



National Science Bee Finals - Round 5

1. In the Han dynasty, price controls were debated in an event named for this commodity and iron. A museum in Zigong is devoted to the history of this substance, as is a work by Mark Kurlansky. Marco Polo's descriptions of currency made from this good validate his travels in China. Brine was retrieved from wells in Sichuan to mine this substance, which can be made by evaporating seawater. For the point, the high sodium content in Chinese foods is primarily due to what commonly iodized substance?

ANSWER: salt

2. In 2014, NASA's WISE mission disproved the idea that a hypothetical planet named Tyche resided within this region. The Hills Cloud is thought to be the inner region of this body, which is roughly spherical in shape due to the influence of galactic tides. Richard Muller hypothesized that a dwarf star called Nemesis travels through this region every 26 million years, making long-term comets bombard Earth and cause mass extinctions. For the point, what region marks the outer limit of the solar system and is named for its discoverer, a Dutch astronomer?

ANSWER: Opik-Oort cloud

3. This substance can be used to treat people with mutated *SHOX* genes. IGF-1, a compound similar to insulin, is produced in the liver in response to this hormone, which is stimulated when ghrelin binds to its G-protein coupled receptor. Somatostatin prevents the release of this hormone from the pituitary gland, which produces too much of it in a condition called acromegaly. For the point, name this hormone that, as its name suggests, stimulates cell production and is also often used by athletes as a performance-enhancing drug.

ANSWER: human growth hormone or HGH

4. Norton's Theorem states that any circuit can use an equivalent ideal source supplying this quantity. Kirchoff's first law states that the amount of this quantity going into a node must equal the amount going out. Diodes only allow this quantity to move in one direction. By Ohm's law, this quantity equals voltage over resistance. For the point, name this quantity measured in amperes which describes the flow of electric charge.

ANSWER: electrical current

5. This thinker's decades-long correspondence with Johann Bernoulli included discussions of integration by parts, which used this man's dx and dy ["d" "x" and "d" "y"] notation for derivatives. This man, who also introduced the integral sign and the use of a dot for multiplication, published a "New Method for Maxima and Minima" after an English mathematician had worked on fluxions, triggering a controversy. For the point, name this German mathematician who discovered calculus independently of Isaac Newton.

ANSWER: Gottfried Leibniz

6. A modification of this algorithm that reverses its behavior on the second pass is named for a cocktail shaker. Like insertion sort, this algorithm has a Big O of n^2 runtime. This algorithm operates by repeatedly passing through an entire list, checking each adjacent pair of elements, and requires a final pass that makes no changes before it will terminate. For the point, name this highly inefficient sorting algorithm, named for the tendency of values to float to the top of the list.

ANSWER: **bubble** sort (prompt on sort before "sorting" is read)

7. The precursor to the NGC, the *General Catalogue of Nebulae and Clusters of Stars*, was published by an astronomer with this last name. The first female astronomer to discover a comet bore this maiden last name. An astronomer with this last name discovered the moons Oberon and Titania as well as the planet that they orbit. For the point, give this surname of the astronomer siblings Caroline and William, the latter of which discovered Uranus.

ANSWER: **Herschel**

8. An approximation involving the "linear combination" of these structures is used to calculate similar, more complex structures that can include "bonding" and "nonbonding" types. These structures, which can have radial and angular nodes, are labeled as "degenerate" when they all have the same energy levels. These structures mix during hybridization, and the Aufbau principle describes the order in which they are filled. For the point, name these regions of space, such as s , p , and d , where electrons can be found.

ANSWER: atomic **orbitals**

9. Jeffrey Bada improved upon this experiment by including iron and carbonate minerals. Following the death of one of the namesakes of this experiment, it was found that more products were produced than expected. The starting molecules of this experiment were water, methane, hydrogen, and ammonia, which were reacted via sparks, a simulation of lightning. For the point, name this experiment that supported the theory of abiogenesis by showing that amino acids could be produced by the hypothetical early atmosphere of Earth.

ANSWER: **Miller-Urey** experiment (accept names in either order)

10. This man succeeded in "magnetizing a ray of light" using his namesake effect to rotate the light's plane of polarization with a magnetic field. This inventor of the first dynamo names a law relating the electromotive force to the negative rate of change of magnetic flux. The electric field at every point is equal to zero inside this man's namesake "cage". For the point, name this English scientist who names the SI unit of capacitance and the namesake of the law of induction.

ANSWER: Michael **Faraday**

11. Collision theory suggests ways to increase this quantity for gases. This quantity's dependence on temperature is described by the Arrhenius equation, which gives this quantity's namesake "constant" in relation to activation energy divided by the gas constant times temperature. When this quantity is equal to its constant "k" times the concentration of only one reactant, the equation describing this quantity is "first-order." For the point, name this quantity, the speed at which chemical reactants are converted into products.

ANSWER: **reaction rate** (accept **rate of reaction**)

12. A 2017 NASA study described how dust around this object can result in different effects on different wavelengths of the spectrum. One hypothesis related to this object is that since the 1890s, a Dyson Sphere was being built around this object. In the 2010s, dimming events of about 15 to 20 percent were observed around this star. For the point, name this star known for its extreme sporadic brightness fluctuations.

ANSWER: **Tabby's Star** [or **KIC 8642852**]

13. Complexes called hnRNPs suppress this process by binding to the polypyrimidine tract. Two transesterification reactions mediate this process, during which SR proteins help bind U2 to the branch point. In this process, a unusual 2'-5' phosphodiester bond between two residues forms the lariat, which is released at the end of this process. This process can be self-catalyzed in Group I and Group II ribozymes. For the point, name this process, where snRNPs make a structure that removes introns from a pre-mRNA transcript.

ANSWER: **RNA splicing**

14. Aside from persuading Kaiser Wilhelm to establish a now-defunct scientific society, this scientist developed a lamp that did not rely on a tungsten filament for incandescence. Max Planck extended this man's "New Heat Theorem" to formulate a statement about the entropy of a solid at absolute zero, the Third Law of Thermodynamics. He names an equation that includes the term "R times T divided by n times F" and calculate voltages of chemical cells. For the point, name this German chemist, the namesake of a foundational equation in electrochemistry.

ANSWER: Walther **Nernst**

15. Due to the bond between carbon and magnesium, Grignard reagents are effective types of these compounds. Schiff names a nitrogen-containing variety of these compounds, whose "super" type includes sodium hydride. According to Lewis, these compounds donate electron pairs, while the Bronsted-Lowry theory states that these compounds are proton acceptors. These compounds, which produce hydroxide ions in water, turn litmus paper blue. For the point, what chemicals have pH values greater than 7?

ANSWER: **bases**

16. An "arrowhead curve" that can be drawn through this shape will take the form of this shape with sufficiently many iterations. Coloring Pascal's triangle on an even/odd split will generate this image, whose area approaches zero as it is progressively drawn. Successively removing the central quarters of an original shape will create, for the point, what fractal named for a Polish mathematician that takes the form of an equilateral triangle with infinitely many holes?

ANSWER: **Sierpinski triangle** (or **Sierpinski sieve** or **Sierpinski gasket**; prompt on "Sierpinski fractal")

17. When ropes are involved, these models typically include the letter T. These models are useful for blocks on inclined planes to identify the vector components of gravity. Arrows on these models are all equal size when an object experiences zero force. One simple version of this construct consists of a square with an upward arrow representing the normal force and a downward arrow representing gravity. For the point, name this drawing which helps one identify which forces act on an object.

ANSWER: **free body diagram** (prompt on "force diagram")

18. Drawing upon the findings of Joseph Priestley, this man opposed the phlogiston theory by analyzing the weights of heated metals, an action that would later lead him to discover oxygen's role in combustion. Hydrogen was named by this author of *Elementary Treatise of Chemistry*. This man developed a statement that is often paraphrased as "Nothing is lost, nothing is created, everything is transformed," the law of conservation of mass. For the point, name this Frenchman, the "father of modern chemistry."

ANSWER: Antoine-Laurent de **Lavoisier**

19. This type of earth exists underneath an active layer which is usually only several feet deep. The deepest examples of this type of earth exist just above the region where geothermal heat and the average air temperature reach an equilibrium temperature of 0 degrees Celsius. The amount of carbon stored in this type of earth, either as methane or in peat, has been estimated to be about 1,500 gigatons, which is one danger of global warming. For the point, name this type of earth which has been at or below the freezing point for at least two years, a common feature of tundra climates.

ANSWER: **permafrost**

20. Aside from termites, these animals use tandem running to find new food sources. In one species of these animals, gamergates mutilate their sisters to reduce their sexual appeal. Their “Argentine” type, which are friendly to each other in non-native habitats, have created the world’s largest supercolony. Some of these animals consume honeydew from aphids in a mutualistic relationship. For the point, myrmecologist E.O. Wilson studies what animals that come in “fire” and “leafcutter” varieties?

ANSWER: **ants**

21. The Poisson ratio, symbolized gamma, gives the ratio of this quantity’s value at constant pressure to this quantity’s value at constant volume. Debye’s model relates this quantity to temperature cubed for solids at low temperatures. The Dulong-Petit law found this quantity to be three times the ideal gas constant per one mole of a solid. Due to hydrogen bonding, water’s value for this quantity is 4.186. For the point, name this quantity, the amount of energy needed to raise the temperature of a unit amount of a substance by one degree.

ANSWER: **specific heat** capacity (accept “heat capacity” until the second sentence is read)

22. This point is the location where a fault’s strain energy is first released. One can calculate the location of this point using a series of equations based on observations made at monitoring stations, taking into account the velocity changes through different mediums of the P and S waves underground. This point is located directly underneath the epicenter of an earthquake. For the point, name this place under the Earth’s surface where an earthquake begins, sometimes also called the focus.

ANSWER: **hypocenter** [accept **focus** before mentioned]

23. One over the square root of vacuum permeability times vacuum permittivity equals this quantity. The Michelson-Morley experiment determined that this quantity is constant in every direction, disproving the existence of a luminiferous aether. The rest energy of an object is equal to this quantity squared multiplied by mass. For the point, name this constant, symbolized c, which in a vacuum is roughly equal to three times ten to the eight.

ANSWER: **speed of light** (prompt on “c”)

24. A related, but rotated, version of this test will determine one-to-one behavior. Every input value must be checked in this test for the relation to pass, though in practice, most students simply visually check for a place where this test will fail by intersecting multiple points. For the point, name this test used on a graph to check if a relation is a function, performed by drawing a certain type of line.

ANSWER: **Vertical Line** test

25. Since these cells are surrounded by weak membranes in the condition Dermatographic urticaria, a phenomenon called “skin writing” results, where welts develop on skin after it has been itched. These cells can be classified as either “T” or “TC” depending on their tryptase and chymase levels. Along with basophils, these cells express the receptor Fc epsilon RI, which binds to immunoglobulin E to induce degranulation, a process where these cells release substances like histamine. For the point, name these white bloods cells known for their roles in mediating allergic responses.

ANSWER: **mast** cells

26. This constellation, Puppis, and Vela were formerly considered together as part of the Argo constellation. This constellation is home to the second brightest star in the night sky, Canopus. This constellation's namesake nebula includes the keyhole nebula, "finger of god", and Homunculus nebulas. For the point, name this constellation named for being the keel of a ship, with a massive nearby luminous blue variable as its Eta star.

ANSWER: **Carina**

27. This weather pattern is the warmer phase of a larger pattern known as the Southern Oscillation. A higher than normal air pressure over the eastern Pacific Ocean during this weather pattern reduces the amount of cold water that can upwell along the South American coast. Fishermen in Peru named this weather pattern in reference to its noticeable effects near Christmastime. For the point, name this recurring weather pattern which results in warmer and wetter conditions in the eastern Pacific, contrasted with drier and cooler La Niña periods.

ANSWER: **El Niño**

28. This task was first performed by Hippasus, who constructed an isosceles right triangle to begin the work. A standard approach to this task constructs a set of equations involving b^2 , $2a^2$, and $4c^2$, with a and b having been assumed to be relatively prime. Traditional lesson plans for teaching proof by contradiction involve Euclid's proof that there are infinitely many prime numbers and, for the point, what mathematical proof that explains why a right triangle with legs of length 1 can't have a fractional-valued hypotenuse?

ANSWER: proving that the square **root of 2 is an irrational** number (accept equivalents, such as "showing that **root 2 is irrational**); prompt on partial answers, such as "proving that irrational numbers exist")

29. This entity's strength is measured in units called teslas, although Gauss was the first scientist to accurately measure it. This entity is generated by the movement of molten iron in the Earth's core, an effect known as a geodynamo. A major anomaly in this system near Kursk in Russia has been attributed to a large deposit of iron ore. This entity is currently tilted about 11 degrees off from the Earth's rotational axis, meaning that compasses do not point to the geographic north. For the point, name this entity, a component of Earth with north and south poles.

ANSWER: **geomagnetic field** [accept **Earth's magnetic field**; prompt on "magnetic field"]

30. The MEP pathway synthesizes this hormone's precursors, such as xanthinin. This hormone prevents α -amylase synthesis and in doing so, counteracts the effects of gibberellins, which promote germination. Levels of this hormone are elevated during droughts because this hormone induces stomatal closure. Like auxin, this inhibitory hormone plays a role in root elongation. For the point, name this plant hormone responsible for seed dormancy and that despite its name, does not directly cause leaves to fall off.

ANSWER: **abscisic acid** (or **ABA**)

31. In January 2019, this spacecraft is scheduled to study Ultima Thule as part of NASA's KEM mission. While preparing for the launch of this spacecraft, astronomers discovered the moons Hydra and Nix. This space probe was the fastest ever to be launched from the Earth. This space probe discovered a large heart-shaped feature on its main target and also studied that target's companion, Charon. For the point, name this space probe that visited Pluto.

ANSWER: **New Horizons**

32. The amount of this quantity enclosed by a surface is equal to permittivity times the electric flux through the surface according to Gauss's law. The force generated by an electric field is equal to its strength multiplied by this quantity. 1.6×10^{-19} is the fundamental unit of this quantity and was approximated in the Millikan oil drop experiment. Particles with opposite signs for this property can create an electric dipole. For the point, name this electric quantity measured in coulombs.

ANSWER: electric **charge**

33. This value is the sum of the hyperbolic sine and hyperbolic cosine of 1 radian. Summing the reciprocals of the factorials, starting at 0, approaches this value, and the expression " $1 + \frac{1}{x}$, all raised to the x power" approaches this value as x approaches infinity. This value is the base of an exponential term in an identity named for the same Swiss mathematician. For the point, name this irrational number, approximately equal to 2.718, that is the base of the natural logarithm.

ANSWER: **e** (accept **Euler's** number before his name is mentioned)

34. A Texas Norther is one of these phenomena which moves very quickly and appears ominous. These phenomena often follow squall lines, and they generally move from northwest to southeast in the U.S. Along this type of weather front, denser air lifts less-dense air, resulting in cloud formation and a following low-pressure zone. When this type of front overtakes another type, the result is called an occluded front. For the point, name this type of weather front, drawn using blue triangles, that is often followed by rain or storms.

ANSWER: **cold front** [accept just **cold** once "front" is read; prompt on front before "front" is read]

35. In rocket propellant, this compound's "red fuming" and "white fuming" varieties can be used as powerful oxidizing agents. This compound turns a solution dark yellow if aromatic amino acids like tryptophan are present during the xanthoproteic reaction. The most common way of manufacturing this compound is in a process that uses a platinum-rhodium catalyst; that process is named for Wilhelm Ostwald and is closely associated with the Haber process, which produces this compound's precursor, ammonia. For the point, name this strong acid with formula HNO_3 .

ANSWER: **nitric acid** (accept **HNO_3** before mentioned)

36. After passing through Ursa Minor and Cepheus, the location of the North Star will be from this constellation. The first black hole discovered was an X-ray source found in this constellation. The largest star in this constellation plus Altair and Vega make up the summer triangle, while five of the stars in this constellation make up the Northern Cross. Deneb is the largest star of, for the point, which constellation depicting a swan?

ANSWER: **Cygnus** [prompt on "swan"]

37. Translation lookaside buffers link virtual and physical forms of this entity. In C, the "malloc" command dynamically allocates this, while "free" releases it. Mismanaging this entity can lead to segmentation faults. External sources of this include floppy disks and USB drives, while two major internal ones are "read only" and "random access". The ROM and RAM of a computer are example of, for the point, what information of a computer?

ANSWER: computer **memory** [or **storage**, prompt on "space"]

38. The historic closure of the Indonesian Seaway may have strengthened this phenomenon by raising the temperature of the Indian Ocean, while Tibetan uplift has been linked to the strengthening of this phenomenon in India. The high heat capacity of water and its ability to convect as opposed to land sets up this large-scale seasonal sea breeze, resulting in about 80 percent of India's precipitation. For the point, name this pattern of seasonally reversing winds and their accompanying precipitation, causing wet and dry seasons.

ANSWER: **monsoon** [accept (South) Asian **monsoon**]