Lederberg 3: Trinity

Hello, carders from the future! You're halfway done. Keep it up.

Will Alston[1], Justin French[2], Jonathen Settle[3], Geoffrey Chen[4,5], Jaimie Carlson[6], Abhinav Godavarthi[7], Steven R. Silverman[8], Akshay Govindan[9], Paul Chungroh Lee[10], Julia Zhou[11], Aakash V. Patel[8], Fred Zhang[11], Anson Berns[12], James Lasker[13, 14]*, Eric M. Mukherjee[15,16]‡

[1]Emeritus, Dartmouth College, Hanover, NH 03755
[2]University of California, Los Angeles, Los Angeles, CA 90095
[3]Department of Computer and Information Science and Engineering, University of Florida, Gainesville, FL 32611
[4]Wayzata High School, Plymouth, MN 55446
[5]University of Minnesota, Minneapolis, MN 55455
[6]School of Engineering and Applied Science, University of Pennsylvania, Philadelphia, PA 19104
[7]Plano West Senior High School, Plano, TX 75093
[8]Emeritus, Carnegie Mellon University, Pittsburgh, PA 15213
[9]Ladue Horton Watkins High School, St. Louis, MO 63124
[10]College of Arts and Sciences, University of Pennsylvania, Philadelphia, PA 19104
[11]Thomas Jefferson High School for Science and Technology, Alexandria, VA 22312
[12]Montgomery Blair High School, Silver Spring, MD 20901
[13]Department of Astronomy and Astrophysics, University of Chicago, Chicago, IL 60637
[14]Kavli Institute for Cosmological Physics, University of Chicago, Chicago, IL 60637
[15]Emeritus, Medical Scientist Training Program, Perelman School of Medicine at the University of Pennsylvania, Philadelphia, PA 19104
[16]Department of Dermatology, Vanderbilt University Medical Center, Nashville, TN 37232

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

1. **The presence of high-atmospheric clouds in a type of variable star that are in this evolutionary phase is responsible for the so-called "washed-out" appearance of their spectral lines. The fact that evolutionary population synthesis overpredicts the number of stars in this phase is called the "boosting effect." The efficiency of the third dredge-up which occurs in this phase is enhanced by convective overshoot. The evolution of stars in this phase is divided into an early phase and a phase during which these stars undergo periodic thermal pulsations. (*)** Mira variables are in this phase of stellar evolution. After evolving beyond the "red clump" or "blue loop," stars exit the horizontal branch and enter this stage. Stars during this evolutionary phase are the primary site of the s-process. After evolving beyond this stage, stars develop a superwind and eject a planetary nebula. For 10 points, identify this phase of stellar evolution named after the fact that the path traced out on a H·R diagram during it is almost aligned with the red giant branch.
ANSWER: __asymptotic giant branch__ stars [or __AGB__ stars; or early __asymptotic giant branch__ stars; or E-__AGB__ stars; or thermal pulsation __asymptotic giant branch__ stars; or TP-__AGB__ stars; antiprompt on Mira variables or Omicron Ceti variables; if the answer of "red giants" is provided, laugh maniacally as you neg them]
<Astronomy, Geoffrey Chen>

2. **A 1997 paper by Alley et al. postulated that rapid occurrence of this process causes long profiles to more rapidly adopt steady-state angles. The rate of this process is proportional to the effective normal pressure in the Boulton model. Robert L. Hooke posited a positive feedback loop in which overdeepenings are created through a continual occurrence of this process. Locations where this process has preferentially *not* occurred may contain micro-crag and tails. Due to the higher rate of basal melting, the rate of this process is higher in warm-based (*)** zones than cold-based zones. Occurrence of this process over an extended period of time can produce striations. Plucking and abrasion are the two most common subglacial forms of this process, which creates U-shaped valleys. For 10 points, what process triggered by glaciers can also occur via fluvial and aeolian mechanisms, and is contrasted with weathering?
ANSWER: __erosion__ (by glaciers) [accept __abrasion__ before "abrasion"; prompt on sediment transport or sedimentation; prompt on glacial motion or glaciation equivalents]
<Earth Science, Will Alston>

3. **In a system that *does not* require this property, Raman-induced coherence is used to create quantum interference; that system that *does not* require this property was realized by Marlan Scully. In one system, this property is achieved via injection into an active region of quantum wells which are sandwiched between distributed Bragg gratings. In the bound-to-continuum approach, this property is achieved by optimizing the injection efficiency to create a quantum cascade. In N·M·R, signal strength in systems with spin-spin coupling can be enhanced by making the system acquire this property using a composite 180-degree (*)** pulse. Two level systems cannot achieve this property, which is a classic example of negative absolute temperature. It is most commonly achieved by transfer of energy into the gain medium via pumping, thus producing stimulated emission. More atoms are in excited than ground states in systems with, for 10 points, what state critical to laser operation?
ANSWER: __population inversion__ [or __inverted population__; prompt on lasing or answers including laser until "laser"]
<Physics, Will Alston>

4. **The number of this ligand present is written using a subscript inside a curly brace, and the oxidation state of the complex is an exponent, in Enemark-Feltham notation. A complex of cyanide and this ligand form an iron coordination complex used as a reference in Mossbauer spectroscopy. Adding a tert-butyl and toluyl ("TALL-yew-ull") group to this compound generates P·B·N, which, like other spin traps, has a stable radical on a functional group with this compound bound to an R group. This ligand binds in a bent geometry when it has a charge of negative 1 and in a linear geometry when it has a charge of plus-one; Jorgensen used the term "non-innocent" to describe that behavior. This compound unusually has a bond order of 2.5, even though it's impossible to draw a (*)** triple bonded resonance structure of it. When not acting as a ligand, this molecule activates guanylate cyclase by binding to heme. This diatomic free radical acts as a vasodilator. For 10 points, name this molecule with formula N·O.
ANSWER: **nitrosyl** ligand [or **nitroso**, or **NO** until mention, or **nitric oxide**, do NOT accept or prompt on nitrous oxide, nitro, or nitrito]
<Chemistry, Geoffrey Chen>

5. **One family of these genes with a characteristic three-amino acid extension are called TALEs ("tails"), and include M·E·I·S·1. The products of these genes use Y·P·W·M domains to interact with binding partners like P·b·x, E·x·d, and H·t·h homologs. The fact that teleosts ("TEE-lee-osts") have a larger cluster of these genes than mammals suggests that a teleost-specific genome duplication occurred. The product of one of these genes restricts the movement of, and interferes with the action of, deca·penta·plegic, and is translated only in the absence of hunchback. T·A·A·T is the core recognition sequence of these transcription factors, which contain a 60 amino acid (*)** helix-turn-helix domain. Ultra·bi·thorax and antenna·pedia are two of these genes in *Drosophila* ("druh-SOFF-ill-uh"), where there are activated by gap and pair-rule genes in the embryo. For 10 points, name these genes responsible for development along the head-tail axis.
ANSWER: **Hox** genes [or **homeobox** genes; or **homeotic** genes; prompt on transcription factors or TFs with "What family?"]
<Biology, Abhinav Godavarthi>

6. **Rademacher ("RAD-uh-mack-ur") developed a namesake contour based on the Farey sequence to estimate these values for the j-invariant. For the modular discriminant, these values are given by the Ramanujan tau function, while for the Eisenstein ("ICE-un-stein") series they are given by the sum of divisors functions. These values are estimated by dividing the contour of integration into major and minor arcs in the modern formulation of the circle method. In the context of modular forms, these values multiply powers of the nome q. These values arise when projecting a function onto a given orthonormal basis for the Hilbert space of (*)** square integrable functions on a finite interval. For the function x minus the floor of x, the nth of these values is given by negative one to the n, over n. The nth one of these values for a given function can be calculated by multiplying the function by e to the negative i n x and then integrating from negative pi to pi. These values arise when decomposing a wave·form into a sum of harmonics. For 10 points, give these values that multiply "sine of k x" and "cosine of k x" in their namesake series.
ANSWER: **Fourier** series **coefficients** [accept **Fourier sine coefficients** or **Fourier cosine coefficients**; prompt on coefficients or series coefficients]
<Math, Justin French>

7. **In a paper co-written with John Haigh, this scientist posited that the probability of fixation at closely linked loci to a selectively favored gene is exp negative N-c. This scientist studied how female *Drosophila* ("druh-SOFF-ill-uh") sub·obscura differentiated between outbred flies and inbred flies in a study of signaling theory. This scientist used the example of a "discoverer" and a "late-comer" in finding a resource to show that escalation in an asymmetric contest is (*)** unstable. With George Price, this man developed a matrix where the payoff for two aggressors is quantity V minus C all over two, where V is the contested resource and C is the cost of flight; that matrix describes the Hawk-Dove game. He developed an extension to the Nash Equilibrium that is preserved by natural selection. For 10 points, name this British biologist, who presented the idea of an evolutionarily stable strategy in his "Evolution and the Theory of Games".
ANSWER: John Maynard **Smith**
<Biology, Julia Zhou>

8. **Post-hoc calculations of this quantity were criticized by Hoening and Heisey for creating its namesake "approach paradox". Methods for calculating this quantity are collected in a textbook by Jacob Cohen named for this quantity's analysis in the behavioral sciences. In designs with multiple comparisons, the Holm-Bonferroni method is preferred to the Bonferroni method because it preserves this quantity. Parametric methods generally have a greater value of this quantity than nonparametric ones for the same experiment. In one setting, the likelihood-ratio test uniformly has the greatest amount of this quantity per the (*)** Neyman-Pearson lemma. This quantity is usually set at 80%. This quantity, significance level, and effect size are used to calculate sample size for a study. This quantity is equal to one minus beta, where beta is Type II error rate. For 10 points, name this quantity, the probability of rejecting a null hypothesis when the alternative is true.

ANSWER: statistical **power**

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

9. **An analogy of this effect is possible in a mini·super·space model when the scale factor is between zero and one over the Hubble parameter; that equation arises in Vilenkin's model of the early universe, which can unusually experience this effect. It's not recombination, but a trap-assisted version of this phenomenon occurs due to repeated high-voltage stress in the dielectric layer of E·E·P·ROM devices. Using this effect instead of thermionic emission overcomes the sixty millivolt per decade swing of (*)** MOSFETs. This phenomenon results in a decrease in current as forward bias voltage increases in Esaki diodes, and in the sun, this effect overcomes the Coulomb barrier to allow fusion to occur. For a particle in a finite potential well, this phenomenon is explained by the decaying exponential form the wavefunction takes outside the barrier. For 10 points, name this phenomenon where a particle moves through a classically insurmountable barrier.

ANSWER: quantum **tunneling**

<Physics, Akshay Govindan>

10. **A high-speed version of this technique requires one part of the apparatus to have a resonance frequency over 1 MHz and an improved Z-scanner. Closed-loop scanning is used to correct for creep and hysteresis ("hiss-tur-EE-sis") of an actuator in this technique. In this technique, "snap-in" occurs when van der Waals or capillary forces causes the apparatus to jump. Width data obtained using this technique is often too large due to broadening from orientation and convulsion effects; this can be mitigated using probes created using E·B·D. Devices for this technique can operate in (*)** contact or tapping mode. This technique, which generally has much higher resolution than S·T·M, uses the reflection of a laser onto a photo·diode to measure the deflection of the tip of a cantilever as it moves across a sample. For ten points, name this form of scanning probe microscopy which can achieve single-atom resolution.

ANSWER: **atomic force microscopy** [or **AFM**; prompt on scanning probe microscopy or SPM]

<Chemistry, Julia Zhou>

11. **The trigger and threshold pins are connected to run a 555 integrated circuit in its a·stable mode, where it acts as one of these devices. A Wien bridge is used to implement a simple device of this type that requires the noninverting input voltage to be one-third of the output voltage. Since they exhibit negative differential resistance past the threshold voltage, Gunn diodes are commonly employed in these devices. The output of one of these devices is mixed with the signal in heterodyne receivers used in radios; that principle is used in (*)** theremins ("THERE-uh-minz"). Circuits used to construct these devices typically consist of an amplifier connected in a positive feedback loop, and L·C circuits act as these devices because d-squared I over dt-squared equals omega-naught-squared times I. For 10 points, name these electronic devices which can be modeled with differential equations analogous to those of a mass on a spring.

ANSWER: electronic **oscillator** [**oscillating circuit**; accept beat frequency **oscillator**; accept **resonator**; prompt on BFO; prompt on circuit]

<Physics, Jonathen Settle>

12. **Krtolica, Stanimirovic, and Stanojevic used this system to construct an algorithm for triangulating polygons. The company most often associated with this system initially implemented a three-level version before eventually settling on the more popular four-level version, and later implemented an operating system named for both this system and Lisp. The programming language Forth relies heavily on this system, since it is stack-based. Dijkstra invented an algorithm that uses a stack and a queue to convert inputs into this system; that algorithm can be visualized as a (*)** wye junction, which is why it is named the "shunting yard" algorithm. The 9100A Desktop Calculator was the first in a long line of Hewlett-Packard products that used this system for data entry. For 10 points, name this technique for representing mathematical operations with operands in front of operators, invented by Jan Łukasiewicz (wewk-uh-shave-itch).
ANSWER: **reverse Polish notation** or Polish **postfix notation** [do not accept or prompt on "Polish notation"] <Computer Science, Steven Silverman>

13. **The Heggie-Hills law states that systems that possess this property strongly, will evolve over time to increase the extent to which they have this property. Lynden-Bell proposed a mechanism in which systems with this property could undergo a form of thermal instability in which a hot system transfers energy to a cold system, causing the hot system to collapse, that occurs because systems with this property have negative heat capacity. Binary systems can be classified as (*)** "soft" or "hard" depending on the extent to which they possess this property. The crossing time is much less than the relaxation time for systems with this property. A gravitational system which possesses this property will obey the virial theorem. Unlike stellar associations, globular clusters possess this property with respect to gravity. For 10 points, identity this property a system has if the magnitude of its gravitational potential energy exceeds that of its total kinetic energy.
ANSWER: gravitationally **bound** [or **self-gravitating**, prompt on hardness or softness before read; prompt on closed, prompt on negative energy]
<Astronomy, Geoffrey Chen>

14. **J.C. Knight et al. built the first of a novel type of these devices using a hexagonal close packed array of air holes that act as a sieve. C·Y·T·O·P is used to create a polymer-based type of these things, which can also use P·M·M·A and silicone resin. One type of these devices has a parabolic profile given by n-one times the square root of the quantity one minus two delta times r over a squared. Two pi times the core radius over the vacuum wavelength times the numerical aperture gives the V-number for these devices, and the number of (*)** modes is just V-squared over two for the step-index type of these devices. Modal dispersion raises the bandwidth-distance product of these devices when they are multi-mode. Charles Kao pioneered the development of these devices, which contain a core surrounded by cladding. For 10 points, name these devices that use total internal reflection to transmit light through silica glass, which can communicate signals at a higher bandwidth than electrical cables.
ANSWER: **optical fiber**s [accept **fiber optic** cables; accept **photonic crystal fiber**; accept **holey fiber**s; accept **photonic-bandgap** fibers; accept **Bragg fiber**s; prompt on optical waveguides; prompt on fibers]
<Physics, Jonathen Settle>

15. **The first paper to use this technique was published by Johnson, Mortazavi and Wold and targeted N·R·S·F. A quality control step in this assay can be analyzed using the percent input method or the fold enrichment method. A modification of this technique links M·m·e·one sites together to form barcoded paired-end tags. Invitrogen's MAGnify system is used for this assay, which sometimes has an end-polishing step before a subsequent ligation step. GEM is a peak-calling algorithm used in this technique, whose results can be displayed on a "custom track" in a browser maintained by U·C·S·C. Either sonication or (*)** micrococcal nuclease is used in the shearing step of this technique. A pre·clearing step removes non-specific interactions in this technique, which can use poly·styrene beads conjugated to protein A and G for pull·down. For 10 points, name this technique in which all D·N·A bound to a particular protein is mapped.
ANSWER: **ChIP**-seq [or **cross-linked ChIP** or **NChIP** or **native ChIP** or **ChIP**-sequencing or **ChIP**-chip or **ChiP**-on-chip or **Chromatin Interaction Analysis by Paired-End Tag Sequencing** or **ChIA-PET**S or **ChIP-exo**; accept **chromatin immunoprecipitation** instead of "ChIP"; prompt on IP or immunoprecipitation]
<Biology, Eric Mukherjee>

16. **A generalization of this result is the Nichols-Zoeller freeness theorem, which shows that a Hopf subalgebra is free of finite rank if it is finite-dimensional. Gagola and Hall showed that every Moufang loop obeys an analogue to this theorem. This theorem is applied before creating a bijection to elements of the orbit in a proof of the orbit-stabilizer theorem. Ruffini showed that A·4 is an exception to the converse of this theorem; that converse of this theorem holds for all supersolvable (*)** groups. The Sylow ("see-low") theorems give a partial converse of this theorem, one statement of which equates the index of a coset with the quotient of the order of G and H. A simple proof of this theorem involves demonstrating a bijection between two left cosets of a subgroup, which shows that all left cosets have the same cardinality. For 10 points, name this theorem that states that the order of every subgroup H of a group G divides the order of G.
ANSWER: **Lagrange**'s theorem
<Math, Steven Silverman>

17. **Athan Shaka developed one method of performing this task that can use either a w5 train or the program z·g·e·s·g·p, called excitation sculpting. One method of doing this uses a symmetric 3-9-19 sequence. A simple method of doing this requires setting the o·1 or o·2 offset and increasing the p·1·9 power preset in TopSpin and uses a z·g·p·r sequence in Bruker instruments. The jump-return method for doing this has the advantage of not attenuating exchangeable signals. Methods of performing this task are often tested on a solution of sucrose in 70% or 90% H2O. Pre-saturation and (*)** WATERGATE are methods of doing this, the latter of which uses two pulsed-field gradients sandwiching a 180-degree pulse. This step, which removes signals at 7.26p·p·m for chloroform and 4.8p·p·m for water, is often required because deuteration ("do-tur-AY-shun") is incomplete. For 10 points, name this step in N·M·R where the signal from the substance dissolving the sample is removed.
ANSWER: **solvent suppression** in NMR [or **water suppression**; anti-prompt on excitation sculpting; presaturation or WATERGATE before mention; accept any answer suggesting that the peaks or signals from the solvent or water are removed; prompt on any answer like cleaning up NMR signal, removing noise in NMR, refining NMR spectrum, calibrating NMR, refining NMR signal, removing peaks in NMR; prompt on NMR or protein NMR, with "what specific aspect of obtaining an NMR spectrum?"; prompt on NMR pulse sequence with "what does the pulse sequence do?"]
<Chemistry, Eric Mukherjee>

18. **These things are divided into "block" and "element" types in S·I·M·D architectures in the "strip-mining" technique. That is an example of "tiling" on these things, which partitions them into smaller blocks to ensure that data remains in the cache. Griebl developed a method which transforms n of these things into an n-dimensional polyhedron of lattice points, then performs an affine transformation on the polyhedron. "Fission" or "fusion" can be done to break up or combine these things to take advantage of (*)** locality of reference. By combining one of these things with a switch statement and wildly abusing fall-through, Duff's device increases the efficiency of that one of these things. Vectorization avoids the use of these constructs. Compilers increase efficiency at the expense of program length by "unrolling" these things. Break or continue keywords can be used to skip out of these things. For 10 points, name these repeating control blocks of code often defined with "for" or "while."
ANSWER: **loop**s
<Computer Science, Jaimie Carlson>

19. **A thio·glycolate lactam auxiliary developed by Gleason is used to create these species via repeated enolization ("ee-nol-uh-ZAY-shun"). Dam·mara·dienol and lanosterol ("LAN-oh-STARE-oll") both have two of these things vicinal to each other, a structure created through polyene cyclization of squalene ("SQUAY-leen") oxide. The presence of a benzene ring and one of these things separated by a two-atom spacer from an amine comprise the "morphine rule" for opioid structure. An asymmetric Heck reaction can be used to create these species, which are then retained because they cannot undergo beta-hydride elimination. These things do NOT show any enhancement in gated decoupling experiments, and show no signal in (*)** D·E·P·T. When one of these things occurs next to a primary or secondary carbocation ("carbo-CAT-ion"), alkyl shifts occur. The neo·pentyl group contains one of these centers, which completely lack signal in proton N·M·R. For 10 points, name these centers consisting of carbon bonded to four alkyl chains.
ANSWER: **quaternary** carbon [or **quaternary** center or **quaternary** stereocenter or chiral **quaternary** carbon; prompt on carbon atom, chiral center]
<Chemistry, Eric Mukherjee>

20. **Intramuscular injections of this hormone, alongside oral vigabatrin ("vye-GAH-bah-trinn"), is used to treat infantile spasms. A high central to peripheral gradient of this hormone detected via inferior petrosal ("puh-TRO-sul") sinus sampling is diagnostic of its overproduction. 250 micrograms of a synthetic analogue of this hormone are injected, and blood is collected at 0, 30, and 60 minutes, in its namesake stimulation test. Because the first 13 amino acids of this hormone form alpha-M·S·H, excessive production of this hormone causes (*)** darkening of palmar creases, which can occur in Nelson's syndrome. Ectopic sources of this hormone fail to suppress at either high or low doses of dexamethasone ("DEX-uh-METH-uh-zone"). This hormone's release is triggered by C·R·H and triggers the release of cortisol. For 10 points, name this pituitary hormone that acts on the adrenal gland.
ANSWER: **ACTH** [or **adrenocorticotropic hormone**; or adreno**corticotropin**]
<Biology, Eric Mukherjee>

21. **In this technique, McCrary's density test can determine if the running variable has been manipulated, an effect called "sorting." The Imbens-Kalyanaraman ("KAL-yan-a-RAH-mun") algorithm selects an optimal bandwidth for this approach, which was used by DiNardo and Lee to compare long-term impacts on wages for different outcomes of narrowly decided union elections. Depending on whether all relevant subjects receive or don't receive treatment, this approach can be "fuzzy" or "sharp". This approach was developed in 1960 as an "alternative to the ex post facto experiment" to deal with situations in which subjects could not be (*)** randomized. Its developers, Thistlewaite and Campbell, used it to compare students who won certificates of merit against those who merely received recommendation letters from the National Merit Scholarship corporation. For 10 points, name this quasi-experimental design comparing groups close to either side of a predefined cut point.
ANSWER: **regression discontinuity** design [or **RDD**; prompt on partial answers]
<Data Science/Stats/Applied Math, Will Alston>

22. **The adjectival form of this process denotes dynamical systems with a wandering set with non-zero measure. When using finite difference methods applied to computational fluid dynamics, this effect dominates when the lowest order partial derivative on the right side of the Modified Equation is odd, leading to shocks near discontinuities being smeared away. To modify Lagrange's equations to describe systems with this process, one adds a term equaling [read slowly] "the partial of a function representing this process with respect to q-dot." A function describing this process equals [read slowly] "one-half times the sum over all particles of k-sub-x times v-sub-x squared, plus k-sub-y times v-sub-y squared, etc." and is named for Rayleigh. This process is linked to (*)** random deviations from equilibrium in a theorem named for this process and "fluctuation." Non-conservative forces like drag and friction cause, for 10 points, what irreversible process in which energy is transformed into a form less able to do work?
ANSWER: energy **dissipation** [accept Rayleigh's **dissipation** function; accept **dissipative** system; prompt on friction or drag by saying "can you be less specific"; prompt on energy loss; prompt on non-conservative forces]
<Physics, Will Alston>

23. **These cells can trans·differentiate into myo·fibro·blasts to drive renal fibrosis. The tumor-associated variety of these cells is targeted by C·S·F·1·R antagonists. A paradoxical lowering of the E·S·R and decreased fibrinogen ("fye-BRINN-uh-jin") in patients with lupus or adult-onset Still's disease suggests these cells' namesake "activation syndrome". Activation of an N·A·L·P·3-containing complex in these cells triggers the release of I·L-1·beta. These cells can differentiate into pro-inflammatory (*)** M·1 and anti-inflammatory M·2 subtypes. Flow cytometric ("sigh-toe-MET-rick") markers of these cells include C·D·64, C·D·68, and F4/80, and they share a cell-of-origin with dendritic cells. Heart failure cells, foam cells, and Kupffer ("CUP-fur") cells all derive from these cells, which use M·H·C class II to present antigen ("ANN-tuh-jen"). For 10 points, name these cells that derive from monocytes, with a name meaning "big eaters".
ANSWER: **macrophage**s [accept **microglia**, **Kupffer** cells, **heart failure** cells, **foam** cells, **dust** cells, **tingible-body macrophages**; prompt on monocytes]
<Biology, Eric Mukherjee>

24. **In this approach, the derivative of energy with respect to occupancy equals the eigenvalue according to Janak's theorem. In the presence of a scalar field, the Runge-Gross theorem is used in the time-dependent form of this approach. Methods using generalizations of the random phase approximation lie above hyper-G·G·A and meta-G·G·A methods on Perdew's "Jacob's ladder" of implementations of this approach. Hybrid methods that use an exact exchange energy are used to estimate the exchange-correlation term in this technique. This approach relies on mapping the input to a set of non-interacting particles using the (*)** Kohn-Sham method. This method was motivated by finding that the kinetic energy of an electron gas is an integral of rho to the five-thirds in the Thomas-Fermi model. For 10 points, name these methods for finding many-body solutions to the Schrodinger equation by calculating ground state energies from a namesake representation of electron probabilities.
ANSWER: **density functional** theory [or **DFT**]
<Chemistry, Will Alston>