Science Monstrosity III: The Gay Science
Round 4

Caltech

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July 2, 2005

1   Caltech Tossups, Round 4

1. *Parakidograptus acuminatus*, a graptolite species, is an index fossil for the beginning of this period. Its major geologic events include the formation of the hematite-bearing Clinton Formation as a result of the erosion of the previous Taconic Orogen, as well as the beginning of the Caledonian orogeny, a spate of mountain-building in present-day England and Greenland. Divided into the Llandoverian, Wenlockian, Ludlovian, and Pridolian epochs, this period's biota included early vascular plants, myriapods, and euteryptids, which were giant sea scorpions. For ten points, identify this geologic period occurring between the Ordovician and Devonian.
   Answer: __Silurian__ period

2. In certain cases this dimensionless number can be determined by measuring the freezing point, the depression of which is proportional to it. However, at high concentrations, the measured value may be lower than the ideal value due to inter-ionic attraction. For barium chloride in water, it is 3. For nitric acid, it is 2. For any substance that does not dissociate in water, it is 1. In general, it is the ratio of the number of moles of dissociated ions to moles of the substance that dissociates. For ten points, what is this number, denoted i and named for a Dutch chemist?
   Answer: __van 't Hoff__ factor

3. It, vacuous red bood cells, and abnormal storage of ceroid material, are symptoms of Hermansky-Pudlak Syndrome. Likewise, it is a symptom along with leukocyte anomalies and occular problems in Chédiak-Higashi Syndrome. It is caused by a lack of tyrosinase, which causes a certain type of cell body to be empty before they are transfered to the keratinocytes. More common in Amish and Mennonite groups, both major types have been isolated to the X chromosome. For ten points, identify this disorder that causes melanosomes to be devoid of melanin, resulting in white hair and pink or light hazel eyes.
   Answer: __Albinism__us or __Congenital Achromia__ or __Hypomelanosis__

4. When designing ANOVA experiments, these are often used to limit experimental interactions. In 1900, Tarry proved that no orthogonal ones of order 6 exist, and in 1960 Bose, Shrikhande, and Parker proved that for all other orders of the form $4n + 2$, there do exist orthogonal ones. The problem was initially proposed by Euler in 1783 as the "36 officers problems," where one attempts to arrange six grades of officers from six regiments into a grid such that each row has each kind of officer and each column has a representitive from each regiment. A Japanese puzzle operating on a similar concept, *Sudoku*, is gaining popularity. For ten points, name these n by n grids where each column and row contains the numbers 1 to n exactly once.
   Answer: __Latin__ or __Euler__ (before mentioned) or __Graeco-Roman__ squares/rectangles

5. The morphology of these anomalies is modeled by the SLIMCAT assimilation, and their deepening is observable using the Kalman filter technique. They may divide due to vertical breaching caused by thermal waves associated with Ferrell Cell return flow strengthening during warm years, and they are constantly being replenished via the Chapman Cycle. Of the three currently extant ones, the creation of the most famous example is catalyzed by polar stratospheric clouds, which accelerate the damage caused by ions like chlorine and bromine. For 10 points, name these anomalies distinguished by their lack of a certain allotrope of oxygen, the most famous of which was discovered over Antarctica in 1985.
   Answer: __Ozone__ layer __holes__ (accept clear knowledge equivalents)

6. The Langmuir isotherm describes its dependence on concentration, which begins to grow linearly but then approaches a saturation value. It is largely due to London dispersion forces. In general, compounds with large molecular weight and a larger number of functional groups are more likely to do it. The chemical type forms a monolayer, while the physical type can form multiple layers and is more often reversible. For industrial use of this process, one chooses substances like activated carbon or silica gel that have a large surface area. For ten points, what is this process in which particles preferentially bind to the surface of a solid?
   Answer: __Adsorption__

7. It directly precludes Mdm2-mediated degradation of p53, and it prevents Rb from binding to E2F. It may be carried out at SQ sites in response to DNA damage, such as on the tails of H2AX variant histones. It is performed by proteins such as CPK, CDK, PKA, EGFR, and a mitogen-activated protein or "Map" family, and it is primarily carried out upon serines, threonines, and tyrosines. For ten points, identify this action which adds a certain negative ion, carried out by kinases and whose "oxidative" form occurs in the mitochondria.

   Answer: **Phosphorylation** (**protein phosphorylation** **or equivalents would be okay up til ox phos**

8. A "gap" in the spectrum of stable nuclei, with Turkevich. A model of the atom, with Thomas. The highest electron energy level of a system at absolute zero. A trolley used to maneuver a target in an early cyclotron. A "Golden Rule" for calculating decay rates. The constant controlling the coupling of the weak interactions, proposed as a theory of four of the particles bearing his name. A paradox about extraterrestrial life. A type of statistics with which Dirac's name is also associated. The national accelerator laboratory in Batavia, Illinois. For ten points, these things all take their name from what Italian-American physicist?

   Answer: Enrico **Fermi**

9. A nonclassical form of this reaction was recently proposed to account for the conversion of Weinreb amides into ketones. Though the cis product is usually favored, the addition of a strong base to an early step favors the trans product, as seen in the Schlosser modification of this reaction. In this reaction, the reaction of triphenylphosphine and an alkyl halide produces a phosphonium ion, which can react with a strong base to produce an ylid. For ten points, name this reaction, named for its Nobel Prize-winning discoverer, which results in the formation of an alkene.

   Answer: **Wittig** reaction

10. The property of this name says that any open covering can be expressed as a finite subcovering. The theorem of the name can be proved by first proving that, for a metric space A (or a subset of a metric space), any arbitrary sequence has a limit point in A. Next, one must prove that every open cover has a finite subcover. Alternatively, for the real numbers, one could work from the Bolzano-Weierstrass theorem and prove – for ten points– what theorem that states that a set is compact if and only if it is closed and bounded?

    Answer: **Heine-Borel** theorem

11. Cancers in this organ are sometimes caused by fusions of the PAX8 and PPAR gamma genes. The Wolff-Chaikoff effect is observed in its autoregulation. It is the first endocrine organ formed during development, and it is connected to the tongue in the fetus by a duct that becomes the foramen cecum. Myxedema coma may occur as a complication of diseases of this organ such as Hashimoto's disease. For ten points, identify this gland which produces calcitonin, and enlargement of which forms a goiter.

    Answer: **Thyroid**

12. A few years ago the DAMA collaboration claimed to have directly detected one, but other experiments have sense demonstrated that this was a false alarm. One of the most natural candidates, which would also solve the strong CP problem, is an axion. The most commonly accepted type would be the lightest supersymmetric particle, generally a neutralino. Modified Newtonian dynamics, or MOND, might obviate the name for them. Their existence is suggested by galactic rotation curves and the fact that MACHOs do not appear to be a good explanation. For ten points, what is this general type of candidate dark matter, named for the strength with which it couples to known particles?

    Answer: **WIMP** or **weakly interacting massive particle** (**prompt on "dark matter" before it is read.**)

13. This reaction requires at least one equivalent of Lewis Acid to remove the halide and create an acylium ion, and at the end ice water is poured into the reaction mixture. The water is necessary to destroy the complex of aluminium trichloride with the final product, the breakdown of which complex allows the desired ketone to be isolated. During the reaction, a pi-electron attacks the carbonyl carbon, then a proton is lost to the aluminum trichloride, and a double-bond is formed, restoring the benzene ring. For

ten points, name this reaction devised by two chemists, transferring an acyl group onto an aromatic ring.
Answer: __Friedel-Crafts__ **Acylation, need acyl before it is said**

14. Is Harry Turtledove's *Worldwar* series, the Race explodes nuclear weapons over every major city in order to create them. In *Starcraft*, it allows Science Vessels to take down a Protoss carrier with a single Yamato gun shot. In *Ocean's Eleven*, Basher suggests using it, created by a "Pinch," to create the seventeenth century instead of Hiroshima. They are produced by Compton-recoil electrons and photoelectrons from photons in a large explosion and can cause damage by creating voltage surges in sensitive electronic devices. For ten points, name this three-word phenomena that destroys electrical equipment, a staple of science fiction stories.
Answer: __E__lectro-__M__agnetic __P__ulse

15. Itoh and colleagues used single-molecule experiments to show that one example of this class of proteins functions as a rotary motor. Proteins of this class usually contain a Walker box which is essential to their activity. A well-known example is the F0F1 (eff-zero-eff-one) variety that, contrary to its name, generates rather than hydrolyzes its namesake molecule, using energy from the proton gradient of the mitochondrial inner space. For ten points, identify this class of proteins that catalyze the hydrolysis of a namesake, very energetic nucleotide.
Answer: __ATPases__ (accept "ATP synthase" on first clue)

16. de Haas and Biermasz found that the mean free path of these, in small samples, is governed by the sample width and determines the thermal conductivity of the specimen. Three of them can have nontrivial interactions in which the momentum vectors do not sum to zero, but instead to a reciprocal lattice vector. These are known as umklapp processes and determine thermal resistivity when sample size is not a limiting factor. Debye's model for their density of states reproduces the Dulong and Petit specific heat at high temperatures, and was improved by Einstein. For ten points, what are these quasiparticles arising from lattice vibration?
Answer: __Phonons__

17. The ionic form of this metal is required for the function of the *E. coli* prolyl isomerase SlyD, explaining why SlyD is a common contaminant during hexahistidine-mediated protein purification. When alloyed with aluminum and treated with sodium hydroxide, it forms the most common catalyst for the catalytic hydrogenation of ketones and aldehydes, which is named for its discoverer Murray Raney. FTP, identify this silvery-white metal, a member of the iron-cobalt group with atomic number 28.
Answer: __Nickel__

18. In a spoof of Faust written for the annual September Celebration, he was depicted as God against Wolfgang Pauli's Mephisto, who argued for removing "mass" and "load," leaving the universe with only the neutron. Before Ehrenfest committed suicide, the depressed physcist felt that he had "lost contact with theoretical physics" after siding with this man over Einstein. For ten points, name this physicist who after winning the Nobel in 1922 took residence in the Carlsberg breweries in Copenhagen.
Answer: Niels __Bohr__

19. Morphological modeling of this body by Lorenz and Lunine suggests that it contains localized karst terranes created by erosion of ammonium hydrates within its Ih-phase ice bedrock. Kargel has proposed potassium-40 leaching of its felsic rocks by methanal as one source for its high argon concentrations. Its features include a formation known as "the snail," which may be an icy plug atop a cryovolcano, and a continent-size high albedo zone named Xanadu discovered using Infrared Mapping Spectrometry to peer beneath its nitrogenous atmosphere. For ten points, identify this moon discovered by Huygens in 1655, the largest satellite of Saturn.
Answer: __Titan__

20. Stockmeyer and Meyer proved that QBF, the quantified version of this problem is complete for PSPACE. The "critical" version, where deleting any clause allows the traditional formulation to return "true," is also complete for DP. If we change the initial quantifier from "there exists" to "for all," it becomes Tautology, a coNP complete problem. Proved NP-complete in 1974 by Cook, for ten points, name

this decision problem for deciding if a truth assignment exists for a 3CNF-formula such that the resulting expression is true.

Answer: **Circuit/Boolean satisfiablility**

2   Caltech Bonuses, Round 4

1. Name the following things that pertain to vapor pressure for ten points each.

    10 This equation states that the rate at which the natural logarithm of the vapor pressureof a liquid changes with respect to temperature depends upon the molar enthalpy of vaporization of the liquid, the temperature, and the ideal gas constant.
    Answer: **Clausius-Clapeyron equation**

    10 Because the lowering of the vapor pressure of a solution by a solute depends upon the number of molecules of solute rather than their type, vapor pressure lowering is considered to be this sort of property.
    Answer: **Colligative property**

    10 This law states that, in ideal solutions, the vapor pressure of a solvent in a solution is proportional to its mole fraction.
    Answer: **Raoult's law**

2. For 10 points each, answer the following about the humble knot.

    10 Most knots are bounded by these orientable surfaces generated by their namesake algorithm. Their least genus gives rise to the knot genus.
    Answer: **Seifert Surfaces**

    10 This specific type of invertible unique prime knot with Alexander polynomial $-x^2 + x - 1$ serves as the Seifert surface for a Möbius band. Its braid word is σ_1^3.
    Answer: **Trefoil knot or overhand knot**

    10 A knot that is pass equivalent to the trefoil knot is given this Arf invariant calculable from the Alexander polynomial of minus 1 via 5 (mod 8).
    Answer: **1**

3. When Halley's comet appeared in 1986, five missions conducted flybys. Name these crafts for ten points each.

    10 Two from the Soviet Union were both from this program, whose name was contraction of the words for "Venera" and "Gallei."
    Answer: **VEGA**

    10 The ESA launched this mission named after an Italian painter and architect.
    Answer: **Giotto**

    10 Japan sent two craft whose names translate as "comet" and "pioneer." Name either.
    Answer: **Suisei or Sakigake**

4. Name the following scheduling algorithms and related concepts for the stated number of points.

    10 This concept refers to how much time a process should get on the processor. In Linux, this property can be changed by the command "renice."
    Answer: **Priority**

    10 One problem with priority queues is that higher-priority processes can displace older, waiting jobs and result in this undesirable condition.
    Answer: **Starvation or infinite/indefinite blocking**

    10 In this type of scheduling, each process gets to make progress but switches out with other queued processes through preemption.
    Answer: **Round-Robin Scheduling**

5. Identify the following plots from enzyme kinetics.

   10 This is a plot of reaction velocity as a function of substrate concentration. It can be used to determine the maximal velocity or the concentration of substrate, called K_m, that yields half of this velocity.
   Answer: **Michaelis-Menten plot**

   10 This double-reciprocal plot is generated by plotting the inverse of reaction velocity as a function of the inverse of substrate concentration.
   Answer: **Lineweaver-Burk plot**

   10 Generated by plotting the ratio of the concentration of bound substrate to the concentration of free substrate as a function of the concentration of bound substrate, this plot is used to determine the number of binding sites and the equilibrium constant.
   Answer: **Scatchard plot**

6. For ten pointseach, questions about nuclear physics.

   10 In the shell model of the nucleus, these are the numbers 2, 8, 20, 50, and so on in which *either* the number of protons or of neutrons is such that the occupation of a group is completed.
   Answer: **Magic numbers**

   10 This is the approximate symmetry that rotates a proton into a neutron, now understood to arise from the near-degeneracy of the up and down quark masses.
   Answer: **Isospin or isotopic spin**

   10 This interaction, between two different types of angular momentum, one intrinsic and one not, plays a large role in determining nuclear energy levels.
   Answer: **Spin-orbit coupling**

7. Answer some questions about the Linear Programming problem for ten points each.

   10 Also known as the ellipsoid method, this was the first discovered polynomial-time algorithm for solving linear programs.
   Answer: **Khachiyan Algorithm**

   10 Although not guaranteed polynomial-time, this algorithm discovered by George Danzig nonetheless performs much better than the Khatchian algorithm and is still widely used.
   Answer: **Simplex Algorithm**

   10 Integer Linear Programming is significantly harder than regular Linear Programming, and was shown to be NP-Complete in a 1972 paper by this man.
   Answer: **Richard Manning Karp**

8. Identify the following biological assays for ten points each.

   10 In this assay, DNA is resolved by gel electrophoresis and transferred to a membrane. Sequences of interest are detected by hybridization of a radioactive probe.
   Answer: **Southern blot(ting)**

   10 In the "sandwich" variety of this assay, the target protein is identified by its binding to a capture antibody and a detection antibody. This type of assay is used clinically to detect antibodies to pathogens such as HIV.
   Answer: **Enzyme-Linked ImmunoSorbent Assay**

   10 In this assay, which is usually used to detect protein-protein interactions, proteins are resolved by gel electrophoresis and then probed with a protein or peptide, but *not* an antibody.
   Answer: **far Western blot (do not accept or prompt on Western blot**

9. Volcanic geomorphology, for ten points each:

10 This is a wide elliptical depression that results from the collapse of a stratovolcano following the evacuation of its magma chamber. One of them hosts Crater Lake.
Answer: **Caldera**

10 The erosion of a caldera commonly exposes this structure formed by intrusion and hardening of magma along conduits produced by arcuate faulting.
Answer: **Ring dike**

10 This type of caldera results from contact of rising magma with groundwater, resulting in a phreatic explosion. An example is Death Valley's Ubehebe Crater.
Answer: **Maar**

10. For ten points each, answer questions about a recent measurement and its consequences.

10 An inconclusive result of torsion balance experiments at the University of Washington suggests a deviation from this inverse-square law below 100 microns.
Answer: **Newton's law of gravity**

10 One explanation might arise from Raman Sundrum's concept of a "fat" one of these, the hypothetical quantum spin 2 particle transmitting the force.
Answer: **Graviton**

10 The project's original goal was to find out why gravity is so weak; one explanation could be that gravity bleeds off into one of the 7 folded dimensions predicted by this theory that treats particles as one dimensional objects at Planck length.
Answer: **String theory**

11. For ten points each, answer these questions about thermodynamics.

10 This state function is defined as the system's internal energy minus the product of the temperature and the entropy.
Answer: **Helmholtz free energy**

10 This equation demonstrates that the intensive quantities chemical potential, temperature, and pressure are not all independent. In a system with only one type of molecule, it can be used to relate chemical potential to temperature and pressure.
Answer: **Gibbs-Duhem equation**

10 The Gibbs-Duhem equation comes from differentiating this equation, namely $U = TS - pV + \mu N$. It is derived by making use of the fact that internal energy is a first-degree homogeneous function of entropy, volume, and particle number.
Answer: **Euler equation**

12. Name some things from cladistics for ten points each.

10 This term refers to a derived or specialized character shared by two organisms that originated in their most recent common ancestor.
Answer: **Synapomorphy** or **synapomorphies**

10 Nematocysts, which contain stinging threads enclosed in chitin-like capsules, are a synapomorphy of this invertebrate phylum, which contains the corals.
Answer: **Cnidarians**

10 This synapomorphy shared by humans and many other vertebrates sits approximately where the spine will be, and in humans, it directs neural tube formation through the secretion of Sonic hedgehog protein.
Answer: **Notochord**

13. Identify eponymous circuit stuff, for ten pointseach.

10 These two laws are expressions of the conservation of energy and charge, in the form of voltage and current respectively.
Answer: **Kirchhoff's** laws

10 This voltage is the ideal open circuit voltage, and this resistance is found by substituting short circuits for voltage sources. It is used to help analyze complicated circuits.
Answer: **Thevenin** equivalent

10 Rather than a voltage source as in the Thevenin case, this simplifies a circuit to a current source in parallel with a resistor.
Answer: **Norton** equivalent

14. Since the biggest moons in regular orbits have already been discovered, astronomers have to turn their attention to irregular moons with eccentric and often inclined orbits. For ten points each...

10 Discovered by Pickering in 1898, this moon's orbit is inclined 170° and may be a Kuiper belt object or comet captured by Saturn.
Answer: **Phoebe**

10 Name either of the two objects discovered by Brett Gladman in 1997 to be irregular moons of Uranus.
Answer: **Caliban** or **Sycorax**

10 Astronomers searching for irregular moons focus on this region, defined as the area where a planet's gravitational sphere is stronger than the sun's; it is in this region that a moon can have a stable orbit.
Answer: **Hill** Sphere

15. Given what it says, give the name of the inequality from probability for ten points each.

10 If x only takes non-negative values, then the probability of x being greater than a is less than or equal to the mean of x divided by a.
Answer: **Markov's** inequality

10 An extension of Markov's inequality, this states that the probability of the absolute value of a variable minus its mean being less than $k\sigma$ is less than or equal to $\frac{1}{k^2}$.
Answer: **Bienaymé-Chebyshev** inequality

10 This inequality explains why non-linear functions don't preserve expectations; it says that for a convex f, f of the sum from 1 to n of x_i is less than the sum from 1 to n of $f(x_i)$.
Answer: **Jensen's** inequality

16. For ten points each, answer these questions about intermolecular potentials.

10 This potential is used as an approximate solution to Schrödinger's equation. It has, schematically, the form of the square of 1 minus e to the negative x, and fails at short bond lengths.
Answer: **Morse** potential

10 Sometimes called bond energy, it is the asymptotic height of the Morse potential at infinity relative to the minimum, and it is denoted D_e.
Answer: **Dissociation** energy

10 This potential is sometimes used to approximate interatomic forces; it has a piece going as distance to the minus 12, and another piece going as distance to the minus 6.
Answer: **Lennard-Jones** potential

17. Name the molecular biology laboratory technique for ten points each.

10 Tag cell surface proteins with fluorescent markers, then use a machine to sorts them by color. This is good for looking at the proportions of cells with such-and-such surface molecules.
Answer: **Flow Cytometry, prompt on Flow Activated Cell Sorter or FACS - it's the machine**

10 Take radiolabeled RNA oligos, incubate with either RNA or DNA in the presence of reverse transcriptase. Run the results on a gel. This is the best method for finding the 5' end of transcripts, and therefore the initiation site.
Answer: **Primer extension**

10 Run a low-density agarose gel, cut out the resulting bands, run them on a high-density agarose gel. This is good for visualizing replication fork structures like transcriptional bubbles and forks.
Answer: **2-dimensional agarose gel electrophoresis**

18. Everybody loves a little Group Theory now and then. Answer the following for ten points each.

10 Two adjectives required. The classification of these groups was a main project throughout the 20th century, and among the 26 sporadic groups discovered in the process were the Matthieu group M11 of order 7920.
Answer: **Finite simple groups (prompt on partial answer)**

10 One large subset of the finite simple groups are the groups of this type, which are all those finite linear groups analogous to the unitary groups. They are similar to a more famous type of infinite group with the same name, which have the structure of a manifold.
Answer: **Lie-type groups** not quite the same as a Lie group, but "Lie" is all I want

10 The smallest non-cyclic finite simple group is this important group of order 60, isomorphic to $PSL_2(F5)$ [read as "P S L sub 2 over the field of order 5"], which is also the 5th Alternating Group. It represents the group of shape-preserving rotations on its namesake 20-sided polyhedron.
Answer: **Icosahedral group**

19. Experimental verification of quantum chromodynamics depends upon the observation of confined bound states. Identify them, for ten points each.

10 These lightest QCD vector particles are spin-1 bound states of quarks. They have masses around 770 MeV.
Answer: **Rho meson**

10 These hypothetical particles would have no valence quarks, but would instead be composed entirely of gluons. None has been conclusively identified.
Answer: **Glueball**

10 Closely related to the search for glueballs is the search for the "hybrid" types of these particles composed two quarks that take the exotic quantum number $J^{PC} = 1^{-+}, 0^{+-}$, or 2^{+-}.
Answer: **Mesons**

20. Name the following classes of organic compounds for ten points each.

10 Characterized by chemistry similar to their oxygen-containing relatives, these compounds contain an -SH group. They are also known as mercaptans.
Answer: **Thiols**

10 These compounds are the cyclical counterparts of amides. The beta variety inhibit D-alanyl-D-alanyl transpeptidases in bacteria; examples of such compounds include penicillin and methicillin.
Answer: **Lactams**

10 These compounds are divalent carbon intermediates in which the carbon atom is linked to two adjacent groups and possesses two free electrons. They are often formed from diazo compounds.
Answer: **Carbenes**