Journey of the Universe - Introduction

Curricular Materials Prepared by
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Overview:

The *Journey of the Universe* film, book, and *Conversations* are part of an expansive, multidisciplinary project that can be used by educators and others to develop a sense of embeddedness and identity within the unfolding universe. This deep sense of belonging and participation can, in turn, not only help students to come to a more meaningful understanding of their own place and role in the story of the universe, but it can also empower them to participate in the story in a way that is mutually enhancing for the human and for the larger Earth community in which we reside.

At first glance, the epic time-scale, the breadth of scientific knowledge, and the deep understanding of history and ecology that is needed to teach the *Journey of the Universe* might appear to be overwhelming. However, a complete understanding of these aspects of *Journey of the Universe* is not required in order to teach these materials effectively. In fact, we are at a transition point in history in which most of us are discovering this new story of the universe for the first time. We have only recently developed the tools and scientific knowledge to understand the world about us; we are all learners. For most educators, teaching *Journey of the Universe* will be a cooperative project, where students and teachers learn side by side as they journey together through the book, film, and *Conversations*. To assist you, we have created a series of scientific summaries, discussion questions, and resources to help you get started. The curricular materials here are primarily designed to accompany the *Journey of the Universe* book (Yale University Press, 2011) and film.

Grade Level:

The *Journey of the Universe* curriculum is primarily designed for use in undergraduate classrooms, in upper-level high school classrooms, in learning centers, in places of worship, and at conferences.

Teaching Philosophy:

While the curriculum provided here is focused on intellectual engagement and discussion, we encourage the use of multiple learning modalities. Art, song, hands-on learning projects, self-reflection, kinesthetic activities and experiences, poetry, and many other forms of teaching and learning can be used. We urge you to be creative in your teaching.

Teaching Goals:

The *Journey of the Universe* curriculum is designed with four broad goals in mind. After reading the book, watching the film and *Conversations*, and using the *Journey of the Universe* curriculum, students should be able to:

1. Understand and express a basic understanding of the unfolding of the universe, Earth, and humans by drawing upon both science and the humanities.
2. Experience a sense of embeddedness and orientation within the evolutionary development of the universe. Students should feel, as the film suggests, that "We belong here. We have always belonged here."
3. Integrate the ideas found in the film, book, and *Conversations* with other areas of knowledge and their own life experiences.
4. Develop a sense of meaningful empowerment and participation in the epic of evolution. Students should feel equipped to participate in this immense journey in a way that is mutually enhancing for both humans and the Earth.

Contents:

The eleven curricular pieces that accompany this introduction each contain the following elements:

1. Index: Each curricular piece is organized thematically to coincide with the chapters found in the *Journey of the Universe* book (e.g. "Beginning of the Universe," "Life's Emergence," "Emerging Earth Community," and so forth). For your convenience, we have listed the corresponding scenes from the film and *Conversations* that supplement that particular chapter in the book.
2. Scientific Summary: Each curricular piece contains a brief summary of the science found in that portion of the book and film.
3. Discussion Questions: A short set of discussion questions are provided. They may be modified to suit your students' needs.
4. Online Resources: A short list of online resources for each section of curriculum is provided in each curricular piece. These resources may aid your search for other videos, audio files, books, charts, timelines, and images needed to add depth and breadth to your teaching.
5. Print Resources and Select Bibliography: These two sections of each curricular piece highlight pertinent books and bibliographic resources that can be used to enhance your teaching or the research of your students. **There is an extended bibliography on the *Journey of the Universe* website.** It is organized from the unfolding of the early universe, through galaxies, stars, and planets, to the present day.

Related Courses and Resources:

The Epic of Evolution:

- Eric Chaisson, an astrophysicist, has taught a course on cosmic evolution since 1976. Download the syllabus for his course entitled "Cosmic Evolution: The Origins and Matter of Life" or visit the course website for videos, graphics and animations, a glossary, and a wide variety of educational resources related to cosmic evolution.
- Ursula Goodenough, a professor of Biology at Washington University in St. Louis, has been teaching a course on the Epic of Evolution for more than 10 years. Visit the course website for a description of the course, a syllabus, and for other pertinent teaching materials.

Big History

- David Christian, a historian at Macquarie University in Sydney, Australia, has published and lectured widely on the topic of "Big History." He is the author of Maps of Time (University of California Press, 2005) and he leads the educational content development for the Big History Project. He is considered the originator of the newly emerging field of "Big History" which expands world history to include the evolution of the universe and Earth.
- Cynthia Stokes Brown has been teaching, and writing about, the "Big History" approach to understanding the evolution of the universe, Earth, and humans for more than twenty years. She teaches at the Dominican University of California where students begin their college education with two courses in "Big History" in a program called the First Year Experience "Big History." A PDF of her syllabus is available on the *Journey of the Universe* website.

Genesis Farm and the Charter School:

- For more than three decades, Sister Miriam MacGillis and her colleagues at Genesis Farm have been educating through the Genesis Farm Eco-learning center and the community supported garden. They have offered hundreds of workshops and courses on the universe story and educated many people in North America, as well as in England, Ireland, and Australia.
- The Ridge and Valley Charter School is an elementary charter school affiliated with Genesis Farm whose curriculum is based on themes of Earth literacy and sustainability within the context of the universe story. You can download a PDF of their curriculum on the *Journey of the Universe* website.
- Drew Dellinger is a spoken word poet who has written poetry and given workshops on the universe story for 20 years.
- Jennifer Morgan has written an award-winning trilogy of children's books based on the universe story.

- A number of interviewees in the *Journey of the Universe Conversations* describe their experience teaching the story of the universe. For the past 20 years, Tom Collins has been a dedicated teacher of the story of the universe at the secondary school level. Other interviewees who describe their experience teaching the story of the universe include Marya Grathwohl, Sachiko Kawaura, Belvie Rooks, and Bindu Mohanty.

Curriculum Updates:

The curricular materials provided on the website represent the first stage in the creation of the *Journey of the Universe* curriculum. We will be expanding the teaching materials with contributions from those already teaching the *Journey of the Universe*, with lesson plans and activities, and with more resources, discussion questions, and study guides. Please check our website for future curricular updates.

We encourage you to share lesson plans, syllabi, useful websites, activities, and other curriculum related resources with us. Additional resources can be sent to matthew.riley@yale.edu

Beginning of the Universe

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Scientific Summary:

The universe emerged 13.7 billion years ago in a moment that is commonly called "the Big Bang," but which we refer to as a "great flaring forth." In the earliest moment of the great flaring forth, all of the matter, energy, space, and time of the observable universe rushed out from a single, dense point. It was a moment of great heat, reaching trillions of degrees, in which boundless amounts of light and heat expanded quickly outwards.

While our universe is certainly expanding, as was observed by Edwin Hubble in the 1920s, there were also strong powers of attraction at play in the early development of the universe. From the very first moments, gravitational, strong nuclear, weak nuclear, and electromagnetic interactions played a role in shaping the unfolding of the universe

Within the first few microseconds of the beginning of the universe, tiny elementary particles called quarks and leptons were brought forth. The quarks quickly combined into protons and neutrons. Energetically churning about and colliding with one another, these first particles formed a dense, gluey form of matter called plasma.

After a few minutes, the protons and neutrons began to combine together in small clusters, called nuclei. These nuclei were constantly torn apart by the violent collisions caused by the vast energy of the early universe. A great deal of energy was expended in these collisions and breakages, some of which took the form of intense flashes of light. Due to the rapidity of these interactions and the density of the early universe, if we could observe it at this point in its expansion it would appear to be a profoundly luminescent, smooth burst of light.

As the universe expanded, it cooled. Due to this rapid decrease in density and temperature, conditions became hospitable to more complex formations of elementary particles called atoms. The hydrogen and helium atoms are the most common of the galaxy and they are, at least in some sense, the building blocks upon which the other atoms are built. In these early stages of the universe, hydrogen and helium were the first to atoms to form from the vast ocean of light and energy of the great flaring forth. While hydrogen and helium make up the vast bulk of atoms in the universe, small amounts of other atoms formed at this time such as lithium. The formation of these first atoms, the early interactions between energy and matter, and the creative interaction between forces

of attraction and repulsion set the stage for the formation of more complex structures including galaxies and stars.

Discussion Questions:

1. The *Journey of the Universe* book says that cultures organize themselves around stories about what they hold to be valuable, beautiful, and essential. Identify some of the values that are embedded in this "universe story." Imagine a future time when this or similar universe stories are told throughout the planet. Would their telling have any effect on the form and functioning of society?
2. The entire universe, even from these very first moments, has always been bound together by forces of attraction such as gravity. How would the universe story change if these forces of attraction did not exist? Identify some of the forces of attraction in the human realm. How would society change if these were to cease to exist?
3. In the *Conversations*, Joel Primack tells us that "almost everything in the universe is invisible." What does he mean by this?
4. What part of this story evokes awe or wonder in you?
5. Take an image, scene, or paragraph from *The Journey of the Universe* film, book, or *Conversations* that you feel conveys an important idea in regards to the first moments of the observable universe. Using an appropriate medium (i.e. prose, poetry, dance, painting, music, the spoken word, etc.), reformulate and express this idea in your own way. After doing so, reflect on how that helped you to better understand the great flaring forth.
6. The *Journey of the Universe* book uses the image of a seed to describe the development of the early universe. What other images occur to you? Does the choice of an image or metaphor to describe a process in the universe affect the way we think and feel about the process?
7. What aspects of your existence were actually present at the Flaring Forth? What does this imply about who you are and your relation to the cosmos?

Online Resources:

- The Wilkinson Microwave Anisotrophy Probe (WMAP), launched in 2001, has brought back some of our most revealing data regarding the early moments of the universe. It has mapped the Cosmic Microwave Background, which is light from the beginning of the universe. And, it has provided countless pieces of data which has allowed scientists to accurately discern the age of the universe (13.73 billion years old); it allowed scientists to determine the exact amounts of dark matter, dark energy, and ordinary matter in the observable universe; and it allowed them to determine what occurred in the first trillionth of a trillionth of a second of the great flaring forth. A predecessor to WMAP was the Cosmic Background Explorer (COBE), which was launched in 1989. Also be sure to explore the website for the Planck mission.

- Much of what we know about the first moments of the universe as well as the formation of the first particles comes from projects such as the Large Hadron Collider (LHC).
- The Hubble Telescope is one of our greatest tools for observing galaxies and stars from the early moments of the universe. Visit the Hubble Telescope website for an interactive tutorial features videos, animations, and images depicting the attractive force of gravity, early supernova, and more moments from the early universe as seen through the Hubble Telescope.
- The National Aeronautics and Space Administration (NASA) has a page on the first moments of the universe as well a page on dark matter and dark energy that can be used to accompany Joel Primack's discussion with Mary Evelyn Tucker in the *Conversations*.
- A variety of images, educational videos, and news on the formation and observation of the universe can be found at the California Institute of Technology's website for the Spitzer Space Telescope. Students can explore similar resources from the Chandra X-ray Observatory such as videos and podcasts.
- The Hayden Planetarium hosts a number of useful educational tools such as the Digital Universe Atlas, the Astrophysics Visualization Archive, and a plethora of useful links, news items, multimedia and programs such as this video on Cosmic Microwave Background.
- NASA's "Astronomy Picture of the Day" website features daily pictures of galaxies and other astronomical bodies. Each photograph is accompanied by explanations, links, and other useful information written by professional astronomers. This photo of Cosmic Microwave Background from the WMAP is an importance piece for understanding the great flaring forth.
- Go to the Yale Forum on Religion and Ecology's website for a comprehensive list of links to scientific organizations and educational resources.

Print Resources:

- *Journey of the Universe* Bibliography.
- Bibliography on Cosmogenesis from the Yale Forum on Religion and Ecology.

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The Formation of Galaxies

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Scientific Summary:

Approximately 13 billion years ago, less than a billion years after the beginning of our observable universe, vast clouds of atoms began to coalesce into the first galaxies. Expansive density waves, which are fluctuations in the density of matter that emerged out of the great flaring forth, helped to shape the early galaxies from the billowing clouds of matter.

Within a billion years of the formation of the first galaxies, more than 100 billion had been formed. While they come in many configurations, the vast majority of the known galaxies in the universe take the shape of either spiral or elliptical galaxies. Our own galaxy, the Milky Way, is a spiral galaxy. The spiral shape allows for a great deal of new stars to be born from the continued action of density waves on the matter present in the spiral arms. These interactions are largely absent in elliptical galaxies. Most of the stars in non-spiral galaxies will eventually die out without being replaced by newly formed stars.

When we look into the night sky or when we utilize powerful telescopes such as the Spitzer Space Telescope or the Chandra X-ray Observatory, much of what we are able to see is the light and energy created by the billions of stars contained in each of the billions of galaxies. But there is more out there than meets the eye. Held together by gravitational forces, approximately ninety percent of the mass of galaxies is composed of what scientists commonly refer to as dark matter. The remaining ten percept of the mass of each galaxy is composed of stars, gas, stellar remnants, and dust.

Many galaxies, such as our own Milky Way, bulge in the center. Within this central bulge one can frequently find a black hole. While they cannot be observed with the naked eye, black holes are a common occurrence throughout the known universe. Black holes can form in many different ways, but they are typically created when stars cannot maintain high enough levels of internal heat and pressure to resist the gravitational pull of their own mass. Literally imploded by their own weight, black holes are stars that have collapsed in upon themselves. When a black hole is formed, a boundary called an event horizon is reached in which matter and light can no longer travel outward from the singularity, or central mass, of the black hole. Since light cannot escape the gravitational

pull of the black hole, we cannot "see" them in the traditional sense. Black holes are predicted by Einstein's theory of General Relativity.

The Milky Way galaxy is one of several dozen galaxies revolving around one another and these galaxies are a part of a larger group of galaxies called the Local Group. The Local Group is comprised of more than thirty galaxies including the three galaxies nearest us: the Large Magellanic Cloud, the Small Magellanic Cloud, and the Andromeda Galaxy. The Local Group, as well as many other clusters of galaxies, is part of an even larger system called the Virgo Supercluster.

Each galaxy and larger cluster of galaxies is in a state of constant motion and change. Collisions between galaxies are not uncommon. Only recently, after the a number of remarkable 20th century discoveries such as the first observation of galaxies outside of our own Milky Way by Edwin Hubble in the 1920s, did we learn that we live in an expanding universe. Over the course of 14 billion years, the observable universe has expanded from a size smaller than a grain of sand into the vastness of a trillion galaxies spread out over many billions of light-years.

Discussion Questions:

1. What caused the clouds of gas and atoms formed during the initial flaring forth to coalesce? How do these forces and events continue to shape new galaxies and stars today?
2. Each culture has its own understanding of the origins of the universe. Choose one or two traditional, cultural explanations for the universe and compare and contrast the cultural explanation to the scientific story.
3. How does the formation and destruction of hundreds of billions of galaxies relate to your lives today? How does one orient oneself in relationship to this vast and ongoing process?
4. What different shapes and configurations do galaxies come in? Do different shapes of galaxies impact the level of creativity possible in those galaxies? Why or why not?
5. What is the shape of our own galaxy, the Milky Way?
6. Does the discovery that we live in an evolving and constantly expanding universe change they way that you think about life on Earth? How does it change your thinking? What questions does it raise for you?

Online Resources:

- The Hubble Telescope is one of our greatest tools for observing distant galaxies. Visit the Hubble Telescope website for images, tutorials, and videos explaining the Hubble Deep Field and the Hubble Ultra Deep Field.
- The National Aeronautics and Space Administration (NASA) has a page on galaxies.
- A variety of images, educational videos, and news on the formation and observation of galaxies can be found at the California Institute of Technology's

website for the Spitzer Space Telescope. Students can explore similar resources from the Chandra X-ray Observatory.

- The Hayden Planetarium hosts a number of useful educational tools such as the Digital Universe Atlas, the Astrophysics Visualization Archive, and a plethora of useful links, news items, and programs relating to the formation of galaxies.
- NASA's "Astronomy Picture of the Day" website features daily pictures of galaxies and other astronomical bodies. Each photograph is accompanied by explanations, links, and other useful information written by professional astronomers. This photo of two galaxies colliding is featured in the *Journey of the Universe* film.

Print Resources:

- *Journey of the Universe* Bibliography.
- Bibliography on Cosmogenesis from the Yale Forum on Religion and Ecology.

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The Emanating Brilliance of Stars

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Scientific Summary:

Stars are formed when clouds of hydrogen and helium implode from the gravitational pull of their own mass. As the atoms draw closer and closer together, they collide and vibrate energetically. The dual increase in density and collisions causes conditions to become hotter and hotter. After reaching temperatures of several thousand degrees, the atoms of helium and hydrogen in these collapsing clouds of gas begin to break apart into their constituent elementary particles – protons and electrons. At this point in time, this hot dense cloud of interacting elementary particles is called a protostar.

Once temperatures reach approximately ten million degrees, the protons and neutrons begin to fuse into new stable relationships in a process called thermonuclear fusion. The nuclei of hydrogen atoms repel each other. However, when the power of the gravitational attraction is strong enough within the interior of stars, the individual nuclei of hydrogen atoms can fuse into more complex formations such as helium. A massive amount of energy is released in the center of the star through this process. The release of this energy is a force of expansion by which stars resist further collapse. As long as this expansive energy and gravitational attraction are kept in creative tension, the star can exist for billions of years. Once one of the powers becomes more powerful than the other, the star comes to an end.

Once all of the hydrogen has been converted to helium, this fusion process comes to a halt. Without the force of thermonuclear fusion pushing out from its interior, the star collapses further until the temperature escalates to a high enough level for helium to begin fusing into carbon. This process continues to repeat itself as each element is used up through fusion. For instance, once all of the helium in a star has been converted to carbon, the core of the star shrinks in upon itself and the temperature rises dramatically until carbon begins to fuse into oxygen. Next, oxygen is fused into silicon and this process continues through the heavier elements up until only iron remains in the core of the star. At this point, the star can only implode in upon itself.

When a large star collapses in upon itself, all of the atoms and nuclei in the star are dismantled as the star precipitously shrinks to a tiny speck. The energy of the implosion is so great in this collapse that the protons and electrons join together to form neutrons. However, the massive amount of energetic neutrinos released in this process

causes the collapse to reverse so violently that the star is blasted apart. The resulting shockwave throws all of the star's matter out in a massive explosion called a supernova. This explosion is so powerful, in fact, that supernovas observed from Earth often outshine all of the hundreds of billions of stars in their own galaxy. During this expansion stage of supernovas, a new round of stellar nucleosynthesis takes place. All of the nuclei of all of the elements in the universe are created in these moments. Every atom of carbon, oxygen, gold, calcium, phosphorous, and the many other elements found on Earth and in our bodies are created in the death of stars.

Discussion Questions:

1. In the *Journey of the Universe* book, Brian Thomas Swimme and Mary Evelyn Tucker state that it is significant that "stars are self-organizing processes" (27). What do they mean by this and why is it a significant discovery?
2. What is fusion and what does it do? Use both the *Journey of the Universe* book and the *Conversations* featuring Todd Duncan to explore this concept.
3. As Carl Sagan has famously said, "we are all made of starstuff," or, as Brian Thomas Swimme and Mary Evelyn Tucker put it in the *Journey of the Universe* book, "the stars are our ancestors" (29). What do they mean by this? Does learning this change the way you think and feel in relationship to the larger universe?
4. In the *Journey of the Universe* book and film, the authors describe the universe as being in state of constant creative tension. How does the life of stars exemplify this observation? Does thinking about creative and destructive forces as existing in tension and as being a seedbed of creativity change your perceptions of how the universe works?
5. In the *Conversations*, Joel Primack talks about the formation of planets around stars. How do we observe these planets? What tools are necessary to observe the formation of stars and planets?

Online Resources:

- The Hubble Telescope is one of our greatest tools for observing galaxies and stars from the early moments of the universe. Visit the Hubble Telescope website for images, tutorials, and videos explaining the Hubble Deep Field and the Hubble Ultra Deep Field. This interactive tutorial features videos, animations, and images depicting the attractive force of gravity, early supernova, and more moments from the early universe as seen through the Hubble Telescope.
- The National Aeronautics and Space Administration (NASA) has a page on stars and stellar evolution.
- A variety of images, educational videos, and news on the formation and observation of stars can be found at the California Institute of Technology's website for the Spitzer Space Telescope. One useful feature is the interactive

guide to the stars found here. Students can explore similar resources from the Chandra X-ray Observatory such as videos and podcasts.

- The National Aeronautics and Space Administration (NASA) website has an educational page on stellar nucleosynthesis. Scroll down to the bottom of the page for news items as well as for activities and lesson plans aimed at 9^{th}-12^{th} grade learners.
- The Hayden Planetarium hosts a number of useful educational tools such as the Digital Universe Atlas, the Astrophysics Visualization Archive, and a plethora of useful links, news items, multimedia and programs such as this short video on the formation of a star cluster.
- NASA's "Astronomy Picture of the Day" website features daily pictures of stars and other astronomical bodies. Each photograph is accompanied by explanations, links, and other useful information written by professional astronomers. This photo of matter blasted out from a supernova shows the dispersion of elements through the death of a star. This remarkable photo of Tycho's supernova remnant is also worth noting.
- Go to the Yale Forum on Religion and Ecology's website for a comprehensive list of links to scientific organizations and educational resources.

Print Resources:

- *Journey of the Universe* Bibliography.
- Bibliography on Cosmogenesis from the Yale Forum on Religion and Ecology.

Select Bibliography:

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Our Solar System

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Scientific Summary:

Our own solar system formed 5 billion years ago. The star that we call the Sun, as well as our eight planets and many asteroids, emerged from a vast cloud of matter made from the remnants of supernovas. While we might tend to think of the creative processes that shaped our solar system as being over, our solar system is still in process. Drawn together in a vast play of gravity, collisions, and shared energy from the Sun, our solar system is an ongoing flow of creativity that we have only recently begun to gather detailed knowledge of.

Even in its very first days, a massive cloud of simple elements such as hydrogen, carbon, and silicon surrounded our Sun. Relatively homogenous at first, the cloud contained small amounts of matter that were slowly drawn together by gravity. These small groupings of elements coalesced into tiny lumps of dust that grew larger and large with time. Occasionally, these tiny collections of elements collided violently and broke apart, but eventually most of the matter in this vast cloud collected into the small planet-sized chunks called "planetesimals." These, in turn would eventually gather more matter and become our eight planets (Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune) and the many asteroids and dwarf planets that, along with the Sun, make up the solar system that we call home.

The Earth, the third planet from the sun, is currently in a state that is both fluid and solid. When it first formed, the Earth was a roiling ball of molten rock and swirling elements. Just as a heavier liquid, such as water, will sink to the bottom of a container that contains both water and vegetable oil, the heavier elements in the Earth sank towards the Earth's center. The heavier metals, such as iron and nickel were drawn by the force of gravity past less dense matter into the core of the Earth. Iron-rich silicates and magnesium piled up on top of this dense, molten core to form the mantle of the Earth. Finally, a crust that ranges from approximately 10-100 miles think formed on the surface. This crust is made from felsic rock such as granite as well as massive areas of oceanic crust that consists primarily of basaltic rocks. Over all of this, after a great deal of time, a fragile atmospheric shell enveloped the Earth's surface.

An important and ongoing feature of the Earth is the slow movement of its crust. Driven by a convection cycle where rising matter floats up to the surface, which

sometimes breaks through as lava and volcanic eruptions, the matter in the Earth's interior is in constant motion. Upon nearing the crust, much of the matter cools and drops back down towards the Earth's core. The solid crust, which is composed of massive plates, floats upon this churning mass in a process referred to as plate tectonics. This process of recycling has been going on for billions of years and has resulted in the creation of several thousand new minerals and polymers in the Earths interior and on its surface.

During its earliest days, the Earth had no moon. However, over three billion years ago a large planetesimal the size of Mars collided with the Earth and the formation of the Moon began. Still largely molten in its early state, the Earth absorbed much of the planetesimal in this dramatic impact. However, the force of the collision was so great that a portion of both planetary bodies were blasted into a ring of lava around the Earth. This ring of lava began clumping together and formed a ball of floating magma that rapidly circled the Earth. Eventually, it cooled into the round shape of the Moon that we see today. At this point in time, the Earth and the Moon were quite close, but over the course of the last four billion years, the Moon has been drifting further and further from the Earth.

The early days of the Earth were a frenetic time of great change and upheaval. Over the course of millions of years the Earth cooled and the surface hardened. Meanwhile, volcanic processes released lava and huge clouds of gases and dust into the atmosphere. Large planetesimals and asteroids regularly struck the earth adding to its mass, its water, and contributing other elements and compounds. Temperatures were high on the early Earth and any water quickly boiled into steam and vapor. This steam then cooled and fell as rain only to be quickly heated up and to repeat the cycle again. In this early formative period, the Earth rotated rapidly with the day being just five hours long. The Moon, which was close to the surface of the Earth, caused massive waves to roll over the face of the Earth's brown oceans. The sky, rich with hydrogen-sulfide, was a pinkish-orange. Millions of years passed until the earth became more stable, the oceans calmed down and a thin layer of atmosphere persisted. In these conditions, at a very early point in time in the history of the Earth, the first cell could form.

Discussion Questions:

1. For tens of thousands of years, cultures around the world have been contemplating the meaning of the movement of the sun, stars, and planets. This knowledge was often used to ground the human in seasonal and cosmic cycles and within the context of the heavenly bodies. How are we still doing this today? How does the *Journey of the Universe*, when considered within the context of the development of our own solar system, help to give the human a sense of meaning and purpose? How does it help us to change what it means to "participate" in the larger story of the universe?
2. In the *Journey of the Universe* film, there is a scene where Brian Thomas Swimme cuts into a hardboiled egg to show that the interior of the Earth looks like. What did you find to be useful, surprising, or inspiring about this image? How did it lead you to think differently about the Earth?

3. The *Journey of the Universe* book describes the Earth as a planet that is finding its way "to remain in the creative zone between the chaos of roiling gas and the rigidity of solid rock" (39). How is the Earth still in a "creative zone?" If so, how does the Earth's current creativity link back to, reflect, or continue the early creative processes involved in the formation of the Earth? What role, if any, does this human play in this creative process?
4. The *Journey of the Universe* book describes several major milestones in scientific discovery that expanded our knowledge of the solar system. How are we still building on the knowledge of Kepler, Copernicus, and Wegener and how is this shaping our perception of the larger story of the universe? How does the film or book change your perception or understanding of these scientific discoveries?

Online Resources:

- The Hubble Telescope is one of our greatest tools for observing galaxies and stars from the early moments of the universe, but it has also made a number of important discoveries in our own solar system. Visit the Hubble Telescope website for images, tutorials, and videos about the planets in our solar system. Visit the Hubble Site News Center for regular updates on discoveries and research concerning our solar system.
- The National Aeronautics and Space Administration (NASA) has a FAQ on our solar system.
- The National Aeronautics and Space Administration (NASA) website has an educational page on the sun. Scroll down to the bottom of the page for news items as well as for activities and lesson plans aimed at 9^{th}-12^{th} grade learners.
- The Hayden Planetarium hosts a number of useful educational tools such as the Digital Universe Atlas, the Astrophysics Visualization Archive, and a plethora of useful links, news items, multimedia and programs such as this set of videos and interactive features on our solar system.
- NASA's "Astronomy Picture of the Day" website features daily pictures of the Sun, the planets, and other astronomical bodies in our solar system. Each photograph is accompanied by explanations, links, and other useful information written by professional astronomers. View thousands of photos of our solar system such as this dramatic sun flare, this surprisingly vivid infrared photo of Saturn's auroras, or this breathtaking rise of the Moon and Venus over Switzerland.
- Another useful resource is NASA's Wavelength Digital Library. Browse by grade level, subject matter, or search with keywords.

Print Resources:

- *Journey of the Universe* Bibliography.

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Life's Emergence

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Index:

Scientific Summary:

The first simple cells to emerge on planet Earth came into being approximately three and a half to four billion years ago when the Earth was still in a state of great upheaval and creativity. It is from these earliest cells, and from their ancestors, that all forms of life on earth descended. After roughly two billion years, these simple life forms evolved into more complex cells with nuclei and differentiated organelles.

Living cells today exist in a great diversity, but we can generally classify living cells into two groups: eukaryotes and prokaryotes. Cells with nuclei are referred to as eukaryotes. Complex multi-cellular creatures such as humans, the tomato plant, or the red-tailed hawk have eukaryotic cells. Those cells without nuclei, such as bacteria, are called prokaryotes. Though usually unicellular and invisible to the human eye, prokaryotes make up the bulk of life on planet earth.

Although they are very simple in comparison to multi-cellular creatures living on Earth today such as the crow or the Asian elephant, even the simplest of cells have a sense of awareness regarding their surroundings. This awareness allows them to interact with their environment and to make intelligent choices as to how to respond to it. All cells and all unicellular organisms have a cell membrane that surrounds them like a skin. Embedded within each membrane is a series of proteins, two of which are called receptor proteins and channel proteins. When the cell membrane comes into contact with something, say a bit of mineral or water, the receptor protein reacts. If it is something desirable to the cell, for example something it can use as food, then the cell membrane will attach itself to the material that it wants to ingest. Next, a channel protein causes a brief opening on the surface of the membrane in order to allow that material to pass through the membrane into the interior of the cell. More often than not, however, the receptor cells do not come into contact with desirable material and thus the cell stays closed. What is critical to note here is that the cell is making a discernment; it is choosing what to ingest and what to block out.

Photosynthesis is another key component of life on Earth. It allows a great transformation and transportation of energy to occur, and is also yet another way in which life as we know it is linked directly to the Sun. Plants, and some other organisms such as some forms of bacteria, contain within them organelles (i.e. small specialized

organs) called chloroplasts. Within each chloroplast is a biomolecule called chlorophyll. While chlorophyll molecules give many plants their green color, they also begin a conversion process whereby sunlight is used to transition electrons to a higher energy state. When struck by photons (small units of light), chlorophyll sets off a chemical cascade that eventually results in the creation of powerhouse molecules in the cell. These powerhouse molecules are what enable the plant to grow and develop, even to live. By the power of photosynthesis, every plant on Earth is suffused with energy coming directly from a nearby star, our Sun.

Discussion Questions:

1. How does thinking about unicellular organisms as possessing discernment change the way in which you perceive the world? What practical implications, if any, does this have for your daily life, for thinking about your place in the larger story of the universe, or for the way in which speak and think?
2. "To commune," write Swimme and Tucker in the *Journey of the Universe* book, "may be one of the deepest tendencies in the universe" (51). What questions does this statement awaken within you? Explain how you interpret this statement in terms of your own life and experience.
3. The *Journey of the Universe* book describes the evolution and creation of life on Earth as being "nested" in the larger processes that preceded and accompanied it. Beginning with the great flaring forth, trace the formation of the human back through the formation of the various parts of the cosmos. How does this change your perceptions of the purpose, role, and story of the human?
4. In the *Journey of the Universe Conversations*, Ursula Goodenough talks about bacteria as a "self." Do you find that this concept enriches your preconceptions and ideas about what it means to be a "self?" How does your conception of "self" rely on how you conceive of "awareness?"
5. The *Journey of the Universe* book talks about the way in which the Earth has adapted itself in such a way so that life can flourish. Why is the power to adapt so important, not just for living organisms, but for more complex structures such as planets? How does the concept of adaptation change and become more complex when considered in the context of community, rather than as an individual act?

Online Resources:

- Go to the Yale Forum on Religion and Ecology's website for a comprehensive list of links to scientific organizations and educational resources. Highlights from this extensive list include: NASA's Earth Science website, the National Science Foundation website, the Union of Concerned Scientists, the Ecological Society of America website, and the National Oceanic and Atmospheric Administration website.

- For information on biodiversity and species preservation, visit the World Wildlife Fund's (WWF) biodiversity page and the United Nations Environment Programme (UNEP) World Conservation Monitoring Centre (WCMC).
- Visit the American Museum of Natural History's website for a wide variety of useful links.
- The TED series can be an excellent source of information from top scientists. This talk by evolutionary biologist, E.O. Wilson, for example, brings a deep knowledge of life's diversity into conversation with religion.
- The PBS website has an extensive education page on evolution.

Print Resources:

- *Journey of the Universe* Bibliography.
- Bibliography on Emergent Communities of Life from the Yale Forum on Religion and Ecology.

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Living and Dying

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Index:

Scientific Summary:

Each living cell on Earth contains DNA. Composed of varying configurations of molecules such as sugars, proteins, and nucleotides, the patterns found in DNA are the coding that gives cells instructions for digesting food, for growth and repair, and for the myriad other functions necessary for an individual organism to live and reproduce. Although relatively stable, DNA often undergoes random changes – which are frequently referred to as mutations. It is through these changes in DNA, as well as through the passing down of successful genes, that life is able to evolve and adapt to its environment at the subcellular level.

Organisms flourish and adapt by being aware of, and responsive to, their surroundings. The ability to see and to sense light is a trait with a long evolutionary path. Even simple forms of life, such as some kinds of bacteria developed sensitivity to light that allowed them to react to their surroundings and increase their chances of survival. The eye, one of the many ways in which living things are able to sense light, is part of a complex and ongoing evolutionary process. Ernst Mayr, the reknowned evolutionary biologist, estimates that the complex water-based eyes found in mammals, fish, and birds have been independently constructed at least forty times since life began. Other types of eyes, such as those of ancient trilobites, are formed from the mineral calcite. These bundled, rod-like eyes were passed down to creatures such as the lobster and the common housefly. Although different from the water-based eyes used by humans, they are not necessarily inferior. Calcite based eyes supply unique advantages such as the ability to see in the violet and ultraviolet range.

Death and violence, although troubling to contemplate, are aspects of life that we must work to understand. Throughout the grandeur and complexity of the universe, death and destruction are present. Stars explode in massive supernovas, elementary particles clash in bursts of devastating energy, and billions of sentient beings reach the end of their lives with each passing day. However, as we have seen, death and destruction can also be moments of unparalleled creativity. The death of ancient stars, for instance, is the source of all of the elements found in life on Earth. Even amongst living beings, predator-prey relationships can be creative moments of reciprocity and coevolution.

Discussion Questions:

1. In the *Journey of the Universe* book, Brian Thomas Swimme and Mary Evelyn Tucker state that "[w]e have such difficulty absorbing the magnitude of the vast amount of adaptive information that life employs because our human life span amounts to a tiny fraction of cosmic time, approximately a millionth of 1 percent" (61). Does thinking about human existence within a broad time scale change the way you think about the role and place of the human in the evolution of the universe? How does thinking about the coevolution of the human with other species within this broad time scale change the way that you understand what it means to be human?
2. "With conscious self-awareness," state Swimme and Tucker, "we have developed a new kind of sight – insight into deep evolutionary time" (63). What do they mean by this? How is seeing into deep evolutionary time a new kind of sight and what does it show us?
3. In the *Conversations*, Terry Deacon and Mary Evelyn Tucker speak of sentience, consciousness, collective sentience and the ability to be "reflexive." Imagine that you had to explain these terms to a family member or a close friend. How would you describe the way that you understand these terms to them? How are these terms different from one another?

Online Resources:

- For more information on evolution and the adaptation of life, go to the National Academy of Science's Evolution Resources website. Their section for educators offers an extensive list of educational resources such as links to articles, journals, websites, and more.
- The Berkeley University website entitled Understanding Evolution has a wide array of useful links and resources for educators. Teachers interested in issues related to evolution might find the Evolution 101 and the Teaching Materials sections of their website to be particularly helpful.
- Go to the Yale Forum on Religion and Ecology's website for a comprehensive list of links to scientific organizations and educational resources. Highlights from this extensive list include: NASA's Earth Science website, the National Science Foundation website, the Union of Concerned Scientists, the Ecological Society of America website, and the National Oceanic and Atmospheric Administration website.
- Visit the National Science Foundation's website for an exploration of Darwin's *The Origin of Species* and the ways in which his ideas have changed and been studied over time.
- Visit the American Museum of Natural History's website for a wide variety of useful links.

- For information on biodiversity and species preservation, visit the World Wildlife Fund's (WWF) biodiversity page and the United Nations Environment Programme (UNEP) World Conservation Monitoring Centre (WCMC).
- The TED series can be an excellent source of information from top scientists. This talk by evolutionary biologist, E.O. Wilson, for example, brings a deep knowledge of life's diversity into conversation with religion.
- The Journal of Evolutionary Biology and Evolution are two of the many peer-reviewed journals that publish academic articles and scientific studies on evolutionary biology. Nature, an international journal of science, is another useful online resource.
- The PBS website has an extensive education page on evolution.

Print Resources:

- *Journey of the Universe* Bibliography.
- Science Bibliography from the Yale Forum on Religion and Ecology.

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The Passion of Animals

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Index:

Scientific Summary:

Passion, desire, parental care, and sexual choice are integral parts of the ongoing evolution of life. Animals exhibit and act upon a wide variety of courtship behaviors ranging from the dance of stickleback fish to the spider's rhythmic plucking of the strings of its web. The process that Darwin called "sexual selection" is a complex one in which animals – and sometimes even plants – make reproductive choices by choosing partners and acting out courtship rituals.

Parental care, especially in species with a longer maturation period such as reptiles and mammals, is a term that ethnologists use to describe the acts of nourishing, protecting, and teaching that parents provide for their progeny. In mammals, females will often spend more time caring for their young than will males both in the actual pregnancy and after giving birth. This means that female mammals are often more selective in choosing their partners than males since they will invest significantly more time, energy, and matter in their offspring. The same can be said for many reptiles, some of which will incubate their eggs or protect their young from predators after they hatch. Paleontologists have even found fossil evidence that suggests dinosaurs were caring for their young as far back as one hundred million years ago.

Reproduction, expressing passion, and caring for the next generation of offspring are activities that are woven into the very fabric of life. Trees devote massive amounts of time and energy to producing seeds, some fish remain near their fry to ward off predators, and each and every organism cares for, and attempts to pass on, the genetic material found in its DNA.

Discussion Questions:

1. What kinds of creative and dynamic tensions do you see present in the process of reproduction and evolution? What comparisons and analogies can you make connecting reproduction in mammals to other non-biological evolutionary processes such as the formation of elements in stars or the emergence of galaxies?

2. Recall a particular image or quote from the *Journey of the Universe* film or *Conversations* that brings the passion of animals to life for you. What is it about this particular image or quote that captures your imagination? What insights, questions, or feelings does that particular scene or quote invoke?
3. In the *Conversations*, paleontologist Scott Sampson talks about the coevolution of flowers and dinosaurs. How does thinking about passion, reproduction, and caring for offspring as a process that is coevolutionary or cooperative change the way that you understand it?
4. How can you apply what you have learned here in other parts of your professional or personal life? How will a particular lesson or concept in this portion of the *Journey of the Universe* project change the way that you think or act?

Online Resources:

- For more information on evolution and the adaptation of life, go to the National Academy of Science's Evolution Resources website. Their section for educators offers an extensive list of educational resources such as links to articles, journals, websites, and more.
- The Berkeley University website entitled Understanding Evolution has a wide array of useful links and resources for educators. Teachers interested in issues related to evolution might find the Evolution 101 and the Teaching Materials sections of their website to be particularly helpful.
- Go to the Yale Forum on Religion and Ecology's website for a comprehensive list of links to scientific organizations and educational resources. Highlights from this extensive list include: NASA's Earth Science website, the National Science Foundation website, the Union of Concerned Scientists, the Ecological Society of America website, and the National Oceanic and Atmospheric Administration website.
- Visit the National Science Foundation's website for an exploration of Darwin's *The Origin of Species* and the ways in which his ideas have changed and been studied over time.
- Visit the American Museum of Natural History's website for a wide variety of useful links.
- For information on biodiversity and species preservation, visit the World Wildlife Fund's (WWF) biodiversity page and the United Nations Environment Programme (UNEP) World Conservation Monitoring Centre (WCMC).
- The TED series can be an excellent source of information from top scientists. This talk by evolutionary biologist, E.O. Wilson, for example, brings a deep knowledge of life's diversity into conversation with religion.
- The Journal of Evolutionary Biology and Evolution are two of the many peer-reviewed journals that publish academic articles and scientific studies on evolutionary biology. Nature, an international journal of science, is another useful online resource.
- National Public Radio can be an accessible and unique way to access information on dinosaurs, reproduction, evolution, and parental care. Whether you are looking

for information on "dinosaur dads" or the relationship between mating and nest decorations in birds, NPR has a wide variety of articles, photos, and of course, interviews and discussions.

Print Resources:

- *Journey of the Universe* Bibliography.
- Science Bibliography from the Yale Forum on Religion and Ecology.

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The Origin of the Human

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Index:

Scientific Summary:

Fossil and genetic evidence suggests that the first ancestors of the human species were birthed five to seven million years ago in what is today central Africa. It began with a small population of chimplike apes, perhaps only one hundred thousand, who faced a rapidly drying climate. In response to this change in their environment, part of the population retreated to the comfortable safety of the shrinking forests and maintained their accustomed patterns of life. Another portion of the population attempted to live in the open vastness of the newly emerging savannahs. As they adapted to the new environment of the open plains, this group developed three traits that would shape the rest of human evolution: bipedalism, or the ability to move about on two legs, behavioral flexibility, and a larger brain size. Over the course of approximately six million years, the brains of these human ancestors almost tripled in size. Then, about fifty thousand years ago, after a relatively brief evolutionary window, these traits allowed our ancestors to migrate out of Africa and into Europe, Asia, and the Americas.

The success of the early humans depended greatly upon the ability to be flexible in their behaviors. This was due, at least in part, to the loss or lessening of some of our instinctual responses. Another factor that increased our capacity for behavioral flexibility was our extended adolescence. Young humans, and all mammals for that matter, have an extended juvenile period in which they play and learn. This extended learning period allows humans to adapt to new settings and new circumstances much more quickly than other species. An additional benefit of this behavioral adaptability and extended juvenile period is the development of symbolic consciousness in humans. From interpreting dreams, to creating art and literature, to communicating simple lessons and messages through written language, the early humans invented something never seen before in the history of life. Rather than merely passing on their genes to the next generations, humans could now pass down enduring knowledge in the forms of music, customs, languages, arts, and science.

Discussion Questions:

1. In *The Journey of the Universe* book, Swimme and Tucker state that "[b]ecause of our symbol-making skills, we became, overnight, a planetary species" (91). In what ways can one understand the human species to be "planetary?" How does the act of symbol-making allow the human species to be planetary in a way that other species are not?
2. During his interview with Mary Evelyn Tucker in the *Conversations*, John Grim talks about the power of meditative practices and rituals to put humans into right relationship with their surroundings. How do meditative practices and rituals still function in this way in your life? How do you use rituals and meditative practices to understand your relationship with your surroundings? Has that changed as you come to understand the *Journey of the Universe* better?
3. What is the link between culture and the survival of the human species? How has the creation of literature, art, plays, scriptures, and music allowed the human species to thrive and grow?

Online Resources:

- Visit the Smithsonian National Museum of Natural History's website and the Hall of Human Origins for news and videos on human origins, for information on the latest research in human evolution, and for useful lesson plans and teacher resources. Their Anthropology Outreach Office promotes education and understanding of a variety of anthropological topics by publishing a journal, bibliographies, and even teacher's packets.
- The National Geographic website can be an exciting introduction to the development of early hominids. The education portion of the website is an excellent resources for both students and teachers. Also be sure to explore and search the National Geographic website for articles such as the discovery of a 1.8 million year old jawbone or the fossilized remains of "Lucy's baby," a member of the early human species *Australopithecus afarensis*.
- Looking for multi-media and articles on human origins published for a general audience? The BBC has a page on human beginnings that offers introductory articles and links to various images and other media on early humans. Or, try the Discovery News website for articles such as this one on the relationship between modern humans and Neanderthals.
- For more information on evolution and the adaptation of life, go to the National Academy of Science's Evolution Resources website. Their section for educators offers an extensive list of educational resources such as links to articles, journals, websites, and more.
- Visit the American Museum of Natural History's website for a wide variety of useful links.
- The Berkeley University website entitled Understanding Evolution has a wide array of useful links and resources for educators. Teachers interested in issues

related to evolution might find the Evolution 101 and the Teaching Materials sections of their website to be particularly helpful.
- Go to the Yale Forum on Religion and Ecology's website for a comprehensive list of links to scientific organizations and educational resources. Highlights from this extensive list include: NASA's Earth Science website, the National Science Foundation website, the Union of Concerned Scientists, the Ecological Society of America website, and the National Oceanic and Atmospheric Administration website.
- The TED series can be an excellent source of information from top scientists. This talk by Louise Leakey, for example, takes listeners to the Rift Valley in Africa where she explores the origin of humanity's ancestors.
- The Journal of Evolutionary Biology and Evolution are two of the many peer-reviewed journals that publish academic articles and scientific studies on evolutionary biology. Nature, an international journal of science, is another useful online resource.

Print Resources:

- *Journey of the Universe* Bibliography.
- Bibliography on Sentience from the Yale Forum on Religion and Ecology.

Select Bibliography:

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Becoming a Planetary Presence

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Index:

Scientific Summary:

The migration of humans into Asia, Europe, and the Americas was both an exciting era of exploration as well as a time of great biological loss. The arrival of humans in North America more than eighteen thousand years ago, for example, was accompanied by the loss of the majority of the large land mammals there. We cannot say with certainty that this extinction of species was anthropogenic, but the overlap between the expansion of humans and the concomitant destruction of so many species is worth noting.

Aided by their symbolic consciousness, humans adapted to, and flourished within, new biomes. After a long period of living as hunter-gatherers, a time span of roughly two hundred thousand years, humans established long-term settlements in the great river valleys of the world. Within a relatively short period of time, cities and civilizations emerged. These cultures developed architecture, ceremonial art, literature, an impressive array of yearly cycles and rites, and complex legal and ethical codes. With the aid of language and symbolic thinking our ancestors also cultivated new foods through agriculture and learned to sail and navigate the worlds' oceans and seas.

Perhaps one of the most significant achievements of humanity came in the form of mathematics and science. Luminaries such as Pythagoras and Newton harnessed the power of symbols to bring our understanding of the universe to new levels of complexity and precision. This recognition of the regularity and patterns observable in the universe that came from the development mathematics and physics was, like our great migration out of Africa, both a source of great possibility and great loss. On the one hand, this allowed us the means to attempt to alleviate poverty, to cure illness, and to feed more people than was previously possible. On the other hand, this ability to measure and predict also led to the development of machines that granted us the power to reshape and commodify our world. For the first time in history, the decisions of humans rather than the power of natural processes are the primary movers of the evolutionary process. Human actions are causing the ice caps to melt. Anthropogenic climate change is killing the coral reefs and pushing thousands of species to extinction each year. We are at a transition point in history as we leave behind the Cenozoic era of the past sixty five

million years and enter into the Anthropocene. Human decisions, amplified enormously by the power of symbolic consciousness, will be the primary shaper of life's future.

Discussion Questions:

1. In *The Journey of the Universe* book, Swimme and Tucker write that "[e]very place we went, we became that place" (93). How are humans shaped by the place that they live in? Think of at least one instance where you "became" a place. How does that place continue to shape you, even today?
2. During her interview with Mary Evelyn Tucker in the *Conversations*, Melissa Nelson describes the stories of indigenous peoples and the ways in which they remind us that we are part of a larger cosmos. Based on her interview, and on *The Journey of the Universe* book, how would you describe the ways in which we have lost that sense of belonging? What other ways have we lost our sense of place and belonging that were not described in the films or book?
3. For the first time in history, we are aware of the ways in which our decisions and actions are profoundly shaping our environment. Create an illustration, a song, a poem, a ritual, or another appropriate artistic representation that depicts or enacts the journey of humans across the globe and through time as we have become a planetary presence. Share this creation with a partner and discuss the differences and similarities of your interpretations of humanity's growing presence.
4. In the *Conversations*, Cynthia Brown uses "Big History" to describe the formation of the universe in terms of "thresholds." Although change can be a moment of great destruction, how might it also be a period of discovery, joy, and celebration? What might the future look like for humans and for other forms of life on Earth if we were to reorient ourselves with the universe in a way that is mutually enhancing for all? Imagine that you had to describe this future to a family member or a close friend. How would you describe this future for them and what would the journey be like in order for us to arrive there?

Online Resources:

- The Intergovernmental Panel on Climate Change (IPCC) is the leading international body for monitoring and assessing climate change. Their annual climate report is one of the most comprehensive and reliable reports of its kind for accurately assessing and reporting climate change.
- The Worldwatch Institute gathers data and insights from all over the world on matters ranging from climate change, to population growth, to the anthropogenic extinction of species. Their reports are expansive and useful resources for educators and students at all levels.
- The Earth Charter is a global, multi-cultural set of ethical principles for a just and sustainable world. Read the Earth Charter here before visiting their Education page.

- The Union of Concerned Scientists is a multi-disciplinary group of top scientists and Nobel Prize laureates who disseminate information on climate change and strategies for sustainability. Their 1992 World Scientists' Warning to Humanity was signed by over 17,000 scientists including the majority of Nobel Prize laureates in the sciences.
- Visit the Smithsonian National Museum of Natural History's website for news and videos on human origins, for information on the latest research in human evolution, and for useful lesson plans and teacher resources.
- Visit the American Museum of Natural History's website for a wide variety of useful links.
- The National Geographic website can be an exciting introduction to the development of early hominids. The education portion of the website is an excellent resources for both students and teachers. Also be sure to explore and search the National Geographic website for articles such as the discovery of a 1.8 million year old jawbone or the fossilized remains of "Lucy's baby," a member of the early human species *Australopithecus afarensis*.
- Looking for multi-media and articles on human origins published for a general audience? The BBC has a page on human beginnings that offers introductory articles and links to various images and other media on early humans. Or, try the Discovery News website for articles such as this one on the relationship between modern humans and Neanderthals.
- Go to the Yale Forum on Religion and Ecology's website for a comprehensive list of links to scientific organizations and educational resources. Highlights from this extensive list include: NASA's Earth Science website, the National Science Foundation website, the Ecological Society of America website, and the National Oceanic and Atmospheric Administration website.
- The TED series can be an excellent source of information from top scientists. This talk by Al Gore, for example, takes listeners through a slide show and talk on climate change.

Print Resources:

- *Journey of the Universe* Bibliography.
- Science Bibliography from the Yale Forum on Religion and Ecology.

Select Bibliography:

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- Tucker, Mary Evelyn. *Philosophy of Qi*. New York: Columbia University Press, 2007.
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Rethinking Matter and Time

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Index:

Scientific Summary:

"Deterministic realism" is the name that we give to a particular worldview that understands reality to be composed of inert, mathematically predictable matter. Originating in the dramatic scientific insights of sixteenth and seventeenth century thinkers, deterministic realism can be thought of as having three core presuppositions: First, it assumes that all things in the universe are made up of tiny bits of inert matter. Second, these bits of matter are assumed to be entirely material and devoid of subjectivity. And, third, it postulates that the movement and composition of these bits of matter can be measured and predicted through mathematical laws. While this worldview has allowed us to make advances in science and technology, it is also a way of viewing the world that allows us to act in destructive ways towards the environment and other living beings.

A number of history's great scientists fall within the tradition of deterministic realism. Galileo, one of the first scientists to think in this manner, formulated the first mathematical expressions for the motion of falling matter. Isaac Newton continued in this tradition when he used observation and mathematics to accurately predict the motion of the planets revolving around the sun. His publication of *Principia Mathematica Philosophiae Naturalis* in 1687 was a groundbreaking moment in deterministic realism. Contained within it were several of Newton's well-known observations such as his laws of motion, his law of universal gravitation, and much of what would later be considered the foundation of classical mechanics.

It was not until the twentieth century that scientists began to rediscover that matter was more than just inert "stuff." Whereas sixteenth and seventeenth century thinkers such as Rene Descartes and Francis Bacon viewed the world as a machine run by natural laws, twentieth century chemists such as Ilya Prigogine discovered that even chemical molecules have the capacity for intrinsic self-organizing. He discovered that trillions of molecules could organize themselves into complex patterns and that they could do so without the instructive patterns of DNA or the organizing power of the animal mind.

In addition to rethinking matter as subjective and as more than inert "stuff," scientists are also beginning to come to new understandings of time. One way to view time differently is to view the progression of time as a measure of the creative emergence of the universe. James Hutton and Charles Lyell were the first to recognize that the Earth was part of a multi-billion year process of geological development. Another nineteenth century thinker, Charles Darwin, is well known for his descriptions of the vast depths of evolutionary time. Later, in the twentieth century, Hubble and Einstein extended this epoch-oriented view of history to the emergence and development of the universe itself.

Discussion Questions:

1. As you rethink matter and time, reflect upon what it means to you to live in cosmological time. How is thinking like this different than your previous understanding of time? What implications does it have for your understanding of yourself and your sense of your relation to the world around you?
2. Take an image, scene, or paragraph from *The Journey of the Universe* film, book, or *Conversations* that you feel conveys an important idea in regards to matter and time. Using an appropriate medium (i.e. prose, poetry, dance, painting, music, the spoken word, etc.), reformulate and express this idea in your own way. After doing so, reflect on how that helped you to better understand matter and time.
3. It might be said that the average person lives his or her life in a way that is consistent with the assumptions of deterministic realism. How might reformulating our notions of matter and time cause us to make decisions differently or to value things like rocks and trees in new and unfamiliar ways? What might some of the advantages be of thinking in such a way? What are the disadvantages?

Online Resources:

- For a better understanding of Big History, there is no better place to start than the Big History Project. An immensely useful website, they provide a number of useful guidelines and resources such as course themes, timelines, and a syllabus.
- Finding a reliable encyclopedia online can be difficult. One reputable – and free – online resource that educators might find useful is the Stanford Encyclopedia of Philosophy. Entries include articles on Newton's *Principia Mathematica Philosophiae Naturalis*, differing views of space and motion, and one on Einstein's theory of General Relativity.
- A number of scientific authors have reached wide audiences by writing about matter, space, and time. Try this article on the beginning of time by Stephen Hawking or this New York Times article on time by Brian Greene.
- The TED series can be an excellent source of information from top scientists. This talk by David Christian, author of *Maps of Time*, challenges and revises how we look at the history and development of life in relation to a broader cosmic timeline.

- Interested in Ilya Prigogine? Watch this video of him talking about complexity or read a copy of his Nobel lecture given in 1977.

Print Resources:

- *Journey of the Universe* Bibliography.
- Science Bibliography from the Yale Forum on Religion and Ecology.

Select Bibliography:

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Emerging Earth Community

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Index:

Scientific Summary:

This portion of the *Journey of the Universe* book and film series is dedicated rethinking the role and place of the human within the context of the *Journey of the Universe*. Since the focus is on the great work that lies ahead of us, this segment of the curriculum will focus on discussion questions and resources rather than on scientific summary.

Discussion Questions:

1. What does Brian Thomas Swimme mean when he says that "Wonder will guide us" during the *Journey of the Universe* film? How has a sense of wonder already guided you and how will it help you to shape your future habits and actions?
2. The *Journey of the Universe* book and film series can be described as a recovery project that is aimed at rediscovering a sense of belonging that we have lost in our modern, industrialized society. For example, Swimme states that "We belong here. We have always belonged here" and Nancy Maryboy and David Begay both describe Navajo ceremonies and ways of knowing as being cosmologically orienting. Do you feel as if you have lost your own sense of belonging and participation? How has your own culture, tradition, or history both contributed to this sense of loss and also helped you to better understand your own place and role within the story of the universe? How can you use this knowledge to empower yourself and others?
3. In the *Journey of the Universe* book, Mary Evelyn Tucker and Brian Swimme write that "we are actually the universe reflecting on itself" and that "this changes everything" (2). What does it mean to be the universe reflecting on itself? And,

what is the significance of this realization? Why would that they say that it "changes everything?"

4. After watching the *Conversations*, which of the clips associated with the concept of Emerging Earth Community resonated most strongly with you? What lessons did you take from it and how might you share those lessons with others?
5. It can be easy to become overwhelmed by the immensity of the task before us or to find ourselves lost in grief over the destruction that we as a species have caused. What practical steps can we, as planetary citizens gifted with the power of symbolic consciousness, take to transform ourselves into a species that contributes to the flourishing of the entire universe? In the *Conversations*, the interviewees spoke of a variety of efforts already taking place: Richard Register spoke of the development of eco-cities, Richard Norgaard described his vision for ecological economics, and Penny Livingston elaborated on the importance and power of permaculture as a way to grow food and to enhance biodiversity. What other examples can you think of that demonstrate how people are already attempting to find a role within the cosmos that contributes to the flourishing of all? How can you teach others about these efforts?
6. The book describes the ongoing story of the universe as a story that we tell; but it also describes it as a story that is telling us (114). What do the authors mean by this? Imagine that you had to explain this concept to a child or teenager: How could you convey this idea effectively to them?
7. Understanding the place of the human in the larger story of the universe is something that many have incorporated into their religious lives. In the *Conversations*, Paula Gonzalez talks about her own involvement with solar power and what she calls her "earth ministry" and Marya Grathwohl describes how prayer and ritual helped her to change her understanding of separation. How might you be able to incorporate the *Journey of the Universe* into your own faith or religious practice? What would incorporating the story of the universe into your religion look like for you and how would it change your understanding of your own self?
8. Several of the interviewees in the *Conversations* speak about the relationship between race and the story of the universe. Carl Anthony, for example, talks about the uprooting of African peoples through the institution of slavery and how some have found new meaning and a new set of ethics by thinking about sustainable urban communities. Belvie Rooks, in her interview, tells of her own attempts to help her students put racism and slavery into the framework of the universe story and she asks them to imagine what healing would look like within this context. Why is it important to consider race when thinking about the *Journey of the Universe*? How can you incorporate it into your own story and your understanding of your own place in the universe?

<u>Online Resources</u>:

- Many of the individuals interviewed in the *Conversations* spoke of communities, concepts, and movements that are working towards the flourishing of all.

Although not a comprehensive list, the following websites might help you as you teach or research the *Journey of the Universe*: Bindu Mohanty talks about a community called Auroville, Drew Dellinger recites one of his poems, Richard Register speaks about Eco-cities, Carl Anthony talks about Breakthrough Communities, Paula Gonzalez is one of the founders of Ohio Interfaith Power and Light, Marya Grathwohl is the founder of Earth Hope, Brian Thomas Swimme has a website, Mary Evelyn Tucker has a website called Emerging Earth Community, and don't forget the *Journey of the Universe* website.

- The Earth Charter is a global, multi-cultural set of ethical principles for a just and sustainable world. Read the Earth Charter here before visiting their education page.
- The Intergovernmental Panel on Climate Change (IPCC) is the leading international body for monitoring and assessing climate change. Their annual climate report is one of the most comprehensive and reliable reports of its kind for accurately assessing and reporting climate change.
- The Worldwatch Institute gathers data and insights from all over the world on matters ranging from climate change, to population growth, to the anthropogenic extinction of species. Their reports are expansive and useful resources for educators and students at all levels.
- The Union of Concerned Scientists is a multi-disciplinary group of top scientists and Nobel Prize laureates who disseminate information on climate change and strategies for sustainability. Their 1992 World Scientists' Warning to Humanity was signed by over 17,000 scientists including the majority of Nobel Prize laureates in the sciences.
- Go to the Yale Forum on Religion and Ecology's website for a comprehensive set of bibliographies, syllabi, news items, events, and resources for educators all related to the academic study of religion and ecology.

Print Resources:

- *Journey of the Universe* Bibliography.
- Science Bibliography from the Yale Forum on Religion and Ecology.

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