TZARA: Doing the things by which is meant Art is no longer considered the proper concern of the artist. In fact it is frowned upon. Nowadays, an artist is someone who makes art mean the things he does. A man may be an artist by exhibiting his hindquarters. He may be a poet by drawing words out of a hat. In fact some of my best poems have been drawn out of my hat which I afterwards exhibited to general acclaim at the Dada Gallery in the Bahnhofstrasse.

CARR: But that is simply to change the meaning of the word Art.

TZARA: I see I have made myself clear.

CARR: Then you are not actually *an artist* at all.

TZARA: On the contrary. I've just told you that I am.

CARR: But that does not make you an artist. An artist is someone who is gifted in some way that enables him to do something more or less well which can only be done badly or not at all by someone who is not thus gifted. If there is any point in using language at all it is that a word is taken to stand for a particular fact or idea and not for other facts or ideas. I might claim to be able to fly . . . Lo, I say, I am flying. But you're not propelling yourself about while suspended in the air, someone may point out. Ah no, I reply, that is no longer considered the proper concern of people who can fly. In fact, it is frowned upon. Nowadays a flyer never leaves the ground and wouldn't know how. I see, says my somewhat baffled interlocutor, so when you say you can *fly* you are using the word in a purely private sense. I see I have made myself clear, I say. Then, says this chap in some relief you cannot actually *fly*, after all. On the contrary, I say, I have just told you I can. Don't you see, my dear Tristan, you are simply asking me to accept that the word Art means whatever you wish it to mean; but I do not accept it.

TZARA: Why not? You do exactly the same thing with words like *patriotism, duty, love, freedom*, king and country, brave little Belgium, saucy little Serbia—

Playing with Science

There's an activity which we call art and an activity which we call science, and to some degree and in certain ways and in different places, they converge; elsewhere they diverge, and elsewhere they interact, and they also intersect.

by Tom Stoppard

Playwright Tom Stoppard came to Caltech as the third annual James Michelin Distinguished Lecturer on October 20. In the afternoon he met with Caltech's Theater Arts group, then rehearsing Julius Caesar, *and in the evening gave his lecture (which he later described in a* New York Times *article as "60 minutes of desperate free association") to a standing-room-only crowd at Beckman Auditorium. Per tradition, Vice Provost and Professor of Physics and Applied Physics David Goodstein introduced the speaker (see pages 14 and 40 for some of his other activities), and warmly thanked New York fashion designer Bonnie Cashin, whose gift established the lecture series in memory of her uncle. "Bonnie's uncle, James Michelin, was a geologist who always wanted to attend Caltech, but never did, and therefore never lost his affection for us," according to Goodstein. The purpose of the series is to promote a creative interaction between the arts and the sciences, and, said Goodstein, "Tom Stoppard is a living interaction between the arts and the sciences."*

Stoppard's play Hapgood *opened at New York's Lincoln Center in early December.* Arcadia, *currently playing at the Royal National Theatre in London, will come to New York in March.*

Left: Antony Sher plays the Englishman Carr in the 1993 revival of *Travesties* at the Royal Shakespeare Company in London.

I'm going to begin by showing you my first "slide." But now we've begun before we've begun—because I have no slides and yet my first sentence was true. It just happens to contain a metaphor. For a scientist, my first sentence would have been untrue or mistaken. For a playwright, the truth or untruth of a sentence is less rigid: I'm licensed to say "slide" as a metaphor for reading something to you. So we've already noticed, haven't we, that there's another way to use language, different from the one-to-one correspondence of a purely technical—or scientific—language. I wonder whether you think of the one-to-one correspondence of word-to-thing as a limitation to language or as a liberation from the dangers of ambiguity. We will return to the subject of the ambiguity of the very word "language," but in passing I would say that *purposeful* ambiguity, which I suppose has no place in scientific discourse, is an essential feature of what we'll call playful language.

Now let's start again. Here is a new first sentence. I'm going to begin by reading something to you. The passage comes from a play called *Travesties*. This is a play in which, among other people, appears the surreal Dadaist artist Tristan Tzara. He has an argument with a conventional, conservative type of Englishman, named Carr. [The first "slide" appears at left.]

Tzara's list (patriotism, duty, etc.) consists of abstract nouns. Even "Belgium," which enjoys a physical existence, is really an abstraction, an *idea*. So language has immediately moved beyond words-as-things. But there is something else.

The play is set during the First World War, and it was written in 1974. You don't need me to tell you that "saucy little Serbia" has a difference resonance now. The play was revived this

year, and when the actor said "saucy little Serbia" a ripple like wind across wheat went across the auditorium. It is as if *time* were a parameter of change in the "meaning" of the words "saucy little Serbia." Perhaps there is no such thing as "ordinary language," and scientific or logical language is not basic but, rather, a special case. Meaning and intent become functions of historical context (the newspaper headlines about Serbia being the context in this example).

Well, having got through all that and read all that, I think it's really time I showed you a slide. I'm not going to lay my work on you all night, but I do have about half a dozen of these extracts to read. They have to be mine because I don't know about any other writers. And I only speak for myself. I don't know how other playwrights think or work. I meet some occasionally but somehow we never ask each other about that. We say, "Whose round is it?" and that kind of thing. So here's the slide [at left]: the speaker is a Russian physicist named Kerner. He is in England and has learned English, and he absolutely loves spy novels and reads very little else.

Below: David Strathairn (right) as the Russian physicist Kerner and Josef Sommer as the senior intelligence official Blair in the Lincoln Center production of *Hapgood*, 1994.

KERNER: I like them. Well, they're different, you know. Not from each other, naturally. I read in hope but they all surprise in the same way. Ridley is not very nice: he'll turn out to be all right. Blair will be the traitor: the one you liked. This is how the author says, "You see! Life is not like books, alas!" They're all like that. I don't mind. I love the language.

Safe house, sleeper, cover, joe . . . I love it. When I have learned the language I will write my own book. The traitor will be the one you don't like very much; it will be a scandal. Also I will reveal him at the beginning. I don't understand this mania for surprises. If the author knows, it's rude not to tell. In science, this is understood: what is interesting is to know what is happening. When I write an experiment, I do not wish you to be *surprised*, it is not a *joke*. This is why a science paper is a beautiful thing: first, here is what we will find; now, here is how we find it; here is the first puzzle, here is the answer, now we can move on. This is polite. We don't save up all the puzzles to make a triumph for the author—that is the dictatorship of the intelligentsia.

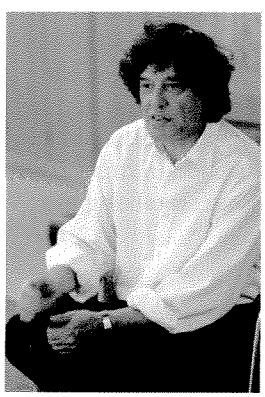
I have two reasons for reading you an extract from this particular play, *Hapgood*. The first reason entails a digression, but I want to tell you how I came to be here. This play was first performed in February 1988. We were in a theater just outside London. If my memory serves, we'd finished rehearsals. I'm not sure if we'd yet had our first audience; perhaps it was the day we were going to have our first audience. Backstage, I borrowed a newspaper from the stage doorman, and looking through it I saw an obituary of Richard Feynman. My grief was acute. I never knew him, had never met him. I have had no education in physics at all. I get interested in things, and I read some science—I call it science; *you* would call it airport paperbacks. I should say that my grief about Feynman was entirely selfish because I had an epigraph from Feynman in front of this play. In a sort of fan-club way, I had intended to send him my play—not really that he should read it; I just wanted this metaphysical connection between us. He'd get it in the mail, and he'd probably throw it on his desk, but somehow a bit of me would be in his house, and that meant something to me. I left it too late. The epigraph was from Feyman's *Lectures on Physics*:

> We choose to examine a phenomenon which is impossible, *absolutely* impossible to explain in any classical way, and which has in it the heart of quantum physics. In reality it contains the *only*

Rather as a lover of Wordsworth might come to the Lake District, I came to Caltech, just to see where Feynman lived and worked.

mystery . . . Any other situation in quantum mechanics, it turns out, can always be explained by saying, 'You remember the case of the experiment with the two holes? It's the same thing.'

A year later, *Hapgood* was being done in Los Angeles. Rather as a lover of Wordsworth might come to the Lake District, I came to Caltech, just to see where Feynman lived and worked. My son, who was studying low-temperature physics, was with me. So I called up David Goodstein—a cold call. He was very sweet to us and showed us around. I looked around thinking, well, Feynman was here, and it's better than nothing, being here myself for a while. So I consider that you, collectively, were awfully kind to me. The final upshot of that meeting is that David asked me to give this lecture, and here I am.



My second reason for choosing this extract from *Hapgood* is that it implies a promise that I would also lay out my agenda, my wares. Then you would know what we were here to do and what we were trying to achieve. I suppose I can go some way towards doing that. We are here under the title of "Playing with Science." Somebody phoned me up and said, "We have to print this thing. Do you have a title?" And after a moment I said, "Playing with Science," which seemed reasonable because I felt I could say almost anything under that title. The agenda which I felt was appropriate is something like this: there's an activity which we call art and an activity which we call science, and to some degree and in certain ways and in different places, they converge; elsewhere they diverge, and elsewhere they interact, and they also intersect. We might consider what esthetics means in the context of science and art, and also the differences and similarities in the creative process between scientists and artists. And we might ask what exactly is reality, which is a favorite subject in theater.

What I'm *not* going to attempt (I hope you're as pleased as I am) is a historical survey of science in plays—*Galileo* and all that. I have no instinct towards learning these things or caring about them. I like individual plays. I don't really get interested in the abstractions and the generalities of what's happening in the history of theater. However, in the same breath I should say that on the occasions that I go to see a play or a film which purports to be about, for example, Turing, or the making of the atom bomb, I feel a sense of broken promise when I discover, as of course one invariably does discover, that there's simply no science in them at all, really. So, clearly, you have to take me with a pinch of salt when I disclaim that I'm a frustrated scientist, or a closet scientist. I feel I really am not, but there's something in me which often causes a reaction when I come across some science news. I had one term of physics when I was 13. I did no chemistry. We all did biology, but all I remember is cutting up dogfish; I remembered the smell for years. So I emerged from school with no science whatever. I think I'm here because I've written two plays which have some science in them, and apparently it does take two. One play may be thought an aberration, but two suggests purpose. Don't be misled, however. My next play is about India, and it includes some words on the miniature art of the Mogul empire in the 19th century in northern India. I'm confidently expecting an invitation to lecture at the Huntington Library next year.

What is a play? And what is theater? I'm going to do this *at* you, although you think you already know what a play is. Well now, suppose you were to go into the campus bookshop and say, "I want *Pride and Prejudice*, please, and Beethoven's Fifth, and I'd like Warhol's Marilyn Monroe print, and I would like *Death of a Salesman* by Arthur Miller." As the chap's putting this stuff together, he gives you a bound stack of pages between two covers, and he gives you a circular disk, a flat thing, and then he gives you a kind of flat rectangular plane which goes on the wall. And then he gives you another stack of pages. And you say, "No, no. The Arthur Miller one is a *play*." And he'd say, "Well, yeah, that's how they come." There's something odd about this. I suppose a play is a text, but theater is an

event. Already we've shifted the idea nearer towards science in a general way. It is an event.

I might have said Shakespeare's *The Tempest* instead of *Death of a Salesman* because I want to describe to you a scene in a production of *The Tempest* which took place some years ago in Oxford College. The play was set out of doors, on the lawn which backed onto a lake. It began in natural light, and, as the play developed, it was time for Ariel, the sprite, to leave the action. Ariel said what he says, and he turned and ran across the grass. When he got to the edge of the lake, he kept running across the top of the water, because the producer had put a boardwalk just an inch below the water. Evening was coming on now, and you could just barely see him, and then you could hear him go "plish, plash" across the water. As he approached the other side of the lake, the evening swallowed him up, and as he disappeared, from the further shore a firework rocket was ignited, and it went—whoosh—into the sky. The rocket burst into sparks, and then all the sparks went out one by one, and he'd gone. When you look this up it says "Exit Ariel."

So we're talking about an event. It might be true, or at any rate provocative, to say that theater is an experiment which never repeats its results. By that I mean not that every production of *The Tempest* is different; I mean that the same production of *The Tempest* is different night to night. The equation which goes into the event is so complex that it cannot actually be repeated.

For a moment there we looked at art considered as a science. Let's now look at science as a subject matter of art. When I say *art,* I'm really talking only about the one I know about, which is the theater, under which I would also include film. I'm going to read you a speech from a screenplay made from a book called *Hopeful Monsters* by Nicholas Mosely. It has some physics in it, and a lot of other things too. And I'm going to follow that with two other slides: the first deals with quanta, and the last with entropy. But first—atoms. *Hopeful Monsters* takes place in the early twenties in England, and in this scene [left] Hans, a German physicist, is talking to a 12-year-old boy, Max.

MAX: But is it true, Hans?
HANS: See this.
MAX: Your ring?
HANS: Gold, pure gold. If I cut it in half, I still have gold, naturally. If I keep cutting it in half, do I have gold forever? Smaller and smaller pieces of gold? No. Finally I get to an atom of gold. And when I cut that in half, I don't have gold anymore; I just have little pieces of electricity.
MAX: Really?
HANS: Yes, really. The nucleus of an atom of gold is little pieces of electricity stuck together—what are called protons. The difference between gold and radium or any of the natural elements is just the difference in the number of protons which are stuck together like a sugar lump. Radium has 88.
MAX: But how did Professor Brainbox make a bomb?
HANS: Ah, that is his secret. But somehow it seems he broke up his radium sugar lumps and the force which keeps the sugar lumps together is suddenly released. Of course, in each atom there's only a very little bit of force, but in a piece of radium as big as a pineapple, well, there are as many atoms as grains of sand on all the beaches you can ever think of. Boom.

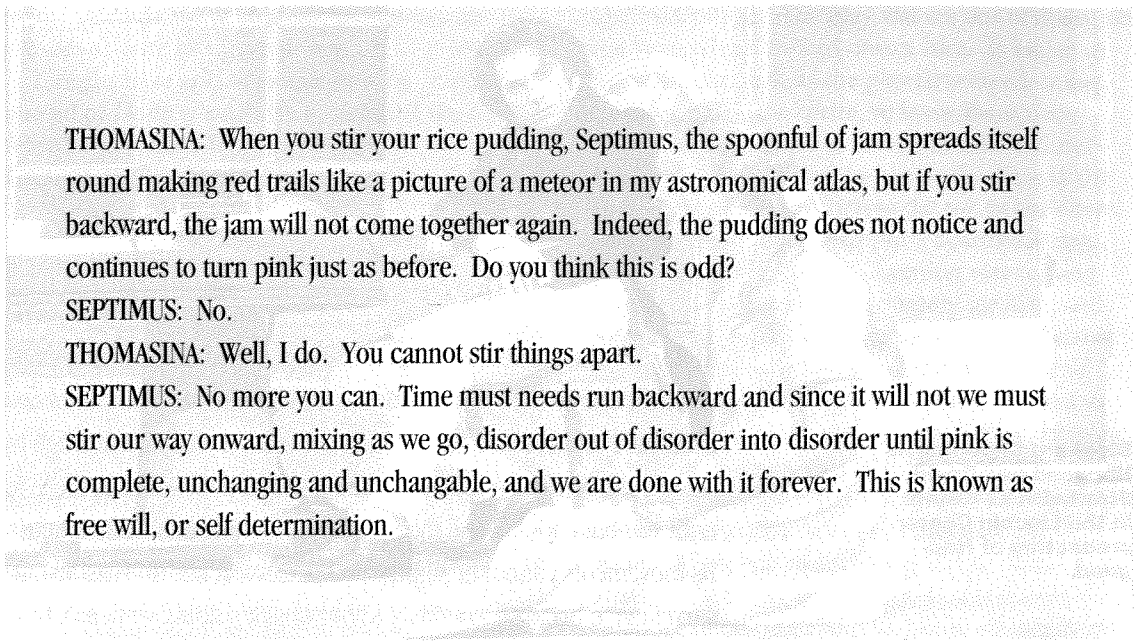
The technique here is, as you can appreciate, bald. The atom explained for 12-year-olds (the mental age of film and theater audiences when confronted with science). I borrowed the idea of cutting an atom endlessly in half from C. P. Snow, the scientist-novelist. Give or take a sugar lump, this is an attempt at unadorned explication—always a troublesome business in my business.

In *Hapgood* the subject is quantum physics. Kerner (the one who reads the spy novels) is co-opted into the espionage world. You can see that to try to get the science into art, one has to try to transmute it in some way. He says: [right]

Stockard Channing as Hapgood and David Strathairn as Kerner in the Lincoln Center production of *Hapgood*.

KERNER: The particle world is the dream world of the intelligence officer. An electron can be here or there at the same moment. You can choose; it can go from here to there without going in between; it can pass through two doors at the same time, or from one door to another by a path which is there for all to see until someone looks, and then the act of looking has made it take a different path. Its movements cannot be anticipated because it has no reasons. It defeats surveillance because when you know what it's doing you can't be certain where it is, and when you know where it is you can't be certain what it's doing: Heisenberg's uncertainty principle; and this is not because you're not looking carefully enough, it is because there is *no such thing* as an electron with a definite position and a definite momentum; you fix one, you lose the other, and it's all done without tricks. It's the real world. It is awake.

Frankly, compared to the electron, everything is banal. And the photon and the proton and the neutron . . . When things get very small, they get truly crazy, and you don't know how small things can be, you think you know but you don't know. I could put an atom into your hand for every second since the world began, and you would have to squint to see the dot of atoms in your palm. So now make a fist, and if your fist is as big as the nucleus of one atom then the atom is as big at St. Paul's, and if it happens to be a hydrogen atom then it has a single electron flitting about like a moth in the empty cathedral, now by the dome, now by the altar . . . Every atom is a cathedral. I cannot stand the pictures of atoms they put in schoolbooks, like a little solar system: Bohr's atom. Forget it. You can't make a picture of what Bohr proposed, an electron does not go round like a planet, it is like a moth which was there a moment ago, it gains or loses a quantum of energy and it jumps, and at the moment of the quantum jump it is like two moths, one to be here and one to stop being there.



THOMASINA: When you stir your rice pudding, Septimus, the spoonful of jam spreads itself round making red trails like a picture of a meteor in my astronomical atlas, but if you stir backward, the jam will not come together again. Indeed, the pudding does not notice and continues to turn pink just as before. Do you think this is odd?
SEPTIMUS: No.
THOMASINA: Well, I do. You cannot stir things apart.
SEPTIMUS: No more you can. Time must needs run backward and since it will not we must stir our way onward, mixing as we go, disorder out of disorder into disorder until pink is complete, unchanging and unchangable, and we are done with it forever. This is known as free will, or self determination.

Rufus Sewell as Septimus Hodge and Emma Fielding as Thomasina Coverly in the Royal National Theatre (London) production of *Arcadia*, 1993.

The entropy passage [above] comes from a recent play, *Arcadia*. The scene involves another young person, a 13-year-old girl this time.

How gratifying that various passages, written years apart, should converge on my title, "Playing with Science." I captioned my three readings: atom, quantum, and entropy. But I turned out to be talking about sugar lumps, moths, and rice pudding. In the third passage, entropy didn't even get a mention, and perhaps on that score the third passage is the successful one. Pure metaphor. Metaphors may be apt (effective) or inapt. The response which makes that decision is a form of *esthetic* response.

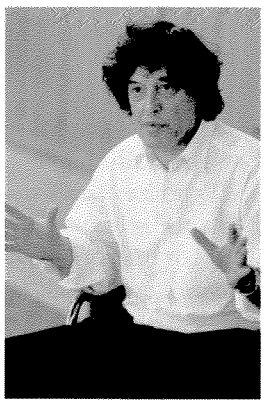
On the subject of esthetics, I'm happy to evoke Richard Feynman again. At an art-and-science meeting in London, I met Prof. Arthur I. Miller, not the author of *Death of a Salesman* but the head of the Department of the History, Philosophy and Communication of Science at University College London. The following is extracted from his paper published in *Languages of Design*.

> In his characteristically emphatic way, the American physicist Richard Feynman described his immediate reaction to a new theory he developed in 1958:
>
> *There was a moment when I knew how nature worked . . . It had elegance and beauty. The goddamn thing was gleaming.*
>
> —Richard Feynman, 1957 [8(338)]
>
> What notions of elegance and beauty did Feynman have in mind? The elegance came from a mathematical formalism which Feynman had been honing since his university days and had served as a basis for his 1948 theory of how electrons interact with light . . . The beauty of Feynman's theory can be seen only in the eye of a physicist. It is a beauty which concerns the theory's universality by which I mean the possibility of its use beyond the discipline to which it was intended.

Prof. Miller makes the point that one can talk about modern science in the way that one talks about modern art. Interestingly, what was happening to science towards the end of the 19th century and beginning of the 20th was happening to art at roughly the same time—cubism was trying to lead towards Picasso and beyond. Prof. Miller has also published a comparative study of Henri Poincaré and Albert Einstein. He uses some of the scientists' own introspections to try to figure out how their minds, their creative processes, worked. He also quotes from the notes of a psychologist named E. Toulouse, who conducted a series of interviews with Poincaré and Émile Zola:

> The one [Zola's] was an intelligence that was willful, conscious, methodical, and seemingly made for mathematical deduction: it gave birth entirely to a romantic world. The other [Poincaré's] was spontaneous, little conscious, more taken to dream than for the rational approach and seemingly throughout apt for works of pure imagination, without subordination to reality: it triumphed in mathematical research.

The convergence between art and science is



When we talk about "universality" having different meanings, we're saying that language works in different ways. It works by association and works through metaphor.

not going to strike anybody here with novelty. I think we've tended to create and talk about a false dichotomy, and I think that we acknowledge that it is a false one most of the time we're talking about it. Science and art are nowadays beyond being *like* each other. Sometimes they seem to *be* each other. But while they converge, interact, and intersect, they diverge, too, and language sometimes throws light on this. When we (on the art side) hear about the beauty of Feynman's insight residing in its universality, we do recognize "universality." That's a word which crops up all the time in lit crit. But we mean something slightly different by it. In mathematics, perhaps, there's a correspondence between the *elegance* of a function and what it represents, say, the correspondence between the function $x^2 + y^2 + z^2$ and what the Greeks considered to be the perfection of a sphere. You then start to think, what exactly is it that we acknowledge as its beauty? A scientist might note that we can rotate it; we can look at it in a mirror; we can turn it upside down; and it preserves itself in all these variations and remains absolutely symmetrical and perfect. But that's a special way of talking about esthetics.

Science and art are nowadays beyond being like *each other. Sometimes they seem to* be *each other.*

One day some time ago, I had the pleasure and honor of meeting Mandelbrot of "the set" at a sort of art exhibition. As you're probably aware, sections of Mandelbrot's set are now postcards, posters, and so on. I was quite keen on the whole thing and ended up buying about 40 postcards, 38 of which I never managed to think of anybody to send to. They never seemed right. I thought this was telling me something about the kind of art I was trying to palm off on my friends. On the whole I don't think there is much correspondence between what the computer generates from an equation and what artists do. And when I say artists here, I mean the kind which I am not—people who actually make pictures.

When we talk about "universality" having different meanings, we're saying that language works in different ways. It works by association and works through metaphor. This is where we came in, isn't it, with the Dadaist? Curiously enough, it was a mathematician in *Through the Looking Glass* who made somebody say "a word means whatever I choose it to mean." And in a way it does. Take as an example the word "cowboy." What's the first thing that comes into your head? Somebody will think of John Ford, and somebody will think of John Wayne, and somebody will think of a hat, and the cowboy icon, and also the sort of macho image of cowboys in our culture. I have always thought that was quite an interesting thing, because the job of looking after cows exists all over the place. Where I come from it tends to be done by a man in rubber boots, wearing a smock. Now, imagine that for one reason or another this Englishman had to change his work clothes; say he emigrated to America in 1880. He arrives in New York and says, "I'm a cowman. Is there any work here?" They say, "Here? No, you have to go West." So he gets on the train and shows up somewhere in the West. When he asks people for a job, they say, "Well, what do you do?" He says, "I'm a cowman." And they say, "Cow*boy*, surely." And he says, "Well, yes, OK." And they

At the age of forty-something I was exclaiming, "My gosh, this is amazing! How interesting!" about stuff which anybody who had stuck with physics through high school was wearily familiar with. . . . My interest in it, of course, was as metaphor.

Stoppard answers questions for members of TACIT (Theater Arts at Caltech).

say, "Fine. Sign here. You've noticed that the weather here is very hot; you need a rather wide-brimmed hat. And so that you don't burn your neck, you put this thing, this neckerchief, around your neck. The bushes here have gigantic prickles on them so we tend to put these leather things around our trousers, which themselves are made of very tough material because we ride horses, there being no roads here. And you need boots with a high heel because otherwise they'll fall out of the stirrups." The person has not changed. There *is* no person to change. I just invented him. But our response to the person may have changed. He has become a more romantic, macho kind of figure. But only one thing has really changed—the word which triggers the response: from "cowman" to "cowboy." It was all done by association. Creative language works associatively.

But we don't mean, do we, that language works by association word by word. In the two plays, which I've read bits of, with some science in them, what I was interested in was the metaphor. *Hapgood* is a play which derived from my belated recognition of the dual nature of light—particle and wave. As I said before, I've never done any physics. At the age of forty-something I was exclaiming, "My gosh, this is amazing! How interesting!" about stuff which anybody who had stuck with physics through high school was wearily familiar with. But I was thinking, "Gosh, I've found something out which I can use." My interest in it, of course, was as metaphor.

In a play called *The Fire Raisers* by Max Frisch, two arsonists are burning down a town. One day a very sinister man comes and knocks at the door of a bourgeois household, insinuates himself into the household, and in no time at all is in the attic as a lodger. Soon after that he introduces an equally sinister friend, and they share the attic. They leave the house and come back; then they leave the house and come back again, and it seems that when they've left the house and come back, another building has burned down. Then they start bringing cans of gasoline into the house and filling the attic with it. They'd take a few cans out and come home, and each time there would be a building burned down. Meanwhile, downstairs this bourgeois family is getting more and more concerned but they won't really talk about it. The father is there with his pipe and his newspaper, saying, "It's awful. When are they going to catch these arsonists?" And none of them can quite meet each other's eye. The moment finally comes when the larger and more sinister of these two people comes downstairs and asks the leader of the household, "Do you happen to have a box of matches?" After a rather long and thoughtful pause, the gentleman puts his hands in his pocket and hands over a box of matches. The sinister man says, "Thank you very much," and goes upstairs, whereupon the husband turns to his wife and says, "Now, look, if they were the arsonists, they'd have their own *matches*."

I saw this play when I was quite young, and I loved it, and I knew exactly what it was about. In fact, I went around telling people exactly what it was about: it was quite clearly about how the Nazis came to power in pre-war Germany. Some

time later, I discovered that the author was under the impression that it was about how the Communists came to power in post-war Eastern Europe. The reason I mention it is that I wasn't wrong. In a certain sense the author can't say that I'm wrong. And I feel that I can't, and I never do, say that somebody is wrong in the way they interpret what I write. How can one refuse the existence of a response? It is its own validation.

We're talking now about language operating in a way which perhaps it doesn't in Kerner's scientific paper in the passage I read earlier. The subject matter in theater, in a more abstract sense than I've dealt with so far, has very often to do with what actually is real. A lot of people at Caltech might be said to be concerned with that single question. What is happening? What is real? Theater is not real. Now, again, we think we already knew that, don't we? I mean, we know that it's not actually a salesman coming home from failing to sell something and having a miserable evening. We know it's not really some chap finding out that he's married his mother. We know that that's not the kind of reality we're talking about.

What is real? Theater is not real. . . . I mean, we know that it's not actually a salesman coming home from failing to sell something and having a miserable evening. We know it's not really about some chap finding out that he's married his mother.

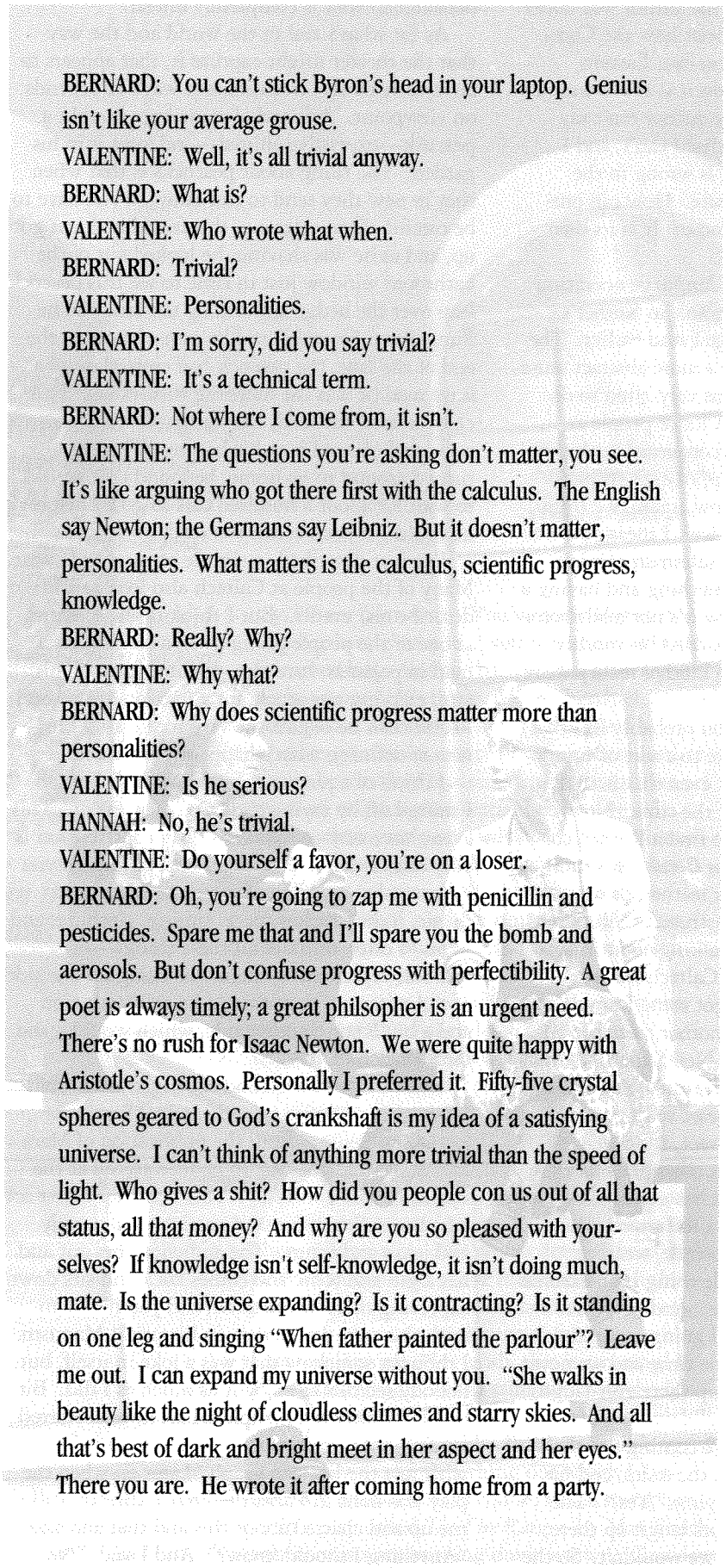
But on the other hand, you probably feel that certain kinds of theater aspire to a sort of simulation of reality. I don't think even that is true. Clearly, it's not true most of the time. Nowadays, one would be lucky to find a Roman column in a production of *Julius Caesar*. It's more likely to be chrome, or black leather, or whatever. This is fine; it can be very instructive, illuminating, and effective. I'm not talking about that. [Actually, the audiences for Caltech's recent production of *Julius Caesar* got some Roman columns.] At one time or another, possibly all of us have enjoyed a play by Neil Simon. At his best he's given me a lot of pleasure. You can tell by the design that there appears to be something real going on: it's never abstract, it's never symbolic. The action always takes place in a room, and tremendous effort has gone into making this room resemble a real room. People onstage are, as it were, real people, wearing proper clothes, and the whole thing is an exercise in re-creation of a slice of life. And yet, there's something completely weird going on up there on the stage. It's there all the time and we never notice it. It is that nobody up there ever laughs at any of those things we're all laughing at. These brilliant wisecracks are coming out three a minute and *we're* falling in the aisles, and up there, it's all these people saying, "Yes?" The convention is that if the actors laugh up there, they'd be doing it for us, so we wouldn't. So the behavioral event is completely unreal.

As for what's real in the world and the way that the theater might capture it, that appears to be equally elusive in a different way. It depends on viewpoint. A friend of mine once bought a peacock—expensive animal—and kept it in his garden. The thing about peacocks is that when they're new they tend to run away, so you have to be careful. One morning, this friend had just got up, and as he was shaving, he looked out of the bathroom window just in time to see this peacock leap over the hedge and run up the lane. So he flung down his razor, and he gave chase. At the end of the lane, the peacock had crossed quite a busy road (it was the morning rush-hour). This chap crossed the road, caught up with the peacock, and clasped it to his bosom. When he turned around to go home, he found that he had to wait for about a hundred cars to go by before he could get back across the road.

I've just described in simple terms a real event. Many of the people at Caltech also look at and describe real events. But I think of the scientist as one of the people going by in a car: he sees a man in pajamas, bare feet, shaving-foam on his face, carrying a peacock, for a fraction of a second —and then he begins the very interesting business of defining what's happened out there.

I think of a play as constituting an equation. I started off by saying the thing is an event. This event has many components. My contribution is only one of them. The experience acting on you is a complex equation of sense, sound, sight, music, light, shadow, pace, timing, clothing, and so on. I often think of all these things—or symbols representing them—as being on one side of the equation; then there'd be an equals sign and a big *S* on the other side, which would stand for Satisfaction.

In *Travesties*, the second act began with what I thought was quite a good idea: a 15-minute lecture on Lenin—from the publication of Marx's *Das Kapital* all the way to Lenin's arrival at the Finland Station in 1917. This was after a first act which was lots of fun and pastiche and parody and jokes and songs. The audience goes out and has a gin and tonic and comes back and sits down expecting more of the same, and you hit them with this very dry lecture on historical Marxism. I thought somehow that was a joke in itself, but nobody seemed to enjoy it as much as I did. Bit by bit (theater is an empirical art form) I started cutting away at this lecture, and we ended up with just the last paragraph. Later on when the play was done in Paris, the French director called me up and chatted about this and that and asked, "Anything I should know?" And I said, "No,"



Bill Nighy as Bernard Nightingale and Felicity Kendal as Hannah Jarvis in the Royal National Theatre production of *Arcadia*.

BERNARD: You can't stick Byron's head in your laptop. Genius isn't like your average grouse.
VALENTINE: Well, it's all trivial anyway.
BERNARD: What is?
VALENTINE: Who wrote what when.
BERNARD: Trivial?
VALENTINE: Personalities.
BERNARD: I'm sorry, did you say trivial?
VALENTINE: It's a technical term.
BERNARD: Not where I come from, it isn't.
VALENTINE: The questions you're asking don't matter, you see. It's like arguing who got there first with the calculus. The English say Newton; the Germans say Leibniz. But it doesn't matter, personalities. What matters is the calculus, scientific progress, knowledge.
BERNARD: Really? Why?
VALENTINE: Why what?
BERNARD: Why does scientific progress matter more than personalities?
VALENTINE: Is he serious?
HANNAH: No, he's trivial.
VALENTINE: Do yourself a favor, you're on a loser.
BERNARD: Oh, you're going to zap me with penicillin and pesticides. Spare me that and I'll spare you the bomb and aerosols. But don't confuse progress with perfectibility. A great poet is always timely; a great philsopher is an urgent need. There's no rush for Isaac Newton. We were quite happy with Aristotle's cosmos. Personally I preferred it. Fifty-five crystal spheres geared to God's crankshaft is my idea of a satisfying universe. I can't think of anything more trivial than the speed of light. Who gives a shit? How did you people con us out of all that status, all that money? And why are you so pleased with yourselves? If knowledge isn't self-knowledge, it isn't doing much, mate. Is the universe expanding? Is it contracting? Is it standing on one leg and singing "When father painted the parlour"? Leave me out. I can expand my universe without you. "She walks in beauty like the night of cloudless climes and starry skies. And all that's best of dark and bright meet in her aspect and her eyes." There you are. He wrote it after coming home from a party.

and then I said "Oh, yes, Cecily's lecture, top of Act II—don't feel you have to use all of it because we didn't. I thought I'd get away with it because it's a new character and she's young and pretty." He said, "*Mais, non.* We must have it all." And I said, "No, listen, I've been there; you don't really have to do this." And he said, "But it's *magnifique*!" So I said, "All right. Fine." Several months later this play happened and I called him up and said, "How are things?" "Wonderful," he said. And I said, "And Cecily's lecture?" "*Formidable*," he said. I thought, "Well, that's the kind of audience I deserve." So I go over to Paris to see the show. And he's right. She does the whole thing. The audience is rapt. You could hear a pin drop. The thing he hadn't told me was that she's doing it stark naked.

So, going back to our equation, the Cecily Lecture I was warning him against would look something like this: $n\,(t) = S - (co)$, where n is the scene, t is the 15 minutes, S is satisfaction, and (co) is the clothes-off factor. By adding clothes off to each side of the equation, the Parisian director achieved satisfaction. In London, we got S by doing $n\,(t - m)$, where m is most of the 15 minutes, but it wasn't as much fun.

There's a lot that might be said about where the artist and the scientist diverge, but all we really know about it is that there's some kind of attitude of the artist towards the scientist Here [left] is a literary man talking to a scientist (he studies grouse, birds) from *Arcadia*.

Well, of course, I load the dice. That's what I do for a living. But we do recognize something.

Well, of course, I load the dice. That's what I do for a living.

We recognize that it's like two kinds of animal meeting in the street. But elsewhere, Bernard, the literary Byron-lover of *Arcadia*, talks about the creative moment, and in trying to describe it he describes something which I believe is the same experience known to scientists in *their* most creative moments.

And because I want to end on a point where art and science intersect, I'll end with what Bernard says:

> BERNARD: I'll tell you your problem. No guts. By which I mean a visceral belief in yourself—gut instinct. The part of you which doesn't reason. The certainty for which there is no back-reference, because time is reversed. Tock tick goes the universe, and then recovers itself. But it was enough. You were in there and you bloody *know*. □

AUTHOR'S NOTE

This article is based on a transcript of a talk delivered from notes. I am grateful to the editors of *Engineering & Science* for giving me the opportunity to sweep up after myself. I have added some remarks, and rephrased others, while trying to retain the general order and sense of what was received by my—as the transcript makes clear to me—tolerant audience.

Tom Stoppard was born in Czechoslovakia, moved with his family to Singapore when he was two years old, and then escaped just ahead of the Japanese invasion to India. When World War II ended, his family settled in England, where he still resides. After graduating from school and beginning his career as a journalist, Stoppard turned to writing short stories and radio plays, and eventually stage plays. His first major dramatic success came with his 1966 comedy, Rosencrantz and Guildenstern Are Dead, *which immediately drew acclaim from both sides of the Atlantic for Stoppard's language virtuosity and wit, not to mention his knowledge of probability theory (a coin comes up heads 126 times in a row, provoking much discussion throughout the play).* Jumpers *followed in 1972; then came* Travesties *(1974), and, among others,* Every Good Boy Deserves Favor *(1978),* The Real Thing *(1984), and* Artist Descending a Staircase *(1988), all of which played in New York as well as in London. He has also written screen adaptations of* Rosencrantz and Guildenstern Are Dead, *J. G. Ballard's* Empire of the Sun, *and John Le Carré's* The Russia House, *and co-authored (with Terry Gilliam, formerly of Monty Python) the original screenplay of* Brazil.

*This year Stoppard had two plays running in London—*Arcadia *and a revival of* Travesties. *When* Hapgood, *which had originally played in London in 1988 and in Los Angeles in 1989, opened December 4 in New York, one critic described Stoppard as a "writer of uncommon cleverness, {who} has always laced his plays with antic wit and provocative ideas banging against other provocative ideas." But understanding this play, the critic complained, required "a nimble mind, an alert eye and graph paper."*