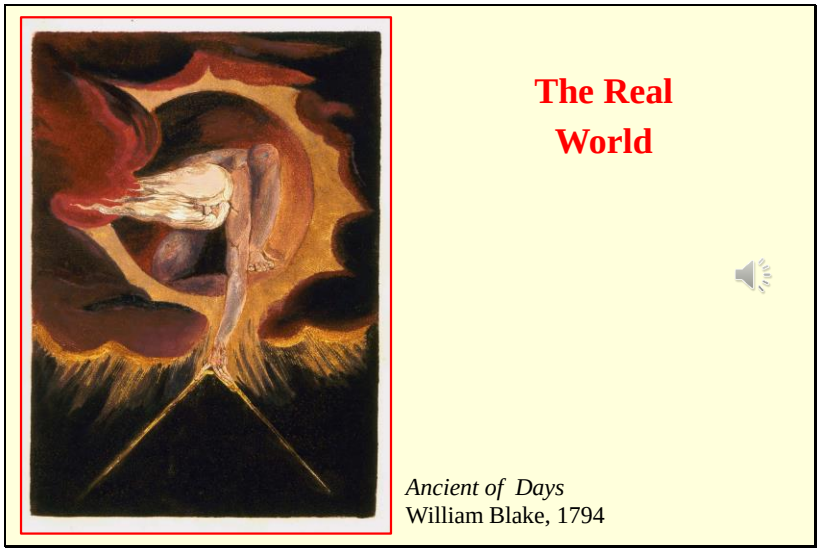
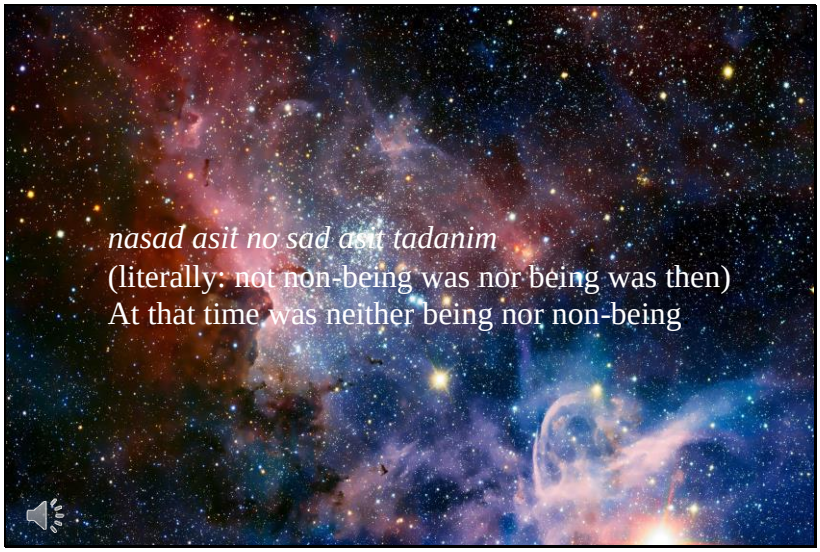



This session will consider the world we live in: how it began and what it is made of.

The illustration shows the *Ancient of Days* laying the foundations of the earth. As is clearly stated in the Book of Job, we were not there when the universe began. Is it hubris to believe that we might know what happened then? As God spoke to Job out of the whirlwind (*Job* 38: 4-7):

> Where wast thou when I laid the foundations of the earth? declare, if thou hast understanding.
>
> Who hath laid the measures thereof, if thou knowest? or who hath stretched the line upon it?
>
> Whereupon are the foundations thereof fastened? or who laid the corner stone thereof;
>
> When the morning stars sang together, and all the sons of God shouted for joy?

Recitation is by Alexander Scourby




The quotation is the beginning of Nasadiya Sukta. This is a creation hymn in the Hindu scripture RigVeda (X: 129) from about 1000 BCE.
https://en.wikipedia.org/wiki/Nasadiya_Sukta

Audio is from
https://www.youtube.com/watch?v=88zA8Rz4s90
https://www.youtube.com/watch?v=nN5xgf9gFeo
(first contains transliterations and translations)

Vedic texts are difficult to translate since they consider abstract concepts in a poetic manner using a language that is no longer spoken. The first line of the creation hymn is a marvel of poetic paradox. The first five words are either negatives or variants of the verb to be (*sad* being, *asit* was). Affirmation and denial are completely interwoven in this incantation. It is and it is not are not yet differentiated.

In the 20th century Martin Heidegger posed the fundamental question: “Why are there beings at all instead of nothing?” Though this became a focal issue for the existentialist movement, the idea goes back to the Vedas and to the early Greek philosopher Parmenides (5th century BCE), who was concerned about the difference between “it is or it is not” (*estin e ouk estin*). To be or not to be, that is the question.

The Creation hymn in the Rig Veda concludes

> Whence all creation had its origin,
> he, whether he fashioned it or whether he did not,
> he, who surveys it all from highest heaven,
> he knows - or maybe even he does not know.
> (translated A. L. Basham)

**Shiva Nataraja**
**Lord of the Dance**

In the night of Brahma, Nature is inert, and cannot dance till Shiva wills it: He rises from His rapture, and dancing sends through inert matter pulsing waves of awakening sound, and lo! matter also dances appearing as a glory round about Him. Dancing, He sustains its manifold phenomena. In the fulness of time, still dancing, he destroys all forms and names by fire and gives new rest. This is poetry; but none the less, science! (Ananda Coomaraswamy, 1918).

From the abstract philosophy of the creation hymn in the Vedas, we move to a more poetic description of creation in the Upanishads: the world set into motion by the dance of Shiva. The sculpture was made in Southern India in the 10th century CE.

Shiva dances within a flaming aureole that represents both the universe and the mind of man. The universe moves into and out of existence, into and out of consciousness. Shiva's posterior right hand holds a small drum (*damaru*) that beats the rhythm of creation and his posterior left hand cradles the fire (*agni*) of destruction. The anterior right hand is raised in the *abhaya* (Be not afraid) gesture, and a cobra is coiled around his right forearm. The anterior left hand points down to his raised left foot in the *gaja* (elephant) gesture: the drooping hand mimics the elephant's trunk and raised fingers suggest his tusks. This alludes to Shiva's son Ganesha, the elephant-headed god, who provides the means to overcome all obstacles. The raised left foot represents the release from suffering, and the stable right foot represents the defeat of evil. The lower locks of Shiva's hair fly out in the frenzy of the dance. Through these braids flow the sacred waters. On Shiva's right, the Goddess Ganga, whose incarnation is the River Ganges, rests in the flowers that float upon the waters. Shiva's right earring is serpentine (male) and his left earring circular (female).

## Genesis

In the beginning God created the heaven and the earth.

And the earth was without form, and void; and darkness was upon the face of the deep. And the Spirit of God moved upon the face of the waters.

And God said, Let there be light: and there was light.

And God saw the light, that it was good: and God divided the light from the darkness.

Haydn, *The Creation*

Michelangelo, Sistine Chapel, 1511

The monotheistic religions of the West were far more specific about the creation than the Eastern religions. They attributed the universe to God who worked hard for six days to create everything that is. The story in *Genesis* is enthralling. The most striking moment is the command "Let there be light." *The Creation* in English is by Birmingham Symphony and Chorus conducted by Simon Rattle with David Thomas (Bass) and Philip Langridge (Tenor).

Michelangelo's portrayal of *God Separating the Light from the Darkness* is surrounded by four "ignudi," who likely represent angels. These are perhaps Michelangelo's greatest creation – male nudes in poses of restrained power. This fresco, though the first in the historical story, was the last to be painted.

## Goodness of Creation

And God saw every thing that he had made, and, behold, it was very good. (*Genesis* 1: 31)

Many people have tried to explain why the universe is the way it is. Various answers are that our universe is

**absurd** – the universe happened by chance alone

**fine-tuned** – this particular universe was set up with all the necessary parameters adjusted to allow the development of life and intelligence

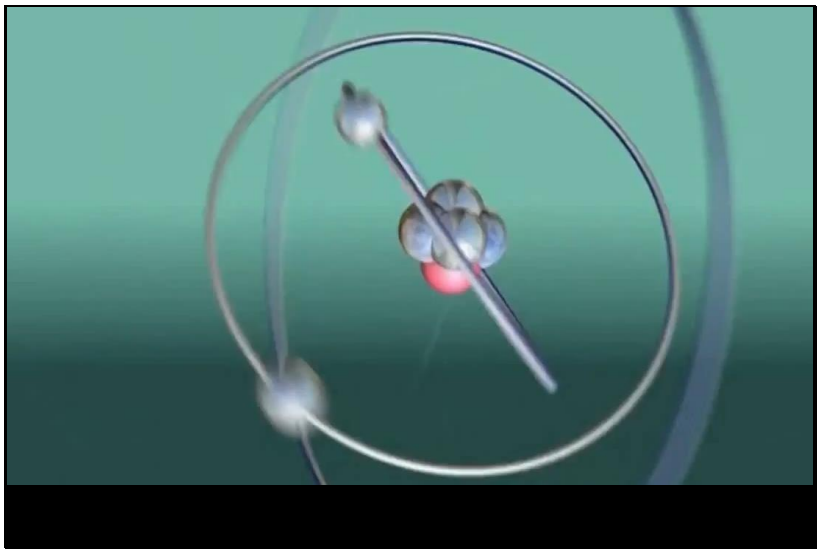
**multiple** – an infinite number of universes occur and we live on one that supports life (or there is a natural selection of universes with only those that support life surviving)

**conscious** – only universes that can develop consciousness can exist because nothing is the way it is unless it can be perceived

**fake** – we live in a virtual simulation

Fine-tuning also goes by the name of the "anthropic principle."
One way of looking at creation is that God designed the universe – determined the physical laws and set all the physical constants – so that it would be a perfect place for human beings.

Another way is that we are creatures that have adapted to where we live:
“It is no more surprising that we live in a universe suited for us than it is that we live on the planet suited for us—Earth rather than Mars or Venus. The universe is not fine-tuned to life; life is fine-tuned to the universe” (Stenger, 2005)



We shall soon come later the Big Bang Theory of the origin of the universe. Now we shall consider the TV program *The Big Bang Theory*. Sheldon (Jim Parsons) asks Leonard (Johnny Galecki) about the Anthropic Principle.

**Story of Noah**

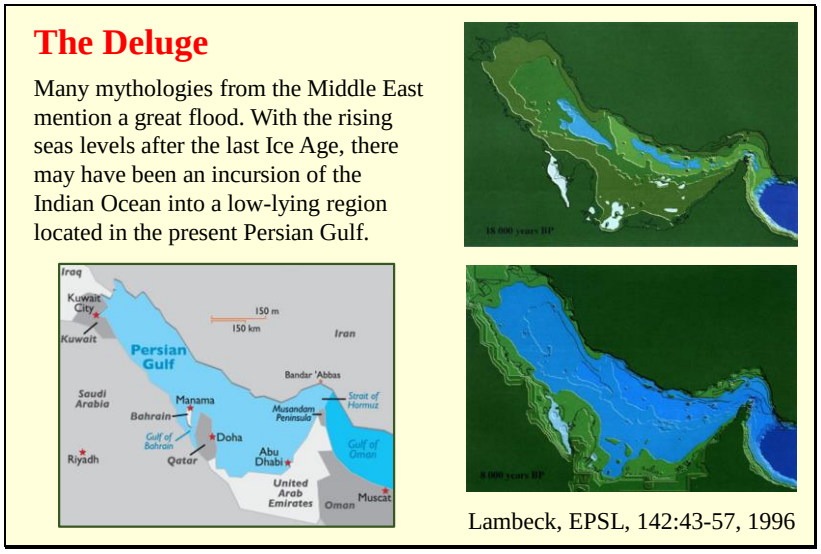
Lorenzo Ghiberti
*Gates of Paradise*
1452

Although God initially thought that his creation was good, he quickly changed his mind and decided to drown everyone and start anew.

The upper part of the panel shows the ark – a huge pyramidal structure – at rest upon a mountain. (Some old interpretations suggested that the top of the ark was tied together as in a pyramid.) Noah and his family release the animals and survey the destruction and the drowned. In the upper right God gives instructions to Noah. His instructions form the basis of the natural law – rules to live by before the commandments were given to Moses. These are the Noahide laws

Do not deny God.
Do not blaspheme God.
Do not murder.
Do not engage in illicit sexual relations.
Do not steal.
Do not eat from a live animal.
Establish a legal system to ensure the laws are obeyed.

The lower portion of the panel shows on the right Noah's sacrifice in thanks to God, and on the left Noah's shameful drunkenness. The drunkenness of Noah – wherein he exposes himself (and more) to his sons – is the primal sin of the new world created after the flood. Just like in Eden man takes of the fruit of a tree (here the grape rather than an apple), commits a sin, and is ashamed of his nakedness.

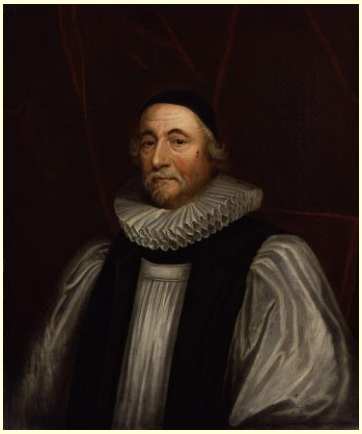



The prehistorical regions of the Persian Gulf would have been very fertile – there would have been lakes and marshland where the Tigris and Euphrates Rivers descended toward the Indian Ocean. Some have suggested that this area might have been the mythical garden of Eden. There never could have been a flood that covered the entire Earth. The sea levels rose slowly after the Ice Age ended about 10,000 BP, but there may have been cataclysmic flood in the region of the Persian Gulf associated with a tsunami in the Indian Ocean.

EPSL - *Earth and Planetary Science Letters*.

## James Ussher (1581-1656)

Ussher was a brilliant student of theology and went on to become an Archbishop in the Church of Ireland (part of the Anglican Communion). He wrote an important history of Christianity in Britain. In 1648 he published his chronology of the Bible: the Universe was created at around 6 pm on 22 October 4004 BCE; Solomon's Temple was built in 1004 BCE. Dating could be given as *Anno Mundi* (years since the creation).



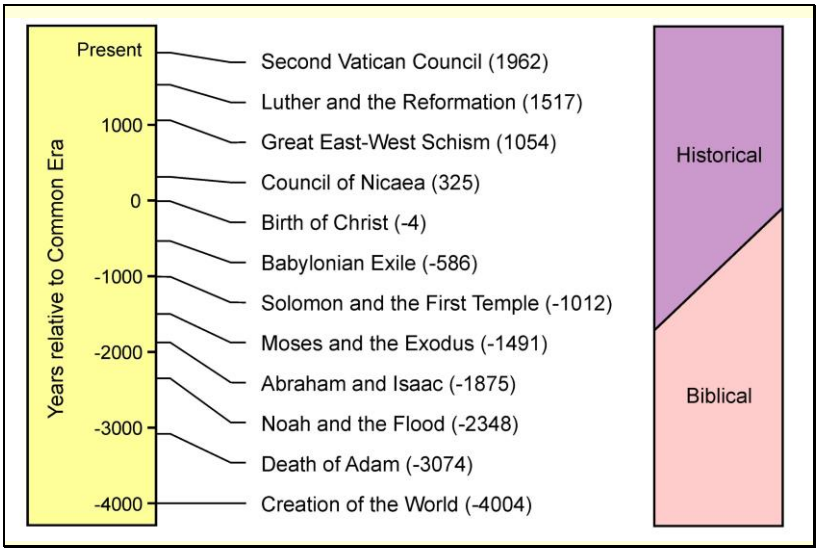
Portrait by Peter Lely, about 1655

Ussher's chronology was based on all the "begats" that occur in the bible.

And Adam lived an hundred and thirty years, and begat a son in his own likeness, and after his image; and called his name Seth …

And Seth lived an hundred and five years, and begat Enos … And Enos lived ninety years, and begat Cainan (*Genesis* 5 3-9)

Current geological studies suggest that there might have been a flood in the region of the Persian Gulf about 10000 years ago. This fits with the stories told in the Bible. But the dates do not compute. Ussher dated the origin of the world to 4004 BCE and the flood to 2348 BCE.



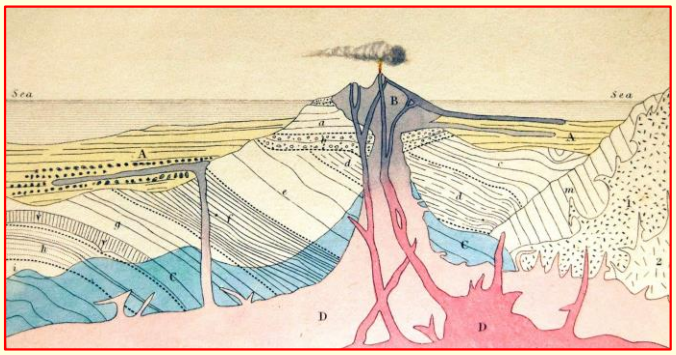
The left shows the dates of the world according to chronologies such as that of Bishop Ussher. There is historical evidence for the more recent of these events – from Solomon onward. Most people consider Biblical events earlier than Solomon as mythological. The stories of Abraham and Moses have no real historical evidence. But they make for wonderful stories – the birth and binding of Isaac, Sodom and Gomorra, burning bushes, the babe in the bulrushes, the parting of the Red Sea.

Reconstruction of *Megalosauros*, bones of which were discovered in England in the 17th Century CE (about 9 m from nose to tail) .

## The Fossil Record

Fossil remains of plants and animals discovered in layers of sedimentary rock were initially attributed to the Deluge described in Genesis. However, it was not easy to explain why the fossils were at multiple levels if there had only been one flood. Furthermore, some of the fossils were from animals that no longer existed. This contravened the idea that Noah had preserved all God's species in the Ark.

Dinosaur bones were known since ancient times. They were thought to be the bones of giants, dragons, elephants. etc. In the 17th century they were considered more scientifically.




from *Elements of Geology* by Charles Lyell 1838

## Geology

Studies of mountains and rocks led the idea that the crust of the Earth had been altered over many thousands of years by volcanic activity and by earthquakes.

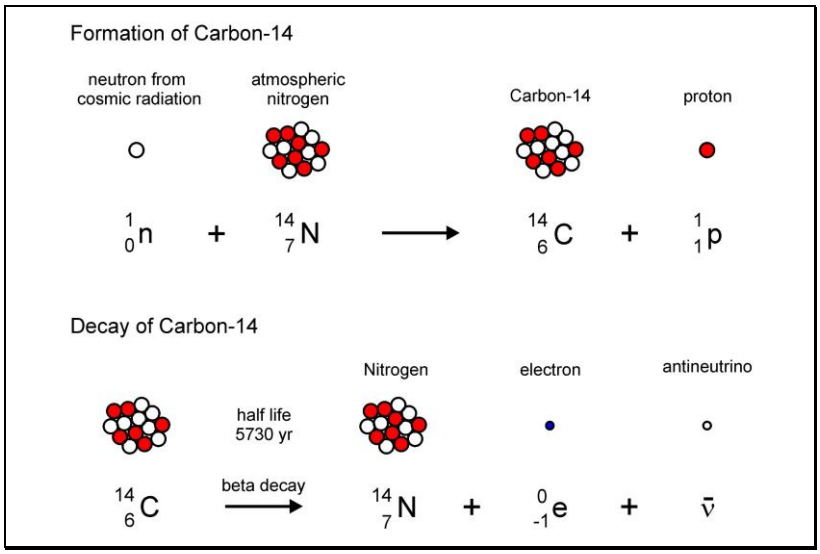
There are three main kinds of rocks:

- igneous rocks formed by the crystallization of molten rock (magma)
- sedimentary rock formed by the erosion of other rocks and the deposition of the resultant material in layers at the bottom of the sea

- metamorphic rock formed by compression of igneous and sedimentary rock deep within the earth.

Modern geology began in the 18th Century with James Hutton who proposed that the processes that made and modified the earth have continued over many thousands of years. His *Theory of the Earth,* published in 1788, proposed uniformitarianism in geology (that geological forces have been the same since the beginning of the world). This was opposed to catastrophism that postulated a brief world history characterized by sudden unpredictable changes like the Great Deluge reported in the Bible. Charles Lyell was a follower of Hutton. His textbook, published in multiple editions, was the mainstay of geology through to the 20th Century.

The ideas of geologists like Hutton and Lyell about how long the earth has existed allowed Darwin to theorize about how evolution could have occurred by multiple small changes over millions of years. The context for the theory of evolution was Lyell's geological time + Malthusian population studies + Darwin and Wallace's ideas of variation and selection. We shall consider these ideas in next week's session.

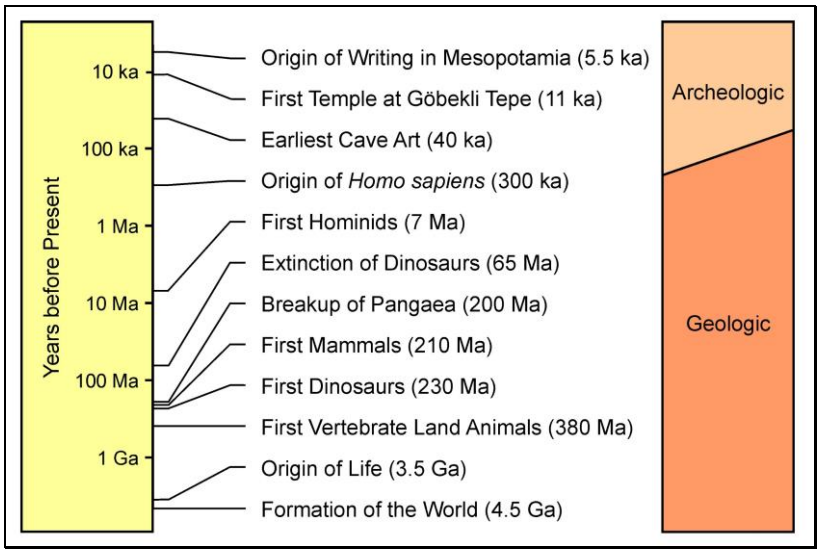



Hutton and Lyell proposed that the Earth had existed much longer than the few thousand years claimed by Bishop Ussher's interpretation of the Bible. They proposed various geological ages based on how different rocks were layered – strata. However, they had no way of measuring the actual times. Modern dating involves radiometric techniques which estimate how long various radioactive isotopes have been decaying. These did not become available until the 20th Century. The illustration shows the principles underlying the Carbon-14 technique

Carbon-14 is continually formed in the earth's atmosphere by cosmic radiation: nitrogen-14 absorbs a neutron, emits a proton and becomes carbon-14. Carbon is taken up into plants from the atmosphere's carbon dioxide during photosynthesis. This plant carbon then becomes part of the animals that feed on the plants (or on other animals that feed on plants). In living organisms,

carbon is continually ingested and the ratio of carbon-14 to carbon-12 is therefore the same as the ratio in the atmosphere. When a living organism dies, however, no more carbon is taken in from the atmosphere. In nonliving material, the carbon-14 decays and the ratio of carbon-14 to carbon-12 decreases.

Radiocarbon dating is not applicable to ages of greater than about 50,000 years because the amounts of the remaining carbon-14 become too small to measure accurately. For earlier dates, radioactive isotopes of elements such as uranium are used. These have half-lives that last for millions of years




Note that the timescale is logarithmic for this diagram. Radiometric dating of the earliest rocks in the Earth and of the meteors (which come from the protoplanetary dust of the asteroid belt) give the age of the world as 4.5 Billion years.

One key date is the origin of writing. Before that date, and in most places long after that date, history was oral. Most scholars suggest that the book of Genesis was written down in its present form in the 6th-5th Centuries BCE. These writings may have been based on earlier written versions dating back to Solomon's time (10th Century BCE) but this idea is speculative.

The Dinosaurs, at least those that we nowadays recognize as dinosaurs, died out long before human beings evolved. Some believe that birds are the present remains of the ancient dinosaurs.

This is the scientific history of the world and of our place in it.
Many people do not believe it

Ark Encounter, Kentucky, 2016

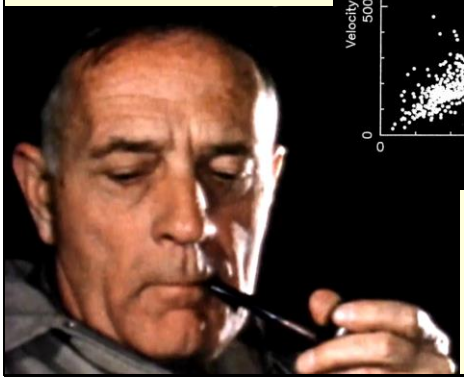
## Young Earth Creationism

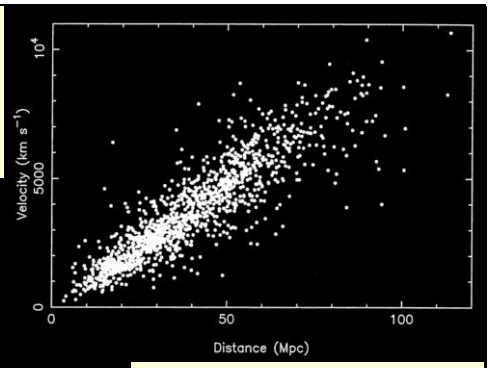
Many people still believe in a literal interpretation of *Genesis*. The question is usually asked in terms of evolution: Do you believe that "God created human beings in their present form within the last 10,000 years." In the USA about 40% answer "yes," in Canada 22% and in Britain 19%.

The polling numbers in the slide have been stable over the past decade.

The illustration shows a representation of Noah's Ark just before it was opened in July 2016. It was built by the organization *Answers in Genesis,* founded by Ken Ham. This group also runs a nearby Creation Museum, which has dioramas illustrating how both dinosaurs and human beings lived at the same time.

## Recession of the Galaxies






Edwin Hubble
(1889-1953)

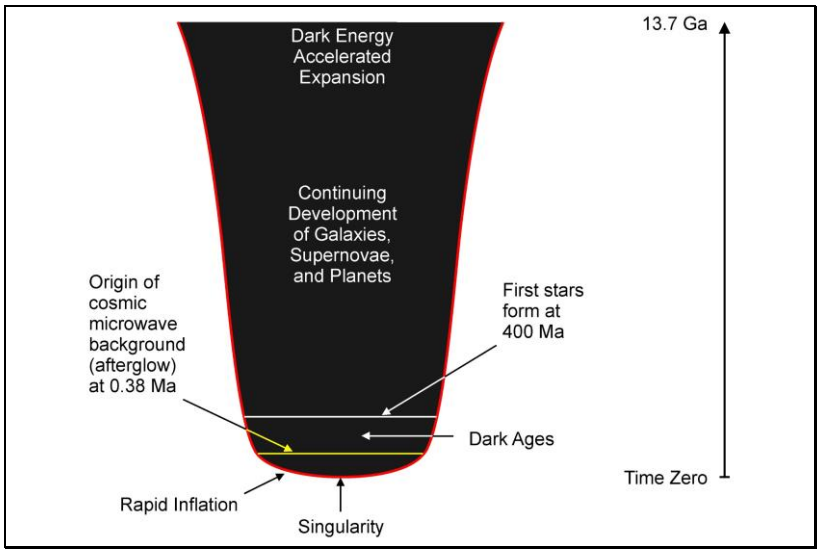
If the Earth is over 4 billion years old, how old is the universe?
The main facts allowing us to measure the age of the universe were

- the stars are moving away from us
- the further they are away the faster they are moving.

Edwin Hubble made these measurements in the early 1920s. The speed of the galaxies was measured by the "red-shift" in the observed frequency of various spectral lines (coming from

different elements) in the light of the galaxies. This is akin to the Doppler shift in a sound. The pitch of a train's horn decreases as it passes us and moves away. The frequency of the spectral lines decreases as the galaxies travel away from us. The graph plots the velocity in km/s against the distance in Mega-parsecs (where one parsec is about 3.26 light years or 31 trillion km. The closest star is about 0.5 Mps away.

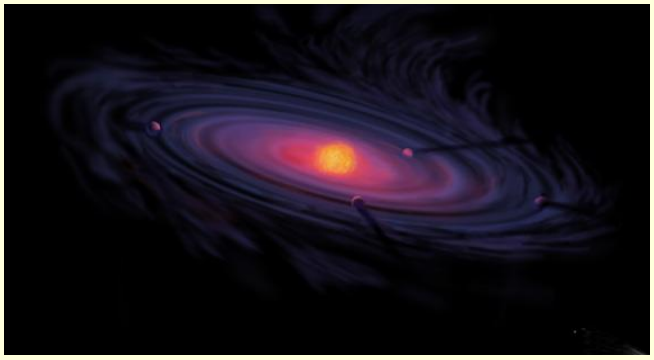
Combining Hubble's measurements with Einstein's theory of relativity and Lemaître's mathematics led physicists to propose that the universe began almost 14 billion years ago with the explosion of a "singularity." It has been expanding ever since.




Our universe has not existed forever: the universe began 13.8 billion years ago. It began as a point of tremendous density and temperature. In 1949, Fred Hoyle called the explosion of this singularity the "Big Bang." The term "began" may not be appropriate, since then there was no time. The singularity was a "now without a yesterday." (Lemaître, 1946).

The diagram plots time on the y-axis. The x-axis plots size. Here the three dimensions of the universe are collapsed into one. Although this diagrammatic history of the world is supported by many different astrophysical measurements, it remains mysterious. What is dark energy (something we cannot see or measure)? And what it will progress to in the future is unknown.

## Planet Earth



The evolution of the universe may be compared to a display of fireworks that has just finished. A few red embers, ashes and smoke. Standing on an optimally cooling cinder, we see the gentle fading of the suns, and try to recall the vanished brilliance of creation. (Lemaître, 1946)

The quotation is from Georges Lemaître, the physicist-priest whom we met in the first session.

After the initial singularity had exploded, the particles fused to form hydrogen nuclei. These collapsed to form stars and galaxies. The gravitational collapse of stars led to the formation of heavier elements. Some of the collapsing stars exploded as supernovae scattering dust into space. Clouds of dust accumulated as a disc around other stars, and the dust accreted to form planets. The Earth began around 4.5 billion years ago.

## Classical Mechanics

In his *Principia*, Newton laid the groundwork for understanding the physical world.

The action at a point can be completely determined in terms of

(i) its position

(ii) its momentum (the product of mass and velocity)

(iii) the forces acting upon it.

Newton's physics worked well for planets and their orbits and for simple objects that could be characterized by a center of gravity

Isaac Newton (1642-1726)
by Geoffrey Kneller, 1702

The term "classical" is often used to denote something coming from the time of the Ancient Greeks and Romans. However, it is also used to characterize Newtonian physics, and (from an even later time) the music of Haydn and Mozart. Here it is used to mean "exemplary"

Newton's physics worked well for the planets. Indeed, it accurately predicts the movements of any object greater than an atom.

Pierre-Simon Laplace
(1749-1827)

## Determinism

We ought then to regard the present state of the universe as the effect of its anterior state and as the cause of the one which is to follow. Given for one instant an intelligence which could comprehend all the forces by which nature is animated and the respective situation of the beings who compose it – an intelligence sufficiently vast to submit these data to analysis – it would embrace in the same formula the movements of the greatest bodies of the universe and those of the lightest atom; for it, nothing would be uncertain and the future, as the past, would be present to its eyes.
(Laplace, 1812)

Newton was able to predict the exact motions of the planets. Using his laws, later physicists were able to determine the existence of planets such as Neptune, that had not yet been observed. Newton's science suggested that everything occurred according to the laws of nature. Nothing happened by chance, or by choice. This is the philosophy of determinism, as clearly delineated by Laplace. We shall return to this idea as in relates to free will in a later session.

A true determinist believes that the whole history of the universe was completely known at the moment of the Big Bang. From the movements of molecules of air in this room to the latest tweet of Donald Trump. However, 20th Century physics concluded that some events may not be fully predicted by what has occurred before. They are "indeterminate" or "uncertain."

## Quantum Mechanics

20th Century Physics showed that the world was stranger than we might imagine.

**Complementarity:** To explain earlier findings that light can act as both a wave and a particle. Bohr (1927) proposed that all matter at the level of the atom can be conceived in these two complementary ways.

Werner Heisenberg and Niels Bohr, 1934

**Uncertainty:** Heisenberg (1927) showed that the more precisely the position of some particle is determined, the less precisely its momentum can be known, and vice versa

Bohr had won the Nobel Prize in 1922 for his work in defining the energy levels of the electron orbits. Heisenberg won the prize in 1932 for his studies of uncertainty.

## Complementarity

The two views of the nature of light are rather to be considered as different attempts at an interpretation of experimental evidence. …. we are not dealing with contradictory but with complementary pictures of the phenomena, which only together offer a natural generalization of the classical mode of description. (Bohr, 1928)

In 1947 when Bohr was awarded the Order of the Elephant, he chose to place the *taijitu* symbol on his shield. The motto was "Opposites are complementary"


The *Taijitu* or Yin-Yang symbol is part of Taoism. The outer circle represents the whole and the light and dark areas represent its opposing manifestations. Yin is water, earth, night, female; yang is fire, sky, day, male. The symbol is often described as sunlight on a mountain, with yin the shady slope and yang the sunlit.

## Tao te Ching (Way of Life)

The movement of the Way is a return
In weakness lies its major usefulness
From What-is all the world of things
was born
But What-is sprang in turn from
What-is-not.

All things bear the shade on their backs
And the sun in their arms;
By the blending of breath
From the sun and the shade
Equilibrium comes to the world.

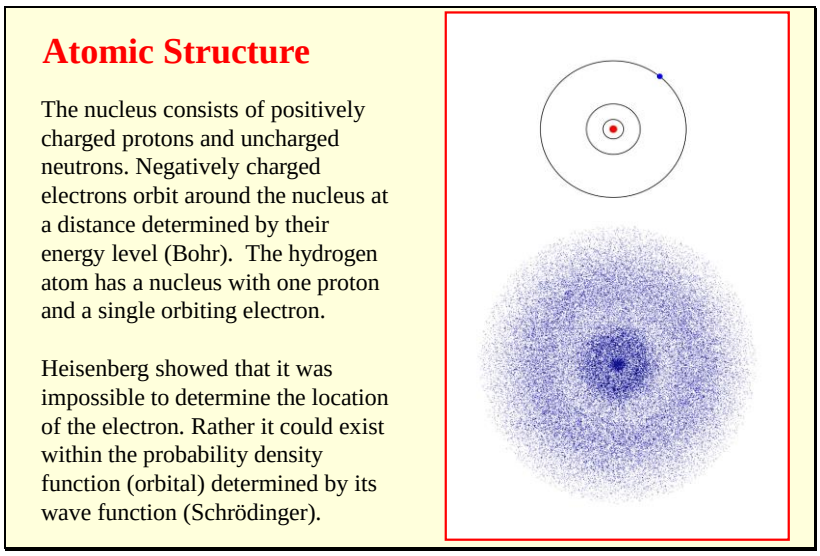
(from sections 40 and 42)

Lao Tzu Riding an Ox,
Zhang Lu (16th Century CE)

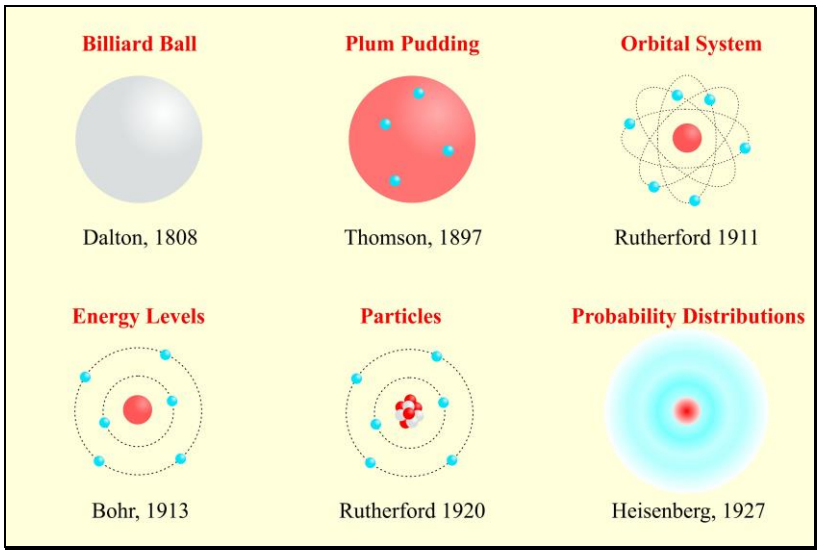
This slide points to some of the ideas of Taoism as given in the *Tao te Ching*.

In the illustration, Lao Tzu (old master) holds his book *Tao te Ching* in his hand  The image of the sage riding the bull is common in the literature of the East. The idea is that wisdom allows one to master the forces of life. This is particularly true of the destructive passions.

The What-is and What-is-not recall the *Nasadiya Sukta* of the *RigVeda,* that we considered at the beginning of this presentation.




This shows how the Rutherford-Bohr idea of the atom changed to the probability density functions of Schrödinger. In the upper diagram the single electron in the hydrogen atom is located in the second orbit – it has been excited and has more energy than can be contained in the first orbit. The idea of electrons floating around a central nucleus came from Ernst Rutherford and the idea of specific orbits came from Niels Bohr. Schrödinger's work indicated that the orbits of an electron around the nucleus are not a clearly defined path. Rather the electron occurs in a cloud of possible locations around the nucleus.




Dalton (1808) thought of atoms as tiny billiard balls. This then changed to the idea that there are positively and negatively charged particles (Thomson). Rutherford proposed that most of the "space" of an atom was empty and that the electrons orbited around a small central nucleus. Bohr showed that the electrons could exist in different orbits depending on their energy. Rutherford and his colleagues discovered that the nucleus consisted of both protons and neutrons.

Heisenberg and Schrödinger described “orbitals” that followed probabilistic wave functions. The illustration uses the carbon atom (6 electrons and 6 protons) to follow these developments.

## Orbitals

The nucleus sets up a box or shell around itself to contain the electrons. The probabilities of where these particles exist take up shapes or “orbitals” that are determined by wave equations

From a poster at
http://toutestquantique.fr/en/

1933 Photograph

## Erwin Schrödinger (1887-1961)

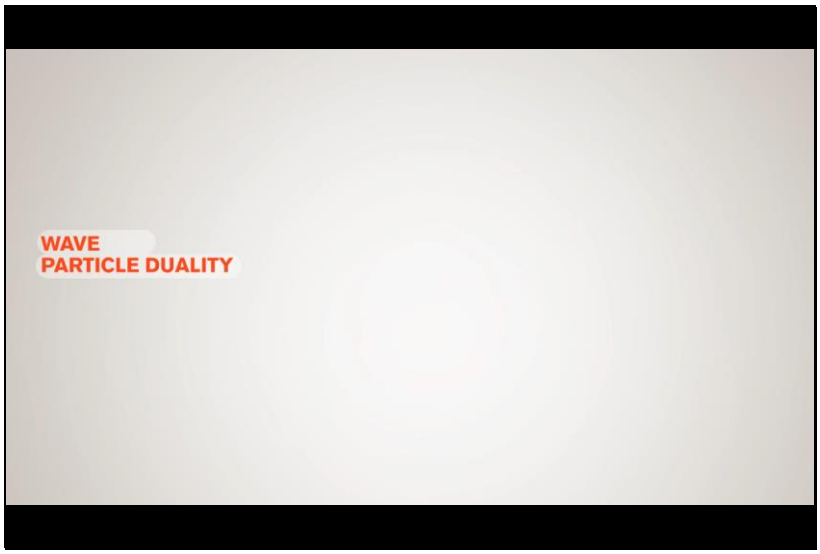
In 1926, Schrödinger created the equations that would define the behavior of all subatomic particles in time and space.

$$i\hbar\frac{\partial}{\partial t}\psi(\mathbf{r},t) = -\frac{\hbar^2}{2m}\nabla^2\psi(\mathbf{r},t) + V(\mathbf{r},t)\psi(\mathbf{r},t)$$

$i$ is the imaginary number, $\sqrt{-1}$.
$\hbar$ is Planck's constant divided by $2\pi$: $1.05459 \times 10^{-34}$ joule-second.
$\psi(\mathbf{r},t)$ is the wave function, defined over space and time.
$m$ is the mass of the particle.
$\nabla^2$ is the Laplacian operator, $\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}$.
$V(\mathbf{r},t)$ is the potential energy influencing the particle.

Schrödinger won the Nobel Prize for this work in 1933. Schrödinger expanded on the earlier work showing that photons could be either waves or particles and demonstrated that all particles could be considered waves. The interesting thing about the wave function is that it extends forever. The particle exists not at particular location but is everywhere.

Schrödinger supposedly came up with his wave equations during an erotic holiday with a mistress in the Alps. One wonders whether his mistress should have shared the prize.

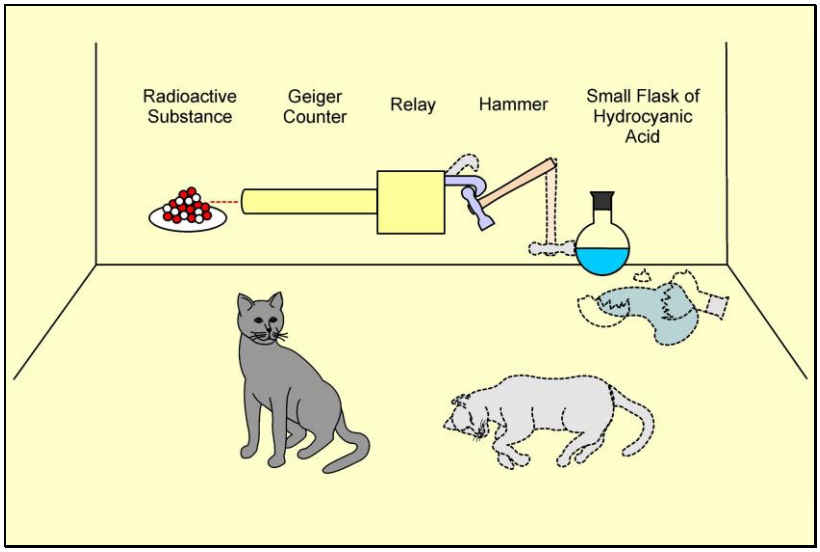



One of the foundational findings of the new physics was that light sometimes acted like a wave and at other times like a particle. One of the main experiments that demonstrate wave-particle duality is the passage of light through a diffraction grating. If light were composed of particles (photons) these would reach all sections of the screen. If it were composed of waves these would cancel each other out at various locations giving a "diffraction pattern' on the screen.

In quantum mechanics each photon is a wave-function. Thus it acts as a wave when going through the grid.

One key aspect of quantum mechanics is that measurement determines the properties of a quantum by collapsing the wave-function. What was once a whole range of possibilities becomes limited by observation. This is illustrated in the video by the eye looking at the photon.

video clip is from
https://toutestquantique.fr/dualite/




One of the thought experiments that illustrated the indeterminacy of quantum mechanics involved Schrödinger's cat. We can imagine how a cat could be placed in a closed chamber together (with a glass flask containing deadly hydrocyanic acid, a hammer, a Geiger counter and a small amount of radioactive substance. If the Geiger counter is activated by a particle emitted during the decay of the radioactive substance, it will cause a hammer to break the flask, releasing the hydrocyanic acid and killing the cat. At a particular time after setting up the experiment, the probability that one atom will have decayed is 0.5. At that time, is the cat dead or alive? Physicists are not sure. Some say that the cat is both alive and dead until an observer looks into the box and determines the outcome one way or the other. The act of observation collapses the probabilistic wave function that underlies radioactive decay. Other physicists postulate that two universes have diverged, with the cat alive in one and dead in the other.

The experiment is directly related to the postulate of determinism. The past state of the world is known. The laws of physics concerning the decay of the radioactive substance are known. Although expressed in terms of probability, these laws are very precise. Yet the present state of the cat in the box is indeterminate. It cannot be predicted, not by me, not by you, not even by an omniscient God. It can only be observed.

In The Big Bang Theory, Penny (Kaley Cuoco) is uncertain about whether she should date Leonard. Sheldon tells Penny about Schrödinger's cat.

## Einstein-Bohr Debates

Albert Einstein was never comfortable with quantum mechanics, and had many debates with Niels Bohr Einstein's "God does not play dice" comes from these debates. Einstein, Podolsky and Rosen designed a thought experiment to demonstrate the inadequacy of quantum mechanics. Collapsing the wave function of one particle of a pair (by observing it) would affect the measurements of the other particle in the pair. Einstein considered that this was "spooky action at a distance."

Einstein and Bohr
Brussels, 1934

Schrödinger's cat was one of many thought-experiments debated by Einstein and Bohr in the 1930s.

## Participatory Anthropic Principle

John Wheeler (1911-2008), an American physicist, described three types of baseball umpires:

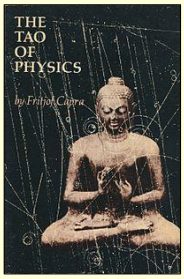
Number 1: I calls 'em like I see 'em.
Number 2: I calls 'em the way they *are*.
Number 3: They ain't *nothing* till I calls 'em.

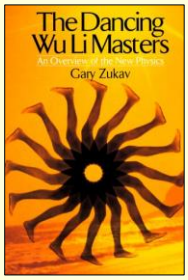
The second is like Einstein. The third is like Bohr.

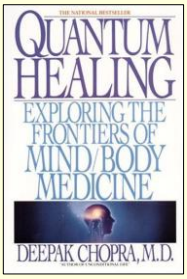
The role that observation plays in determining what is happening is the essence of the participatory anthropic principle: "They ain't nothing till I calls 'em."

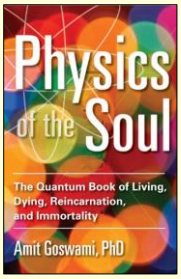
## Quantum Mysticism

We must not over-interpret these interactions between self and world. Much nonsense has derived from suggesting that magical interactions between souls and things can be explained in terms of quantum mechanics. Just because some strange things can be explained by the new physics does not mean that "any weird thing you can think of can be true." (Spufford, 2012)



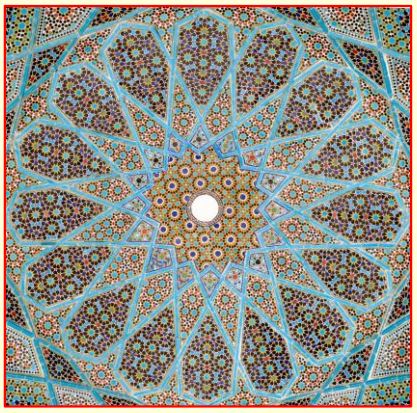




Nevertheless, the quantum physicists were very partial to Eastern mysticism.

## Mind and Matter

In his 1958 lectures, Schrödinger quoted from the Sufi mystic Aziz Nafazi (13th Century CE):

The spiritual world is one single spirit who stands like unto a light behind the bodily world and who, when any single creature comes into being, shines through it as through a window. According to the kind and size of the window less or more light enters the world. The light itself however remains unchanged.



Ceiling of the tomb of the 13th century Sufi poet Hafez built in 1773

St Nicholas Church

## Copenhagen

During World War II, Werner Heisenberg became the scientist in charge of Germany's effort to make nuclear weapons. In 1941, Heisenberg visited Niels Bohr in occupied Denmark. Exactly what happened at that meeting is uncertain. Michael Frayn's play considered some of the possibilities. Heisenberg may have thought that Bohr could know whether the allies were making progress on nuclear fission. Perhaps, Heisenberg wished to request absolution from his scientific father, to have Bohr agree that it was not immoral to work on nuclear physics even though this could lead to atomic weapons.

To end this session we shall consider Michael Frayn's 1998 play *Copenhagen*. The play imagines a meeting between Bohr and Heisenberg after the war. At this time, they attempt to remember what actually happened in 1941. A brief recent paper on this meeting is http://www.defensemedianetwork.com/stories/the-copenhagen-meeting-of-heisenberg-and-bohr/

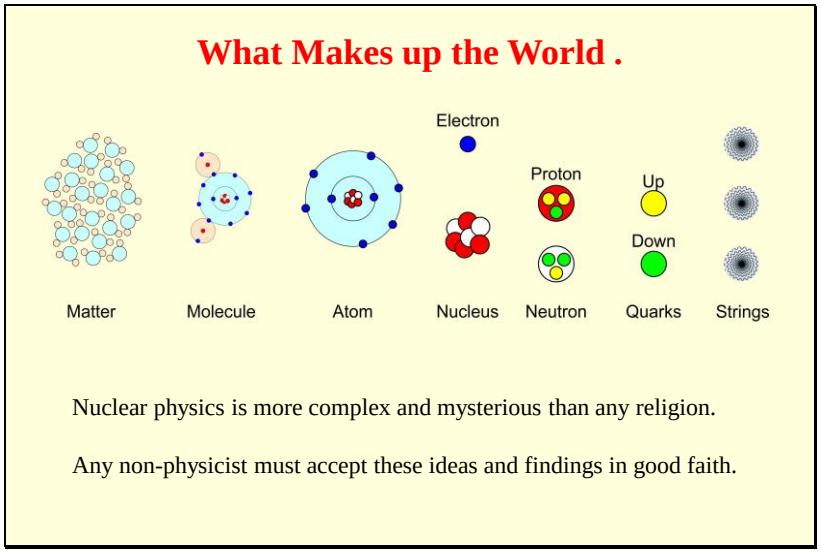
In the play Bohr discusses with Heisenberg the changes that occurred in 20th Century physics and how this affected man's place in the cosmos. Remember how the Catholic Church was afraid that Galileo and Copernicus conceived a universe wherein man was insignificant. The new physics made man the measure of the universe.

This scene in the play considers how quantum mechanics changed our idea of the world. The piano music is Schubert's B flat major Sonata D960. The scene is imagined by could certainly have happened – Heisenberg was indeed an accomplished pianist.

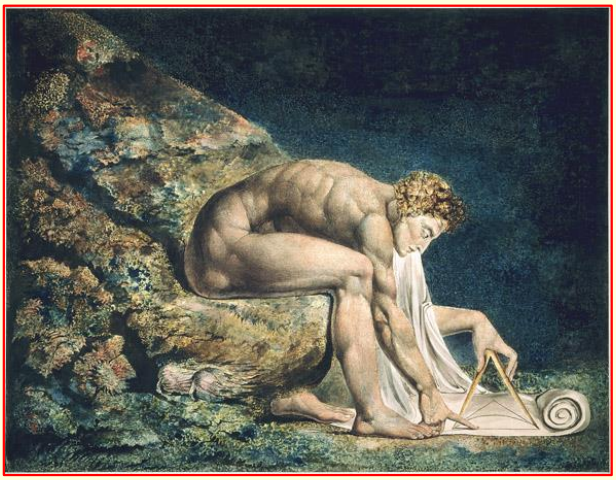
**Bohr:** It works, yes. But it's more important than that. Because you see what we did in those three years, Heisenberg? Not to exaggerate, but we turned the world inside out! Yes, listen, now it comes, now it comes. ... We put man back at the centre of the universe. Throughout history we keep finding ourselves displaced. We keep exiling ourselves to the periphery of things. First we turn ourselves into a mere adjunct of God's unknowable purposes, tiny figures kneeling in the great cathedral of creation. And no sooner have we recovered ourselves in the Renaissance, no sooner has man become, as Protagoras proclaimed him, the measure of all things, than we're pushed aside again by the products of our own reasoning! We're dwarfed again as physicists build the great new cathedrals for us to wonder at — the laws of classical mechanics that predate us from the beginning of eternity, that will survive us to eternity's end, that exist whether we exist or not. Until we come to the beginning of the twentieth century, and we're suddenly forced to rise from our knees again.

**Heisenberg**: It starts with Einstein.

**Bohr**: It starts with Einstein. He shows that measurement — measurement, on which the whole possibility of science depends — measurement is not an impersonal event that occurs with impartial universality. It's a human act, carried out from a specific point of view in time and space, from the one particular viewpoint of a possible observer. Then, here in Copenhagen in those three years in the mid-twenties we discover that there is no precisely determinable objective universe. That the universe exists only as a series of approximations. Only within the limits determined by our relationship with it. Only through the understanding lodged inside the human head.




Physics has traveled far from the days of Bohr and Heisenberg. It has taken to heart the idea that man is the measure of all things. Current physics proposes that matter is made up of atoms and that these contain electrons and nuclear particles. The structure of matter has been determined down to the quarks (and gluons) that make up protons and neutrons. Quarks are difficult to represent diagrammatically. I have used color to signify the up vs down quarks. However, quarks also have a “color” (and in both protons and neutrons the quarks are of three different colors). String theory postulates that all these basic particles are composed of strings of vibrating energy.



**The Real World**

*Newton*, William Blake, 1805

This is Blake's ink-and-watercolor print of *Newton*. We have now considered two of Blake's representations of calipers (measuring-compass) – the *Ancient of Days* and *Newton*. These instruments were used by the Creator to design the universe and by man to measure it.

From the notes at the Tate website:

Blake, however, was critical of reductive scientific thought. In this picture, the straight lines and sharp angles of Newton's profile suggest that he cannot see beyond the rules of his compass. Behind him, the colourful, textured rock may be seen to represent the creative world, to which he is blind.

http://www.tate.org.uk/art/artworks/blake-newton-n05058