

# SOS

*Stan's Open Science*

Special thanks to Aadi Karthik, Anish Kodali, Pranav Sivaram, Shiva Tegulla, and Geoffrey Wu for playtesting.

**One type of this phenomenon decays via the strong interaction into a nucleon and a pion or a delta baryon and a pion. Another type of this phenomenon forms an asymmetric (\*\*) line-shape in a type of scattering. One type of this phenomenon drives spiral density waves in (\*) galaxies and in Saturn's rings. For 10 points, name these phenomena, one of which occurs when slow atoms collide and is named for Herman Feshbach.**

ANSWER: **resonances** [accept types; accept “**resonance** scattering”] (the resonances mentioned in order are Roper, Fano, Lindblad, and Feshbach) {**Physics**} [Ed.]

**Anderson et al. used solid-phase peptide synthesis to synthesize a variant of this protein containing alanine at its seventh residue. This bicyclic (\*\*) heptapeptide contains an unusual cysteine-tryptophan linkage, and it can be used in fluorescence photo-oxidation to image the (\*) filamentous form of one protein. For 10 points, name this toxin found in the death cap mushroom that prevents the depolymerization of actin.**

ANSWER: **phalloidin** [I guess prompt on “**phallotoxin**”; reject other types of toxins] {**Biology**} [Ed.]

**Dwingeloo 1 and 2 were discovered in this region by using their neutral hydrogen emissions. Pablo (\*\*) Maffei discovered and named two galaxies in this region located in the constellation Cassiopeia. Richard Proctor originally named, for 10 points, what region containing (\*) “few nebulae” that is obscured by the Milky Way?**

ANSWER: **Zone of Avoidance** [accept “Zone of Few Nebulae” until read] {**Astronomy**} [Ed.]

**The differential of quanta, or  $Dq$ , and energy are divided by one of these quantities on the axes of one diagram. One of these quantities (\*\*) decreases when a transition metal ion forms a coordination complex in the (\*) nephelauxetic effect. For 10 points, name these three parameters that quantify electrostatic repulsion in multielectron atoms.**

ANSWER: **Racah** parameters [accept “A”, “B, or “C” for the parameters] (the first line refers to Tanabe-Sugano diagrams) { **Chemistry** } [Ed.]

**This theory posits that certain organisms will produce dimethylsulfoniopropionate, which will be broken down, producing sulfur aerosols that act as (\*\*)** cloud condensation nuclei. The “anti-” form of this theory involves lowered atmospheric sulfur dioxide concentrations that decrease Earth’s (\*) albedo. For 10 points, name this theory partially developed by James Lovelock that states that phytoplankton stabilize the Earth’s climate.

ANSWER: **CLAW** hypothesis [accept “**Charlson-Lovelock-Andreae-Warren** hypothesis”; accept “anti-**CLAW** hypothesis”; prompt on partial; reject “Gaia hypothesis”] { **Earth Science** } [Ed.]

**Non-topological solitons called gauge-mediated Q-balls are hypothesized to explain a problem presented as a result of this process, which can be explained by the Affleck-Dine mechanism. Static saddle point solutions to electroweak theory called (\*\*)** sphalerons are thought to have a role in this process. Thermodynamic nonequilibrium and C and CP violation are two (\*) conditions required for this process to occur according to Andrei Sakharov. For 10 points, name this process that resulted in the imbalance of matter and antimatter in the universe after the Big Bang, resulting in a particle’s namesake asymmetry problem.

ANSWER: **baryogenesis** [I guess accept descriptive answers like “**the production of baryonic matter and antimatter**” or “**baryon production**”; do NOT accept or prompt on “Big Bang,” “Big Bang nucleosynthesis,” or “nucleosynthesis,” as the Big Bang occurred before baryogenesis, and nucleosynthesis occurred after it] (gauge-mediated Q-balls explain the baryon asymmetry problem) { **Physics** } [Ed.]

**The induction of lysogens into the lambda phage can happen as a result of this response, whose namesake genes are regulated by the repressor LexA. Miroslav (\*\*)** Radman discovered this response, which can induce nucleotide excision repair. For 10 points, name this response to DNA (\*) damage in which the cell cycle is arrested and mutagenesis and DNA repair occur.

ANSWER: **SOS** response [prompt on “DNA damage” and “DNA repair” until read] { **Biology** } [Ed.]

**A component of this compound converts a *threo* betaine to a *trans* olefin in one reaction, and its namesake referred to it as the (\*\*)** LICKOR reagent. This compound is produced by combining *n*-butyllithium with potassium *tert*-butoxide. For 10 points, name this (\*) superbase named for a German scientist who modified the Wittig reaction.

ANSWER: Schlösser's base [accept "Schlösser modification"; prompt on "potassium *tert*-butoxide" or "*n*-butyllithium" before "LICKOR" is read; prompt on "LICKOR" until read] {Chemistry} [Ed.]

**This mathematician and Van Vu developed a theorem that establishes universality for local spectral statistics of random non-Hermitian matrices, the Four Moment Theorem. This mathematician is the second namesake of a theorem that was extended to cover polynomial progressions with (\*\*)** Tamar Ziegler. Proving that theorem required extending a theorem concerning arithmetic sequences, Szemerédi's theorem. For 10 points, name this mathematician who names a theorem stating that the sequence of (\*) prime numbers contains arbitrarily long arithmetic progressions with Ben Green.

ANSWER: Terence "Terry" Chi-Shen Tao [accept "Green-Tao theorem"] {Mathematics} [Ed.]

**These domains mediate the dimerization of White Collar 1 and 2 in fungi. Fluorescent proteins that bind flavin nucleotides called FbFPs were developed from a subclass of these domains called (\*\*)** LOV domains. A namesake protein comprising these domains interacts in a negative feedback loop with Tim. For 15 points, name these sensory domains involved in the regulation of circadian rhythms.

ANSWER: PAS domains [accept "Per-Arnt-Sim domains"; prompt on partial; antiprompt on "LOV domains" or "light-oxygen-voltage-sensing domains" until read] (Per interacts with Tim to regulate circadian rhythms) {Biology} [Ed.]

**Besides naming a ketosteroid detection test, Wilhelm Zimmermann names a reaction that involves the formation of this intermediate complex. The cationic analogue of this complex for a similarly named reaction is called a (\*\*)** Wheland intermediate, or an arenium ion. For 10 points, name this negatively charged reactive intermediate that forms during (\*) nucleophilic aromatic substitution reactions.

ANSWER: Jackson-Meisenheimer complex (a Wheland intermediate forms during electrophilic aromatic substitutions) {Chemistry} [Ed.]

**C. J. Foot described the methodology behind this technique, which requires two counter-propagating linear polarizations. This technique can approach, but not reach, the (\*\*)** recoil limit. Optical molasses can be explained by this technique's principle, which was developed by Claude (\*) Cohen-Tannoudji. For 10 points, name this mythologically-named laser cooling technique in which atoms are cooled below the Doppler limit.

ANSWER: Sisyphus cooling [accept "polarization gradient cooling"; prompt on "laser cooling"; I guess prompt on "Doppler cooling" until read] {Physics} [Ed.]

**Edward Steele and Robyn Lindley found that ADARs have a role in this process, which supports the reverse transcriptase model of it. This process begins when cytosine residues in (\*\*\*) RGWY/WRCY or DGWY/WRCH motifs are deaminated by the enzyme AID. This process, which takes place in the dark zone of germinal centers, occurs after (\*) clonal expansion and before clonal selection. For 10 points, name this first step of affinity maturation in which the immunoglobulin genes of B cells are modified.**

ANSWER: **somatic hypermutation** [or “**SHM**”; prompt on “affinity maturation” until read; reject partial; reject “V(D)J recombination,” “clonal expansion,” “clonal selection,” “class switching,” “isotype switching,” or “isotypic commutation”] {**Biology**} [Ed.]

**Charmonium and bottomonium states exemplify this rule, which is displayed by the separation of Feynman diagrams through the removal of internal (\*\*\*) gluon lines. The decay of a phi meson into three pions is suppressed by this rule, as are hadronic decay modes of the (\*) J/ψ meson. For 10 points, name this rule that explains the prevalence of certain decay modes based on quark-antiquark annihilation.**

ANSWER: **OZI** rule [accept “**Okubo-Zweig-Iizuka** rule”; I guess prompt on partial] {**Physics**} [Ed.]

**The Arp protein, which is unable to inhibit phagocytosis on its own, is a member of this protein’s family. This protein contains the conserved pentapeptide LPXTG motif and binds to serum factor H, destroying (\*\*\*) C3-convertase. The discoverer of this protein, Rebecca Lancefield, also names a classification for organisms that carry it. For 10 points, name this virulence factor used by (\*) *Streptococcus* bacteria.**

ANSWER: **M** protein [reject “myeloma protein”] {**Biology**} [Ed.]

**These compounds can be used in the rhodium-catalyzed hydroboration of styrene as well as in the synthesis of the herbicide (S)-metolachlor. The term planar chirality describes a (\*\*\*) precursor to these compounds, Ugi’s amine. Antonio Togni first worked with these compounds, which are named for (\*) Josi Puleo. For 10 points, name these chiral diphosphine ligands containing a ferrocene scaffold.**

ANSWER: **Josiphos ligands** [I guess accept word forms of “**Josi Puleo’s phosphine ligands**”; I guess prompt on “**ligands**” or “**Josi Puleo’s ligands**”; reject “ferrocene” or “metallocene”] {**Chemistry**} [Ed.]

**Nanoparticles called SIPPs and the DPDP chelate-containing mangafodipir can alter the time it takes for this process to occur. One over the time it takes for this process to occur for pure substances can be calculated under (\*\*) Bloembergen-Purcell-Pound theory. For a dipolar system, this process can be described by a set of differential equations named for Ionel Solomon. The exponential decay times (\*)  $T_1$  and  $T_2$  characterize, for 10 points, what process in which the transverse component of the magnetization vector returns to its equilibrium value during NMR?**

ANSWER: **spin relaxation** [or “**spin-spin relaxation**”; accept “**spin-lattice relaxation**”; prompt on “**relaxation**”] (the first sentence refers to MRI contrast agents;  $T_1$  is the spin-lattice relaxation time and  $T_2$  is the spin-spin relaxation time) {Physics} [Ed.]

**By heating this compound, Friedrich Reinitzer observed that it had two melting points at 145 and 178.5 °C. Otto (\*\*) Lehmann’s study of this compound led to the naming of phases such as (\*) smectic and nematic. For 10 points, name this compound that was the first liquid crystal to be discovered.**

ANSWER: **cholesteryl benzoate** [or “**5-cholesten-3-yl benzoate**”; reject partial answers] {Chemistry} [Ed.]

**The products of this process give a bright red coloration in Rothera’s test, which is a modification of a urine test that uses sodium nitroprusside. High rates of this process lead to low blood bicarbonate levels, which result in a deep and labored (\*\*) respiration pattern called Kussmaul breathing. The only amino acids that can undergo this process are (\*) lysine and leucine. For 10 points, name this process in which fatty acids are broken down into beta-hydroxybutyrate, acetoacetate, and acetone, its namesake bodies.**

ANSWER: **ketogenesis** [accept equivalents such as “**ketone body formation**”; accept “**ketosis**” or “**ketoacidosis**”; prompt on “**fatty acid metabolism**” or “**metabolic acidosis**”; I guess prompt on “**intermittent fasting**,” “**starvation**,” or “**caloric restriction**”; grudgingly prompt on “**metabolism**”] {Biology} [Ed.]

**A technique for deriving this phenomenon that uses the Atiyah-Singer index theorem and the correspondence between functional determinants and the partition function is called the Fujikawa method. A one-loop Feynman diagram depicting the decay of a (\*\*) neutral pion into two photons is an example of this phenomenon named for Adler, Bell, and Jackiw. For 10 points, name this phenomenon, the nonconservation of a namesake type of (\*) current.**

ANSWER: **chiral anomaly** [or “**chiral anomalies**”; prompt on “**anomaly**” or “**quantum anomaly**”; prompt on descriptions like “**nonconservation**” or “**anomalous nonconservation of chiral current**” until read; I guess prompt on “**chiral symmetry breaking**” or “**symmetry breaking**”; reject “CP

violation,” “charge-parity violation,” “CP nonconservation,” or “charge-parity nonconservation”] {Physics} [Ed.]

**When cleaved, this compound releases carbamate, which partially decomposes into carbon dioxide. A mixture of piperidine and dimethylformamide can (\*\*)** cleave this compound during one process, which requires it to be bound to chloride. For 10 points, name this compound, which, like (\*) BOC, is used as a protecting group for amines during peptide synthesis.

ANSWER: **Fmoc** [or “**fluorenylmethoxycarbonyl** protecting group”; reject “BOC” or “*tert*-butyloxycarbonyl protecting group”] {Chemistry} [Ed.]

**The compounds that make up the denominator of this quantity can be displayed on a Bjerrum plot. This (\*\*)** buffer factor equals the change in carbon dioxide over the change in total DIC, and it can be used to measure the resistance of carbon dioxide’s resistance to being (\*) absorbed. For 10 points, name this factor used to quantify ocean acidification.

ANSWER: **Revelle** factor [accept “buffer factor” until read] {Earth Science} [Ed.]

**An advance to this system with a high yield uses a bipyrimidine catalyst in concentrated sulfuric acid to produce methyl bisulfate. This system is performed biologically by a diiron-containing enzyme with soluble and particulate types found in (\*\*)** *M. capsulatus* that goes through intermediates P and Q. Platinum chlorides catalyze this system, which partially oxidizes a hydrocarbon to an alcohol like (\*) methanol. For 10 points, name this system that is a classic example of catalytic C-H activation.

ANSWER: **Shilov** system [prompt on “MMO,” “methane monooxygenase,” “C-H activation,” or “carbon-hydrogen bond activation”] (*M. capsulatus* stands for *Methylococcus capsulatus*) {Chemistry} [Ed.]

**A web tool implementing a maximum likelihood estimator called bz-rates was developed to analyze the results of this experiment. A mechanism observed during this experiment was elucidated by studying a tonB-activated ferrichrome transporter called (\*\*)** *fhuA*. The results of this experiment were analyzed using a method implementing filtered Poisson processes named for Lea and Coulson. Cultures of (\*) *E. coli* were exposed to the T1 bacteriophage in, for 10 points, what experiment that showed that mutations are spontaneous?

ANSWER: **Luria-Delbrück** experiment [prompt on “fluctuation test” or “fluctuation analysis”] {Biology} [Ed.]

**A component of this model can be overdamped or underdamped depending on whether a quantity denoted  $\beta_c$  is less than or greater than one, respectively. That quantity, the (\*\*) Stewart-McCumber parameter, can describe the drive of DC current in this model. For 15 points, name this model consisting of two namesake components placed in parallel with a Josephson junction.**

ANSWER: **RCSJ** model [or “**shunted junction**” model]; accept “**resistively and capacitively shunted junction**” model”; prompt on “Josephson junction” or “Josephson effect” until read; reject partial answers like “capacitor,” “resistor,” or “junction”] (the model is named because it consists of a resistor, a capacitor, and a Josephson junction) { **Physics** } [Ed.]

**Marat Freytsis and Samuel Gralla developed quantum force-free electrodynamic equations to describe the diffuse plasma around these objects. Vacuum (\*\*) birefringence has been observed in these objects, whose existence was proposed by Robert Duncan and Christopher Thompson. The existence of (\*) AXP and SGRs may be explained by, for 10 points, what neutron stars with very strong magnetic fields?**

ANSWER: **magnetars** [prompt on “pulsar”, “anomalous X-ray pulsars”, “soft gamma repeaters” and “neutron star” until read] { **Astronomy** } [Ed.]

**This compound’s namesake test and the isatin and chloranil tests can be used to determine if one technique’s coupling reactions are complete. In the Kaiser test, this compound can produce a deep blue or purple color named for (\*\*) Siegfried Ruhemann. A pyrrolidine side chain causes proline to turn yellow upon reacting with this compound, which can be used as a stain for amino acids in (\*) thin-layer chromatography. For 10 points, name this compound commonly used in forensic chemistry to detect fingerprints.**

ANSWER: **ninhydrin** [or “**2,2-dihydroxyindane-1,3-dione**”; accept “Ruhemann’s purple” until read] (the first clue refers to solid-phase peptide synthesis) { **Chemistry** } [Ed.]

**Under this theory, Carlo Rovelli and Francesca Vidotto theorized the existence of stars named for Max Planck that exist within a black hole’s event horizon. The entropy of a black hole under this theory contains a quantity denoted gamma naught, the (\*\*) Barbero-Immirzi parameter. This theory models one phenomenon as spin networks called spin (\*) foam. For 10 points, name this quantum theory that treats gravity as namesake circular objects.**

ANSWER: **loop quantum gravity** [accept “**LQG**”; I guess prompt on “quantum gravity”; reject “gravity”] { **Physics** } [Ed.]

**Adler et al. discovered this system by noticing how mutants generated minicells. The “C” component of this system disassembles the ZapA, ZapB, and ZapC proteins that bind to an**

(\*\*) FtsZ scaffold. This system interacts with the nucleoid occlusion system and is involved in the centering of the Z-ring. For 15 points, name this system of three proteins used by *E. coli* for proper cell division.

ANSWER: Min system [accept “MinC”, “MinD”, or “MinE”] {Biology} [Ed.]

Norman Alling showed that these numbers are isomorphic to the field of a formal power series with real coefficients called a Hahn series. Performing transfinite induction beyond the set of these numbers produces ordinal numbers, which leads to the (\*\*) birthday property. These numbers are the largest possible ordered field according to a set theory partially named for Paul Bernays and John von Neumann. For 10 points, name these numbers containing the infinite, infinitesimal, and (\*) real numbers developed by John Conway.

ANSWER: surreal numbers [or “surreals”; antiprompt on “hyperreals” or “hyperreal numbers”; grudgingly prompt on “reals,” “real numbers,” “infinite numbers,” “infinitesimals,” or “infinitesimal numbers” until read] (the set theory is von Neumann-Bernays-Gödel set theory) {Mathematics} [Ed.]

*Description acceptable.* A bottom-up method for performing this process using glucose as the starting material is called the Tang-Lau method. The hazardous Staudenmeier-Hoffman-Hamdi method for performing this process involves the addition of (\*\*) potassium chlorate, while a safer alternative adds potassium permanganate to a solution partially consisting of sodium nitrate and sulfuric acid. (\*) Hummers’ method accomplishes, for 10 points, what process of producing a substance abbreviated GO?

ANSWER: synthesizing graphite oxide [or “synthesis of graphite oxide”; accept equivalent answers like “forming graphite oxide” or “creating graphite oxide”; accept “graphene oxide” in place of “graphite oxide”; prompt on “Tang-Lau method” or “Hummers’ method” before read; prompt on answers mentioning “GO” before read; reject answers mentioning “graphene” or “graphite” alone] {Chemistry} [Ed.]

This technique can generate a molecule that treats macular degeneration by inhibiting angiogenesis, pegaptanib. Unlike G-quadruplex-containing molecules such as (\*\*) TBA and HD22, this technique cannot produce L-ribose Spiegelmers. The first step in this technique involves randomly generating and subsequently filtering an oligonucleotide sequence (\*) library. For 10 points, name this combinatorial chemistry technique that produces peptide aptamers, which bind to target molecules.

ANSWER: systematic evolution of ligands by exponential enrichment [or “SELEX”; accept “selected and amplified binding site,” “SAAB,” “cyclic amplification and selection of targets,”

or “**CASTing**”] (pegaptanib antagonistically binds to VEGF; TBA and HD22 are anti-thrombin aptamers) {Biology} [Ed.]

**In one formulation, this operator denoted  $\Omega_i$  equals the reciprocal of negative  $\tau$  times the difference between the particle population and the local equilibrium value for the particle population. Using this operator and introducing the (\*\*) Knudsen number via Chapman-Enskog expansion enables the Navier-Stokes equations to be derived from the discrete (\*) lattice form of one equation. For 10 points, name this operator that approximates the collision operator in the Boltzmann transport equation.**

ANSWER: **Bhatnagar-Gross-Krook** operator [or “**BGK** operator”; prompt on “collision operator” until read; reject answers mentioning “Boltzmann”] {Physics} [Ed.]

**Ferreira et al. found that this compound’s mechanism of action stems from it being derived from teprotide. The fact that this compound’s terminal thiol group gives it its potency was elucidated via (\*\*) QSAR, which was used to design it based on a peptide extracted from a Brazilian pit viper. This compound can be used to measure the plasma levels of aldosterone in its namesake (\*) suppression test. For 10 points, name this first synthetic inhibitor of angiotensin-converting enzyme.**

ANSWER: **captopril** [accept “**captopril** suppression test”; I guess accept “**Capoten**”] (the Brazilian pit viper’s scientific name is *Bothrops jararaca*) {Biology} [Ed.]

**As  $N$  approaches infinity, the  $Z_N$  model becomes a special case of this model, whose critical temperature estimations are determined by the (\*\*) helicity modulus. This model is a special case of Stanley’s  $n$ -vector model for  $n$  equals two. This model allows for excitations in bound vortex-antivortex pairs to drive the (\*) Berezinskii-Kosterlitz-Thouless transition as predicted by the Mermin-Wagner theorem. For 10 points, name this lattice model of statistical mechanics whose dimensionality is two.**

ANSWER: classical **XY** model [accept “**classical rotor** model,” “**classical rotator** model,” or “**O(2)** model”; prompt on “ $n$ -vector model” until read] {Physics} [Ed.]

**This pathway is named after a compound derived from the Chinese star anise that is the starting material in the total synthesis of oseltamivir. A pericyclic Claisen rearrangement can convert this pathway’s product to (\*\*) prephenate. DAHP synthase acts on phosphoenylpyruvate and erythrose-4-phosphate in the first step of this pathway, which produces the anthranilate precursor (\*) chorismate. For 10 points, name this pathway that synthesizes aromatic amino acids.**

ANSWER: **shikimate** pathway [or “**shikimic acid** pathway”] {Biology} [Ed.]

**It's not Irving Langmuir, but a rule developed by this scientist states that 16-electron and 18-electron intermediates undergo oxidative addition and reductive elimination, respectively. A parameter named for this scientist is quantified via (\*\*\*) infrared spectroscopy to determine the steric and electronic properties of phosphine ligands. Besides the electronic parameter, this scientist's name is attributed to an (\*) angle formed by the outermost edge of van der Waals spheres and a metal. For 10 points, name this scientist whose name is attributed to the ligand cone angle.**

ANSWER: Chadwick A. **Tolman** [accept “**Tolman**'s rule,” “**Tolman**'s electronic parameter,” or “**Tolman** cone angle”] {**Chemistry**} [Ed.]

**This model shows that antiferromagnetic Kramers-Anderson superexchange can produce high critical temperature superconductivity in cuprates. The first term of the Hamiltonian in this model derived by (\*\*\*) Józef Spalek equals the negative of the hopping integral times the sum of the fermionic creation and annihilation operators. For 10 points, name this special case of the (\*) Hubbard model in which the limit of  $U$  over  $t$  is much greater than one.**

ANSWER:  **$t$ - $J$**  model [prompt on “Hubbard model” until read] {**Physics**} [Ed.]

**Bergmann et al. found that activated olefins containing nitrile or sulfone groups can be used as Michael acceptors in a reaction that produces this compound. Proline catalyzes an asymmetric reaction named for (\*\*\*) Hajos and Parrish that produces this compound, which is used as the C-ring in Samuel Danishefsky's total synthesis of Taxol. For 10 points, name this bicyclic racemic (\*) ketone used as the starting material in the total synthesis of many steroids.**

ANSWER: **Wieland-Miescher ketone** [prompt on “ketone” or “carbonyl”]; reject answers mentioning “aldehyde” (the first clue refers to the Robinson annulation) {**Chemistry**} [Ed.]

**The lubridate package is included in this language's open source tidyverse extension. The pipe operator was introduced by Stefan Milton Bache's (\*\*\*) magrittr package for this language, whose core packages include tibble and ggplot2. This is the alphabetically latest of the three languages supported by Project Jupyter, and like (\*) Python, it can be used for data visualization. For 10 points, name this programming language used for statistical analysis that can be run in a namesake studio.**

ANSWER: **R** [accept “**RStudio**”] {**Computer Science**} [Ed.]