National Science Bee
Semifinals - Round 4

1. The inventor of the stethoscope, Rene Laennec, was diagnosed with this disease when his nephew used Laennec's stethoscope to do so. French monarchs used the "Royal touch" to rid their subjects of this disease, which is often diagnosed with a test created by Charles Mantoux, the PPD test. The Bacillus Calmette-Guerin vaccine targets this disease, which is caused by a bacteria of genus *Mycobacterium*. For the point, what disease affects the lung and was historically known as "consumption"?
ANSWER: **tuberculosis**

2. Twisted magnetic flux causes this region's namesake loops, which have been analyzed by NASA's TRACE observatory. Heavily-ionized iron explains this region's unique spectral lines, which were initially attributed to an element named for this region. This region's "streamer belt" is the origin for the slow form of a certain phenomenon, whose fast form is emitted from places of open magnetic field lines, called this region's "holes." Solar wind interacts with mass ejections of plasma that are released from this region. For the point, name this extremely hot, outermost layer of the Sun.
ANSWER: **corona**

3. The protein MDM2 regulates this protein's function. People are often affected by Li-Fraumeni syndrome when they inherit only one copy of this protein, which is inactivated by E6, a protein associated with Human Papillomavirus. This protein upregulates p21 and can arrest the cell cycle at the G1/S checkpoint. While its expression can be stimulated by UV light, this protein can initiate apoptosis when DNA is irreparable. For the point, name this protein commonly described as the "guardian of the genome" for its role in preventing cancer.
ANSWER: **p53** (or **tumor protein p53**)

4. Richard Taylor, a student of this thinker, assisted him in revising the paper "Modular Forms, Elliptic Curves, and Galois [[gal-wah]] Representations," which was found to have a serious error shortly after its 1993 publication. This man was knighted for his efforts on the Taniyama-Shimura conjecture, which resolved a centuries-old conjecture of number theory. For the point, name this British mathematician who solved Fermat's Last Theorem.
ANSWER: Sir Andrew **Wiles**

5. A faulty telescope reflecting the blood vessels of his eye may be the reason that this astronomer thought he had discovered spoke-like features on Venus. After this astronomer's death, Clyde Tombaugh [tom-bo] took over much of his work. This American astronomer was the foremost supporter of Giovanni Schiaparelli's observations of Martian canals. For the point, name this astronomer who names a major observatory in Flagstaff, Arizona.
ANSWER: Percival **Lowell**

6. This scientist's namesake equation is modified for relativity in the Klein-Gordon equation. That equation was first published in this scientist's paper "Quantization as an Eigenvalue problem" and describes a particle's wavefunction. This man criticized the Copenhagen interpretation by imagining an atom's decay causing a hammer to break a flask of poison. For the point, name this Austrian physicist who developed a thought experiment about quantum states involving a dead and alive cat.
ANSWER: Erwin (Rudolf Josef Alexander) **Schrödinger**

7. During development, members of this phylum can go into dauer stage, where larvae hibernate due to harsh environmental conditions. Members of this phylum possess a pseudocoelom, and one species in this phylum invades the small intestine in a disease called *Trichinosis*, which occurs due to the consumption of undercooked meat. UNC genes were discovered in a member of this phylum by Sydney Brenner, who established *C. elegans*, that member of this phylum, as a model organism for developmental biology. For the point, name this phylum that includes roundworms.
ANSWER: **Nematoda** (accept **Nematodes**; accept **roundworms** before mentioned)

8. Plants known as halophytes thrive in water that contains this dissolved compound. Most ocean current activity is attributed to differences in heat and the amount of this compound. It is theorized that this compound emerged by the composition of leached sodium from ocean floor rocks with hydrochloric acid from volcanic vents. On average, this compound makes up about 35 grams of each kilogram of sea water, and it can be harvested for human consumption. For the point, name this compound present in about 97 percent of the Earth's water, primarily in the oceans.
ANSWER: **salt** [accept **sodium chloride**]

9. In a branch of trigonometry named for this shape, edge lengths are measured as angles. A coordinate system named for this shape locates points using two angles and the distance to the origin. Archimedes showed that a cylinder with a cone removed had an equal volume to this shape. This shape, which consists of all points at a fixed distance from the center, has a volume of "four-thirds pi r-cubed". For the point, name this 3-dimensional analog of a circle.
ANSWER: **sphere**

10. This quantity remains constant in the Joule-Thomson effect. Born-Haber cycles are used to calculate this quantity for ionic solids with Hess's Law. The change in this quantity when one mole of a compound is made from the pure elements it is made up of is known as this quantity's standard of formation. Equal to internal energy added to the product of pressure and volume for a system, this state function is related to entropy and temperature by the equation for Gibbs free energy. For the point, name this thermodynamic quantity symbolized "H."
ANSWER: **enthalpy** (prompt on "H" before mentioned)

11. A "mailbox" apparatus was hastily built during this mission to remove carbon dioxide from the Lunar Module. Ken Mattingly did not fly this mission due to concerns about contacting German measles and was replaced by Jack Swigert. During this mission, a malfunctioning "Main B Bus Undervolt" was the reason for James Lovell's often wrongly-quoted line "Houston, we've had a problem." For the point, name this 1970 NASA space mission where astronauts were prevented from landing on the moon due the explosion of an oxygen tank on board.
ANSWER: **Apollo 13** mission (prompt on "Apollo")

12. Translational symmetry of this quantity leads to its conservation by Noether's theorem. According to the Heisenberg uncertainty principle, it is impossible to know both the exact position and this property of a particle. Newton's second law can be written using the time derivative of this quantity. It is conserved in elastic collisions, and impulse is equal to the change in it. For the point, name this quantity equal to mass times velocity.
ANSWER: (linear) **momentum** (do not accept or prompt on "angular momentum")

13. In one branch of this field, a hyperplane is placed with the maximum separation between support vectors. Neural networks exemplify the "deep" variant of this field. The two major categories in this field are supervised and unsupervised. Image classification and spam filtering are two tasks involving decision making in this field. For the point, name this new field of computer science where computers, on their own, improve on performing tasks.
ANSWER: **machine learning** [prompt on "deep learning", "reinforcement learning", "decision making", "classification", "regression"]

14. This class's earliest members were anapsids, whose skulls only had openings for eye sockets and a nose. Some organism in this class have improved jaw mobility due to extremely versatile quadrate bones and belong to the order of squamates. Another order of this class includes gharials and caimans. The study of this class of organisms is known as herpetology. Birds are descended from this class from a lineage of these organisms that died out 65 million years ago. For the point, name this cold blooded class of vertebrates that include snakes and lizards.
ANSWER: **reptile**s (or **reptilia**)

15. This substance's "f" form is naturally made in some types of cyanobacteria. This substance includes both a phytol tail of hydrocarbons and a tetrapyrrole ring. Two "special pairs" that involve this substance are called P700 and P680. This substance, which passes on excited electrons to primary acceptors like pheophytin, is protected by carotenoids. Its porphyrin ring contains a magnesium atom. For the point, name this substance that is embedded in the thylakoid membrane, a green pigment found in plants.
ANSWER: **chlorophyll**

16. A spacecraft from this project was the first to perform a gravitational slingshot. The original ideas of the Cassini spacecraft derived from the cancelled "Mark II" series of these spacecraft. The tenth member of this project was the first probe to visit Mercury, while the ninth member was the first space probe to ever orbit Mars. For the point, name this set of 10 American inner planet space probes.
ANSWER: **Mariner**

17. Multiplying by this number is equivalent to a 90 degree counterclockwise rotation in an Argand diagram. This number is represented by the point (0,1) [[zero comma one]] in the complex plane. This fourth root of unity is multiplied by a square root in the quadratic formula whenever the discriminant is negative. This solution of "x squared plus 1 equals 0" is multiplied by b in the standard form of a complex number. For the point, name this imaginary number, the square root of negative one.
ANSWER: ***i***

18. It's not mucus, but Langerhans cells reside in this organ before migrating to lymph nodes. Two stratum make up this organ's Malpighian layer, and its sebaceous glands secrete a substance known as sebum. Basal-cell carcinoma is the most common cancer of this organ. This largest organ of the integumentary system is affected in an autoimmune disease where red patches are covered with dead cells, psoriasis. Melanin levels dictate the color of this organ. For the point, name this organ that forms the outer layer of your body.
ANSWER: **skin**

19. This object has bright spots possibly made up of brine in its Occator crater. Cryovolcanic activity may have formed the Ahuna Mons on this object. The Dawn spacecraft is currently orbiting this object after it visited a neighbour, Vesta. This object was discovered by Giuseppe Piazzi in 1801 and its orbit was correctly predicted by Carl Gauss. For the point, name this largest body in the asteroid belt and the largest dwarf planet.
ANSWER: **Ceres**

20. Nitroglycerin was used in the "exploding torpedo," a drier, early version of this process. The substances used during this process include slickwater and proppants such as sand or ceramics. Horizontal drilling allows access to a higher output from a single site of this process. Flowback and formation brine are byproducts of this process which are sometimes disposed of by re-injecting them into the same wells used for this process. For the point, name this controversial process in which pressurized liquid is injected into rock to help extract fossil fuels.
ANSWER: **hydraulic fracturing** [accept **frack**ing]

21. This variable can affect charged particles reflected of a magnetic mirror in a type of it named for Fermi. This quantity for revolving bodies is equal to velocity squared divided by the radius. By Newton's second law, this quantity can be expressed as force divided by mass. For the point, name this quantity, the rate of change of velocity which measures how fast an object is speeding up or slowing down.
ANSWER: **acceleration**

22. In the presence of a strong Lewis acid catalyst, this compound can undergo the Friedel-Crafts reactions. James Dewar names an isomer of this compound. A derivative of this compound, anisole, is made up of an amine group and a phenyl group, which is this compound without a hydrogen atom. Xylene and toluene are methyl-group derivatives of this compound. Due to resonance, each bond length in this compound's ring is 140 picometers. For the point, chemist August Kekule discovered the structure of what organic compound with formula C_6H_6?
ANSWER: **benzene**

23. Convective overshoot may be responsible for turbulent airflow in this atmospheric layer. Warming of this layer causes the polar vortex to move closer to the equator. The creation of chlorine in this layer of the atmosphere can interact with and deplete the concentration of ozone in this layer. Because of this ozone, temperature in this layer increases with altitude and thus this layer is generally stable compared to the troposphere below. For the point, name this layer of the atmosphere in which most commercial flight takes place and which lies underneath the mesosphere.
ANSWER: **stratosphere**

24. This theory explains how parts of the universe that are not in causal contact can generally be in thermal equilibrium. This theory, which was first put forth by Andrei Linde and Alan Guth, explains the absence of magnetic monopoles, the horizon problem, and the smoothness of the cosmic microwave background radiation. For the point, name this theory which said that right after the big bang, the universe expanded very quickly.
ANSWER: cosmic **inflation**

25. The order Redlichiida is the earliest type of this organism to appear in the fossil record. Niles Eldredge developed a theory of punctuated equilibrium largely using evidence from these marine organisms. Geologists working on continental drift used fossils of several of these well-preserved arthropod species to show the existence of the paleologic Iapetus Ocean. The organisms are a clear marker of the Cambrian Period in rock stratigraphy. For the point, name these ancient organisms whose collective name refers to the three lateral sections of their bodies.
ANSWER: **trilobite**s

26. Britton and Robinson name a "universal" type of these substances, which can be created by combining solutions with slightly different pK_a values. Norman Good famously developed twenty biologically-useful types of these substances. One of these substances works in the blood and uses both carbonic acid and bicarbonate. The Henderson-Hasselbach equation is used to determine ranges when these substances are most useful. For the point, name these substances that resist changes in pH.
ANSWER: **buffer** solutions

27. In a conservative field, this quantity is zero for a closed path. For a moving charged particle, this quantity is equal to the charge times the change in electric potential. This quantity equals zero when a gas freely expands, and power is equal to the rate of this quantity per unit time. This quantity is classically defined as the energy transferred to an object. For the point, name this quantity that is equal to force times distance.
ANSWER: **work** (prompt on "change in energy")

28. This value for a function can be found by dividing the definite integral of the function by the distance between the integral's endpoints. Taking the reciprocal of the sum of the reciprocals of a set of n numbers, then multiplying by n, gives the harmonic type of this quantity; that value is always less than or equal to the geometric and arithmetic types of this quantity. For the point, name this statistical measurement of a set of numbers whose arithmetic type is commonly known as an average.
ANSWER: **mean** (accept **average** before mentioned)

29. The rate at which these systems are stabilized is directly proportional to the valence of oppositely-charged ions, according to Schulze-Hardy rule. These systems, which are studied by the DLVO theory, include an inner Stern layer and an outer slipping plane, where zeta potential is measured. Particles in these systems come together in flocculation, and these systems scatter light in the Tyndall effect. For the point, particles are dispersed in another in what systems that include aerosols and milk?
ANSWER: **colloid**s

30. Due to a higher relative amount of elastin fibers, this structure has the highest compliance, as accounted for in the Windkessel effect. The ventricular septal defect lies directly under this structure in a congenital condition affecting it known as "overriding," which is noted in the tetralogy of Fallot. The sinus of Valsalva is part of the namesake root of this structure, whose ascending portion branches off into the coronary arteries. For the point, name this largest blood vessel in the body that distributes oxygenated blood from the heart.
ANSWER: **aorta**

31. The second largest satellite galaxy of the Milky Way is found in this constellation. The extra-terrestrial "Wow" signal came from the direction of this constellation. This constellation is home to the Trifid, Omega, and Lagoon nebulae as well as the black hole at the center of the Milky Way. This constellation is found along the ecliptic between Scorpius and Capricorn. For the point, name this zodiac constellation that depicts an archer.
ANSWER: **Sagittarius** [prompt on "archer" before it is read]

32. Along with potassium, this element makes up the mineral saltpeter, still used today as an oxidizer in pyrotechnics. Bacteria known as diazotrophs help to increase the amount of this element in the soil in a process known as "fixing" this element. Eutrophication is the addition of compounds of this element to surface water, promoting the growth of algae, and is usually the result of over-fertilization of crops with urea or ammonia. For the point, name this element whose "cycle" on Earth includes its making up about 78 percent of the Earth's atmosphere.
ANSWER: **nitrogen**

33. Expansion by minors and calculating cofactors is a common method for calculating this value in 3-by-3 or 4-by-4 matrices. In identity matrices, this value is 1, as multiplying another matrix by an identity matrix will not change this value for the original matrix. For the point, name this quantity that represents a scaling factor for square matrix transformations that, for a 2-by-2 matrix with elements a, b, c, and d, is equal to "a times d" minus "b times c."
ANSWER: **determinant** of a matrix

34. In one variety of this technique, particles in a trap are excited to their cyclotron frequencies, which are then converted into analyzable data via Fourier transform. Peptides are broken down into fragments during the "tandem" form of this technique, whose first step can involve "soft" ionization techniques like ESI and MALDI. When examining output from this technique, a common reference point is "M," the value for the molecular ion peak. For the point, name this analytical laboratory technique used to sort ions based on their mass-to-charge ratios.
ANSWER: **mass spectrometry**

35. In a letter to this man, Newton claimed "If I have seen further, it is by standing on the shoulders of Giants" which might have been a sarcastic reference to this man's hunchback. Young's modulus equals the force constant in this man's law which relates stress to strain, and this man's work with microscopes led to his discovery of the fundamental unit of life. For the point, name this English scientist who coined the term "cell" and names a law governing springs.
ANSWER: Robert **Hooke** (accept **Hooke**'s law)

Extra Tossup – ONLY READ IF A QUESTION IS BOTCHED!

36. This technology's L5 frequency was released to be used for life safety applications. Receivers for this technology often translate its signals into a WGS geodetic datum. There are currently 31 satellites used in this technology, including 12 in the newest Block II-F, and at least 9 are visible at any given time from most places on Earth. For the point, name this technology which relies on triangulated satellite transmissions to provide precise location data on Earth, such as in a smartphone's navigation tools.
ANSWER: **GPS** [accept **Global Positioning System**; prompt on **GNSS** or **Global Navigation Satellite System**]