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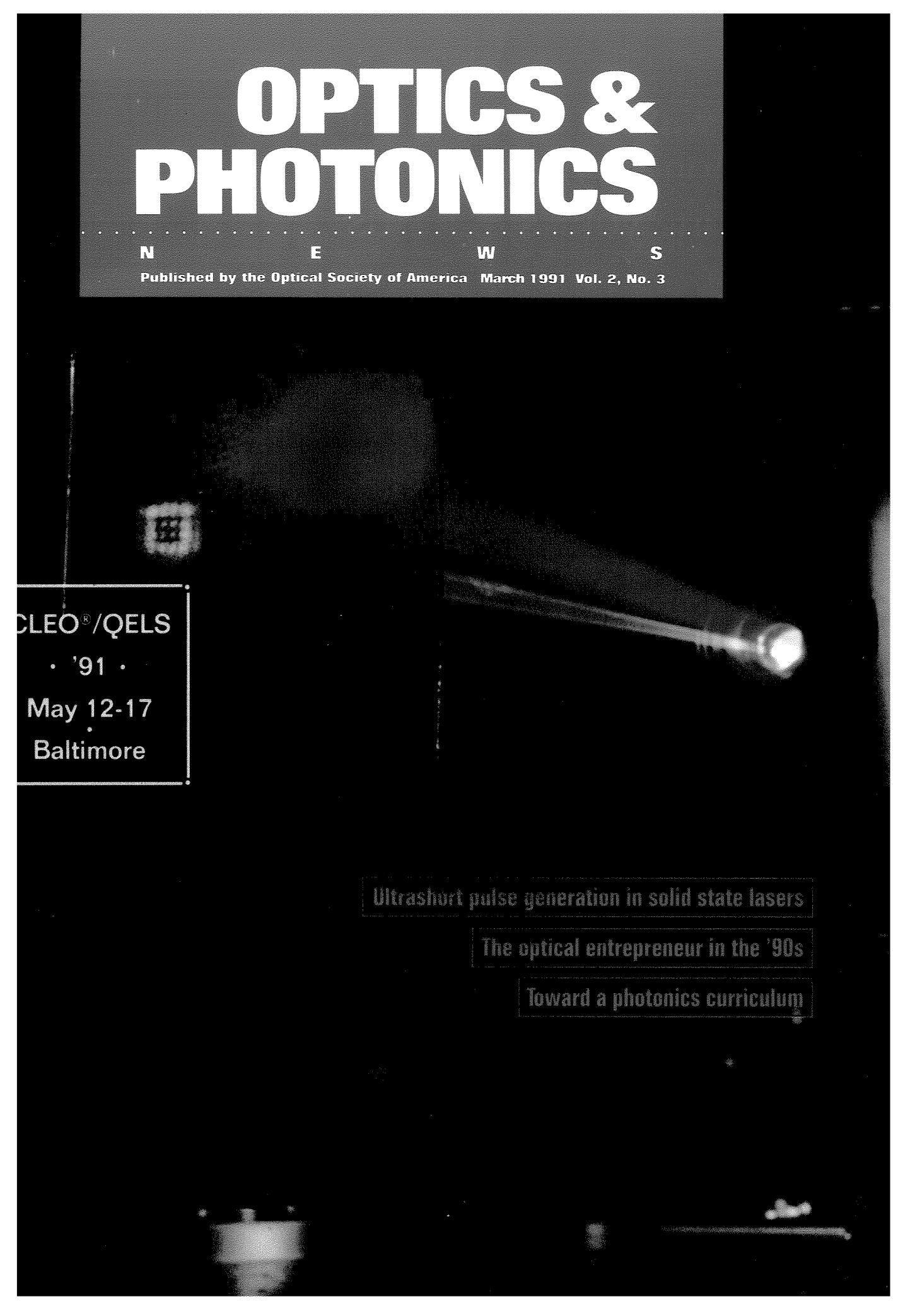

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From Hollywood with love: A Bronowskian view of science

He was dressed all slovenly and untidy, in a great gown..., with a cap...; and a long old flapped waistcoat; with no braces, no strings, very few buttons...Tom knew by these signs, and by his not being shaved, and by his not being over-clean, and by a sort of wisdom not quite awake...that he was a scientific gentleman.–Charles Dickens, The Lamplighter (1841).

The cultural expressions of any society are not only produced by the scientific and technological skills that society possesses at the time, but they also reflect the state of its scientific knowledge and technological achievements. Early cinema portrayed scientists modeled after Arthur Conan Doyle's Professor Challenger, their exploits reminiscent of the intrepid European explorers[1] who brought tall tales of the mysterious to their compatriots. It would appear from such movies that these Linnaean scientists lived only to catalog the unusual and the strange, and to haul specimens—dead or alive—into European capitals for the public to view in their Sunday best for a shilling per person.

As cinema (and later, television) evolved, so did the image of the scientist. From being the tight-lipped doer of wondrous deeds with fierce-looking machines initially, Dr. Zharkov of the Flash Gordon series came to be a suave individual explaining (bizarre) scientific ideas in a seemingly logical fashion. Dr. Spock of the Star Trek series took this metamorphosis further: the cold rationality of his logic gave his human (except for his ears) countenance the lie.

At least Dr. Spock was a Vulcan with a three-chambered heart. But human scientists on the screen also became Spock-esque, as typified in the Godzilla movies usually set in a crumbling Tokyo: the scientist, in his thirties and a lab smock, is shown working away amidst retorts, burettes, and Ruhmkorff coils, with a demure female assistant in the background. But he does not care for her until the monster is about to snatch her away. Then, in the nick of time, the scientist fires a gun loaded with his yet untested monster-tranquilizing compound NC@P$*43S; an irritated Godzilla backs off from Tokyo, leaving a swooned female in the young man's arms.

This lack of human dimensions came to be rectified. On screen, the scientist became flashily debonair "Batman," pleasantly eccentric "Chitti Chitti Bang Bang," downright idiotic (in many cartoon films), simply evil "The Island of Dr. Moreau," or entrepreneurial for the sake of love "It Happens Every Spring."

Since this magazine is meant for opticspeople, I chose cinema to introduce my thoughts; but I believe other classes of artistic and literary endeavors will also yield similarly to similar enquiry. But cinema, being intensely visual as well as a truly mass medium, shapes public perspectives much more rapidly than any other form of cultural expression.

Science: From magic to panacea to magic

During the European Dark Ages and earlier, scientists were imbued with extra-causal world-views and conveyed their musings only to select disciples.[2] Not surprisingly, the public responded by labeling them as sorcerers and witches, and held SCIENCE to be MAGIC. This last sentence begs the question: What is science? In answering it, I can do no better than to summarize Jacob Bronowski:[3] Science is the refinement of communication to convey precise ideas about our perceptions of Nature, and must have (or aim to have) predictive content.

The coming of the mechanistic world-view in Europe—aided and abetted by Nicolaus Copernicus (1473-1543) Francis Bacon (1561-1626), Galileo Galilei (1564-1642), Johannes Kepler (1571-1630), Rene Descartes (1596-1650), John Locke (1632-1704), and Isaac Newton (1643-1727), among others—began to alter the practice of science. Increasing use of the Hindu-Arabic numerals made computations less tedious;[4] in turn, this pointed to the use of mathematics as a precise and compact language for the conveyance of both information and knowledge.

Almost concurrently came the printing press. Mass production of books led to the dissemination of ideas far and wide, as scientists began to publish their findings in books.[5] This contributed to, and was aided by, the evolving democratization of the European political order. More importantly, as Peter Medawar has eloquently pointed out,[6] the practice of science steadily became a mass enterprise as science came to be taught in schools and schools multiplied. Over some two centuries, science gradually turned from being perceived as magic to being thought of as a panacea:[7] The ills of the world had just to be cast in terms of precise mathematical equations to find the remedies. True, this scheme of things would take time; so what?

All through this century, scientists have contended with what Morris Kline[8] has called "the loss of certainty." And, though science-literate individuals are in the know, this new facet has not yet permeated science and technology policies. Indeed, the public and its lead-

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ers increasingly demand instant gratification[9] from investments in science. I see this on several planes. Calculators appear to have replaced arithmetic skills, even in the high school. Many undergraduate students study science or engineering just to secure highly paid employment; many graduate students tend to deify computer printouts; many professors so intently chase research dollars that they get to experience the thrill of discovery secondhand, if at all. Industrial sponsorship of academic research programs seems to require successful outcomes even before funds begin to flow. Legislatures fund research programs to up the ante against the enemy of the day. With my apologies to Bronowski,[10] the scientific personnel in the "Star Trek - The New Generation" series rely on an individual endowed with ESP, and SCIENCE is rapidly being perceived as MAGIC once more.[11]

Who's responsible?

It is wise to ponder how scientists may be responsible for this relapse. First, scientists contribute—actively or otherwise—to myth-making.[12] As an example, a mathematician of repute recently confessed his fear of looking up telephone directories to a journalist,[13] perhaps in an attempt to glorify his achievements by contrast. Writers of glib textbooks in established fields also contribute to mythicizing science,[14] though that may not be a grievous crime since it is perpetrated only on the initiates.

Second, scientists are popularly considered ignorant of what goes on around them. That may not be appalling, however, compared to the ignorance many display about their own and related disciplines. In an address to the Paris Academy of Sciences,[15] "the difficulty even the most active scientists have today to keep themselves up-to-date with the very numerous publications..." was pointed out. The address was delivered in 1872 and the problem has not abated! (I will not mention here lapses, unknowingly or otherwise, of citation in literature; nor will I comment on the impervious shrouds many scientists cover their research topics with.)

Third, the establishmentarians among scientists generally refuse to examine new paradigms on their merits. Scientists are quite conservative, and rightly so, in most instances. After all, scientific fraud can be perpetrated all too easily.[16] The flip side is the flirtation some indulge in with science journalists.[17] (Should I mention the escapades of the two cold-fusion scientists?) When scientists elevate the public's hopes to unreasonable levels in interviews with the press, they do everyone involved a disservice. But, alas, sensation sells!

Science vs. technology?

Scientists are not immune to political and/or economic forces. Societal pressures on them stem from the confusion between science and technology:[18] While science is an ongoing attempt to better communicate about Nature, technological research is comprised of problem-solving exercises for immediate societal benefits. Scientific and technological research efforts are not necessarily at odds with each other, and oftentimes reinforce each other.[19] But the fact remains that their missions are not identical and may actually be divergent in certain instances.

Bronowski identified two major impediments to progress in science: secrecy and ideology. Whereas secrecy may be necessary to maintain technological edges,[20] and hence commercial and/or military ones, it does distort the open plan of science.[21] Scientists must be free to air their views and findings in open forums; otherwise, intellectual development is stunted. Somewhat closely allied is the impact of ideology:[22] It warps the democratic values inherent in science and invites eventual retribution. Examples abound: Lysenko's psychiatry in a Stalinist police state, Mengele's quasi-medical experiments during the Shoah, nuclear irradiation of the Marshall Islanders during the 1950s.

When Bronowski delivered his Bampton Lectures,[2] the Great Society experiment was still going on in the United States. A third societal impediment to science has since emerged: avarice. The lust for immediate profits impels governmental and industrial funding to be channelled away from science; it also degrades education by pyramidizing universities according to their research expenditures. Whereas societal funding is necessary for progress in science, it is ludicrous to believe that doubling the expenditures will necessarily double either the amount of scientific knowledge or the rate of acquisition.

Yes, Virginia, the responsibility of scientists in these circumstances is particularly acute. Having come so far from magical practices, they must continue to aim relentlessly at the Lamarckian evolution of the entire humanity, not to mention the welfare of our mothership itself. Or else, the practice of science will decay to a degree when its resuscitation may well nigh become impossible.

I conclude with a thought that must have occurred to many, but was so succiently put by Whewell:[23]

The popular mind is caught by the character of an eventful narrative which the anecdote gives to this occurrence; and by the antithesis which makes a profound theory appear the result of a trivial accident.

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Continued on page 62

Crosstalk—from page 7

3. J. Bronowski, *Magic, Science, and Civilization*, Columbia University Press, New York, 1978, 46-49.
4. G. Ifrah, *From One to Zero*, Viking Penguin, New York, 1985, 475-484.
5. T.S. Kuhn, *The Structure of Scientific Revolutions*, New American Library, New York, 1986, 16.
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7. J. Fauvel, *et al.*, *Let Newton Be!*, Oxford University Press, Oxford, 1988, 127.
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9. On the modern ill of incessantly seeking instant gratification, my sole comment here is to nudge the reader to a splendid essay: R. Rosenblatt, "Snuff this book! Will Bret Easton Ellis get away with murder?" The New York Times Book Review, Dec. 16, 1990, 16.
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22. J. Bronowski, *op. cit.*, p. 81.
23. W. Whewell, *History of the Inductive Sciences*, 3rd ed., John W. Parker and Son, West Strand, 1857, Book VIII, Chap. II.

Engineering—from page 52

manufacturing environment. Restoring American competitiveness requires putting increased emphasis on high quality efficient manufacturing methods.

■ Engineering problems are rarely as "clean" as a course's homework problem set. Advanced courses should involve engineering trade-offs, including the ambiguities that usually accompany real engineering tasks.

■ Participation in cooperative education programs and development of summer student internship programs must be encouraged and expanded.

Education—from page 53

week and was consequently more intensive. Future workshops, following the 1990 format, will likely be held every two years beginning in 1992. Proceeding of the 1990 workshop was videotaped and copies are available. For further details, please contact the authors.

Acknowledgements

CHTM is an interdisciplinary organization with a central mission to support research, advanced study, and technology transfer in optics and optoelectronics. Overall management of both workshops was handled by John G. McInerney and Steven R.J. Brueck, with assistance from Vivienne H. Mattox of Management Plus Inc. The authors are grateful to her and to the technical and administrative staffs of the Center for High Technology Materials for extensive logistical support before and during each workshop. We acknowledge financial support from the National Science Foundation through contract numbers USE-8854282 and USE-8954342. Finally, we thank all the workshop alumni for their enthusiastic participation and follow-up.

Light touch—from page 59

proportional to the perceived height of the discontinuity. A new pattern arises from the remaining dots that continues until the next depth discontinuity is reached. Following this recipe, crude stereograms can be made using a typewriter. The more sophisticated stereogram in Figure 1 was produced by David G. Stork at Stanford University using a Macintosh computer. Using his program,[3] a typical stereogram containing 18,000 dots takes only a few minutes to create. According to Stork, future auto-random-dot stereograms will use gray levels and color to enhance the 3-D effect.

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3. D.G. Stork and C. Rocca, "Software for generating auto-random-dot stereograms," Behavior Research Methods Instruments and Computers **21**, 1989, 525-534. Also see the inside front cover of "Seeing the Light," by D. Falk, D. Brill and D. Stork, Wiley, 1988.

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Abstract deadlines

March 4: OSA Coherent Laser Radar Topical Meeting, July 8-12, Snowmass, Colo.

March 15: OSA Photorefractive Materials, Effects and Devices Topical Meeting, July 29-31, Beverly, Mass.

March 28: OSA Nonlinear Guided Wave Phenomena Topical Meeting, Sept. 2-4, Cambridge, UK

April 5: Optical Amplifiers and their Applications Topical Meeting, July 24-26, IEEE-LEOS/OSA, Snowmass, Colo.

May 1: OSA Persistent Spectral Hole-Burning Science and Applications Topical Meeting, Sept. 26-28, Monterey, Calif.