Evolution of Evolution

Evolution of Evolution:

The Survival Value of Caring

By

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To your grandchildren and ours and to their children's children, whose evolution to hopefully richer and better and more meaningful lives we cannot even imagine

What is special about this work? Numerous scholarly articles and books have been written about biologic and social evolution, compassion, life's meaning, violence and predictions of future outcomes. However, what is not often addressed, but is increasingly desperately needed is the realization of the evolutionary survival value of caring for others. This realization can link our humanities and religious philosophies to a scientific understanding of human destiny, and provide a key to meaning in our lives. Though this idea has incubated over 18 years, recent extremism in Charlottesville and global threats of inhumanity and violence make this more timely than ever for all who care about who we are and about our children's future. Furthermore, our capacity for benefit or destruction of *Homo sapiens* (wise humanity) or of civilization as we know it sets a ticking timer on the urgency of this realization and focused action; we don't have 'forever' to 'get it!'

Hence this writing.

Richard Littleton Guerrant, MD

MLK Day, Jan 15, 2018

Charlottesville

We're in it together. How you do determines how I do.

Cover art by Pierson Guerrant (age 12) and Wren Bolick (age 16), after they heard about the study of the difference between humans and our closest primate relatives, the bonobo chimpanzees (see page 91).

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

PREFACE

It has been noted many times throughout history that "these are tumultuous and rapidly changing times, like never before." With increasing change and even rates of change, it may be that this statement has validity each time it is said. This book seeks to wrestle with this change and how we are changing. Though technology and science are driving our *capacity* for change, it is our critically important history, philosophy and the humanities that will profoundly influence the *direction* that change takes. It is the recognition, appreciation and even incorporation of the other by both science and the humanities that hold the keys to our evolution and ultimately to our survival. The accelerating pace of that change likely places a timer of urgency on this recognition.

To the important non-science oriented readers that I hope to engage, I apologize, especially for chapters two and parts of chapter five, where I get superficially into Darwinian selection, balanced genetic polymorphisms, how traits evolve and how even that may be changing, as well as into assessing health with disability adjusted life years (DALYs). As I've had to tell my insightful wife and several non-science colleagues, you can just skip those parts if you wish. But there is a part of me that cannot let go of my passion to link our science with our humanity; indeed it's a core message I seek to impart.

I should also apologize to the historians and philosophers into whose fields I have strayed on a very naïve level. But again, I beg tolerance on the grounds that we non-aficionados need to be struggling with history and philosophy, most especially those of us who are in science, education or parenting. It is the longed-for broad reach of this message that had me weighing an alternative title of "Why care? Our urgent next step to evolving or extinction." However, the very changes or evolution in what is driving evolution itself had grabbed me as I hope to engage you. The survival value of caring has both qualitative and quantitative elements, as we wrestle with how caring for others is key to our meaning and to our survival. The quality of the meaning in our lives is of utmost importance to whether it even matters that we survive. Hopefully we can find the common ground as wise humanity (*Homo sapiens*, as we've named

ourselves) to agree on what is ultimately most deeply meaningful, as I would argue that this is what will also optimize our survival, progress and meaning over time to come.

This writing is divided into 7 chapters; it may be helpful to consider 7 questions in setting up the main message/s of each:

1. What impresses you most about what is changing? (ex: population, computers, the drivers of evolution itself?)

2. Can traits that were once helpful become more harmful than helpful with changes over time? (ex: sickle cell trait; aggressive behavior)

3. Can spiritual philosophies, religions and the humanities actually join with the sciences to complement or reinforce (rather than exclude or conflict with) the other?

4. Can we isolate ourselves or our countries? (ie: are protective 'walls' possible?)

5. Is it important to care for others whom we may not even know? And why? (Why care for "others," and who are "they?")

6. How might (or should) we be changing? Who are "we?" (expand our concept of "self;" the power of purpose – beyond ourselves)

7. What can (or should) we do? (Have a dream; do the doable; & persevere)

It is your answers to these questions and your responses that matter; it is my hope that our grandchildren and their children will enjoy enriched lives and extending great changes for the better that we cannot even imagine.

ACKNOWLEDGEMENTS

These perspectives have been shaped by more remarkable family and colleagues than I even realize. These start with my parents who not only listened but engaged actively with the many foreign notions and ideas Nancy and I brought home from our experiences living and working in the Congo, East Pakistan, Brazil and more recently in South Africa. In particular, these extend to Drs. Bill Rule and John Miller and literally life-saving Colleagues in Tshikaji and Bulape Congo, then Captain Bob Phillips (our Commanding Officer) and remarkable colleagues like Ansaruddin Ahmed, Mobarek, Jon Rohde, Lincoln Chen, George Curlin, Al Sommer, Henry Moseley, Jack Stoekel and their families in Dacca (now Dhaka) who imprinted our lives and thinking more than we know.

I am forever indebted to remarkable colleagues who have enabled and led our collaborations abroad, first in the South of Brazil (Florianopolis) and then in the Northeast (Fortaleza); gracious colleagues like Waldomiro Dantas, Galba Araujo, Auxiliadora de Souza, Manasses Fonteles and then my brother in collaboration, Aldo A.M. Lima, along with Reinaldo Oria and too many welcoming colleagues and families to name who made our Rockefeller and NIH then Bill and Melinda Gates Foundation/NFID supported collaborations over 40 years one of the longest such collaborations in the US. These collaborations in Northeast Brazil have now extended to similarly incredible colleagues in South Africa, including Pascal Bessong among many others. This is what enabled us to see long-term associations of enteric and other infections in early childhood from birth with troubling impairment of children's growth and development. Other remarkable colleagues include John Cooley (who introduced me to Teilhard de Chardin's work when we were in medical school), Ken Henry, Jay McAuliffe, Marilyn Nations, Jim Hughes, Bob and Terry Brennan, Mike McLean, Cindy Sears, Christine Wanke, Ted Steiner, Sean Moore, Peter Patrick, Jim Nataro, Margaret Kosek, Becca Dillingham, Luther Bartelt, Rebecca Scharf, Mark DeBoer and Liz Rogawski.

Incredible mentors and faculty colleagues include Drs. Cal Kunin, Maxwell Finland, Chuck Carpenter, Ed Hook, Jerry Mandell, Jack Gwaltney, Merle Sande, Ken Warren and Tom Hunter; the remarkable models that shape us more than we know. And colleagues, in addition to

many above, include Dick Pearson, Erik Hewlett, Bill Petri, Eric Houpt, James Platts-Mills, Chris Moore, Scott Heysell and Tania Thomas. Extraordinarily gifted administrators have consistently made the impossible doable; three who especially stand out include Lorna Borri, Joy Boissevain and Liz Olmsted. Dedicated leadership in our laboratory especially includes Leah Barrett and, in recent years the incredibly gifted David Bolick, whose remarkable energy, compassion, insights and experience have us all competing for precious moments of his busy time. It is David's critical thinking, information gathering, computing "can do" expertise and tireless assistance with editing and formatting that enabled this work to make it to publication.

Most of all, through thick and thin, 2 evacuations --one with our 2 oldest children, and enabling and shaping an amazing lifetime, to my incredible wife of over 53 years, Nancy Brearley Guerrant, and our 3 deeply thoughtful and insightful children, Jeff, Amy and David, and their families; to quote the African Ubuntu wisdom, "I am because of you."

INTRODUCTION

Ever since I can remember from deep discussions with my father, I have been fascinated by the concept of time. Whether trying to comprehend our prehistoric origins, history itself or the role of time in Einsteinian physics, this "fourth dimension" holds a fascination and mystery that takes on living intrigue when we consider what is changing over time. For the advancing biologic complexity and adaptation over time, we use the term "evolution." But my father often said that the thing that is most beyond his comprehension and "boggles his mind" is that the thing that is changing the fastest is the *rate of change*! I confess that this is profoundly challenging for me to fathom as well. Consider what is changing about what is changing. What about the possibility, indeed probability, that the very drivers of change, like the slow plodding pace of Darwin's natural selection over generations are now being totally outstripped ("left in the dust" the runners in our family would say) by human behavior, now with industrial and scientific revolutions having vastly extended our potential for changing our lives and the world around us. What does that say about "adaptation" or "survival of the fittest?" Fittest for what? Who are we and what do we want? These are the questions that have been the stimulus for this writing, consciously incubating for over 18 years and for who knows how much longer, but, at least for these hands with limited time to pass this challenging baton, needing to get on with it.

Amidst our tumultuous sea of ever increasing change, it becomes more important than ever to ask ourselves who we are and what really matters. It is in this context that understanding what gives humanity, our *Homo sapiens* species, its distinction and meaning takes on an urgency that we should all address—not only for the sake of the meaning of our personal lives, but for the very survival of a meaningful civilization.

What time is it?

Even asking this question is a very recent part of history. Unlike the clocks of astrophysics or the many biological clocks that drive the unconscious behavior of all living creatures, just our conscious awareness of time, let alone our preoccupation with it, is relatively recent in our long human

history. Preceded by obelisk shadows and then complex sundials, as early as 2000 BC the Sumerians then Egyptians, Chinese (Zhou dynasty), Japanese, and Greeks used water clocks (first dripping, then with "escapement" converting pendulum swings to a rotating wheel with cogs), or sand in hourglasses to measure passing time. It was adding the balance spring to the pendulum clocks that enabled mechanical clocks to emerge in the 14th Century. Radio communications allowed multiple places to coordinate time, as by the gongs from Big Ben (completed in 1859) being broadcast in Britain to BBC listeners only in the last 100 years, since 1923. And now, of course, precise quartz and atomic clocks link the world as never before. But what is most interesting is how we use or ignore time. For example, casinos without windows or clocks want their patrons to be oblivious to time while focused instead on the seductive task at hand of continuing to gamble. In stark contrast, prophets warn of time getting very late for us to make positive changes in our myopic, destructive behavior.

It's a privilege to know what time it is

One might even argue that it is a privilege to "know what time it is" in one's lifetime. Those with targets and goals with limited time or deadlines for their realization or achievement may have advantages over those with unlimited time. Some would challenge the wisdom of the dream of immortality, discussed with the Gilgamesh Project to eradicate aging in Chapter 2. Witness the young patients with HIV/AIDS in the devastating early 1980s before any hope for effective treatment existed who sometimes said such startling things as "AIDS was the best thing that ever happened to me!" as it was only then that they realized how precious is each day in our lives, and what really matters to us. Perhaps like never before, they realized what is important in their lives, what really mattered to them, what they really *cared* about for themselves and those around them. Like many who learn of potentially fatal diagnoses, I can appreciate that feeling.

From the perspective of an infectious diseases physician researcher who has lived and worked with his family in Congo, Bangladesh and Brazil, I am increasingly convinced that our children's future is being determined by whether we recognize our *inter*dependence across the entire human family. Some of our research has introduced me to evolutionary biology, and our family's experiences have taught me respect for diverse religious perspectives and heroes in just my lifetime such as Nelson Mandela, Mahatma Gandhi and Martin Luther King, Jr. who have taught the history-

changing power of compassion, forgiveness and passion itself. Testifying in the US Congress as president of the American Society of Tropical Medicine and Hygiene for NIH and CDC support for research and caring for those in greatest need focused my concern for the urgency of recognizing how increasingly rapid change promises either continued remarkable improvements in the quality of life and its meaning for all…or our extinction as a civilized species.

I shall return to the evolution of evolution (what may be changing about what is changing) in Chapter 2 and to what this means to us as *Homo sapiens* ("wise humanity") in the remaining five Chapters, but we must begin with a sense of where we have been, our time and origins.

CHAPTER ONE

HISTORY OF CHANGING RATES OF CHANGE

What impresses you most about what is changing? (ex: population, computers, drivers of change, evolution itself?)

We've been here through so little time, yet so much change.

Timeline to the present

Although constantly emerging new discoveries keep moving best estimates of prehistoric dates, current estimates for the age of the universe, earth, life on earth, and early humans and their migrations out of Africa are summarized and referenced in **Table 1.1**, **Figures 1.1** and **1.2** and in the descriptions that follow. The common abbreviation of bya or mya means 'billion or million years ago.'

Best estimates for the origins of the universe, matter and energy are placed at 13.5 to 14 billion years ago, with the "Big Bang" explosion from a very high-density and temperature state from which accelerating expansion of giant clouds of primordial subatomic and atomic particles cooled and coalesced over another 10 billion years into galaxies, stars and planets. Most date the formation of our planet Earth some 4.3-5b years ago. After another billion years, methane, ammonia and hydrogen gases formed basic organic monomers such as amino acids, then peptide polymers, cells and then enzymes, nucleotides and microbial life 3.5 to 4 billion years ago. The "Precambrian" era then took another 86% of the earth's history (another 3b years) before hard shelled creatures first opened the explosion of Cambrian diversity of plants and animals. These eons of meteor bombardment, chemical coalescence and early, single cell microbial and protozoal life that preceded our relatively recent invertebrate, fish,

amphibian, reptile and mammalian life and our shifting continental origins are summarized in **Table 1.1** and **Figures 1.1-1.3** below.

Table 1.1a. Earth's Geologic Eons, Eras, Periods and Epochs. (Lutgens and Tarbuck 2012)

Hadean Eon (4540 mya; "hellish" meteorite bombardment)
Archean Eon (4000 mya; prokaryotic bacteria and blue-green algae)
Proterozoic Eon (2500 mya; eukaryotes and protozoa)
Phanerozoic Eon (541 mya; Eon of visible life forms)
Paleozoic Era (541-252 mya)
Cambrian Period — Age of Invertebrates
Ordovician Period (485 mya) — "
Silurian (444 mya) — Age of Fishes
Devonian (419 mya) — "
Carboniferous/Mississippian (359 mya) — Age of Amphibians
Carboniferous/Pennsylvanian (323 mya) — "
Permian Period (299 mya/Pangaean Continent) "
--The Great Dying/Extinction (loss of 70-96% of land and marine species taking 10-30m years to 'recover'; ?meteor impact, volcanos, Siberian traps→coal/gas fires; runaway greenhouse→methane)
Mesozoic Era (252-66 mya) — Age of Reptiles
Triassic Period (252 mya; Reptiles replace many land amphibians)
Jurassic Period (201 mya *Pangaean breakup;* Age of Dinosaurs)
Cretaceous [K] Period (145-66 mya; gradual warming)
--The K-T Extinction Event (Yucutan Asteroid) German Kreide-Tertiary loss of Dinosaurs and half of known species
Cenozoic Era (66 mya-present) — Age of Mammals
Tertiary Period (66-2.6 mya)
Paleocene Epoch (cooler, then abruptly warmer)
Eocene (54.8 mya; tropical, 'dawn' of fauna)
-E-O extinction with meteors hitting Siberia and Chesapeake Bay
Oligocene (33.7 mya; 'few' mollusks; expanding grasslands)
Miocene (23.8 mya; warmer)
Pliocene (5.3 mya; cooler, preglacial)
Quaternary Period (1.8-2.6 mya - present) Humans Develop
Pleistocene Epoch ("ice age")
Holocene Epoch (0.01 mya; current 'warm' period)

Table 1.1b. Timeline summary of events before and into human history from the Big Bang to the present.

- Big Bang 14bya; Earth 4.3-5bya;
- Life; Microbes 3.5bya; Precambrian (can reach to 1.8bya in Grand Canyon); Cambrian 'explosion' of life (1st Paleozoic geological period) = 541-485m yrs ago; 200-146mya = Jurassic; 300-100mya Pangaea; Continental shift = 75mya; Cambrian/land/Dinosaurs/Yucatán asteroid 230→65m;
- Ardipithecus 4.4m; hominids out of Africa 2mya; European Neanderthals 0.5mya; *Homo sapiens* 0.2-0.3mya (from discoveries in Ethiopia and Morocco, respectively) out of Africa→all landmasses (recently challenged by Hershkovitz, et al, (Hershkovitz, Weber et al. 2018), to be closer to 185-200kya, not 10-70kya, from new findings of an early human jaw and teeth in Misliya Cave just east of Hebron);
    - Indonesian Hobbits 30k;
    - 23-30k Siberian crossing from Asia, Beringia (land mass that became the Bering Straits), Americas
    - 11.5k years ago Beringian babies and Salmon fishing dated east of Fairbanks, from Ice Age Alaska, fitting the "Beringian Standstill" of a people there for some 10k yrs before moving south into the American subcontinent (Moreno-Mayar, Potter et al. 2018); Also surprisingly, the African haplotypes recently seen in Northeast Brazil are more similar to East Africa (from before the Bantu migration to West Africa only 4-5k years ago), suggesting that they too came via Asia long before the Bantu migration across to W. Africa. (Mychaleckyj, Havt et al. 2017)
    - 10k Neolithic agriculture in the Fertile Crescent; 5k logs→spoked wheels in Indus Valley (also Egypt, Mesopotamia); Noah, Abraham 4k;
    - Darwin's voyage to Galapagos on the Beagle 1831;
    - Antibiotics discovered (sulfonamides, penicillin, etc 1944);
    - Watson-Crick DNA 1953; Human genome 2001;
    - Interdependence and survival ???

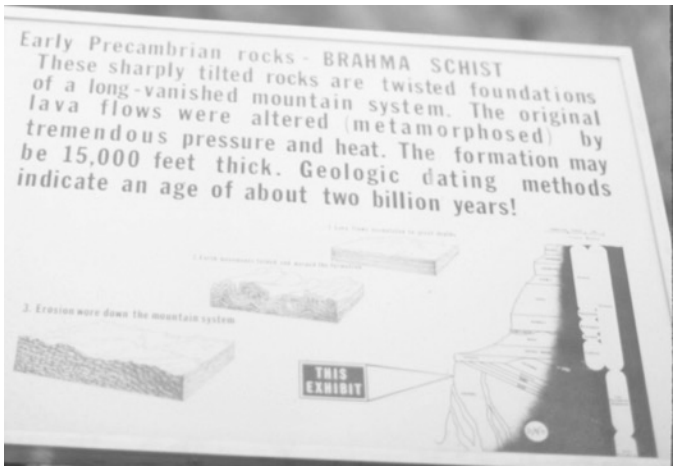
The Cambrian and Jurassic periods are named for Cambria (the Latinized Welsh '*Cymru'* for Wales' exposed rocks) and the Jura mountains in the European Alps (where the limestone strata first uncovered the period fossils). Remarkably, one can descend through the Jurassic back into the Precambrian period layers from 200mya (million years ago) to 2bya (billion years ago) in the Grand Canyon, as our grandson Pierson

photographed on his recent hike there (**Figure 1.1a**). Familiar Bryce and Zion Canyons enable tracing through the Cenozoic and Mesozoic (including the dinosaur) geologic eras, while the Grand Canyon descends through the eons of most visible life forms to the early Precambrian eon/s when the only life forms were microscopic organisms like protozoa, blue-green algae and bacteria (**Figure 1.1b**).

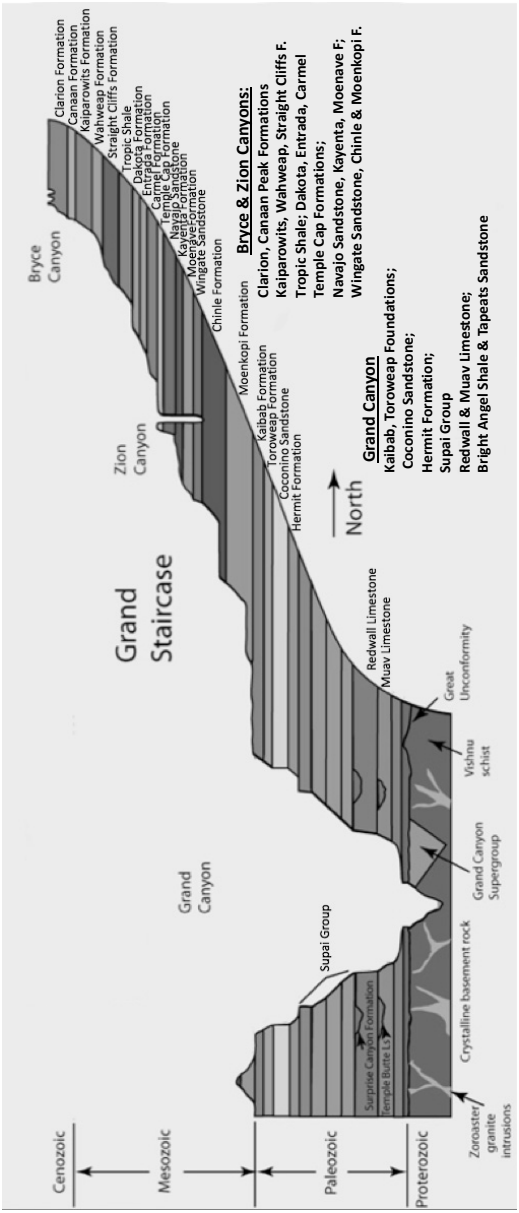
Following the Cambrian 'explosion' of life (1st Paleozoic geological period) from 541 to 485m yrs ago, the ages of the invertebrates, fishes and amphibians took over half of the last 541 million years of the earth's history until the "Great Dying Extinction" ended the Paleozoic Era 252 mya (see **Table 1.1a**). This greatest extinction event resulted in the loss of 70-96% of land and marine species on the planet, from which it took another 10-30 million years to "recover!" Debated causes of this massive extinction range from the impact of giant meteors or meteor showers to volcanoes or "Siberian traps" of coal and gas fires or runaway greenhouse production of methane. Whatever the cause, it brought to an end the Permian Period, the last Period of the Paleozoic Era and heralded the very slow emergence of the age of reptiles and the Mesozoic Era over 10-20 million years as the supercontinent Pangaea started to break up with continental drifts that eventually (over the next 100 million years) became our 7 modern continents.

Figure 1.1. Layers of geologic time through which one can hike in the Grand Canyon.

a.



b.


Cenozoic
Mesozoic
Paleozoic
Proterozoic
Zoroaster granite intrusions
Crystalline basement rock
Sixtymile Canyon Formation
Temple Butte LS
Supai Group
Grand Canyon
Grand Canyon Supergroup
Vishnu schist
Great Unconformity
Redwall Limestone
Muav Limestone
Hermit Formation
Coconino Sandstone
Toroweap Formation
Kaibab Formation
Moenkopi Formation
Chinle Formation
Wingate Sandstone
Moenave Formation
Kayenta Formation
Navajo Sandstone
Temple Cap Formation
Carmel Formation
Entrada Formation
Dakota Formation
Tropic Shale
Straight Cliffs Formation
Wahweap Formation
Kaiparowits Formation
Canaan Formation
Clarion Formation
Grand Staircase
Zion Canyon
Bryce Canyon
North
Grand Canyon
Kaibab, Toroweap Foundations;
Coconino Sandstone;
Hermit Formation;
Supai Group
Redwall & Muav Limestone;
Bright Angel Shale & Tapeats Sandstone
Bryce & Zion Canyons:
Clarion, Canaan Peak Formations
Kaiparowits, Wahweap, Straight Cliffs F.
Tropic Shale; Dakota, Entrada, Carmel
Temple Cap Formations;
Navajo Sandstone, Kayenta, Moenave F;
Wingate Sandstone, Chinle & Moenkopi F.

In the reptilian Mesozoic Era, the more familiar 56 million year Jurassic period of the dinosaurs from 201 to 145 mya came between the Triassic and Cretaceous periods. (see **Table 1.1** and **Figure 1.1**) The Jurassic dinosaurs then persisted through the beginning Pangaean Continental shift until the 10-15km Yucatán asteroid plunged the planet into violent global volcanic activity, atmospheric ash causing global cooling and extinction of some 75% of life worldwide, including the dinosaurs 65 million years ago. **Figures 1.2** and **1.3** below show these timelines and continental shifting linking these epochal periods in our history.

Figure 1.2: Timeline from the "Big Bang" to earth, life, dinosaurs and *Homo sapiens* and their migrations.

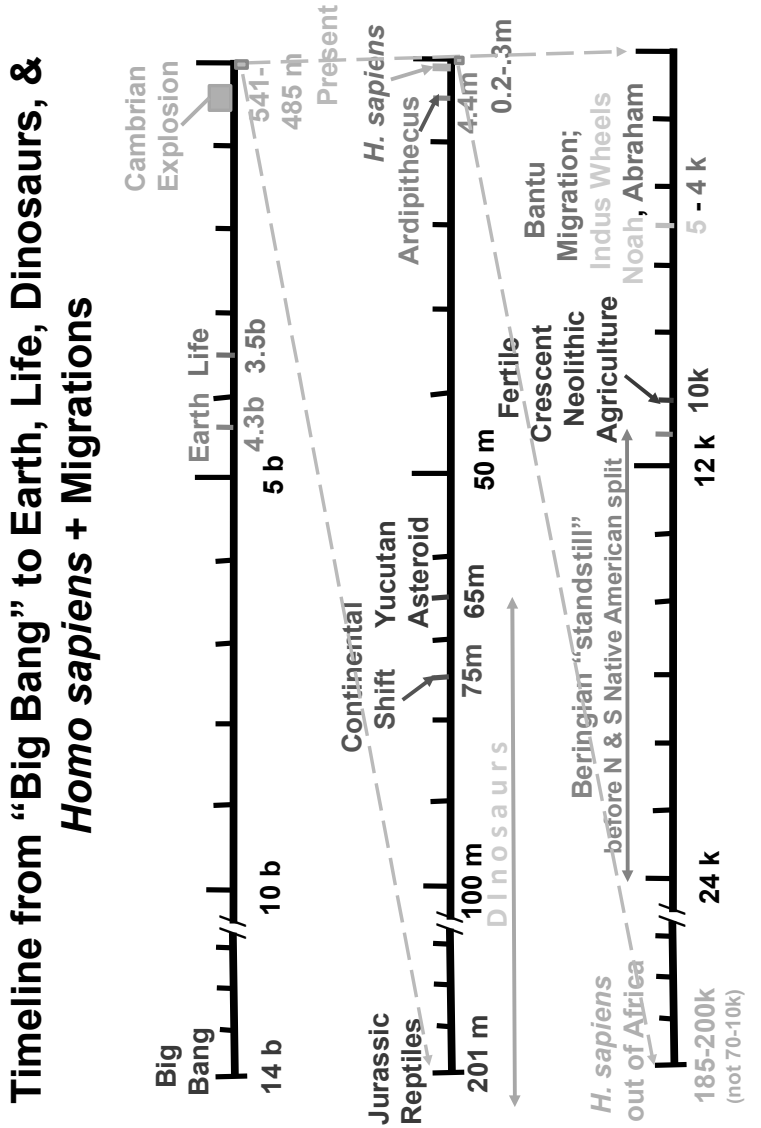


Figure 1.3: Continental drifts of tectonic plates over the last 225 million years to form today's continents.