

Name _____

Date and Block _____

*Questions to accompany NOVA's
"Elegant Universe" Part One "Einstein's Dream"*

1. ____ In the 2nd floor study of his Princeton, New Jersey home, Einstein spent his last days, weeks and months working on a theory to unify all the known laws of physics... a theory so powerful that it would describe all the workings of the universe- a unifying theory called
 - a. The Principles of Relativity
 - b. Quantum Mechanics
 - c. Mike and the Mechanics
 - d. The Theory of Everything

2. ____ Today physicists are working on such a theory- String Theory... which of the following describes such a String Theory universe?
 - a. A universe with eleven dimensions where parallel universes are next to one another
 - b. A universe where everything (tiny particles to distant stars) are made from unimaginably small vibrating strands of energy called strings
 - c. A universe in which nature has differences because the strings vibrate differently
 - d. All answers apply

3. ____ The first step toward unification came in 1665 when the concept of gravity was created, unifying the heavens and the earth, by a fellow named
 - a. Albert Einstein
 - b. Stephen Hawking
 - c. Isaac Newton
 - d. Galileo

4. ____ For over 250 years no scientist really understood how gravity worked... this is a problem that was taken on by Einstein (at the age of 26)... his thoughts, works and equations on the nature of ____ conflicted with the accepted understanding of gravity.
 - a. Light
 - b. Nuclear reactions
 - c. Chemistry
 - d. Gravity

5. ____ Gravity was thought to be a force that acts over distances instantaneously (immediately)... for example, if the sun suddenly disappeared, the earth would simply begin traveling in a straight line immediately upon the disappearance of the sun...this presented a problem because nothing (not light, not gravity, not burps) travel instantaneously... **what would happen to the earth in the case given above?**
 - a. The earth would travel in a straight line motion when the sun ceased to exist
 - b. The earth wouldn't be released from orbit to go in a straight line before the lack of light from the sun reached (or didn't reach in this case) the earth
 - c. The earth would begin traveling in a straight line when the lack of sunlight reached halfway to the earth... thus obeying the inverse square law
 - d. None of the above answers propose a likely answer that was presented in this film

6. _____ Warps and curves in the fabric of space and time could best be described as
- Light
 - Gravity
 - Atoms
 - Travel
7. _____ Who was the person that came up with a theory (four simple equations) that unified (explained the relationship between) magnetism and electricity (creating the force of electromagnetism)?
- Samuel Morse
 - John Wesley Powell
 - Albert Einstein
 - James Clark Maxwell
8. _____ Which of the following statements is correct?
- The electromagnetic force is weaker than the force of gravity
 - The force of gravity is stronger than the electromagnetic force
 - The electromagnetic force is stronger than gravity
9. _____ A group of physicists led by Niels Bohr found that atoms are made of protons, electrons and electrons... they were in unfamiliar atomic territory where the laws/theories of electromagnetism and gravity didn't work... they developed a new theory to describe the functioning of the atomic (and subatomic) realm ruled by the laws of chance called
- Relativity
 - Quantum Mechanics
 - String Theory
 - Unification
10. _____ & _____ By the 1930's it appeared that four forces seemed to govern the known universe... these forces were gravity, the electromagnetic force, _____ and _____.
- The quantum force (acts as an undercurrent for all reactions)
 - The strong force (acts as a glue holding protons and neutrons together)
 - The dark force (made up to explain the mass that must exist to drive expansion)
 - The weak force (allows neutrons to turn into protons and give off radiation)
12. _____ Black holes were first proposed in 1916... these would "warp the fabric of space – time" so that nothing, not even light, could escape... in the depths of a black hole's center it is both massive and small... that means you have to use the Quantum Mechanics (tiny) and General Relativity (heavy)... when these theories are combined, things cease to make sense. The theory that unites the theory of the large with the theory of the small is
- The theory of General Relativity
 - The Quantum Mechanics Theory
 - The String Theory
 - The Quantum Foam Theory

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*Questions to accompany NOVA's
"Elegant Universe" Part Two "String's The Thing"*

1. ____ & ____ Up until the string theory came along, our universe was "ruled" by two separate theories... Einstein's Theory of Relativity which deals with the ____ and Quantum Mechanics which deals with the ____.
 - a. The whole picture
 - b. The big picture
 - c. The small picture

2. ____ The birth of our universe from a small "nugget" happened some
 - a. 14 hundred years ago
 - b. 14 thousand years ago
 - c. 14 million years ago
 - d. 14 billion years ago

3. ____ The String Theory states that all matter is composed of tiny vibrating strands of ____ called strings.
 - a. Light
 - b. Energy
 - c. Heat
 - d. Neutrons

4. ____ Einstein's Theory of General Relativity explains how ____ works.
 - a. Quantum Mechanics
 - b. The Weak Nuclear Force
 - c. The Strong Nuclear Force
 - d. The ElectroMagnetic Force
 - e. Gravity

5. ____ On the very small scale, Quantum Mechanics says that the fabric of space and time would be
 - a. bumpy, chaotic and turbulent
 - b. smooth, flat and static
 - c. smelly, warm and non-changing
 - d. smooth, orderly and geometric

6. ____ Experiments have been devised that have proven that the tiny vibrating strings called for in the String Theory exist.
 - a. True
 - b. False

7. ____ String Theory was born in 1968 when Italian Physicist Gabriele Veneziano, searching for an equation to explain the Strong Nuclear Force, reworked a two hundred year old math formula by Leonhard Euler and eventually it wound up on a chalkboard in front of American Physicist Leonard Susskind who realized that the formula described particles not as points but as strings... Susskind wrote this theory up and it was
- published
 - rejected
8. ____ Through research, physicists realized that the forces of nature can also be described or explained as particles...what do you call the particle of “force” being transferred to and from matter?
- Alpha particle
 - Omega particle
 - Messenger Particle
 - Beta One Particle
9. Research shows and theory predicts that as we run backwards in time (back to “event one” or the big bang) that the ElectroMagnetic Force combines with the Weak Nuclear Force becoming one force known as the _____.
10. Continuing on with question number 9, the force described would unite with the Strong Nuclear Force to become one force called the _____ which could be described by Quantum Mechanics (elementary particle physics or the “standard model”).
11. String Theory had some problems... check all those problems listed in the video
- ____ predicted an “unphysical” particle called a tachyon that travels faster than light
 - ____ the theory required ten dimensions
 - ____ it predicted the existence of a mass less particle
 - ____ anomalies (mathematical inconsistencies)
12. ____ Along about 1973 only a few folks were still working with String Theory... for four years John Schwarz mangled and rearranged the equations trying to “fiddle” with it... almost ready to abandon the theory, he wondered if the equations were describing
- gravity
 - gravitons
 - neutrinos
13. ____ The mass less particle called for in String Theory turned out to be
- gravity
 - gravitons
 - neutrinos

14. ____ In 1984 all of the mathematical anomalies were eliminated by Michael Green and John Schwarz when calculations on a blackboard equaled _____ on both sides.
- 694
 - 964
 - 964
 - 496
15. ____ To put things in scale, if an atom were enlarged to the size of our solar system, a string would only be as large as a _____ on earth.
- Doggie
 - Hot dog
 - Tree
 - Parking place
16. What gives particles their unique properties (such as mass and charge)?
17. ____ The mathematics of String Theory demand how many extra “hidden” dimensions that are twisted and curled into complex little shapes?
- One
 - Four
 - Six
18. ____ The universe as we know it is built upon twenty fundamental constants of nature (“known numbers” such as electron weight, strength of Gravity; the electromagnetic force; the Weak and Strong Nuclear Forces)... what determines or sets the values of these twenty constants so precisely?
- The tiny curled up six dimensional shapes predicted by string theory making strings vibrate in just such a way to make, say, an electron or a photon
 - Yeah, just answer “a” and get on with it... what do you think I am made of, questions?
19. ____ By 1985 String Theory was in a bit of a mess... there were multiple theories that were not in agreement... how many independent String Theories were there?
- One
 - Two
 - Three
 - Four
 - Five

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*Questions to accompany NOVA's
"Elegant Universe" Part Three "Welcome to the 11th Dimension"*

1. In the cab ride sequence, what does Brian Greene say is the ultimate speed limit (nothing can go faster than this...)?
2. Space can warp and stretch... a bridge or tunnel that links distant regions of space as a "cosmic shortcut"?
3. According to Einstein's Theory of General Relativity, can the fabric of space actually "rip" in order to form the thing referred to in question number two?
4. ____ If we could shrink down to a millionth billionth of our normal size, our little world would be ruled by
 - a. The Theory of General Relativity
 - b. Quantum Mechanics
5. ____ According to the String Theory, can the fabric of space actually "rip" in order to form the thing referred to in question number two?
6. Whoa! The extra dimensions called for in the string theory suggest that the three dimensions we recognize (up and down, right and left and back and forward) might just be like sheets hanging on a clothesline... a three dimensional sheet hanging in some higher dimensional space... what are these sheets called?
7. ____ The string theory and the extra dimensions referred to in question number six would mean that it would be possible for parallel dimensions (parallel universes).
 - a. true
 - b. false
8. Place the following list of things in order from largest to smallest by placing the letters "a" through "d" in the blanks with "a" being the largest...
 - _____ atoms
 - _____ wiggly strands of energy like strings
 - _____ point particles like quarks
 - _____ point particles like neutrons, protons, electrons

9. ____ As noted in the last episode, there were FIVE string theories in the 1980's... they had things in common (vibrating strings) but they had mathematical differences... What did Ed Witten do at a conference in 1995 that rocked the world of String Theory?
- Provided a new way of looking at String Theory
 - Eliminated all but one of the five String Theories
 - Created the M-theory
 - All answers apply
10. Before Ed Witten's talk in 1995, String Theory operated in how many dimensions total? After Ed Witten's talk how many dimensions total?
- Before _____
- After _____
11. ____ What are membranes (or branes) in relation to strings?
- Tiny pieces of the larger brane
 - Stretched out strings themselves
 - Tiny pieces of atoms
12. If the universe is just one membrane hanging in a larger dimensional space, what do you call this larger dimensional space? (hint- we are one slice of bread from the larger loaf, or the "____")
13. ____ We can't "reach out and touch someone" on another membrane because our atoms and molecules just can't escape the membrane the membrane that we are on... Although we can overcome gravity with our muscles and magnets make gravity look laughably weak, gravity might be just as strong as the other forces and we just can't notice... like billiard balls on a pool table, the balls want to stay on the table... when they collide what escapes the plane of the table?
- light
 - energy
 - sound waves
14. ____ For years String Theory involved closed strings (like rubber bands)... nowadays String Theorists believe that everything we see around us (matter and light) are made of open-ended strings that are
- Tied to our three dimensional membrane
 - Free floating about the membrane
 - Tied down to the membrane only occasionally
15. ____ What do you call free floating closed loops of strings?
- Wedding bands
 - Gravitons

16. ____ Supposedly, gravitons, not being tied down
- are closed loops like rubber bands
 - are free to escape our membrane
 - dilute the strength of gravity within our membrane
 - could be used to make a “brane to brane” communication with gravity waves
 - answers a and b apply
 - all answers apply
17. ____ The expansion of time and space called the Big Bang could have been just an expansion of a membrane caused by what?
- The dying of a super-sized star
 - Collisions of a couple of membranes
 - A collapse of gravity
 - A reversal of the polarity of the neutron flow of all matter
 - Repeated collisions of membranes in the past (and the future)
 - Answers c and e
 - Answers b and e
18. ____ In North America, Fermilab is hot on the trail of trying to prove that extra dimensions are real... with a four mile circular tunnel to smash particles head on... they are trying to find ____ and then watch it disappear into another dimension...
- protons
 - neutrons
 - gravitons
 - electrons
 - quarks
19. ____ Fermilab has competition from the border of France and Switzerland in the massive complex called CERN... both Fermilab and CERN are trying to discover the particles that would prove “Supersymmetry” (a central theory of String Theory)... Supersymmetry says that for every subatomic particle we are familiar with (electrons, photons and gravitons) there should be a much heavier particle that exists called what?
20. Hah! Just to keep you watching, what are the very last two words that host Brian Greene says in this program?