

xraser and reduce the estimated time it would take to perfect the system.

Then, in 1985, a Nevada test demonstrated the effectiveness of a plasma lens for focusing and directing xraser beams. This test blew the lid off even the most optimistic previous projection. While there is still a significant scientific debate on the interpretation of the 1985 results, Dr. Teller stands by the projections he made at that time. Moreover, there are indications that new information on these results will shortly be released.

In any case, the projection for the xraser improved, such that instead of envisaging the development of a system only capable of intercepting slower, submarine-launched ballistic and intermediate-range missiles in their boost phase, the accepted estimate was that a single xraser module could generate upward of 100,000 individual beams, each capable of functionally disabling, if not physically destroying, the hardest targets, such as reentry vehicles and warheads.

### Vindication: the GAO report

The June 1988 GAO report, "Accuracy of Statements Concerning DOE's X-Ray Laser Research Program," presented the following "Summary of Findings":

"We found that the LLNL official channel, which included Mr. Woodruff, had made statements about the status and potential of the x-ray laser, which were similar to most of the statements identified by Mr. Woodruff as being 'overly optimistic and technically incorrect.'

"Mr. Woodruff prepared letters to send to [presidential science adviser] Dr. Keyworth and [arms negotiation] Ambassador Nitze clarifying the statements made by Dr. Teller. However, Dr. Batzel said that he preferred that Mr. Woodruff's clarifying letters not be sent [because Woodruff's letters included funding projections which Batzel did not think it proper to present to Keyworth and Nitze before sending these funding proposals through proper channels, as later detailed in the GAO report], and they were not. We found that Mr. Woodruff presented his opinions on information that had been provided by Dr. Teller to Dr. Keyworth and Ambassador Nitze. Mr. Woodruff told us he did not have opportunities to present his views to Mr. McFarlane and Mr. Casey.

"In addition, we asked selected LLNL scientists, who had specific knowledge about the x-ray laser program, for their opinions as to the accuracy of the statements challenged by Mr. Woodruff. From these interviews, we concluded there was no general agreement among these scientists regarding the accuracy of the statements. . . ."

The GAO report also quoted a Department of Energy (DOE) review of the statements of Drs. Teller and Wood:

". . . In summary, they found that Drs. Teller and Wood were optimistic about the potential of the x-ray laser. They concluded that the views of Drs. Teller and Wood were presented as views of individual scientists and not represented as the official position of LLNL."

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## Book Reviews

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# NATO is into chaos

by Warren J. Hamerman

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### Chaos in Biological Systems

ed. by H. Degn, A. Holden, and L. Olsen

Plenum Press, New York, N.Y. 1987

323 pages with index, \$62.50 hardbound

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For four days in December 1986, the NATO military alliance sponsored an "Advanced Research Workshop" at Dyffryn House, Cardiff, Wales on the seemingly unlikely theme of "chaos" in biological systems. In this volume of the proceedings of the NATO seminar, one can read papers of some 75 scientists which prove, among other things, that:

- the dynamics of a healthy heart beating is pure chaos, while disease and arrhythmias are orderly;
- the oscillatory water transpiration in plants is governed by pure chaos;
- platelet production in the healthy person is random and chaotic;
- "chaos" runs everything from cell behavior and nerve impulses to the ecology and epidemics.

At the workshop, NATO reviewed "chaos models" in the following organisms: man, rabbits, plants, squids, and mollusks.

While the reader will have no trouble accepting that "chaos" took over our foreign policy and economy, he or she may be startled to learn that scientists around the world in every conceivable discipline are trying to elevate "chaos" to the level of a full-scale universal theory of all natural processes.

Recently, science journals in every field—from physics and meteorology to mathematics and biology—have been flooded with articles and reports which claim to prove that "chaos" explains everything.

Teams of computer programmers are racing to outdo each other in showing "chaos" on the screen in full-color graphics. A newspaper reporter has written a popular nonfiction best-seller which explains to the ordinary man just how important chaos is, and how, in a few years, it grew from being the pet project of a few crankish computer scientists to the fastest-spreading religion since Islam.

The chaos model promotes itself *falsely* as the *only* alternative to static, equilibrium systems characterized by linear dynamics. It maps complex physiological structures and pro-

cesses with multiple scales of length and time. The chaotic model is everywhere unstable and everywhere unpredictable. Against a background of pure turbulence, random and irregular "bifurcations" are provoked. Chaos "accumulates" in certain areas. Out of this mess, therefore, computers generate points of "strange attraction" around which patterns form. The complex and irregular shapes which appear on the screen look like a computer's Rohrschak Test which the experts can interpret. Some of the chaos-salesmen modestly call their projects the "New Art" as well as "the" universal scientific theory.

There is an alternative to both the static equilibrium model and the chaos model.

The classical scientific tradition of Leonardo da Vinci and Johannes Kepler through Karl Gauss and Bernhard Riemann in the last century intensively studied and "modeled" nonlinear complex processes. What is present in their work and absent in the chaos models, is that the process is characterized by *self-development*, not statistical randomness.

Just as computer simulations of "artificial intelligence" are intrinsically incapable of replicating human creative mentation, the chaos models are a crude simplification of self-developing living processes.

The alternative to chaos and linearity alike is the beauty embodied in the common geometry and tuning system of the heavens, classical music, and living processes. The human singing voice, the harmonies of the planets, and the harmonies of the biosphere, are all tuned to the well-tempered musical scale based on  $C = 256$ . We have recently demonstrated, for instance, that one can study the harmonies of living processes by organizing their interactions with light—their nonlinear optical spectra—into three octaves: a "pre-biotic" octave, a "higher life" octave, and a "lower life" octave. When the characteristic wavelengths associated with fundamental biological processes such as photosynthesis, mitosis, vision, and growth (e.g., the absorption bands of chlorophyll, DNA, and proteins) are normalized to a tuning system of  $C-256$ , they correspond precisely with the tones of the musical scale out of which all great music has been composed. Beauty is the fundamental characteristic of our universe. Without classical proportion and creative self-development, there is merely chaos.

## Books Received

**The Overview Effect: Space, Exploration and Human Evolution**, by Frank White, Forward by Gerard O'Neill, Houghton-Mifflin, New York, 1987, \$18.95 hardbound, 304pp.

**Spy-tech**, by Graham Yost, Facts On File, New York, 1985, \$10.95 paper, 288pp.

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