1. *Note to moderator: read answerline instructions beforehand.*
Descriptive answer acceptable; the answer is the broadest possible.
The CAPRI experiment studied these phenomena. Structures exhibiting many of these phenomena can be "party hubs" or "date hubs" based on their local or global nature. These phenomena can be studied through the construction of fused Rosetta stone sequences. "Hot spots" and "hot regions" likewise differ in the scope of these phenomena, which can be obligatory or not, and permanent or transient. CYP-YFP and BiFC use fluorescence to highlight these phenomena. One method of studying them involves attaching (*) Cub and Nub fragments and is known as the split-ubiquitin system. One method for detecting them depends on the association of binding and activating domains of the transcription factor Gal4. That method involves the interaction of "bait" and "prey" domains, and is a yeast two-hybrid assay. These phenomena can be identified with far-western blotting. For 10 points, identify these phenomena that occur between two polypeptides.
ANSWER: **protein–protein** interaction [accept anything in place of "interaction" such as **binding** or **docking**; anti-prompt on anything involving **proteins** recognizing ligands or binding to things by saying "What are the two kinds of molecules involved?"]

2. **A galaxy with this name was home to a planet named Lantea, to which the Athosians relocated after being culled by the Wraith. An impressed crewmember on a ship of this name designed the obsolete DDG-62 engines used in the *Blackbird*. The commander of that *Mercury*-class ship with this name removed all the chairs from her cabin, forcing people to stand. An unexpectedly corpulent commander of that ship with this name defies his father's orders and jumps it to help with the evacuation of New Caprica, where it is destroyed. (*)** *Stargate Atlantis* takes place in a galaxy with this name. The discovery of an *Oberth*-class ship with this name revealed a violation of the Treaty of Algeron. It is the name of the ship commanded by Admiral Cain on *Battlestar Galactica*, as well as a Federation ship where a cloaking technology experiment went bad. For 10 points, identify this name of various science fiction objects that comes from a mythological winged horse.
ANSWER: **Pegasus** [accept the **Pegasus** Galaxy, Battlestar **Pegasus**, or USS **Pegasus**]

3. **The open source program Wanderer provides level 3 TCGA data in mapping this process. COBRA is a program that detects this process' completion after its DIP-chip method, which can be combined with CGH for higher efficacy. This process names a differential hybridization technique that uses BstU I and MseI enzymatic pretreatment. C6-amino linkers are used to connect targets to probes in Gitan's microarray of this process. Reader complexes have PHD finger domains that recognize this process. The NotI enzyme detects this process in (*)** restriction landmark genomic scanning. Dam-Dcm and DpnI and II are [THIS-sensitive restriction endonucleases] used in Southern blots to detect this process. In *E. coli*, MutH nicks GATC sequences without this functional group. It can be quantified by bisulfite sequencing. S-A-M is a donor of this type. Doing this to uracil's 5-carbon gives thymine. For 10 points, name this process of adding a CH3 group.
ANSWER: **methylati**on [accept **adding a methyl** group until read]

4. **One group of bacteria, which dominates the oxic-anoxic transition zone produces large quantities of greigite which has this property. Linearity, independence, and additivity are three laws of the process by which rocks acquire this property according to Thellier. The most notable mineral with this property is the dominant mineral in Algoma-type formations where it is associated with (*)** chert. Columbite, ilmenite, and pyrrhotite all exhibit this property. Gilbert and Matuyama name chrons delineated by measurements of this property in bands of rocks on the seafloor where reversals in its orientation are periodically observed. For 10 points, name this property of rocks and minerals such as hematite and lodestone which was used in some of the first compasses.
ANSWER: **magnetism** [accept all subtypes]

5. **Though it has nothing to do with investment banks, the "Too Big to Fail" problem concerns discrepancies between the masses of these things in simulation and observation. Groups in Cambridge and Fermilab simultaneously discovered 9 of these things in the Science Verification data from the Dark Energy Survey. Vasily Belokurov created an image showing objects that result from the disruption of globular clusters and these objects, known as the "Field of Streams." They are not black holes, but these objects have some of the highest observed (*)** mass-to-light ratios and lowest observed metallicities in the universe. Draco, Fornax, and Sculptor name prominent examples of the spheroidal variety of these objects. For 10 points, name these objects, such as the Large and Small Magellanic Clouds, which are less massive versions of similar spiral or elliptical objects.
ANSWER: **dwarf galaxies** [prompt on "**satellite galaxies**"; accept dark matter **halos** until "observation" is read]

6. **This man is the alphabetically second namesake of a model which allows molecular collisions to equilibrate momentum in front of shock waves on a shorter timescale than chemical reactions. He co-names that detonation model with Döring and Zeldovich. His other works in fluid dynamics led to numerical calculations of weak-shock Mach reflections that originally resulted in a triple point paradox. This physicist names an equation relating "*i* times *h*-bar times the time derivative of the (*)** density matrix" to the commutator of the Hamiltonian and the density matrix. In addition to inventing the density matrix, he names a value equal to the trace of the density matrix times the natural log of the density matrix, his namesake entropy. For 10 points name this polymath whose work in computer science includes inventing mergesort and a widely used computer architecture.
ANSWER: John **von Neumann**

7. **This work says that you can quote "the direct product of two irreducible representations of the rotation group into the direct sum of irreducible representations" to impress your friends. This book leaves "calculating the fine structure constant from first principles" as an exercise and remarks that if you solve this you have a sure Nobel prize, but that many smart people have tried and given up. An appendix in this book discusses foundational issues including the EPR paradox, Bell's theorem, and measurement. A discussion of the (*)** ladder operator method is accompanied by a cute picture of a cat climbing a ladder. This work introduces the infinite square well, harmonic oscillator, delta function, and free particle systems in chapter two, and then discusses the Hilbert space formalism in chapter three and the hydrogen atom in chapter four. For 10 points, name this book that introduces undergraduates to quantum mechanics, written by a Reed College professor who has also written a book on Electrodynamics and one on Particle Physics.
ANSWER: David **Griffiths**' book on **Quantum Mechanics** [it's called ***Introduction to Quantum Mechanics*** but accept anything about how it's **Griffiths**' **QM** book, and prompt if they give you part of that]

8. **They aren't classes, but René Thom proved that the Stiefel–Whitney ones of these objects classify smooth compact manifolds up to cobordism. In 1888, Richard Dedekind published a monograph asking what these objects are and what they should be. John Conway paired these objects with "games" in the title of a book in which he interpreted particular combinatorial games as one kind of these objects. A classic textbook by (*)** Hardy and Wright is titled *An Introduction to the Theory of* these things. Famous open problems in a branch of mathematics named for these objects include the Elliott–Halberstam conjecture, the Hardy–Littlewood conjecture, the abc conjecture, and the Riemann hypothesis. For 10 points, name these mathematical objects that include the ordinals and the cardinals.
ANSWER: **number**s [accept **Stiefel–Whitney number**s, **surreal number**s, **number theory**, **ordinal numbers**, or **cardinal numbers**]

9. **The PTOC-thiol method is used to calibrate these reactions. The rates of bimolecular examples of these reactions can be measured by simultaneously running a unimolecular reaction with a similar intermediate and a known rate, in the "clock" technique. These reactions' intermediates are stabilized by both an electron acceptor and donor in the captodative effect. Their substitutions can be divided into S_H1 and S_H2 classes. The (*)** Barton reaction, which produces an oxime, is among these reactions, which are often driven by forming nitrogen gas. At room temperature, tin hydride is often used to trap the intermediates of these reactions, which include the Bergman rearrangement. Fenton–Haber–Weiss reactions have metal cations acting as these reactions' "scavengers." For 10 points, name these reactions which often have "active oxygen" intermediates, and whose mechanisms are drawn with fishhook arrows showing single-electron transfers.
ANSWER: **radical** reactions [if they say **photolysis** or **photochemical** reaction or **light-catalyzed** reaction, prompt by saying "What kind of reaction mechanism?" or "What property do the intermediates share?"]

10. **A version of this equation that is important in optimal control theory was created by Richard Bellman. Applying a type-2 generating function to one of the namesakes' principal functions can be used to derive this equation. The optical analogue to this equation is the eikonal equation. When a central quantity to this equation is time independent, one can define an invariant torus using (*)** action-angle coordinates. Since this equation can be derived from the Schrödinger equation using a wavefunction proportional to "*e* to the *i* times the action over *h*-bar," it is considered to be the closest classical analog to quantum mechanics. For 10 points, name this doubly-eponymous equation that sets the time derivative of the action, plus a total energy operator, equal to zero.
ANSWER: **Hamilton–Jacobi** equation

11. **Friedrich von Hayek borrowed this man's conception of scientific inquiry as a "spontaneous order." This man wrote that a process that extracts tap water from champagne which might be an invention, but not technology since technology requires a resulting material advantage as one of its "Operational Principles." This man gave a set of Gifford Lectures which Kuhn may have plagiarized in *The Structure of Scientific Revolutions*, as evidenced by their first section, "The Lesson of the Copernican Revolution." This man built on work by Arnold Eucken in developing his (*)** adsorption potential theory. This man contrasts the "Domain of Sophistication" with an "ineffable domain" of prejudgments and traditions that form a crucial part of scientific practice. This man labels those habits "tacit knowledge." For 10 points, name this author of *Personal Knowledge*, the younger brother of Karl, who wrote *The Great Transformation*.
ANSWER: Michael **Polanyi**

12. **During the back-end-of-line step for these devices, metal connections are made with vias. Interconnections involving these devices are typically done with wire bonding. A textbook by Lynn Conway and Carver Mead revolutionized the teaching and creation of these devices. In addition to supporting the design of these things, most EDA software also supports using them within PCBs. Though they aren't the only thing it can simulate, the program (*)** SPICE is known for its emphasis on the analysis of these devices, especially their VLSI type. Many bitcoin miners use an "application-specific" type of these devices. These devices were independently invented by Jack Kilby and Robert Noyce. For 10 points, name these devices in which many circuit components are fabricated on a single chip.
ANSWER: monolithic **integrated circuit**s [or **IC**s; prompt on "microelectronic **circuit**," "**chip**," or "**microprocessor**"]

13. **The CIA machinery helps mature these proteins, which are protected from oxidative stress and are supplied one of their namesakes by the SUF system. Sprouty proteins of this type use their active sites like nanobatteries. Frataxin, which assists in these proteins' biosynthesis, is mutated in Friedreich's ataxia. Nitric oxide attacks their active sites to form DNICs. Forming a 5'-deoxyadenosyl radical is the function of radical SAM enzymes of this class of proteins. High redox potential proteins called (*)** HiPIPs belong to this class of proteins. One protein of this type isomerizes citrate to isocitrate in the Krebs cycle, and is named aconitase. They don't contain zinc, but a common cubane-like motif in them involves either four cysteines, or two cysteines and two histidines, coordinating their main catalytic structures. For 10 points, name this family of proteins that includes Rieske ("risky") proteins and ferredoxin, whose ISC catalytic centers are complexes of two elements.
ANSWER: **iron-sulfur** proteins [or **FeS** proteins]

14. **The most popular GUI framework for this language is TkInter. This language is by far the most popular language to use C3 linearization for method resolution order, which is necessary because it implements multiple inheritance. Generator expressions in this language are enclosed in parentheses. This language does not automatically pass references to instance or class objects, requiring one to use (*)** "self" when declaring a method. Packages for this language can be installed using pip or setuptools. This dynamically typed, interpreted language uses whitespace as a delimiter and is ubiquitous in science because of its namesake "Num" and "Sci" libraries. For 10 points, name this language developed by Guido van Rossum and named for John Cleese-led comedy troupe.
ANSWER: **Python**

15. **The product operator formalism is used to track the effects of these artificially produced events. The invention of these ended one type of spectroscopy that slowly scanned a range of frequencies, named the continuous wave technique. On a timing diagram, depending on their strength and shape, they are usually shown as thin, thick, or rounded thick bars. A technique called WATERGATE rapidly uses six of them to dampen water signals, while the WALTZ-16 program applies 48 of them to cause decoupling in the proton channel. NOESY ("nosy") is enhanced by adding these events to select a coherence. A sequence of these called (*)** INEPT occurs at the start and end of an HSQC. After these events are implemented, a [free induction decay signal] is recorded and Fourier-transformed to be interpreted in the frequency domain. Magnetization is transferred between nuclei with these actions in 2D-NMR experiments, and their length determines whether the strength will be 180 or 90 degrees. For 10 points, name these radiofrequency signals which rotate spins.
ANSWER: radiofrequency **pulse** sequences or programs [prompt on partial answer; prompt on "**nuclear magnetic resonance** (**NMR**) procedure or experiment"; prompt on answers describing "**rotating spins in NMR"** by asking "What is causing the rotations?"]

16. **Raising one of these objects to the *k*th power is bounded above by *k* factorial, according to Wirtinger's inequality. The maps which define the de Rham cohomology are between cochain complexes of these objects but on a contractible surface those groups are all trivial due to Poincaré's lemma. A symplectic manifold is equipped with one of these structures, which is closed, non-degenerate, and has degree two. In *k* dimensions, there is only one of these structures of degree *k*; that example of these is proportional to the (*)** volume. When these structures are degree one, they are in a manifold's cotangent bundle, and can be combined to form higher degree ones with the wedge product. All closed ones are exact on the plane and the generalized Stokes theorem is stated in terms of them. For 10 points, name these exterior forms on the tangent bundle of manifolds which vary smoothly with position.
ANSWER: **differential form**s [prompt on "**forms**" or "**exterior forms**" until read; accept **symplectic form**s]

17. **The space between these phenomena is called Alexander's band. The angle of minimum deviation, equal to 137.5 degrees, is called this phenomenon's namesake angle. Airy determined that propagation of a wavefront in these phenomena caused the formation of a caustic. Exotic duplicates of these phenomena called "twins" appear at an odd angle. Rene Descartes calculated an important angle at (*)** 59.39 degrees describing these phenomena. These phenomena are slightly larger on Titan due to the presence of methane. Positive and negative interference cause supernumeraries adjacent to this phenomenon. This phenomenon is weaker in fog because water droplets are less than 0.5 millimeters, and a second internal reflection causes secondary ones. For 10 points, identify this phenomenon usually caused by the diffraction of sunlight through water droplets, forming colored arcs.
ANSWER: multiple **rainbow**s [prompt on "**bows**"]

18. **The PMV model includes this quantity as a type of intensity. A postprandial increase in this quantity is called specific dynamic action. The UTD hypothesis proposes that this quantity depends on temperature via a Boltzmann–Arrhenius factor. Eight assumptions underlie one model of this quantity, which describes space-filling, hierarchical transport systems with fractal geometries. That West–Brown–Enquist model sets the flow through a lossless vascular system equal to this quantity. The (*)** cell size model evaluates the exponent theta that this quantity is raised to. Kleiber's law states that this quantity is proportional to the three-fourths power of size, and is now called the mouse-to-elephant curve. Q10 values refer to this quantity 10 degrees above or below body temperature. The Harris–Benedict equation uses height, age, and weight to evaluate this quantity. For 10 points, name this quantity whose basal value is abbreviated BMR in humans.
ANSWER: **metabolic rate** [or **rate** of **metabolism**; accept **BMR** before read; prompt on "**metabolism,**" "**metabolic** activity," "**energy use/expenditure,**" or equivalents]

19. **One amino acid with this side chain group can have peroxidatic, resolving, or regulatory types, and is found in peroxiredoxin active sites. Peptide folding requires QSOX, which "exchanges" this functional group for another. One protein topology technique uses reagents specific to this functional group, and is called (*)** SCAM. In a reaction catalyzed by a beta-ketoacyl enzyme, this functional group attacks a ketone, reducing a carbon chain's length by two carbons in the last step of beta-oxidation. Two of these functional groups are found in dihydrolipoamide, and, when two electrons are added, they bond to form lipoic acid. The "swinging arm" of coenzyme A ends in this functional group. "Super-reactive" amino acids with a selenated derivative of this functional group are present in selenoenzymes. GST and glutathione use disulfides and this functional group to maintain redox homeostasis. For 10 points, identify this functional group found in cysteine.
ANSWER: **thiol** [or **SH**]

20. **Joel Yang used this phenomenon to create a three hundred micrometer wide replica of Monet's *Impression, Sunrise*. Optical spectra of this phenomenon reveal Fano resonances caused by coupling and interference of its bright and dark modes. This effect is possible when one of the two media involved when one of the two materials has a negative permittivity with a higher magnitude than that of the other material. Reflected light reaches a dip at this effect's angle, which is sensitive to surface adsorption. Whether or not the metal film is evaporated onto the prism determines if this procedure is in the (*)** Otto or Kretschmann configurations. Light causes nanoparticles suspended in glass of the Lycurgus cup to exhibit this phenomenon. This phenomenon occurs when the momentum of incident light striking a layer of metal matches the momentum of a certain quasiparticle. For 10 points, identify this phenomenon that boosts signal in a certain kind of enhanced Raman spectroscopy.
ANSWER: **surface plasmon resonance** [prompt on partial answer; prompt on "**Raman spec**"]

21. **The first device used for this purpose relied on the the destructive power of micro-oxygen, although its side effects eventually resulted in a separate disaster. A branch of the United Nations dedicated to creating this sort of technology developed the Garuda airship despite the ineffectiveness of the Super X and Super X2. Additionally that group, the UNGCC, developed the MOGUERA using remnants of a previous disaster. Jet Jaguar was a robot, which was useful for this purpose, as are Maser cannons and the Markalite FAHP. The (*)** Kiryu was developed by the AMF for this purpose by turning a giant corpse into a mecha, which in turn went on a rampage and smashed up Tokyo. I guess transforming into ultraman or megazords count as technology used for this purpose. For 10 points name this kind of technology needed after Hiroshima since its side effects caused giant monsters to attack from the sea.
ANSWER: **Kaiju countermeasure**s [accept ways to **deal with** or **kill Godzilla** or **Kaiju**s or **giant monster attack**s, or obvious equivalents]

22. *Note to moderator: read answerline instructions beforehand.*
In [contrast-matching small-angle neutron scattering], this compound is added to a sample until an unwanted scattering pattern matches the solvent and can be subtracted. This molecule is added to samples in the first step of the Linderstrøm–Lang model, in a variant of MS. The only known method of chemically altering circadian rhythms without interfering with other biological processes uses this compound. The first chemist to isolate this compound was Gilbert Lewis. In the (*) NMR of aqueous samples, the solvent typically contains 10 percent of this compound. The proton inventory method finds enzyme *K*-cat values using aqueous solutions of this molecule. Alcohols can be identified by adding this compound and shaking until the alcohol peak disappears. For 10 points, name this molecule that replaces exchangeable hydrogens with deuterium, and which has formula D_2O.
ANSWER: **deuterium oxide** [accept **D_2O**, **deuterated water**, or **heavy water**; prompt on "**water**" until read; do not prompt on "deuterium"]

23. **In cosmological simulations, these structures' namesake "field estimator" is used to convert from particle positions to density and velocity fields. These structures can be computed using Lawson's flip algorithm or Su and Drysdale's spiral search modification to a gift-wrapping algorithm. Constrained versions of these structures are computed by considering a constrained edge to "block the view." Projecting a set of points in the plane *z* equals zero onto a unit elliptic paraboloid, then connecting the downward-facing facets of a convex hull to *z* equals zero, yields one of these structures. For a finite point set, they always contain a (*)** Euclidean minimum spanning tree, and they have no points interior to the circumcircles of their components. For 10 points, name this structure created by connecting the points in adjacent cells of a Voronoi diagram to divide a plane into triangles.
ANSWER: **Delaunay** triangulation [or **Delaunay** tessellation]

24. **Interference between artificial objects used in this system is called fratricide. One form of those artificial objects in this system is created by ignition of the atmospheric sodium layer. Another source of error within this system is known as the cone effect and is due to those objects not being infinitely far away. One Zernike component can be addressed by one actuator in this type of system, but orders higher than tip and tilt are rare since the number of Zernike components grows with increasing order. Devices like (*)** Shack–Hartmann sensors are central to this system which was significantly developed under Reagan's Star Wars initiative. Deformable primary or secondary mirrors are used in telescopes employing this technique which aims to restore diffraction limited seeing. For 10 points, name this technique which tries to remove wavefront distortions and acts on a shorter timescale than its active counterpart.
ANSWER: **adaptive optics** [do not accept "active optics"]