anomaly will affect the surface temperature because many other atmospheric and oceanic processes interact in a complex way. These processes, called feedbacks, can amplify or dampen an anomaly. Some of these damping mechanisms to a negative radiation anomaly are exhibited in the present atmosphere during the seasonal change:

> When the pole cools in winter, the north-south temperature gradient increases, tending to produce more northward heat transport which would counteract the cooling. A colder pole would also produce less outgoing IR (infrared) radiation which would also counteract cooling.[40] (Parentheses added.)

Research indicates that damping mechanisms predominate: "A number of feedback mechanisms have since been investigated as to their importance in causing major climate change. In many instances the results have been more-or-less negative."[41] The reason for this is probably because the earth is an efficient heat engine and must be viewed as a whole, and not with the high latitudes isolated. Most of the energy that heats latitudes higher than 50° is transported by the atmosphere and ocean from lower latitudes. In comparing these "night-storage heaters" to the Milankovitch changes, Sir Fred Hoyle states:

> If I were to assert that a glacial condition could be induced in a room supplied during winter with night-storage heaters simply by taking an ice cube into the room, the proposition would be no more unlikely than the Milankovitch theory.[42]

Consequently, a negative summer radiation anomaly would likely cause only a slight temperature drop of, at most, a few degrees, which would not cause an ice age.

C) Atmospheric Climate Simulations

1) INTRODUCTION

Despite the small changes of radiation in the astronomical theory of the ice ages, atmospheric climate simulations for the past have recently shown that these small changes can cause ice ages.[43-53] Fluctuating ice sheets have been modelled to the tune of the tilt and precession cycles. Even the eccentricity cycle, now the dominant frequency, has been duplicated by a few researchers with the aid of amplifying mechanisms. These results seem impressive and are tantamount to proof of the Milankovitch mechanism. However, there are many simplifying assumptions and unrealistic parameterizations in these models, and the results have been subjectively forced.

2) FORCED AGREEMENT

Simplifying assumptions in climate simulations are common, mainly for practical reasons, since extensive computer time is required for computations. Also many atmospheric and oceanic processes are poorly understood. Several examples are annual averages, land-sea averages, and linear or statistical relationships for complex nonlinear mechanisms. The latter are called parameterizations, and the results can be very sensitive to the values used.[54]

> For example, Weertman[55] notes that changing the value of one parameter by less than 1 percent of its physically allowed range made the difference between a glacial regime in one portion of an experimental run, while leaving the rest virtually unchanged.[56]

It is common practice to manipulate these parameterizations until the desired results are approximated. This is essentially what Pollard[57] has done. After two previous failures to model the dominant 100,000 year glacial/interglacial cycle,[58,59] he used a bedrock-ice sheet loading time parameterization and other "unrealistic parameter values"[60] with many computer runs until the desired results were obtained. The goal, of course, was to match the model to the oxygen isotope results of deep-sea cores. Oerlemans[61] also has duplicated the 100,000 year frequency with an amplifying mechanism. He suggests that eccentricity has nothing to do with this frequency, but that it is a function of isostatic readjustment to ice sheet loading and unloading, which indicates the problems of modeling this cycle. He admits that the parameterization in his model for isostatic readjustment is crude and he adjusts his time scale until the assumed cycle is reproduced. Again, the results have been forced with repeated experimentation. Calder[62] simply assumed that an ice sheet automatically develops when the radiation at 50°N drops 17 langleys/day below the present. A quick glance at Figure 6 reveals that cyclical ice ages, highly correlated to the astronomical theory, are not difficult to derive with this "parameterization."

As already indicated, these modelers have assumed that the Milankovitch theory has been "proved" by the results of deep-sea cores. Now it is up to them to show how it physically happened. Needless to say, bias, which will be discussed later, is a prime factor behind the impressive results. Imbrie and Imbrie[63] have no qualms about forcing the results to the paleoclimatic record: "Tuning a model to the climatic record is an essential feature of our strategy."[64] Thus they fit their model to the oxygen isotope results of deep-sea cores,[65] which will be shown to have been matched to the Milankovitch radiation cycles. In fact, Imbrie and Imbrie put the cart before the horse when they say: ". . . we should use the geological record as a criterion against which to judge the performance of physically motivated models of climate."[66] In other words, if the model cannot "predict important features of the paleoclimatic record,"[67] it is a failure.

3) RADIATION SENSITIVE PARAMETERIZATIONS

Several parameterizations in these models are particularly sensitive to the Milankovitch radiation anomalies. One of these is the high latitude snowfall, which is unrealistically high for Northeastern North America, one of the areas of Pleistocene ice sheet initiation and the only one henceforth referred to in this paper. Figure 7 shows the area under consideration. Two centers of ice sheet growth are assumed: Keewatin and the Labrador-Ungava Plateau. Keewatin is the area west and northwest of Hudson Bay, and the Labrador-Ungava Plateau is the area east and southeast of Hudson Bay. The elevation is relatively low with few mountains. Weertman[68] and Birchfield and others[69] used a snowfall of 1.2 meters/year to develop an ice sheet. This is more than three times the yearly snowfall for the Labrador-Ungava area and 10 times that of the much drier Keewatin. In their most recent modification, Birchfield and others used the latitudinal average snowfall.[70] This has been common practice in recent climate models, but it is still two to three times too high for Northeastern North America.

A second radiation sensitive parameterization is the albedo or reflectivity of snow or ice in these climate simulations. "The manner in which these feedbacks are parameterized can have a large impact on the sensitivity of a climate model."[71] A yearly snow and ice albedo of 0.7 (zero means no reflection and 1 is all solar radiation reflected) is commonly used.[72,73] This is much too high for ice and melting snow, and even fresh snow in many areas during winter. The albedo of snow drops rapidly down to 0.4 or 0.5 as it begins melting due to the meltwater and the change in snow crystal size. Dust particles in the top layer of snow will drop the albedo substantially more, depending on their concentration.[74] Aircraft measurements over relatively deep, fresh snow in winter revealed that an albedo of 0.7 or more is characteristic of Northern Keewatin, Northern Labrador-Ungava and northward, but is much too high for areas to the south.[75] The reason for this is forests with a snow cover have a significantly lower albedo in winter than the tundra or plains. Consequently, an excessively high yearly albedo, coupled with very high snowfall make these models extremely sensitive to decreased summer radiation. Large temperature drops and ice sheets will thus result, and correlate with the Milankovitch radiation minimum, which are initial conditions in these climate simulations. Saurez and Held[76,77] seem to justify this procedure by asking: "But are not ice ages, in fact, evidence for such exceptional sensitivity?"[78] The circular reasoning is evident. It should be noted that their model predicts an ice age now with temperatures even colder than at the maximum ice extent of the last ice age.[79]

A third highly sensitive parameterization is an unrealistic vertical shift of the summer freezing level with Milankovitch radiation cycles.[80-82] Since the freezing level tilts downward towards the north in the mid and high latitudes, lowering this boundary will cause the snowline to intersect the ground and shift south, allowing an ice sheet to develop to the north. This "very much simplified direct forcing"[82] method has been used to shift an ice sheet through a range of 17.2° latitude.[83] (This model actually assumed an ice sheet as an initial condition with its snow-albedo positive feedback. However, this tells us little about the origin of the ice sheet, a much more difficult problem.) Large north-south shifts in the snow accumulation zone is like moving a locality further north or southward. Zeuner says this procedure "lends itself to misinterpretation, as the *imaginary* displacement of the locality may be taken as something real."[84] This practice ignores all the variables related to the snowline other than radiation, and the fact that during summer, the higher latitudes actually receive more radiation than the lower latitudes due to the longer days.

4) NEGATIVE RESULTS

Previous to the modern revival of the astronomical theory of the ice ages, climate simulations indicated the Milankovitch mechanism was too small to cause

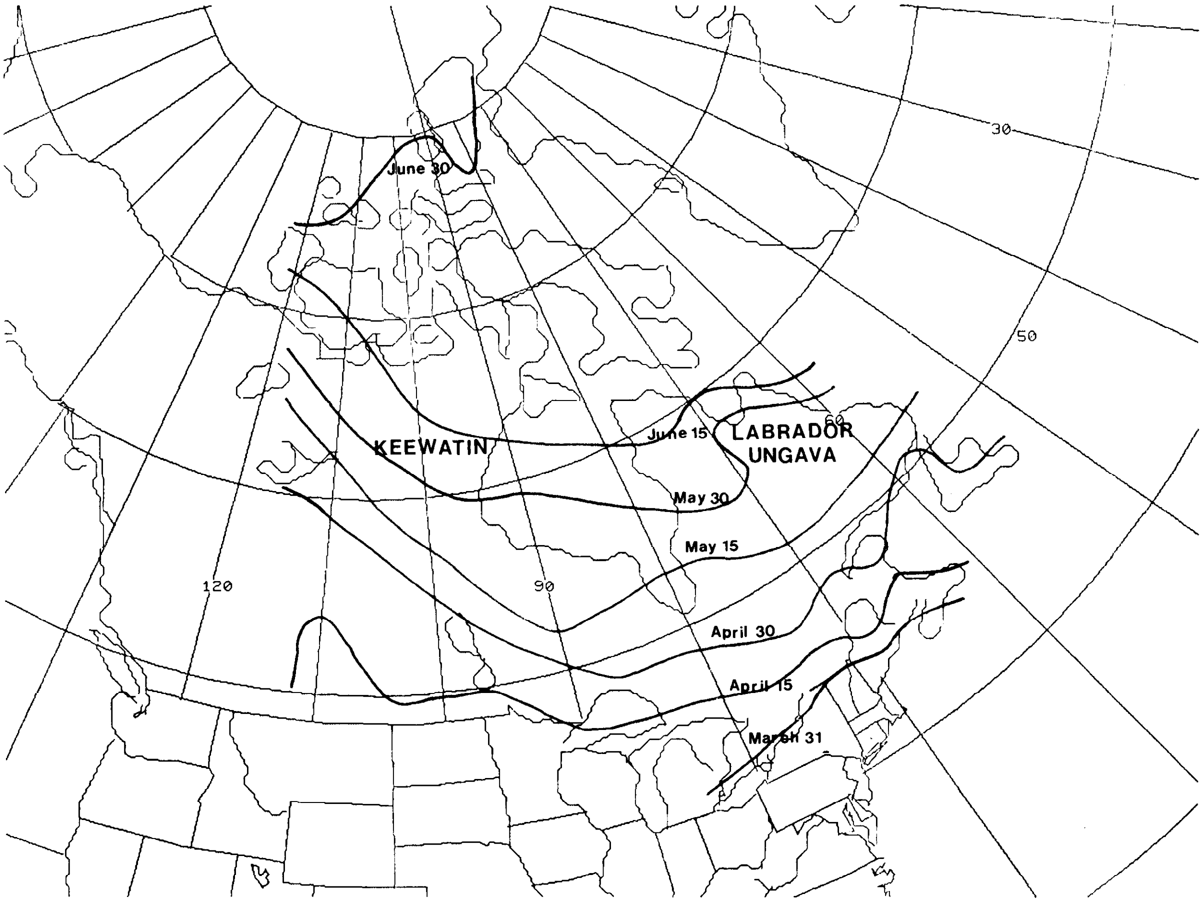

Figure 7. Keewatin and the Labrador-Ungava Plateau and the median date of last snow cover of one inch or more for 20 winters in Eastern Canada. (Redrawn from Potter, 1965)

ice ages.[85-88] These models were simple energy-balance models and have been criticized for this. Much of this was justified. However, earlier workers did not feel a need to fit the model to the supposed paleoclimate record, and consequently were more objective. In spite of the recent "positive" results, some sophisticated models have not produced the Milankovitch cycles or ice ages. Coakley used modern parameterizations for present day radiation derived from satellite measurements, although with an unrealistically high albedo of 0.63. He concluded that the earth's climate is hardly affected by the Milankovitch mechanism.[89] His model was criticized for using annual averages instead of including seasons. In an updated version, of his model, he added the seasonal cycle. North and Coakley conclude:

> The distribution of the incident solar radiation in the models is shown to be insensitive to changes in the eccentricity and the longitude of the perihelion and sensitive only to changes in the obliquity of the earth. For past orbital changes, both the seasonal and the mean annual model fail to produce glacial advances of the magnitude that are thought to have occurred.[90]

This result is more consistent with the small radiational changes of the Milankovitch mechanism and the most recent information on conditions needed to produce an ice age.

D) Glaciation of Northeastern North America Very Difficult

1) INTRODUCTION

A 6 °C summer temperature drop from the average with the same precipitation was long considered the threshold for glaciating Northeastern North America.[91, 92] However, this value was never rigorously tested.[93] While the astronomical theory of the ice ages was being "confirmed," research from other quarters showed that starting an ice sheet over Northeastern North America was much more difficult than previously thought.[94, 95] (Similar difficulties would be encountered for other Pleistocene ice sheets.) As a result of his research, Loewe states: "The origin of the North American ice sheets consequently raises some difficult questions."[96] This, of course, is within the uniformitarian framework, which includes the astronomical theory.

2) CLIMATOLOGY OF KEEWATIN AND LABRADOR-UNGAVA

Winters in Keewatin and Labrador-Ungava are currently very cold while summers are relatively warm, except for the coastal locations where cool water suppresses the temperature. According to uniformitarian assumptions, Hudson Bay likely was non-existent due to isostatic rebound before "each" ice age.[97] Hudson Bay exerts a very pronounced regional cooling effect, which means that without *it*, summers would have been significantly warmer than today before an ice age. Currently, the average June to September temperature for Keewatin and Labrador-Ungava is about 10 °C,[98] which is relatively warm. If the average fell to 4 °C, an ice sheet would not necessarily develop because other variables come into play, like precipitation, upper-air temperatures or the lapse rate (the change in temperature with height), solar radiation (regardless of small anomalies), and cloudiness. Presently, the April to August snowline is well over 2000 meters for most of the area.[99] The average lapse rate in the lower 8000 meters of the atmosphere in this region is usually taken to be 6 °C per 1000 meters descent. Since the average elevation is about 500 meters,[100] a surface temperature drop of 6 °C, due to a radiation minimum and assuming no lapse rate change, would lower the freezing level to about 1200 meters. This is still above the surface, except for the mountains. However, it is more realistic that upper-air temperatures would change less and the freezing level would be significantly higher than where solar radiation is primarily absorbed. The upper air is controlled more by the general circulation of the atmosphere which would tend to resist change.

Precipitation for the two areas is much different. Labrador-Ungava is relatively wet with a yearly average of about 29 inches, half of which is rain. Keewatin is much drier with a yearly average of only six to 10 inches, most of which is rain during the warmer months.[101] Consequently, very little snow accumulates by spring and "at present the summer temperatures are so high that the snow easily disappears."[102] Since storms in Northeastern North America are very windy, the precipitation gages do not collect all the rain and snow. The actual snowfall is higher. However, the wind also causes bare or thin spots on exposed areas, where the albedo will be locally lowered in spring, and partially compensate for the low precipitation readings. Regardless of the exact snowfall, it usually melts by June 15, except for the extreme north which is not far behind. Figure 7 shows the average date of the last snow cover of one inch or more for 20 springs in Eastern Canada.[103] A drop in the average summer temperature of 6 °C will cause a larger proportion of the precipitation to fall as snow.[104] However, this could not be excessive because cooler air is drier and would offset the above effect to some degree (Figure 8).[105] With a 6 °C drop, Keewatin would be very comparable to present day Northern Siberia, where there are no ice sheets.[106]

3) 10-12 °C SUMMER COOLING REQUIRED

The implication of the above section is that much more than a 6 °C summer temperature drop is needed with the present atmospheric circulation to glaciate Northeastern North America. The amount of change has recently been shown by Williams.[107] He used a computer model for the energy balance over a snow cover to simulate the conditions needed to cause glaciation of Keewatin and Labrador-Ungava. The model had realistic values of albedo under a variety of snow and cloud conditions. It compared favorably to the observed seasonal changes on the Decade Glacier on Baffin Island. To test the strength of the Milankovitch mechanism to initiate glaciation, he used the strong radiation minimum at 116,000 years ago (Figure 6). He began with the presumed 6 °C temperature drop, and from there decreased the average by increments of 2 °C. The amount of precipitation was assumed to be the climatological average in the early experiments, but the proportion falling as snow was allowed to increase with decreasing temperature. The model showed that Baffin Island was the most likely site of ice sheet initiation. However, even with a strong radiation anomaly, it was very difficult for the ice sheet to spread from there, and "much more climatic change is required for extensive glacierization of either Keewatin or Labrador-Ungava than has been suggested, equivalent to a *10 to 12 °C summer temperature decrease*."[108] (emphasis mine) This conclusion apparently has been accepted by paleoclimatologists, since Birchfield and others, referring to Williams' conclusion, use the above temperature change as a goal to be reached in testing the Milankovitch mechanism.[109] This much cooling is almost impossible for any uniformitarian ice age theory.

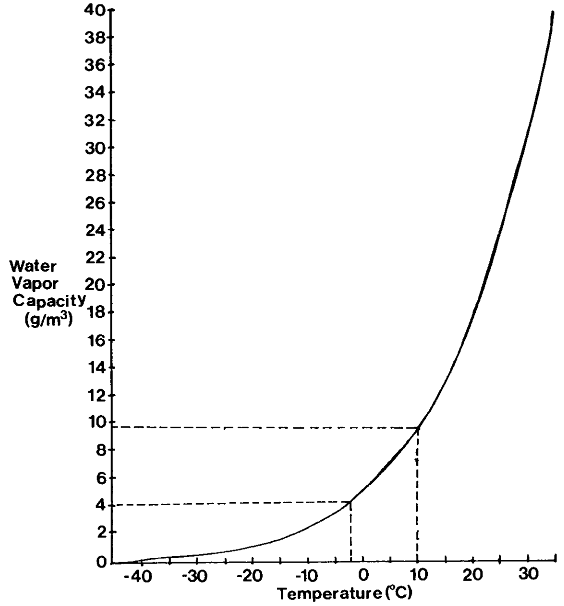

Figure 8. The relationship between the temperature and the water vapor capacity of saturated air.

4) COOLER AIR IS DRIER

A 6 °C or more summer temperature drop in Northeastern North America would be accompanied by cooler than normal spring and fall temperatures. Also, a snow cover would be established quicker in the late summer and early fall, so that autumn temperatures would be chilled further due to the snow-albedo feedback mechanism.[110] It is difficult to know whether winter temperatures would be below normal. Since the yearly average temperature would be much below the present day average, the yearly precipitation would be significantly less from this factor alone, for cooler air is drier. Figure 8 shows the direct relationship between temperature and the water vapor capacity of the air.[111] If the average summer temperature decreased from 10 °C to the previous threshold of 4 °C, saturated air would hold one-third less moisture. If the average plummeted 12 °C (shown by the dashed lines in Figure 8), the air would contain about 60% less water vapor! It is known that cooler than normal summers are also drier.[112] Similar arguments can be made for drier conditions in fall and spring, and even if winter temperatures were several degrees warmer, Figure 8 indicates little change in the moisture capacity of the air at such low levels. The relationship between temperature and the moisture content of the air at saturation is perhaps the most difficult problem all ice age theories have to face, and probably accounts for why there are so many.

5) A PROPOSED ATMOSPHERIC CIRCULATION CHANGE

Even a 6 °C summer temperature drop was considered very difficult to attain under uniformitarian conditions. To avoid such a drastic change, not to mention the new problems presented by Williams' research, it has been proposed that a more modest temperature plunge would be enough to cause an atmospheric circulation change. This would bring more moisture into the area to offset the smaller temperature change and force an ice age. Support for this comes from Ruddiman and McIntyre who claim from geological evidence from deep-sea cores that the surface temperature of the North Atlantic was 1 to 2 °C warmer than average for about the first half of ice sheet growth.[113] Above normal sea-surface temperatures would generate more water vapor that would be carried by southerly or easterly winds to a growing ice sheet. A large temperature difference between the warmer ocean and the adjacent ice sheets of North America and Greenland would force the storm track along the coast further aiding ice sheet growth.[114] (This is almost the same scenario proposed by this author for a rapid post-flood ice age.[115,116] However, an adequate summer cooling mechanism, plus much warmer ocean water, would make the author's model much more likely and rapid.)

It is doubtful that a modest summer or yearly cooling could trigger a significantly moister circulation change, or that above normal sea-surface temperatures off the coast could be maintained for very long. First, the drying tendency of cooler air would have to be overcome. In referring to the glaciation of the climatologically moister Labrador-Ungava area, Loewe states:

> . . . it is not easy to see how a substantial rise of total, or a shift to winter, precipitation can be reconciled with the smaller capacity of the cooler air to hold water vapor. It is also doubtful whether a simultaneous change in general circulation would be able to provide the necessary snowfall.[117]

Second, there are characteristics of the atmosphere that would tend to develop a drier circulation pattern for Northeastern North America caused by cooler temperatures. This is an area of speculation and misinformation. Lamb and Woodruffe estimated 150-300% of normal precipitation for the circulation at the beginning of an ice age,[118] based on extreme months in the current climate which came closest to the "assumed" pattern of glacial onset. Barry, Ives and Andrews questioned their use of extreme months, which were actually only 200 percent above normal at the most, and stated: "It is doubtful to what extent an extreme circulation pattern may persist for a full season or even so for a long time interval."[119] Below normal temperatures in the present climate in the area of consideration may cause above normal snowfall in the autumn, the season of highest snowfall, but it is difficult to know which is the cause and which is the effect.[120] In an analysis of the cool year, 1972, Williams found that precipitation was only 20 percent above normal from September to December, and this was primarily due to the early fall snow.[121] To illustrate the drying potential of the atmosphere caused by a Milankovitch radiation minimum, I will assume that during one of the cooler summers, the snow failed to melt over Keewatin and Labrador-Ungava. This would reinforce the summer cooling by the snow-albedo feedback.[122] and cause much cooler fall temperatures. This in turn would strengthen the ever-present upper air cold trough (low pressure area):

> Because incident solar radiation is mostly reflected from a snow surface, the air above an extensive snow cover is colder, and atmospheric pressure decreases more with altitude in the colder air. This tends to create an upper 'cold trough' above an extensive snow cover . . .[123]

This would have the tendency to drive the storm track further south and east, and hence act as a retarding influence on the snow accumulation, especially in the northern sections. On the surface, the snow cover and the cooler air would strengthen the dry Arctic high pressure system, especially during the colder months and in the north.[124] The above changes are seen on a larger scale in the modern climate during the seasonal change. As winter approaches, high latitude cooling drives the storm track further south as the Arctic anticyclone develops. This drying tendency when snow and/or ice would remain over the summer or become established was recognized by Ruddiman and McIntyre:

> But the growth of these extensive bodies of ice also implies an expansion of the polar anticyclone normally positioned over ice cover in high latitudes of the Northern Hemisphere. This expansion of dry cold air would reinforce the normal high-Arctic aridity and slow or stop the rapid growth of ice sheets unless opposed by other parts of the climatic system.[125]

The above sequence would have the tendency to cause the presently dry Keewatin to become even drier due to its northerly position and its location in the very dry northwesterly circulation west of the upper trough.[126] The snow would consequently melt in this region the next summer, if it could last even the one summer. Labrador-Ungava is closer to the moisture source of the North Atlantic Ocean and would be in a better location for glaciation, except that the storm track probably would be further southeast. The postulated above normal sea-surface temperatures are the "other parts of the climatic system"[127] proposed by Ruddiman and McIntyre which they hope would lift the storm track further northward and provide the necessary increased moisture for glaciation. It is difficult to understand how a small change of 1 to 2 °C warmer sea-surface temperatures could have a significant effect and overcome those factors tending to cause drier conditions. Even though they claim that the Labrador Sea would be ice free,[128] modern observations indicate this is doubtful and that above normal sea-surface temperatures adjacent to Northeastern North America could not be maintained. Barry and others recognize the need for warmer water, but they add: ". . . if the recent climatic fluctuation is any guide, we must note that Rodewald reports a 2 °C cooling between 1951-1955 and 1968-1972 in August in the Western North Atlantic . . ."[129] The cooler water was likely caused by the below-normal temperatures in Eastern Canada during those years, which were due to a cooler average atmospheric circulation.[130-132] In other words, cooler air blowing off the land over the adjacent ocean causes cooler sea-surface temperatures.[133] In addition, sea ice in the Davis Strait and the Labrador Sea is much more extensive when it is cooler than average.[134, 135] Sea ice will reinforce the cooling and drying because of its much higher albedo than water and its barrier to the escape of the ocean's heat and moisture. Barry and others conclude: "This evidence suggests that it may be difficult to sustain high sea-surface temperatures during the initial phase of a glacial period."[136] Consequently, if a snow cover could survive through a cooler summer, it is likely that the resulting atmospheric circulation change would cause drier conditions or, at best, would not cause a significant increase in snowfall. Thus, the snow cover over Labrador-Ungava would surely melt the next summer. Reviewing research on the cryosphere (snow and ice), including the work of Ruddiman and McIntyre, Washburn says:

> . . . the nature of the climatic changes responsible for the present ice sheets and for the growth and decay of the Pleistocene glaciers are still problematical. The moisture sources and the mechanisms permitting the growth of the Northern Hemisphere ice sheets also remain to be established.[137]

Consequently, a circulation change with less summer cooling than needed will not help glaciate Northeastern North America.

6) INCREASED SNOWFALL NOT HELPFUL

Even if snowfall could be greatly increased with summer cooling, recent research indicates it would not cause an ice age. In a modification of his experiments on a snow cover energy balance model, Williams substituted the maximum observed March 31 snow accumulation in Northeastern North America for the yearly average. Even with a summer cooling of 12 °C, the snow still melted over the summer during a strong Milankovitch radiation minimum. He even tried to elevate the land to account for possible isostatic adjustment to ice sheet unloading. He concludes: ". . . increased winter snow accumulation (the maximum observed at each station) does not greatly increase the area of perennial snow cover, nor does the possible effect of unrecovered glacioisostatic rebound . . ."[138] In other words, increased precipitation does not help initiate an ice sheet and certainly will not offset a lack of cooling, no matter what the circulation change that results from cooler summers. This result makes it practically impossible for a uniformitarian ice age to have occurred.

The reason for this somewhat surprising result is the efficiency of the melting process.[139] Snow melt equations in the past depended mainly on the temperature, and the direct effects of solar radiation were poorly parameterized. It is now known that "radiation is the dominant component of the surface energy balance over snow during the melting season."[140] Since the mid and high latitudes receive as much or more radiation than the tropics in the summer, solar radiation is a powerful influence in Northeastern North America during the melt season. This is even more efficient as the snow becomes dustier.[141] Increased cloudiness in summer would not appreciably change the results. Decreased solar radiation in this case would be offset to a large degree by increased infrared radiation from the clouds to the snow. The net heating or cooling effect of long term changes in cloudiness is not really known and currently is much debated.[142] Besides, summers are presently very cloudy in the region, particularly in Labrador-Ungava.[143]

III) SUMMARY

The three orbital variations in the astronomical theory of the ice ages were examined. It was shown that the changes in radiation are too small. Even though some modern climate simulations have indicated these small changes can cause ice ages, a closer look revealed that the results were forced by preconceived ideas and based on poor radiation-sensitive parameterizations. Other climate simulations have produced negative results. While the Milankovitch theory was being revived in the 1970's, research on the needed conditions for glaciation of Northeastern North America indicated much more climate change was required than previously thought. Even a 12 °C summer cooling is not enough, mainly because cooler air is drier and the resulting atmospheric circulation change would tend to either dry the air further or else cause little change. Even the unlikely possibility of much more snow does not appreciably change the conclusions because summer sunshine in mid and high latitudes is very efficient at melting snow. Consequently, it is very difficult, if not impossible, for a uniformitarian ice age to occur over Northeastern North America. The problem is compounded greatly when it is realized that as many as 30 ice sheets are believed to have developed and melted in regular succession during the Late Pliocene and Pleistocene.[144] Clearly, a non-uniformitarian mechanism is needed for an ice age.

The basis for the renewed interest in the astronomical theory of the ice ages, mainly statistical correlations with oxygen isotope fluctuations in deep-sea cores will be discussed in subsequent articles. Despite many assumptions, unknown variables and problems, the oxygen isotope results are made to fit the astronomical theory. How this is accomplished will be shown in detail.

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CRSQ	— Creation Research Society Quarterly
JAM	— Journal of Applied Meteorology
JAS	— Journal of Atmospheric Sciences
JGR	— Journal of Geophysical Research
MWR	— Monthly Weather Review
NAT	— Nature
QR	— Quaternary Research
SCI	— Science
TEL	— Tellus

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HUTTONIAN BIOLOGY AND GEOLOGIC UPHEAVAL

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Abstract

James Hutton's views of essentialist biology lead to the necessity of a singular epoch of rapid geologic activity.

Introduction

The central theme of James Hutton's *Theory of the Earth* is that the terrestrial surface is constantly being eroded into the sea from which solidified sediments are uplifted to form new land. This continual process of "reproduction" not only affects the mineral constituents of the world, but also produces soil suitable for land plants which provide nourishment for an extensive variety of animals. As Hutton noted:

> The formation of the present earth necessarily involves the destruction of continents in the ancient world . . . we clearly see the origin of that land, by the fertility of which, we, and all the animated bodies of the sea, are fed.[1]

Hutton views the global actions of dissolution and renovation as integral factors in the generation of fertile soil which enables our planet to "maintain and perpetuate" a system of flora and fauna.[2] According to Hutton, diverse biota have sustained a distinct existence with respect to the earth throughout geologic history. In like manner, he affirms the individuality of *terra* by rejecting Buffon's proposal concerning the solar origin of the earth.[3] Buffon suggested that an accidental collision of the sun with a comet was the mechanism which formed the planets.

Hutton's attitude of discontinuous essentialism considers the sun, the earth and numerous classes of life to be discrete entities of nature. Although he argued against the transformation of one basic organizational structure into another, his synthesis was not entirely static. In his unpublished *Principles of Agriculture,* Hutton describes the diversification of "varieties" within "species":

> . . . let us suppose only one form originally in a species; and that there had been established in the constitution of the animal, a general law or rule of seminal variation, by which the form of the animal should constantly be changing, more or less, by the influence of different circumstances or in different situations; and we should in this see a beautiful contrivance for preserving the perfection of the animal form, in the variety of the species.[4]

Strikingly unique individuals may arise within a "species" yet among these the essential adaptive features are *preserved.* This anti-evolutionary stance denies the premise that there are no natural constraints on heritable variation. Manier points out that it was impossible for Darwin to demonstrate that the postulate of unlimited variation "either followed from or was compatible with some well-established law of nature."[5] The basically minor modifications observed through artificial and natural selection suggest that distinct bio-

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