

Brave New Worlds

If we don't want the revolution in life sciences to turn into the snake oil of the 21st century, argues geneticist Sharon Kardia, we need to act now to address the social and ethical implications of what we're doing.

YOU SEE THEM in the *New York Times* magazine and in college newspapers like the *Michigan Daily*—ads that promise “fully prescreened egg donors,” many of whom have doctoral degrees or other “special accomplishments, talents, or ethnicity.”

Most often, says University of Michigan economist Sherrie Kossoudji, human egg donors are in their early to mid-twenties and are tall, thin, and college-educated, with a healthy genetic background and no family history of substance abuse. Young women who fit the profile and are willing and able to donate their eggs to infertile couples can earn as much as \$20,000 per egg.

Welcome to the 21st century, where parents can not only purchase their children's genetic makeup—or try to—but can also screen embryos before implantation for genetic diseases. Though few would admit it, parents can also screen for gender.

And that's just at the beginning of life, says Toby Citrin, co-director, with SPH epidemiologist Sharon Kardia, of the University of Michigan Life Sciences and Society Program, a cross-campus initiative aimed at exploring the ethical and societal questions raised by advances in the life sciences.

by Leslie Stainton



DNA NOT INSURABLE

The recent debate over Terri Schiavo, a brain-damaged Florida woman who was kept alive for 15 years in what physicians termed a “persistent vegetative state,” proves that the end of life is just as riddled with profoundly troubling questions.



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“People are increasingly defining themselves in terms of their DNA structure,” Citrin says. Genetic tests for cancers and other diseases are becoming routine. Scientists are experimenting with devices that can decipher our genomes. Pharmaceutical companies are working to tailor drugs to suit specific genetic profiles.

Before long, says Kardia, personalized health information—a complete panel of genomic indicators for each individual— “will be part of our mainstream consciousness. In 50 years, it’ll be as normal as computers and the web.”

Kardia jokes that it may be just a matter of time before we find ourselves wearing our own genetic bar codes—but the potential is there.

So it’s vital that we address the ethical and social implications of life sciences research now and not later, she says. “Otherwise, this great scientific revolution will become the snake oil of the 21st century.”

Through the Life Sciences and Society Program, Kardia and Citrin are confronting such issues as how corporations are exploiting new developments in the life sciences, from genetic screens to custom-designed pharmaceuticals; how life sciences research is affecting America’s aging population—a population that is obsessed with “dying healthy,” Citrin notes; and how new technologies and treatments should be discussed and disseminated globally.

The program originated in 1999 as the Life Sciences, Values and Society Program, under the direction of Richard Lempert, the Eric Stein Distinguished University Professor of Law and Sociology at the University of Michigan, with SPH alumna Amy Sheon, MPH ’84, as associate director. Last spring, Lempert and Sheon stepped down from the program, and the cross-campus initiative moved into the School of Public Health, where its mission has broadened to include an undergraduate minor in life sciences and society and graduate-level courses exploring the intersection between science and society, as well as graduate student training opportunities.

Kardia, Citrin, and their colleagues in the program have also published a curriculum guide to courses on the UM campus that deal with the convergence of science and society, and they’re deepening ties with the life sciences research community. Recently they submitted a grant proposal to the National Science Foundation to fund the creation of a broad-based UM research community around the issues of genomics and race identity, and they’ve appointed a campus-wide steering committee to ensure broad university participation in planning and programs.

“A lot of what we’re doing is the basic building of bridges between disciplines,” says Kardia.

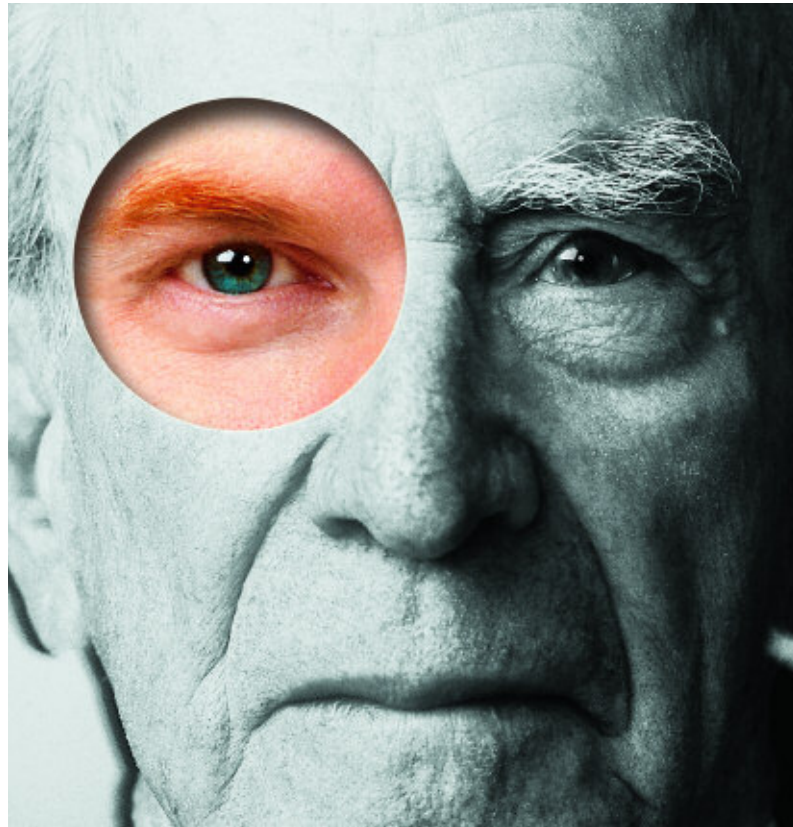
Both she and Citrin have extensive backgrounds in the complex issues of genetics and genomics. An associate professor of epidemiology, Kardia directs the Public Health Genetics Program in the School of Public Health. Citrin directs

The Beauty That Comes from Difference

Among the initiatives to which the newly expanded Life Sciences and Society Program has lent its support in its first months is an exhibition of works by photographer Rick Guidotti, entitled “Positive Exposure: The Spirit of Difference Exhibit.” The theme of the exhibition, says LSS co-director Sharon Kardia, shown here with fellow co-director Toby Citrin, “is an exploration of the beauty that comes from difference.”

Guidotti, a former portrait and fashion photographer, has devoted much of the past decade to taking positive—indeed radiant—pictures of individuals with genetic conditions, such as the woman in the photograph above, who has albinism. “Guidotto is working to incorporate genetic diversity into our overall definition of social diversity,” says Kardia. “He’s celebrating our individuality rather than our group differences.”





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the school's Office of Community-Based Public Health and heads the Michigan Center for Genomics and Public Health, with Kardia as co-director.

Citrin hopes the LSS program will help change the means by which life sciences research is translated into technology and then into practice, so that products are not rushed onto the market before guidelines and policies governing their use have been put into place. He says researchers in the life sciences need to address the societal implications of their work from the outset—and he believes LSS can play a major role in that process.

“Part of what we want to do in our program is to try to shed light on the implications of a particular path of research by studying it and seeing how it is playing out now, and how it is likely to play out in society,” he says. “We want to study the kinds of policies that might be used to guide research in the right direction and prevent it from going in the wrong direction.”

Even a decade ago, things were simpler. But the sequencing of the human genome in 2003, coupled with rapid advances in information technology and the emergence of nanotechnology, has wrought a sea change in both medicine and public health. We've revolutionized our understanding of the human organism as well as our ability to analyze and manipulate huge amounts of data, say Kardia and Citrin. Fields like epidemiology and health behavior, which traditionally focused on the health of populations, are now zeroing in on individuals as well. Lab scientists have gone from the demographic to the nanospheric.

Nanotechnology—which scales down the universe to a billionth of a meter—holds out the promise of super-sensitive diagnostic tests and novel therapies, the manufacture of synthetic heart and eye tissue, high-speed computers the size of sugar cubes, nanomaterials with unknown health risks, and nanomachines that could slow aging, monitor moment-to-moment

physiological changes, and even enable direct brain-machine interfaces.

“These systems are so small and complex they bridge the quantum and physical worlds,” Kardia says. “We have a hard enough time deliberating on the ethical issues of the physical world—how are we ever going to be able to predict ethical ramifications in the strange and wonderful quantum world?”

Health policy, too, faces challenges. Should insurance companies be privy to the results of genetic tests, researchers are asking, and if so, under what circumstances and with what constraints? If an embryo tests positive for a genetic disorder, and a couple chooses to bring that embryo to term, can a health care provider refuse to insure that child?

Both Citrin and Kardia are wary of the potential for the resurgence of eugenics, a movement founded on the belief that the human species can be improved through selective breeding.

“Where do you draw the line between the avoidance of certain conditions that cause suffering and death, and the enhancement of certain characteristics, such as skin and hair color?” asks Citrin, who has conducted community dialogues on ethical and policy questions related to genetics research, with an eye toward helping policymakers create rules governing this area.

One set of community dialogues took place in Alabama, site of the infamous “Tuskegee Experiment,” a United States Public Health Service study that lasted from 1936 to 1972, in which hundreds of African-American men suffering from syphilis went untreated so that the progress of the disease could be monitored by physicians whose training reflected eugenic beliefs.

In today's world of reprogenetics, a couple's quest for a “perfect baby” could easily lead to decisions that verge on eugenics, Kardia says. “Should we be allowed to select the potential attributes of our potential children?” she asks. And if so, what do we weed out? Disability?

Deafness? Tone-deafness? Where does one draw the line?

“We absolutely think we're above eugenics,” Kardia says, “and we absolutely are not.”

Timothy Johnson, Bates Professor and chair of the Department of Obstetrics and Gynecology, UM Medical School, says he's seen technology produce both medical miracles and excruciating predicaments. Prenatal genetic screening is much more prevalent than it used to be, for example, and much less invasive than traditional tests such as amniocentesis, but because the new screens take place earlier in gestation—at 10 to 11 weeks, versus 15 to 16 weeks for amniocentesis—the results are more complex and can therefore be difficult to interpret.

“Just because a test is negative doesn't mean a baby doesn't have a disease,” says Johnson. “It opens huge issues in terms of patient choice and anxiety.”

In his 30-year career, Johnson has witnessed huge technological changes. “Back in 1976, the idea of in vitro fertilization would never have occurred to me, not in a million years,” he laughs. Now Johnson works regularly with couples who conceive offspring through IVF, the process by which an egg is surgically removed from an ovary, fertilized in the laboratory, and then reimplanted in a woman's uterus.

Earlier this year, Johnson delivered an IVF baby to a woman in her fifties who'd bought an egg from a Stanford University co-ed. The woman and her husband had been trying for 30 years to have a child, and were elated that technology had finally made their dream possible.

But such happiness comes at a cost. For starters, couples can spend as much as \$200,000 to conceive a child through IVF, particularly if they first undergo preconception genetic screening themselves and then subject a blastocyst—a pre-embryonic fertilized egg—to genetic screening before implantation. If the blastocyst screens positive for a devastating genetic disease, couples face not

If a **blastocyst** screens positive for a devastating **genetic disease**, couples face not only a painful **personal decision** but significant **financial loss**.

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Johnson wonders whether they should bear that expense. “What is the social cost of identifying an embryo with cystic fibrosis?” he asks. When parents elect not to implant such an embryo, they’re arguably saving society a significant sum of money down the line—so shouldn’t society help pick up the tab?

Sherrie Kossoudji, an associate professor in the UM School of Social Work who studies the economics of assisted reproduction, notes that it’s extremely

For Kardia, this raises the larger issue of whether we should allow free-market economics to define our children’s futures.

As scientists’ ability to freeze eggs and sperm improves, some of these questions may be rendered moot. Kossoudji can envision a day when, at puberty, young men and women will “donate” sperm and eggs to their future selves by allowing their reproductive cells to be harvested and frozen until such time as they are ready to have children through IVF—whether it’s at 25 or 55 years of age.

I don’t have any question but that we’re very, very close to human cloning.” He worries that physicians can’t keep up. “And if they can’t get their arms around technological changes, how on earth can they communicate with their patients?”

One of Kardia’s principle aims with LSS is to improve what she calls the “genetics literacy” of health professionals—not only doctors, but nurses, dentists, pharmacists, and public health workers. She notes that standardized genetic training is not currently an integral part of medical practice, and the consequences can be dire. “Fifty percent of physicians think women can only inherit a genetic predisposition for breast cancer from their mother’s side,” she says. “It’s medieval.”

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She’d also like to bring physicians like Johnson together with religious leaders to discuss topics related to genetics and reproduction, so that when patients need to make big life decisions, they can draw on an informed social support network. Through LSS, Kardia recently launched an interfaith group whose members—Hindu, Buddhist, Unitarian, Christian, and Jewish—get together to talk over ethical issues raised by life sciences research.

“If religious organizations are going to have an impact on policy as well as the use of the life sciences in our day-to-day worlds, then this is something the life sciences can’t ignore,” Kardia insists. “People in life sciences think they impact society—well, society impacts us.”

Nowhere is that more evident than in the debate over embryonic stem cell research. Both adult and embryonic stem

Donor Program. These donors are required to have an undergraduate degree, graduate degree, SAT scores of 1275+, or currently have a GPA of 3.50 or higher. The compensation of Extraordinary Donors is expected to be over \$5000.00, with many of these donors setting their own fees. We currently have Extraordinary Donors available for

the only web site that provides you with the unique opportunity to bid on eggs from beautiful, healthy and intelligent women.

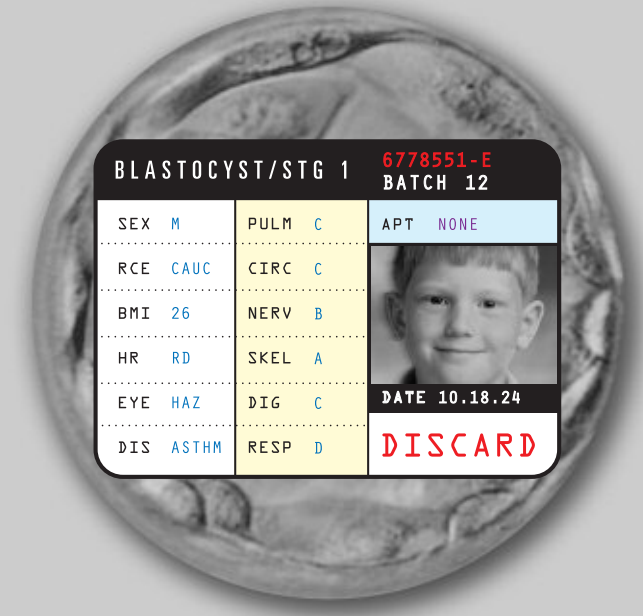
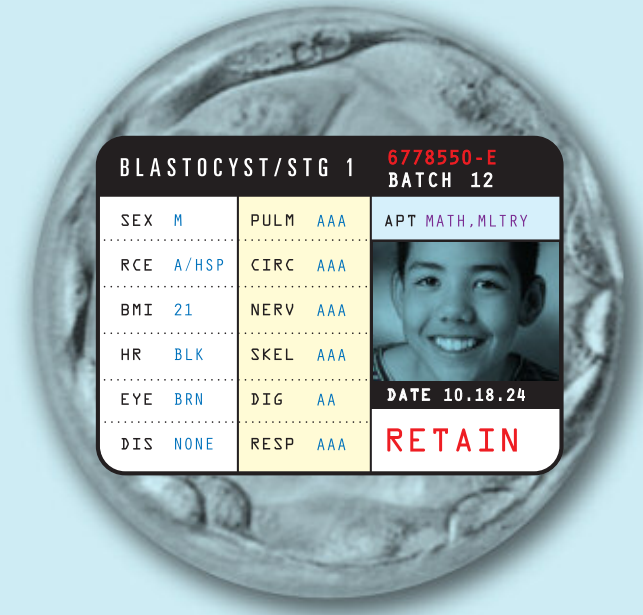
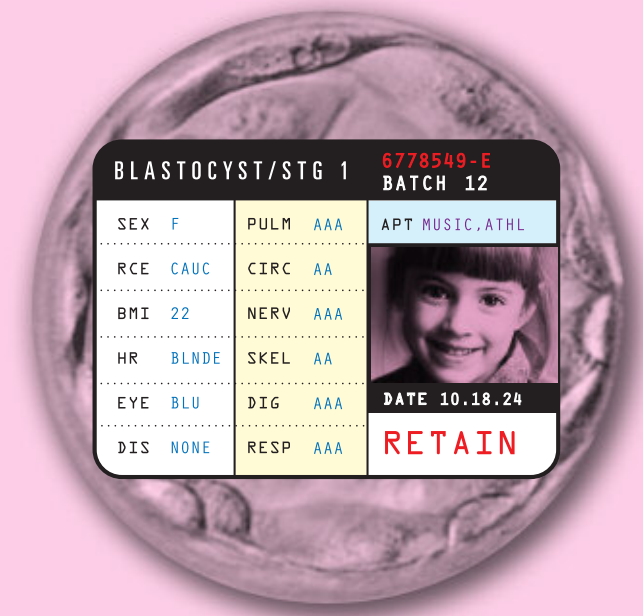
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difficult to put a price “on something that has so much more embedded in it besides its commodity.” She questions whether markets for sperm and eggs should be regulated, “and if so, how?”

Currently, the sale of sperm and eggs is governed by state, not federal, law. But interstate transactions take place routinely, and there seems to be little or no consistency in the pricing of these “people pieces,” as Kossoudji calls them. While agencies typically set the fee for donor sperm (usually under \$300 a vial), egg donors seem to determine their own asking price—which can be anywhere from \$7,000 to \$20,000.

IVF itself is an ethical minefield. As Johnson points out, because the process requires producing more blastocysts than a couple ultimately needs in order to create a child, and because blastocysts contain embryonic stem cells, once a couple decides not to implant a blastocyst, a moral dilemma exists. Can those embryonic stem cells be used for research or should they be discarded?

More troubling still, are they human? “As usual in medicine, technology is way far ahead of ethics and moral decision-making and policy,” Johnson says. “Technology used to change every five to ten years—now it’s every six months.



A Glossary of Terms from the Life Sciences Revolution

Reprogenetics

new techniques at the intersection of reproductive medicine and genetics.

Social and ethical issues:

prenatal genetic screening; genetic engineering; the ethics and economics of the egg and sperm trade; in vitro fertilization.

Stem Cell Medicine

the use of adult and embryonic stem cells to develop medical therapies for debilitating diseases; stem cells are unspecialized cells that can self-renew indefinitely and also differentiate into more mature cells with specialized functions.

Social and ethical issues:

use of embryonic stem cells; cloning.

Nanotechnology

the ability to build and shape matter one atom at a time.

Social and ethical issues:

how to define life at the human-nanomachine interface; the prolongation of life; the distribution of new diagnostics and therapeutics.

Personalized Health Information

the use of information technology to assess an individual's health, identify risks, and deliver personalized information and recommendations.

Social and ethical issues:

privacy, including health insurers' access to information; moral and life decisions linked to predictions of personal risk; microchip implants to monitor individual health status; genetic screens.

cells have the ability to generate new cells, and therefore hold out immense promise for the treatment of diabetes, some types of cancer, Parkinson's and other neurological diseases, and certain types of birth defects.

One idea, says Sean Morrison, an associate professor of internal medicine at the UM Medical School and a Howard Hughes Medical Institute investigator, is to get stem cells to produce healthy, functioning cells that can replace diseased or dysfunctional ones.

But embryonic stem cells, which can make any type of cell in the body in unlimited quantities, are a political volleyball. "A minority here and abroad feel

If an embryo tests positive for a genetic disorder, and a couple chooses to bring that embryo to term, can a health care provider refuse to insure that child?

the human embryo is so sacred that they shouldn't be used at all," says Morrison, who studies the mechanisms by which adult stem cells function. Yet human embryos are produced in large quantities in IVF clinics around the country, and surplus embryos are routinely discarded.

So the debate isn't about whether embryos should be created for their stem cells—no one is suggesting that, says Morrison—but whether pre-existing embryos should be used for medical research.

"If you're being ethically consistent," he argues, "you'd have to shut down IVF clinics." He's said the same in a briefing to members of Congress. But he acknowledges that people are intrinsically uncomfortable with new technologies like this. "They don't realize we're talking about growing microscopic cells in dishes—not making Frankensteins."

Stem cell research is beginning to revolutionize our ability to study the human organism. Shu Takayama, an assistant professor of biomedical engineering in the UM College of Engineering, makes tiny rubber chips in which adult stem cells can be grown, differentiated, and tested. Nicknamed "animals on a chip" or "mini-humans," these lightweight devices are replacing the petri dish for applications where a controlled microenvironment is needed.

Scientists are now using such chips to test the viability of sperm cells and the potential efficacy of chemotherapies, and to construct microengineered artificial tissues. Even "weirder," Takayama says, it's probable that some day at birth, our umbilical cords, rich in stem cells, will be made into chips that can be stored throughout our lives and used to test for a range of things, from disease susceptibilities to drug reactions.

This kind of personalized health information is familiar territory to Vic Strecher. A professor of health behavior and health education and the chair and founder of HealthMedia, Inc., he is pioneering the use of the Internet and other computer technologies to communicate health risks to millions of people—one at a time.

With a \$10 million grant from the National Cancer Institute, he has formed the UM Center for Health Communications Research, which looks at how new information technology and digitally customized print materials can be used to tailor behavior-change advice to the specific needs and interests of individuals.

As part of the project, Strecher is working with television chef and author Graham Kerr to develop a computer-based cookbook program that will collect information from individual users, process it, and deliver customized recipes based on a user's needs and likings.

Such tailoring "ferrets out the reasons why people don't eat healthy foods," says Strecher, and as a result is much more successful at changing behaviors. "It may turn out that someone doesn't like veg-

etables because she can't find them, or doesn't know how to cook them, or dislikes the texture."

Custom interventions can also reduce unhealthy behaviors like smoking. The key point, says Strecher, is that we're moving from population to molecular epidemiology. He can see a day when we're each outfitted with chips that monitor our stress, glucose, and blood pressure levels, as well as our vital signs, so that when we visit the doctor, that information is instantly accessible. The chips could also beam data to a computer that would create goal-setting behavioral programs to optimize our physical activity—a sort of "super coach."

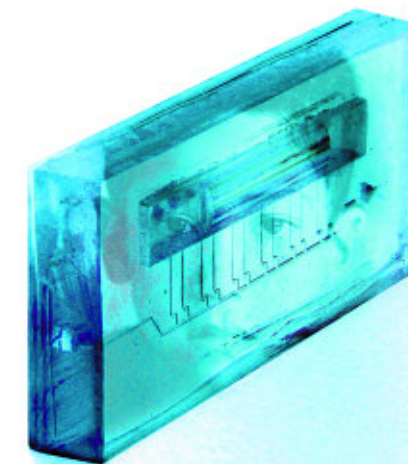
Obviously, such scenarios introduce huge concerns about privacy and other issues. "I think the harm could be tremendous if we're not very careful about this," Strecher says, "but at the same time I think we can get reactionary about this and throw the baby out with the bathwater. The best way to predict the future is to create it," he adds. "That's what I try to do."

Like it or not, the future is here. Not long ago, Kardia read about a group of researchers who'd created a nanobiological machine by linking individual heart cells on a highly flexible, gold-bridge platform. When they applied glucose to it, the bridge of cells could contract and expand—in essence, "walk." Some day, this technology may be used for internal surgery or drug delivery.

"This is going to happen," Kardia says. "And it's going to happen in ways that we don't even imagine right now, because the world of biology has got so many possibilities."

The only remaining question, say Kardia and Citrin, is how we're going to react to those possibilities, mold them, and direct them toward our future good.

"The important thing to focus on is our humanity," says Kardia. And our humanity is what the Life Sciences and Society program is about. ■



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