## The Great Story Timeline

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- I. **GREAT RADIANCE** 13.7 billion yrs ago
- II. GALACTIC phase begins 12 billion yrs ago
- III. **HADEAN** early Earth, pre-life begins 4.6 billion years ago (bya)
- IV. ARCHAEAN first bacteria begins 3.8 bya
- V. **PROTEROZOIC** amebas begins 2 bya
- VI. **PALEOZOIC** Era of complex life begins 540 million years ago (mya)

540-500 mya CAMBRIAN

500-440 mya **ORDOVICIAN** 

440-410 mya **SILURIAN** 

410-360 mya **<u>DEVONIAN</u>** 

360-290 mya **CARBONIFEROUS** 

290-245 mya **PERMIAN** 

VII. MESOZOIC Era (Age of Dinosaurs) 245 mya

245-210 mya TRIASSIC

210-45 mya JURASSIC

145-65 mya **CRETACEOUS** 

VIII **CENOZOIC** Era (Mammals & Birds) 65 mya

- IX **HOLOCENE** human-caused extinctions begins 13,000 years ago
- X **ECOZOIC** Era??? Vision for the future

#### I. Great Radiance phase

(Use small transparent beads for spacers.)

- **THE GREAT MYSTERY** wholly beyond human language and understanding. That **ULTIMATE REALITY** (God, Goddess, Great Spirit, Allah, the Tao, Ground of Being, Higher Power, Cosmic Creativity, etc.) which brings all things into existence, sustains all things, is revealed in all things, and draws all things unto Itself.
- 13.7 bya THE GREAT RADIANCE / BIG BANG / PRIMORDIAL FLARING FORTH.

#### II. Galactic phase

(Use small gold beads for spacers.)

- **12 bya GALAXIES** emerge, consisting only of the simplest elements: hydrogen, helium, and primordial energy. The contraction of GRAVITY balances the expansive forces of the Great Radiance.
- **11 bya** Gravity draws hydrogen into dense spheres of gas, sprinkled throughout each galaxy. At a threshold pressure, nuclear fusion begins: this is the birth of **STARS**. *Let there be Light!*
- 10 bya to present SUPERNOVAS and RED GIANT STARS forge COMPLEX ELEMENTS (atoms heavier than helium: carbon, nitrogen, oxygen, calcium, iron, gold, etc.) and then spread these atoms throughout the galaxies by exploding or pulsing out streams of atoms.
- **5 bya** A SHOCK WAVE from a nearby supernova explosion energizes the primordial cloud of hydrogen gas, now enriched with complex atoms, that will become our swirling solar system. Our **SUN IGNITES.**

#### III. Hadean Eon of early Earth

(Use small red beads for spacers.)

- **4.6 bya EARTH** and other planets in our solar system form by aggregating space debris in their orbital paths. Meteors and comets that crash into Earth *become* Earth.
- 4.5 bya The MOON is carved out of Earth by a huge meteor impact;

its orbit around Earth gradually becomes more distant through time.

• **4.1 bya** - The Great Bombardment of meteors ends; Earth begins to cool and water vapor in the atmosphere falls as **RAIN** for the first time. **OCEANS** form. *Let there be rain!* 

#### IV. Archaean Eon of early bacterial life

(Use small copper beads for spacers)

- **3.8 bya** The first **LIFE** forms (Archaea, a heat-loving form of bacteria) evolve in a very hot environment, possibly at great depth within Earth's crust or at hydrothermal fissures in the floor of oceans.
- **3.2 bya** Water-based **PHOTOSYNTHESIS** is invented by blue-green cyanobacteria to cope with a shortage of hydrogen atoms, previously scavenged from volcanic gases: pure hydrogen and hydrogen sulfide. The energy in sunlight is used to break apart water (H2O) molecules, thus opening up a virtually unlimited supply of hydrogen atoms. The amount of life on Earth (biomass) increases as a result.
- 2.8 bya CRISIS AND OPPORTUNITY: Iron atoms that had long been dissolved in the oceans combine with oxygen released by photosynthesis. Rust crystallizes out of solution and falls to the bottom, forming massive RED BEDS that will later be mined for iron by humans. When all the dissolved iron is gone, and geology can no longer soak up oxygen as rust, the "OXYGEN CRISIS" threatens microbial life, because free oxygen begins to accumulate in water and air, yet it is poisonous to early life (which evolved in an oxygen-free environment). This crisis is also an opportunity because:
  - (1) an ultraviolet-absorbing **OZONE SHIELD** composed of 3 atoms of oxygen in each molecule is formed in the upper atmosphere.
     This means bacterial life can now safely come out onto land.
  - (2) Bacterial precursors of mitochondria evolve a way to use gaseous oxygen (O2) for a high-energy-yielding form of **RESPIRATION**. This form of metabolism would later prove crucial for big brains (and consciousness) to evolve, because brains

require a continuous and abundant supply of oxygen.

- **NITROGEN FIXATION:** Life copes with a nitrogen shortage by learning how to break the triple bond of nitrogen (N2) molecules that make up the bulk of the atmosphere, and to affix nitrogen atoms onto hydrogen atoms for fertilizer; biomass increases again. And yet the only form of life ever to evolve to do this will be bacteria including bacteria who live symbiotically in the roots of alfalfa and other nitrogen-fixing plants. Every atom of nitrogen in our DNA and living cells was at one time or another brought into the life stream by nitrogen-fixing bacteria.
- Closed-cycle metabolisms of **GAIA** are now fully in place. Life mediates crucial links in the biogeochemical cycles of carbon, nitrogen, and oxygen, thereby maintaining an endless re-supply of Earth's finite reserves of elements vital for life. One form of life's waste is another's food. Several billion years later, humans will realize that they too must RECYCLE fully in order for their cultures to remain sustainable.

### V. Proterozoic Eon of Amebas and Microscopic Life

(Use small orange or yellow beads as spacers.)

- **2 bya EUKARYA** arise via symbiogenesis (in response to Oxygen Crisis and possibly a shortage of phosphorus?). Life becomes nested one center of creativity within another, as oxygen-using mitochondria and photosynthesizing plastids cooperate with the larger host cells. Single-cell "protozoa" (protists) emerge.
- **1.5 bya MEIOTIC SEX** emerges in eukarya, which is the first step in what will eventually evolve into a mode of reproduction that entails egg and sperm. Genetic exchange and reproduction are now linked into a single process.
- 1 bya Single-celled creatures invent **PREDATION** by developing flexible amoeba-like pseudopods that can surround a "prey" and secrete enzymes into that enclosed space (vacuole).
- **565-543 mya** The **GARDEN OF EDIACARA** is the time when the first multicellular life forms in the sea evolve distinctive body forms.

Multicellularity is an innovation in which the offspring of dividing cells stay in bonded association with one another, resulting in synergies of community. These synergies include (1) the ability of individual cells to specialize at different tasks, and (2) the presence of new pattern and structure at the group level that brings forth emergent properties (as in the possibilities of a fin or an eye). The first multicellular creatures are soft-bodied ediacarans, which may be neither animals nor algae but something unique. Thus the microcosm expands into a mesocosm, with fossils (some as long as 3 feet) that a human eye will later easily be able to see.

• **EXTINCTION.** All the ediacarans go extinct, possibly because of the evolution of hard parts by animal predators that ate the ediacarans. Predation intensifies and is now part of the mesocosm. The peaceable garden is ended.

#### VI. Paleozoic Era of complex life forms

(Use small blue beads as spacers, with different hues of blue for each of the six geological periods within the Paleozoic).

#### **540-500 mya CAMBRIAN** Explosion

- First true **ANIMALS**, including jellyfish, sponges, and worms, as well as creatures with hard parts for protection (clams, trilobites) and hard parts for eating (the rasping "teeth" of snails). All of these animals live in the oceans.
- **SIGHT** is invented, and is most sophisticated in the compound eyes of trilobite arthropods, the lenses of which are transparent crystals of calcite. *Earth begins to see!* Sight will be invented afresh well more than a dozen times by different lineages of life.

#### 500-440 mya *ORDOVICIAN*

• Earliest tabulate and rugose "corals" begin building **REEFS**, along with older reef-builders such as sponges and calcareous algae. Graptolites (hemichordates) are abundant. The first **SEA URCHINS** evolve.

• **440 mya END OF ORDOVICIAN EXTINCTION.** This is the first of six major mass extinctions that suddenly and globally appear in the fossil record (in this case, marine rocks). All forms of planktonic graptolites go extinct, never to re-evolve. Many families of trilobites and brachiopods (clamlike creatures distinct from mollusks) go extinct.

#### **440-410 mya** *SILURIAN*

- **JAWED FISHES** appear. Before then, there were only jawless fishes, such as lampreys. These fishes are joined by **GIANT SEA SCORPIONS** (Eurypterids) as top carnivores of the sea. These sea scorpions are the biggest arthropods (relatives of crabs and insects) of all time, some measuring 4 feet long.
- A freshwater green alga and aquatic fungus pool their talents (symbiosis), merging into the first LAND PLANTS. Life thus embarks on the adventure of weather and gravity. The continents grow green with low-lying ancestors of today's MOSSES and liverworts, which lack roots, and so must go dormant in dry conditions.

#### 410-360 mya *DEVONIAN*

- The first **LAND ANIMALS** evolve from ancestors leaving the sea. These are all arthropods: mites, springtails, and ancestral SPIDERS.
- The first **FRESHWATER MOLLUSKS** evolve from marine ancestors. Now lakes and rivers contain CLAMS and SNAILS.
- **ROOTED PLANTS** evolve: FERNS, HORSETAILS, CLUB MOSSES. The long vessels in vascular plants allow water to be moved upward from the soil against gravity, so plants can finally grow above the height of mosses and keep functioning even when it hasn't rained in awhile.
- The first **LAND VERTEBRATES** evolve. The ancestors of AMPHIBIANS AND REPTILES come out of the sea onto land
- Meanwhile, in the sea arise the distant ancestors of modern **SHARKS**.

From now on, sharks tend to be the top carnivores of the sea.

• 367 mya LATE DEVONIAN EXTINCTION. This is the second major mass extinction recorded in marine sedimentary rocks. Many brachiopod, cephalopod (nautiloid), gastropod (snails), trilobite, tabulate coral, and fish groups die out. Interestingly, there is a huge difference in survival between animals that use silica for stiffening their bodies and those that use calcium carbonate: the reef-building carbonate sponges (stromatoporoids) suffer huge losses in diversity, but the siliceous sponges are unharmed. Single-cell foraminifera that build "shells" of silica all survive the extinction, but half of the kinds that protect themselves with calcareous shells go extinct. Note: Only carbonate shells dissolve in acidic waters, so perhaps a meteor impact or volcano resulted in a lot of acid rain.

#### 360-290 mya CARBONIFEROUS

- The peak of the "sea lily forests" in oceans; these **CRINOIDS** are echinoderms like starfish on stems. This is also the heyday of the **BRACHIOPODS**, which look like clams but are not even mollusks. Both crinoids and brachiopods are filter feeders, filtering floating food out of flowing water.
- Land plants discovered in the Devonian that by retaining the cells of previous generations and reinforcing these with lignin **(WOOD)**, they can rise to new heights. But now **TREES** are abundant, having evolved independently in several different lineages (lycopods, horsetails, tree ferns), as plants compete for sunlight by overtopping their neighbors. Horsetails obtain their glory in the genus *Calamites*, which can grow to a height of 60 feet. Propagating clonally by rhizomes, clonal forests of *Calamites* may have been the biggest "individual" life form that ever evolved on Earth.
- The kind of fungi that can decompose wood have not yet evolved, so massive coal fields result. The **OXYGEN** level in the atmosphere is much higher than that of today (owing to undecomposed coal?). This allows terrestrial arthropods to grow to the biggest sizes of all time, as a distinct system of "tracheid" vessels for air circulation (separate from the blood system) prohibits large size in all arthropods forevermore. Carboniferous **DRAGONFLIES** have wingspans like that of modern-day

seagulls. Millipedes grow to perhaps six feet long. *Earth learns to fly*, as insects evolve **FLIGHT**.

Reptiles appear with the first land-worthy eggs that can survive out of water; this is the **AMNIOTIC EGG**, whose shell and membrane allow for gas exchange without water loss (chicken eggs will be later examples of this). Reptiles also invent the **PENIS** — but not yet a distinct vagina, as reptiles (and, later, birds) retain a cloaca that combines the three functions of reproduction, metabolic waste excretion, and fecal elimination. Reptiles are thus freed to copulate outside of water.

#### 290-245 mya *PERMIAN*

- **PANGAEA** forms, a single supercontinent. The vast landmass, with central sections far removed from marine moisture, produces deserts in the interior reaches, depositing **RED** (highly oxidized) sediments that contain fossils. Many FERNS gradually go extinct in the early Permian, as landscapes become more arid (ferns absolutely require a surface film of water for sexual reproduction.) HORSETAILS begin their decline becoming in modern times a single genus of "living fossil": Equisetum, with just fifteen species worldwide.
- 245 mya END OF PERMIAN EXTINCTION. This marks the end of the Paleozoic Era. This third major mass extinction is the most devastating extinction Earth will ever endure, affecting both marine and land life. More than 50% of animal families go extinct, meaning that 95% of species can be inferred to have gone extinct. Nearly 75% of all amphibian and reptile families go extinct on land. In the land plant realm, all of the tree forms of horsetails and club mosses vanish, never to re-evolve. In the sea, one half of all marine families (80% of all genera in the sea) die out. All blastoids (stalked echinoderms similar to crinoids), eurypterids, trilobites, stromatoporoids, and rugose and tabulate corals go entirely extinct, never to reappear. Dying out, as well, but not fully extinct are: 98% of all crinoid families, 78% of all articulate brachiopod families, 76% of bryozoan families, 71% of cephalopods (squid family), 50% of planktonic foraminfera. Recently discovered evidence indicates that the extinction was caused by an asteroid impact.

#### VII. Mesozoic Era (Age of Dinosaurs)

(Use small purple beads as spacers, with different hues of purple for each of the three geological periods.)

#### 245-210 mya TRIASSIC

- Pangaea is still a supercontinent and thus an arid continental interior continues to deposit sediments as "TRIASSIC RED BEDS."
- 225 mya is a MINI MASS EXTINCTION (not one of the 6 majors)
- At the end of Triassic, **PANGAEA BREAKUP** begins, opening up an archaic east-west waterway called the Tethys Sea. First to split off is *Laurasia* to the north, which consists of the bedrock foundations of what will one day become North America (the Laurentian Shield) and Eurasia. To the south, across the Tethys Sea, is the supercontinent of *Gondwanaland* (South America, Africa, Antarctica, Australia, India). Eventually, as the continents draw apart, Earth will bring forth six times more biodiversity than when all land was together as Pangaea.
- **210 mya END OF TRIASSIC EXTINCTION.** This is the fourth major mass extinction. Because it is the third time Earth has been hit hard by extinctions in just 35 million years, biodiversity is severely stressed.

#### 210-45 mya JURASSIC

- The **ATLANTIC OCEAN** is forming, as the northern vast continent of Laurasia now starts to break apart. Gondwanaland in the southern hemisphere is still intact and evolving plants very different from those in the north.
- Proliferation of wind-dispersed **POLLEN**: Except for the plants that evolved in the early Paleozoic (mosses, ferns, horsetails), land plants

now can have long-distance sex without depending on water to disperse sperm. Pollen grains that land on receptive female parts grow sophisticated "pollen tubes" to deliver swimming sperm to the ovule.

- **GYMNOSPERMS** cycads, GINKGOS, and ancient CONIFER TREES (such as redwoods, but not yet the pines) originate: all are seed plants that produce pollen. Great gymnosperm forests of the Mesozoic tower over the remnant lineages of lycopods and horsetails that lurk on the forest floor lineages which had once been the forests of the Paleozoic.
- **DINOSAURS**, which originated in the Triassic, become the largest land animals of all time, in the form of the great herbivorous sauropods (e.g. *Brachiosaurus*, *Diplodocus*), which reach their zenith in size and diversity during the Jurassic. **LARGE MARINE REPTILES** (the snakenecked PLESIOSAURS and dolphinlike ICHTHYOSAURS) arise, as do the flying **PTEROSAURS**.
- The first **BIRDS** (*Archaeopteryx*) with feathers and teeth, originate.
- The first **FROGS** evolve from salamander-like amphibian ancestors.

#### 145-65 mya CRETACEOUS

- Early **MAMMALS** diversify, but have little ecological presence and get no bigger than squirrel-size. Modern lineages of mammal replace the cloaca in females with three separate orifices, including a **VAGINA**.
- This is a time of glorious increase in the complexity of life on both land and at sea. Marine PREDATION AND PROTECTION escalates in an evolutionary arms race: the shells of mollusks grow thicker and some develop spininess, while clams live in deeper burrows. SCALLOPS invent a fast, clapping form of movement, like swimming castanets. And lizards similar to Komodo Dragons return to the sea as frightening MOSASAURS.
- Earth is in a **GREENHOUSE** climate, with no polar ice.
- MORE DINOSAURS: T. rex, Triceratops, duckbills, and raptors.

- The biggest flying life form of all time, the pterosaur **QUETZALCOATLUS**, spreads its wings over 45 feet (15 meters)!
- Earth bursts into SONG, with birds, insects, and crested dinosaurs making noises, largely as a means of sexual seduction.
- Flowering plants become important parts of the flora, but remain as low, herbaceous plants or vines, until the very late Cretaceous (70 mya) when the tree form evolves in several different lineages (magnolia family, sycamores). Earth adorns herself magnificently and invites the sky creatures into a mutualistic symbiosis with plants. FLOWERS AND INSECTS CO-EVOLVE in an attractive dance of pollination (flower nectar) and a protective dance of chemical warfare (invention of alkaloids and aromatic oils, as in basil) to repel insect herbivores.
- **AMMONITES** (cephalopods related to the chambered nautilus and squid) flourish, with their intricately joined segments of coiling shell, just before they go extinct.
- **65 mya END OF CRETACEOUS EXTINCTION** marks the K/T (Cretaceous/Tertiary) boundary. This is the end of the Mesozoic Era. This is the fifth major mass extinction, affecting both land and sea creatures. It brought an end to all dinosaurs, pterosaurs, marine reptiles (ichthyosaurs, plesiosaurs, mosasaurs), ammonites, and many lineages of foraminifera. (Plants, which could wait out the holocaust as seed or spore, generally did not suffer a mass extinction at this time.) In 1980, scientists found compelling evidence that the extinction was caused by one or more giant meteor impacts. Ten years later, a huge buried crater, dated to 65 million years ago, would be found off the Gulf coast of Mexico.

# VIII. Cenozoic Era (Age of Mammals and Birds) begins.

(Use small green beads as spacers, with different hues of green for the first 6 of 7 epochs of the Cenozoic. Use pink and white beads for the final, Holocene, epoch.) The Cenozoic has only two geological "periods" — the Tertiary and the Quaternary (or sometimes divided into the Paleogene and the Neogene) — but it is more helpful to speak of the geological "epochs" within these periods. The Tertiary entails the Paleocene, Eocene, Oligocene, Miocene, and Pliocene epochs. The Quaternary includes just the Pleistocene and the Holocene epochs. For our purposes, we treat the Paleocene through the Pleistocene as hues of green. Even though humans originated in the Pleistocene, we did not become a dominant force on Earth until the Holocene. We use various shades of pink and white beads for the Holocene, to mark significant periods within the human realm.

#### 65-57 mya PALEOCENE

- The "GOLDEN AGE OF TURTLES" in North America, as turtles that could hibernate in the mud may have been the only large vertebrates in North America that made it through the Mexico impact event. This is also the birth of TURTLE ISLAND a Native American name for North America. The inland sea that had, during the Mesozoic, flooded the middle of the continent from the Arctic to the Gulf of Mexico is now vanished, revealing a single continent. Note: Because North America is our home, we focus on North American events during the Cenozoic.
- 61 mya **MAMMALS** embark on a stunningly fast evolution. Within just four million years (65—61 mya) amazing new forms evolve to fill the empty ecological roles left by the dinosaurs. Hoofed mammals achieve glorious diversity, though they are still no larger than dog-size.

#### **57-34 mya** *EOCENE*

- HORSE, CAMEL, AND DOG families arise in North America.
- **ELEPHANT, RHINO, AND PRIMATE** families arise in the Old World. Ancestral rhinoceroses migrate into North America from Asia across the Bering Land Bridge and will be present here for 50 million years, going

extinct in North America just 5 million years before humans arrive.

- A global **GREENHOUSE** means that GINKGO forests thrive far north in the Arctic zones of the Northern Hemisphere.
- **DIATRYMA**, the "terror crane," evolves in North America. It is a gigantic, eight foot tall, flightless bird with a stout nine-inch beak, who stalks prey upright, as T. rex did. It then migrates across the Canadian Islands, Greenland, and Scandinavia (which are all connected by land still) and terrorizes Europe.
- **WHALE** ancestors return to the sea.

#### 34-23 mya OLIGOCENE

- Paleontologists refer to this time as "The Big Chill." The sea ridge that connected Australia to Antarctica at a shallow depth disappears, giving birth to the deep Antarctic Circumpolar Current. A globally cooler climate and intense **SEASONALITY** develops.
- **SQUIRRELS** originate in North America and co-evolve with **NUT TREES**.
- **RAVENS** fly into North America for the first time, having originated in Australia.
- **TOADS** and **TREE FROGS** enter North America for the first time, rafting across the sea from South America.

#### • 23—5 mya *MIOCENE*

• The entire Miocene is the **GOLDEN AGE OF MAMMALS**, with an astounding diversity of mammalian species on land. Camels, still confined to North America, diversify into forms that resemble African gazelles and giraffes. Many kinds of peccaries fulfill the "pig" niche in

North America. These are examples of "convergent evolution": Earth itself is calling forth the gazelle form, the giraffe form, the pig form, and will work on whatever lineage is available!

- At the water's edge, the bear family sends ancestors of **SEALS** back into the sea.
- The global climate warms, but it is still very dry, providing ideal conditions for modern **GRASSES** to flourish. Grasses cope well with drought and are superbly adapted to survive mammal grazing (because the growing cells of grasses are concealed at the base, not exposed at the tip). Some mammals co-evolve high-crowned teeth to withstand abrasion from silica granules embedded in grasses. Woody/grassy savannas spread throughout the world. (Grasses wheat, barley, rice, maize, oats— will later support the emergence of agriculture.)
- The first elephants **MASTODONS** arrive in North America from the Old World.
- The **PRONGHORN** family (Antilocapridae) originates in North America (only one species remains today: the American pronghorn). Meanwhile, **CHEETAHS** originate in North America, and chase speed into the pronghorn. This is the only cat genus to ever originate in the Western Hemisphere, although there were catlike forms of the nimravid lineage much earlier in the Cenozoic. (Meanwhile, isolated South America had marsupial "cats" that evolved the same body forms and teeth as our placental true cats and as the nimravids.) The cat form is thus another remarkable example of "convergent evolution" during the Cenozoic.

#### 5-2 mya PLIOCENE

- **MAMMOTHS** venture into North America from the Old World and proliferate.
- The **DEER** family immigrates into North America from Asia for the first time. Meanwhile, the **DOG** and **CAMEL** families, which arose long ago in North America, successfully send their first emissaries out to the rest of the globe via Asia.

- 5 mya hominids, chimpanzees, and **BONOBOS** (pygmy chimpanzees) diverge from a common ancestor in Africa. Recent studies have shown that 98.7% of human DNA is identical with the bonobos and chimpanzees revealing them to be our closest genetic cousins.
- The Colorado Plateau is rapidly uplifted, which produces the GRAND CANYON and the geological extravagances of Bryce and Zion parks.
- 3 mya the **ISTHMUS OF PANAMA** forms, joining the two continents for the first time since the Mesozoic. Formation of the isthmus also prompts "THE GREAT AMERICAN INTERCHANGE," an event that is a crisis for some lineages and an opportunity for others. Small ground sloths had swum across earlier, but now South America sends north its giant ground sloths, tanklike glyptodonts, porcupines, and armadillos (all of the taxonomic order Edentata, which originated in South America), plus marsupial opossums, and a ten-foot tall carnivorous bird: Titanis. In exchange, North America sends southward its foxes, deer, mice, skunks, rattlesnakes, rabbits, squirrels, tapirs, camels (llamas), cats, bears, weasels, snapping turtles, and small mastodons (gomphotheres) — none of which South America had ever before experienced. The influx of northern animals honed by ecological interactions in the vast northern hemisphere proves too much for many South American endemic species, which go extinct. "Native" South American animals alive today are thus mostly less than three million years native.
- 2.5 mya **HUMAN BEINGS** (*Homo habilis* "handy human") use stone tools.

#### 2 mya to 13,000 years ago — *PLEISTOCENE*

- **GLACIAL ICE** advances and retreats at least 17 times, with four major advances in North America.
- 1.4 mya humans (*Homo erectus*) domesticate **FIRE**.
- CARIBOU originate about a million years ago, probably in North

America. **POLAR BEAR**S evolve from the Asian grizzly bear in just 200,000 years.

- **BISON** emigrate from Asia into the New World for the first time about 400,000 years ago, eventually producing endemic species native to North America.
- 50,000—500,000 years ago SYMBOLIC LANGUAGE emerges, marking the birth of beliefs and metaphors for comprehending the nature of Reality and our relationship to it in all its manifestations. This marks a radical shift. For 80-95% of human history we experienced life — we remembered, made choices, learned, pair-bonded, raised children, and were guided by instinct, experience, and non-verbal tradition, or "culture" — without any internal conversation going on in our heads. In other words, we lived and communicated as other animals do intuitively and experientially, making full use of our senses — and were guided by the whole of Reality (within and outside us) just as all other creatures are. Mythically, while this can be considered HUMANITY'S FALL FROM THE GARDEN, it should also be recognized as AN ENORMOUS LEAP IN COMPLEXITY, and a hugely positive development at a number of levels. Symbolic language widens the range of possible feelings that can be experienced. It makes abstract thought achievable - hence, science and religion. It also allows us to communicate something of the past — storytelling — and to work with others in planning future actions. In all of these ways, symbolic language makes it possible for the Universe to come to know and experience itself in a new way, in and through the human.
- 50,000 years ago, humans enter **AUSTRALIA** via a land bridge from Southeast Asia, uncovered by a decline in sea level resulting from glacial ice piling up on land. They, and the dingo they bring with them, cause an "extinction of the massive" among Australia's biggest marsupials, reptiles, and flightless birds. Australia loses all but one of its sixteen genera of terrestrial vertebrates weighing 100 pounds or more. **THE SIXTH MAJOR MASS EXTINCTION** thus begins with this **AUSTRALIAN EXTINCTION**.
- 13,000 years ago, humans enter the Americas. In just 300 years, the CLOVIS culture causes EXTINCTION OF THE MASSIVE IN NORTH AMERICA, owing to overkill. Mastodons, mammoths, ground sloths,

glyptodonts, horses, camels, long-horned bison, giant tortoises, and those who preyed or scavenged upon them (sabertooth cats, short-faced bear, American lion, dire wolf, giant hyena, teratorn birds) all go extinct. North America loses 32 of its 47 genera of "megafauna" — those animals with adult weights of 100 pounds or more. Meanwhile, South America loses 47 of its 59 genera of megafauna. Mammals that had learned to cope with humans in Asia now successfully migrate into North America for the first time: elk, moose, plains bison, grizzly bear.

#### 12,000 years ago to the present: HOLOCENE

(The entire remaining segments of beads can be highly individualized to highlight one's particular interests in the human story, including religious orientation and artistic, scientific, intellectual, political, and other cultural interests, as well as ecological impacts of humans, including extinctions that accompany human entry into frontier landscapes. It is important to include your own birthday and significant events in your life and human heritage.)

- 11,000-9,000 years ago the practice of **AGRICULTURE** (farming) emerges independently three times in the New World and twice in the Old World and dogs are tamed in both hemispheres. Humans begin domesticating plants and animals the world over. Within five thousand years we domesticate in the Eastern Hemisphere goats, sheep, wheat, barley, rice, pigs, chickens, cattle, millet, horses, camels, donkeys, elephants. Meanwhile in the Western Hemisphere we domesticate corn, squash, peppers, beans, amaranth, quinoa, peanuts.
- 7,000 years ago, humans arrive in Cuba and cause **CUBAN EXTINCTION** of the massive (including the loss of all six species of tree and ground sloth).
- 5,500 years ago the **WHEEL AND CUNEIFORM WRITING** are invented by the Sumerian civilization in Mesopotamia. Writing allows for, even encourages, a level of abstraction of thought not possible in oral cultures.

- 3,500-4,000 years ago megalithic structures are built in Europe. The earliest **ALPHABET** arises in the region of Palestine. Aryan-Vedic peoples with Sanskrit language enter India.
- 3,200-2,400 years ago is the **AXIAL AGE**; philosophy and **CLASSICAL RELIGIONS** emerge. This is the time of Homer, Zoroaster, Moses, Buddha, Confucius, Lao Tzu, Plato, Socrates, Aristotle, Pythagoras, etc. Reality that same reality that humans and all other animals had been experiencing seemingly forever was understood using a variety of analogies, images, metaphors, and symbols some religious, some philosophical, some mathematical.
- **JUDAISM** brings a developmental sense that in the events of history there is an irreversible and non-repeatable revelation of meaning. Reality is understood monotheistically using metaphors of Lord and King, and redeemer of the Jewish people. Also known as the Hebrews, the oral sacred stories of the Jewish people were written down and edited, and experienced as scripture, some 2,200-3,200 years ago.
- 2,000 years ago is the time of **JESUS**. **CHRISTIANITY** begins. The gospels are written. Reality is understood and experienced as a Forgiving Father (*Abba*, Dad), redeemer of humanity, and Jesus knows himself (and is recognized by others) to be one with, and a unique revelation of, the Source and wholeness of Reality (the Son of the Father).
- 400 C.E., Polynesian seafarers arrive on Hawaii. Overkill of large flightless birds, along with destruction caused by domestic pigs that go feral and the rats that had stowed away on the boats begin the EXTINCTION OF HAWAIIAN native birds and plants, exacerbated much later when European and Asian colonists arrive.
- 622-700+ C.E., MOHAMMAD / ISLAM / KORAN / MUSLIM EMPIRE
- 800 C.E., humans arrive on the island of Madagascar and cause the MADAGASCAR EXTINCTION of the massive, killing off gorilla-size lemurs, half-ton "elephant birds" that stand 10 feet tall, tortoises with shells 4 feet across, and mongooses the size of bobcats.
- 900-1250, **ISLAMIC SCIENCE**; Toltec, Incan, and Mongolian empires;

the Crusades.

- 1400, humans arrive in New Zealand and cause the **NEW ZEALAND EXTINCTION** of all dozen species of flightless moa birds.
- 1347-1620, the **BLACK DEATH** ravages China, Africa, and Europe, bringing about major social, political, and religious reforms including the **SPLIT BETWEEN SCIENCE AND RELIGION** in western consciousness: religion focusing largely on redemption out of this world, science attempting to understand and improve conditions for the humans in this world.
- 1450, Gutenberg invents a PRINTING PRESS of movable type.
- 1500, Europeans bring diseases to the Americas that **DECIMATE AMERICAN INDIANS**, even before genocidal colonial and U.S. practices.
- 1543, The **COPERNICAN REVOLUTION** and the beginning of the mechanistic paradigm that is, using human-made machines (clocks) as a primary metaphor for understanding the nature of Reality. Earth is no longer at the center of the Universe in western consciousness.
- 1609, GALILEO gazes at the moon through a telescope and observes imperfections there too: mountains on the moon. The telescope also allows Galileo to determine that Jupiter has moons revolving around it, too.
- 1637, Rene **DESCARTES** furthers the segregation of science and religion by declaring matter as distinct from mind. He also invents analytical geometry, once again demonstrating the usefulness of mathematics for scientific inquiry.
- 1687, Isaac **NEWTON** firmly establishes the modern, **MECHANISTIC** view of the Universe. From this perspective, creativity resides outside the universe, in a God who is removed from his creation. The stage is set for deism (in which God creates a clockwork Universe and then lets it run by itself) and atheism (in which a Supreme Being external to the universe is denied).

- 1720-1750, VOLTAIRE writes a new way of viewing history (a new story based on the mechanistic model of the universe) that discredits the older, mythic worldview, by placing the achievements of Copernicus and Newton as the foundation.
- 1750-1762, **LINNAEUS** invents the modern system of taxonomic classification of life, concluding that some species of plants came into existence after others (i.e., not at the beginning of time).
- 1755-1781, Immanuel **KANT** proposes the first systematic theory to explain the formation and evolution of the heavens and the solar system. His *Critique of Pure Reason* sets the groundwork for a turning away from the mechanistic view of the universe toward what we might call today an organic, wholistic, or "creatheist" worldview (where divine creativity is recognized as happening over time at multiple levels i.e., Reality is understood less like a clock and more like nested creativity).
- 1795, James **HUTTON** offers a developmental thesis for landforms, thus giving birth to the science of geology.
- 1796-1827, Georges CUVIER establishes that **EXTINCTION IS A FACT**, and advances the use of detailed anatomical observation for classifying animals by resemblance of form.
- 1815, Percy Bysshe SHELLEY, who was expelled from Oxford in 1811 for publishing *Necessity of Atheism*, writes in his poem, *Hymn to Apollo*, "I am the eye with which the Universe beholds itself and knows itself divine."
- 1858, Charles Darwin and Alfred Russel Wallace both independently propose EVOLUTION BY NATURAL SELECTION. The following year, Darwin publishes his *On The Origin of Species*, providing convincing evidence that evolution has, in fact, occurred.
- Mid 1800s, Louis AGASSIZ establishes glacial ages as a fact.
- 1898, Marie and Pierre Curie discover RADIUM, which leads to a new tool (measuring radioactive decay) for absolute dating of certain rocks.
- 1905-1917, Albert **EINSTEIN** profoundly alters our understanding of

space, time, motion, matter, and energy.

- 1907, Henri **BERGSON** sets forth the idea of "creative evolution," and counters the idea of "survival of the fittest" by describing how the life force, or élan vital, produced greater and ever-more conscious levels of life and culture over time.
- 1909, William **JAMES** popularizes the philosophy of pragmatism, in his book, *Pluralistic Universe*. If truth cannot be fully known, then one should adopt an outlook that is helpful, fruitful, empowering. His previous book, *Varieties of Religious Experience*, is still widely read.
- 1914, the last **PASSENGER PIGEON DIES** in captivity, showing us the sobering fact that humans can unwittingly cause the extinction of even the most populous animals.
- 1929, Edwin **HUBBLE** observes a "redshift" (shift toward the red lightwaves) in the spectral features of light coming from distant galaxies, thus concluding that the UNIVERSE IS EXPANDING. Humanity now realizes that the Milky Way Galaxy is not the entire universe.
- 1930s, Julian HUXLEY, an evolutionary biologist, writes, "through the human, EVOLUTION BECOMES CONSCIOUS of itself," an idea that Teilhard de Chardin and Thomas Berry will develop further in the decades to come.
- 1948, George GAMOW gives a mathematical description of the beginning of the Universe, which would come to be known as the Big Bang.
- 1953, the double helix structure of **DNA** is discovered, furthering our understanding of the processes that underlie genetic heritage.
- 1957, **STELLAR NUCLEOSYNTHESIS** is proposed as the way that the chemical elements in the Periodic Table of Elements are sequentially created in the fiery depths of massive stars. *Earth learns that it and all its creatures are made of stardust!*
- 1959, TEILHARD DE CHARDIN is published, posthumously, thus
  presenting to the world a view of evolution that is spiritual, uplifting,

and congruent with his Christian faith. (Thomas Berry refers to Teilhard as, "the most significant theologian since St. Paul.")

- 1962, Karl **POPPER** publishes *Conjectures and Refutations*, highlighting the role that disproving theories plays in the evolution of science, and Thomas **KUHN** publishes *Structure of Scientific Revolutions*, stressing the role of unconscious paradigms and anomalies in the development of scientific understanding.
- 1962, Rachel **CARSON** exposes the effects of pesticides in her *Silent Spring*. This marks the beginning of the environmental movement.
- 1965, Robert Wilson and Arno Penzias detect the BACKGROUND RADIATION generated during the Big Bang, thus confirming the cosmological view of a developmental universe.
- 1960s, **PLATE TECTONICS**, and thus movement of continents through time, is established as a fact by the detection of rock features and paleomagnetic banding on the seafloor.
- 1969, through the eyes of astronauts and captured on their cameras, **EARTH SEES ITSELF WHOLE.**
- Throughout the 1970s and 80s Lynn **MARGULIS** develops her theory of the symbiotic origins of the eukaryotic cell. The theory is widely confirmed in the 1990s.
- 1977, Ilya **PRIGOGINE** awarded the Nobel Prize. A pioneer of Chaos Theory and Complexity Theory Prigogine shows mathematically how matter, life, evolution, and human culture self-organizes.
- 1979, James LOVELOCK proposes that Earth, "Gaia," is a self-organizing system far more like a living organism than like a machine or a rock with life on it.
- Late 1970s, a growing recognition that humans are inadvertently causing the SIXTH MAJOR MASS EXTINCTION.
- 1980, a team of scientists led by Luis and Walter ALVAREZ provide convincing evidence that a meteor impact killed off the dinosaurs. The

notion that change is gradual and that the universe is past its dangerous stages is called into question. Conversely, we begin to suspect that Earth (Gaia) may not have caused its own mass extinctions.

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- 1988, Thomas **BERRY** publishes *The Dream of the Earth*, in which he proposes that humans take on the cosmological role of "Celebrants of the Universe Story" and that we envision a new geological era, "The Ecozoic Era," as a time when humans live in ecological harmony with the full community of life. In 1992 Thomas Berry joins with Brian **SWIMME** to publish *The Universe Story: From the Primordial Flaring Forth to the Ecozoic Era A Celebration of the Unfolding of the Cosmos* In this landmark book, Swimme and Berry show how human story and the cosmic story are inseparable. One cannot be understood without understanding the other. Knowledge of the universe is self-knowledge.
- 1992, World Wide Web (the **INTERNET**) is created.
- 1995, The **HUBBLE DEEP FIELD PHOTO** stuns us with its beauty and the vast number of galaxies calculated to exist.
- The future: The ECOZOIC ERA emerges!