Questions written

The Theil–Sen estimator is a regression line with slope equal to this quantity for a certain set of lines' slopes. For a random variable *X*, the expectation of the absolute value of quantity *X* minus *a* is minimized when *a* equals this quantity for *X*. This quantity can be estimated in linear time with an algorithm named "this quantity" of "this quantities." This quantity is the *n* over 2 order statistic. This quantity is the most resistant statistic because it is (*) robust against outliers. In a box plot, the line inside of the box shows this quantity. This statistic for a data set equals its fiftieth percentile. For 10 points, name this measure of centrality that serves as a common alternative to the mean and the mode.
ANSWER: **median**s [accept **median of medians**; prompt on "fiftieth percentile" before "fiftieth" is read]
<DB, Science - Math> [Ed. DB]

A "parking garage" structure is possessed by Terasaki ramps in this organelle. In eukaryotes, signal recognition particles target proteins to this organelle which is also the organelle where the final step of gluconeogenesis occurs. Vesicles secreted by this organelle are coated with COPII ("cop-two") proteins. Muscle cells contain a (*) "sarcoplasmic" form of this organelle. It's not the mitochondria, but detoxification most commonly occurs in this organelle. Vesicles from this organelle are transported to the *cis* ("sis") face of the Golgi apparatus. Membrane-bound ribosomes adhere to this organelle. For 10 points, the nucleus in many cells is surrounded by what organelle with "smooth" and "rough" varieties?
ANSWER: **endoplasmic reticulum** [or **ER**; accept **smooth ER**, **SER**, **rough ER**, or **RER**; accept aforementioned answers with "**endoplasmic reticulum**" instead of "**ER**" prompt on sarcoplasmic reticulum or SR]
<DB, Science - Biology> [Ed. JF]

The trapezoid body precedes the superior olivary nucleus in a pathway found in this structure. Linear areas of bleeding in this structure characterize Duret hemorrhages. Climbing fibers *originate* in this structure and innervate Purkinje cells in another structure. Parkinson's disease is characterized by the loss of dopaminergic neurons in this structure's (*) substantia nigra. One part of this structure controls heart rate and breathing. Cerebellar peduncles connect the cerebellum to this structure which connects with ten cranial nerves and is a conveyor of important pathways such as that controlling motor function. For 10 points, name this structure comprised of the medulla, pons, and midbrain, which connects the cerebrum to the spinal cord.
ANSWER: human **brain stem** [prompt on brain; anti-prompt on medulla oblongata, pons, or midbrain before mentioned with "What larger structure contains the [answer given]?"]
<DB, Science - Biology> [Ed. JF]

A one-form is a functional with this property. Functions with this property have homogeneity of degree one and are additive. An affine function equals the sum of a constant function and a function with this property. The span of a set of vectors *X* is the set of all "combinations" named for this property of vectors in *X*. A "general" group named for this property contains all invertible *n*-by-*n* (*) matrices, for some natural number *n*. Matrices represent transformations between vector spaces with this property. Matrices are primarily studied in a field of mathematics named for "algebra" with this property. For 10 points, name this property that describes the graph of the equation *y* equals *m x* plus *b*.
ANSWER: **linear**ity [accept **linear function**als, **linear combination**s, **general linear group**s, **linear transform**ations, or **linear algebra**; accept lines after the entire tossup has been read; prompt on GL*n*]
<DB, Science - Math> [Ed. DB]

A synthetase named for this molecule binds to its D arm. Rules explaining how this molecule binds to smaller parts of another molecule are provided by the wobble hypothesis, which describes the role of inosine in this molecule in three of the four wobble base pairs. Class I release factors mimic this molecule to bind to a certain

site blocking this molecule from binding. The (*) cloverleaf model describes the secondary structure of this molecule. The A-, P-, and E-sites of a certain organelle are binding sites for this molecule. During translation, codons are recognized by anticodons on the "aminoacyl" type of this molecule. For 10 points, name this molecule that brings amino acids to the ribosome during translation.
ANSWER: **tRNA** [or **aminoacyl-tRNA**; accept **aminoacyl-tRNA synthetase**; prompt on RNA; accept aforementioned answers with "ribonucleic acid" instead of "RNA" or "transfer" instead of "t"]
<DB, Science - Biology> [Ed. JF]

The *x*-axis of the TAS diagram is the percent weight of a compound containing these *two* elements. Kyanite and andalusite are polymorphs of a compound containing aluminum and these two elements. The relative content of a compound containing these two elements distinguishes andesite from basalt. (*) Opal is an amorphous hydrate of a compound containing these two elements. These two elements and aluminum are present in all feldspars and these two elements are in the chemical formula for quartz. These two elements are the most abundant two elements in the Earth. The most common constituent of sand is these two elements. For 10 points, name these two elements found in silica.
ANSWER: **silicon** and **oxygen** [or **Si** and **O**]
<DB, Science - Other Science (Earth Science)> [Ed. JF]

Stephen Bustin developed the MIQE guidelines to prevent the publication of unreproducible results from the "quantitative real-time" form of this technique. DMSO is used in this technique to reduce thermostability due to high GC-content. The development of this technique was enabled by the isolation of a certain enzyme found in a bacteria in a Yellowstone National Park geyser, (*) *Thermus aquaticus*. This technique is performed in a thermocycler that iterates through three temperature settings in order to allow for denaturation, annealing, and elongation stages. For 10 points, name this most common technique used to amplify DNA samples.
ANSWER: **PCR** [or **polymerase chain reaction**; accept **qRT-PCR**, **qPCR**, or **RT-PCR**; accept aforementioned answers with "**polymerase chain reaction**" instead of "**PCR**"]
<DB, Science - Biology> [Ed. JF]

Wilson's theorem gives that a number *n* is prime if and only if this function of quantity *n* minus one equals negative one mod *n*. The *n*th derangement number equals this function of *n*, divided by *e*, rounded to the nearest integer. Stirling's formula approximates this function. The order of the *n*th symmetric group equals this function of *n*. The denominator of the *n*th term of a (*) Taylor series is this function of *n*. This function is applied to all terms in the formula for binomial coefficients. The number of permutations of *n* distinct objects equals this function of *n*. For 10 points, name this function of a natural number *n* that equals the product of all natural numbers less than or equal to *n*.
ANSWER: **factorial** [anti-prompt on gamma function; reject "subfactorial"]
<LM + DB, Science - Math> [Ed. DB]

They're not bacteria, but some of these organisms have a type of antenna called phycobilisomes ("phyco-billa-somes"). Coral bleaching occurs when coral polyps expel a type of these organisms called zooxanthellae ("zoh *ox* anthellay"). Diatoms ("*die*-a-tom") are a group of these organisms that are responsible for 20 to 50 percent of oxygen produced on Earth. The study of these organisms is phycology. (*) Lichens ("likens") consist of fungi and either cyanobacteria or these organisms. Eutrophication is commonly detected by the presence of "blooms" of these organisms. Cyanobacteria are sometimes erroneously referred to as the "blue-green" type of these organisms. For 10 points, name this broad category of aquatic photosynthetic eukaryotes that includes seaweeds and red and green groupings.
ANSWER: **algae** [accept **microalgae** or **algal bloom**s; prompt on eukaryotic organisms or phytoplankton]
<DB, Science - Biology> [Ed. JF]

In category theory, compositions of functions that have this property can be written as sequences of arrows that start and end at the same objects. The center of a group is the set of its elements for which the group operation has this property. In ring theory, performing an operation named for this property on ring elements *a* and *b* yields *a*-dot-*b* minus *b*-dot-*a*. A group is (*) abelian ("a-*beel*-ian") if its operation has this property. In a field, addition and multiplication have distributivity, associativity, and this property. Subtraction has the "anti-" form of this property because *a* minus *b* equals negative quantity *b* minus *a*. For 10 points, name this property of certain operations, exemplified by *a* plus *b* equals *b* plus *a*.
ANSWER: commutativity [accept **commutative**, **commute**, **commuting**, **commutative diagram**; prompt on commutator]
<DB, Science - Math> [Ed. DB]

The Lebesgue ("le-*beyg*") form of this operation can be visualized as stacking horizontal rectangles, while its Riemann form can be visualized with vertical rectangles. For 10 points each:
[10e] Name this operation that gives the area under the curve of a given function.
ANSWER: integration [or **integral**, **Riemann integration**, **Riemann integral**, **Lebesgue integration**, or **Lebesgue integral**]
[10m] Performing Riemann integration with right trapezoids instead of rectangles overestimates the area under the curve where the function has this property. Functions with this property have positive second derivatives.
ANSWER: convex [or **concave up**]
[10h] Riemann integration of a function of the reals is defined on one of these increasing sequences of points, which serve as the horizontal bounds of rectangles. If one of these objects P contains all of the points in Q, then P is a refinement of Q.
ANSWER: partition of an interval [or **refinement** of a **partition**]
<DB, Science - Math> [Ed. DB]

Concentrated solar power can be achieved with parabolic troughs ("troffs") consisting of these objects. For 10 points each:
[10e] Name these objects, often contrasted with lenses, that can be used to reflect sunlight towards solar cells.
ANSWER: mirrors
[10m] Parabolic troughs are positioned such that solar cells are at this point, where parallel rays reflected by the mirror all meet.
ANSWER: focal point [accept principal **focus** or **image point**]
[10h] This scientist invented a lens to concentrate light from a central source with dioptric ("die-*op*-trick") and catadioptric ("*cat*-a-die-*op*-trick") prisms. This scientist lends their name to a near-field diffraction model, contrasted with Fraunhofer's ("*frown*-hoffer's") far-field diffraction.
ANSWER: Augustin-Jean **Fresnel** ("fray-*nell*")
<DB, Science - Physics> [Ed. SB]

With Gauss, (rhymes with "house"), this mathematician names a theorem giving conditions under which the ordinary least squares estimator is the minimum-variance unbiased estimator. For 10 points each:
[10m] Identify this mathematician whose namesake "chains" are stochastic processes in which the probabilities of future states are determined only by the current state.
ANSWER: Andrey (Andreyevich) **Markov** [accept **Gauss–Markov theorem**, **Markov chain**s, or **Markov** processes]
[10e] A common example of a Markov chain is a "walk" with this property. Variables with this property take on unpredictable values based on a probability distribution function.
ANSWER: randomness [or **random walk**s or **random variable**s]

[10h] This model, central to financial mathematics, predicts European-style call option prices with the assumption that the distribution of instruments' prices follows a random walk with constant drift and velocity.
ANSWER: Black–Scholes model [accept **Black–Scholes** equation]
<DB, Science - Math> [Ed. DB]

This experiment observed a peak intensity value at 50 degrees and 54 electronvolts. For 10 points each:
[10h] Name this experiment that confirmed de Broglie's ("de *broy's*") hypothesis that electrons exhibit wave-like behavior by measuring diffraction patterns produced by electrons fired from a tungsten filament at a nickel crystal.
ANSWER: Davisson–Germer experiment
[10m] The intensity peaks observed in the Davisson–Germer experiment agree with this law, which describes the scattering of waves by a crystal lattice with the equation "*n* lambda equals two *d* sine theta."
ANSWER: Bragg's law [or **Bragg**'s equation]
[10e] Davisson and Germer detected electrons with a "cup" named for this scientist. Conducting "cages" that block electromagnetic fields are named after this English physicist.
ANSWER: Michael **Faraday** [accept **Faraday cup** or **Faraday cage**]
<DB, Science - Physics> [Ed. SB]

The "type-II" variety of these materials can levitate due to flux pinning. For 10 points each:
[10e] Name these materials, which often have to be kept near absolute zero, that exhibit zero electrical resistance.
ANSWER: superconductors
[10h] Upon being cooled below its superconducting transition temperature, a material expels the magnetic field inside of it via an effect named for this scientist. A superconductor containing no magnetic field is in this scientist's namesake "state."
ANSWER: (Fritz) Walther **Meissner** [accept **Meissner effect** or **Meissner state**]
[10m] BCS theory describes type-I superconductors as a condensate of Cooper pairs, in which pairs of electrons act as bosons, and thus do not obey this law. This law states that no two fermions in a solid can have identical energy states.
ANSWER: Pauli exclusion principle [prompt on exclusion principle]
<DB, Science - Physics> [Ed. DB]

A "hypothesis" named for this property is often assumed in computational physics so that the average value of a property over time can be set equal to its average value over the statistical ensemble. For 10 points each:
[10h] Name this property of a physical system that visits all of its possible states uniformly and randomly.
ANSWER: **ergodic**ity [accept **ergodic hypothesis**]
[10m] This scientist, the father of thermodynamics, formulated the ergodic hypothesis. The speeds of particles in an ideal gas follows a distribution named for this scientist and Maxwell.
ANSWER: Ludwig (Eduard) **Boltzmann** [or **Maxwell–Boltzmann** distribution]
[10e] The speed of a given particle equals the magnitude of this quantity for the particle.
ANSWER: **velocity** [prompt on *v*]
<DB, Science - Physics> [Ed. DB]

Approximately 500 trillion of these particles will pass through my body while I read this sentence. For 10 points each:
[10m] Name these nearly massless fermions that come in electron, muon, and tau flavors.
ANSWER: **neutrino**s [accept **electron neutrino**s, **muon neutrino**s, or **tau neutrino**s]
[10h] Via this phenomenon, a neutrino's flavor may change over time. This phenomenon causes observatories to detect fewer electron neutrinos from the Sun than would be expected in its absence.
ANSWER: neutrino **oscillation**

[10e] Many neutrinos on Earth originate from the first step of the Sun's fusion process, which is named for these particles. The nucleus of an atom contains neutrons and these particles.
ANSWER: **proton** [accept **proton–proton** chain reaction; prompt on p or p–p chain reaction]
<DB, Science - Physics> [Ed. DB]

Questions edited (original authors' initials are given in angle brackets)

The master theorem can be used to calculate this quantity for certain recurrence relations. Amortized analysis estimates this quantity in the average case, thus ignoring worst-case scenarios. A problem is in the complexity class P if it admits a solution for which this quantity is bounded above by a polynomial of *n*. (*) Bachmann–Landau notations like Big O notation provide bounds for space complexity and this quantity, which are expressed as "*n* times log-*n*" for certain sorting algorithms. The number of operations that an algorithm performs is, for 10 points, what quantity most often used to estimate how long an algorithm takes to run?
ANSWER: **runtime** [accept **time** complexity, **polynomial time** complexity, **average-case** run**time**, or **worst-case** run**time**; prompt on big O with "what quantity is most commonly represented in big O notation?"]
<LM, Science - Other Science (Computer Science)> [Ed. DB]

Zeta function regularization can be applied to define a quantity relevant to certain mathematical objects with this property. An operator that shares its name with this property equals the trace of the Jacobian matrix of a given vector field. Replacing certain terms with their successors and then combining them to achieve a contradiction is used in a proof that the (*) harmonic series has this property. A geometric series has this property if its common ratio has magnitude greater than or equal to one. The sequence of partial sums of a series with this property does not have a finite limit. For 10 points, name this property of a series that does not converge.
ANSWER: **divergence** [accept **diverge**s; accept descriptions of the **opposite** of **convergence**; prompt on div; prompt on answers describing a series whose limit is either infinite or undefined]
<LM, Science - Math> [Ed. DB]

This operation and "NOT" make up the "bit clear," or "BIC," A · R · M assembly instruction. The "NOR" operator and the (emphasize) *complement* of this operator are functionally complete. The logic gate that implements this operation is symbolized with a half square, half semicircle shape. In logic, this operation is known as (*) conjunction. Performing this operation on an input and its complement always produces "false" because this operation only produces "true" if both of its inputs are "true." For 10 points, name this boolean operation symbolized by an ampersand.
ANSWER: **AND** [accept bitwise **AND**, logical **AND**, short-circuit **AND**; or logical **conjunction** before read]
<LM, Science - Other Science (Computer Science)> [Ed. DB]

You and I are hosts to a fungal community called a mycobiome. For 10 points each, answer some questions about the fungus among us.
[10e] The *Malassezia* ("mal-a-*seeja*") fungus found naturally on the skin can cause this common condition in which skin cells flake off of the scalp.
ANSWER: dandruff [accept seborrheic **dermatitis**, **pityriasis capitis**, or **scurf**]
[10h] Humans host this genus of yeast among their gut flora, which is the most common cause of fungal infections in humans. Members of this genus accumulate in growths called thrushes, which can cause white oral lesions.
ANSWER: *Candida*
[10m] Filamentous fungi like *Aspergillus* ("asper-*jillus*") colonize the airways of people with this genetic disorder that primarily affects the lungs. Sweat tests screen for this disorder by measuring chloride content.
ANSWER: cystic fibrosis [or **CF**]
<PQ + SB, Science - Biology> [Ed. DB]

In early 2020, researchers at the Technion – Israel Institute of Technology created a biological computer using cells of this bacteria. For 10 points each:
[10e] Name this rod-shaped bacteria that serves as a common model organism in microbiology. Food poisoning from undercooked ground beef is primarily caused by this bacteria.
ANSWER: *E. coli* [or ***Escherichia coli***]
[10h] The researchers created the computer by restructuring these enzymes in *E. coli*. This class of bioluminescence-producing enzymes, which includes a "firefly" type, is contrasted with photoproteins.
ANSWER: bacterial **luciferase**s [accept firefly **luciferase**]
[10m] The *E. coli* computer successfully detected nalidixic acid, which is a synthetic quinolone type of these compounds. These compounds are often used in combinations like amoxicillin ("a-*mock*s-a-sillin") with potassium clavulanate ("clav-*you*-la-nate").
ANSWER: antibiotics [or fluoro**quinolone antibiotics**; prompt on antimicrobials; prompt on bactericides, bacteriocides, or Bcidals; reject "antiseptics" or "antibodies"]
<SB, Science - Biology> [Ed. DB]

At least 65 essays in computer science have titles playing on the title of Edsger Dijkstra's ("*edz*-ger *dike*-stra's") essay "[this statement] Considered Harmful." For 10 points each:
[10m] Name this statement, which Dijkstra described as "an invitation to make a mess of one's program." This statement causes the compiler to jump to a designated label.
ANSWER: **go to** statement [or **goto** statement]
[10e] Jonathan Amsterdam wrote that this programming language's "new" keyword is "considered harmful." This language has a coffee cup as its logo.
ANSWER: **Java** [reject "JavaScript"]
[10h] Alexander Rush criticized deep learning frameworks with the blog post "[this variable type] Considered Harmful." A popular open-source machine learning library is named "[this variable type]·Flow."
ANSWER: **tensor**s [accept **Tensor**Flow]
<LM, Science - Other Science> [Ed. DB]

This drug is thought to suppress SALL4 in fetal cells, leading to phocomelia in the fetus if taken during the first trimester of pregnancy. For 10 points each:
[10h] Name this birth defect-inducing drug, whose behavior as an angiogenesis inhibitor allows it to be used as a cancer drug. FDA reviewer Frances Kelsey prevented this drug from entering US markets.
ANSWER: thalidomide [accept **Contergan** or **Thalomid**]
[10e] More than 10,000 children were born with deformities due to the use of thalidomide in order to alleviate this side effect of pregnancy. Despite its name, this feeling of nausea can occur at any time of day.
ANSWER: morning sickness [accept **nausea and vomiting of pregnancy** or **NVP**]
[10m] Morning sickness is also observed in people undergoing this therapy, indicating that it may be due to heightened estrogen levels. This therapy is used to treat gender dysphoria and symptoms of menopause.
ANSWER: hormone replacement therapy [or **HRT**, accept post**menopausal hormone therapy**, accept **transgender hormone therapy** or **gender-affirming hormone therapy** or **GAHT**, accept **feminizing hormone therapy**, prompt on hormone therapy]
<SB, Science - Biology> [Ed. DB]

The Laplace transform converts signals to the *s*-domain from the *t*-domain, where *t* typically represents this quantity. For 10 points each:
[10e] Name this quantity, whose inverse is frequency, that can be measured in seconds.
ANSWER: **time**

[10m] The Laplace transform can be used to solve this type of differential equations, which do not involve partial derivatives. Solutions to these equations can be approximated by Runge–Kutta methods like the Euler method.
ANSWER: **ordinary** differential equations [accept **ODE**s]
[10h] A "cover-up" method named for this mathematician can be used to perform partial fraction decomposition when calculating the Laplace transform of a function. This mathematician names a step function whose bilateral Laplace transform equals one over *s*.
ANSWER: Oliver **Heaviside** [accept **Heaviside cover-up method** or **Heaviside step function**]
<QP, Science - Math> [Ed. DB]

Hungry? For 10 points each, answer the following about food-derived terms in physics.
[10h] Name this property of an elementary particle that distinguishes it either from other leptons or from other quarks. A quark can have this property changed via a W boson interaction, but not a Z boson interaction.
ANSWER: flavor [or **flavor quantum number**]
[10e] J. J. Thomson proposed this atomic model in which electrons are embedded in a solid, positively charged substance. This atomic model was replaced by the Rutherford model.
ANSWER: plum pudding [prompt on partial answers]
[10m] Stephen Hawking used this food to describe what happens to an astronaut near a black hole as the non-homogeneous gravitational field induces vertical stretching.
ANSWER: spaghetti [accept **spaghettification**, **noodle**s, or **noddle effect**]
<PQ, Science - Physics> [Ed. DB]

For 10 points each, answer some questions about notable women in marine biology.
[10h] This author wrote several acclaimed books on marine biology, including *The Sea Around Us*. This author also wrote a book documenting how chemical companies attempted to hide the carcinogenic effects of DDT.
ANSWER: Rachel **Carson** [full name Rachel Louise **Carson**] (The book is *Silent Spring*.)
[10m] Ángeles Alvariño ("*ann*-hey-less al-va-*ree*-nyo") was a leading expert on these organisms, which cannot propel themselves against a current. These organisms are the primary food source of most filter feeders.
ANSWER: plankton [accept **zooplankton**, **phytoplankton**, or **plankter**s]
[10e] Eugenie Clark spent most of her career promoting conservation of this class of fish, which includes "hammerhead" and "great white" types.
ANSWER: sharks [or ***Selachimorpha***; accept hammerhead **shark**s or great white **shark**s or ***Sphyrnidae*** or ***Carcharodon*** *carcharias*]
<PQ + SB, Science - Biology> [Ed. DB]

The convention of representing this quantity as flowing from positive to negative comes from an arbitrary description made by Benjamin Franklin. For 10 points each:
[10m] Kirchoff's junction rule equates certain sums of what quantity?
ANSWER: electric **current** [prompt on *i*]
[10h] Franklin was also among the first to propose this principle that forms the basis for Kirchoff's junction rule. This principle can be expressed as the continuity equation "*dQ*-*dt* equals *q*-sub-in minus *q*-sub-out."
ANSWER: conservation of charge [or **charge conservation**; accept answers describing how electric **charge cannot be created or destroyed**]
[10e] Franklin is widely credited as inventing a device containing a rod that attracted this natural phenomenon. He flew a kite with a key attached to it in order to prove that this phenomenon is a discharge of electricity.
ANSWER: lightning [accept **lightning** rod]
<LM, Science - Physics> [Ed. DB]

Two of the largest flowers in the world, the titan arum and the rafflesia, ("ra-*flee*-sha"), share this nickname. For 10 points each:

[10h] Give this common name for the category of plant that includes the titan arum and the genus *Stapelia*, which are known for their fuzzy, dark-red appearance and characteristic odor.
ANSWER: carrion flowers [or **corpse** flowers or **stinking** flowers]
[10m] Carrion flowers mimic rotting corpses in order to trick scavengers into facilitating this process. Colony collapse disorder is a major factor in the decline of organisms that facilitate this process.
ANSWER: pollination [accept word forms; accept **pollinator**s; prompt on word forms of reproduction and fertilization]
[10e] These insects are the best-known pollinators. Apiarists maintain colonies of this genus of insects, which produce a namesake sugary substance by regurgitating nectar.
ANSWER: honey bees [or ***Apis***; accept specific species of genus ***Apis***; prompt on bees; reject "bumblebees" or other specific kinds of bees]
<SB, Science - Biology> [Ed. DB]

For sufficiently large sample sizes, the sample mean of independent observations from any population follows this distribution. For 10 points each:
[10e] Name this continuous, bell-shaped distribution whose standard deviations follow the 68-95-99.7 rule.
ANSWER: **normal** distribution [or **Gaussian** distribution or Laplace-**Gauss** distribution]
[10m] The standard normal distribution, which has a mean of zero and a variance of one, is named for its correspondence with these quantities. This quantity for an observation *x* and a normal distribution with mean *mu* and standard deviation *sigma* equals "quantity *x* minus *mu*" over *sigma*.
ANSWER: **Z**-scores [or **Z**-values, **standard score**s, **normal score**s, or **standardized variable**s]
[10h] The error function can be derived from this function for a certain normal distribution. This function for a random variable *X* gives the probability that *X* is less than or equal to a given value.
ANSWER: **cumulative distribution** function [or **CDF**; prompt on distribution function]
<SB, Science - Math> [Ed. DB]

The Kepler conjecture concerns the maximum packing efficiency of these mathematical objects. For 10 points each:
[10e] Name these mathematical objects that contain volume equal to four-thirds times pi times its radius cubed.
ANSWER: 2-**sphere**
[10m] The Kepler conjecture gives that the average density of equally sized spheres filling space is maximized by both a face-centered cubic arrangement and a "close packing" arrangement named for this polygon. The sum of the interior angles of this polygon equals 720 degrees.
ANSWER: **hexagon**
[10h] The Kepler conjecture gives this value as the maximum average density of equally sized spheres filling space. Give your answer as a percentage or decimal within five percent of the exact value.
ANSWER: **74**.048% [or **0.74**048; accept answers between **69**% and **79**% or between **0.69** and **0.79**]
<LM, Science - Math> [Ed. DB]

For 10 points each, answer the following about Cheddar Man, a ten-thousand-year-old skeleton discovered in Great Britain in 1903.
[10h] In 2018, a high-throughput "next-generation" technique for this process was used on Cheddar Man. Illumina, Inc. develops a technology to perform this process on flow cells via bridge amplification.
ANSWER: DNA **sequencing** [accept high-throughput **sequencing**, next-generation **sequencing**, Illumina **sequencing**, or **sequencing** by synthesis]
[10m] Cheddar Man's DNA was obtained from nuclei and these organelles in his cells. The existence of an ancestral "Eve" is evidenced by the fact that DNA in these organelles is inherited maternally.
ANSWER: mitochondria [or **mitochondrion**; accept **Mitochondrial Eve**]
[10e] A facial reconstruction of Cheddar Man revealed that, unlike modern British peoples, he had this trait. This trait results from high levels of melanin and is common in people of African descent.

ANSWER: dark skin [accept **brown** skin or **black** skin; prompt on melanism with "What trait does melanism cause?"]
<SB, Science - Biology> [Ed. DB]

For 10 points each, answer some questions about the first computer-assisted proof.
[10m] Kenneth Appel and Wolfgang Haken used a computer to prove a theorem stating that a two-dimensional map of contiguous regions can be colored with at most this many colors such that no two adjacent regions share a color.
ANSWER: **four** [accept the **four color theorem**]
[10e] Appel and Haken proved the four color theorem by representing maps as graphs, in which regions are represented by these objects, also known as nodes. The edges of polygons meet at these points.
ANSWER: **vertex** [or **vertices** or **node**s]
[10h] Appel and Haken's proof sets up a system of equations via the fact that this quantity equals two for any connected planar graph. This quantity for a polyhedron equals the number of vertices minus the number of edges plus the number of faces.
ANSWER: **Euler characteristic** [or **Euler number** or **Euler–Poincaré characteristic**; prompt on chi]
<SB, Science - Math> [Ed. DB]

This protocol was developed as an alternative to more vulnerable protocols like Telnet. For 10 points each:
[10h] Name this protocol often used for remotely logging into other computers. This protocol is invoked in the command line via its three-letter acronym.
ANSWER: **Secure Shell** Protocol [or **SSH** Protocol]
[10m] The Secure Shell Protocol was developed for use in operating systems that are said to be "like" this family of operating systems. macOS is in this family of operating systems whose members feature shells like Bash.
ANSWER: **Unix** [accept **Unix-like** operating system or **AT&T Unix**]
[10e] The user authentication layer of the Secure Shell Protocol allows for client authentication by prompting the user to input one of these phrases. These phrases often appear as dots or stars when typed alongside usernames.
ANSWER: **password**s [or **passcode**s]
<LM, Science - Other Science (Computer Science)> [Ed. DB]

For this flow regime in a cylindrical pipe, the Darcy–Weisbach ("*vice*-bock") equation reduces to the Hagen–Poiseuille ("pwa-zeh") equation. For 10 points each:
[10m] Name this flow regime, contrasted with turbulent flow, in which all flow lines are parallel.
ANSWER: **laminar** flow
[10e] Laminar flow between two plates gives rise to a velocity profile with this shape. This shape is graphed by the function y equals x squared.
ANSWER: **parabola** [accept word forms, prompt on quadratic]
[10h] For laminar flow in a cylindrical pipe, a factor in the Darcy–Weisbach equation named for this force equals 64 divided by the Reynolds number. Head loss is the dissipation of energy in a fluid due to turbulence and this force.
ANSWER: **friction** force [anti-prompt on drag force]
<QP, Science - Physics> [Ed. DB]

This enzyme's namesake "deficiency" is also known as Tarui's disease. For 10 points each:
[10h] Name this enzyme that catalyzes the conversion of fructose 6-phosphate to fructose-1,6-bisphosphate. This enzyme is commonly inhibited by PEP and citrate.
ANSWER: **phosphofructokinase**-1 ("phospho-fructo-kinase") [Accept **PFK**-1]
[10e] In addition to PEP and citrate, phosphofructokinase is inhibited by this molecule, the "molecular unit of currency." This molecule's P-O-P bonds release large amounts of energy when broken.
ANSWER: **ATP** [or **adenosine triphosphate**; reject "adenine triphosphate" or "ADP"]

[10m] Phosphofructokinase plays a key regulatory role in this pathway. This pathway forms pyruvic acid for use in the Krebs cycle, which occurs after this process in cellular respiration.
ANSWER: **glycolysis** [or **E**mbden-**M**eyerhof-**P**arnas pathway]
<MS, Science - Biology> [Ed. DB]

Along with microfilaments and intermediate filaments, these polymers form the cytoskeleton. For 10 points each:
[10m] Name these cylindrical polymers that are roughly 25 nanometers in diameter. Flagella consist of a "nine plus two" arrangement of these polymers.
ANSWER: **microtubule**s [prompt on MTs]
[10h] These motor proteins, which are contrasted with dyneins, typically transport cellular cargo by "walking" from the center of the cell to its periphery along a microtubule
ANSWER: **kinesin**s
[10e] Kinesins and dyneins are involved in axonal transport, in which cargo is transported along these cells' axons. The brain is mainly made up of these cells.
ANSWER: **neuron**s [or **nerve** cells]
<SB, Science - Biology> [Ed. DB]