onant effect and molecular length is less critical. However, it is challenging to design molecules with the required electronic structure.

Hales *et al*. now report a breakthrough in the design and synthesis of a polymethine-type dye molecule capped with aromatic selenium (Se)–containing end groups. The aromatic end groups allow the frontier molecular orbitals to extend beyond the polymethine chain; they thus effectively increase the conjugation length and reduce E_g without the symmetry-breaking problem encountered in long chains. Moreover, the Se substitution increases the dipole moment above the value expected for the given polymethine chain length. These factors result in exceptionally high γ values. In addition, two-photon absorption losses at telecommunications wavelengths are minimized in these molecules because of a gap in the two-photon absorption spectrum at $2\hbar\omega$. The combination of high γ and low absorption losses results in an unprecedented ratio of γ to absorption. If these results for solution can be reproduced in solid films, the molecules could find application as some of the first high-performance, low-cost all-optical switches.

The work of Hales *et al*. demonstrates that the design and synthesis of functional pi-conjugated materials for specific purposes is reaching a new maturity. Similarly striking achievements have been made recently in other fields. For example, use of conjugated polymers in electrically pumped lasers requires high charge mobilities as well as high luminescent efficiency. A recent study showed that polyfluorene polymers with a small fraction of short side chains can achieve both goals, because the side chains increase interchain hopping and raise charge mobility by almost two orders of magnitude, but do not reduce the luminescence efficiency (*6*). Similarly, in organic solar cells, a free-energy difference between the photoexcited donor or acceptor molecule and the separated charged state is required to drive efficient charge separation. This free-energy difference limits the electrochemical potential energy that can be harnessed. Recent studies (*7*, *8*) have shown that charge separation can be achieved at lower energetic cost through use of donor polymers with in-chain donor-acceptor character, possibly by polarizing the excited state during the charge-transfer step. Given these advances, technological applications of these sophisticated materials should not take long to be realized.

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BEHAVIOR

Fairness in Modern Society

What features of a society motivate individuals to behave fairly?

Karla Hoff

Experiments in psychology and economics have demonstrated that in industrialized societies all over the world, a substantial fraction of individuals will be fair in anonymous interactions and will punish unfairness (*1*, *2*). However, it has not been clear whether this benevolent, prosocial behavior depends on innate human psychology or norms peculiar to industrialized societies. Henrich *et al*. explored the motivation for fairness in anonymous interactions across dramatically diverse societies and on page 1480 of this issue (*3*), they report that this behavior increases with the level of the society's market integration, measured as households' average percentage of calories that are purchased.

A game used to study how people behave toward others who are not linked to them by kinship or friendship is the Dictator Game, in which an individual (the "dictator") is matched with an anonymous person. The pair is allocated a stake of 10 monetary units (equal to 1 day's wage in the study by Henrich *et al*.). The dictator decides how much of the stake to keep and how much to send to the other player, who is passive. Pure self-interest would lead the dictator to send zero to the other player. Henrich *et al*. now show a strong and robust positive relationship between the mean amounts sent in 15 societies, including foraging and nomadic hunter-gatherer bands, and the level of the society's market integration. This is convincing evidence that societal standards of behavior in anonymous interactions have coevolved with market institutions.

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Economic game. A "Third-Party Punishment Game" was used by Henrich *et al*. to assess preferences across different societies. An experimenter is shown demonstrating such a game in a remote region of Papua New Guinea.

By varying the rules of the Dictator Game, studies have shown that one motivation for sharing is the desire not to violate standards of expected behavior. For example, in one variant of the Dictator Game, the dictator, after making an allocation decision, is given the option to exit the game and keep the full stake less a small amount. The exit option leaves the other player with zero but also ensures that he never knows that a Dictator Game was to be played. One-third of the dictators take the exit option (*4*). Thus, some participants are willing to pay a price to avoid a situation in which they are expected to share because they dislike not doing so in that situation. In another variant of the Dictator Game, the dictator's choice set is enlarged to include taking money from the other player. If the dictator's choice set ranges from –$5 to +$5 instead of from zero to $5, the proportion of positive offers falls from 71 to 10% (*5*). This suggests that another motivation for sharing is a desire to avoid the most selfish feasible action. This motive would lead dictators to share when the choice set ranges from zero

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to $5 but not to share when the choice set includes negative values.

It has been argued that Britain's leadership in the Industrial Revolution—the onset of modern economic growth—depended on the unusual strength among European countries of its informal norms against opportunism in business. Although markets were highly competitive, businessmen displayed a high degree of class solidarity, defined as "sufficient trust in one another so that pairwise cooperative behavior was expected and maintained" (*6*, *7*). In this secure environment, unprecedented levels of cooperation occurred between individuals with commercial acumen and those with technical skills. The exceptional cheaters risked punishment in the form of the exclusion from social groups.

In many settings, maintaining cooperation when interactions are impersonal is greatly enhanced by "altruistic punishment" of norm violations. Games in which disinterested parties have the opportunity, at a cost, to punish norm violators provide a measure of such altruism (see the figure). An open question, however, is how specific features of a society shape the willingness of individuals to engage in altruistic norm enforcement. Experimental evidence indicates that selective social status is accorded to those who altruistically contribute to group welfare and that such status enhances individuals' willingness to contribute to the group in the future (*8*). Henrich *et al*. report evidence that group solidarity rituals have coevolved with social complexity. These findings predict that denying members of a group the possibility to enjoy social status and participate in community rituals and religion will interfere with the emergence of altruistic norm enforcement. An experiment in India (*9*) examined the effect of caste status on the willingness to punish violations of the norm to reciprocate cooperation. The norm was held by both caste groups that participated in the experiment—the low castes, who had been subject to the practice of exclusion (so-called "Untouchability"), and the high castes. Although there were controls for individual wealth, education, and political participation, low-caste individuals exhibited a much lower willingness to punish norm violations that hurt members of their own caste, suggesting a cultural difference across caste status in the concern for members of one's own community. Low-caste individuals adopted an attitude toward norm enforcement that was closer to pure self-interest than did individuals at the top of the caste hierarchy. There was, however, no caste difference in norm enforcement when the victim was not a member of one's own community—both low- and high-caste members punished little in that case. Because low castes were traditionally denied the possibility of any social status and entry to temples, these results support the idea that altruistic norm enforcement is learned, not innate. The findings also suggest that groups denied free cultural expression are at a disadvantage with respect to norm enforcement and collective action.

A society is not just a random group of people with a shared territory. It is a group that shares cognitive frames and social norms (*10*, *11*). We cannot know for certain how fairly our ancestors in foraging bands behaved in situations lacking relationship information, but Henrich *et al*. bring us a closer understanding by studying people in simple societies that may be very like those of our early ancestors. These findings call into question the standard assumption in economics that preferences are innate and stable, and suggest instead that cultural conditioning of the expression of human selfishness is a part of the process of economic development.

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MATERIALS SCIENCE

Expanding the Repertoire of Shape Memory Alloys

An iron alloy may open up new applications for strong materials that are also capable of large reversible shape changes.

Ji Ma and Ibrahim Karaman

The exceptional properties of many materials often come at the expense of limited performance in other areas. For example, conventional metals and their alloys are strong—they are good at resisting stress (i.e., an applied load)—but they tolerate only a very small amount of strain (i.e., deformation) before they are irreversibly deformed. Rubber can easily return to its original shape, even after large deformations, but is much weaker than conventional metals. However, some metal alloys exhibit "shape memory"; they are strong but can recover from being deformed when heated. This process seems counterintuitive, but these alloys take advantage of solid-to-solid "diffusionless" phase transitions: The atoms rearrange how they pack into crystals in an orderly fashion, and this process changes the material's macroscopic shape. Few other materials possess this combination of strength and flexibility (see the figure), and clever engineering has exploited these properties—for example, in implanted medical devices such as stents. On page 1488 of this issue, Tanaka *et al*. (*1*) report on a superelastic alloy that almost doubles the useful range of deformation that can be induced in such alloys.

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Superelasticity is the term used to describe a particular mechanical response of shape memory alloys, or SMAs. When a stress is applied to an SMA—for example, through pulling or bending—a phase transition is induced, most commonly from a high-symmetry solid called austenite to a solid with lower symmetry, called martensite. When this applied stress is removed, the material fully recovers its original shape. Because superelasticity is stress-driven, it must compete with other deformation mechanisms such as dislocation motion and deformation twinning. The victor will be the process that is triggered by the least amount of stress.

Superelasticity appears only when the temperature is high enough for austenite to