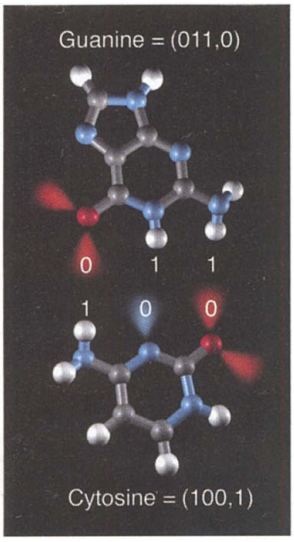
three bonding sites that each nucleotide presents to its partner. Each site is either a hydrogen donor or acceptor; a nucleotide offering donor-acceptor-acceptor sites would be represented as 100 and would bond only with an acceptor-donor-donor nucleotide, or 011. The fourth digit is 1 if the nucleotide is a single-ringed pyrimidine type and 0 if it is a double-ringed purine type. Nucleotides readily bond with members of the other type.



Binary bases. Representing nucleotides as binary numbers reveals how they were chosen to avoid errors.

Mac Dónaill noticed that the final digit acted as a parity bit: The four digits of A, T, G, and C all add up to an even number. Nature restricted its choice to nucleotides of even parity, says Mac Dónaill, because "alphabets composed of nucleotides of mixed parity would have catastrophic error rates." For example, nucleotide C (100,1) binds naturally to nucleotide G (011,0), but it might accidentally bind to the odd parity nucleotide X (010,0), because there is just one mismatch. Such a bond would be weak compared to C–G but not impossible. However, C is highly unlikely to bond to any other even-parity nucleotides, such as the idealized aminoadenine (101,0), because there are two mismatches. So, nature has avoided such mistakes by banishing all odd-parity nucleotides from the DNA alphabet.

Computational chemist Graham Richards of Oxford University thinks the finding is important: "It is a novel idea which should provoke others to explore aspects of informatics in the genetic code," he says, adding: "Instinctively, one feels that the DNA code should have evolved systems to minimize errors. Mac Dónaill's work shows how this could have been achieved." Larry Liebovitch of Florida Atlantic University, Boca Raton, agrees. "Mac Dónaill's clever analysis shows how well different nucleotides could serve as matches in DNA and how much different pairs differ from each other," he says. "This analysis gives us a reason to believe that the A–T and G–C choice forms the best pairs that are the most different from each other, so that their ubiquitous use in living things represents an efficient and successful choice rather than an accident of evolution."

–DAVID BRADLEY

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PATENT LAWS

Report Urges Leeway For Developing World

An independent commission appointed by the British government is advocating weaker intellectual property (IP) laws in developing countries in hopes of fostering innovation. The report, released this week, also criticizes the World Trade Organization's agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), which in 1995 delineated minimum global standards that nations should achieve.

"We've recommended that patents aren't necessarily a good idea for many developing countries," says Charles Clift, a London economist and head of the secretariat that managed the six-member commission. Commissioners believe that developing countries can ill afford to pay fees on patented inventions, both domestic and foreign, that would help them expand their technological base. Devinder Sharma, an analyst at the Forum for Biotechnology and Food Security in New Delhi, India, says he's pleased that "for the first time, a high-powered body is saying, 'Go slow on patents.'"

The U.K. government launched the commission after a review of the problems associated with globalization. Its conclusions (www.iprcommission.org) reinforce arguments made for years by nongovernmental organizations. But some say a position that favors narrower patents is misguided. "A policy saying you should not grant patents on things that are really, truly inventive makes no sense for developing countries," says Jeffrey Kushan, a patent attorney at Sidley Austin Brown & Wood LLP in Washington, D.C. "At the practical level, a lot of these issues don't have any data."

The commissioners acknowledge that a dearth of IP regulations in the least developed countries forced them to guess the impact of U.S. or European-type IP laws on a country's technological development. After consulting with institutions in nine developed and developing countries, however, they concluded that many developing nations ought to avoid issuing patents that, for example, allow the kind of broad protection available in the United States because it would stifle additional innovation. The commissioners also encouraged developing nations to adopt broad exemptions for educational and research use of patented materials. The group agreed, too, that a single IP system cannot serve the diversity of developing countries. Commission member Raghunath Anant Mashelkar, a polymer engineer and director-general of India's Council of Scientific and Industrial Research, says the report's message to authorities is "Don't force-feed stringent IP [rights] laws to poor countries that do not have the inherent capacity to implement them."

The commissioners were also concerned about the potential high cost of licensing a patent. For example, developing countries are generally not permitted to sell cheap generics of drugs still under patent protection (AIDS drugs being a notable exception). Stanford University law professor John Barton, who chaired the commission, suggests that such fees might prevent widespread use of an invention.

Kushan dismisses that argument, saying that "if a company wants to make money in a market, it's going to adjust its license fees." He also says that raising IP standards has historically promoted international competition and investment, citing reforms in Brazil in the late 1990s that preceded a $2 billion infusion from U.S. drug companies. Lila Feisee, IP director at BIO, an industry group in Washington, D.C., agrees. "Obviously, every country's got its own special criteria," she says. Still, "we push very hard to try and harmonize the patent laws of different countries."

Patent potpourri. More lenient patent laws allow Indian biotech companies to produce generic AIDS drugs.

The report will be presented next week to officials from the World Trade Organization and the World Intellectual Property Organization. The commissioners hope that their ideas will be incorporated into TRIPS, which continues to undergo revisions, or other international agreements.

–JENNIFER COUZIN AND PALLAVA BAGLA