

Lederberg 3: Trinity

Hear that? That's the sound of your wavefunction collapsing.

Will Alston¹, Justin French², Jonathen Settle³, Geoffrey Chen^{4,5}, Jaimie Carlson⁶, Abhinav Godavarthi⁷, Steven R. Silverman⁸, Akshay Govindan⁹, Paul Chungroh Lee¹⁰, Julia Zhou¹¹, Aakash V. Patel⁸, Fred Zhang¹¹, Anson Berns¹², James Lasker^{13, 14*}, Eric M. Mukherjee^{15,16‡}

¹Emeritus, Dartmouth College, Hanover, NH 03755

²University of California, Los Angeles, Los Angeles, CA 90095

³Department of Computer and Information Science and Engineering, University of Florida, Gainesville, FL 32611

⁴Wayzata High School, Plymouth, MN 55446

⁵University of Minnesota, Minneapolis, MN 55455

⁶School of Engineering and Applied Science, University of Pennsylvania, Philadelphia, PA 19104

⁷Plano West Senior High School, Plano, TX 75093

⁸Emeritus, Carnegie Mellon University, Pittsburgh, PA 15213

⁹Ladue Horton Watkins High School, St. Louis, MO 63124

¹⁰College of Arts and Sciences, University of Pennsylvania, Philadelphia, PA 19104

¹¹Thomas Jefferson High School for Science and Technology, Alexandria, VA 22312

¹²Montgomery Blair High School, Silver Spring, MD 20901

¹³Department of Astronomy and Astrophysics, University of Chicago, Chicago, IL 60637

¹⁴Kavli Institute for Cosmological Physics, University of Chicago, Chicago, IL 60637

¹⁵Emeritus, Medical Scientist Training Program, Perelman School of Medicine at the University of Pennsylvania, Philadelphia, PA 19104

¹⁶Department of Dermatology, Vanderbilt University Medical Center, Nashville, TN 37232

*Editor

‡Head Editor and Corresponding Author: ericmu@pennmedicine.upenn.edu

ACKNOWLEDGEMENTS: The authors would like to thank Ike Jose for valuable input and suggestions, Jason Thompson for negotiating a time to play the tournament at ICT, the players for their generous donations to the Leukemia and Lymphoma Society, and the staffers who made this tournament possible.

1. Nick Gnedin's CROC code tracks how this property is acquired through cosmic time. This property for the universe is often measured in terms of the redshift and optical depth at which it happens. A prefactor of the inverse cube of the deBroglie ("duh-broy") wavelength times the ratio of two degeneracies of state multiplies a Boltzmann factor in one equation for the degree of this property. "The cube root of three fourths pi times flux over number density squared over the rate of the inverse of this process" is the radius of a region produced by O and B stars which fully possesses this property, the (*) Stromgren sphere. The Langmuir-Saha equation is used to assess the degree of this property within stars. H-II ("H-two") regions are defined by fully possessing this property. The "dark ages" end when the universe began possessing this property, since before then, electrons could absorb photons and prevent their transmission. For 10 points, name this property of an atom which has lost an electron.

ANSWER: reionization [accept word forms like ionized]

<Astronomy, James Lasker>

2. Meisner et al used a sulfide group and a carbon-carbon pi bond to form a one-molecule example of these devices. A digital type of these devices, also called resistive digital-to-analog converters, are used to trim analog signals. Soft membrane examples of these things can be activated by touch. "String" examples of these things are used to measure position and velocity and are often "multi-turn." These devices are used to provide position feedback to motors in a (*) servo ("SUR-voh") mechanism. These adjustable devices feature a wiper changing a contact point by moving along a long linear groove or an arc. Using only two terminals of these devices creates a rheostat. In circuit diagrams, the symbol for these elements are resistor symbols with arrows. For 10 points, name these three-terminal circuit elements often used to make voltage dividers, whose variable resistance can be adjusted by turning a knob.

ANSWER: potentiometer

<Physics, Jaimie Carlson>

3. An enzyme called BASU that quickly transfers this molecule is fused to the Lambda-N aptamer binding domain for use in the RaPID procedure. "Painting" with this molecule preferentially targets intrinsically disordered regions. A phenol-containing derivative of this molecule is the substrate for the evolved peroxidase APEX-2. 2-imino and desthio-derivatives of this molecule obviate the need for harsh conditions. BioID and TurboID transfer this molecule promiscuously in proximity labelling. The displacement of the dye H·A·B·A is used to measure its concentration. This molecule contains a valeric ("vuh-LAIR-ick") acid side chain attached to a bicyclic (*) thiophene-ureido ("THIGH-oh-feen-u-RYE-doh") moiety. A 15-amino acid recognition sequence for Bir·A, called the AviTag, attaches to this molecule, which is a cofactor in several carboxylase enzymes. For 10 points, name this molecule whose non-covalent interaction with streptavidin ("strep-TAV-id-in") is very strong.

ANSWER: biotin [or vitamin B7; or vitamin H]

<Chemistry, Eric Mukherjee>

4. A structural protein in this virus has Y·93·H and L·31·V resistance mutations. The Huh·7 cell line is often used to grow this virus, whose replication requires the micro·R·N·A m·i·R-122. Antibodies that neutralize this virus often bind to its E·2 envelope glycoprotein. Up to 50% of patients with porphyria ("pore-FEAR-ee-uh") cutanea ("kew-TAYN-ee-uh") tarda ("TARD-uh") are infected with this virus, infection with which is also associated with Type II mixed cryoglobulinemia ("CRY-oh-glob-yew-lin-NEE-mee-uh"). Several drugs targeting this virus bind to its N·S·5·A and N·S·5·B non-structural proteins. All six genotypes of this virus are targeted by the combination of (*) so·fos·bu·vir and vel·pat·as·vir. A secondary structure formed by this virus' genome binds directly to the 40·S ribosomal subunit, bypassing the need for a cap; that it is internal ribosome entry site. This virus is commonly transmitted through injection drugs and sex work, and usually causes a chronic infection. For 10 points, name this flavivirus ("FLAHV-ee-virus") that infects the liver.

ANSWER: Hepatitis C [or Hep C or HCV; prompt on hepatitis or hepatitis virus]

<Biology, Eric Mukherjee>

5. Ishwaran and Lauer developed a random forest method for this kind of analysis, which uses the Nelson-Aalen method of estimating one parameter. One model used in this kind of analysis uses Breslow's method to resolve ties and assumes that covariates have a multiplicative effect on a function symbolized λ_0 . Prentice's generalized Wilcoxon test or a log-rank version of the Mantel-Haenszel test is used to compare samples in this kind of analysis. In this kind of analysis, the product of $1 - d_{i-1} / n_{i-1}$ is an estimator of a function S of t ; that estimator is named for Kaplan and Meier. Cox names a proportional (*) hazards model used in this analysis, whose data is often right-censored due to withdrawal or avoiding events. This kind of analysis is used to compare mortality rates in clinical trials by calculating a hazard ratio. For 10 points, name this method which models the duration until a particular event.

ANSWER: survival analysis [or time-to-event analysis, or lifetime analysis, or failure time analysis, or TTE analysis, or reliability analysis, or duration analysis, or event history analysis accept Cox proportional hazards model until "hazards"; accept "modelling" instead of "analysis"]

<Data Science/Stats/Applied Math, Eric Mukherjee>

6. Raychaudhuri's equation for the time derivative of expansion contains a term equal to 2 times the shear squared minus 2 times a quantity representing this property squared. The size of an object with this property is modified by a prefactor of "1 plus the square root of 1 minus a^2 " where 'a' is a parametrization of this quantity. The unusual existence of Killing [emphasize] tensors for systems with this property leads to the existence of (*) Carter's constant in systems with this property. Magnetic field squared times radius to the fourth times a measure of this property squared divided by the speed of light gives the power radiated by the Blandford-Znajek ("zuh-NYE-eck") process which can only occur in objects with this property. Metrics with this property often possess an ergosphere between the "inner" and "outer" event horizons, and can stretch spacetime in the process of frame dragging. For 10 points, name this property possessed by a Kerr ("care") black hole.

ANSWER: rotation or rotating [accept common-language equivalents, accept things like nonzero angular momentum]

<Physics, Akshay Govindan>

7. A solution of this compound is required to stain amyloid A β , which doesn't stain with Congo Red. It's not the hydroxyl radical or DNase I, but single-stranded DNA can be footprinted using this compound. A solution of this compound, $K_2C_2O_8$, and N_2O_4 is used to stain TLC plates when the analyte contains olefins. This compound is used to measure the kappa number, or lignin content, of wood pulp. 18-crown-6 is used to help dissolve this substance in benzene to create purple benzene. It's not ozone, but an acidic solution of this compound cleaves alkenes ("AL-keen-z") to carboxylic acids. Sodium oxalate is used to standardize a (*) solution of this compound in a common redox titration. When added to an alkene or alkyne ("AL-kine"), a solution of this compound evolves a brown precipitate in Baeyer's test for unsaturation. For 10 points, name this oxidizing agent whose metal atom has an oxidation state of 7, with formula $KMnO_4$.

ANSWER: potassium permanganate [accept KMnO4 before mention]

<Chemistry, Eric Mukherjee>

8. This substance is inactivated via phosphorylation ("fos-FOR-il-ay-shun") to create its 22-phosphate. Cryptocephal is a trans-activator of this substance's receptor, which is agonized by tebufenozide ("te-bew-FEN-oh zide"). Genes called Spook, Shadow, Disembodied, Phantom, and Shade all code for enzymes in the biosynthesis of this substance from keto-diol. P-T-T-H triggers the release of this substance from the ring gland. The receptor for this substance forms a hetero-dimer with the R-X-R-homolog ultra-spiracle for signaling. This substance triggers the formation of Balbiani ("BAL-bee-AHN-ee") rings and puffs on salivary (*) polytene chromosomes. This hormone triggers the formation of exuviae ("ecks-SU-vee-ae"), and is often required for complete metamorphosis. For 10 points, name this insect hormone that triggers molting.

ANSWER: 20-hydroxyecdysone [or 2-deoxyecdysone or ecdysterone or 20E]

<Biology, Eric Mukherjee>

9. In the Ising (“ICE-ing”) model, this quantity multiplies a Hamiltonian function of configuration in the expression for the configuration probability. It’s not length, but Rudolf Peierls (“PIE-earls”) showed that for large values of this quantity, magnetization remains near negative one. In the grand canonical ensemble, absolute activity is equal to the exponential of this quantity times chemical potential. An expression for this quantity consisting of a single differential is derived by maximizing the number of (*) microstates at equilibrium to show that this quantity is equal for two systems at that point. The canonical partition function is equal to the sum over microstates of the exponential of negative this quantity times energy. This quantity equals the derivative of the natural log of number of microstates with respect to energy. For 10 points, name this quantity equal to the reciprocal of Boltzmann’s constant times temperature.

ANSWER: thermodynamic **beta** [accept **one over Boltzmann’s** constant **times temperature** before mention]

<Physics, Akshay Govindan>

10. The two branches of K-theory can be related using the equivalence of two of these structures provided by the Serre-Swan theorem. If one of these structures S is locally small, then maps from S correspond to transformations of the map taking elements of S to their Hom-set. Natural transformations act on maps between these objects. One of these structures is “total” if its natural embedding into Set has a left adjoint. The group-theoretic Cayley’s theorem generalizes to these structures via the (*) Yoneda (“yoh-nay-duh”) lemma. Depending on whether they preserve the direction of morphisms, maps between them are called covariant or contravariant functors. Diagrams of these structures commute if different paths give the same morphism. One of these structures is defined by taking monoids and their homomorphisms to objects and arrows. For 10 points, name these structures whose namesake theory is often called “abstract nonsense” because they generalize much of mathematics.

ANSWER: **categories** [accept **category** theory]

<Math, Justin French>

11. Solving the hidden subgroup problem for the direct product of Z sub n with itself is equivalent to solving this problem. When solving this problem, the prime degree p of the finite field must be chosen so that p minus 1 is B-smooth for a large B. A factor base is used to search for a set of random relations that are solved as linear systems in the index calculus methods for solving this problem. For a primitive member of a field a , a message m , and two random integers x and y , ciphertext whose first member is a to the y and whose second member is a to the xy (“ $x \cdot y$ ”) is used in an (*) encryption scheme that relies on the difficulty of solving this problem. It’s not factoring, but the hardness of this problem ensures the security of the ElGamal (“el guh-MAHL”), Diffie-Hellman, and other public-key encryption schemes. The solution to this problem is an integer x such that b equals a to the x . For 10 points name this problem, which involves calculating the inverse of discrete exponentiation.

ANSWER **discrete logarithm** problem [accept **discrete logarithm**]

<Computer Science, Jonathen Settle>

12. Compounds with this property reactively prefer even-numbered polyenes, cyclic polyenes, and even-hapticity polyenes by the Green-Davies-Mingos rules. The fact that hydroperoxide has more of this property than hydroxide is evidence of the alpha effect, in which proximity of species with this property increases it. Edwards and Ritchie’s correlation are the basis for the oxibase scale of this property. A quantity measuring this property multiplies susceptibility in the extended Grunwald-Winstein equation and a substrate constant in the Swain-Scott equation. When adding to an arene (“AIR-een”), a compound with this property can form a Meisenheimer complex. The Kolbe synthesis has multiple products because the (*) cyanide anion can act as an ambident compound with this property. Compounds with this property induce inversion of configuration via backside attack in S_N2 reactions. For 10 points, name this property that lets compounds react with electrophiles.

ANSWER: **nucleophilicity** [accept word forms of **nucleophile**; accept word forms of **electrophile** or **electrophilicity** before “Meisenheimer”, because some of the clues before that apply to both, but the clues after that all only apply to nucleophiles]

<Chemistry, Eric Mukherjee>

13. Molecular subtypes of this disease include Luminal A and Luminal B. The C·D·K·4 and C·D·K·6 inhibitor ribociclib (“ree-BO-sick-lib”) is approved to treat this disease. M·C·F·7 cells are primarily used to study this disease. One drug used to treat this disease induces downregulation of neuregulin-1 (“new-REG-yew-lin-one”) in cardiac myocytes, causing cardio-myopathy. Lapatinib (“luh-PAH-tuh-nib”) is a dual tyrosine kinase inhibitor used to treat this disease. One drug used to treat this disease is conjugated to the cytotoxic agent D-M-1 to form Kadcyla (“cad-SIGH-luh”). The Gail model provides a 5-year and lifetime probability of developing this condition. A symptom of this disease is skin textured like an orange rind, or (*) peau d’orange. Trastuzumab (“traz-TOO-zoo-mab”) is used to treat this disease, which is classified by the presence of HER·2, estrogen receptor, and progesterone receptor. Mutations in BRCA (“BRACK-uh”) 1 and 2 can increase susceptibility to this disease. For 10 points, name this type of cancer detected by a mammogram.

ANSWER: breast cancer [prompt on cancer]

<Biology, Julia Zhou>

14. Trujillo-Gomez, Klypin, et al 2011 used this technique to produce a generalization including both the Tully-Fisher and Faber-Jackson relations. This technique was developed by Kravtsov et al 2004 in order to model S·D·S·S correlation functions. Extending this technique to satellite galaxies led to the discovery of the “too big to fail” problem. This technique is necessary because of the increase in computation complexity when including sub-grid baryonic physics in simulations. It can be graphically represented by tracing from the x-axis of one graph in mass up to the point on a number density function curve, then tracing that same number density over to a luminosity function curve to find a luminosity. For 15 points name this technique which assigns galaxies of an observed luminosity function to dark matter halos from an n-body simulation.

ANSWER: halo abundance matching [prompt on partial answer]

<Astronomy, James Lasker>

15. When only a half-filled one of these states is occupied, composite fermions consisting of an electron and two flux quanta form the basis of a mean field theory of Fermi liquids developed by Halperin, Lee, and Read. Assuming the vector potential is equal to negative one-half of $\mathbf{r} \times \mathbf{B}$, the eigenfunction of the lowest of these states is the exponential of negative r squared over four times the magnetic length squared. The periodicity of the energy of these states is measured as oscillations in the magnetic moment with strong applied field in an effect used to map Fermi surfaces, called the (*) de Haas-van Alphen effect. Fermion doubling is absent in a model developed by Haldane that explains the quantum Hall effect as a result of T-symmetry breaking without the formation of these states. These states are analogous to the harmonic oscillator where ω is the cyclotron frequency. For 10 points, what are these quantized orbitals of electrons named for a Soviet physicist?

ANSWER: Landau levels [accept Landau quantization]

<Physics, Jonathen Settle>

16. A group at Rice excited impurities in a Bose gas to create polarons named for this scientist. A bound pair of H-plus and H-minus forms a “heavy” state named for this scientist. A quantity named for this scientist times $2 \cdot h \cdot c$ gives the Hartree energy. When the reduced mass is *not* being used for calculations, a quantity named for this scientist is typically written with an infinity subscript. His namesake correction subtracts “delta” from the principal quantum number to account for (*) screening. The constant named for this man has units of inverse length and multiplies a term equal to [read slowly] “quantity one over n-sub-1 squared minus quantity one over n-sub-2 squared,” where n-sub-1 and n-sub-2 are principal quantum numbers. This man generalized a formula developed by Johann Balmer to apply to all similar transitions in hydrogen atoms. For 10 points, what Swede’s namesake formula calculates spectral line wavelengths?

ANSWER: Johannes Rydberg

<Chemistry, Will Alston>

17. Lloyd N. Trefethen observed that, although error analysis suggests it should be half as efficient, a quadrature method based on these functions converges just as fast as Gaussian quadrature for most integrands. These functions may be defined by the equation “ T_n of the cosine of theta equals the cosine of n theta.” In Clenshaw-Curtis quadrature, Runge’s (“RUN-guh’z”) phenomenon can be minimized when the integrand is approximated using an (*) interpolation scheme based on these functions. Frequency is inputted into one of these functions in the frequency response of a filter with a steeper roll-off than the Butterworth filter but with more ripples in the pass-band. The namesake of these functions also names the statement that no more than “one over k squared” of a distribution’s values can be further than k sigma from the mean. For 10 points, name this sequence of orthogonal polynomials named for a Russian mathematician.

ANSWER: Chebyshev polynomials

<Data Science/Stats/Applied Math, Justin French>

18. The action of this complex on liprin (“LIP-rinn”)-alpha in *Drosophila* (“druh-SOFF-ill-uh”) regulates synapse size. One protein which inhibits this complex has a G·L·E·B·S sequence adjacent to a low-complexity region; that protein is named for not being inhibited by benzimidazole (“ben-zuh-MID-uh-zole”) and is part of the M·C·C, which is inhibited by p·31-comet. E·m·i·1 serves as both an inhibitor and substrate of this complex. This complex contains a “platform”, a “catalytic core”, and an arc-lamp shaped T·P·R lobe which interacts with the C-terminal W·D·40 motifs of c·d·h·1 and c·d·c·20. In vertebrates, the substrate of this complex lacks a (*) D-box motif, and instead contains a portion known as the KEN-box. This complex, which contains 19 subunits, uses its E·3 ubiquitin ligase activity to degrade securin, leading to the release of separase, which cleaves cohesins. For 10 points, name this protein complex that drives the transition from metaphase to the phase after.

ANSWER: anaphase promoting complex [or cyclosome or APC/C]

<Biology, Akshay Govindan>

19. A low-pass filter is used to remove the effects of “satellites” of this substance in the DISPEL experiment. Pee Dee Belemnite is used as a standard for a ratio in which this substance is the heavier species; that ratio named for this substance has a negative anomaly in mass extinctions. Coupling between individual atoms of this substance is detected using the INADEQUATE experiment. Dynamic nuclear polarization is used to hyper-polarize this substance for measuring the forward (*) metabolic rate. Distortionless enhancement by polarization transfer is used to decouple signals between hydrogen and this substance; those signals appear between 0 and 220p·p·m in one technique. It makes up about 1.1% of the abundance of its element. For 10 points, name this N·M·R-active isotope of atomic element number 6.

ANSWER: 13C [or carbon-13; or C13; prompt on carbon]

<Chemistry, Eric Mukherjee>

20. The slope of these things is directly proportional to the relative geostrophic vorticity according to the Margules (“mar-GOO-less”) equation. The conditions of vertical circulation required for the formation of these things are described by the Sawyer-Eliassen equation. Locations where these things overlap can be represented by trowal (“TROW-ul”) symbols. Parcel deformation processes contribute to the formation of these things if the axis of dilatation (“die-luh-TAY-shun”) lies within 45 degrees of an (*) isentrope. Jacob Bjerknes (“YAH-kob BYURK-nes”) introduced the term for these formations, whose presence is indicated by kinks in isobars that represent pressure at zero geopotential meters. They aren’t on phase diagrams, but “triple points” can form when one of these formations occludes another. Two types of them are depicted using red lines with semicircles and blue lines with triangles. For 10 points, name these boundaries between air masses which come in “hot” and “cold” types.

ANSWER: weather fronts [accept surface fronts or hot fronts or cold fronts; accept frontogenesis or frontolysis; prompt on temperature gradients]

<Earth Science, Will Alston>

21. DeVries and Taylor added a cutout procedure to these constructs, which improved their performance on CIFAR-10 (“see-far ten”). Girschik created one of these constructs that begins by analyzing region proposals; that is their “Faster R-” type. Increasing the dilation factor in one part of these constructs obviates the need for upsampling. The depth, stride, and padding are hyperparameters that characterize these constructs. These constructs often use max pooling for dimensionality reduction after creating a feature map using their (*) namesake operation, which can be visualized by moving a matrix stepwise over a larger matrix of pixels. These algorithms are inspired by the mammalian visual cortex, where individual neurons have receptive fields. For 10 points, name these deep learning algorithms that usually use cross-correlation instead of their namesake operation, which for functions f and g is symbolized $f \star g$.

ANSWER: convolutional neural networks [accept CNNs or ConvNet; accept SIANN or shift-invariant artificial neural network or space-invariant artificial neural network; prompt on partial answers, prompt on perceptron or multilayer perceptron or neocognitron]

<Computer Science, Steven Silverman>

22. This operation is applied to an exponential generating function and then evaluated at one in Borel’s integral summation method. If the result of this operation converges everywhere except for a pole at $z = 1$, then the input of this operation is asymptotic to a constant times e to the x , according to the Wiener-Ikehara theorem. Applying this operation to a step function yields a general Dirichlet (“deer-uh-CLAY”) series. The moment generating function of a random variable is the result of applying the two-sided form of this operation to the (*) probability density function. Euler derived the integral representation for n factorial by taking the n th-order derivative of the identity “this operation applied to one equals the function one over s .” This operation transforms differential equations with constant coefficients into polynomial equations. The kernel of this transform is the negative exponential “ e to the negative $s t$.” For 10 points, give this integral transform that converts functions from the time domain to the s -domain, denoted with a script L .

ANSWER: Laplace transform [accept just Laplace after “transform”]

<Math, Justin French>

23. One protein found in this structure, S·e·h·1, associates with a scaffolding unit called a Y complex. The anti-p·62 antibodies in primary biliary (“BILL-ee-air-ee”) cirrhosis (“sir-OH-sis”) target this structure. Mutations in both inner and outer components of this structure are linked to steroid-resistant nephropathy. The SAGA and T·REX-2 complexes aid in one process carried out by this structure. Alkylation of C·R·M·1 by leptomycin (“lep-toh-MY-sin”) B inhibits this structure’s function. Conjugating I·B·B to a quantum dot is one method of studying this structure, which are also modelled using Frey and Gorlich’s hydrogels. This structure contains several intrinsically-disordered (*) F·G repeats. The reduction-of-dimensionality, selective-phase, and virtual gating models apply to this structure, which contains an inner ring attached to a basket and an outer ring attached to filaments. This complex is assisted by the Ran-G·T·P cycle, import·ins, and export·ins. Nup subunits make up, for 10 points, what complexes in the nuclear membrane?

ANSWER: nuclear pore complex [accept NPC; prompt on nucleus, pore, nuclear envelope, nuclear membrane]

<Biology, Abhinav Godavarthi>

24. In d dimensions, the size of these objects is set to two to the power of the floor function of d over 2. In dimensional regularization, one-loop calculations often use “trace technology” to simplify expressions containing these objects. The product of these objects and “A sub mu,” a covariant vector, is reduced to one symbol in Feynman (“FINE-mun”) slash notation. The anti-commutator of two of them equals 2 times the metric times the identity, a relation which generates a Clifford algebra. The (*) fifth of these entities, which in the chiral (“KYE-rull”) basis is diagonal, can be found by multiplying i times the product of the other four of them. In covariant form, i times \hbar times one of these entities times d sub mu of ϕ (“fye”), all minus $m c \phi$ equals zero. For 10 points, name these matrices that appear in a relativistic wave equation describing spin one-half particles, named for a British physicist.

ANSWER: Dirac matrices [or gamma matrices; accept matrix instead of matrices; do NOT accept “spinor” or “Dirac spinor”, as those are different]

<Physics, Eric Mukherjee>