

# Science Monstrosity II: Science of the Lambs

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## Tossups

1. Translation-invariant differential operators are polynomial in the differentiation operator with coefficient functions of this type. The only continuous real-valued functions from a space with the indiscrete topology are of this type. The Maximum Modulus Principle states that a complex function will have this property on any region where it is analytic and bounded. For a real-valued function of this type, the Fourier transform is a multiple of a Dirac delta function. For a function from  $\mathbb{R}$  to  $\mathbb{R}$ , this property implies that the graph is a horizontal line. FTP, give this adjective describing a function which attains only a single value.

Answer: **constant**

2. Ketorolac is the only drug of this class available for parenteral administration in the United States. Although shunting of arachidonic acid metabolism to leukotriene production may worsen asthma sensitive to one member of this group, it is inhibition of prostaglandin E-1 production that is responsible for its most notorious effect. Newer drugs such as rofecoxib selectively inhibit cyclooxygenase-2, and reduce the risk of GI bleeding associated with medications of this type. FTP, what is this class of drugs often used for inflammatory conditions such as arthritis and which includes aspirin and ibuprofen?

Answer: **NSAIDs** or **Non-Steroidal Anti-Inflammatory Drugs**

3. Some distortions in it are described by the integrated Wolfe-Sachs effect, which accounts for variations in gravitational potential. Its angular power spectrum shows acoustic oscillations with peaks at 2 degrees and 10 arc-minutes, but smooths out at small angular scales due to diffusion during the recombination epoch. 2 degrees is the horizon size at redshift 1000, while 10 arc-minutes is the thickness of the last scattering surface. The WMAP (pron: "w"-map) and COBE (pron: COH-bee) satellites studied its anisotropies. The most perfect known blackbody is, FTP, what pervasive radiation with a temperature of about 2.7 Kelvin?

Answer: **Cosmic Microwave Background Radiation** or **CMBR** (accept **Cosmic Background Radiation** or **Microwave Background**)

4. In 1977, Misra and Sudarshan proposed an experimental demonstration of this process, delaying the decay of an excited state in what they called the "quantum Zeno effect." It results in a wavefunction which is the normalized projection of the previous wavefunction onto the eigensubspace associated with the observed eigenvalue. Some physicists add terms to Schrödinger's equation to account for this process; others prefer to consider the wavefunction of the combined system and measuring apparatus. It occurs whenever a measurement is made, and incorporates the observed fact that immediately repeated measurements give the same results. FTP name this sudden truncation of the wavefunction about an observed value.

Answer: **collapse or reduction of the wavefunction or wave packet** (accept logical equivalents)

5. First described in 1881 by Claparede and its namesake discoverer, this organic chemistry reaction is catalyzed by enzymes such as malate synthase and ATP citrate lyase. An alkoxide removes the acidic alpha-hydrogen from an ester, with the ester enolate undergoing a nucleophilic substitution reaction to form a

tetrahedral intermediate with another ester. The alkoxide leaving group is expelled and a beta-keto-ester results. FTP, what is this reaction, the ester analogue of the aldol condensation?

Answer: Claisen condensation

6. This name is given to a process that can only occur in faults with very low normal stresses, or in faults lined with very ductile or weak material, such as fault gouge, which acts as a fault lubricant; that process is also known as aseismic slip. This name is also given to an eolian process which slowly moves heavy sand grains as they are hit by lighter, saltating grains. This term is also used to refer to a process similar to solifluction, which consists of a movement of less than one centimeter per year of unconsolidated flow. FTP, give the common term for continuous sliding of a fault, and the gradual downhill movement of regolith and soil.

Answer: creep (accept aseismic slip before mention in the question)

7. This equation is equivalent to the statement that the 4-divergence of the d'Alembertian of the four-potential is zero. It follows from invariance with respect to general gauge transformations, according to Noether's theorem. It can be obtained by substituting Gauss's Law into the divergence of Ampere's Law with the displacement current term included. This results in a continuity equation setting the partial time derivative of the density of the involved quantity plus the divergence of the current density to zero. Kirchhoff's current rule is a restatement of, FTP, what conservation law important in electromagnetism?

Answer: electric charge conservation

8. Their shear stress is proportional to the strain rate by a ratio known as the dynamic viscosity and the equation governing their motion in a pipe can be derived from the Darcy-Weisbach law. When they flow between parallel plates with one plate fixed and the other moving, their motion is known as Couette flow and their flow through an annulus is similar to their motion through a hollow tube, known as Hagen-Poiseuille flow. Governed by the Navier-Stokes equations and by the equation " $\text{div } \mathbf{V}$  equals zero," FTP, identify these eponymous fluids whose viscosity does not vary with applied force.

Answer: Newtonian fluids

9. Rice's theorem, stating that only trivial properties of programs are algorithmically decidable, can be proved by referring to this problem, which is solvable for machines with less than four states. It was introduced in the paper "On computable numbers, with an application to the Entscheidungsproblem," in which Turing reduced the Entscheidungsproblem to this statement, the first explicit example of an undecidable decision problem. FTP, name this generally undecidable problem of determining whether a given algorithm acting on a given input will run forever or stop.

Answer: halting problem

10. Over half of the 20,000 species of this plant are epiphytic, and the roots of these members are covered with a thick layer of epidermis called velamen which helps prevent water loss from the exposed roots. A type of monocot, it has 3 sepals and 3 petals, the middle of which is folded into an intricate structure called a labellum and which gives decorative varieties such as the ladies' slipper its name. FTP, what is this plant, the original source of vanilla?

Answer: orchid

11. It predicts a value of 70 to 90 J/mole degree, although it fails spectacularly for very small molecules such as helium and for molecules with extensive hydrogen bonding such as water and methanol. It works primarily because the increase in disorder generated as a substance transitions from the liquid to gas phases is relatively independent of the material undergoing the transition. FTP, name this rule that states that at normal boiling temperatures the entropy of vaporization is constant.

Answer: Trouton's rule

12. In 1936, Philip Kuenen was able to model and film these phenomena using a long, narrow tank with a sloping bottom. They were first noticed over a century ago where the Rhone River enters the clear water of Lake Geneva, and additional evidence for Kuenen's model came from breakages of transatlantic cables. Active sediment transport on the continental slope and rise are due to these phenomena, which occur when earthquakes trigger slumps of sediment on the edges of continental shelves. Submarine fans and canyons are produced by, FTP, these flows of dense, muddy water along the ocean bottom.

Answer: turbidity currents

13. Give the shared last name: George proposed a now-discredited theory that the Moon formed by resonant spin-off of material from Earth, and that tidal friction slows the Earth's rotation. A physicist who, with Fowler, developed the method of steepest descents, and lends his name to a correction term in the Pauli Hamiltonian which pertains when the orbital angular momentum is zero. Hexley the platypus is the mascot of the open-source, Unix-based operating system of this name, which forms the core of Mac OS X. The physician who published *Zoonomia*, anticipating some of Lamarck's theories, and was a grandfather of Francis Galton. FTP give the last name of the author of *The Descent of Man* and *The Origin of Species*.

Answer: Darwin (all of the people mentioned in the question are related)

14. Group B of this class of viruses is known as ADRV and has caused major diarrhea epidemics in China. An oral vaccine against this virus will begin clinical trials in Mexico later this year, almost five years after a similar vaccine was withdrawn in the US because of an increased risk of intussusception. Although its only complication is dehydration, this virus causes up to 1 millions deaths annually worldwide and is the leading cause of gastroenteritis, which is produces by blunting the intestinal villi. FTP, identify this virus, named for its distinctive wheel-like shape under electron microscopy.

Answer: rotavirus

15. This postulate can be used to explain the directing effects of substituents on benzylic acid rearrangements, and the greater regioselectivity in bromination of alkanes compared with chlorination of alkanes. It relies heavily on transition-state theory, and works best on highly endothermic or highly exothermic reactions. FTP, what is this postulate, which states that the structure of a transition state more resembles either the starting material or product depending on which one is closer in energy to the transition state?

Answer: Hammond's postulate

16. The site-specific variety was first characterized in 1968 by Smith, Wilcox, and Kelley, and today over 900 different ones have been isolated from 230 strains of bacteria. The Type I variety cleaves at a site over 1000 base pairs away from the recognition site, while the more commonly used Type II enzymes cut within the recognition site. Named for the strain of bacteria and order of discovery from that bacteria, commonly used examples include EcoRI (Eee-koh-are-won) and HindII (hind-two). FTP, name this type of enzyme, which is used to digest DNA and which has allowed the growth of recombinant DNA technology.

Answer: restriction enzymes or restriction endonucleases

17. For quantity  $k$  minus 1 times  $k$  over 4 comparisons within an ANOVA, this method is preferred over the Sheff comparison, but is inferior to the Tukey method if all pairwise comparisons are of interest. Also known as Dunn's multiple comparison procedure, a familywise error rate that is the sum of the per comparison significance levels is calculated, essentially dividing alpha evenly among the set of planned contrasts. FTP, what is this statistical test, in which the adjustment to alpha is known as the namesake correction, and which is based on Student's t-distribution?

Answer: Bonferroni t-test (accept Dunn's multiple comparison procedure prior to mention)

18. In a system under the influence of inverse square-law forces, no static configuration can achieve this state, according to Earnshaw's theorem. Examples include rigid-body rotation about the principal axes with the smallest and largest associated moments of inertia, but not the principal axis with the in-between value. When the primary mass is much larger than the secondary mass, the last two Lagrange points, but not the first three, are examples. Configurations in a local minimum of the system's potential energy function are, FTP, what type of configuration where any small perturbation results in a restoring force returning the system to the unperturbed configuration?

Answer: stable equilibrium

19. The Allred-Rochow scale uses the covalent radius and effective charge, while the Mulliken scale uses the average of ionization energy and electron affinity to predict this value. Although not originally assigned, the Allred-Rochow scale predicts values of 4.84 for neon and 5.5 for helium, significantly higher than the 4.0 maximum originally assigned to fluorine. FTP, what is this property, which increases as you go up and to the right of the periodic table, a measure of the tendency of an atom to attract a bonding pair of electrons?

Answer: electronegativity

20. Examples of these structures include metamicts, which result from radiation damage to minerals. Sir Nevill Mott shared a Nobel prize for his work on semiconductors of this type, which have a continuous range of localized states from the bottom of the conduction band to a critical energy known as the mobility edge. In late June, scientists at Oak Ridge found that by adding trace amounts of yttrium, they could produce centimeter-sized samples of steel with this type of structure, allowing the steel to be processed like a plastic since it lacks any long-range order. Rubber, butter, and water ice are examples of, FTP, what type of solid which is non-crystalline?

Answer: amorphous solids (prompt on mineral or mineraloid before "minerals" is read; do not accept glasses-glasses are a specific type of amorphous solid, and metamicts are not glasses)

## Bonuses

1. Answer the following about a redox reaction 5-10-15.

[5 points] Patented by R. F. Borkenstein in 1958, this device relies on the reducing power of alcohol to generate a color change in one of two ampules, and is calibrated such that approximately 2 liters of air corresponds to 1 cc of blood.

Answer: **breathalyzer**

[10 points] Alcohol reduces this yellow-orange substance, with formula  $K_2Cr_2O_7$ , to a green  $Cr^{3+}$  ion.

Answer: **potassium dichromate**

[10 points] The potassium dichromate is dissolved in this chemical, which is commonly produced using a vanadium oxide catalyst.

Answer: **sulfuric acid** or **H<sub>2</sub>SO<sub>4</sub>**

2. Answer the following on models of the nucleus, FTPE.

[10 points] This model treats the nucleus as an incompressible sphere of uniform density, with the strong force providing cohesion. Differences in the forces on nucleons at the surface or in the interior result in an analogue of surface tension.

Answer: **liquid drop** model

[10 points] The shell model of the nucleus was suggested by the existence of these numbers-2, 8, 20, 28, 50, 82, 126. Nuclei with this number of protons and/or neutrons are particularly stable.

Answer: **magic numbers**

[10 points] Name the woman who, with Jensen, proposed the shell model.

Answer: Maria **Goeppert**-Mayer (her maiden name was Goeppert; her work on the shell model was after she married, but I'd say Goeppert is uniquely identifying)

3. Answer the following on distance-finding techniques used in astronomy, FTPE.

[10 points] Unlike classical Cepheids or W Virginis stars, these Population II variable stars typically have periods of less than a day, and lie on the horizontal branch of the HR diagram. Answer: **RR Lyrae** variables

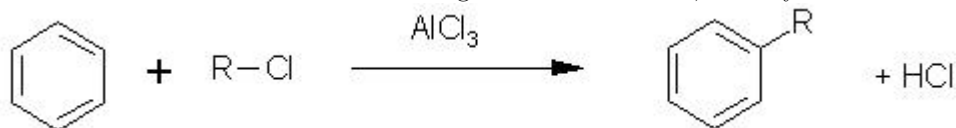
[10 points] The Faber-Jackson law, relating root-mean-square velocity dispersion of stars in these objects to their intrinsic luminosity, allows these objects to be used as standard candles.

Answer: **elliptic galaxies** or **ellipticals**

[10 points] The moving cluster method has been applied successfully only to this open cluster which, with Aldebaran, forms the head of Taurus. Then other distances can be calibrated with main-sequence fitting.

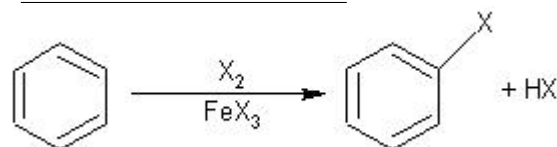
Answer: **Hyades**

4. Given the reaction mechanisms for the following aromatic reactions, identify the reaction type FTPE.



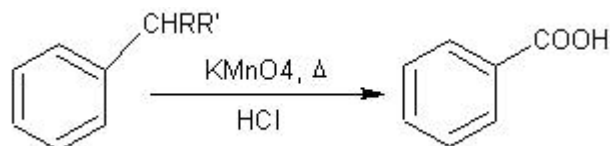
[10 points]

Answer: **Friedel-Crafts alkylation**



[10 points]

Answer: **Halogenation**



[10 points]

Answer: **Oxidation**

5. Name these special potentials in quantum mechanics FTPE.

[10 points] In this simple potential, the wavefunction is entirely confined to some region where the potential is identically zero. In this region, the bound states are sinusoidal functions.

Answer: **infinite square well** potential

[10 points] This potential named for a Japanese physicist is a screened Coulomb potential which provides a crude model for the binding force in an atomic nucleus.

Answer: **Yukawa** potential

[10 points] Sometimes used to model ion cores, this potential takes on the form of its namesake function, which is the derivative of the Heaviside step function.

Answer: **Dirac delta** potential

6. Answer the following on waves traveling in materials on a 15-10 basis.

[15 points] The Goos-Hnchen effect is a small lateral shift associated with this phenomenon, due to the presence of an evanescent wave.

[10 points] This phenomenon occurs for incidence angles above the critical angle, which can be calculated using Snell's Law.

Answer: **total internal reflection**

[15 points] The circular form of this effect can be used to study the secondary structure of proteins. At the quantum mechanical level, it is identical to optical rotation.

[10 points] Literally meaning "two-colored," this phenomenon arises when a material has a different absorption spectrum for left handed and right handed circularly polarized light.

Answer: **dichroism** (or **dichroic**)

7. Answer the following on planetary magnetic fields, FTSNOP.

[10 points] This spacecraft, part of a cooperative mission run by NASA, the European Space Agency and the Italian Space Agency, recently showed that Saturn's poles are on opposite sides of its equator.

Answer: **Cassini-Huygens**

[10 points] The ionization of the atmosphere of this gas-rich moon produces a magnetospheric plasma that then interacts with Saturn's magnetic field to create a slingshot-like effect.

Answer: **Titan**

[5 points each] Like Saturn, these two planets have strongly tilted magnetic fields. Unlike Saturn, their magnetic fields have very strong quadrupole components-in fact, the strongest in the solar system, relative to their dipole components.

Answer: **Uranus and Neptune**

8. Answer the following about epidemiology FTPE.

[10 points] This type of plot can be constructed to estimate the probability of survival for members of a population based on time.

Answer: **Kaplan-Meier** plot

[10 points] The Kaplan-Meier plot is valuable because it allows for the handling of data from patients who have been lost to follow up, also known as what kind of patients?

Answer: **censored** (accept word forms)

[10 points] This type of analysis examines outcomes for patients according to the group to which they were randomized, regardless of whether they actually received that treatment or not, and is considered a better measure of effectiveness.

Answer: intention to treat analysis or intent to treat analysis

9. Answer the following about cardiac electrophysiology FTPE.

[10 points] Digitalis acts by inhibiting the Na<sup>+</sup>/K<sup>+</sup> ATPase, which then leads to an increased intracellular concentration of this cation important in muscle contraction.

Answer: calcium

[10 points] Conduction velocity is fastest in these cells, modified cardiac myocytes that act as the terminal extensions of the left and right bundle branches.

Answer: Purkinje fibers

[10 points] In a junctional rhythm, the electrical impulse originates in this structure rather than the sinoatrial node.

Answer: atrio-ventricular node or AV node

10. Identify these scientists who lend their names to unit scales, FTPE.

[10 points] This man lends his name to mass, length, and time units given by combinations of the speed of light, the universal gravitational constant, and his namesake constant.

Answer: Max Karl Ernst Ludwig Planck

[10 points] This man lends his name to the length or mass at which a molecular cloud of a certain density will collapse under its own gravity.

Answer: Sir James Jeans

[10 points] With Lorentz, this man lends his name to a set of rationalized electromagnetic units derived from Gaussian units which eliminate factors of 4 pi in Maxwell's equations.

Answer: Oliver Heaviside

11. Name these structures from abstract algebra, FTPE.

[10 points] A set with an associative binary operation, with an identity element and inverses for every element in the set.

Answer: group

[10 points] A vector space over a field, together with a binary operation \* (read: STAR) that is bilinear, satisfies the Jacobi identity, and  $x * x = 0$  (read: X STAR X EQUALS 0) for all x.

Answer: Lie algebra (do not accept Lie group)

[10 points] A ring that satisfies the ascending chain condition on ideals, or, equivalently, a ring in which every ideal is finitely generated.

Answer: Noetherian ring

12. Answer the following about stereochemistry FTPE.

[10 points] All or nothing, give the names of the three scientists in the convention used to assign priority to substituents at a chiral center.

Answer: R.S. Cahn, Christopher Ingold, Vladimir Prelog

[10 points] Stereoisomers which have a different relative configuration and are not related as mirror images are known by this name.

Answer: diastereoisomers or diastereomers

[10 points] This is the name given to a structure created from an original by inversion at a single stereogenic center.

Answer: epimer

13. Answer the following about biologically important amino acids which are not incorporated into proteins FTPE.

[10 points] Formed by the addition of CO<sub>2</sub> and ammonia to ornithine, this amino acid is found primarily in the liver and functions in the urea cycle.

Answer: **citrulline**

[10 points] Encephalopathy and cardiomyopathy are the classic presentations of a primary deficiency of this amino acid, which functions mainly to transport fatty acids into the mitochondria [10 points]

Answer: **carnitine**

[10 points] This amino acid is the product of decarboxylation of glutamate by vitamin B<sub>6</sub>, and functions primarily as an inhibitory neurotransmitter.

Answer: **gamma-amino-butyric acid** or **GABA**

14. Answer the following on a programming language, FTPE.

[10 points] This polymorphically typed, purely functional programming language offers pattern matching. It is based on lambda calculus and named for a logician. Popular implementations include Hugs and GHC.

Answer: **Haskell**

[10 points] As opposed to eager or strict evaluation, this feature of Haskell allows construction of an infinite data structure, meaning that Haskell evaluates only as much of a program as needed to get the answer.

Answer: **lazy** evaluation

[10 points] Haskell, like Python, has this feature, a syntax similar to standard set-building notation. Haskell converts these to expressions using the higher-order functions map and filter.

Answer: **list comprehensions**

15. Answer the following about plant growth FTPE.

[10 points] Synthesized in root and shoot meristematic tissue, this class of plant hormones promote chlorophyll production, unrolling of leaves, and shoot formation, among other things.

Answer: **cytokinins**

[10 points] Members of this class of hormones cause elongation of both sides of a shoot, and are absent in dwarf plants.

Answer: **gibberellins**

[10 points] Similar to phototropism and geotropism, this is the tendency for a plant to grow toward an object it is in physical contact with.

Answer: **thigmotropism**

16. Answer some questions about that ubiquitous phenomenon, noise, FTPE.

[10 points] This type of noise occurs during current flow and results in random fluctuations in the current due to the fact that the charge carriers are discrete. Its frequency is governed by the Poisson distribution.

Answer: **shot noise**

[10 points] In contrast to shot noise, this type of noise is ever-present in electrical conductors and is the result of thermal fluctuations.

Answer: **Nyquist** noise (or **Nyquist-Johnson** noise)

[10 points] Sometimes called pink noise or flicker noise, this noise contains equal energy in all octaves and takes its name from the fact that in its frequency spectrum the spectral energy density is proportional to the reciprocal of the frequency.

Answer: **one-over-f** noise (like 1/f)

17. Answer the following about oxidative phosphorylation FTPE.

[10 points] Proposed by Peter Mitchell in 1961, this hypothesis states that the energy from electron transport is used to create a proton gradient, and the flow of protons down this gradient is then coupled to ATP



production through an ATP synthase.

Answer: **chemiosmotic** hypothesis

[10 points] Give the collective name for chemicals such as 2,4-dinitrophenol which allow proton transfer without generating ATP, consuming oxygen and generating heat.

Answer: **uncoupling** agents (accept word forms)

[10 points] Chemicals such as cyanide, azide, and carbon monoxide interrupt oxidative phosphorylation by interfering with this protein in the electron transport chain.

Answer: **cytochrome oxidase** or **complex IV**

18. Answer the following on atmospheric circulation, FTPE.

[10 points] Atmospheric circulation takes place in cells in this lowest layer of the atmosphere.

Answer: **troposphere**

[10 points] This man's studies of a simple 3-dimensional model of atmospheric cell convection led to his discovery of a namesake strange attractor.

Answer: Edward **Lorenz**

[10 points] These atmospheric cells lie between the Hadley cells and the polar cells.

Answer: **Ferrel cells**

19. Name these quantities useful in statistical mechanics, FTPE.

[10 points] This thermodynamic potential is given by the internal energy minus the temperature times the entropy.

Answer: **Helmholtz free energy**

[10 points] Taking the derivative of the Helmholtz free energy with respect to the temperature yields this quantity, the logarithm of the number of microstates available to the system.

Answer: **entropy**

[10 points] For a given energy level, this is the number of states corresponding to that energy.

Answer: **multiplicity** or **degeneracy**

20. Answer the following about a medical procedure FTPE.

[10 points] Its first recorded therapeutic use was to instill cocaine intrathecally as a treatment for "habitual masturbation," but today is most commonly used as a diagnostic tool or to provide anesthesia below a certain level of the body.

Answer: **lumbar puncture** or **spinal tap**

[10 points] All or nothing, name the outer two layers of the meninges through which the spinal needle is passed during a lumbar puncture.

Answer: **dura** mater and **arachnoid** mater

[10 points] A lumbar puncture poses little risk of damage to nerves exiting the spinal cord because at the level at which it is usually performed, the nerve roots have left the cord and are traveling in this bundle of fibers named for its resemblance to a horse's tail.

Answer: **cauda equina**