



## National Science Bee Prelims - Round 3

1. This virus's regulatory elements include the TAR element and genes called *env*, *pol*, and *gag*. The type of cell that this virus affects is determined through the Trofile assay. This virus uses CXCR4 and CCR5 receptors to enter its target cells, which bind to this virus with the help of gp120. A drug that selectively inhibits reverse transcriptase, AZT, is used to treat this lentivirus. For the point, the amount of T cells expressing CD4 decreases upon infection with what virus that causes AIDS?

ANSWER: HIV or human immunodeficiency virus (do not accept or prompt on "AIDS")

2. A man from this country pioneered the use of an airtight, pressurized cabin, which he used while measuring cosmic rays. That man's grandson, Bertrand, is also from this country, and circumnavigated the world in the first nonstop flight by balloon. Aside from Auguste Piccard, this nation was home to a man who developed a principle stating that a rise in a fluid's velocity accompanies a fall in its pressure, a law that also helps explain how airplanes generate lift. For the point, name this European country, the birthplace of physicist Daniel Bernoulli.

ANSWER: Switzerland

3. The brightest supernova seen since the 1600s was discovered in 1987 in this galaxy. This galaxy is home to a rapid star formation region called the Tarantula Nebula and one of the brightest known stars, S Doradus. This is the fourth largest galaxy in the local group and the largest satellite galaxy of the Milky Way. For the point name this companion to a "small" galaxy, both of which are named for a Portuguese explorer.

ANSWER: Large Magellanic Cloud [or LMC]

4. When water flows through ion deposits of this element and magnesium, hard water is formed. The majority of kidney stones are made up of a compound consisting of oxalate and this element's ion. Milk-alkali syndrome is caused by elevated levels of this element, whose ionic form is released from bone in response to actions of the parathyroid hormone. Vitamin D increases absorption of this element from the intestine. For the point, what element, necessary for healthy teeth, has atomic number 20 and is represented by Ca?

ANSWER: calcium

5. Mazuku are pockets or layers of this gas that collect in low-lying areas, often killing vegetation or unlucky humans. A limnic eruption can release this gas into the atmosphere, perhaps having concentrated from the decomposition of organic matter. Degassing is the primary contributor of this compound into the atmosphere from the mantle. Ash and aerosols released from volcanoes along with this gas can often cancel its infamous atmospheric heating effects. For the point, name this greenhouse gas released from volcanoes at a rate of about half a billion metric tons each year.

ANSWER: carbon dioxide [accept CO<sub>2</sub>]

6. RNA from the *Xist* gene inactivates these structures in lyonization, where they become Barr bodies. Too many CGG triplet repeats in the *FMR1* gene on these structures are the cause of a disorder that is named for the fragility of these structures. One of these structures is missing in women affected by Turner syndrome, while men have at least two of these structures in Klinefelter's syndrome. For the point, name this sex chromosome present in both males and females.

ANSWER: X chromosomes (prompt on "chromosomes")

7. The Mark-Houwink equation relates the molecular weight of these substances to their intrinsic viscosity. Amorphous types of these substances become rubbery above the glass transition temperature. These substances, which are modeled by the Flory-Huggins theory, can be synthesized with different types of tacticity through use of Ziegler-Natta catalysts. The “chain-growth” method produces these substances, which include PVC and teflon. For the point, name these substances made up of many monomers.

ANSWER: **polymers**

8. Complex numbers whose modulus is a squared prime number are known as Gaussian prime numbers. Wilhelm Jordan and this man co-name a variant of elimination used on systems of equations whose coefficients are entered into an augmented matrix. The normal distribution in statistics is named for this man, who proved the fundamental theorem of algebra. A childhood stunt of adding the numbers from 1 to 100 is among the legends attributed to, for the point, what 19th century German mathematician and polymath?

ANSWER: Carl Friedrich **Gauss**

9. On Earth, this process may be possible by magnetically confining deuterium and tritium in a tokamak. This process absorbs energy in elements heavier than iron and occurs when the strong force overcomes the Coulomb barrier formed from electrostatic forces. The CNO cycle and proton-proton chain are two reaction cycles of this process that form Helium from Hydrogen atoms. For the point, name this process that powers the sun, the act of two nuclei merging together.

ANSWER: nuclear **fusion**

10. Pristane and porphyrin are biomarkers used to identify the sources of this substance. Kudryavstev’s rule claims that hydrocarbon-rich areas exist in multiple layers, which he saw as support for an abiogenic origin of this substance. Thomas Gold proposes a “deep hot biosphere” with decaying bacteria providing the source for this substance. Modern theories instead suggest that this substance arises from the formation of wax-like kerogen, which is then transformed by heat and pressure into liquid hydrocarbons. For the point, name this liquid fossil fuel sometimes called crude oil.

ANSWER: **petroleum** [accept **crude oil** before mentioned]

11. One of only two known organisms to emit red light, Siphonophores belong to this phylum. Myxozoa, parasitic members of this phylum, have polar capsules that are similar to nematocysts, which are used by members of this phylum such as Lion’s mane. Sessile members of this phylum have a polyp body form, as exhibited by the class Anthozoa, while the class Cubozoa displays its mobile medusa form. For the point, name this phylum of radially-symmetric marine invertebrates that includes anemone, coral, and jellyfish.

ANSWER: **Cnidaria**

12. This ancient mathematician found the area between a parabola and a line, as described in his treatise *The Quadrature of the Parabola*, and tried to estimate the number of grains of sand that could fit in the universe in his *The Sand Reckoner*. The first proof of the volume of a sphere within a cylinder was written by this man, who had the formula inscribed on his tombstone. This man was killed during the Roman siege of his hometown, Syracuse, in 212 BC. For the point, name this ancient Greek mathematician and physicist.

ANSWER: **Archimedes** of Syracuse

13. A shape named for this property has a volume equal to the triple product of vectors forming three of its edges. Playfair’s Axiom concerns this property, and lines with this property form equal alternate interior angles when cut by a transversal. In analytic geometry, lines with equal slope have this property, which is represented in diagrams using arrows on their middles. For the point, name this adjective for lines in a plane that do not intersect.

ANSWER: **parallel**

14. Since low-temperature serpentinization produces diatomic hydrogen on this body, it has been theorized that methane-producing archaea may be able to survive on it. The fact that this object experiences more tidal heating than an icier relative is the subject of a paradox named for Mimas and this object. In the south polar region of this object, cyro-volcanism has been detected in its “Tiger Stripes,” where geysers spew material that replenishes the E-Ring. For the point, what is this moon of Saturn, named for a Greek giant?

ANSWER: **Enceladus**

15. This device’s strength, when unknown, can be measured using a Wheatstone bridge circuit. They aren’t inductors, but the strength of these devices is the sum of the reciprocals if they are added in parallel and directly if they are in series. This device often comes with four colored bands to indicate its strength and is represented by zigzagging lines on a circuit diagram. For the point, name this electrical component that slows down current, whose strength is measured in Ohms.

ANSWER: **resistors**

16. A sturzstrom is one of these events in which the horizontal distance is much longer than the vertical distance. One of these events in 1958 created the largest tsunami wave ever measured and is thought to have been triggered by an earthquake. When these events reach active streams, they can become much bigger thanks to the added water and debris. As a type of mass wasting, these events can be distinguished by their contents being largely soil or rock. For 10 points, name these sudden movements of earth down a slope which are similar to avalanches.

ANSWER: **landslides**

17. One proof that there are infinitely many prime numbers uses the fact that any two Fermat numbers have this property. An integer  $a$  has a multiplicative inverse modulo  $n$  when  $a$  and  $n$  have this property, and the number of integers with this property is counted by Euler's totient function. The least common multiple of two numbers with this property is their product. For the point, identify this property in which two integers share no common prime factors.

ANSWER: **coprime** or **relatively prime** (do not prompt on or accept “prime”)

18. Aldehydes are converted into alkanes during a reaction of this type named for Clemmensen, and lithium aluminium hydride commonly catalyzes these reactions. In acidic solutions, permanganate become manganese (II) ions through a reaction of this type, a fact made more clear with half reactions. Because fluorine is the most electronegative element, it most often undergoes this type of reaction. For the point, the second half of the mnemonic OIL RIG refers to what chemical reaction involving the gain of electrons, the opposite of oxidation?

ANSWER: **reduction** reactions

19. The Hubble Space Telescope took the Hubble Deep Field image from this constellation, also the home to the Pinwheel Galaxy. Mirza and Alcor are a pair of visual binary stars in this constellation. Two stars in this constellation, Dubhe and Merak, form a straight line towards Polaris. For the point, name this constellation whose seven major stars forms the shape of a plough or a dipper that is larger than a nearby companion.

ANSWER: **Ursa Major** [prompt on “big bear” or “big dipper” or synonyms, do not accept or prompt on answers that use the adjective “little”, “minor”, or its synonyms]

20. Shor and Grover name quantum types of these things. Edgar Dijkstra [[dike-stra]] names a greedy example of one of these things for a graph. Big O notation calculates the time and space requirements for these things. One named for Euclid calculates the greatest common factor of two integers. For the point, name these sets of computer instructions to do specific tasks like searching, which are implemented in computer programming.

ANSWER: **algorithm** [prompt on computer “program” or descriptions before mentioned]

21. Powers of this number are the only positive integers that are not trapezoidal numbers. If  $n$  is a perfect number, then its factors sum to this number times  $n$ . This number is equal to the geometric series "one plus one-half plus one-fourth and so on". Writing an integer as a sum of powers of this number can be used to find its representation in binary, a system that uses this number of digits. For the point, name this smallest prime number.

ANSWER: 2

22. Defects in the structures of these objects occur at grain boundaries. "Quasi" types of these objects lack translational symmetry, which is used to describe fourteen arrangements of these objects named for Bravais. Miller indices specify the orientation of planes in these materials, whose smallest fundamental component, the unit cell, can be defined in terms of lattice points. For the point, Bragg's Law links X-ray diffraction patterns to what solids that include diamond and table salt?

ANSWER: crystals

23. This compound's active form is used as a coenzyme in the Krebs cycle's pyruvate dehydrogenase complex. A deficiency of this compound causes a disease manifested by a triad of ataxia, mental confusion, and paralysis of eye movements in alcoholics. Low levels of this compound result in a "wet" form of a disease that weakens capillary walls and a "dry" form characterized by neuropathy. For the point, over-consuming white rice is a risk factor for beriberi, a disease caused by a deficiency of what vitamin?

ANSWER: Vitamin B1 or thiamine

24. This scientist worked with Roger Penrose to model singularities in spacetime. He built on Jakob Bekenstein's idea that black holes have finite entropy to show that virtual particles should be able to escape black holes in this man's namesake radiation. Until 2009, he served as the Lucasian Professor at Cambridge for 30 years despite having early-onset ALS. For the point, name this British physicist, author of A Brief History of Time, who passed away in 2018.

ANSWER: Stephen (William) Hawking

25. The first step of this process is catalyzed by an enzyme that is activated when a magnesium ion binds to carbamate. Malate breaks down in bundle-sheath cells to produce a molecule that begins this process, where 3GP molecules are reduced by NAPH and ATP. This process occurs in the daytime for CAM plants so that they can reduce water loss. For the point, RuBisCO is used in what light-independent cycle of reactions that occurs in the stroma and synthesizes sugars from carbon dioxide?

ANSWER: Calvin-Benson cycle (prompt on "photosynthesis")

26. To perform this operation on expressions like "the square root of the sine of  $x$ ," the chain rule must be applied; in doing so, it's helpful to know that this operation on sine gives cosine. Performing this operation on a constant value  $c$  gives zero, because the graph of  $y$  equals  $c$  is a horizontal line whose slope is zero. For the point, name this operation, the inverse operation of integration, a primary tool used in calculus.

ANSWER: differentiation (or finding the derivative; accept word forms and equivalents)

27. Large values of this quantity allow for the stabilization of conjugate bases through charge delocalization, according to the inductive effect. In one definition of this quantity, Sanderson suggested that it is proportional to atomic size and was equalized in molecular compounds. A method devised by Mulliken calculates this quantity from the average of first ionization energy and electron affinity. The Pauling scale measures this quantity. For the point, fluorine has the highest value for what quantity, the ability of an atom to attract electrons?

ANSWER: electronegativity

28. The north pole of this astronomical object contains a prominent hexagonal pattern. Pioneer 11 was the first space probe to fly by this planet. This planet's moon Iapetus has two distinct colors while its moon Mimas includes a huge impact crater. This planet, which is the least dense planet of the solar system, was the target of the recent Cassini-Huygens spacecraft. For the point, name this outer solar system gas giant with prominent rings.

ANSWER: **Saturn**

29. The lenticular type of these objects are created by waves of air rising along mountainsides. These objects are named by combining words for five forms, defined by convection patterns, with prefixes for three altitude-based levels. These objects can be created by humans using silver iodide in a process known as "seeding," or they can be created by water vapor released by factories, power plants, or airplanes. For the point, name these objects in the sky which are collections of condensed water droplets.

ANSWER: **clouds**

30. In quantum mechanics, this quantity is given by the Hamiltonian operator. The "lattice" type of this quantity is released when gaseous ions condense into a solid. The conservation of this quantity is stated in the first law of thermodynamics. For a falling object, this quantity is calculated as mass times little g times height plus one-half mass times velocity squared. For the point, name this quantity that has both potential and kinetic forms.

ANSWER: total **energy** (accept lattice **energy**; accept potential **energy**; accept kinetic **energy**)

**Extra Tossup – ONLY READ IF A QUESTION IS BOTCHED!**

31. GPCRs pass through this structure 7 times. The protein whose mutation causes cystic fibrosis is found within this structure. This structure can be described using the fluid mosaic model. Embedded in this structure include proteins called aquaporins. In plant cells a similarly named wall made up of mainly cellulose surrounds this structure. For the point, name this phospholipid bilayer that surrounds the cytoplasm of a cell.

ANSWER: **cell membrane** (accept **plasma membrane**; prompt on "membrane")