

The Placenta's Second Life

by

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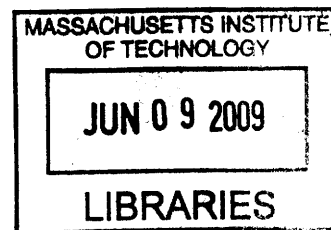
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ABSTRACT

This thesis, written for a popular audience, explores the many facets of the placenta, an organ that facilitates the growth of the fetus during pregnancy. It looks at what happens when the placenta dodges the hospital incinerator—taking on a second purpose, a second life. Once the placenta is expelled during the third stage of labor, once it has served its role in the body and is facing retirement, it can take on whole new forms of usefulness. Humans, artful at manipulating the materials of life, have created new—and often controversial—purposes for this discard tissue after it has served its primary role: expelled placenta is used in eye surgery, in training dogs to sniff dead bodies, in toxicology research, in forensics, in cosmetics, and, most significantly, in an emerging field of stem cell research. From ritual use to research subject to health treatment, we have taken the placenta from the realm of the dead and given it new vigor.

Thesis Advisor: Alan Lightman

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Thanks to Alan Lightman for wading through page after page of placenta and offering honest and constructive critiques.

The shapes clash: the round, meaty placenta and the square bucket. The placenta looks like a ball of rising pizza dough, with a thick spiraled cord coming out of its center, and thin sack-like membranes around the edges. The organ looks exhausted. It is leaking blood from its severed cord, sinking in the bucket as the fluids settle, and rapidly cooling from body temperature. Viewed as an animal, then, yes, it's slowly dying.

I take the blue square bucket to the utility room at Mount Auburn Hospital in Cambridge. It is a narrow closet-like space with an industrial sink, medical supplies, clean towels, and three or four bins for laundry and waste. There is a container marked "Placentas Only" that has the signature red biohazard trash bag—but I'm not interested in disposing of this placenta. I put on some gloves and tentatively approach the organ. A whiff of musky organ blood hits me, and I try to practice the skip-the-receptors "nurse breathing" once taught to me.

The placenta is still warm. I gently lift it from the bucket, and can feel its significant weight. I would guess it's a little over a pound. This is a substantial hunk of flesh, with a diversity of textures. The latex gloves speckle with bright red blood as I shift the placenta from one hand to the other. I notice the stark difference between the two sides of the placenta, reminding me of a coin. Heads up: mama. Tails: baby.

The placenta implants, at random, to the wall of a woman's uterus. The maternal side, which attaches to the uterine wall, is deep maroon and very fleshy. It separates into pieces like a squishy jigsaw puzzle, with all the pieces firmly attached at the base. This flesh makes up much of the placenta's volume.

The fetal side is a tight, almost gray membrane with a spiraling umbilical cord and bulging blood vessels. They remind me of the pop-out veins in my uncle's feet. As I run my fingers along the fetal side, I can feel the individual vessels. I close my eyes for a moment, and the experience is similar to reading Braille. Ok, placenta, I murmur, tell me your story.

When a sperm meets an egg, the fetus is not the only product of conception. The body simultaneously creates a partner for the embryo, an organ to facilitate the growth of this foreign object within the mother's body. A placenta.

The placenta connects the mother and the developing baby, providing food and oxygen and hauling away waste. It has unique circuitry, acting as a mediator between two separate circulatory systems—the maternal and the fetal. The physiology of the placenta allows nutrients and waste to be exchanged without ever directly mixing blood.

The placenta is a pregnancy-specific tissue, and it is the only organ to develop in adulthood—unlike eggs, a female does not harbor placentas in her uterus for her entire life. It comes and goes with the cycle of birth, thus giving the placental organ another unique quality: a definite end-stage.

I'm interested in what happens when the placenta dodges the hospital incinerator—taking on a second purpose, a second life. Once the placenta is expelled during the third stage of labor, once it has served its role in the body and is facing retirement, it can take on whole new forms of usefulness. Humans, artful at manipulating the materials of life, have created new—and often controversial—purposes for this discard tissue after it has served its primary role: expelled placenta is used in eye surgery, in training dogs to sniff dead bodies, in toxicology research, in forensics, in cosmetics, and, most significantly, in an emerging field of stem cell research. From ritual use to research subject to health treatment, we have taken the placenta from the realm of the dead and given it new vigor.

It's a Monday in early December, and Dr. Jean Fechheimer calls from Mount Auburn Hospital at noon, to tell me a patient has come in to be induced for labor. With the promise of a patient (and accompanying placenta), I hurry to the hospital and arrive a little breathless—but when I get there, the pace changes.

Robin, the expectant mother, is calm. She's 41 yrs old; it's her second child. She already has a 3 yr old son, and she's expecting another boy.

The 5th floor, Labor and Delivery, is rather warm—Jean says something’s broken with the heating system and that they’re all sweltering. It feels like the temperature of the heat lamps they put on the babies—but you kind of get used to it.

Robin’s room has a wide, landscape window that lets in lots of light; Fresh Pond sparkles in the brisk sunlight, and you can see why Jean calls it the Ritz delivery room. Robin’s husband is on his way over, but in the meantime, I find her a box of Kleenex, which is about the limit of my usefulness. Robin, long brown hair tied loosely in a ponytail, knows what to expect. Her nurse starts a pitocin drip and takes her blood pressure, mentioning that this placenta will probably be a good one to look at because it used to be twins and may have calcification of the dead twin. “I lost one,” Robin says simply—it happened early, in the first seven weeks.

After about an hour on the pitocin drip, Robin’s water breaks. Jean—with wavy gray hair, a warm smile, and calm authority—comes to check on her. Birth is still a long way away: to work in obstetrics is to work in waves and bursts.

During a lull, Jean and I start talking about placental burial, which she says was hot in the 80s, but has since tapered off. Not as many people request to take their placentas home nowadays, Jean says.

The conversation shifts to animal placentas. “I always wanted to see a non-human primate placenta,” says Jean. Beth, another doctor, also gets interested in topic. Soon a crowd of people in scrubs are all talking about animal placentas, and everyone has a story. One of Beth’s patients sent her pictures of a seal’s placenta that they saw at a zoo. Beth also was given a “placenta print” from a patient, which is a piece of art made by patting the fresh placenta on heavy paper, with blood for ink. “Limited edition,” jokes Beth, as she heads to the operating room.

5pm: “It’s a boy and he’s out,” a nurse announces, referring to the c-section Beth just performed. I can hear the faint sound of a baby crying from the OR, and then a couple minutes later I catch a glimpse of a baby, swaddled in blankets and headed to the nursery.

With a surgical mask hanging loosely off her face, Beth hands me the second product of the birth: the placenta, in a blue bucket with a blue towel draped over it. I take it to the utility room.

As I look at the aftermath of this organ, I try to recreate its pre-birth appearance. Where exactly did the baby sit?

To get a sense of this, I start to lift up the sheaths of membrane that formed the amniotic sac. The amniotic sac, while given its own name, is part of the placenta package—the amniotic sheaths could only be separated from the placenta with a sharp knife and steady hands. The placenta is slippery, squirmy even, as it flips inside out, outside in, but I do eventually get a grasp on the sheaths. These paper-thin, stretchy layers are firmly attached around the circumference of the placenta, even though they look flimsy at first glance. When a woman's water breaks, it means that these layers have ruptured and the baby no longer floats within the protected sac membrane.

I hold the sheaths up and it forms a shape similar to the hood of a raincoat, or the entrance to a small round cave. Insert baby here, I tell myself, creating a mental picture of baby-in-utero. Attached to the umbilical cord, the baby sits inside this amniotic cave throughout pregnancy, relying on the interface of the placenta to ferry across its nutrients and oxygen, up through the cord.

The sheaths of the amniotic sac are two-fold. The first layer is the amnion, which is like a clear balloon—sheer, stretchy, and surprisingly strong. If you delicately peel the amnion away (like peeling a fruit roll up from its plastic), then you can separate out the second, outer layer—the chorion. The chorion has knobbles on its thin surface and feels rather like plucked chicken skin. It is a watercolor of blood red and fleshy tones. When I hold it up, light can still shine through it.

I let the amniotic membranes collapse and try to visualize the insides of this thick placenta pancake. The exchange of blood that occurs here is a remarkable feat of human evolution—the mother can provide a host of life-sustaining nutrients and gases to the fetus, all without ever directly swapping blood (a necessary feature considering the variations in maternal and fetal blood types, and the severe consequences of mixing unmatched blood). The placenta is filled with the branching roots of the chorionic villi, which house the tiniest of the fetal blood vessels. These villi feed into the bulging blood vessels I could feel on the fetal surface, which then funnel into the umbilical cord.

Maternal blood, carrying nutrients, flows into the inner portion of the placenta, bathing the villi. What makes the process so special, though, is the outer layer of the villi—the syncytiotrophoblast. It's a clunky word, but its function is rather beautiful. Dr. Michael Nelson, OBGYN at Washington University School of Medicine and editor of the journal *Placenta*, first introduced me to the uniqueness of the syncytiotrophoblast. It is an outer cell layer that is one continuous structure, as compared to traditional outer cell layers that are divided cell by cell. "Try thinking of cells as bricks," Nelson said to me—if you just lined up your bricks and it rained, water would get through the cracks. But if you pour concrete to fill in the gaps between the bricks, no water gets through because it is one continuous mass. The syncytiotrophoblast is like bricks with concrete: no gaps between cells, just one continuous cytoplasm that holds multiple nuclei. This means that everything has to be *transported* across the expanse of the 'blast; there are no cracks for blood droplets to leak in.

Jean checks in on Robin—she's totally relaxed (epidural in full force) and totally dilated. Her room is dimly lit; the brightest object is the muted television, flashing image after image, as John Mayor plays on the Ritz's stereo. Robin had no clue she was fully dilated, but she's happy to hear it. It's 8:45pm, about 8 hours since she checked into the hospital, and her baby is ready to come out.

Jean asks her to take one experimental push, and—a surprise to everyone—Robin's baby boy is already crowning. I can see the top of his head now exposed to the air. Jean and the nurse rush to get things in place for delivery, and the baby slides out with one more push.

"He practically fell out," laughs Jean.

He's 9 lbs, with black hair and big feet ("They run in our family," says Robin, still completely cool). The nurse puts the boy on the baby table, underneath a heat lamp, and he gives a good cry, then squints and looks quietly around. His dad is nearby, following his eyes, murmuring to him. We towel off the bloody floor, and after a couple minutes, Jean gently pulls on the umbilical cord to see if the placenta is ready to come out. Not yet. So she starts a slow stomach massage, and soon enough, the placenta is ready to follow the baby out. Robin gives a

final push, and Jean slowly, gently, expertly, rotates the placenta out of the vagina. She catches the slippery creature in a blue bucket. The pregnancy organ is at the end of its cycle.

But it is not necessarily at the end of its journey.

The placenta can have a spiritual second life. For many cultures around the world, the handling of the organ after birth is important to the future health and prosperity of the child, mother, and sometimes the community at large—thus the placenta has a functional role even after it's expelled from the body.

The placenta “is the embodiment of a fundamental human fear—marginality,” writes J.R. Davidson, a former faculty member in the anthropology department at UCLA. And no wonder. As the baby heads for the basinet, its anonymous twin is cast aside, its job now concluded. But in many cases, the placenta, once expelled, has only begun its story. Davidson, among others, has chronicled the rituals greeting the afterbirth. These practices, she writes, “operate as anxiety releasing mechanisms [that restore] the social and biological equilibrium disrupted by the birth process.” In a 1985 article, she argues that birth is an anxiety-inducing event in all cultures, and that correct placenta disposal offers release to many people. The rituals of disposal—such as wrapping the placenta in special dressings, burying it in specific locations, sending it out to sea in a coconut—are all means of facing the unknown. The placenta is a shadowy, formless presence with powers to heal as well as threaten, she writes. The unborn child—still on the cusp of “infant” status—is also a marginal being, writes Davidson, and thus the danger and anxiety of this transitional state is relieved by proper placenta disposal.

In Thailand, for example, the placenta can be placed in a bamboo pipe and buried or hung near a tree, to ensure the protection of the infant's soul and health. The placenta is thought of as alive in parts of Peru, and thus if it is not properly buried, it is thought to cause harm to the community as a whole. In Nigeria, the placenta can be buried in a river to guard against fevers in the child. Placentas are often wrapped in straw and burnt in fireplaces in

Korea, and this practice can have implications for a woman's childbearing future. Placenta rituals in Mexico also relate to a woman's future fertility—if the placenta is improperly buried and thus eaten by a dog, for example, then it is understood to have a negative effect on future childbearing.

Elaine Jones, professor at the University of Arizona College of Nursing and author of an article on the cultural anthropology of the placenta, says that these rituals are a form of protection for the infant. Many areas of the world have high infant mortality rates, she says, and placental disposal practices can provide emotional reassurance during this precarious time. The placenta also can play a role in keeping the soul in the baby's body, Jones says. Ground-up umbilical cord, for example, is put in an amulet and placed around the baby's neck to help protect the newborn soul.

Anthropologists have long been fascinated with the placenta, and the cultural rituals surrounding the organ are well documented. Not only is its disposal important, but it is often given symbolic meaning, such as a being a companion, a guide, or a twin for the baby, as well as representing the infant's connection to the land and community. These symbolic associations go way back: the Egyptians, for example, bundled up the Pharaoh's placenta and used it as a stand-in for the Pharaoh at public events. Hieroglyphs show ceremonial processions with the Pharaoh's placental bundle carried high atop a pole.

But placenta rituals are not just a relic of history, nor are they limited to certain cultures. America in 2009, a cross-cultural nation, has a rich variety of placental spiritual practices. Ariel Cook, who worked as a doula (a mother's aid during birth), told me about one important ritual: burial of the placenta. Midwives, at least in the California bay area where Cook worked, "have a reverence for the placenta," and some see it as a means to preserve ties to one's home and family—a "symbol of blood connection," she says. Cook knows many California midwives who will plant rosebushes over the placentas they deliver, so the children can come back to visit the roses they nurtured. One family told me that they flew their frozen placenta home from Switzerland, where they were traveling when they had their baby, so they could bury it in their backyard.

Placenta burial can be a family event—sometimes worthy even of a home video. “Hello. My name is Colette Lara Cambey. This is a movie about my placenta,” announces the confident young narrator of one such film. The video starts with Colette as a one-year-old, sitting on her North Carolina porch swing with her father and grandmother. She’s dressed in a light pink hoodie, sucking on her thumb. The next shot shows her placenta in a plastic Tupperware container, set on a leaf-scattered ground in her backyard. “It looks very disgusting,” the now older Colette narrates, “It’s pink and looks like my brain.” The family dog sniffs at the bucket, while her dad plants an unwieldy shrub next to the placenta hole. One-year-old Colette plops down next to the freshly dug hole, alongside the placenta bucket. It’s a “big fat bowl of jelly,” says narrator Colette, as her dad slides the placenta (blood, membranes, umbilical cord, and all) into the dirt hole. Colette ends the film by explaining, “And now my dad is planting my placenta next to my big plant, and I’m sitting like a little girl, right next to it.” The pride exudes from her voice—she’s happy to have this family ritual, happy to be the center of attention, happy to know she’s got a home with her lifeblood tucked into its soil.

Dr. Sarah Buckley, physician and author of *Gentle Birth, Gentle Mothering: A Doctor’s Guide to Natural Childbirth and Gentle Early Parenting Choices*, describes another placenta ritual started in the 70s: Lotus birth. Lotus birth is a practice where the umbilical cord and placenta are left attached to the baby after birth. Families let the cord dry up and separate completely on its own, usually within ten days after birth. Buckley calls this attachment period a “time of transition,” allowing the baby to gently separate from the mother’s body. It is a way, she writes, to avoid that “strange and uncomfortable feeling of cutting through the gristly, fleshy cord” that she says is akin to “cutting through a boneless toe.” It is also a way to “reclaim the so-called third stage of birth for ourselves and our babies, and to honour the placenta...”

The birth story is one of momentum—and it has a generally agreed upon climax. *Mothering Magazine*, a publication focused on natural family living, has an online forum where mothers share their birth stories, in the same style as blog entries. Some of these stories are of lotus births; many are not, but they still give the placenta a role in the birth story. Some stories go into pages of detail, while others keep it crisp, sometimes poetic. It’s interesting to see

which ones include the placenta as a “character” in the birth story. Does it get full attention? Or is it an afterthought? Does the birth story, as recounted by the mother, form an arch with the baby’s birth as the final scene? Does the placenta create a second climax, or is it a small detail as the story concludes?

Some mothers mention the practice of eating their placenta. Although this is not a mainstream thing (even within the *Mothering Magazine* circle), it is a spiritual ritual nonetheless. *USA Today* spotlighted the practice in 2007 in an article seemingly written to stir controversy and dial up the public “gross” reaction (“Ingesting the placenta: is it healthy for new moms?”). Various magazines and books have printed recipes for Placenta Cocktail (with V8), Placenta Pizza, Placenta Lasagna...celebrity chefs have even fried it up on television, with garlic.

Eating the placenta wholesale, lasagna-style, might take a strong will and hearty stomach. But a more common form of consumption of the placenta is through encapsulation. In her online birth story, one mother writes, “I delivered the placenta painlessly about ten minutes after he was born, and my doula prepared it for encapsulation in the kitchen...” The placenta can be cooked down to “basically a jerky,” and then ground and made into capsules, says former doula Ariel Cook.

Chantia Smith, a midwife from San Francisco, specializes in this sort of placental preparation. Smith has a background in Chinese medicine, and says that birth is a “yin” condition that needs warmth to restore it. “In the bay area, I got to be known as the placenta lady,” she jokes. She sends the following information to people requesting placental encapsulation:

Processing placentas is a lengthy multi-stage process. I process them in the tradition of Chinese Medicine. In this vein it is vital that the medicine has a warming quality for mom and babe. Before I dry the placenta I steam it lightly with ginger, jalapeño pepper, and lemon. Then I slice it thinly and dry it

in my dehydrator for several hours. I also dry the umbilical cord as it can be stored in the freezer and used as a teething ring for your little one (they love them!). When it is ready I grind and powder the placenta and then put it into capsules. Depending on the size of your placenta, you usually receive between 100-200 capsules...

The steaming, says Smith, brings out the herbs and helps the placenta become digestible. The herbs themselves help preserve the placenta (along with the dehydration) and add warmth. As for the actual nutrient content of the placenta, she says that the evidence is “anecdotal,” but that it’s thought to help in postpartum recovery as well as (later in life) relief of menopausal symptoms. Usually people who have their placenta encapsulated are motivated for health reasons, says Smith, rather than for spiritual use. For spiritual closure, she says, people tend to bury the placenta. Some women, realizing the many options they have for their afterbirth, choose to split the placenta in half: part for capsules, part for burial, Smith explains.

Bing Yang, Chair of the Chinese Herbal Medicine Department at the New England School of Acupuncture, says that human placenta is called “Zi He Che” in Chinese medicine, meaning “purple river vehicle.” Placenta’s medicinal purpose is to nourish the blood and “augment the essence.” Yang describes a similar drying and grinding process as Smith, but adds, “Now it is not widely used. I have been practicing Chinese medicine for 20 years, but never used it once.” Online, you can get 50 sachets of Zi He Che for \$82, via a Chinese medicine export company, so the product is definitely not dead.

Placental proteins need not be crushed and dried: they can also be found in liquid suspension. A slew of cosmetics contain placental derivatives—and because cosmetic companies are under no obligation to provide product labels with a full list of chemical content, you may not even know whether you’re rubbing placenta on your face every morning.

At Mount Auburn Hospital, Jean told me that that the hospital used to sell placentas to pharmaceutical companies for use in cosmetics. One of the nurses concurred, saying, “Yeah, they use them in deep cream conditioners.” Here’s how it worked: staff would stick the expelled placentas in industrial-size freezers (provided by the cosmetics companies) and then couriers would come pick them up. One nurse recalls that the couriers would bring them donuts. In 2000, Mount Auburn stopped trading donuts for placentas and ended the arrangement.

How are placentas used in cosmetics? My mother landed me a piece of evidence: placenta chapstick. She’d been traveling in the Czech Republic, and found it on the counter of a drug store. The solid white product is housed in a sturdy pale green tube and sells for about two U.S. dollars. It is simply called “PLACENTA.” Uncapped, it smells of heavy perfume mixed with petroleum, and maybe a hint of musk. The list starts with Paraffin, Vaseline, Album...and then the kicker comes about a third of the way down: “Placental Lipids (and) Zea mays.” Placental lipids are easy to figure out: they’ve squeezed fat from some mammal’s placenta (human or otherwise) into this chapstick. Why they combine it with “Zea mays,” a.k.a. corn, is a mystery of the cosmetics industry.

Placenta is touted to have “beneficial hormonal effects” for wrinkle control and tissue growth, according to a newsletter published by the U.S. Food and Drug Administration (FDA) in 1992. As far as disease transmission, the FDA article reports that the tissue is processed to destroy bacteria and viruses. It is up to the cosmetics industry to police themselves about the safety of product ingredients, though. The industry is completely self-regulated; the FDA has no power over it.¹

The cosmetics trade association—now called the Personal Care Products Council—funds and oversees the Cosmetic Ingredient Review (CIR), a group that assesses about 10% of all cosmetic ingredients. This means that 90% of ingredients get no review (and that the handful of assessed ingredients are reviewed by researchers with an industry slant). That said, the CIR did publish a 2002 study in the *International Journal of Toxicology* that evaluated the use of both human and animal placenta in cosmetics. The CIR study—written by former CIR staff

¹ For more information, Stacy Malkin’s recent book *Not Just a Pretty Face* offers a comprehensive look at the current state of the cosmetics industry.

members Bindu Nair and Amy R. Elmore—highlighted the use of placenta in cosmetics sold in the United States, citing 30 products that used human placental protein, as well as 12 products that contained human placental extract. Another 30+ products contained animal placenta. These placenta products were primarily shampoos and moisturizing formulas. The study determined that placental protein was not a bioactive substance, meaning that the protein would not have any of the touted (or feared) hormonal and metabolic effects. This CIR finding is at odds with a 1997 survey in *Military Medicine* that suggested the use of placenta hair cream among children could speed up sexual maturation because of the hormonal content.

The CIR report carefully dances around the use of placental *extract* in cosmetics; the report focuses only on the bioactivity of placental *protein*. A group of pharmaceutical scientists working at Josai University in Japan and the Hollywood Cosmetic Company did address the use of placental extract in cosmetics, though: researchers tested twelve placental extracts (from humans and cows) and found a wide variety of bioactivity. Some of the extracts, when applied to cells, caused significant cell growth and anti-inflammatory action. Some didn't. Some extracts, especially in high concentrations, actually killed cells. The paper (released in the *Japanese Journal of Toxicology and Environmental Health*) concluded—unhelpfully—that some extracts are potent while others are duds.

Amanda Schaffer, a medical columnist for *Slate*, visited a clinic in Tokyo that offers IV drips of placental extract, for both cosmetic and general health purposes. Placental extract has been available in Japan since the 50s, writes Schaffer, and the country's national health insurance even covers placental treatments for liver diseases and menopausal symptoms. But "the academic literature remains thin," she writes, while the extract's health claims—such as treatment for liver disease, menopause symptoms, fatigue, insomnia, aging, wounds, as well as tonic and whitener for skin—are as thick as ever. Placenta has a soup of "hormones, growth factors, immune molecules, lipids, and nucleic acids," writes Schaffer, after conferring with Dr. Michael Nelson, editor of the journal *Placenta* and OBGYN physician at Washington University School of Medicine. All of these soup ingredients, when isolated, "could turn out to have particular clinical applications," Schaffer says, but you never really know what exactly is in the extract. It's possible that creams containing placenta may aid in wound-healing because the

compounds in the extract nurture the growth of skin cells and collagen, Nelson suggests to Schaffer. But Schaffer remains incredulous of the health treatment, concluding her article by saying that “placental drips do not seem ready for prime time, even among the clinically adventurous.”

The issue of placental bioactivity is central to the discussion of its safety in cosmetics. The difference between a placental protein and an extract is fuzzy at best. The CIR report ultimately endorsed a cautious approach (even after stating that the placental protein was not bioactive), saying that there was insufficient evidence to assess the overall safety of the placenta as a cosmetic ingredient. What effect this CIR report had on the cosmetic industry is unclear, given that the CIR is not a regulatory agency and has no authority over the industry.

In response to this regulatory gap, the Environmental Working Group (EWG)—a nonprofit environmental research organization—maintains a database of ingredients in cosmetic products and EWG ranks the products based on the safety of the ingredients. EWG list about 15 products with “placenta” listed on the label; this short list includes Hask Placenta Hair Repair, Earth Science Placentagen Eye and Throat Cream, Golden Sunshine Collagen Peptide Extract, and so on. These placenta products share the same EWG category as products containing lead and mercury—that is, they all fall under the consumer webpage of “What Not To Buy.”

An article published by Jessica Mousseau through an “open content network,” called Associated Content, paints a very different portrait of placenta’s use in cosmetics. “Placenta cosmetics have been proven to produce wonders for the skin,” writes the author, whose credentials (if any) are undisclosed. Mousseau cites placenta as a “proven trend” yet does not back-up this claim with any scientific literature. “Ultimately, [their] cell renewal function helps to slow down the aging process we dread,” she continues. The article talks glowingly about the potential uses of placenta, in everything from cellulite treatment to aftershave. It also mentions that placenta cosmetics are “as natural as you can get,” which fits into the drive toward holistic health products. Elaine Jones, professor at the University of Arizona College of Nursing, says that placental products were originally marketed to those seeking natural, back-to-earth sort of products.

Amber Erkiletian, cosmetics purchaser for Harvest Coop in Cambridge, Massachusetts, says she hadn't heard of the use of placenta in cosmetics (and gives spiritual reasons for not using placentas in products), but she does mention a curious industry "loophole" wherein cosmetics companies can sneak virtually any ingredient into their product, unannounced, and label the chemical simply as "fragrance." The fragrance category encompasses "anything that could go into a perfume" or basically anything that works as a "fluid base," including proteins, lipids, esters/alcohols, etc, says Erkiletian. This obscurity is allowed because fragrance is considered an industry trade secret, says Erkiletian. She has no way of knowing whether placental ingredients fall into this "fragrance" category in certain cosmetics, but she says it is possible.

The absence of any mention of placental content on product labels suggests that the "back-to-nature" marketing angle for placenta in cosmetics—tried out in the 70s—has fizzled. Few readily-available U.S. products promote the use of placenta; there are consumer concerns about infectious diseases or other unpleasant associations. But cosmetics companies may still be using placental ingredients if they are part of the companies' trade secret, their homespun recipe.

Where do the placentas for these cosmetics come from? Numerous sources confirm what I heard at Mount Auburn Hospital: placentas get trucked from delivery wards to biotech companies. The U.K. magazine *DailyMail* did a recent feature on the practice ("How the NHS 'sold' by placenta to a luxury cosmetics firm instead of using it for medical research," May 17 2008), generating outrage about the improper use of a woman's biological tissues. The article quotes a new mother saying, "It's my DNA and I feel like they tricked it from me." The woman thought her placenta was being donated to "vital medical research," when it turns out that the Poole Hospital in Dorset had an arrangement with Sigma-Aldrich, a biochemical company, where the hospital would get a donation from the company in exchange for weekly placenta specimens. The article links the placentas from the Poole Hospital to American research toward a "new 'anti-aging' skin cream."

Biological tissue ownership is still a blurry issue, and placentas certainly fall into this societal debate. Consent paperwork for hospitals and researchers is getting lengthier and more

complicated, with new wrinkles forming on a regular basis. Lawsuits are commonplace. *The Oregonian* (“Placentas taken, but moms were not told,” February 12 2006) ran an article that featured a mother, a baby, a placenta, and a lawsuit. The mother contended that her baby, born unable to walk or talk, suffered severe birth defects because of the doctor’s delay of her delivery. When she sued the hospital, the hospital built a defense based on tissue evidence from her placenta. The woman was outraged that her placenta—her biological property—was passed among pathologists without her permission, and then used as evidence against her in court. The hospital, in addition to sending the woman’s placenta to the in-house hospital pathologist for examination, also sent it for a second evaluation to a separate institute, financed and maintained by an insurance company. The pathologist on staff at the insurance-company institute determined that the baby’s birth defects arose from a “true knot” in the umbilical cord, choking the fetus of oxygen. This report differed from the hospital pathologist’s initial report, which found no abnormalities. Both pathologists testified in court, using placental evidence.

This practice of using placentas as evidence in the courtroom is not a new phenomenon. Dr. Maureen Sander, a recently-retired placental pathologist at Michigan State University and co-founder of the Michigan Placental Tissue Registry, was asked to testify numerous times throughout her career. Sander created the tissue registry in 1970, as a means to study the connection between placenta abnormalities and poor pregnancy outcomes. The registry saw a lot of success and interest in its initial years: they gradually adapted a fee-for-service model, charging around \$200/placenta, and were able to be completely self-supporting. In 2005, though, the registry was shut down. “I encountered a lot of resistance,” Sander tells me, “There are lots of politics in this area—that’s why I withdrew.” The registry “didn’t have the support of the medical school,” she continues, so when the school hit financial trouble and needed to cut programs, the tissue registry was one of the first departments on the chopping block. Her 30,000 odd formaldehyde-preserved placentas now sit in a closet somewhere.

When Sander announced her intent to retire, she got many thank-you letters from grateful attorneys and hospitals. The placenta evidence was highly valued in the court room,

she says; malpractice suits craved evidence. The “pendulum swung from neglect [of placenta evidence] to over-expectation for answers,” she says.

IfMamaAintHappy, a senior member of the *Mothering Magazine* online forum, was curious about the size of her pregnant dog’s placenta—do they have several small ones, or one big organ? What she found instead (during her Google search) was a link to the Missing You Foundation, a nonprofit organization formed in 2001 that assists in finding missing and deceased persons. The Missing You website—the format a bit haphazard—gives updates on active cases, coordinates rescue efforts, and provides a forum for families and volunteers. As a nonprofit, they’re used to soliciting donations, but it’s not always cash that they’re looking for. They need placental tissue to train their Human Remains Detection Dogs (HRD Dogs): “This is where you, the pregnant donor, come in,” says a posting on the website, “By donating your placenta after birth, you supply one dog with approximately six months worth of training material.” The posting says that human cadavers are tough to obtain, but placenta is a perfect substitute. These dogs—“able to detect the tiniest traces of human material as the body goes through the chemical changes that occur after death”—need placentas to train on, so they can help locate missing people. “These dogs are crucial to the success of Missing You Foundation’s mission,” says the website, requesting that donors seal their placentas in a bio-hazard bag and put it on ice. Donors can receive updates on the HRD Dog that they’ve helped train.

The organ is “another tool, another training aid,” says Theresa Christ, HRD Dog Trainer for Canine Search Solutions, a company that provides HRD Dogs to law enforcement for investigating missing persons and homicide cases. Christ confirms that the placenta is useful to HRD instruction, although it’s not the only medium for training the dogs’ noses.

IfMamaAintHappy posted her findings on the *Mothering* forum—under the thread title “placentas and dog training”—which created a stir from other mother bloggers. “Yep, it’s true, my boy was trained to his cadaver certification on human placenta,” responds one blogger (it takes a second to figure out that this is a dog-trainer writing, and she’s talking about her dog,

not a human baby). “We freeze dried it and then used it as a sprinkle,” she explains. “We can reliably use pseudo scents for everything else,” she continues, “but for cadaver...real decayed human tissue is always the best.” Another blogger speculates whether placenta sprinkles, if scattered in your garden, would keep raccoons and rabbits away. When an astute mother asks, “What would be the value of a placenta?” the dog-trainer is able to give her a literal answer: about \$6/lb. Whether it comes through the same channels as placenta for cosmetics, she doesn’t say. In fact, she says her monetary figures are probably a little off, given that it’s been eight years since she “was involved in the purchase of placenta.” I can’t help but imagine placenta sprinkles in the bulk bins at a food co-op. “Ok, this has to be one of the weirdest thread titles I have ever seen,” remarks one blogger; I find myself agreeing.

With little hope, a laundry worker presented his mangled hand to Maximilian Stern, in 1913. He’d caught his left hand in a machine, “denuding the palmar aspect of the ring and middle fingers throughout the length of the two terminal phalanges”—that is, the machine ripped the flesh off his two tallest fingers. Stern decided to experiment with a curious substance—placental membrane. Stern grafted membrane from the amniotic sac onto the laundry worker’s “raw surfaces” and after only two days, the fingers “were found diffusely and entirely covered with healthy skin.” Even with the stiff tone, you can tell that Stern is excited about the results: “In spite of the fact that there is but one case in this group I am encouraged to believe that the result could not have been obtained in any other way...”

The placenta, as expelled flesh, has interested not only modern day dog-trainers, but researchers from as early as the 1900s as well. In the early twentieth century, the discarded membrane was tested by researchers at John Hopkins Hospital for use on burned and ulcerated skin—and found to be very effective. Building on this work, assistant surgeon Maximilian Stern wrote a short but enthusiastic article in the influential publication *Journal of the American Medical Association*, detailing the benefits of using amniotic membrane and citing his success with the laundry worker.

Amniotic membrane has seen sporadic popularity within the medical community since the 1900s. A recent review article in a burn care journal documents the progression of Human Amniotic Membrane (HAM—unfortunate acronym) in medicine: it started as a skin substitute, moved to a form of burn treatment, had an interlude where it was used to create artificial vaginas, and finally it's proved helpful to eye surgery. When researchers discovered its usefulness to eye surgery in the 90s, the membrane got a major boost. In a recent article, Sonia June Hill, a nurse and eye bank technician at Misericordia Health Center in Manitoba, Canada, lays out the benefits of the membrane to eye surgery. Hill starts off the article with a bit of flare: "Consistent with the current societal influence to recycle or reuse, ophthalmologic scientists have discovered an innovative use for discarded human placenta: amniotic membrane transplantation." The membrane, taken with informed consent from elective cesarean births and processed with meticulous infection control procedures, is sewn onto the clear surface of the eyeball. It acts as a band-aid for an eye that has cuts or ulcers or defects of some sort. But it's more like a super band-aid: the unique properties of the amniotic membrane protect the eye from inflammation as well as promoting nerve regeneration. One donated placenta could provide 30 or so eyes with this healing membrane, although, as Hill notes, "the lack of North American literature describing placental use indicates that there may be a gap in knowledge about this available resource." Celgene Corporation aims to close that gap by marketing its product "Ambiodry," which is dehydrated human amniotic membrane designed for use in eye surgery. Convincing doctors to reach for Ambiodry is one thing; convincing patients is quite another. Hill's article includes an educational training packet for nurses on how to talk with patients about this treatment, giving nurses tips on coaching patients through the creepiness of having part of a placenta stitched on their eyeball.

In addition to eyes, amniotic membrane has been increasingly used to treat burns over the last decade, as Marco Kesting and colleagues from the surgical department at the Technische Universität München highlight in a 2008 article for the *Journal of Burn Care and Research*. Unlike the shaky scientific evidence for placental use in cosmetics, over 30 recent journal articles and a number of clinical trials attest to the fact that the amniotic membrane

actually does provide antimicrobial effects and pain relief for scorched skin and ulcerated eyeballs.

The placenta wasn't always a figure in mainstream medical research, though. In the late seventies, a handful of carefully chosen researchers convened in London for an intimate conference with a specific goal: How can we prove the importance of the placenta as a research subject to the rest of the scientific world? The answers they came up with soon appeared in print, with the title *Placenta: a neglected experimental animal*. In this book, authors presented many different ways in which the placenta could benefit science, including research studies on aging, cancer, immunology, and more. As is apparent in the title, the authors felt that since the organ was discarded *human* tissue, it has a vital role in medical research.

Thirty years since the book's publication, it seems as though demand for the organ as a research subject has surpassed supply. Nelson, editor of the journal *Placenta*, told me that the organ has garnered more importance in medicine over the last couple decades and is "no longer neglected." Dr. Drucilla Roberts, placental pathologist at Massachusetts General Hospital, confirmed this, saying, "There are a lot of people who would love to get their hands on placentas." In a '94 article from the *Canadian Journal of Infection Control* entitled, "Where do all the placentas go?" the author argues that placentas (if not useful to families as part of a cultural ritual) should be available for researchers. C.E. Barry, the author, refers to this practice as placenta "recycling" and "reprocessing," and thus uses the language of waste management. Worry over transmission of infection should not exclude this highly valuable tissue, Barry argues, because we have effective procedures for ensuring the safety of placenta for research use. Kate Virostko, a New Haven midwife and mother of two, shares a similar view: "I wouldn't ever allow any testing whatsoever on my baby, but I'd happily offer up my placenta," she told me. Virostko says she believes her patients "would easily consent to donating placenta," but no researcher has ever asked them to consider it.

Environmental health research—a field not highlighted in the *neglected experimental animal* conference of the 70s—is particularly interested in the placenta as a research subject.

The field, with the guidance of the U.S. Environmental Protection Agency, is moving away from animal research models (e.g. rats, dogs, monkeys) and towards the use of human tissue, such as the placenta. Recent, rapid advances in cell technologies provide cheaper, faster, more reliable and more humane environmental health research methods.

Dr. Richard Miller, an OBGYN professor of Environmental Medicine at the University of Rochester School of Medicine, uses placental tissue to study toxicology and birth defects. Miller started out as a kidney researcher, he tells me, until “my wife informed me one day we were going to have twins.” He then built his graduate thesis on placental transport functions, and his interest in the organ has grown from there. Miller refers to three key aliases of the placenta: the anchor, the conduit, and the controller. It is the anchor because it holds tight to the uterine wall; it is the conduit because it conducts nutrients and other chemicals from the mother to the fetus; and it is the controller because it releases hormones that prepare the mother’s body for pregnancy and labor. If an environmental “agent” modifies even one of these roles, he says, it could compromise the pregnancy and affect the health of both the baby and the mother. While the placenta is often thought of as an impermeable barrier—protecting the fetus from all dangerous toxins—this is inaccurate. The basis for a molecule’s passage through the placenta, and subsequent entry to the fetus, has to do with its size and charge, as well as its ability to bind to certain proteins or dissolve in fat.

Miller describes to me the case of cadmium. Cadmium is a metal, used in products such as batteries, paints, and plastics, that is toxic to the human body. Humans are generally exposed to it through cigarette smoke and by eating contaminated food such as grains and shellfish. Welders and manufacturers who work with cadmium often have kidney problems, says Miller. Two women, both industrial arts teachers who instruct students in welding techniques, were referred to him when they experienced multiple pregnancy losses. They were also having kidney problems and had high levels of cadmium in their bodies, so Miller and colleagues theorized that the pregnancy losses were due to the teachers continued exposure to cadmium. From rat studies, they knew that cadmium caused death of the placental tissue. They cultured early human placenta to test this theory, and found that cadmium altered hormone production and cell division. We found “all signs of cell death,” says Miller.

What happens molecularly when a pregnant woman is exposed to cadmium? To figure this out, Miller used a placental perfusion. To perform a placental perfusion, an expelled placenta becomes the research subject. You follow an artery or vein, says Miller, put in a catheter (or tube), and create both a fetal circuit and a maternal circuit. You inject the chemical of interest into the side of interest (generally the maternal side), wait a day or so, and see if the chemical appears in the fetal circuit. If it does, this means that the chemical crossed the placenta. (Drug companies are often interested in knowing whether their products will cross, says Miller.) In the case of cadmium, within the first hour of the cadmium's injection into the maternal circuit, the maternal levels of Cadmium dropped dramatically. But very little of the cadmium made it into the fetal circuit, even after six hours of perfusion. Where did the cadmium go? Into the placenta. The placenta gulped up the metal, protecting the fetus as much as it could, before becoming intoxicated itself. When the placenta could no longer neutralize the accumulating levels of cadmium, the tissue started dying. Because the fetus relies so entirely on the placenta for its well-being, the fetus will suffer if the organ starts failing.

Even at low levels, Miller found, cadmium spells trouble for the fetus. Normally, copper and zinc—essential fetal nutrients—bind with the protein metallothionein. It is through this binding that they secure entry across the placenta, and are able to nourish the fetus. But when cadmium is present, it'll push the copper and zinc out of the way and bind with metallothionein itself. Thus, even at “non-toxic” levels, cadmium exposure can alter the ability of the fetus to receive proper nutrition.

Cadmium is certainly not the only chemical of concern to fetal development. In the report he authored for the U.S. Environmental Protection Agency, Miller describes the danger posed by other toxins, including agricultural pesticides, like organochlorine (think DDT). Placenta perfusion studies show how these chemicals can not only cross the placenta, but they can also damage its ability to care for the fetus. In this 2001 report, Miller recommends much further research into this area, especially research that utilizes the human placental perfusion technique. “For the development of future test guidelines and guidance documents,” he writes, “it is becoming important to know not only what is happening relative to toxicokinetics

[the mechanics of toxins] in animal models but also what may be occurring in humans...Thus, test guidelines will need to incorporate human model systems, e.g. *in vitro* human placental perfusions..." Miller argues for the placenta's second life to take the shape of a perfusion model, so that we can use the data to better understand how to protect our developing babies.

At a recent holiday party, family friends started discussing the placenta. The conversations were punctuated by the presence of two-year-old Ava—in a zebra outfit, clutching broken sticks of chalk and two large teddy bears. Ava's young parents didn't spend much time contemplating the placenta, but they did say, almost proudly, that they donated their placenta to stem cell research. Their OBGYN was also a researcher and he'd asked their consent to collect the placenta for his work at the University of Iowa. They seemed happy to turn the discard into something useful.

The phrase "stem cell" is pretty powerful. What does it mean, to donate your placenta to stem cell research? What are researchers doing with this tissue, post-birth?

The placenta plays a role in a controversial new area of science: regenerative medicine. Regenerative medicine aims to create and restore damaged organs through the use of stem cells. Stem cells are master cells, with the ability to form and repair various tissues in our bodies. For example, stem cells are used to replenish blood cell populations in treatments for disorders such as leukemia and sickle cell disease. Blood cell therapy, however, is the extent of current clinical stem cell application.

Stem cells differ in their abilities—not all stem cells can form all the cells of the body. Researchers are still tinkering with stem cell definitions that account for the cells' various regenerative capabilities. To keep it simple, you could group stem cells into two loose categories: **super stem cells** and **average stem cells**. A super stem cell can form any other cell of the body, such as a blood cell, a liver cell, a neuron, etc. Embryonic stem cells, first isolated from human embryos about ten years ago, are super stem cells. Embryonic stem cells are steeped in ethical concerns because of their intimate tie to conception and life; the controversy

lies in varying beliefs about the start of human life, and how research use of embryonic stem cells could constitute a destruction of life. Actual therapies have yet to come from the much-discussed embryonic stem cell.

Current cell therapy, for diseases such as leukemia, makes use of average stem cells. Average stem cells can only form a limited number of cell types. Blood stem cells, for example, create a range of blood cell types, such as platelets and red and white blood cells. But blood stem cells cannot create nerve or brain cells, making them an average stem cell.

Researchers have explored one approach to creating super, embryonic-like stem cells, free from ethical messiness: “induced pluripotent stem cells,” or iPS. With this technique, average stem cells are reprogrammed to become more like super stem cells, with the ability to differentiate into any cell type. iPS uses the machinery of a virus to place certain proteins into average stem cells that turn genes on and off. These new proteins change the genetic signature of the cells, and allow researchers to select for cells that have a similar signature to embryonic stem cells. iPS holds much promise, but also a host of problems: the reprogramming technology uses a cocktail of cancer-causing genes and potentially dangerous viruses.

iPS is one important research approach to creating super, embryonic-like stem cells, but not the only. New research shows that afterbirth tissues, including the placental blood and membranes, are not only a good source of average blood stem cells, but also may be a source of a new super stem cell.

Dr. Anthony Atala, a researcher at the Wake Forest Institute for Regenerative Medicine and editor of the 2008 textbook *Regenerative Medicine*, was part of the team to develop the super stem cell line from amniotic fluid and placenta.

The reception area of Atala’s North Carolina lab is peppered with framed journal covers that highlight the lab’s diverse, interdisciplinary publications, including their recent success with amniotic fluid stem cells. Atala’s office, by contrast, has clean white walls, along with a bright wood desk and towering houseplants. Atala himself is calm and friendly, wearing a white lab coat with *Dr. Atala* scrolled in black across the right breast. He has slightly curly black hair and gestures often. He sees patients as well as working in the lab, and you can tell that he’s practiced in the art of working with people.

His lab, in collaboration with other researchers, developed super stem cells from amniotic fluid. They've coined the cells "amniotic fluid-derived stem cells" or AFS. While they can derive the cells from common prenatal diagnosis procedures such as amniocentesis and chorionic villus sampling (CVS), Atala reasons that the "best way to get these [AFS] cells is from the placenta after birth." Amniocentesis is a procedure that involves taking a syringe-full of amniotic fluid out of the amniotic sac, and CVS is a procedure that takes a small bite out of the placenta; both carry low but significant clinical risk. Luckily, the expelled placenta also harbors AFS cells, and it poses no risk to the baby or the mother. Placentas, as a discard tissue, are a "very nice resource," Atala says, a "very generous source of cells."

By scraping the sides of the placenta membranes, researchers can harvest the cells trapped in the villi of the placenta, and then sort them by their surface proteins. Each cell has unique surface proteins (called markers), so a machine can sort cells by using antibodies to bind to these unique surfaces. The AFS cells are sorted by the protein marker TH1, which is also known as c-Kit. When they started this research, they sorted cells by a "whole panel of markers," and then put each type of cell through vigorous testing to analyze their cell characteristics. The cells sporting the c-Kit marker performed the best, and were most similar to embryonic stem cells, which was their goal.

It's been known for years that the amniotic fluid contains cells of all different types, says Atala, but they were not interested in working with cells that had already committed to a specific tissue type. "Our whole goal," says Atala, was to "isolate a primitive stem cell population" rather than gather cells of the amniotic fluid's "mixed soup." To prove that they'd developed a pure stem cell population, they needed to clone the cells, which they did prior to publication of their findings in a 2007 article in the journal *Nature Biotechnology*.

After establishing clonal lines of the AFS cells, they used retroviral marking and Southern blot analysis to confirm that the cells were indeed clones that were capable of turning into all three embryonic germ layers. The germ layers consist of the ectoderm (primarily forming nerves and skin), the mesoderm (muscle and bone), and the endoderm (digestive system and lungs). The ability to form cells of all three germ layers means that the cells can turn into nearly every cell in the body, and it is one key signature of embryonic stem cells. Mathew Lensch, a

stem cell researcher at Children's Hospital Boston, finds AFS cells "very interesting," but points out that they don't form teratomas—a kind of benign tumor that has cells from all three germ layers. Embryonic stem cells do form teratomas. Teratoma formation "is a good sign of a potent cell," says Lensch. But Lensch agrees that researchers should continue exploring AFS cells, especially since they can expand and produce a great number of cells.

Another key signature of embryonic stem cells is their ability to maintain the length of their telomere, the region of DNA at the end of a chromosome that protects the integrity of the chromosome. "It's the fountain of youth gene," says Atala, and marks the capacity of a cell to renew itself. Progressive shortening of the telomere is a hallmark of cellular aging, and every replication cuts the telomere a bit more. Committed cells, "by definition," he says, have telomere shortening. But AFS cells maintain the original length of the telomere. This fact, in combination with the establishment of clonal lines of AFS cells, strengthens the idea that these cells may form the best comparative cell to embryonic stem cells.

The next step is to prove that these AFS cells, once directed to a certain tissue type, can function as normal cells of the tissue. In other words: do these guys hold up in the real world? Can they pass functionality tests? This is where Atala's lab now puts the thrust of their research.

Thus far, the function tests are "going very well," says Atala. "There are papers out already that show our cells turning into cartilage, kidney, and lung cells," he says. Since publication of their established AFS cell line in 2007, labs from around the world have called up to request cells. They're up to about one request each week, says Atala, and they're happy to send the cells out: "The more people the better," is his philosophy. So far, they've gotten positive responses from the labs that have worked with the cells. But, just like embryonic cells, some lines—or families of cultured cells—are better than others.

Still, "many, many fewer researchers are working on [these cells, rather] than embryonic stem cells," says Atala, although he sees the numbers "growing slowly over time." Embryonic stem cell research started out small, he reminds me, but then grew exponentially. AFS cells could follow a similar path. "People will just have to work with these cells themselves," he says, to be able to understand and test their clinical application. To Atala, it is a boon that AFS cells

do not form tumors or teratomas (unlike embryonic stem cells); this fact, coupled with the large available quantity of AFS cells (unlike bone marrow cells) and AFS cells' potential to ease rejection by the body upon implantation, make the cells an appealing therapeutic source.

Atala intercepts a researcher en route from a hood, and asks to borrow his Petri dish of AFS cells. The Petri dish has a splash of thin red liquid in it. The researcher puts it under a scope and I peer inside. The cells are uniformly beige, spotted with small dark circles, which are the nuclei. Not many other structures are visible—just a whole lot of cytoplasm. There are about one million AFS cells in this dish. Atala's lab proved that these AFS cells differentiated into the cells of a specific tissue, the researcher excitedly tells me. He uses the name of the specific tissue, but since it's unpublished research, it cannot be released just yet. The next step, though, will be to inject these cells into mice and see how they function upon implantation.

The order of operations here seems to follow this rough chronology: fingerprint the differentiated cells, expand them, test their physiology and responses, and then see how they function in animal models.

The researchers give the cells a rigorous workout, it seems. Once cells are fingerprinted and expanded, the lab starts by testing the properties and functions of a single cell, then progresses to bigger samples. A cell is given a barrage of physiological tests—including response to electricity as well as to drips of sodium solutions, etc. They also test the cell's response to drips of various drugs—this is the pharmacological side of things.

The cellular workout is like a military boot camp. Can you stretch, strengthen, perform to the same abilities as your predecessors? Can you navigate the tire-jumping, fence-climbing, and the belly-crawling? Can you achieve the physical perfection and elite performance of the already-initiated soldier? Will you live up to the standard set? These cells must prove themselves.

And, in animal trials, they have. Researchers are awaiting clearance from regulatory agencies to start human clinical trials, and Atala guesses that human trials won't start for another four years. Atala's lab has federal funding to help realize this speedy timeline. Because they are not primarily working with embryonic stem cells, the lab can receive National Institutes of Health (NIH) money. Atala is one of five recipients of the million dollar/yr

“Quantum Grant” from the NIH. According to the NIH website, the multi-year grants are awarded to interdisciplinary research projects that have the ability “to make a profound (quantum) improvement in health care.”

As Atala walks through the hallways of his lab, he points left and right at the various posters lining the walls, rattling off cell types and techniques that the lab’s worked with. They’ve experimented with the whole range—“We’re not married to any one cell type,” says Atala—but it is the amniotic –fluid cells they find most promising. This is because AFS cells show the key properties for clinical translation: they grow in large quantities, they have the potential to turn into nearly every type of cell, and they don’t produce tumors upon implantation.

Atala cautions that there is still much to figure out before AFS cells are ready for therapies (such as to treat brain disorders like Parkinson’s disease or chronic diseases like diabetes), but he also points out that not all of the clinical applications need to be proved prior to starting a national placenta bank. “It would be very beneficial” to start banking placentas now, he says, but it’s an “expensive endeavor.” Matching every person with cells from their own placenta would be ideal, says Atala, but placentas can also be a universal source of cells rather than patient-specific. There’s been interest in the federal government about starting a bank—Senator Richard Burr (R-NC) introduced the “Amniotic Fluid and Placental Stem Cell Banking Act” in March 2007 that would fund the collection and banking of 100,000 units of AFS cells from amniotic fluid and placenta—but it never became law, and Atala reports no further progress on this front.

Even though no federal placenta bank exists as of yet, people are privately banking placentas in order to create a reserve of stem cells for themselves.

The phenomenon of saving afterbirth tissues for future cell therapy begins with cord blood. Umbilical cord blood, drawn from the cord right after birth, is the primary unit for banking blood stem cells. Cord blood is a source of average blood stem cells, meaning they can create all sorts of **blood** cells but not other types of cells (unlike the premise of Atala’s super AFS cells). These blood stems cells are used in therapies to treat blood disorders and certain

cancers, and they can also be extracted from an adult's bone marrow (found in the middle of our bones), although it is a very painful procedure. Mathew Lensch, stem cell researcher at Children's Hospital Boston, says that cord blood is a proven treatment for lots of conditions, but you "can put all of [the conditions] under one category: blood disease." Other hopes for cord blood, such as a treatment for stroke, he says, are simply "not accurate." This doesn't stop Lensch from a heartfelt recommendation, though: "Everyone should bank their cord blood," he says.

The non-profit organization Parent's Guide to Cord Blood Banks watchdogs the cord blood bank industry and tracks the pricing and reliability of the services, as well as the history and legislation of the practice. The non-profit officially started up in 2007, although the founder has maintained a cord blood website since 1998. This date provides a good estimate of the start of this new banking practice, this new western ritual.

"So, first things first," the female voice says directly to the viewer, "you're having a baby. Congratulations." The Parent's Guide website links to an interactive computer video that explains your options for cord blood storage. After doling out congratulations and describing the collection process and benefits, the 12-minute video lays out your options for *where* to store your cord blood stem cells. You could decide to send them to a private banking facility, of which there are numerous companies in the U.S. and around the world (such as ViaCord, Cord Blood Registry, and LifebankUSA), or you could donate them to a public bank. The U.S. government established the C.W. Bill Young Cell Transplantation Program, which operates a public registry of bone marrow donors as well as (starting in 2005) cord blood units. Each option has its perks. Public banking is free, and the cells will go directly to people in need. On the other hand, you relinquish all claims toward the cells, whereas with private banking (also called "family" banking), the cells are reserved for your family alone. Private banks charge a significant up-front fee (usually between \$1500-2000) and then a yearly storage fee (\$100-150).

Vincent Lepinay, an MIT professor in the Science, Technology, and Society department, tracked the cord blood banking industry from 2004-2007, just as the phenomenon was getting hot. When I go to speak with him, his office is rather dark, illuminating the lightning storm background on his wide-screen Mac. "I'm not trained as a biologist," he says to me, right off

the bat. His background is in economics and philosophy. But he's interested in all forms of banking.

By privately banking, Lepinay says, you are "building assets, building wealth, building biological capital for the newborn and for the family." Companies are capitalizing on the richness of afterbirth tissues, he continues. They aim to make cord blood banking among the "portfolio of things you do for your children," such as sending them to good schools, getting braces, starting piano lessons. To grow up with this "biological life insurance," he asks, his philosophy background coming front and center, "What kind of wealth is that?"

When I ask him whether he thinks it's a good investment, he stretches his back, leans his elbow on the neighboring office chair, looks me in the eye and says, "I don't know." Are they ripping people off?—he wonders aloud—Or is it a good thing? I can tell he's asked himself this same question for a while now, with no clear answer emerging.

The private banks are "very secretive, very opaque," he says, interested in protecting their business plan as well as shielding themselves from fanatics of any sort. While he was tracking the industry, he would call up the banks and talk with them as if he were an expecting parent, rather than a researcher. This was a more effective way to get answers, he found.

Not only are the private cord blood banks competing with each other, but they're competing with the public donation model as well. "Parents," warns the website of the Parent's Guide to Cord Blood Banks, "be advised that private and public bankers regard themselves as rivals and are inclined to talk trash about each other. Don't believe everything you hear in interviews or read in the official opinions of medical societies..." Lepinay also talks about the tension between public donation and private banking. Public banks criticize the philosophy of private banks, he says, because it encourages people to keep for themselves "a good that could be used for people in need right now." He furthers the public bank argument, saying that if everyone donated their afterbirth tissues, we'd all have good odds of finding a cell match if and when we need it.

But both private and public banks present compelling arguments about why their odds and payoff are ultimately better. This controversy is a "prism" within which you see two opposing philosophies at work, says Lepinay. Which model should reign: will we collectively

help many people or build the social contract around the family, through private banking? As one cord-blood-banking parent said, “I think the public banks are great because they offer some kind of potential solution, just not as potentially helpful as a precise match from a private bank.” For this parent, it was worthwhile to ask her in-laws for help in gathering the private storage fees, because “the potential benefits were—and remain—innumerable.” The founder of the Parent’s Guide website forecasts that a hybrid for-profit model will emerge in the cord blood industry, where parents can publicly donate or store the cells privately, both under one roof. She also forecasts that this hybrid bank of the future will sell some of their donations to researchers.

LifebankUSA fits this hybrid model almost to a T. It also happens to be the only cord blood facility that banks the placenta as well. In fact, LifebankUSA touts their new placenta banking (2006) at every opportunity—it is at the forefront of their marketing campaign because it sets them apart from all other cord bank facilities. They’re careful to only advertise blood stem cells from placenta, though. In the small print of their brochure, it says, “Cord blood and HPDSC [human placenta-derived stem cells] infusions are performed to provide hematopoietic progenitor cells for hematopoietic reconstitution.” This translates into: the placenta stem cells are meant for the same purpose as the cord blood, and this purpose is to create more blood cells, NOT cells of any other type of tissue. To extract blood stem cells from the placenta, a LifebankUSA technician opens up the blood vessels and flushes them with saline. Then the technician kneads the placenta (think pizza dough) for an hour or two. The extracted placental blood is processed and treated the same way as the cord blood, although it is stored separately. Although only harvesting blood stem cells from the placenta, this doesn’t mean LifebankUSA isn’t interested in developing a primitive stem cell line, such as Atala’s AFS cells, but these research approaches (if they exist) have not surfaced in their marketing as of yet.

On the front of the LifebankUSA promotional package, there’s a pregnant mother facing her young child, who clutches curiously at her mother’s belly. They are both shadowy figures. Even from the outside of the envelope, they plant the idea of placenta banking with the sentence: “They have a lot to protect so they’re banking *more* than cord blood.”

LifebankUSA coins their practice “Placenta-Cord banking.” The marketing material explains that the blood collected from the placenta is higher in a specific type of stem cell (namely CD34+) that has been shown to be more successful for transplants. Independent research affirms LifebankUSA’s claims about the promise of CD34+ stem cells. At the 2009 Annual Meeting of the American Association for the Advancement of Science (AAAS), Northwestern University researcher Douglas Losordo told the audience that CD34+ stem cells are a key component of successful cell therapy. In Losordo’s own research, CD34+ stem cells repaired heart cells better than stem cells with different marker proteins.

Further strengthening the science behind placental blood banking, UCLA researcher Hanna Mikkola and colleagues used a mouse embryo with no heartbeat (and thus no blood circulation) to prove that a newborn’s blood stem cells originate from the placenta. Harvesting blood stem cells from their source of origin would ensure a pure and potent population, as LifebankUSA argues. Just two months after Mikkola’s article came out in 2008, LifebankUSA announced their first therapeutic use of placenta-derived stem cells: they’d released cells for use in a transplant for a child with Acute Lymphoblastic Leukemia, a cancer of the bone marrow and blood. The press release from this event mentions that the patient was released earlier from the hospital than expected, and the doctor in charge of the transplant commented that engraftment of the blood stem cells (i.e. how well the cells repopulate within the patient) “occurred earlier than anticipated in this proof-of-principle study further raising our hopes regarding the benefits of this treatment.”

While the marketing may be tiresome, the benefits of having these cord blood and placenta cells on hand are already proven in a small but significant number of cases. LifebankUSA has released cells for transplant—mainly to treat leukemia—a total of 17 times since 2003. In all of these cases the banked cells provided a genetic match, foregoing the need to perform a painful bone marrow operation on an imperfect donor. Dr. Helen Vitiersky, a physician, banked her baby’s afterbirth tissues and has no regrets. In fact, she has the opposite: peace of mind. The banking company sends her letters periodically, updating her on the cell counts, etc. “All of my friends do it,” she told me; it’s a trend. She heard about it while in medical school, and she would “absolutely” recommend it to others. To have your baby’s

own genes and a family match, she told me, is a crucial factor. “I hope I never have to use them,” she quickly added, but to know they are waiting is an important source of reassurance.

Because cord and placenta blood is such (as Lepinay said) “biological capital,” the consent process for banking companies is extensive. The LifebankUSA consent form has options for you to select whether your placenta will be donated to the company (after stem cell processing, if chosen) for “non-clinical research uses” or if you’d rather have it discarded as medical waste. Placental incineration, though, is not LifebankUSA’s piece of cake: they’ll do everything they can to politely dissuade you from this option. They’d like to have your money, by banking your placental blood, but they’d also like to have your leftover placenta, whether you bank the blood or not.

This is because they use the placenta for further stem cell research (perhaps akin to Atala’s work?) as well as using the placenta to develop proprietary medical products. Ambiodry, for example, is a dried and sterilized patch of the amniotic sac that is used in eye surgery—and it’s developed, marketed, and sold by LifebankUSA’s parent company, Celgene Corporation.

Prior to the use of corpses in physician training, medical knowledge was gathered solely by studying the physiological responses of living, breathing human beings. Knowing these human responses is essential to treatment, yet the approach is limited. The advent of corpse dissection—of studying the dead—fundamentally changed medicine. Instead of *inferring* the location and connectivity of various bodily systems, dissection allowed physicians to pinpoint the heart, to understand the digestive pathways, to see the architecture of the skeleton. Taking knife to scores of lifeless bodies illuminated human anatomy; understanding anatomy propelled the field of medicine in a radical new direction.²

The expelled placenta is a corpse, of sorts. It is an independent creature, living in the hollows of a woman, until birth occurs and its natural lifespan is complete. More often than

² See Mary Roach’s *Stiff* for a lively account of the uses of human cadavers.

not, the placenta is incinerated—yet, scientists and society-at-large are reconsidering the biohazard disposal of the organ.

Just as human bodies can be gifted to scientific research, so too can placentas. Ethically, it follows the same logic of a corpse donation: a family would only consent to the donation if burial or incineration or other rituals were not important to them. Whether the placenta serves as a spiritual practice, a source of stem cells, a medium for environmental toxicology studies, a substitute human membrane, or even flesh for dog-training, it can have a useful second life. Not all of its second life incarnations may turn out to be beneficial to humans (such as its use as an extract and in cosmetics), but in a future where placenta donation is commonplace, other potential uses for the organ may emerge; scientific disciplines with no relation to OBGYN may develop novel research approaches based on the flesh. Researchers in regenerative medicine have taken one such novel approach, and the gamble has turned into one of the most promising applications of placenta research thus far. The afterbirth corpse, coupled with advanced cell technologies, may have the ability to once again fundamentally alter the path of medicine.

As I hold the warm placenta in the utility room at Mount Auburn Hospital, with the full weight of the flesh in my hands, I find myself marveling at the raw potential of the organ. The placenta, both in its intended role in pregnancy and in its multitude of second lives, embodies one of our culture's most impressive notions: resurrection.

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