CONNECTING CREATIONS

Science-Technology-Literature-Arts

Edited by

MARGERY ARENT SAFIR

CGAC Centro Galego de Arte Contemporánea

SCIENCE-IN-THEATER:
From Oxygen

Carl Djerassi and Roald Hoffmann

The play Oxygen *is headed for American, Swedish, and British productions in 2001. The authors' discussion and presentation of excerpts from it here is an* avant-première. Editor's note.

Science is inherently dramatic – at least in the opinion of scientists – because it deals with the new and unexpected. But does it follow that scientists are dramatic personae? Or that science can become the stuff of drama? Until now, "science-in-theater" has proved to be a rare genre, although playwrights of the caliber of Brecht, Dürrenmatt, Whitemore, and Stoppard have on occasion chosen scientists or scientific themes as components for the plots of major plays.

A more recent phenomenon of the London theater scene is the appearance of "pure" science-in-theater plays by prominent playwrights who are not scientists. Steven Poliakoff's *Blinded by the Sun* attempted to illuminate some of the idiosyncratic aspects of a scientist's drive for name recognition as well as the competitive aspects of a collegial enterprise through a theatrical version of the chemical "cold fusion" debacle of the early 1990s. Michael Frayn's *Copenhagen* calls upon quantum mechanics and the uncertainty principle for much of the scintillating interplay during a wartime encounter in Copenhagen between two physicists, Niels Bohr and Werner Heisenberg, under the skeptical eye of Bohr's wife. Although Frayn made no concession to scientific illiteracy, the play still became a major West End theatrical success.

But can science-in-theater also fulfill an effective pedagogic function on the stage, or are pedagogy and drama antithetical? Must pedagogic motivation be an automatic kiss of death when writing for the commercial theater? "Didactic," other than "boring," is usually the most damning term used by a reviewer to drive a prospective audience from a given play. Is that because the dictionary definition of the term is "designed or intended to teach" and that common wisdom tells us that a theatergoing public abhors being taught?

However, *Webster's Dictionary* contains also an expanded definition of "didactic," namely, "intended to convey instruction and information, *as well as pleasure and entertainment*" (emphasis added). We have attempted to accomplish both aims in a science-in-the-

ater play in which we transmit information about an important aspect of chemical history and at the same time shed light on some idiosyncratic aspects of the scientific culture.

There is one other point worth mentioning about science-in-theater before proceeding with a direct description of *Oxygen*. Written scientific discourse is invariably monologist, so that even a lecture based on such a text lacks any dialogue. Yet dialogue is the most human form of communication and the defining characteristic element of theater. *Oxygen*, though dealing entirely with science, is pure dialogue.

First, we introduce the cast of characters spanning well over two hundred years.

Stockholm, 1777:

ANTOINE LAURENT LAVOISIER, 34 years old. (French chemist, tax collector, economist, and public servant; discovered oxygen).

ANNE MARIE PIERRETTE PAULZE LAVOISIER, 19 years old. (Wife of the above).

JOSEPH PRIESTLEY, 44 years old. (English minister and chemist; discovered oxygen).

MARY PRIESTLEY, 35 years old. (Wife of the above).

CARL WILHELM SCHEELE, 35 years old. (Swedish apothecary; discovered oxygen).

SARA MARGARETHA POHL (FRU POHL), 26 years old. (Became MRS. SCHEELE three days prior to Carl Wilhelm's death).

Stockholm, 2001:

Professor BENGT HJALMARSSON, member of the Chemistry Nobel Prize Committee of the Royal Swedish Academy of Sciences. (*Same actor as ANTOINE LAVOISIER*).

Professor SUNE KALLSTENIUS, member of the Chemistry Nobel Prize Committee of the Royal Swedish Academy of Sciences. (*Same actor as CARL WILHELM SCHEELE*).

Professor ASTRID ROSENQVIST, chair of the Chemistry Nobel Prize Committee of the Royal Swedish Academy of Sciences. (*Same actress as MRS. PRIESTLEY*).

Professor ULF SVANHOLM, member of the Chemistry Nobel Prize Committee of the Royal Swedish Academy of Sciences. (*Same actor as JOSEPH PRIESTLEY*).

ULLA ZORN, a graduate student in the history of science, and amanuensis to the Chemistry Nobel Prize Committee. (*Same actress as FRU POHL*).

In 2001, the Nobel Foundation decides to celebrate its Centenary by establishing a "Retro-Nobel" award for those great discoveries that preceded the establishment of the Nobel Prizes one hundred years before. The Foundation thinks that this will be easy, that the prize-selecting bodies can reach back to a period when science was done for science's sake, when discovery was simple, pure, and unalloyed by controversy, priority claims, and hype...

(Conference room at Royal Swedish Academy of Sciences, Stockholm, summer 2001. Lights focus on two members of Nobel Committee for Chemistry, Professors BENGT HJALMARSSON and SUNE KALLSTENIUS, who are huddling left downstage in almost whispered private conversation. Rest of stage very dark.)

SUNE KALLSTENIUS: You sounded dubious.
BENGT HJALMARSSON: I didn't notice any excitement on your side.
SUNE KALLSTENIUS: Initially, I thought... a *Retro*-Nobel? There must be better ways of celebrating the centenary of the Nobel Prizes than establishing a new one for work done before 1901...
BENGT HJALMARSSON: With no one alive to receive it. But now?
SUNE KALLSTENIUS: I rather fancy recognizing dead people – it's different.

The Committee decides that the discovery of oxygen – a truly seminal event that started the Chemical Revolution of the late eighteenth century – merits recognition for the first Retro-Nobel Prize in Chemistry. The new element was used by Lavoisier to build a coherent understanding of burning, respiration, and rusting of metals – all combinations with oxygen in the atmosphere. In that new picture of these fundamental chemical reactions, as well as others, weight balances were critical. Reformulation of chemistry as a quantitative science took nothing away from its time-honored role as the ultimate art of transformation (which played such an important role in the relationship of chemistry and alchemy). In fact, it subsequently led to the flowering of chemical analysis and, eventually, synthesis.

But who, specifically, should be honored for that discovery?

ULF SVANHOLM: Why not a Swede for the first one? When it came to the regular Nobel Prizes, the Academy waited until 1903 before giving it to Arrhenius.
ASTRID ROSENQVIST: He can't just be Swedish! He also has to deserve it.
BENGT HJALMARSSON: How about Carl Wilhelm Scheele... for the discovery of oxygen. (*Pause*) Focusing on the eighteenth century may not be a bad idea. People published less... so we have less to read. And most of them worked alone, so none of the usual arguments about dividing the Prize.
ULF SVANHOLM: But if we select Scheele, what about Lavoisier?
SUNE KALLSTENIUS: Or Joseph Priestley?
BENGT HJALMARSSON: Back in the usual Nobel quandary: too many candidates.
ULF SVANHOLM: How about John Dalton, the father of the atomic theory?
SUNE KALLSTENIUS: For that, oxygen had to be discovered first... and its role in chemistry understood! Maybe for the second or third Retro-Nobel...
ASTRID ROSENQVIST: Oxygen ought to come first! Even if a Frenchman or an Englishman gets the credit.
ULF SVANHOLM: *Gets* the credit? Surely you mean *shares* it!
ASTRID ROSENQVIST: That's up to our committee to determine...

Indeed, on an evening in October 1774, Antoine Lavoisier, the architect of the Chemical Revolution, learned that the Unitarian English minister, Joseph Priestley, had made a new gas. Probably during the same week, a letter came from the Swedish apothecary, Carl Wilhelm Scheele, instructing the French scientist how one might synthesize this key element in Lavoisier's developing theory, the life-giver oxygen. But Scheele and Priestley fit their discovery into an entirely wrong logical framework – the phlogiston theory – which Lavoisier was about to demolish.

How did Lavoisier deal with the Priestley and Scheele discoveries? Did he give the discoverers their due credit? And what is discovery after all? Does it matter if you do not fully understand what you have found?

Here is how the 2001 Nobel Committee describes the intellectual setting in 1777:

ASTRID ROSENQVIST: First to the discovery: No one will question that oxygen confers great benefit on mankind, right?

BENGT HJALMARSSON: Oxygen was good for people before it was "discovered."

ULF SVANHOLM: But there are plenty of benefits that *require* for oxygen to be isolated. What about the emphysema victim in an oxygen tent... the Everest climber with his oxygen bottles... the astronaut in the space suit?

SUNE KALLSTENIUS: We didn't pick oxygen for its value to mountain climbers or astronauts or sick people.

ASTRID ROSENQVIST: Who'd like to come up with some simple phrases to explain that without the discovery of oxygen there would have been no Chemical Revolution... no chemistry as we now know it?

BENGT HJALMARSSON: I'll give it a try. Prior to Lavoisier –

SUNE KALLSTENIUS: You mean prior to the discovery of oxygen –

BENGT HJALMARSSON: To me they are the same.

SUNE KALLSTENIUS: To me they are not.

BENGT HJALMARSSON: Bah... Before the Chemical Revolution, people were convinced that when things burned, something was released... called phlogiston...

(*Turns to ZORN*)

Do you want me to spell that?

ULLA ZORN (*Quick and dismissive, without looking up while typing quickly*):

P . . . H . . . L . . . O . . . G . . . I . . . S . . . T . . . O . . . N .

ASTRID ROSENQVIST: Hold it, Bengt! The public at large... and these days, even many chemists... won't have the slightest idea what phlogiston means. They can't even pronounce it. Please... make it clear... and make it short.

BENGT HJALMARSSON (*Impatient*): "Phlogiston: the essence of fire." How's that for a pithy definition? But why even bother with a discarded theory?

ASTRID ROSENQVIST: Because Priestley and Scheele weren't fools. And they believed in phlogiston till they died.

SUNE KALLSTENIUS: And it made sense... in its own way. They thought when anything burns, something... specifically that wondrous phlogiston... *leaves* that burning object and goes out into the air.

ULF SVANHOLM: There was more to the Chemical Revolution than destroying phlogiston: Many

chemists then still believed in the four elements of the Greeks: air, water, fire, and earth.
BENGT HJALMARSSON *(Impatient):* Why not just say, the language of chemistry was a holy mess and the grammar all wrong? Let's get to the business of picking the winner. Prizes are given to people, not to discoveries.
ASTRID ROSENQVIST: Prizes go to people, sure. But they need to have discovered something, understood it.

In a fictional encounter, the play brings the three protagonists and their wives to 1777 Stockholm at the invitation of King Gustav III. The question to be resolved: Who discovered oxygen? In our play a central role is played by the wives of the three. In their voices, in a sauna and elsewhere, we learn of their lives and those of their husbands.

The excerpt that follows comes from the fifth scene in the play, but is the first one where the audience meets the three protagonists.

SCHEELE: How gracious of you to travel so far, Monsieur Lavoisier. I have never left Sweden.
LAVOISIER: The invitation came from His Majesty. But –
SCHEELE: But, Monsieur?
LAVOISIER: His Majesty's curiosity on matters scientific is known to all of us...
SCHEELE: Indeed it is.
LAVOISIER: But does it encompass pneumatic chemistry?
SCHEELE: Perhaps.
LAVOISIER (*Sarcastic*): And includes a personal desire to have us verify in public, as the invitation states... "each savant's claims to Fire Air"?
SCHEELE: Perhaps it does.
LAVOISIER: One does not refuse a king. But –
SCHEELE: But, Monsieur?
LAVOISIER: Ah, Monsieur. You arrived just in time.
(*Addresses Priestley*)
The royal invitation, you may recall, demands from each of us an actual experiment...
PRIESTLEY: Indeed it does.

SCHEELE: Which, His Majesty suggests, will be executed by another.
PRIESTLEY: But why?
SCHEELE: To confirm each person's claim.
PRIESTLEY: Claim? Can what is fact be claimed?
SCHEELE: Once reproduced by another, claims become facts.
PRIESTLEY: So they do. But does the King, or... you doubt my experiments?
SCHEELE: No, my dear Doctor. But the world needs proof.
PRIESTLEY: Proof it shall have. Until tomorrow then!

In the 1777 fictitious Judgment of Stockholm, a scene featuring chemical demonstrations, the three discoverers of oxygen recreate their critical experiments. What follows are selected excerpts from that scene.

(Trumpets, as at the Nobel Award ceremonies, then...)
COURT HERALD'S VOICE: We meet today for the judgment of reason... the Judgment of Stockholm!
LAVOISIER (*Furious, aside to Mme. Lavoisier*): I was invited for a challenge... I have not come to be judged!
COURT HERALD'S VOICE: Your Majesties, esteemed guests! Throughout Europe... pneumatic chemistry... the chemistry of gases or airs... is in the air. A dispute has arisen: Who, among these great savants, discovered the vital air supporting life? (*Pause*) A golden medal... with a likeness of our King Gustavus III... will be struck in honor of the true discoverer. And our King is famed for his munificence in other ways...
PRIESTLEY (*Aside*): As he squanders the people's money...
(Trumpets)
COURT HERALD'S VOICE: Let the Judgment of Stockholm begin! And let the three savants be their own judges! Vital air! Who made it first?
SCHEELE *(Quietly, but quickly)*: I did. And called it *eldsluft*... a good Swedish word for fire air. Or *Feuerluft*... in German.
PRIESTLEY: But is that not air deprived of all phlogiston? The air that inflames all things?

That is why I named it "dephlogisticated air." (*Pause*) But dear Scheele... where should we have learned of your discovery?

SCHEELE: In my book, about to appear...

PRIESTLEY: I made that air in 1774 and communicated that discovery in the same year! (*Addresses Scheele*)

I know of no paper of yours...

LAVOISIER *(Mocking)*: *Mes amis*! He who starts the hare, does not always catch it.

SCHEELE: There is no hare to catch if someone does not start the hunt!

LAVOISIER: It is we who must decide who first captured the essence of that vital air...

PRIESTLEY (*Sarcastic*): What does that mean?

SCHEELE: It is essential to know who *made* the air first...

PRIESTLEY: ... for it is the invention that will be remembered by posterity, not its ephemeral interpretation...

LAVOISIER *(Overriding them)*: Let us do the experiments we judge vital in this matter. Whose experiment will come first?

SCHEELE: Monsieur Lavoisier, do me the honor of performing the experiment I brought to your attention some three years ago in my letter –

LAVOISIER: I know of no letter –

SCHEELE (*Takes paper from his pocket*): Let me read from that letter my prescription to prepare the vital air.

LAVOISIER: Which I will follow.

(Lights dim; spots on two men. This is the first of three experimental scenes. The stage is darkened, except for spots on the bench and on the man who performs the experiment, as well as the one who directs him.)

SCHEELE (*Reads from letter in his hand*): Dissolve silver in acid of nitre and precipitate it with alkali of tartar. Wash the precipitate, dry it, and reduce it by means of a burning lens... A mixture of two airs will be emitted. And pure silver left behind.

LAVOISIER: And then?

SCHEELE: Trap the fixed air... the product of respiration... in limewater.

LAVOISIER: It is done.

SCHEELE: What is left is my fire air... or what you call "vital air."

LAVOISIER: And your evidence for it being vital air?

SCHEELE: Place a newly extinguished splint into the gas you have just collected.

(*Lavoisier does so)*

MME. LAVOISIER: It flares up!

MRS. PRIESTLEY: And still burns!

SCHEELE: I did that experiment in 1771 in a pharmacy in Uppsala... with equipment much more modest than now put at our disposal by his Majesty... on the only day I had each week for research. And I obtained this air over the next three years in many different ways... The very same air.

PRIESTLEY: And how do you explain the action of that air on a splint?

SCHEELE: Through the phlogiston theory! My new air simply craves fire.

LAVOISIER: That red mercury compound – it is also how we... Dr. Priestley and I... made that air.

PRIESTLEY *(Angrily)*: *We*? We were not in the same laboratory, Monsieur Lavoisier! Pray speak clearly of who did what and when. *I* made that air first... and did so alone. And I will now show you how I accomplished that. Mr. Scheele, will you perform the experiment?

SCHEELE: It will be an honor to do so.

(*Both men step to demonstration table; lights dim)*

PRIESTLEY: In August of 1774, I exposed *mercurius calcinatus*... the red crust that forms as mercury is heated in air... in my laboratory to the light of my burning lens.

MRS. PRIESTLEY (*Whispers to Mme. Lavoisier*): I have been told that *mercurius calcinatus* was used in the treatment of venereal disease. Of course, that was not why Dr. Priestley secured his supply in Paris...

MME. LAVOISIER*:* I'm reassured to hear that.

PRIESTLEY (*Addresses Scheele*): As the red solid is heated, an air will be emitted, while dark mercury globules will condense on the walls of the vessel. You will collect the air by bubbling it through water.

LAVOISIER: But where is your balance, Dr. Priestley? Shall the gas not be weighed?

PRIESTLEY: A timepiece is sufficient. We have here two chambers... one with ordinary air... the other with my new dephlogisticated one. Mr. Scheele, now place one mouse in each vessel and let us see which lives the longer.

(*Short darkness, indicating time passage*)

MME. LAVOISIER: This one is dead...

SCHEELE (*Reaches over, holding live mouse by its tail*): But that one lives on... in my fire air.

MRS. PRIESTLEY: My Joseph's dephlogisticated air...

LAVOISIER: There is no doubt that Dr. Priestley's method produces vital air. But –

PRIESTLEY: *But*, Monsieur?

LAVOISIER: Now is my turn. May I proceed?

SCHEELE, PRIESTLEY: Of course.

LAVOISIER: We just observed a mouse living longer in vital air. Yet in the end that mouse also dies, as the vital air... which I propose we henceforth call "oxygen"... is depleted. However, in my *own* work...

(*Faces Priestley*)

I have moved far, far beyond watching mice die. Your Majesty, gentlemen, I have shown that when we breathe, the wondrous machinery of the body transforms a given weight of oxygen... into other gases and water.

PRIESTLEY: But that is obvious!

LAVOISIER: Not until you weigh it! For that... (*confronts Priestley*)... a timepiece is *not* sufficient... Since nothing is gained... nor lost in this world, be it in the economy of a country or a chemical reaction, the balance sheet of life's chemistry must be determined.

PRIESTLEY: Ah, it's the banker in you...

LAVOISIER *(Ignores Priestley's comment)*: I have devised a suit of rubber allowing us to catch all effluents of the body... to balance the equation. Dr. Priestley, are you prepared to perform the experiment?

PRIESTLEY: Indeed I am... even weighing things on your balances. It appears we require a volunteer for the experiment... to wear your modern suit of armor.

MME. LAVOISIER: I will do it!

LAVOISIER: Not only must you weigh my spouse... you must also weigh her suit. One more matter! Water... as a vapor... is also exhaled... It also must be accounted for. The measurements will take several hours.

(Passage of time indicated by light and sound)

(Addresses Priestley and Scheele)

I trust you took care... for the margin of error must not be more than 18 grains in 125 pounds. What do you find?

PRIESTLEY: The subject has lost some weight.

(*Mme. Lavoisier is pale, but smiles*)

SCHEELE: When we take into account the water breathed out, there's indeed a rough balance.

LAVOISIER: Nothing is created –

MRS. PRIESTLEY: Except by God.

LAVOISIER: Nor lost.

MME. LAVOISIER: Except by Man.

LAVOISIER: Gentlemen! That crucial balance (*with emphasis*)... the conservation of mass in chemical reactions... punctures phlogiston's balloon.

SCHEELE: Surely the facts may be explained otherwise, without so radical an assumption.

PRIESTLEY: Indeed, sir... the experiment you so laboriously had us do... did demonstrate... I readily confess... *one* function of your...

(*Assumes sarcastic tone*)

"eminently breathable air."

(Pause)

But, Monsieur, you did not show us *how* you made that air.

LAVOISIER: I knew my air was there in ordinary air... Did I not see metals combine with it... with sulfur... or with phosphorus?

PRIESTLEY: That does not tell us how you produced the dephlogisticated air...

LAVOISIER: Pray stop calling it "dephlogisticated," Dr. Priestley. The name derives from a theory that is *passée*.

PRIESTLEY: Not for me.

SCHEELE: Nor for me.

LAVOISIER: Why not a new name, to avoid this argument? Why not call it "oxygen"? The time will come when all men will see, Messieurs, that when a new structure is needed for a science... new names are also required. (*Pause, then quicker*) I saw the need for a common gas involved in rusting, burning, and respiration.

PRIESTLEY: But you did not know what that gas was!

LAVOISIER: I knew there had to be a vital gas...

PRIESTLEY (*Heatedly*): But until that October 1774 dinner in Paris when I informed you of my observations... you did not know the nature of that air...

SCHEELE (*Untypically forceful*): And until that October 1774 day when you got my letter

which told you how to make fire air...

(They argue simultaneously to the end of the scene)

LAVOISIER: I had begun my experiments with *mercurius calcinatus*...

PRIESTLEY: Only after you heard of what I discovered...

SCHEELE: You did not know how to make that air...

COURT HERALD'S VOICE (*Angry tapping of staff*): Gentlemen! Gentlemen! Show proper respect to your audience! His Majesty is vexed. (*Pause*) Royal displeasure is the only judgment you will receive today!

Meanwhile, in the beginning of the twenty-first century, the Nobel Committee investigates and argues the claims of the three men. The lives of the modern Committee members and their discussions tell us much about whether science has changed in the last two centuries. A young historian, Ulla Zorn, starts by serving as a recorder for the Committee's proceedings. Eventually, she startles the Committee with an astounding discovery. What does she find? And who will get the first Retro-Nobel Prize? The answer, of course, is lodged in the play.

The nature and ambiguity of discovery, the importance of priority in science, the moral collisions that ensue are the themes of *Oxygen.* As are the ironies of revolutions: Lavoisier, the chemical revolutionary, is a political conservative, who loses his life in the Jacobin terror. Priestley, the political radical who is hounded out of England for his support of the French Revolution, is a chemical conservative. And Scheele just wants to run his pharmacy in Köping, and do chemical experiments in his spare time. For a long time, he – the first man on earth to make oxygen in the laboratory – got least credit for it.

Not surprisingly, in science as on stage, the human element remains central in drama.