

1. NOTE: Read capital two- and three-letter words like “IS” as “I-S” and so on.

Through compare and swap, delta updates, and half-splitting nodes, these objects are not present in a variant of the B-tree called a Bw-tree implemented in Microsoft’s Hekaton. These objects are only created for nodes satisfying a total order in a B-link tree. The “next-key” system of creating them solves the problem of phantoms. Allocating these objects with “multiple granularity” requires additional “IS,” “IX,” and “SIX” varieties. The interaction of “modes” of these objects with each other can be described by a compatibility matrix. These objects can be upgraded, leading to a change from “S” to “X.” In one system for managing these objects, the graph of them over time first monotonically increases, then decreases, in the “growing” and “shrinking” phases. That “two-phase” system for awarding these objects has a “strict” variety that (\*) releases all relevant ones in response to a commit. A cyclic dependency graph of these objects characterizes an unwanted situation in which they are effectively “dead.” These objects can come in “shared” and “exclusive” varieties, corresponding to reads and writes. For 10 points, name these permissions granted to a thread or transaction to prevent simultaneous writing, a key concept in concurrency control and databases.

ANSWER: locks [accept latches; accept deadlock; accept more specific answers]

2. To prepare for this project, hydrazine was passed over an iridium catalyst to create hydrogen, which was burned to produce water. A box labeled “Do Not Touch Until Thanksgiving” provided some supplies for this project, which also used freeze-dried fecal matter as (\*) fertilizer. The smaller products of this effort were reseeded, while the larger ones were harvested. This project supplemented the prepackaged food available in the Hab, but it was ended when an airlock exploded and destroyed its products. In a novel by Andy Weir, Mark Watney succeeded at this task because he happened to be a botanist. For 10 points, name this agricultural activity which provided crucial nutrients in *The Martian*.

ANSWER: growing potatoes on Mars [prompt on “farming” or “growing things”, accept anything with farming and Mars]

3. The “dual-role” Deakin–Graeff hypothesis concerns the localization of this broad phenomenon. The four-plates test of this condition does not use conditioning, while the Vogel conflict test does. The BIS mediates this state in Gray’s reinforcement sensitivity theory. Using HAB rats in an elevated-plus maze is a good test of this state. The presence of thigmotaxis in a brightly-lit (\*) open-field test primarily indicates this phenomenon. Mice show stress-induced hyperthermia when in this state. A common but bad test of this phenomenon is defensive or marble burying in mice. Startles are enhanced by diffuse and innately aversive stimuli in this condition. This phenomenon, which has state and trait types, is the opposite of phasic fear, and manifests in PTSD patients. It can be induced by periodic maternal deprivation, and has symptoms including bradycardia and hyperattentiveness. For 10 points, name this disorder of social defeat.

ANSWER: anxiety [prompt on “panic” or “stress”; do not accept “fear”]

4. Diabatic heating or turbulent mixing can non-conservatively resolve “folds” in this region. Hot towers are defined by their presence in, and crossing of, this region. Away from the equator, the surface of the “dynamic” type of this region can be defined in terms of an absolute value of around 1.5 or 2 PVUs. Air rises in a Hadley cell until it reaches this specific region and then moves towards the poles. The (\*) lapse rate changes sign at this boundary, as temperature increases with increasing altitude in the layer above this boundary, as that layer contains the ozone layer. Jet streams are bounded in altitude by this boundary. For 10 points, identify this boundary named for separating the stratosphere from a namesake lowest layer of the atmosphere.

ANSWER: tropopause [prompt on “troposphere”]

5. Note to all: Description or exact title are both acceptable.

Part of this article comments on the sexiness of a thesis topic related to the Alsatian food item *choucroute garnie* (“shoo-KROOT gar-NEE”). Nathaniel Comfort’s response to this article invoked Herbert Butterfield’s concept of “Whig History.” This article begins with a lyrical description of the “beautiful coast and vast salt marshes” that have attracted “visitors” and “flamingos” to the port of Santa Pola on Spain’s Costa Blanca, where Francisco Mojica worked. This article ends by declaring that scientific advancements are usually (\*) “ensemble acts, played out over a decade or more,” and should not be thought of as “eureka moments.” This article has been criticized for neglecting to disclose the multi-billion dollar patent involving its author, Eric Lander, and for downplaying the contributions of Emmanuelle Charpentier and Jennifer Doudna. For 10 points, name, or describe, this 2015 *Cell* article, a controversial historical account of a popular gene-editing technology using Cas9.

ANSWER: “The Heroes of CRISPR” [accept “ article about the history of CRISPR” or “the CRISPR history clusterfuck” or equivalents]

6. Ternary chalcogenides containing this element which are being investigated as potential thermoelectric materials are Chevrel phases. A combination of this element’s hexacarbonyl and resorcinol was superseded by an alkylidyne complex of this non-tungsten metal as an alkyne metathesis catalyst. This element is bound to four sulfur atoms in the active site of DMSO reductase. Atoms of this element adopt trigonal prismatic coordination in the most common form of its disulfide. This element’s disulfide comprises (\*) layers which are being touted as possible alternatives to graphene. This element and chromium alloy with iron to form a family of steels with high strength-to-weight ratios. For 10 points, name this group 6 metal found with iron in FeMoco.

ANSWER: molybdenum [accept Mo]

7. In his 2015 book *A Beautiful Question*, Frank Wilczek challenges any physicist who “bloviates about his Theory of Everything” to explain this constant. The asymmetry of Moller scattering can be written in terms of a similar quantity to this one named for Weinberg. The Wolfenstein parameter lambda is defined in terms of this value and has the advantage that it is of order one. The GIM mechanism explained K-zero to mu-mu decay using two diagrams with amplitudes proportional to the (\*) sine of twice this value. This quantity, which has an accepted value of roughly 13 degrees, corresponds to the Euler angle theta-one-two in the standard parametrization. This value parametrizes the relative degree to which the down and strange quarks mix with the up quark. For 10 points, name this angle named for the C in the CKM matrix.

ANSWER: Cabibbo angle [accept theta-one-two until read]

8. This scientist discovered the Sculptor and Fornax dwarf galaxies, as well his own namesake dense supercluster of galaxies in the constellation Centaurus. In his doctoral thesis, he calculated the orbits of an unprecedented 90 spectroscopic binary star systems. This astronomer referred to one of his ideas as the “liquid water belt” theory. He based one of his ideas on Adriaan van Maanen’s measurements of the rotation rate of the (\*) Pinwheel Galaxy. This astronomer originated the idea of a planetary “habitable zone” around a star. This man made the first reasonable estimate for the distance to the center of the Milky Way, but in his most famous appearance he incorrectly argued that the Milky Way contained the entire universe. For 10 points, name this astronomer who faced off against Heber Curtis in the Great Debate.

ANSWER: Harlow Shapley

9. A protocol maintains one variant of this data structure by ensuring that a nodes “fingers” are correct through a stabilize function. That Chord protocol defines a “distributed” variant of this data structure that is used in many peer-to-peer clients. One over the quantity one minus alpha is the upper limit on the number of operations for insertion in the “open” method of designing this data structure. A sum involving 31 to the power of quantity  $n$  minus  $i$  minus 1 is used in the default Java implementation for one operation using this data structure. This data structure can handle insertion failures through (\*) quadratic or linear probing. The performance of this data structure can be defined in terms of the load factor. Each index of this data structure is replaced with a linked list in the chaining variety of them. When two different keys specify the same index in this data structure, collisions can occur. For 10 points, name this data structure that uses a namesake function on keys in order to insert and fetch values in constant time.

ANSWER: hash tables [accept hash map or hash set]

10. A 10-kilodalton glycoprotein member of the uteroglobin gene family that is only expressed in this organ is overexpressed in a form of cancer. A thrombophlebitis in the superficial veins of this organ is termed Mondor’s disease. The basic structural unit of this organ is the TDLU, or the terminal ductal lobular unit. The structural integrity of this organ is maintained by Cooper’s ligaments. A keratin plug normally blocks a duct in this organ that is lined with a columnar epithelium supported by (\*) myoepithelial cells. It’s not the eyelid, but one consequence of aging is the ptosis of this organ. This organ contains modified sweat glands called Montgomery’s glands. One difficult-to-treat cancer of this organ is termed “triple negative,” but most cancers of it overexpress the Her2/neu receptor. Its exterior surface contains a pigmented region known as the areola. For 10 points, name this organ in female mammals that produces milk.

ANSWER: breast [or mammary gland]

11. Chiral Chern–Simons theory predicts that this phenomenon has nonzero values for its two-point EB and TB correlation functions. Lue (“lway”), Wang, and Kamionkowski proposed using observations of this phenomenon to measure parity violation. The scalar spectral index of this phenomenon is roughly 0.967, differing from 1 at a five-sigma confidence level. Both the BOOMERanG experiment and the Very Small Array measured this phenomenon. Mather and Smoot won a Nobel Prize for finding (\*) anisotropies in this phenomenon using the COBE satellite. BICEP2’s discovery of B-mode polarization in this phenomenon was later discredited. This phenomenon originates from the surface of last scattering and has a blackbody temperature of 2.7 kelvins. For 10 points, name this omnipresent radiation left over from 380,000 years after the Big Bang.

ANSWER: cosmic microwave background radiation [or CMBR]

12. To improve solubility in organic solvents, a carboxylic acid group in this compound was replace with two phenyl motifs and an O-TMS motif in the Jorgensen–Hayashi catalyst system. It’s not glutamic acid, but one stereoisomer of this compound is the starting point for the synthesis of SAMP. An early example of chiral organocatalysis was the use of this compound as a catalyst in an EXTREMELY eponymous asymmetric aldol variant known as the (\*) Hajos–Parrish–Eder–Sauer–Wiechert reaction. Carbonyls can be stereoselectively reduced by borane and the CBS catalyst, which is derived from this compound. This compound and a hydroxylated derivative of it are found in high concentrations in collagen, since they allow for sharp twists in the peptide chain. Containing a secondary amine, for 10 points name this amino acid with a pyrrolidine side chain.

ANSWER: proline [or Pro; prompt on “P”]

13. The adjoint of an operator has this property everywhere that it is defined, and if an operator  $A$  has this property, then  $A$ -double-dagger equals  $A$ . In Sturm–Liouville theory, differential operators notably lack this property, which is identical to continuity in that context. For a linear operator  $L$ , this property is evaluated by examining the ratio of the norm of “ $L$  of  $v$ ” to the norm of  $v$ . Every entire function with this property must be constant according to (\*) Liouville’s theorem. We say that  $f$  of  $x$  is “big-O of  $g$  of  $x$ ” if  $f$  of  $x$  over  $g$  of  $x$  has this property. A subset of a Euclidean space is compact if and only if it is closed and has this property according to the Heine–Borel theorem. A strong version of this property is possessed by sequences with an infimum and a supremum. For 10 points, name this property of functions that don’t get arbitrarily large.

ANSWER: boundedness

14. Seidel and Lee showed how domain-wall defects in one-dimensional systems can behave as these particles. Read and Green first predicted the existence of these particles in  $p$  plus  $ip$  superconductors. A Kitaev chain can support self-adjoint Majorana zero modes that act as these particles, which have also been predicted to exist in the Moore–Read state with filling factor five-halves. Varieties of these particles correspond to different representations of “the” (\*) braid group. Abelian examples of these particles have been observed. Braiding operations on non-abelian ones can be used as gates in topological quantum computers. They can only arise in two dimensions, and they may acquire a complex phase when they are exchanged. For 10 points, name these quasiparticles whose arbitrary exchange phase generalizes the fermion-boson distinction.

ANSWER: anyons [prompt on any answers mentioning “Majorana” until read]

15. When discussing these things, the Dyson index identifies which class of them we are talking about. An Altland–Zirnbauer ensemble is a collection of these things. The zeros of the Riemann zeta function follow the same pair correlation function as a set of these things according to a conjecture of Hugh Montgomery. Freeman Dyson distinguished three ensembles of these things based on whether they respect time-reversal or rotation invariance. The Bohigas–Giannoni–Schmit conjecture asserts that the spectra of chaotic quantum systems have the same statistics as the spectra of (\*) these things. Sampling from the Gaussian unitary ensemble yields a Hermitian one of these objects. Eugene Wigner pioneered describing the spectra of complex nuclei using the eigenvalue distributions of these things. For 10 points, name these rectangular arrays of stochastically-selected values.

ANSWER: random matrices [prompt on “matrices”]

16. In a re-evaluation of this problem, Robert Pennock dismissed another philosopher’s critique of *McLean v. Arkansas*. Massimo Pigliucci invoked Wittgenstein’s theory of family resemblances in response to the article delivering that critique, which claimed that philosophy has failed to solve this problem. In discussing this problem, sociologist Thomas Gieryn coined the term “boundary-work.” Paul Thagard enumerated two conditions in his attempt to resolve this issue, the second of which concerns (\*) practitioners who ignore external input. Larry Laudan wrote about the “demise” of this problem. Thomas Kuhn situated this problem in the context of puzzle-solving. In *The Logic of Scientific Discovery*, Karl Popper rejected verifiability in favor of falsifiability as the sole criterion for solving this problem. For 10 points, name this problem in the philosophy of science that asks how to distinguish science from non-science.

ANSWER: demarcation problem

17. A problem involved with this task can be solved either by squatting or by standing on a box, which might cause physical discomfort or humiliation, respectively. In an ideal model of this task, a rubber band encloses two perfect circles. Stanford mathematicians Dinesh Chugtai and Bertram Gilfoyle published a paper about this task after consulting with Mike Judge. In order to optimize this task, different (\*) d2f ratios must be set equal to one another. A conversation about mathematically modeling this task results in a program achieving a 5.2 Weissmann score, because it inspires Richard to get rid of everything but the compression engine. This task is optimized by maximizing girth similarity and works best if the person performing it can maneuver four objects aligned tip-to-tip. For 10 points, name this action which Erlich contemplates doing to every male in the Startup Battlefield audience so that Pied Piper can win in the season one finale of *Silicon Valley*.

ANSWER: jerk every man in the Startup Battlefield audience [accept clear knowledge equivalents]

18. The host specificity of these organisms is controlled by the Sym plasmid, which some of them use to produce inositol derivatives for free-living conspecifics, and many of these organisms hoard PHB. Depending on whether they contain a meristem, the structures that house these organisms may be determinate or indeterminate. The partner choice and host sanctions hypotheses have been proposed to explain why these organisms do not (\*) cheat more. In response to flavonoids, these organisms secrete Nod factors. Because oxygen inhibits an important enzyme in these organisms, they use an enzyme to buffer oxygen concentrations. That enzyme, leghemoglobin, gives the structures bearing these organisms their pink color. The main function of these organisms is performed by a reductase and another enzyme. For 10 points, name these nitrogen-fixing bacteria that live in nodules on the roots of legumes.

ANSWER: rhizobia [accept answers consisting of a prefix followed by "Rhizobium"]

19. Instanton contributions to the path integral go like *this function* of one over the coupling, which is why they don't show up at any order in perturbation theory. In parametric resonance, when the modulation is tuned to the principal resonance, the energy has this time dependence. The Debye–Waller factor may be written as this function of the B factor times sine of theta over lambda. The bound states of the Dirac delta function potential has this spatial dependence on either side of the well. The magnetic field inside a (\*) superconductor goes like this function of the length of penetration. The charge of an initially charged capacitor in an RC varies like this function of time. The Boltzmann factors are equal to this function of energy times beta. The wavefunction of tunnelling particles falls off like this function. For 10 points, name this function in physics that characterizes a very fast "decay."

ANSWER: decaying exponential [or things like e to the power of negative something; accept hyperbolic cosine or hyperbolic sine or cosh or sinh because of the differential equation clues]

20. To design drugs targeting one member of this class of enzymes, the "bump-and-hole" approach was made. Myelin basic protein is a common substrate in assays of this type of enzyme. These enzymes target the Phocis coding region in a variant of FRET. Metallofluorides are analogues of their transition states, which have beta, gamma-bridging oxygens. "Gatekeeper" residue mutations grant organisms resistance to cancer drugs that inhibit this type of enzyme. These enzymes have conserved lysine and aspartate residues in their active sites, which help their deprotonated serines form (\*) pentavalent phosphorane intermediates. Bisubstrate analogues of these enzymes include phosphonates like phosphotyrosine. Radiolabeled gamma-32-P-ATP concentrations measure these enzymes' activities, which are opposed by phosphatases. For 10 points, name this family of enzymes that phosphorylate amino acids.

ANSWER: kinases [accept any type of kinase]

21. Redistribution reactions involving chlorides of this metal are called Kocheshkov comproportionations. Four atoms of this metal and four isothiocyanate ligands are present in a transesterification catalyst named for Junzo Otera. It's not phosphorus, which isn't even a metal, but triphenyl- compounds of this metal are commonly used antifouling agents. AIBN removes a hydride atom from its (\*) tributyl derivative to form the catalyst for the Barton–McCombie deoxygenation. This metal has the greatest number of stable isotopes of any element, at 10. This group 14 metal prefers to exist in the +2 oxidation state in a classic example of the inert pair effect. The palladium-catalyzed cross-coupling of compounds with this metal is termed the Stille reaction. The Meissner effect was first observed in superconductors of this metal. For 10 points, name this metal, present in organic compounds known as stannanes.

ANSWER: tin [accept Sn]

22. Aphanitic materials in these rocks with a value of less than 62.5 of a certain unit are counted in the statistical Gazzi–Dickinson method. The framework mineralogy of this rock is represented vertically on three receding triangles of different levels of percent matrix in the Dott classification. This rock can be classified by a distribution mostly within values of negative one to four phi units on the logarithmic Udden–Wentworth scale. A matrix-rich type of this rock is known as a graywacke (“gray wack-uh”). Lithic fragments make up the right corner of a triangular diagram used to classify this rock known as a (\*) QFL diagram. A variety of this rock composed of over 25 percent feldspar is called arkose. This rock becomes quartzite after metamorphism. For 10 points, name this sedimentary rock composed of grains larger than silt but smaller than gravel, often found in deserts or beaches.

ANSWER: sandstones [accept arkose sandstone, accept psammite or arenite]

23. A class of these devices invented by Barger and Bergquist uses neutral calcium and the four-beam optical technique. The highest-quality one of these devices to date makes use of ytterbium atoms trapped in an optical lattice. They're not used in NMR, but a type of these devices applies a pair of pi-over-2 pulses separated by a non-interaction zone, and locates the applied frequency when the detuning is zero. Norman Ramsey invented the separated oscillatory field method for use in one type of these devices. The hydrogen (\*) maser served as an early one of these devices. The particles used in these devices are thrown up by an atomic fountain and probed by microwave radiation as they come down. NIST-F1, the official one of these devices for the United States, uses the hyperfine transition of cesium-133 to set a standard value for the second. For 10 points, name these extremely accurate timepieces based on electronic energy level transitions.

ANSWER: atomic clocks [prompt on “clocks”]

24. The Bax group has developed a software called SPARTA to predict these values. Shoolery's rule is a good way to approximate this value for a methylene group. David Wishart developed a computational tool for identifying protein secondary structures, named for the “index” of this value. Conduction electrons in metal produce a phenomenon related to this one, named for Walter (\*) Knight. Dipolar coupling, the quadrupole interaction, and the anisotropy of this value are the three main interactions in magic angle spinning. This value is higher for groups that are deshielded. Tetramethylsilane is the internal standard for calibrating this value for proton NMR. For 10 points, name this value measured in ppm, used in identifying functional groups in NMR.

ANSWER: chemical or NMR shift