LETTERS

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Parsing the Evolution of Language

WHILE NOAH WEBSTER MAY HAVE PRODUCED THE EARLIEST COMPENDIUM ON AMERICAN English, the divergence from British English dates from much earlier. Long before the publication of Webster's Dictionary in 1806, pronunciation in America and in Britain had begun to differ (*1*, *2*). The Dictionary thus does not mark a fixed point when all Americans shifted abruptly from British to American English. The speciation, rather, was gradual, because individual speakers change gradually, by increments, in their lifetimes; individual changes also spread gradually from speaker to speaker.

In the Brevia "Languages evolve in punctuational bursts" (1 February, p. 588), Q. D. Atkinson *et al*. are right that there has yet to be an experimental demonstration of "punctuational bursts" that mark the evolution of language. However, the idea that language evolution proceeds in "bursts" of change alternating with periods of stasis has long been recognized in linguistics. Although there are periods in language evolution when population-wide changes are less noticeable, this does not mean that when changes are noticed they must have occurred abruptly. They are gradual even if their spread within a population took only a few decades.

We believe there is a difference between rapid changes, which can still be incremental, and abrupt changes, as when one speaker says "baht" or "bet" when "bat" is intended. When such a change spreads within a population, it does not affect every word that, for instance, has the American vowel sound of bat (such as pat and lack) simultaneously, nor does every member of the relevant population of speakers participate in the process at a given time.

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Response

IN OUR BREVIA, WE USED THE EXAMPLE OF Webster's Dictionary—widely regarded as the inaugurating dictionary of American English—to illustrate how the desire for a distinct social identity can motivate language changes, such as spelling. Of course, some changes may have begun much earlier. We are not aware that anyone has measured how rapid or gradual these changes were by using the sorts of quantitative methods we have developed, but it would be informative to do so.

Phylogenies use nodes to summarize the outcome of population-level processes that, working forward in time, give rise to distinct entities, be they species or languages. Our statistical methods can detect whether these events occur relatively abruptly or more gradually (*1*–*3*). They do so by detecting whether an excess of evolutionary divergence arises in association with the number of times a new species or language has emerged on a phylogeny. They do not make assumptions about precisely when these species or languages emerged.

Changes to languages that occur over a few decades may seem gradual at the time but can be relatively abrupt in the lifetime of a language or language family. As an example, the frequency with which meanings are used in everyday language affects their rate of word replacement over thousands of years (*4*). Some words are replaced dozens of times in the history of a language family (such as the word for "bird" in Indo-European) while others may never be replaced (such as the word for "two").

To speakers "on the ground" even these extremes are probably indistinguishable, but over historical time they give rise to very different outcomes.

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Inspecting Urban Health

C. DYE'S PERSPECTIVE, "HEALTH AND URBAN living" (8 February, p. 766), provided an excellent overview of the history and trends of health in urban areas but is silent on some key issues. In addition to comparisons of urban and rural health, the growing urban health research field has benefited from examining health within urban communities (*1*–*5*). These studies have helped expose the wide disparities between the rich and poor not only in environmental health but also in health outcomes (*6*). Wilkinson *et al*., in a review of more than 150 studies, found that "health is less good in societies where income differences are bigger" (*7*).

The most likely underlying reason for the

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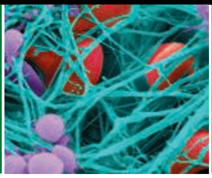

Blood clot elasticity

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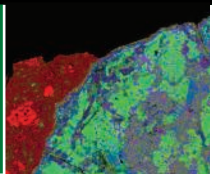

Identifying ancient asteroids

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disparities in health is not, as Dye suggests, "governance and the organization of civil society," but rather structural problems such as inequality, poverty, debt, globalization, unemployment, and education (*8*). Many of these are indeed governance-related, but others fall squarely in the realm of global and national economics. In contrast to Dye's proposal that "a nation may now be judged by the health of its urban majority," I suggest that nations be judged by the health of their most vulnerable, especially the urban migrants, children, and residents of urban slums and informal settlements.

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Response

MY REVIEW OF CHILD MORTALITY CONCLUDED not only that urban inhabitants enjoy better health on average than their rural counterparts but also that the benefits of urban living are greater for the rich than for the poor, thus magnifying the differences between them. The sites included in my review were mostly in low- and middle-income countries, and this picture of better but more uneven urban health may not apply in richer parts of the world. In England, for example, the concentration of relatively poor people now living in London and in other large metropolitan areas means that infant mortality rates are equal to or higher than the national average (*1*).

Among the factors that determine the distribution of ill health in populations, I predict that governance will indeed turn out to be vital in many countries. However, to find out whether this is right or wrong, we need to carry out substantial investigations of the structural causes, which will identify the functional relations between unemployment, education, and poverty (however measured), and how these act as determinants of health.

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The Quest for Stronger, Tougher Materials

THE PERSPECTIVE "STRUCTURAL NANOcomposites" (Y. Dzenis, 25 January, p. 419) describes a quest for improved structural materials and indicates that composites with nanoscale reinforcements would have "exceptional mechanical properties." Is this true?

Why would reinforcements that are small in size or volume offer any particular benefit over larger-scale reinforcements? As the Perspective correctly asserts, if the composite material is to be used for a small-volume structure, clearly the reinforcements must also be small. In addition, small-volume reinforcements are stronger, as has been known since the early days of research on whiskers (*1*). In this regard, reinforcement by carbon nanotubes, for example, which are thought of as one of the strongest materials in existence (*2*), would seem ideal.

The problem with this notion is that new materials are not limited by strength, but by resistance to fracture (also known as fracture toughness). It is not by accident that most critical structures, such as bridges, ships, and nuclear pressure vessels, are manufactured from materials that are low in strength but high in toughness. Indeed, the majority of toughening mechanisms mentioned by Dzenis—i.e., crack deflection, plastic deformation, and crack bridging—are promoted by increasing, not decreasing, reinforcement dimensions [e.g., (*3*)]. Is it any surprise that "results obtained so far are disappointing"?

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Response

RITCHIE'S REJECTION OF STRENGTH IN FAVOR OF toughness is perfectly suitable for ceramics but can be less appropriate when applied to other materials, such as polymers or even metals. Advanced polymer composites—a class of lightweight, strong, and stiff materials based on high-performance continuous fibers—are now being used in a variety of critical applications, such as primary aerospace structures. Unlike metals, these composites do not experience large deformations before failure. Instead, a degree of toughness is provided by multiple damage and crack accumulation and deflection mechanisms, many involving strong fibers. There is high interest in further improving composites' strength and other mechanical properties, as exemplified by the continuous industrial effort to produce stronger reinforcing fibers. For some of the fibers (e.g., carbon, glass, and ceramic fibers), higher strength has been linked, among other factors, to finer fiber diameters.

From a composites perspective, it was only natural to try to use the strength of nanoscale reinforcement, such as carbon nanotubes, in a superstrong and lightweight composite. Early predictions were optimistic (*1–3*). However, as Ritchie correctly asserts, the question of whether nanoscale materials will be beneficial to bulk structural materials is still open to discussion. Experience with high-strength polymer composites calls for a strong interface and high volume fraction of nanoreinforcement. Research to date has not uncovered any fundamental drawbacks for achieving these, except for possible deterioration of the intrinsic carbon nanotube strength as a result of covalent bonding, as mentioned in the Perspective. The situation is more complex with regard to toughness. The benefits of larger reinforcement diameters mentioned by Ritchie may not be universal. After all, there are multiple toughening mechanisms in composites, and some of them can be expected to benefit from the enhanced strength and resilience of nanoreinforcement and/or its larger surface-to-volume ratio. There is experimental evidence of improvements in toughness of brittle materials as a result of carbon nanotube nanoreinforcement (*4*, *5*). Continuous nanofibers (*6*) are also expected to produce improvements while removing some of the problems associated with discontinuous nanomaterials. Yet, clearly more studies are needed to elucidate the fundamentals of fracture in the nanoreinforced materials, including possible limiting effects of small scale.

Finally, toughness and strength are not always mutually exclusive. True, for the intrinsically ductile materials, such as metals, improvements in strength usually come at the expense of toughness. However, for brittle materials, such as ceramics, in the presence of flaws that individually cause fracture, strength can be proportional to toughness. In the example used in the Perspective, we used nanoscale reinforcement to toughen the thin interfacial layers in advanced composites. We expect this to result in improvements in composite strength, as well as fatigue durability and impact resistance. Similar effects can be predicted for other medium-term applications described in the Perspective. We will continue to hope for a time when we can demonstrate the existence of bulk supernanocomposites (defined as nanocomposites exceeding the performance of modern advanced fiber-reinforced composites).

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TECHNICAL COMMENT ABSTRACTS

COMMENT ON "Eddy/Wind Interactions Stimulate Extraordinary Mid-Ocean Plankton Blooms"

Amala Mahadevan, Leif N. Thomas, Amit Tandon

McGillicuddy *et al*. (Reports, 18 May 2007, p. 1021) proposed that eddy/wind interactions enhance the vertical nutrient flux in mode-water eddies, thus feeding large mid-ocean plankton blooms. We argue that the supply of nutrients to ocean eddies is most likely affected by submesoscale processes that act along the periphery of eddies and can induce vertical velocities several times larger than those due to eddy/wind interactions.

Full text at www.sciencemag.org/cgi/content/full/320/5875/448b

RESPONSE TO COMMENT ON "Eddy/Wind Interactions Stimulate Extraordinary Mid-Ocean Plankton Blooms"

Dennis J. McGillicuddy Jr., James R. Ledwell, Laurence A. Anderson

The alternative mechanism proposed by Mahadevan *et al*. is an unlikely explanation for our observations because their model predicts a bloom at the periphery of the eddy, whereas the observations show it located at the eddy center, and because the vertical displacements caused by the nonlinear Ekman effect are too small to lead to an extraordinary biological response in this eddy.

Full text at www.sciencemag.org/cgi/content/full/320/5875/448c

Letters to the Editor

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