

1. *Description acceptable.* Jackman and McPeters showed that this process can be caused by solar proton events. Another paper by Jackman *et al.* showed that this process could reach 35 percent of its maximum potential due to a gamma ray burst hitting earth, which may have been what caused the late Ordovician mass extinction. This process is exacerbated by polar stratospheric clouds. A measured value of less than 220 (*) Dobson units implies that this process is occurring. The formation of reservoir species such as hydrogen chloride can remove atoms that are causing this process. This process is typically caused by free radicals, especially halogens. For 10 points, name this process caused by CFCs that led to the formation of namesake "holes."

ANSWER: ozone depletion [accept reasonable equivalents, for example "destruction of the ozone layer"]

2. Kingman's approximation is used on one type of these data structures, whose evolution is described by the Lindley equation. A continuous time Markov chain serves as the background process for the "fluid" type of these data structures. These data structures can be classified using Kendall's notation. Finite sized examples of these data structures can be made to operate in constant time by utilizing a (*) circular buffer. An extension of these data structures, which is often implemented using heaps, first returns the element with the highest priority. These data structures work in the opposite manner of stacks. For 10 points, name these first-in-first-out data structures that can be used to represent people waiting in a line.

ANSWER: queues

3. The thermo-resistant material Kapton is a polymer of this functional group. Lithium or sodium bases cleanly transform compounds with this functional group into their respective (Z)-metal enolates in a reaction whose stereoselectivity must be greater than 100:1. Silver cations can induce the oxidative decarboxylation of N-acyl amino acids into these compounds, although a more common way to synthesize them involves the use of the iodine reagent DMP to oxidize secondary amides. For 10 points, name this functional group that consists of (*) two acyl groups bonded to nitrogen.

ANSWER: imides

4. Ertel's theorem states that the time derivative of the "potential" type of this quantity is equal to zero. Crocco's theorem can be stated as velocity crossed with this quantity equals specific volume times the gradient of stagnation pressure. Helmholtz's third theorem states that if this quantity is initially zero, then it will stay zero in the absence of external forces. (*) Stoke's theorem can be used to show that the surface integral of this quantity is circulation, and this quantity is equal to the curl of the fluid velocity. For 10 points, name this quantity that is equal to zero for irrotational flows and represents the local rotation in fluids.

ANSWER: vorticity

5. Campbell *et al.* showed conductive needles of this element can form a 3D electrode array that is used for chronic intracortical stimulation. Non-linear optical loss caused by two photon absorption-induced free carrier absorption posed a significant challenge to developing a continuous-wave Raman laser with this element. In solid phase epitaxy, ions of this element are implanted onto a film of it; that technique reduces defect density in an integrated (*) circuit component with low parasitic capacitance named for this element "on sapphire". Crystals of this element are formed in the Czochralski process. For 10 points, give this semiconducting element with atomic number 14 and chemical symbol Si.

ANSWER: silicon [accept Si until mention]

6. **The Bertrand-Diquet-Puiseux theorem allows one to calculate this quantity using the circumference of a geodesic circle. This quantity is equal to the determinant of the second fundamental form divided by the determinant of the first fundamental form. This quantity is related to the Euler characteristic of a manifold by the (*) Gauss-Bonnet theorem. The optimal way to eat a pizza without having it flop over can be understood by a theorem which states that this quantity is invariant under local isometry and intrinsic to a surface. That theorem is Gauss's Theorema Egregium. This quantity is equal to the reciprocal of its namesake radius. For 10 points, name this quantity, which is equal to zero for a straight line and gives a numeric description of how not straight a line is.**
ANSWER: Gaussian curvature
7. **Proteins belonging to the Trithorax group promote this process by tri-methylating histone H3 lysine 4 and acetylating histone H4. SMAD proteins 1, 5, and 8 in the bone morphogenic protein pathway induce this process in neural (*) progenitor cells. The presence of OCT4, SOX2 and NANOG transcription factors inhibit this process, as do proteins from the Polycomb group. Hox genes tag cells to undergo this process according to a body plan, and stem cells undergo it to become somatic cells. For 10 points, name this process in which cells becomes specialized.**
ANSWER: cell differentiation
8. **One theory developed by this man makes use of the idea of "incidence" between its namesake objects and spacetime points and takes place in a 4-dimensional space of reduced spinors. Ed Witten suggested that the topological B model of string theory could be embedded into that space, thus uniting string theory with this man's (*) twistor theory. His namesake graphical notation is used throughout his book that claims to contain the complete guide to the laws of the Universe. His weak cosmic censorship hypothesis states that no naked singularities exist, and he names some theorems about singularities with Stephen Hawking. This guy wrote the books *The Road to Reality* and *The Emperor's New Mind*. For 10 points, name this British guy who names an impossible triangle and a form of aperiodic tiling.**
ANSWER: Sir Roger Penrose
9. **A cyclic-citrullinated peptide was synthesized in order to use this technique for rheumatoid arthritis diagnosis. When using this procedure to screen for HIV, an optical density of greater than 1 indicates a positive result. PBS is a common wash-buffer for this technique, which often sees the conversion of TMB to TMB diimine via horseradish peroxidase. A secondary antibody is used in the (*) "sandwich" type of this procedure, which typically entails measuring the intensity of a color-change after enzyme-antibody complexes bind to antigens that are adsorbed onto the surface of a 96-well microtiter dish. For 10 points, name this technique used to identify how much of a particular protein, often an antibody, is present in a liquid sample.**
ANSWER: ELISA [accept EIA or enzyme-linked immunosorbent assay]
10. **An experiment at Jefferson lab attempted to calculate the form factor of this particle using the VGL/Regge model. An older way to try to calculate its form factor is the the Chew-Low method. The rho meson decays into two of these particles and the OZI rule explains why the decay of the phi meson into three of them is suppressed. Kaons can decay into either two or three of these particles, the study of which led to (*) Cronin and Fitch receiving the Nobel prize. Their neutral variety can consist of an up and an anti up quark or a down and an anti down quark. Yukawa incorrectly predicted that this particle was the carrier of the strong force. For 10 points, name this lightest meson.**
ANSWER: pions [accept pi mesons]

11. For a gaseous mixture, the natural log of this quantity's namesake coefficient is the integral with respect to pressure of the partial molar compressibility minus 1, all over pressure. At high pressures, the Poynting correction factor for this quantity deviates from its typical value of 1. According to the Lewis-Randall rule, this quantity for each species in an ideal solution is equal to (*) mole fraction times its total value. Change in Gibbs free energy for a non-ideal gas with respect to the natural log of this quantity equals RT , but for an ideal gas this quantity is equal to the pressure. For 10 points, give this measure of the tendency of a gas to escape a certain phase, symbolized f .

ANSWER: fugacity

12. Boonserm and Visser found a variant of the Buchdahl transformation between coordinate systems with this property. The three scalar fields of Solid inflation lack this property individually, but have it when they are combined. Measurements of large peculiar velocities could suggest the lack of this property, which may challenge the (*) Lambda-CDM model. Kepler's second law is a result of the conservation of angular momentum, which can be derived by considering space to have this property. For 10 points, name this property meaning space looks the same in whatever direction you look, which is combined with homogeneity in the cosmological principle.

ANSWER: isotropy [accept word forms like "isotropic", prompt on "rotational symmetry"]

13. This organism toggles with the production of anthranilate synthetase and glycerolphosphate synthetase, based on nutrient composition of its surroundings. The medium of choice to grow this organism was developed for the genus *Shigella*, which should be classified as a strain of this species based on its evolutionary origin. That aforementioned medium is (*) Luria broth. This model organism was cultured with nitrogen-15 to show that DNA replication is semiconservative in the Meselson-Stahl experiment. The O157:H7 serotype of this bacterium causes illness primarily via fecal-to-oral transmission. For 10 points, name these gram-negative, rod-shaped bacteria found in gut flora.

ANSWER: *Escherichia coli*

14. An attempt to access an ancient example of these things returns a page advertising cosmetics in Japanese. An even more ancient example of these things required formatting in LaTeX and was named Jerome. The alpha version of one of these sites was announced in May of 2006, but its primary purpose was made basically obsolete by Google Docs. (*) One of these sites was announced under the hope that it was "not just another" one of them by Aseem Keyal. In early May of 2015, one of these sites was brought back "with a vengeance." Rohit Lalchandani announced a "hassle-free" type of these sites in 2013, but it was eventually taken over by Jacob Reed. Matt Jackson made a great post about how difficulty does not correspond to hits on these sites. For 10 points, name these sites exemplified by Quinterest and QBDB.

ANSWER: quizbowl question databases [accept "quizbowl databases" and other reasonable equivalents, prompt on "quizbowl websites" and similar stuff]

15. A 1986 paper in *Science* reported that data from the COCORP study in Nevada suggested that this region had formed after the formation of the continent. The *JOIDES Resolution* unsuccessfully attempted to study this region in 2005. The Soviet Union attempted to drill to this region on the (*) Kola peninsula, but only managed to get about 12 km deep, which is about 20 km short of the average continental depth of this region. Its namesake discovered its existence in 1909 by realizing that since waves from more than 200 km away were arriving faster than expected, then they must have traveled through a denser medium. For 10 points, name this region of the earth that separates the crust and mantle, which is named for its Croatian discoverer.

ANSWER: Mohorovicic discontinuity [accept "the Moho", prompt on "mantle"]

16. *Description acceptable.* In August 2014, it was shown that a proof of the generalized Elliott-Halberstam conjecture would allow one to prove this value is equal to six an infinite number of times. That result was by Polymath, which is a group that was able to definitively prove that this value is equal to 246 an infinite number of times. The prime number theorem suggests that the average length of this value following a prime p is the natural log of p . The aforementioned work on this value came after a 2013 paper establishing the first (*) finite bound on them by Yitang Zhang. For 10 points, name this value that is equal to 2 for twin primes
ANSWER: prime gaps [accept things like “the distance between two consecutive primes”]
17. **nph4/arf7 mutants are unable to undergo this process, which depends on D6 protein kinases to promote hypocotyl bending in low light conditions. One receptor in this process is composed of an ACG domain and two LOV domains. In one proposed mechanism for this process, which only occurs at wavelengths near 500 nanometers, a namesake blue-light photoreceptor controls (*) PIN localization through the transcriptional down-regulation of PINOID. Proton pumps activated by auxin lower the pH on the ‘shady’ side of the plant in this process. For 10 points, name this tendency of plants to grow toward a source of light.**
ANSWER: phototropism [accept gravitropism in first clue due to ambiguities]
18. **Kalnins and Miller noted that separated solutions to this equation cannot be confined within a static spheroidal MIT bag. Chandrasekhar fully separated this equation in Kerr spacetime using the Newman-Penrose formalism. One set of structures involved in this equation form a clifford algebra, and this equation is often represented using Feynman’s slash notation. In that way, this equation can be written as the slash operator acting on the wave function equals negative i times rest mass times the wave function divided by \hbar . In order to make this equation first order in both (*) space and time, its discoverer took the square root of the wave operator in his namesake “coup.” To deal with the negative energy states predicted by this equation, its namesake developed his hole theory. For 10 points, name this equation that describes the dynamics of spin one-half particles and was used by its namesake to predict the existence of the positron.**
ANSWER: Dirac equation
19. **According to Eckart theory, bulk viscous stress is given as negative three times the viscosity coefficient times this value. The mass of a fundamental particle can be approximated as the cube root of this value times \hbar squared divided by G and c according to Weinberg’s relation. The deceleration parameter is equal to negative one minus the time derivative of this value divided by this value squared. This value can be defined as the (*) time derivative of the scale factor divided by the scale factor. The inverse of this value is approximately equal to the age of the universe. For 10 points, name this value that is equal to recession velocity divided by distance according to the law named for the same American astronomer as this value.**
ANSWER: Hubble’s parameter [accept Hubble’s constant]
20. **This phenomenon is signified by the t_{-1u} derived multiplet in the IR spec of fulleride molecules containing rubidium and caesium, which has been shown to persist into metallic states. Ceulemans and Linjen gave a permutational explanation of this phenomenon using Hall’s theorem. The splitting of bands in UV-Vis absorption spectroscopy is indicative of this effect. This effect was (*) recently shown to allow materials that look like insulators to behave like conductors. This effect requires degeneracy in either the t_{-2g} or e_{-g} orbitals, and it most often occurs in octahedral complexes like six-coordinate copper (II). Less than a month ago, a new state of matter named after this effect was announced. For 10 points, name this effect in which nonlinear molecules undergo a geometric distortion to remove degeneracy.**
ANSWER: Jahn-Teller effect

21. The Lindblad equation is a master equation for quantum mechanics in which the system behaves as one of these things. If all the possible configurations of one of these things are aperiodic and positive recurrent, then they are said to be ergodic. Google's PageRank program treats surfing the web as one of things. A half-inning in baseball can be treated as one of these processes with 25 different possible (*) configurations. The Metropolis-Hastings algorithm combines these things with the Monte Carlo method. These processes are defined through state vectors and transition matrices, and random walks are a classic example of them. For 10 points, name these processes, in which a system has no memory of its history, named for a Russian mathematician.

ANSWER: Markov chain