

### III. TEACHING BIG HISTORY

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#### Big History and Elementary Education

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##### **Abstract**

*Big History can be viewed as a comprehensive origin story of everything in the universe. It is perhaps the most important piece of scientific literacy that every well-educated person should know, at least in its general outlines. For this to happen, society cannot wait for the university level to begin teaching the story. Happily, there is already such a curriculum at the elementary grade level that has existed within the Montessori education community for most of the last century under the rubric of 'Cosmic Education'. Through a series of lessons that roughly track the thresholds of David Christian, Montessori elementary teachers provide their students with basic impressionistic concepts and a supply of materials for them to explore each chapter of the story.*

*Keywords: Montessori, Cosmic Education, elementary education.*

The teaching of Big History should begin in elementary schools – and Montessori education provides a model for this to happen. The all-inclusive theory that science has developed, particularly over the past half century, attempts to explain everything from the Big Bang to modern human societies. By the time students finish their undergraduate degree, they should have a general knowledge of this theory to provide the context for any field of study they have chosen to pursue.

For this to happen, society cannot wait for the university level to begin teaching the story. The university structure is so geared toward specialization that this kind of general theory can easily be bypassed in favor of major-driven curriculum requirements that leave little time for such Renaissance outcomes. Hopefully, that is beginning to change. 'There is a growing sense, across many scholarly disciplines, that we need to move beyond the fragmented account of reality that has dominated scholarship (and served it well) for a century', notes David Christian, one of the founders of the Big History movement (Christian 2004: 3).

But even before the university level, some familiarity with the full scope of the story should be part of every high school curriculum. And,

even before that, it should be incorporated into the elementary and middle school curricula. Each level should build upon the previous one so that the story of the universe is visited in ascending cycles that lead students to an ever deeper appreciation of the full scope of the story.

Happily, there is already such a curriculum at the elementary level that has existed within the Montessori education community for most of the last century under the rubric of Cosmic Education. While elementary schools do not have to become Montessori schools to implement the major portions of this curriculum, much can be learned from the Montessori experience about how to translate the overall Big History message into terms that can be understood by children between the ages of 6 and 12. The pedagogy to deliver the content of Big History to younger students is a contribution that Montessori educators can make to the movement to make this all-inclusive story more familiar to all educated people.

Maria Montessori, the Italian physician who founded the Montessori method of education in the beginning of the 20<sup>th</sup> century, concluded from her work in the field of education that everything needs to be understood in the largest possible context.

Let us give the child a vision of the whole universe... If the idea of the universe be presented to the child in the right way, it will do more for him than just arouse his interest, for it will create in him admiration and wonder... The knowledge he then acquires is then organized and systematic; his intelligence becomes whole and complete because of the vision of the whole that has been presented to him... No matter what we touch, an atom, or a cell, we cannot explain it without knowledge of the wide universe (Montessori 1973: 8-9).

As a result of this vision, so similar to the basic tenets of Big History, Montessori's pedagogy for the elementary aged child is based on putting everything in the context of the universe and gradually working inward toward the child and his immediate world. Every subject is studied as part of an integrated, step-by-step exploration of the unfolding of the universe, of the solar system, of our Earth, of life on this planet, and finally of the human race.

In *Children of the Universe* (Duffy M. and Duffy D. 2002), we depict this as a series of concentric circles representing the successive chapters of the story, with each chapter representing a story within the previous story and all of them contained within the story of the universe itself.

Thus, the story of the stars and the solar system (Chemistry and Physics) is part of the story of the universe (Astronomy and Cosmology), the story of the Earth (Geology and Geography) is part of the story

of the stars and solar system, the story of life (Biology) is part of the story of Earth, and the story of early humans (Archeology) and written history (History) is just part of the story of life on this planet.



Fig. 1

This is exactly parallel to the approach taken by Christian in his lecture course on Big History.

Big History surveys the past at all possible scales, from conventional history, to the much larger scales of biology and geology, to the universal scales of cosmology. It weaves a single story, stretching from the origins of the Universe to the present day and beyond, using accounts of the past developed within scholarly disciplines that usually are studied quite separately.

Human history is seen as part of the history of our Earth and biosphere, and the Earth's history, in turn, is seen as part of the history of the Universe. In this way, the different disciplines that make up this large story can be used to illuminate each other. The unified account of the past assembled in this way can help us understand our own place within the Universe (Christian 2006).

In his book, Christian explains that the creation stories involved in this approach to history 'offer answers to universal questions at many different scales, which is why they sometimes appear to have a nested structure similar to a Russian *matryoshka* doll - or to the Ptolemaic vision of the universe, with its many concentric shells' (Christian 2004: 6).

This is the vision embodied in the cover illustration of our book, *Children of the Universe*, following the original insight of Maria Montessori about the unified nature of the story of Cosmic Education. Christian's questions – 'Who am I? Where do I belong? What is the totality of which I am a part?' (Christian 2004: 1) – are very similar to the questions we express as the basic search of Cosmic Education – 'Who am I? Where do I come from? Why am I here?' (Duffy M. and Duffy D. 2002: 4–5)

Montessori and those who embraced her method developed an entire curriculum and collection of teaching materials to make the unified account of the past accessible to elementary-aged children. Spread throughout the curriculum are a series of timelines that highlight various chapters of the story, physical representations of each period that can be studied and manipulated by the students in many cases to construct their own versions of the timelines.

### 1. The Universe Story and the Story of the Stars

The story begins with the emergence of the universe itself in the Big Bang and the formation of the first stars and galaxies. The parts of the Montessori curriculum devoted to this chapter are the equivalent of the first three thresholds in Christian's course – Creation of the Universe, Creation of the Stars, and Creation of Chemical Elements in Dying Stars. The Montessori curriculum covers this for elementary-aged children in a simplified version with materials that help make the story accessible.

The elementary-level story told in the Montessori tradition is the youngest elementary child's introduction (in the equivalent of Grades 1–3) to the study of chemistry and physics. The story is followed by a collection of experiments (called 'Nature of the Elements') that the children can carry out on their own, with a series of trays containing the required materials and command cards to direct their work. For example, there is a tray with three glasses where students are directed to leave one with nothing in it but air, fill another with water, and a third with ice to demonstrate and experience the three states of matter. There are also simple experiments to distinguish the concepts of mixture, suspension and solution; saturation and super-saturation; and the effect of gravity on substances that have different densities (METTC 2013b: 80–83).

Some schools, seeking a more scientifically modern version of the story of the early universe for young children, use resources like Jennifer Morgan's *Born with a Bang* to tell this chapter. Her book, the first in a trilogy that tracks major elements in Montessori's Cosmic Education curriculum, is a beautifully illustrated and solidly scientific story about the early universe found in many Montessori classrooms (Morgan 2002). James Lu Dunbar's 'Universe Verse' comic book trilogy, starting with *Bang! Is an-*

other child-friendly resource that tells the comprehensive story of Big History – and Cosmic Education – in a form that is pedagogically accessible and engaging for elementary-aged students (Dunbar 2009).

At the upper elementary level (equivalent to Grades 4–6), some Montessori schools have developed a 'Timeline of the Early Universe' to explain how atomic matter came to be from the Big Bang through the successive Quark Era, Hadron Era, Lepton Era, and Radiation Era.<sup>1</sup> This is told in story form that first introduces the students to the main characters of the story – atoms, protons, neutrons, electrons, and quarks; then it traces the drama of the unfolding story as energy turns into particles of matter, quarks bind into protons and neutrons, protons and anti-protons nearly annihilate each other, electrons and anti-electrons go through a similar near annihilation, photons dominate for a time after these epic struggles, then the atoms we know emerge with electrons orbiting a nucleus of protons and neutrons.

Many other Montessori schools who have students at this level study the 'Life Cycle of the Stars', from small stars to medium to giant stars that end up as supernovae, so they can understand how stellar nucleosynthesis produces the elements of the periodic table above the early Big Bang elements of hydrogen and helium (using marbles and other models to illustrate nucleosynthesis). This is their introduction to 'Evolutionary Chemistry' – and the discovery for the students that we are all literally made of stardust (CMTE/NY 2012a: 9–12 Evolutionary Chemistry Resources).

This first chapter in the story – encompassing three of Christian's thresholds – is the least developed in the traditional Montessori curriculum, partly because much of the science behind it was not widely known by the time of Montessori's death and partly because it is more removed from the experience of children.

Montessori teachers could take advantage of resources developed by authors within the Big History community to flesh out their own understanding of the science behind the story, in this and the following chapters, particularly since the approach of those who teach Big History is rooted in telling a comprehensive story about the universe. Storytelling is the preferred technique for delivering information in a Montessori environment, and the accounts of those who teach Big History – science in the form of story – provide ready-made material for that approach for teachers whose preparation does not necessarily include a heavy background in science.

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<sup>1</sup> See Duffy 2011. Also *The Timeline of Light* which is an artistic depiction of part of the story of the Universe, created in scroll form by John Fowler.

## 2. The Story of the Solar System and Earth

The next chapter in the Montessori curriculum corresponds to the fourth threshold in Christian's course, Creation of Planets and Earth. For the lower elementary level (Grades 1–3), there is a series of manipulative-based lessons called 'Sun and Earth'. Young children are taught about night and day with the rotation of a globe around itself as it faces a light bulb, about the year by the revolution of the globe around the light, and the 'reason for the seasons' by the effect of the tilt of the Earth in relation to the sun as it makes its yearly dance (METTC 2013b: 103–128). In this series, the students learn about the equinoxes, the solstices, and the origin of the imaginary lines of the Equator, the Tropics of Cancer and Capricorn, and the Arctic and Antarctic Circles.

With a series of studies called 'Composition of the Earth', these younger students are taught about the formation of the early planet by the forces of gravity acting on particles left over from the Sun's formation following a supernova explosion of our Mother Star. They learn about the layers of the Earth – crust, mantle, and core – using clay models and other didactic tools. And they learn why the Earth is still alive with earthquakes and volcanoes (METTC 2013b: 129–148). Jennifer Morgan's *Born with a Bang* and *From Lava to Life* (Morgan 2002, 2003), while not specifically part of the official Montessori curriculum, flesh out these parts of the story beautifully and are widely used in Montessori classrooms.

The upper elementary grades, and even the lower elementary grades at times, expand on these subjects with studies called 'The Work of Air' and 'The Work of Water'. Both involve a series of lessons and activities on the part of the students with collections of materials to demonstrate major concepts about how the Earth is shaped and changed by air and water. The Work of Air begins with a number of simple experiments to explain the origin of the movement of air in our atmosphere and how wind patterns are formed (METTC 2013b: 149–153). The Work of Water consists in an examination of the impact of water on the planet as it creates rivers and causes erosion on its way to the sea in the water cycle (*Ibid.*: 172–190). Upper elementary students often expand on the lower elementary geography studies with a more advanced examination of tectonic plates, Pangaea to today's continents, formation of the Earth's major mountain ranges, the geology of rocks and minerals and similar studies.

As with the first chapter of the story, Montessori offers pedagogical tools to tell this part of the story to young children – and Montessori teachers can enhance their own scientific background by reading the works of Big History proponents.

### 3. The Story of Life

This chapter in the Montessori curriculum corresponds to the fifth threshold in Christian's course, the Creation of Life on Earth. As a physician before she became an educator, Montessori was particularly interested in Biology, and the traditional Montessori curriculum contains many lessons and materials to teach elementary children the story of the evolution of life on this planet.

The simplest of these for the emerging readers of first grade are a collection of classified cards called the 'External Parts of Animals'. They consist in a series of line drawings of a sample animal from each of the five familiar types of vertebrates, with each part highlighted in red. Each picture is accompanied by a label that names the part and a brief paragraph describing its function. There is a collection of these cards for the fish, the frog, the turtle, the bird, and the horse to introduce the very youngest of elementary children to the evolutionary order of familiar classes of vertebrates (METTC 2013a: 12-20). There is a similar series of cards to introduce children to the 'External Parts of Plants,' including seaweed, moss, fern, conifer, and flowering plant, again in evolutionary order (*Ibid.*: 21-27).

For the more advanced readers in the middle of lower elementary, there are the 'First Knowledge of Animals and Plants' cards, broadening the selection of plants and animals and introducing some of their primary characteristics with accompanying 'Who Am I?' cards that make a game out of guessing the right match from a carefully crafted description (children can check their work on their own with a control booklet once they have done their best to match the cards themselves) (METTC 2013a: 28-45). These young children are introduced to the rudiments of research with a series of 'Question and Answer' cards to apply to the First Knowledge cards - asking such questions as 'What does the animal eat?' with possible answers of 'plants', 'animals', or 'plants and animals' or 'Where does the animal live?' - water, land or air.

Another material, the 'Clock of Eons,' is in the form of a clock, with successive sections after the starting point of 12 o'clock indicating the passage of the Hadeon, Archean, Proterozoic, and Phanerozoic eons (METTC 2013c: 37-46). This traces the evolution of the Earth itself and introduces the children to a formal study of the evolution of life on this planet, a study that is continued with the 'Timeline of Life'. This timeline, generally introduced to third grade students, is a series of poster-sized panels that move them through the Paleozoic, Mesozoic and Cenozoic eras of the Phanerozoic Eon. These charts depict a representative sampling of animals and plants from the various eras and periods, and a mute chart with loose pieces allows the students to learn from hands-

on manipulation where each organism fits in the overall scheme of living creatures (METTC 2013c: 47-58).

Finally, the oldest children in lower elementary are introduced to 'First Classification' studies. This consists in a series of poster-sized charts to introduce them to the five-kingdom classification system and from which they can learn the principal characteristics of the different phyla, classes, and down to the level of orders for the most prevalent kinds of plants and animals. This at once reinforces the information from the Timeline of Life and gives characteristics that help explain the evolution and emergence of various groups of animals and plants without getting into a discussion of the mechanisms of evolution that would be beyond the developmental level of these young students (METTC 2013a: 62-85).

At the upper elementary level, the students begin (at the equivalent of 4<sup>th</sup> grade) with a study of the 'Vital Functions of Animals'. This consists in a series of materials to track the growing complexity of organisms in the animal kingdom along the evolutionary trajectory from single cell animals to mammals in relation to the functions of nutrition, respiration, circulation, support and movement, sensation, and reproduction (CMTE/NY 2012a: 7-21). This series of matching activities and accompanying descriptions provide a fairly dramatic lesson on the place of complexity in the forward movement of evolution as outlined by Christian in his course. It highlights the emergent characteristics at each higher level of complexity.

Students in the middle of upper elementary class do a more 'Advanced Classification' study, moving all the way down to the level of genus and species for some organisms and learning to distinguish for themselves the ways to separate one group of organisms from another with a nesting box system of materials. After doing this work with animals, many of the students are equipped to create their own classification nesting boxes for plants with a little guidance from their independent research (CMTE/NY 2012a: 62-71).

Finally, the oldest students at this level (equivalent to grade 6) study 'Human Biology,' surveying the anatomy and physiology of the systems of the human body dedicated to digestion, respiration, and circulation, the muscular-skeletal, immune and central and peripheral nervous system, and reproduction. Coming in the context of previous studies, this places the study of humans in the context of other developing life forms (*Ibid.*: 72-87).

Given the richness of this part of the Montessori curriculum, there are numerous pedagogical tools that are available to make the Big History chapter on the emergence of life and biological evolution comprehensible to younger students.

#### 4. The Story of Humans

This chapter in the Montessori story of Cosmic Education contains the remaining three thresholds of Christian's Big History course, with special attention to the first of the three, Creation of our Species. Lower elementary students in Montessori classrooms are first introduced to a study of the way humans track time, using materials to learn about the clock and the calendar, about our BC/AD timeline, and about how to count centuries. (METTC 2013c: 13-27).

A fascinating lesson in the midst of this study is the one called the 'Long Black Line,' where the teacher unrolls a 30-meter length of black yarn while she tells a summary version of the story of the planet Earth and its life forms, alerting students to watch for the change in color to red signifying the arrival of humans on the planet - which finally reveals itself in the last centimeter of the roll (METTC 2013c: 30). Maria Montessori is said to have developed this lesson to put in perspective the boasts of the antiquity of their civilization by her student-teachers in India.

Yet another dramatically impressionistic lesson consists in stretching out the tiny strip of red (indicating the presence of humans) at the very end of the Timeline of Life into a long red strip of cloth indicating the full scope of human history. A human hand clutches a handaxe about halfway through to signify that we are toolmakers. Children are asked to look for a change in color once again to indicate another significant development. At the very end of the lengthy strip of red cloth is a thin gold strip indicating the relatively brief time since humans have used the tool of writing (CMTE/NY 2012b: 21-23).

Students are first exposed to what we traditionally call world history through a series of studies called 'Fundamental Human Needs'. This begins with the identification of elements that we tend to consider essential for human survival, such as food, shelter, clothing, defense, transportation, and more spiritual needs such as art and religion (METTC 2013c: 31-36). Students use picture and card materials placed on a timeline to do a 'vertical' study that traces particular needs back in time (the deeper we dig archeologically, the older artifacts we find); then they compile all the information from the same time period - or horizontal level of the dig - to do a profile of a particular culture. The main point of the whole study is that all groups of human beings, in every place and time, have the same fundamental needs and simply meet them in different ways because of the time and place they live - human unity in diversity, a major theme of Cosmic Education.

At the upper elementary level, beginning in the equivalent of 4<sup>th</sup> grade, students formally explore the 'Timeline of Humans', beginning with a cladogram-aided search for our closest living relatives and then our

closest fossil relatives. In the process, they learn that we are at once alike and different from other animals. Through a series of materials, students learn about *Australopithecus*, *Homo habilis*, *Homo erectus*, *Homo sapiens neanderthalensis*, and *Homo sapiens sapiens*, focusing on their growing similarity to us and the characteristics that distinguish them from each other. (CMTE/NY 2012b: 13–40) As they move into the study of the ‘Timeline of Modern Humans’, they learn about the impact of the transition from a hunter-gatherer, nomadic, tribal society to the agriculture-based beginnings of settled village life. This is when humans moved out of the Paleolithic into the Neolithic, or new stone age period (CMTE/NY 2012b: 54–75).

Next, students at this level study ‘Ancient Civilizations’ of every continent. These lessons focus more on the way each group of people met their fundamental needs and went about their daily living than on the rulers, monuments and events like wars that helped define each people (*Ibid.*: 76–89). This sometimes leads into studies of the Middle Ages and the Renaissance in Western culture.

Finally, they study their own nation within the context of the preceding chapters of the story. For those in the United States, for example, the study of US History is preceded by a lengthy preface on Early Americans from the time humans first settled the continent. The study of American History itself is in the context of all that has gone before, making it just an example of ways in which a particular group of people once met and continue to meet their fundamental human needs (CMTE/NY 2012b: 90–121). The same would be true for students anywhere in the world studying their own nation.

### **Some General Remarks**

This survey of the Montessori curriculum contains many parts that are similar to what is taught in traditional schools (*e.g.*, Ancient Civilizations and U.S. History). However, there are other parts of the curriculum that are not usually taught to elementary-aged children (*e.g.*, The Life Cycle of the Stars and the Timeline of Early Humans). It is not unusual for Montessori elementary students to know as much about early humans, at least in broad outlines, as students in university level paleoanthropology courses. At a lecture of Donald Johanson at a local university in Georgia, Montessori elementary students interested in his account of the discovery of ‘Lucy’ were the only audience participants to raise their hands when Johanson asked if anyone knew the scientific classification of humans (and one 11-year-old Johanson called on recited the full classification flawlessly). Many of these non-traditional lessons for elementary children are needed to flesh out the comprehensive story of Big

History on its most basic level – and they are an integral part of Maria Montessori's concept of Cosmic Education. Even those parts of the curriculum that are similar to a traditional curriculum are taught in a different way:

- Lessons are given with materials, and students are expected to work independently with the materials to internalize the main ideas and to expand on them as their interest dictates. There are no textbooks or lengthy lectures in Montessori classrooms. Students are expected to be active explorers who discover information on their own once they have been introduced to an area of study.

- The Montessori curriculum moves from the big picture of the universe itself inward to the immediate surroundings of the child, rather than the traditional approach of beginning with the child and moving outward to family, classroom, neighborhood, city, country, and world. This means that everything is taught in a larger context for better understanding.

- The materials include a series of inter-connected timelines, starting with the Clock of Eons (the history of our planet), the Timeline of Life (the history of the evolution of life), the Timeline of Humans (the history of the emergence of humans), the Timeline of Modern Humans (the history of human development into the Neolithic period), and the Timeline of Civilizations (the recorded history of ancient people in every continent). Each timeline is an expansion of the final portion of the previous timeline. The pedagogical approach of using sequential, interconnected timelines could be put to good use at the middle or high school level as well to highlight the major events in the unfolding of Big History.

- There are large collections of 'classified card' materials, consisting of a picture, label, and definition, in the subjects of History, Biology, Geography and the Physical Sciences. These materials – in addition to being a tool for developing the reading skills of young students – offer a summary of the minimum amount of nomenclature and basic information students need to learn in each subject area, give students a means to learn independently of the teacher, and provide a stimulus to exploring a subject in further detail according to one's interest.

An elementary school does not have to become a Montessori school to teach elements of Big History. But the experience of Montessori schools with the Cosmic Education curriculum can provide any school with age-appropriate tools and strategies to teach the fundamentals of Big History and leave them better prepared for a deeper study at the high school and university levels.

Montessori teachers certainly have a lot to learn from the Big History movement, particularly in relation to the scientific discoveries of

the more than half century since Maria Montessori's death. Tools that could be particularly helpful are the Big History Project and Chrono-zoom; while developed with high school students in mind, they can be a rich resource for Montessori elementary teachers and their students. However, the Big History movement can also learn a lot from the more than century-old experience of Montessori pedagogy related to teaching elementary aged children the story of the universe and our place within it. Big History and Cosmic Education share the vision that we humans are truly 'Children of the Universe'.

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