LETTERS

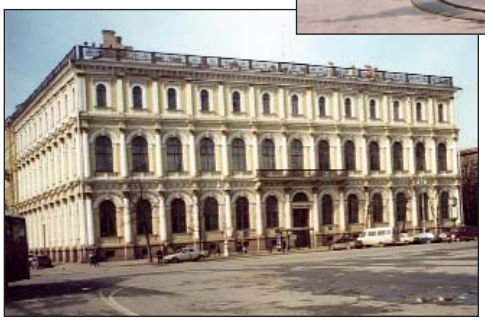
Letters to the Editor

Letters (~300 words) discuss material published in *Science* in the previous 6 months or issues of general interest. They can be submitted by e-mail (science_letters@aaas.org), the Web (www.letter2science.org), or regular mail (1200 New York Ave., NW, Washington, DC 20005, USA). Letters are not acknowledged upon receipt, nor are authors generally consulted before publication. Whether published in full or in part, letters are subject to editing for clarity and space.

A History Lesson for President Putin?

SOMEONE SHOULD INFORM RUSSIAN President Vladimir Putin, who is seeking to displace scientists and germ plasm at the Vavilov Institute of Plant Industry so federal bureaucrats can move into the space ("Prestigious plant institute in jeopardy," News of the Week, 31 Jan., p. 641), that 61 years ago, several Vavilov scientists sacrificed their lives in a truly heroic, unprecedented, and ultimately successful effort to preserve the Institute's invaluable seed collections (*1*). During the 880-day seige of Leningrad by the Germans during World War II, tens of thousands of city residents died of starvation. Fully understanding that the country's agricultural future depended on their ability to preserve the Institute's diverse gene stocks, the scientists knew that they must protect the collections, which were largely made up of seeds, fruits, and tubers, all very edible and nutritious. The scientists divided and dispersed some of the collections and guarded others around the clock.

Despite being severely undernourished themselves and despite working within meters of a vast supply of food, the scientists chose death over depleting the country's genetic heritage. A total of eight of Vavilov's scientists died in 1942, and at least one, Alexander G. Stchukin, a peanut specialist, actually died at his desk (*1*). Putin should make sure these true Russian heroes did not die in vain. Rather than trying to supplant the Institute, Putin and his advisers should be taking steps to protect the underfunded and embattled gene bank (the second largest in the world), so that Russia's agricultural genetic diversity can be preserved and used to help feed Russia's future generations.



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Cranial Base Flexion and *H. Erectus* Skulls

OUR HYPOTHESIS ABOUT THE ROLE OF cranial base flexion in the evolution of modern human cranial form is mischaracterized by Ann Gibbons in her article "Java skull offers new view of *Homo erectus* (News of the Week, 28 Feb., p. 1293). The highly flexed cranial base angle of the new *H. erectus* skull from Java, Sm 4, is extremely interesting but would not be expected to have a simple relationship to aspects of overall cranial shape such as neurocranial globularity (the three-dimensional roundedness of the cranial vault) because of substantial interactions that occur between the cranial base and both the brain and the face (*1*). Indeed, other hominid species such as *Paranthropus boisei* are known to have flexed cranial bases without globular skulls or retracted faces (*2*). Our study (*3*), which focused solely on the evolutionary transformation of modern humans from archaic *Homo* (and thus did not include any *H. erectus* skulls), proposed that increased cranial base flexion in combination with a large brain and a smaller face contributes to facial retraction and neurocranial globularity. So far, we know of no archaic *Homo* crania with a large brain and a flexed cranial base in the range of modern *H. sapiens*. Sm 4 has a flexed cranial base (141°) but also has a small brain (1006 cm^3) and a presumably large face. As midsagittal flexion alone does not play a decisive role in either facial retraction, facial projection, or neurocranial globularity, we would not expect Sm 4 to have either a globular neurocranium or a retracted face. Contrary to what was reported, our hypothesis would require modification only if additional *H. erectus* skulls were found with very flexed cranial bases combined with large brains and small faces, but which did not have globular cranial vaults and retracted faces.

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Revisiting Disorder and Tsallis Statistics

IN HIS ARTICLE, "A FRESH TAKE ON DISORDER, or disorderly science?" (News Focus, 23 Aug., p. 1268), Adrian Cho reports on a new theory of disorder. It may be useful to the reader to supplement this discussion with more substantive information (*1–4*). First, it is essential to note that this new theory, known as "Tsallis statistics," is not concerned with thermal equilibrium of simple systems, but with meta-equilibrium states of complex systems (such as nonlinear systems at the edge of chaos). What is remarkable is that, phenomenologically, such complex systems have fairly long lifetimes and therefore may be described by a generalized entropic principle different from the traditional Boltzmann-Gibbs (BG) form, even though they may finally approach the equilibrium BG state. Therefore, any generalization should subsume the BG state as a particular case. One may suspect that there are many possible candidates for such generalized entropies. However, the macroscopic principles of thermodynamics and the microscopic dynamical principles put serious constraints on the nature of such a possibility (e.g., finite entropy production rate).

So far, the entropy associated with Tsallis statistics seems to be a unique one that satisfies all these essential requirements (the macroscopic principles of thermodynamics and the microscopic dynamical principles). In addition, this theory explains the behaviors of a variety of complex systems, such as collossal magnetoresistance, amorphous and glassy nanoclusters, and high-energy collision processes, which are all examples of nonequilibrium phenomena.

Just as the BG theory successfully explained the equilibrium features of simple systems, the Tsallis theory explicates nonequilibrium stationary features of complex systems.

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AS AN ACTIVE WORKER IN THE "PHYSICS OF information" field, I think that parts of Adrian Cho's article "A fresh take on disorder, or disorderly science?" (News Focus, 23 Aug., p. 1268) could be construed as misleading.

As far as I know, most workers in the field of Tsallis statistics are not interested in replacing Boltzmann-Gibbs entropy S with Tsallis' entropic form S_q, for the usual systems whose thermal equilibrium is consistent with ergodicity. However, there is no doubt that on many occasions, for specific (but important) physics problems, the form S_q has been found to be a preferable alternative to S.

Let us denote with C_S the set of physical contexts for which, as shown by Jaynes (*1*, *2*), Shannon's measure can be placed in a one-to-one correspondence with Boltzmann-Gibbs' entropic form S. This is a large set indeed. Workers in nonextensive statistics have likewise shown that the Tsallis entropic form S_q can be placed into a one-to-one correspondence with an information measure I_T that derives from an axiomatic slightly different from that of Kinchin (which yields Shannon's measure).

A large body of recent literature (about 1000 papers) makes it absolutely clear that either S_q (or I_T) is the appropriate entropic form (or information measure) for the description of physical features in other scenarios, not usually associated with C_S. In a similar vein as above, let us call C_T the associated set. Trivially, C_T includes C_S, because S_q is a generalization of S. If a special parameter of the entropic form/information measure (called q) tends to unity, S_q tends to S. There is no large overlap between C_S and C_T for q different from unity. The exploration of new, suitable environments belonging to C_T is a quite reasonable, valid, and exciting field of endeavor. It is not at all disorderly. In any case, one might argue that "orderly" fields would be those established ones in which all the fundamental issues are well understood and no new frontiers are easily discernible.

A large part of the nonextensive statistics work is of an entirely formal and analytical nature. I am persuaded that, in most of the material that has been published, there is no "mindless curve-fitting" at all, as reported in the article.

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IN HIS ARTICLE "A FRESH TAKE ON DISORDER, or disorderly science?" (News Focus, 23 Aug. p. 1268), Adrian Cho treats the controversial topic of Tsallis entropy with a look at both sides of the argument. The Tsallis formalism (*1*, *2*) has attracted much interest, but it has yet to achieve universal acceptance of its usefulness in physical applications.

It does have physical relevance when describing states of systems with hindered or fractal phase space. This is illustrated in the case of low-dimensional maps at critical transitions where the ordinary Lyapunov exponent vanishes, as happens for all the tangent and pitchfork bifurcations of unimodal maps and, even more dramatically, at the edge of chaos. In this case, the actual value of the entropic index q to be used is unambiguously related to the universal properties of the map critical states and is determined with as much precision as desired. Actually, q can be calculated from the algebraic sensitivity to initial conditions (*3*, *4*), from the attractor's fractal spectrum (*5*), from the linear increase of generalized entropy (*6*), and, as recently and rigorously derived (*7*, *8*), also from Feigenbaum's Renormalization Group transformation. It also provides an analytical link between the generalized Lyapunov exponent and the generalized Kolmogorov-Sinai entropy, thereby establishing a further connection between dynamical systems and statistical mechanics. These findings seem to be quite general and have been confirmed for several two-dimensional maps (*9*).

Some physicists could argue that low-dimensional maps have little overlap with statistical mechanics and that, in order to prove the Tsallis entropy's real deep foundation, it is still necessary to determine states of Hamiltonian systems where the Tsallis entropy rigorously applies. These studies are in progress, and a connection between many-body Hamiltonian states (*10*) and Tsallis formalism has already been reported (*11*). Nevertheless, the Feigenbaum constant can be measured in real experiments and, for the reasons and results stated above, it would

seem difficult to deny a fundamental physical basis to the Tsallis entropy.

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Malnutrition, Disease, and the Developing World

WE COMMEND THE GENEROSITY OF BILL GATES for his plan to reduce human diseases, especially in developing countries ("Bill Gates plans a hit list, with NIH's help," M. Enserink, 31 Jan., p. 641). Tuberculosis, malaria, AIDS, and other diseases are increasing worldwide (*1*). One of the factors contributing to these increases is a rise in malnutrition, which is making people more susceptible to a wide array of diseases. According to the World Health Organization, more than 3 billion people worldwide are malnourished (including calorie, protein, vitamins, iron, and iodine deficiencies) (*2*). People are dying from any one or combinations of nutrient deficiencies, but of equal concern is their increased susceptibility to infections.

Unfortunately, to successfully tackle the problem of human diseases, we cannot deal only with one aspect of the problem. World population is increasing rapidly and is projected to double to 12 billion in about 50 years (*3*). Food production per capita, based on cereal grains, which are estimated to provide about 80% of the world's food, has been declining for nearly two decades (*4*). More than 99% of the world's food comes from agriculture.

Growing water shortages are plaguing agricultural production. Agriculture consumes more than 70% of the world's fresh water (*5*). In some areas, water is so polluted that it is unsafe for agricultural production and human use. Reports indicate that 90% of human infections with diseases in developing countries are attributed to polluted water (*6*).

Thus, we encourage a holistic approach to reducing the disease burden in developing countries. Such an effort would include reducing population growth, increasing the food nutrient supply, providing clean sources of fresh water, and researching prevention and treatment of the various diseases plaguing humans. Placing emphasis only on measures to decrease death rates, without at the same time dealing with the factors that affect birth rates, would greatly exacerbate the world's population problem (*7*). In addition, improving economic development, increasing education and political stability, and increasing support of research are needed to help reduce the human burden of diseases and malnutrition.

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CORRECTIONS AND CLARIFICATIONS

News of the Week: "Distant quasars give astronomers a massive puzzle" by D. Normile (28 March, p. 1962). The title of this article should have been "Distant galaxies gauge young cosmos's fecundity."

Reports: "Protein insertion into the mitochondrial inner membrane by a twin-pore translocase" by P. Rehling *et al.* (14 March, p. 1747) In the third sentence of the abstract, the word "losing" was mistakenly substituted for "using." The sentence should read "After the precursor is tethered to the translocase without using energy from the $\Delta\psi$..."

Policy Forum: "Before it's too late—addressing genetic information" by K. H. Rothenberg and S. F. Terry (12 July, p. 196). Reference 6 was incorrect. The reference should be E. Matloff *et al., J. Clin. Oncol.* **18**, 2484 (2000).