supply; instead, it fed into Germany's need for ammunition to fight two world wars. Ammonia from the Haber–Bosch factories was converted to nitric acid and thence to explosives. After 1945, however, the overwhelming use of such factories was to fix nitrogen for fertilizers.

Smil recounts how the industry developed, and how much of the world's population is now supported by it. He discusses how this chemical bounty is disbursed. Relatively little is used by US agriculture, but a great deal by Chinese farmers. Smil considers what will happen when developing economies also want their protein to be in the easily digested and tasty kind that comes from meat, even though this is the least efficient way of producing food. But can our planet support another 5 billion people on a Western diet, and won't more food simply encourage more humans to have yet more children? Smil's answer is found in his chapter "Nitrogen and civilization". The future looks surprisingly reassuring. The annual increase in global population will continue to decline even though food production is rising, and the total might well peak at less than 9 billion by the year 2050, declining thereafter.

This is a wonderful book, highly readable and replete with referenced data. It is soundly based on the chemistry that underpins our food supply, or at least the protein part of it, and is an ideal corrective to the misleading ideas we are constantly being fed by the organic food movement. Humans have a stark choice to make: do we farm four hectares of land 'organically' to feed 40 souls, or do we farm one hectare 'artificially', thereby leaving the other three to natural woodland and wildlife? There is a place for 'organic' farming, but only insofar as it permits us to recycle nitrogen that would otherwise go to waste. ■

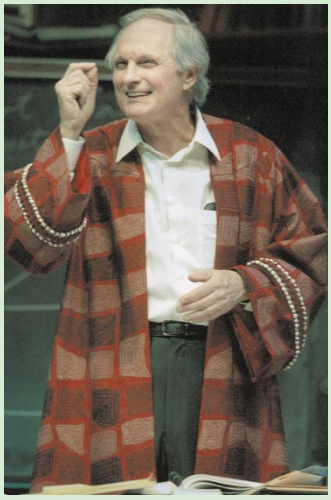
John Emsley is in the Department of Chemistry, University of Cambridge, Lensfield Road, Cambridge CB2 1EW, UK.

Science in culture

Enter Feynman, as clown

QED, a play by Peter Parnell, directed by Gordon Davidson.

Horace Freeland Judson



The public Richard Feynman: O-rings, safe-cracking, bongo drums, naked women, atheism, the joyful questioning of authority, whether in physics or bureaucracies. The one thing everybody knows about him is that, when testifying before a panel of the US Senate investigating the Challenger disaster, he dropped a piece of O-ring, a rubberoid gasket, into a glass of ice water and demonstrated that such rings get brittle when cold — thus illustrating the cause of the fuel leak and explosion. Many have also read that, arriving at Los Alamos National Laboratory in 1943, a brilliant kid, PhD at 24, he could crack any of the offices' safes containing the secrets of the bomb research, thereby demonstrating that security was lax. And he played bongo drums, and was an obdurate, thoughtful atheist, and frequented topless bars in Los Angeles, and took art lessons so that he could draw nude models. Some also know that he was an inspired teacher at Caltech. The persona grew from interviews, public appearances and several books about him in which he connived. He played himself as trickster, an eccentric genius.

Enter Alan Alda as Feynman, rushing in to the bongo beat. Except for some voices on his answering-machine, and a brief appearance of a young woman student in Act II, this is a one-man show, and Alda plays Feynman broadly, as clown. The play is set in Feynman's office during an afternoon and evening in 1988, while he was dying, as we learn, of a crushing abdominal carcinoma. The office is cluttered, bongo up front, desk piled, behind it a blackboard scrawled with mystifying mathematical jottings. Alda drums, jumps about the stage, drums, talks to the audience, to the telephone — his surgeon, his oncologist, this colleague or that — drums, piles up the Feynman anecdotes.

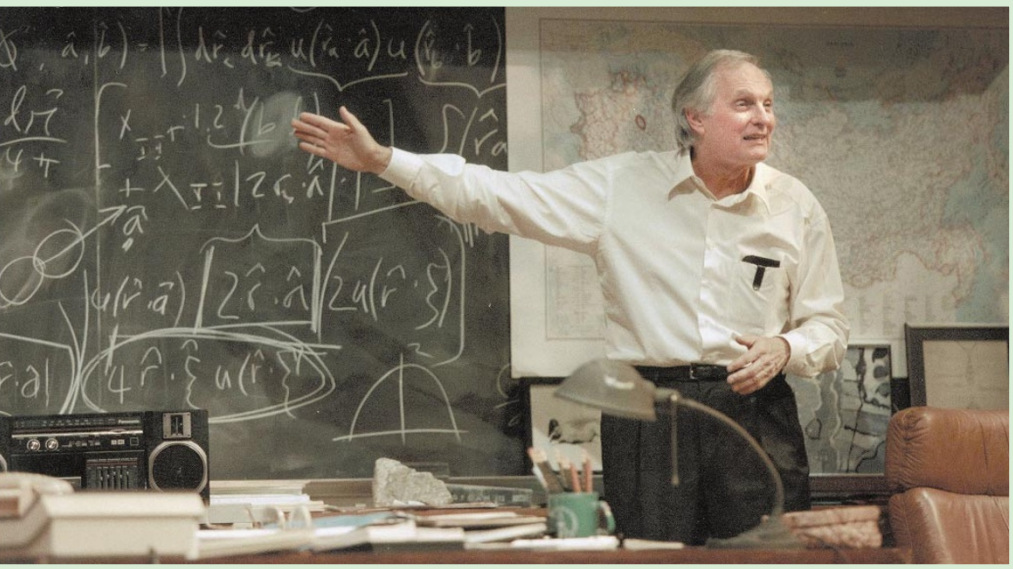
Alda is an actor celebrated for a variety of theatre and film work, but above all for 11 years in the TV series *M*A*S*H*. His New York accent is perfect, he even looks acceptably like the man, his comic timing is professional — but there are occasions in theatre when 'professional' is a substitute for depth, a term of reproach. What was behind the persona? Almost any photograph of Feynman shows his alert intelligence, twinkling with speculation, waiting to pounce. In the bruising intellectual world of high-energy physics, where everyone who makes it is an alpha male, Feynman's wit and assertiveness sprang from the originality and speed of his understanding. He applied this to the public world as well. Scientists know that he invented a graphic method, astonishingly original — Feynman diagrams — for anatomizing interactions of subatomic particles so that their behaviour could be calculated. This led to his work developing quantum electrodynamics, QED, the theory of almost everything, which won him a Nobel prize.

Actor, playwright, director — in this piece of theatre they have conspired to keep us from Feynman's intelligence. We get 40 seconds of a Feynman diagram scrawled on that blackboard as a gee-whiz illustration, when these were tools for discovery. Instead of Feynman's speed of comprehension we get frenetic, fussy movement. Elements of potential pathos — in Act I reminiscing about his first wife, dead of tuberculosis in 1945, in Act II facing the imminence of his own death — are drained of emotion by the constant straining for laughs.

What's left? An anthology of anecdotes and aphorisms. "Nature is a woman." "We must think in probabilities." "All science is a constant attempt to describe nature" — standing alone, a silly statement. "If you ask Nature the right question, she will give you the right answer." And at the end an embarrassing brief homily to that young student, to the effect that if she works really, really hard and can find the courage not to know certainty, she too can be a physicist. ■

Horace Freeland Judson is at the Center for History of Recent Science, George Washington University, Washington DC 20052, USA.

QED is playing at the Mark Taper Forum, Los Angeles, until 13 May 2001.



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