1. **A form of this phenomenon used to investigate the interstellar medium in radio astronomy equals its namesake measure times the square of wavelength, where this phenomenon's namesake measure depends on the integral of a component of the interstellar magnetic field. The von Ziepel theorem gives a measure of flux during one kind of this phenomenon. Evidence cited by Harlow Shapley for his estimation of the size of the universe included observations of this phenomenon taken by (*)** Adriaan van Maanen that turned out to be flawed. Quasars are powered by energy generated from this phenomenon in the Blandford–Znajek ("znah-yeck") process. A plot named for this phenomenon shows a curve that surprisingly remains flat instead of falling off as the square root of distance. Calculations regarding rates of this phenomenon by Vera Rubin led to the theory of dark matter. For 10 points, name this type of movement commonly shown for galaxies in a namesake curve.
ANSWER: **rotation** [prompt on more general answers like "**movement**" or "**motion**"; accept **galaxy rotation**, **black hole rotation**, or **stellar rotation**]

Commented [1]: Prompt accretion?

2. **A man who more notably worked in this field also discovered an astronomical effect in which pendulums purportedly experience anomalous precession during solar eclipses. The result of a statistical test named for another man better known for his work in this discipline is normalized via Kendall's W, and is the complete-block simplification of the Durbin test. Another man best known for his work in this discipline is the namesake of a theorem stating that the energy of the (*)** HOMO equals the negative of a molecule's first ionization energy. A mathematician who nonetheless won a Nobel for his work in this field proved that all Riemannian manifolds can be embedded isometrically in some Euclidean space. For 10 points, identify this discipline whose Nobel Prize winners include the namesakes of the Allais effect, Koopmans' theorem, the Friedman test, and the Nash embedding theorem.
ANSWER: **economic**s [begrudgingly accept **game** theory after "Riemannian manifolds"]

3. **A model for these enzymes' mechanisms was made by Chatt and added to by Hidai. The room-temperature catalytic Schrock–Yandulov cycle mimics these enzymes' activity. The Thorneley–Lowe model describes the eight states of one protein in this two-protein enzyme complex. One component of these enzymes has a catalytic site where two iron-sulfur clusters are bridged by a hexacoordinated sulfur, called a (*)** P-cluster. Their activity is quantified by an assay that reduces acetylene to ethylene gas, evolving hydrogen. The main function of anaerobic heterocysts in filamentous cyanobacteria involves these enzymes' activity. These enzymes most often act with a homocitrate-iron-molybdenum cofactor, and are made by the NiF regulon in prokaryotic diazotrophs. For 10 points, name these enzymes that uniquely reduce their namesake molecule to ammonia.
ANSWER: **nitrogenase**s

4. **Rearrangement effects that influence this process are modeled in an equation that sets a certain difference proportional to the square of the difference in the new and original dipole moments, all divided by *a* cubed. That equation is the Lippert equation. It has nothing to do with NMR, but depolarization resulting from this process may be described in terms of a quantity that is proportional to [3 cosine-squared gamma] minus 1, where gamma is the angle between two dipoles; that quantity is this type of (*)** anisotropy. Decreases in this process's intensity can be displayed on Stern–Volmer plots. Tryptophan residues are used to study protein dynamics in this type of spectroscopy. In 2009, Huang et al. discovered this type of super-resolution microscopy. For 10 points, name this property exhibited by molecules like ethidium bromide that re-emit redshifted light that they previously absorbed.
ANSWER: **fluorescence**

5. **A way to detect these SPECIFIC objects takes them to a grid diagram, uses it to construct a graph, eliminates zig-zags, then divides the number of remaining vertices by a power of 2, and checks if the result is 1. That method, whose validity was proved by Ozsvath and Szabo, checks if an object is equivalent to one of these specific objects by verifying that the Floer homology implies a genus of zero. Birman and Hirsch gave a solution to a problem named for them using Bennington's braid foliation theory. Hass and Lagarias developed an earlier algorithm for solving that problem named for these specific structures, giving an exponential upper bound on the number of Reidemeister moves required. These structures are ambient isotopes to the circle, and the are the only known objects with a (*)** Jones polynomial of 1. For 10 points, identify these closed loops, which as their name suggests, do not contain figure-eights, trefoils, or any other prime knots.
ANSWER: **unknot**s, because fuck you [or **trivial knot**s; prompt on "**knots**"; prompt on "**circles**"]

Commented [2]: Accept torus?

6. **Consideration of the phase in this phenomenon is simplified by noticing that at regions much farther away from the central objects as their separation distance, the circulation cancels out. In Josephson junctions, this phenomenon causes a sudden jump from linear dependence of voltage on current to cubic. As one approaches the temperature at which this phenomenon occurs, the correlation length unusually diverges proportional to the exponential of one over the square root of the temperature difference. The critical temperature at which this phenomenon occurs is kappa over twice Boltzmann's constant, as that is the point at which (*)** vortices begin to have negative Helmholtz free energy. This phenomenon is sometimes co-named with Berezinsky, and sees a vortex unbind from an anti-vortex. For 10 points, identify this doubly-eponymous phase transition, which is typically considered in the two-dimensional XY model.
ANSWER: Berezinsky–**Kosterlitz–Thouless** transition [or **KT** transition]

7. **Mathematical models of this phenomenon include Lagrangian trajectory models like CRIEPI and CALPUFF, and Eulerian models such as STEM and RADM. Areas with ANC values of greater than 50 microequivalents per liter are less sensitive to this phenomenon. This phenomenon causes the leaching of calcium from red spruce needles and deficiencies of certain cations in sugar maples in Pennsylvania. Perhaps the most important result of research in the (*)** Hubbard Brook Experimental Forest was the study of the effects of this phenomenon. The most familiar form of this phenomenon is a type of wet deposition, as opposed to dry deposition and cloud or fog deposition. Primary anthropogenic causes are emissions of nitrogen oxides and sulfur dioxide. For 10 points, name this form of precipitation with an unusually low pH.
ANSWER: **acid rain** [accept **acid deposition**, or anything indicating **precipitation** that's **acid**ic]

8. **A hydroxylated version of this compound is the product when this compound is reacted with potassium persulfate in the Boyland–Sims oxidation. Glycerol and sulfuric acid can be used to convert this compound to a quinolone in the Skraup reaction. In the presence of a base, this compound reacts with an aromatic nitro compound to produce a phenazine in the Wohl–Aue reaction. The (*)** Hammett acidity function was derived by using a series of this compound's derivatives. Iron and hydrochloric acid are used in the Bechamp reduction to produce this compound. Addition of nitrous acid to this compound produces diazonium salts, which can be converted to aryl halides in the Sandmeyer reaction. Reducing nitrobenzene yields this compound. For 10 points, name this organic compound that is a benzene with an amine attached.
ANSWER: **aniline** [accept **phenylamine**, **benzenamine**, **benzamine**, or **aminobenzene**]

9. **Cryptic diversity in one species complex in this order, *Astraptes fulgerator*, was demonstrated in one of the first applications of DNA barcoding to species delimitation. Some idiot named Étienne Léopold Trouvelot introduced a major hardwood pest in this order to America. Ilkka Hanski has used a metapopulation of one species in this order on Fasta Åland in his studies on the eco-evolutionary dynamics of metapopulations. Ehrlich and Raven developed the "escape and radiate" model of coevolution using case studies involving plants and members of this order. Some members of this order, including the (*)** cabbage white, use glucosinolates as cues for egg-laying. Bernard Kettlewell proposed that coatings of soot onto trees during the Industrial Revolution caused selective pressure for melanism among a "peppered" species in this order. A group of these organisms that lay their eggs exclusively on milkweeds includes the monarch. For 10 points, name this insect order that includes the skippers, moths, and butterflies.
ANSWER: **Lepidoptera** [or **moth**s and **butterflies** with both parts required; anti-prompt on just **moth**s or just **butterflies**]

10. **The characteristic property of one form of these devices was derived by Strukov et al. to be *R*-off times the quantity 1 minus ion mobility times *R*-on times *q* over *D*-squared. These devices can be represented by a two-part pipe with a hollow piston. A simple model of them is a combination of two resistances, often called *R*-on and *R*-off. These devices are characterized by the shape of their phi-*q* curve, which plots the magnetic flux versus charge and represents the nature of their (*)** "passivity property." The *I*–*V* curve of these devices features a characteristic pinched hysteresis loop. Pinched Stanley Williams' on these devices HP Labs uses a thin film of titanium dioxide. Leon Chua theorized these devices, calling them the "fourth fundamental circuit elements." For 10 points, identify these circuit components whose resistance changes based on the current they remember flowing through them previously.
ANSWER: **memristor**s

11. **In 2002, eggs were discovered harboring the organism that causes this condition, though similar eggs didn't reach US soil until six months later. Recent research on this condition has been done in the lab of Namba et al. Recovery from this condition is now typically denoted in shorthand on a patient's record with a red and yellow or purple and pink smiley with a horizontal mouth. Yanase Berlitz discovered some patients with this disease, and the first nurse to notice it claimed that it was caused by "tiny life-forms stuck to" the hosts. Those afflicted with this disease always pass it on to one of the at most five other creatures travelling with them. Sufferers of this condition gain twice (*)** as many effort values in battle as they would otherwise, and the curing of this disease can be slowed by placing those affected in a PC box. For 10 points, identify this virus that makes it easier to train creatures like Shedinja, Wooper, Zubat, or Pikachu.
ANSWER: **Pokérus** [2002 is the Japanese release date of *Pokémon Ruby and Sapphire,* the first games in which eggs could be infected]

12. **Replacing a binary-min heap with this structure allows one to do Huffman coding in big-O of *n* log log *n* time. As first developed in Harald Prokop's master thesis, the layout of these structures is mimicked in many cache-oblivious data structures. The desirable runtimes of these structures, the first structure to have them, are replicated by the second structure to have them, the y-fast trie. Finding the min or max in these structures takes constant time because they are stored as a separate data field. It takes big-O of log log *u* time, where *u* is the maximum (*)** number of elements these structures can hold, for insertions, deletions, lookups, successor, and predecessor. The "universe" of this structure is required to be a power of two because it divides the universe into square root of the universe-sized blocks that are also this type of structure. For 10 points, identify these recursive trees named for a Dutch computer scientist.
ANSWER: **van Emde Boas** trees [or **vEB** trees]

13. **If one chemist hadn't died in an accident involving one of these apparatuses, he might have shared Suzuki's Nobel for his discovery of an analogous cross-coupling with organotin compounds. That man was John Kenneth Stille. Chalmers Gillman demanded extra money from the research team employing him if he could pull off one achievement using one of these apparatuses. C. O. Alley et al. verified the results of one experiment that unusually made use of these apparatuses. Early creators of these devices were convinced of their impossibility thanks to an inaccurate value of the Smeaton coefficient. An incredibly cheap test of (*)** relativity made use of atomic clocks and these experimental apparatuses, and was carried out by Hafele and Keating. Supersonic speeds were attained by the Bell X-1 example of these devices, and more regularly by the continent-hopping Concorde. For 10 points, identify these devices, whose mechanism of action is often erroneously described by Bernoulli's principle.
ANSWER: air**plane**s [accept equivalents]

14. **In cryo-TEM, grids of various metals are often used with a holey film made of this element to support the specimen. A plasma burner is used to generate hydrogen gas and a form of this element in the Kvaerner process. The "at" sign is used in the name of a type of molecule composed of this element that has high spin coherence times; that form of this element may revolutionize atomic clocks and is its endohedral variety. Allotropes of this element can be produced via the Huffman–Kratschmer method. (*)** Andre Geim and Konstantin Novoselov found an electric field in a thin-film allotrope of this element. For 10 points, name this element that makes up graphene.
ANSWER: **carbon** [accept **fullerene**s, **graphene**, or **carbon black** in case someone misses the pronoun]

15. **This man posited that the iron abundance in the interior of stars was due to a neutron-to-proton ratio that eventually was shown to be too high, thus making this man's "e-process" irrelevant. With his student and frequent collaborator Chandra Wickramasinghe, this man developed the theory of Panspermia. Barbara Gamow wrote a hilarious poem about arguments that this scientist had with Martin Ryle regarding quasar distribution in the universe. Along with (*)** William Alfred Fowler, and Geoffrey and Margaret Burbidge, this man published a paper developing the theory of stellar nucleosynthesis, for which Fowler but not this man would win the 1983 Nobel Prize. The discovery of the CMBR essentially ended the case for the steady-state theory that this man had heavily advocated for. For 10 points, name this man who is credited for coming up with the name of the Big Bang theory.
ANSWER: Sir Fred **Hoyle**

16. **An intermediate in the biosynthesis of these compounds affects the interaction of the transcription factors Bas1 and Bas2, which also regulate histidine biosynthesis. One class of these compounds can be synthesized with the enzyme APRT, whose deficiency results in "orange sand," or insoluble DHA in urine. In the biosynthesis of these compounds, their final ring atom is added in a formylation reaction catalyzed by AICAR transformylase. The committed step in that pathway is the [de-pyrophosphorylation of PRPP to make PRA]. A (*)** salvage pathway depends on the enzyme HGPRT, whose deficiency causes Lesch–Nyhan syndrome. In their biosynthesis, a derivative of hypoxanthine named inosine monophosphate is produced. For 10 points, name these bases with cores of fused six- and five-membered rings, like guanine and adenine.
ANSWER: **purine**s

17. **For a set *X*, a set named for having this property can be created by considering the set of all continuous functions from *X* onto the unit interval, then taking that set's closure; that set with this property is typically denoted by placing the letter beta before *X*. One theorem about these sets is set in a topology which is coarser than the box topology, and Kelley proved that theorem to be equivalent to the axiom of choice. One theorem about this type of space may be proven using nested intervals, or by using the lemma that every (*)** sequence has a monotonic subsequence. Metric spaces have this property if and only if every sequence has a convergent subsequence that is its sequential type. The topological product of sets with this property has this property, according to Tychonoff's theorem. For 10 points, identify this property which, in Euclidean space, is equivalent to being closed and bounded by the Heine–Borel theorem.
ANSWER: **compact** sets [accept **compact**ification]

18. **George Whitesides pioneered the use of microcontact printing using PDMS stamps for the spatial patterning of these structures. These structures are often employed to prevent adhesion in MEMS systems. Transitions from "lying down" to denser "standing up" configurations are often observed as the dose of these structures' constituents is increased. Van der Waals interactions between "tails" and covalent bond formation are the thermodynamic driving forces for the formation of these structures, whose preparation does not require the use of (*)** Langmuir–Blodgett troughs unlike similar structures formed at water-vapour interfaces. Organosilicon derivatives are used to prepare these structures on insulators, but thiols are used to form them on gold nanoparticle surfaces. Spontaneous chemisorption of head groups onto a substrate can form, for 10 points, what structures comprising a single ordered layer of molecules?
ANSWER: **self-assembled monolayers** [or **SAM**s; prompt on "**monolayers**"]

19. **Holstein's paper named for this theorem and the Berry phase shows that the existence of such a topological phase factor depends on the approximation of this name. This term describes computers which allegedly include D-Wave's "Orion" and which can solve optimization problems by using an analogue of simulated annealing. Northrop and Teller proved that the line integral of momentum component parallel to the magnetic field is a quantity described by this adjective. A theorem of this name says that a system in an eigenstate will state in the (*)** corresponding eigenstate if the Hamiltonian is varied slowly. Diatomic gases have a value of seven-fifths for an quantity described by this term, which is to *C*-p over *C*-v and is denoted gamma. For 10 points, what word describes isentropic processes in which no heat is transferred from the system?
ANSWER: **adiabatic** [accept **adiabatic** quantum computer, **adiabatic** process, **adiabatic** index, **adiabatic** invariant; prompt on words in the preceding answerline that aren't adiabatic]

Commented [3]: ?

Commented [4]: ?

Commented [5]: ?

20. **A domain of this protein binds to the basic-helix-loop-helix domains of MyoD, inducing expression of late muscle differentiation markers, and later arresting muscle cell division. Early mutations in this protein's gene lead to namesake "trilateral" tumours and/or primitive neuroectodermal tumours. Homologues of this protein are in the DREAM complex that represses genes during quiescence. This protein and two similar ones comprise the pocket protein family, and bind to the E2F family of transcription factors, thus arresting cell cycle growth in G1. The (*)** large T oncoprotein of SV40 binds and sequesters both this protein and p53. Alfred Knudson's "two-hit" hypothesis arose after he studied this protein's coding gene. For 10 points, name this tumor suppressor protein that shares its name with a cancer of the retina.
ANSWER: **retinoblastoma** protein [or p**RB** or **RB**1]

21. **A stringy approach to these materials uses K-theory of classifying spaces to label them as AII ("A-two") in *d* equals 3. Mercury telluride quantum wells were shown to exhibit the spin quantum hall states characteristic of these materials. Helical Dirac fermions in three-dimensional examples of these materials help to prevent backscattering. A type of them composed of densely packed tin atoms can display some superconductive properties at room temperature and is called stanene. These materials display characteristic strong spin-orbit coupling, which forces the spin of electrons to be perpendicular to their momentum. That phenomenon is (*)** spin-momentum locking. Their surfaces states are protected by time-reversal symmetry. These materials, which do not display "mottism," have their Fermi level between the conduction and valence bands. For 10 points, identify these insulators that conduct electricity on their surface but not on their interior.
ANSWER: **topological insulator**s [prompt on partial answer]

Commented [6]: ?

22. **NMR techniques developed for measuring this quantity use the Strange–Rahman–Smith equation to map melted signal amplitude at particular temperatures. A class of methods for determining this quantity depends on mercury injection into the sample, and the most famous of those is the Washbum–Bunting method. The pressure drop of a fluid flowing through a bed is directly proportional to the square of one minus this quantity, which is cubed in the denominator of the (*)** Kozeny–Carman equation. This quantity is much higher for materials which are well sorted. Fluid flow through materials possessing a high value for this quantity is studied in Darcy's law. This quantity equals the ratio of void volume to total volume. For 10 points, name this measure of how much open space is in a rock.
ANSWER: **porosity** [accept word forms]

23. **The diagonalization technique of "blowing holes" can be used to construct problems in this class. A dichotomy excluding the constraint satisfaction problem from this class was conjectured by Feder and Vardi. Because every problem in the statistical zero-knowledge proof class is reducible to the MCSP, SZK is likely a subset of this class. A collapse of the polynomial time hierarchy to the first level, meaning NP equals co-NP, is required if many problems are not in this class. Though not the class BQP, it's believed that most (*)** quantum algorithms that perform better than classical algorithms solve problems in this class. If this class is non-empty, then, by Ladner's theorem, P does not equal NP. László Babai's quasi-polynomial solution to the graph isomorphism problem likely places it in this class, which probably also contains integer factorization. For 10 points, name this hard class of problems that is not in NP-complete or in P.
ANSWER: **NP-int**ermediate [or **NPI**; do not accept wrong answers, including "NP"]

24. **One of these things was the site of Rom Mohc's research on a next generation of droids called Dark Troopers. An incomplete one of these objects contained databanks leading to the massive imperial vaults and was guarded by three Cardan V-class stations located above Kuat. That one of these objects was captured by Tyber Zann and equipped with a superlaser. Examples of these objects included the *Eclipse*. Arvel Cynryd's heroism led to the destruction of another of these objects called the (*)** *Executor*, when the failure of its bridge deflector shields allowed him to kill Admiral Piett with a kamikaze A-wing attack. For 10 points, identify these absurdly large ships, one of which crashed into the second Death Star during the Battle of Endor.
ANSWER: **Super Star Destroyer**s [prompt on partial answer; do not accept "Imperial Star Destroyers"; anti-anti-prompt on specific examples or classes of SSDs, such as Arc Hammer, Eclipse, or Executor]