

## (E) Science Bee Semifinals

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### Regulation Tossups

(1) **The first of these objects discovered by the Keck Observatory was the Gliese 876b, and Michel Mayor and Didier Queloz won the Nobel Prize in Physics in 2019 for discovering one of these objects named 51 (+) Pegasi b.** These objects can be detected with the radial-velocity method, while other methods for detecting these objects include Doppler spectroscopy and transit photometry. Gas (\*) Giants, Neptunian, and Super-Earth are types of, for the points, what planetary bodies that orbit a star outside of the solar system?

ANSWER: **Exoplanets** (or **Extrasolar Planets**; prompt on "planet"; prompt on "Neptunian" or "Super-Earth" before mentioned)

(2) **One pathway of this process involves dimers of the protein Bax and Bak. TNF-alpha receptors can initiate this process upon binding by activation of death domain proteins. (+) Cytochrome c is released into the cytosol during this process, and caspase-9 causes the final destruction of the cell in this process. Blebbing (\*) is a characteristic stage of,** for the points, what process of programmed cell death, contrasted with necrosis?

ANSWER: **Apoptosis**

(3) **Members of this genus develop from trophozoites into schizonts, and then burst into multiple merozoites to infect red blood cells. Tertian fever can be caused by both the (+) ovale and vivax species of this genus. Artemisinin and quinine are used to treat infections caused by the falciparum species of this parasitic genus, which is carried by the Anopheles (\*) mosquito.** For the points, name this genus of protozoa that causes malaria.

ANSWER: **Plasmodium** (accept **Plasmodium** falciparum; accept **Plasmodium** vivax; accept **Plasmodium** ovale)

(4) **The phenomenon of "marine snow" or "ocean dandruff" is caused by the falling this material from the water column to the seafloor. In aquatic ecosystems, this material is a source of nutrients for microbes living in the (+) benthic zone, and a standard example of a food chain named after this material on terrestrial ecosystems begins with dead leaves being eaten by a woodlouse, which is then eaten by a (\*) blackbird.** For the points, name this biological debris that is primarily made of decomposing plant and animal parts, including feces.

ANSWER: **Detritus** (prompt on answers synonymous to "dead matter" or "debris")

(5) **This region is the namesake of a hypothesis that predicts domal topographic uplift events. Post-perovskite (+) most likely exists in the bottom-most part of this region. The asthenosphere lies below the Moho discontinuity in this layer of Earth. The D-double prime layer marks the boundary between this layer and the (\*) outer core. For the points, name this largest layer of Earth below the crust.**

ANSWER: **Mantle** (accept **Mantle** plume hypothesis)

(6) **This region of Earth's atmosphere contains the Kennelly-Heavyside layer. The plasmasphere lies above this atmospheric region. The D (+) layer, E and sporadic E layers, and the F layer subregions all make up this region. The thermosphere is encompassed within this region, which also contains parts of the mesosphere and (\*) exosphere. For the points, name this electron-charged region of the atmosphere.**

ANSWER: **Ionosphere** (prompt on mentioned layers until "encompassed")

(7) **These land features' location qualifies them as ecotones between river and maritime environments. One (+) of these bodies of water drains into the Atlantic Ocean, and it was formed at the Punta Gorda by the confluence of the Uruguay and (\*) Parana Rivers. For the points, name this body of water with a direct connection to the ocean and with one or more rivers or streams flowing into it.**

ANSWER: **Estuary**

(8) **Leopold von Buch divided this period into three categories called the Black, Brown, and White. Remnants (+) of limestone from this geological era were first identified in the French-Swiss mountain range after which this period was named. Constituting the middle of the (\*) Mesozoic Era, this is, for the points, what geological period preceded by the Triassic and succeeded by the Cretaceous?**

ANSWER: **Jurassic** Period

(9) **The organizers of the KEO, one of these objects in space, said, "All the messages received, without undergoing any censorship, will be embarked aboard," when it launched in 2003. Another one of these objects launched aboard the (+) Voyager spacecraft in 1977 exists as two phonograph records containing 115 images as well as audio samples of greetings spoken in 55 languages. The Voyager (\*) Golden Record is an example of, for the points, what memory box that contains present-day objects to be opened in the future?**

ANSWER: **Time Capsules** (accept **Voyager Golden Record** before mentioned; prompt on "Capsules"; prompt on "Satellite")

(10) **Along with yttrium and copper, this metal names a type of high-temperature superconductor. This element gives fireworks their green color, and its most common isotope has a mass number of (+) 138. Patients consume a drink containing a sulfate of this element as a contrasting agent before undergoing radiographic (\*) examination. For the points, name this Group Two element symbolized Ba.**

ANSWER: **Barium** (accept yttrium **barium** copper oxide; or **YBCO**; accept **Barium** Sulfate; accept **Ba** alone before mentioned)

(11) **A polymer's glass transition can be quantified using the "differential scanning" type of these devices, and constant volume is maintained in the "bomb" type of these devices, which can more accurately measure a sample's (+) enthalpy of combustion. A simple example of these devices can be constructed with a stirring rod, thermometer, (\*) and two nested styrofoam coffee cups. For the points, name these devices that measure the heat given off by a chemical reaction.**

ANSWER: **Calorimeters** (accept **Calorimetry**; accept Differential Scanning **Calorimeters**; accept Bomb **Calorimeters**; accept Coffee Cup **Calorimeters**)

(12) **This mathematician found six proofs of quadratic reciprocity. Complex numbers that have both an integer real and imaginary part are known as this man's (+) "integers." This mathematician names a probability distribution that resembles a "bell curve." According to legend, this man stunned his teacher by calculating the sum of the first 100 positive (\*) integers rapidly. For the points, give this mathematician, the namesake of the normal distribution.**

ANSWER: Carl Friedrich **Gauss** (accept **Gaussian** integers; accept **Gaussian** Distribution; or Laplace-**Gauss** Distribution)

(13) **This Loss of Coolant Accident was rated a level seven on the International Nuclear and Radiological Event scale, and was triggered by an earthquake. This nuclear (+) disaster released roughly ten times less radiation than the accident at Chernobyl and resulted in a full closure of an island (\*) facility. For the points, name this 2011 nuclear reactor accident that took place in Japan after the Tōhoku tsunami and earthquake.**

ANSWER: **Fukushima** Daiichi accident (accept synonymous answers for "Accident" such as "Disaster")

(14) **The Heawood [[HAY-wood]] conjecture outlines the optimal way of doing this process on different surfaces. A theorem about this process was proven in 1976 by Kenneth (+) Appel and Wolfgang Haken, making it the first proof to use a computer. In graph theory, the minimum number required to perform this process is the (\*) chromatic number. For the points, name this process of labeling a graph requiring only four of the namesake properties.**

ANSWER: Graph **coloring** (accept Graph **labeling**; accept four **color** theorem)

(15) **Numbers that have this property but satisfy Fermat's little theorem are known as Carmichael numbers. It's not pronic, but "rectangular numbers" are (+) numbers with this property. The Sieve of Eratosthenes crosses these numbers out in its algorithm. Numbers with this property have at least one other (\*) divisor between one and itself. For the points, give this property of a number which can be factored into the product of two smaller numbers, the opposite of prime.**

ANSWER: **Composite** Number

(16) **This term is used to refer to a hypothetical situation where technological development becomes uncontrollable or irreversible. A misapplication of general (+) relativity to an infinite time in the past would predict the formation of an object described by this term that contained all of the mass in the universe. (\*)** For the points, give this term that refers to the infinitely dense center of a black hole.

ANSWER: **singularity** (accept technological **singularity**; accept gravitational **singularity**; or spacetime **singularity**)

(17) **The geometric mean theorem relates the length of one of these segments in a triangle to the lengths of the segments it creates. The inverse (+) Pythagorean theorem relates the length of these segments. These segments of a triangle coincide at its orthocenter. The area of a triangle can be calculated by multiplying one-half (\*) times a base times one of these segments. For the points, name these segments drawn from a vertex and perpendicular to the opposite side.**

ANSWER: Triangle **altitudes**

(18) **This phenomenon is responsible for the Ekman spiral, and its vertical analogue is known as the Eötvös [[OHT-vohs]] effect. The National (+) Geographic tested this phenomenon in an experiment where a person throws a ball to the person in front of them while on a roundabout. Contrary to popular opinion, this effect does not have an impact on the direction of toilet (\*) flushing in different hemispheres. For the points, name this effect that deflects objects while rotating, an effect caused by a fictitious namesake force.**

ANSWER: **Coriolis** Effect (or **Coriolis** Force)

(19) **This process and its terminology is still commonly used despite our advances in the understanding of the quantum-mechanical (+) nature of the atom. This process, developed under the Bohr model of the atom, has to do with the arrangement of certain particles into their (\*) energy sublevels. For the points, name this process of summarizing and arranging electrons into their orbitals, governed by concepts such as the Aufbau principle.**

ANSWER: Electron **Configuration** (accept **Electronic Structure**; prompt on descriptive answers)

(20) **The lever rule can be applied to these diagrams after drawing their tie lines. The Widom and Frenkel lines on these diagrams separate different parts of a (+) supercritical fluid. The Clausius-Clapeyron equation is used to measure the slope of the coexistence curves on these diagrams, which meet at the (\*) triple point. For the points, name these diagrams that plot temperature against pressure to show where a substance exists as a solid, liquid, or gas.**

ANSWER: **phase diagrams** (or **P-T** diagrams)

(21) **This compound has the lowest melting point of any alkane. This molecule is both the lightest and most major constituent of liquid (+) petroleum gas. The combustion of this compound results in four molecules of water and three molecules of carbon dioxide. This molecule contains one less carbon than (\*) butane. For the points, what compound with chemical formula C<sub>3</sub>H<sub>8</sub> is commonly used in portable stoves?**

ANSWER: **Propane**

(22) **Orally active drugs have no more than five donors of these interactions according to Lipinski's rule. The secondary structure of proteins is determined by these interactions. (+) These interactions are stronger than van der Waals forces but weaker than covalent bonds. (\*) These interactions hold together water molecules. For the points, identify these bonds named for the first element on the Periodic Table.**

ANSWER: **hydrogen bonds** (accept **H-Bond**)

(23) **One form of this quantity is calculated as effective nuclear charge over the covalent radius squared when using the Allred-Rochow (+) scale. Differences in this quantity between atoms give rise to inductive effects. Cesium has the lowest value for this quantity on the Pauling scale, which ranges from 0.8 (\*) to 4.0 and increases towards the top right of the periodic table. For the points, name this quantity, the tendency of an atom to attract electrons.**

ANSWER: **electronegativity** (accept word forms)

(24) **Marian Smoluchowski proposed a theoretical perpetual motion machine powered by this process called its namesake “ratchet”. In mathematics, this phenomenon is modeled by the Wiener (+) Process, a stochastic one-dimensional model of it. This phenomenon was the subject of the second of Albert Einstein’s *Annus Mirabilis* papers, and was first observed by its namesake in (\*) pollen grains in water. For the points, name this random movement of particles in a fluid.**

ANSWER: **Brownian motion** (accept **pedesis**, accept **Brownian Ratchet**; prompt on “random walk”)

(25) **This asterism is surrounded by stars like Rigel, Castor, and Pollux. This asterism encompasses much of the faint constellation (+) Monoceros. Its three component stars form an equilateral triangle when drawn on the celestial sphere. This asterism contains the brightest stars from Orion, Canis Major, and Canis (\*) Minor. For the points, name this asterism which contains three of the brightest stars in the winter sky.**

ANSWER: **Winter Triangle** (do not accept or prompt on “Summer Triangle”)

### Extra Questions

(1) **Pebbles of this rock are nicknamed Apache tears. Gray spherulites at crystallization sites in this rock define its "snowflake" variety. This rock, which is often formed by (+) cooling polymerized felsic lava, contains few crystals due to its viscosity. This extrusive igneous rock has a conchoidal [[kon-KOY-dul]] fracture that makes it a common material for (\*) scalpel blades.** For the points, name this glossy black volcanic glass.

ANSWER: **Obsidian**

(2) **An increased risk of developing this condition has been associated with the FOXD3 gene, as well as variations of the NLRP1 and (+) PTPN22 genes. This condition is classified as segmental or non-segmental, the latter of which can be further classified into focal, acrofacial, and mucosal. Michael (\*) Jackson notably suffered from,** for the points, what condition that occurs when the body stops producing melanin, leading to patchy discolorations of the skin?

ANSWER: **Vitiligo** [[vih-tuh-"LIE"-goh]] (or **Leucoderma**; accept Segmental **Vitiligo**; accept Non-segmental **Vitiligo**; accept Generalized **Vitiligo**; accept Universal **Vitiligo**; accept Focal **Vitiligo**; accept Acrofacial **Vitiligo**; accept Mucosal **Vitiligo**)

(3) **The Sleeping Beauty system uses one of these sequences to splice genes into vertebrate chromosomes. LINEs, SINEs, and Alu elements are examples of the (+) "retro" type of these sequences, which act though a "copy and paste" mechanism with an RNA intermediate. Barbara McClintock's studies of corn led to the discovery of these "jumping (\*) genes."** For the points, name these DNA sequences which can change their position within the genome.

ANSWER: **transposons** (or **transposable elements**; or **TEs**; accept retro**transposons**; accept **jumping genes** before mention but prompt afterwards)