

SCIENCE & HUMAN DEVELOPMENT

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Kavli Institute
for
Theoretical
Physics



BRIDGES TO PEACE

THE GIFTS OF SCIENCE
THE SCIENTIFIC METHOD
THE KNOWLEDGE OF NATURE
THE CONTROL OF NATURE
INTERNATIONALISM
QUESTIONS & PREDICTIONS

BRIDGES TO PEACE

THE SCIENTIFIC METHOD

- ★ Understanding is obtained by subjecting our ideas to **OBSERVATION** and **EXPERIMENT**.
- ★ The only authority for truth is agreement with Nature, through **OBSERVATION** and **EXPERIMENT**, **NOT** Political Power or Religious Faith.
- ★ All of our theories are **provisional** and are subject to continual quantitative test and improvement.
- ★ Scientific findings must be made **available to all**.

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A healthy scientific
culture requires
an open society.

Science promotes
tolerance.

Science promotes
democracy.

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KNOWLEDGE OF NATURE

PHYSICS

ASTROPHYSICS-
COSMOLOGY

BIOLOGY

BRIDGES TO PEACE

PHYSICS

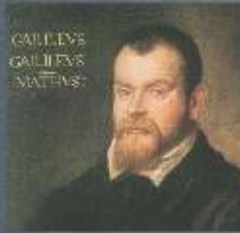
Over the last 400 years we have discovered the basic laws of motion and the symmetries that govern all physical phenomena.

We have unveiled the underlying atomic structure of matter and discovered the quantum nature of reality.

We have constructed a comprehensive theory of the atomic and nuclear forces, identified the basic constituents of matter and are striving to unite all the forces of nature.

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The language of physics
is mathematics.



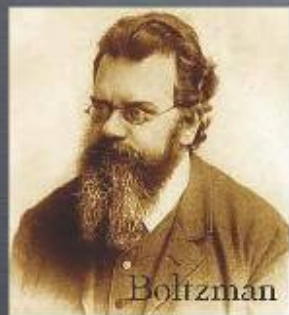
The laws of physics
govern the motion of
planets and apples.



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THE LAWS OF
**ELECTRICITY
MAGNETISM
& LIGHT**



$S = k \ln W$ **HEAT
ENERGY
& ENTROPY**

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ATOMIC THEORY

All ordinary matter is made of atoms,
electrons revolving around nuclei-
governed by the probabilistic laws of
QUANTUM MECHANICS.

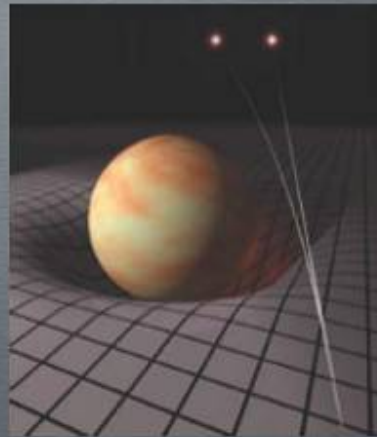
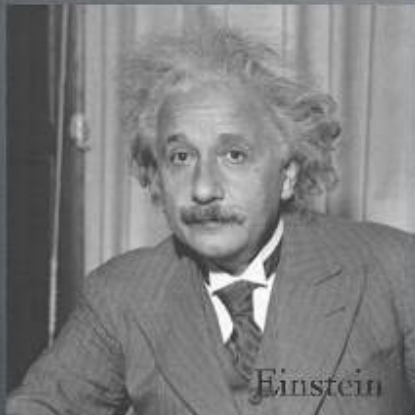


TO PE

The collective behavior of atoms is
responsible for all the
properties and phases of matter.

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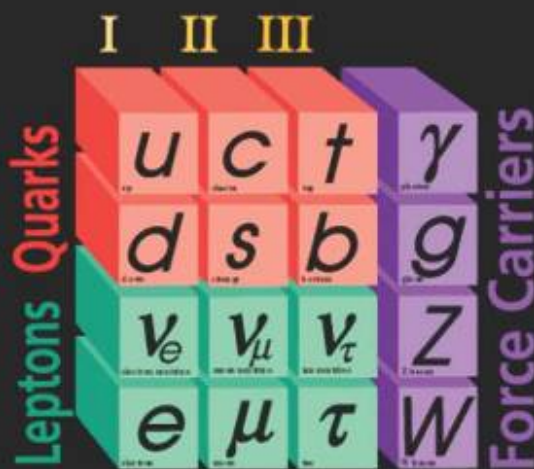
SPACE-TIME IS DYNAMICAL
ENERGY CURVES SPACE
CURVATURE GIVES RISE TO GRAVITY



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The Standard Model of
Particle Interactions

Three Generations of Matter

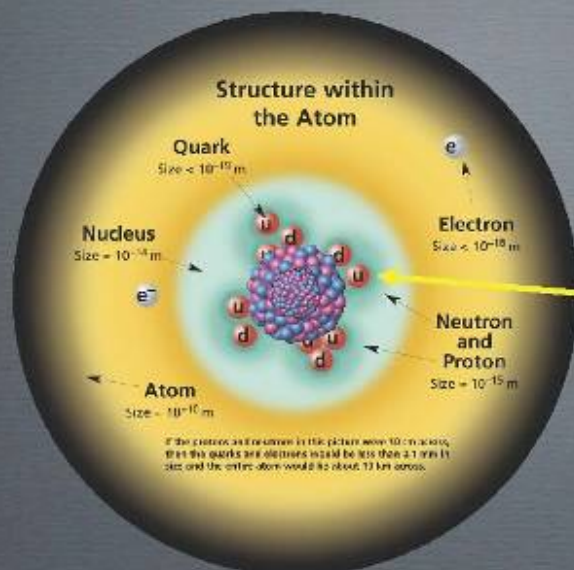


ELECTRO-
MAGNETISM

STRONG
NUCLEAR
FORCE
WEAK
NUCLEAR
FORCE

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THE NUCLEAR FORCE



Experiment showed that the proton looked as if it were made of freely moving **quarks** at short distances.

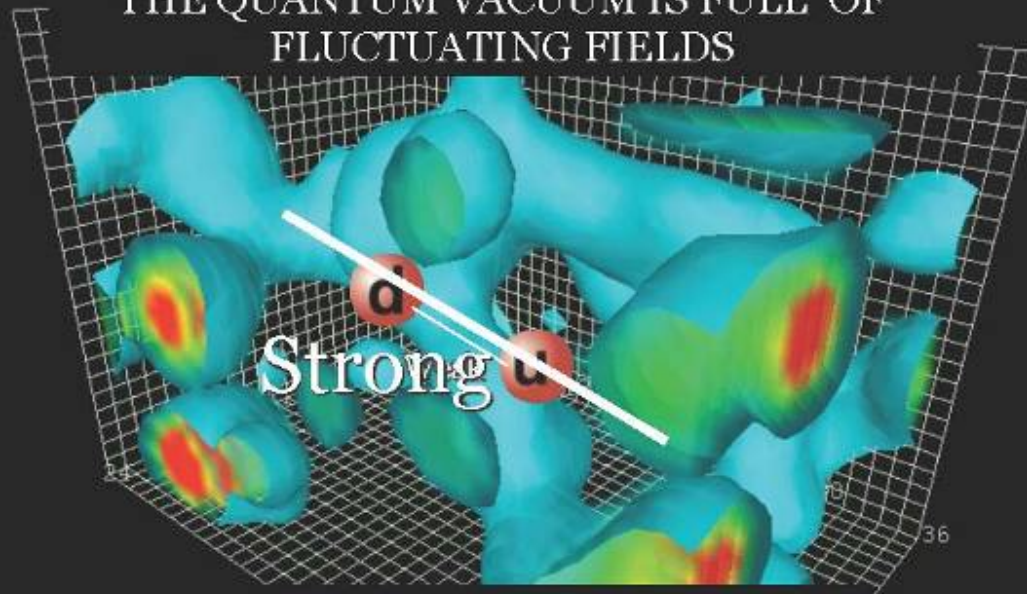
But one could not pull the quarks out of the proton.

THE
VACUUM

**THE
CLASSICAL
VACUUM IS
EMPTY**

BRIDGES TO PEACE

THE QUANTUM VACUUM IS FULL OF
FLUCTUATING FIELDS



ASYMPTOTIC FREEDOM

10^{-15} cm.

ASYMPTOTIC
FREEDOM



QCD

Quantum
Chromodynamics



THE NOBEL PRIZE IN PHYSICS 2004

A colourful connection

The Standard Model and the four forces

The quarks are present in the Standard Model, but they are not the only particles. There are also leptons, photons, gluons, and the Higgs boson. The Standard Model is a mathematical framework that describes the interactions between these particles. It is the most successful theory of physics ever developed, but it is not complete. It does not include gravity, and it does not explain why the universe is the way it is.

Inside the proton

The proton is made of three quarks: two up quarks and one down quark. They are held together by gluons, which are the carriers of the strong force. The gluons are constantly exchanging between the quarks, creating a complex web of interactions. This is why the proton is so stable and why it is the building block of all matter.

A good start...

Frank Wilczek and David Gross discovered asymptotic freedom in 1973. This means that the strong force between quarks gets weaker as they move faster. This was a major breakthrough in understanding the strong force and earned them the Nobel Prize in 2004.

David J. Gross
 Stanford University
 1935-08-19

Frank Wilczek
 MIT
 1950-01-29

Herbert A. Politzer
 MIT
 1928-04-26

A unified theory for all forces?

The quest for a unified theory of all four forces (gravity, electromagnetism, and the strong and weak nuclear forces) has been a major goal of physics. The Standard Model unifies the electromagnetic and weak forces, but it does not include gravity. The search for a theory of everything continues.

Pulling quarks
out of a proton
in QCD

$$\langle r \rangle = 0.15 \text{ fm}$$

$$\langle d \rangle = 0.35 \text{ fm}$$



COSMOLOGY

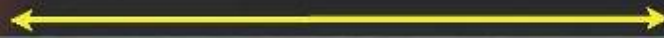
Over the last century we have learned that our sun is only one of 100 billion stars in the galaxy; in an expanding universe that contains ~100 billion galaxies; that emerged from a hot big bang 13.7 billion years ago.

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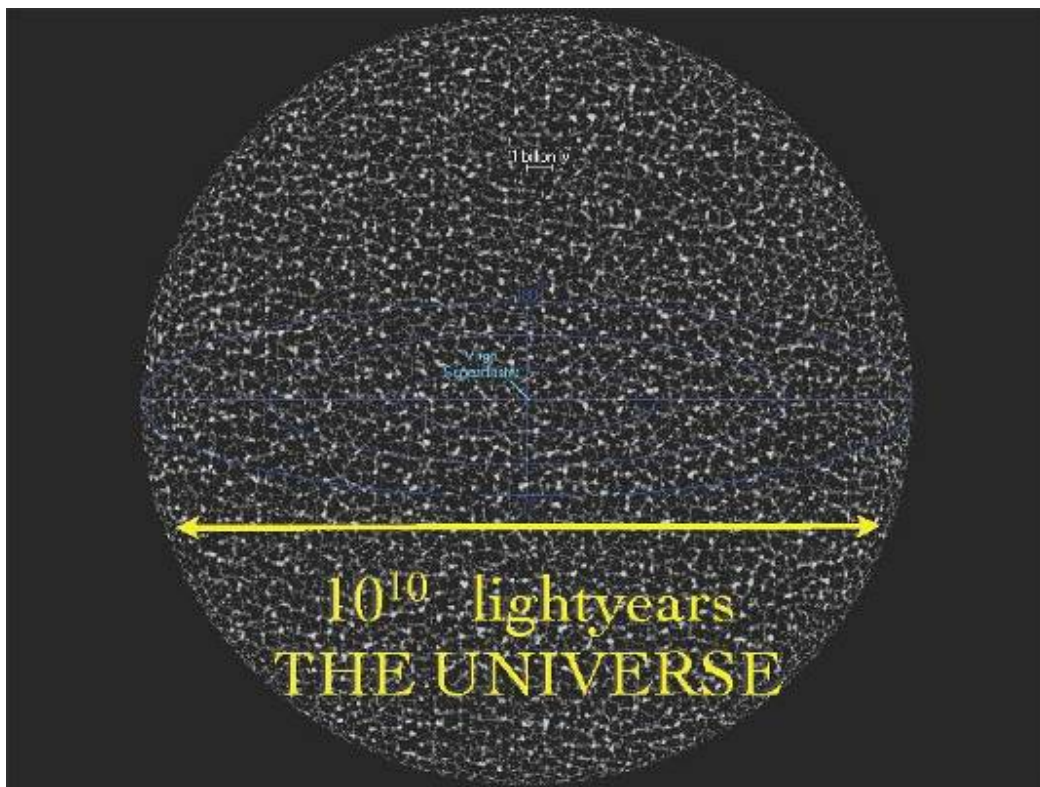
10^7 meter ~ 10^{-15} lightyear
THE EARTH

BRIDGES TO PEACE

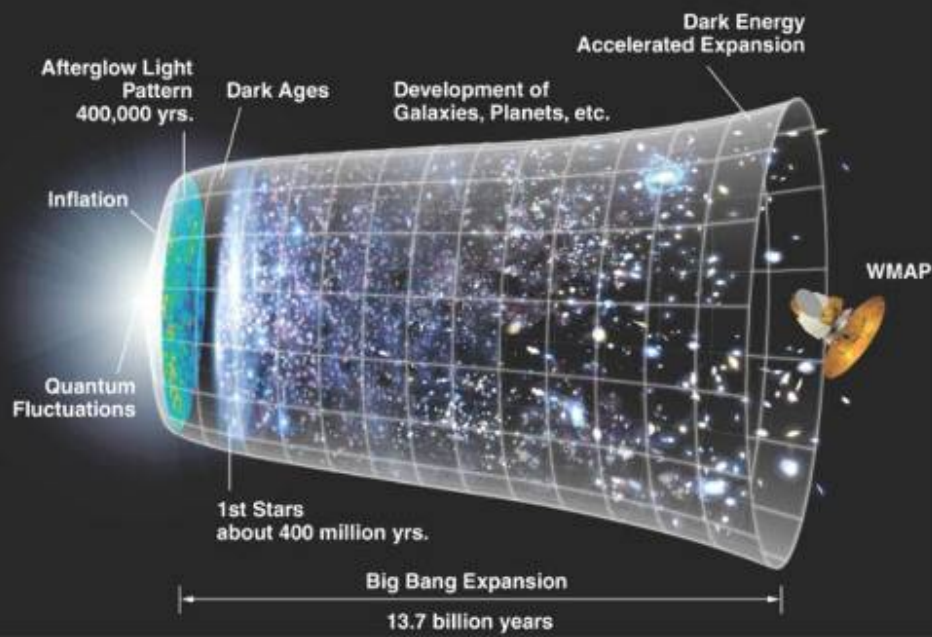


10^{12} meter ~ 10^{-4} lightyear
THE SOLAR SYSTEM

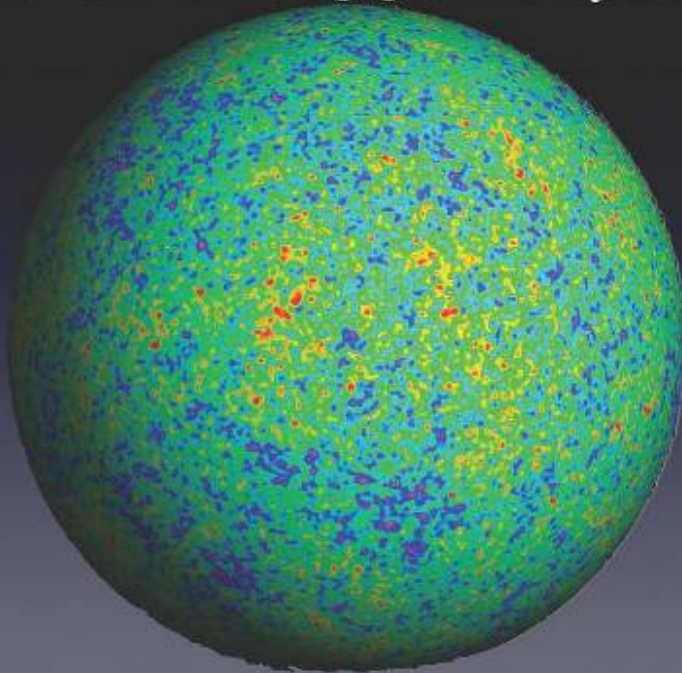
BRIDGES TO PEACE



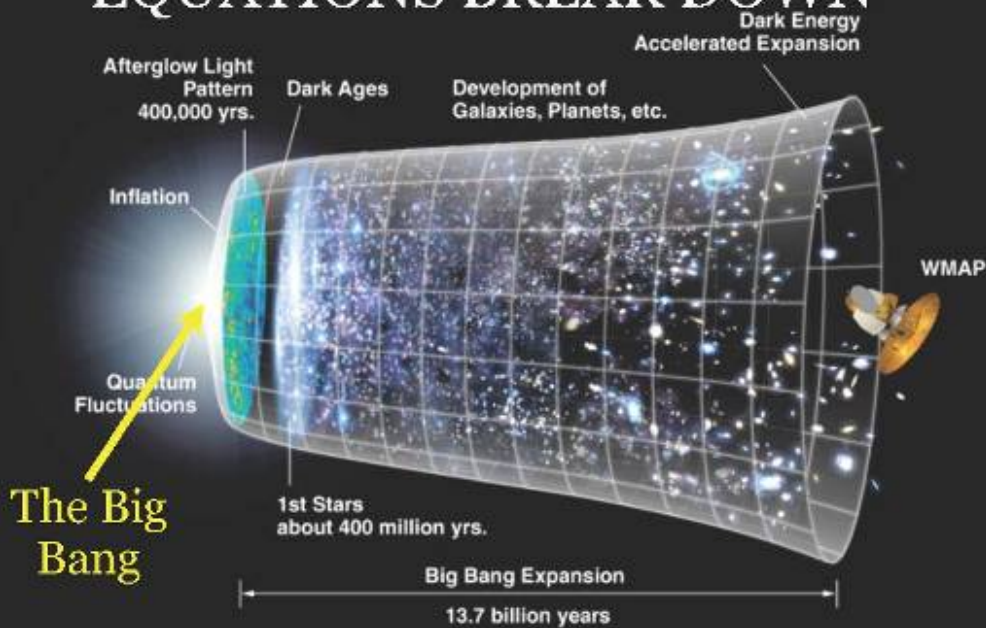
THE HISTORY OF THE UNIVERSE



The Universe 13.5 billion years ago



AT THE BEGINNING ALL OF OUR EQUATIONS BREAK DOWN



BIOLOGY

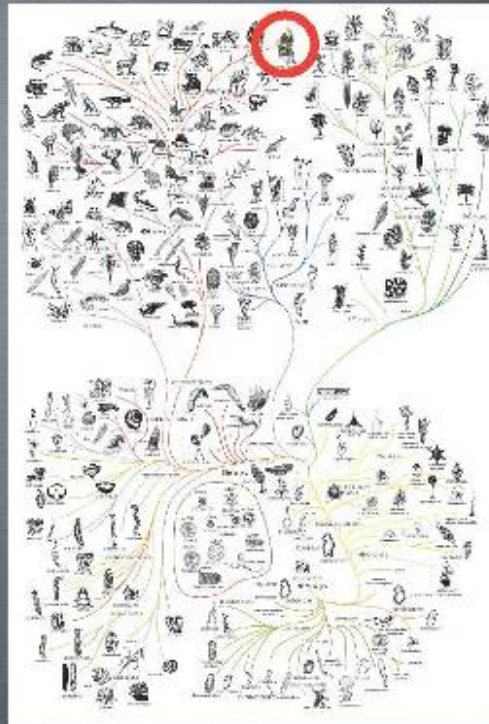
Over the last 150 years we have learned that life emerged over 3 billion years ago and evolved by mutation and natural selection.

We have located and deciphered the genetic code and outlined the basic mechanism of living cells and discovered the cause of disease.

We have located the source of consciousness and emotion in the brain, and have started to explore its mysteries.

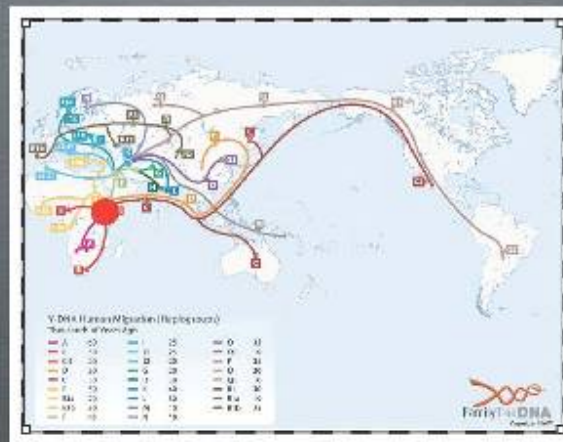
BRIDGES TO PEACE

Evolution, via natural selection, produces all the variations of living matter.



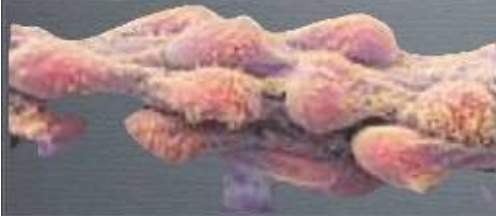
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All humans have a (rather recent) common ancestor and a common origin.

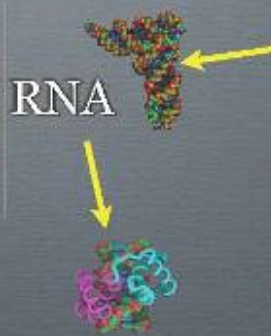


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The Microscopic Structure of Life.

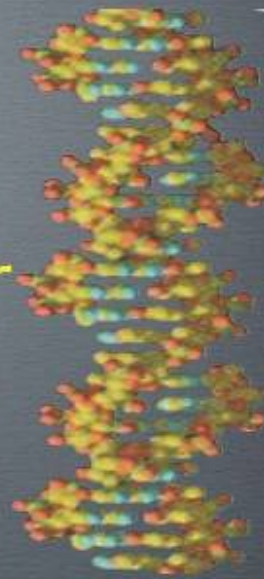


The cell



RNA

Proteins



DNA

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Disease is caused by bacteria, viruses, parasites and genetic mistakes.

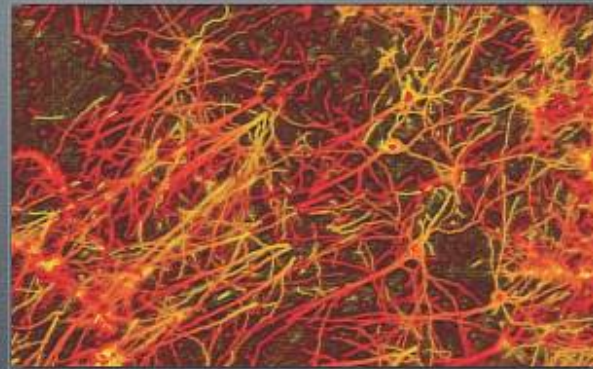
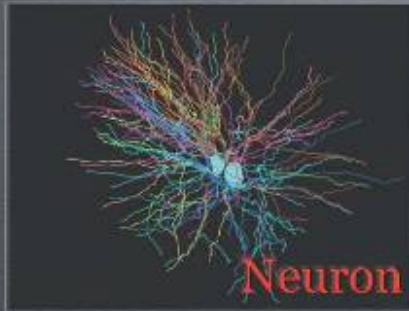


www.hfpca.com

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The locus of thought and
emotion is the brain.

A vast collection of 100 billion
interconnected neurons



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THE CONTROL OF NATURE

Basic science inevitably leads to
greater control over nature and
unpredictable new tools

The technology that science
has produced is of immense
benefit to humankind-
but also presents grave dangers

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The industrial revolution



computing
power



rapid transit



communication

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MEDICINE



DRUGS

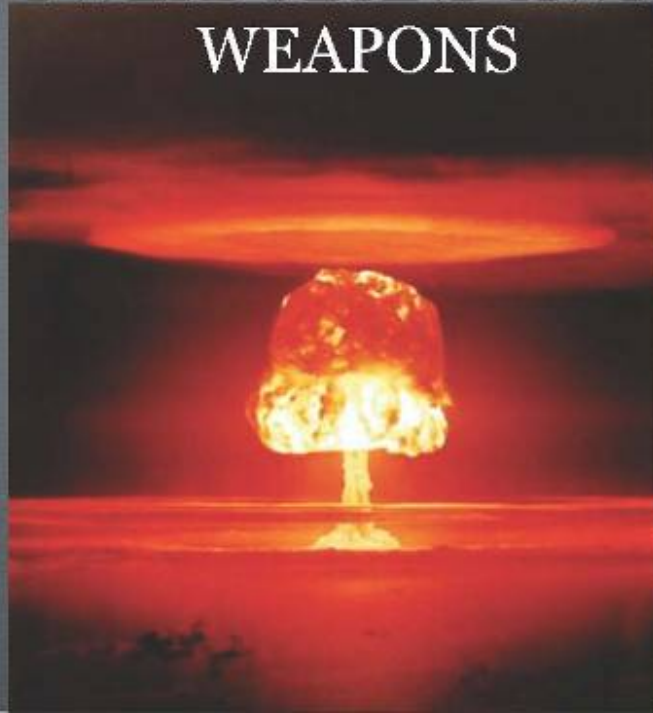


IMAGING

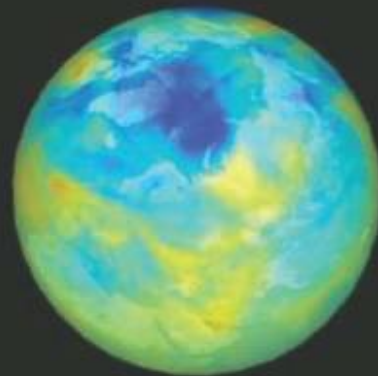
THE HUMAN
LIFESPAN HAS
DOUBLED IN
THE LAST 200
YEARS

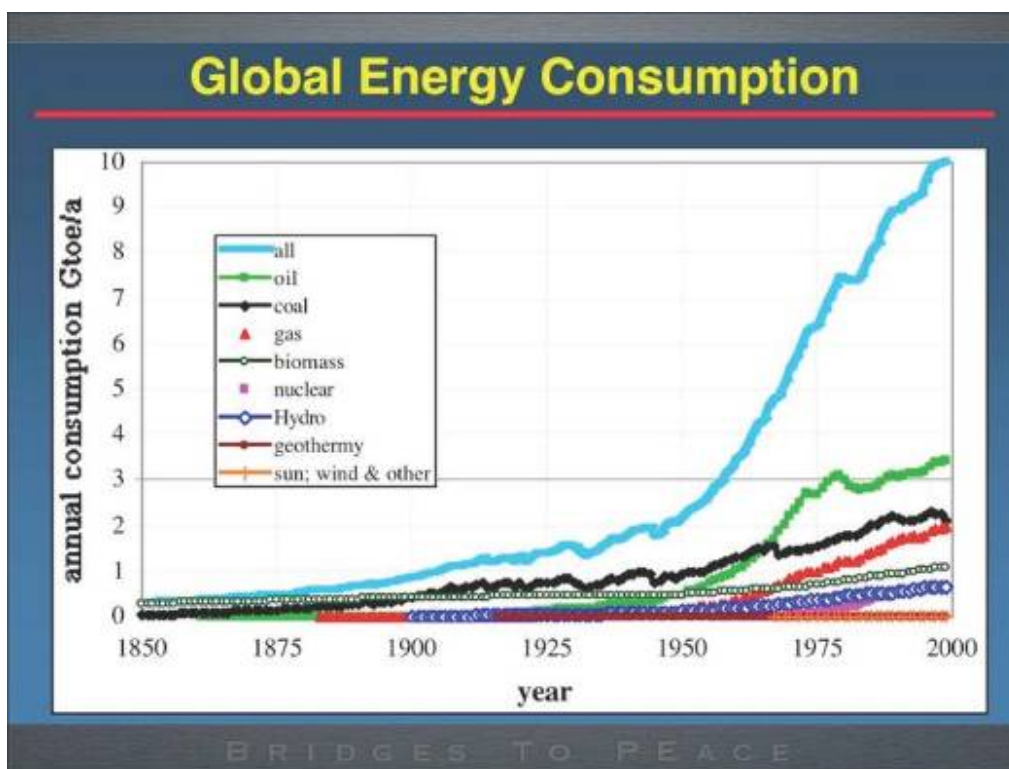
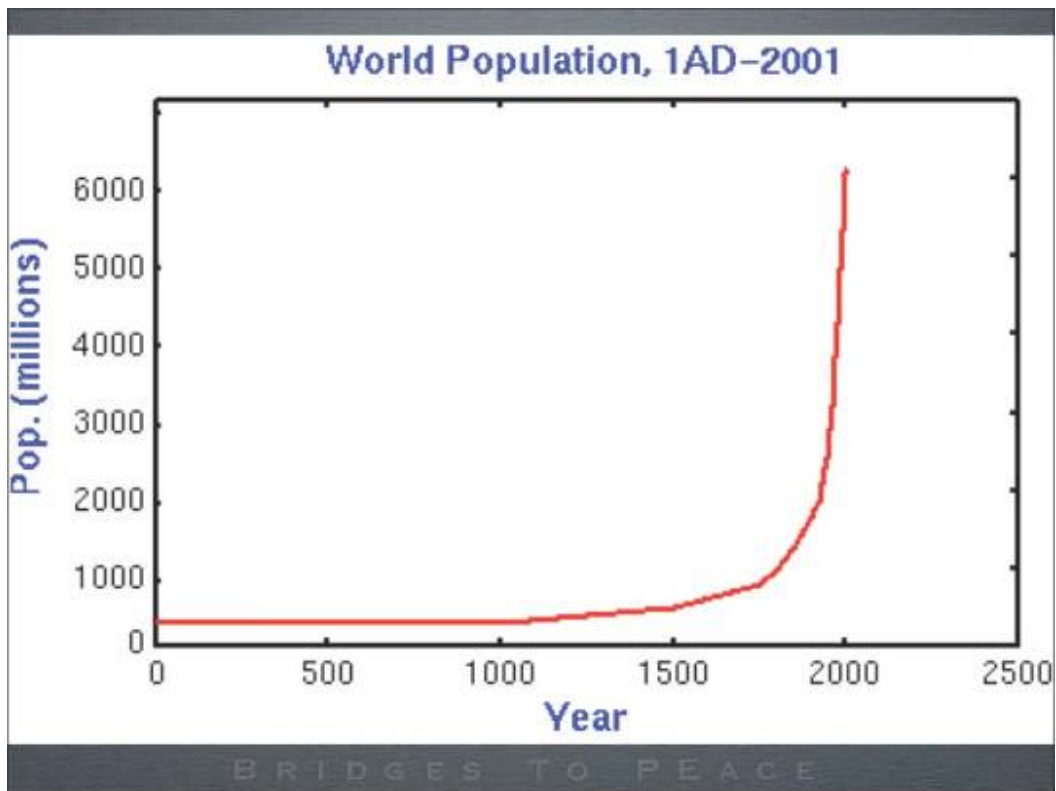
BRIDGES TO PEACE

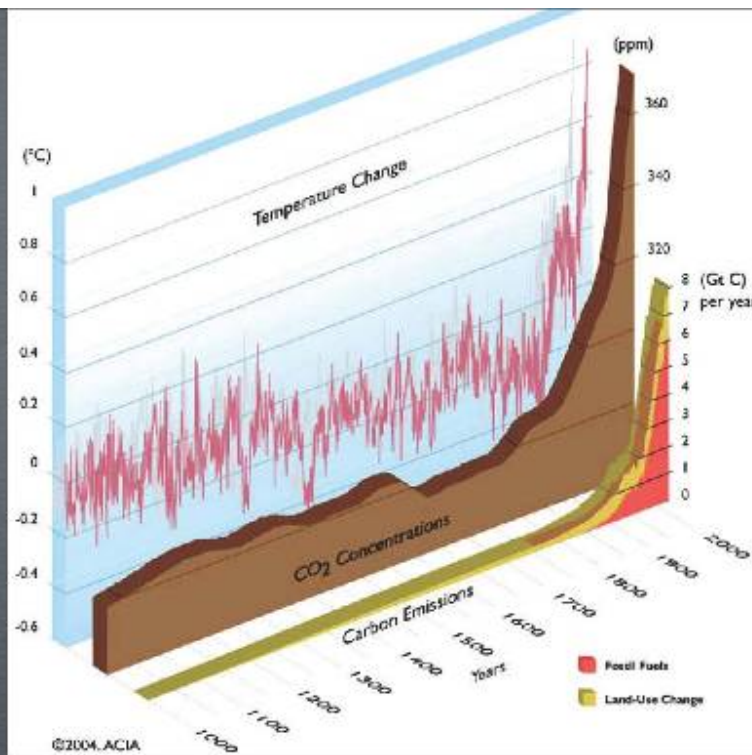
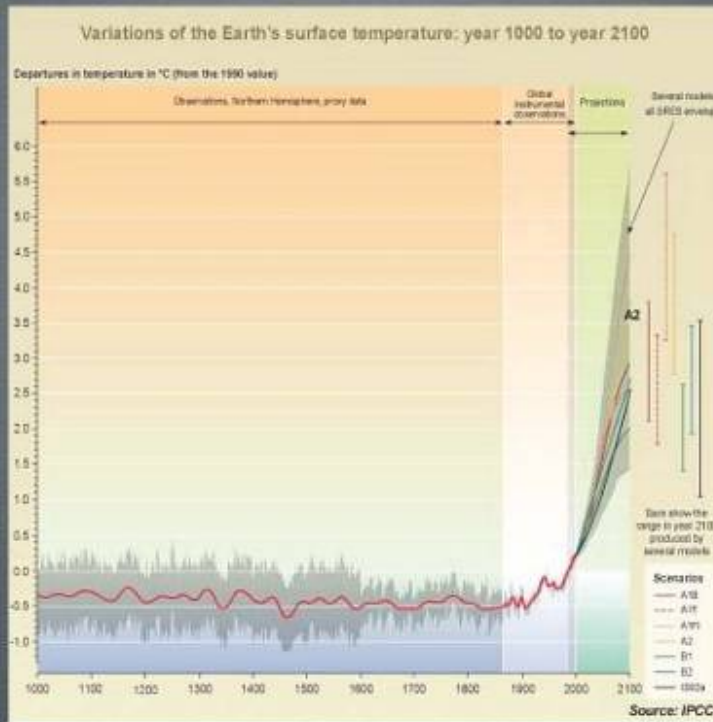
POWERFUL AND AWFUL WEAPONS

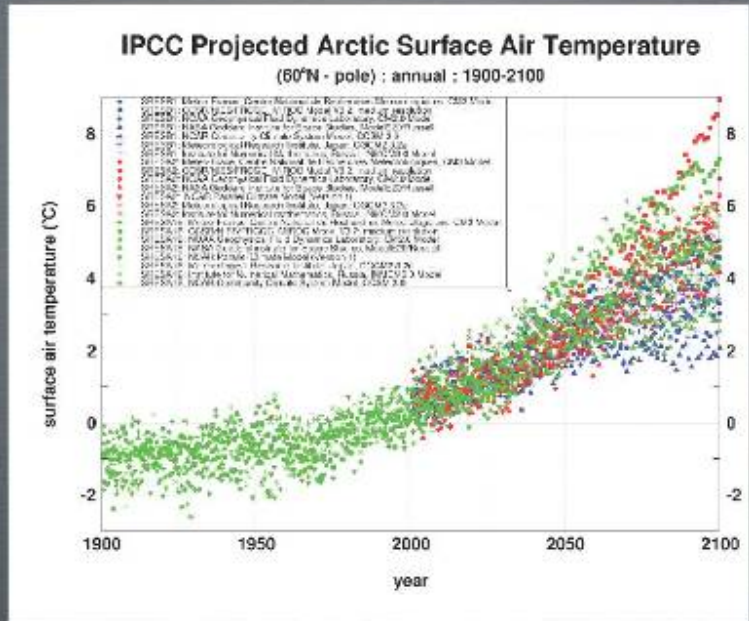


THREATS TO THE HEALTH OF OUR PLANET









Greenland Ice Sheet

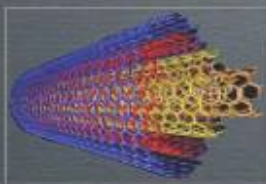
Coral Bleaching



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SCIENCE CAN AND MUST HELP

Nanotechnology



Solar Power



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BUT MORE THAN SCIENCE IS
NEEDED

**WE MUST BUILD AN ECONOMIC
AND POLITICAL SYSTEM THAT IS
NOT DEPENDENT ON
UNLIMITED CONSUMPTION
AND GROWTH**

**WE MUST MOVE TOWARDS
WORLD GOVERNMENT**

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INTERNATIONALISM

THE PROBLEMS EXPLORED BY BASIC
SCIENCE ARE POSED BY NATURE

ALL ARE EQUAL IN SCIENTIFIC RESEARCH

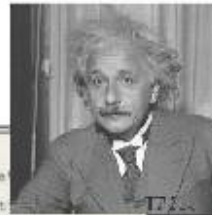
BASIC SCIENCE IS A TRULY
INTERNATIONAL ENDEAVOR
A MODEL OF COOPERATION,
COLLABORATION AND COMPETITION

BRIDGES TO PEACE

Thank you. I am grateful for this opportunity to send

With all my heart I believe that
the world's present system of
sovereign nations can only lead to
barbarism, war and inhumanity
----that only world law can assure
us progress towards civilization,
peace and true humanity

Albert Einstein



peaceful agreement.

There is no effective defense against our modern means
mass destruction. There will be no defense to save civilization

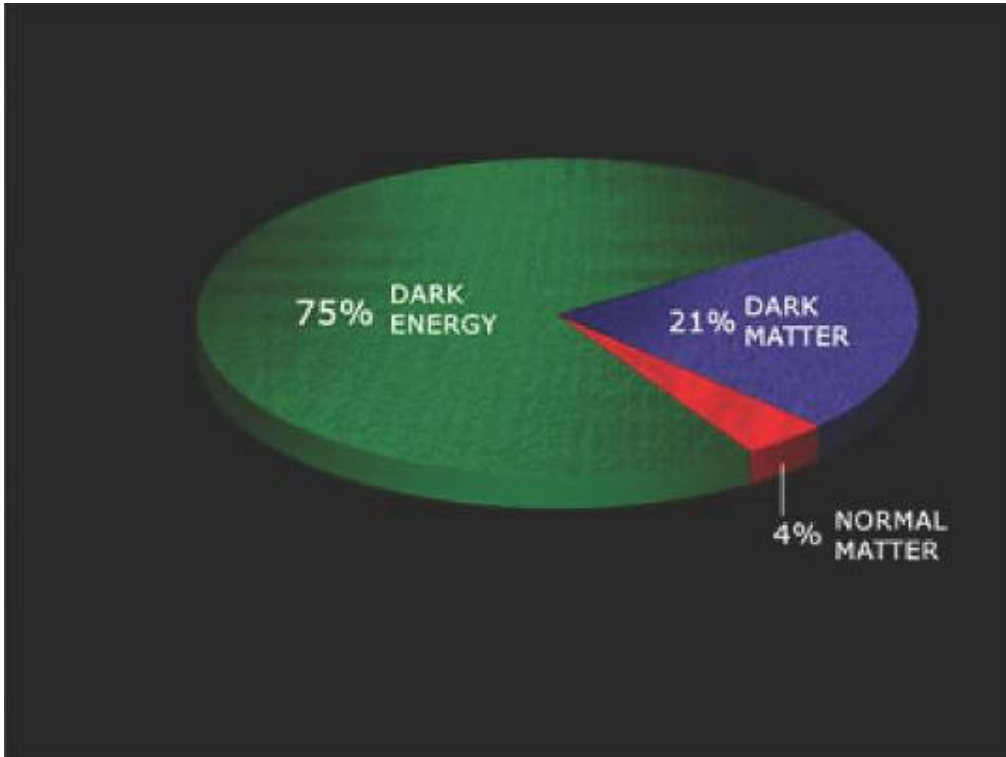
QUESTIONS & PREDICTIONS

THE MOST IMPORTANT
PRODUCT OF KNOWLEDGE
IS IGNORANCE

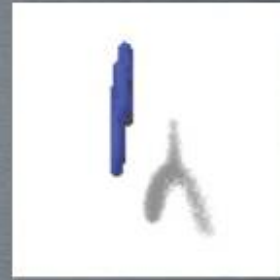


QUESTIONS THAT CAN
BE ANSWERED BY
OBSERVATION,
EXPERIMENT & THEORY

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* Is string theory the answer?



* What is the nature of space and time ?

* How does consciousness arise from the collective behavior of neurons ?

AND MANY MORE

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PREDICTIONS

50-100 YEARS

Most of the questions of basic science that we ask today will be answered, but we will have new questions to ponder.

As we learn how the human mind works social science, political science, economics...will begin to be true sciences .

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We will be well on our way towards a sustainable economic and social arrangement and a world government.



100-1000 YEARS

Increased Lifespan

Speciation

The Spread of Life



BRIDGES TO PEACE

Science will be even more important in tomorrow's world.

Science will continue to reveal more of nature's secrets and increase our control over its forces-- with consequences good and bad.

The culture of Science will inspire us to exploit the good and avoid the bad.

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THE END

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