Science Monstrosity II: Science of the Lambs

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Tossups

1. His first introduction to mathematics was a book by G. S. Carr called Synopsis of Elementary Results in Pure Mathematics, and it influenced his intuitive style. Independently, he discovered Bernoulli numbers and investigated the harmonic series. In 1909 he underwent his first operation, but his professional luck soon changed when a letter he had sent to England was taken seriously and he was invited to come to Cambridge by a prominent English mathematician. Elected a Fellow of the Royal Society in 1918, the year of his untimely death, FTP identify this Indian mathematician, a collaborator of Godfrey Hardy.

Answer: Srinivassa **Ramanujan**

2. It was developed by Tukey and Cooley in 1965 as a special case of a more general procedure, and it reduces computation time from order N squared to order N log N. If N is a power of two, it can be computed using the Danielson-Lanczos lemma, and it comes in two types, decimation-in-time and decimation-in-frequency. Widely used in digital signal processing applications, FTP, identify this special case of a discrete transform named after a French mathematician.

Answer: **FFT** (or Fast Fourier Transform)

3. Its coherent states were first discovered by Schrodinger and are currently called after Glauber. Its partition function is equal to one half the hyperbolic cosecant of the quantity beta times h-bar omega over 2. Its analytic solutions can be written in terms of Hermite polynomials, and anisotropic effects in it are treated using perturbation theory. It is also possible to derive its eignenergies by using the ladder operators, and the spacing between those energies is h-bar omega over 2. With a non-zero ground state equal to the energy spacing, FTP, identify this quantum-mechanical system whose analog is a system of the same type as a pendulum.

Answer: **quantum harmonic oscillator**

4. The speed of its transfer down the stem from the shoot apex is about 10 milimeters per hour, too fast for diffusion, and it is believed that it is transported directly through parenchyma tissue by polar transport. One of its secondary effects is to induce cell division in the vascular cambium, and at higher concentrations than 10 to the negative 3rd moles, it can actually inhibit the effect it is meant to produce. Also known as idoleacetic acid, and synthesized in the apical meristem, FTP, identify this plant hormone that stimulates proton pumps and promotes the growth of plant cells

Answer: **auxin**

5. The second step involves a sequential dehydration and rehydration reaction, performed by the enzyme aconitase. Step five involves substrate-level phosphorylation, at which point energy from Succinyl-CoA is used to form a single GTP molecule. In step seven, fumarase catalyzes the hydration of the carbon-carbon

double bond in fumarate, and the last step produces oxaloacetate to complete the process. FTP, what is this biological process which yields 4 moles of ATP per one mole of glucose, alternately known either by the name of its discoverer or for the first product it yields?

Answer: **Krebs cycle** or **citric acid** cycle

6. Cathode ray oscillograph delineation of the ground pulse employed by its discoverer revealed its capability of magneto-ionic echo splitting, and confirmed Radcliffe's belief that it is a double-refractor. Splitting into two layers at night, the sunspot cycle changes its ionic composition, though it is not affected by atmospheric conditions, making it a dependable reflector of radio waves. FTP, name this region characterized by the highest concentration of free electrons and ions in the atmosphere, located above the E-layer, the highest level of the ionosphere.

Answer: **Appleton** Layer (accept **F2**-layer) Prompt on ionosphere before given.

7. In its natural form, it occurs in most parts of the Earth's crust and can be mined directly from it. There are two types of it, amphibole and crystotile, and it is believed that amphibole is the more harmful of the two. Its fibrous nature makes it particularly good in environments which require high friction and it is an excellent flame retardant. Unfortunately, the fibers flake off easily and can be inhaled, greatly increasing the risk of cancer. FTP, what is this material which until the 1970s was widely used to fireproof homes?

Answer: **asbestos**

8. In all types of them, the current flows along a narrow channel whose effective electrical diameter can be varied by the application of voltage to a control electrode. In the junction type, the gate is made of the type of semiconductor opposite to the substrate, and the "junction" itself refers to the boundary between the gate and the channel. More famous is the metal oxide type, in which the gate is a piece of metal isolated from the channel by an oxide layer; in both cases, current flows from source to drain. FTP, identify this common type of circuit element which has mostly supplanted bipolar junction transistors in home electronics.

Answer: **FET** (or **Field Effect Transistor**)

9. In graphics processing, the morphological type of it is a composition of a dilation, an erosion, and a subtraction operator. In convective derivatives, the convective term is the dot product of the velocity with this object operating on the quantity in interest. Its cross product with the result of its operation on a vector is always zero, as is its dot product with the result of its cross product with a vector. FTP, identify this mathematical object whose square is called the Laplacian and the symbol for which is know as "del."

Answer: **gradient** (accept del before it is mentioned; also accept nabla)

10. It is most common in heavily agricultural regions, where it often occurs in animals, and when it affects humans, it is usually due to occupational exposure to infected animals. Its cutaneous and gastrointestinal forms are less deadly than its third form, and are more difficult to transmit because they require either ingestion or direct physical contact. However, its pulmonary form can be transmitted by inhalation of spores which can live up to several years in almost any conditions. Caused by a bacillus, FTP, identify this bacterial disease which killed several people in the US in 2001.

Answer: **anthrax**

11. In anchialine caves, it is stratified into nitrate, nitrite, and sulfate zones that mark the incipience of sulfur cycling. Dansgaard-Oeschger oscillations and Bond-Heinrich events cause this gradient to deepen in the North Atlantic. Its widening causes a strong pycnocline to develop between surface and intermediate waters, and its weakness along the Reykjanes Ridge allows dense water to sink. Polar catastrophes involving this boundary prevent the formation of deep ocean water due to the reduction in surface area of high salinity equatorial surface waters. FTP, what is this sharp drop-off with depth in oceanic salinity?

Answer: **halocline**

12. The exact forms of both potential and kinetic energy may be derived from this quantity, rather than the other way around. It is the Legendre transform of the Hamiltonian and using the variational principle, the differential equations of motion may be obtained from it. To obtain those equations, the action integral over time of this quantity must be constant. A function of generalized coordinates, momenta, and time, FTP, identify this quantity which for a mechanical system is equal to the kinetic energy minus the potential energy.

Answer: **Lagrangian**

13. In Visual Basic, one manifestation of this feature is the Variant data type, which can accept any kind of stored information. Other implementations of this concept include overloaded operators and the ability to define data types at run time. It is closely tied to the concept of inheritance because by using it, complex classes can be derived from basic ones while retaining the characteristics of the parent class. FTP, what is this programming concept which together with inheritance and encapsulation is one of the pillars of object oriented programming, and which takes its name from the Greek for "many forms?"

Answer: **polymorphism**

14. Although its direct cause is unknown, some scientists suggest that the autoimmune system may play some role in it. It has also been found that people with this disorder have higher levels of glutamate in the serum and spinal fluid than normal, and it has further been shown that neurons exposed to high glutamate levels for long periods of time die off. Early symptoms include spasticity and muscle weakness, and it is invariably fatal. Also known as Lou Gehrig's disease, FTP, identify this degenerative neural disorder which attacks and destroys motor neurons.

Answer: **ALS** (or **Amyotrophic Lateral Sclerosis**)

15. Italian scientists recently discovered that this substance could be used to manipulate a Fermi gas. A rotating quantity of it can be used to model a black hole and in general it can be used to slow down light or even capture it and release it in pulses. It was first created with a mixture of laser and magnetic evaporative cooling, and comes into existence at about 200 nanoKelvin. FTP, identify this state of matter, first created using rubidium atoms by Eric Cornell and Carl Wieman, winning them the 2001 Nobel Prize in Physics.

Answer: **Bose-Einstein condensate**

16. The first step in its operation is the reduction catalyst, during which rhodium or platinum catalyzes nitrogen monoxide or nitrogen dioxide into diatomic nitrogen and oxygen. The oxidation catalyst is next, during which previously unoxidized hydrocarbons are burned over a platinum or palladium catalyst, which aids in the reaction of carbon monoxide with oxygen from the previous stage to form carbon monoxide. A similar process can be carried out for sulfides as well in, FTP, what device located in all modern cars which reduces toxic emissions that result from the burning of gasoline?

Answer: **catalytic converter**

17. Their cells are organized into tracts that form nerve-like endings, even though they are not nerves. Their cells are long and barrel-shaped, with a few myofibrils surrounding a clear core of sarcoplasm, and their central region is rich in glycogen. They form gap junctions, fasciae adherents, and desmosomes with surrounding cells, but not through intercalated disks. Ventricular depolarization is mainly dependent on them, and they extend down the interventricular septum, penetrate the heart apex, and spread up the lateral ventricle walls. Located in the bundle of His, FTP, identify these tendrils of modified cardiac cells that generate the electrical stimulus for cardiac contractions.

Answer: **Purkinje** fibers

18. Though its dark biotite and hornblende phenocrysts give it a porphyritic appearance, this rock is never (*) volcanic. It may form from the partial melting of oceanic crust in subduction zones, though it is more commonly a product of fractional crystallization caused by hydration in the Wadati-Benioff Zone or assimilation of continental crust by basaltic melts. This phanerite may form stocks around granitic plutons, and it typically has gradational contacts with gabbro, leading to its erroneous classification as black granite. Composed of 90% intermediate plagioclase, FTP, name this plutonic equivalent of andesite.

Answer: **diorite** (accept "andesite" or "andesite porphyry" before (*)).

19. It was first discovered during attempts to solve coupled differential equations describing convection in a fluid. For a constant temperature, in that case, it was a point, but for small fluctuations in temperature a steady flow emerged, characterized by a periodic orbit on the computer-generated graph. Ruelle and Takens fully characterized it in 1971 and Henon showed that the chaotic trajectory of a star was one of these. FTP, identify these regions in phase space which show the bounds of a system in phase space, discovered by the scientist at MIT by whose name they are sometimes called.

Answer: **Lorentz attractors** or **strange attractors**

20. Samples for it are usually prepared with solvents such as tetrachloromethane, which lack hydrogen, although solvents which do have hydrogen will work if the hydrogen is replaced with deuterium. The energy difference between states that gives rise to its spectrum is given by the product of Planck's constant, the gyromagnetic ratio, and the applied field, divided by two pi and arises from the interaction of a pulse with the atomic spin state. FTP, identify this analysis technique in which a sample in a magnetic field is pulsed with radio frequency waves to achieve a particular condition in the hydrogen atoms of the sample?

Answer: **NMR** (or Nuclear Magnetic Resonance)

Bonuses

1. It simply wouldn't be a Berkeley tournament without a question about STDs, so here's one. Identify these sexually transmitted diseases FTPE.
[10 points] One of the few curable STDs, this is probably the most widespread STD in the USA. It is characterized by an abnormal urinal discharge and can cause pelvic inflamatory disease in women if not treated.
Answer: **Chlamydia**
[10 points] When active, this viral infection causes lesions and sores in the genital and mouth areas and puts sexual partners at risk for contracting it. There is no cure for it because the virus remains inside the body during the person's lifetime.
Answer: **herpes** (or **Herpes Simplex Virus**)
[10 points] Everyone's favorite STD, it killed Nietszche and Lenin. It is caused by the bacteria Treponema pallidum. It can be treated with pennicillin, but if left untreated develops tertiary forms that usually end in blindness, insanity, and death.
Answer: **syphillis**

2. Identify these different spectroscopy techniques FTPE.
[10 points] This type of spectroscopy is based on its namesake effect, which consists of the recoilless emission of a gamma particle from a radioactive specimen.
Answer: **Mossbauer** spectroscopy
[10 points] Complementary to Raman spectroscopy is this type of spectroscopy with a wide range which takes its name from the fact that it uses wavelengths smaller than those of the visible spectrum.
Answer: **IR** (infrared) spectroscopy
[10 points] This type of spectroscopy determines chirality by taking advantage of the fact that different chiralities respond differently to circularly polarized light.
Answer: **ORD** (or Optical Rotary Dispersion)

3. Name these sedimentary rocks, FTPE:
[10 points] This is a sandstone containing over 25% feldspars. It is usually cemented by calcite or hematite, and is indicative of deposition following extremely short transport. No lithic fragments are present.
Answer: **arkose** [10 points] Often accompanying arkose in deposits, this rock composed of angular lithic fragments may be formed from the collapse of a cave, or may occur in pipes. If volcaniclastic, it is known as agglomerate.
Answer: **breccia** [10 points] A mixture of clay minerals, mica and quartz, this fissile rock is derived from ancient mud deposits called rudites. Sometimes considered a variety of mudstone, its metamorphism produces pelites like slates.
Answer: **shale**

4. Answer some questions related to Fermat's last theorem FTPE.
[10 points] FLT is one of these types of equations for which only integer solutions are allowed.
Answer: **Diophantine**
[10 points] This man's tenth problem dealt with finding a universal algorithm for determining whether a Diophantine equation has a solution.
Answer: David **Hilbert**
[10 points] This Diophantine problem involves finding solutions to the equation x raised to the p power minus y raised to the q power equals plus or minus 1. A conjecture of the same name states that the only solution is 3 squared minus 2 cubed.
Answer: **Catalan's Problem** (do not accept "Catalan's conjecture")

5. Identify these concepts from thermodynamics FTPE.

[10 points] One of the central assumptions of standard thermodynamics is this conjecture that given enough time, a system will realize all microstates compatible with energy conservation.

Answer: **ergodic hypothesis**

[10 points] This quantity represents the summation of Boltzmann factors over all possible states of a system. Its cannoical form includes the chemical potential as well as energy and it is usually denoted by Z.

Answer: **partition function**

[10 points] The trasitivity of thermodynamic equilibrium is also know by what name?

Answer: **zeroth law of thermodynamics**

6. Answer some questions about orbitals FTPE.

[10 points] For a given primary level, maximize spin, then maximize the allowed angular momentum, and then maximize the total momentum. When you do this, you're following what guidelines?

Answer: **Hund's rules** [10 points] Hund's rules are a direct application of this statement which dictates that the wave function of two fermions must be antisymmetric.

Answer: **Pauli exclusion principle**

[10 points] Applying Hund's rules to the second element explains why this form of it, with an electron in the 1s state and a second electron with spin parallel to the ground state electron, has lower energy levels than if the second electron were antiparallel to the first.

Answer: **orthohelium**

7. Identify these parts of your body that you probably wouldn't want to damage FTPE.

[10 points] One of the four stabilizing tissues of the knee, this frontal band of connective tissue prevents abnormal displacement and rotation of the lower leg with respect to the thigh. You often hear about soccer players tearing these.

Answer: **ACL** (or **Anterior Cruciate Ligament**)

[10 points] Ruptures of this connective tissue which attaches the back of the foot to the calf muscle requires reconstructive surgery. You'll be in so much pain if this happens that you won't be able to outrun the proverbial tortoise.

Answer: **Achilles** Tendon

[10 points] This tendon attaches the knee to the quadriceps muscle. In case of rupture, the lower leg can no longer hold up the weight of the body and reconstruction is necessary.

Answer: **patellar** tendon

8. Identify these people important in the life of Albert Einstein, FTPE.

[10 points] With this man, Einstein designed a refrigerator which had no moving parts. Although he had helped out on the Mahattan Project, in later years he became a staunch opponent of nuclear development.

Answer: Leo **Szillard**

[10 points] When Szillard and Fermi reached the point where they thought they could achieve a nuclear reaction, Einstein wrote a letter to this man, advocating the acceleration of a project to design and build a nuclear bomb.

Answer: **F**ranklin **D**elano **R**oosevelt

[10 points] One of Einstein's fiercest opponents, this man ended up proving the general theory of relativity and graciously conceded that Einstein was right.

Answer: Sir Arthur **Eddington**

9. Identify these mathematical terms associated with the real numbers FTPE.

[10 points] This was Cantor's graphical method for proving that the reals are uncountable.

Answer: **diagonal method** (or diagonal argument or diagonal proof)

[10 points] This was Cantor's conjecture that there is no infinite set with a cardinal number between that of

the integers and that of the reals. Since its acceptance or rejection leads to different types of set theories, it is undecidable.

Answer: **continuum hypothesis**

[10 points] These objects were introduced by their namesake as a method of constructing the reals from the rationals. They are partitions (A,B) of an ordered field that A is closed downwards, B is closed upwards, and A has no maximum.

Answer: **Dedekind cuts**

10. Name the following about a kind of fault, FTPE:

[10 points] This type of fault is characterized by vertical upward displacement of the hanging wall relative to the footwall.

Answer: **reverse** fault

[10 points] This is a reverse fault with horizontal or low angle displacement.

Answer: **thrust** fault

[10 points] The opposite of a fenster, this is the erosional remnant of a thrust sheet associated with a zero-angle reverse fault. They may occur in overturned anticlinoria. A famous example is the Samail in Oman.

Answer: **nappe**

11. Answer some questions about bonds, FTPE.

[10 points] When a carbon has bonds which are somewhere between single and double bonds, they are called by this name.

Answer: **aromatic**

[10 points] Aromatic bonds behave the way they do because they have electrons which move from bond to bond instead of permanently staying on some one bond. What is the term for such an electron?

Answer: **delocalized** (accept delocalization or clear equivalents)

[10 points] Due to the fact that rings with bonds in bridgehead positions will have too much strain to be stable, bonds as a rule do not form there. What is the name given to this rule?

Answer: **Bredt's Rule**

12. Identify these physics installations all over the world FTPE.

[10 points] Located in the Mozumi mine in Japan, this neutrino observatory saw neutrino oscillations in 1998.

Answer: **Super-K**amiokande

[10 points] Its telescope's main collecting dish is 305 meters in diameter and is located in a depression left by a karst sinkhole. Located about 50 miles southwest of San Juan, this observatory in Puerto Rico is run by Cornell.

Answer: **Arecibo** Observatory

[10 points] Located in New York, researchers at this national laboratory has won five Nobel Prizes, all in particle physics, including the discovery of the muon neutrino and CP violation.

Answer: **Brookhaven** National Laboratory

13. Answer some questions about things which are not conserved in particle interaction FTP.

[10 points] In 1957, Lee and Yang received the Nobel Prize in Physics for explaining this phenomenon, first observed in Cobalt-60 by C.S. Wu.

Answer: **parity** violation

[10 points] CP violation is only known to occur in this type of meson; it is manifested by the difference in lifetimes of the different subtypes of the meson.

Answer: **K-meson** (or **kaon**)

[10 points] Both parity and CP violation are committed by this nuclear force.

Answer: **weak** nuclear force

14. Identify the debilitating disorder of the nervous system FTPE.
[10 points] One of several nervous degenerative diseases, it causes gradual loss of brain cells and an onset of dementia. It is named after the German doctor who first observed it in 1906.
Answer: **Alzheimer's** disease
[10 points] Patients with this disease experience degeneration of the substantia nigra, an area of the brain that produces dopamine. Its exact causes are not known and common symptoms include trembling hands.
Answer: **Parkinson's** disease
[10 points] People who inherit the genes for this disease are usually stricken in their early 30s. It manifests itself in the genetically programmed destruction of neurons, resulting in its namesake spastic movements.
Answer: **Huntington's** chorea

15. Answer some questions about engines FTPE.
[10 points] This cycle consists of an intake of air, adiabatic compression, followed by ignition, adiabatic expansion, and finally the opening of an exhaust valve that drops the engine to atmospheric pressure.
Answer: **Otto** cycle
[10 points] A special case of the Otto cycle is this engine which contains a rotor and an eccentric shaft which relays the mechanical energy outside the system.
Answer: **Wankel** rotary engine
[10 points] This engine is isolated from the outside and contains two pistons as well as a cooler and a heater. It operates on a closed regenerative cycle by cyclic compression and expansion of the air inside.
Answer: **Stirling** engine

16. Identify these alcohols FTPE.
[10 points] Blood levels of it greater than 0.45% can be fatal. This is the standard alcohol consumed in by humans.
Answer: **ethanol** (or **ethyl alcohol**)
[10 points] Produced by the distillation of wood, it may have a sweet odor, but its ingestion leads to heavy production of formic acid which can cause death or blindness.
Answer: **methanol** (or **methyl alcohol**)
[10 points] More potent than ethanol as a CNS depressant, this alcohol is the main ingredient in rubbing alcohol as well as in various cleaners.
Answer: **isopropyl** alcohol

17. Identify these things from the study of geometry FTPE.
[10 points] This is the special metric used in relativistic geometry; it arises directly from the definition of the Lorentz transformation.
Answer: **Minkowski** metric [10 points] A topological space which is locally Euclidean is known by this term.
Answer: **manifold**
[10 points] The intersection of this object with the normal plane yields the principal normal vector and it is spanned by the tangent and normal vectors.
Answer: **osculating** plane

18. Identify some parts of flowers FTPE.
[10 points] These flower parts are part of the stamen and reside on top of filaments. They contain a pouch that holds the pollen grains.
Answer: **anther**

[10 points] Consisting of the stigma, style, ovary, and ovule, this is the female part of the flower.
Answer: **pistil**
[10 points] This is the term for the collection of sepals which forms a protective structure around the flower.
Answer: **calyx**

19. Answer some stuff about air FTPE: [10 points] This is the term for wind that is caused by air traveling over an ice surface, becoming heavier as a result, and draining down-valley.
Answer: **katabatic** wind
[10 points] Caused by adiabatic heating of air as it descends on the lee side of mountains, this phenomenon causes the Santa Anas of Southern California and the Austru of Eastern Europe.
Answer: **Foehn Wind** or Heating
[10 points] Foehn winds may be disrupted via this wavelike airflow that rises over an obstacle like a mountain range or plateau while paralleling its surface.
Answer: **orographic** wave

20. Answer some questions about low-temperature physics FTPE.
[10 points] This is the procedure by which a sample is subjected to a high magnetic field. Since the system is closed and the entropy must remain constant, turning off the field causes the sample to cool.
Answer: **adiabatic demagnetization** (or **isentropic demagnetization**)
[10 points] This condition can be brought about in some materials by cooling them below a critical point. It was first discovered in mercury by Kammerlingh-Onnes.
Answer: **superconductivity**
[10 points] This is the rule which can be used to estimate the maximum current flowing through a wire before the wire's superconductivity is destroyed.
Answer: **Silbee's** rule