

1. These molecules are synthesized in a reaction catalyzed by DMAP in which an acid anhydride intermediate reacts with an alcohol to form it and a urea compound. It's not a carboxylic acid, but the Favorskii rearrangement in the presence of an alkoxide anion yields these compounds. Compounds with two instances of this functional group and two compounds each containing this functional group are transformed into their another variety of them in the (*) Dieckmann and Claisen condensations respectively. One of these compounds reacts with a Lewis acid to form a ketone in the Fries rearrangement. Reacting an alcohol with a carboxylic acid produces these compounds in the Fischer synthesis. For 10 points, name these fruity-scented compounds with general formula RCOOR' .

ANSWER: esters

2. A 2014 paper in *Nature* by Küppers *et al.* reported the detection of about 6 kilograms per second of water vapor being released from this body's surface. One theory of its origin states that it actually formed beyond the snowline before migrating into its current location. A probe studying this body was recently able to determine that the high (*) albedo feature in one of its craters is actually two different bright spots. Giuseppe Piazzi first observed this body in 1801, incorrectly believing it to be a comet. This body is currently being orbited by the Dawn spacecraft, which also spent about a year studying Vesta. For 10 points, name this dwarf planet, which is the largest member of the asteroid belt.

ANSWER: Ceres

3. Stephen Haggerty recently noted that *Pandanus candelabrum* appears to require the presence of this mineral in its surrounding soil in order to grow. Round examples of these minerals are often covered with nyf, and the coupling of photons to the (*) nitrogen-vacancy center of these minerals has many optical applications. Chromium diopside is an indicator of the presence of the primary source of these minerals, which are called Kimberlite pipes. It's very difficult to form this mineral out of graphite, despite them both being allotropes of carbon. For 10 points, name this mineral that has a value of 10 on the Mohs hardness scale.

ANSWER: diamonds

4. BCX4430 - a synthetic analogue of this compound - protects against Ebola virus by acting as a non-obligate RNA chain terminator. This compound lengthens the anagen hair-growth phase by increasing cysteine levels via FGF 2 and 7. This compound can cause lightheadedness and heart block since it inhibits (*) adenylyl cyclase and reduces cAMP when bound to its namesake A1 receptor. By antagonizing that receptor for this molecule, caffeine causes alertness. For 10 points, adenine is attached to a ribose sugar to form what compound, a nucleoside that is bound to three phosphates in ATP?

ANSWER: adenosine [do not accept or prompt on "adenine"]

5. The 'thousand pores' that characterize one order in this class can be divided into gastropores for eating, ampullae, and dactylopores with small, venomous hairs. A pelagic organism of this class contains a central, gas-filled, chitinous disc to keep it afloat. In addition to (*) condrophores, members of the siphonophore order of this class may or may not be single organisms, as they are colonies of functionally specialized zooids. For 10 points, name this class of Cnidaria, that isn't cubozoa or anthozoa, which includes the Portuguese man o' war, as well as hydra.

ANSWER: hydrozoa

6. If these materials exhibit time reversal symmetry, then there exists some exponentially localized Wannier function describing them. For small t over U and zero temperature the Bose-Hubbard model acts as one of these materials. When a material acts as one of these things in its interior but not on its exterior, it is deemed (*) "topological." A variety of these materials with strong electron-electron interactions that, according to band theory, should not be one of these materials are named for Neville Mott. These materials have a characteristic breakdown voltage and a large band gap. For 10 points, name these materials that don't let current flow through them.

ANSWER: insulators [accept Mott insulators or topological insulators]

7. **Buchdahl's interior solution sets 12 times the square root of the product of this quantity and a constant all subtracted by 5 times this quantity equal to a different quantity. The TOV equation is a differential equation for this quantity with respect to radius. In the relativistic regime this quantity is equal to a constant multiplied by density to the four thirds power. Three out of the four components on the main diagonal of the (*) stress-energy tensor represent this quantity. The equation of state for a cold electron gas gives this quantity as approximately one third of density. This quantity counteracts gravity in hydrostatic equilibria, and white dwarves are maintained by the electron degeneracy type of it. For 10 points, name this quantity equal to nRT divided by V for an ideal gas and force per unit area in general.**

ANSWER: pressure

8. **The energy of these systems is given by negative one-half times the summation of the product of two different states and their connecting weight matrix; that formula was developed by Hopfield. If these models have a hidden layer, then a method involving the calculation of the gradients of loss functions is used to correct weighting in these models. That method is referred to as backpropagation. Frank Rosenblatt invented one of the first examples of these models consisting of input, intermediate, and output layers, for which weights are immediately updated as the model runs. That example of these models is referred to as a (*) single-layer perceptron. These models calculate a weighted sum of inputs and return a value of one if the sum surpasses a specified threshold. The inputs of these machine learning models can be thought of as dendrites and the outputs as axons. For 10 points, name these algorithms that use data to try to "learn" and make predictions similar to how the human brain functions.**

ANSWER: artificial neural networks [accept ANNs, prompt on single-layer or multilayer "perceptrons" until mentioned, prompt on "machine learning" models or algorithms]

9. **In one commercial this man claimed "For millions of years mankind lived just like the animals. Then something happened which unleashed the power of our imagination: we learned to talk". That commercial was sampled in a 1994 song by Pink Floyd called "Keep Talking." Remy Buxaplenty hires this ex-roommate of Mr. Crocker to prove that (*) $2+2=5$. This self proclaimed "Snoop Dogg of science" informs Adolf Hitler that he is standing over the Rancor Pit. The star of "White and Nerdy" claims to have this guy in his library. A 2004 film depicting this dude's college days starred Benedict Cumberbatch, and he was recently portrayed by Eddie Redmayne in *The Theory of Everything*. For 10 points, name this physicist who wrote *A Brief History of Time*.**

ANSWER: Stephen Hawking

10. **The formation of beta cyclodextrin inclusion complexes is one method to separate these types of compounds in drugs. In a study by Papke, Sandburg and Shytle, one of these for mecamlamine was found to have greater affinity for neuronal nicotinic acetylcholine receptors. The optical (*) purity, or ee, of a sample of them can be determined by the specific rotation caused by their presence divided by the specific rotation of a pure sample times 100. The maximum number of these for a molecule is 2 to the number of chirality centers. R/S notation and the Cahn-Ingold-Prelog rules are used to name these compounds. Subdivided into diastereomers and enantiomers, for 10 points, name these types of isomers that have different 3D orientations.**

ANSWER: stereoisomers [accept enantiomers and diastereomers until mention; prompt "isomers"]

11. **Vibronic coupling effects during this process are accounted for by the PKS theory of it, and Joshua Jortner extended the main theory of this process to account for quantum effects. Henry Taube was awarded the 1983 Nobel prize for discovering the mechanism of one type of this process, and he also names a complex with (*) Creutz that can be used to explain it. One theory of this process states that the probability of its occurrence during a transition state is inversely proportional to the distance between the donor and the acceptor. That theory's formulation in 1956 was only for the outer sphere type of this process. For 10 points, name this process described by Marcus theory in which a negatively charged particle moves from one species to another.**

ANSWER: electron transfer [prompt on "redox" reactions, "oxidation," or "reduction", also prompt on things like "electrons moving" since this has a common name]

12. **Laurentis *et al.* proposed the emergence of a gravitational form of this phenomenon from ghost modes in alternate theories of gravity. The total amount of energy per unit length due to this phenomenon can be found by integrating an expression over frequencies that correspond to a sufficiently high velocity. The Askaryan effect can produce this phenomenon, and a unique form of it in periodic materials is called the (*) Smith-Purcell effect. The spectrum produced by this phenomenon can be calculated using the Frank-Tamm formula, and it can be observed around nuclear reactors. For 10 points, name this phenomenon in which charged particles travel faster than the speed of light in a medium, emitting a characteristic blue glow.**

ANSWER: Cherenkov radiation [accept Cherenkov effect]

13. **Shen and Vial showed that this object admits a self-dual multiplicative Chow–Kunneth decomposition. A second countable T4 space is homeomorphic to a subspace of this object. Any separable and metrizable T1 space is homeomorphic to this object according to Urysohn’s metrization theorem. This object is homeomorphic to the metric space formed by the set of sequences a_{-n} such that 0 is less than or equal to a_{-n} which is less than or equal to $1/n$. This object is the Cartesian product of a countably infinite number of copies of the closed interval from 0 to 1 . For 10 points, name this object named for a (*) German mathematician who put forth 23 unsolved problems.**

ANSWER: Hilbert cube

14. **The autoimmune condition Pemphigus occurs when the body attacks these structures, which act as anchors for intermediate filaments. Another type of these structures forms when a segment of ER crosses the phragmoplast before cytokinesis. Transmembrane proteins called cadherins connect to catenin in one type of these structures, while ions less than 2 (*) nanometers in diameter are free to pass through a type of these made of the protein connexins. The blood-brain barrier is maintained by a type of these structures that have high electrical resistivity. For 10 points, give these structures, which come in “tight” and “gap” varieties, that allow for cell-to-cell communication.**

ANSWER: cell junctions [accept specific types such as gap junctions, tight junctions, adherens junctions; accept desmosomes in first sentence, anti-prompt after; anti-prompt “plasmodesmata”]

15. **The Gaspard-Rice scattering system and the kicked rotator both have this property. The “Double Scroll” is used to model Chua’s circuit, which exhibits this property. Farey maps can be used to show that a solution of Einstein’s equations, found by Charles Misner and called the Mixmaster Universe, has this property. Devaney’s definition of this property includes topological transitivity and dense (*) periodic points. A system exhibiting this property has a positive Lyapunov exponent. Logistic maps can be used to study systems with this property that are undergoing period doubling. Both water wheels with leaky paper cups attached to them and double pendulums exhibit this property. For 10 points, name this property of systems that are sensitive to initial conditions, exemplified by the butterfly effect.**

ANSWER: chaotic [accept chaos]

16. **This phenomenon may be explained as the propagation of a forced Kelvin wave excited by the envelope of a Yanai wave-group. One mechanism proposed to explain this phenomenon is wind induced surface heat exchange. While not ENSO, this phenomenon can often lead to Pineapple Express systems. This phenomenon builds up over the Indian ocean and then travels easterly across the tropics at about four to eight meters per second. Around July, this phenomenon moves out over the Pacific leading to a break in the Asian (*) monsoon season. For 10 points, name this doubly eponymous oscillation in the atmosphere, which is sometimes called the 30-60 day oscillation.**

ANSWER: Madden-Julian oscillation [prompt on “30-60 day” oscillation until mentioned]

17. A concept utilized in the proof of this theorem is defined by an equation which states that the partial derivative of the metric tensor with respect to time is equal to negative 2 times R_{ij} . This statement was proved by proving a more generalized conjecture, which states that certain manifolds can be cut into pieces that can be classified as one of eight possible geometries. The proof of this statement followed as a corollary of the proof of (*) Thurston's geometrization conjecture, which was done using surgery methods on Ricci flows. This statement says that every simply connected closed three-manifold is homeomorphic to the three-sphere. For 10 points, name this conjecture included in the Millennium Prize Problems, which became a theorem following Grigori Perelman's proof of it.

ANSWER: Poincaré conjecture [accept Poincaré theorem, accept "Thurston's geometrization conjecture" until mentioned]

18. Tygacil is a new drug in this class with an additional dimethyl-glycyl-amido side chain. Acetylation of this molecule inactivates it, although a more common mechanism of resistance, termed "efflux", is found on the artificial plasmid pBR322. Tet(O), Tet(M) and OtrA are part of a class of ribosomal protection proteins that either dislodge this molecule from the A-site or induce a conformational change that allows translation to go on even in its presence. This class of drugs is used to treat (*) anthrax, bubonic plague, typhus, syphilis, chlamydia, and severe acne. For 10 points, give this class of antibiotics which bind to the 30S ribosome unit in order to inhibit protein synthesis and named for their 4 connected benzene rings.

ANSWER: tetracyclines [accept anything implying cycline drugs/antibiotics; generously prompt on "antibiotics"; anti-prompt "glycylcycline" in the first line]

19. The time evolution of a function named for this scientist is given as the negative Moyal bracket of that function and the Hamiltonian. A mapping named for him is proportional to the integral with respect to y of the density matrix times the exponential function of negative $2iy$ times momentum over \hbar . His namesake transform projects an operator onto a fortuitous choice of phase space point functions, and its inverse is the Weyl transform. A formal expression for the conservation of angular momentum is given by the theorem this scientist names with Eckart. A solid phase of electrons is known as his namesake crystal, and (*) Xenon-135 poisoning in nuclear reactors is sometimes named for him. For 10 points, name this author of *The Unreasonable Effectiveness of Mathematics in the Natural Sciences* who formulated an extension of Schrodinger's Cat known as his namesake "friend."

ANSWER: Eugene Wigner

20. This compound undergoes a cycloaddition with an alkyne and an alkene in the Pauson-Khand reaction. Hydrochloric acid, a Friedel-Crafts catalyst, and this compound are used to convert benzene derivatives into aromatic aldehydes in the Gattermann-Koch reaction. This compound is combined with hydrogen in the Fischer-Tropsch process, and this compound reacts with (*) impure nickel in the second step of the Mond process. This compound reacts with water vapor in the water-gas shift reaction. This compound has a much higher binding affinity for hemoglobin than oxygen and is produced in incomplete combustion. For 10 points, name this poisonous gas that consists of a carbon atom triple bonded to an oxygen atom.

ANSWER: carbon monoxide [accept CO]

21. One equation that governs this process can be stated as "particle mass times x double dot equals negative gamma times x dot plus a noise term". This process's mean square displacement is proportional to (*) diffusivity times the square root of elapsed time. A thought experiment that seeks to extract work from this process fails because the entire device is at a uniform temperature. For 10 points, give this process – the subject of an Annus Mirabilis paper and Feynman's ratchet – defined as the random motion of particles suspended in a fluid.

ANSWER: Brownian motion