Earth Sciences 089G
Short Written Assignment: Our Perceptions of Geological Time

This assignment is designed to give you an appreciation of concepts of geological time within a historical context. Unlike the term paper, this report will not require "Introduction" or "Conclusions" sections. However, your report must contain the following components in the following order:

Title Page (include name, student number and course number in addition to title)
Part 1: Early Estimates for the Age of Earth (23 marks)
Part 2: Stratigraphic Principles and Concepts and the Discovery of Deep Time (51 marks)
Part 3: Revised Concepts of the Geological Record (14 marks)
Part 4: Constructing Time Scales (completed worksheet) (36 marks)
Part 5: Putting Geological Time into Perspective (completed worksheet) (10 marks)
References (6 marks)
General Presentation and adherence to instructions (10 marks)

Assignment Total: 150

Part 1: Early Estimates for the Age of Earth (*1½-3 double spaced pages*) (23 marks)

The age of the Earth has been debated since the beginning of human history and a wide variety of methods have been used to estimate its absolute age. Identify the calculated age and method of determination of the age of the Earth as put forward by the following individuals: James Ussher; Georges-Louis LeClerc De Buffon (also known as "Buffon"); William Thomson (Lord Kelvin); John Joly (as determined from the age of the oceans), and Bertram Boltwood. In your answer, be sure to also mention any obvious or noted problems with the assumptions, data and methods employed (scientific methods only!) to determine the Earth's age and how they might have affected the resultant age dates.
Note: *Information for each individual should be obtained from separate articles, and ideally, more than one article for each.*

James Ussher (1654)
Age (2 marks): Estimated Earth to have been formed October 23 4004 B.C (about 6000 years ago). Assign 2 marks for providing both the date (month and year) and absolute age, 1½ marks for providing the full date only; 1 mark for providing the year only; 1 mark for providing the absolute age (around 6000 years) only. Assign 1½ if they took pains to calculate the absolute age from present day (~6010 years), or at the time of Ussher's calculation (1654; 5658 years) without indicating the date.

Method (3 marks): Interpretation based on the number (1) and duration (1) of generations documented in the Bible plus events up to a known date in history (584 BC) (1).

Georges-Louis LeClerc De Buffon (Buffon) (1760)
Age (1 mark): Estimated Earth to be about 75,000 years old (students might say that original figure was 96,670 years, but was modified to the 75,000 year to take into account presence of materials other than iron). Assign ½ mark if they indicate 96,670 years alone.

Method (2 marks): Based on rate of cooling of iron balls (from incandescent state) (1) and extrapolation of this to a mass of iron the size of Earth (1).

William Thomson (Lord Kelvin) (1846)
Age (2 marks): Originally calculated that 98 million years had elapsed since solidification of Earth's crust from molten condition (1/2); estimated Earth to be between 20 and 400 million years old (any age within this range is acceptable) (1). Later narrowed the range to 24-30 million years (1/2).

Method (2 marks): Took into account the predicted heat loss of Earth via heat conduction and radiation from the time Earth was molten to its present state (1½). 20-400 million year age inferred on the basis of estimate of time when the Earth was molten to a depth of 50-100 miles (1/2).

John Joly (1899)
Age (1 mark): Estimated Earth to be 80-100 million years old.

Method (2 marks): Interpretation based on total amount (mass) of salt in oceans at that time (1) and the rate at which salt is transported to the oceans by rivers (1); calculated age of oceans in years as: total salt in oceans (in grams) divided by rate of salt added to oceans by rivers (grams/year)

Bertram Boltwood (2 marks) (1907)
Age (2 marks): Ten samples from three continents produced dates ranging from 410-2200 million years (using estimated half life of Uranium), or 250-1300 million (using known half-life of radium) (2-they need to get the range approximately correct). Assign one mark for single dates within this range, zero, for dates outside this range.

Method (2 marks): Radiometric dating techniques using the Uranium-Lead system (measurement of daughter and parent isotope concentrations) (1½); Boltwood also needed to calculate the half life of Uranium in this system (1/2) to determine the age of the samples (uranium-lead dating).

Assumptions (2 marks total—assign no more than one mark for each individual): Assign one mark each for the mention of any of the following: 1) The earth was a solid homogenous sphere which was originally entirely molten (Buffon or Kelvin), 2) The Earth lacked an renewable internal heat source/engine and therefore its cooling reflects the dissipation of finite remnant heat from the original molten mass (if the Earth had a renewable internal heat source, it would still be molten) (Buffon or Kelvin) 3) Most rocks melt at about 7000 deg. F at 1 atmosphere (Kelvin), 4) Calculations using (uncertain) uniform average geothermal gradients (Kelvin), and 5) homogenous uniform rock conductivities (Kelvin), 6) Oceans were originally fresh water (Joly), 7) No salt is lost from oceans, 8) Delivery rates of salt to the oceans remained constant (Joly), 9) All salt in the oceans comes from dissolved minerals in eroded rocks (Joly), 10) The age of the oceans was approximately equal to the age of the Earth (Joly), 11) Average global salinity used to determine total salt content (Joly), 11) All of the daughter isotope atoms formed from parent isotope atoms (no primary souces of lead) (Boltwood), 12) only one uranium-lead isotope system or decay series is present within uranium-bearing minerals (Boltwood), 13) the samples were unaltered (Boltwood), 14) thorium-lead ratios were of no, or minimal, significance (Boltwood). If there are others that look reasonable, please let me know.

Effect of assumptions on determined date (2 marks total—assign no more than one mark for each method). Assign a mark if they correctly explained the probable effect of assumptions employed in the dating method (often incorrectly) on the absolute dates obtained. The assumptions in some cases will have an obvious positive or negative effect on the magnitude of the dates obtained, while in others, the effect will be indeterminate. e.g. in #2 the date would be underestimated due to the fact that the Earth does have a renewable internal heat source, #7 (assumption of uniform rock conductivities) may cause overestimation or underestimation (indeterminate effect on date). Award half marks here as you see fit.

Part 2: Stratigraphic Principles and Concepts and the Discovery of Deep Time (*3-5 pages*) (51 marks)

Identify the prime contributions of the following individuals to the understanding of geological time as it relates to the stratigraphic/rock record: Georges Cuvier, James Hutton, Nicolas Steno, William Smith, Charles Lyell, Charles Darwin and Thomas Henry Huxley. In your answer, you should identify and define any relevant theories or principles associated with these individuals and the role of the individual in their conceptual development or acceptance within the contemporary scientific community. Note: some of these roles were more "scientific" in nature while others were more "cultural". Also be sure to outline how non-quantitative evidence identified by some (at least two) of these individuals suggested that the Earth was much older than suggested by the absolute age dates in existence at the time.

Georges Cuvier (5 marks total)
Georges Cuvier was the founder and prime advocate of the concept of (scientific) catastrophism (1).

Catastrophism was closely associated with religious (predominantly Christian) doctrines and biblical accounts such as the Great Flood (1), though Cuvier founded it on the basis of empirical (observed) evidence (1).

OR

Cuvier was a highly influential figure in eigthteenth century science (1).

Catastrophism is the notion that the geological structure and/or rock record of the Earth is solely a product of many short-lived, sudden, violent events (catastrophes) (2).

Recognized that species became extinct (1).

Plants and animals living in those parts of the world where such events occurred were often killed off according to Cuvier. Then new life forms moved in from other areas. As a result, the fossil record for a region shows abrupt changes in species (1-for either or both of these points).

James Hutton (5 marks total)

Formulated the concept of uniformitarianism (1)

Uniformitarianism is the assumption(1) that the natural processes operating in the past are the same as those that can be observed operating in the present (1): "The present is the key to the past."

Uniformitarianism's main idea was that gradual forces gave rise to all geological features that we see today (1). Synonymous with gradualism (1).

Involves the concept of a much older Earth (1) than that suggested (or required) by Catastrophism.

Rocks and landforms are the product of continuous cyclical development (1). "No vestige of a beginning, no prospect of an end".

Nicolas Steno (8 marks total)

Identified 3 of the laws or principles of stratigraphy which allow interpretation of the relative age of strata in the rock record (1)

1) *Law/principle of Original Horizontality* (1): (sedimentary) rock layers (strata) form in the horizontal orientation (1), and any deviations from this position are due to the rocks being disturbed later (1).

2) *Law/principle of Superposition* (1): layers of rock are arranged in a time sequence, with the oldest on the bottom and the youngest on the top (1), unless the strata have been overturned by later disturbances (1).

3) *Law/principle of lateral continuity* (1): Sedimentary layers are spread out laterally in all directions in a continuous distribution (1) (they are laterally continuous). Sedimentary layers of the same character at the same stratigraphic level which are now discontinuous may be assumed to have been originally continuous (1).

William Smith (6 marks total)

He was a self-educated surveyor and engineer (1) notably on surveying and digging of Somerset canal (1).

The job of surveying canal routes required detailed knowledge of the rocks through which the canal was to be dug. This led Smith to examine the local rocks very carefully.

While doing this, Smith observed that the fossils found in a section of sedimentary rock were always in a certain order from the bottom to the top of the section (1). This order of appearance could also be seen in other rock sections elsewhere (1), even those on the other side of England.

Also noted that each formation contained unique fossils or fossil assemblages (1).

Observations became the Law/Principle of faunal succession (2): Layers of sedimentary rock in any given location contain fossils in a definite sequence/order (2); the same sequence can be found in rocks elsewhere, and hence strata can be correlated (2) between locations.

Charles Lyell (6 marks total)

Lyell's first book "Principles of Geology" (1) (1830-1833) was highly influential in that it firmly entrenched Uniformitarinanism as the predominant concept of geological evoloution (2), through presentation of an overwhelming body of evidence in in favour of the uniformity of geological processes from the ancient past to the present day (2) and gradual (non-catastrophic) development of geological features(1). Violent (Catastrophic) events may occur but their occurrence is also uniform through geological time (e.g. there aren't more earthquakes in one span of geological time than there are in any other of the same length) (1).
Lyell interpreted (1) and publicized (1) uniformitarianism for the general public.

First volume strongly influenced Charles Darwin's (1) concept of gradual biological evolution (phyletic gradualism) (1), although Lyell did not allow for organic evolution.

Charles Darwin (8 marks total)

In addition to Lyell's "Principles of Geology", Darwin was also influenced by observations made during his voyage as naturalist on the HMS Beagle, particularly in terms of observations made on the Galapagos Islands (e.g. "Darwin's finches", Galapagos iguanas etc.) (1 mark for mention of any aspects of this).

In 1858, Darwin published "On the Origin of Species by Means of Natural Selection" (1) that gathered and synthesized extensive evidence for the concept of organic evolution (1).

Previously, the the predominant and accepted view as defined by Lyell's publications had been of a "fixed species concept" in which it was not possible for one species to evolve into another (1).

Contents of Darwin's book provoked considerable outrage among members of the religious community, as well as some scientifists (1).

Darwin's theory of evolution has four main parts:

1. Organisms have changed over time, and the ones living today are different from those that lived in the past (1) Furthermore, many organisms that once lived are now extinct (1). The world is not constant, but changing. The fossil record provided ample evidence for this view.

2. All organisms are derived from common ancestors by a process of branching. Over time, populations split into different species, which are related because they are descended from a common ancestor. Thus, if one goes far enough back in time, any pair of organisms has a common ancestor. This explained the similarities of organisms that were classified together -- they were similar because of shared traits inherited from their common ancestor. It also explained why similar species tended to occur in the same geographic region. (1 mark for any aspects of this)

3. Evolutionary change is gradual and slow, taking place over a long time (phyletic gradualism) (1). This was supported by the fossil record at that time as no naturalist had observed the sudden appearance of a new species in the fossil record (1).

4. The mechanism of evolutionary change was natural selection (1).

Implications for relative dating of strata: Since evolution is irreversible (1) and fossil species and assemblages represent finite and distinct intervals of geological time (1) due to speciation and extinction events, it is possible to use fossils for relative dating (1).

Thomas Henry Huxley (8 marks total)

Huxley is best known as "Darwin's Bulldog" (1) as a result of his early and strong support for Darwin's theory of organic evolution (1).

Darwin was a relatively shy and retiring individual (1), who tended to avoid conflict and controversy (1) and due to his personality and relatively poor health, was not up to the task of successfully defending his theory on his own (1). The strong reaction to his theory of organic evolution among clergymen and some scientific colleagues, necessitiated a backlash in an attempt to discredit Darwin and his theory (2).

Huxley is best known for his famous debate in June 1860, at the British Association meeting at Oxford against Archbishop Samuel Wilberforce (1).

Wilberforce was coached against Huxley by Richard Owen (1) his #1 adversary.

Despite Wilberforce's best attempts, all accounts of the debate agree that Huxley trounced Wilberforce, defending evolution as the best explanation yet advanced for species diversity (1).

Award 1 mark for recounting any details of the debate.

Huxley did not support Darwin's concept of evolution in toto (1). He suggested that evolving lineages may, in some cases, make rapid jumps or leaps (saltation) (1) which translates into the concept of rapid speciation(1)—akin to punctuated equilibrium.

Huxley's defense of Darwin's theory of organic evolution ensured that it remained in the forefront of biological and geological thought (1) and was not a overshadowed by creationist, catastrophist or "fixed species" interpretations of living organisms that did not necessarily require long periods of geological time (2).

Evidence of Deep time (non-quantitative evidence) (5 marks total)

Hutton's unconformity (1): Angular unconformity (2) at Siccar Point, Scotland.

Hutton's Interpretation: Unconformity represents a break in the rock record due to non-deposition and/or erosion (2).

The grey vertical beds below were originally flat-lying marine sediments (1) that over eons hardened and were turned on end (1). They were slowly planed away by erosion (1) and overlain by a horizontal layers of sand (1).

These events would have required an extremely long time in which to occur (1), assuming uniformitarianism (1) as Hutton would.

Certainly longer than the 75,000 years suggested by Buffon which was the "accepted" age of the Earth at the time (1).

Darwinian evolution (1): Darwinian (gradual) evolution (1) (speciation) requires vast time scales (1), and to account for all of the evidence known from the fossil record (1) even at that time, spans of geological time on the order of the 24-30 million years as suggested by Lord Kelvin (1) and even the 80-100 million years suggested by Joly (1), are too short to accommodate these changes (1).

Please let me know if there are other answers that look reasonable.

Part 3: Revised Concepts of the Geological Record (*1-2 pages*) (14 marks)

Explain why Catastrophism and Uniformitarianism (Gradualism) may not be completely mutually exclusive with reference to the modern concepts of "Neocatastrophism" and "Punctuated Equilibrium".
Note: *The concept of Punctuated Equilibrium may be conceived of in terms other that those of biological evolution.*

Following the discoveries and publications of Hutton, Lyell and Darwin, uniformitarianism (gradualism) became the predominant model for Earth and biological evolution (2—award these for part 2 or part 3 if this concept appears in either part—only once).

Neocatastrophism (6 marks)
Neocatastrophism involves the concept that rare (1), large magnitude (catastrophic) (1) events have episodically played an important role in the development of the Earth's structure and the geological record (1).

It is partially consistent with Catastrophism as it infers significant contributions of catastrophic events to the rock record (1)

It is consistent with uniformitarianism (gradualism) (1) as it assumes that catastrophic events are rare and that catastrophism does not constitute the primary mechanism of Earth evolution (1).

Similarly, it does not require or suggest a young Earth (1) as was the general case for Catastrophism

It is entirely based upon scientific observation and theory rather than religious ideology (1).

Neocatastrophism recognizes and accounts for the potential and obvious effects of relatively rare, high-magnitude events on the geological record such as major physical events (e.g. Earthquakes, Volcanic eruptions, bolide impacts etc.) (1) and bioevents (1) (e.g. mass extinctions).

Punctuated Equilibrium (8 marks)

Punctuated Equilibrium: The current alternative to the Darwinian concept of strict phyletic gradualism (1). Credit for concept goes primarily to Niles Eldredge and Stephen Jay Gould (1972 paper) (1)

Phyletic gradualism (according to Eldredge and Gould 1972) involves gradual (slow) transformation (1) of ancestor species into descendant species over much of the time between origination of the ancestor species and the descendant species (1), and over all or most of the ancestral species' geographic range (in most or all individuals of the species) (1)

Implications for the fossil record (if Phyletic gradualism is correct):

The fossil record should contain numerous examples of a long sequence of continuous, insensibly graded intermediate forms (1) linking ancestor and descendant.

Morphological breaks in a postulated phyletic sequence must be due to breaks in the stratigraphic record (1).

Punctuated Equilibrium by contrast suggests that most biological evolution (particularly speciation) occurs in an episodic fashion (1) over relatively short periods of geological time (1). Between these episodes of speciation, evolutionary change occurs either very slowly or not at all (2).

Implications for the fossil record (if Punctuated Equilibrium is correct):

No significant variation in species morphology or anatomy during its entire stratigrapic range (1).

If variation did occur, you would likely recognize two or more species in the same stratigraphic range (1).

Sudden appearance of new species in the fossil record (1) without evidence of transitional (ancestral-descendant) forms (1).

Support for Punctuated equilibrium is suggested by the fact that these characteristics are commonly observed in the fossil record (1).

Punctuated equilibrium obviously has catastrophist overtones (1) in terms of its indication that biological evolution occurs largely as a result of significant, short-lived events (1). These events, like those in Neocatastrophism are interpreted to be relatively rare (1). It is, therefore, not mutually exclusive with phyletic gradualism (as suggested by Gould and Eldredge) (1) and may be considered a form of gradualism (1)

General Presentation and adherence to instructions:

An additional 10 marks will be allotted for spelling, grammar, sentence structure (general presentation), and following instructions:
It is important for students to realize that spelling, grammar and sentence structure, are also important aspects of an assignment of this nature. Deduct up to 6 marks (two marks allotted for each category; ie. spelling: x/2, grammar: x/2, sentence structure: x/2) for significant errors/problems in these aspects within the first three sections (The amount you award or deduct for each category is left to your judgement).

The students were also expected to follow the instructions exactly. The general instructions for the written part of the assignment that are of relevance to this part of the evaluation have been highlighted above. Deduct up to 4 marks for not following these instructions adequately (i.e. assign a "following instructions" mark out of 4 for parts 1-3). The suggested deductions for not following each of the highlighted intstructions are indicated above. You may deduct half marks as you see fit.

Reference format:
An additional 6 marks will be for reference use (3 marks) and reference formatting (3 marks).
Deduct up to 3 marks for not citing sources adequately through use of in-text citations (nearly everything should be cited) or (if they have used them) footnotes. The remaining 3 marks are for proper in-text citation format (1), incusion of all necessary information in full citations (1) and correct ordering of references. You may deduct half marks within as you see fit.
If footnotes were used, assign a zero for the reference formatting portion even if they provided a reference list.

Part 4: Constructing Time Scales (*Completed Worksheet*) (36 marks)

You are provided with a chart labeled "Worksheet for Part 4: Constructing Time Scales" with two timelines (the geological time scale and a comparative timeline for the past 106 years of world history). This part of the assignment involves completion of the chart as instructed. References for information sources used in this part of the assignment are not required.

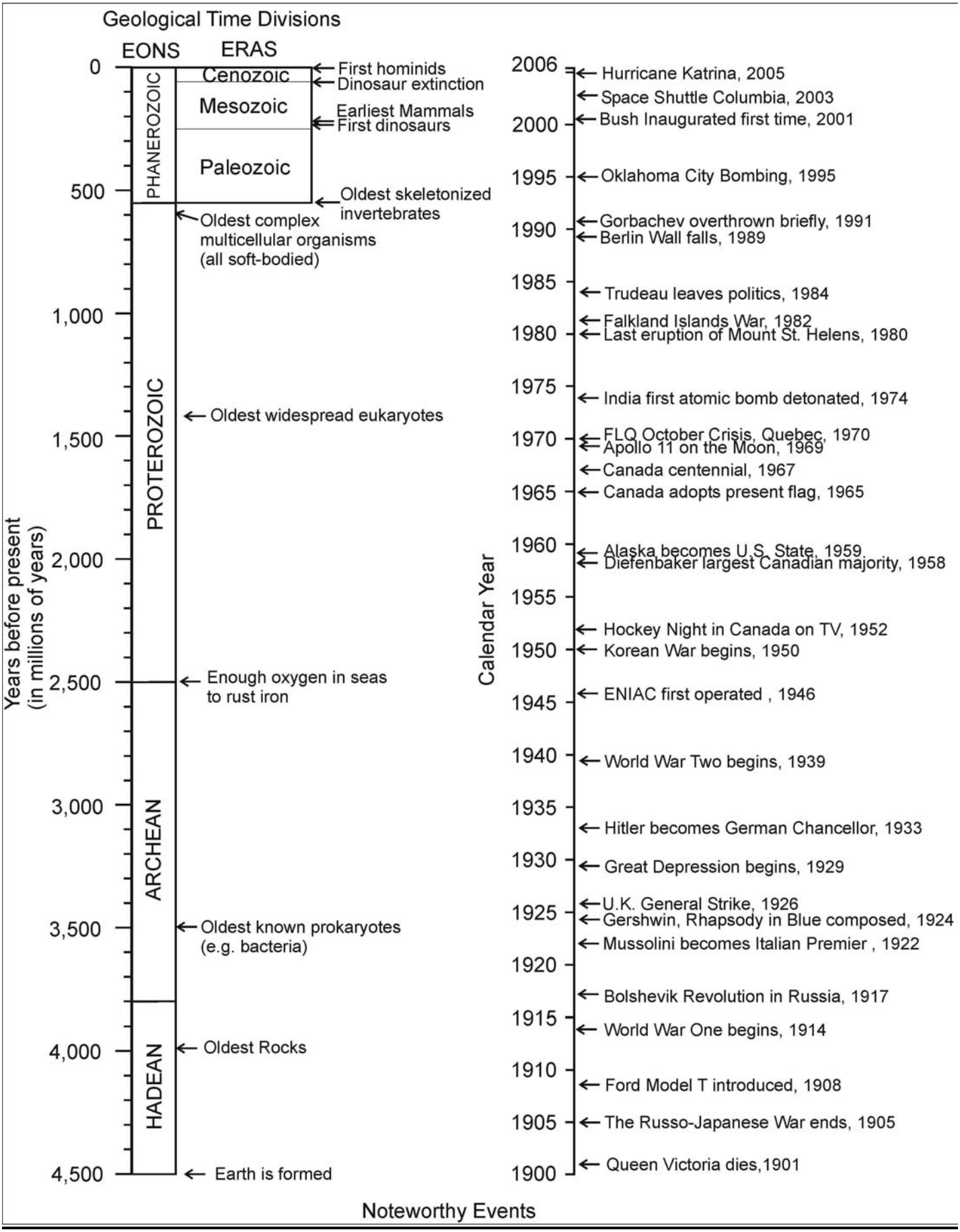
The following information is to be indicated on your chart:

a) In the long "EONS" column of "Geological Time Divisions," fill in the names of the four eons of Earth History and the boundaries separating them according to the time increments provided on the left timeline (6 marks: 4 for inserting correct names of eons in correct positions; 2 for inserting Hadean-Archean and Archean-Proterozoic boundaries at the correct absolute ages).

In the shorter "ERAS" column provided on the chart, draw in the boundaries the three eras of the youngest eon in the same manner. Then write the names of the eras in the appropriate spaces (5 marks: 3 for inserting correct names of Phanerozoic eras in correct positions; 2 for inserting Palaeozoic-Mesozoic and Mesozoic-Cenozoic boundaries at the correct absolute ages).

b) The timeline on the right side of the page represents the past 106 years of world history (1900-2006) in calendar years. The dates of several significant events have already been plotted on the timeline. Plot the remaining events listed in the chart below in the same manner. Once again, it is up to you to do some research to determine the years associated with these events. (Award ½ marks for the correct corresponding year in the table below and ½ marks for correct plotting of the events on the historical timeline—25 marks total).

Year	Event
1982	The Falkland Islands War breaks out between Great Britain and Argentina.
1908	The Ford Model T is introduced for public use.
1952	"Hockey Night in Canada" debuts on television.
1917	The Bolsheviks overthrow the Czar and the provisional government of Russia.
1974	India detonates its first atomic bomb.
1924	George Gershwin composes "Rhapsody in Blue".
1989	The Berlin Wall falls and German reunification begins.
1967	Canada celebrates its centennial.
1933	Adolf Hitler is appointed Chancellor of Germany.
1901	Queen Victoria dies.
1950	The Korean War begins.
1929	The Great Depression begins.
1958	John Diefenbaker wins the largest majority government in Canadian political history.
1991	Mikhail Gorbachev and his gov't are overthrown (briefly) by communist hard-liners.
1914	World War One begins.
2001	George W. Bush, 43rd U.S. President is inaugurated as president for the first time.
1959	Alaska becomes the 49th U.S. state
1946	ENIAC, the world's first large-scale electronic computer first operated.
1995	The Alfred P. Murrah Federal Building in Oklahoma City, Oklahoma is bombed.
1922	Benito Mussolini becomes Premier of Italy.
1969	Astronauts of Apollo 11 land on the Moon.
1965	Canada officially adopts its current flag.
1984	Pierre Trudeau resigns as Prime Minister of Canada, and from politics in general.
2005	Hurricane Katrina devastates northern coastal areas of the Gulf of Mexico.
2003	NASA space shuttle Columbia disintegrates upon re-entry to Earth's atmosphere.


Geological Time Divisions
EONS
ERAS
PHANEROZOIC
PROTEROZOIC
ARCHEAN
HADEAN
Cenozoic
Mesozoic
Paleozoic
0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
4,500
Years before present (in millions of years)
First hominids
Dinosaur extinction
Earliest Mammals
First dinosaurs
Oldest skeletonized invertebrates
Oldest complex multicellular organisms (all soft-bodied)
Oldest widespread eukaryotes
Enough oxygen in seas to rust iron
Oldest known prokaryotes (e.g. bacteria)
Oldest Rocks
Earth is formed
Calendar Year
2006
2000
1995
1990
1985
1980
1975
1970
1965
1960
1955
1950
1945
1940
1935
1930
1925
1900
Hurricane Katrina, 2005
Space Shuttle Columbia, 2003
Bush Inaugurated first time, 2001
Oklahoma City Bombing, 1995
Gorbachev overthrown briefly, 1991
Berlin Wall falls, 1989
Trudeau leaves politics, 1984
Falkland Islands War, 1982
Last eruption of Mount St. Helens, 1980
India first atomic bomb detonated, 1974
FLQ October Crisis, Quebec, 1970
Apollo 11 on the Moon, 1969
Canada centennial, 1967
Canada adopts present flag, 1965
Alaska becomes U.S. State, 1959
Diefenbaker largest Canadian majority, 1958
Hockey Night in Canada on TV, 1952
Korean War begins, 1950
ENIAC first operated , 1946
World War Two begins, 1939
Hitler becomes German Chancellor, 1933
Great Depression begins, 1929
U.K. General Strike, 1926
Gershwin, Rhapsody in Blue composed, 1924
Mussolini becomes Italian Premier , 1922
Bolshevik Revolution in Russia, 1917
World War One begins, 1914
Ford Model T introduced, 1908
The Russo-Japanese War ends, 1905
Queen Victoria dies,1901
Noteworthy Events

Part 5: Putting Geological Time into Perspective (*Completed Worksheet*) (10 marks)

Now suppose we compress the entire geological time scale to fit into the past 106 years of world history. By doing this, we can compare the relative timing of events in geological history to points of reference (significant events in twentieth and early twenty-first century history) on a much shorter time scale to which we can better relate. In the table provided (Worksheet For Part 5: Putting Geological Time Into Perspective"), you are given a list of "significant time markers" in Earth history. It is your task to name the event during the period 1900-2006, which most closely corresponds to that time marker in Earth history if 4.5 billion years were condensed to 106 years. To facilitate this, it is recommended that you plot the additional Earth History events on the chart for Part 4 (once you have determined the appropriate geological age of the events—the first two are already plotted) and then compare their position with events on the recent world history timescale.

Worksheet For Part 5: Putting Geological Time Into Perspective

Significant Event in Earth's history	**Corresponding Significant Event in Recent World History (1900-2006)**
Earth is formed	*Queen Victoria Dies (1901)*
Enough oxygen in the oceans to rust iron	*ENIAC first operated (1946)*
Earliest known multicellular animals	*Gorbachev overthrown (1991)*
First abundant animals with mineralized hard parts.	*Gorbachev overthrown (1991)*
Oldest known rocks	*World War One Begins (1914)* ***or*** *Bolshevik revolution (1917)*
Oldest known mammals	*George W. Bush inaugurated for first time (2001)*
Oldest known dinosaurs	*George W. Bush inaugurated for first time (2001)*
Extinction of dinosaurs	*Hurricane Katrina (2005)*
Earliest known prokaryotic organisms (bacteria)	*George Gershwin composes Rhapsody in Blue (1924)*
First australopithecines (early relatives of humans)	*Hurricane Katrina (2005)*

10 marks total—Award 1 mark for each correct response in the right column.