

Science Monstrosity III: The Gay Science
Round 3

UCLA
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1 UCLA Tossups, Round 3

1. The potential energy of objects here is given by $-\frac{1}{2}n^2(x^2 + y^2)$ and the Gravitational energy with respect to m_1 and m_2 . They are found by applying the principle of least action to the three body problem, where the third body has a negligible mass compared to the other two. An early result and inspiration for one of the reformulations of Newtonian mechanics, they are the location of the several thousand Trojan asteroids that are in orbit near Jupiter. Where the sun and earth's gravity are in equilibrium, for ten points what are these points of stable orbits for a third body with respect to two others in a gravitational system?

Answer: Lagrange points or Lagrangian point

2. Modern proofs of it depend on the Stieltjes-Osgood theorem, and on an argument developed by Koebe whose name, in English, roughly translates as "cozying-up procedure." It is unique in part because its analog for multiply connected domains is not true, and it is amazingly powerful, as it proves, for example, that any two simply connected domains in the plane are homeomorphic. For ten points, what is this, the ultimate theorem of undergraduate courses in complex analysis, named for a German mathematician?

Answer: Riemann mapping theorem

3. This compound is heated with sulfuric acid to produce diethyl ether. Because ADH has a higher affinity for it than methanol, it is used to treat methanol poisoning. Found in below -40 degree Celcius thermometers, and as solvents in perfumes, paints, varnishes, explosives, and glues, it is produced by the enzyme zymase, which changes glucose to it, releasing carbon dioxide. Mixed with gasoline to form gasohol, it is made industrially from waste sulfite liquor, or by hydration of ethene. For ten points, name this product of fermentation, a grain alcohol with formula C_2H_5-OH .

Answer: ethanol; or ethyl alcohol

4. The barotropic variety of this phenomena may be brought to rest by baroclinic drag, and is a significant source of perturbation during diapycnal mixing. Their period is given by twice their length divided by the square root of the product of depth and the acceleration due to gravity, and they are especially devastating when they match the natural harmonics of the fluid they effect, such as during the 1946 Hilo Bay tsunami. Caused either by seismic activity or by high wind – for ten points– what are these long oscillations lasting from minutes to hours that occur in enclosed, landlocked bodies of water?

Answer: seiches

5. One of its consequences is that the difference in temperature times the difference in heat capacities between product and reactant gives the difference in enthalpies of reaction at those two temperatures, also called Kirchhoff's law. Subtracting bond enthalpies of products from bond enthalpies of reactants gives enthalpy of reaction, as if bond breaking and bond forming are sequential. Derived from path independence of a state function, for ten points, name this law of heat summation stating that the change in enthalpy is the same whether the reaction occurs in one step or a series of steps.

Answer: Hess's law; accept "Kirchhoff's law" before it is mentioned

6. Essential for the metamorphosis of a tadpole to a frog, it is released in greater amount in the cold. Isolated by Edward Calvin Kendall and 1st synthesized by Charles Harington, it is secreted as a plasma globulin and is made from diiodotyrosine. Over production results in the tremor, appetite, and fatigue of Grave's disease, and under production causes myxedema in adults and cretinism in children. Converted to T3 in cells, its production is regulated by TSH. For ten points, name this hormone that increases the rate of metabolism, secreted by the thyroid gland.

Answer: thyroxine; or tetraiodothyronine or T4

7. The main assumption behind their interpretation is Eskola's bulk chemistry hypothesis. As they change, an ACF diagram may be used to track the most common progress of a basic system through them from the epidote-actinolite-chlorite to the andesine-augite-orthopyroxene stability field, a pathway which is parallel to the mean continental geotherm. Miyashiro proposed five series of them, including the extreme Franciscan and Contact series, though most rocks follow the Barrovian series. Their usefulness lies in their applicability to a specific set of isograds even in the absence of index minerals like staurolite or garnet.

For ten points, name these mineral assemblages that correspond to characteristic temperature-pressure conditions during metamorphism.

Answer: metamorphic facies

PROMPT on “Metamorphic Rock”

8. Their selectivity comes from 8 glycine carbonyl oxygens in glycine-tyrosine-glycine sequences in P segments that bind to the substrate when it loses its hydration shell. Made up of subunits with a S5 outer helix, S6 inner helix, and an exoplasmic P turret with a loop for a selectivity filter, they contain a central vestibule formed by the 4 subunits in an inverted teepee position spanning the membrane. Studied by patch clamps – for ten points– name these nongated proteins specific for potassium, sodium, or calcium that facilitate diffusion of small charged atoms across the phospholipid bilayer.

Answer: ion channels; accept “potassium,” “sodium,” and “calcium” in place of “ion” before they are mentioned

9. This phenomenon was observed by Don Eigler at IBM for Xenon, although more important was the action of electrons developed into an analytic technique by Binnig and Rohrer. It is the fundamental principle behind Hawking radiation, allowing black holes to emit detectable radiation. A common example is the inversion of the ammonia molecule, and it is largely responsible for the current leakage that plagues chip-makers as they try to continue miniaturizing their microchip designs. An uniquely quantum-mechanical phenomenon – for ten points– what is this nonzero probability for a quantum particle to be found on the outside of a potential barrier that it could not classically penetrate?

Answer: quantum tunneling

10. At a conference in Japan, Encantadora claimed to offer it for sale, but only had enough to make one demonstration of its use in nanotechnology. The president allegedly had a ring made out of this material, and although it gave him radiation poisoning, it was swapped out for a fake by Batman. The “blue” variety only affected the creation of Dr. Teng, Bizarro, and the “red” version – apparently laced with tar by Gus Gorman – doesn’t just block the rays of the yellow sun, it turns Superman evil. For ten points, name these fragments from the planet Krypton.

Answer: Kryptonite

11. This algorithm can be interpreted as a sequence of projections between manifolds obtained by alternately minimizing the Kullback-Leibler Divergence between the empirical and complete model distributions. Maximizing the auxiliary function with respect to the averaging distribution forms the step 1, while maximizing with respect to the parameters in step 2 is equivalent to maximizing the expected complete log likelihood. For ten points, name this hidden variable coordinate ascent algorithm that averages over complete data before parameter estimation for the largest log likelihood.

Answer: EM algorithm; or expectation-maximization algorithm

12. Its orbit generates a current of approximately 3 million amperes in the magnetosphere of the planet it orbits. An area of low strength in that planet’s magnetic field has led some to believe that this moon has its own magnetic field. Photographs of its Tvashtar region indicated a sapping-like process that occurs presumably with sulfur dioxide. Better known geological features are the so-called collapsing mountains and Loki, the most powerful volcano in the solar system. For ten points, identify this densest and innermost Galilean moon of Jupiter.

Answer: Io

13. This effect can be eliminated in haloalkanes by rapid magnetic equilibration, and in alcohols by fast proton exchange. Either geminal or vicinal, its ratios are given by Pascal’s triangle under first order conditions, but if nonequivalent neighbors are involved, the sequential $N + 1$ rule is applied to find the number of peaks. When its coupling constant is comparable to the frequency difference, higher field strength is needed to improve resolution. Caused by local magnetic fields of neighboring atoms – for ten points– name this phenomenon observed in NMR in which a peak in the spectrum splits up.

Answer: spin-spin splitting/coupling; prompt on “NMR” before it is mentioned

14. This field of study whose name was coined in 1986 by Thomas Roderick uses EST to supplement open reading frames in more complex analyses. This word also is the second word in the corporation founded 1998 by the Perkin-Elmer Corporation. Hidden Markov models, Needleman-Wunsch and Smith-Waterman algorithms, and the BLAST program have been used for DNA and proteins, with data stored at EMBL and GenBank. For ten points, what field of study takes its name from the Greek for the “complete” study of an organism’s genetic makeup?

Answer: genomics

The corporation is “Celera Genomics”

15. Axial skeleton and ribs characterize this group of animals which evolved in the late Cambrian period out of need to maintain internal salt concentrations. Instead of functioning in gas exchange and locomotion, its coelom supports internal organs and maintains the circulation system. Neural crest cells migrate from the dorsal neural plate of its embryos, giving rise to skin pigments, nerves of the peripheral nervous system, and bones of the cranium. Increased cephalization and a jointed dorsal nerve column evolved in – for ten points– what subphylum of chordates, our very own.

Answer: Vertebrata; or vertebrate; prompt on “chordate”

16. One of its consequences can be proved by using the fundamental theorem of algebra to contradict an assumption that a trigonometric polynomial must have infinitely many zeroes. Established by using a Dirac comb and any other continuous function, it is often misstated with the assumption of a low-pass signal, leading to the substitution of bandwidth with maximum frequency. For ten points, name this theorem of signal processing that describes the minimum frequency necessary to convert an analog signal into a digital signal so that the analog signal can be perfectly reconstructed from the digital one.

Answer: Nyquist-Shannon sampling theorem; prompt on “Shannon”

17. Proceeding from carboxyl to amino terminus, it begins by flushing the solution with base to remove the 9-fluorenyl-methoxycarbonyl (Fmoc) protecting group from the alpha-amine. Fmoc attaches to amine of the next residue, which is activated at the carboxyl end by dicyclohexylcarbodiimide (DCC). The original strand, now attached to polystyrene beads, attacks the activated carboxyl to form a peptide bond, leaving behind dicyclohexylurea. Deprotection with HF leaves an elongated peptide. For ten points, name this solid-phase protein synthesis reaction named for a 1984 chemistry Nobel winner.

Answer: Merrifield protein synthesis

18. One of the more interesting uses of this phenomenon is in plastic surgery in a procedure called UAL where piezoelectric transducers are placed at the end of a titanium tube during liposuction. Inability to give an exact maximum temperature and later experiments using deuterated acetone fueled speculation that the energy produced in this reaction would be enough to catalyze fusion. Its exact mechanism is unknown, though it is typically caused by rapid adiabatic compression known as acoustic cavitation. Coming in “multi-bubble” and the more heavily studied “single-bubble” types – for ten points– name this phenomenon, the conversion of sound energy into light.

Answer: Sonoluminescence

19. A consequence of Liouville’s theorem proves a simplified version of it by implying that the convective time derivative of the local state density will be zero. A more rigorous treatment involving measure theory due to Birkhoff limits itself to transformations whose only measurable sets that it holds invariant have measure zero or one, and is the basis of the field of dynamical systems. For ten points, what is this theorem, most commonly used in thermodynamics in its paraphrased version, that states that the time average is the same as the average over the statistical ensemble?

Answer: ergodic theorem/principle/hypothesis

2 UCLA Bonuses, Round 3

1. Because he's a German mathematician with a French last name, no one knows how to pronounce it. In his personal life he married a sister of the composer Mendelssohn, and in his professional life he made advances in number theory and certain classes of differential equations. For ten points each:
 - 10 First, name him.
Answer: Johann Gustav Lejeune Dirichlet
 - 10 In differential equations, he is particularly known for this field that involves the study of solutions of Laplace's equation.
Answer: potential theory
 - 10 He first stated this principle that if you want to put objects into slots and you have more objects than slots, you must reuse one of the slots.
Answer: pigeonhole principle
2. Make some conservative school board members in Kansas upset by answering these questions about physical cosmology for the stated number of points.
 - 15 For fifteen points, name either the Belgian cosmologist who published "hypothesis of the primeval atom" or the Russian mathematician cum meteorologist author of 1922's "On the curvature of Space" who disagreed that a stationary universe was a consequence of general relativity.
Answer: Georges LeMaître or Alexander Friedmann
 - 5 Further evidence for the big bang theory was provided by Penzias and Wilson with the discovery of this radiation.
Answer: cosmic microwave background radiation
 - 10 The background radiation spectrum coincides almost perfectly to that of a black body at this temperature (to within plus or minus 0.1 Kelvin).
Answer: 2.7 K; accept 2.6 to 2.8
3. Answer the following question about this algorithm placed in the top five most influential in the 20th century, just behind the Fast Fourier Transform.
 - 10 Invented in a seminal 1953 paper titled "Equation of state calculations by fast computing machines," name this algorithm that samples from a stationary distribution of a Markov chain by drawing samples from a symmetric proposal distribution with probability based on the ratio of probabilities of the new and old candidates.
Answer: Metropolis-Hastings algorithm
 - 10 This sampling algorithm is a special case of the Metropolis-Hastings algorithm in which the acceptance probability of new candidates is one. To get you pity points, we'll mention that it's named for an American scientist and a type of free energy.
Answer: Gibbs sampling
 - 10 Another thermodynamically motivated algorithm proposed by Metropolis was this technique of gradient descent where the probability of taking downward paths decreases with a parameter called "temperature." It takes its name from techniques used in metal working.
Answer: simulated annealing
4. This type of reaction is utilized in preparing methanol from carbon monoxide, and in determining relative stabilities of various substituted alkenes for ten points each.
 - 10 Usually taking place on the surface of a heterogeneous catalyst, this stereospecific syn addition makes alcohols from carbonyls and breaks double bonds in alkenes by reacting them with protons.
Answer: hydrogenation; prompt on "reduction"

- 10 Amino acids are made in the lab by catalytic hydrogenation of enamides in rhodium or ruthenium catalyst. It also requires this ligand of element number 15 to control stereospecificity.
Answer: phosphine ligand; accept “phosphorous”
- 10 Used to attach free hydrogens so they can react with the alkene carbons, this platinum oxide catalyst used in hydrogenation is in colloidal metal form, and is named for a University of Illinois professor.
Answer: Adams’s catalyst
5. Name these elements for ten points each.
- 10 Used in semiconductors with arsenic and in high-temperature thermometers, it stays in liquid state at room temperature, and over the widest range of temperatures.
Answer: gallium
- 10 Discovered by Bunsen and Kirchhoff, it is used for atomic clocks like Cesium. It was used in radioactive dating and to demonstrate the Bose-Einstein condensate.
Answer: rubidium
- 10 Its oxide can prevent corrosion of iron by water. Used in medical imaging, it was the first artificial element, as found by Segre and Perrier.
Answer: technetium
6. Stuff from general theory of relativity for ten points each.
- 10 General relativity explained why the advance of the perihelion of this planet was twice as large as Newton’s laws predicted.
Answer: Mercury
- 10 One of the first uses of general relativity was by this man, who determined the space-time curvature first of a massive point mass.
Answer: Karl Schwarzschild
- 10 This tensor of rank (1, 3) at every point in 4-D space-time has twenty independent components, 10 of which correspond to the Ricci tensor and 10 to the Weyl tensor.
Answer: Riemann curvature tensor
7. Global air circulation can be described as a series of cells in which winds are largely self-contained. Identify the following related to global air circulation for the stated number of points.
- 5,5,5 Above the equator, there are three types of cells that circulate the air and cause the prevailing winds. One is named for its geographical location, one for an English meteorologist, and one for a Nashville school teacher. Name them for five points each.
Answer: Polar cell, Hadley cell, and Ferrel cell
- 5 Between the Polar and Ferrel cells, there is this belt of winds, the northern component of which is largely responsible for the movement of US weather patterns from west to east.
Answer: jet stream
- 10 These offset circulation regions form when the jet stream is diverted around an area of high pressure, and may pinch out, introducing warmer air parcels to Polar Cells.
Answer: omega blocks
8. Continuum mechanics is a branch of mechanics that deals with solids and fluids in the infinitesimal limit. Identify these things related to continuum mechanics for ten points each.
- 15 This subfield of continuum mechanics deals with materials that return to their rest shape after an applied stress.
Answer: elasticity

- 15 This subfield straddles the domains of solid and fluid mechanics by dealing with materials that are viscoelastic and determining the characteristics of flows of these materials.
Answer: rheology
9. It can make orthorhombic crystals appear hexagonal and trigonal crystals appear monoclinic. For ten points each. . .
- 10 Identify this phenomenon typically recognized by the presence of composition surfaces and mirror planes in a crystal.
Answer: twinning
- 10 Albite Law twinning occurs exclusively in this group of tectosilicates, of which albite is a common member.
Answer: feldspar group; accept "plagioclase"
- 10 In this type of twinning, repeated twins composed of more than 2 parts twinned according to the same law possess parallel successive composition surfaces.
Answer: polysynthetic twins
10. It is defined as a normed space where the limit point of every Cauchy sequence is included. For ten points each. . .
- 10 Name this space named for a Polish mathematician.
Answer: Banach space
- 10 If the norm of a Banach space is induced from an inner product, then it is also this type of space.
Answer: Hilbert space
- 10 Alternatively, one can check that a Banach space is a Hilbert space by showing that, for this quadrilateral, the sum of the squares of the four sides equals the sum of the squares of the diagonals.
Answer: parallelogram
11. Identify these terms related to fractals for ten points each.
- 10 A set F is called a fractal if the fractal dimension is greater than this other quantity.
Answer: topological dimension
- 10 The function used to generate this set is the recursive equation $Z_n = (Z_n - 1)^2 + C$, where $Z_0 = 0$ and C varies. It is named after a Polish-French mathematician.
Answer: Mandelbrot set
- 10 This set is similar to the Mandelbrot set except that Z_0 is varied while C is held constant.
Answer: Julia set
12. There are many connections between classical and quantum mechanics for ten points each.
- 10 This formulation of quantum mechanics was developed by Richard Feynman as an extension to his doctoral thesis and relies on the classical concept of action.
Answer: path integral formulation
- 10 This theorem, which states that the derivative of the expectation of momentum yields the force is analogous to Newton's second law.
Answer: Ehrenfest's theorem
- 10 In the canonical formulation of quantum mechanics, the Poisson brackets of classical mechanics are replaced by these relations between operators.
Answer: commutators
13. The first laser was not actually a laser. For ten points each. . .

- 10 The device, because of the range of the output, built by Townes was actually called what?
Answer: maser
- 10 Lasers operate by producing this condition in a laser medium, created by optically pumping the medium.
Answer: population inversion
- 10 Name either of two Soviet physicists who also worked on the laser and shared the 1964 Nobel Prize in physics for their work creating lasers capable of producing continuous output.
Answer: Nikolai Basov or Alexander Prokhorov
14. Identify these genetic disorders for fifteen points each .
- 15 1 of 3 collagen chains disrupts the other 2 in this dominant negative disorder also called brittle-bone disease, whose symptoms include skin and ligament ailments as well as bone malformation.
Answer: osteogenesis imperfecta
- 15 Caused by a CGG triplet repeat on FMR1 that expands in the next generation, this X-linked recessive disorder responsible for mental retardation is named for the constriction at the lower tip of the X chromosome.
Answer: fragile X syndrome
15. Given discrete probability distributions p and q , identify the following forms of entropy for ten points each.
- 10 $\sum_x p(x) \log q(x)$.
Answer: cross entropy of q with respect to p
- 10 $\sum_x p(x) \log p(x)$.
Answer: negative entropy of p
- 10 Negative entropy of p minus cross entropy of q with respect to p , a.k.a. the Kullback-Leibler Divergence of p with respect to q .
Answer: relative entropy of q with respect to p
16. Answer these questions on transport in plants for ten points each.
- 10 As opposed to the symplast, this is the meshwork of walls and intercellular spaces outside a cell's plasma membrane through which water and ions flow unregulated.
Answer: apoplast
- 10 Material in the apoplast of the cortex cannot enter the stele because these suberin-containing strips line the endodermal cells all around. However, it doesn't prevent material from entering via the symplast through plasmodesmata.
Answer: Casparian strips
- 10 This is the woody part of plants consisting primarily of tracheids and vessels that transports water upward and provides support.
Answer: xylem
17. Name these types of carbohydrate derivatives for ten points each.
- 10 The C-2 OH is replaced by a namesake nitrogen group that is attached to acetic acid in these compounds that make up bacterial cell walls, including N-acetylmuramic acid with an ether-linked lactic acid.
Answer: amino sugars
- 10 Urionic acids occur when the terminal carbon is oxidized from a carbonyl to a carboxylic acid. This type of acid occurs when the C-1 aldehyde is so oxidized.
Answer: aldonic acid

- 10 These are intramolecular esters formed by urionic and aldonic acids. They look just like a regular sugar except for the presence of the namesake cyclic ester group between C-1 and C-5.
Answer: lactone sugars
18. Identify the types of bacteria for ten points each.
- 10 Containing axial filaments composed of flagella running along the long cylindrical cell body, this family of bacteria include *Treponema pallidum*, which causes syphilis in humans.
Answer: Spirochetes or Spirochaetaceae
- 10 This genus of gram-negative coccus bacteria has three species: psittaci, pneumoniae, and trachomatis. They are responsible for trachoma, an STD, and a type of pneumonia.
Answer: Chlamydiae
- 10 Containing elaborate branching systems of filaments, this order is the source of most of our antibiotics.
Answer: Actinomycetes
19. Continuum mechanics is a branch of mechanics that deals with solids and fluids in the infinitesimal limit. Identify these things related to continuum mechanics for ten points each.
- 15 This subfield of continuum mechanics deals with materials that return to their rest shape after an applied stress.
Answer: elasticity
- 15 This subfield straddles the domains of solid and fluid mechanics by dealing with materials that are viscoelastic and determining characteristics of flows of these materials.
Answer: rheology
20. Answer the following about genetic techniques for ten points each.
- 10 The most common way to look at mutations is to breed the mutant against the “normal” strain, which is given this designation.
Answer: Wild-type strain
- 10 Screens for suspected lethal mutations often rely on this type of mutation whose phenotypic expression is only evident in nonpermissive circumstances, e.g. Hartwell’s temperature-sensitive mutations of cell cycle genes in *Saccharomyces cerevisiae*.
Answer: Conditional mutations
- 10 In this test, two recessive mutations are found to be in the same gene if crossing the two mutants yields mutant, otherwise the alleles are of different genes.
Answer: Complementation