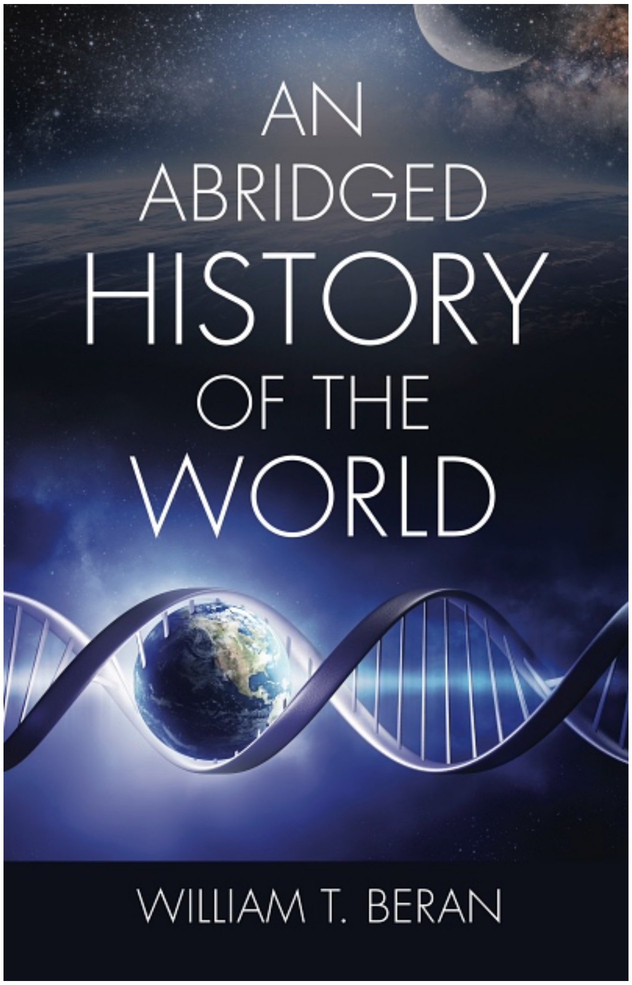
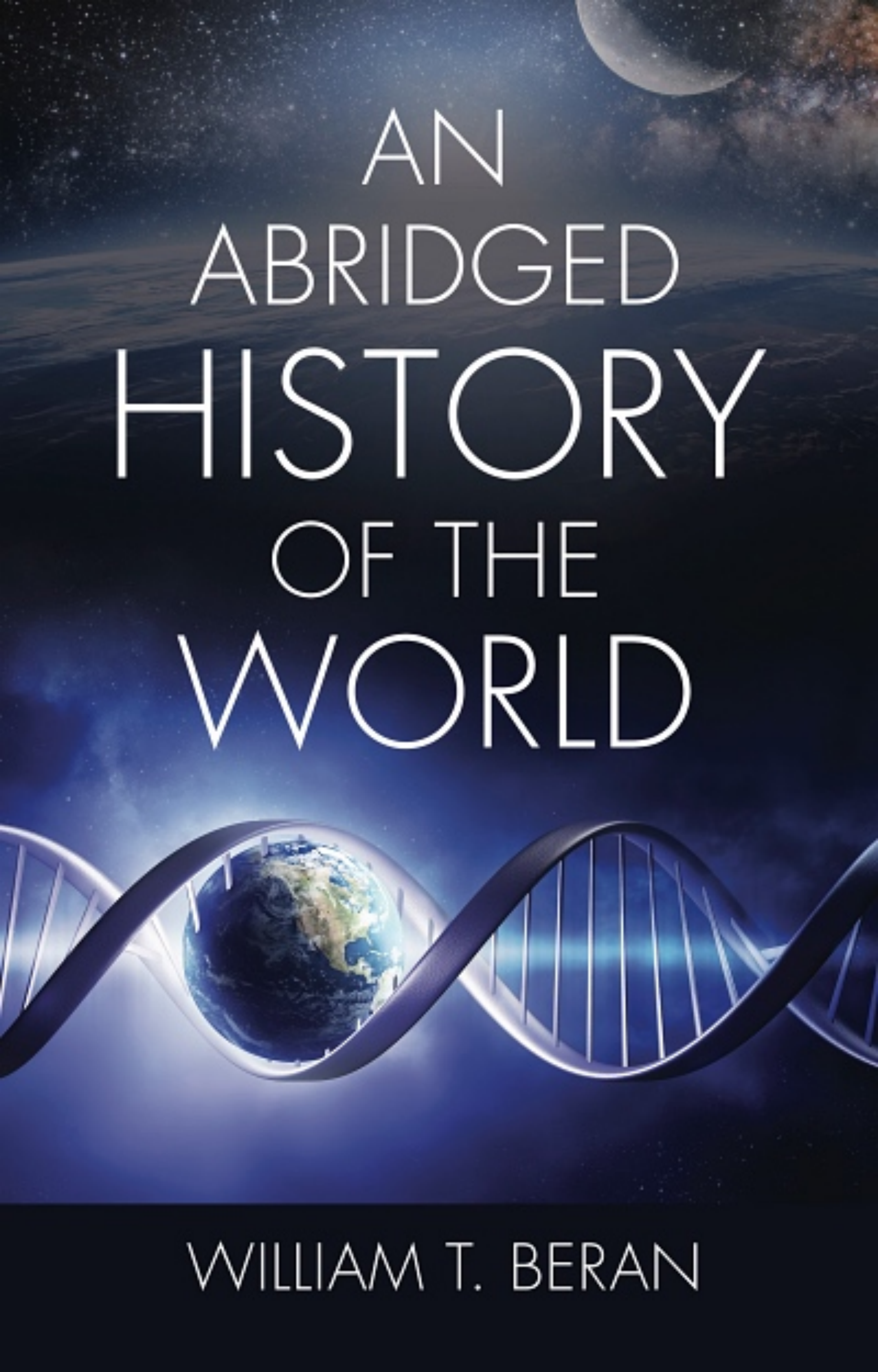


This treatise addresses the evolution of our planet from a red-hot ball of space debris to our human-dominated modern world. It's a concise account of the changes over time to earth's geology, geography, atmosphere, and living creatures.

An Abridged History of the World

By William T. Beran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Chapter 1:
A Matter of Time

One of the hardest things to grasp with regard to earth's history is the time span involved. The many millions, even billions, of years associated with geological periods defy comprehension because they so vastly exceed the time-frame we personally experience. It's also not easy to remember the names and chronology of geological Eras, Periods, and Epochs unless one is an expert in the field.

In an attempt to improve our perception of geologic time and associated events, this chapter separates them into five Exhibits. Starting with the big picture in Exhibit 1, each succeeding Exhibit expands on the more modern and seemingly least significant geologic period at the very top of the previous Exhibit.

These exhibits have brief notes (on the right) that point out salient events or conditions at the corresponding geological time (on the left). Geologic times are indicated both by name and by number of years past. All such numbers represent time in *millions of years* ago (unless otherwise indicated).

By comparison, the times often used in history books employ the BC or AD notations, because time zero is based on the birth of Christ; a roughly two-thousand-year difference. Except for Exhibit 5, this distinction is actually inconsequential when looking back millions of years.

The timelines selected for "Salient Features of the Time" are based on numerous technical sources, primarily extracted from on-line technical papers and blogs related to the various subjects, as well as from Encyclopedia Britannica and Wikipedia. Not all of these sources agree with each other, hence some judgement was required as to which times to select. Typically, preference was given to the more recent findings or those deemed more technically confirmed.

Nor was there universal agreement on the start and end times of the geological periods, and even the names of these periods sometimes differ. For example, the same Ice Age is referenced by a different name depending on whether the source is European or American. New geologic periods are also sometimes proposed…there is a current movement afoot to rename the latest part of the Holocene the "Anthropocene" Period, which is intended to mark the beginning of significant human influence on ecosystems, climate, and geology.

Scientists deduce the nature and time of prehistoric events and geological conditions from: a) direct evidence, e.g., fossils, buried structures, artifacts, and rock, soil, or ice conditions; and b) indirect or proxy evidence, e.g., tree rings, chemical isotope ratios, coral makeup, and pollen constituents. Solid theories have developed based on such evidence, but conflicting new information, or new interpretation of old information, often shakeup established concepts.

Of course, many events have gone unnoticed simply because no evidence is available. Sometimes, it becomes necessary to theorize such events must have happened based on an obvious missing connection between one event and another. In other words, something is hypothesized to have happened in order to get from an earlier condition to a later condition, even though there is absolutely no direct or proxy evidence of the intervening event.

With the preceding notes in mind, let’s now delve into the history as we know it by browsing through the following five Exhibits. These are best read from the bottom up in order to follow the chronological sequence from one Exhibit to the next. The listed events are necessarily concise so that the remarkable transition of our world from a ball of molten rock to modern times can be encompassed in one sitting. You’ll read many interesting facts, some of which will simply refresh your memory while others will be completely new.

Exhibit 1 - Earth's Entire History

Era			Salient Features of the Time
Cenozoic			Age of Mammals, Human Evolution
Mesozoic			First Birds, First Flowering Plants Dinosaurs Dominate
Paleozoic			First Reptiles First Amphibians, First Insects First Fish, First Land Plants
Ends 540 Million years ago			Supercontinent *Gondwana* forms
			Supercontinent *Pannotia* forms & breaks up
			"Snowball Earth" Glaciation events (two in quick succession)
			Rodinia breaks up
1,000			By now, 18-hr days, but our moon continually slows earth rotation
			Supercontinent *Rodinia* forms
			First mult-celled organisms
			Nuna breaks up
			Earth's magnetic field takes a leap in strength to modern levels
			Supercontinent *Nuna* forms
			Sudbury meteorite impact (3rd largest meteor crater)
			Vredefort meteorite impact (largest earth meteor crater)
2,000			
			Ozone (O_3) layer begins forming & shielding earth from Sun's UV rays
Precambrian			
			Great Oxygenation Event (finally adds O_2 to the atmosphere)
			Oxygen producing bacteria (photosynthesis)
			Superior Craton formed (oldest & largest land mass still identifiable)
3,000			Start of Viruses & their ongoing evolution to present time
			First one-celled organisms (anaerobic prokaryotes)
			First plate tectonic movement
			"Shield" rock formed (earliest continental nuclei)
			All early O_2 used up to oxidize iron & othe minerals on land & in sea
			Earliest O_2 (produced by solar UV dissociating water vapor)
			Oceans form (rich in iron)
			Torrential rains for 100 million years
4,000			Small island land masses float on molten rock
			Earth's iron core develops, evidence of a weak startup magnetic field
			Moon formed following a collision with mars-sized "Theia"
Starts 4.5 Billion years ago			Origin of Earth - coalescing of gas, dust, rocks, and water vapor

Exhibit 2 - Bursts of Life and Mass Extinctions

Era	Period		Saliant Features of the Time
	Quaternary 2.6		Ice Ages & the ascent of mankind
Cenozoic 66	**Tertiary** 66		Emergence of primates, incl. human ancestors Climate similar to modern world, incl. polar ice caps Proliferation of deepsea life, corals, plankton, mollusks, & others Accelerating development of insects, birds, Burgeoning growth of flowering plant species Big evolutionary expansion of mammals
	Cretaceous 140		Major mass extinction including dinosaurs & flying reptiles Continents begin to vaguely look like modern counterparts Very warm climate, no polar icecaps; flowering plants appear At times, oceans were 500 to 900 ft higher than present day Long-necked marine reptiles, sharks, rays, & other predators Big dinosaurs & flying reptiles still dominant on land Unusually high rate of seafloor spreading/continent forming
Mesozoic	**Jurassic** 200		Rock strata laid down is the source of our gold, coal, & petroleum Early palm trees and conifers made up large forests Abundant large fish & marine reptiles; molluscs, snails, starfish Big dinosaurs & flying reptiles dominate; small mammals & birds Dragonflies, beetles,bees, flies, and other insects abound New seas and continents form/vigorous plate tectonic activity
250	**Triassic** 250		Mass extinction (volcanism, breakup of Pangea) First mammals emerge (shrew-like, derived from reptiles) New land vertebrates evolve, incl. precursors of dinosaurs First fossil evidence of live birth in marine reptiles One giant supercontinent Pangea, comprising 1/4 earth's surface
	Permian 300		Largest mass extinction ever (90%) Significant volcanism; very hot and dry climate; 80°F ocean Nearly equal land masses in Northern & Southern Hemispheres Evolving land and marine reptiles abound Initially, glaciation persisted; then global warming
	Carboniferous 350		Winged insects, cockroaches, scorpions Amphibians and reptiles develop Land masses spreading to the Northern Hemisphere Finned fish, bony fish, lung fish Ferns proliferate, trees to 100 ft tall, conifer precursors
Paleozoic	**Devonian** 420		Series of extinctions, mainly the marine community Preponderance of trees/forests Insects and 4-legged land animals appear Year was 400 days; lunar cycle was 1 day longer than now Land masses still lay mainly in Southern Hemisphere Warm and equitable climate Armored jawed fish; freshwater fish appear
	Silurian 440		Gondwana + six other continents mostly in Southern Hemisphere Fish with simple jaws, advent of vascular land plants
	Ordovician 490		Series of mass extinctions - major glaciation and low sea levels Shark ancestors begin a very successful lineage Wide range of marine invertebrates, incl. corals and mollusks Highest sea levels in history; renewed expansion of marine life Mass marine extinction
540	**Cambrian** 540		Accelerating lifeforms - "Cambium explosion" Development of legs and spinal cords Trilobites & other shelled species Sponges, worms & other borrowing animals Gondwana breaks into Laurentia, Baltica, & other land masses

Exhibit 3 - The Age of Mammals

Era	Period	Epoch	Salient Features of the Time
Cenozoic	Quaternary 2	Pleistocene	Multiple Ice Ages & the ascent of mankind
	Tertiary	Pliocene 5	Climate cooling/glacier expansions on roughly 41,000-yr cycles Greenland Ice Cap develops First "true" humans (*Australopithecines*), bi-pedal & stone tools
		Miocene 23	Human and Chimp ancestors follow their own evoluntionary paths Continental collisions cause Mediterranean Sea to dry up Andes Mountains arise & stretch S. America towards Antarctica Killer whales & large sharks evolve Mid-Miocene Climate Transition - cooling creates Antarctic Ice Cap Oceans develop Kelp forests which support a vibrant ecosystem Himalayan Mountain uplift in Asia cause Monsoon cycles to develop Rising Rocky Mountains lead to extensive Midwest grasslands Globally warm climate, high humidity
		Oligocene 34	Modern carnivores & herbivores proliferate throughout this time Earliest ape-like mammal (*Parapithicus*) Largest land mammal ever, *Indricotherium* (a 30-ton plant-eater) Early pigs, horses, & beavers Warm & humid, grasslands expanded, replacing some forests
		Eocene 56	North America becomes very cold, killing off the local primates Nearly modern Tarsier, many near-modern bird species First elephant-like creatures and flying mammals (bats) Deer, cattle, giraffes, hippos, antelope, & sheep predecessors Sabre-toothed cats long lineage begins Great diversification of snails, slugs, & limpets Horse, rhino, and tapir predecessors Primate development slows; ecological niche usurped by rodents Whales, porpoises, dolphins, manatees, & dugongs appear Widespread temperate & subtropical forests Warm & humid climate
66	66	Paleocene 66	Cat-like & dog-like mammals Herbivorous & carnivorous hoofed mammals Largest snake, Titanoboa, 40 ft long, over 1 ton in weight Abundance of mammals, total lack of dinosaurs General warming trend, no frost, alternating wet & dry seasons

Exhibit 4 - The Epoch of Ice Ages

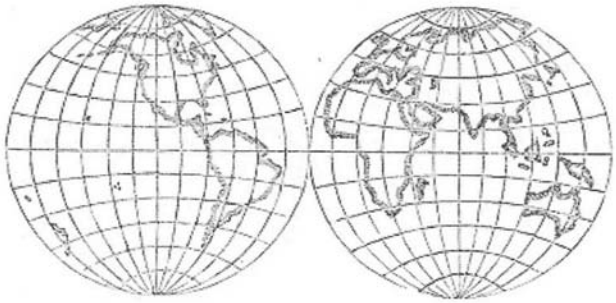
Era	Period	Epoch	Salient Features of the Time
		Holocene .01	The ascent of mankind
			Younger-Dryas cold spike interrupts post Ice Age recovery
			Wisconsinan Ice Age (N. American terminology)
			Modern humans arrive in Europe; Neanderthals disappear
		0.2	*Illinoian Ice Age* (N. America terminology)
			Based on tool design, right-handedness prevailed
			Kansan Ice Age (N. American terminology)
		0.4	Species *Homo sapiens* (modern humans) emerges in Africa
			Controlled use of fire, used for heating, cooking, & protection
			Stone implements prevail throughout this entire epoch
		0.6	Very large land animals still exist (e.g., mammoths, sloths)
			Many large lakes formed from periodic thawing of ice sheets
		0.8	Latest earth magnetic field reversal, lasting 22,000 years
Cenozoic			Extensive grasslands, limited forests
	Quaternary	1.0	Species *Homo neadertalensis* (Neanderthal man) evolves in Europe
		Pleistocene	*Homo erectus* migrates out of Africa to Europe & Asia
		1.2	Modern-looking dogs, cats, deer, bear, cattle, apes, rabbits
			Previous Ice Ages on ~41,000-yr cycles now begin ~100,000-yr cycles
		1.4	The present-day Sahara Desert was a lush savanna (treed grassland)
			Flight-less and, especially, flying bird species flourish
		1.6	Species *Homo erectus* evolves in Africa
			Simple flake tools for for cutting
		1.8	*Homo habilus* range extends beyond Africa
			Antarctica is ice-bound throughout the Pleistocene
			Nebraskan Ice Age (N. American terminology)
		2.0	Species *Homo habilus* evolves in Africa
	2.2	2.2	Continents are essentially in their current position

Exhibit 5 - The Ascent of Mankind

Era	Period	Epoch	Saliant Features of the Time
		Current	Industrial Revolution; WWI; WWII; Atomic Age; man on the moon; Digital Age
			Invention of piano, microscope, telescope, & flintlock musket; 1st Thanksgiving
			First watches invented; Mona Lisa painted; Gregorian calendar adopted
			European settlements in Western Hemisphere
			Little Ice Age; Black Plague devastates Europe (1/3 of population died)
		1000 yrs ago	*Medieval Warm Period*, Viking settlement in Greenland
			Algebra invented
			Viking raids of Scotland, Britain, & Ireland
			Fall of the Roman empire; Maya civilization develops
			Birth of Muhammad, founding of Islam; smallpox plague ravages Europe
		2000 yrs ago	Birth of Jesus Christ, founding of Christianity
			Roman Warm Period; rise of Roman empire
			Early Shintoism (Japan); Mediterranean traders first use coinage
			Birth of Gautama Buddha, founding of Buddhism
			Confucianism & Taoism - teachings developed from earlier Chinese beliefs
		3000 yrs ago	
			Collapse of a vibrant globalized economy (9 Mediterranean states)
			Rudimentary alphabet (Semetic) - refined, used, & promoted by Phoenicians
			Beginning of the *Iron Age*
		4000 yrs ago	
Cenozoic			Start of a global drought that accelerated world-wide human migration
			First Egyptian stone pyramid (3rd dynasty)
	Quaternary		
		5000 yrs ago	Founding of Egyptian culture (1st dynasty)
			Beginning of the *Bronze Age*
		Holocene	Sahara desert forms out of a savanna climate in less than 200 years
			Domestication of the horse & chicken
		6000 yrs ago	
			Hieroglyphic (picture) writing, starting written history
			Invention of the wheel
		7000 yrs ago	
			Estimated 40 million world-wide population
			Beginning of the *Copper Age*
			First beer is brewed from grain (near East)
		8000 yrs ago	
			Abrupt cold spell lasting 200 to 400 years (N. Hemisphere)
			City of Jerico destroyed by a great earthquake
		9000 yrs ago	
			Domestication of the cat; dogs likely domesticated up to 30,000 yrs earlier
			Evidence of agriculture in the near East & China
		10,000 yrs ago	
			Many ice age fauna die off, incl. sabre-toothed cats & wooly rhinoceros
			Start of *Holocene Warm Period*
		11,000 yrs ago	City of Jerico emerges (one of the oldest continuously inhabited cities)
			Land elevation rebounds 180' in areas weighed down by prior glaciers
		0.0117	Ice Age/Younger-Dryas glacier melting causes sea-level rise of 115'

From the foregoing time spans and related events, we can begin to comprehend how unique our planet's evolutionary process really is. It also underscores the enormous time span that preceded the dawning of mankind.

We'll next explore the dynamic nature of the earth's geology and geography starting around the time marine animals (fish, sponges, worms) were first becoming major players in the world's oceans.



Chapter 4:
Fins to Feet

The evolution of fish to land animals and ultimately to humans, holds a deserved fascination for most of us. After all, it’s a seemingly miraculous breakthrough given the remarkable changes needed for this feat.

It’s been depicted, cartoon style, as a simple stroll out of the water by a funny-looking fish on four fin-looking legs. Of course, we know there is a lot more to the story, starting with the question: what was the incentive to do so? The metamorphosis took place only because it offered some advantage for survival. In this case, there were likely the usual three drivers: 1) predator avoidance; 2) improved food supply; and 3) better environmental conditions.

The urge to leave the water habitat evidently started in more than one global location and by at least two different animal species because there are fossil “footprints” on land of both centipedes and 4-legged amphibians. The centipede descended from marine *arthropods* (the forerunners of our current millipedes, spiders, insects, and shrimp, for example), while the amphibian descended from lobe-finned fish, or *Sarcopterygii*, (the forerunners of all reptiles, birds, and mammals).

Some of the adaptations needed for terrestrial living were already accomplished, or were well underway, in Sarcopterygii long before the first step of becoming an amphibian actually took place. One example of this is the proto-amphibian's relatively big eyes, unlike those of fish. Larger eyes are more effective in air than underwater for providing a much farther range of vision. Not only were the eyes bigger, they'd also moved up from their usual location on the side of the head to the top of the head. Located there, it was easier to see above the water surface and view their surroundings for prey or predators.

The proto-amphibians also had fish fins, but these were the more robust, lobe-shaped fins rather than the more delicate "ray-fins" seen to this day on most fish. Originally, these bottom-feeding fish probably used their four fins more like legs to slowly move about while navigating shallow water looking for food. Some began the process of developing what eventually became necks, giving their head more mobility to snatch prey. The mouth already had teeth, but a more flexible tongue evolved to help ingesting food.

It turns out that the all-important ability to breathe air had also developed in some early fish, like the ancestors of the currently living three *Lungfish* species. The need for getting oxygen from the air rather than their normal habitat speaks poorly for water quality in the shallow-water areas these fish called home. Also, at the time lungs evolved, some 400 million years ago, the oxygen level in the atmosphere was very high, upwards of 30%. These factors apparently favored the pivotal evolution from gills to lungs.

With all these great modifications already available for occupying a terrestrial habitat, what else was needed to seal the deal? For one thing, the bones in the body needed strengthening to support the added weight when out of water, and also some reconfiguration (flattening) of rib cages helped to distribute weight better when laying on its belly.

The leg bones, evolving from lobe-fins, also became re-located more under the body to better raise the belly off-ground when walking. The characteristic 4-fin configuration of these fish carried over into the 4-leg arrangement of their land-based descendants.

Interestingly, the bone structure typical of a lobe-fin was also retained, giving legs the single upper bone (femur), the double lower bone (fibula and tibia), and the transition bones (ankle) leading to five or more digits (toes). The fin's original pivot joints, now a hip or shoulder joint, was also strengthened. The joint that connected upper and lower parts of the legs became flexible enough to become a rudimentary knee.

Another major adjustment made to amphibians was loss of its earlier fish scales, leaving only the thin skin. A modest amount of oxygen and CO_2 exchange was actually possible through the skin…either in or out of water. This gave them an ability to seek refuge underwater for extended time despite normally breathing with their lungs. (Several current salamander species have neither lungs nor gills, and "breathe" exclusively through their thin skin!)

Several downsides to thin skin are that it is susceptible to injury, it doesn't block environmental toxins very well, and it also makes the "wearer" susceptible to dehydration when out of water. This dehydration issue, along with still having to lay their soft-shelled eggs in water, greatly restricted these amphibians' range of habitability…proximity to water was obviously essential.

The amphibians' evolutionary descendants, the *reptiles*, actually reverted back to scales and thick skins that greatly lessened their dependence on a water environment. They further underscored that independence by laying hard-shelled or leathery coated eggs on land, a critically important development. These two defining characteristics markedly expanded the reptiles' range of survivable environments, all the way from aquatic to arid desert.

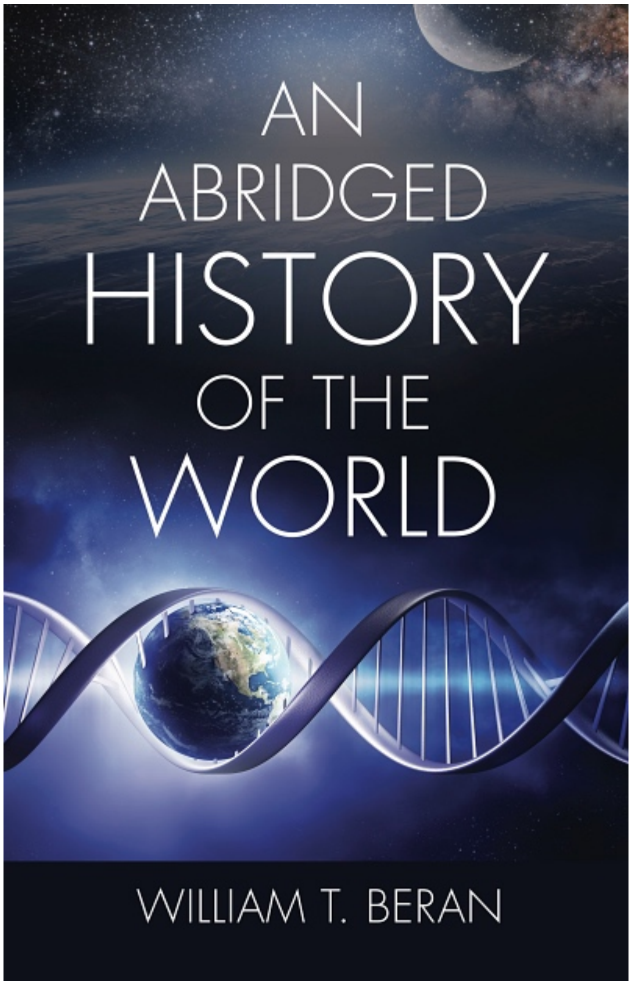
Reptiles also evolved more robust lungs and legs than their amphibian predecessors, which gave them more stamina to roam for food. They also had larger brains which increased their sensory development (sight, smell, hearing) and improved their hunting skills.

Some small reptiles (e.g., geckos) developed specialized skin on their feet to enable them to cling to vertical surfaces by means of molecular attraction of the foot and wall! At the same time, this force has to be voluntarily broken in order to move their feet when walking…a truly remarkable adaptation.

Reptiles also successfully returned to the sea even though they had evolved lungs and had to breathe air just like whales. These marine reptiles were especially prominent during the Age of Dinosaurs. Plesiosaurs, for example, were a huge predator, but most lizards suffered the same fate as their cousins, the dinosaurs.

Only a few aquatic reptiles now survive, such as crocodiles, sea turtles, and sea snakes.

Reptiles, like amphibians, were not well-adapted to cold environments because they were *ectothermic*, or “cold-blooded” so their body temperature varied with the environmental temperature. This handicapped their performance on land in high mountainous terrain or polar regions. But, aside from that, their hibernating skills afforded them a wide seasonal environmental range. This adaptability enabled them to evolve into many more variants, eventually developing into all the species of dinosaurs and birds.



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