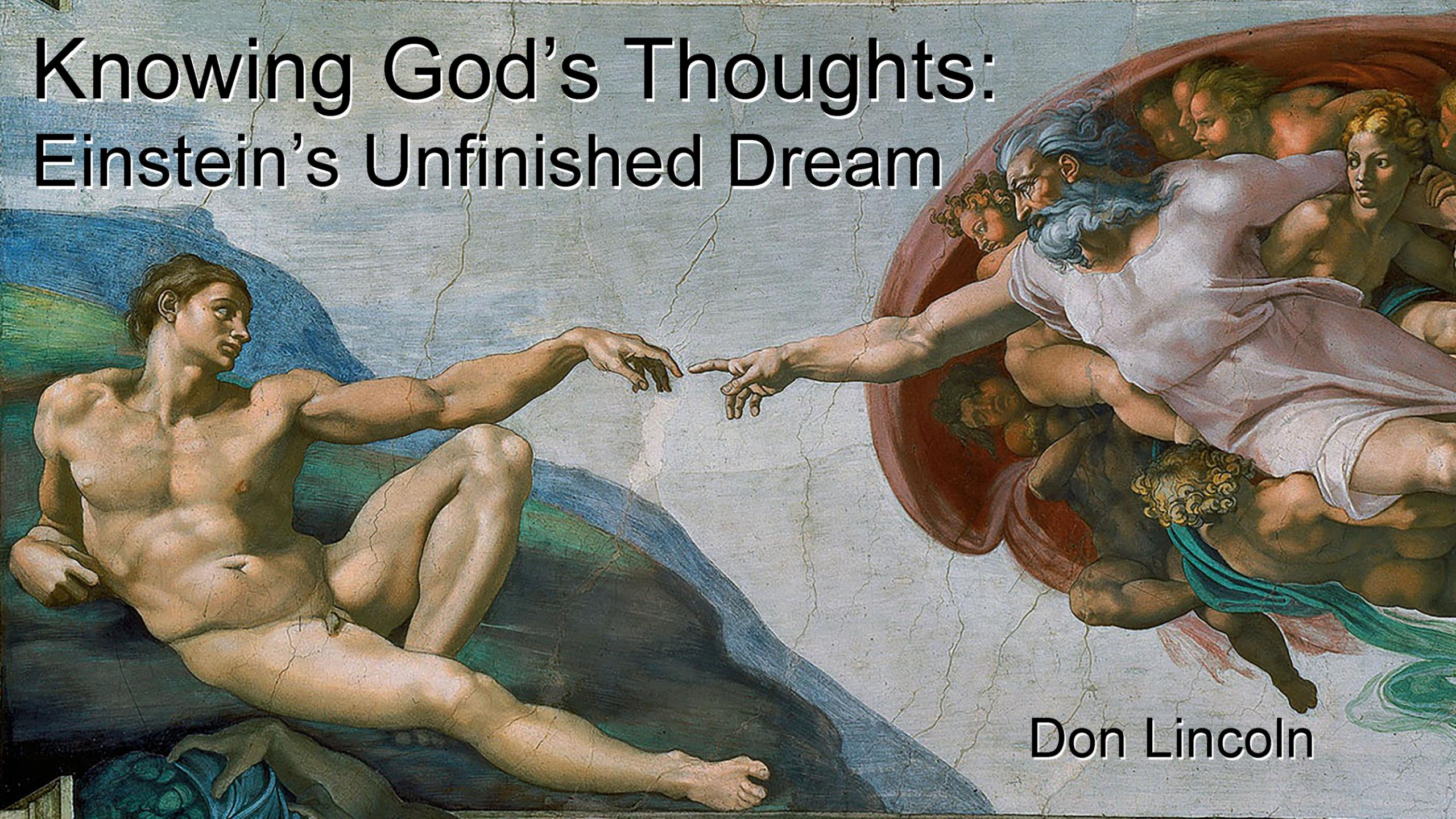
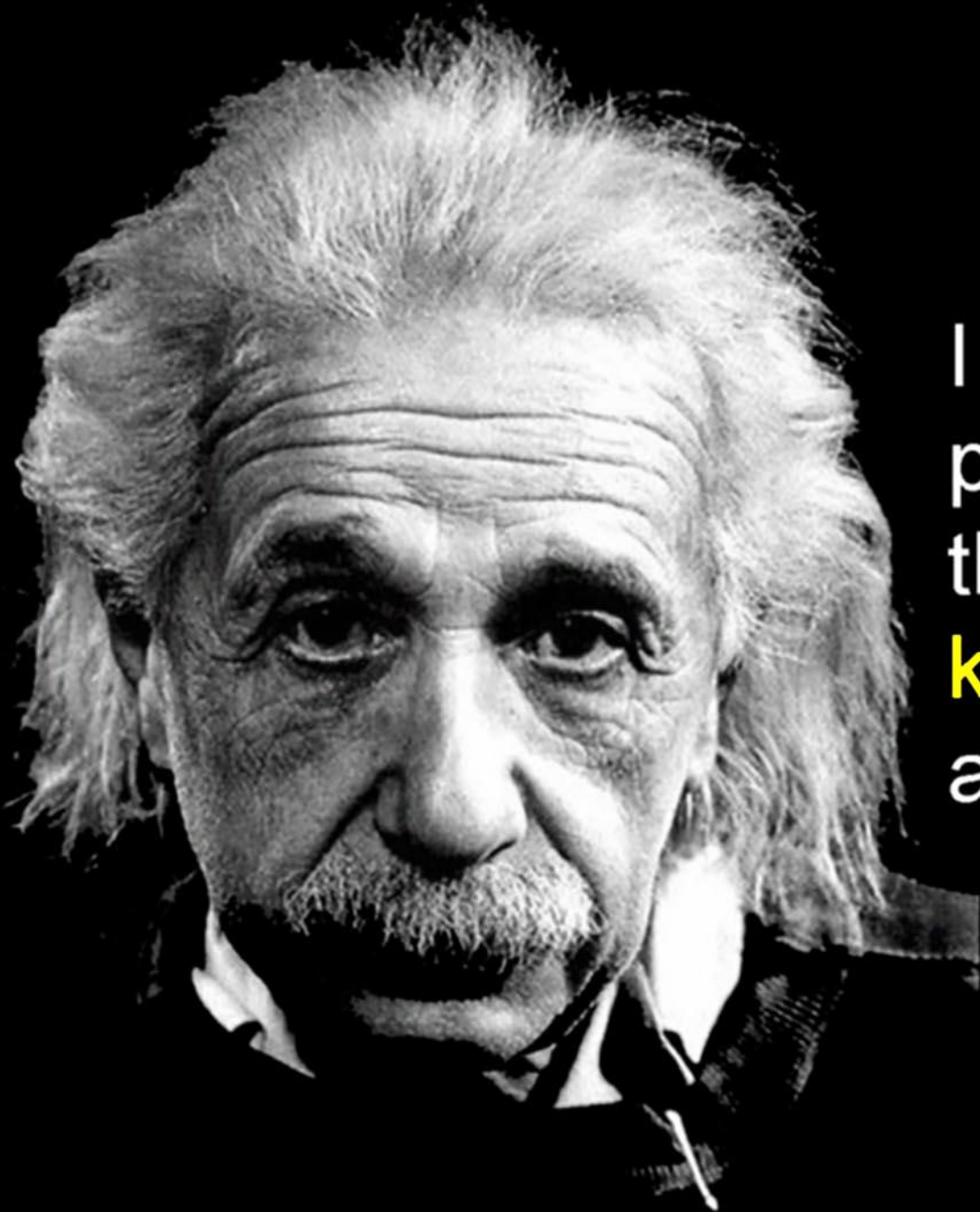


# Knowing God's Thoughts: Einstein's Unfinished Dream



Don Lincoln



I am not interested in this or that phenomenon, in the spectrum of this or that element; **I want to know God's thoughts**; the rest are just details.

Author: Esther Salaman  
Journal: Listener  
Date: 1955

# A Theory of Everything

- Determine the smallest building blocks of the universe.
- Work out the forces that make the universe tick and do they have a single origin?
- Figure out how the universe came into existence and how it will end.
- How does everything hang together?

# A Theory of Everything

- Determine the smallest **building blocks** of the universe.
- Work out the **forces** that make the universe tick and do they have a single origin?
- Figure out how the universe came into existence and how it will end.
- How does everything hang together?

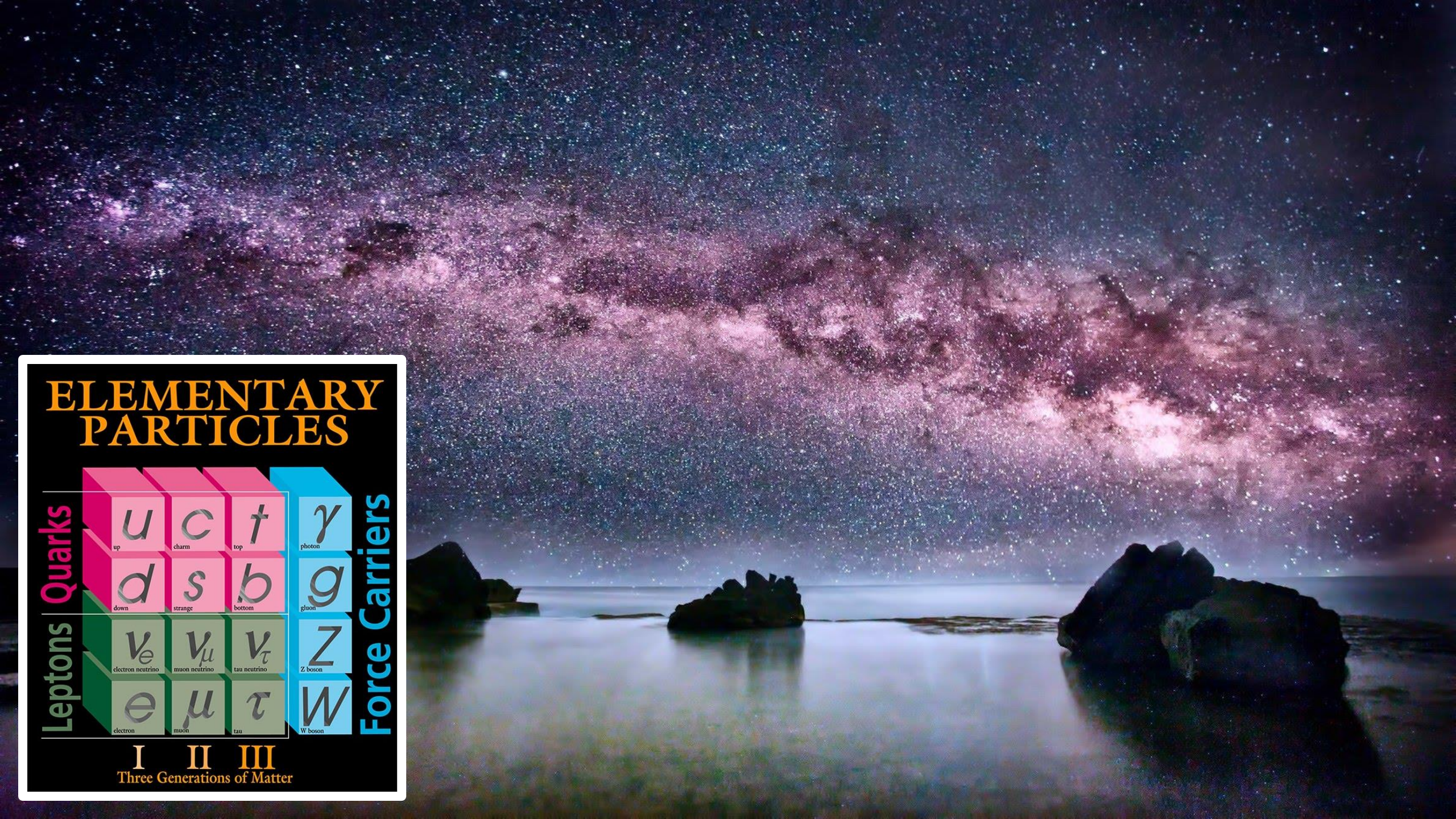
What do I mean by **everything**?

# ELEMENTARY PARTICLES

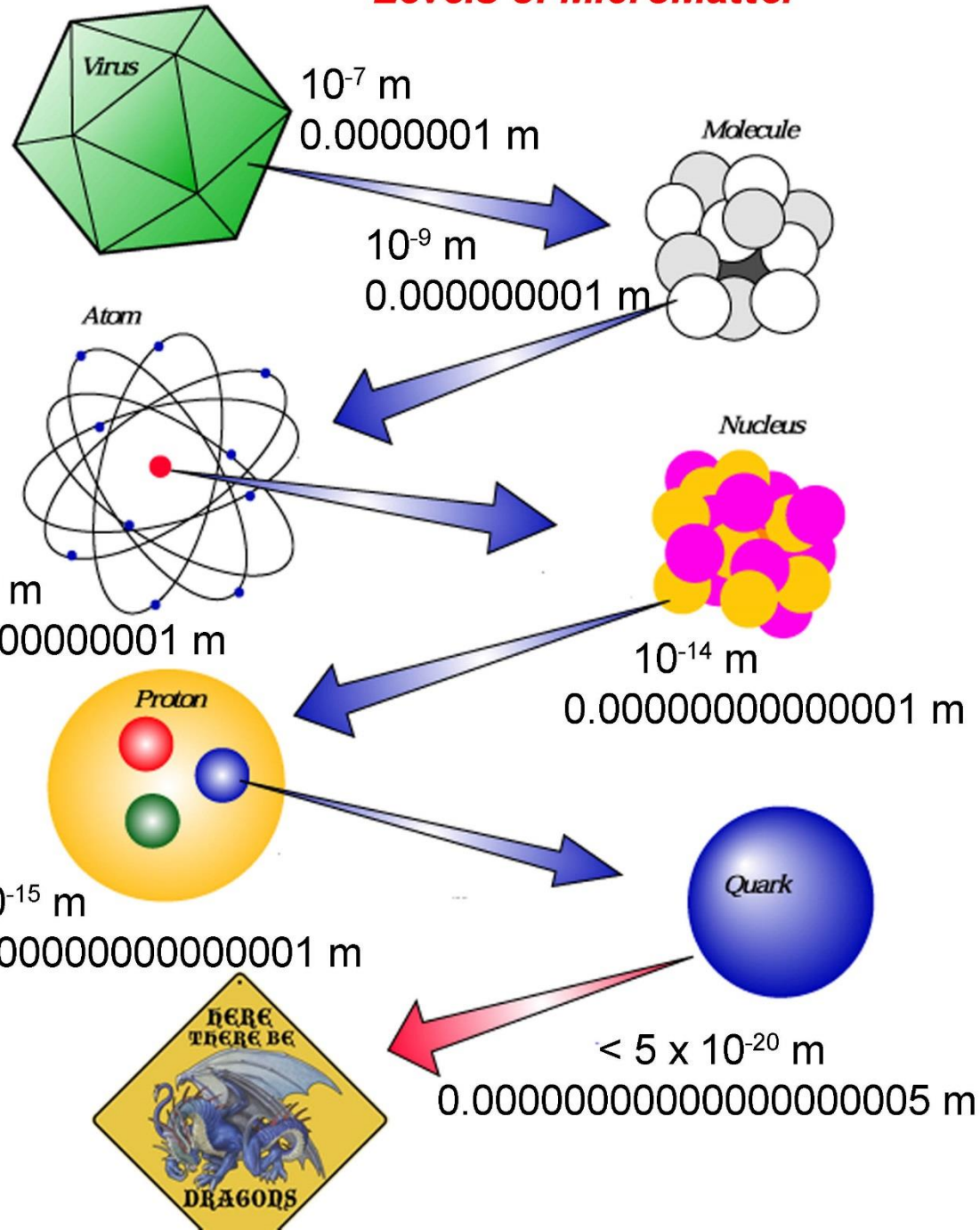
Quarks	$u$ up	$c$ charm	$t$ top	$\gamma$ photon
	$d$ down	$s$ strange	$b$ bottom	$g$ gluon
Leptons	$\nu_e$ electron neutrino	$\nu_\mu$ muon neutrino	$\nu_\tau$ tau neutrino	$Z$ Z boson
	$e$ electron	$\mu$ muon	$\tau$ tau	$W$ W boson

Force Carriers

I II III  
Three Generations of Matter



## Levels of MicroMatter



# Remember the Journey

Big things are built from smaller things.

Those smaller things are governed by laws that we've discovered.

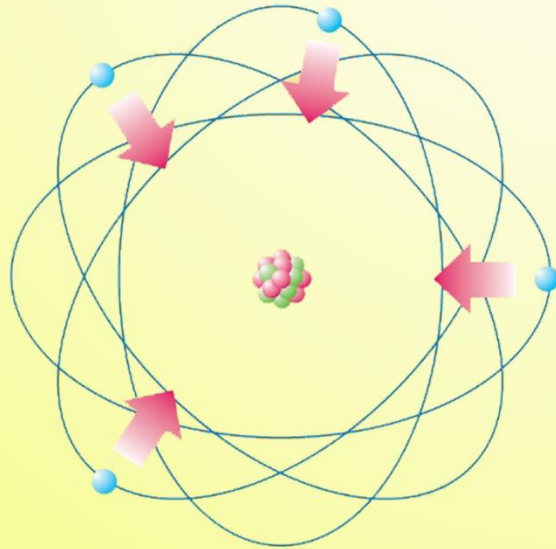
Seemingly disparate phenomena arise from common origins.

# Four Fundamental Forces

Gravitation



Electro-magnetism



Strong Force



Weak Force









$$F_1 = F_2 = G \frac{m_1 \times m_2}{r^2}$$



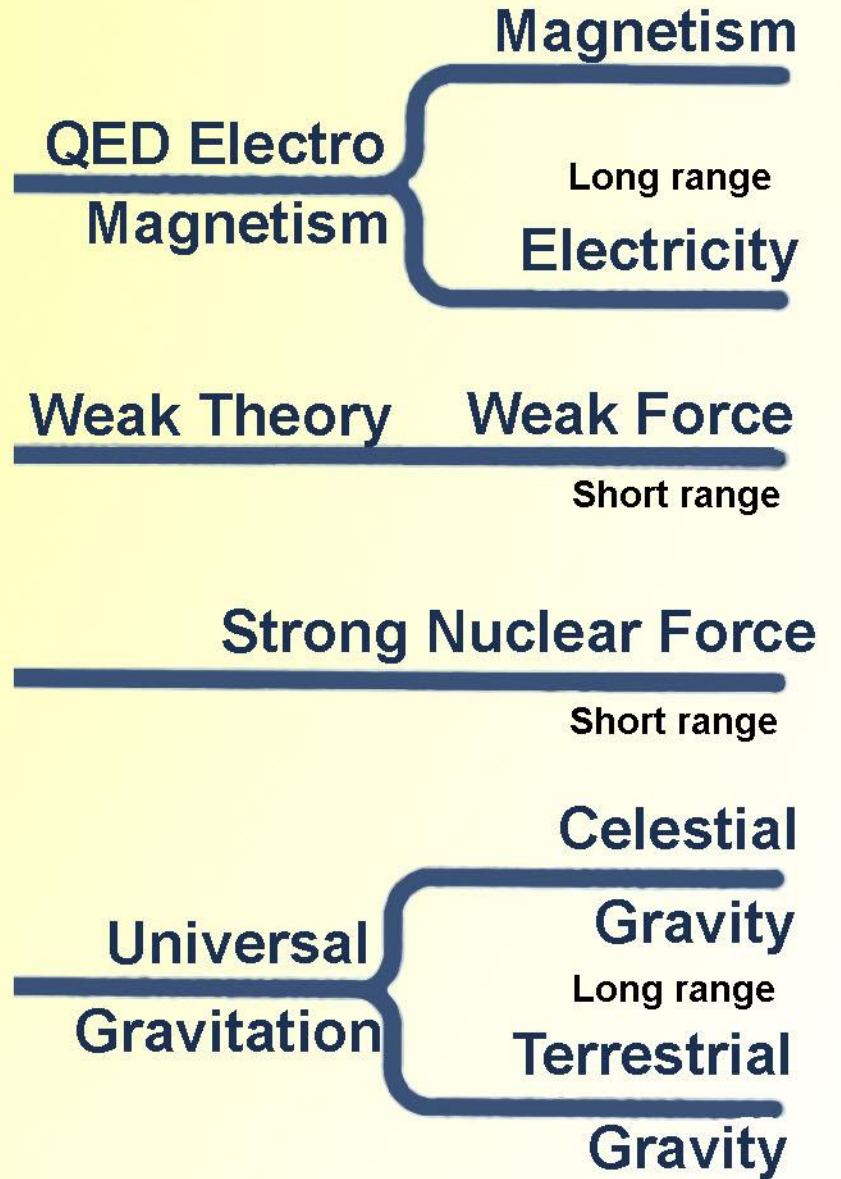

$$\nabla \cdot \mathbf{D} = \rho$$

$$\nabla \cdot \mathbf{B} = 0$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

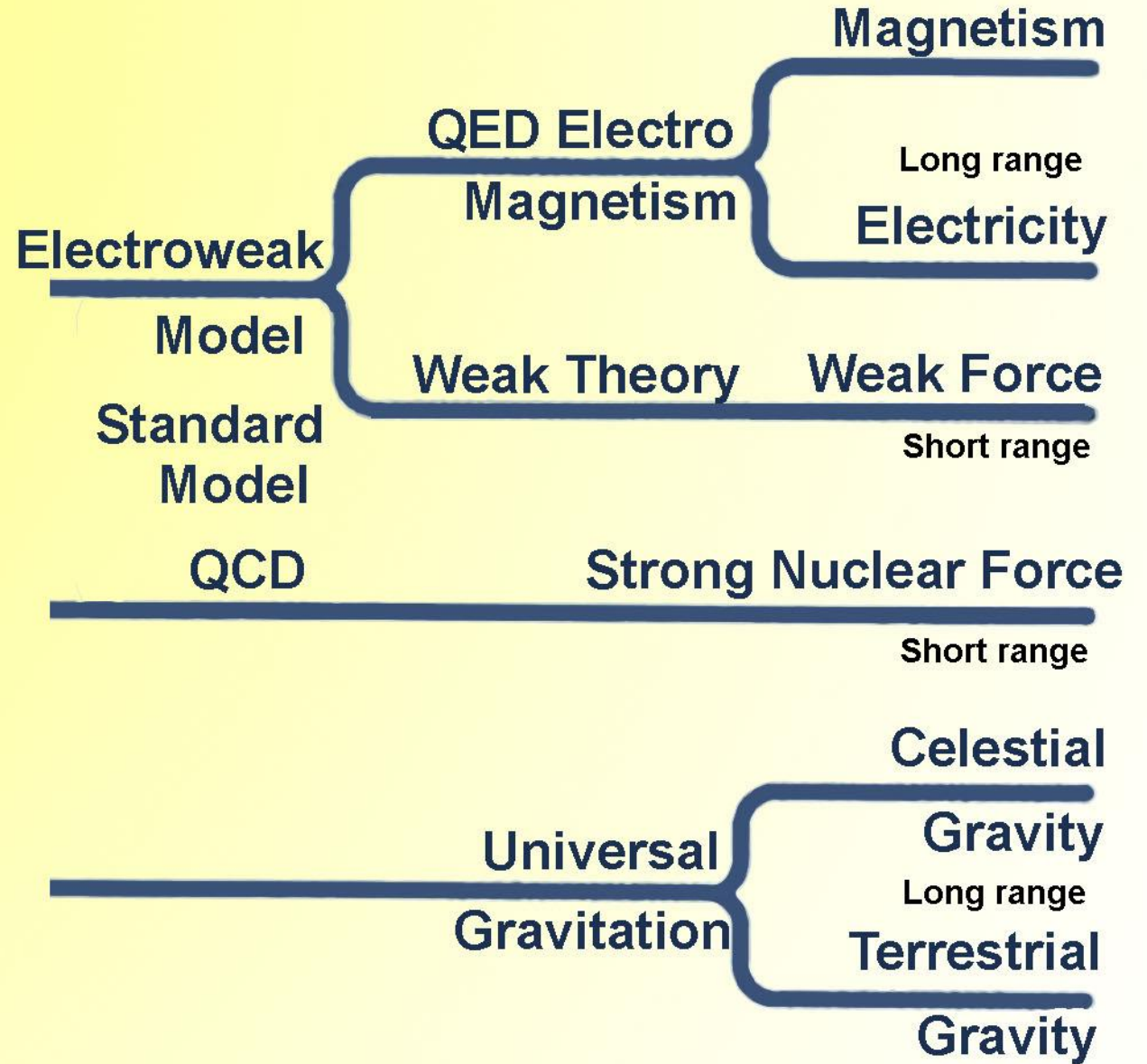
$$\nabla \times \mathbf{H} = \mathbf{J} + \frac{\partial \mathbf{D}}{\partial t}$$

# Can all forces be unified?

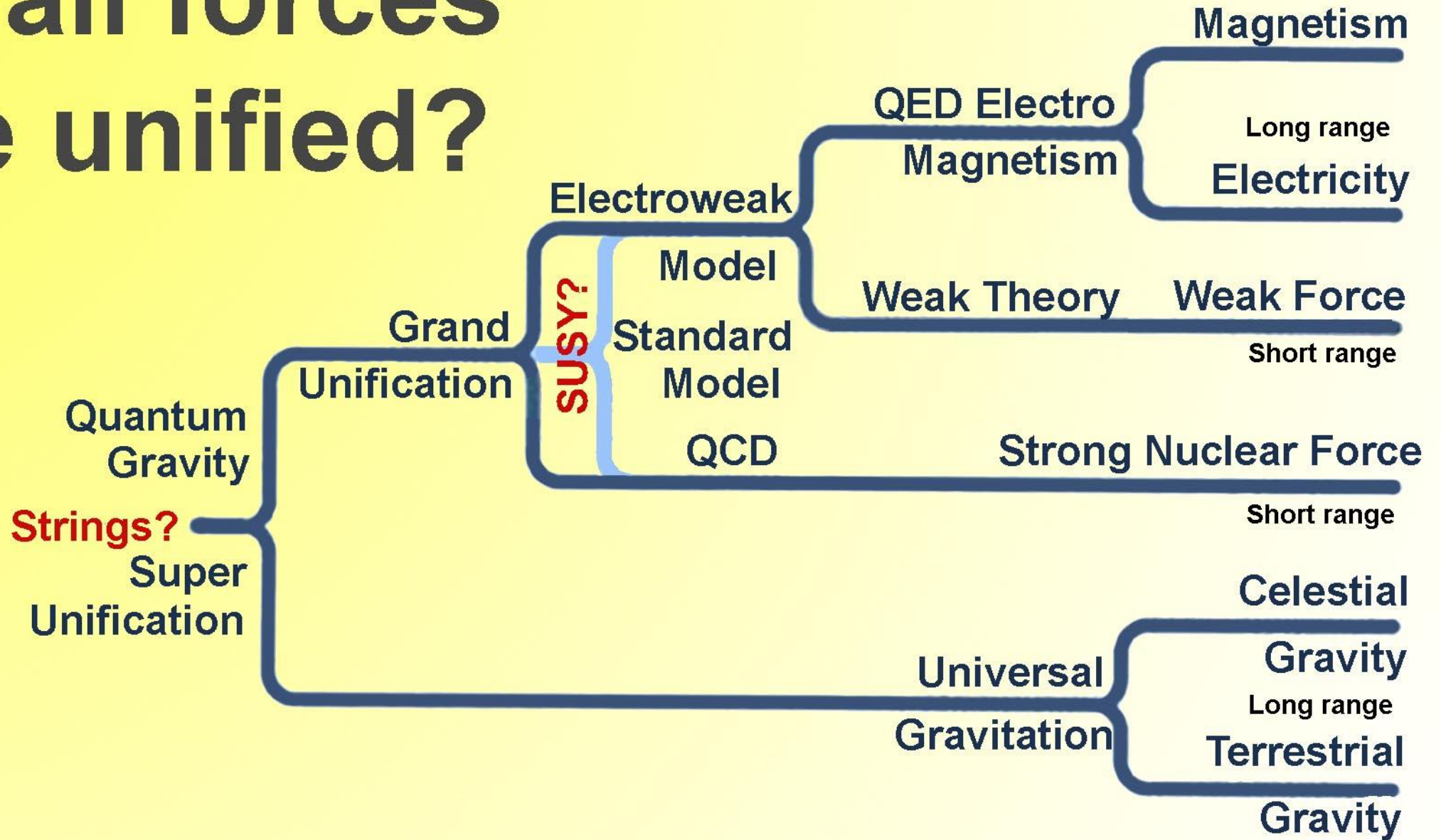


1960

# Can all forces be unified?

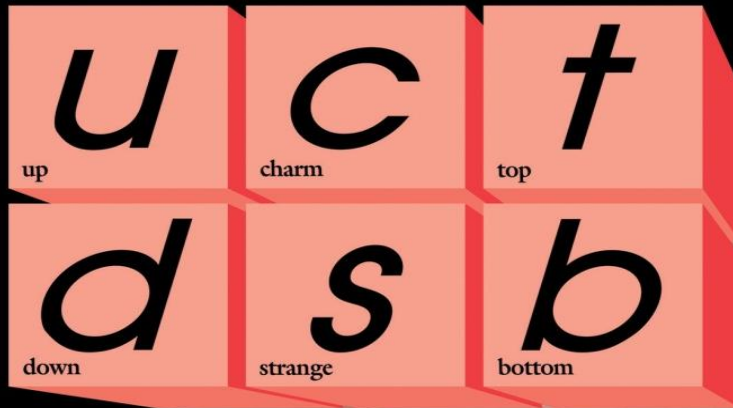


# Can all forces be unified?

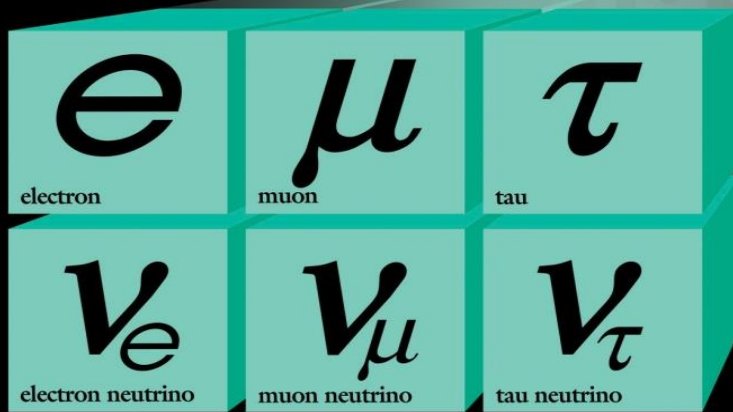
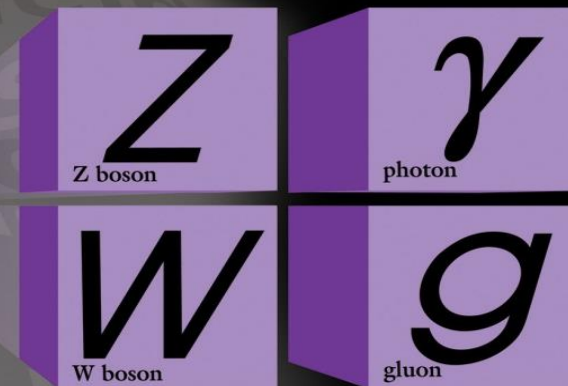


Future?

# Quarks



# Forces



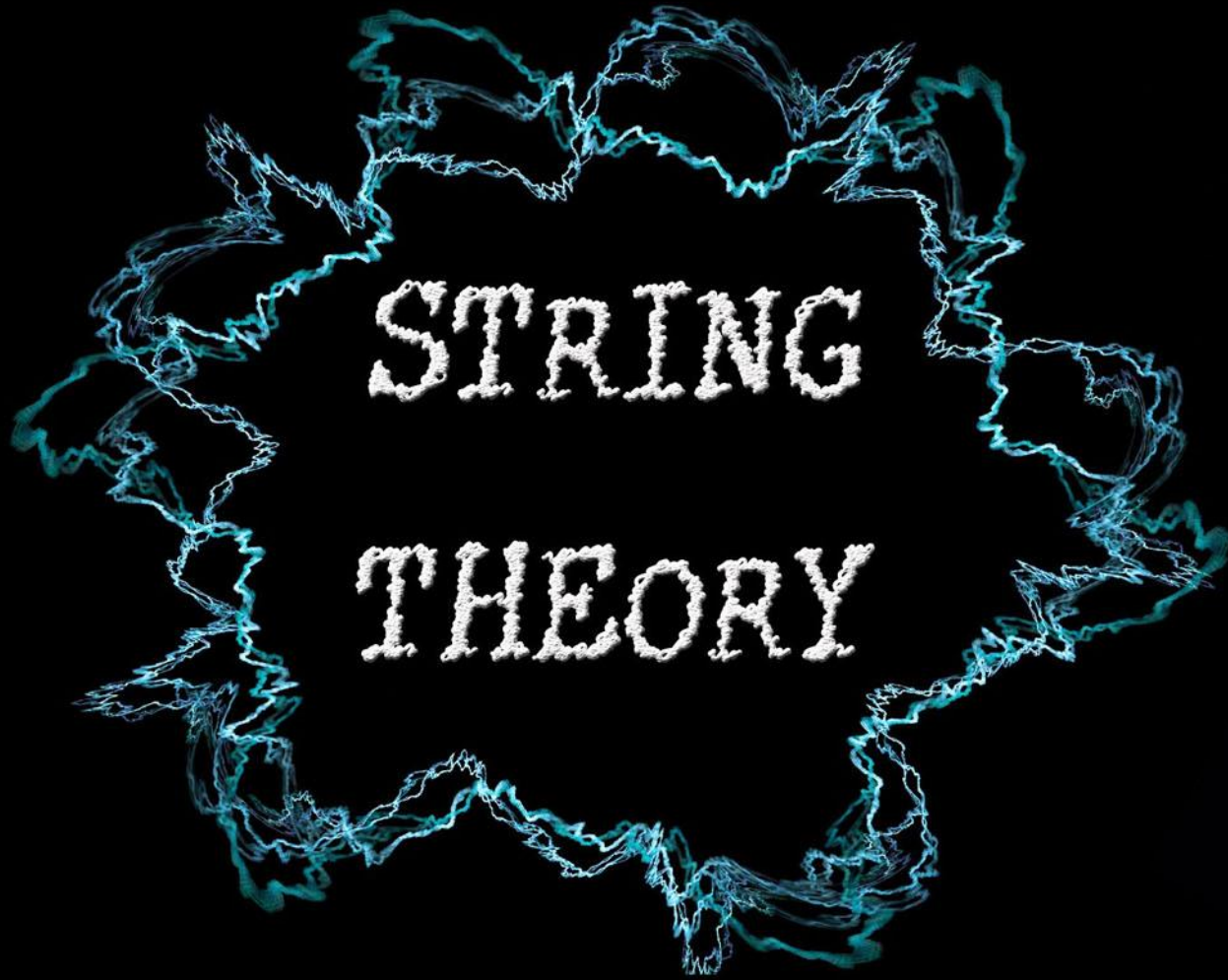
# Leptons

But....

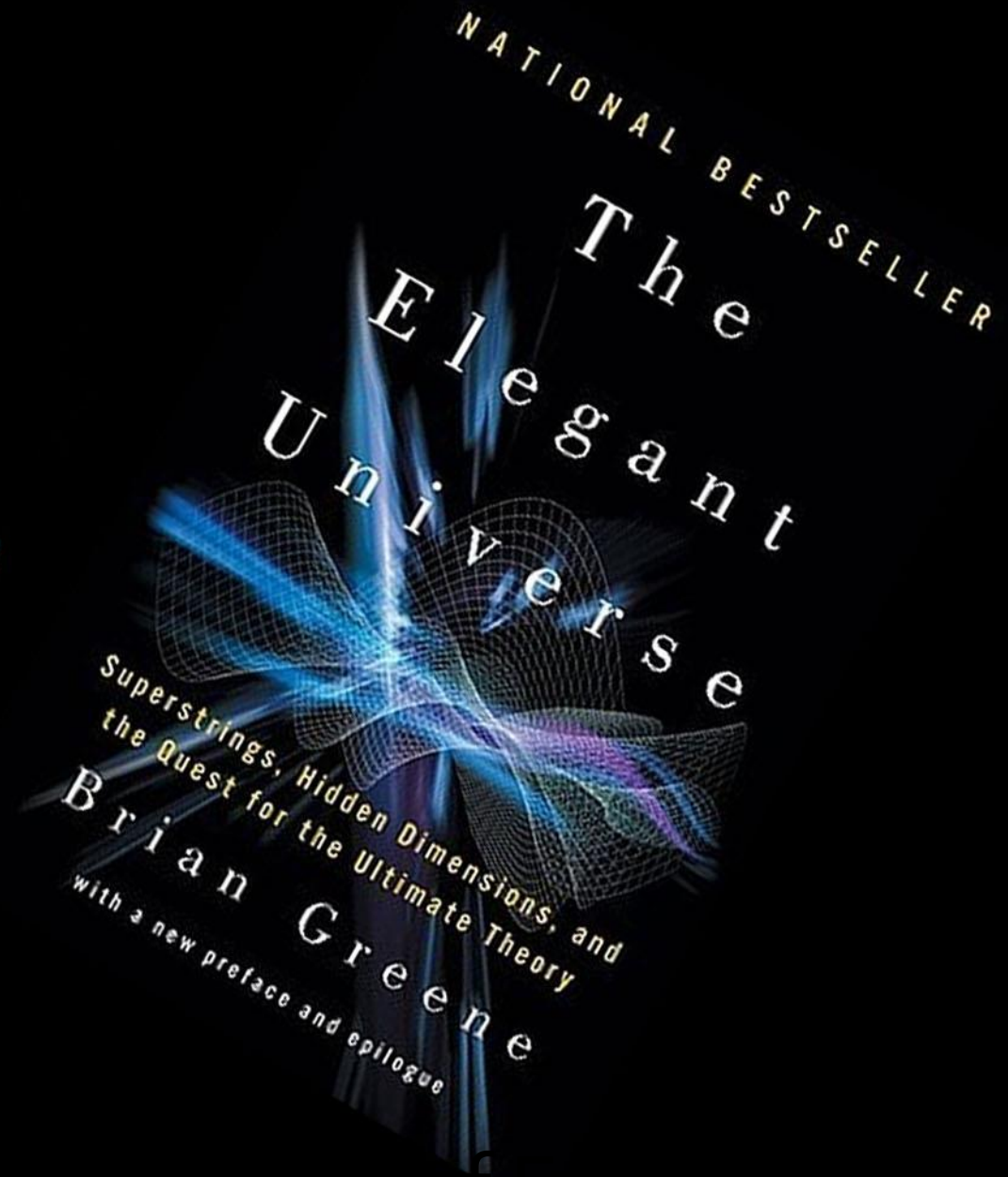


Is the Standard Model  
a  
Theory of Everything?

Candidate Theory of Everything



STRING  
THEORY



NATIONAL BESTSELLER

The  
Elegant  
Universe

Superstrings, Hidden Dimensions, and  
the Quest for the Ultimate Theory

Brian Greene

with a new preface and epilogue

Candidate Theory of Everything

# Things the Standard Model Doesn't Explain

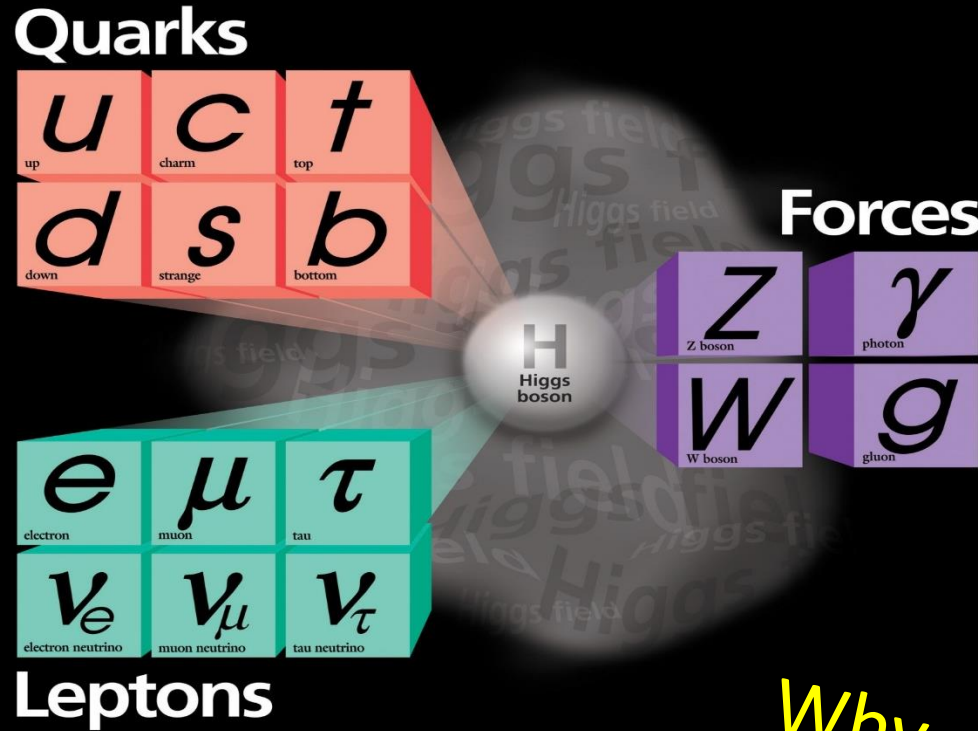
Why quarks?

Why leptons?

Why three generations?

Why four forces?

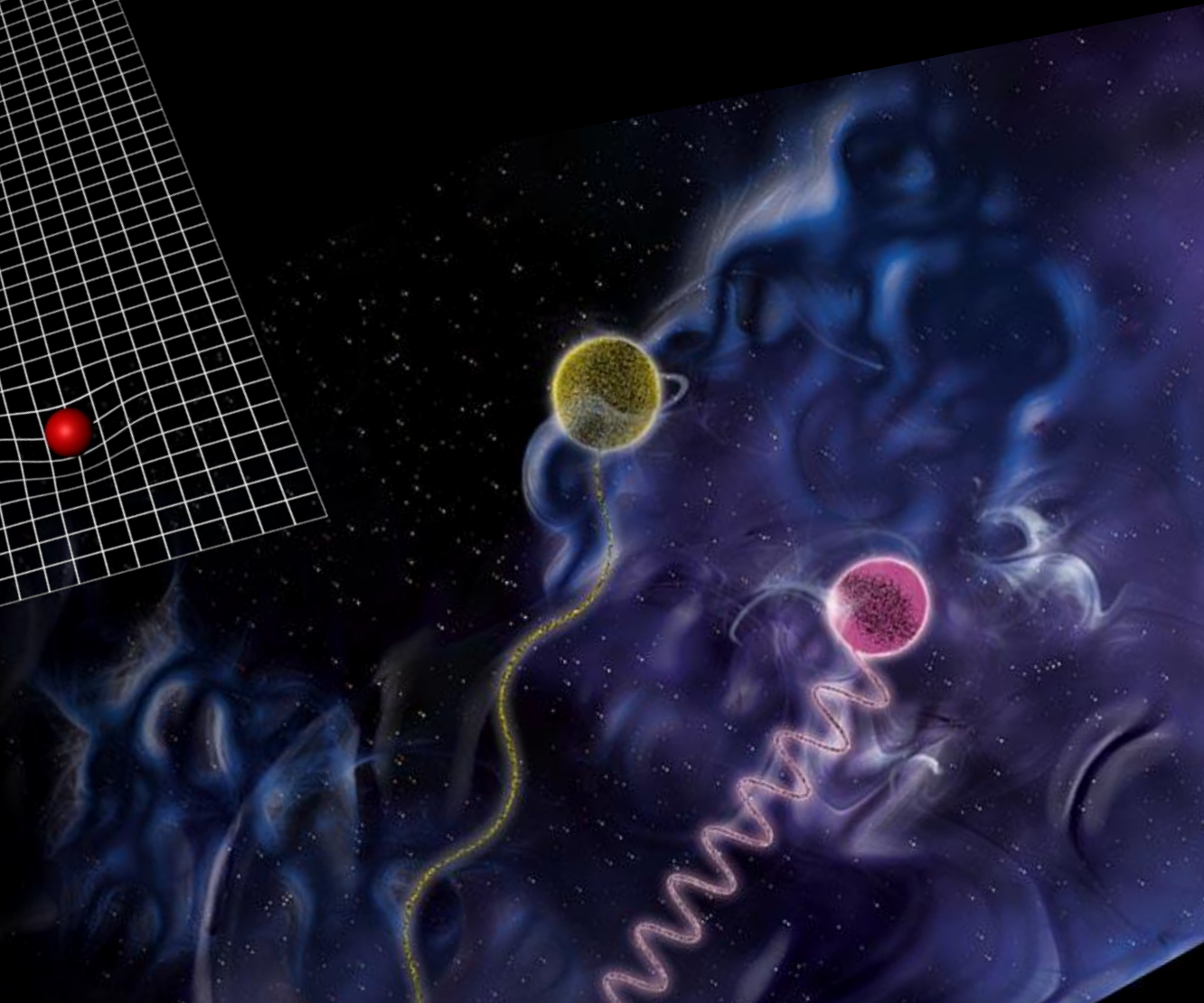
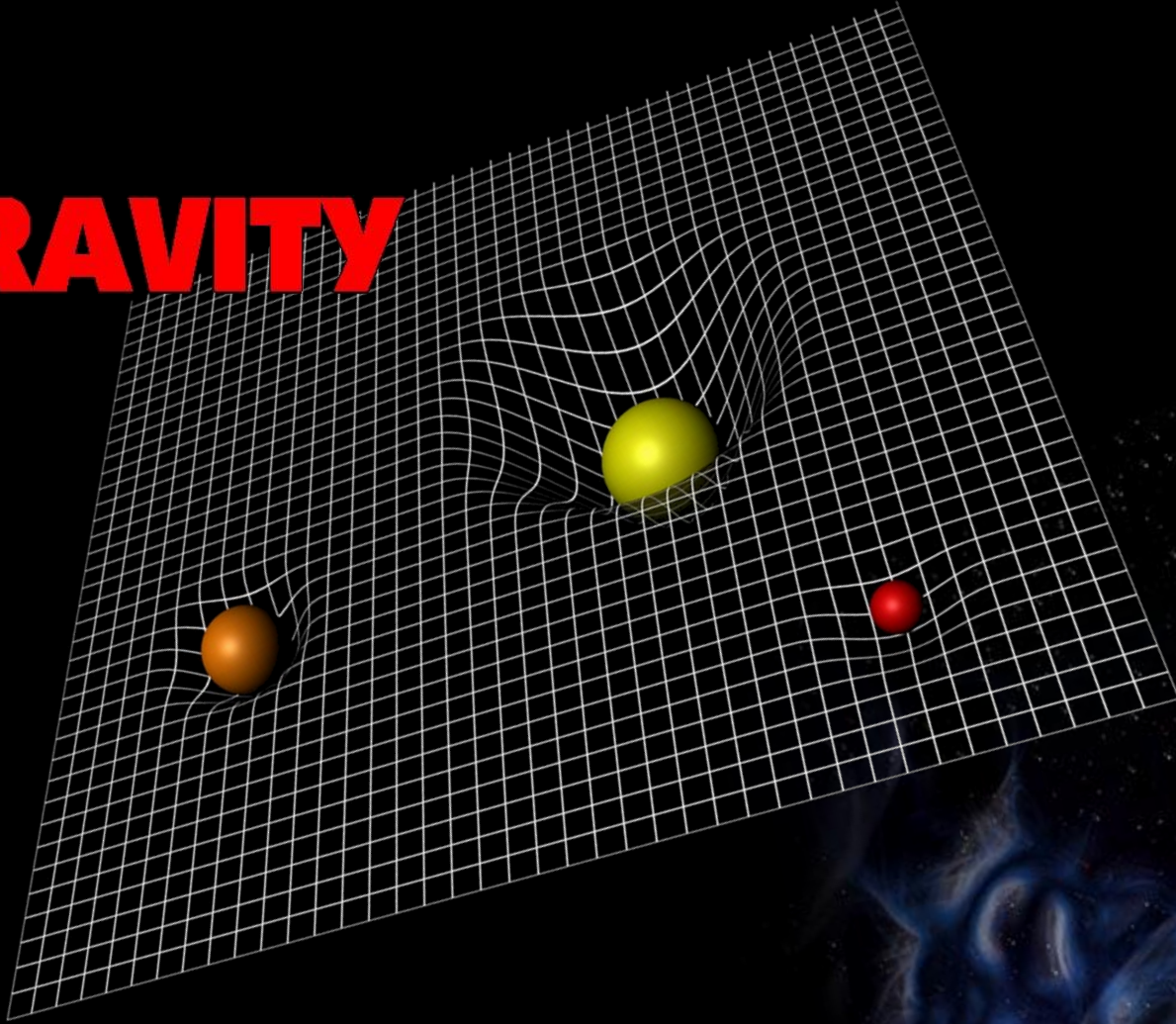
Why a Higgs field?



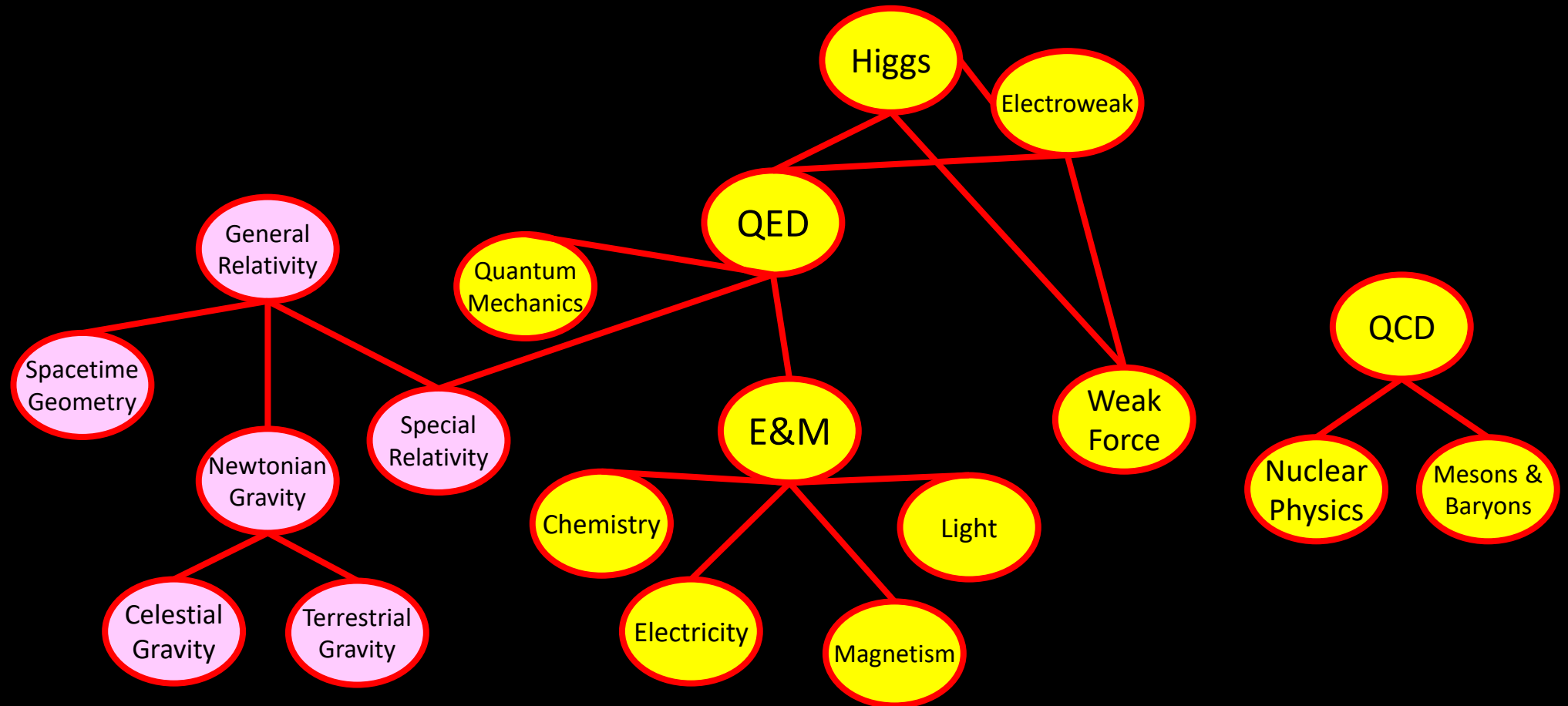
# Things the Standard Model Doesn't Explain



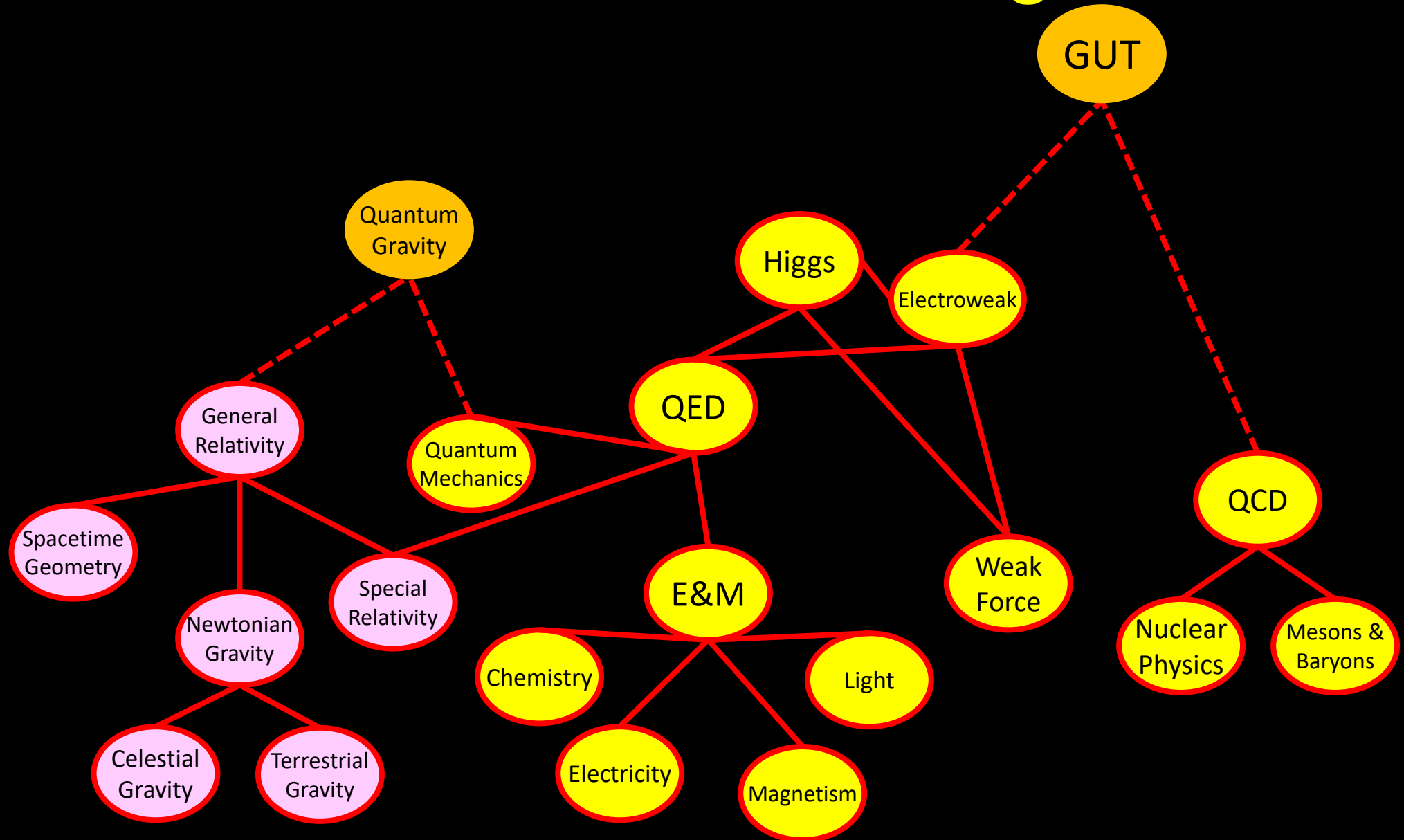
**GRAVITY**



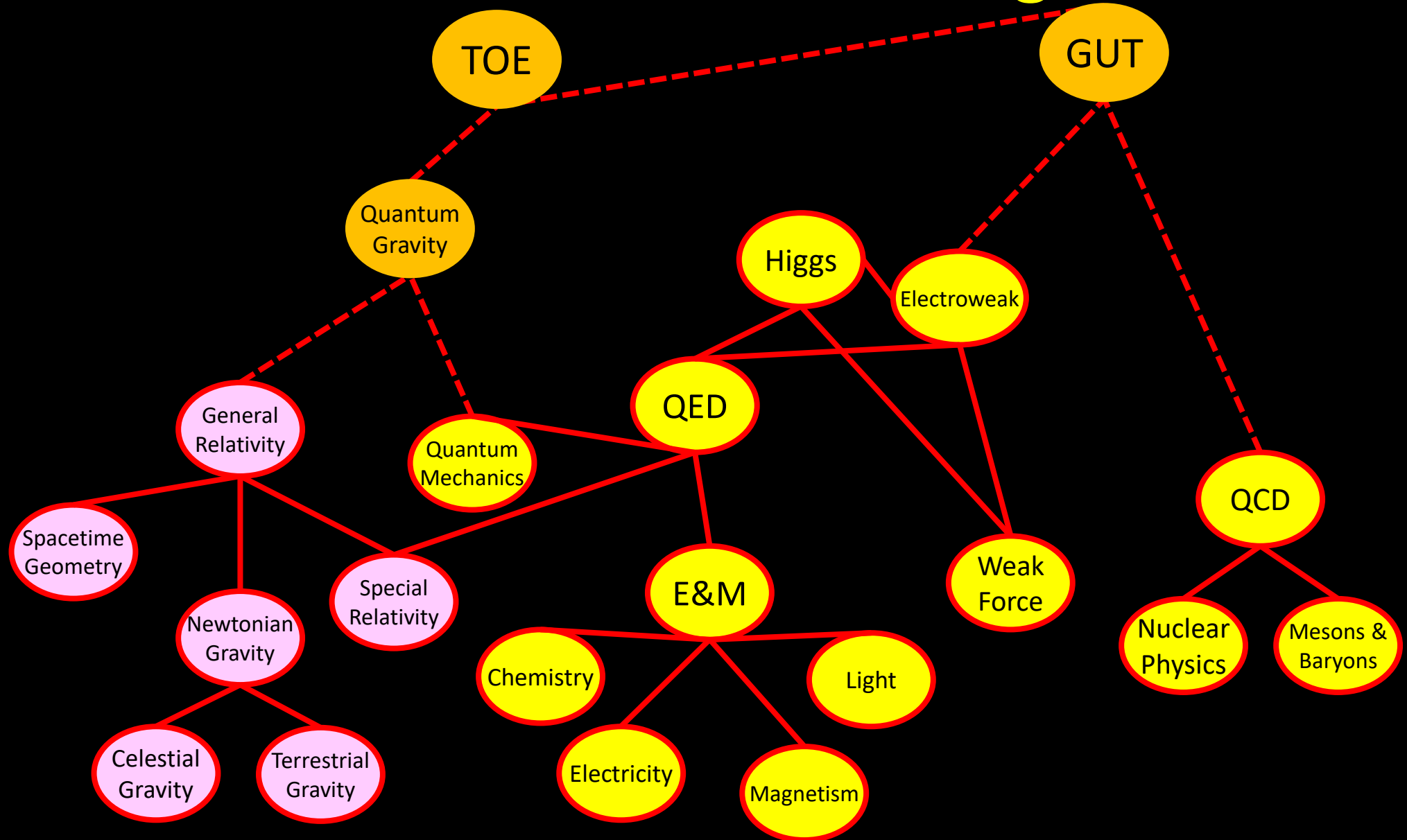
# Connections: Known and Imagined



# Connections: Known and Imagined

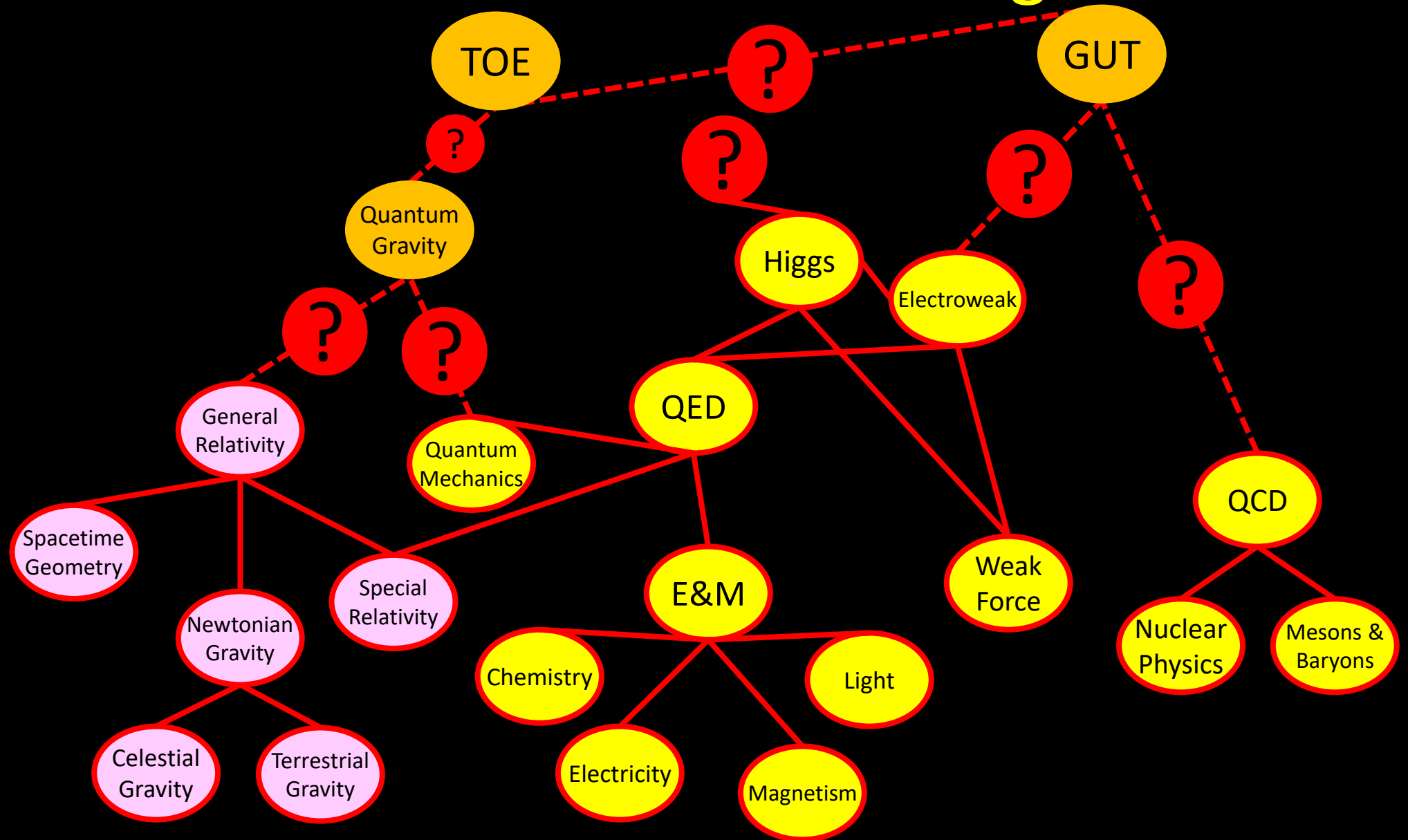


# Connections: Known and Imagined

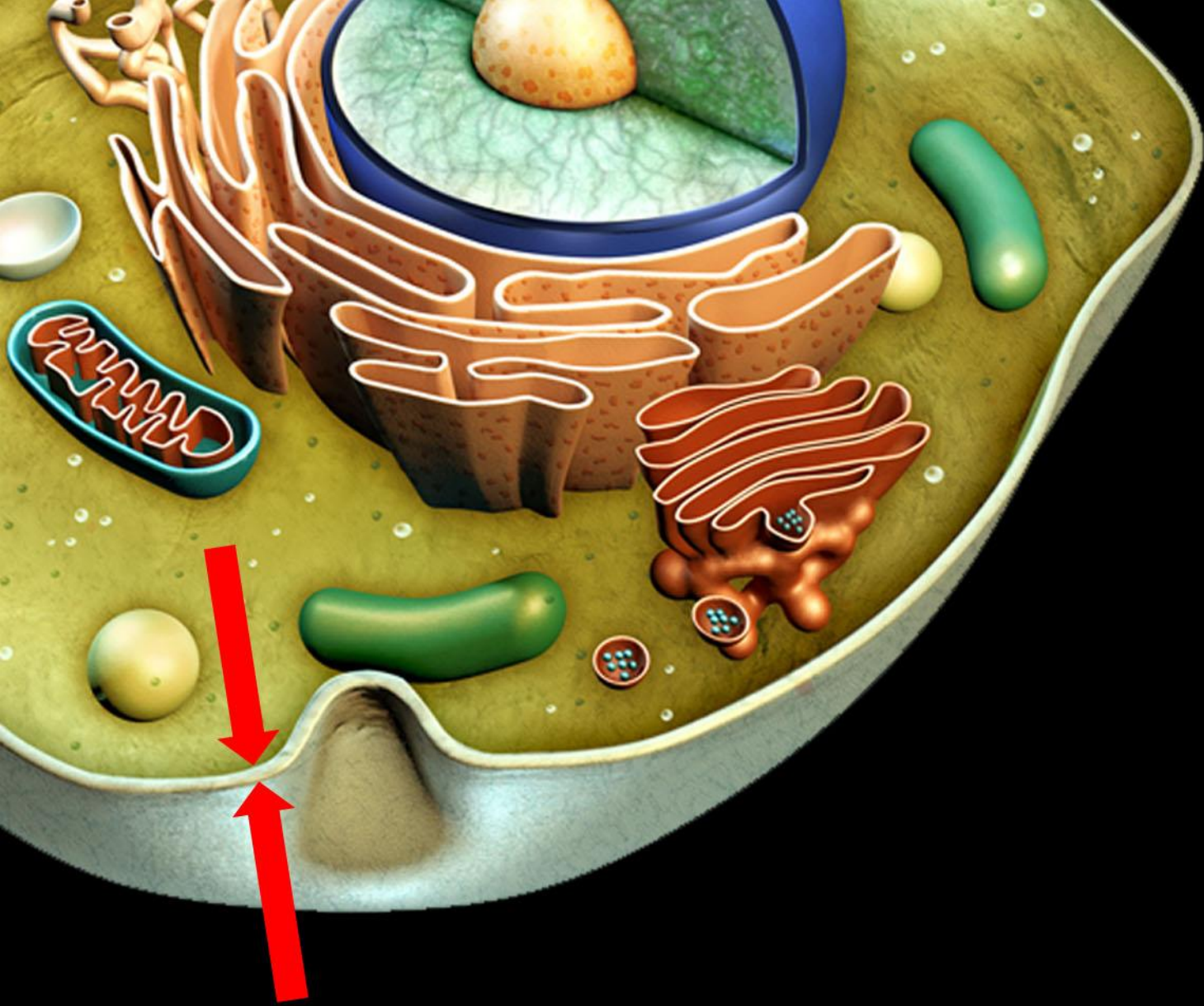




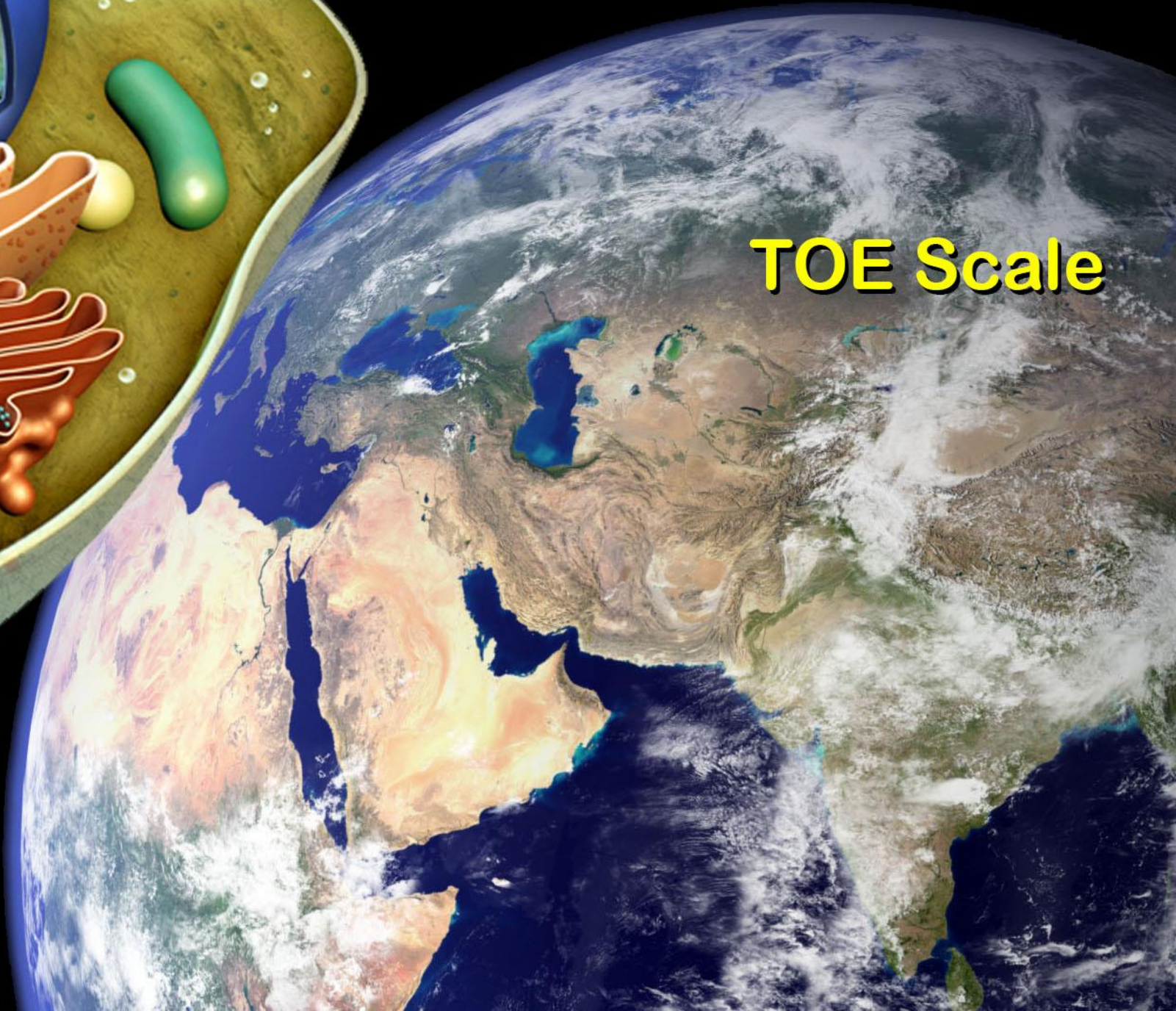
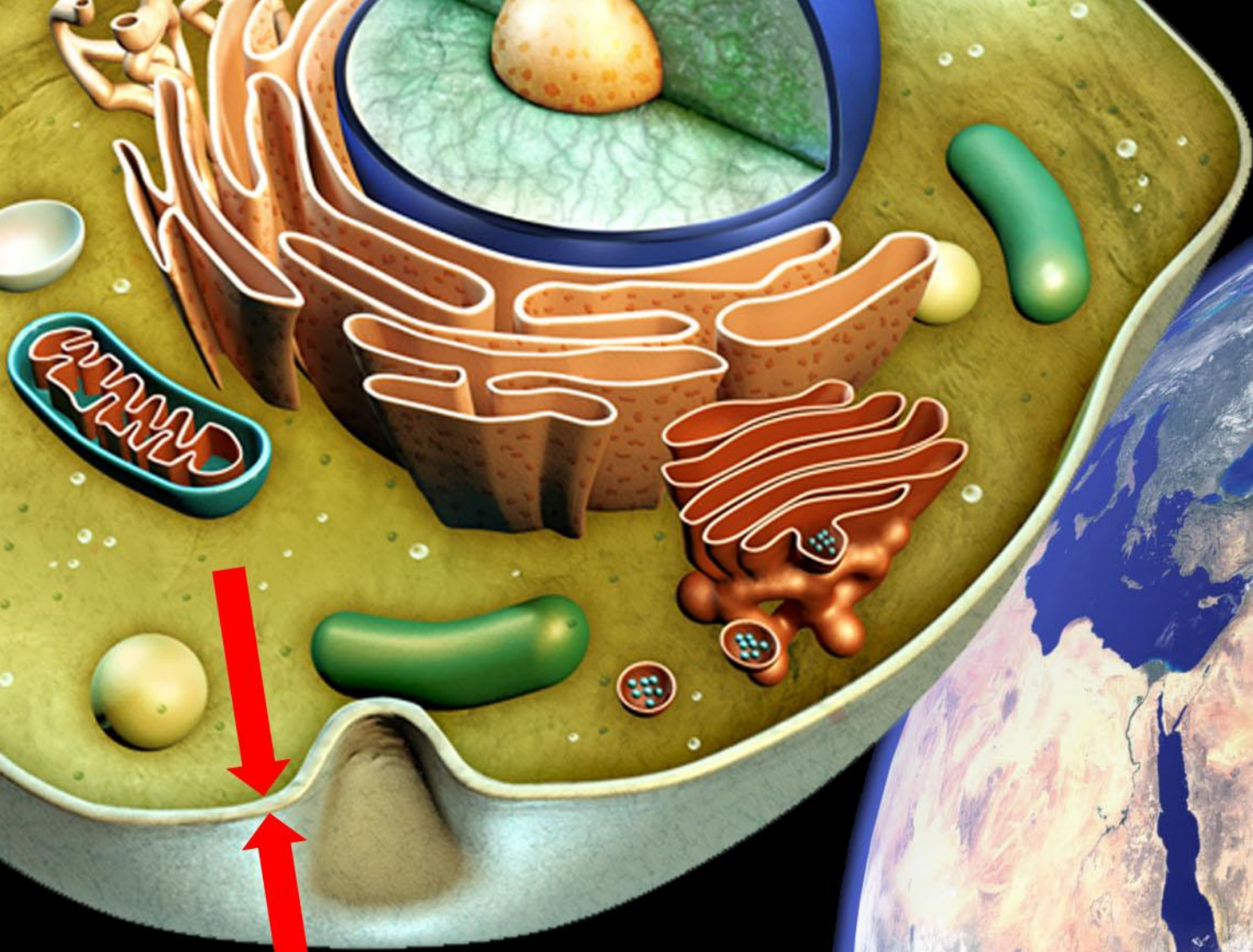
# Connections: Known and Imagined







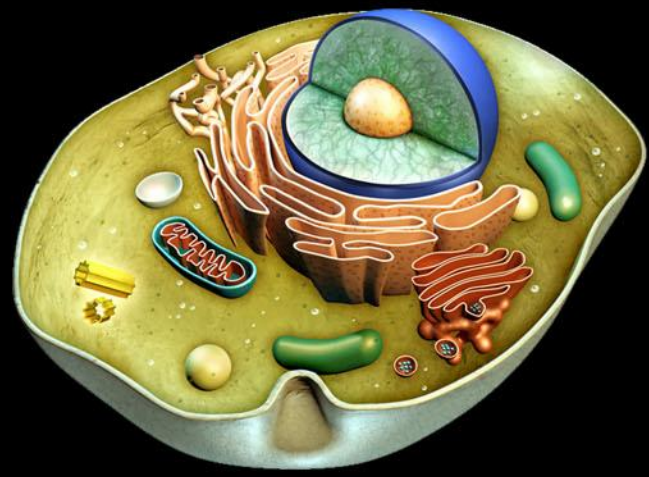
**LHC Scale**

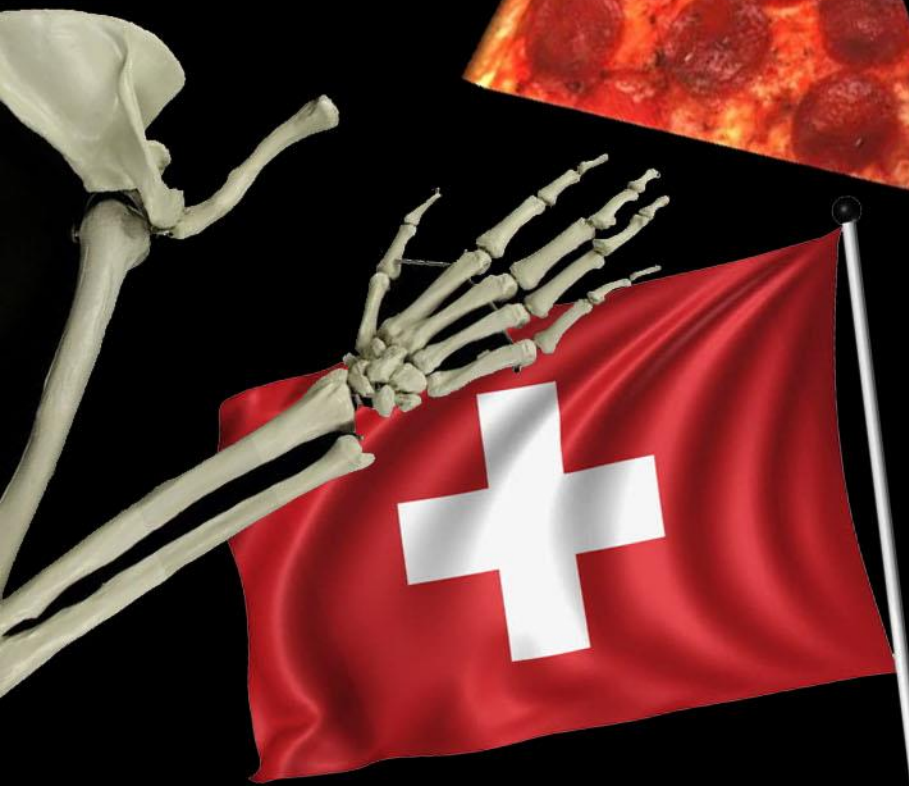
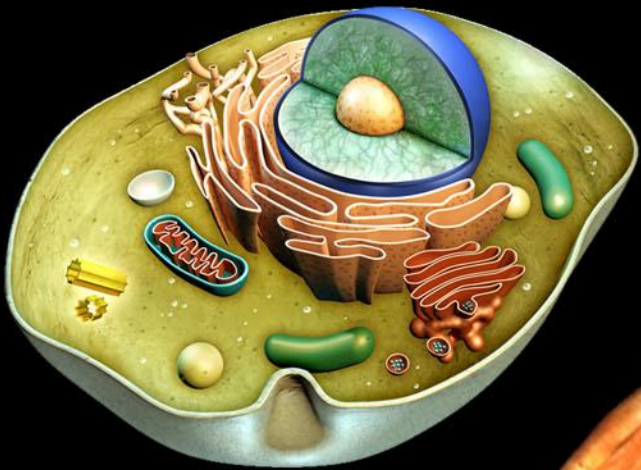


**TOE Scale**

**LHC Scale**



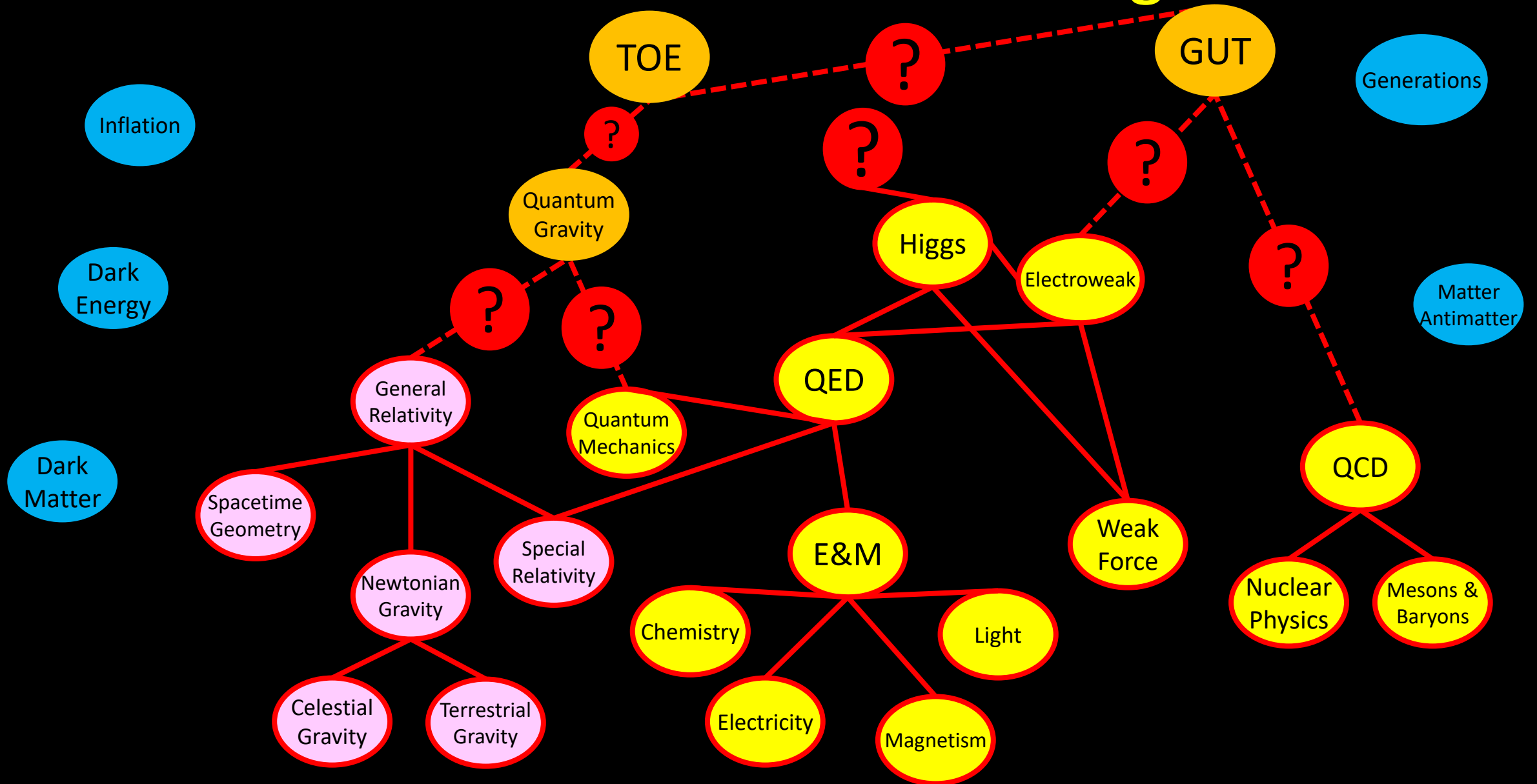




Currently Accessible Scale  $\sim 10^4$  GeV  
TOE Scale  $\sim 10^{19}$  GeV

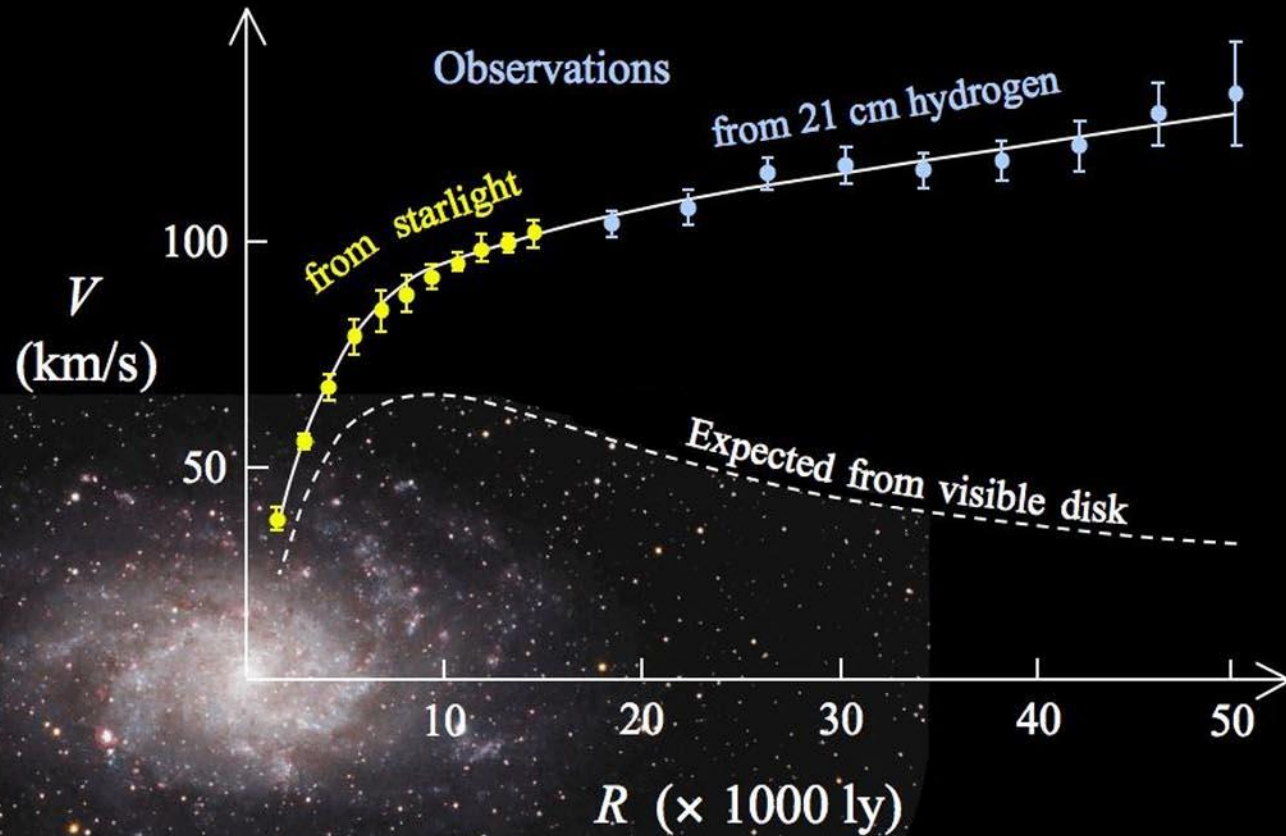
Fifteen orders of magnitude!  
(proton to human scale)  
(e.g.  $\times 1,000,000,000,000,000$ )

# Connections: Known and Imagined

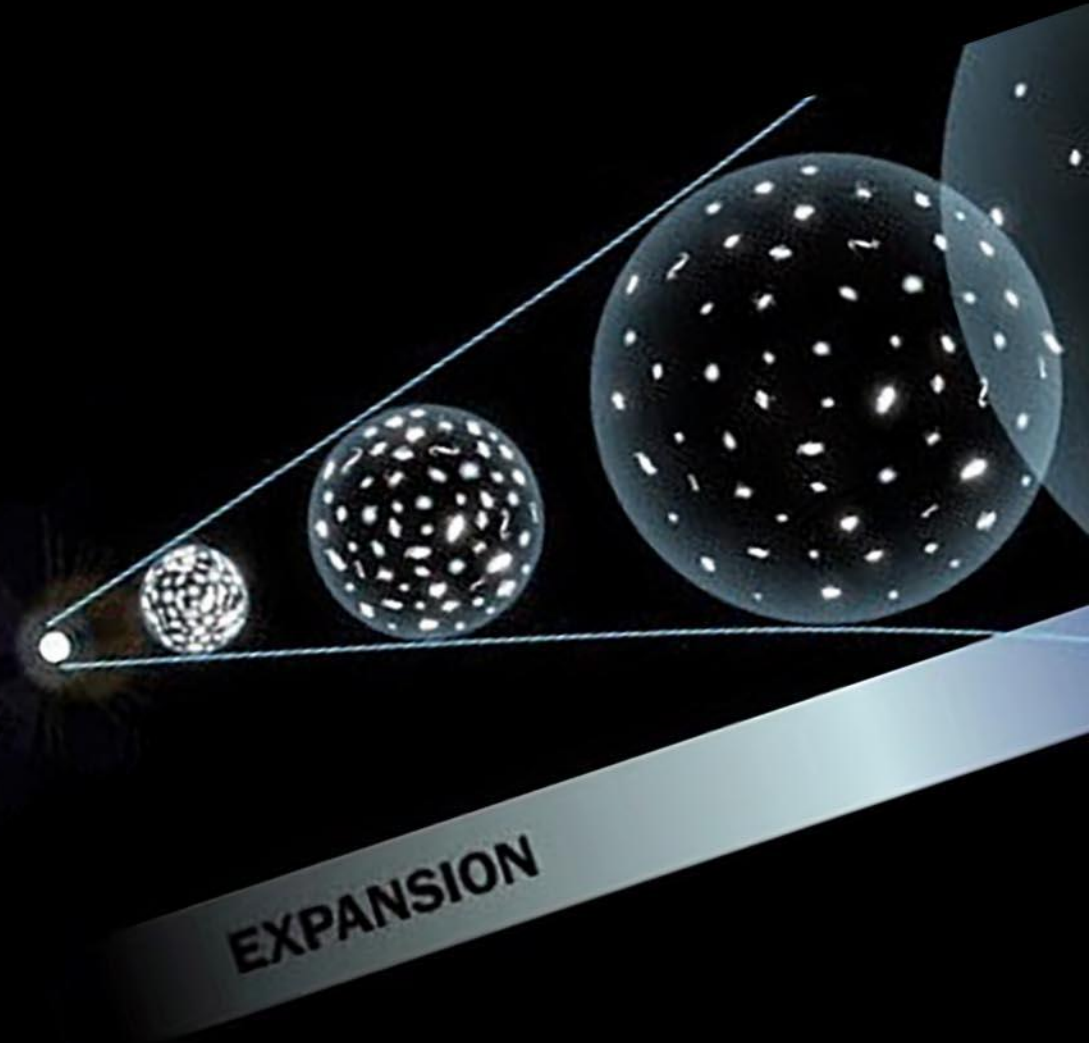
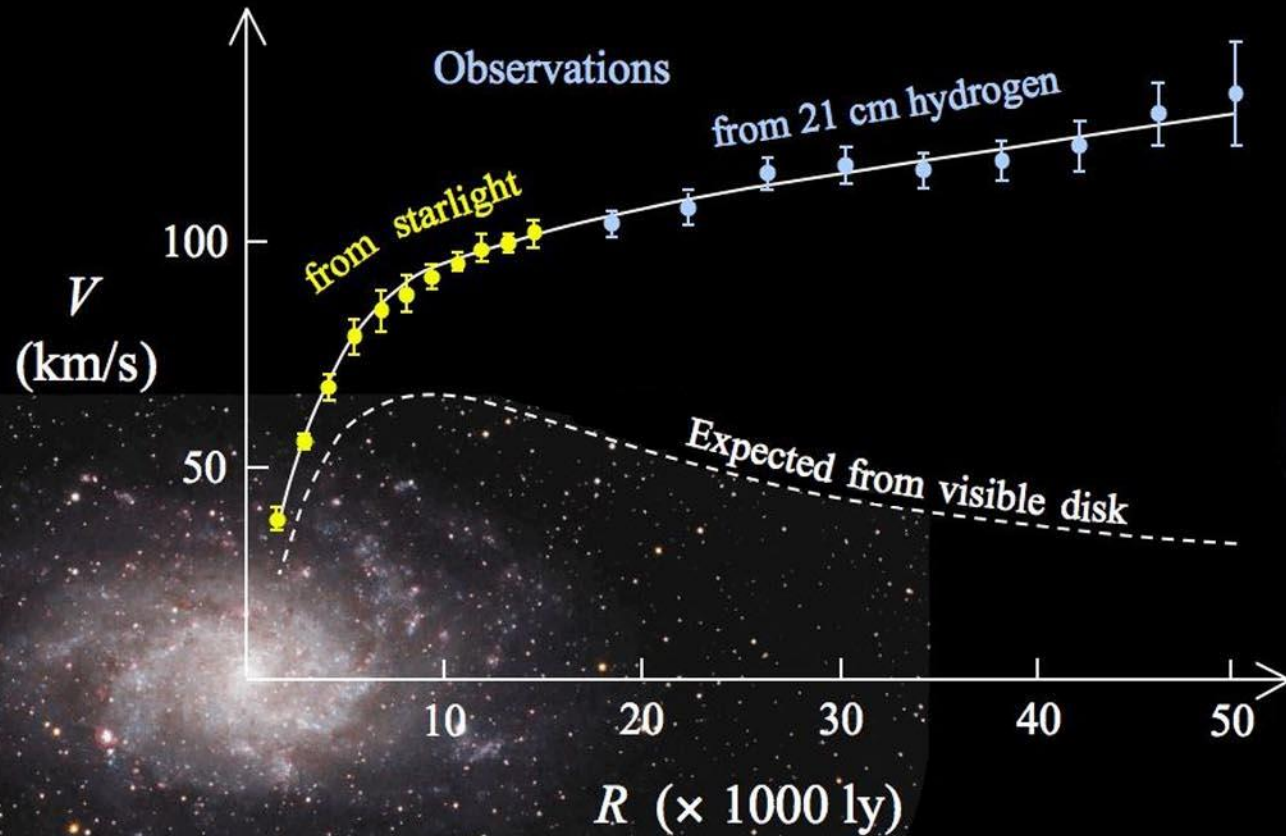




# Observations from the Cosmos



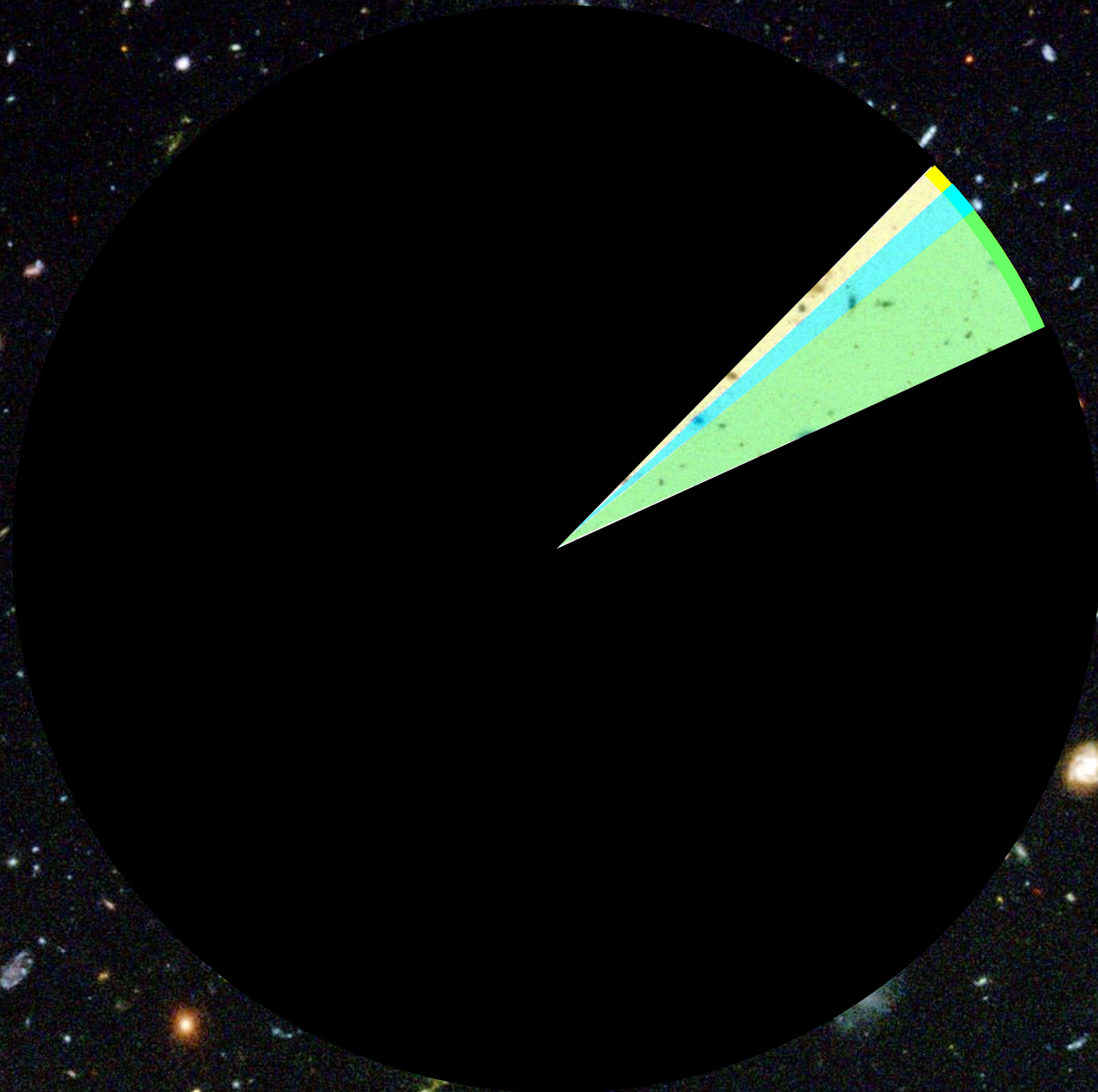
# Observations from the Cosmos







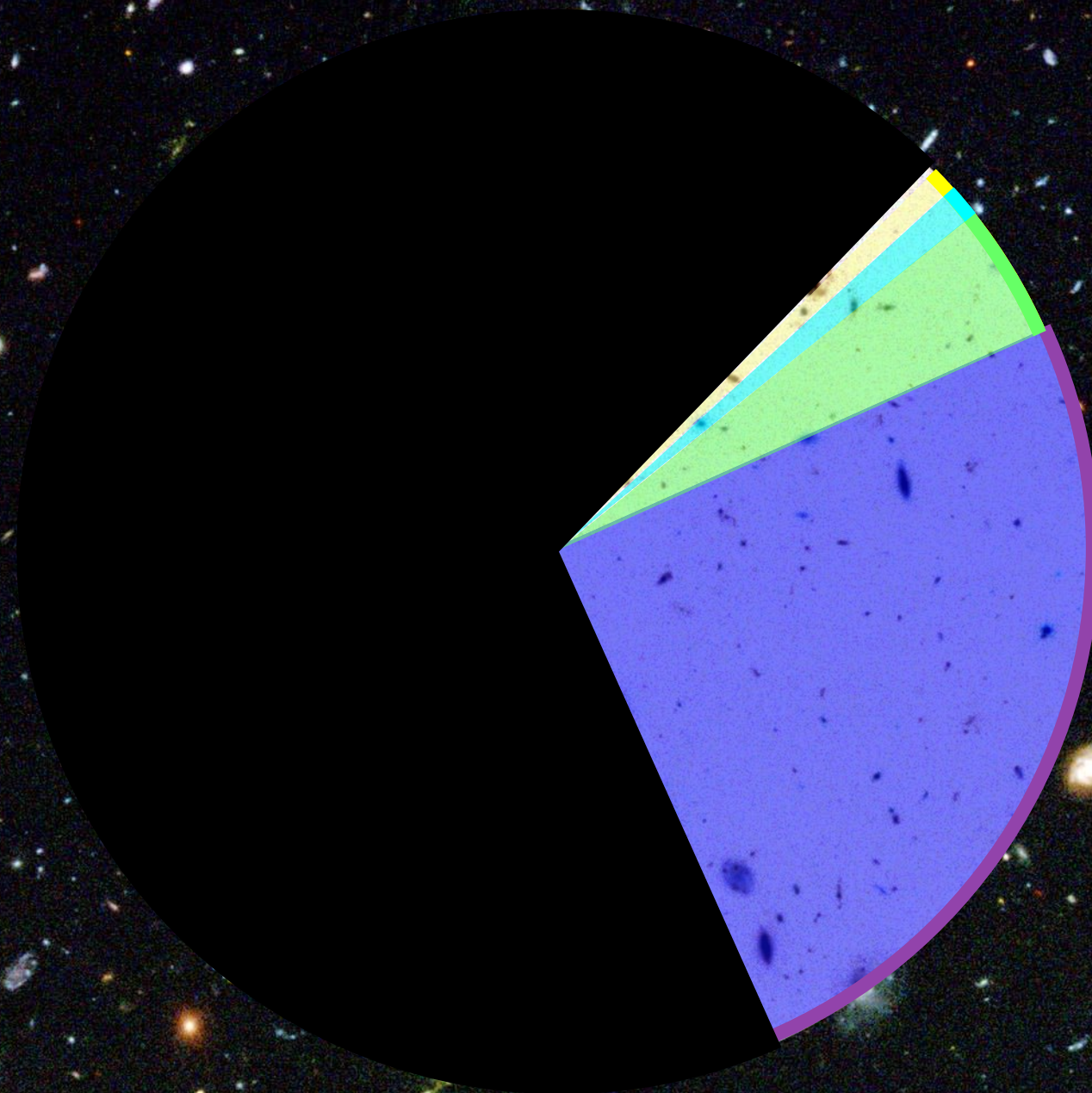
Stars  
0.5%



Neutrinos  
0.3%

Stars  
0.5%

Gas Clouds  
4%

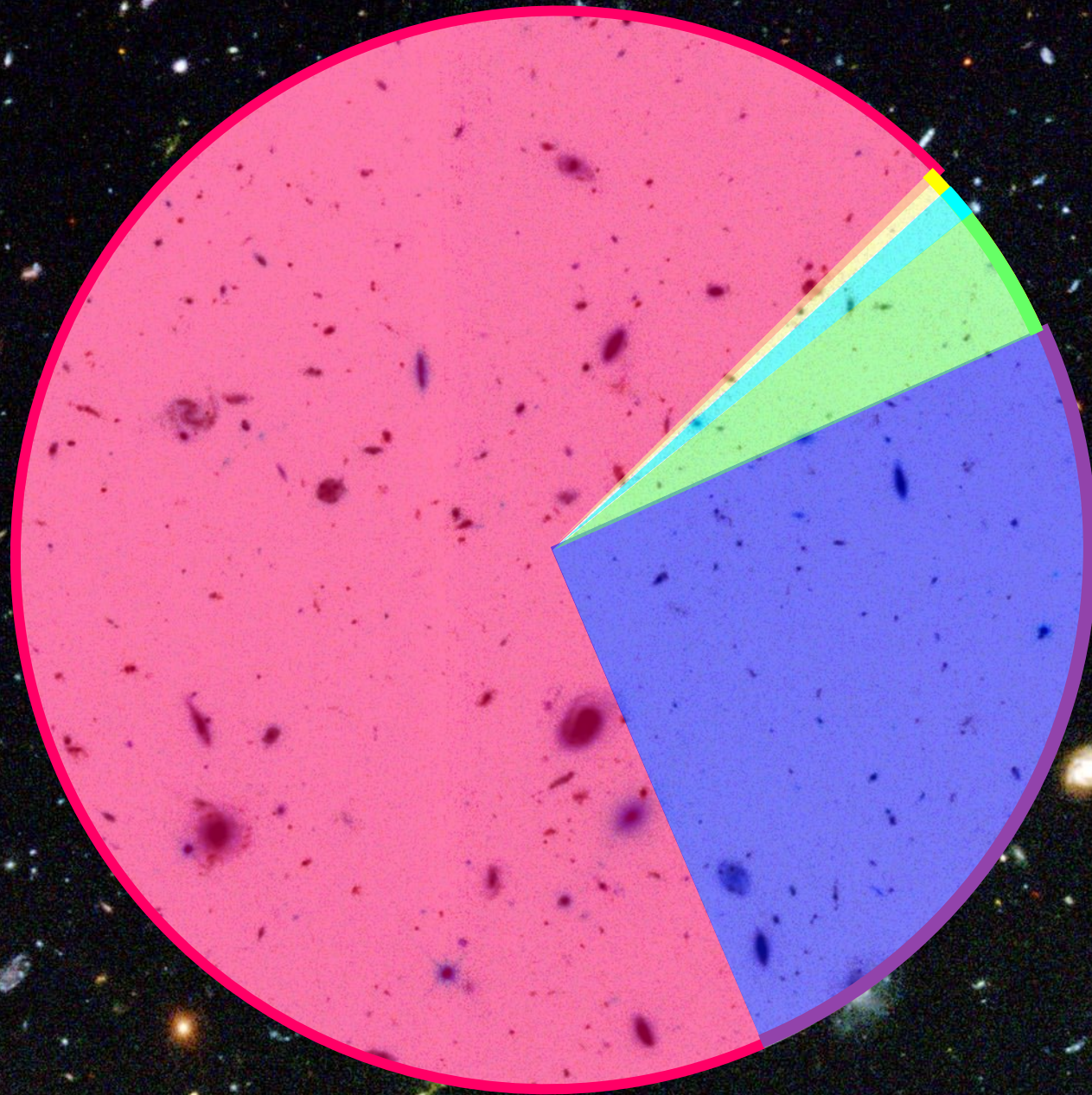


Neutrinos  
0.3%

Stars  
0.5%

Gas Clouds  
4%

Dark Matter  
27%



Neutrinos  
0.3%

Stars  
0.5%

Gas Clouds  
4%

Dark Matter  
27%

Dark Energy  
68%

Dark matter

May or may not exist (probably does)

If particulate

$$10^{-5} \text{ eV} < M < m_{\text{asteroid}}$$

Does not experience  
weak force

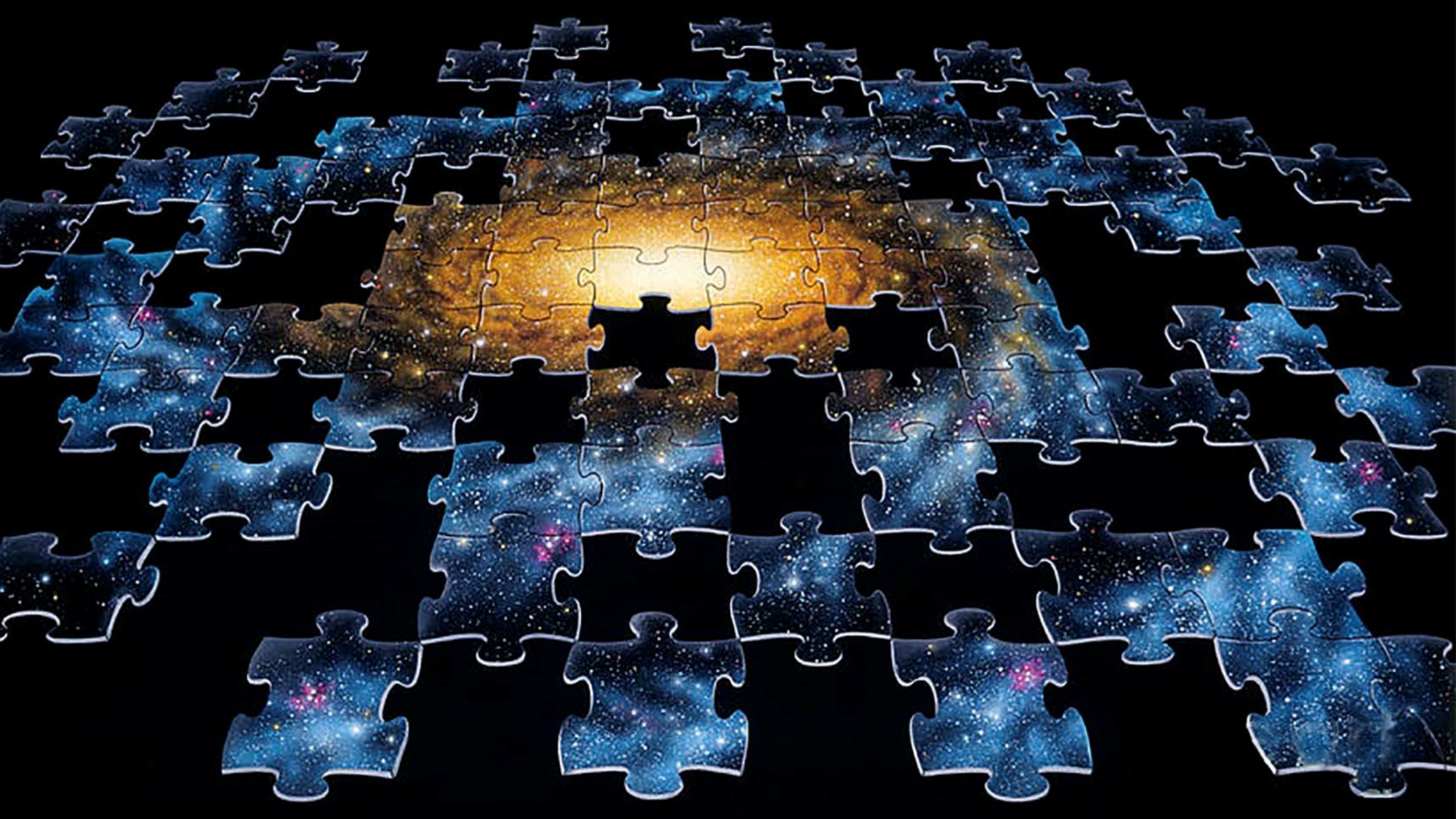
Dark energy

Expansion is accelerating

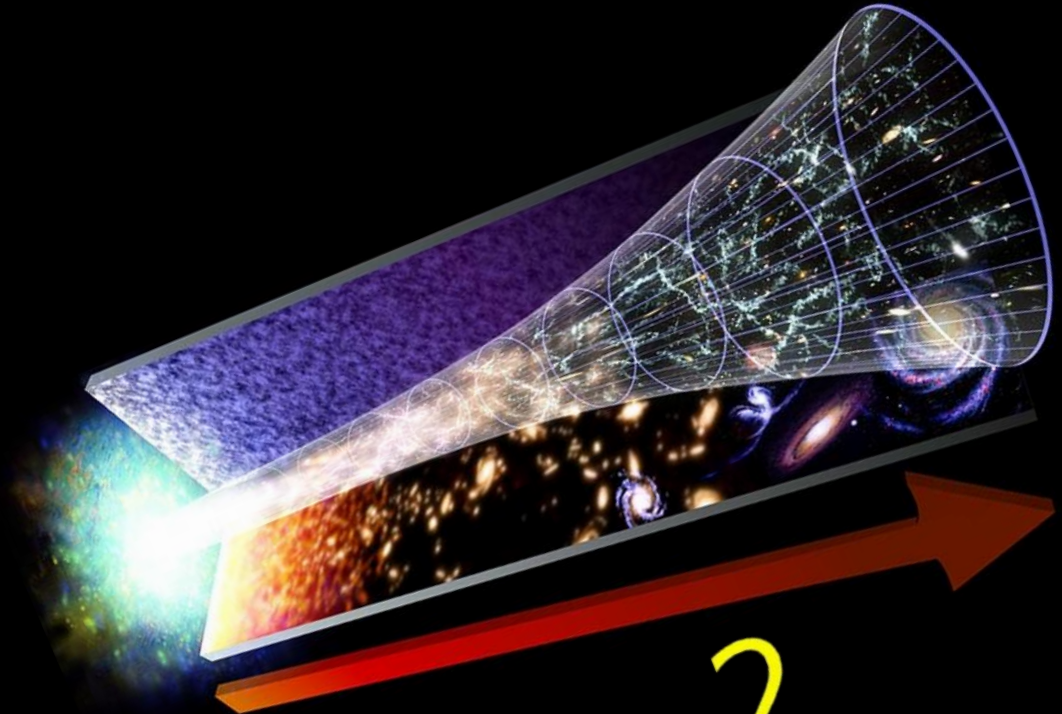
Origin is unknown, although it  
appears to be constant

The amount of dark energy disagrees with QFT  
predictions by a staggering factor  $10^{120}$ .

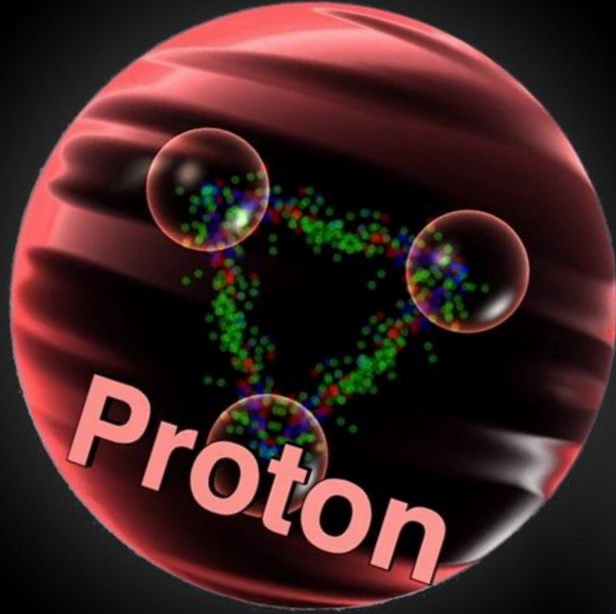
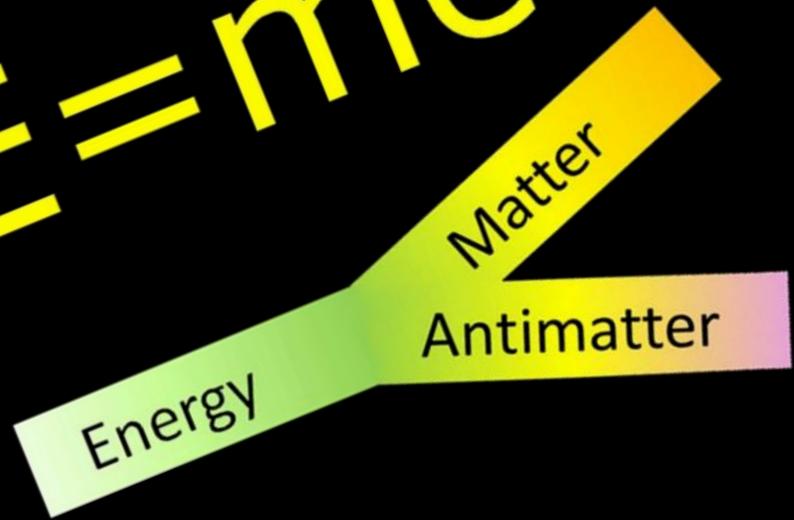




Where did the antimatter go?



$$E=mc^2$$



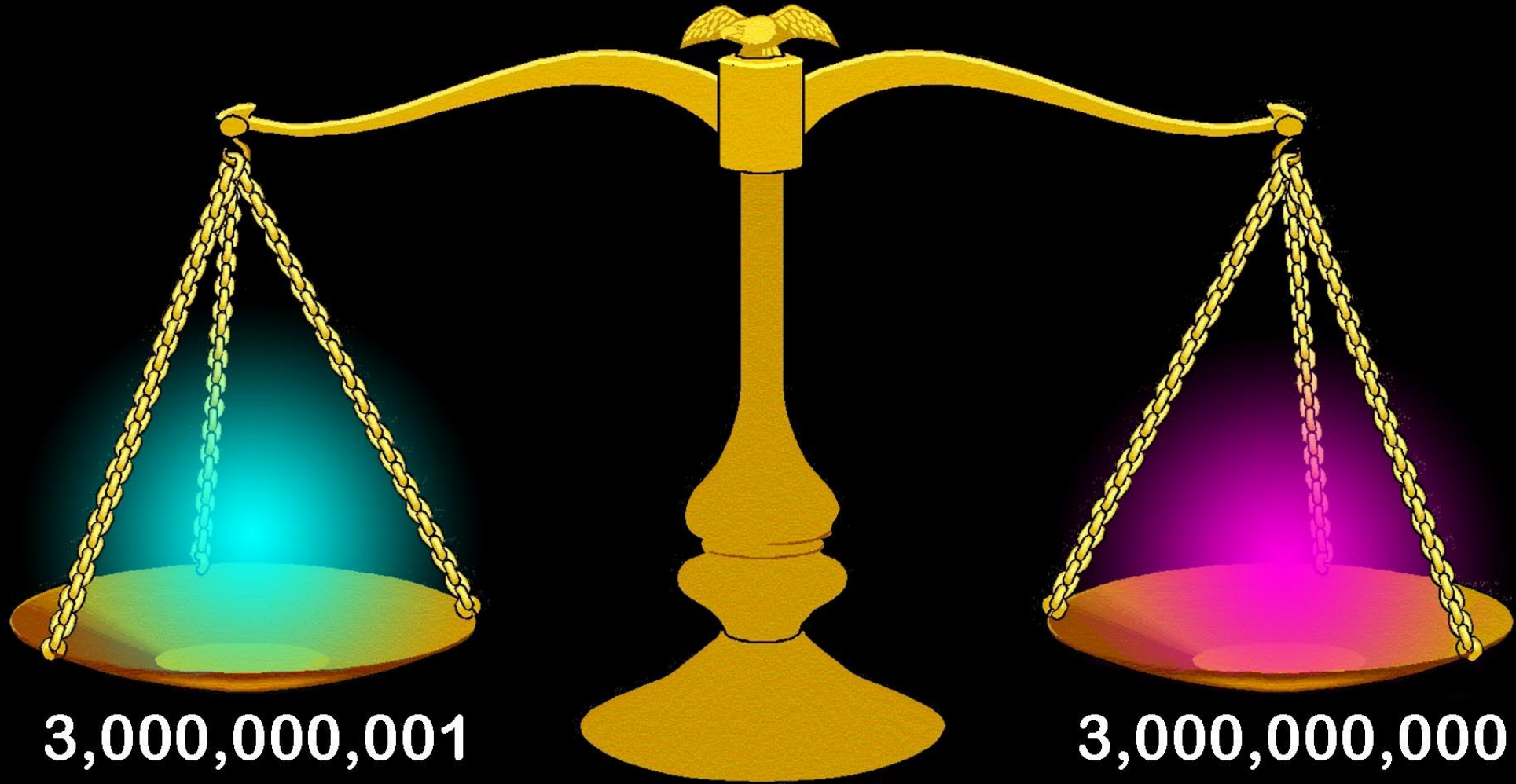
Primordial Matter

Primordial Antimatter



Primordial Matter

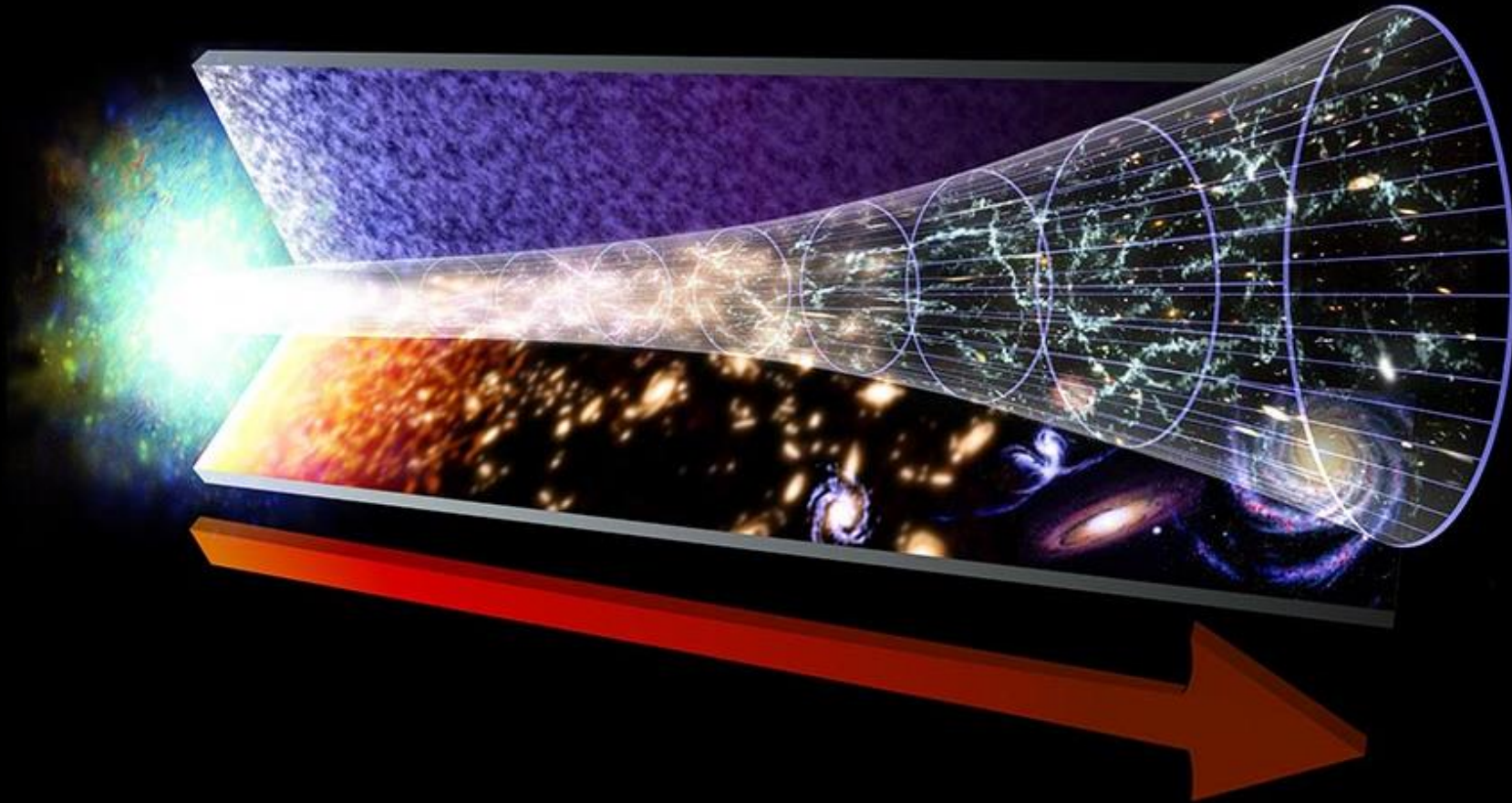
Primordial Antimatter



3,000,000,001

3,000,000,000

# The Big Bang: What started it?



Was there a "before?"

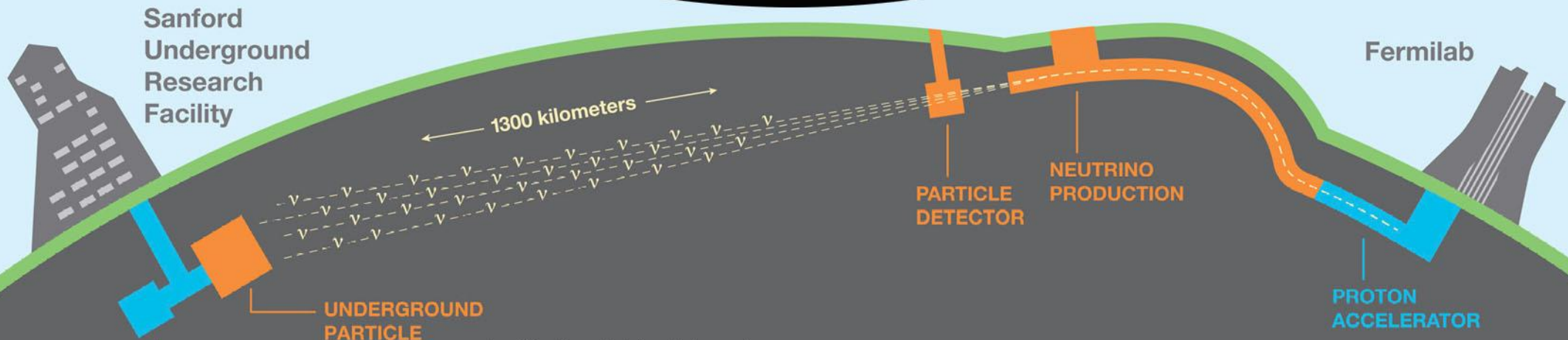
# The Large Hadron Collider

- Unification
- Dark Matter
- New Forces
- New particles
- Hint of what's next

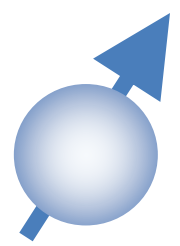
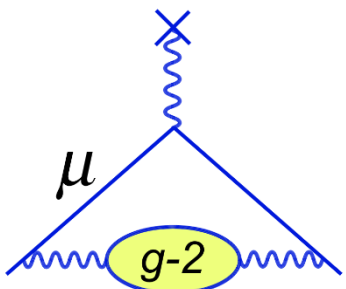



Matter/antimatter asymmetry  
Proton decay


LBNF accelerators cavern universe future  
experiment science research  
universities energy DUNE rock global countries antimatter  
proton decay international stars collaboration global countries neutron stars  
big bang cosmology black holes countries technology underground  
cosmos antineutrino stars particle unified theory matter deep detector  
nature antineutrino stars particle unified theory matter deep laboratories  
neutrino physics



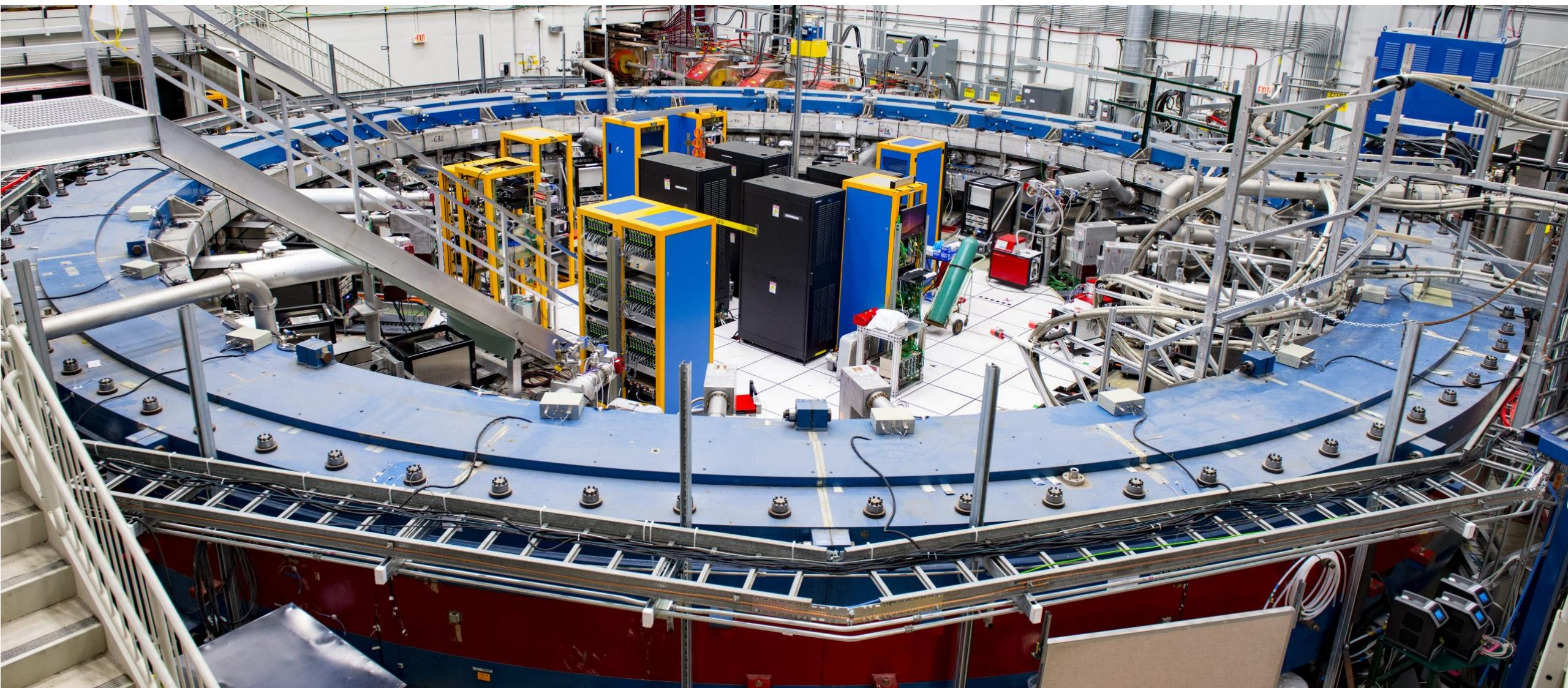
**DUNE:** (Deep Underground Neutrino Experiment)



Theory  


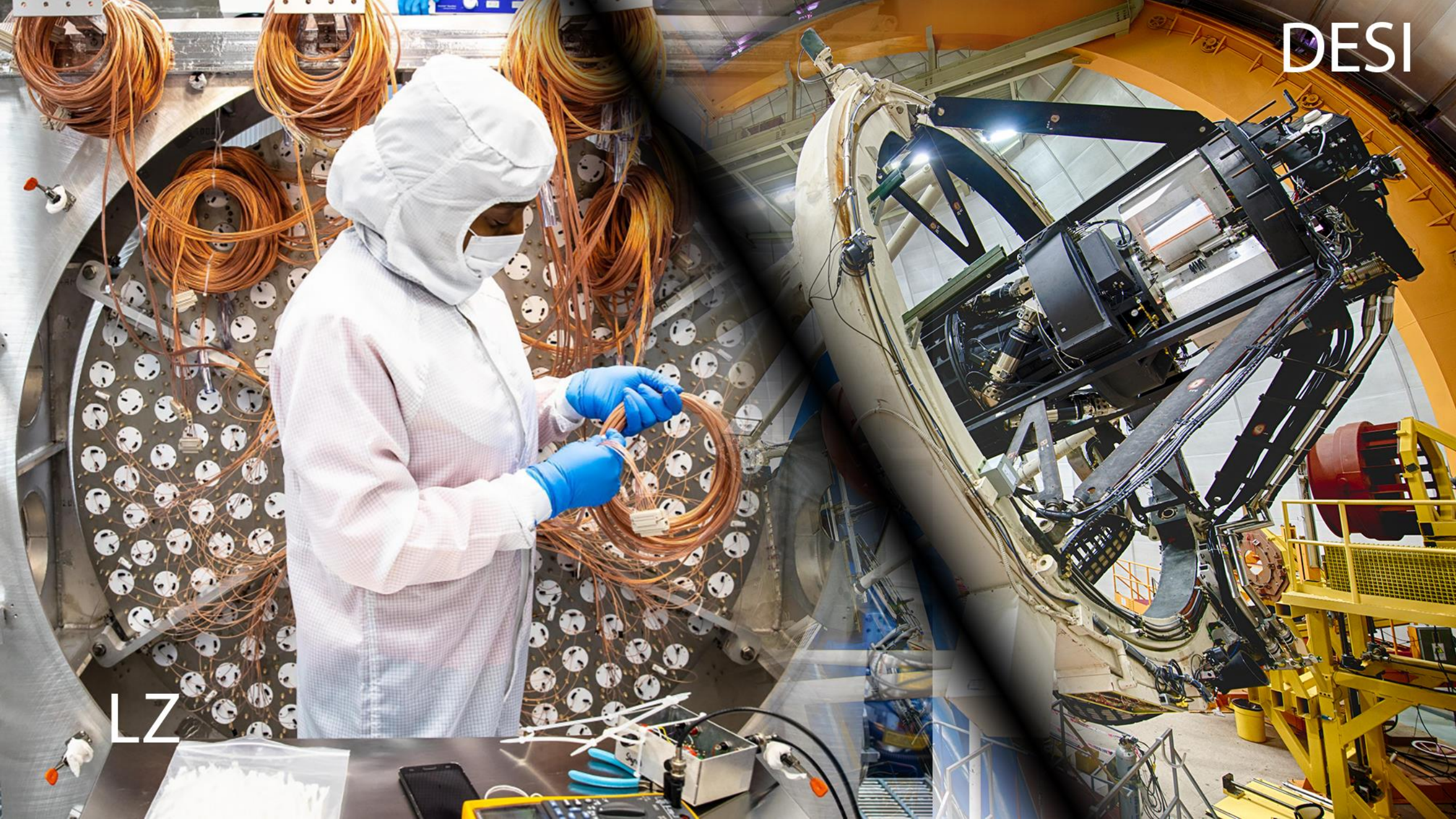
Measurement  


First beam: May 31, 2017  
Next result: Summer 2023



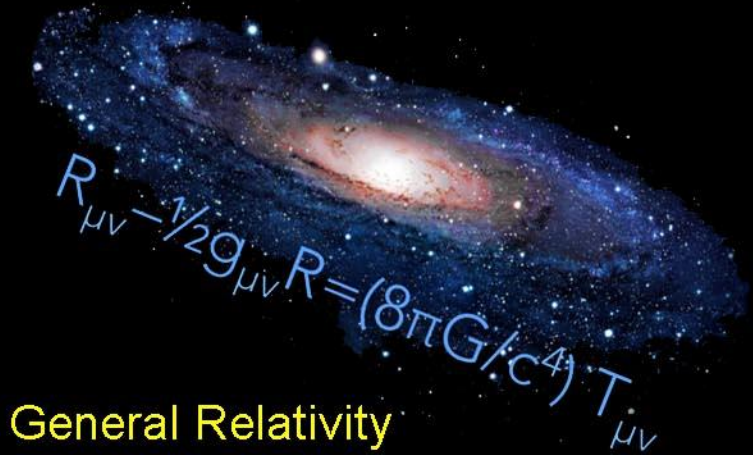
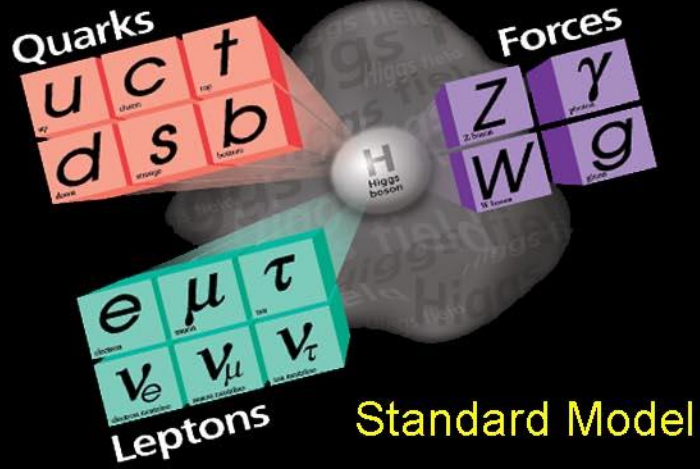


DESI



LZ

# What we know and what we don't



# What we know and what we don't

**Quarks**

u	c	t
d	s	b

**Forces**

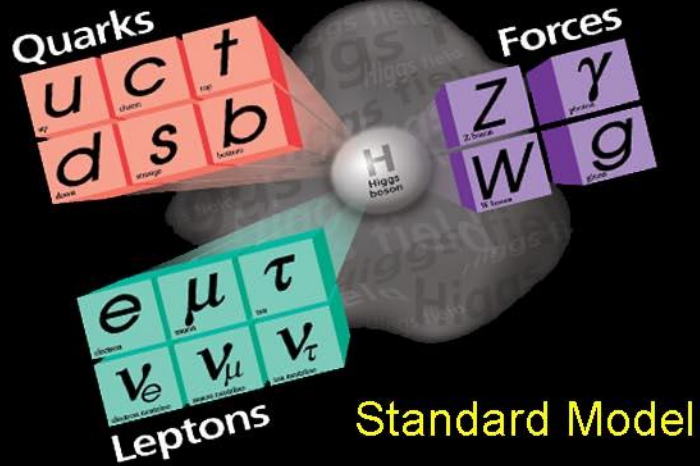
Z	$\gamma$
W	g

**Leptons**

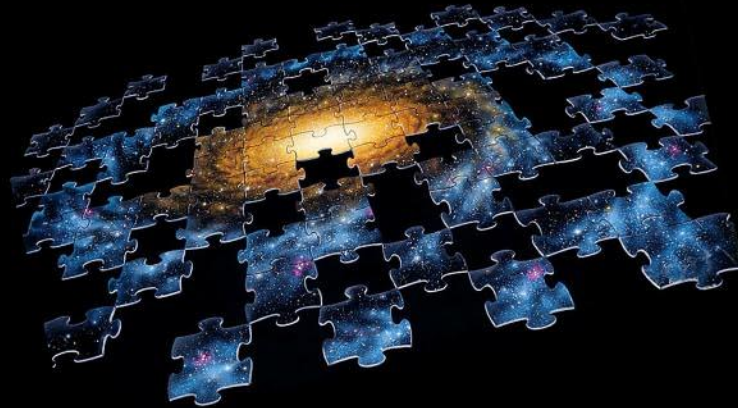
e	$\mu$	$\tau$
$\nu_e$	$\nu_\mu$	$\nu_\tau$

Higgs boson

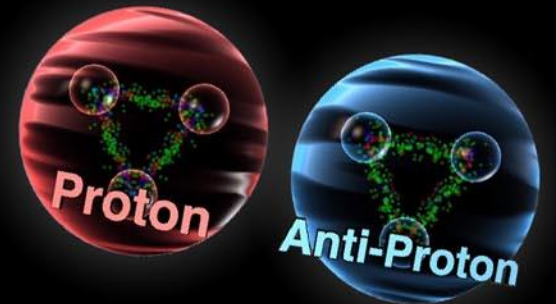
**Standard Model**



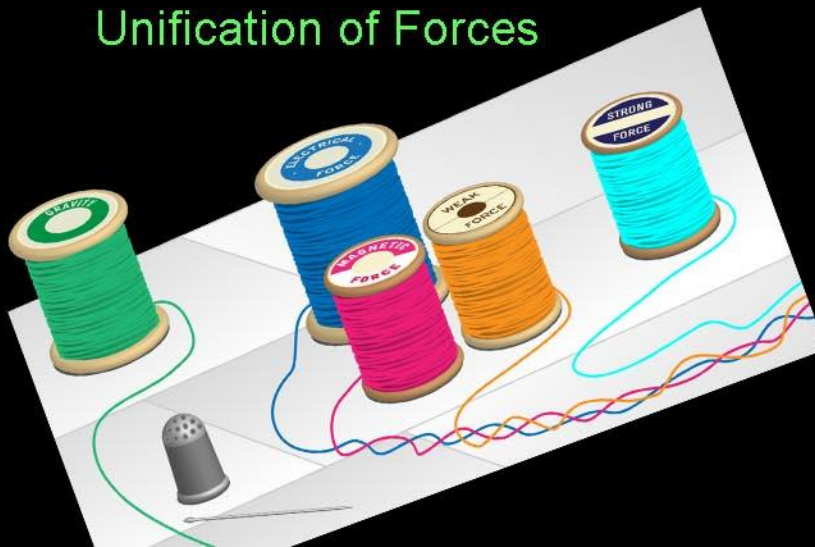
Dark Universe



Antimatter disappearance

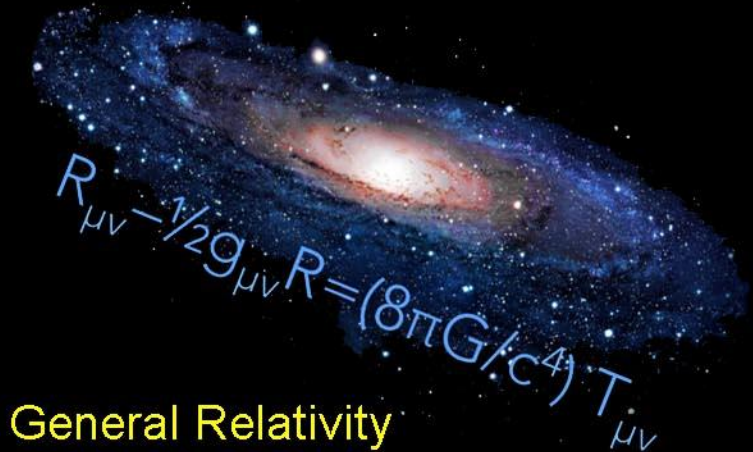


Unification of Forces



And others!

**General Relativity**

$$R_{\mu\nu} - \frac{1}{2}g_{\mu\nu}R = (8\pi G/c^4)T_{\mu\nu}$$


*The Theory of Everything*

*Quantum  
Gravity*

*Grand Unified  
Theory*

**General  
Relativity**

**QCD**

**Electroweak**

**Newtonian  
Gravity**

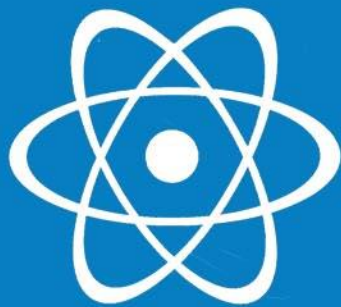
**Weak  
Theory**

**QED**

**Electromagnetism**

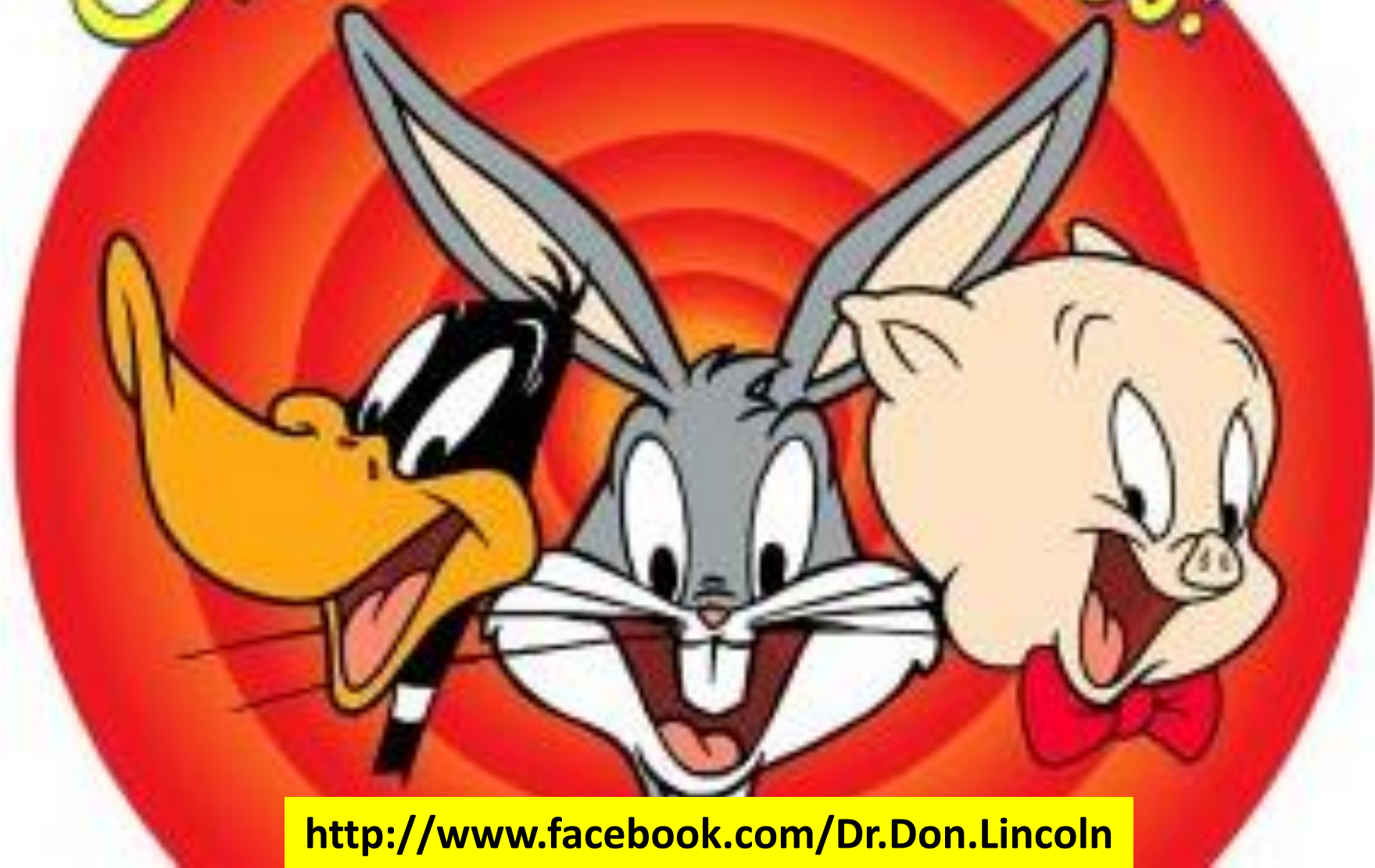
# Perspective

- Unification is a slow process
  - ~ 1680 – Newton merged celestial & terrestrial gravity
  - ~ 1880 – Maxwell merged electricity & magnetism
  - ~ 1970 – Higgs and many others merged E&M & weak force
- Many experiments are ongoing, looking for clues
  - Particle accelerators are exploring high energy and high precision
  - Dark matter experiments deep underground
  - Extraordinary telescopes look far away and back in time.



**KEEP  
CALM  
AND  
COLLECT  
MORE DATA**

*“That’s all Folks!”*



<http://www.facebook.com/Dr.Don.Lincoln>

The background of the entire image is a deep space photograph showing a vast field of galaxies and stars. The galaxies are in various orientations and colors, including orange, red, and blue. The stars are bright and scattered throughout the dark space. The text is overlaid on this background.

# **EINSTEIN'S UNFINISHED DREAM**

**PRACTICAL PROGRESS  
TOWARDS A THEORY  
OF EVERYTHING**

**DON LINCOLN**