Tiebreaker 1. **Samuel Bowles used this equation to partition effects of altruism between among-deme and within-deme effects. Loreau and Hector used an analog of this equation to partition complementarity and sampling effects in biodiversity and ecosystem function experiments. When the expected value term of this equation is set to zero, the remainder constitutes Robertson's secondary theorem. This theorem has controversially been used to argue that (*)** group selection is consistent with Hamilton's rule. By taking the covariance of fitness with itself, this equation simplifies to Fisher's fundamental theorem. This equation contains terms corresponding to the effects of transmission and selection. It was revived in the 1990s by Steven Frank after its creator's 1975 suicide. For 10 points, name this theorem that describes the change in distribution of a character over time.
ANSWER: **Price** equation

Tiebreaker 2. **This program includes 48 feature planes and uses the REINFORCE and PUCT algorithms. This program applies the APV-MCTS algorithm through four stages: selection, expansion, evaluation, and backup. It was built by first training a fast rollout policy and supervised learning policy and then improving them both through a policy gradient. Features built into this program include identifying nakade patterns and recognizing (*)** atari. This program uses policy and value networks that it developed through machine learning in order to evaluate possible moves in a Monte Carlo tree search. This program uses convolutional layers to construct a position representation from a 19 by 19 image of the gameboard. It developed an artificial neural network by playing itself, other computers, and humans like Fan Hui. For 10 points, name this program developed by Google that beat Lee Sedol in a Go match in March, 2016.
ANSWER: **AlphaGo**

Tiebreaker 3. **If one of these objects is nonzero outside of the first quadrant, it has an associated "five-term exact sequence" which contains some of its low-degree edge homomorphisms. The Grothendieck one of these objects can be used to compute the derived functors of a composition of two functors and the Serre one of these objects relates the homology of the total space of a fibration to the homology of the base space and fiber space. These objects can be constructed from exact couples of bigraded modules by repeatedly taking the derived couple. These objects are made of bigraded modules together with differentials on those modules whose squares are zero; those modules are called (*)** "sheets" or "pages". In 2006, Timothy Chow wrote an expository paper on these objects, claiming that "you (the reader) could have invented" these objects. For 10 points, name these objects which are associated to filtered complexes and which can be used to compute their homology.
ANSWER: **spectral sequence**s [prompt on "**sequences**"]

Tiebreaker 4.**This field's parameters are often displayed in radial pentagons and hexagons. Some of its homogeneous catalysts use "hydrogen borrowing." This field often makes platform molecules using tunable catalysts like Starbon. In this field, adding CO_2 to [switchable or tunable solvents] can change their polarities. Its use of solid-phase extractions can reduce Sheldon's (*)** E-factor. "On-water" conditions, "neat reactants," and supercritical CO_2 refer to this field's alternative solvent conditions. Its "cradle-to-cradle" reactions optimize [redox, pot, step, and atom economies], and time-space yields. Anastas and Warner made this field's 12 principles. This field replaces "end-of-pipe" technologies with "at-source" ones using renewable feedstocks and source reduction. For 10 points, name this environmentally friendly subfield of chemistry.
ANSWER: **green chemistry**/**synthesis** or **sustainable**/**biomimetic chemistry**; both parts required [prompt on "**organic synthesis**/**chemistry**"; do not accept "environmental chemistry" or "green engineering"]

Tiebreaker 5. **The lasso and spatula techniques are used on this technique's samples under cryoprotection. Button microdialysis has replaced the Zeppezauer method in one cryoprotected step of this technique that produces JCPDS cards. It's not cell culture, but the hanging and sitting drop methods are used with VDX plates in this technique. Isomorphous replacement by heavy atoms or molecular replacement by a similar structure can overcome this technique's (*)** main problem. 100 atoms is the size limit of this technique's "small" samples. This technique's central problem can also be solved using Multiwavelength Anomalous Diffraction, or MAD, and its counterpart SAD. In this technique, the sample is often placed on a 4-circle goniometer and undergoes precession imaging while being bombarded by waves stronger than UV rays. For 10 points, identify this technique that Rosalind Franklin used to discover the structure of DNA.
ANSWER: **x-ray crystallography** [or **x-ray diffraction**]

Tiebreaker 6. **A programmer from this country, phk, wrote the Varnish HTTP accelerator and a BSD email about "bikeshedding." After developing Basecamp, a programmer from this country, dhh, released the free web framework Ruby on Rails. A programmer from this country led the creation of Delphi and Turbo Pascal at Borland, and TypeScript and C-sharp at Microsoft. A programmer born in this country created a Forms Interpreter using CGI and C to make his Personal Home Page, which became (*)** PHP. Two brothers from this country started Google Maps using a language created by a programmer from here, who added operator overloading and classes to C. A computer scientist from this country expanded a notation for context-free grammars devised for Algol by John Backus. Peter Naur and the inventor of C++, Bjarne Stroustrup, are from here. Programmers from here studied at Århus University. For 10 points, name this country where Greenland-born Rasmus Lerdorf is from.
ANSWER: **Denmark**

Tiebreaker 7. **One powerful example of these reactions that acts upon beta-keto esters is initiated by the thermal decomposition of AIBN and is named for Dowd and Beckwith. The Buchner-Curtius-Schlotterbeck reaction can facilitate one of these reactions by reacting diazomethane with a cyclic ketone. One of these reactions that can be used to generate spiro derivatives of penicillin sees the formation of a carbene from ethyl-diazoacetate in the first step and is named for Buckner. (*)** Carbocations can rearrange through one of these reactions that converts it from secondary to tertiary and lowers angle strain. These reactions can proceed via migration to an exocyclic group or the opening of a bicyclic compound. For 10 points, name this class of reactions in which a carbon atom is added to the ring of a cyclic compound, the opposite of contractions.
ANSWER: ring **expansion**s [prompt on carbon "**insertion**", prompt on "**rearrangement**" reactions]

Tiebreaker 8. **A protein often found in buffers for this biological test can be extracted in the fifth step of the Cohn purification process, which is why that protein's alternate name is "Fraction V." In this test, the samples turn blue after tetramethylbenzidine or TMB is applied to react with an enzyme that is responsible for enhanced chemiluminescence. The (*)** "sandwich" version of this assay sequesters the reactant between two antibodies that are linked to usually either Alkaline Phosphatase or Horseradish Peroxidase. Diseases such as HIV or West Nile Virus can potentially be diagnosed through this assay since it tests for the presence of antibodies in human serum. For 10 points, name this assay that is used to determine the presence of an antigen in liquid solution.
ANSWER: **ELISA** [or **Enzyme-Linked Immunosorbent Assay**]

Tiebreaker 9. **The tetracarboxylic acid Aspergillomarasmine A["Asp-er-jill-oh-sah-mine-A"] is a potent inhibitor of these enzymes. Classes A, C and D of these enzymes rely on a serine residue for activity according to the Ambler classification system. The appearance of a red color is used to test for their presence upon the application of nitrocefin. An enzyme of this type is encoded on cloning vectors like pUC19 by an ampR ["amp-R"] or bla ["blah"] gene. One of these enzymes was named after the city in (*)** India it was discovered in, and clavulanic acid is commonly administered to inhibit them during antibiotic therapy. One of them, the carbapenemase NMD-1, portends a major antibiotic resistance crisis. They are responsible for conferring resistance to a class of drugs that function by inhibiting the enzyme transpeptidase and preventing cell wall synthesis. For 10 points, name this class of enzymes that degrade 4-membered cyclic amides like penicillin.
ANSWER: **beta-lactamase**

Trash Tiebreakers?
A three step model that was an improvement on this program first took the vector average of the embeddings associated with an input sequence of tokens, passed those averaged through feed-forward layers, and performed linear classification on the final layer's representation. One version of this program measured its success against the "rap" and "index-sub-n" strategies. The "Fixed" version of this program uses the same DT-RNN configuration but with constant answer vectors. Using Tree-LSTMs, one group from Stanford claimed to have a five-percent improvement on some of the tasks this program can perform. One limitation of this program was that it wasn't able to clarify a response of (*) "hydrogen bonding" when posed a question about Van der Waals forces. This model's first public appearance led to a 200-200 tie. For 10 points, name this computer program designed to answer tossup questions that premiered to the public at the 2015 NAQT HSNCT.
ANSWER: **QANTA**

This song was inspired by a track whose chorus ends each line with "we runnin this rap shit." The artist of this song claimed that "ghosts and spirits were afraid of the fumes" and he wanted to "affect [this song's subject] with my weapon and get to his soul." It inspired a response which included the lines "I got myself a gun / but I really don't need the heat / you're heart pump project Kool-Aid." That response was (*) Supa Ugly. The first word of every line of this song's hook spells out "I will not lose. This song, which begins "brace yourself for the main event / y'all impatiently waiting / it's like an AIDS test," appeared on its artist's second album, Stillmatic, and was targeted at Jay-Z. For 10 points, name this Nas diss track that shares its name with a functional group consisting of an oxygen linkage between two alkyl groups.
ANSWER: **Ether**

Submissions
(Mukherjee)
The matrix element for the initial state in this phenomenon corresponds to the superposition of an incoming plane wave and an outgoing spherical wave. It doesn't produce antimatter, but this phenomenon is characterized by the Furry–Sommerfeld–Maue wavefunction and is inhibited at high energies or densities in the Landau–Pomeranchuk–Migdal effect. Elwert and Haug derived the analytic expression for this phenomenon's (*) cross section, generalizing the non-relativistic Bethe–Heitler formula. The Duane–Hunt law gives the maximum frequency of this phenomenon that can be generated in an X-ray tube. This phenomenon is the primary mechanism of energy dissipation in high-temperature plasma. For 10 points, identify this phenomenon that occurs when a scattered electron decelerates and has a name meaning "braking radiation" in German.
ANSWER: **bremsstrahlung** [or **free-free radiation**; accept **braking radiation** until read]

(Schindler/Dogra)
The formation of these structures often results in recruitment and activation of the serine threonine kinase ATM, a member of the PIKK family, which then phosphorylates downstream substrates such as NBS1. A protein kinase catalytic subunit is targeted to these structures following Ku70/80 heterodimer binding to them. A eukaryotic homologue of the *E. coli* protein RecA involved in one method for the removal of these things is known as Rad51 and associates directly with BRCA1 and BRCA2. One of these structures is created by RAG1 before a hairpin is formed during (*) VDJ recombination. The most common pathways for removing these structures are nonhomologous end joining and homologous recombination. For 10 points, name this kind of DNA damage where both strands of a double helix are cut.
ANSWER: **double strand break**s [or **DSB**s; prompt on more general answers like "DNA **damage sites**" or "DNA **strand break**"]

(Prieto/Lasker)
A formula that relates the limit of the spectral density to the chiral condensate in the chiral version of this process is called Banks–Casher relation. This process would create 2 *N* minus 1 particles if it occurred in an SU(*N*) theory. Only scalar particles can undergo this process without because particles with spin cannot have a vev without violating Lorentz invariance. The simplest construction of it may be observed by writing a field in the Lagrangian as a new field minus its vacuum expectation value, and example occurs in a theory with a phi to the fourth term and a (*) *negative* mass squared. This process implies the existence of a massless scalar particle for each broken generator according to Goldstone's theorem, and the Higgs mechanism involves this process ruining the electroweak's pretty SU(2) cross U(1). For 10 points, name this situation in which a Lagrangian possess a symmetry but the ground states do not.
ANSWER: **spontaneous symmetry breaking**

In the presence of 1M7, flexible regions of RNA undergo this modification more readily than constrained regions in the SHAPE technique. The pro•apop•totic genes *PUMA* and *BAX* are upregulated by p53 when this modification occurs on residue 120 of p53. Gcn5 codes for the catalytic subunit of several protein subunits that perform this modification, including the SAGA complex. Side chains with this modification are targeted by (*) bromodomains. Aspirin inhibits prostaglandin synthesis by performing this modification on a cyclo·oxygenase or COX enzyme. HATs perform this modification on the lysine residues of histones, *increasing* gene expression. For 10 points, identify this process that attaches an acetyl group to a molecule.
ANSWER: **acetylation**

(Auroni)
This is the lightest and simplest compound commonly used as a volatile pH modifier in HPLC. Keggin-type polyoxometalates are used to catalyze the oxidation of wet biomass into CO2 and this compound. In the Leuckart-Wallach and Eschweiler-Clarke reactions, this compound acts as a hydride source. It doesn't have a carbon-carbon double bond and isn't an (*) aldehyde, but this compound gives a positive result for Baeyer's reagent. This compound shows a negative deviance from Trouton's rule because it exists as a stable dimer in the gas phase. By heating oxalic acid with glycerol, CO2 and this compound can be obtained. This is the most oxidized byproduct of methanol poisoning, and is naturally found in stinging ants. For 10 points, name this simplest carboxylic acid.
ANSWER: **formic acid** [or **formate**]

This bacteria uses a type III secretion system with Tarp to invade epithelial cells. Because it lacks muramic acid in its cell wall, this bacteria does not Gram stain well. Infection with this bacteria results in a thick wall of scar tissue called Arlt's line. It's not a GI bacteria, but infections with this bacteria can trigger Reiter's syndrome, or reactive arthritis. After this bacteria infects a cell, it switches from an elementary to a reticulate body. Types L1, L2, and L3 of this bacteria target lymph nodes to cause the disease (*) LGV. This bacteria's species name reflects the fact that it can cause roughening of the inner surface of an eyelid until eyelid turns inward, in a condition called trachoma. Alongside an organism from genus *Neisseria*, this bacteria is the top cause of PID. For 10 points, name this most common cause of bacterial STDs in the US.
ANSWER: ***Chlamydia*** *trachomatis*

The hepes-glutamic acid buffer-mediated organic solvent protective effect, or HOPE system, is a popular new way to perform this technique. By binding to histones, picrates can perform this task. You can trade off quality for toxicity in this technique by using zinc chloride instead of mercuric chloride in an agent named for Zenker. The bacterial (*) mesosome is an invagination in the plasma membrane created as an artifact in this technique. To preserve the glycocalyx in capsule staining, the heat form of this technique cannot be performed. Calcium ions and tryptophan are commonly added when performing this procedure with osmium tetroxide. A simple way to perform this process is to pass a dried sample on a slide over a Bunsen burner. For 10 points, name this technique of preserving a biological sample, often done just before staining.
ANSWER: **fixation** [accept word forms]

(Garg)
It's not "clonal", but this adjective describes a process that relies on MINK to activate the Jnk (Junk) pathway, but not the Erk pathway, so that Bim can be expressed. The AIRE gene is critical for that process described by this adjective, because it allows for the transcription of genes that are not normally expressed. Cells described by "double" and this adjective go through four stages of development starting in the medulla and ending in the subcapsular region of the thymus. Central tolerance is achieved by performing this type of (*) selection on T cells, and not normally on B cells. This adjective describes bacteria that are recognized by lipo·poly·saccharide-binding protein, as opposed to pep·tido·glycan-recognition proteins. For 10 points, give this adjective that describes bacteria that don't stain violet in a Gram stain.
ANSWER: **negative** [or **negative** selection; or double-**negative** thymocytes; or Gram-**negative**]

In a mouse model of this disorder, the protease ZMPSTE24 is absent. The farnesyltransferase inhibitor Lonafarnib is being studied as a potential treatment for this disorder. This disorder is caused by a point mutation at position 1824 of the LMNA gene with cytosine being replaced by thymine. Symptoms of this disorder include alopecia and a shallow, recessed jaw, and most sufferers of this disease die from complications of atherosclerosis. A disorder similar to this one that is usually diagnosed at a later age is (*) Werner syndrome, and is often called the "adult" form of this disorder. Unlike the related Cockayne syndrome, this disorder is not caused by defective DNA repair. This disorder is often named for Hutchinson and Gilford. For 10 points, name this genetic disorder that causes rapid, premature aging.
ANSWER: **progeria** [or Hutchinson-Gilford **progeria** syndrome]