MARIA MONTESSORI'S COSMIC STORIES AND CONTEMPORARY SCIENCE

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MARIA MONTESSORI'S COSMIC STORIES AND CONTEMPORARY SCIENCE

by Gerard Leonard

Gerard Leonard uncovers the living organic vision of Montessori scientific thought principles to ponder for our generation of Montessori: "To be ecoliterate is to understand the basic principles of ecology and to endeavor to live by them. Having a systems view of life, or what we would call in Montessori education, 'an understanding of the interdependencies in the natural and man-made worlds and between these worlds,' provides the framework within which the human values of justice, compassion, love, beauty, and peacemaking can be examined."

This talk was presented at the NAMTA conference titled Montessori History: Searching for Evolutionary Scientific Truth *in Cleveland, OH, April 20–22, 2018.*

Maria Montessori devised Cosmic Education as "a universal syllabus"[1] for children ages six to twelve years. Her decades of experience with children of this age told her that they wanted to understand the workings of their universe and that their seemingly endless how and why questions about the world could only be approached if we centered the children in the story of our universe as a whole. She wrote that the new generations must apply themselves to this universal syllabus of studies where "all items of culture must be concerned as different aspects of the knowledge of the world and the cosmos."[2]

> …it is through a childhood modified and freed from the ties of unconsciousness, of weakness, of psychic deviations and of ignorance, that it is possible to act by giving a new form of intellectual culture and by cultivating new sentiments for humanity. It is this later part, culture, that which represents the study to be carried out in schools, the universal syllabus that can unite the mind and the consciousness of all men in one harmony, that we intend by Cosmic Education.[3]

Cosmic Education is based on what Dr. Montessori called the Cosmic Theory. The theory derives from the thinking of the great Italian geologist Antonio Stoppani.[4] Stoppani was one of the first geologists to look at life as an integral component of Earth's geological processes. He also described modern human activity (since industrialization) as "a new telluric force which in power and universality may be compared to the greater forces of nature."[5] He wrote in his book *Acqua ed Aria* of the role of corals, foraminiferans, crinoids, and many other life forms and their incessant work in both building our islands and continental landmasses, and of their central role in preserving the purity of our water and air.[6]

The atmospheric chemist Paul Crutzen has called Antonio Stoppani the father of biogeochemistry.[7] The field of biogeochemistry studies the great cycling of chemical elements on our planet via interrelated biological and geological processes. The cycling of carbon, nitrogen, and water, for example, have now become areas of major concern because of the accelerating effects of human interventions in these cycles on the atmosphere, hydrosphere, and lithosphere, and the implications of climatic change

1 Maria Montessori, *Cosmic Education*, Lecture, India, 1946 in *The Child, Society and the World,* Oxford: Clio, 1989, 111.
2 Ibid.
3 Ibid.
4 Ibid. 106; Maria Montessori, *From Childhood to Adolescence,* Kalakshetra, Madras (Chennai), India: Madras Press, 1973 ,48.
5 See: Will Steffen, Paul J. Crutzen, and John R. McNeill, "The Anthropocene: Are Humans Now Overwhelming the Great Forces of Nature?" *Ambio,* vol. 36, no. 8, 2007, 614–621.
6 Antonio Stoppani, Acqua ed Aria ossia la purezza del mare e dell'atmosfera, Milan: Hoepli, 1882.
7 Paul Crutzen was a co-recipient of the 1995 Nobel Prize in chemistry for work in atmospheric chemistry, particularly concerning the formation and decomposition of ozone.

[Montessori] believed that a tendency towards harmony and the maintenance of balance on the planet as a whole was an important factor in evolution. Today many scientists point to the fact that not only ecosystems but the Earth itself demonstrates tendencies towards self-organization and self-maintenance in order to consistently work towards a state of homeostasis.

on human habitation, energy sources, and food production, and on the entire biosphere.[8]

Dr. Maria Montessori's genius brought these cycles, through the study of the work of creatures both living and extinct, into the consciousness and the hearts of children via stories of what she called their "cosmic tasks." By this term she meant the work of these creatures as they transformed their environments by living and dying but seen from the vantage point of Earth's total balance (what Montessori also called Earth's household or the telluric economy). The work, on a global (or cosmic) scale, of the sun, water, air, carbon, and other inanimate elements is also presented to the minds of elementary children in a way in which they can imagine their vast effects and explore various aspects through experiments and going-out into the natural world. She believed that a tendency towards harmony and the maintenance of balance on the planet as a whole was an important factor in evolution. Today many scientists point to the fact that not only ecosystems but the Earth itself demonstrates tendencies towards self-organization and self-maintenance in order to consistently work towards a state of homeostasis.[9]

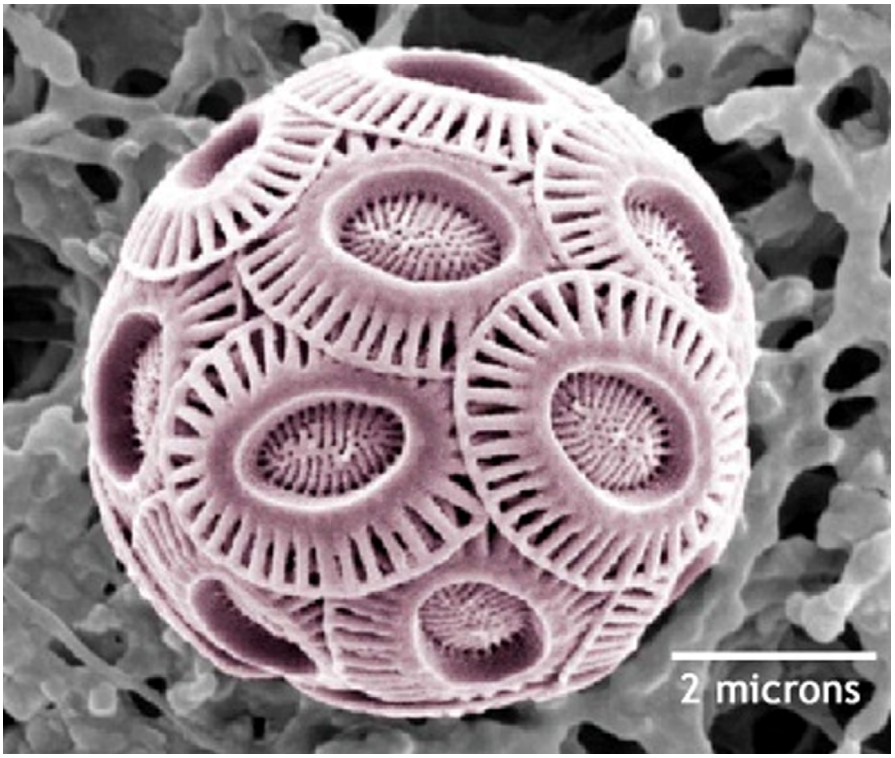

Image credit: Claudia Sprengel

Phytoplankton

Here is an example of a cosmic tale:

> Every early summer off the west coast of Ireland one can see from high up in space huge swirling turquoise patterns in the ocean below. These are made by a phytoplankton called *Emiliana huxleyi*. These little single-celled algae are only four thousandths of a millimeter in diameter and yet together they have been seen to cover an area of 100,000

8 William H. Schlesinger and Emily S. Bernhardt, *Biogeochemistry: An Analysis of Global Change*, Oxford: Academic Press, 2013.

9 Fritjof Capra and Pier Luigi Luisi, *The Systems View of Life*, Cambridge, UK: Cambridge University Press, 2014.

> square kilometers at this time of year. They are the "grass" of the ocean's food chain. The ocean blooms at this season with these little beauties because of nutrients that rise up from the sea floor. They shimmer and shine so beautifully because of their coccoliths, platelets made of calcium carbonate with gorgeous designs. We see their legacy in the cliffs of Antrim in Ireland and the famous white cliffs of Dover in England. The Irish naturalist Michael Viney has called these little beings "a shining star among organisms so vital to ocean life," but also, so vital "to the future of human comfort." What did he mean by this? Their photosynthesis generates oxygen both for the ocean water and for the atmosphere above. But these little fellows also help to balance our climate! "The shimmering armour that makes the blooms of coccolithophores so obvious reflects light and heat back into space rather than warming the ocean. One satellite study found an annual area of blooms covering 1.4 million square kilometers. And the algae's mass manufacture of coccoliths from calcium and carbon adds to the ocean's seabed store of carbon and affects the amount of carbon dioxide held in the atmosphere."[10]

The power of using such big numbers when describing the cosmic tasks of the very small is one method that Maria Montessori used extensively to fire the creative imaginations of elementary-aged children in order to help them visualize Earth systems on a global or cosmic scale, or to imagine the incredible networks of relationships one can observe under a microscope.

She wrote, "We can imagine how many there must be of those microscopic creatures that light up miles and miles of a tropic sea with phosphorescence, rivaling the stars on a clear night. In a single drop of water under the microscope one can detect hundreds of minute living things, what must be their number in the great ocean?"[11]

Montessori waxes lyrical about the work of the microscopic foraminiferans (the tiny zooplankton doing similar cosmic work to the coccolithophores) and she especially extols the work of the corals. The work of the corals, as exemplars of living beings performing a tireless work that for long ages have maintained the purity of our oceans, was extremely important to Maria Montessori. Her grave in Noordwijk in The Netherlands is surrounded by a necklace of corals. She used their role in the calcium carbonate cycle as a means of communicating a deep understanding of the great cycles of nature, and of the interdependencies within the biosphere. She wrote that to understand the nature of the work of such living beings in the cosmic order of things would also help us to better understand the work of children who similarly work tirelessly when given the freedom and the suitable environment needed to follow their natural tendencies.

Stories such as these are designed to inspire wonder and a sense of awe at the patterns, the order, and the harmonies that are revealed once one begins to look at the interrelatedness of things, whether on a grand scale or even on a small scale.

Dr. Montessori followed Stoppani in seeing humanity as a new geological force on the planet; such was the power of human beings to make changes on a scale only formerly seen in the work of enormous ice sheets or as a result of volcanic eruptions.[12] Antonio Stoppani had over a century ago come up with the term Anthropozoic Era to distinguish the uniqueness of the human presence in the Earth. Paul Crutzen is now well-known in the world of climate change studies for his delineation of the Anthropocene—a period beginning around 1800 with industrialization and the rapid growth of the use of fossil fuels.

> The term *Anthropocene* suggests that the Earth has now left its natural geological epoch, the present interglacial state called the *Holocene*. Human activities have become so pervasive and profound that they rival the great forces of Nature and are pushing the Earth into planetary 'terra incognita'. The Earth is rapidly moving into a less biologically diverse, less forested, much warmer, and probably wetter and stormier state.[13]

10 Michael Viney, "The Ocean Blooms," in *Reflections on Another Life,* Dublin: Irish Times Books, 2015.
11 Maria Montessori, *To Educate the Human Potential*. Madras (Chennai), India: Kalakshetra Press, 1973, 21.
12 See Maria Montessori, *Education and Peace,* Chicago: Henry Regnery, 25.
13 Steffen, Crutzen, and McNeill, "The Anthropocene," op. cit., 614.

In her book *From Childhood to Adolescence,* Maria Montessori noted that when elementary-aged children understood the workings of some of the great chemical cycles and the interrelationships, that an interest in research was activated and a natural philosophy was opened up in the enquiring minds of the children. In her concluding remarks she states:

> We have touched upon several cycles, as, for example, that of calcium carbonate. But all is interrelated. And what is interesting is to be able to orient ourselves among these correlations. To present detached notions is to bring confusion. We need to determine the bonds that exist between them. When the correlation among the notions, by now linked one to the other, has been established, the details may be found to tie together among themselves. The mind, then, is satisfied and the desire to go on with research is born.[14]

Research is a pivotal aspect of the human enterprise. Teilhard de Chardin speaks to this in his book *Building the Earth.*

> We must put in the forefront of our concrete preoccupations the systematic arrangement and exploration of our Universe, understood as the true country of Mankind…The time has come to realize that research is the highest human function.…[15]

It is quite extraordinary that Cosmic Education introduces children to the work of researching the intimate workings of their home planet. And this is primarily done through exploring in an all-inclusive manner that Montessori calls "the needs of growth and of life."[16] For example, the children's studies of the needs of the plant will include ventures into meteorology, hydrology, geology, biology, chemistry, and ultimately the cycles of biogeochemistry. This kind of research leads to ecological understanding.

We need human beings who are deeply connected to distant human beings and to other living beings and can see our planetary systems on a vast scale, that is, can overview large regions of the globe and also look into deep time. Dr. Montessori called this the development of "human solidarity in time and space" and pointed to this consciousness as a necessary element in "world reconstruction."[17]

> If we wish to bring to children knowledge of the real and material world, nothing can be more significant and accurate than the image of the tree that is human solidarity, rooted in a distant past and extending its branches towards eternity, while we live the infinitesimal second allotted to human life.[18]

In Cosmic Education we devote considerable time to stories and presentations, and experiments showing the work of water on a cosmic scale. The great hydrological cycle is presented in a way that integrates the cycling of calcium carbonate and the role of corals and other sea creatures in this work of planetary maintenance. An entire chapter in *From Childhood to Adolescence* is devoted to water. In this chapter Maria Montessori describes the work of life in the sea solving the cosmic problem of all the limestone carried to the sea by Earth's rivers.

From time immemorial, she writes, "there have been animals exercising this function…the task of seizing the excessive calcium carbonate and fixing it."[19]

Here is a story of water when viewed from a cosmic perspective:

> Water is very important. Water is found everywhere across our entire planet, as rivers and streams, as seas and oceans and lakes, as rain, as clouds, and as in the form of ice. Plants and animals drink water and many plants and animals and other kinds of living beings live in water. In fact, there is more life in the oceans than on land, and life began in the oceans many eons ago.

14 Montessori, *From Childhood to Adolescence,* op. cit., 97.
15 Pierre Teilhard de Chardin, *Building the Earth,* https://www.teilharddechardin.nl/oud/Teilhard-Earth.pdf
16 Ibid, 97.
17 Maria Montessori, "Human Solidarity in Time and Space," *AMI Communications,* 2003/4.
18 Ibid., 20.
19 Montessori, F*rom Childhood to Adolescence,* op. cit., 50.

Look at the globe and observe how much of the surface area of our planet is covered by water. Some people think our planet should be called "planet water" rather than "planet Earth"! When astronomers look for signs of life on other planets, one of the first things they look for is evidence of the presence of water.

Our oceans are vast and deep. Our tallest mountains could be placed into the deepest parts of our oceans and their peaks would not come above the surface. And life exists from the surface right down to the deepest parts. The largest mammal that has ever lived, the blue whale, which weighs as much a twelve school busses and can reach 30 meters in length, can live comfortably in the oceans of our world. And the tiniest of shelled creatures, such as the microscopic foraminiferans live in vast quantities in our oceans and have done so for millions of years. These and many other creatures do their work day in and day out. They never rest.

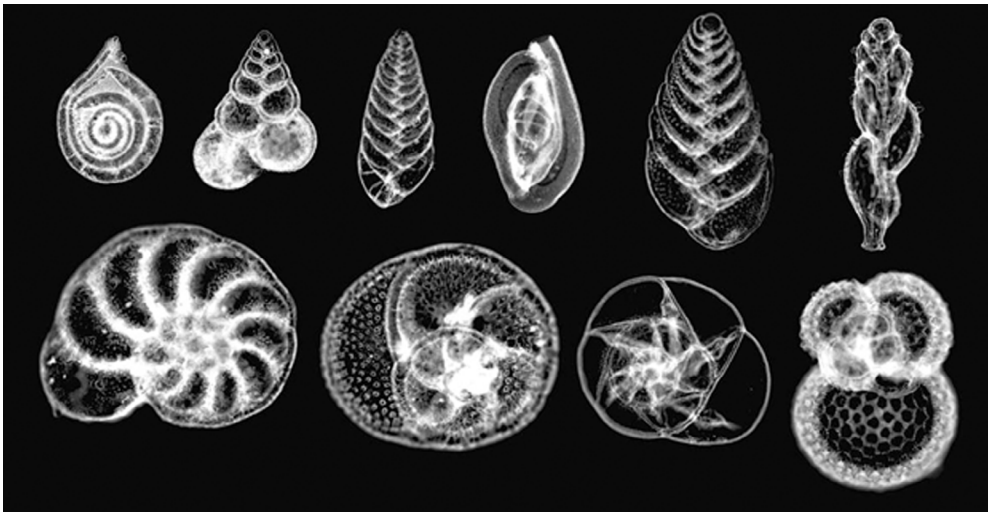

Image by GeologyCafe.com

Foraminiferans

Now, water has a very hearty appetite. Water's appetite is for rocks! When she falls as rain she combines with carbon dioxide gas in the atmosphere and forms a weak acid called carbonic acid. When the water then penetrates the Earth's rocks and flows as great rivers it carves the rocky surface and sculpts the landscape and even carves and sculpts underground in beautiful forms. Water is an artist! Water also carries enormous amounts of sediments to the sea. The sediments are deposited into the seas and oceans, and amazingly after thousands of years the sediments, which are so great they could build mountains many miles high, have not polluted the seas and oceans. That is because many living creatures doing their work of eating other creatures and plants have taken the sediments and built them into the hard parts of their bodies, into their shells for example, or into their exoskeletons. Scientists say that a very important substance in these sediments, called calcium carbonate or limestone, is being "buried" or "fixed" by these creatures. They are performing the task of keeping our water pure.

Enormous quantities of calcium carbonate have been carried to the oceans in solution and extracted by creatures such as foraminiferans, trilobites, sea lilies, mollusks, and the corals as they filter the ocean water. One little one-celled creature drinks as much water as if an adult human were to drink two cubic feet of water per second for a whole lifetime. So, such creatures work to purify huge volumes of water. They do something very important that we could not do. The corals have been doing this work for a long time. Let's look at our timeline of life and see when they began in the early Paleozoic Era. The corals and all kinds of shelled creatures have over millions of years built up islands and even huge mountains. Many mountains on Earth are mainly composed of the fossils of these marine creatures.

The corals need special conditions to do this work. They need ocean water of just the right temperature and they need the help of ocean currents, of tiny little algae that live

> on the coral, and of the many little shoals of fish they provide a home to, in order to stir the water in just the right way to bring their food and calcium carbonate in solution to them so they can continue to live and build their beautiful reefs. The Great Barrier Reef alone is the size of 25 states of Connecticut and is about 8,000 years old.[20]

This is part of the cosmic tale we tell about water and the calcium carbonate cycle.

Recent discoveries in biogeochemistry stress the tremendous importance of the calcium carbonate cycle, both the research into its evolutionary history and the research into its important role in the chemistry of the atmosphere and hydrosphere.

> …[the calcium carbonate cycle is] one of the most ancient biogeochemical cycles and one which reflects the profound geochemical and biological changes that have occurred as the Earth system has evolved through time.… [21]

> …biologically driven carbonate deposition provides a significant buffering of ocean chemistry and of atmospheric CO_2 in the modern system.[22]

Furthermore, we have now discovered that "the calcifying organisms that underpin the deep-sea carbonate sink are threatened by the continued atmospheric release of the fossil fuel CO_2 and increasing acidity of the surface ocean."[23]

It would appear that some 80 plus years after Dr. Montessori first wrote about the importance of calcium carbonate biogeochemical cycle[24] that its significance in our "universal syllabus," and in Cosmic Education, has not diminished but rather has become even more essential as we strive to better understand how to preserve the health of our water and air, of the coral reefs, and of the other calcifying creatures of our oceans. [25]

The fundamental idea of the cosmic theory of Stoppani promoted by Montessori is an integrated view of Earth's geology and biology, and the powerful geological scale effect of human life on the biosphere. This theory is increasingly being supported by the most recent studies in ecosystems science and biogeochemistry.

> …clearly, since the industrial revolution, humans have added more carbon dioxide to the atmosphere than the carbonate-silicate cycle or the ocean can absorb each year.[26]

> In the past 50 years, humans have changed the world's ecosystems more than in any other comparable period in human history.[27]

Maria Montessori understood that in order for children to construct themselves cognitively, ethically, and socially, they needed prepared environments and certain essential keys, so they could explore, order, name, and classify their world. For children under the age of six, she gave keys to the world in the form of sensorial materials. These "materialized abstractions" for color, size, length, weight, pitch, temperature, and so on are the keys for the child's mind to begin to classify their immediate natural and built environments. For children between six and twelve years old she said we should give the child keys to the universe. These keys have a sensorial basis but now the powerful creative imaginations and reasoning faculties of the minds of six- to twelve-year olds are also highly engaged in addition to the hands.

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20 Adapted from Montessori, *From Childhood to Adolescence*, op. cit., chapter on water.
21 Andy Ridgewell and Richard E. Zeebe, "The Role of the Global Carbonate Cycle in the Regulation and Evolution of the Earth System, *Earth and Planetary Science Letters,* vol. 234, no. 3–4 (2005), 300.
22 Ibid.
23 Ibid.
24 Maria Montessori, *Six Lectures on Cosmic Education*, 1935/36, London, in *AMI Communications* 2007–2009.
25 David Attenborough, *The Great Barrier Reef* (2015) and *The Blue Planet* (2001), BBC Films.
26 Schlesinger and Bernhardt, op. cit., 8.
27 Steffen, Crutzen, and McNeill, op.cit., 617.

One example of these keys are models for the elements hydrogen, oxygen, nitrogen, and carbon. These are given to the children as classic atomic representations each showing respectively, one, two, three, and four arms, thus indicating how they bond with other atoms to form molecules.[28] Montessori observed that it was through the process of exploring how the atoms of these elements combined (i.e., according to their valences) that the children's interest was aroused.

> The four elements we symbolize for the children in this way are, as it were, the key to the universe [H, O, N, C]. They are easy to remember because they have 1, 2, 3, and 4 lines. They do, in fact, make us think of keys. We could depict them in the form of bodies having arms capable of grasping one another… The way in which the elements unite is what maintains the attention of the child.[29]

For example, Montessori writes in considerable detail about how these elements are composed and decomposed in the "cycle of rocks" and of how the children become passionately interested to see what happens to the symbols in the various chemical reactions. She writes that the elements involved could be considered "as the keys that command the intimate movements of nature."[30]

"The four elements we symbolize for the children in this way are, as it were, the key to the universe." Maria Montessori

The choice of these four elements is interesting. They are still currently seen as the central elements involved in organic molecules, and carbon, hydrogen, and oxygen together with calcium and some others are important in many inorganic molecules.

Current microbiology, biogeochemistry, and other sciences attest to the importance of understanding the work of these four elements in Earth's laboratory. Two more elements have now been added to these four in order to complete the pantheon of major actors in the drama of life on Earth.

"Six elements, H, C, N, O, P, and S are the major constituents of living tissue and account for 95% of the mass of the biosphere."[31] This is how the current major text (2015) on biogeochemistry describes their relevance.

Of these six elements, Brian Swimme and Thomas Berry wrote in *The Universe Story:*

> Centuries of analysis have provided us with an unparalleled understanding of the role carbon plays. Besides carbon, life involves primarily, hydrogen, oxygen, nitrogen, sulfur and phosphorus. *To know this is to know something real and irreducible about the nature of life, something detailed, something essential*.[32] [author's emphasis]

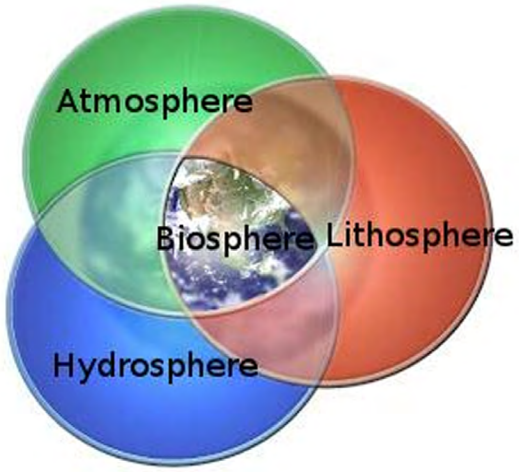
28 Dr. Montessori gave these elements impressionistic colors that connect them to their roles in the great cycles: H-blue (for water H_2O), O- red (for combustion/energy), N-pink (for flesh, life, and the nitrogen cycle), C-black (for coal).
29 Montessori, *From Childhood to Adolescence*, op. cit., 72, 74.
30 Ibid., 77.
31 Schlesinger and Bernhardt, op.cit., 15.
32 Brian Swimme and Thomas Berry, *The Universe Story*, 36-37.

Lynn Margulis wrote in her seminal book *Microcosmos*: "These six elements are now the chemical common denominator of all life, accounting for 99 percent of the dry weight of every living thing."[33] She added that "the flexibility of carbon is one of the great secrets of life on Earth."[34] Cosmic Education offers children the means to explore the wonder, the mystery, and the science of carbon, an element Montessori calls "one of the activators of the universe."[35]

The exploration of these elements and the way they combine and cycle through the spheres of the Earth lays the basis for what Thomas Berry has termed "ecological geography," the essential understanding of how planet Earth works.[36]

> The well-being of the Earth depends to an extensive degree on our understanding of the planet in its global extension, in its bioregional diversity, and in the intimacy of the component parts of the whole. We depend on this understanding of the Earth in all its diversity if we are to know how humans are to be present to the planet in some mutually enhancing manner. Such understanding is the proper role of ecological geography.[37]

The notion of a biosphere was first introduced by Eduard Suess and later developed by the Russian geologist Vladimir Vernadsky.[38]



> Vernadsky used for the first time the term biosphere in 1924, in his essay La Géochimie, which was based on a series of lectures he had given at La Sorbonne in 1922 and 1923. Philosopher and paleontologist Pierre Teilhard de Chardin (1881–1955), philosopher Henri Bergson (1859–1941), and mathematician and philosopher Le Roy (1870–1954) attended those lectures, and they and Vernadsky influenced each other's thoughts. It is the concept of biosphere related to biogeochemistry, expressed in La Géochimie, that is widely accepted today. Vernadsky understood biosphere as the external envelope of the Earth which is inhabited by living things and comprises both all the living organisms of the planet and the elements of inorganic nature providing the medium for their habitat. Thus, oxygen, carbon, hydrogen, nitrogen and other elements and chemical compounds involved in the vital process are constituent parts of the biosphere. As are the products of organisms' activities, such as animal burrows and lairs, birds' nests, deposits of lime and of fossil fuels. Even water is a component—a major component—of the biosphere [8]. Solar radiation, which is crucial for the maintenance of life on Earth, should be

33 Lynn Margulis and Dorion Sagan, *Microcosmos*, Berkeley: University of California Press, 1986, 48.
34 Ibid.
35 Montessori, *From Childhood to Adolescence*, op. cit., 73 (see chapter on carbon).
36 Thomas Berry, *The Great Work*, New York: Bell Tower, 1999. See chapter 8 on ecological geography.
37 Ibid., 96.
38 Vladimir Vernadsky, *The Biosphere.* (1929), trans. David B. Langmuir, edited by M. A. S. McMenamin, New York: Copernicus, 1998.

> considered also a biosphere's component, and so should products of human activities. In fact, the human species is a major changing force in the current composition of the biosphere.[39]

Maria Montessori was also aware of the concept of the biosphere and of its central role in presenting the universe to the child's imagination.[40] The contemporary Gaia theory of James Lovelock comes close to the way Montessori describes the biosphere.[41] Montessori also spoke of the psychosphere in a manner similar to the way Vernadsky, de Chardin, and le Roy spoke of the noosphere, a term they invented in 1924 to describe the world of thought, human knowledge, and technological communication skills taking shape around the planet and in turn shaping its future.[42] This latter sphere has

expanded greatly over the last couple of decades and its integration presents new possibilities and new challenges. The new Systems View of Life seeks to unite the biological, the cognitive, and the social dimensions into one unified conception of life and consciousness.[43]

Montessori wrote:

> Life is considered by the geologist as an additional sphere surrounding the Earth. Besides the hydrosphere and the atmosphere there is also the immense multitude of vital energies that forms the biosphere. Were it not for these, were the Earth abandoned to the mercy of non-living energies, it would soon be plunged into the primitive chaos, in the confusion of elements. Humanity must have been allotted a major part towards the fulfillment of the common purpose. Its multitudes cover the Earth, contributing a new energy: the additional envelope of a psychosphere, which participates in the perfecting of nature.[44]

> Current thinking in the field of ecological literacy stresses the importance of not just comprehending the workings of ecosystems but of understanding that we are participants in a global system, a biosphere. Over the past 50 years or so the sciences of ecology and biogeochemistry have expanded their knowledge of how living systems great and small operate. Indeed, many scientists now see evidence that the Earth as a whole system is a self-generating, self-organizing, and self-maintaining system.[45]

The new Systems View of Life has, over the past 30 years, been stepping to the forefront of science. There have been major shifts in thinking. Some of these would include a change of perspective from parts to the whole, a multidisciplinary approach, an understanding that relationships are more important than objects, and that processes and networks must be understood in order to understand structures.[46] Maria Montessori's Cosmic Education perspective integrates fairly seamlessly with this new thinking.

Maria Montessori has given us beautiful, imaginative ways to open the child's mind and heart to seeing the Earth as what we might now call "a living system." It is clear that her vision in this regard was far ahead of her time. Recent discoveries and environmental crises point to the necessity of bringing this cosmic perspective to the next generation.

She writes in *To Educate the Human Potential*:

> …the 'Biosphere,' or sphere of life…is as intimately part of the Earth as the fur is of an animal, not something which suddenly rained on the Earth from outside. Part, then, of

39 Mercè Piqueras, "Meeting the Biospheres," *International Microbiology,* vol. 1, no. 2 (1998): 165–170.
40 Montessori, *To Educate the Human Potential*, op. cit., 28–29.
41 Capra and Luisi, op. cit., 67, 348.
42 Steffen, Crutzen, and McNeill, op. cit., 615.
43 Capra and Luisi, op. cit., 297.
44 Maria Montessori, "The Unconscious in History," *The NAMTA Journal,* no. 2 (1998).
45 Ibid., 349.
46 Ibid., 80–83.

> the Earth's body, like an animal's fur, is essentially one with it, its function is to grow with it, not only for itself, but for Earth's upkeep and transformation.[47]

She proceeds to describe how the truth that life is a cosmic agent can be presented to children's imaginations. Montessori describes using the power of large numbers to bring the child's mind to see the vastness of animal life on land, in the sea, and in the air, and the work of the "infinitely small beings…the microbes."[48]

Fritjof Capra and Pier Luigi Luisi writing in the 2014 text *The Systems View of Life* stress the necessity of what they call "an education for sustainable living."

> In the coming decades the survival of humanity will depend on our ecological literacy—our ability to understand the basic principles of ecology and to live accordingly. This means that ecoliteracy must become a critical skill…and should be the most important part of education at all levels—from primary and secondary schools to colleges, universities… and the training of professionals. We need to teach our children the fundamental facts of life—that one species' waste is another species' food; that matter cycles continually through the web of life; that the energy driving the ecological cycles flows from the sun; that diversity assures resilience; that life from its beginning more than 3 billion years ago, did not take over the planet by combating but by networking.[49]

To be ecoliterate is to understand the basic principles of ecology and to endeavor to live by them. Having a systems view of life, or what we would call in Montessori education "an understanding of the interdependencies in the natural and man-made worlds and between these worlds," provides the framework within which the human values of justice, compassion, love, beauty, and peacemaking can be examined.

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The principles to be understood and experienced as outlined by those currently defining ecoliteracy are:

- Interdependence
- The cyclical nature of ecological processes
- The importance of solar energy
- Partnership (cooperation and co-evolution)[50]
- Flexibility
- Diversity[51]

Montessori wrote that we have to develop an "eye that sees" patterns and harmonies in nature and in the built environment, in botany, zoology, geology, astronomy, and also in geometry, architecture, music, visual arts, dance, and poetry. An ecological mind and heart are multidisciplinary.

E. O. Wilson has recently written in his book *The Origins of Creativity* of the central importance at the present time of both scientists and scholars in the humanities working together, blending the best

47 Montessori, *To Educate the Human Potential,* op. cit., 28–29.
48 Montessori, *From Childhood to Adolescence,* op. cit., 29–33, 74, 91–92.
49 Capra and Luisi, op. cit., 356.
50 "Life did not take over the globe by combat, but by networking." (Capra, op. cit.)
51 Flexibility allows for adaptation to changing conditions and diversity relates to the importance of a multiplicity of feedback loops. (Capra op. cit.)

and most relevant insights from these great branches of learning to give us a better understanding of our human condition and our relationship with the natural world.

Here are Maria Montessori's own words as scientist and poet, as she describes the cosmic task of water:

Continents dissolve into the sea,

and seas yield to growing land.

Fantastic stalagmites and stalactites in caverns,

snow white towers and

pinnacles of glittering salt,

and turfaceous formations of marvelous colors

…the toiler for all this beauty

has been Water.

Water is the great builder, creating and transforming.

Drop by drop it leaves behind the load it was carrying.

It hurries in love to the ocean,

bearing gifts,

purifies itself,

floats to heaven in its lightest form, to return as rain,

and begin work again. [52]

There are several areas for further research which could add to our depth of understanding of Cosmic Education.

An expanded investigation of the biogeochemical cycles as understood by contemporary science, and the interrelatedness of the different cycles as could be discovered by elementary children.[53]

The children's work with the key elements in relation to the Montessori Needs of the Plant chart and related botany experiments leads naturally to a study of the periodic table of the elements. Montessori poetically alludes the periodic table as the alphabet of creation.[54] We now know so much more about this alphabet of the elements; their origins, their functions, and the stories of their discoveries. The exploration of the periodic table as it relates to both the physical and life sciences can be an important area of work for elementary children.

52 Adapted as a poem from Montessori's *From Childhood to Adolescence* op. cit., chapter on water.

53 Montessori charts for the carbon and nitrogen cycles developed at The International Centre for Montessori Studies in Bergamo deserve study in the light of our new understanding of the educational necessity of understanding these and other biogeochemical cycles.

54 Montessori, *From Childhood to Adolescence,* op. cit., 72, 84. 2019 is The International Year of the Periodic Table of the Elements.

Maria Montessori was well aware of the amazing work of the microbes (microorganisms) and writes about their essential work.[55]

Here is a short cosmic tale from a very special little microbe:

> I am a tiny microbe, a microscopic bacterium. Some call me the ferruginous microbe. My scientific name is *Gallionella ferruginea.* My species name comes from the Latin word *ferrum,* meaning iron, because we ferruginous microbes while living our lives and doing our work deposit iron. Scientists say, "we fix iron." You may have noticed the enormous deposits of iron in the Carboniferous Period on your Timeline of Life. That is because one of your great human scientists, Dr. Maria Montessori, knew about our important work. She dignified us by saying we were "a humble worker in Earth's laboratory." She said that my friends and I "performed an essential task in Earth's household economy." Please remember me when you see reddish-brown strata in rocks. And when you see the letters Fe on the Periodic Table of the Elements, think of me…the ferruginous microbe.[56]

> Many good and beautiful things owe their existence to the contact with microbes…[57]

> In order to fix the idea of these special tasks of life we call it the cosmic work of each being. A cosmic task is carried out by every being, even those that are microscopic. If we consider these different cosmic tasks we shall find that they are all interrelated.[58]

We now know so much about the microcosm, its evolutionary history during the Archaean and Proterozoic eons, and the essential role of microorganisms today in the maintenance of the planet. These amazing stories can be easily integrated into our biology, history, and geography presentations for older elementary children and into their own studies and research.[59]

The idea of the universal syllabus of studies, of a Cosmic Education, is clearly a great gift to future generations of children. Noel Laureate Paul Crutzen has written (2007) that the next few decades "will surely be a tipping point in the evolution of the Anthropocene" and that "humankind will remain a major geological force for many millennia."[60] Given this reality we must redouble our efforts to bring Cosmic Education to all of the world's children.

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55 Ibid., 74, 91–93 and Montessori *To Educate the Human Potential,* op. cit., 48–49.
56 Ibid., 48–49.
57 Montessori, *From Childhood to Adolescence,* op. cit., 92.
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59 See Big History: Threshold 5 Life, school.bighistoryproject.com
60 Steffen, Crutzen, McNeill, op. cit., 620.

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