

Science Monstrosity II: Science of the Lambs

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Tossups

1. It asserts that "clouds are not spheres, mountains are not cones, and lightning does not travel in a straight line." In one chapter, it applies its titular idea to geology, demonstrating that the fractional dimension of the earth's surface is between 2.1 and 2.5. It does this by asking how long the coastline of Britain is and then showing that it is infinite. FTP, identify this landmark book by Benoit Mandelbrot which introduced fractals as a method of modeling the real world.

Answer: The Fractal Geometry of Nature

2. In a five-year retrospective paper, its formulators defended it by emphasizing its relevance to the greater pattern the fossil record. It draws on Ernst Mayr's idea of parapatric speciation in the sense that geographic landscapes are translated into abstract fitness landscapes consisting of ridges and valleys. Its central idea is that an accumulation of genetic material or a sudden beneficial mutation may push a species to a higher level of evolution over a relatively short timescale. An opposing theory to phyletic gradualism, FTP, what is this evolutionary mechanism, first proposed by Stephen Jay Gould and Niles Eldredge in 1972?

Answer: punctuated equilibrium

3. It was first noted by Newton, but Rayleigh credited it to the man whose name it bears. It arises from the asymmetric distortion of the boundary layer. Its reverse form arises from the introduction of anomalies in the boundary layer and may occur for smooth spheres. When a spinning motion is imparted to the layer, the wake left by the passing object shifts toward the side moving against the free stream flow. FTP, identify this eponymous effect which is responsible for the curved trajectories of spinning baseballs.

Answer: Magnus effect

4. It is the underlying principle of the ultra-microscope, which can detect particles less than 0.1 micron in a liquid. The brightness of the refractive cone generated by it is directly proportional to the difference in refractive index of the particle and the medium, and an example of it is the blue color of tobacco smoke when light shines on it, or the scattering in a searchlight cone. FTP, what is this effect in which a colloid scatters focused incident light?

Answer: Tyndall effect

5. In generalized form, it bears the name of Hurwitz and it may be expanded in a Taylor series about 1 in terms of Stieltjes coefficients. For even numbers it may be computed analytically either by contour integration or by using Parseval's theorem with the appropriate Fourier series. It was Euler who first noticed its relation to prime numbers, and the distribution of its zeros has important consequences for the prime number theorem. FTP, identify this mathematical object whose nontrivial roots are hypothesized to all have real a part of magnitude $1/2$.

Answer: Riemann Zeta function

6. It is currently believed that its spirals are distributed in a cigar-shaped prolate filament which connects at its back end with the W cloud. It contains at least three subclumps, with the largest having a mass of about 10 to the 14th solar masses. The large mass of this object is indicated by the high peculiar velocities of many of its galaxies, and it is located at the heart of the Local supercluster, approximately 15 to 22 megaparsecs away from Earth. Subtending a maximum arc of about 8 degrees and centered in its namesake constellation, FTP, identify this galactic cluster containing the galaxies M49, M86, and its largest, M87.

Answer: Virgo cluster

7. It was discovered independently by Leon Heppel and David Lipkin and its creation suggested a route for biosynthesis. It is formed from another, better-known molecule by the action of adenylate cyclase and is destroyed by a specific phosphodiesterase, which hydrolyzes it. Its concentration in animal cells is directly proportional to their biological response to hormonal stimulation and it acts as a second messenger for many hormones. FTP, identify this molecule, synthesized from ATP by the addition of barium hydroxide.

Answer: cyclic AMP (or cAMP)

8. The assumptions required for deriving them are that the stress tensor, heat flux, energy, and entropy are only functions of density, absolute temperature, velocity, and the gradients of velocity and temperature. A further requirement is that those dependencies must be linear in the gradient of temperature and velocity, at which point the balance and continuity equations are required. Adding to that the constitutive relations for the fluid yields, FTP, what famous nonlinear equations which completely describe fluid flow?

Answer: Navier-Stokes equations

9. It undergoes cold flow, meaning that a screw may be wrapped in it, screwed in, and it will flow to seal up the empty space. With a molecular weight of 30,000,000, it is one of the largest molecules known. It was discovered during work with Freon when a frozen, compressed sample of tetrafluoroethylene was discovered to have polymerized spontaneously into a waxy solid, polytetrafluoroethylene. FTP, Roy Plunkett discovered what polymer, which today is used in non-stick cookware and to label slippery individuals such as John Gotti and Ronald Reagan?

Answer: teflon

10. In some species, its first part is skipped completely and the second division begins immediately. During it, the polar fibers continue to lengthen, the spindle disappears, and the chromatin fibers uncoil, while the interphase microtubule array reforms. It also sees the formation of nuclei and the reappearance of nucleoli, as well as the formation of the nuclear envelopes from pieces of the parent cell's envelope and endomembrane system. Preceded by anaphase and followed by cytokinesis, FTP, what is this last stage of meiosis?

Answer: telophase

11. Its ion form is an important stabilizing effect in ignited tokamak plasmas. It can be derived by linearizing the Vlasov equation and solving for the perturbed distribution function. This must be done by integrating around the poles of the plasma dielectric function along the Bromwich contour. Once the complex dispersion relation has been obtained, the sign of this effect may be found by examining the imaginary part of the angular frequency. FTP, identify this collisionless type of amplitude change in plasmas named for the Russian physicist who first calculated it.

Answer: Landau damping

12. Acceptors produce a "yes or no" answer in response to an input, Recognizers categorize the input, and Transducers generate an output from a given input. The deterministic type consists of an alphabet, a

set of "positions," and a transition function, and imposes the condition that at every position there is at most one transition for each possible input. The nondeterministic type replaces the transition function with a more general relation, thus enabling the automaton to have more than one transition for a given input. FTP, identify this general type of automaton which takes its name from the fact that it has a limited amount of memory.

Answer: finite state machine

13. The close association of this mineral with cassiterite leads to its usefulness in locating tin-bearing pegmatites. Formed from the reaction of fluorine vapor with eutectic granites, where it occurs in cavities, its prismatic habit and orthorhombic crystallography derive from independent silica tetrahedra that cross-link its octahedral chains of aluminum hydroxide and fluoroxide. Named for a Red Sea island, FTP, what is this mineral with formula $Al_2SiO_4(F,OH)$ and a Mohs Hardness of 7, the birthstone of November?

Answer: topaz

14. The black hole of this type has no charge and no angular momentum, and represents an exact solution to the Einstein field equations for the general static isotropic metric. A more famous quantity bearing this name refers to the point where the metric of the same name becomes singular. Inside the metric of this name, there are no stationary frames, as the region where this metric is valid represents a region outside a black hole from which light cannot escape. FTP, this black hole and metric share what name with the eponymous radius the value of which is obtained by setting the escape velocity of a black hole to the speed of light?

Answer: Schwarzschild

15. It is produced by the transamination of an alpha-keto acid and along with tyrosine is one of the end products of the prephenate branch from chorismate. Both it and tyrosine are degraded by oxygenases to acetoacetate and fumarate during the urea cycle. In the event of an absence of its hydroxylase, it accumulates in bodily fluids, and if untreated can lead to severe mental retardation and death. FTP, identify this amino acid the deficiency of which is autosomal recessive and which is present in many sodas.

Answer: phenylalanine

16. People lacking it may experience problems with sepsis and it may become inflamed due to mononucleosis or blood cancers. Its "red pulp" part is often referred to as the red blood cell graveyard due to the fact that damaged and destroyed red blood cells are stored there. When it becomes enlarged, it can clog and take blood out of circulation, resulting in anemia and serious bleeding. Its "white pulp" part is responsible for the production of lymphocytes and is an important part of the immune system. FTP, identify this small fist-shaped organ, the largest lymph node in the body, which can rupture when enlarged.

Answer: spleen

17. Their general behavior may be derived from the phase difference between two points on its loop, thereby deriving the flux quantization condition that dictates its properties. From this relation, it is possible to obtain the an equation for the maximum current that can flow in the loop as a periodic function of the applied flux and a linear function of the critical current. Widely used to measure small magnetic fields, FTP, identify these microscopic devices consisting of two Josephson junctions located on the same current loop.

Answer: SQUIDS (or Superconducting Quantum Interference Device(s))

18. In the lithosphere, they are detected by stacking velocities, and their presence is an indicator of porosity anomalies used to detect producible gas zones. Identified through the loss of the head-wave and a single refracted wave on seismograms, in the most commonly used terminology, they are water-rich planes or par-

tially molten pockets of plastic material. Usually located between 100 and 350 kilometers of depth, FTP, name these regions of the upper mantle characterized by the braking of P and S waves below the Moho.

Answer: low velocity zones

19. Evolving between 2.5 and 3.4 billion years ago, these organisms contributed to the evolution of plants by initiating endosymbiosis with eukaryotic cells. Thus, these organisms are distantly related to chloroplasts in plants, and they exist in filament, colonial, and unicellular forms. Their individual cells stain gram-negative and they lack flagella, moving about by gliding. Found mostly in fresh water, they contain chlorophyll a as well as phycobilins, which give them their distinctive color, and their name is erroneous since they are unrelated to other algal groups. FTP, identify this phylum of aquatic bacteria, sometimes, known as blue-green algae.

Answer: cyanobacteria (prompt on "blue-green algae" before it's mentioned)

20. In free space, the particular solution of this form is called the fundamental solution. One example of their application is in the solution of Laplace's equation; in free space, the solution is singular. For the simple harmonic oscillator it is a sum of two exponentials and if the Friedholm Alternative Theorems are valid, their construction is simplified. FTP, identify these mathematical object which are useful in solving differential equations and which represent the kernels of integral operators.

Answer: Green's functions

Bonuses

1. Identify these types of isomers FTPE.

[10 points] This is an isomer which is related to a central atom about which the arrangement of the bonded groups varies in such a way that the different arrangements are not superimposable. Their two types are designated R and S.

Answer: **stereoisomer** (or **configurational** isomer)

[10 points] These isomers come in cis and trans form and arise from different permutations of element positions in a molecule.

Answer: **structural** isomer

[10 points] What is the specific term for isomers that differ only in the arrangement of their chiral atoms and are thus mirror images of each other?

Answer: **enantiomers**

2. Given some mammals, identify what order of the class Mammalia they fall into FTPE.

[10 points] Moles and shrews.

Answer: **insectivora**

[10 points] Sheep, goats, pigs, giraffes, and other cloven-hooved ungulates.

Answer: **Artiodactyla**

[10 points] This extinct order was originally thought to be the ancestor of modern Carnivora, but today this is no longer considered the case.

Saber-toothed tigers belonged to this order.

Answer: **Creodonta**

3. Identify some things from solution chemistry FTPE.

[10 points] This law states that the product of the concentrations of the products of a reaction divided by the product of the reactant concentration is always the same.

Answer: **law of mass action**

[10 points] This law states that the absorbtivity of a solution is proportional to its concentration and the path length.

Answer: **Beer-Lambert** law (accept just **Beer's** law)

[10 points] What is the term for properties of a solution which depend only on the concentrations and not the natures of the solute particles?

Answer: **colligative**

4. Answer some questions about global wind systems FTPE.

[10 points] These are the winds that blow from the east at an angle to the equator such that they bring air from higher latitudes to an equatorial zone of convergence.

Answer: **trade winds**

[10 points] When seen in profile, the trade winds appear as part of these circulations of air named for an 18th century British meteorologist.

Answer: **Hadley cells**

[10 points] This is the general term for the low-pressure areas surrounding the equator. They are so called because the prevailing winds here are calm.

Answer: **doldrums**

5. Identify these electromagnetic laws or effects FTPE.

[10 points] This theorem can be formulated in integral form, or in the form of a continuity equation. It is essentially a conservation theorem concerning the cross product of the electric and magnetic fields.

Answer: **Poynting** theorem

[10 points] This effect results from the fact that given two rays of circularly polarized light with different handed polarizations, the one with the polarization in the direction of the field travels faster, causing the plane of the linearly polarized light to spin.

Answer: **Faraday** rotation

[10 points] This law gives the radius of a charged particle's orbit in a certain type of machine and can be found by setting the centripetal force equal to the magnetic force.

Answer: **cyclotron** formula

6. Identify these communication protocols FTPE.

[10 points] Probably the best known of all communication protocols is this protocol which allows you to connect to web sites.

Answer: **TCP/IP** (Transfer Connection Protocol/Internet Protocol)

[10 points] Invented by Hewlett-Packard to facilitate communication with remote instruments, most remote instrumentation is handled through this special protocol.

Answer: **GPIB** (General Purpose Interface Board; also accept **HPIB**)

[10 points] This is the standard protocol for communicating with devices over a serial cable.

Answer: **RS-232**

7. Identify some things from nuclear physics FTPE.

[10 points] Since protons and neutrons are close in mass, sometimes it is useful to regard the proton and neutron as eigenstates of this operator. Answer: **isospin** [10 points] This is the law that gives the charge as a function of the isospin, the strangeness, and the baryon number.

Answer: **Gell-Mann - Nishima** law

[10 points] This term refers to the fractional quantity of energy released by the fusion of hydrogen into helium. In solid state physics, it also refers to the percent of space the atoms occupy in a unit cell.

Answer: **packing fraction**

8. Identify these concepts from population genetics FTPE.

[10 points] This phenomenon occurs when a small group breaks off from the main body and forms a new population. Since the sample size is small, the new population could have a very different genetic ratio than the original one.

Answer: **founder effect**

[10 points] This type of separation occurs when the sexual organs of a part of the population change to the extent that they can no longer reproduce with members of their species.

Answer: **mechanical** isolation

[10 points] Similar to the founder effect, this is a reduction of the population's gene pool when a small subset of the population survives the widespread elimination of the species.

Answer: **bottleneck** effect

9. Given the antecedent clause of a theorem, supply the result F15P. If you need the name of the theorem, you will only get 5 points.

[15 points] If G is a group of finite order and H is a subgroup of G , then

[5 points] Lagrange's theorem

Answer: **the order of H divides the order of G** (accept logical equivalents)

[15 points] Let T be a linear operator on a finite-dimensional vector space V and let $f(t)$ be the characteristic polynomial of T . Then

[5 points] Cayley-Hamilton theorem

Answer: **T satisfies its own characteristic equation** (or $f(T)$ is the zero transformation; accept log-

ical equivalents. At least one person in every room should be able to tell if the answer given is correct)

10. Answer some questions about our close neighbor Venus FTPE.

[10 points] The atmosphere of Venus is composed mostly of sulphuric acid and carbon dioxide, leading to this effect that traps heat at the planet's surface.

Answer: **greenhouse effect**

[10 points] Like Pluto and Uranus, the rotation of Venus is of this type.

Answer: **retrograde**

[10 points] This mission, running from 1989 through 1994, gathered most of the modern data on Venus.

Answer: **Magellan**

11. Identify the following scientists who contributed greatly to the Manhattan project FTPE.

[10 points] The director of Berkeley's Radiation Laboratory, this man introduced Oppenheimer into the Manhattan project. Room 329 in Berkeley's Le Conte Hall is named the "cyclotron room" in his honor.

Answer: Ernest Orlando **Lawrence**

[10 points] She discovered and explained the process of nuclear fission, but missed out on the 1944 Nobel Prize because her former partner published first.

Answer: Lise **Meitner**

[10 points] He studied under Enrico Fermi in Rome and was head of the radioactivity group at the Manhattan project. Together with Owen Chamberlain, he shared the Nobel Prize for discovering the antiproton.

Answer: Emilio **Segre**

12. Answer some questions about the physiology of plants FTPE.

[10 points] Also known as ground tissue cells, these cells make up the pith of the shoot, the fruit storage tissue, and the roots, as well as any other underground tissues.

Answer: **parenchyma**

[10 points] Most of the cell reproduction takes place in these types of cells. Once a plant reaches maturity, only these cells are allowed to continue reproducing.

Answer: **meristem**

[10 points] If both xylem and phloem are present, this type of lateral meristem separates them from each other. In trees, it penetrates into every branch and serves as the central area for cell reproduction.

Answer: **cambium**

13. FTPE, identify these particles whose discovery lent experimental support to various particles theories.

[10 points] Discovered independently in 1974 by Samuel Ting and Burton Richter, this charmed meson put Gell-Mann's Eightfold Way on solid experimental ground.

Answer: **J/psi**

[10 points] After Martin Perl discovered the lepton, there appeared an inconsistency between the number of lepton generations and hadron generations. The discovery of this particle by Leon Lederman confirmed that both numbers of generations was the same.

Answer: **bottom quark**

[10 points] The discovery of this heavy particle eliminated the divergences which arose in the theory of electroweak unification and provided experimental verification for that theory.

Answer: **Z-0** boson (read: "Z-nought," or "Z-zero," or "neutral Z")

14. Identify these various concepts from computer architecture FTSNOPE.

[10 points] This is the term given to guaranteed maximum response time of a system to an electronic event.

Answer: **interrupt latency**

[10 points] What is the name given to the data structure consisting of a fixed number of bytes which can be recognized directly by the processor's hardware?

Answer: **word**

[5 points each] A word may be addressed by the address of its most significant bit or its least significant bit. What is the name given to these two modes of addressing words?

Answer: **big endian** and **little endian**

15. Identify these concepts from analysis FTPE.

[10 points] If a sequence is such that the difference between adjacent points goes to 0 as the index goes to infinity, it is said to be this kind of sequence.

Answer: **Cauchy** sequence

[10 points] A metric space on which all Cauchy sequences converge, such as the reals, has this property.

Answer: **completeness** (or, it is complete)

[10 points] According to this theorem, every bounded real sequence contains a convergent subsequence.

Answer: **Bolzano-Weierstrass** theorem

16. Identify these processes for obtaining particular elements or compounds FTPE.

[10 points] Aluminum is extracted from bauxite by dissolving the bauxite in cryolite and applying a current, causing aluminum to gather at the negative cathode.

Answer: **electrolysis**

[10 points] The end product of the Haber process can then be used in this industrial method, wherein the ammonia is heated, oxidized, and combined with water to obtain nitric acid.

Answer: **Ostwald** process

[10 points] Hot water is conducted through the outer pipe, melting the sulfur, and pressurized air is sent down through the inner pipe, forcing it through the middle pipe, in this sulfur extraction process.

Answer: **Frasch** method

17. Identify the part of the cell responsible for the described process FTPE.

[10 points] These organelles are responsible for the degradation of waste matter and products of ingestion in the cell.

Answer: **lysosome**

[10 points] This is the name given to the convoluted inner membranes of mitochondria which increase its surface area and ATP production.

Answer: **cristae**

[10 points] Unique to eukaryotic cells, this structure consists of microfilaments, microtubules, and intermediate filaments. It provides the internal support of the cell.

Answer: **cytoskeleton**

18. Answer some questions about polarization FTPE.

[10 points] This takes place when the angle between the transverse components of the magnetic field is less than 90 degrees and the magnitudes of the two components are different.

Answer: **elliptical** polarization

[10 points] These matrices can be defined for polarizing optical components and facilitate ease of computation for polarization problems.

Answer: **Jones** matrices

[10 points] This is the angle from the normal at which reflected light will be completely polarized.

Answer: **Brewster** angle

19. Answer some questions about projections in chemistry FTPE.

[10 points] This projection is a convention for drawing carbon chains such that vertical bonds project behind the frame of the paper and horizontal bonds project towards the observer.

Answer: **Fischer** projection

[10 points] What is the term for a projection obtained by looking along a carbon-carbon bond?

Answer: **Newman** projections

[10 points] What is the name for the projection which is designed to indicate the spatial arrangement of bonds on two adjacent carbons? The carbon bond is usually drawn as a diagonal and the other bonds branch up and down from it, thus giving it its name.

Answer: **sawhorse** projection

20. Identify these astronomical laws FTPE.

[10 points] These laws govern the motion of a tidally locked body. These three laws impose limits on the rotation rate, the spin axis, and the orbit normal.

Answer: **Cassini's** laws

[10 points] This theorem relates the distance between two positions of a planet in an elliptical orbit and the time needed to traverse that distance. The distance is given in terms of the mean orbital distance, the eccentricity, and the eccentric anomalies.

Answer: **Lambert's** Theorem

[10 points] This law states that a line from a planet to the sun sweeps out equal areas in equal times.

Answer: **Kepler's Second** Law