PLAYING SCIENCE

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ABSTRACT

In the past twenty years there has been an explosion of theatre work in English depicting scientific ideas, the culture of science, and even the embodiment of scientific principles through the technologies of the actor's body, visual imagery, and virtual technology. My paper will present a brief overview of the phenomenon, touching on specific plays and productions, as well as providing taxonomies for understanding their thematizations and modes for addressing science as a subject. The overview will encompass "physical theatre" (Second Stage's recent *Notebooks of Leonardo da Vinci*, Tina Landau's *Space*), "image theatre" (Glass's & Wilson's *Einstein on the Beach*, Laurie Anderson's *The Speed of Darkness*), and "conventional theatre" (Carl Djerassi's *Oxygen*, Michael Frayn's *Copenhagen*, the plays of Tom Stoppard, among others).

KEY WORDS: Science, drama, *Copenhagen*, plays.

RESUMEN

En los últimos veinte años ha habido una explosión de obra dramática en inglés que muestran ideas científicas, la cultura de la ciencia, e incluso la personificación de principios científicos a través de las tecnologías del cuerpo del actor, imaginería visual y tecnología virtual. Mi ensayo hará un breve repaso del fenómeno, aludiendo a producciones y obras concretas, y ofreciendo una taxonomía para entender su temática y formas en las que la ciencia se convierte en la materia misma de la obra. La revisión comprenderá el "teatro físico" (la reciente *Notebooks of Leonardo da Vinci*, de Second Stage; *Space* de Tina Landau), el "teatro de la imagen" (*Einstein on the Beach*, de Glass y Wilson; *The Speed of Darkness*, de Laurie Anderson), y el "teatro convencional" (*Oxygen*, de Carl Djerassi; *Copenhagen*, de Michael Frayn, y las obras de Tom Stoppard, entre otras.

PALABRAS CLAVE: ciencia, teatro, *Copenhague*, obras dramáticas.

The arrival of a cavalcade of plays and performances dealing with scientific ideas, issues, and expressive forms derived from scientific models in the last decade has occasioned a variety of recent critical responses. Important work has already been done or is in progress archiving these and older examples of science plays, elucidating their ideas and describing their place within expanded histories of thea-

tre and aesthetics. As part of a larger investigation of possible confluences between two divergent but socially critical cultures, the study of science plays takes place within the debates over the arts and sciences that ground much of Western thought from fifth-century Greece to the present.

In this essay, I endeavor to categorize both some of the plays and critical responses to them, not so much to establish a fixed taxonomy but rather in order to provoke some questions that might guide future pursuits. Much of what I have to say is stimulated by what I heard at a recent conference entitled "Theatres of Science: Crossovers and Confluences," convened with skill and foresight by Michael Carklin and others at the University of Glamorgan, Pontypridd, Wales in September 2004. There, a number of viewpoints were expressed in the compressed timeframe of the academic conference, allowing certain patterns to emerge that might otherwise have gone unnoticed.[1] What follows is an attempt to tease out some of the implications of these patterns.

For those who believe that science plays have emerged as a sub-genre only recently with hits like David Auburn's *Proof*, Tom Stoppard's *Arcadia*, and, preeminently, Michael Frayn's *Copenhagen* (the play often credited with marking the arrival of science plays as a field of critical analysis), the work of Kirsten Shepherd-Barr and others has revealed a much longer and more varied assemblage of work ("Science as Theater"; "*Copenhagen* and Beyond: New Trends in Science and Theater"). According to their findings, beginning with Marlowe's *Dr. Fautus* and incorporating Jonson's *The Alchemist*, the presence of science plays accelerates noticeably after the rise of theoretical and experimental science at the outset of the Industrial Revolution to produce the science-based plays of Ibsen (medical ethics in *An Enemy of the People*) and Shaw (various interpretations of biological and evolutionary theory in *The Doctor's Dilemma* and *Back to Methuselah*, Newtonian science in *In Good King Charles's Golden Days*). Following the rising arc of technocratic societies in the West, science plays increasingly show up both on the margins of the modern canon (Hallie Flanagan's $E=mc^2$, Sidney Kingsley's *Men in White,* Lawrence and Lee's popular Darwinian potboiler *Inherit the Wind*, Ewan McColl's *Uranium 235*) and comfortably within its borders (apek's *R.U.R*, Durrenmatt's *The Physicists*, both pre- and post-Hiroshima versions of Brecht's *Galileo*). As we enter the contemporary period and its fascination with not only ideas stemming from science but the ethical and moral issues they explicitly raise —often in conjunction with perspectives drawn from feminist, intercultural, and critical race studies— the form comes into its own with scores of works dealing directly or more tangentially with the scientific realm.[2]

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[1] There are plans to publish the proceedings of the conference in the near future.

[2] Although a complete list is not possible here, readers may consult the Harry Lustig/Kirsten Shepherd-Barr article "Science as Theater" (*American Scientist* 90) for a partial catalogue. Shepherd-Barr's forthcoming book on science theatre (Princeton UP) will feature a more expansive list.

Of course, such lists are always open to expansion and contraction as definitions of what actually constitutes "science" as a form of knowledge and social activity are altered under the pressure of new thinking and conceptualizations (after all, the Latin root of "science," the verb "to know" [*scire*] is related as well to *scindere*, "to cut or shed"). Most modern scientists would not consider, for instance, the dialogue in John Redford's medieval *The Play of Wit and Science* to even approximate the concerns, methodologies, or forms of inquiry that today would be termed science, yet in its time it might well have represented the cutting edge of the science play. Earlier still, when the distinctions between science and other forms of knowledge were not so explicit, the brief appearance in Aristophanes' *The Birds* of the geometer Meton (complete with geometric instruments) might indicate at least a casual interest in bringing mathematical perspectives to bear on the playwright's excoriating critique of sophist thought. Any number of Latin and medieval plays, as well as early modern masques, featuring human and extra-human representatives of learning, wisdom, and natural philosophy (as in, for instance, Marianus Capella's *On the Marriage of Hermes and Philology* [410], that includes The Seven Liberal Arts as characters) might also be considered science plays within this more expansive definition. And even these broader categories leave out work, both scientific and imaginative, that use dialogue to communicate scientific thought in lively dramatic manner (Galileo's *Starry Messenger*, Fontanelle's "Conversations on the Plurality of Worlds").

Similarly, once one accepts the category of "science play," the emphasis will fall naturally on text-based drama and narrative expressions of scientific ideas based in dialogue and character and driven by plot. Such an approach also makes room for most of the science-based popular musicals that have lately arrived on the scene (*Fermat's Last Tango, Dream True*, *Star Messengers*, *Quark Victory*, *Imperfect Chemistry*, *People Be Heard*) —although exceptions exist, such as the postmodern musical *Einstein's on the Beach* by Robert Wilson and Philip Glass. However, we should be wary of limiting research to dramatic texts only. A number of recent critics have chosen to study how scientific ideas and models may actually be embodied in the very expressive forms of live performance, for example, using scientific notions based in "chaos science" and complexity theory to speculate about Nietzsche's concept of the Dionysian-Apollonian dynamic, or to draw analogies between futurist performance and entropy theory, or to speculate as to how nonlinearity, complementarity, uncertainty, chaos, and complexity as well as other scientific phenomena are inscribed in the work of performance artists such as Richard Foreman (*Love and Science*, and *The Universe, i.e. How It Works*) Rachel Rosenthal (*Rachel's Brain*), and Theatre de Complicite *(Mnemonic*), as well as in the productions of directors such as Peter Brook (*The Man Who...*), Luca Ronconi (*Infinities*), Mary Zimmerman (*The Notebooks of Leonardo da Vinci*), and Jean-François Peyret (*La Génisse et le pythagorien*, *Chimères en automne, Les Variations Darwin*, *Un Faust, Histoire Naturelle*, *Traité des passions*). Even farther afield from the conventional dramatic text, the understanding of actor training has been considerably influenced by application of scientific knowledge to its history (Joseph Roach's magisterial *The Player's Passion: Studies in the Science of Acting*) and theory

(Stanislavski's positivist basis for the Method, Meyerhold's biomechanics, the organic basis of Michael Chekhov's psychological gesture, Lecoq-based mime, and so forth). Indeed, many text-based dramatists already mentioned incorporate movement, body kinesics and proxemics, and design elements into the *mise-en-scene* of their plays to communicate on non-discursive levels the scientific ideas and models that their characters describe or discuss through speech: Stoppard's use of the increasingly chaotic mix of props on the omnipresent table in *Arcadia*, Frayn's employment of movement patterns in *Copenhagen* to mimic the orbits of subatomic particles, the design and dance elements in Tina Landau's *Space*, and so on.

Given the variety of topics and expressive forms available to playwrights and performance artists who desire to reference science in their work, then, it is natural that one form of critical response would attempt to categorize science plays in order to draw distinctions between the various means, aims, and topics used in creating such work. This is sometimes done casually as part of journalistic reviews of plays that attempt to set a given work in relation to other plays still in the immediate cultural memory of audiences. Robert Myers, for example, wrote a Sunday review in the December 5, 1999 *New York Times* that ostensibly described an upcoming festival of science plays as well as the recent Manhattan Theater Club opening of Shelagh Delaney's *An Experiment with an Air Pump*. Along the way, he offhandedly reviewed the history of science plays in the Western canon and previewed a variety of science-based work scheduled to arrive in the near future. Understandably such a topical response to the newly-emerging genre is inclusive and open-minded (all the plays, says Myers, represent an attempt to counter C.P. Snow's infamous dictum regarding "the two cultures"), rather than invested in drawing distinctions between types of science plays.

Similarly, one can detect a tendency to distinguish science plays from one another by reference to content alone, for example, in terms of which scientific field dominates the action of a given play. While it is useful and probably worthy of further analysis to know that initially the majority of science plays were based in cosmology before giving way in the twentieth century to dramas centered on physics and then more recently on topics related to biology and the medical sciences (with the neurosciences emerging as a special concern), such a single focus on the matter of the play does little to explain the specific function of science in the plays, nor does it comment on what thematic concerns are being addressed through reference to science. Aligned with this approach, and perhaps even less useful, are the distinctions drawn between science plays in which the science is "central" as opposed to "tangential." Lurking quite noticeably beneath the surface of such distinctions are implicit value claims that suggest either that too much science is a bad thing in a play, or else that not enough of it will prevent the work from being valued as a science play. Although useful for understanding a given spectator's (or critic's) biases in terms of what is expected from the sub-genre of the science play, such distinctions in the long run are not particularly helpful. The value of the approach dwindles, for instance, once one recognizes that some of the most successful science plays —perhaps Auburn's Pulitzer-Prize winning mathematics play, *Proof*, preemi-

nently— contain very little in the way of explicit scientific or mathematical reference. Auburn reportedly researched the personalities of prominent mathematicians and some of their work, even going so far as to invite members of the New York University mathematics department to visit rehearsals and offer comments on the work-in-progress. Yet the final script, while it is infused with the drama of how the mathematical mind might operate, finds little need to explain the long-lost theorem that forms the basis for the action.

Another category of critical response that takes itself more seriously than casual observations on a play's context or content is the prescriptive account that argues the case for one approach over others in the integration of science and theatre. Carl Djerassi, the award-winning scientist-turned-playwright, has established himself as a strong polemicist for what he calls variously "Science-as-theatre" and "science-in-theatre." In public lectures and published articles, Djerassi argues that, after a period during which playwrights generally included references to science solely in order to critique it and to "express their skepticism about science" (he cites as examples *The Physicists* and Brecht's later version of *Galileo*), writers eventually began to risk didacticism by using the stage to communicate real scientific ideas and (equally important for Djerassi) "to illustrate *how* scientists *behave*" ("Science as Theatre"). Pointing first to the success of *Copenhagen,* and marveling at the patience of audiences willing to listen to long set-speeches on quantum science and the dynamics of the inner workings of Bohr's inner circle of fellow researchers, Djerassi then turns to uncovering earlier science-in-theatre plays that were equally successful in the pursuit of plausibly explaining important scientific ideas without sacrificing interest in character or story. Citing Stephen Poliakoff's *Blinded by the Sun* and Hugh Whitemore's *Breaking the Code* as predecessors, Djerassi then turns to his own work (*An Immaculate Misconception*, *Oxygen* and, by implication, later plays such as his recent *Calculus [Newton's Whores]*) to explain the differences between plays —such as *Arcadia*, which he holds in great esteem— that use science only for its "intellectually attractive metaphors" and those which take as a primary pedagogical task the use of drama to communicate science and to present an anthropology of its "tribal culture." I will return to this issue near the end of the essay in order to unpack some of its assumptions and consequences for the study of science plays.

If at the far end of this spectrum is the notion that theatre somehow serves the need to communicate existing science clearly and dramatically, at its opposite pole are critical responses to science plays that seek in them evidence of a far-reaching paradigm shift that would threaten the very foundations of science as it is constituted presently. Without doubt a number of science plays set out, as Djerassi argues, to critique science, particularly in its Cartesian and Western manifestations. However, most early versions of such plays (Ibsen's work, Flanagan's $E=mc^2$, *Galileo*, Kipphardt's *In the Matter of J. Robert Oppenheimer*, and so on) launch their appraisal using the same rational analysis and objective moral logic that undergirds the very science under critique. What distinguishes some contemporary science plays, and the critical response they engender, is a willingness to subvert the foundational principles and methods of science *tout court* on epistemological and/or

moral grounds. A feminist deconstruction of the objective masculine gaze as it operates in Freudian clinical psychoanalysis as described by Hélène Cixous (*A Portrait of Dora*) does not reproach science only for the nature of its ethics or the moral cowardice of its practitioners, but undermines as well the very standpoint from which science is launched and the language with which it describes the objects of its study. Even a more conventionally written and staged play like *Copenhagen* offers the suggestion that postclassical physics might herald, not simply an extension of deterministic and rule-bound Cartesian and Newtonian scientific inquiry, but a sea-change toward something rich and strange, what Cara Gargano calls (in an essay characteristic of this approach) "another shift in our mythic-scientific paradigm" (151).

Not surprisingly, plays serving these ends are often associated with postmodernism and its rejection of traditional modes of representation. However, rather than associating the nonlinearity and chaos embedded in a work like *Arcadia* with the corrosive skepticism and extreme relativism of much postmodern theory, critics are more apt to seek in the outcome of the play (and others like it) what some refer to as a "constructive postmodernism." As I have written elsewhere concerning this branch of postmodern theory:

> Against the perceived radical nihilism of [...] postmodernism, constructive postmodernism attempts an ecological and phenomenological response that seeks patterns in the deconstructed free play of meaning and origins. Although the ideas associated with constructive postmodernism are transparently an attempt to refute the more extreme claims of postmodern theory, and to recuperate in modified form the ideologies of humanism, science, and spiritualism that most postmodern theory attempts to evacuate, there is no denying that these ideas attract a number of important thinkers from across the disciplines (perhaps most prominently the art historian Suzi Gablik).

As part of the more general reaction against the extremes of poststructuralist and postmodern theories that begins with Habermas's *The Philosophical Discourse of Modernity* (1985), constructive postmodernism argues, in N.F. Gier's somewhat overwrought formulation, that "the French deconstructionists are throwing out the proverbial baby with the bath water. [They] wish to reject not only the modern worldview, but any worldview whatsoever" (13). Sharing deconstruction's suspicion of logocentrism and the dominance of Cartesian rationalism and the Enlightenment faith in science, the constructive postmodernists would attempt, not simply to affirm this state of radical multiperspectivism, but to join forces with the "new sciences" of nonlinear systems theory, cybernetics and other forms of pattern-based thinking to rediscover and "re-enchant" the world by divining orders of meaning and value hidden to linear and logocentric thinking. The New Age rhetoric of much constructive postmodernist thought arises from its desire to forge an integrated concept of humankind and social reality out of "the best" elements of pre-modern and modern societies, seeking a union of *Gemeinschaft* and *Gestellschaft* that will "avoid the liabilities of both premodernism and modernism" (Gier 14).

As expressed in cultural terms by Gablik in *The Reenchantment of Art*, the hope is for a new art "ushered in by twentieth-century physics, ecology and general systems theory, with its call for integrative and holistic modes of thinking" (6).[3]

Sometimes based in the ideas of science popularizers such as Fritjof Capra or Robert Pirsig, and often willing to find a continuity of purpose between what are in reality quite different forms of scientific thought studying objects at vastly different scales (Gargano typically conflates "Heisenberg's Uncertainty Principle, Einstein's Theory of Relativity, Schroedinger's wave equation, Bell's Theorem, Mandelbrot's fractal world and Lorenz's strange attractors" as scientific ideas that "all propose a world based on instability, indeterminacy, fragmentation and chaos" ["Complex Science" 151-52]), critics espousing the paradigm-shift argument run the risk of reductionism and are sometimes easy prey for historians and scientists whose methods are more conservative and generalizations less dazzling (a dynamic apparent at several stages of the recent "Theatres of Science" conference in Wales). Early manifestations of chaos science, such as those popularized by James Gleick's bestselling *Chaos: The Making of a New Science*, are often the source of much of this theorizing, despite convincing critiques by Katherine Hayles and others of its limited and somewhat overstated presentation of the sciences of deterministic chaos.[4] Nevertheless, such interpretations of a number of contemporary science plays and performances have discovered an important utopian strain in the evolution of science plays, and the best examples of such work —Natalie Crohn Schmitt's early *Actors and Onlookers: Theater and Twentieth-Century Scientific View of Nature*, William Demastes' *Theatre of Chaos: Beyond Absurdism, into Orderly Disorder*, among others— argue convincingly that playwrights and performance artists are actively seeking new metaphors and expressive dynamics in their work in order to theatricalize science for purposes other than its critique.

The final critical perspective I will sketch before going on to attempt my own taxonomy focuses its critical lens on the different forms of theatrical language and speech acts deployed in different kinds of science plays. Kirsten Shepherd-Barr has suggested that a number of the most successful science plays tend to be "more traditional, realistic and character-driven plays" that successfully "employ a particular scientific idea or concept as an extended metaphor —they literally *enact* the ideas that they engage" ("*Copenhagen* and Beyond" 1). The theatricality of "traditional" science plays such as *Copenhagen*, *Arcadia*, Timberlake Wertenbaker's *After Darwin*, and others is placed in the service of literalizing the scientific concepts operating in the work so that they can be experienced as metaphors relating to love, moral uncertainty, ethical action, and the like. Such work tends to be conventional as well in its genesis, following the accepted Western practice of proceeding from an author's written text to the director's condign interpretation of its language and

[3] See also Vanden Heuvel forthcoming "A Different Kind of Pomo."
[4] See for instance Hayles, and Cilliers.

mise-en-scene, and finding final physical expression in the company's acting and design. The work is thus heavily "mediated" in a phrase Shepherd-Barr takes from Ronconi, by which is meant the process by which the scientific concepts and ideas are explained through discursive language, relatively traditional manifestations of character (often associated with biographical material on the scientist), and plots that may be uncertain, nonlinear, and even chaotic —but which nevertheless establish strong links between scientific ideas and the metaphors used to portray them. Interestingly, then, in many ways these and the majority of conventional science plays mimic quite closely the Newtonian worldview that they are often at pains to surpass.

As somewhat distinct from (although often overlapping with) "traditional, realistic and character-driven plays" Shepherd-Barr recognizes forms of the science play less dependent on such mediation, which work to immerse audiences directly in the experience of temporal and spatial realities that science seeks to explain abstractly and conceptually: hence, "the experience of the audience becomes much more about imbibing or sensing the science through its enactment than about listening to explanations of it from characters and following their stories" ("*Copenhagen* and Beyond" 1-2). By nature of the sciences being deployed in such work, the presentations are often themselves fragmented, partial, nebulous, many-layered and incomplete. Indeed, Shepherd-Barr argues that the genesis of these plays and performances must circumvent the usual linear sequence of author-director-production team and explore instead collective and improvisational forms of creation in which stories branch out in unexpected directions, double back on themselves in feedback loops, absorb both public texts and the private recollections of the company members, and engage in constant transformation that in some cases (as with Theatre de Complicite and Jean-François Peyret's *Théâtre-Feuilleton)* may continue until very close to the show's opening. The primacy of physical research, both as a means to embody scientific concepts and as the use of the body as a site for exploring non-discursive forms of knowledge, means that the final realization in performance will not be addressed to the intellect nor directed toward clarifying conceptual material.

Shepherd-Barr's approach performs the welcome task of distinguishing not just different styles of science plays, but different ideas about how science plays might function and be interpreted —and used— by audiences. I find this helpful because, despite the laudable efforts to bring scientists and theatre artists together (or indeed artists of any stripe) at conferences such as those convened yearly by the Society for Science and Literature or by faculty at campuses like Glamorgan, there remain notable rifts between the two camps. To draw out just one of the more obvious differences, in Pontypridd it was evident that many of the scientists —from fields such as Applied Science and Science Education, or from corporate entities with an investment in science curricula such as the Wellcome Trust and Techniquest— attending the conference were naturally there to explore how theatre could serve the agenda of science communication, including providing a means to inculcate in young students a greater enthusiasm for studying science. Toward this eminently worthy goal, panels and workshops were staged to provide examples of

how dance, mime, patterned movement, circus and street theatre techniques and the like could effectively convey sophisticated scientific ideas, as well as the imaginative process by which scientific discovery is often made.

Despite a good deal of collaboration and a very positive sense that such cross-disciplinary work could only benefit both artists and science educators (and Britain's longstanding commitment to theatre in education guaranteed a certain *rapprochement* between science and theatre educators), the absence of any discussion regarding the means by which the equation could be reversed, and by which theatre could influence the manner in which science is conceived of or practiced, left some feeling that once again the arts were being positioned as merely a helpmeet to the more powerful or authentic discourses of science. Comments made in the closing plenary that not enough time had been spent on explaining or demonstrating how theatre practice could assist the more practical ends of science communication, and that many of the panels were "too theoretical" and speculative, revealed this consistent bias, evident as well in Djerassi's keynote address on "science-in-theatre" and in a number of papers discussing the application of theatre training or practice to the communication of science.

The assumptions nested within such attitudes are easy to discern: that science itself remains the domain of rational discourse and speech acts, but which needs to be sexed up a bit by theatrics to hook young audiences into its culture. Further, there is a strong sense from this view that theatre's representational logic remains fixed in simple and transparent models of communication, that is, that theatricalizing a scientific concept or some aspect of the history of science simply communicates its content without altering its meaning in any way —theatre as a mirror held up to whatever nature the science already provides, or a transparent window through which scientific ideas and history may be clearly seen. These powerful assumptions are rendered more potent still when one considers a material cause of the appearance and support of so many contemporary science plays: that is, the funding of such work —and often symposia and other events surrounding the plays— by entities like the Wellcome Trust and the Sloane Foundation which have an investment in science education.

To make this case more compellingly and to provide one final taxonomy of science plays, let me suggest that we can distinguish between science plays lying along a continuum, one end of which is defined by the purpose of science education and communication, and the opposite end by an intent to question and complexify scientific methods, practices, and concepts in order to unsettle their clarity and rigor. For a case study I choose the omnipresent *Copenhagen* as a science play the critical interpretations of which reveals the issues at stake in such distinctions.

An unremarked aspect of the presence of science plays in the contemporary repertory is the tendency for their productions to elicit journalistic responses, not initially from theatre critics and scholars, but from expert scientists. *Copenhagen* is hardly along in this light: as mentioned already, David Auburn invited mathematicians to sit in on rehearsals while he fine-tuned *Proof*. But further examples could be drawn from *Arcadia*, the original production of which included program notes from the mathematical ecologist Robert May, and which drew published responses

from a number of notable scientists. Frayn's play, however, had the unique experience of being reviewed quickly by both scientists and historians of science, among whom were several Heisenberg biographers. Most notable among these were Thomas Powers, whose non-fiction work *Heisenberg's War: The Secret History of the German Bomb*, and Paul Rose, author of *Heisenberg and the Nazi Bomb Project* provided antithetical accounts of Heisenberg's degree of complicity. Powers reviewed Frayn's play positively (see Powers "The Unanswered Question") because it conformed largely to his version of the historical record and left Heisenberg's guilt uncertain (see Powers), while Rose published one of the very few negative reviews of the play based primarily on his sense of its historical inaccuracies and the way that exempted Heisenberg from blame (see Rose).

As Gerald Horton said at a symposium at the CUNY Graduate Center in conjunction with the New York production of the play in 2000, *Copenhagen*'s volatile mix of science, history, and theatre necessarily runs the risk "that the intermingling of playwright, actors, physics and history of science, might in some minds strengthen the all-too-common failing to confuse the play, a work of fiction, with a documentary" (1). Indeed, this confusion seems to me an extension of the desire to see theatre as a transparent window or medium of clear communication, a aspiration that undergirds the relationship between theatre and science espoused by those who want theatre to serve the helpmeet's role of making science more palatable and pellucid. Historians of science express a similar desire, as when David C. Cassidy, who has done important work on Heisenberg's wartime activities, criticizes the play ("solely as an historian [...] a viewer or a playwright would have other considerations") for failing to broaden the historical spotlight on the action in order to display other controversial visits that Heisenberg made to Nazi-occupied countries (Cassidy 2-3). Thus, historians want theatre to be fully-fleshed out history, while the scientists insist it must be scientific, or at least "science-in-theatre": nobody seems, however, to want it to be *theatre*.

A counter-argument to these criticisms of *Copenhagen* and to the underlying assumptions about the relationship of theatre to science that motivate them is provided by Reed Way Dasenbrock's "*Copenhagen*: The Drama of History. "*Copenhagen* is a play," he argues, "and genre does exert some force here" (221). In a period that has seen theatre play an important metaphorical role in the critique of positivist science and history (in the work of Hayden White, Foucault, Stephen Greenblatt and the "New Historians," among others) one would assume that the notion of theatre merely reflecting like a neutral mirror historical facts and scientific concepts would have disappeared long ago. As Dasaenbrock says, "Today, we may need to be reminded the other way, not that the theater is an isolated monad, but indeed that it does possess some features of its own and does not stand simply in relation to forces outside of it" (221). Certainly one of these features is the use of dramatic character to refract authorial voice and point of view. There is, despite Bakhtin's infamous rejection of theatre as a site of true heteroglossia, a fundamentally dialogic quality to dramatic performance. As Marvin Carlson points out, "it is particularly in the modern drama where a variety of forces have worked to increase the plurality of voices and to encourage [...] open forms," by which he means

patterns of dramatic action that resist closure and an objective determination of the author's point of view or intention. "The reality they [Ibsen, Hauptmanm, Chekhov] sought to depict was shifting, ambiguous, evanescent [...]" (Carlson 316). The purpose of the dialogic form, says Bakhtin —whether found in carnival, Rabelais, or Dostoevsky— is "an indeterminacy, a certain semantic open-endedness, a living contact with the unfinished, still-evolving contemporary reality (the open-ended present)" (7). What happens, then, if we grant this dialogic capacity to modern drama, and specifically to the presentation of science on the stage?

Frayn's play is not the resolution of an historical riddle nor the theatricalized explanation of the indeterminacy principle inflated to the macro scale: it is a play, and in its play of plural voices there are those who speak "for" indeterminacy and relativism in the ethical realm (Heisenberg) and those who speak "against" it (Bohr and, equally powerfully, Margarethe). In fact, in this play it happens three times! The point is that in theatrical performance, unlike written history or science, the voices are related dialogically, and what gives the performance its life is just the "semantic open-endedness" that creates the context for unending refraction and —in the spectator— perpetual reflection. The theatre, then, seems to me an unlikely site of clarification, and so I wonder if the use of performance for science communication, apart from methods developed specifically for theatre in education curricula, might not be eternally fraught with contradictions and working at cross-purposes.

This is not to say that *Copenhagen* takes theatrical dialogism to its furthest limit: both Luca Ronconi (director of *Infinities*, a play based on the writings of scientist John Barrow) and Jean-François Peyret have decried the textual containment of Frayn's play, with Peyret going so far as to refer to it as "*faux theatre*" and "*théâtre de la morgue*": "If they want to know whether Heisenberg was good or bad, they have access to scientific debates of they want to, they don't have to come see a play. We don't have to do night school" (qtd. in Shepherd-Barr, "*Copenhagen*..." 2). Further along the continuum, the "alternative" and unmediated forms of science play described by Shepherd-Barr might substantially extend the ability of theatre, not to explain science or popularize it, but to estrange and defamiliarize it to the point that we may begin to see it for the strange and sometimes disturbing human activity it has always been.

I do not expect, nor would I wish for, collaborations between scientists and theatre artists to cease; but it will be interesting to observe whether one end or the other of the continuum I have sketched will come to dominate these alliances. In the end, it seems likely that the categories of science plays, as well as the nature of collaborations between scientists, educators, and artists, will expand rather than contract. While concerns should be raised about the institutional pressures shaping the discourse (powerful and well-funded science programs within academia, corporate funding for science and theatre collaborations, and the like), such hegemonies are always open to resistance and transgression and will likely never dominate the desire of imaginative thinkers and artists to delve into the fascinating possibilities presented by the prospects of making theatre scientific and science more theatrical.

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