1. The first step of the pressure swing absorption method to produce this compound relies on the Joule-Thompson effect to cool the expanding gas. That method uses an array of carbon molecular sieves to filter out impurities such as oil, water and hydrocarbons. Another industrial process to generate this compound involves the fractional distillation of (*) air and was developed by Carl von Linde. This compound undergoes the Leidenfrost effect: it boils instantly on contact with a warmer object, thereby enveloping the object in a gas. It is typically stored in vacuum-sealed dewars. For 10 points, give this extremely cold, liquid compound used in cryogenics and sometimes by kids who want to make instant ice cream.
ANSWER: **liquid nitrogen** [accept **LN2**; prompt on partial]

2. This person went to senior prom with Harold Gast, the best English and history student in the school. She participated in an experiment in which Coke bottles and books were touched and then had their smells examined. This girl purchased a charcoal broiler from a Sears catalog, which was used to cook steaks along Route 66. She gave her lover (*) pencils with the engraving "I LOVE YOU! PUTSY" on them. She was played by Patricia Arquette in the film *Infinity*. Her husband came to visit her by driving Klaus Fuchs' car to the hospital, and she was the subject of the letter "I love my wife. My wife is dead." She succumbed to TB while her husband was working on the Manhattan project at Los Alamos. For 10 points, name this first wife of Richard Feynman.
ANSWER: **Arline** Greenbaum Feynman [prompt on "Feynman" or "Feynman's wife"; anyone who's read *Surely You're Joking, Mr. Feynman!* or *What Do You Care What Other People Think?* should be able to pull her name ]

3. Golomb found that for any integer $k$, there exists an integer $n$ greater than 1 such that $n$ divided by this function of $n$ equals $k$. Even though one approximation of this function exceeds its true values up and through x equals three million, Littlewood showed that the error on that approximation changes sign infinitely often. Stanley Skewes was able to find a numeric bound on where the first sign change for the error of this function's approximation occurs. Gauss improved upon his earlier approximation for this function by utilizing the (*) logarithmic integral. He had first proposed that for any number x, this function can be approximated by x over the natural log of x. For 10 points, name this function, which for a real number x tells you how many primes are less than or equal to x.
ANSWER: **prime-counting** function [accept **pi function**]

4. This man names the coherent elastic scattering of photons in the electric field of heavy nuclei. This man is the second namesake of a distribution that predicts the bacterial mutation rate is equal to cellular growth rate times log of the ratio of cultures without resistant bacteria to total cultures all over 1 minus $e$ to the negative growth rate times time. That result was obtained when this man and his (*) Italian co-author inoculated some E. coli and plated the separate cultures with T1 bacteriophage. For 10 points, give this biophysicist and co-founder of the Phage Group who showed that bacterial mutations occur randomly, not in response to selection, to win the 1969 Nobel with Salvador Luria.
ANSWER: Max **Delbruck**

5. Forward slash followed by an at-sign maps over multiple expressions in this program. As of late 2013, the Raspberry Pi comes with a free copy of this program preinstalled. This program's language is based on pattern matching, in which functions are defined by putting an underscore after each variable. Starting a line with an equals sign in this program specifies natural language input. Theodore Gray designed the front end of this program that allows one to create and edit (*) Notebook documents. CDF Player can be used to view files written for this program without actually having to pay for it. The language that this program utilizes is named for its egotistical creator. For 10 points, name this program based on symbolic mathematics, whose creation was spearheaded by Stephen Wolfram.
ANSWER: Wolfram **Mathematica**

6. **This scientist is the alphabetically first namesake of a theory that states the universe contains a region of matter and a region of antimatter separated by electromagnetic fields formed from double layers. His namesake theorem says that the magnetic field lines of an infinitely conductive fluid are frozen into it. The detection of certain things named for this guy in the (\*)** corona in 2011 provided a possible solution to the coronal heating problem. The velocity of certain entities named for this scientist is equal to magnetic field strength divided by the square root of the permeability of free space times mass density. Low-frequency ion oscillations propagating in the direction of the magnetic field in plasma are waves named for this guy. For 10 points, name this Swedish plasma physicist.
ANSWER: Hannes **Alfvén**

7. **In a frustrated Lewis pair, steric hindrance prevents an attack on one of these entities, thereby preventing the formation of an adduct. Walsh diagrams operate on the principle that molecules adopt a structure that best stabilizes one of these. The energy of the other of these is equal to negative the (\*)** ionization energy. Electrons from one of these on a diene flow into the corresponding one on the dienophile in the Diels-Alder reaction. Fukui recognized that interactions between these entities explained the Woodward-Hoffman rules for pericyclic reactions. For 10 points, give this term for the pair of HOMO and LUMO.
ANSWER: **frontier orbitals** [anti-prompt on "HOMO" or "LUMO"]

8. **Orr-Gillespie theory utilizes the Gumbel distribution to estimate this quantity. Kobayashi and Sughiyama recently developed fluctuation relations for this quantity using a path integral approach where this quantity is treated as a kind of entropy. The covariance of this quantity with $z$ appears in the Price equation, and Fisher's fundamental theorem states that the rate of increase in this quantity is proportional to population variance. (\*)** Wright's model of this quantity states that it tends towards a maxima on its namesake landscape. W.D. Hamilton introduced the inclusive type of this quantity, which accounts for dependence upon others and is often used in kin selection. This quantity generally decreases due to inbreeding and mules have a value of zero for it. For 10 points, name quantity that measures how capable an organism is of passing on its genes.
ANSWER: **fitness**

9. **A recent theory of this phenomenon considers a second-order transition to a Dicke superradiance phase. One value used in studying this phenomenon is the Blake threshold. The Keller-Miksis formulation accounts for the oscillations that occur during this phenomenon, and Flynn's formulation is used to study the conduction of heat that occurs during it. Models of this phenomenon include the imploding shock wave and Bremsstrahlung models. The (\*)** Rayleigh-Plesset equation is often used when studying this cavitation-related phenomenon, which may be explained by the argon rectification hypothesis. For 10 points, name this phenomenon in which a bubble collapses in on itself and some sound is turned into light.
ANSWER: **sonoluminescence** [prompt on "cavitation"]

10. **An effective viscosity term is added to this statement in its Brinkman form. At very high velocities, this law can be corrected using the Forchheimer term to account for inertial effects. This law can be stated as negative permeability times cross sectional area times the drop in pressure divided by viscosity and length is equal to the total discharge. This law is valid in (\*)** fine grained soil since the relevant flow is approximately laminar. For 10 points, name this law that describes the flow of groundwater, which is often applied to aquifers.
ANSWER: **Darcy**'s law

11. **Rainer Verch showed that this statement holds in curved spacetimes defined by a single field obeying the Wightman axioms. The Klein transformation makes a slight correction to this statement by re-defining fields. Faddeev-Popov ghosts are seen as physically meaningless due to their violation of this statement. Richard Feynman criticized the complex proof of this theorem put forth by (*)** Pauli. This theorem states that the wave function changes sign when half-integer-spin particles are interchanged, but stays the same when integer-spin particles are interchanged. For 10 points, name this theorem from QFT , which establishes that bosons have integer-spin and fermions have half-integer-spin.
ANSWER: __spin-statistics__ theorem

12. **The Kaposi's sarcoma-associated herpesvirus encodes two proteins that can induce clathrin-dependent endocytosis of this complex. The HIV protein Nef mediates internalization of this protein via ADP-ribosylation factor 6. Peptides that fail to bind to this complex are removed from the endoplasmic reticulum by sec61. (*)** TAP moves proteolysed ribosomal translation products from the cytoplasm to the ER, where Erp57 helps load them onto this protein. Natural killer cells attack cells which express low levels of this protein, and it presents intracellular peptides to CD8 on cytotoxic T cells. For 10 points, give this surface protein that distinguishes between self and nonself cells.
ANSWER: __MHC__ Class __I__ [prompt on "major histocompatibility complex" or other partial answers; do not accept "MHC Class II"]

13. **Non-symmorphic space groups result from applying the screw and glide operations to this set of structures. Wigner and Seitz name a region in these structures that, in two dimensions, equals the cross product of the primitive vectors. A honeycomb is notably not a part of this set, although it may be considered one with a two-atom basis. Specific planes in them are denoted by (*)** Miller indices. In 3 dimensions there are 14 total of these arrangements, including body-centered and face-centered ones. For 10 points, give this set of lattices, named for a Frenchman, that look the same when viewed from any lattice point.
ANSWER: __Bravais__ lattices

14. **The original formulation of this algorithm used Hadamard gates, exponentiation by squaring, and a Fourier transform on steroids. Unlike the most common scheme, the McEliece system is immune to attacks from this algorithm, which runs in polynomial time and works on a problem that is in complexity class (*)** BQP. This algorithm would theoretically render RSA encryption useless. In 2001, IBM worked with seven qubits to implement this algorithm on the number 15. For 10 points, name this algorithm introduced by its namesake in 1994 for integer factorization on quantum computers.
ANSWER: __Shor__'s algorithm

15. **In Reissner-Nordstrom geometry, a form of this quantity is equal to the negative of the square root of two times the interior mass divided by radius. An extension of this quantity is equal to the hyperbolic arctangent of this quantity divided by the maximum value possible for this quantity. That extension of this quantity is (*)** additive unlike the form of this quantity defined as the vector tangent to the world line of a particle. This quantity is divided by c squared in the definition of the Lorentz factor. The four dimensional variety of this quantity times mass is equal to the four-momentum. For 10 points, name this quantity that can't exceed the value symbolized by c, and is equal to the time derivative of position.
ANSWER: __velocity__ [accept four-__velocity__, accept rapidity until "unlike"]

16. **Terence Tao has shown that if a locally compact group has a Gleason metric, then it is isomorphic to a structure named for this mathematician. The Hilbert-Smith conjecture would also provide sufficient conditions for a group to be isomorphic to structures named for this mathematician. Hilbert's fifth problem concerns the topological description of structures named for this mathematician. By Cartan's theorem, if G is an example of a structure named for this mathematician, then any topologically closed subgroup of G is also an example of those structures named for him. Two by two real invertible matrices form a four-dimensional example of a type of group named for this guy. For 10 points, name this mathematician who names a type of group that is also a (\*)** differentiable manifold.
ANSWER: Sophus **Lie**

17. **Taro Kihara extended this equation to account for non-spherical situations, and a point dipole moment is added to this equation in the Stockmayer modification. The minimum on a graph of this equation occurs at about 1.122 times the value at which it crosses the x-axis. This equation is often truncated at a separation distance of 2.5 times the distance at which the potential is zero. In its most common form, this equation has a coefficient of (\*)** four times well depth, which is the dip that can be seen when plotting this equation on a separation distance versus potential energy graph. For 10 points, name this potential that has a sixth power attractive term and twelfth power repulsive term.
ANSWER: **Lennard-Jones** potential [accept **L-J** potential, accept "**6-12**" or "**12-6**" potential until "sixth"]

18. **A theory of one process these stars go through claims that it is due to the quantum vacuum friction of surface fields. Freytsis and Gralla derived quantum force-free electrodynamic equations for the plasma surrounding these stars. It is difficult to determine whether standard or fast neutrino cooling processes take place in these stars, and 1E 2259+586 is an important one of them. A 2013 paper that appeared in *Nature* by Kaspi *et al.* reported the detection of one of these stars unexpectedly slowing down, referred to as an (\*)** "anti-glitch." Robert Duncan and Christopher Thompson proposed the existence of these stars, which have the strongest observed starquakes and dynamo effects. Soft gamma repeaters and anomalous X-ray pulsars are thought to be these stars. For 10 points, name these neutron stars that have a very strong namesake field.
ANSWER: **Magnetar**s [prompt on "neutron star" and "pulsars" until mentioned, prompt on "soft gamma repeater" until mentioned]

19. **In Arabidopsis, this chemical induces the dehydration-responsive gene rd22, whose transcription is promoted by AtMYC2 and AtMYB2. Molybdenum cofactor enzymes control accumulation of this hormone, which - at high enough concentrations - will induce the expression of rab genes that adapt cells to osmotic (\*)** stress. Biosynthesis of this plant hormone via the MEP pathway begins with the cleavage of the C40 carotenoid zeanthanin to form xanthoxin, which is further oxidized to its namesake aldehyde. Named for its role in causing leaves to fall, for 10 points, give this plant hormone that promotes seed dormancy and stomatal closure.
ANSWER: **abscisic acid** [accept **ABA** or **abscisin**; accept **dormin** even though it's not called that anymore]

20. **The Ginzburg-Shiller approximation can be used when studying the coupling of these particles to photons. Dougall and Wick found a mass limit of greater than 370 GeV for these particles based on calculations of their production from photon fusion during proton collisions. One equation describing these particles states that F equals the hodge star of the covariant derivative of the Higgs field; that equation is the Bogomolny equation. A smooth solution representing these particles is a topological soliton with finite energy, and is named for (\*)** 't Hooft and Polyakov. The first solution to the Yang-Mills field equation was one of these particles now named for Wu and Yang. Their namesake problem was resolved by inflation since it predicts them to be far less abundant in the early Universe than previously believed. These particles, which have never been detected, were proposed by Dirac, but their existence would violate Gauss's law of magnetism. For 10 points, name these hypothetical particles that only have a North or South pole.
ANSWER: magnetic **monopole**s

21. **This mathematician's namesake configuration consists of two mutually inscribed tetrahedrons. His namesake surface is the fibre bundle over the one sphere. This mathematician's inversion formula makes use of his namesake function that returns zero if the input has a squared prime factor. His namesake (\*)** transformation of the complex plane is given by the function $az$ plus $b$ divided by $cz$ plus $d$, where $a$, $b$, $c$, and $d$ are all complex numbers. His namesake surface can be formed by cutting a Klein bottle in half and has an Euler characteristic of zero. For 10 points, name this mathematician who names a nonorientable, one-sided surface.
ANSWER: August **Möbius**