Science Monstrosity II: Science of the Lambs

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Tossups

1. Their subject was T2, a bacteriophage that infects *E. coli*, and which was raised in a radioactive medium that contained either sulfur-35 or phosphorous-35. Bacteriophages raised in the radioactive sulfur would incorporate sulfur into their protein coats, as both cystine and methyanine contain sulfur, but when they were allowed to infect the host, after removing the viral coats, the host would remain non-radioactive. However, bacteriophages raised in radioactive phosphorous would incorporate it into their DNA, thereby passing it on to the host, which also became radioactive. Coming 7 years after Avery's experiment, FTP, identify this doubly-named series of experiments that conclusively established that genes are DNA.

Answer: **Hershey-Chase** experiments

2. The first reaction of this cycle produces 3-phosphoroglycerate, which is converted into 1,3 bisphosphoroglycerate, then 3-phosphoglyceraldehyde, then ribulose 5-phosphate, and finally back into ribulose 1,5 bisphosphate, more commonly known as RuBP. The enzyme it depends on is generally recognized as the most common protein on earth, RubisCO. Producing the 1967 Nobel Prize in Chemistry for its eponymous discoverer, for ten points, what is this cycle, also known as the "dark cycle", by which plants produce glucose?

Answer: **Calvin**-Benson cycle (accept "dark cycle" on early buzz)

3. Originally hypothesized by Maxim Polyakov, Dmitri Diakonov, and Victor Petrov in 1997, it was believed purely speculational, although permitted by QCD, until compelling evidence was found in 2003 by Takashi Nakano and Ken Hicks. The particle, given the symbol + (theta-plus), has a mass of approximately 1540 million electron volts, and while its baryon number is 1, like an ordinary baryon, it does not have the same flavor properties since the antiquark has a different flavor from all of the quarks. For ten points, what is this new type of particle, consisting of four quarks and an antiquark, five in all?

Answer: **pentaquark**

4. Biological molecules that fit this classification include chlorophyll a and vitamin B12. They can form when salts containing transition metals are dissolved in water, and EDTA forms them with most transition metals as well. Their most common structures are tetrahedral, square planar, and octahedral, although trigonal planar and trigonal pyramidal structures arise in the cases when their namesake number is odd. When they are formed with the use of bidentate ligands, they are known as chelates, while monodentate ligands of them include ammonia and water. FTP, identify these compounds which are products of Lewis acid-base reactions in which neutral molecules bond to a central metal atom.

Answer: **coordination** compounds

5. The very first of these was the IBM 305 RAMAC, which was produced on September 13, 1956 and featured a whopping 8,800 bytes per second transfer rate. In 1962, IBM introduced the "air bearing" which

reduced the distance to 250 microns, and in 1973, the model 3340, or "Winchester", was developed, which reduced the flying height to 17 microns and featured two spindles, each with a capacity of 30 MB. For ten points, what is this magnetic storage medium used today as the principal permanent storage for computers?
Answer: **hard drive** or **hard disk**

6. The first photovoltaic cell was developed here, and Claude Shannon developed his concept of the entropy of information while working here. In 1933, Karl Jansky first discovered that the center of the galaxy was emitting radio waves, while more recently, physicist Jan Schn was fired from here after it was discovered he had fabricated his data. Also the place where the transistor was first developed, for ten points, what is this research institute, which began life as an arm of a telephone company?
Answer: **Bell Labs** (prompt on "Lucent" or "AT&T")

7. Of these objects, octahedrites, ataxites, and hexahedrites are differentiated by the amount of nickel that they contain, (*) pallasites and mesosiderites are of the stony-iron variety, and the stony types include achondrites, which include the eucrites and SNC varities, and chondrites. The first basaltic one to have its origin conclusively identified was ALHA 81005, discovered in the Allan Hills area of the Antarctic, while the SNC varieties come from the Tharsis region and the eucrites come from Vesta. For ten points, what are these objects, rocks from outer space which have landed on earth?
Answer: **meteorites** (accept "iron meteorites" before the (*))

8. The Pesin identity shows that the Kolmogorov-Sinai entropy is equal to the sum of these in a dynamical system, while the Osedelec theorem gives them for an n-dimensional map. For Hamiltonian systems, they exist in additive invers pairs and one of these is always 0 for any system. They are never negative, which is why convergence of orbits is never observed in Hamiltonian systems, and a positive value for these values indicates that the system is not integrable. For ten points, what is this quantity, which describes the rate at which two initially-close trajectories diverge, a measure of chaos in a dynamical system?
Answer: **Lyapunov exponent**

9. The first experimental verification of this effect was produced by Chambers in 1960. In the case of a charged bead on a ring, this effect splits the degeneracy of the energy levels in the two directions. Berry showed that it can be thought of as an example of geometric phase. For ten points, what is this effect where the presence of a vector potential can affect the phase of the wavefunction even when the magnetic field in the region is zero?
Answer: **Aharonov-Bohm** effect

10. The linear type of this phenomenon include screw and edge dislocations and their direction and strength can be calculated with the help of the Burgers vector. Planar ones involve interfaces between material regions, and the number of vacancies resulting from point ones can be computed using the Boltzmann factor. Interstitial ones involve atoms being squeezed between vertices, while twin boundaries give rise to shape memory metals. With the point type existing in Frankel and Schottky types, FTP, identify these "mistakes" in the lattices of regular solids.
Answer: **crystal defects**

11. The solution to Dido's Problem involves the application of this technique, as does the solution of Sinclair's Soap Film Problem, to which the solution is a catenoid. Morse theory is a generalization of this technique, drawing a relationship between the stationary points of a smooth, real-valued function on a manifold and the global topology of the manifold. In solving problems with this method, one frequently encounters functional derivatives, and its most famous result, the differential equations of motion, are a result of the functional differentiation of the Hamiltonian. Applied in physics to find maxima and minima,

FTP, identify this mathematical technique concerned with finding the path for which a given function has a stationary value.

Answer: **calculus of variations**

12. In its integral form, it can really only be used to solve three situations: a spherically symmetric distribution, a cylindrically symmetric distribution, and a mirror-symmetric planar distribution, and it can also be used to prove Earnshaw's theorem. In differential form, it states that the divergence of the field is equal to the charge density over the permittivity of free space. For ten points, what is this equation, one of Maxwell's equations, which can be used to calculate the electric field?

Answer: **Gauss' Law** of electricity

13. One example of this phenomenon occurs in humans with regards to IGF2, and if it fails in this case, it can result in Wilms' tumor. To mark an entity destined to undergo this process, methyl groups are added to cytosines in the DNA, resulting in CpG islands. It is the reason that parthnogenesis does not occur in mammals, and when the XIST locus is the subject of this process, the X chromosome becomes an inactive Barr body. Violating the usual rule according to which both the father's and the mother's alleles are expressed, FTP, identify this process during which one gene is expressed while another is suppressed.

Answer: **imprinting**

14. The monument at this site is a stone obelisk approximately 12 feet high, and it was declared a National Historic Landmark in 1972. 260 people attended the event, none of them closer than 9000 meters. The actual cause was acknowledged three weeks later, but at the time the military claimed it was an accidental explosion at a munitions dump. Preceded by an explosion of 100 tons of TNT for the purposes of instrument calibration, FTP, what is this event that took place at the Alamogordo Bombing range, the first atomic bomb test?

Answer: **Trinity** (prompt on "Manhattan Project" or similar; prompt on "first A-bomb test" or similar on early buzz)

15. Rheumatoid arthritis or the rejection of a transplanted organ can trigger Cushing's syndrome, which results from the overproduction of hormones by them. Addison's disease can result if they are attacked by an infection or as the result of an autoimmune malfunction, but glucocorticoid and mineralcorticoid replacement can allow sufferers to lead normal lives. The excessive production of androgens here can cause premature puberty in males or male-like characteristics in females. Consisting of their namesake medulla and cortex, FTP, identify these glands situated on top of the kidneys which secrete various steroid hormones, including the one that triggers the fight-or-flight reflex.

Answer: **adrenal** glands

16. The first of these was discovered in the Vulpecula constellation and was named CP 1919. One of the most well-known is located in the center of the Crab Nebula, and is often used as a calibration source for X-ray detectors due to its strength. Originally referred to as "LGM", since they initially suggested the possibility of extraterrestrial intelligence, it was quickly realized that they were actually neutron stars. For ten points, what are these objects discovered by Anthony Hewish and Jocelyn Bell, which periodically emit electromagnetic radiation?

Answer: **pulsars**

17. One result in this branch of mathematics is Ornstein's theorema, which gives the conditions under which any two Bernoulli schemes are measure-theoretically isomorphic. Dye's theorem states the existence of isomorphisms between two probability spaces for measure-preserving transformations, and Kolmogorov introduced entropy into it when he applied Shannon's concept of entropy to dynamical systems. Originating

in the study of transformations under which the only invariable sets have measure 0 or 1, FTP, identify this branch of mathematics that grew out of a hypothesis that the time average and the average over the statistical ensemble are equivalent.

Answer: **ergodic** theory

18. One result of this effect is the orbital precession of X-ray emitting gas near black holes, resulting in specific X-ray emission peaks. Frederick Lamb predicted that motions arising from it would result in weak sidebands on the oscillations produced by neutron stars in binary systems; the strong oscillations were observed in 1996 by the Rossi Explorer satelite. The decay of oscillations arising from it is known as the Bardeen-Petersen effect, and in calculations of the precession frequency in gravitational systems, this term appears as del cross h. Also known as frame dragging, FTP, identify this effect of general relativity in which the orbit of a small body around a large rotating one is perturbed by the rotation.

Answer: **Lense-Thirring** effect (accept **frame dragging** before it's mentioned)

19. When a cell that secretes these becomes cancerous, the cancer is called a myeloma. Their application to human treatments has spawned such medicines as the immunosuppressant OKT3, used in kidney transplants, and Rituximab, used to fight B-cell lymphomas. Chimeric ones have been introduced to solve the HAMA problem, and Kohler and Milstein solved the problem of their creation for mice with a technique called somatic cell hybridization. The result of their work was a hybridoma culture that could be maintained indefinitely and used to produce, FTP, what kind of antibodies of a single specificity that are all alike because they were derived from a single clump of plasma cells.

Answer: **monoclonal** antibodies

20. One of the main functions of this molecule is the transfer of nitrogen from peripheral tissue to the liver. In muscle tissues, it is transformed into pyruvate, and its alpha carbon is substituted with a levorotary methyl group. When its transfer between the muscels and the liver is couple with glucose transport from liver to muscle, this namesake cycle with glucose is formed. It can be produced directly through protein degradation or by the transamination of pyruvate by glutamate-pyruvate aminotrasferase, also known as its namesake transaminase, ALT. FTP, identify this circulating amino acid with chemical formula CH3-CH(NH2)-COOH, the simplest after glycine.

Answer: **alanine**

Bonuses

1. Identify these equations fundamental to quantum mechanics FTSNOP.
[5 points] This fundamental equation of nonrelativistic quantum mechanics can be solved to yield the wavefunction.
    Answer: **Schrodinger** equation
[5 points] This relativistic equation is used for spin-1/2 particles. Its discoverer also hypothesized the existence of the positron.
    Answer: **Dirac** equation
[10 points] This relativistic equation applies to spin-0 particles, and can be derived from the relativistic energy-momentum relation.
    Answer: **Klein-Gordon** equation
[10 points] This relativistic equation is used for spin-1 particles.
    Answer: **Proca** equation

2. Identify these celestial objects from their Messier number for 10 or from an easier clue for 5.
[10 points] M31
[5 points] This large spiral galaxy is the closest spiral galaxy to the Milky Way.
    Answer: **Andromeda** Galaxy
[10 points] M1
[5 points] This nebula consists of the remnants of a 1054 supernova and is now more than 6 light-years across.
    Answer: **Crab** Nebula
[10 points] M20
[5 points] This emission nebula in Sagittarius gets its name from its three-lobed appearance.
    Answer: **Trifid** Nebula

3. Identify the following about classical scattering theory of two particles FTPE.
[10 points] This value is the distance between a line through the initial trajectory of the particle and the scattering center.
    Answer: **impact** parameter
[10 points] This quantity, often measured in barns or millibarns, is the proportionality constant between the incoming area and the outgoing scattered angle.
    Answer: **cross-section**
[10 points] This simple form of scattering involves a charged particle scattering off a much heavier charged particle. Classically, its total cross-section is infinite.
    Answer: **Rutherford** scattering

4. Identify the following things about feldspar FTSNOP:
[10 points] This type of feldspar consists of potassium aluminum silicate.
    Answer: **orthoclase** feldspar
5, [5 points] In plagioclase feldspars, the potassium is replaced by one or both of these two elements. Name them for five points each.
    Answer: **sodium and calcium**
[10 points] For a final ten, give either the name of the plagioclase feldspar consisting of pure sodium aluminum silicate, or the name of the feldspar consisting of pure calcium aluminum silicate.
    Answer: **albite** (all sodium) or anorthite (all calcium)

5. Identify these things related to the electron transport chain FTSNOPE.
[5 points each] Name the two electron carrier molecules produced by the citric acid cycle which carry electrons into the chain.

Answer: **NADH** and **FADH2**

[10 points] This very useful complex in the electron transport chain is found in the inner mitochondrial membrane and carries electrons between steps of the chain.

Answer: **cytochrome c**

[10 points] At the end of the electron transport chain, ATP is produced by this two-part enzyme, a type ATP synthase.

Answer: **F0F1**

6. Identify the following about quantized things FTPE.

[5 points] These quanta carry electromagnetic radiation.

Answer: **photons**

[5 points] These quanta of vibration in a crystal lattice are responsible for properties such as heat conduction and sound transmission.

Answer: **phonons**

[10 points] These particles carry multiples of h/2e, which is equal to 1 over the Josephson constant.

Answer: **fluxons** or magnetic flux quanta

[10 points] The explanation of the quantum Hall effect utilizes these particles, so named because their spins can take on any value.

Answer: **anyons**

7. Name these ringed compounds that aren't benzene or benzene derivatives FTPE.

[10 points] Because of the stress on the ring, this compound is not planar, but is found in "chair" and "boat" conformations.

Answer: **cyclohexane**

[10 points] This class of heterocyclic compounds has a six-member ring with nitrogens in positions 1 and 3 in the ring instead of carbon.

Answer: **pyrimidines**

[10 points] This five-element ring has delocalized electrons like benzene, which come from the lone pair on the oxygen in the ring.

Answer: **furan**

8. Answer some questions about cell locomotion FTPE.

[10 points] Like the contraction of skeletal muscle fibers, the bending of cilia and flagella operates according to this model.

Answer: **sliding filament** model

[10 points] Cilia and flagella are composed of cross-bridges of this protein.

Answer: **dynein**

[10 points] This is the term for the stem of cilium or flagellum. It anchors the cilia in the cytoplasm and is derived from the centriole.   Answer: **basal body**

9. insert math bonus here

10. Identify these circuit elements or simple circuits given their composition FTPE.

[10 points] Two sets of coils wound around an iron core.

Answer: **transformer**

[10 points] An op-amp with the positive input at ground, a resistance at the negative input, and a second resistor in the negative feedback loop.

Answer: **multiplier**

[10 points] A JFET with gate tied to source.

Answer: **current source**

11. Answer the following about wrong turns in science FTPE.
[10 points] In 1989, Pons and Fleischmann claimed to have obtained this holy grail of nuclear physics.
    Answer: **cold fusion**
[10 points] Soviet physicist Nikolai Fedyakin claimed to have discovered this form of water in the 1960s with much higher viscosity, higher boiling point, and lower freezing point.
    Answer: **polywater** (or "polymerized water")
[10 points] The man set back agriculture in the Soviet Union with his advocacy of "vernalization" and other strange ideas.
    Answer: Trofim **Lysenko**

12. Identify these things about everyone's favorite law of thermodynamics, the Second Law of Thermodynamics, FTPE.
[10 points] One formulation of the 2nd law is that it is impossible to build a perfect refrigerator. Whose name is attached to this statement?
    Answer: **Clausius**
[10 points] The maximum efficiency allowed by the 2nd law is given by this efficiency.
    Answer: **Carnot** efficiency
[10 points] This man in 1929 created the first information-theoretical argument as to why Maxwell's demon could not work.
    Answer: Leo **Szilard**

13. Identify the particle that was the subject of these famous quotes FTPE.
[10 points] I. I. Rabi: "Who ordered that?!"
    Answer: **muon**
[10 points] Wolfgang Pauli: "I have done a terrible thing. I have postulated a particle that cannot be detected."
    Answer: **neutrino**
[10 points] Leon Lederman: "I think it's important to emphasize that this story is one of missed opportunities, abysmal judgment, monumental blunders, stupid mistakes, and inoperative equipment."
    Answer: **upsilon**

14. Identify these things from abstract algebra, FTPE.
[10 points] This equation states that the order of the group is equal to the order of the center plus the sum over the orders of the orbits.
    Answer: **class** equation
[10 points] The class equation may be used to derive the first of these three theorems named after a Norwegian mathematician.
    Answer: **Sylow** theorems
[10 points] The Sylow theorems can in turn be used to show that every alternating group on 5 or more letters is is this type of group, which has no non-trivial proper normal subgroups.
    Answer: **simple**

15. Identify these transcription factors important in DNA replication, FTPE.
[10 points] This is the term for transcription factors that control regions of DNA thousands of base pairs away from where they are bonded and speed up transcription.
    Answer: **enhancers**
[10 points] These factors work like enhancers, except they perform the opposite function, suppressing the

gene expression.

Answer: **silencers**

[10 points] Located between enhancers and promoters, or between silencers and promoters, these factors shield specific genes from the actions of other transcription factors.

Answer: **insulators**

16. Given a chemical property, tell me what element has the greatest value of that property FTPE.

[10 points] electronegativity

Answer: **fluorine** or F

[10 points] (absolute value of) electron affinity

Answer: **chlorine** or Cl

[10 points] atomic radius

Answer: **francium** or Fr

17. Answer the following about plate tectonics FTPE:

[10 points] In plate tectonic theory, the plates "float" on this part of the mantle.

Answer: **asthenosphere**

[10 points] This largest divergent plate boundary provided great support for the theory of plate tectonics.

Answer: **Mid-Atlantic Ridge**

[10 points] When two continental plates collide, as in the Himalayas, this type of plate boundary is produced.

Answer: **orogenic belt**

18. Identify these point mutations, FTPE.

[10 points] In this type of mutation, exemplified in sickle-cell disease, the new nucleotide alters the codon so as to produce a different amino acid.

Answer: **missense** mutation

[10 points] This type of mutation changes an amino acid codon into one of the STOP codons, resulting in premature termination of translation.

Answer: **nonsense** mutation

[10 points] This is the term for mutations that change one codon into another codon that codes for the same amino acid. They are called this because they have no visible effect.

Answer: **silent** mutation

19. Identify these different types of cell junctions, FTPE.

[10 points] Exemplified by epithelial cells, these junctions take their name from the fact that they prevent passage from the lumen through the spaces between the cells.

Answer: **tight** junctions

[10 points] One example of this type of junction is the connection between the smooth muscle of the uterus; these junctions are constructed from connexins and the space between them allows relatively free passage through the space between cells.

Answer: **gap** junctions

[10 points] In plant cells, these fine strands of cytoplasm connect cells together, extending through pores in the cell wall to link with the cytoplasm.

Answer: **plasmodesmata**

20. Identify these chemical phenomena in the atmosphere, FTPE.

[10 points] It can occur in dry conditions as well as in wet ones, and most of its damage results from the conversion of sulfur dioxide into H2SO4.

Answer: **acid rain** [10 points] The combination of volatile organic compounds, oxides of nitrogen, and

sunlight result in the production nitrogen dioxide, which then reacts hydrocardbons to produce this type of smog.

Answer: **photochemical** smog

[10 points] Nitric acid and sulfuric acid form nucleation sites where water vapor can condense. As these droplets grow, the water they contain is removed from circulation, resulting in this phenomenon.

Answer: **rainout**