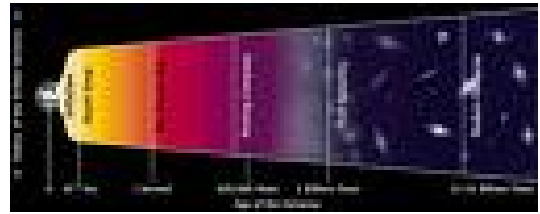


Big Bang



Source: <http://www.crystalinks.com/bigbang.html>

Planck Era



Source: <http://www.odec.ca/index.htm>

This theory:

- cosmological model of the universe that is best supported by several aspects of scientific evidence and observation

This era:

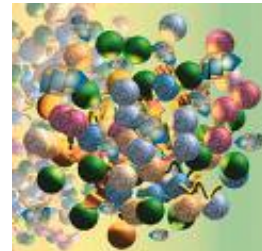
- we don't know exactly what happened
- $0 - 10^{-43}$ seconds after the Big Bang
- gravity becomes distinct from other forces

GUT Era



Source: <http://tzywen.com/modules.php?name=News&file=article&sid=659>

Electroweak Era



Source: <http://www.lip.pt/~outreach/docs/cms1/universe/p3.htm>

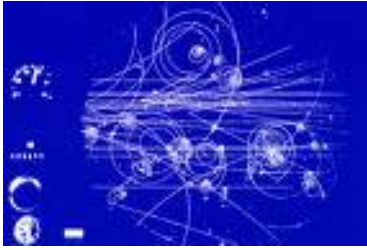
This era:

- elementary particles?
- $10^{-43} - 10^{-38}$ seconds after the Big Bang
- strong force becomes distinct, possibly causing inflation of the universe

This era:

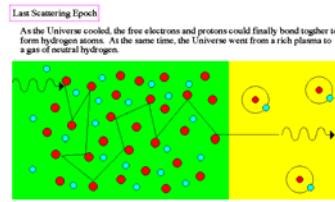
- elementary particles
- $10^{-38} - 10^{-10}$ seconds after the Big Bang
- electromagnetic and weak forces become distinct

Particle Era



Source: <http://livefromcern.web.cern.ch/livefromcern/antimatter/history/AM-history02.html>

Era of Nucleosynthesis



In a plasma, the mean free path of a photon is very short. In a gas of atomic hydrogen, the mean free path is very long, as long as the size of the Universe. Thus, the transition from the early plasma to atomic hydrogen is the epoch of last scattering, the point in time when the photons became free to travel without hindrance.

Source: <http://abyss.uoregon.edu/~js/ast123/lectures/lec21.html>

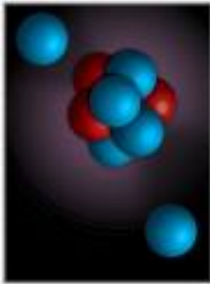
This era:

- elementary particles
- antimatter common
- 10^{-10} – 0.001 seconds after the Big Bang
- matter annihilates antimatter

This era:

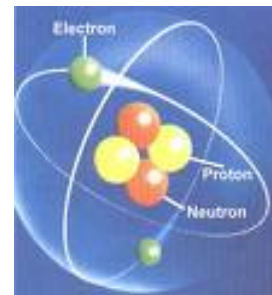
- protons, neutrons, electrons, neutrinos
- antimatter rare
- 0.001 seconds – 3 minutes after the Big Bang
- fusion ceases
- normal matter is 75% hydrogen and 25% helium by mass

Era of Nuclei



Source: http://www.ornl.gov/info/ornlreview/v39_3_06/article24.shtml

Era of Atoms



Source: http://www.eskom.co.za/nuclear_energy/fuel/fuel.html

This era:

- plasma of hydrogen and helium nuclei plus electrons
- 3 minutes – 380,000 years after the Big Bang
- atoms form
- photons fly free and become microwave background

This era:

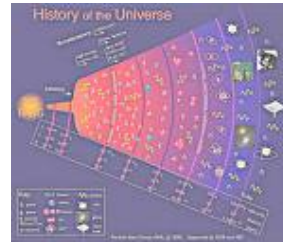
- atoms and plasma
- stars begin to form
- 380,000 – 1 billion years after the Big Bang
- first galaxies form

Era of Galaxies



Source: <http://geology.com/nasa/nasa-universe-pictures.shtml>

Cosmology



Source: <http://universe-review.ca/F02-cosmicbg.htm>

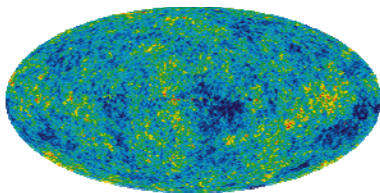
This era:

- stars, galaxies, and clusters of galaxies made of atoms and plasma
- 1 billion – 14 billion years after the Big Bang
- humans observe the cosmos

This science:

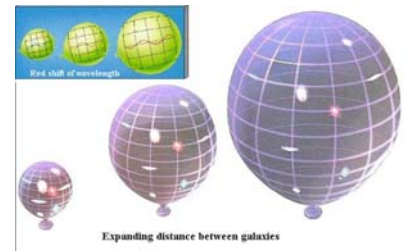
- study of the overall structure and evolution of the universe

Cosmic Microwave Background



Source: http://en.wikipedia.org/wiki/File:WMAP_2008.png

Inflation



Source: <http://universe-review.ca/F02-cosmicbg.htm>

This term:

- remnant radiation from the Big Bang
- detected using radio telescopes sensitive to microwaves

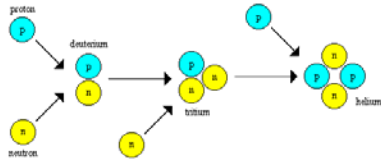
This theory:

- dramatic expansion of the universe

Nucleosynthesis

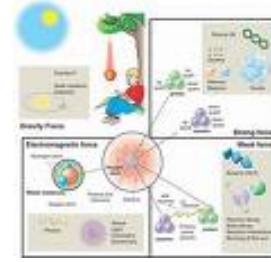
Nucleosynthesis

as the Universe cools, protons and neutrons can fuse to form heavier atomic nuclei



Source: <http://abyss.uoregon.edu/~js/ast123/lectures/lec21.html>

Grand Unified Theory



Source: <http://satyamparamdheemahi.blogspot.com/>

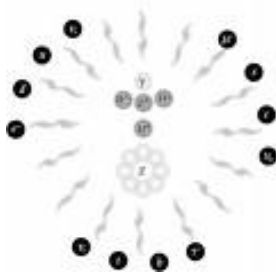
This term:

- production of nuclei other than those of H-1 during the early phases of the universe

This theory:

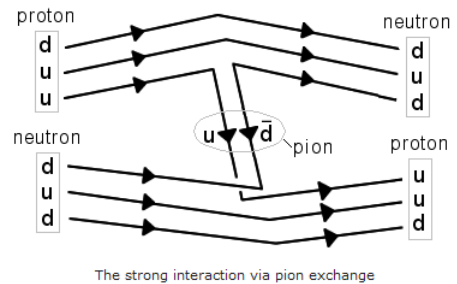
- unifies 3 of the 4 fundamental forces, the strong nuclear, weak nuclear, and electromagnetic, in a single model

Electroweak Force



Source: http://nobelprize.org/nobel_prizes/physics/laureates/1999/press.html

Strong Nuclear Force



Source: http://www.ipod.org.uk/reality/reality_small_world.asp

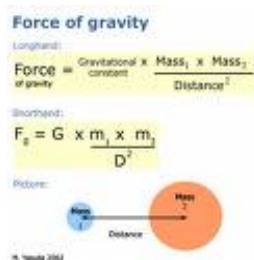
This force:

- electromagnetic and weak forces lose their separate identities under conditions of very high temperature or energy and merge together as a single force

This force:

- operates over very short distances
- force that holds atomic nuclei together

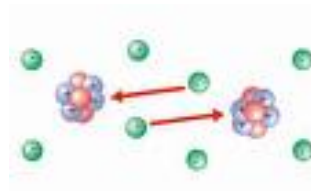
Gravitational Force



Source:

<http://www.williamsclass.com/EighthScienceWork/AstronomyUniverseBeyond.htm>

Electromagnetic Force



Source: http://www.antonine-education.co.uk/Physics_AS/Module_1/Topic_5/topic_5.htm

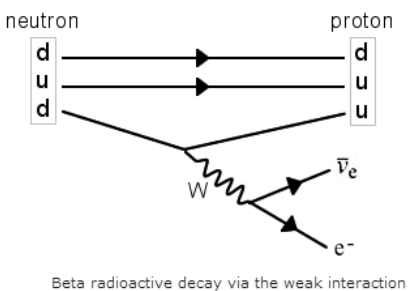
This force:

- “glue” that holds planets, stars, and galaxies together
- most familiar of the 4 forces

This force:

- force that dominates atomic and molecular interactions
- related to light

Weak Nuclear Force



Source: http://www.ipod.org.uk/reality/reality_small_world.asp

Antimatter



Source: <http://www.sciam.com/article.cfm?id=matter-antimatter-split-hi>

This force:

- operates over short distances
- mediates nuclear reactions
- only force besides gravity felt by weakly interacting particles

This term:

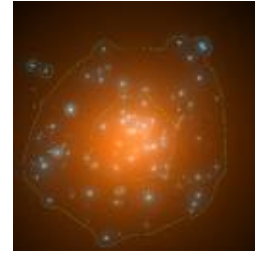
- refers to any particle with the same mass as a particle of ordinary matter but whose other basic properties, such as electrical charge, are precisely opposite

Baryonic Matter



Source: <http://arstechnica.com/news.ars/post/20071130-dark-matter-stars-may-have-lit-the-early-universe.html>

Nonbaryonic Matter



Source: <http://abyss.uoregon.edu/~js/ast123/lectures/lec16.html>

This term:

- refers to ordinary matter made from atoms

This term:

- refers to exotic matter that is not part of the normal composition of atoms, such as neutrinos or WIMPs

Fermions

FERMIONS			matter constituents spin = 1/2, 3/2, 5/2, ...		
Leptons spin = 1/2			Quarks spin = 1/2		
Flavor	Mass GeV/c ²	Electric charge	Flavor	Approx. Mass GeV/c ²	Electric charge
ν_e electron neutrino	$<1 \times 10^{-8}$	0	u up	0.003	2/3
e electron	0.000511	-1	d down	0.006	-1/3
ν_μ muon neutrino	<0.0002	0	c charm	1.3	2/3
μ muon	0.106	-1	s strange	0.1	-1/3
ν_τ tau neutrino	<0.02	0	t top	175	2/3
τ tau	1.7771	-1	b bottom	4.3	-1/3

Source: <http://astronomyonline.org/Science/QuantumPhysics.asp>

Bosons

BOSONS			force carriers spin = 0, 1, 2, ...		
Unified Electroweak spin = 1			Strong (color) spin = 1		
Name	Mass GeV/c ²	Electric charge	Name	Mass GeV/c ²	Electric charge
γ photon	0	0	g gluon	0	0
W ⁻	80.4	-1			
W ⁺	80.4	+1			
Z ⁰	91.187	0			

Source: <http://astronomyonline.org/Science/QuantumPhysics.asp>

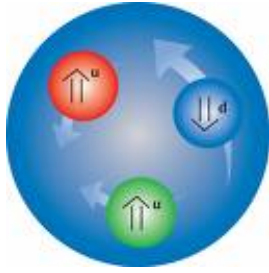
This particle:

- includes electrons, neutrons, and protons that obey the Pauli Exclusion Principle

This particle:

- includes photons, to which the Pauli Exclusion Principle does not apply

Quarks



Source: <http://www.aip.org/png/2003/207.htm>

Leptons

LEPTONS

e^- μ^- τ^-
 ν_e ν_μ ν_τ

ANTILEPTONS

e^+ μ^+ τ^+
 $\bar{\nu}_e$ $\bar{\nu}_\mu$ $\bar{\nu}_\tau$

Source: <http://www.tcd.ie/Physics/Schools/what/quarks/>

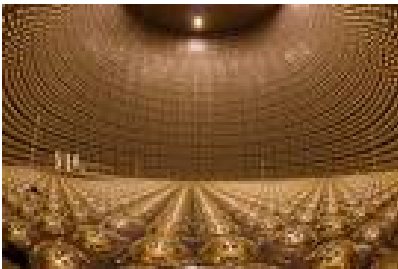
This particle:

- building blocks of protons and neutrons
- one of the 2 basic types of fermions

This particle:

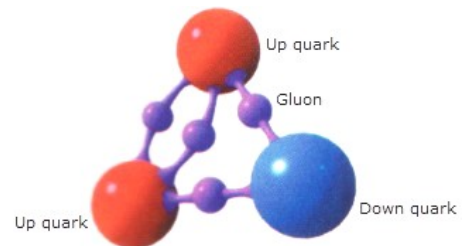
- fermions not made from quarks, including electrons and neutrinos

Neutrinos



Source: <http://www.gizmodo.com.au/2007/09/12/>

Gluons



Gluons holding quarks together to form a proton
(diagram from *Scientific American*)

Source: http://www.ipod.org.uk/reality/reality_small_world.asp

This particle:

- fundamental, with extremely low mass
- responds only to the weak force
- comes in 3 types: electron, mu, and tau

This particle:

- carries the strong force
- holds nuclei together

Photons

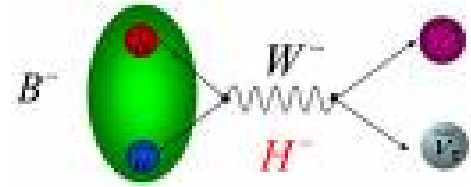


Source: http://commons.wikimedia.org/wiki/File:Photon_waves.png

This particle:

- carries the electromagnetic force
- light, with a wavelength and a frequency

Weak Bosons

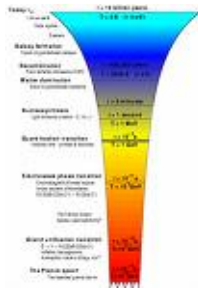


Source: <http://www.kek.jp/intra-e/press/2006/BellePress8e.html>

This particle:

- carries the weak force
- responsible for nuclear reactions

Gravitons

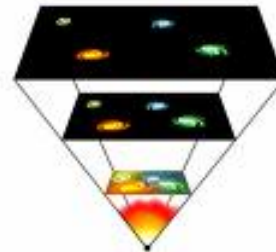


Source: <http://www.physicsforums.com/showthread.php?t=34923>

This particle:

- carries gravity
- responsible for the integrity of large-scale structures

Big Crunch



Source: <http://www.teamrenzan.com/archives/writer/nagai/cosmos5.html>

This theory:

- one possible scenario for the ultimate fate of the universe, in which the expansion of space eventually reverses and the universe recollapses, ultimately ending as a black hole singularity

Dark Energy



Source: <http://www-news.uchicago.edu/releases/03/030903.darkmatter.shtml>

Cosmic Acceleration



Source: http://www.scienceagogo.com/news/20050120215050data_trunc_sys.shtml

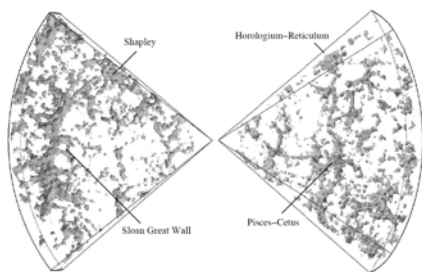
This term:

- hypothetical exotic form of energy that permeates all of space and tends to increase the rate of expansion of the universe

This term:

- observation that the universe appears to be expanding at an accelerating rate

Large Scale Structure



Source: <http://en.wikipedia.org/wiki/File:2dfdte.gif>

Heisenberg Uncertainty Principle

$$\Delta p \Delta x \geq \frac{1}{2} \hbar$$

$$\Delta E \Delta t \geq \frac{1}{2} \hbar$$

Source: <http://www.woodwardweb.com/2006/09/>

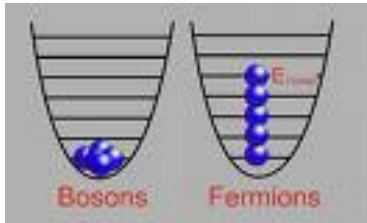
This term:

- characterization of observable distributions of matter and light on the order of billions of light-years
- sky surveys of the various wavelength bands of electromagnetic radiation provide information on the content and character of the universe
- organization of structure appears to follow as a hierarchical model with organization up to the scale of superclusters and filaments

This principle:

- the more we know about where a particle is located, the less we know about its momentum; and conversely, the more we know about its momentum, the less we know about its location

Pauli Exclusion Principle



Source: <http://vanha.physics.utu.fi/opiskelu/kurssit/FFYS4497/>

Quantum State



Source: <http://cvitae.org/content/view/166/>

This principle:

- two particles cannot be in the same place or quantum state at the same time

This term:

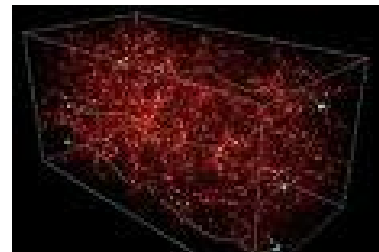
- location, momentum, orbital angular momentum, and spin of a particle

Degeneracy Pressure



Source: <http://sanchezluis.blogspot.com/2007/12/doomsday.html>

Vacuum Energy



Source:
<http://www.daviddarling.info/archive/2003/archiveNov03.html>

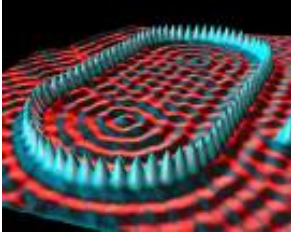
This term:

- resistance to compression that arises from the Pauli Exclusion Principle

This term:

- same as zero point energy
- combined energy of virtual particles in a vacuum

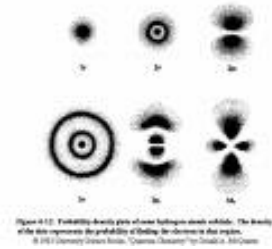
Virtual Particles



Source:

<http://www.physforum.com/index.php?showtopic=3392&st=75>

Wave-Particle Duality



Source: <http://chemie-wereld.uwstart.nl/>

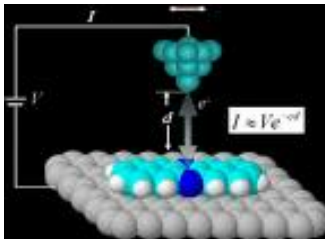
This particle:

- come in and out of existence before being detected

This term:

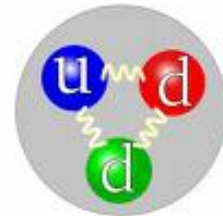
- all matter and energy exhibits both wave-like and particle-like properties

Quantum Tunneling



Source: <http://michellehyers.com/reu.htm>

Neutron



Source: http://commons.wikimedia.org/wiki/File:Quark_structure_neutron.svg

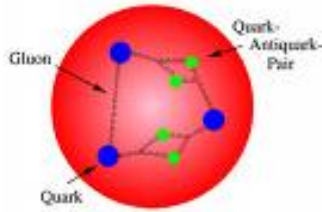
This term:

- particles pass through wall-like barriers

This particle:

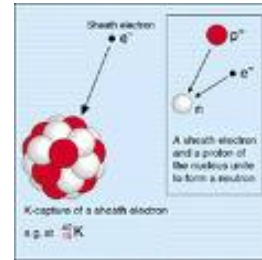
- has a neutral charge
- is located in atomic nuclei
- number determines if an atom is an isotope

Proton



Source: <http://www.desy.de/f/hera/engl/chap1.html>

Electron



Source: http://www.daviddarling.info/encyclopedia/B/beta_decay.html

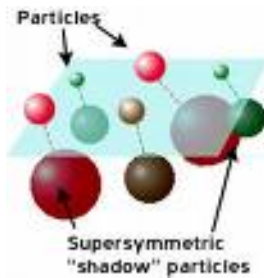
This particle:

- has a positive charge
- is located in atomic nuclei
- number determines which element

This particle:

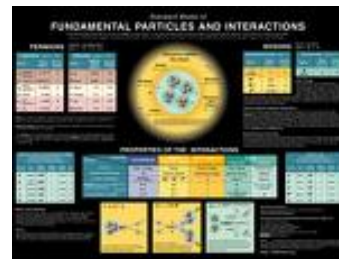
- has a negative charge
- is part of an atom, but is not found in the nucleus

Supersymmetry



Source: http://physicsweb.creighton.edu/faculty/duda/dark_matter.htm

Standard Model



Source: http://philosophyofscienceportal.blogspot.com/2008_05_01_archive.html

This term:

- symmetry that relates elementary particles of one spin to another particle that differs by half a unit of spin which are known as superpartners
- for every type of boson there exists a corresponding type of fermion, and vice-versa

This theory:

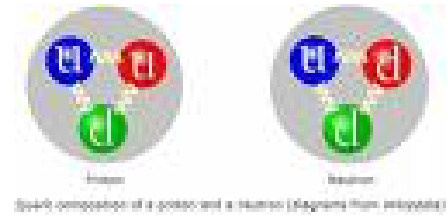
- describes 3 of the 4 known fundamental interactions and elementary particles that take part in interactions
- does not include gravity

Cosmological Redshift



Source: <http://snap.lbl.gov/science/darkenergy.php>

Exchange Particles



Source: http://www.ipod.org.uk/reality/reality_small_world.asp

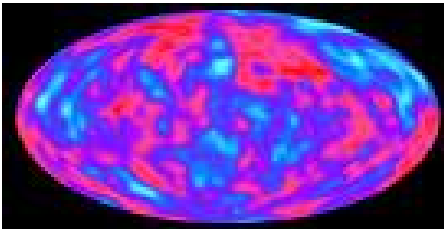
This term:

- seen from distant galaxies
- caused by the expansion of the universe, which stretches all photons to longer and redder wavelengths

This term:

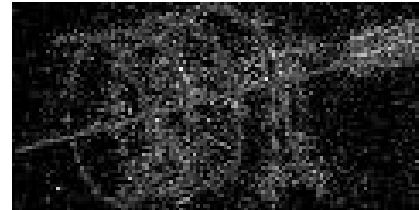
- includes gluons, photons, weak bosons, and gravitons

Cosmological Principle



Source: <http://abyss.uoregon.edu/~js/cosmo/lectures/lec05.html>

Cosmological Horizon



Source: <http://www.eitgaastra.nl/print/comtwee.html>

This term:

- matter is distributed uniformly throughout the universe on very large scales
- universe does not have a center or an edge

This term:

- boundary of the observable universe

History of the Universe Card Data Set #1 Color: maroon

A	B	A	B	A	B	A	B
Question card number	Answer card letter(s)	Question card number	Answer card letter(s)	Question card number	Answer card letter(s)	Question card number	Answer card letter(s)
1	G	14	GG	27	M	40	OO
2	P	15	H	28	SS	41	W
3	FF	16	ZZ	29	C	42	A
4	UU	17	VV	30	BB	43	Y
5	HH	18	Q	31	MM	44	NN
6	N	19	F	32	T	45	B
7	YY	20	EE	33	L	46	PP
8	TT	21	R	34	J	47	V
9	S	22	E	35	KK	48	JJ
10	D	23	DD	36	RR	49	K
11	CC	24	WW	37	Z	50	QQ
12	LL	25	I	38	AA	51	XX
13	O	26	II	39	U	52	X

History of the Universe Card Data Set #2 Color: yellow

A	B	A	B	A	B	A	B
Question card number	Answer card letter(s)	Question card number	Answer card letter(s)	Question card number	Answer card letter(s)	Question card number	Answer card letter(s)
1	R	14	J	27	WW	40	N
2	I	15	Q	28	Z	41	D
3	QQ	16	PP	29	A	42	DD
4	HH	17	C	30	ZZ	43	UU
5	E	18	VV	31	XX	44	X
6	W	19	Y	32	AA	45	SS
7	TT	20	CC	33	O	46	F
8	EE	21	OO	34	L	47	FF
9	S	22	JJ	35	NN	48	V
10	H	23	K	36	KK	49	RR
11	T	24	P	37	M	50	U
12	GG	25	BB	38	LL	51	G
13	II	26	B	39	MM	52	YY

History of the Universe Card Data Set #3 Color: tan

A	B	A	B	A	B	A	B
Question card number	Answer card letter(s)	Question card number	Answer card letter(s)	Question card number	Answer card letter(s)	Question card number	Answer card letter(s)
1	Y	14	T	27	S	40	XX
2	F	15	L	28	N	41	I
3	AA	16	YY	29	GG	42	V
4	Z	17	HH	30	EE	43	KK
5	MM	18	C	31	VV	44	LL
6	J	19	DD	32	B	45	QQ
7	U	20	UU	33	O	46	Q
8	K	21	G	34	R	47	ZZ
9	JJ	22	X	35	RR	48	P
10	SS	23	W	36	PP	49	II
11	BB	24	H	37	A	50	CC
12	E	25	M	38	WW	51	D
13	NN	26	OO	39	FF	52	TT

History of the Universe Card Data Set #4 Color: green

A	B	A	B	A	B	A	B
Question card number	Answer card letter(s)	Question card number	Answer card letter(s)	Question card number	Answer card letter(s)	Question card number	Answer card letter(s)
1	J	14	JJ	27	YY	40	QQ
2	S	15	LL	28	D	41	U
3	GG	16	O	29	P	42	EE
4	MM	17	A	30	KK	43	PP
5	R	18	Y	31	NN	44	H
6	K	19	AA	32	WW	45	FF
7	HH	20	B	33	BB	46	I
8	L	21	C	34	F	47	OO
9	M	22	X	35	UU	48	T
10	II	23	Z	36	SS	49	CC
11	XX	24	N	37	G	50	E
12	ZZ	25	W	38	V	51	VV
13	Q	26	TT	39	DD	52	RR

History of the Universe Card Data Set #5 Color: blue

A	B	A	B	A	B	A	B
Question card number	Answer card letter(s)	Question card number	Answer card letter(s)	Question card number	Answer card letter(s)	Question card number	Answer card letter(s)
1	K	14	MM	27	X	40	F
2	R	15	WW	28	D	41	Q
3	JJ	16	O	29	YY	42	L
4	QQ	17	M	30	ZZ	43	KK
5	C	18	LL	31	AA	44	PP
6	Y	19	P	32	A	45	S
7	XX	20	OO	33	B	46	RR
8	CC	21	TT	34	BB	47	J
9	V	22	GG	35	Z	48	II
10	FF	23	H	36	NN	49	HH
11	G	24	U	37	E	50	I
12	UU	25	DD	38	W	51	T
13	N	26	VV	39	EE	52	SS

History of the Universe Card Data Set #6 Color: gray

A	B	A	B	A	B	A	B
Question card number	Answer card letter(s)	Question card number	Answer card letter(s)	Question card number	Answer card letter(s)	Question card number	Answer card letter(s)
1	F	14	G	27	HH	40	NN
2	DD	15	EE	28	MM	41	JJ
3	QQ	16	PP	29	FF	42	L
4	R	17	B	30	OO	43	KK
5	D	18	V	31	H	44	XX
6	BB	19	TT	32	P	45	K
7	T	20	ZZ	33	Y	46	M
8	SS	21	U	34	W	47	II
9	S	22	Z	35	WW	48	LL
10	E	23	AA	36	UU	49	A
11	RR	24	C	37	I	50	X
12	CC	25	N	38	GG	51	YY
13	Q	26	J	39	O	52	VV