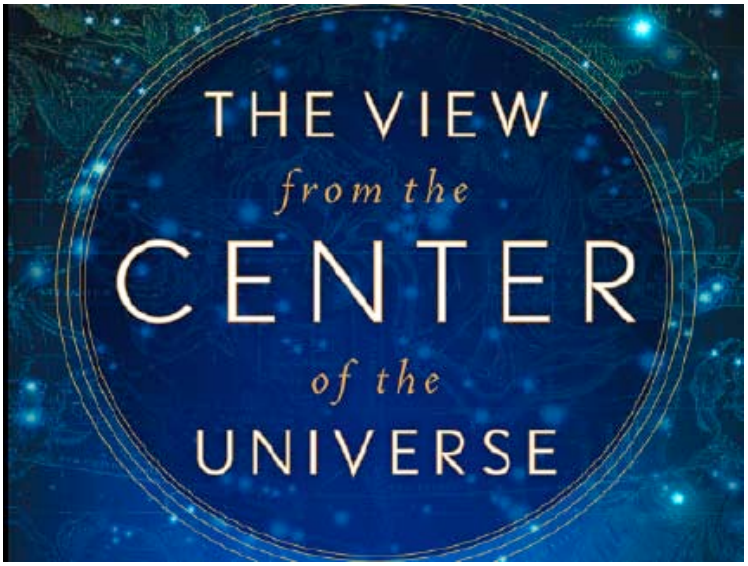
Granada Public Talk, Sept. 12, 2008



JOEL:

Are we insignificant specks in a vast, cold universe where no place is central or special? This is what most educated secular people today assume, but it's as wrong as the flat earth. This assumption is an extrapolation of Newtonian physics (which accurately explains how the solar system works) to the entire universe, for which it doesn't work. For centuries this was the best humans could do because no one knew anything about the universe beyond the sun and planets. There was no way to get data.

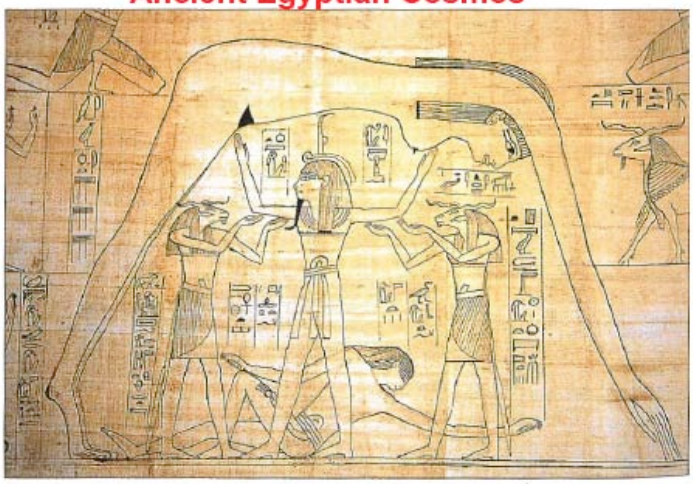
But through amazing new telescopes and other instruments, in just the last couple of decades we have gotten data on the universe all the way back to the Big Bang. Cosmology used to be the laughing-stock of the sciences. The joke was that the ratio of theory to data in cosmology was infinite – endless theories, no data. But that has completely reversed.

We have for the first time a scientific theory of the origin and evolution of the universe that is not only supported by huge amounts of data but predicting much of it. **What is emerging is humanity's first picture of the universe as a whole that might actually be true.**

NANCY:
What is a picture of the universe? We can get the idea by looking briefly at a few earlier ones.

For thousands of years in the ancient Middle East everyone knew that the earth was flat, although the local details varied from culture to culture.

Ancient Egyptian Cosmos



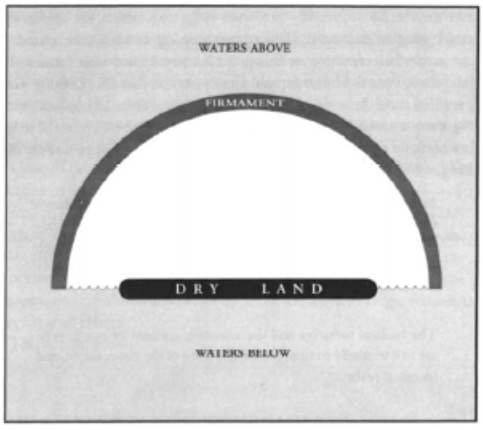
From *Book of the Dead* papyrus belonging to Nesitanebeteshru, a 21st Dynasty priestess.

In this simplified picture of the Egyptian cosmos, the flat earth is a god, named Geb [CLICK FOR NAMES] and the heavens is his sister and lover, the goddess Nut. They were born locked together in an embrace and only separated by the god Shu, their father, the air, who would hold them apart, thus maintaining the creation, as long as the Egyptians performed their rituals properly. So Egyptians felt they were upholding the cosmos, and major spiritual and ethical implications followed.

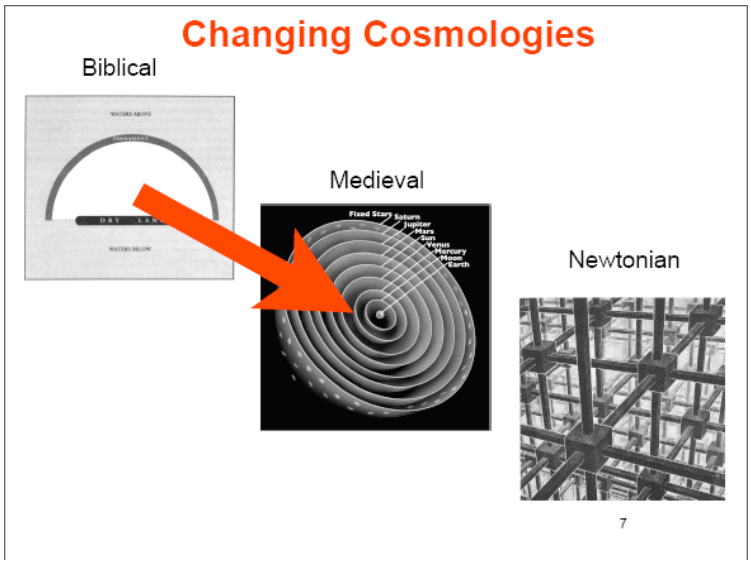
They understood the everyday world as being embedded within an awe-inspiring but mostly invisible spiritual cosmos that was smoothly connected to the world. The lives of the spiritual beings gave meaning to life here. The ancient Egyptians had what anthropologists call a "cosmology" – a rich and satisfying explanation of life, nature, cosmos, and the gods – even though the nature and cosmos parts were far from accurate by modern standards. **[CLICK]**

Changing Cosmologies

Biblical



Two thousand years later, in ancient Israel, the three-part flat earth cosmos was still unquestioned, but the parts were no longer gods [CLICK FOR EGYPTIAN GODS] but inanimate earth, air, and firmament, [CLICK FOR BIBLICAL PIC] since for the Hebrews there could only be one God.

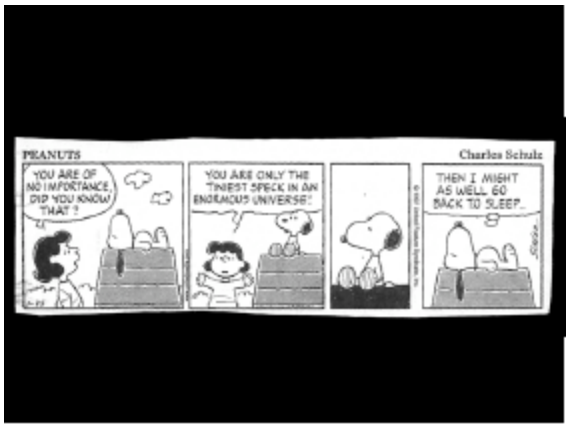


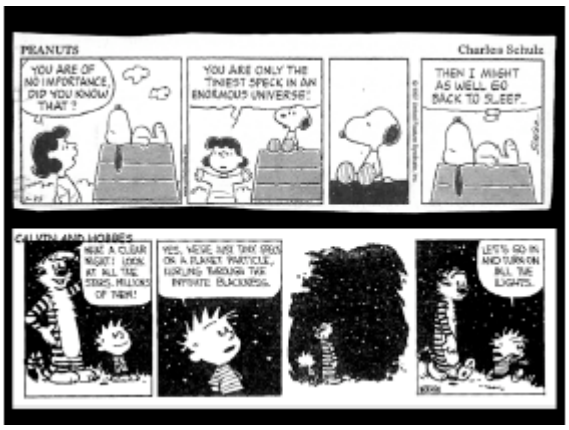
It was the ancient Greeks who realized that Earth is not flat but a sphere, and from that time through the Middle Ages, educated people from North African through Europe to Scandinavia believed that the earth was the spherical center of a spherical universe. Around the earth, they thought, there were nested crystal spheres that carried the moving planets, with the outermost sphere holding the fixed stars. The whole universe rotated around the earth once a day, and beyond the sphere of the stars was Heaven. In this medieval picture of the universe, as in the Egyptian picture, the everyday world was surrounded by a spiritual cosmos whose doings gave meaning to daily life here on the ground.

But then came the Copernican revolution, and soon every educated person believed that earth is of course not the center of the universe but just a planet like other planets,

orbiting an average star, in a universe where no place is special or central, least of all ours. ***There was no longer a place where the physical became the spiritual. It was physical all the way out, possibly to infinity.*** This is the universe that D.H. Lawrence once described as "a dreary on and on without any meaning."

Over the centuries since Newton, secular culture has assumed that this picture is true and our "place in the universe" is that we are insignificant specks. This is how most people think today. It has become so common that **[CLICK]** here it is in Peanuts.…and in Calvin and Hobbes





Meanwhile, many religious people are mentally living in the Biblical or Medieval universe, and still others in the large New Age tent imagine vague universes made of some inexplicable energy. The West may be the first major culture in human history without a shared cosmology.

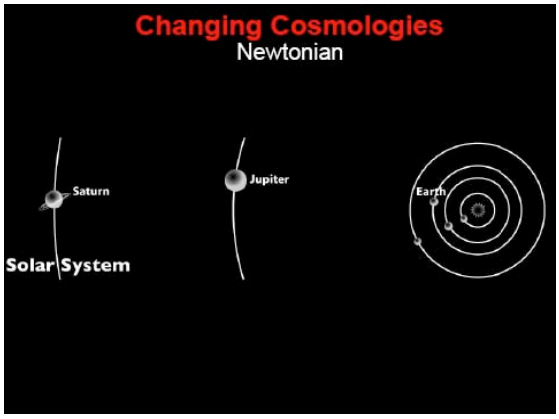
For scientists, "cosmology" has a very different meaning from the word as anthropologists use it and as I've been using it. Scientific cosmology is a branch of astrophysics. There is some overlap, but the two kinds of cosmology answer different questions, and their methods of evaluating truth are different. Traditional cosmologies were not

factually correct, but they offered guidance about how to live with a sense of belonging in the world. Modern scientific cosmology says nothing about human beings or how we should live or feel. It aims to provide scientific accuracy, not meaning.

The West really can't really afford to see these as separate anymore. The human race needs a believable picture of the universe that includes all of us. The key to finding a cosmically motivating outlook for scientifically literate people is to connect these two different understandings of cosmology into a science-based appreciation of our human place in the universe.

Why do we need a story if we have science? Because no one can comprehend the universe directly. For every one of us, scientists included, some ***story*** presents the universe – *not just represents it but presents it.* Scientific theories, after all, are attempts to tie together mathematical calculations into a coherent, meaningful story that makes sense to the idiosyncratic structure of our evolved brains. The goal for science is to get the story as close as possible to being in harmony with the real universe.

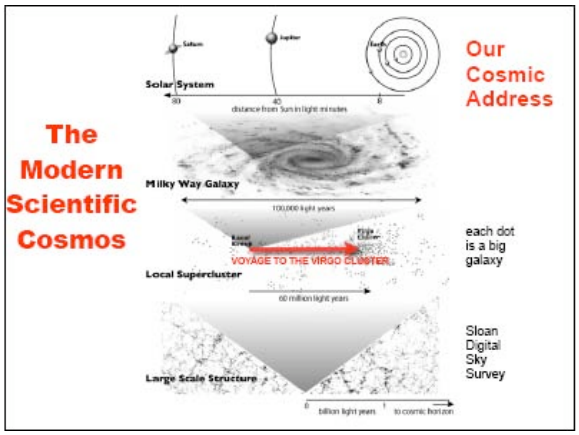
What will be the next cosmology? **[CLICK for Newton-?]**



The new theory of the origin and evolution of the universe is based on dark matter and dark energy, so in the book that Joel Primack and I have written, THE VIEW FROM THE CENTER OF THE UNIVERSE, we call it the ***Double Dark theory***, though its technical name is Lambda CDM. Joel is one of the creators of the theory. Much, of course, still needs to be discovered. But the general outlines of the evolution of the universe and the birth of galaxies are now known. We are for the first time in a position to ask, what is our place in ***this*** Big Picture?

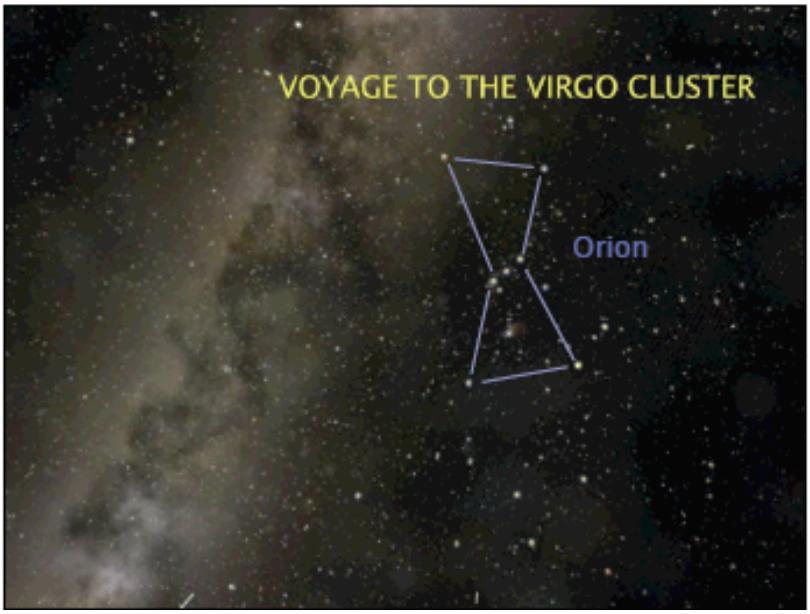
The answer, which surprised those of us who assumed we were insignificant specks, is that in the new picture of the universe it turns out that we humans are special or central in absolutely fundamental ways. Of course we're not geographically central (Galileo was right: the Earth is not the center of the universe!) but we are central to the *principles* that underlie the Double Dark universe.

JOEL: Let me give you a sense of this big picture to help you get oriented.



This is a map of our local neighborhood on progressively larger size scales. It shows our geographic place (so to

speak) in the universe, and we're going to use this map to orient ourselves. First our solar system, where we live on the third rock from the sun – Earth. Each of the large, shaded V's shows how the entire picture above it is just a tiny point in the much **larger scale** picture immediately below. So our solar system is about halfway out in the Milky Way galaxy – it's at the tip of the first "V". Light crosses the solar system in just a few hours, but it takes light about 100,000 years to cross the Milky Way. The Milky Way in turn is just a dot on the scale of the Local Supercluster of galaxies. In the video I'm about to show, we're going to go on a virtual voyage from Earth, past the local stars, out of the disk of the Milky Way galaxy, and then across our Local Supercluster to the Virgo Cluster of galaxies at its center **[click to show arrow]**. The galaxies you will see after we emerge from our own Galaxy have recently been mapped, and you will be seeing actual telescope images that the computer lets us move through. This mapping is still going on and will for many years, out to larger and larger distances.



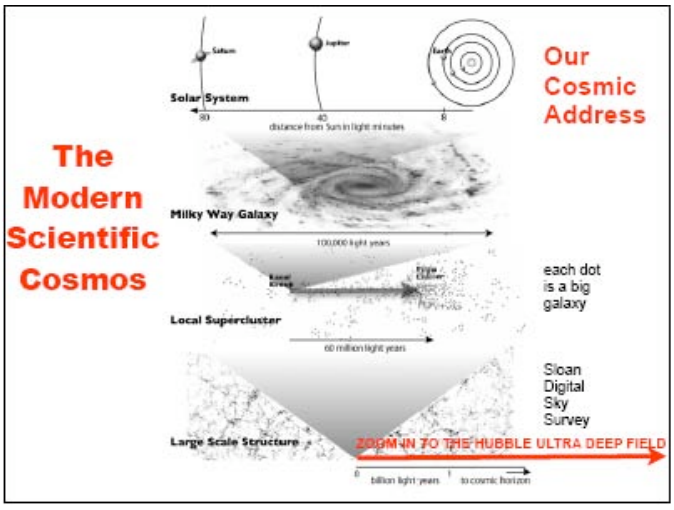
[Narration during Video:]
We're starting this virtual voyage from Earth. We see the constellation Orion with the disk of the Milky Way arcing across the sky beyond it. As we fly toward the sword hanging below Orion's belt, the sword comes apart, because all the stars making it up are at different distances. We see that the center of the sword is the Orion Nebula, a gas cloud illuminated by the young stars forming there. Now 1500 light years from home, we pass the Horsehead Nebula. The next ball of glowing gas we see is the Rosette Nebula, another nearby stellar nursery. Now we pass the Crab Nebula, the 1000 year old remnant of a supernova explosion, with the Crab Pulsar in its center blinking 30 times a second.

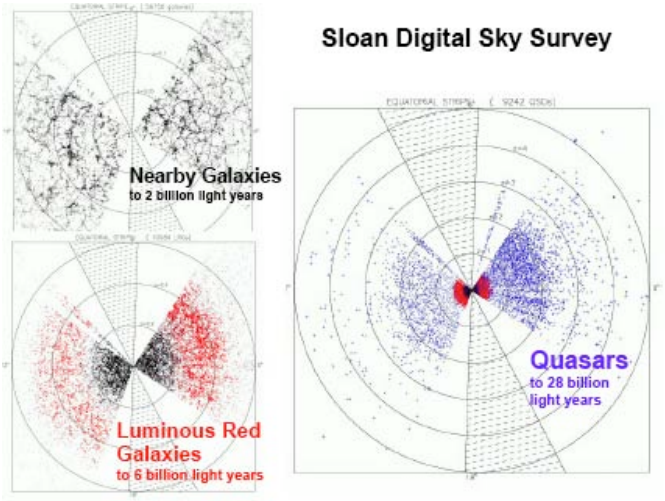
Until now we have been inside the disk of the Milky Way, with its dust clouds blocking part of the light. Now we change direction and rise above the disk, and we see the full panorama of our Galaxy with its hundred billion stars. Our two nearby satellite galaxies – the Magellanic Clouds – now become visible, along with other satellites of the Milky Way. Turning, the other two large galaxies in our Local Group come into view, the Andromeda Galaxy and, in the foreground, its smaller spiral galaxy companion M33. As we pass through a nebula of hot gas in M33, we are two million light years from home.

All the little patches of light in the background are not stars but galaxies, each one comparable to our Milky Way. All of them are in our Local Supercluster, and the clump of galaxies on our left is the Virgo Cluster – where we are headed. On the way we pass by several particularly beautiful spiral galaxies you can see with an amateur telescope: M81, and then the Whirlpool Galaxy M51. We are flying along a long chain of galaxies. As we approach the Virgo Cluster we see more elliptical galaxies – galaxies

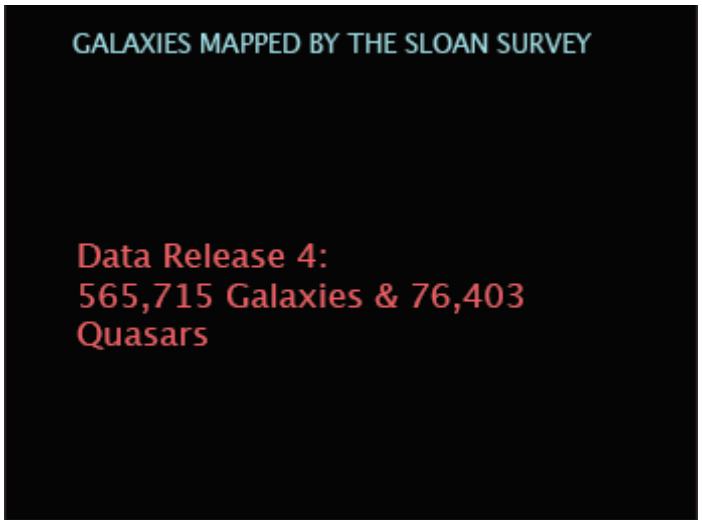
that are more or less spherical without a disk of stars. We are 60 million light years from home as we fly in toward the central galaxy of the Virgo cluster, the giant elliptical galaxy M87, which weighs more than two **billion** times the mass of our sun and has a jet coming from its giant central black hole.
[End of video]

Now we're going to take a virtual voyage over a much greater distance – all the way to the edge of the visible universe! Our local supercluster is just a point at the bottom of this V.





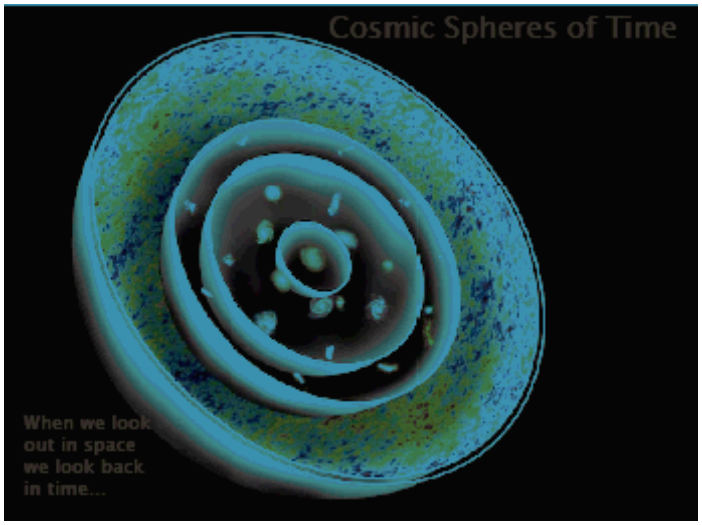
The next video will take us all the way out to the heat radiation of the Big Bang. It shows the actual locations of more than half a million galaxies, based on data from the ongoing Sloan Digital Sky Survey. The first video we saw showed a flight from Earth out of our Galaxy and across our Local Supercluster. **Every galaxy you saw in that video is inside the dark space at the center of this video!** [video narration points out galaxies, quasars, and Cosmic Microwave Background Radiation of the Big Bang]



NANCY:

What kind of picture or symbol could represent the theory, the understanding, behind the universe as we've just seen it?

[CLICK]

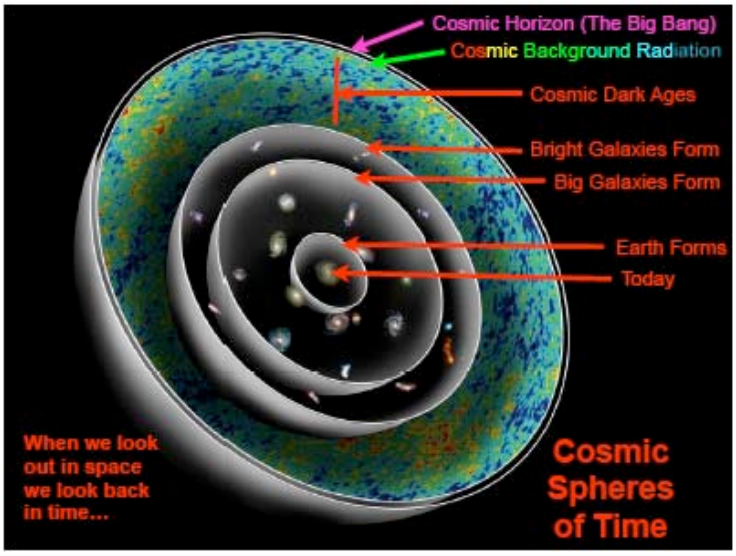


This is the Cosmic Spheres of Time. It's a symbolic picture of the entire visible universe from the point of view of Time. Our Galaxy is at the center. These concentric spheres don't represent just space – each sphere moving outward represents an earlier **time** in the history of the universe, with the earliest time, the Big Bang, represented by the outermost sphere.

When we look through telescopes, we see galaxies as they were when the light that's reaching our eyes now, left them -- long ago. Since light travels through space at a fixed speed, the light from farther away has been traveling much longer to get here. And so, ***when we look out in space we look back in time***. ***[CLICK for "When we look]***

We are at the center of our past. **[CLICK for TODAY]** The past is not "over" – it's racing away from us at the speed of light like ripples from a pebble thrown into a pond but not circles: in spheres – of time.

JOEL:

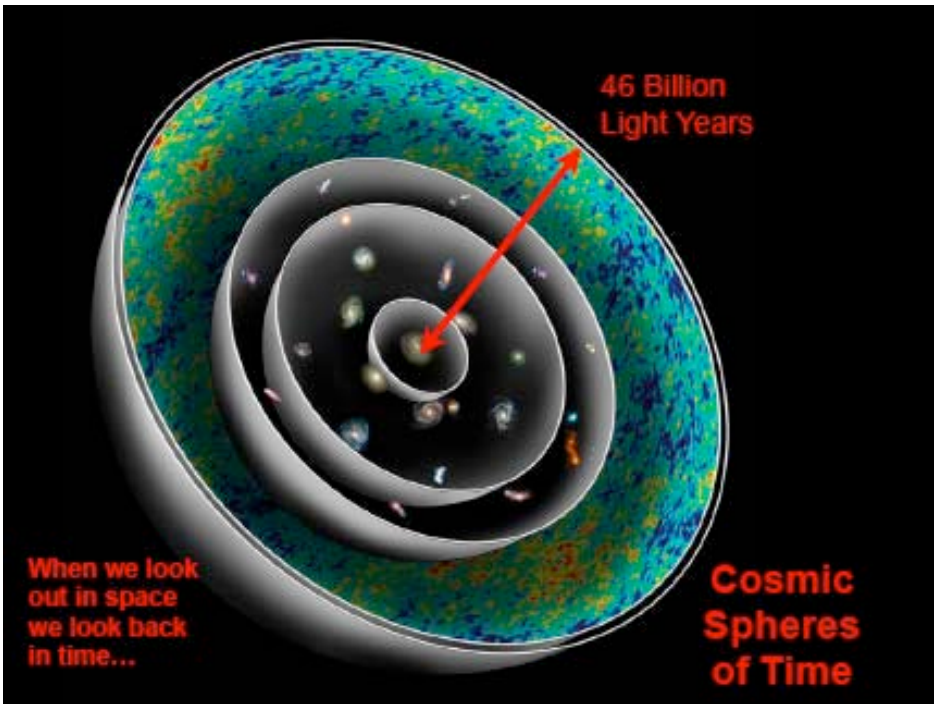


The ***era*** when our sun and earth were forming, four and a half billion years ago, is still out there **[Click]**, spherically enfolding our solar system, our Galaxy, and all the nearby superclusters. Far beyond that is the era when the first big galaxies formed **[Click]**.

Far, far beyond, the era of the earliest bright galaxies engulfs us **[Click]**, and beyond that is a deep sphere of utter blackness that theory tells us is the Dark Ages **[Click]** of the universe before the first galaxy had formed. Earlier still lies the sphere of the cosmic background radiation **[Click]** and at last the cosmic horizon **[Click]**.

With telescopes we see galaxies as they were millions and billions of years ago, but in the Cosmic Spheres of Time **we are showing you WHERE THEY ARE NOW but what they looked like then**. Because of the finite speed of light, we can't know what they look like now, but we can calculate ***where they are*** now with the Double Dark theory.

The Big Bang happened less than 14 billion years ago. But the distance out to the Cosmic Background Radiation sphere is about **46 billion light years [CLICK]**.

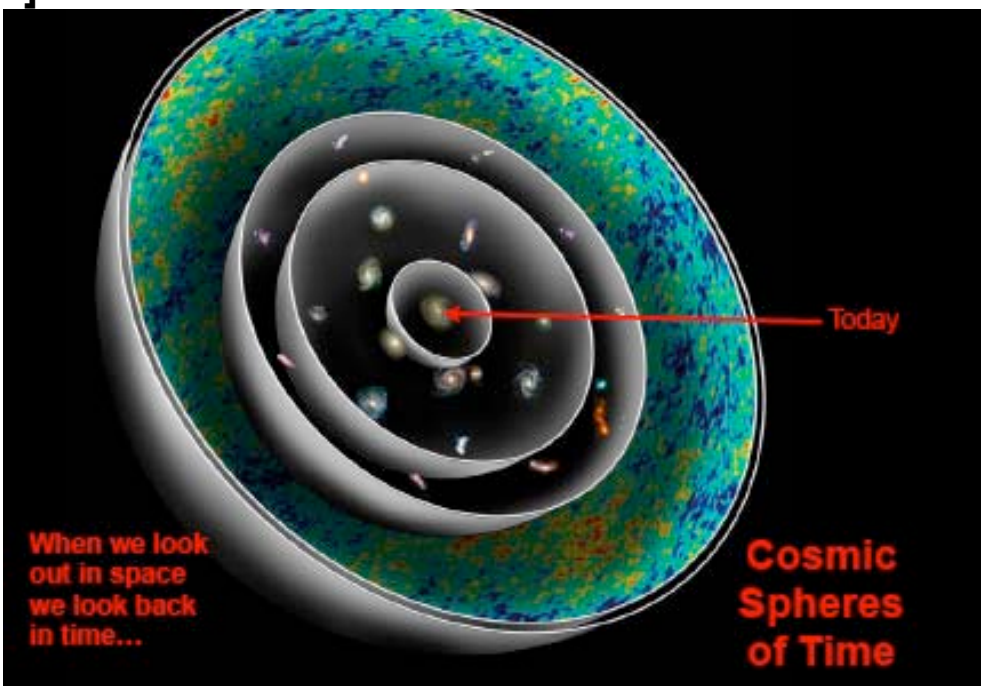


This is of course much farther than light could have traveled since the Big Bang, but the radiation that we see now was emitted when that matter was much closer to us, and the universe has expanded by a factor of 1000 since then – that's how it got to be so far away now **[CLICK]**.

NANCY:
You can discover your place in the universe without mastering the underlying theories like a scientist, the same way you can drive a car without being a professional auto mechanic. But all drivers do have to know a few things – you have to learn the rules, and you have to get a feel for the road by practicing driving – and in the same way we have to learn a few basic rules of science and practice living *consciously* in the real universe to get the benefits of being central. One way to stay conscious of our centrality is to represent ourselves as central in any symbol of the universe. Unlike the last video, which looked at our universe "from the

outside," we need to learn to look at it from the inside, where we actually are.

The Cosmic Spheres of Time place us at the center, but it's still drawn as if they are on the screen and we are outside here, looking at them. ***Jump in!*** In your imagination *take* your place there in the center of the symbol, at "Today" **[click]**



and then close the spheres around yourself. We are all immersed in the history of the universe.

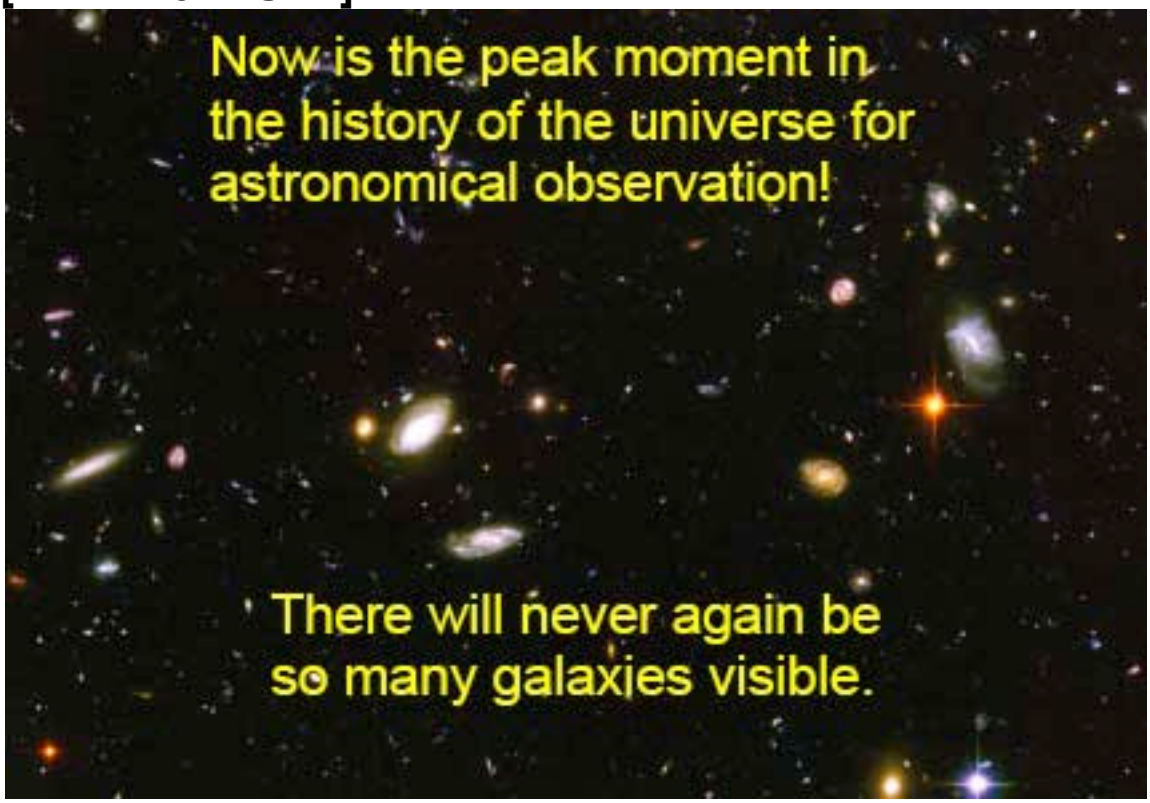
When we do this, we begin to see what it means to have a place in the universe. ***It's not a geographical place but a meaningful place,*** created by the interaction of space, time, light, and consciousness. Without consciousness, after all, there would be no visible universe.

The Cosmic Spheres of Time are real because the past is real – evidence of it in the form of light is arriving constantly.

Let me illustrate this. In the ancient world, when people needed to get a message to someone, they had no instant media – they had to send a runner, and that took time. Imagine that a runner from ancient Greece were just arriving here today, breathless, having run for thousands of years, carrying the news that the Persians had been defeated at Marathon, and we were the first to hear it from his lips. Messengers in every form of radiation and speaking the strangest languages anyone's ever heard have been running for billions of years toward Earth and are arriving at our telescopes at every moment from all over the universe with news of their ancient eras – and our generation is the first to hear them. The cosmological revolution of today is human beings finally beginning to decode all their languages, understand the news, and put the whole story together.

JOEL:

[CLICK for HUDF]



The time at which we are now living is cosmically special in several ways.

[CLICK FOR WORDS "PEAK MOMENT"

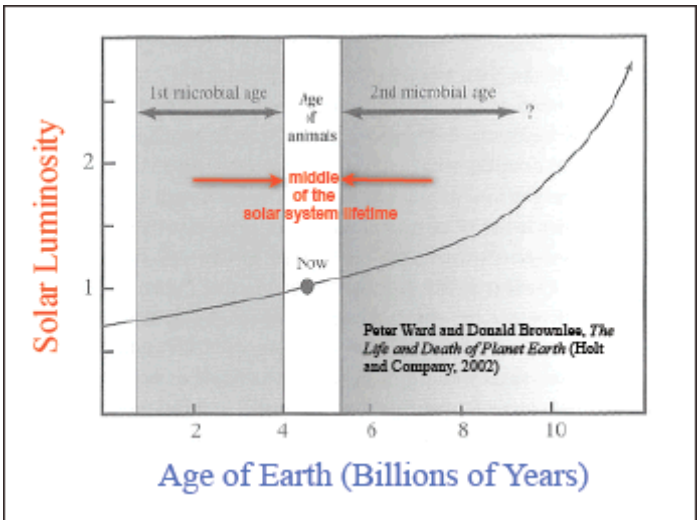
First, this is the **peak moment in the history of the universe for astronomical observation.**

It took billions of years of evolution on Earth to produce creatures with the technological ability to see the distant galaxies. But because the expansion of the universe is accelerating, the most distant galaxies are beginning to disappear over the cosmic horizon.

[CLICK FOR WORDS]

There will never again be so many galaxies visible.

Second, we are living close to the **midpoint of the life of the sun and Earth**. [***CLICK]**

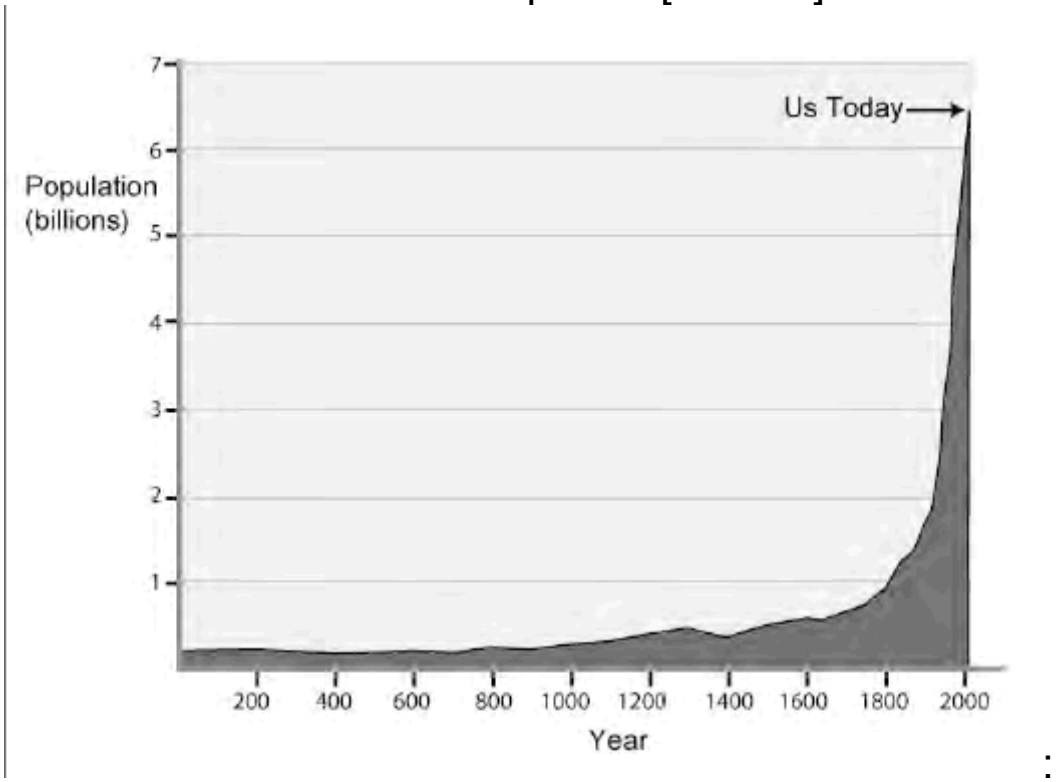


The solar system is about four and a half billion years old, and in about six billion years the sun will evolve into a red

giant star that will swallow the inner planets of Mercury and Venus and possibly burn Earth to a crisp. But **don't worry** – this process is very slow, and the sun will provide Earth with a perfectly livable amount of heat and light for at least several hundred million years – an almost unimaginably long time. As the sun heats up, our descendants will have plenty of time – millions of generations – to move to another suitable planetary system or move Earth farther from the sun (which could be done by changing the orbits of large comets). [Don Korycansky, Greg Laughlin, and Fred Adams]

Third, we live not only near the midpoint of Earth's existence, but also at the **midpoint of its approximately one billion year habitable period, when Earth has an oxygen-rich atmosphere.**

Fourth, and *much* more pressing, today is a pivotal moment for the human species [*CLICK]



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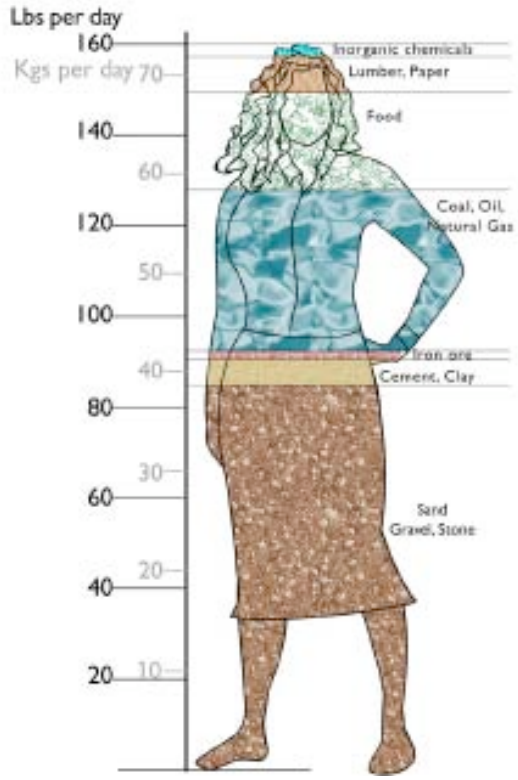
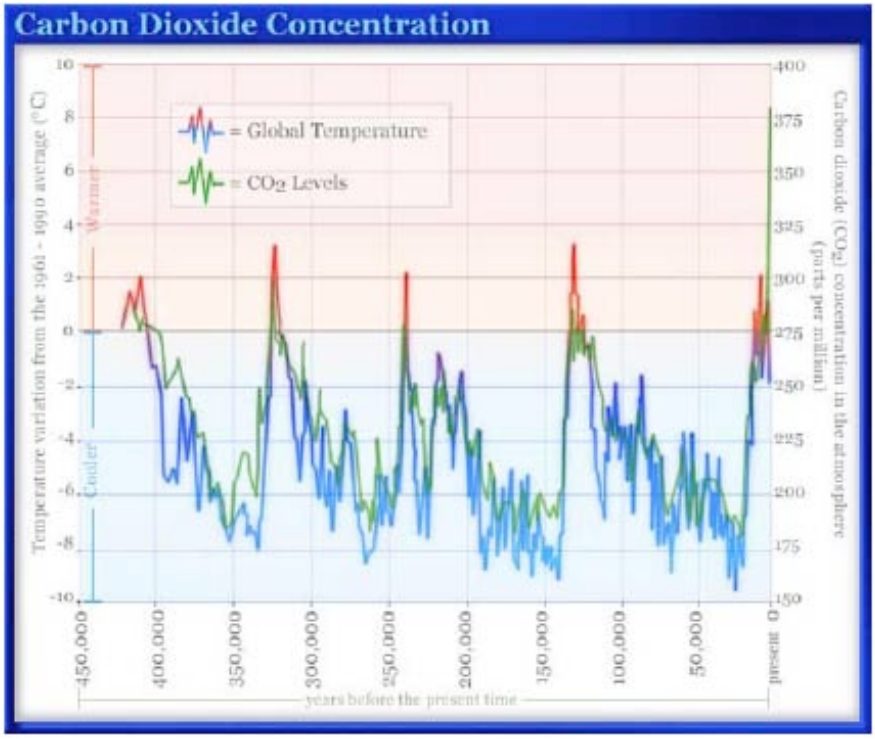
we are at a population-growth turning point and a turning point in the rate at which we will be able to exploit Earth's resources.

Americans each consume their weight in resources every day. [*CLICK]



PEOPLE IN THE U.S. CONSUME THEIR WEIGHT IN RESOURCES *EVERY DAY*

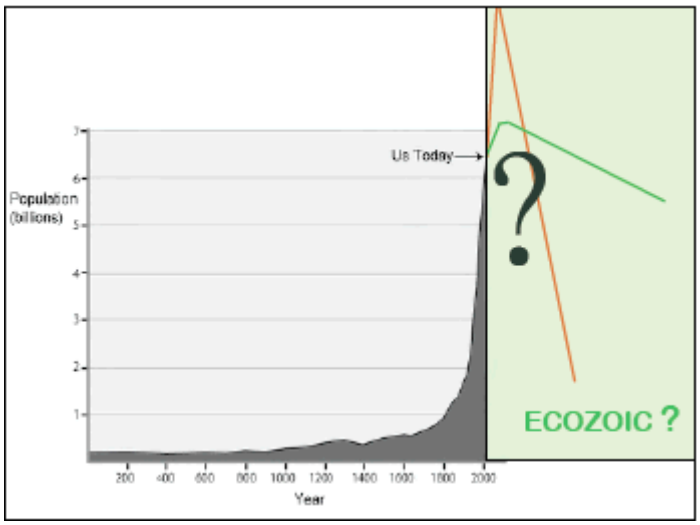
[CLICK]



On this graph of carbon dioxide concentrations in the atmosphere going back half a million years, you can see that temperature and CO2 concentrations move together (blue is the ice ages and red is the earth's warmer periods). Never has the CO2 concentration ever gone above 300 parts per million, but right now you can see that it is past 375 and rising, and there doesn't seem to be any way to stop it before 400 or 500. This is unprecedented .

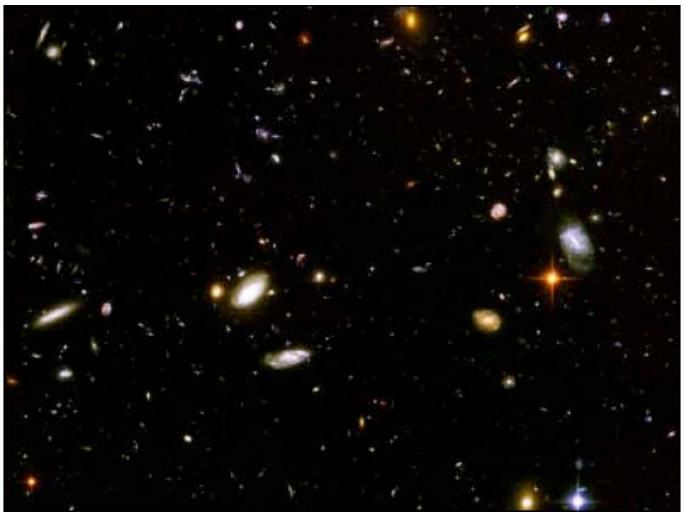
For the whole world to achieve sustainable prosperity in this age of electronics and information should not require profligate resource use.

Putting all these together, our descendants could have at least hundreds of millions of years to live together – ***if*** we can get through the next few decades without disaster.



We are at a pivotal point for the human species, because this curve cannot continue the way it's going. As time goes on, will it keep rising until there's a disastrous crash? Will it level out sanely? Decisions being made at this very moment are helping determine which future it will be.

NANCY: [CLICK]



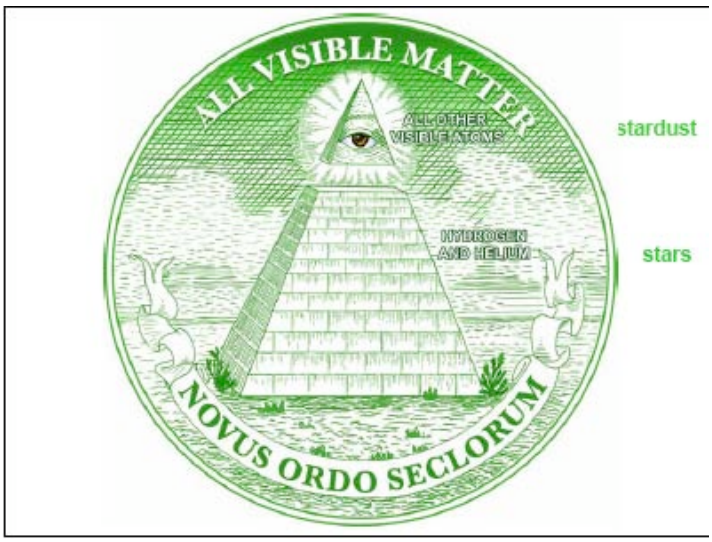
Why does it matter that we're at the midpoint of time on so many size scales? Because we're looking for our place in the universe, and our place in the modern universe is in both space and time. Traditional creation stories explained the

landscape, stars, animals, and people. But now that we have this new cosmological knowledge, a truly satisfying creation story must explain that we have evolved at the midpoint of cosmic time, and at the midpoint of Earth's best period, which falls at the midpoint of Earth's natural lifetime. These and other ways of understanding ourselves as central or special create a **sense** of place that is coming into sharper and sharper focus as science progresses. This cosmic place will be setting for creation stories of the future – as well as a rich source of new metaphors for life in general.

Not only are we at THE MIDPOINT OF TIME and the center of our visible universe – we (and our whole planet) are made of the *rarest material in the universe*, stardust, heavy elements, which account for a mere hundredth of one percent of the universe

This is what the universe looks like to the Hubble Space Telescope. It's awesomely beautiful, but it's actually very misleading as a picture of the universe because it only shows light, and light reveals less than **half of one percent** of what's out there. What's the rest? Dark matter and dark energy.

It has been a tremendous challenge to figure out what the universe is made of, but it was essential to figure it out, because what the universe is made of determines how it works. **[CLICK]**



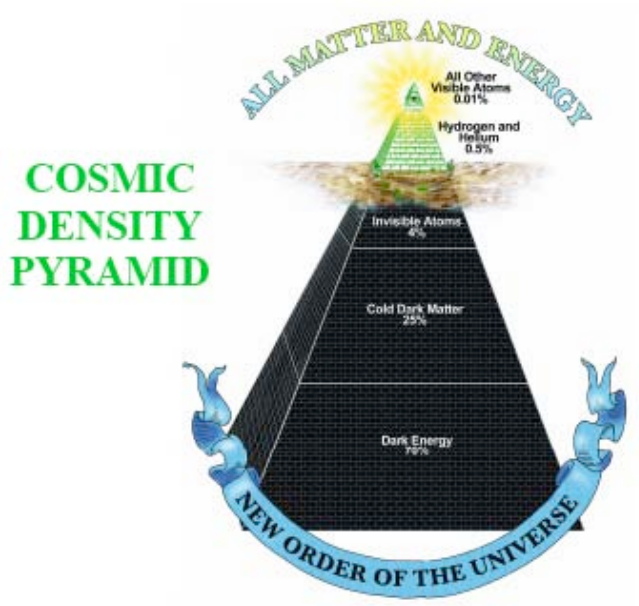
We call this symbol **The Pyramid of All Visible Matter**, and of course we borrowed it from the pyramid on the back of the dollar bill and the reverse of the Great Seal of the United States. We are using it to represent the universe as a whole, like the other symbol, but this time from the point of view of what it's made of. The volume of each section of the pyramid is proportional to the amount of that ingredient in the visible universe.

The ribbon at the bottom says in Latin "The New Order of the Ages," and that is what the new universe picture will become.

JOEL:
Almost all the atoms in the universe are just the two lightest kinds – hydrogen and helium – almost all of which came right out of the big bang. They fill the entire bottom section of the pyramid. The hydrogen and helium became **stars** [**CLICK**], and inside those stars nuclear processes created new kinds of atoms like carbon, oxygen, iron, and all the other heavy elements. These heavy atoms are ejected when the dying stars explode – and they become **stardust**

[**CLICK**] floating through interstellar space. We and our planet are made of this stardust.

The capstone of the pyramid – the floating part at the top – represents the mass of the stardust compared to that of hydrogen and helium. The Eye in the capstone represents the minuscule amount of stardust in **us** – in intelligent creatures – and it's the only cosmic ingredient not drawn to scale, since if it were to scale, it would be a microscopic point at the very tip of the capstone. This pyramid represents everything visible in the universe. But the next slide shows everything, period. [**CLICK**]



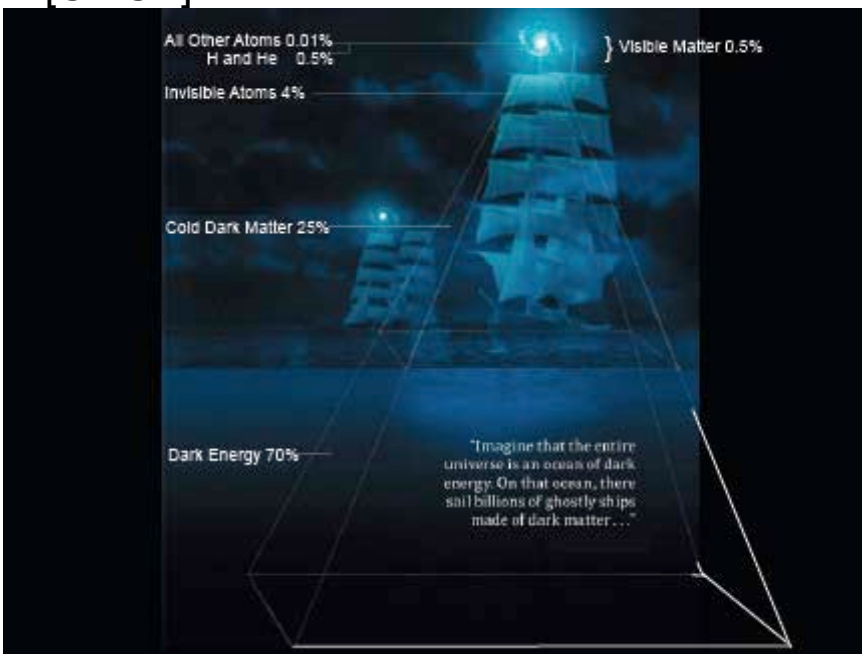
We call this symbol **The Cosmic Density Pyramid** because it contains everything that gives the universe density, including not only matter but energy. As you can see, The Pyramid of All Visible Matter is just the tip of the iceberg – or the underground pyramid, as it were.

Not all matter is made of atoms. In fact, most matter is **not** atoms. Most of the matter holding the Milky Way and all

other galaxies together is **dark matter**. It's not actually "dark" – it's invisible. It doesn't emit, reflect, or absorb light – in fact, it doesn't interact with light at all. We know it is there only because of its immense gravitation. The nature of this dark matter controls the origin and evolution of galaxies, galaxy clusters, and all the larger structures we showed earlier in this talk.

The largest portion of the pyramid, 70% of the density of the universe, is **Dark Energy**. We have only known this since 1998, but the evidence is now convincing. This Dark Energy is causing the universe to expand faster and faster.

NANCY: [CLICK]



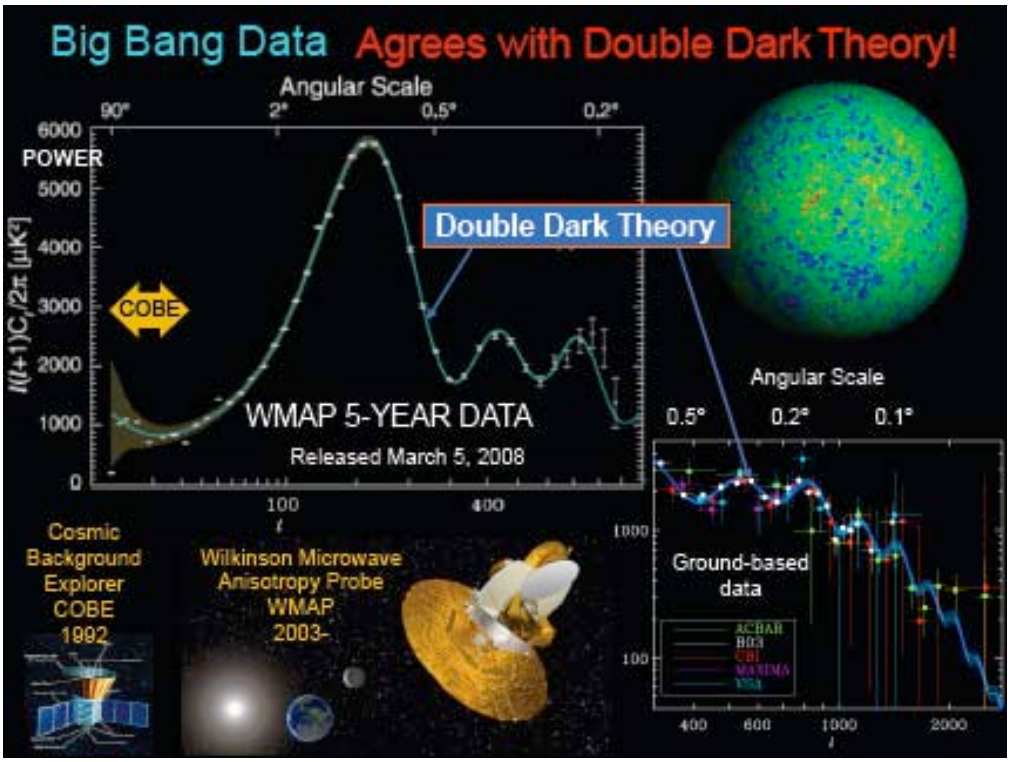
Another way to think about it is to imagine that there is an invisible ocean filling the universe, and this ocean is made of **dark energy**, the energy that powers the expansion of the universe. On that vast and ever-expanding ocean sail billions of ghost ships, made of **dark matter.** Dark matter is a unique, invisible substance that contains no atoms or any of the parts of atoms. No one really knows yet what dark matter

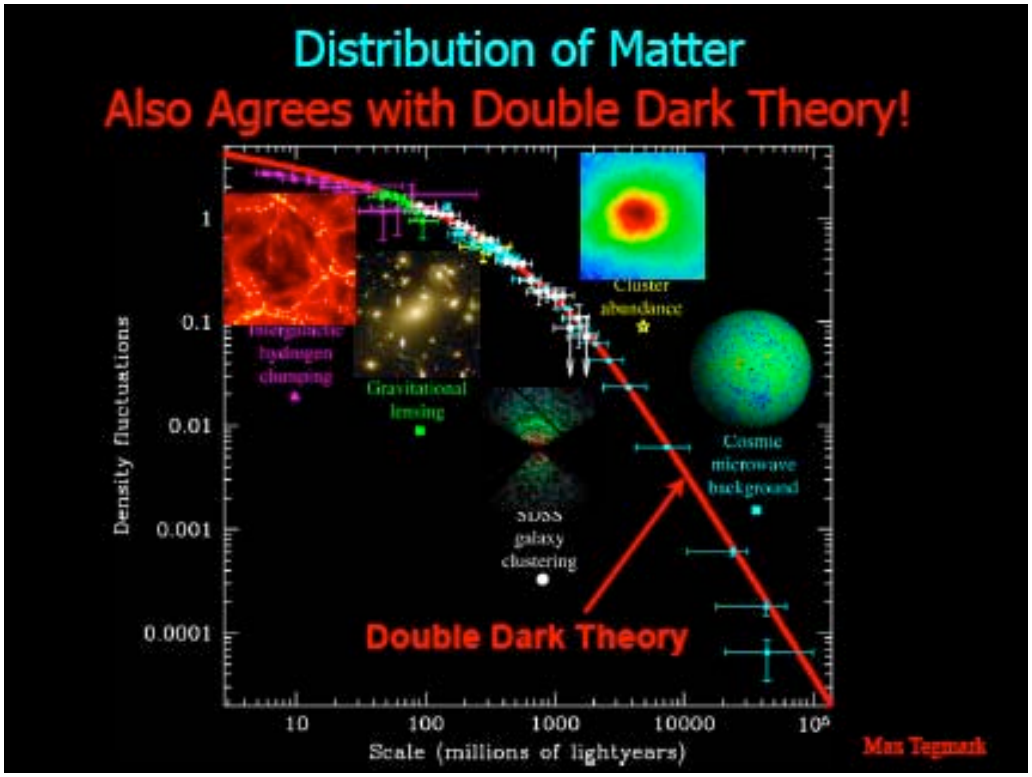
is, though we know how it behaves. At the tips of the tallest masts of the largest ghost ships are tiny beacons of visible light, called galaxies, and with Hubble Space Telescope, those beacons are all we see. We don't see the ghost ships or the ocean, but we know they're there through theory, specifically the Double Dark theory.

JOEL:
Why do we scientists now believe that dark matter and dark energy exist?

The reason is that the Double Dark theory has continued to predict observations successfully as huge amounts of new data have become available from the wonderful telescopes on the ground, like Keck Observatory in Hawaii, and in space, like the Hubble Space Telescope. These have been tremendously important, but crucial evidence has come from satellites observing not light, but the heat radiation of the Big Bang.

I will show you the clinching evidence that has convinced astronomers all over the world. I'm going to get a little bit technical for just a minute, but I think you'll see why it's worth it.


Big Bang Data Agrees with Double Dark Theory!
Angular Scale
90°
2°
0.5°
0.2°
POWER
$l(l+1)C_l/2\pi$ [μK²]
6000
5000
4000
3000
2000
1000
0
Double Dark Theory
COBE
WMAP 5-YEAR DATA
Released March 5, 2008
100
400
l
Cosmic Background Explorer COBE 1992
Wilkinson Microwave Anisotropy Probe WMAP 2003-
Angular Scale
0.5°
0.2°
0.1°
1000
100
Ground-based data
ACBAR
BOI
CBI
MAXIMA
VSA
400
600
1000
2000
l

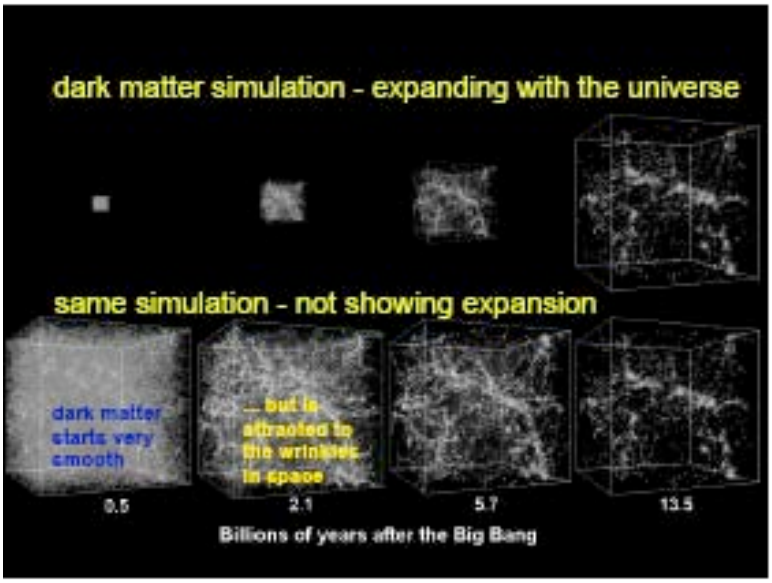

Distribution of Matter
Also Agrees with Double Dark Theory!
Density fluctuations
1
0.1
0.01
0.001
0.0001
Intergalactic hydrogen clumping
Gravitational lensing
Cluster abundance
Cosmic microwave background
SDSS galaxy clustering
Double Dark Theory
10
100
1000
10000
10^5
Scale (millions of lightyears)
Max Tegmark

NANCY: [click]

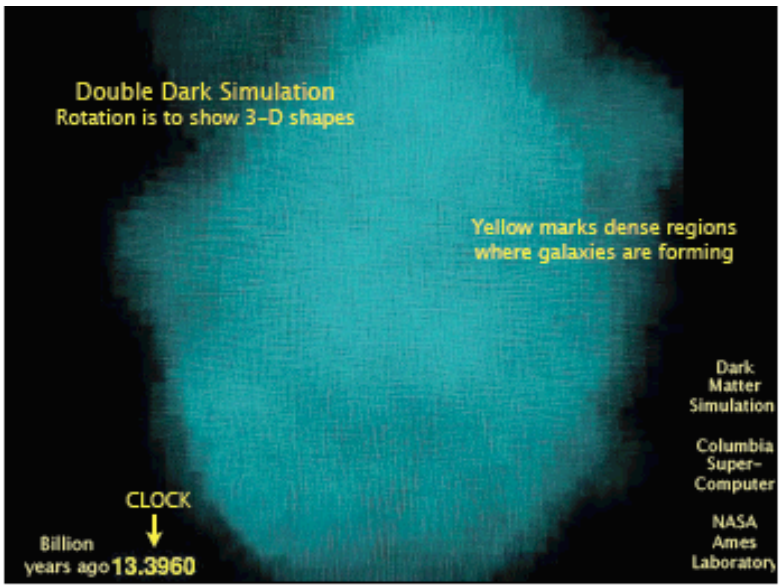
And now you too can ***see* what cannot be seen**! The next two videos often confuse people, so let me explain what's coming. In the prior videos when you saw galaxies, you saw actual observations of their light captured by telescopes. But no light ever comes from dark matter. We only detect it through its gravitational effects. However, by using computer simulations, we can show the **invisible dark matter**.

What will look bright and sparkling in the next video is in reality not bright and sparkling at all **– it's completely invisible.** The video uses brightness to represent density – the brighter a region appears, the more dark matter it contains.

JOEL:

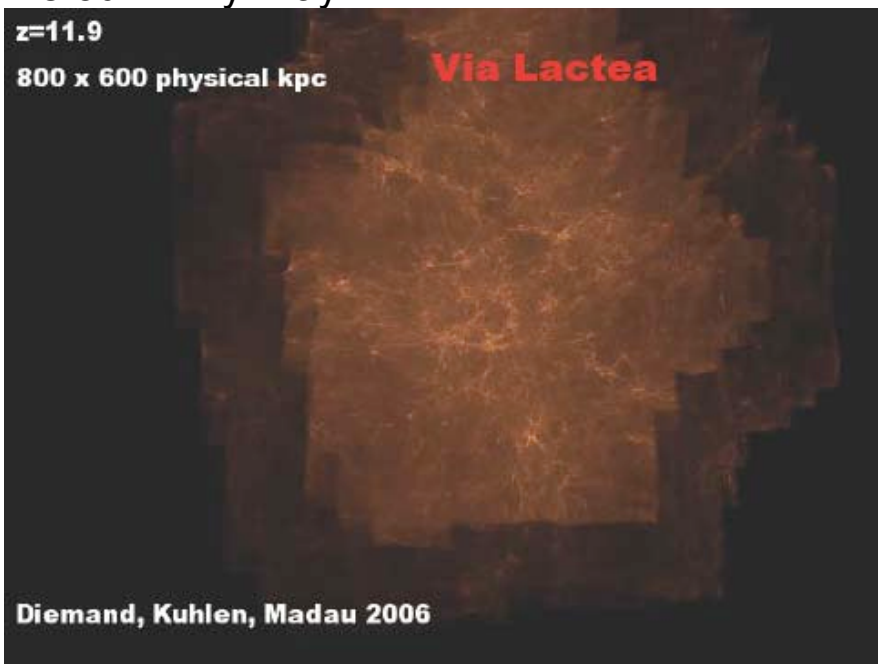


The first video shows how a region about 75 million light years across evolves, starting shortly after the Big Bang. Notice the clock in the lower left corner, showing billions of years **ago**.



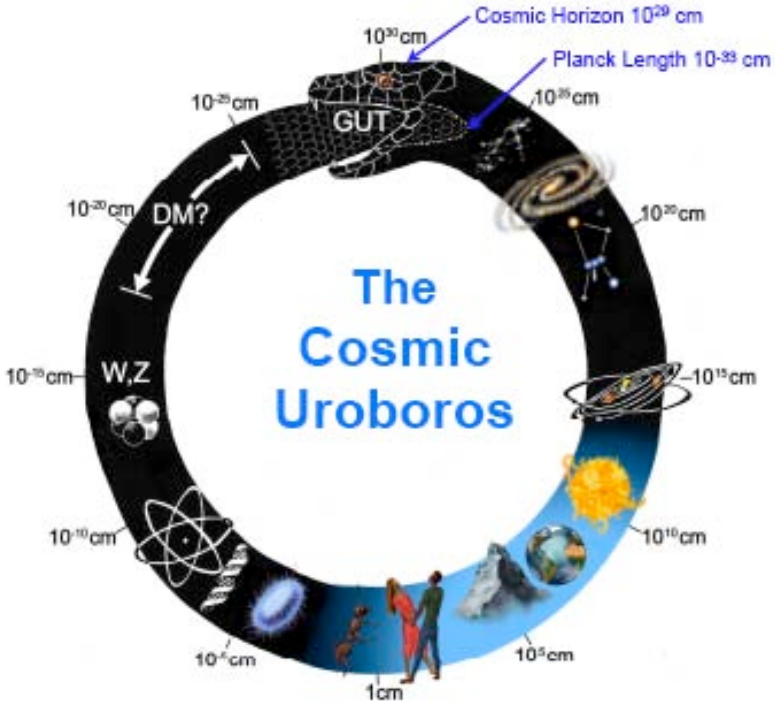
You just saw how the cosmic web of dark matter forms, and that at the intersections of the filaments the density is much greater – that's where clusters of galaxies form. Now we are going to zoom all the way in to one tiny dot on the prior

video, and look at the formation of the dark matter halo of a galaxy like our Milky Way.



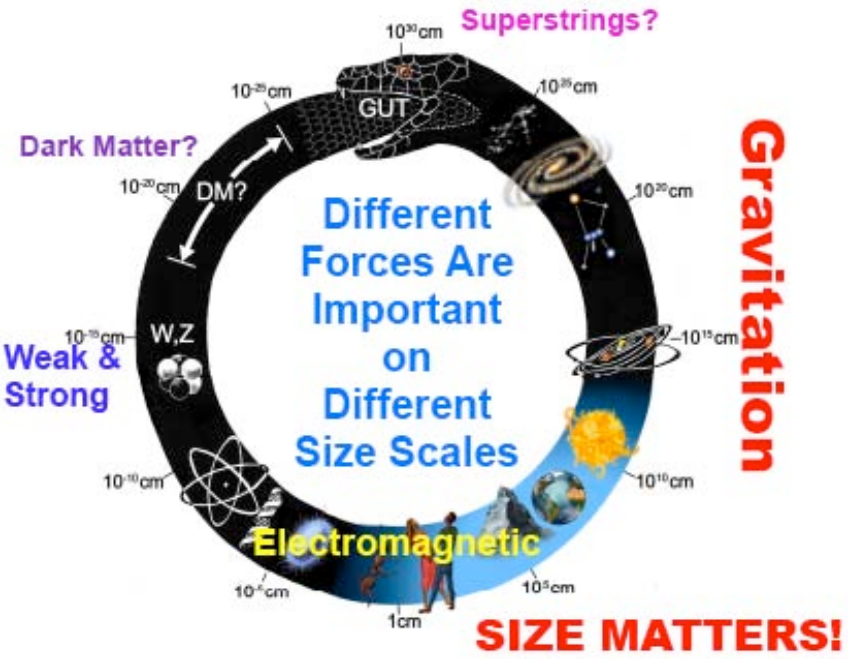
NANCY:
The way to intuitively grasp this new picture of the universe as a whole is to visualize in the Mind's Eye the invisible as well as the visible. What lets us do this **accurately** today is a combination of technological tools like telescopes and supercomputers and conceptual tools like the Double Dark theory. But what lets us do it **meaningfully** is that we include ourselves in the picture.

We've suggested two ways so far: the symbol of the Cosmic Spheres of Time lets us visualize ourselves immersed in the entire past of the visible universe. The Cosmic Density Pyramid lets us visualize ourselves in relation to all the ingredients of the universe, both visible and invisible. We're going to suggest one more way of visualizing the universe as a whole. This way focuses not on time or material but on the meaning of size.



This is what we call the Cosmic Uroboros, and it represents all the possible sizes in the universe. We've arrayed them logarithmically around the serpent, from the smallest size current physics allows, called the Planck length, at the tip of the tail to the largest size we can say anything meaningful about – the size of the visible universe – at the head.
It's an almost unimaginably wide range of sizes, but it turns out that **we humans are almost exactly in the middle**.
And we couldn't be anywhere else. If we were much smaller we wouldn't have enough atoms to be complex. If we were much larger, the speed of thought and other internal communications (which are limited by the speed of light) would be too slow. Only near the center of possible sizes can consciousness as complex as ours exist, and this tells us something about intelligent life anywhere in the universe.

JOEL:



On different size scales, different laws of physics control what happens. **[CLICK for Gravitation to Superstrings but DON"T discuss.]** Everything has to be the size it is – it could never work if its size were substantially different. Size matters! [CLICK]

SIZE MATTERS!

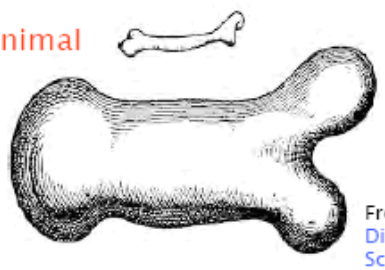
No animal could be 3 times its normal height and stay the same shape, simply scaled up.

If height increases 3 times,
strength of bones increases 3x3 = 9 times.
But weight increases 3x3x3 = 27 times.
Its weight would crush its bones!

That is why an elephant does not look like a large gazelle.

Bone of small animal

Bone of animal 3 times longer



From Galileo's last book, Discourses On Two New Sciences (1638).

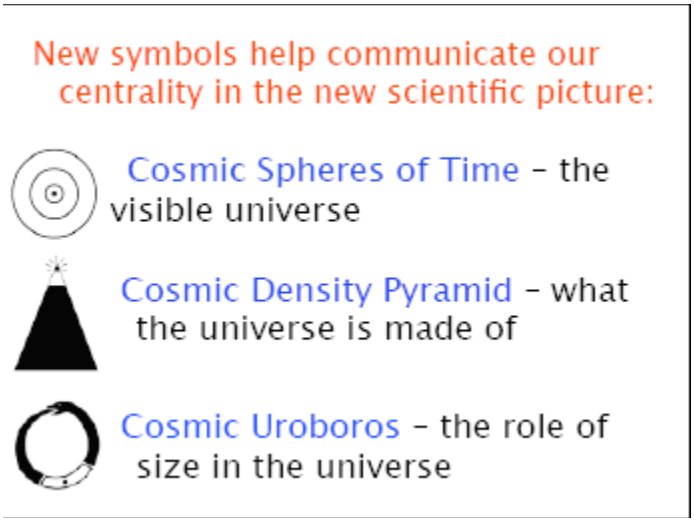
Do you think Hollywood knows that? **[CLICK]**

NANCY: Here we are at the center of the Cosmic Uroboros, and the size scales surrounding us make up our conscious world, the section that we show here in sunlight. It includes everything from the littlest creatures humans can see with the naked eye, smaller than ants, up to the sun. In our book, we have named this group of size scales Midgard, a name that comes from the Norse mythology of the Eddas. This is what most people think of as reality – but it's not all of reality; it's the special part of the universe for which human beings have intuition. Midgard is our homeland in the universe. [**CLICK** FOR "HOME SWEET HOME"]

Midgard is everywhere in the universe. It's not a place. It's a setting of the intellectual zoom lens. On a planet in a distant galaxy a billion light years away, your Midgard intuition about how things work would be very useful, though fallible. But if you stay right here in this room and just change your mental focus to encompass size scales far outside Midgard – your intuition becomes worthless. Without science, no one can – and no one ever did – imagine accurately how the universe began or how very small or very large things behave. Everything ***outside*** Midgard can only be known through science, and only experienced, if at all, spiritually.

"Spiritual" is a controversial word, so let me define it. Many people assume that if there is a spiritual reality, it's different and separate from physical reality. But for us, spirituality has nothing to do with a separate reality – quite the contrary. It's about *experiencing* reality – this reality, the only reality – all the way out and all the way in, using everything that not only science but history and other fields of scholarship can tell us about the universe and ourselves. Spirituality is about feeling and appreciating my personal connection to the universe that the evidence says exists.

JOEL:



In our new scientific picture, no matter which of these perspectives we look from, we humans occupy a central or special place. We are the **point** of each symbol.

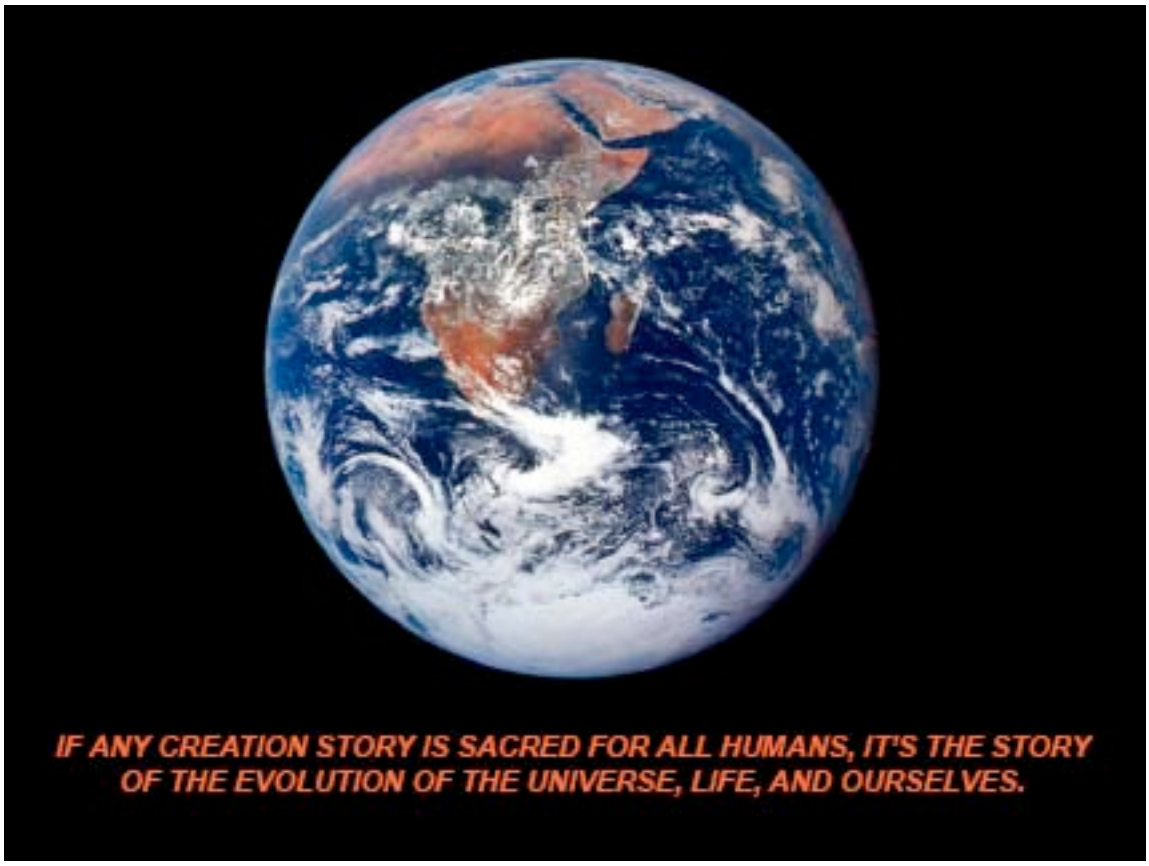
These three metaphors express different aspects of a single scientific worldview. They are not mutually exclusive. The fact that they're so different inspires humility and helps us realize that the universe is beyond any particular metaphor.

NANCY:
We can, of course, write off all this centrality stuff as meaningless, nonscientific coincidence. But is that SMART? If being **truly** central to the universe in these interesting ways is meaningless, it is hard to imagine what discovery about our place could ever be meaningful.

No scientific explanation that assumes we are objective observers of a universe "out there" can ever be satisfying – but more than that, no such explanation can ever be complete, since the universe exists not just on large size

scales but on all size scales, and on our scale we are indisputably here and must be explained.

There is already a small but growing movement around the world to transcend the narrow thinking of today's religions and recognize [CLICK FOR EARTH]



that if any creation story is sacred for all humans, it's the story of the evolution of the universe, life, and ourselves.

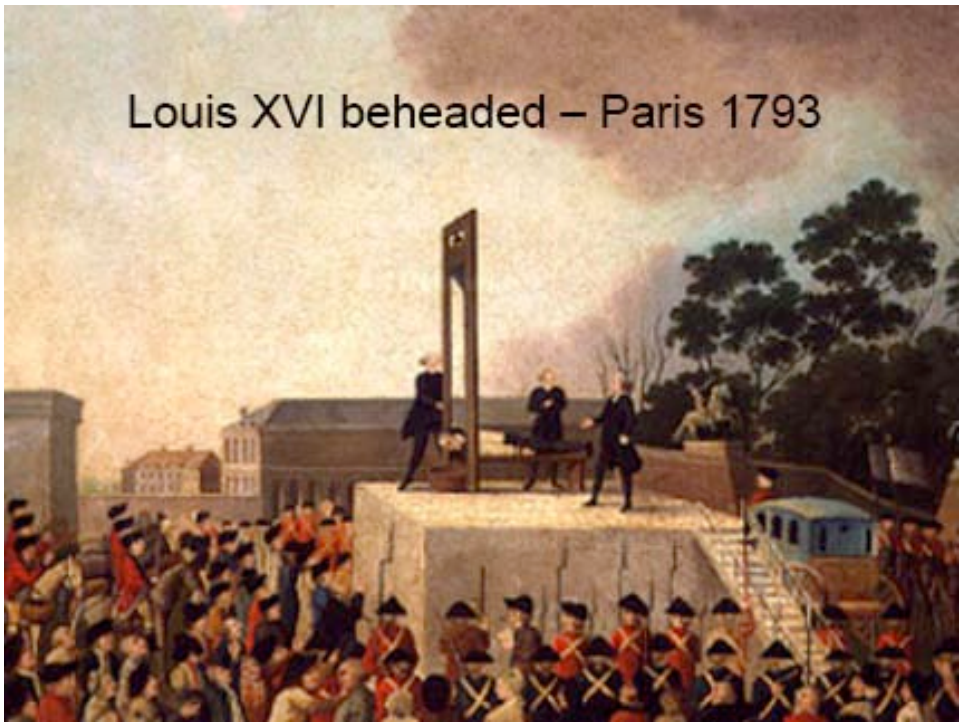
Many scientifically literate people automatically assume that this notion is a mish-mash of science and religion that pollutes science, and they dismiss it out of hand as both

impossible and undesirable. But Joel and I are not talking about religion. We're talking about understanding and appreciating our place in ***the universe that we now know exists***. The universe doesn't belong to the experts. This is everyone's universe. It is the cosmic context of our lives and our planet and reveals a larger scale meaning to what we are doing today on Earth and to Earth.

A future shared cosmology could provide for the first time ever, BOTH a scientifically accurate map of reality AND the felt certainty of belonging to and having a meaningful place in that reality. Without this, it may be difficult if not impossible to motivate enough people around the world to do what must be done to recover from our destructive ways. But with it, the inspirational power that centrality always held for earlier cultures would be ours. The new understanding that intelligent life matters to the cosmos would encourage us to think big. Each one of us is connected to a multi-billion year past: we need to start thinking of our legacy on a comparable scale, something worthy of our distant descendants – not only protecting the environment on Earth, important as this is, but laying the foundations for a wise and just global civilization. A stable, long-lived civilization is probably a prerequisite for major accomplishments like serious space exploration and possibly even colonizing the Galaxy.

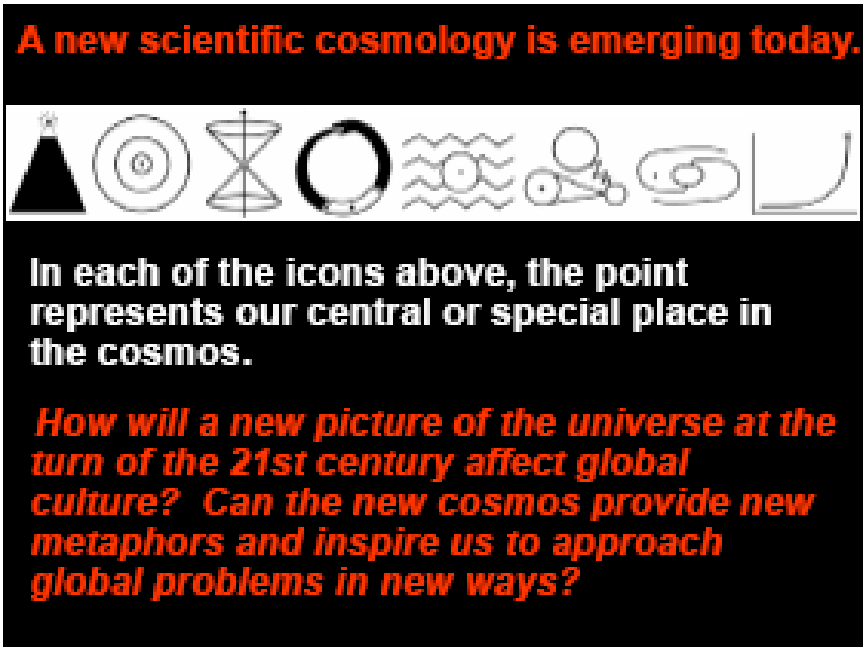
Why fight to save humanity if you think we're nothing but nuclear waste? Romantics will inherit the earth.

JOEL:
A new cosmology has the power to overturn the fundamental institutions of society. This is in fact what happened in the last cosmological revolution on the scale of this one, when the Copernican-Newtonian cosmology overthrew the medieval cosmology of the heavenly spheres. That revolution undercut the rigid social and religious hierarchies of medieval society that had been justified by their picture of the heavens. And soon the divine right of kings was challenged and kings of England and France lost their heads. [*CLICK]



This is the kind of practical consequence that can result from a change in cosmology.

NANCY: As global-scale disasters very likely unfold over the coming years, many more people may begin to recognize the limits, for taking care of Earth, of all local assumptions, both political and religious. Once that happens, many may open to an overarching, unifying vision for Earth that would help us cooperate for the long-term good of the species. By understanding the basic principle of the Cosmic Uroboros -- that different laws control events on different size scales – we would see that it is possible to preserve diversity on local scales while seeking harmony with the universe – an ancient goal with new meaning – on the global scale.



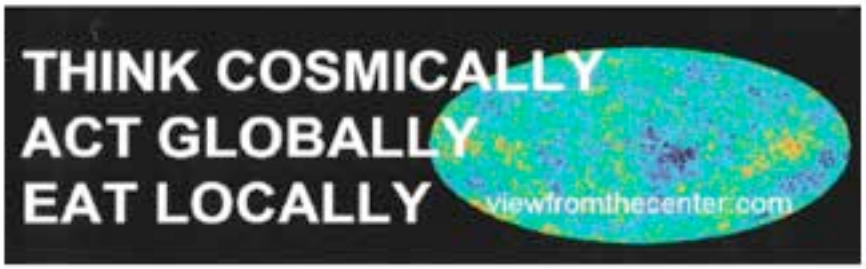
Our time may seem ordinary to us, but it will be mythic in the future of our planet. If we wake up to the reality of our universe and our predicament on Earth, if we become willing to expand our interpretations of our religious traditions to encompass this new knowledge, if we begin to teach this new picture of the universe to our children **[CLICK**]

and to each other and integrate its principles wherever appropriate into our thinking and our art ***as if*** this is the real universe – our culture could have a new Enlightenment.

We are at the *center* of a vast, cosmic adventure – not outside it and not at its end.

[CLICK]

SO THINK COSMICALLY, ACT GLOBALLY, AND EAT LOCALLY!



Thank you. [**CLICK]**

Credits

Videos:

Voyage to Virgo Cluster - www.ifa.hawaii.edu/~tully
SDSS map galaxies - astro.uchicago.edu/cosmus
Cosmological simulation - Allgood & Henze, NASA Ames
Via Lactea simulation - Diemand, Kuhlen, Madau

Music:

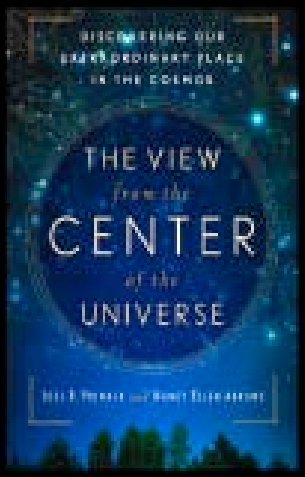
Nancy Abrams
Nancy Abrams
R. Stoltzman
J. S. Bach

Symbolic Images of the Cosmos:

Cosmic Density Pyramids

Spheres of Time

Cosmic Uroboros



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