BOOKS & ARTS

Security in an uncertain world

Biological protection systems that have evolved over billions of years could be the key to strengthening national defences against unforeseen threats, says **Jessica Flack**.

Natural Security: A Darwinian Approach to a Dangerous World
Edited by Raphael D. Sagarin and Terence Taylor
University of California Press: 2008.
289 pp. $49.95, £29.95

S. HUNT/GETTY IMAGES

The porcupine fish evolved spines to protect it from attack in its aquatic environment.

In 1957, commenting on the power balance between the Soviet Union and the United States, physicist Robert Oppenheimer said: "In time, the transnational communities in our culture will begin to play a prominent part in the political structure of the world, and will even affect the exercise of power by the states." Writing in 1986 in *The Making of the Atomic Bomb*, Richard Rhodes interpreted Oppenheimer's transnational community as that of science, arguing that with the invention of the atomic bomb, "science became the first living organic structure strong enough to challenge the nation-state itself".

Since the end of the cold war, during which relative stability prevailed, threats to national security have become unpredictable. Oppenheimer's comment foreshadowed the growing role of science, particularly physics, in international politics. It also foreshadowed the current source of the unpredictability: loosely organized, transnational networks of individuals seeking to attack nation-states.

In this uncertain age, we might look to an evolutionary theory of organizational robustness to provide a basis for a predictive science of national security. A good starting point is the engaging book *Natural Security*, edited by ecologist Raphael Sagarin and security expert Terence Taylor. Political scientists, anthropologists, ecologists, epidemiologists, evolutionary biologists and palaeontologists share lessons from 3.5 billion years of experimentation by biological systems in maintaining their security in a hostile and unpredictable world.

The concept is not new. For thousands of years, humans have sampled nature's strategies to improve their quality of life. What is new is the idea that by studying how organisms survive unpredictable events, we might identify general principles that apply to national security. Sagarin introduces the book by identifying critical questions: when do major shifts occur in human and natural systems? What types of organisms survive mass extinctions? And which events lead to escalations of armaments and defences?

Rather than being built around these foundational questions, *Natural Security* is organized around scientific disciplines. The book does not offer an analysis of principles but a diverse sampling of potential solutions to problems of national security drawn from observing the history of life. A danger of this approach is that solutions that seem to be generic are not, having evolved in a particular context and with a particular set of supporting mechanisms. In addition, as Sagarin and evolutionary biologist Geerat Vermeij note, nature can experiment without ethical concern for study subjects and risks arising from failure, whereas societies cannot.

The book would have been more compelling had it advocated a systematic study of what works and why, and at what cost. It might have been organized around the three main classes of robustness mechanisms observed in stable systems in the biological world — management, repair and prevention.

Management mechanisms control the spread and severity of damage induced by perturbations, either by actively countering them or by using structural tactics that maintain functionality despite damage. Virologist Luis Villarreal explains how humans have three immune systems to block attacks. The innate immune system builds barriers such as skin to keep pathogens out; the adaptive immune system can recognize, respond to and improve its response to invading foreign agents; and a 'behavioural immune system' excludes infected individuals socially. The book might have explored the implications of adopting a multi-tiered defence system for homeland security, with mechanisms operating on different timescales and tuned to different kinds of perturbations.

Repair mechanisms allow a system to rapidly recover its initial state. Ferenc Jordán, an ecologist who studies food webs, suggests that stability can be increased by building networks with links that can be rewired to maintain connectivity if parts of the network are damaged. Analogously, disaster-relief systems could establish back-up relationships among relief agencies to ensure that bottlenecks do not hinder the distribution of emergency resources.

Preventative mechanisms can reduce the likelihood of perturbations by altering the environment to reduce conflicts of interest between parties, or to create dependencies that are beneficial. One explanation for the evolution of the arrest of meiosis, the process by which gametes are produced, is that early sequestering of the germline protects it by minimizing the total number of possible mutations. In this way, conflict is pre-emptively eliminated. Bradley Thayer, an expert in national security, suggests that the motivation behind the US policy of spreading 'effective democracy' is to change the environment from one that fosters extreme positions to one that is open to negotiation. By drawing on analogous processes in biology, one might show the conditions under which such policies are likely to work.

Robustness has its costs. The trade-off between robustness and the ability of a system to reconfigure into a new state when faced with a changed environment — known as evolvability — is poorly understood in evolutionary theory. The consequences for the evolvability of the mechanisms discussed in *Natural Security* are unknown, and these ideas should be adopted with caution. Modularity, for example, may allow reconfiguration and limit damage by decoupling the fates of components and providing a flexible architecture. However, coordinating the different parts can be costly and difficult to manage. In hunter–gatherer societies, the division of labour requires the building of a distribution system supported by exchange rules; if the rules are unclear or violated, then conflict can result. When components are too specialized, their ability to adopt other functions is sometimes lost, making the system less evolvable and less robust.

Natural Security is a stimulating read. It opens the door to an exciting merger between political science and evolutionary theory. The task now is to use the ideas of organizational robustness that are developing in evolutionary theory to formulate principled hypotheses about the consequences of national-security decisions. ■

Jessica Flack is a research fellow at the Santa Fe Institute, 1399 Hyde Park Road, Santa Fe, New Mexico 87501, USA.

Genetic medicine at the bedside

Heredity and Hope: The Case for Genetic Screening
by Ruth Schwartz Cowan
Harvard University Press: 2008. 270 pp. $27.95, £18.95

Despite the fresh veneer of technology, medical genetics still follows the old-fashioned practice of medicine. It remains the most clinical of disciplines — in the literal sense, from the Greek *klinikos*, meaning 'of a bed' — in that most of the genetic physician's work is done at the bedside.

The story of the patient's illness, their family history and the physical examination remain the cornerstones of diagnosis. A clinician must examine the whole body to catalogue subtle and obvious signs and symptoms: the texture of the skin, how the ears are slung, the shape of the uvula in the back of the throat. Clinical findings then cohere, much like stars in constellations, into the eponymous syndromes with which we are familiar.

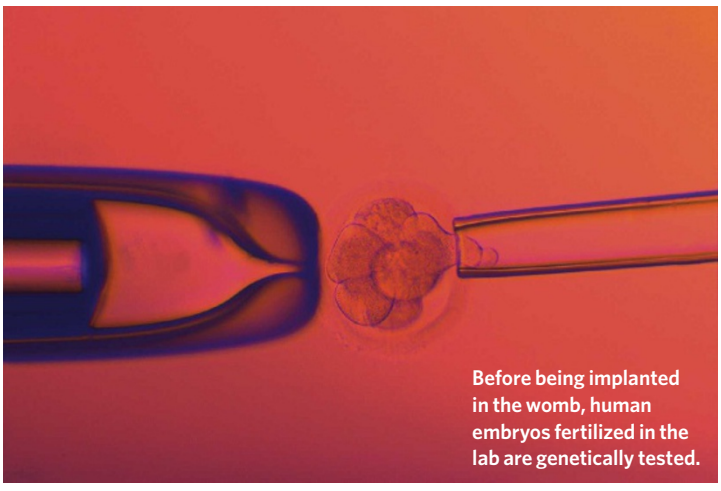
In *Heredity and Hope*, technology sociologist and historian Ruth Schwartz Cowan writes brief histories of several hereditary diseases and the scientists and clinicians who developed screening tests for them. Of the thousands of genetic diseases, Cowan focuses on a handful that are atypical in that they are well understood biochemically, genetically and sociologically. These include Tay–Sachs disease and phenylketonuria, which result from enzyme deficiencies, and sickle-cell anaemia and β-thalassaemia, which arise from defects in β-haemoglobin, one of the most studied of all proteins. For each disease, the probability of clinical expression given a specific genotype is very high, making predictions reliable and early detection routine.

The consequences of these diseases remain devastating to patients and their families. This is especially true in the case of phenylketonuria, where a delayed diagnosis may result in irreversible brain damage. Physicians, parents, patients and insurance providers all agree on the benefits of identifying carriers of the mutant genes or diagnosing disease either *in utero* or at the time of birth, and identification protocols have been crafted that are acceptable to most. The greatest disagreements centre on what action to take once we have this genetic information.

The author's brief history of eugenics presses the point that medical genetics owes no apologies to society. There is no overlap between those who care for patients with genetic disease and anyone who has advocated the purification of the general germplasm through genetic isolation, including sterilization. This is obvious given that eugenics as public policy and as science met its deserved end in the first half of the twentieth century, whereas medical genetics as a sub-speciality formally began in the 1950s when Victor McKusick opened the Moore Clinic at the Johns Hopkins Hospital in Baltimore, Maryland.

That medical genetics and eugenics sprang from the same scientific soil has given ground to a small chorus of opponents to genetic screening. Trying to pull the ugly thread of eugenics through the fabric of genetics to discredit it, these opponents range from what Cowan calls 'reproductive feminists' to advocates of rights for people with disabilities, and span both the political left and right. This is not to dismiss the defensible reasons to object to population-based screening for specific diseases.

Clinical variability can be huge, even for specific genotypes, so the decision to establish a screening programme is not straightforward. Every medical geneticist has been confronted by the fluid meaning of disability. Despite clear clinical challenges, many deaf people, for example, do not consider themselves disabled and rightly



Before being implanted in the womb, human embryos fertilized in the lab are genetically tested.

P. GOETGHELUCK/SCIENCE PHOTO LIBRARY