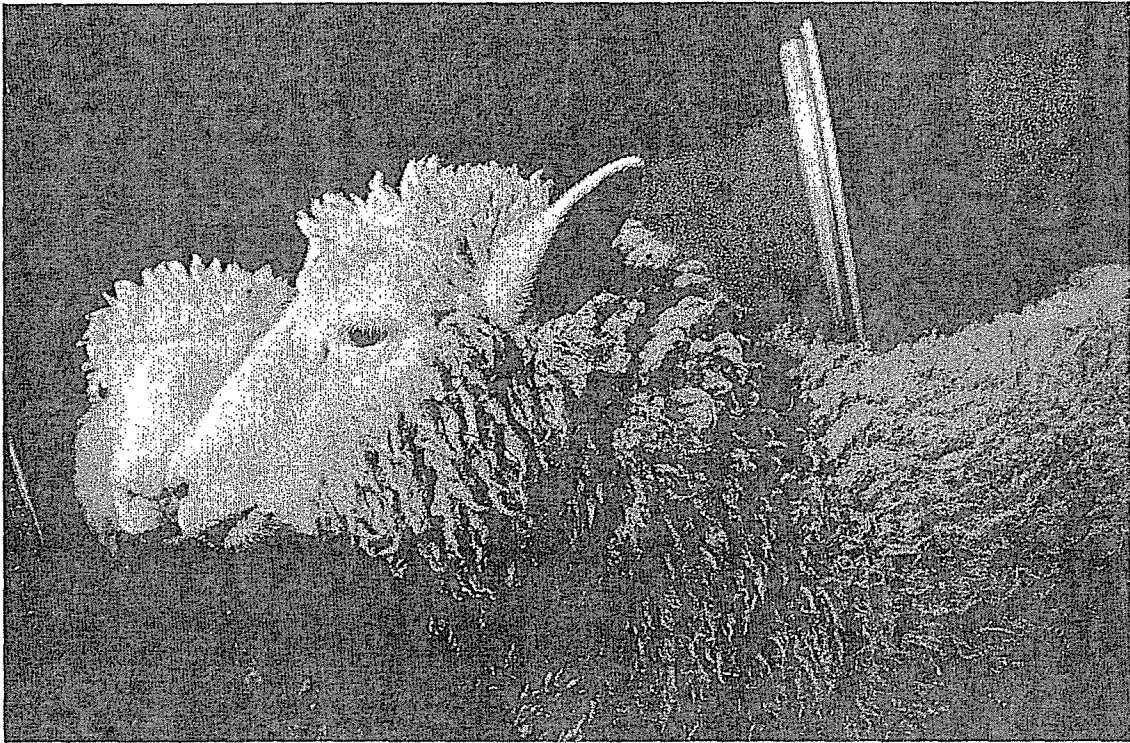


- I. Question 1 in your Questions Booklet is based on this photographic composition. Questions 10 and 11 require you to consider this reading together with Reading II. Questions 19 to 21 require you to consider this reading together with readings II, III, and IV.

from WORLD PRESS PHOTO



photograph by Stephen Ferry

Dolly the sheep became the world's most controversial animal. Scientific history was written at the Roslin Institute in Scotland, which announced on February 22¹ that it had produced the first cloned mammal. Biologists took one mammary cell from an adult ewe and inserted it into a sheep's ovum, which divided and
5 developed to become Dolly, carrier of an exact replica of her mother's DNA. The news sparked heated discussions about the ethics of cloning.

Terri J. Kester

¹February 22—February 22, 1997

- II. Questions 2 to 9 in your Questions Booklet are based on this essay from a magazine. Questions 10 and 11 require you to consider this reading together with Reading I. Questions 19 to 21 require you to consider this reading together with readings I, III, and IV.

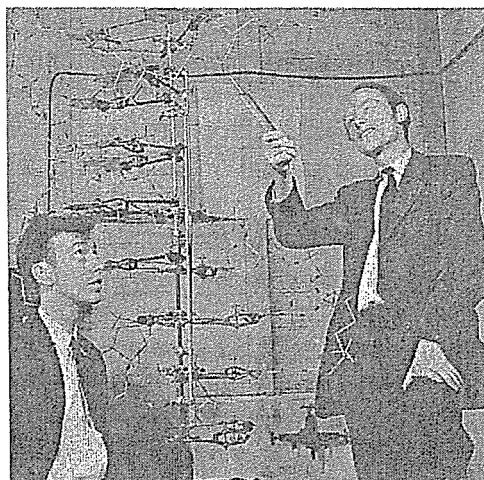
CRACKING THE GENETIC CODE

It's 50 years since two brash, ambitious scientists unveiled the double helix

A FEW years back, not long after Dolly the cloned ewe was sprung on an unsuspecting world, an Australian researcher reported that DNA was so ubiquitous¹ it was literally oozing out of our pores. We humans were leaving little biological Post-Its² of ourselves on everything we touched. Little bits of genetic code—how to build a nose, how to fight disease—searching perhaps for a chemical soulmate.

For a writer, this was a notion almost as staggering as the invention of Dolly. (Even if you don't read this article all the way through, Gentle Reader, touch the page and we will have danced the dance.) For one, it helped align the moral compass at a time when the genetic revolution seemed to be messing about madly in God's tool box. Think of it this way: if DNA, the chemical blueprint that we store in almost every cell of the body, and that we share with mice and flatworms, is *that* pervasive, that relentlessly life-seeking, then maybe redirecting its course—by putting fish genes into plants or injecting adult brains with fetal cells—isn't as Frankensteinish as it might appear. Though there has certainly been plenty of that to go around.

It's 50 years since Cambridge-based upstarts James Watson and Francis Crick kick-started the genetic revolution with their depiction of what deoxyribonucleic acid, or DNA, looked like (a double helix, like an entwined pair of circular staircases) and how it might replicate itself. A more accurate beginning would have been nine years earlier, in 1944, when cautious, Halifax-born Dr. Oswald Avery, and two associates at the Rockefeller Institute in New York, showed DNA was, in fact, the suitcase of heredity.



Watson (left) and Crick opened the doors to DNA evidence, cloning, and genetic therapies

¹ubiquitous—ever-present and widespread

²Post-Its—self-adhesive notes used by individuals to serve as reminders

Continued

But in many ways the double helix proved to be the perfect up-and-down-staircase metaphor for an inventiveness that often held as much hype as promise.
35 And Watson and Crick were perfect poster boys. Brash, competitive and on the make, both had migrated to genetics from other disciplines and had little time for the leadened ways of older practitioners. Watson, an American, was only 24 at the time, a brainy, slightly awkward birdwatcher who has since told the world way too much about his difficulties dating young women. Crick, at 36, was an
40 unrepentant theoretician. He was the one who strode into a Cambridge pub on Feb. 28, 1953, and announced, “we have found the secret of life,” something his wife had heard several times before. (He would later theorize that biological life on earth had been seeded millions of years ago from outer space.)

Together they proved a fateful pairing of two brilliantly compatible minds
45 obsessed with resolving the biggest intellectual challenge of their day, and unafraid to march over the less ambitious on their path to glory. Their big break came when a disgruntled colleague of King’s College rival Rosalind Franklin, a smart, tragic figure, surreptitiously³ showed Watson one of her X-rays with the shadowy outline of the entwined helix. Franklin was proceeding more cautiously
50 with her research. But for Watson, the imagery matched all that he and Crick had been talking about. So they dashed off a paper for the science journal *Nature* and, from those hothouse beginnings, it’s been pretty much a straight line to the sex-obsessed, jump-the-gun, let’s-clone-a-human Raelians,⁴ with stops en route at Dolly and Craig Venter, the science mogul who tried to patent the entire human
55 genome.

It would be nearly 25 years before Watson and Crick’s double helix could actually be seen on a modern electron microscope. But this was a revolution that had no time to wait. In the early 1970s, scientists cloned the first small African tree frog and began the earliest experiments in genetic engineering. Among them
60 was Vancouver’s Michael Smith, a transplanted Brit, who discovered—after a series of propitious⁵ chemical explosions—how to produce what is known as recombinant DNA by altering the sequences of a gene in a lab. Rewriting, in effect, the chemical code of life.

His findings were so freakish that the leading journal of his day refused to
65 publish them. He would later win a Nobel Prize (as did Watson and Crick in 1962) and earn a tidy fortune as his technique became the mainstay of the first bioengineering boom, in the 1980s. That was when scientists began talking about

³surreptitiously—secretly

⁴Raelians—members of a sect, founded in France in 1973, who believe that humans were created by extraterrestrial beings who had mastered genetic engineering. Stemming from the belief that the human soul perishes when the body dies, the Raelians’ interest in cloning led to their founding of the organization Clonaid in 1997. The group claims to have cloned a human being.

⁵propitious—advantageous or favourable

ridding the world of inherited disorders like Down's syndrome, of tailoring drug treatments to an individual's genetic makeup, of stopping cancer in its tracks, of
70 finding the DNA switch to extend the human lifespan, of ending global hunger with disease-resistant foods, of growing new pharmaceuticals simply and cheaply in a field of wheat.

It was also a time when evolutionary biologists started hypothesizing genes for specific types of behaviour, everything from why certain men fool around so
75 much to why some kill. By that point, anthropology was already being rewritten by the molecular biologists: the time since humankind broke from the apes was reset 10 million years closer to the present and the human tree was being much more precisely delineated. The law would be next.

The mysterious entity at the heart of the revolution, DNA, is a kind of
80 chemical soup, an ultra-complex blueprint of nearly three billion possible connections for directing proteins, the building blocks of life, and telling individual cells what to do—to release insulin, say, when sugar levels are high, to send white blood cells to fight an infection, or to build an organ like the heart from scratch. DNA is a soup we share with all of life. But humans are also like
85 snowflakes. No two of us are exactly alike (save for identical twins) and the tiny, less-than-one-per-cent difference in each person's DNA makeup comprises a genetic fingerprint that transformed the legal system.

O. J. Simpson's celebrity murder trial in 1995—and the much-debated bloody glove—brought DNA evidence to the tabloids. David Milgaard, Guy Paul
90 Morin—the vanguard⁶ of Canada's wrongfully convicted to benefit from DNA forensics—forever moved justice's steely yardsticks. Today it is commonplace for national police forces to maintain a DNA database that can reactivate “cold files,” and Canadian judges routinely order the newly convicted to give over a DNA swab to see if there is a connection to an earlier crime.

95 DNA evidence, with the imprimatur⁷ of complex, confident science on it, revived the capital punishment debate in the United States and helped empty Illinois's death row earlier this year. From there it was only a short jump to prime-time TV, where DNA-dominated police shows top the ratings. Everyone loves a mystery. Especially the kind we believe we can solve.

100 Disease, though, proved a harder nut. Some found it ironic that on Feb. 28, 50 years to the day since the Watson-Crick eureka,⁸ medical regulators in the U.S. met to pronounce an end to gene therapy, except when it might be a treatment of last resort. The reason: two young boys in France, injected with a genetically altered virus to give them an immune system where nature had not, had

Continued

⁶vanguard—individuals at the forefront

⁷imprimatur—approval or endorsement

⁸eureka—triumphant discovery

105 developed leukemia. It was not the first mishap. In 1999, Jesse Gelsinger, an
18-year-old from Tucson, Ariz., became the first known death by gene therapy. It
was then revealed that hundreds of other “serious” reactions had not been
reported to American authorities.

Canada’s role in all this has been modest but not insignificant. The good
110 news, notes Alan Bernstein, president of the Canadian Institutes of Health
Research and a genetics researcher of repute, is that we have the second largest
biotech industry in the world. The bad news is that it’s made up mostly of small,
undercapitalized companies in a country that ranks in the bottom third of
industrialized nations in terms of per-capita research spending.

115 Still, federal funds are beginning to flow in handsome amounts (nearly
\$1.4 billion in the past three years just to the CIHR alone) and we’ve had our
share of stars. Apart from Smith, the Nobel winner, and Bernstein, whose
Toronto lab was among the first to introduce a genetically altered retro-virus into
the stem cells of mice, one of the more far-reaching techniques, Canadians have
120 taken the leading role in identifying key disease genes for cystic fibrosis,
muscular dystrophy and early-onset Alzheimer’s.

We have set the gold standard—the Edmonton protocol—for modifying
pancreatic cells to treat certain types of diabetes. We have also been in the
vanguard of examining the environmental mysteries of genetic disorders. The
125 ethical dilemmas, too—not surprising for a country that can ferret out how to
inject altered DNA into a cell (Bernstein’s research among others) but has been
reluctant to extend that to clinical use. “Yes, we haven’t moved as quickly into
gene therapy as others,” allows Bernstein. “But maybe the rest of the world
moved too fast.”

130 As revolutions go, DNA’s blustery march has followed the historic pattern of
advance and retreat. Dolly, the famous exact replica of an adult ewe, was beset
by problems of old age before dying at six years, about half a normal sheep’s
lifespan. Before and since her, animal clones have been born with horrendous
abnormalities from which they did not survive. Genetically modified foods have
135 been dogged by controversies over taste, their potential as a health hazard and
their ability to spread into neighbouring crops, with a potential of creating a broad
tolerance for herbicides or pesticides that could prove difficult to overcome. The
great biotech promise can be summed up in part by the stock fortunes of Venter’s
Maryland-based Celera Genomics: three years ago it traded at US\$247, today it’s
140 worth about US\$8.20.

Still, thanks to gene therapy, at least a dozen young boys in France, Britain,
Italy and the U.S. are living near-normal lives, released from the virus- and
bacteria-free “bubbles” where they’d been confined after being born without an
effective immune system. So, too, is the first gene-therapy patient, 17-year-old

145 Ashanti de Silva, 13 years after doctors in Boston injected genetically altered
blood cells into her veins for the same problem. Cancer and genetic disorders like
schizophrenia are no longer clinical black holes, void of understanding. And
even if science can't yet figure out the complex pathways to cure or switch off
faulty genetic wiring—and remember, we are dealing with a minute, self-
150 propagating⁹ strand with billions of complex chemical interactions twisted upon
itself in a chromosome that can compress to a thousandth of a millimetre—the
genetic revolution has fundamentally changed the way we think about disease.
We have entered an era where many (and soon most) newborns have their genetic
blueprint identified. That will give them advance notice of their predilection¹⁰ to
155 one disease or another—adding, of course, as Watson and Crick did, to the
burden of choice. That most human of dilemmas, it fairly oozes out of us.

Robert Sheppard

⁹self-propagating—reproducing independently

¹⁰predilection—susceptibility or predisposition

III. Questions 12 to 17 in your Questions Booklet are based on this commentary from a newspaper. Questions 19 to 21 require you to consider this reading together with readings I, II, and IV.

This commentary was written in 2002.

BIOTECHNOLOGY ADVANCES SET TO BECOME HUGE GLOBAL ISSUES

Quandary of progress will create tensions this year

WASHINGTON / In 2003 the focus of interest in biotechnology will move away from stem cells, embryos and cloning, where it has been stuck for the past few years, and shift to other areas of concern.

- 5 First among these will be neuroscience,¹ which gets to the essence of who we are.

This will have a much greater effect on the way people live in the short term than anything coming out of the Human Genome Project.²

- 10 For example, brain scans that map individuals' unique brain functions will begin to see their first use as diagnostic, and ultimately predictive, tools.

Employers will demand better ways of predicting whether workers will suffer from depression, be abusive or violent, or have the cognitive abilities required by a high-tech workplace.

- 15 And as the realization sinks in that each individual possesses a vast array of biological and psychological data that can be used by employers, the police, ex-lovers, extortionists³ and the like, there will inevitably be intensive discussions about how to protect privacy in areas no one thought would ever be made public.

- 20 Sport—and specifically the approach of the 2004 Olympics in Athens—will raise the public's awareness of the knotty moral problems of neuropharmacology:⁴ essentially how can we change who we are by the things we take? The answer to that most basic of questions—what is an athlete's natural talent?—will be unclear.

¹neuroscience—life science that deals with nerves and nerve tissue, especially with their relation to human conduct and learning

²the Human Genome Project—an international, collaborative research program whose goal was to completely map all of the genes of human beings. As a result, an accurate and complete human genome sequence was completed in 2003.

³extortionists—criminals who obtain money or property from others by threatening to disclose private personal information

⁴neuropharmacology—branch of medical science that deals with the action of drugs on and in the nervous system

Of course the taking of artificial drugs is traceable and outlawed. But what about perfectly natural genetic material that, in a few years' time, may be part of everyone's therapeutic medicine box?

Fast-paced research

The race is already out of control.

There are genes that have been injected into the muscles of mice that have increased muscle mass by 60 per cent, and that prevent the deterioration of muscles due to aging. They leave no residue and are invisible to drug testers because they mimic natural chemicals. They have already become of intense interest to coaches and athletes.

These possibilities will lead to a much more open debate over the uses of biotechnology for enhancement, rather than therapeutic, purposes. This will begin with arguments over whether professional sports should simply recognize the fact of pharmacological enhancement, and compete on the basis of who has the better team of pharmacologists.

Traditionalists will argue that athletics is about the perfection of natural abilities, and progressivists will assert that nature is an outmoded concept. Of course, many athletes will pragmatically welcome anything that gives them a competitive edge.

These developments will not be confined to sport. They will extend into your working life. People will realize, for example, that there are pharmacological means of overcoming, at least for 48- to 72-hour cycles, the need for sleep. This will open up vast new areas of competitive behaviour in already highly competitive societies.

The coming year is also likely to bring the internationalization of genetic research, and with it the growth of an ethical divide on biotech issues not just between the U.S. and Europe, but between the West more broadly and Asia.

The Chinese will announce the successful cloning of human embryos, causing moral mayhem in the United States and Europe. Singapore and South Korea, in addition to China, have both taken advantage of western restrictions on biotechnology to create openings for their own researchers.

They will move ahead with stem-cell and embryo research, as well as with agricultural biotechnology. The United Nations will debate a Franco-German proposal for a global ban on human reproductive cloning, which will find precious little support in Asia outside Japan.

Continued

The law will catch up with technology in some areas, and fall behind in others. The Canadians will put into place comprehensive legislation to regulate embryo
60 research and reproductive genetics. Other countries such as Australia and France will make progress in a much more piecemeal fashion.

A stem-cell deadlock

The debate in the United States, however, is likely to remain deadlocked between proponents of stem-cell and embryo research and right-to-life advocates,
65 neither of whom will muster enough support to overcome each other.

The need for a broad overhaul of the regulatory system for human biomedicine in the United States, though much needed, will be dodged.

Expect manifold⁵ difficulties in the patent protection of genetic discoveries in 2003. The demand for intellectual-property rights will run up against the limited
70 institutional capacity of most of the world's patent offices. They will, quite simply, be overwhelmed.

In 2003 we will also see a sharper debate on agricultural biotechnology. In 2002, a number of African countries suffering from drought-induced famine rejected American food aid because it contained genetically modified foods. The
75 resistance to such foods can be seen as self-indulgence on the part of Europeans, but it is now having genuinely disastrous consequences for the Third World.

The tightening of European labelling requirements for GM foods is going to clash in the coming year with the fact that agricultural exporting countries like Argentina and Brazil have been producing large quantities of crops that have
80 already got into the European food chain.

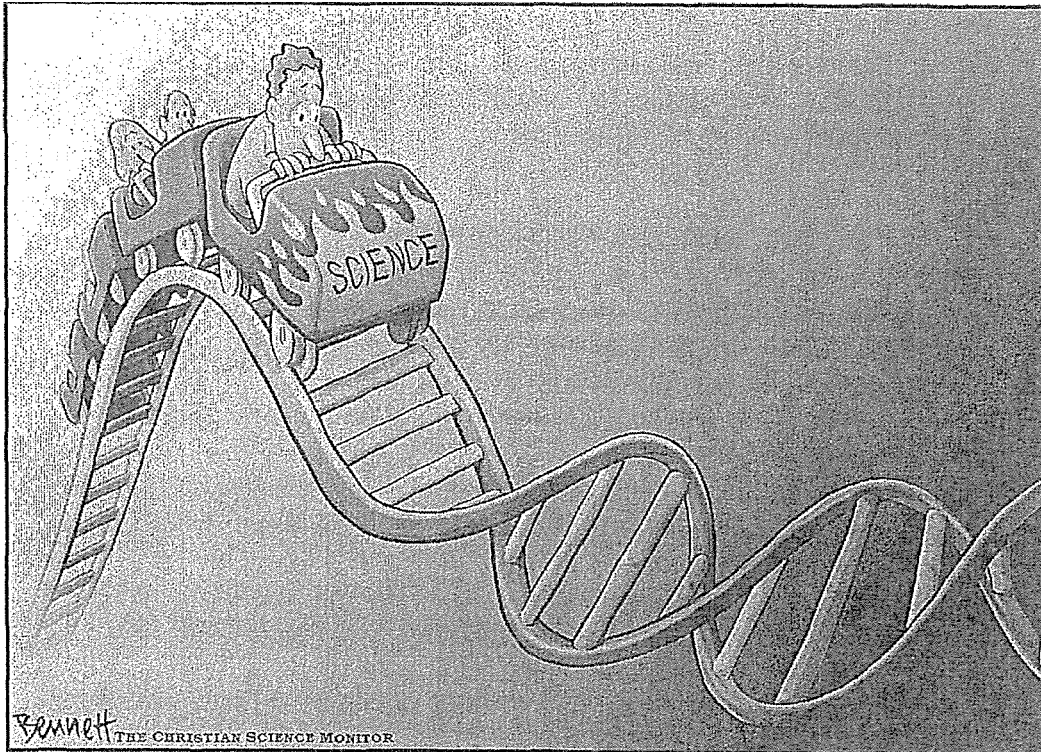
Finally, there is the issue of bioterrorism. The capability to make truly dangerous new viruses and disease agents is so widespread throughout the global biotech industry that future attacks are simply a disaster waiting to happen.

But whether this will come in 2003 or in a later year is something known only
85 to the terrorists themselves.

Francis Fukuyama

⁵manifold—multiple

- IV. Question 18 in your Questions Booklet is based on this cartoon. Questions 19 to 21 require you to consider this reading together with readings I, II, and III.



Clay Bennett

V. Questions 22 to 31 in your Questions Booklet are based on this excerpt from a novel.

This is the opening chapter of the novel.

from FLESH AND BLOOD

1 9 3 5 / Constantine, eight years old, was working in his father's garden and thinking about his own garden, a square of powdered granite he had staked out and combed into rows at the top of his family's land. First he weeded his father's bean rows and then he crawled among the gnarls and snags of his father's vineyard, tying errant tendrils back to the stakes with rough brown cord that was to his mind the exact color and texture of righteous, doomed effort. When his father talked about "working ourselves to death to keep ourselves alive," Constantine imagined this cord, coarse and strong and drab, electric with stray hairs of its own, wrapping the world up into an awkward parcel that would not submit or stay tied, just as the grapevines kept working themselves loose and shooting out at ecstatic, skyward angles. It was one of his jobs to train the vines, and he had come to despise and respect them for their wild insistence. The vines had a secret, tangled life, a slumbering will, but it was he, Constantine, who would suffer if they weren't kept staked and orderly. His father had a merciless eye that could find one bad straw in ten bales of good intentions.

As he worked he thought of his garden, hidden away in the glare of the hilltop sun, three square feet so useless to his father's tightly bound future that they were given over as a toy to Constantine, the youngest. The earth in his garden was little more than a quarter inch of dust caught in a declivity of rock, but he would draw fruit from it by determination and work, the push of his own will. From his mother's kitchen he had spirited dozens of seeds, the odd ones that stuck to the knife or fell on the floor no matter how carefully she checked herself for the sin of waste. His garden lay high on a crown of scorched rock where no one bothered to go; if it produced he could tend the crop without telling anyone. He could wait until harvest time and descend triumphantly, carrying an eggplant or a pepper, perhaps a tomato. He could walk through the autumn dusk to the house where his mother would be laying out supper for his father and brothers. The light would be at his back, hammered¹ and golden. It would cut into the dimness of the kitchen as he threw open the door. His mother and father and brothers would look at him, the runt, of whom so little was expected. When he stood in the vineyard looking down at the world—the ruins of the Papandreous' farm, the Kalamata Company's olive groves, the remote shimmer of town—he thought of climbing the rocks one day to find green shoots pushing

¹hammered—shaped or marked by hammer blows

Continued

35 through his patch of dust. The priest counseled that miracles were the result of
diligence and blind faith. He was faithful.

And he was diligent. Every day he took his ration of water, drank half, and
sprinkled half over his seeds. That was easy, but he needed better soil as well.
The pants sewn by his mother had no pockets, and it would be impossible to steal
handfuls of dirt from his father's garden and climb with them past the goats' shed
40 and across the curving face of the rock without being detected. So he stole the
only way he could, by bending over every evening at the end of the workday, as if
tying down one last low vine, and filling his mouth with earth. The soil had a
heady, fecal taste; a darkness on his tongue that was at once revolting and
strangely, dangerously delicious. With his mouth full he made his way up the
45 steep yard to the rocks. There was not much risk, even if he passed his father or
one of his brothers. They were used to him not speaking. They believed he was
silent because his thoughts were simple. In fact, he kept quiet because he feared
mistakes. The world was made of mistakes, a thorny tangle, and no amount of
cord, however fastidiously tied, could bind them all down. Punishment waited
50 everywhere. It was wiser not to speak. Every evening he walked in his
customary silence past whatever brothers might still be at work among the goats,
holding his cheeks in so no one would guess his mouth was full. As he crossed
the yard and ascended the rocks he struggled not to swallow but inevitably he did,
and some of the dirt sifted down his throat, reinfecting him with its pungent black
55 taste. The dirt was threaded with goat dung, and his eyes watered. Still, by the
time he reached the top, there remained a fair-sized ball of wet earth to spit into
his palm. Quickly then, fearful that one of his brothers might have followed to
tease him, he worked the handful of soil into his miniature garden. It was
drenched with his saliva. He massaged it in and thought of his mother, who
60 forgot to look at him because her own life held too many troubles for her to
watch. He thought of her carrying food to his ravenous, shouting brothers. He
thought of how her face would look as he came through the door one harvest
evening. He would stand in the bent, dusty light before his surprised family.
Then he would walk up to the table and lay out what he'd brought: a pepper, an
65 eggplant, a tomato.

Michael Cunningham (1952–)

Cunningham is an American writer who
received the Pulitzer Prize for Fiction for *The Hours*.
He lives in New York City.