

AMERICAN CONSERVATORY THEATER
Carey Perloff, Artistic Director Heather Kitchen, Executive Director

PRESENTS

WORDS ^{on} PLAYS

INSIGHT INTO THE PLAY, THE PLAYWRIGHT, AND THE PRODUCTION

A Number

BY CARYL CHURCHILL
DIRECTED BY ANNA D. SHAPIRO
GEARY THEATER
APRIL 28–MAY 28, 2006

WORDS ON PLAYS PREPARED BY

ELIZABETH BRODERSEN
PUBLICATIONS EDITOR

JESSICA WERNER
CONTRIBUTING EDITOR

MICHAEL PALLER
RESIDENT DRAMATURG

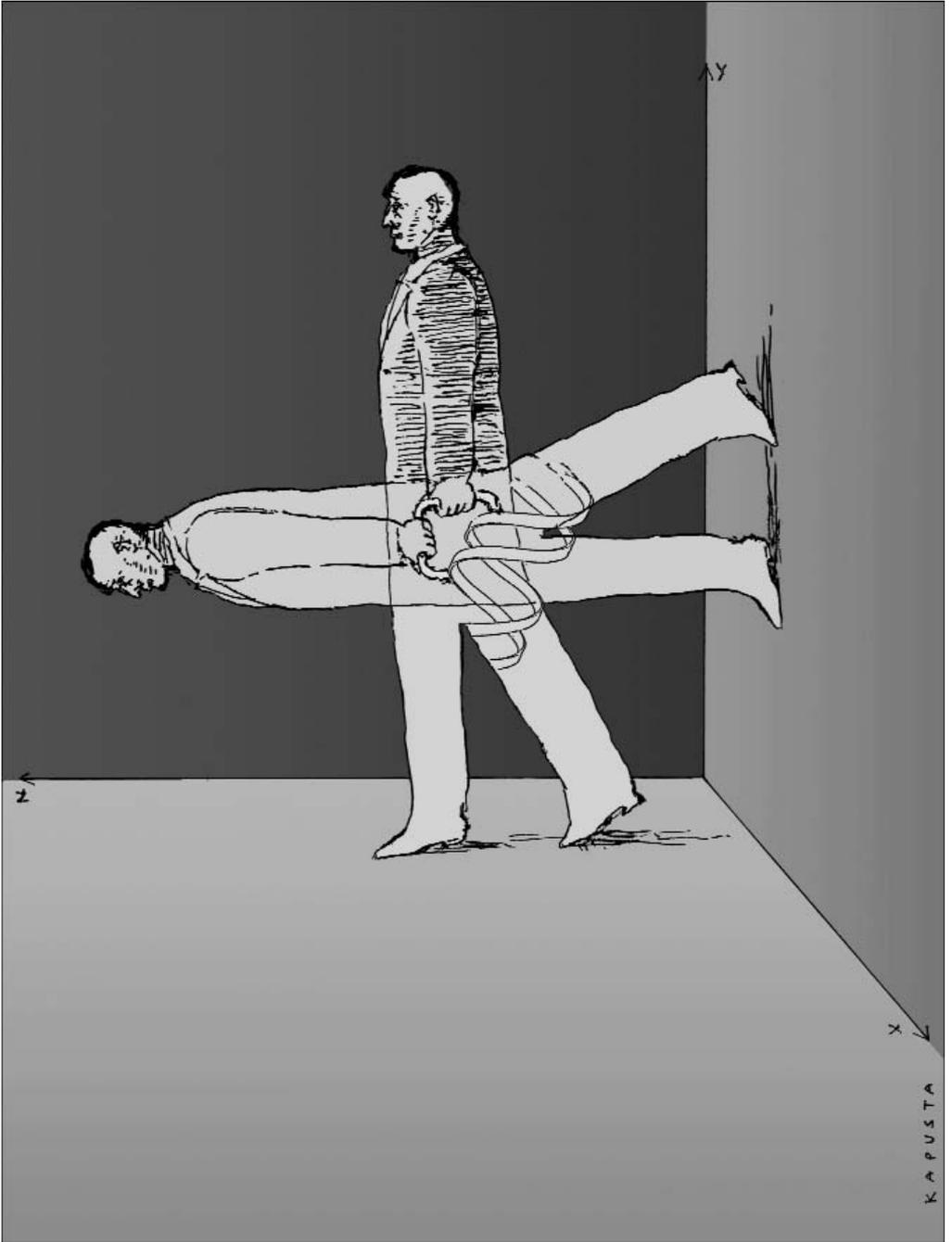
MARGOT MELCON
PUBLICATIONS ASSISTANT

A.C.T. is supported in part by grants from the Grants for the Arts/San Francisco Hotel Tax Fund and the National Endowment for the Arts, which believes that a great nation deserves great art.



TABLE OF CONTENTS

1. Characters, Cast, and Synopsis of *A Number*
6. The Mysteries of Caryl Churchill
by Sarah Lyall
7. Caryl Churchill's Drama: An Introduction
by Elaine Aston
12. Churchill on Churchill
13. Biology Is Not Destiny
by Brian Alexander
18. Duplicates That Can Beat the Real Thing
by Caryn James
21. Multiplicity: Cloning, Nature, and Nurture
by David Berreby
24. Baby, It's You! And You, and You . . .
by Nancy Gibbs
35. Cloning History: Scientific Background
43. A Cloning Timeline
50. Questions to Consider
51. For Further Information . . .



Man with His Clone, by Janusz Kapusta. ' Images.com/CORBIS.

CHARACTERS, CAST, AND SYNOPSIS OF *A NUMBER*

The original production of *A Number* opened at the Royal Court Theatre's Jerwood Theatre Downstairs in London, September 23, 2002. The u.s. premiere of *A Number* opened at New York Theatre Workshop, December 7, 2004.

CHARACTERS AND CAST

SALTER, <i>a man in his early 60s</i>	Bill Smitrovich
BERNARD (B1), <i>his son, 40</i>	Josh Charles
BERNARD (B2), <i>his son, 35</i>	Josh Charles
MICHAEL BLACK, <i>his son, 35</i>	Josh Charles

THE SETTING

Salter's living room.

SYNOPSIS

SCENE ONE. Salter is in his living room with his son Bernard (B2). Bernard has just revealed to Salter that he has recently discovered a number of copies (clones) have been made from his genetic material. Bernard is unsure of the exact number of replicates that exist. Salter assures Bernard that he is the first, original one, the product of a normal birth, that Salter is his father, and that the others are illegal, unauthorized copies of Bernard's genetic material. Salter refers to the copies as "things," however, which upsets Bernard, who insists that they are people. Salter becomes increasingly indignant, threatening to sue the doctors responsible and the hospital, speculating on what each copy of his son would be worth, while Bernard wonders what it would be like to meet another version of himself. Bernard finally tells Salter that he believes he is one of the copies, and not the original. Salter confesses that Bernard was created after his four-year-old son and wife were killed in a car accident. Salter named the new child after his first son, who was also called Bernard.

SCENE TWO. Salter is with his first son Bernard (B1), the one he has just said died in a car accident. Salter is trying to lay blame on the doctors for the multiple copies of this son, the supplier of the original genetic material. Bernard confronts his father about the fact that he was sent away and replaced by a new, genetically identical son. Salter tries to reassure Bernard, claiming the reason he didn't have another child with another woman was because

Bernard had been the perfect son. Bernard asks his father why he never came to him when he cried out at night after his mother died (he was two years old when she died). Salter replies that he never heard Bernard's cries. Bernard demands that Salter look him in the eye now and acknowledge him.

SCENE THREE. Salter is again with B2, the Bernard we met in the first scene. They are discussing B1, the other Bernard, who recently paid B2 a visit. B2 was frightened by the meeting with his genetic "brother," who was aggressive, and whom he thought had died in a car accident; unsettled by the notion that identical copies of himself exist, B2 is considering leaving the country, going off by himself. B2 demands to know how his mother died. Salter says that his wife committed suicide by throwing herself under a train when B1 was two years old. Salter tried to care for the first son for two more years, but he was a bad father and finally sent him away to start over again, hoping to do a better job with the second version. B2 tells his father that he does not blame him, but that he and B1 both hate him for what he has done. Salter tells B2 that he loves him and does not want him to leave. B2 says he is afraid that B1 might kill him and that he (B2) might feel better if he went away.

SCENE FOUR. The original Bernard, B1, has returned to Salter after murdering B2. Salter wants to know all about the murder, where and how it happened. B1 only gives him a few details and refuses to say more. Salter acknowledges that he was a terrible father to B1 before he sent him away; he did hear his cries in the night but was incapable of responding or taking care of his son. Salter says he could have killed B1, but instead sent him away so he would be cared for. He decided to start again with a copy of B1, instead of having another, new child, because he remembered how perfect B1 had been before his mother died, and he loved that perfect child.

SCENE FIVE. Salter, in a quest to meet his other "sons," has found another of the number, Michael, who is genetically identical to the other sons but was raised by an entirely other family. Salter tries to get Michael to tell him something unique about himself, so he can get to know him, and perhaps see how he is similar to or different from the others. Michael tells Salter various facts about himself—he is married with three children and is a math teacher, basically happy with his life, and likes banana ice cream—but nothing seems to satisfy Salter. Salter then asks Michael how he feels about finding out that he is one of many copies; Michael says he is fascinated, that he finds it "delightful." Salter is stricken with grief, because the original Bernard (B1) has committed suicide; he has lost both of the sons he knew and loved, and it is no longer possible for him to correct his failures as a father.

THE MYSTERIES OF CARYL CHURCHILL

BY SARAH LYALL (2004)

Caryl Churchill is one of the most critically acclaimed playwrights in the English-speaking world, and perhaps the single most acclaimed female one, but she is a mystery wrapped in an enigma. In a world where serious playwrights constantly sit on panels, hold forth at academic conferences, and appear on behalf of institutions like the British Council, Churchill remains a rare thing, a hugely successful playwright who lets her work speak entirely for itself.

Churchill is generally regarded with something close to awe in the London theater world for her passion, curiosity, rigor, openness to collaboration, and for being, as the critic Charles Spencer wrote in the *Daily Telegraph*, “the least predictable of contemporary playwrights.” Her elusiveness can be maddening for those trying to understand her plays, which are elliptical, provocative, shocking, and increasingly pared down; they seem to cry out for a cool authorial voice to help answer the questions they raise. But by the same token, it adds to her mystique and forces audiences, so often spoon fed with official interpretations, to take some initiative. That is certainly the case with *A Number*, which premiered at the Royal Court Theatre in London in 2002.

A slip of a play, only 65 minutes long, it has just two parts: Salter, a flustered and defensive father, and three of his sons, clones of each other. On the surface, *A Number* is about the moral and personal implications of genetic engineering. But there is much more to it. In a barrage of tense, spare conversations between Salter and the sons, the work also explores sibling rivalry; the expectations and responsibilities of parents and children; nature versus nurture; and the essence of identity itself.



“Ms. Churchill is not offering us a debate on the ethics of cloning,” the critic Michael Billington wrote in the *Guardian*. “What she does, in a series of fraught, emotional encounters, is use the scientific possibility to address basic human questions: above all, what the source is of that mysterious thing we call personality.”

Churchill stopped giving interviews some years ago, but as to her personal details, this much is known: now 67 years old, she has been writing plays for more than 40 years. She was born in London in 1938, just before World War II broke out, and spent most of her teens in Montreal, where her family moved when she was ten. In 1957, she went to Oxford and began to write plays for student productions. Four years later, she married a barrister, David Harter. She wrote even while her three sons were small, mostly short radio plays, characterized by a necessary economy of style that carries through to her current plays.

But it was a difficult time, and she said later that she had been writing “depressed plays about depression.”

“I was fed up with the situation I found myself in in the 1960s,” she said in an interview some years later. “I didn’t like being a barrister’s wife and going out to dinner with other professional people and dealing with middle class life. It seemed claustrophobic. Having started off with undefined idealistic assumptions about the kind of life we could lead, we had drifted into something quite conventional and middle class and boring. By the mid 1960s, I had this gloomy feeling that when the Revolution came I would be swept away.”

Her husband, though, shifted to working with the poor and disadvantaged, and his sense of social responsibility mirrored hers; one of her first plays was *Owners* (1972), about (in part) the rapacity of landlords. But subjects plumbed by her subsequent plays are so multifarious as to make it impossible to pin down her work. To name just a few, she takes on 1980s greed in *Serious Money* (1987); the steep price of women’s success in *Top Girls* (1982); the brief period of revolutionary idealism in 17th-century England in *Light Shining in Buckinghamshire* (1976); the limits of playwriting as a form, and of the ability of words to express meaning, in *Blue Heart* (1997); the horror of a violent world in *Far Away* (2000).

“Though she has described herself as a socialist and a feminist, it is difficult to categorize Churchill,” the critic Benedict Nightingale wrote in the *Times* of London. “She is certainly not a preacher or a propagandist, while her mind is as wide ranging and unpredictable as her creative genius.”

Although their personal significances are hidden under her art, Churchill’s plays sometimes can provide personal clues as to who she is and what her contemporaneous obsessions are. *Owners*, which raises disturbing questions about motherhood and babies, for instance, was written in a three-day frenzy when Churchill had just come home from

the hospital after “a particularly gruesome late miscarriage,” she revealed in an interview in 1980.

“Into it went for the first time a lot of things that had been building up in me over a long time, political attitudes as well as personal ones,” Churchill said.

Similarly, *Far Away*—a dystopian play in which a child inadvertently sees her uncle herding prisoners into a barn and beating them, and later features a world at war and a grotesque parade of orange-clad condemned prisoners bizarrely dressed in elaborate hats—most likely has its roots in Churchill’s experience as a grandmother, said James C. Nicola, artistic director of New York Theatre Workshop, which presented the u.s. premiere of *A Number* in 2004.

“I couldn’t help but look at the play as a response to Caryl’s dealing with her love of her grandchildren and thinking, What do I say to them about this horrific world that we live in, and how can I prepare them for it without frightening or intimidating them?” he said.

If Churchill’s plays have one signature, it is their highly stylized conceits. The works are as creative in form as they are varied in content, as if she wants to push the boundaries each time. They feature, in different instances, flashbacks, twisted chronologies, huge leaps of logic, elements of absurdity, overlapping dialogue, different actors playing the same character in different scenes, interjected songs and, in the case of *Serious Money*, dialogue written almost entirely in verse. “She is a structuralist,” said Max Stafford-Clark, artistic director of the Out of Joint theater company and longtime director of Churchill’s work. “It’s not just the range of subject matter, but also the form which is continually surprising to critics and audiences.”

In an interview in 1989, Churchill tried to explain. “I do enjoy the form of things,” she said. “I enjoy finding the form that seems best to fit what I’m thinking about. I don’t set out to find a bizarre way of writing. I certainly don’t think that you have to force it. But on the whole, I enjoy plays that are nonnaturalistic and don’t move in real time.”

She is also adored, and her privacy fiercely protected, by her friends in the theater world. She can be guarded, even with the directors who work with her, when it comes to the thought processes behind her plays. A strikingly handsome woman, she is strong and forceful and does not let people push her around in rehearsal, theater friends say, but she can be reticent when it comes to accounting for the plays themselves.

Still, directors love working with her because of her theatrical instincts and her willingness to use the text of her play as the starting point, rather than the endpoint, of a production.

“She’s terrific in rehearsal,” Stafford-Clark said. “Her theatrical intelligence—which is not the same thing as ordinary intelligence—is very astute. She doesn’t have much ego, but she’s quite forceful and stubborn about what she believes in.”

Her work seems of its time and also timeless, Nicola said: “What excites me about *A Number* is that it’s a 20th-century psychological drama re-imagined for the 21st century. As much as things may actually, physically change, the human drama is the same.”

“It seems to be the great crime of the day, that we’re dehumanized over and over again,” Nicola added. “But she always tries to remind us that we’re human and that we have souls.”

Other British playwrights are known for their distinctive, consistent traits: Harold Pinter’s plays are always Pinteresque; and Tom Stoppard invariably reveals himself with his erudition and clever, multilayered wordplay. But Churchill is a constant surprise.

“If you look at the arc of her creative life, she’s someone in her sixties who is as out on the edge and willing to reinvent herself as she was in her twenties,” Nicola said. “Most artists—whether painters or novelists or composers—find some sense of what their voices and concerns are in their twenties and thirties, and in their sixties and seventies they’re still doing variations on it. But it’s not true of her. She’s as fresh and new and unpredictable and inspiring now as she was at the beginning of her working life.”

Excerpted from the *New York Times*, December 5, 2004. © 2004 New York Times Company.

A BRIEF BIOGRAPHY OF CARYL CHURCHILL

Caryl Churchill (b. 1938) has written prolifically for the stage as well as for television and radio. She was resident dramatist at the Royal Court Theatre (1974–75) and spent much of the 1970s and 1980s working with the theater groups Joint Stock and Monstrous Regiment. She received OBIE Awards for playwriting for both *Cloud Nine* (1982) and *Top Girls* (1983). She received the Hollywood *Drama-Logue* Critics Award for *Cloud Nine* and the Susan Smith Blackburn Award for *Fen* in 1984 and for *Serious Money* in 1987. *Serious Money* also won the Olivier Award for best play of 1987, the *Evening Standard* Award for best comedy, an OBIE Award for best new play and the Plays and Players Award. Her success continued in the 1990s with such works as *Lives of the Great Poisoners* (1991), *The Skriker* (1994), *Hotel* (1997), *Blue Heart* (which toured internationally in 1999), and *Far Away* (2000). Churchill received the OBIE Award for sustained achievement in 2001. *A Number* premiered at the Royal Court Theatre in London and won the 2002 *Evening Standard* Award for best new play.

CARYL CHURCHILL'S DRAMA: AN INTRODUCTION

BY ELAINE ASTON (2004)

Caryl Churchill is an important figure in British playwriting today; indeed, many critics and theater scholars would argue that she has played a leading role in shaping our contemporary theatrical landscape, on national and international stages. Characteristic of her work is her enduring commitment to a socialist and to a socialist-feminist politics, coupled with a desire to experiment with theatrical form: to find a theatrical means of giving expression to her ideas about and concerns for a world that, as she presents it, is increasingly damaged by the relentless march of global capitalism. As philosophical, political, and critical thinkers such as Michel Foucault, Frantz Fanon, or Hannah Arendt have been an influence on Churchill's work, her performance interventions into the field of ideas have proved both theatrically stimulating and intellectually insightful. More particularly, Churchill has been vital to the field of women's theater and scholarship where her work has pioneered women's playwriting and furthered critical and theoretical feminist activity.

Born in the late 1930s, Churchill began writing as a young girl, producing mostly short stories and poems for family entertainment. As a child in the 1940s, she belonged to a generation that grew up listening to the radio rather than watching television. It is largely through the medium of the radio play that Churchill developed her craft (not least because it was possible to combine a career in radio with motherhood and family life). Among her first pieces is the play for voices *You've No Need to Be Frightened* (1959), which was given a student production during Churchill's university years (1957–60) spent at Lady Margaret Hall, Oxford. Her first professional production, *The Ants* (1962), deals with the subject of emotionally violent and damaging family relationships. . . . In the wake of *The Ants*, *Lovesick* (1966), *Abortive* (1971), *Henry's Past* (1972) and *Perfect Happiness* (1973) all thematized the power structures of marital and familial relations, while Churchill dramatized identity in crisis in *Identical Twins* (1968) and the schizophrenic world of *Schreber's Nervous Illness* (1972). Crisis of identity, as explored in this early drama, is something to which Churchill has returned in her recent stage play *A Number* (Royal Court, 2002), where a father-son relationship is thrown into crisis, as the "son" discovers he has been cloned, several times over. Similarly, Churchill's ecological concerns that appear in later plays such as *Lives of the Great Poisoners* (1991) are given an early treatment in the radio drama *Not Not Not Not Not Not Not Enough Oxygen* (1971). The unperformed stage play *The Hospital at the Time of the Revolution*, written at the same time as *Schreber's Nervous Illness*, brought together several issues that continue to haunt Churchill's canon: oppression, inequality, madness, and

war. Moreover, in this early work is found evidence of the experimental techniques that would come to characterize Churchill's theater, most significantly her imaginative and subversive play with the dramatic conventions of form, time, narrative, structure, language, and dialogue.

Owners, Churchill's first professionally produced stage play, performed at the Royal Court Theatre in 1972, is significant for the way in which it highlights gender and class issues that would become central to her theater in the 1970s and 1980s. "Ownership" of property, people, and money is dealt with through the representation of a property-owning (but childless) couple (Marion and Clegg), and their tenants (Alex and Lisa), who are raising a family in reduced, poor circumstances. To reinforce her political point about the "haves and the have nots," Churchill engaged in a gender role reversal and made the aggressive property owner a woman (Marion), and the tenant a passive, nonresistant man (Alex). The aggressive, property-owning Marion can be read as a precursor to her "super-woman" successor, Marlene, in *Top Girls*.

Part of what fuelled Churchill's dramatization of gender in the 1970s was the feminist climate of that decade and her coming into contact with other feminist writers and practitioners—in particular the socialist-feminist theater company Monstrous Regiment. The "Monsters" performed *Vinegar Tom* (1976), Churchill's play about witchcraft set in 17th-century England; an exploration of the demonization of women as witches, composed as a montage of short scenes interspersed with songs. Gillian Hannah, founding member of Monstrous Regiment, commented at the time on the way in which Churchill's composition looked to reflect the "broken-backed" experience of women's lives: moved away from the narrative linearity and classic realism associated with the malestream.

Also in the mid 1970s, Churchill wrote her first play for Joint Stock, *Light Shining in Buckinghamshire* (1976). Joint Stock was a company with a reputation for collaborative theater and for choosing to work with left-wing writers and plays. The company's director, Max Stafford-Clark, would become an important figure in Churchill's theater career: he has since directed a number of her plays for Joint Stock, the Court, and for the company he formed in the 1990s, Out of Joint. Like *Vinegar Tom*, *Light Shining* was set in the 17th century and drew on a Brechtian dramaturgy to realize an epic picture of the English civil war; to historicize the failure of revolution and the possibilities of a more democratically organized society. Revolution in the interests of democratization has remained an enduring concern of Churchill's theater and surfaces again, for example, in her later play *Mad Forest* (1990), in which she collaborated with Mark Wing-Davey (a former Joint Stock member) on a dramatization of the social upheaval in contemporary Romania that led up to the fall of Ceausescu. While *Light Shining* and *Mad Forest* come from different

generational moments in Churchill's writing career, they share not only an interest in revolutionary ideals, but also a performance style evolved through workshopping methods. Joint Stock's emphasis on and commitment to ensemble theater and workshopped productions served to break down the traditional hierarchical arrangement of writer and performers. It is a collaborative way of working which, as the East European project *Mad Forest* testifies, is one that remains important to Churchill's playwriting.

Cloud Nine (1979), offers an exploration of sexual politics. Act one introduces a patriarch (Clive) and his family in a colonial setting to critique the Victorian values of empire and family. Act two relocates the family to London, 1979, although the time shift for the characters is only 25 years. The continuity of linear history is, therefore, displaced by a historical memory of sexual politics. After its original Joint Stock production, *Cloud Nine* went on to be performed around the world, picking up an OBIE Award in 1982 after the New York production. The play regularly attracts performance and scholarly interest for its cross-gender playing (Clive's wife is played by a man, his son by a woman, and his daughter by a doll) and cross-racial casting (the black servant is played by a white actor).

Among the many plays that have earned Churchill recognition as a "woman writer," as a playwright for whom feminism is an important and central dramatic concern, is the internationally acclaimed and award-winning *Top Girls* (Royal Court, 1982). *Top Girls* has been hailed by the playwright Mark Ravenhill as "the best play of the past 20 years" and has been listed by the *Guardian* critic Michael Billington in the ten best British plays of the century and by reviewer Benedict Nightingale as "the play of the century." The use of overlapping dialogue in *Top Girls* is a technique that has since influenced the playwriting of a number of contemporary British dramatists (including Ravenhill). In feminist terms, the play's all-female cast drew attention to the paucity of stage roles for women, but, more importantly, in political terms spelled out the dangers of an individualist model of bourgeois feminism, taking issue with the 1980s Thatcherite "superwoman." The play's opening dinner scene, in which women come together to celebrate Marlene's "top job" promotion in an employment agency, astonished spectators through its undermining of the mimetic fictions of realism by bringing together the following invited dinner guests: Isabella Bird (a Victorian traveler), Lady Nijo (a Japanese courtesan turned Buddhist nun), Dull Gret (a figure from a Brueghel painting), Pope Joan (a woman disguised as a man and thought to have been pope 854–56), and Patient Griselda (the obedient wife from Chaucer's "The Clerk's Tale" in *The Canterbury Tales*). That women as well as men might perpetuate gender inequalities is an issue that the play explores through subsequent scenes set in the employment agency and through the final showdown between Marlene and her working-class sister, Joyce. While Marlene enjoys her high-flying career, Joyce has a less

“successful” (in economic terms) life caring for Marlene’s daughter, Angie (a low achiever and unlikely to become a “top girl”). The difficulty of combining work and family life is posed as an unresolved problem in *Top Girls*, while the dangers of espousing Marlene’s masculinist, capitalist values, oppressive to other women (and men), are signaled in the final line of the play, delivered by Angie: “Frightening.”

For those, like Churchill, committed to a left-wing politics, the 1980s under Thatcher’s leadership was a truly “frightening” decade as social and economic inequalities and injustices hardened, rather than softened. *Soft Cops*, originally written by Churchill in 1978 but performed by the Royal Shakespeare Company in 1984, offered a Foucauldian examination of social systems of control and punishment. The Joint Stock production of *Fen* (1983) struck an especially dark note in its “frightening” portrait of East Anglian fen workers. The danger of an “us and them” economy that Churchill signaled in *Top Girls* is revisited in *Fen* through her dramatization of an oppressed community of women laborers who work the potato fields. While the multinational companies that own the land they work profit by their labor, the women workers and their families are exploited and unable to find a way out of the poverty and hardship that condition their working and domestic lives. Money, capital, had in the 1980s become the most important commodity—as satirically exposed in Churchill’s hugely successful, multi-award-winning “City comedy,” *Serious Money* (1987).

While socialist and socialist-feminist politics have been important in Churchill’s dramatic landscape, so too has the “politics of style”: her play with theatrical form in the interests of giving expression to political and social concerns. Her experimental approach to theater making is one that has involved “exploding” the word and exploring the language of performance. This has drawn her into crossdisciplinary work, most notably into dance-theater collaborations with the choreographer Ian Spink and the company Second Stride. Churchill’s first production with Spink was *A Mouthful of Birds* (cowritten with David Lan, 1986). She collaborated again with Second Stride on *Lives of the Great Poisoners* (1991), *The Skriker* (1994), and *Hotel* (1997).

Of these collaborations, *The Skriker* is the most significant. *The Skriker* is a mythological shape-shifting figure from a fairy underworld evocative of damage: the “underside” of a world that thrives only on material greed and self-interest. While writing *The Skriker*, Churchill made a decision to pare the central action of the play down to three main figures—the Skriker and two teenage girls, one pregnant, one institutionalized for killing her baby. The numerous stories and creatures, which she had originally thought of weaving into plots and events, were realized in different ways, through music and dance. There is no “happy ever after” to this tale; rather, child murder, and the Skriker’s attempts to lure the girls away to the underworld, offer a dark and menacing stage picture.

Churchill's theater demonstrates an enduring interest in the damage caused as people feel socially and culturally alienated in their lives. Drawing on the genre of the road movie, *Icecream* (1989) stages a series of disastrous transatlantic, crosscultural encounters that arise as characters fail to "locate." Experiences of alienation come to dominate Churchill's 1990s canon: the music-dance piece *Hotel* (also with *Second Stride*) examines urban alienation in the setting of a hotel bedroom, and *Blue Heart* (with *Out of Joint*) demythologizes ideas of family and kinship. *Heart's Desire*, the first half of *Blue Heart*, like *The Skriker*, distorts the "real" through fairy logic. Although realistically set in a kitchen in which we expect to see a family reunion (a daughter is expected to return home), setting and events are stylized and made "unreal" through the way in which the play begins, gets so far, then begins again, several times over and at different speeds. The reunion is constantly deferred; never takes place. Moreover, the kitchen space is variously invaded by children (rushing out of a kitchen cupboard), by two gunmen who burst in and shoot everybody "dead," by a man who comes demanding the family's papers, and by a truly wonderful ten-foot-tall bird!

. . . In recent years, as a response to the erosion of socialism from national and international politics (and this despite Britain's election of a New Labour government in 1997), Churchill's theater has warned of the dangers of living in a world in which people fail to connect their personal/local lives to the political/global. In the style of Magritte, *This Is a Chair*, her short, 20-minute play performed at the Royal Court in 1997 with Stephen Daldry directing, has each of its eight brief scenes captioned with a title that bears no relation to the scene (nor do scenes connect to each other). While the titles signal major political or social issues on a global scale, each scene, by contrast, offers a glimpse into the private and personal trivia of everyday lives. The overall effect of this is to show the failure of contemporary lives to connect with the political in any effective or meaningful way.

The consequences of this failure to connect become all too apparent in Churchill's first play of the 21st century, *Far Away* (2000), a Royal Court production, also directed by Daldry. In *Far Away* all life forms—human and animal—are at war. While the play's middle sequence recalls the horrors of the 20th-century holocaust, its overarching imaging of global terror is an anticipation of the events surrounding 9/11. It is a bleak vision for a new century, but one that brings a renewed emphasis to Churchill's concern to show just how "frightening" the legacy of an unequal world damaged by a political and social creed of self-interest is—a legacy that, her theater shows us, is not so very "far away."

CHURCHILL ON CHURCHILL

[I know] quite well what kind of society I would like: decentralized, nonauthoritarian, communist, nonsexist—a society in which people can be in touch with their feelings, and in control of their lives. But it always sounds both ridiculous and unattainable when you put it into words.

—Caryl Churchill, interviewed by Judith Thurman, *Ms.* (May 1982)

It's almost impossible not to take [a moral and political stance], whether you intend to or not. Most plays can be looked at from a political perspective and have said something, even if it isn't what you set out to say. If you wrote a West End comedy relying on conventional sexist jokes, that's taking a moral and political stance, though the person who wrote it might say, "I was just writing an entertaining show." Whatever you do your point of view is going to show somewhere. It usually only gets noticed and called "political" if it's against the status quo. There are times when I feel I want to deal with immediate issues and times when I don't. I do like the stuff of theater, in the same way people who are painting like paint; and of course when you say "moral and political" that doesn't have to imply reaching people logically or overtly, because theater can reach people on all kinds of other levels too. Sometimes one side or the other is going to have more weight. Sometimes it's going to be about images, more like a dream to people, and sometimes it's going to be more like reading an article. And there's room for all that. But either way, the issues you feel strongly about are going to come through, and they're going to be a moral and political stance in some form.

—Interviewed by Kathleen Betsko and Rachel Koenig, *Interviews with Contemporary Women Playwrights* (1987)

I do enjoy the form of things. I enjoy finding the form that seems best to fit what I'm talking about. I don't set out to find a bizarre way of writing. I certainly don't think that you have to force it. But, on the whole, I enjoy plays that are non naturalistic and don't move at real time.

—Interviewed by Jackie Kay, *New Statesman and Society* (April 21, 1989)

BIOLOGY IS NOT DESTINY

BY BRIAN ALEXANDER

A few years ago I visited Douglas Melton, a renowned stem cell scientist at Harvard who told me that if the university had any guts it would approve and fund this experiment:

Let's take monkeys and take human embryonic stem cells and put them in a monkey blastula [embryo]. So here's the question: What portion of the monkey's brain and vocal chords do I need to have composed of human cells to allow the monkey to speak? This is an extremely legitimate scientific question . . . Suppose I discover you only need this portion of the brain up here to give the monkey speech . . . If you and I were to walk into my lab right now and the monkey would say, "Oh Doug, so this is Brian?" It would chill us, right? That would really say, What is it about being human?

What indeed? This has become one of the fundamental questions of our age, proposed with annoying frequency by the advance of the biological sciences. This is also a question that resonates in Caryl Churchill's *A Number*.

Though cloning features prominently, it's really a dramatic device Churchill uses to explore the human dimensions of love, kinship, and familial failing. She seems to have grasped the idea that while the myth of human cloning—the cloned armies, the teams of Michael Jordans, the recreation of ourselves—is flawed in many ways, it does force us to ask ourselves some uncomfortable questions.

Both Salter and B2 fall prey to the cloning myth. "They've damaged your uniqueness," Salter tells B2. And B2 later says that a clone may not be "very like but very something terrible which is exactly the same genetic person."

There is no such thing as "exactly the same genetic person," especially when it comes to the hypothetical idea of cloning a human being in a lab. There are scientific reasons for this. For example, the mitochondria, the little powerhouses of cells, have a small number of their own genes. When a cell from a person to be cloned is placed into an egg to begin the process, that egg will not have the same mitochondrial DNA as the mother's egg used to conceive the original person. Second, the way in which genes are switched on and off, epigenetics, varies according to many, often unknown circumstances, including our environment. And of course, a clone would probably not gestate in the same mother and certainly not at the same time.

In other words, identical twins would be closer genetic copies than any lab-created human clone could ever be. Yet even they would soon diverge genetically in small ways. We are all unique.

The Talmud seems to agree: “For a human being stamps many coins with one stamp, and all of them are alike; but the King of the kings of kings, the Holy One, blessed be He, has stamped every man with the stamp of Adam the First, and nevertheless not one of them is like the other.”

But there are other, even more important, reasons why you could never copy people. Churchill seems to understand the truth that human, as opposed to homo sapiens, is not really about genes at all.

This simple statement can be a profoundly disturbing one. People find comfort in the myth that genes are like cairns in the wilderness, firm reference points for our self-knowledge. In a world of change, we want to grab hold of something that seems permanent and uniquely us. If we can do that, we won't have to think quite as hard about who we are, what makes us human, and just how little separates us from other living things.

Mostly, we don't have to face the deeper and scarier truth that we are all ultimately responsible for our humanness.

This is why a proposal like Melton's seems so disturbing at first and why themes like cloning make for such interesting literary devices. They make us ask the hard questions. We are forced to realize that the boundaries of what it means to be human are surprisingly hazy.

When people ask such questions, exploring this nether region of our identities as human, nobody can predict just where the questioning will stop or what the answers will be. This, perhaps more than any purely scientific breakthrough, is the true revolution of cloning and such related technologies as in vitro fertilization, embryonic stem cells, genetic engineering.

Adam Wolfson, the former editor of *The Public Interest* and a contributor to other conservative political journals, has written that “the problem of biotechnology has less to do with the applications it unleashes than the novel ideas it introduces. What's at issue is the shaping of public opinion in potentially harmful directions.”

Few people, caught up as we've been in the fun, creepy, sci-fi imaginings such technologies can evoke, have taken the time to think like Wolfson. Churchill obviously has. Among others who have are a contingent of politically conservative social thinkers who are not, for the most part, scientists. Leon Kass, Francis Fukuyama, Charles Krauthammer, and William Kristol, among others, have been animated by the fear of the hazy boundaries

around the concept of “human.” They worry about what happens when we lose sight of that cairn in the wilderness.

These worries predate the dawn of biotech. They are the questions raised by modernism itself, which is why conservatives and neoconservatives have taken such a great interest in biotechnology. (Kass headed President Bush’s bioethics council; Fukuyama and Krauthammer have been prominent members; Kristol has written frequently about biotechnology.)

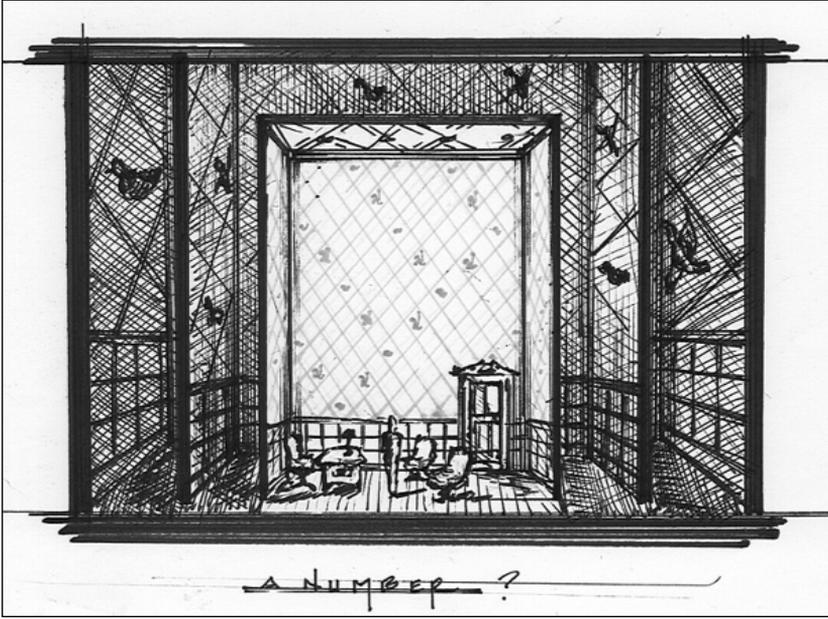
Modernism—and biotechnology cannot help but be called a modernist work in progress—is a threat to established order. Pope Pius x recognized this as early as 1907, when he condemned modernist theologians who argued that there could be flexibility in interpreting God’s word, and in finding common ground with other theologies. “It is pride which rouses in them the spirit of disobedience and causes them to demand a compromise between authority and liberty.” Starting in 1910, every priest, as part of taking his orders, had to swear an oath against modernism.

Technology, architecture, politics, art all changed with the coming of modernism and not always for the good. Nazism and Leninist communism were two sides of the same modernist coin. Each believed in the perfectibility of man and his society through science, and that by following scientific principles, man could be molded and shaped like machines. Just take a look at Leni Riefenstahl’s *Triumph of the Will*, a modernist masterpiece.

On the other hand, c. s. Lewis saw the modernist impulse as destructive. “Man’s conquest of Nature, if the dreams of some scientific planners are realized, means the rule of a few hundreds of men over billions upon billions of men,” he wrote in *Abolition of Man*. “Stepping outside the Tao, they have stepped into the void.”

For Lewis, the Tao was that indefinable something of human nature, what Fukuyama has called “Factor X” in his book *Our Posthuman Future: Consequences of the Biotechnology Revolution*. So, for his own good, man has to live according to Factor X, and the system of “natural law” that has grown up around it. Natural law should be our cairn in the wilderness, our immutable reference point that could prevent us from getting lost in the swirls of modernism where there don’t seem to be any rules, and where, in that confusing mist, we risk leaving ourselves behind in a misguided leap for salvation by following some false messiah.

Natural law tells us our place in the world and in our societies. We know where the boundaries are, what acceptable behavior looks like, the dues we owe to others. Since natural law is the ultimate basis for the u.s. Constitution, we should obey our leaders unless they themselves break the natural law. It is in these ways that our social and political culture is ordered. If it weren’t, then, we would simply be making it up as we went along and



Sketch for the set of *A Number* by scenic designer David Korins

that is unacceptable because if we are simply making it up, without reference to immutable laws, then we can too easily make tragic errors.

The problem with this view is that natural law itself is something of a fuzzy concept

based on a line of philosophy running from Aristotle through Thomas Aquinas and on to Thomas Hobbes. Since it also is open to interpretation and shifting ways of thinking, it also needed some of its own reference points. What better arbiter than our unchanging biology, the formula that dictates our lives?

Our biology tells us about how long we'll live, how we will make children, how we will be vulnerable to Nature. We know who is male and who is female, who is an individual person. Genes set our natural boundaries. Our natural boundaries help us interpret natural law. Natural law is the basis for free democracy, the best form of government even if it is susceptible to the suspect passions of the enfranchised masses.

Some of the conservatives, like Wolfson, view the biotechnical prospect with such alarm precisely because they fear it will reveal to average folk that there are no rules, or at least much more expansive rules than we had thought, and that society and government could be threatened.

And as it has turned out, though, our biology is far jazzier than most of us like to think. Take, for example, chimeras. Sometimes, if two eggs are fertilized by two different sperm, fraternal twin embryos can begin to develop. But along the way, one embryo can actually be absorbed into the other. A baby is born. This new person now has the genes of two people. Some human chimeras have a mixed set of genitals—true hermaphrodites. They are

neither female nor male. Sometimes their skin color features zebra-like striations, literally the coloring of two separate people.

So, is this person one, or two?

Introduce the man-made jazz riff of biotechnology and we can make embryos in dishes. We can take cells, like, say, a type of cell called a fibroblast, and turn them into nerves. Hocus pocus! Already the u.s. Department of Defense is funding a program to give wounded soldiers the regenerative power of salamanders so that if a soldier loses a finger, or even an arm, it will grow back.

Such work is proving that biology is not destiny except in the most mundane sense—where your high cholesterol comes from, your brown hair, whether you have a shot at the NBA. As a cloning expert once told me, “There are other ways of making people identical. We can put them through the same schools and subject them to eight hours of TV every day. That works a lot better.”

In *A Number* a father has failed. He recognizes his failure and wants another chance. So he turns to cloning. He is trying to break through natural human boundaries; we don't really get second chances at parenting. This has negative consequences. Some clones, their perception based more on the flawed relationship with their “father” than their status as clones, are troubled by the knowledge of being a clone. They believe genes are destiny.

But one is not. He has taken responsibility for himself, not relied on his genes to tell him who he is. This has allowed him to find comfort in his kinship not only with his clone brethren, but other humans, monkeys, lettuce.

This is where we stand right now, tugged on one side by pessimists and on the other by optimists. The pessimists believe that, freed from the natural boundaries imposed by our biology we will not choose wisely, that should Doug Melton ever make a monkey that talks to us, our own meaning will be destroyed.

The optimists do not believe “human” is so fragile. They see our conception of human as flexible. This view is more difficult, of course. Without what we used to think of as immutable boundaries, we could drift. We've certainly done it before. To succeed with the new knowledge that we've been improvising the score of “human” will require responsibility, wisdom, and discipline. But this new concept of ourselves could prove all the stronger for its flexibility because it will rely not on genes, or “natural law,” but on values like love, kinship, and, perhaps the most human feeling of all, hope.

Brian Alexander has written for the New York Times, New York Times Magazine, and Wired, and is the author of the book *Rapture: How Biotech Became the New Religion* (2003). He lives in San Diego.

DUPLICATES THAT CAN BEAT THE REAL THING

BY CARYN JAMES (2005)

There is a simple theme that unites the latest works by the literary master Kazuo Ishiguro, the demanding playwright Caryl Churchill, and the action-film director Michael Bay: hold on to your heart. And your kidneys and your liver and any other bit of DNA that could be used to create another you. Central figures in all of these works are clones, and sympathy for the clones drives the emotions in each piece.

Cloning, once just a cheap device in thrillers, has become the controlling metaphor in works by serious artists. Churchill's play *A Number* is a series of confrontations between a man and his son, and two cloned versions of the son. Ishiguro's haunting novel *Never Let Me Go* is narrated by a woman who recalls her girlhood (or clonehood) at an exclusive school, where she and her fellow students slowly realize that they have been created so their organs can be harvested for real people. Far from creating genre fiction, these artists use cloning as a way to get at profound emotions of love and loss, and to address a mechanized culture in which individuality itself sometimes seems threatened.

And the theme still flourishes in popcorn movies and potboiler fiction. As in the Ishiguro novel, harvesting organs and a love affair between clones are major features of Bay's *Island*, in which Ewan McGregor and Scarlett Johansson discover they are clones and must escape the island where they have been bred.

Never Let Me Go and *The Island* have such similar themes, offered from the clones' points of view, because even thrillers have to address basic fears. All these fantasies—set in the near future or the recent past—deal with the destructive potential of unknown, rapidly accelerating medical science. One day you're cloning a sheep, the next day it's Ewan McGregor.

But while pop culture can address those fears playfully (how bad would it be to have a world full of Ewan McGregors?) serious artists use cloning for its chilling metaphorical value. Both the Ishiguro and Churchill works are infused with a sense of loss, and in depicting the humanity of the clones, they are really exploring how science and mass culture can constrict individuality and emotions for the rest of us.

Artists may be newly fond of cloning, but they are building on a genre so well established that a few standard themes have emerged: there are clones to replace a lost loved one, clones to ensure eternal life, clones to take over the world. Back in 1978 cloning was an excuse to watch Laurence Olivier and Gregory Peck ham it up in *The Boys from Brazil* (based on Ira Levin's thriller), about a plot to clone little Hitlers.

Replacing the beloved dead was the premise for the quickly departed 2004 film *Godsend*, in which Robert De Niro plays a doctor who clones a little boy killed in an accident. The parents (Greg Kinnear and Rebecca Romijn-Stamos) should have suspected that the doc had stirred some extra-special DNA into the mix; the clone is always a bad seed in a thriller.

Godsend is one of those De Niro films that make you think: I hope he was paid a lot; he has a film festival to run. But precisely because of its clichés and heavy-handedness, the film emphasizes how thoroughly cloning has become the new Frankenstein: shorthand for a mad scientist with a God complex, whose experiment goes haywire. The movie even thumps away at the theme behind all cloning or Frankenstein adventures. “This isn’t about science, it’s about moral trespass,” the dead boy’s father screams at the doctor (they are in a church, no less) after learning that he has been given a warped variation of his son.

Another mad doctor creates an evil clone in Kevin Guilfoile’s *Cast of Shadows*, a current novel with a twist: the doctor uses DNA from his daughter’s unknown murderer to clone the killer so he can identify him. As potboilers go, this one is well written, but its commercially calculated plot could have been invented by novel-writing software.

And long before either of these recent works, there was *Clonus*. Originally released in 1979 and newly out on DVD, the film combines so many motifs that it is virtually a template of clone fiction. Peter Graves, in a small role, plays a senator running for president, who has had himself and his brother cloned so they can replace failing organs and enjoy longer lives; it’s like an extended warranty plan on the body. Made fast and dirty, the film is also known as *Parts: The Clonus Horror*, an overheated title that hints at its moments of unintended hilarity. The senator angrily tells his brother, “Do you know the strings I had to pull to get you cloned?”

Yet the movie is amazing in the way it anticipates motifs that run through newer thrillers and serious works: harvested organs, political ambition, a clone who tries to escape from the isolated facility where he’s been created, and most important, a love affair between clones. They were never bred to have such strong emotions. “So you’re creating Frankensteins here?” a mad scientist in *Clonus* is asked. He denies it, but creating Frankenstein monsters is just what he’s up to. In Mary Shelley’s 1818 classic, after all, the monster’s tragedy was his loneliness and isolation, his lack of love and companionship.

Those basic emotions are what serious artists explore when they take up cloning as a theme. In Churchill’s play, the all-too-human father (Sam Shepard in the New York production) is the monstrous character. It seems at first that he has had his dead son cloned, but *A Number* toys with the conventions of the genre. It turns out he had done a bad job of raising his child, so he sent the boy away and replaced him with a clone so he could start

fresh. This is the clone as good seed. (All of the sons were played by one actor, Dallas Roberts, in the New York production.)

This intense one-act play is a little about fathers and sons, a little about individual identity, and not enough about either. Yet it successfully highlights contemporary culture's need for perfection; the father literally tossing his child aside for an unblemished model is the exaggerated example of that. And in making us feel for the misguided father and all the variants of his son, the play works through the cloning theme to create genuine emotions for the characters and to evoke them from the audience. "You called them things; I think we'll find they're people," a clone says about the unknown number of his other selves rattling around the world.

This idea, that clones are people, too, shapes the Ishiguro novel, which takes the theme to a more profound level. Kathy H, the narrator who looks back on her childhood and young adulthood, gives the novel a slow start. Yet when she reaches the point at which she and her adolescent schoolmates recognize the truth about their futures, the story becomes heartbreaking as we share the clones' meek acceptance of their fates and their yearning for the simplest things. Kathy's friend Ruth fantasizes about working in an office; Kathy and Tommy fall in love and long to plan a life together; these most ordinary plans are denied them. As with Frankenstein's monster, emotions creep in until the clones' inner suffering seems unbearable.

Ishiguro enhances the emotional impact of the novel by ignoring the medical details (he never says which organs go or when). His social commentary is more Orwellian; the clones have been raised with a dissembling vocabulary. When they lose organs they "donate"; they don't die, they "complete." The eeriness of the language only emphasizes how human the clones are in their desires.

The Island is essentially an escape thriller, but the romance of its clones is significant, too. Walter F. Parkes, one of its producers, said the clones played by McGregor and Johansson "are portrayed as innocents in a morally compromised world, who are in many ways more decent, more 'human' than the people of whom they are copies." The clones are obviously the characters the audience is meant to identify with.

Today's clones poignantly echo Frankenstein's monster as he begs his creator for a mate. "Every where I see bliss, from which I alone am irrevocably excluded," he says. And like Mary Shelley, the creators of today's clone-themed works are less concerned with science than with its consequences for the human heart, that most indispensable of vital organs.

MULTIPLICITY

Cloning, Nature, and Nurture

BY DAVID BERREBY (1997)

Dolly, the world's first cloned mammal and thus probably history's most famous sheep, is likely to leave a somewhat ironic legacy. This triumph of genetic engineering, achieved last week by Scottish embryologist Ian Wilmut, might well mark the defeat of the idea that genes determine who and what we are.

A clone is an identical twin, a second creature with a genetic code identical to the first's. Dolly, in other words, is the twin sister her original never had. Identical twins are rare in nature, and because they're created when a single fertilized egg divides into two embryos, they're born at the same time. If Wilmut's techniques for cloning mammals prove to be practical, that time constraint will no longer exist. It will be possible to make twins whenever we want, to replace your old dog Pete with Puppy Pete, to replicate a deceased human infant, or to copy yourself.

But twins usually grow up in the same family and community (studies of their rearing suggest that people treat identical twins much more alike than they treat siblings or even fraternal twins). A clone's environment will be different. It will grow from a different egg, develop in a different womb, possibly grow up in a different place, and have different triumphs and disasters.

Cloning, in other words, offers the possibility of the mother of all "twin studies"—comparisons of how often a trait appears among identical twins vs. how often it appears among others. Twin studies these days are invoked to feed the popular notion that genes determine behavior, since they suggest that genes play a role in such things as schizophrenia, alcoholism, performance on intelligence tests—even proneness to divorce (a 1992 study of 1,500 sets of twins found that if one twin had been divorced, the likelihood that the co-twin had also been divorced was 45 percent in identical twins, but only 30 percent in fraternal twins).

It was Sir Francis Galton, cousin of Charles Darwin and founder of the eugenics movement, who first suggested twin studies as a means of teasing out the role of heredity in shaping human traits. Galton wanted to use the studies to establish the primacy of Nature over Nurture. In fact, he was the one who coined that cliché, seizing a snatch of verse from Shakespeare's *The Tempest* in which Prospero calls Caliban "[a] devil, a born devil, on whose nature / Nurture can never stick; on whom my pains, / Humanely taken, all, all lost, quite lost!"

Since Galton's time, the Nature-Nurture dichotomy has hardened into competing ideologies. A vigorous intellectual movement in favor of Nature in the 1920s gave rise to a countertradition emphasizing the importance of Nurture, which spawned the field of cultural anthropology. Meanwhile, the school of Nature, following the discovery of DNA in 1953, evolved into sociobiology and evolutionary psychology, whose adherents believe that the common heritage of human nature, transmitted through genes, has a greater effect on behavior than culture and history do.

The political and cultural arguments, however, lag behind the lab work. At conferences and seminars, biologists and psychologists have been overheard remarking to one another that the Nature-Nurture dichotomy can't accommodate what they're finding.

Consider, for example, oxytocin, a hormone found in the bodies of many mammals, including human beings, where it is associated with uterine contractions and breast-feeding. Add a little oxytocin to female rats' brains, and they get friendlier. Block receptors for oxytocin, and the creatures threaten each other more. Oxytocin also seems to raise tolerance for pain, and it decreases blood pressure. Sounds like the rule of Nature.

But what triggers the release of oxytocin in the rat brain when there's no researcher to inject the hormone? Warmth, touch, and friendly social interactions. So, does a hormone cause an action? Or does an action cause a hormone to be released? It seems to be a bit of both, especially in big-brained animals, like us, that have a lot of flexibility to their behavior. In primates, says Kim Wallen, a behaviorist at the Yerkes Regional Primate Center in Atlanta, hormones "act in concert with so many other factors. I think we might see these not as chemical signals that turn things on and off but as things that permit an organism to do certain things under certain circumstances."

The question of where characteristics come from also turns out to be too complicated to divide neatly into Nature or Nurture, according to Stephen Suomi, director of the Laboratory of Comparative Ethology at the National Institutes of Health. His research suggests that a rhesus monkey's sexual behavior, aggression, thinking, and responses to stress are affected by "prenatal stressing"—that the strains and pains to which the pregnant mother is subjected will have an immense impact on her infant long after it is born.

Not even DNA, that supposedly impregnable "digital" code, is viewed as platonically separate anymore. "DNA doesn't do anything," says James Shapiro, a cell biologist at the University of Chicago Medical School. A gene is an instruction for making a protein. Reading that instruction, following it, folding the protein into the shape it must have to do its job—all this is the job of the cell, and the cell is affected by its environment.

In twin studies, too, as Elizabeth Spitz, a researcher at the Université René Descartes in Paris, has noted, Nurture is nearly impossible to tease out. Identical twins, at the

moment of birth, may have already had very different experiences during their nine months in the womb. This is because the number of membranes identical fetuses share depends on when exactly their single egg split into two embryos. If this divisional split occurred early (within four days after fertilization), then each twin grew to birth in its own little world. Each developed its own chorion, the outermost membrane, and its own amnion, the inner membrane that contains the amniotic fluid in which the fetus floats. If the cell division happened later (four to eight days after fertilization), each twin got its own amnion but shared a chorion. If the division happened later still (eight to ten days after conception), the two fetuses shared both chorion and amnion.

How similar twins are depends in part on how many membranes they shared. That amazing story about how two separated twins both married red-headed engineers in the same year—the resemblance could be because they shared the same amnion, and not because of their genes. So it's a little premature to propose a genetic predisposition to divorce.

In fact, the standard laboratory procedure for sorting out one influence from another—controlling the genetics, the prenatal environment, and the rearing of the twins—turns out to be impossible. The point may seem abstruse now. But once all those millions of Dollies have been gamboling about for a few years, and it's plain that they don't all look and act alike, we'll have no choice but to get off Galton's seesaw.

David Berreby writes regularly about science and culture for Slate. This article was originally posted at <http://www.slate.com/id/2427/#sb98029> on March 2, 1997; accessed March 30, 2006.

BABY, IT'S YOU! AND YOU, AND YOU. . .

Renegade scientists say they are ready to start applying the technology of cloning to human beings. Can they really do it, and how scary would that be?

BY NANCY GIBBS (2001)

Before we assume that the market for human clones consists mainly of narcissists who think the world deserves more of them or neo-Nazis who dream of cloning Hitler or crackpots and mavericks and mischief makers of all kinds, it is worth taking a tour of the marketplace. We might just meet ourselves there.

Imagine for a moment that your daughter needs a bone-marrow transplant and no one can provide a match; that your wife's early menopause has made her infertile; or that your five-year-old has drowned in a lake and your grief has made it impossible to get your mind around the fact that he is gone forever. Would the news then really be so easy to dismiss that around the world, there are scientists in labs pressing ahead with plans to duplicate a human being, deploying the same technology that allowed Scottish scientists to clone Dolly the sheep four years ago?

All it took was that first headline about the astonishing ewe, and fertility experts began to hear the questions every day. Our two-year-old daughter died in a car crash; we saved a lock of her hair in a baby book. Can you clone her? Why does the law allow people more freedom to destroy fetuses than to create them? My husband had cancer and is sterile. Can you help us?

The inquiries are pouring in because some scientists are ever more willing to say yes, perhaps we can. Last month a well-known infertility specialist, Panayiotis Zavos of the University of Kentucky, announced that he and Italian researcher Severino Antinori, the man who almost seven years ago helped a 62-year-old woman give birth using donor eggs, were forming a consortium to produce the first human clone. Researchers in South Korea claim they have already created a cloned human embryo, though they destroyed it rather than implanting it in a surrogate mother to develop. Cover stories in *Wired* and the *New York Times Magazine* tracked the efforts of the Raelians, a religious group committed to, among other things, welcoming the first extraterrestrials when they appear. They intend to clone the cells of a dead ten-month-old boy whose devastated parents hope, in effect, to bring him back to life as a newborn. The Raelians say they have the lab and the scientists, and—most important, considering the amount of trial and error involved—they say they have 50 women lined up to act as surrogates to carry a cloned baby to term.

Given what researchers have learned since Dolly, no one thinks the mechanics of cloning are very hard: take a donor egg, suck out the nucleus, and hence the DNA, and fuse it with,

say, a skin cell from the human being copied. Then, with the help of an electrical current, the reconstituted cell should begin growing into a genetic duplicate. "It's inevitable that someone will try and someone will succeed," predicts Delores Lamb, an infertility expert at Baylor University. The consensus among biotechnology specialists is that within a few years—some scientists believe a few months—the news will break of the birth of the first human clone.

At that moment, at least two things will happen—one private, one public. The meaning of what it is to be human—which until now has involved, at the very least, the mysterious melding of two different people's DNA—will shift forever, along with our understanding of the relationship between parents and children, means and ends, ends and beginnings. And as a result, the conversation that has occupied scientists and ethicists for years, about how much man should mess with nature when it comes to reproduction, will drop onto every kitchen table, every pulpit, every politician's desk. Our fierce national debate over issues like abortion and euthanasia will seem tame and transparent compared with the questions that human cloning raises.

That has many scientists scared to death. Because even if all these headlines are hype and we are actually far away from seeing the first human clone, the very fact that at this moment, the research is proceeding underground, unaccountable, poses a real threat. The risk lies not just with potential babies born deformed, as many animal clones are; not just with desperate couples and cancer patients and other potential "clients" whose hopes may be raised and hearts broken and life savings wiped out. The immediate risk is that a backlash against renegade science might strike at responsible science as well.

The more scared people are of some of this research, scientists worry, the less likely they are to tolerate any of it. Yet variations on cloning technology are already used in biotechnology labs all across the country. It is these techniques that will allow, among other things, the creation of cloned herds of sheep and cows that produce medicines in their milk. Researchers also hope that one day the ability to clone adult human cells will make it possible to "grow" new hearts and livers and nerve cells.

But some of the same techniques could also be used to grow a baby. Trying to block one line of research could impede another and so reduce the chances of finding cures for ailments such as Alzheimer's and Parkinson's, cancer and heart disease. Were some shocking breakthrough in human cloning to cause "an overcompensatory response by legislators," says Rockefeller University cloning expert Tony Perry, "that could be disastrous. At some point, it will potentially cost lives." So we are left with choices and trade-offs and a need to think through whether it is this technology that alarms us or just certain ways of using it.

By day, Randolf Wicker, 63, runs a lighting shop in New York City. But in his spare time, as spokesman for the Human Cloning Foundation, he is the face of cloning fervor in

the United States. “I took one step in this adventure, and it took over me like quicksand,” says Wicker. He is planning to have some of his skin cells stored for future cloning. “If I’m not cloned before I die, my estate will be set up so that I can be cloned after,” he says, admitting, however, that he hasn’t found a lawyer willing to help. “It’s hard to write a will with all these uncertainties,” he concedes. “A lot of lawyers will look at me crazy.”

As a gay man, Wicker has long been frustrated that he cannot readily have children of his own; as he gets older, his desire to reproduce grows stronger. He knows that a clone would not be a photocopy of him but talks about the traits the boy might possess: “He will like the color blue, Middle Eastern food, and romantic Spanish music that’s out of fashion.” And then he hints at the heart of his motive. “I can thumb my nose at Mr. Death and say, ‘You might get me, but you’re not going to get all of me,’” he says. “The special formula that is me will live on into another lifetime. It’s a partial triumph over death. I would leave my imprint not in sand but in cement.”

This kind of talk makes ethicists conclude that even people who think they know about cloning—let alone the rest of us—don’t fully understand its implications. Cloning, notes ethicist Arthur Caplan of the University of Pennsylvania, “can’t make you immortal because clearly the clone is a different person. If I take twins and shoot one of them, it will be faint consolation to the dead one that the other one is still running around, even though they are genetically identical. So the road to immortality is not through cloning.”

Still, cloning is the kind of issue so confounding that you envy the purists at either end of the argument. For the Roman Catholic Church, the entire question is one of world view: whether life is a gift of love or just one more industrial product, a little more valuable than most. Those who believe that the soul enters the body at the moment of conception think it is fine for God to make clones; he does it about 4,000 times a day, when a fertilized egg splits into identical twins. But when it comes to massaging a human life, for the scientist to do mechanically what God does naturally is to interfere with his work, and no possible benefit can justify that presumption.

On the other end of the argument are the libertarians who don’t like politicians or clerics or ethics boards interfering with what they believe should be purely individual decisions. Reproduction is a most fateful lottery; in their view, cloning allows you to hedge your bet. While grieving parents may be confused about the technology—cloning, even if it works, is not resurrection—their motives are their own business. As for infertile couples, “we are interested in giving people the gift of life,” Zavos, the aspiring cloner, told *Time* this week. “Ethics is a wonderful word, but we need to look beyond the ethical issues here. It’s not an ethical issue. It’s a medical issue. We have a duty here. Some people need this to complete the life cycle, to reproduce.”

In the messy middle are the vast majority of people who view the prospect with a vague alarm, an uneasy sense that science is dragging us into dark woods with no paths and no easy way to turn back. Ian Wilmut, the scientist who cloned Dolly but has come out publicly against human cloning, was not trying to help sheep have genetically related children. “He was trying to help farmers produce genetically improved sheep,” notes Hastings Center ethicist Erik Parens. “And surely that’s how the technology will go with us, too.” Cloning, Parens says, “is not simply this isolated technique out there that a few deluded folks are going to avail themselves of, whether they think it is a key to immortality or a way to bring someone back from the dead. It’s part of a much bigger project. Essentially the big-picture question is, To what extent do we want to go down the path of using reproductive technologies to genetically shape our children?”

At the moment, the American public is plainly not ready to move quickly on cloning. In a *Time/CNN* poll last week, 90% of respondents thought it was a bad idea to clone human beings. “Cloning right now looks like it’s coming to us on a magic carpet, piloted by a cult leader, sold to whoever can afford it,” says ethicist Caplan. “That makes people nervous.”

And it helps explain why so much of the research is being done secretly. We may learn of the first human clone only months, even years, after he or she is born—if the event hasn’t happened already, as some scientists speculate. The team that cloned Dolly waited until she was seven months old to announce her existence. Creating her took 277 tries, and right up until her birth, scientists around the world were saying that cloning a mammal from an adult cell was impossible. “There’s a significant gap between what scientists are willing to talk about in public and their private aspirations,” says British futurist Patrick Dixon. “The law of genetics is that the work is always significantly further ahead than the news. In the digital world, everything is hyped because there are no moral issues—there is just media excitement. Gene technology creates so many ethical issues that scientists are scared stiff of a public reaction if the end results of their research are known.”

Of course, attitudes often change over time. In vitro fertilization was effectively illegal in many states 20 years ago, and the idea of transplanting a heart was once considered horrifying. Public opinion on cloning will evolve just as it did on these issues, advocates predict. But in the meantime, the crusaders are mostly driven underground. Princeton biologist Lee Silver says fertility specialists have told him that they have no problem with cloning and would be happy to provide it as a service to their clients who could afford it. But these same specialists would never tell inquiring reporters that, Silver says—it’s too hot a topic. “I think what’s happened is that all the mainstream doctors have taken a hands-off approach because of this huge public outcry. But I think what they are hoping is that some fringe

group will pioneer it and that it will slowly come into the mainstream and then they will be able to provide it to their patients.”

All it will take, some predict, is that first snapshot. “Once you have a picture of a normal baby with ten fingers and ten toes, that changes everything,” says San Mateo, California, attorney and cloning advocate Mark Eibert, who gets inquiries from infertile couples every day. “Once they put a child in front of the cameras, they’ve won.” On the other hand, notes Gregory Pence, a professor of philosophy at the University of Alabama at Birmingham and author of *Who’s Afraid of Human Cloning?*, “if the first baby is defective, cloning will be banned for the next 100 years.”

“I wouldn’t mind being the first person cloned if it were free. I don’t mind being a guinea pig,” says Doug Dorner, 35. He and his wife, Nancy, both work in health care. “We’re not afraid of technology,” he says. Dorner has known since he was 16 that he would never be able to have children the old-fashioned way. A battle with lymphoma left him sterile, so when he and Nancy started thinking of having children, he began following the scientific developments in cloning more closely. The more he read, the more excited he got. “Technology saved my life when I was 16,” he says, but at the cost of his fertility. “I think technology should help me have a kid. That’s a fair trade.”

Talk to the Dorners, and you get a glimpse of choices that most parents can scarcely imagine having to make. Which parent, for instance, would they want to clone? Nancy feels she would be bonded to the child just from carrying him, so why not let the child have Doug’s genetic material? Does it bother her to know she would, in effect, be raising her husband as a little boy? “It wouldn’t be that different. He already acts like a five-year-old sometimes,” she says with a laugh.

How do they imagine raising a cloned child, given the knowledge they would have going in? “I’d know exactly what his basic drives were,” says Doug. The boy’s dreams and aspirations, however, would be his own, Doug insists. “I used to dream of being a fighter pilot,” he recalls, a dream lost when he got cancer. While they are at it, why not clone Doug twice? “Hmm. Two of the same kid,” Doug ponders. “We’ll cross that bridge when we come to it. But I know we’d never clone our clone to have a second child. Once you start copying something, who knows what the next copies will be like?”

In fact the risks involved with cloning mammals are so great that Wilmut, the premier cloner, calls it “criminally irresponsible” for scientists to be experimenting on humans today. Even after four years of practice with animal cloning, the failure rate is still overwhelming: 98% of embryos never implant or die off during gestation or soon after birth. Animals that survive can be nearly twice as big at birth as is normal, or have extra-large organs or heart trouble or poor immune systems. Dolly’s “mother” was six years old when

she was cloned. That may explain why Dolly's cells show signs of being older than they actually are—scientists joked that she was really a sheep in lamb's clothing. This deviation raises the possibility that beings created by cloning adults will age abnormally fast.

"We had a cloned sheep born just before Christmas that was clearly not normal," says Wilmut. "We hoped for a few days it would improve and then, out of kindness, we euthanized it, because it obviously would never be healthy." Wilmut believes "it is almost a certainty" that cloned human children would be born with similar maladies. Of course, we don't euthanize babies. But these kids would probably die very prematurely anyway. Wilmut pauses to consider the genie he has released with Dolly and the hopes he has raised. "It seems such a profound irony," he says, "that in trying to make a copy of a child who has died tragically, one of the most likely outcomes is another dead child."

That does not seem to deter the scientists who work on the Clonaid project run by the Raelian sect. They say they are willing to try to clone a dead child. Though their outfit is easy to mock, they may be even further along than the competition, in part because they have an advantage over other teams. A formidable obstacle to human cloning is that donor eggs are a rare commodity, as are potential surrogate mothers, and the Raelians claim to have a supply of both.

Earlier this month, according to Brigitte Boisselier, Clonaid's scientific director, somewhere in North America, a young woman walked into a Clonaid laboratory whose location is kept secret. Then, in a procedure that has been done thousands of times, a doctor inserted a probe, removed 15 eggs from the woman's ovaries and placed them in a chemical soup. Last week two other Clonaid scientists, according to the group, practiced the delicate art of removing the genetic material from each of the woman's eggs. Within the next few weeks, the Raelian scientific team plans to place another cell next to the enucleated egg.

This second cell, they say, comes from a ten-month-old boy who died during surgery. The two cells will be hit with an electrical charge, according to the scenario, and will fuse, forming a new hybrid cell that no longer has the genes of the young woman but now has the genes of the dead child. Once the single cell has developed into six to eight cells, the next step is to follow the existing, standard technology of assisted reproduction: gingerly insert the embryo into a woman's womb and hope it implants. Clonaid scientists expect to have implanted the first cloned human embryo in a surrogate mother by next month.

Even if the technology is basic, and even if it appeals to some infertile couples, should grieving parents really be pursuing this route? "It's a sign of our growing despotism over the next generation," argues University of Chicago bioethicist Leon Kass. Cloning introduces the possibility of parents' making choices for their children far more fundamental than whether to give them piano lessons or straighten their teeth. "It's not just that parents will have particu-

lar hopes for these children,” says Kass. “They will have expectations based on a life that has already been lived. What a thing to do—to carry on the life of a person who has died.”

The libertarians are ready with their answers. “I think we’re hypercritical about people’s reasons for having children,” says Pence. “If they want to re-create their dead children, so what?” People have always had self-serving reasons for having children, he argues, whether to ensure there’s someone to care for them in their old age or to relive their youth vicariously. Cloning is just another reproductive tool; the fact that it is not a perfect tool, in Pence’s view, should not mean it should be outlawed altogether. “We know there are millions of girls who smoke and drink during pregnancy, and we know what the risks to the fetus are, but we don’t do anything about it,” he notes. “If we’re going to regulate cloning, maybe we should regulate that too.”

Olga Tomusyak was two weeks shy of her seventh birthday when she fell out of the window of her family’s apartment. Her parents could barely speak for a week after she died. “Life is empty without her,” says her mother Tanya, a computer programmer in Sydney, Australia. “Other parents we have talked to who have lost children say it will never go away.” Olga’s parents cremated the child before thinking of the cloning option. All that remains are their memories, some strands of hair and three baby teeth, so they have begun investigating whether the teeth could yield the nuclei to clone her one day. While it is theoretically possible to extract DNA from the teeth, scientists say it is extremely unlikely.

“You can’t expect the new baby will be exactly like her. We know that is not possible,” says Tanya. “We think of the clone as her twin or at least a baby who will look like her.” The parents would consider the new little girl as much Olga’s baby as their own. “Anything that grows from her will remind us of her,” says Tanya. Though she and her husband are young enough to have other children, for now, this is the child they want.

Once parents begin to entertain the option of holding on to some part of a child, why would the reverse not be true? “Bill” is a guidance counselor in Southern California, a fortysomething expectant father who has been learning everything he can about the process of cloning. But it is not a lost child he is looking to replicate. He is interested in cloning his mother, who is dying of pancreatic cancer. He has talked to her husband, his siblings, everyone except her doctor—and her, for fear that it will make her think they have given up hope on her. He confides, “We might end up making a decision without telling her.”

His goal is to extract a tissue specimen from his mother while it’s still possible and store it, to await the day when—if—cloning becomes technically safe and socially acceptable. Late last week, as his mother’s health weakened, the family began considering bringing up the subject with her because they need her cooperation to take the sample. Meanwhile, Bill has already contacted two labs about tissue storage, one as a backup. “I’m in touch with a couple

of different people who might be doing that,” he says, adding that both are in the United States. “It seems like a little bit of an underground movement, you know—people are a little reluctant that if they announce it, they might be targeted, like the abortion clinics.”

If Bill’s hopes were to materialize and the clone were born, who would that person be? “It wouldn’t be my mother but a person who would be very similar to my mother, with certain traits. She has a lot of great traits: compassion and intelligence and looks,” he says. And yet, perhaps inevitably, he talks as though this is a way to rewind and replay the life of someone he loves. “She really didn’t have the opportunities we had in the baby-boom generation, because her parents experienced the Depression and the war,” he says. “So the feeling is that maybe we could give her some opportunities that she didn’t have. It would be sort of like we’re taking care of her now. You know how when your parents age and everything shifts, you start taking care of them? Well, this would be an extension of that.”

A world in which cloning is commonplace confounds every human relationship, often in ways most potential clients haven’t considered. For instance, if a woman gives birth to her own clone, is the child her daughter or her sister? Or, says bioethicist Kass, “let’s say the child grows up to be the spitting image of its mother. What impact will that have on the relationship between the father and his child if that child looks exactly like the woman he fell in love with?” Or, he continues, “let’s say the parents have a cloned son and then get divorced. How will the mother feel about seeing a copy of the person she hates most in the world every day? Everyone thinks about cloning from the point of view of the parents. No one looks at it from the point of view of the clone.”

If infertile couples avoid the complications of choosing which of them to clone and instead look elsewhere for their DNA, what sorts of values govern that choice? Do they pick an uncle because he’s musical, a willing neighbor because she’s brilliant? Through that door lies the whole unsettling debate about designer babies, fueled already by the commercial sperm banks that promise genius DNA to prospective parents. Sperm banks give you a shot at passing along certain traits; cloning all but assures it.

Whatever the moral quandaries, the one-stop-shopping aspect of cloning is a plus to many gay couples. Lesbians would have the chance to give birth with no male involved at all; one woman could contribute the ovum, the other the DNA. Christine DeShazo and her partner, Michele Thomas, of Miramar, Florida, have been in touch with Zavos about producing a baby this way. Because they have already been ostracized as homosexuals, they aren’t worried about the added social sting that would come with cloning. “Now [people] would say, ‘Not only are you a lesbian, you are a cloning lesbian,’” says Thomas. As for potential health problems, “I would love our baby if its hand was attached to its head,” she says. DeShazo adds, “If it came out green, I would love it. Our little alien . . .”

Just as women have long been able to have children without a male sexual partner, through artificial insemination, men could potentially become dads alone: replace the DNA from a donor egg with one's own and then recruit a surrogate mother to carry the child. Some gay-rights advocates even argue that should sexual preference prove to have a biological basis, and should genetic screening lead to terminations of gay embryos, homosexuals would have an obligation to produce gay children through cloning.

All sorts of people might be attracted to the idea of the ultimate experiment in single parenthood. Jack Barker, a marketing specialist for a corporate-relocation company in Minneapolis, is 36 and happily unmarried. "I've come to the conclusion that I don't need a partner but can still have a child," he says. "And a clone would be the perfect child to have because I know exactly what I'm getting." He understands that the child would not be a copy of him. "We'd be genetically identical," says Barker. "But he wouldn't be raised by my parents—he'd be raised by me." Cloning, he hopes, might even let him improve on the original: "I have bad allergies and asthma. It would be nice to have a kid like you but with those improvements."

Cloning advocates view the possibilities as a kind of liberation from travails assumed to be part of life: the danger that your baby will be born with a disease that will kill him or her, the risk that you may one day need a replacement organ and die waiting for it, the helplessness you feel when confronted with unbearable loss. The challenge facing cloning pioneers is to make the case convincingly that the technology itself is not immoral, however immorally it could be used.

One obvious way is to point to the broader benefits. Thus cloning proponents like to attach themselves to the whole arena of stem cell research, the brave new world of inquiry into how the wonderfully pliable cells of seven-day-old embryos behave. Embryonic stem cells eventually turn into every kind of tissue, including brain, muscle, nerve, and blood. If scientists could harness their powers, these cells could serve as the body's self-repair kit, providing cures for Parkinson's, diabetes, Alzheimer's, and paralysis. Actors Christopher Reeve, paralyzed by a fall from a horse, and Michael J. Fox, who suffers from Parkinson's, are among those who have pushed Congress to overturn the government's restrictions on federal funding of embryonic stem cell research.

But if the cloners want to climb on this train in hopes of riding it to a public relations victory, the mainstream scientists want to push them off. Because researchers see the potential benefits of understanding embryonic stem cells as immense, they are intent on avoiding controversy over their use. Being linked with the human-cloning activists is their nightmare. Says Michael West, president of Massachusetts-based Advanced Cell Technology, a biotech company that uses cloning technology to develop human medicines: "We're really concerned that if someone goes off and clones a Raelian, there could be an

overreaction to this craziness—especially by regulators and Congress. We’re desperately concerned—and it’s a bad metaphor—about throwing the baby out with the bath water.”

Scientists at ACT are leery of revealing too much about their animal-cloning research, much less their work on human embryos. “What we’re doing is the first step toward cloning a human being, but we’re not cloning a human being,” says West. “The miracle of cloning isn’t what people think it is. Cloning allows you to make a genetically identical copy of an animal, yes, but in the eyes of a biologist, the real miracle is seeing a skin cell being put back into the egg cell, taking it back in time to when it was an undifferentiated cell, which then can turn into any cell in the body.” Which means that new, pristine tissue could be grown in labs to replace damaged or diseased parts of the body. And since these replacement parts would be produced using skin or other cells from the suffering patient, there would be no risk of rejection. “That means you’ve solved the age-old problem of transplantation,” says West. “It’s huge.”

So far, the main source of embryonic stem cells is “leftover” embryos from IVF clinics; cloning embryos could provide an almost unlimited source. Progress could come even faster if Congress were to lift the restrictions on federal funding—which might have the added safety benefit of the federal oversight that comes with federal dollars. “We’re concerned about George W.’s position and whether he’ll let existing guidelines stay in place,” says West. “People are begging to work on those cells.”

That impulse is enough to put the Roman Catholic Church in full revolt; the Vatican has long condemned any research that involves creating and experimenting with human embryos, the vast majority of which inevitably perish. The church believes that the soul is created at the moment of conception, and that the embryo is worthy of protection. It reportedly took 104 attempts before the first IVF baby, Louise Brown, was born; cloning Dolly took more than twice that. Imagine, say opponents, how many embryos would be lost in the effort to clone a human. This loss is mass murder, says David Byers, director of the National Conference of Catholic Bishops’ commission on science and human values. “Each of the embryos is a human being simply by dint of its genetic makeup.”

Last week 160 bishops and five cardinals met for three days behind closed doors in Irving, Texas, to wrestle with the issues biotechnology presents. But the cloning debate does not break cleanly even along religious lines. “Rebecca,” a thirtysomething San Francisco Bay Area resident, spent seven years trying to conceive a child with her husband. Having “been to hell and back” with IVF treatment, Rebecca is now as thoroughly committed to cloning as she is to Christianity. “It’s in the Bible—be fruitful and multiply,” she says. “People say, ‘You’re playing God.’ But we’re not. We’re using the raw materials the good Lord gave us. What does the doctor do when the heart has stopped? They have to do direct massage of

the heart. You could say the doctor is playing God. But we save a life. With human cloning, we're not so much saving a life as creating a new being by manipulation of the raw materials, DNA, the blueprint for life. You're simply using it in a more creative manner."

A field where emotions run so strong and hope runs so deep is fertile ground for profiteers and charlatans. In her effort to clone her daughter Olga, Tanya Tomusyak contacted an Australian firm, Southern Cross Genetics, which was founded three years ago by entrepreneur Graeme Sloan to preserve DNA for future cloning. In an e-mail, Sloan told the parents that Olga's teeth would provide more than enough DNA—even though that possibility is remote. "All DNA samples are placed into computer-controlled liquid-nitrogen tanks for long-term storage," he wrote. "The cost of doing a DNA fingerprint and genetic profile and placing the sample into storage would be \$2,500. Please note that all of our fees are in U.S. dollars."

When contacted by *Time*, Sloan admitted, "I don't have a scientific background. I'm pure business. I'd be lying if I said I wasn't here to make a dollar out of it. But I would like to see organ cloning become a reality." He was inspired to launch the business, he says, after a young cousin died of leukemia. "There's megadollars involved, and everyone is racing to be the first," he says. As for his own slice of the pie, Sloan says he just sold his firm to a French company, which he refuses to name, and he was heading for Hawaii last week. The Southern Cross factory address turns out to be his mother's house, and his "office" phone is answered by a man claiming to be his brother David—although his mother says she has no son by that name.

The more such peddlers proliferate, the more politicians will be tempted to invoke prohibitions. Four states—California, Louisiana, Michigan, and Rhode Island—have already banned human cloning, and this spring Texas may become the fifth. Republican state senator Jane Nelson has introduced a bill in Austin that would impose a fine of as much as one million dollars for researchers who use cloning technology to initiate pregnancy in humans. The proposed Texas law would permit embryonic stem cell research, but bills proposed in other states were so broadly written that they could have stopped those activities, too.

"The short answer to the cloning question," says ethicist Caplan, "is that anybody who clones somebody today should be arrested. It would be barbaric human experimentation. It would be killing fetuses and embryos for no purpose, none, except for curiosity. But if you can't agree that that's wrong to do, and if the media can't agree to condemn rather than gawk, that's a condemnation of us all."

This article originally appeared in *Time* February 19, 2001. Reported by David Bjerklie and Andrea Dorfman/New York, Wendy Cole/Chicago, Jeanne DeQuine/Miami, Helen Gibson/London, David S. Jackson/Los Angeles, Leora Moldofsky/Sydney, Timothy Roche/Atlanta, Chris Taylor/San Francisco, Cathy Booth Thomas/Dallas, and Dick Thompson/Washington, with other bureaus. © 2001 Time, Inc.

CLONING HISTORY: SCIENTIFIC BACKGROUND (2002)

In 1997, the report of the production of a newborn lamb by a process that involved the transfer of a nucleus from an adult cell of a donor sheep to a recipient enucleated egg sparked the interest of the world. “Dolly” became an instant celebrity and a public dialogue was rapidly initiated to explore the possibilities of human reproductive cloning and to consider the ethical, legal, and social issues that might be raised should such technology be developed and put to use. While the achievements of Ian Wilmut, Keith Campbell, and their colleagues at the Roslin Institute in Scotland are notable from both a practical and a fundamental scientific standpoint, as with virtually everything else in science, this work rested on the prior contributions of many others.

CLONING BEFORE DOLLY

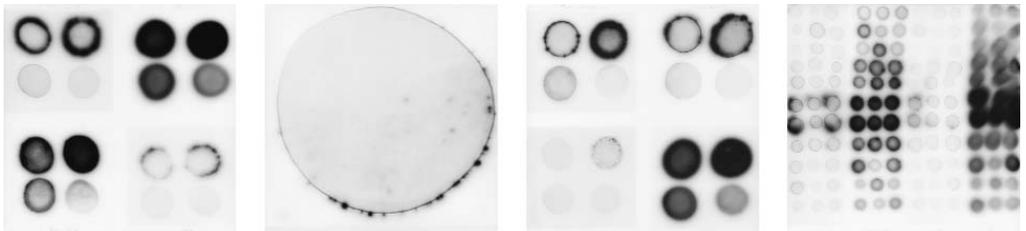
Since the beginning of the 20th century, scientists had speculated on the nature of the early events in embryonic growth that result in the differentiation of the various cells’ tissues and organs that constitute a mature animal. The cell’s nucleus was known to be the repository of the genetic program that guided development, but the nature of the changes that took place in the nucleus during differentiation was (and to a considerable extent still is) unknown. The German embryologist August Weismann first theorized that the nucleus of the single cell zygote, i.e., a fertilized egg, must be totipotent, that is, it contains all of the information required to direct the development of a complete animal. He also incorrectly believed that with subsequent cellular and nuclear division, there was a progressive loss of genetic information that resulted in the restriction of developmental potential of the daughter cells. He attempted to demonstrate this experimentally, but inevitably encountered many technical difficulties in an attempt to prove what we now know to be an incorrect hypothesis.

In 1892, Hans Driesch, using sea urchin eggs and embryos, was able to separate the daughter cells resulting from early embryonic cell division and showed that each cell from two- and four-celled embryos could continue to divide independently and to give rise to a complete and intact sea urchin. This was probably the earliest example of reproductive cloning by the process of embryo splitting. In the 1920s and 1930s Hans Spemann carried out some technically extraordinary experiments that demonstrated that totipotency, i.e., the ability to develop into all the cells needed to make an adult, could be retained by embryonic nuclei through a number of cell divisions. Using a “noose” constructed from a human hair, he was able to partition part of the cytoplasm of early developing salamander embryos.

Then he was able to coax nuclei that were produced via cell division (mitosis) in another part of the embryo to move into the isolated bud of embryo cytoplasm. Here the “transplanted” nucleus, though in the same embryo, would initiate the development of a second distinct embryo. This work suggested that at the eight- or even sixteen-cell stage, nuclei still retained the ability to specify the development of a complete new individual. In subsequent experiments, for which he was awarded the Nobel Prize in 1935, Spemann showed that there were changes that determined the fate of cells later in development. Thus transplanted cells and tissues derived from embryos further along in development retained their differentiated characteristics even when moved to a new location within the embryo. Clearly there were restrictive changes, i.e., loss of totipotency that occurred to the nuclear genetic program as development progressed, but whether these changes could be reversed was still not known.

By the early 1950s techniques had been developed which enabled individual cell nuclei from amphibians to be removed from their surrounding tissues and to be injected into eggs whose own nucleus had been removed or destroyed. With these methods, called “nuclear transfer,” new questions could be asked regarding the restrictive changes in the programming of nuclei with development. Briggs and King demonstrated in 1951 that nuclei removed from early frog embryos called blastocysts, which contained several thousand cells, could be introduced into enucleated eggs and direct development at least until the tadpole stage. John Gurdon then carried out some key experiments in which intestinal cell nuclei derived from tadpoles were transferred to enucleated eggs in a similar fashion and gave rise (albeit with low efficiency) to mature adult frogs. This research demonstrated that even the well-differentiated cell nuclei of tadpoles could be reprogrammed to direct full embryonic development. In subsequent experiments, Gurdon used nuclei from adult frog skin cells and showed that these could direct differentiation up to the tadpole stage (although apparently not beyond this point). All of this work suggested that much of differentiation and development was not associated with any irreversible changes in the nucleus.

Success in cloning and nuclear transplantation in mammals required overcoming many new technical hurdles as compared to work with sea urchins or amphibians. Mammalian eggs are much smaller, more fragile, and, unlike the eggs of frogs and sea urchins, which are released by the mother, mammalian eggs need to complete their development inter-

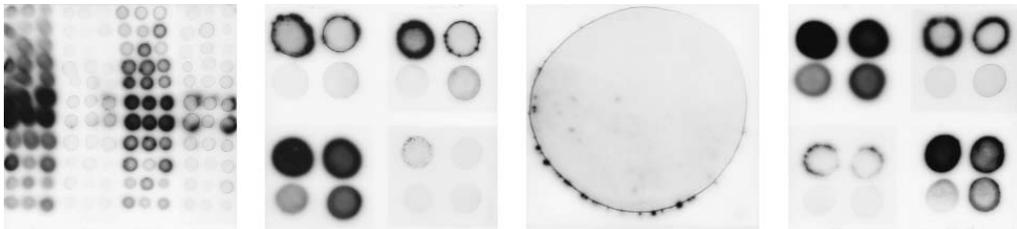


nally. By 1979, Willadsen had achieved the artificial production of identical twin sheep by splitting very early embryos. Although this could be considered a form of cloning, it merely reproduced artificially the natural process that causes identical twins; it did not create a genetic duplicate of a sheep that had already lived.

Throughout the 1980s conflicting results were reported regarding the possibility of achieving embryonic development following nuclear transfer in mice. In retrospect, these results were difficult to interpret because of incomplete scientific understanding and imperfect technique. Subsequent work seems to indicate that, at least in mammals, eggs that are in the process of the second meiotic division are more competent recipients for nuclear transfer studies than are zygotes due to the presence of high levels of a molecule known as maturation promoting factor (MPF). Furthermore, reprogramming of the donor nucleus is markedly facilitated by causing it to stop its progression through the cycle of events required for cell division (the cell division cycle or mitosis) prior to transfer to the enucleated egg. In 1986, Willadsen made use of this new information to produce the first mammals utilizing nuclear transfer technology from eight- or sixteen-cell embryos into enucleated sheep eggs. He was able to obtain live born lambs from these experiments that in some instances were genetically identical to one another; that is, they were clones. Shortly thereafter, First and colleagues obtained similar results in cattle in efforts to accelerate genetic improvements in dairy herds. Thus, nuclear transfer technology had been used to create cloned mammals a decade before Dolly, but these clones were all created using cells taken from early stage embryos, not from adult animals. Based on the work with amphibians, DNA from adult cells was not thought capable of directing the new development of a complete animal.

DOLLY

In the early 1990s Drs. Keith Campbell and Ian Wilmut worked together in Scotland to investigate systematically the requirements for successful nuclear transfer by manipulating both donor cells and recipient eggs. This work culminated in the discovery that cultured embryonic epithelial cells could act as nuclear donors if the cells were first induced to leave the active cell division cycle and enter the so-called quiescent (Go) state. Five live born lambs resulted from the early efforts. Two of the lambs died within minutes of birth and



the third succumbed after ten days. However, two other animals that came to be known as Megan and Morag lived well into adulthood. This work was highly significant because it demonstrated for the first time that mammals could be cloned from nuclei derived from well-differentiated cells that had been maintained in tissue culture. Yet, these were still cells that had originally been derived from fetal sheep.

Subsequently, Campbell and Wilmut extended their efforts to the use of cultured cells from an adult donor, and this work produced Dolly. Dolly was part of a wide-ranging experiment that involved the transfer of donor cell nuclei into nearly one thousand enucleated sheep eggs. Roughly a third of the eggs received nuclei from embryonic cells, a third from fetal cells, and a third from a cell line created with cells from the mammary tissue of a six-year-old ewe. Although the adult cells were used to create numerous embryos that were implanted into ewes, Dolly was the only successful pregnancy. Her distinction is not that she is the first cloned mammal. Dolly, however, was the first mammal successfully cloned from an adult cell, thus opening, for the first time, a plausible scientific prospect for cloning living humans.

REPRODUCTIVE CLONING SINCE DOLLY

In the four and a half years since the announcement of Dolly's birth, researchers have used nuclear transfer cloning with adult donor cells to produce cattle, goats, pigs, mice, and one gaur (an endangered wild ox native to South Asia)[, as well as a domestic cat and a dog]. At the same time, research in other species has not been successful. No primates of any kind have been successfully cloned from adult cells; only two primates (two monkeys) have been successfully cloned by nuclear transfer from embryonic cells. As far as we know, no human clones have been born, or have even been implanted for possible birth. It is not known at this point whether human cloning by nuclear transfer is even possible, although each new mammalian species cloned makes human cloning seem more plausible.

Even if human cloning by nuclear transfer is possible, several scientific issues regarding this kind of cloning need to be emphasized. These affect the relationship between the clone and the source of the donated cell nucleus, as well as the likely safety of such a procedure.

Technically, "clones" produced by these methods are not completely genetically identical to the individual that donated the nucleus. The donor cell has DNA in both the nucleus and in its mitochondria, which are cellular energy producing organelles—structures in the cytoplasm of cells separate from the nucleus. When a nucleus is transferred to an enucleated egg,

PAGES 36 AND 37 Gray #6, by Jaq Chartier. Chartier's paintings explore scientific methods through experimentation with paint and process. All of her works are "tests" to discover something about materials and what they do. Inspired in part by images of gel electrophoresis, Chartier investigates the migration of various stains through layers of paint and acrylic gels, like those employed in DNA mapping.

the donor mitochondria are either left behind entirely or grossly outnumbered by the mitochondria in the recipient egg. As a result, the new embryo derives its mitochondria from the recipient egg. While this is theoretically significant, the size of the nuclear genome is approximately 200,000 times larger than the mitochondria genome, and as far as is known, the mitochondria genes only encode proteins that relate to energy production. Nevertheless, mutations in the mitochondrial genes can produce serious disorders in humans.

Another unresolved scientific issue relates to internal changes, called epigenetic changes, in the nucleus of somatic cells. It is now fairly clear that the DNA in most differentiated somatic cells is not fundamentally different from the DNA in the single-celled zygote. It has the same sequence of adenine, cytosine, guanine, and thymine that make up the organism's genetic code. But a series of chemical changes to the primary structure of DNA, such as the addition of methyl groups to DNA, regularly occurs during development. Another example of such epigenetic changes is genomic imprinting. In mammals, the paternally inherited copy of the genome and the maternally inherited copy of the genome are not functionally equivalent. A heritable "imprint" is created during gametogenesis (the formation of sperm and eggs) so that subsequently certain genes are expressed by only one of these contributions, i.e., only from maternal or only from paternal genome. To be successful in directing development, an adult nucleus would have to have maintained a stable imprinting pattern and this pattern would need to be preserved or replaced following nuclear transfer. The success of producing live-born animals by this procedure suggests that such issues are not insurmountable, but there may be imprinting errors that contribute to the high failure rate seen in cloning experiments to date.

Another issue relates to the possibility that genetic damage (mutations) may have accumulated in the differentiated adult somatic cell selected to be the donor nucleus. The longer cells are maintained in culture and the more divisions that they undergo either in vitro or in the body, the greater is the possibility that an error in DNA replication might occur or that some other form of DNA damage might accrue. Any one cell uses only a small fraction of the 30,000 or more genes encoded in a person's DNA. A skin cell uses the genes it needs to function as a skin cell; a liver cell uses some of the same genes and some different genes. A skin cell could function perfectly well as a skin cell in spite of a crucial mutation in a gene vital to, for example, liver function. A cloned fetus produced from such a cell might not be able to produce a functioning liver and therefore would die. Such mutations might render certain somatic cells incapable of directing full and normal development.

Questions of telomere shortening and cellular senescence are also important and unresolved. Telomeres are the ends of chromosomes that shorten each time a cell divides and that therefore represent a log of the functional age of a somatic cell. There is a lower limit

to the size of telomeres that is compatible with cell life, and therefore adult cells that have undergone many rounds of replication during the life of an animal have fewer additional divisions still available to them—they are “aged cells.” Germ cells and cancer cells seem to evade this problem of cellular aging because they possess an active telomerase enzyme, which repairs and re-elongates the chromosome ends. In the case of the use of an adult, presumably “aged” somatic cell for nuclear transfer and cloning, it is not certain at present what effect such telomere shortening of the chromosome in the donor nuclei might have on the longevity of the resulting animal following nuclear transfer. Conflicting evidence has been presented with respect to the length of the telomeres in Dolly’s cells and it is not yet established whether or not Dolly is aging at a rate different from other sheep her birth-defined age. Yanagamachi’s group has serially cloned mice for up to six generations by using somatic cell nuclei from cloned mice as the donors in subsequent rounds of embryo transfer experiments. This might suggest that telomere shortening will not be a problem, but the normal lifespan of a mouse is only two years, and the scientists did encounter progressive difficulty in creating clones with each succeeding generation.

A final scientific issue, very poorly understood at present, has to do with precisely what is occurring during the so-called reprogramming process when the somatic cell nucleus is first placed inside an egg’s cytoplasm. Normal reprogramming occurs within sperm and egg and takes place over a prolonged period of time. Because cell division is usually triggered shortly after nuclear transfer, in such systems there is a very short period of time in which reprogramming may occur. This may result in incomplete reprogramming in some instances.

Work carried out to date in the various animals that have been the subjects of reproductive cloning experiments suggests that there are important species differences in procedures and outcomes among them. This will be vital to keep in mind before any human cloning attempts might be made. Furthermore, the efficiency of obtaining healthy live born clones is very low (on the order of one percent of attempts implanted) in essentially every species that has been studied to date. Many of the embryos die early in development and others progress to later stages of gestation, but often demonstrate severe defects incompatible with further normal development and life. A significant number of nuclear-transfer-cloned animals have died in early infancy of either respiratory problems or overwhelming infections. And, in some species, such as cattle, the newborns that result from such pregnancies are larger than normal, giving rise to the so-called large-calf syndrome. Finally, and quite disturbingly, more recent work suggests that some animals that appear normal at birth may have significant health issues later in life including the sudden onset of obesity without apparent increase in caloric intake, although other work on cloned cattle indicates that those who appear normal at birth remain normal as they age.

NONREPRODUCTIVE OR THERAPEUTIC CLONING

In addition to the reproductive potential for human cloning, a number of other applications have been described under the general headings of “non-reproductive” or “therapeutic” cloning. These methods would not be intended to produce living, fully developed human beings, but rather to provide a source of what have come to be called embryonic “stem cells” for the cellular treatment of human diseases that otherwise cannot be treated effectively by established drug- or cell-based methods. These embryonic “stem” cells are found only in the early human and other mammalian embryos or in particular locations in the early fetus. They are called “stem cells” because they have a potential to develop into any and all types of cells that are found in a fully developed human or other mammalian organism. Embryonic stem cells from mice were isolated more than a decade ago; human embryonic stem cells were only isolated in 1998. A full discussion of the science of stem cells is beyond the scope of this report. A brief summary follows; one clear and useful reference is a primer on stem cells issued by the Office of the Director of NIH in May 2000.

As a result of extensive studies in other mammals, especially the mouse, researchers believe that only these embryonic stem cells are “pluripotent;” that is, they have been shown to be able to differentiate into all cell types in the adult animal. In the mouse system, such cells can, entirely on their own, develop into all cell types found in a fully developed and normal mouse after they are placed into the properly supportive location in a mouse embryo. Since by most current methods they require such support, they are usually termed “pluripotent” rather than “totipotent.” Totipotent would indicate that they can, without help, develop into a fully mature mouse. While some experiments have suggested that these cells may, in fact, turn out to be totipotent, most researchers still consider that as unproven and therefore prefer the term “pluripotent” to describe the embryonic stem cells.

These embryonic stem cells have exciting therapeutic potential because, when they are exposed in the laboratory to one or another of the many known kinds of “growth factors,” they convert to more adult-like fully differentiated cells such as muscle cells, neurons, glandular cells and others. In the case of the mouse, when these manipulated stem cells are introduced into tissues in a fully developed mouse, they can become part of the tissue into which they have been introduced and take part in the normal structure and function of that tissue. It has therefore become possible to envision the use of “stem cells” to treat serious human disorders such as Parkinson’s disease, muscular dystrophy, cancer, many forms of genetic disease, and many other disorders. For example, “stem cells” derived from human embryos might be introduced into the brain of patients with Parkinson’s disease to provide normal neurological functions that are damaged in the disease as the nerve cells degenerate. Similar use can be imagined to restore normal liver cells to patients with life-

threatening liver damage, cardiac muscle cells to patients with heart damage, muscle cells to patients with muscular dystrophy, and so on.

Embryonic stem cells could be used without any human cloning in the sense used in this report. Nuclear transfer cloning may be attractive for stem cell use, however, because of its implications for a patient's immune system. If a patient received embryonic stem cells that had been grown into heart muscle cells, his immune system might recognize those cells as invaders and attack them. As a result, the attempted treatment might fail or might require expensive and dangerous suppression of the patient's immune system. It is plausible that the nucleus from one of the patient's own cells could provide the DNA for the stem cells. This might be done in one of two ways. First, doctors might create an embryonic clone of the patient, transferring the nucleus of one of his cells into an enucleated egg. That pre-embryo would then be destroyed in order to harvest stem cells from it. Alternatively, it might be possible to insert DNA from the patient into an already isolated embryonic stem cell. In either case, if effective the procedure would produce heart muscle cells with the patient's DNA. The patient's immune system would presumably consider these cells part of itself, and thus not attack them.

Research has identified other kinds of "stem cells" from the adult tissues in mammals. These cells have been called "adult stem cells" and have been identified in organs such as the bone marrow, the brain, liver, muscle, and other tissues. These special cells are rare in each of these organs and their isolation is a difficult task. Some recent evidence indicates that some of these adult stem cells can, in some circumstances, be converted to other cell types when exposed to growth factors or when transplanted into new body environments. For instance, some researchers have found that the best known of these adult stem cells, those found in the bone marrow, can become muscle cells when introduced into adult muscle.

The recently discovered multipotent "stem"-like cells from many kinds of adult tissue can theoretically be used in the same way as embryonic stem cells. Human embryonic or fetal tissue may therefore not be required to isolate functional and therapeutic "stem cells" for the treatment of many human diseases. If adult stem cells from the patient can be used, the immune system problems should not arise. If the adult stem cells used come from another person, cloning by nuclear transfer might still be used to produce adult stem cells with the patient's DNA. At this stage, adult stem cells appear to be more difficult to maintain in culture and their ability to change may not be as unlimited as embryonic stem cells. Research in this area is still limited and much remains to be learned.

A CLONING TIMELINE

1663 Robert Hooke, an English polymath who played an important role in the Scientific Revolution, coins the biological term “cell” (so called because his observation of plant cells reminds him of monks’ cells, called *cellula*).

1677 Sperm is first viewed under a microscope.

1790 The first child conceived by artificial insemination (i.e., where sperm is injected into the female, not during sex) is born.

1859 Charles Darwin publishes *The Origin of the Species*.

1866 Gregor Mendel publishes *The Theory of Heredity*, which states that physical traits are passed from parents to their offspring. The theory is not proved until 1910.

1869 DNA is first isolated in the sperm of trout by a Swiss scientist.

1879 Walter Flemming witnesses mitosis (cell division).

1885 August Weissmann theorizes, incorrectly, that genetic information of a cell diminishes with each cell division. The conclusion of this theory is that each daughter cell resulting from division carries one-half of the cell’s genetic information.

1892 Hans Driesch, using sea urchin eggs and embryos, separates the daughter cells resulting from early embryonic cell division, showing that each cell from two- and four-celled embryos could continue to divide independently and give rise to a complete and intact sea urchin. This is probably the earliest example of reproductive cloning by the process of embryo splitting.

1902 German embryologist Hans Spemann splits a two-celled newt embryo into two parts. Each of the split cells goes on to successfully form complete larvae, leading to the conclusion that early embryonic cells contain complete genetic information and disproving Weissmann’s earlier theory. Spemann also concludes that at a certain stage in an embryo’s development, which he calls “determination,” the specialization of the cells of the embryo is determined. According to Spemann’s findings, only before this stage can complete organisms be created from individual embryo cells.

Walter Sutton publishes the chromosome theory of heredity, based on observations that during meiosis each sperm or egg receives only one chromosome of each type. He hypothesizes that chromosomes carry the cell’s units of inheritance, occurring in distinct pairs within a cell’s nucleus, and that the behavior of chromosomes during the division of sex cells is the basis for Mendel’s law of heredity.

1909 Danish botanist Johanssen coins the term “gene” (from the Greek word for birth) to describe the Mendelian unit of heredity.

1910 The u.s. Eugenics Office is established to collect family histories and to encourage the breeding of “good” families.

1928 Spemann performs the first nuclear transfer experiment, in which he transfers the nucleus of an embryo into a cell without a nucleus.

1938 Spemann proposes a “fantastical experiment” to transfer the nucleus of a differentiated cell into an egg without a nucleus, the basic method that would eventually be used in cloning. Freezing sperm is successful for the first time.

1944 Oswald Avery determines that a cell’s genetic information is carried in the nucleic acid DNA, not in the proteins of the cell, as was widely speculated at the time.

1947 The Nuremberg Code delineates the ethical rules for human experimentation, stating that “the voluntary consent of the subject is absolutely essential.”

1952 Scientists Robert Briggs and Thomas J. King clone tadpoles using a method of nuclear transfer. Their many experiments lead them to believe that genetic potential diminishes as a cell differentiates and that it is impossible to clone an organism from adult differentiated cells.

1953 British physicist/biologist Francis Crick and American biochemist James Watson (with Rosalind Franklin) determine the double-helix structure of DNA.

1955 Four pregnancies succeed using previously frozen sperm.

1958 F. C. Steward, a biologist working at Cornell University, succeeds in growing a complete carrot plant from a fully differentiated carrot root cell.

1962 John Gurdon of Oxford University announces that he has used the nucleus of fully differentiated adult intestinal cells to clone South African frogs. Gurdon’s experiment proves that a cell’s genetic potential does not diminish as the cell becomes specialized, disproving the previously held conclusion of Robert Briggs and Thomas King.

1963 J. B. S. Haldane, a British biologist, uses the term “clone” in his speech “Biological Possibilities for the Human Species of the Next Ten Thousand Years.” Chinese embryologist Tong Dizhou successfully clones the first fish by inserting DNA from a male carp into the egg of a female carp.

1966 Marshall Nirenberg, Heinrich Matthaei, and Severo Ochoa crack the genetic code, opening the door for the explosion of genetic engineering studies and achievements beginning in the late 1970s.

1967 The enzyme DNA ligase, which binds together strands of DNA, is isolated. Its discovery, with the isolation of the first restriction enzyme in 1970, paved the way for the first recombinant DNA molecules to be created in 1972. In the recombinant DNA process, ligase bonds the “sticky” ends of complementary DNA strands previously cut by a restriction enzyme.

1969 James Shapero of Harvard University and Jonathan Beckwith isolate the first gene, a gene directing the digestion of sugar in a certain type of bacteria.

1970 Both Howard Temin and David Baltimore, working independently, isolate the first restriction enzyme. The restriction enzyme, called Reverse Transcriptase, cuts DNA molecules at precise locations. This capability will lead to the future manipulation of DNA.

1972 Paul Berg of Stanford University creates the first recombinant DNA molecules by combining the DNA of two different organisms. His discoveries lay the foundation for the field of genetic engineering and the modern biotechnology industry. A U.S. scientist fertilizes an egg “in vitro” (in a dish, as opposed to “in vivo,” in a body).

1973 Stanley Cohen and Herbert Boyer create the first recombinant DNA organism using techniques pioneered by Berg a year earlier. A Florida couple is the first in the United States to try in vitro fertilization (IVF).

In *Roe v. Wade* the U.S. Supreme Court awards the right to abortion when it decides the unborn are not constitutional “persons” and that the right to privacy includes the right of a woman to have an abortion without interference from the state.

1976 Attorney Noel Keane arranges the first surrogate motherhood contract.

1977 German developmental biologist Karl Illmensee, working with Peter Hoppe, creates mice with only a single parent (only a father as well as only a mother). Just after fertilization, the genes of the father and mother are separated and make up two different pronuclei in the egg cell. Illmensee removes one of these pronuclei from a fertilized mouse egg and then uses special enzymes to duplicate the remaining pronuclei. As a result of this process, the egg now carries the genes of only one of its parents.

1978 The release of David Rorvik’s controversial novel, *In His Image: The Cloning of a Man*, sparks a worldwide debate on cloning ethics, leading many in the scientific community to reassure a public increasingly suspicious of the work being done in biotechnology and genetic engineering. A dead man’s sperm is harvested for the first time (on record).

1978 The first test-tube baby is born. “Miracle Baby” Louise Brown becomes the first human ever conceived outside of the body when she is born at the Bourn Hall Clinic in Cambridge, England. Although some attack the conception as morally wrong, saying doc-

tors are playing God, in vitro fertilization will go on to help in the birth of more than a million babies in the next 25 years. The moral debate about IVF is similar to the controversy that now surrounds human cloning.

1980 In *Diamond v. Chakrabarty*, the U.S. Supreme Court rules that a “live, human-made microorganism is patentable material.” By making man-made biological products profitable commodities, the decision leads to the development of a multibillion-dollar biotechnology industry.

1981 Karl Illmensee and Peter Hoppe claim to have cloned mice by transplanting the nuclei of mouse embryo cells into mouse eggs. Other scientists are unable to reproduce the results. It is later discovered that the results were falsified.

1983 In what has been called by some the greatest achievement of modern molecular biology, Kary B. Mullis develops the polymerase chain reaction (PCR), which allows the rapid synthesis of designated fragments of DNA. Using the technique, more than one billion copies of a specific stretch of DNA can be synthesized in a matter of hours.

Davor Solter, working with David McGrath, attempts to clone mice using his own version of the nuclear transfer method. Solter and McGrath hope to use the experiment to determine whether DNA specializes as a cell specializes. Their attempts are unsuccessful; Solter concludes that nothing is wrong with the process of his cloning experiment but his failure is due to the impossibility of cloning. In a 1984 paper published in *Science*, Solter states, “The cloning of mammals, by simple nuclear transfer, is biologically impossible.”

1984 Steen Willadsen, a Danish scientist, succeeds in cloning a sheep from embryo cells. Willadsen’s work is the first verified cloning of a mammal using the method of nuclear transfer. Willadsen fuses a cell from an eight-cell lamb embryo with an unfertilized egg from which the nucleus has been removed. Willadsen finds that an unfertilized egg receives a transplanted nucleus more easily than a fertilized egg. The egg is then tricked into thinking it has been fertilized. Two of the lambs die at birth, and another survives as the first mammal cloned by the nuclear transfer method.

British scientists create the “geep” chimera by combining the embryos of a sheep and a goat. The first baby conceived through egg donation is born in Australia.

1985 Willadsen joins Grenada Genetics, where he uses his cloning technique to duplicate the embryos of prize cattle. He successfully clones cattle from differentiated week-old embryo cells, proving that the DNA of specialized cells can be returned to its original state.

1986 Neal First, Randal Prather, and Willard Eyestone, working at the University of Wisconsin, clone a cow from early embryo cells.

1990 In October, the National Institutes of Health officially begin the Human Genome Project, a massive international collaborative effort to locate the 50,000 to 100,000 genes and sequence the estimated three billion nucleotides that make up the entire human genome. By determining the complete genetic sequence, scientists hope to begin correlating human traits and predisposition to a variety of illnesses with certain genes.

1995 Ian Wilmut and Keith Campbell of the Roslin Institute in Scotland successfully clone two sheep from differentiated embryo cells. Wilmut decides to abandon traditional gene insertion methods and investigate the possibility of cloning. He puts embryo cells into an inactive state before transferring their nuclei to sheep eggs. The eggs then develop into normal lambs.

1996 On July 5, Dolly, a newborn lamb and the first organism ever to be cloned from adult cells, is born. Wilmut and Campbell create Dolly using a technique similar to that with which they created the first sheep from differentiated embryo cells in 1995. Dolly's successful creation is not announced publicly until 1997.

1997 In March, then-President Clinton, in response to the large-scale human cloning ethics debate brought about by Wilmut's announcement of the creation of Dolly, proposes a five-year moratorium on federal and privately funded human cloning research. Clinton also asks the National Bioethics Advisory Commission to review the prospects of human cloning and determine whether legal preventive action should be taken. Clinton follows this proposal with the Cloning Prohibition Act of 1997, but to date, largely due to the lobbying efforts of scientists who fear that a cloning ban could jeopardize the continuation of potentially life-saving research, no anticloning legislation has been passed into federal law. (Five states, including California, have since passed statutes banning human cloning.)

In July, Wilmut and Campbell create Polly, a transgenic sheep cloned from skin cells grown in a lab and genetically altered to contain a human gene. Gene, the first cloned bull, is born in the United States.

In December, Harvard graduate Richard Seed, the so-called "Clone Ranger," announces that he plans to clone a human being before any federal laws can be enacted to ban the process, even if he has to go to Mexico to do it. Seed's announcement adds fuel to the raging ethical debate on human cloning.

1998 In July, scientists at the University of Hawaii, including Teruhiko Wakayama, announce that they have cloned 50 mice from adult cells since October 1997. Wakayama's cloning success rate was about three in every 100 attempts, much better than Wilmut's 1 in 277. Wakayama and colleagues began to make clones of the clones. By the time they announce their research, they have produced three generations of genetically identical mice.

1999 Researchers in Seoul succeed in cloning a human cell from an infertile woman, creating a four-celled embryo, but stop the experiment due to ethical and legal concerns.

2000 Britain becomes the first country to grant a patent for cloned early-stage human embryos. Geron Corporation, which receives the patent, says it has no intention of creating cloned humans. PPL Therapeutics clones the first pigs, designed to help produce organs for human transplant.

2001 In January, Britain becomes the first country to effectively legalize the cloning of human embryos when the government approves a controversial measure aimed at allowing research on stem cells found in embryos. The clones created under the new regulations must be destroyed after 14 days, and the creation of babies by cloning remains outlawed. Britain's Human Reproductive Cloning Act is approved by Queen Elizabeth II, prohibiting the implanting of cloned embryos in a womb. The Human Cloning Protection Act banning human cloning is passed by the U.S. House of Representatives. It does not pass the Senate.

U.S. fertility specialist Panayiotis Zavos and a team of international scientists announces in March that hundreds of couples have volunteered for an experiment to create cloned children. The team said it was poised to help infertile couples bear clones as early as 2003.

Advanced Cell Technology, a privately funded company in Massachusetts, clones a human cell, which divides six times before expiring.

2002 California Governor Gray Davis signs a bill legalizing and regulating research that involves the creation and use of human embryonic stem cells, human embryonic germ cells, and human adult stem cells from any source. A U.S. delegate to the United Nations proposes a global ban on all human cloning research.

Advanced Cell Technology announces that cells from cloned cow embryos are used to grow kidney-like organs. Scientists at Texas A&M University clone a domestic cat for the first time. The calico-and-white female—named “cc,” for “CopyCat”—is a twin of her genetic “mother,” but her fur has a different pattern because of developmental factors.

In December, Clonaid, a company associated with the Raelian religious cult, which believes mankind was created by aliens, announces the first human clone, a baby girl. Later, the independent scientist and journalist brought in by Clonaid to verify its experiment denounces their claim as an “elaborate hoax.”

2003 In February, Dolly the sheep is euthanized after developing premature arthritis and progressive lung disease. Researchers have found that cloned mammals often develop genetic abnormalities. In the case of six-year-old Dolly, the sheep aged faster than normal—sheep usually live to be about twice her age. A banteng, an endangered cattle-like species,

is cloned in Iowa from the frozen cells of an animal that died 20 years before, as a test of the potential for cloning to help save endangered species. In July, the first UK research license of its kind permitting a technique that creates embryonic stem cells from human eggs is granted to the scientists who cloned Dolly; this is therapeutic, not reproductive, cloning.

The entire human genome sequence is completed, two years ahead of time.

In August, Italian scientists say they have created the world's first cloned horse, Prometea, from an adult cell taken from the horse who gave birth to her.

2004 Fertility expert Dr. Panayiotis Zavos says he has transferred a cloned human embryo into a woman. He later announces that the experiment failed.

In February, South Korean scientists claim to have cloned 30 embryos and developed them over several days to a stage where embryonic stem cells could be extracted.

In November, nearly 60% of California voters approve Proposition 71, the California Stem Cell Research and Cures Initiative, authorizing a new state agency to issue up to \$3 billion in bonds to fund stem cell research. The California Institute for Regenerative Medicine is established, with headquarters in San Francisco, to oversee implementation of the initiative. Anti-abortion and taxpayer organizations file lawsuits against the initiative, claiming it violates the California Constitution; litigation delays issuance of the first round of bonds.

2005 In March, the United Nations approves a declaration urging nations to ban all forms of human cloning. South Korean scientist Hwang Woo Suk clones an Afghan dog named Snuppy. In June, Hwang claims to have cloned human embryos from 11 patients with an efficient new technique using very few human eggs. South Korea announces plans for a World Stem Cell Hub to teach his techniques.

2006 Hwang's claims to have cloned human embryos are exposed as fraudulent; he is fired from his position at Seoul National University in disgrace. Other leading organizations—including Advanced Cell Technologies (Worcester, Massachusetts), the California Institute for Regenerative Medicine (San Francisco), Edinburgh University, Harvard University (Boston), the Karolinska Institute (Sweden), Shanghai Second Medical University, UC San Francisco, UCLA, and the University of Newcastle's Centre for Stem Cell Biology and Developmental Genetics—redouble their therapeutic cloning efforts.

Sources: Bloodlines: Technology Hits Home: Timeline, <http://www.pbs.org/bloodlines/timeline/timeline.html>,
Conceiving a Clone: The Development of Cloning through Time,
<http://library.thinkquest.org/24355/data/timelinenav.html>;
The History of Cloning,
<http://www.msnbc.com/modules/cloningTimeline/>.

QUESTIONS TO CONSIDER

1. Why did Salter lie to his son about how his mother died, and about how he was born? When would have been the right time to tell him the truth? Did Salter recreate his son because he loved him, or because he failed him? Was his choice justified or selfish?
2. Is it correct to refer to the second Bernard as “brother” to the first? Do you think of Salter’s sons as identical copies of the same person, or more as siblings?
3. What satisfaction is Salter trying to get from his meeting with Michael in the final scene? Why does Salter keep asking Michael for personal information? Is he searching for similarities or differences between this son and the others?
4. What is different about Michael’s reaction to his own cloned identity? Why do you think he is less upset by the news than Bernard? Does his reaction, and Bernard’s, reflect different ways of thinking about our own individuality? How?
5. How much does genetic makeup define a person? How much does environment define a person? If Salter’s sons are all from the same genetic material, why did the three we meet become so different? How much do you think we are affected by our upbringing and by the way we are treated as children? Do you believe in the “nature vs. nurture” argument? How do you think Caryl Churchill would answer the same questions?
6. Do you consider this story “science-fiction” or just fiction? What is the difference? What if you had seen this play 25 years ago? What has changed in science in the last 25 years that would change how you characterize this play?
7. Is cloning human beings fundamentally wrong, or does it depend on the circumstances? Under what circumstances would it be right? Does the situation portrayed in *A Number* crossing the line? How?
8. What do you think of the actor playing the three sons? How was each character he created similar to and different from the others?
9. Much of Churchill’s dialogue is written in half-sentences and clipped phrases. Characters speak over and interrupt each other frequently. How does this writing style heighten the tension between the characters? Do you think it is more or less like real, natural speech?
10. The words “clone” and “cloning” are never used in the play. Instead, characters use the words “copy” and “thing” to refer to Salter’s sons. Why do you think the playwright did that? Was there any doubt in your mind while listening to them as to what they were really talking about?

FOR FURTHER INFORMATION . . .

ON CARYL CHURCHILL AND *A NUMBER*

Aston, Elaine. *Caryl Churchill*. Plymouth, UK: Northcote House, 1997.

Aston, Elaine, and Janelle Reinelt, eds. *The Cambridge Companion to Modern British Women Playwrights*. Cambridge: Cambridge University Press, 2000.

Betsko, Kathleen, and Rachel Koenig. *Interviews with Contemporary Women Playwrights*. New York: Beech Tree Books, 1987.

Contemporarywriters.com: Author Profile: Caryl Churchill. <http://www.contemporary-writers.com/authors/profile/?p=auth259>.

Fitzsimmons, Linda, ed. *File on Churchill*. London: Methuen Drama, 1989.

Keyssar, Helen. "The Dramas of Caryl Churchill: The Politics of Possibility," *Massachusetts Review*, Spring 1983.

Kritzer, Amelia Howe. *The Plays of Caryl Churchill: Theatre of Empowerment*. New York: St. Martin's Press, 1991.

Madoff, Steven Henry. "The Wonder of Genetics Breeds a New Art." *New York Times*: May 26, 2002.

Nightingale, Benedict. "An Imagination That Pulls Everyone Else Along." *The New York Times*, November 10, 2002.

Rabillard, Sheila. *Essay on Caryl Churchill*. Blizzard Publishing, 1997.

Randall, Phylis, ed. *Caryl Churchill: A Casebook*. New York: Garland Publishing, 1998.

Royal Court Theatre. *The Royal Court Production of A Number by Caryl Churchill: Education Resources*. http://www.royalcourttheatre.com/files/downloads/a_number_edupack.pdf.

Solomon, Alisa. "Witches, Ranters, and the Middle Class: The Plays of Caryl Churchill," *Theater*, Spring 1981.

Wilma Theater: The Caryl Churchill Festival. <https://www.wilmatheater.org/index2.html>.

ON GENETICS AND CLONING

Alexander, Brian. *Rapture: How Biotech Became the New Religion*. New York: Basic Books, 2003.

Backbone Media. Bloodlines: Technology Hits Home. <http://www.pbs.org/bloodlines/resources/about.html>.

California Advisory Committee on Human Cloning. *Cloning Californians? Report of the California Advisory Committee on Human Cloning*. Sacramento, CA: January 11, 2002.

Center for Genetics and Society: Analysis: Art and Popular Culture. <http://www.genetics-and-society.org/analysis/popular.html#overview>.

Fukuyama, Francis: *Our Posthuman Future: Consequences of the Biotechnology Revolution*. Picador, 2003.

Human Cloning Organization. <http://www.humancloning.org/>.

Human Genome Project Information. http://www.ornl.gov/sci/techresources/Human_Genome/home.shtml.

Kolata, Gina. *Clone: The Road to Dolly and the Path Ahead*. New York: Quill, 1999.

MSNBC. The History of Cloning. <http://www.msnbc.com/modules/cloningTimeline/>.

Park, Alice and Christine Gorman. "Inside the Korean Cloning Lab." *Time*, May 30, 2005.

Pence, Gregory. *Who's Afraid of Human Cloning?* Lanham, MD: Rowman & Littlefield Publishers, Inc., 1998.

The President's Council on Bioethics. *Human Cloning and Human Dignity: An Ethical Inquiry*. Washington, DC: July 2002. <http://www.bioethics.gov/reports/cloningreport/execsummary.html>.

Rabie-Azoory, Vera. "Sibling Rivalry: The Truth About the Family Favorite with Vera Rabie-Azoory." WebMD Live Events: June 6, 2000. http://my.webmd.com/content/article/1/1700_50681.

Ridley, Matt. *Nature Via Nurture: Genes, Experience, and What Makes Us Human*. New York: HarperCollins, 2003.

Silver, Lee M. *Remaking Eden*. New York: Harper Perennial, 1998.

Talbot, Margaret. "A Desire to Duplicate." *The New York Times*, February 4, 2001.

ThinkQuest. Conceiving a Clone. <http://library.thinkquest.org/24355/home.html>.

Wilmut, Ian, Keith Campbell, and Colin Tudge. *The Second Creation: Dolly and the Age of Biological Control*. New York: Farrar Straus Giroux, 2000.