Beginning with C–H Bonds
Carbon-hydrogen bonds in organic molecules and biopolymers are among the least reactive chemical groups, and in chemical synthesis, a C–H bond is first activated by oxygenation or halogenation reactions that can be unselective or difficult to control. Godula and Sames (p. 67) review recent progress in transition metal catalysis that has allowed direct, selective formation of carbon-carbon bonds from isolated C–H bonds. These synthetic routes offer great potential for increased synthetic efficiency in preparing complex molecules such as drug precursors.

From Quantum Kittens to Flying Cats
Quantum information processing will require the reliable preparation of quantum states of matter. While these are easy to specify theoretically, experimental realization of such states has been difficult, especially the type of “flying” states that are expected to be useful for quantum communication purposes. By subtracting a single photon from a squeezed coherent optical pulse, Ourjoumtsev et al. (p. 83, published online 9 March; see the Perspective by Gisin) report on the production of small Schrödinger cat states, or Schrödinger kittens, and show that these kittens can be grown into cats through a suitable amplification and distillation process.

Superalloying Cobalt
Superalloys, which are based on iron, cobalt, or most commonly nickel, can be safely used at temperatures in excess of 0.7 of the absolute melting temperature, unlike conventional alloys, which are prone to creep and oxidation. Through the addition of solutes like aluminum or titanium, or both, a two-phase equilibrium microstructure forms that consists of γ and γ' phases; the latter phase is largely responsible for the elevated-temperature strength of the material and its incredible resistance to creep. Cobalt superalloys typically have lower strengths than those based on nickel, which is why the latter has dominated in applications. However, Sato et al. (p. 90) now show that a ternary cobalt alloy based on the addition of aluminum and tungsten has properties that compete with those of the nickel superalloys.

H₂ Leaves Pt Unexcited
The Born-Oppenheimer (B-O) approximation, which treats nuclear and electronic motion independently during chemical interactions, is a cornerstone of computational modeling. Without it, theoretical analysis of even small molecule reactions in the gas phase would prove dauntingly complex. However, the ease with which electrons can be excited at metal surfaces has cast doubt on the validity of the approximation for simulating molecular-surface collisions, which play a major role in industrial catalysis. Nieto et al. (p. 86, published online 9 February; see the Perspective by Wodtke) show that data for scattering and dissociative adsorption of H₂ at a platinum surface are well predicted with a density functional theory approach with the B-O criteria intact. The absence of Pt electronic excitation during the H₂ interaction suggests that accurate modeling of a wide range of heterogeneous reactions should be feasible.

Repeating Ring Properties
Two new outer rings and moons were recently discovered around Uranus. Using the infrared Keck adaptive optics system, de Pater et al. (p. 92) show that the rings are blue and red like Saturn’s E and G rings. Blue ring R1 is associated with moon Mab, and Saturn’s E ring hosts the active moon Enceladus. This correspondence suggests that Mab may be the source of ring material and the blue color, because only small grains survive gravitational forces, solar radiation pressure, and electromagnetic forces. Ring R2 is as red as Saturn’s G ring and shows the same forward- and back-scattered light ratios. Both the uranian and saturnian rings are also at similar locations in planetary radii.

Hunting Hurricane Causes
A number of different factors can affect the formation and development of hurricanes, including sea surface temperature (SST), lower tropospheric humidity, vertical wind shear, and large-scale atmospheric circulation patterns. Which of these factors are most important and which are responsible for the increase in global hurricane intensity observed since 1970? Hoyos et al. (p. 94, published online 16 March) use a method based on Bayesian statistics and information theory to isolate the causes of the trend from short-term variability, for all of the major ocean basins where these storms occur. They conclude that only rising tropical SSTs have had a significant influence on the recent multi-decadal trend.

No Pain, No Gain
Societal behavior is complex and multifaceted. One complicated question is the conditions under which cooperation and altruism emerge. Experimental results using a public goods game suggest that the threat of costly punishment of free-riders by altruistically minded souls suffices to maintain groupwide compliance. Güerker et al. (p. 108; see the Perspective by Henrich) show that if allowed to choose freely, individuals first elect to join a sanction-free game where punishment is not permitted. As successive rounds are played, they come to appreciate that cooperation yields greater rewards, so they switch to the sanctioning regime where punishment (which makes free-riding costly) is allowed and themselves become active monitors of compliance.

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Ant Family Tree

Ants are a dominant feature of terrestrial ecosystems and yet we know surprisingly little about their evolutionary history. Moreau et al. (p. 101; see the cover) sequenced DNA from multiple genes for a representative sample of ant species from around the world to reconstruct an ant family tree. A single group, the Leptanillinae, lies at the base of the tree, while all the other groups fall into two major clusters. By using fossils to calibrate the rates of DNA evolution in ants, they conclude that present-day ants arose approximately 140 to 168 million years ago. However, ant diversification only took off ~100 million years ago, immediately after the rise of flowering plants, the angiosperms.

MicroRNAs in Embryogenesis

Early in animal development, the embryo switches from using maternally provided messenger RNA (mRNA) transcripts to expressing mostly zygotic genes. During this maternal-to-zygotic transition, a large number of maternal mRNAs are somehow eliminated. Giraldez et al. (p. 75, published online 16 February; see the Perspective by Cohen and Brennecke) examined possible microRNA (miRNA)-based mechanisms and identified 203 putative targets for the zebrafish miRNA miR-430, which is specifically expressed at the maternal-to-zygotic transition. Hundreds of miR-430 target mRNAs are maternally expressed during early development, and miR-430 can promote their deacetylation and decay. Thus, during the maternal-to-zygotic transition in zebrafish embryogenesis, miR-430 plays a critical role.

Serotonin and Liver Regeneration

The liver can regenerate after severe injury or surgery, even when up to 70% of the tissue has been removed. Lesurtel et al. (p. 104) report that in a mouse model, serotonin carried by platelets circulating in the blood plays a role in the regenerative process. Liver was found to express serotonin receptors. Mice with impaired platelet function had a reduced regenerative response, but when treated with a serotonin receptor agonist, hepatocyte proliferation was restored. Liver regeneration in mice lacking peripheral serotonin was also restored when their platelets were reloaded with serotonin. Therapeutic treatment with serotonin receptor agonists may thus be useful in tissue recovery.

Limits to Evolutionary Flexibility

Genetic mutations are the substrate for evolution. Genes conferring fitness can accumulate multiple mutations during a period of selection. There are, of course, many potential evolutionary trajectories for the appearance of these mutations. However, it is likely that not all trajectories are available because the fitness of individual mutations may depend on the genetic background in which they appear. Weinreich et al. (p. 111) chart the available evolutionary trajectories for five mutations in β-lactamase in Escherichia coli, which together confer a 100,000-fold increased resistance to the antibiotic cefotaxime. Only 18 of a potential 120 routes to high fitness are accessible to selection, due to pleiotropic effects of the mutations on the enzyme.

Therapy for Marfan Syndrome

Marfan syndrome (MFS) is a hereditary disorder characterized by systemwide defects in connective tissue. People with MFS have a greatly increased risk of developing an aortic aneurysm, a bulge in the wall of the aorta that can rupture and cause life-threatening internal bleeding. Studying a mouse model of MFS, Habashi et al. (p. 117; see the news story by Travis) found that aneurysm formation is accompanied by activation of the transforming growth factor–β (TGF-β) signaling pathway in the aortic wall. Treatment of the MFS mice with losartan, a drug recently shown to antagonize TGF-β signaling in other disease states, almost completely normalized the aortic phenotype in the MFS mice, even after an aneurysm had formed. Losartan is already widely used to control high blood pressure, and the authors suggest that a prospective clinical trial in MFS patients is warranted.