

## Ontogeny, Ontology, and Phylogeny: Embryonic Life and Stem Cell Technologies

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Biomedicine and biotechnology increasingly draw on marginal forms of living tissue as sources of therapeutic substances. More and more biomedical treatments rely on the collection, storage, transformation, and redistribution of tissues, the development of new kinds of “separable, exchangeable, and reincorporable body parts.”<sup>1</sup> Some of these tissues—cancerous cells, placentas, DNA extracted from saliva—are considered marginal, or indeed dangerous, to the continuing life of the donor. As Robert Mitchell points out, these tissues are, generally speaking, collected and technically transformed with little social objection or controversy, precisely because of their status as waste.<sup>2</sup> As such, they are relatively open to forms of commodification and patent, and form the basis for an increasingly lucrative biotechnology industry:

From the sale by hospitals of infant foreskins (used to manufacture artificial skin) and aborted embryo gonads (a source of stem cells) to the patenting of

1. Paul Rabinow, *French DNA: Trouble in Purgatory* (Chicago: University of Chicago Press, 1999), p. 95.

2. The profitability of such waste body parts has lead to several legal attempts to gain ownership or patent rights for the donors in subsequent profits. See Paul Rabinow, “Severing the Ties: Fragmentation and Dignity in Late Modernity,” in idem, *Essays on the Anthropology of Reason* (Princeton, N.J.: Princeton University Press, 1996); Robert Mitchell, “\$ell: The Rhetorical Ecology of ‘Dignity,’ ‘Waste,’ and ‘Information’ in U.S. Tissue Economies” (unpublished MS, 2003) on the now well analyzed case of *Moore v. the Regents of University of California* for accounts of the stakes in such cases.

infected cell lines as research materials, to the sale of celebrity DNA-rich saliva, body wastes are fully integrated into the structures of late capitalism.<sup>3</sup>

Other forms of therapeutic tissue are marginal in a slightly different sense: they can only be collected from bodies at the margins of life or death, bodies that are nearly dead or not-quite-alive. The most familiar of these is the donor cadaver. An ever-growing array of biotechnologies enable the vitalization of the legally dead body so that the cadaver can be utilized as a donor for organs, corneas, connective tissue, bone, heart valves, cells, and skin.<sup>4</sup> The definition of death as "brain death" has allowed the process of death to be instrumentalized in a number of productive ways in the United States and Europe, though in Japan this remains a contested medical category. The cadaver can be connected up to a complex system of ventilators, intravenous fluid pumps, biosensors, and thermosensor warmers that maintain vital function, so that the legally dead body can act as a source of organs and tissue for transplants, or for pharmaceutical or medical research. At the other margin, that of the recently alive, fetal tissue is utilized for the production of cell lines, vaccine development, tissue transplantation, and Human Genome research.<sup>5</sup>

While tissues classified as waste can be collected with little public controversy, tissues collected from beings in marginal states of life or death are, generally speaking, in the context of the West, more subject to controversy and hence to contestation and governance. This is because entities like donor cadavers and fetuses have particularly problematic relationships to the human community and to the legal and ethical status of personhood. Conflicting notions of death—as a discrete point, or as a process—have produced different responses to transplant technology in Euro-America and Japan.<sup>6</sup> Even in the USA and Europe, where there is general acceptance of the notion of a punctual death, donor cadavers may be defined as "brain dead," while for grieving relatives and even casual onlookers they may appear alive, breathing and warm. They have only recently lost the qualities of personhood, and they may convey the possibility of re-

3. Robert Mitchell, "Sell: Body Wastes, Information and Commodification" (unpublished MS, 2003), p. 1.

4. Linda F. Hogle, "Tales from the Cryptic: Technology Meets Organism in the Living Cadaver," in *The Cyborg Handbook*, ed. C. Gray (New York/London: Routledge, 1995), pp. 203–216; Margaret Lock, *Twice Dead: Organ Transplants and the Reinvention of Death* (Berkeley: University of California Press, 2002).

5. Monica J. Casper, "Foetal Cyborgs and Technomoms on the Reproductive Frontier: Which Way to the Carnival?" in Gray, *Cyborg Handbook* (above, n. 4), pp. 183–202.

6. Lock, *Twice Dead* (above, n. 4), especially pp. 3–4, 69–75, 130–146.

covery. The margin of usable vitality created by the declaration of brain death creates an ambiguous status for the donor cadaver, where personhood seems not quite extinguished, leading to careful and complex procedures in the United States and Europe around the declaration of brain death and the securing of relatives' consent for the use of organs.<sup>7</sup>

Recently, a new potential source of therapeutic tissues has been developed that confronts these questions of personhood with renewed force: stem cells. The term "stem cell" refers to any cell that can renew tissue in the body. The type most prominent in the media at present is "pluripotent" stem cells, undifferentiated cells that have the capacity to develop into almost all of the body's tissue types. It is thought that stem cells may be very useful in treating currently intransigent medical conditions—Parkinson's disease, Alzheimer's disease, stroke, spinal-cord injuries, arthritis—through the introduction of tissue into damaged or degenerated sites. Stem cells might also provide alternative therapies for common conditions like diabetes, promoting the growth of insulin-producing tissue to replace pharmaceutical insulin regimes.<sup>8</sup> Moreover, it may be possible to produce stem cell lines that are genetically and immunologically compatible with particular hosts, avoiding the problem of tissue typing found in whole-organ transplants.

Stem cells can be found in umbilical-cord blood and some adult tissues, such as bone marrow. However, the best source is human embryos; cord-blood stem cells, at present, can only generate blood tissues, while stem cells harvested from embryos can differentiate into all of the tissues that make up the human body. Stem cells harvested from adult tissues do not appear to be as flexible or as active as tissue derived from embryos. As tissue sources, embryos present the same sort of opportunities for controversy as do donor cadavers and fetuses: they also reside at the margins of human life, and their relationship to the human community and human status is ambiguous and contestable.

In Britain, public controversy over the use of embryos for medical research first erupted in 1984 with the publication of the Warnock Report into legal and ethical aspects of assisted human reproduction. The report described the unregulated use of embryonic tissues for medical research, precipitating a wide and bitter public debate in Parliament and the media regarding the status of the embryo and

7. *Ibid.*, especially pp. 358–362.

8. "Stem Cells: A Primer," National Institutes of Health (2000), at [www.nih.gov/news/stemcell/](http://www.nih.gov/news/stemcell/) (September 2002).

the ethics of its use in medical research. Michael Mulkay summarizes the opposition to embryo research:

The basic arguments against embryo research were much the same as those used to condemn abortion; that is, that the early embryo is a person with full moral standing, that embryo research contravenes the rights of the experimental embryo and that failure to respect the embryo's rights is both a symptom of, and potentially a contributory factor in, the long-term decline of moral standards and proper family life.<sup>9</sup>

That is, opponents of the use of embryos for medical research positioned the embryo, from its earliest moments, as a full member of the human community, with full moral and legal status. Proponents of embryo research, particularly biologists and scientists directly involved in research, argued the converse—that early embryos lacked the fundamental aspects of biological organization that would qualify them for the legal protection afforded to human beings. The Human Fertilisation and Embryology Act of 1990 eventually established a regulatory framework that allowed medical research on embryos for the first fourteen days after conception, or until the appearance of “the primitive streak” (the first sign of the developing nervous system), at which point the embryo was considered to begin to show features consistent with human being.

Hence, like the creation of the brain-death criterion for harvesting organs, in Britain a pragmatic margin of usable life has been made available, through an act of linguistic redefinition, for biomedical instrumentalization. And like the legislative and ethical framework for the governance of brain death,<sup>10</sup> this margin is hedged around by statutory laboratory-licensing and clinical-consent procedures, and by criminal sanctions if these constraints are ignored. A dedicated statutory body, the Human Fertilisation and Embryology Authority (HFEA), oversees this strict regulatory framework and adjudicates bioethical issues as they arise. The 1990 legislation was extended in 2001 to allow for embryonic stem cell research as well.

In the United States, in contrast, the public debate about stem cells has been more heavily influenced by right-to-life groups, who take a position on the embryo similar to the conservative one set out above. As a consequence, President Bush has declared that U.S. federal funding for stem cell research will be made available only where existing stem cell lines are used, “where life and death decisions

9. Michael Mulkay, *The Embryo Research Debate: Science and the Politics of Reproduction* (Cambridge: Cambridge University Press, 1997), p. 22.

10. Lock, *Twice Dead* (above, n. 4), pp. 103–129.

have already been made," rather than new lines established by harvesting spare embryos.<sup>11</sup> The logic informing this decision is evident in a more recent piece of legislation. On October 3, 2002, the Bush administration finalized 42 CFR Part 457, "State Children's Health Insurance Program [SCHIP]; Eligibility for Prenatal Care for Unborn Children." This rule, first published in the *Federal Register* in March 2002, designated that "an unborn child may be considered a 'targeted low-income child' by the State and therefore eligible for SCHIP if other applicable State eligibility requirements are met. Under this definition, the State may elect to extend eligibility to unborn children for health benefits coverage, including prenatal care and delivery, consistent with SCHIP requirements."<sup>12</sup> As National Abortion Rights Action League president Kate Michelman pointed out:

In an unexpected move, the Administration's rule also allows the embryos and fetuses of immigrant pregnant women to be covered under SCHIP. This creates a strange dichotomy because under current law, legal immigrants cannot receive Medicaid or SCHIP benefits until they have been in the country for five years. (Illegal immigrants do not qualify at all.) Therefore, under the scenario the Administration has now created, the three-year-old daughter of a recently immigrated pregnant woman cannot receive public health care, but the woman's fetus can. This illustrates again that the true nature of this rule is not to deliver health care to children who need it, but to grant legal rights to embryos and fetuses.<sup>13</sup>

It is evident that the Bush administration has more or less accepted the right-to-life groups' position that equates the embryo with personhood, and regards the transformation of an embryo into a stem cell line as the equivalent of a person's death, if not precisely murder. British public debates echoed this linking of embryos and persons; for example, an *Evening Standard* editorial compared embryo research to Dr. Mengele's murder of his medical research subjects during World War Two.<sup>14</sup> This is clearly not the understanding of the

11. George W. Bush, "Looking for a Firm Footing on an Ethical Slippery Slope," *Sydney Morning Herald*, August 13, 2001, p. 10 (reprint of article appearing in the *New York Times*).

12. CMS Quarterly Provider Update, "State Children's Health Insurance Program: Eligibility for Prenatal Care for Unborn Children," *Federal Register*, 67:43, March 5, 2002; accessed at <http://cms.hhs.gov/providerupdate/regs/cms2127p.pdf>.

13. Kate Michelman, "Bush Administration Rule to Make 'Unborn Children' Eligible for SCHIP—Part of Stealth Campaign to Undermine Abortion Rights," *Online Newsroom*, October 3, 2002, at [www.naral.org/mediaresources/fact/schip\\_memo.html](http://www.naral.org/mediaresources/fact/schip_memo.html) (October 7, 2002).

14. Cited in Mulkay, *Embryo Research Debate* (above, n. 9), p. 80.

advocates of embryo research. Rather, they argue that supernumerary embryos from in vitro fertilization (IVF) are not viable forms of human life, because they will not be implanted in a woman's uterus and hence will never have the opportunity to become persons; they can, however, become the starting point for useful research and viable therapy. So, for example, the Chief Medical Officer's report into stem cell technologies argues:

The vast majority of embryos used in research are embryos created in the course of infertility treatment and which, for whatever reason, are no longer required for treatment. The only options at this stage are to let the embryos perish or to use them, with the express consent of the individuals whose eggs or sperm have been used to create the embryo, in licensed and controlled research as part of the effort to enhance . . . human lives.<sup>15</sup>

At the same time, the U.K. legislation and the activity of the HFEA are designed to minimize the number of embryos used for stem cell research. Currently a stem cell bank is being set up by the Medical Research Council to ensure that existing stem cell lines are accessible to the maximum number of researchers, and that no new lines will be created unnecessarily.

These constraints on stem cell use in the United States and Britain seem to indicate the continuing force of President Bush's line of argument in the public domain of stem cell regulation: the sense that something of human life is killed when an embryo is used to establish a stem cell line. In what follows we want to investigate this sense more thoroughly. What ontological status does the embryo have, considered in the light of the new stem cell technologies? On the one hand, the relentless public imaging and discussion of the embryo gives it a new prominence as the widely recognized starting point for human life, our moment of beginning as human beings. On the other, stem cell technologies introduce a decisive disruption into any imagined continuity between embryonic life and infantile or adult life. Any biotechnology that changes the temporal trajectory of human life has implications for ways of being human:

The biotechnology of tissue culture participates in this broader twentieth-century reconceptualization and reconstruction of the human life-span. . . . This reshaping of life is being accomplished, simultaneously, in biomedical science and in literature and popular culture. . . . One kind of material and cultural reconfiguration of life is produced by biomedical practices, so that people

15. Chief Medical Officer's Expert Group (CMOEG), *Stem Cell Research: Medical Progress with Responsibility* (report reviewing the potential of developments in stem cell research and cell nuclear replacement to benefit human health) (London: DOH, 2000), p. 38.

are conceived differently, born differently, age and die differently. The new technique of cloning, or more precisely nuclear fusion, which has tissue culture as its foundation, has already provoked a rethinking of the notion of aging on the animal level that is certain to travel—even if the technology does not—to the human realm. . . . When the journey from birth to death is rerouted, lengthened or curtailed, meaning too is changed. In each of these different settings (the scientific, the literary, and their intersection in various forms of medical writing) the practical and symbolic resources of creatures that border on the human (animals and human embryos and fetuses, as well as tissues cultured from them) are used to reshape that birth to death journey and thus redefine the human. This robs human beings of some old certainties and enables us to imagine new options.<sup>16</sup>

Stem cell technologies have profound temporal implications for the human life course, because they can potentially utilize the earliest moments of ontogenesis to produce therapeutic tissues to augment deficiencies in aging bodies. Hence, they may effect a major redistribution of tissue vitality from the first moments of life to the end of life. In doing so, however, they demonstrate the *perfect contingency* of any relationship between embryo and person, the non-teleological nature of the embryo's developmental pathways. They show that the embryo's life is not proto-human, and that the biology and biography of human life cannot be read backward into its moments of origin. This is, we will argue, one of the anxieties that underlie the complex regulations asserting the embryo's right to dignity and ethical treatment, at the same time as its inhuman vitality is reorganized and exploited. Two other anxieties, which we will explore later, concern the boundary of species and the question of normalization, both illuminated by transactions with stem cells.

### Immortalization

Stem cell lines are produced using embryos left over from IVF procedures. IVF treatment routinely produces more embryos than can be used in actual reproduction, and couples in the United Kingdom may consent to their use for reproductive medical research or stem cell research. At this very early stage in development, the embryo is simply a tiny cluster of about two hundred cells, with the most elementary kind of organization, known as a blastocyst. Embryonic cells at this stage have particular cell capacities and qualities that are quite different from those of adult, differentiated tissues and organs. They have undergone the first kind of differentiation by this stage:

16. Susan Squier, *Prospectus Liminal Lives: Imagining the Human at the Frontiers of Biomedicine* (Durham, N.C.: Duke University Press, 2004).

they have moved from being totipotent to pluripotent—that is, the cells that form the embryo have divided from the cells that form the placenta and supporting tissues.<sup>17</sup> These pluripotent cells are able to gradually differentiate into all the cell types that constitute the human body. A pluripotent cell, with a generic structure, will gradually take on the typical structure of a muscle cell, for example. As one embryology textbook describes this process:

Muscle cells . . . take on an elongated shape, fused with other muscle cells to give a multinucleate muscle fiber. New proteins are now synthesized which provide the muscle's contractile machinery, and it becomes ordered in the cell into a highly ordered array of filaments, which give muscle its striated appearance.<sup>18</sup>

It is precisely this quality of pluripotency, the cells' potential to give rise to all of the more-differentiated tissue types, which is of interest to biomedical scientists wishing to establish stem cell lines. A cell line is unorganized tissue that is grown in vitro. Stem cell lines are established by disaggregating the blastocyst into individual stem cells, breaking up the elementary embryonic tissue structure. These cells are then immortalized; that is, they are induced to clone themselves continuously in their undifferentiated state, and are prevented from moving down pathways of further differentiation. Cells that are immortalized will continue to divide and multiply indefinitely, and have been demonstrated to retain their pluripotency. In the study that established the first human embryonic stem cell lines, cells were cultured for four to five months without differentiation—that is, one stem cell multiplied to produce two stem cells, without differentiating into more-specialized tissues; these cell lines were later induced to differentiate into the main groups of embryonic tissue layers.<sup>19</sup>

17. Bioethicists and scientists have debated the validity and implications of the distinction between pluripotency and *totipotency*—the ability to be directly implanted into a uterus and grown into a conceptus. Accepting the distinction between pluripotency and totipotency, the NIH *Guidelines for Research Involving Embryonic Stem Cells* stipulate that the pluripotent stem cell is not an embryo. However, some bioethicists have challenged that position, pointing out that advances in cell *reprogramming* increasingly suggest that any somatic cell—even a skin cell—may at some point in the not too distant future be induced to begin the process of totipotent cell division that would give it the potential to implant and develop as a human embryo. See, for example, Ted Peters, “Embryonic Stem Cells and the Theology of Dignity,” in *The Human Embryonic Stem Cell Debate: Science, Ethics, and Public Policy*, ed. Suzanne Holland, Karen Lebacqz, and Laurie Zoloth (Cambridge, Mass.: MIT Press, 2002), pp. 131–132; Paul Root Wolpe and Glenn McGee, “‘Expert Bioethics’ as Professional Discourse: The Case of Stem Cells,” *ibid.*, p. 189.

18. Lewis Wolpert, *The Triumph of the Embryo* (Oxford: Oxford University Press, 1991), p. 93.

19. J. Thomson et al., “Embryonic Stem Cell Lines Derived from Human Blastocysts,” *Science* 282 (1998): 1145–1147.



Subsequent experiments have induced stem cell lines to differentiate into the precursors of several mature tissue types, including neurons. Stem cell lines can be frozen, stored, and grown again once thawed.<sup>20</sup> Thus immortalization permits the arrest, immobilization, and redeployment of undifferentiated cells at specific points in their development, and the reactivation of differentiating activity on command.

This, then, is the process that President Bush refers to when he says that life-and-death decisions have already been made. There is a clear implication here that the creation of a stem cell line involves the death of the embryo. But what actually dies in the establishment of a cell line? The embryo's tissues are not destroyed in the process—rather, they are removed from one form of organization, the blastocystic, whose order depends on particular patterns of intercell communication and gene-cytoplasm interactions,<sup>21</sup> to another form, the cloned cell line, where tissues reproduce but do not differentiate or self-organize. Immortalized cell lines are certainly, almost frighteningly, alive; cell-line technology involves the deactivation of apoptosis, or programmed cell death. A cell line, if properly maintained, is self-perpetuating and self-expanding to an infinite degree—literally immortal. Cell lines can be subdivided and distributed to different growth cultures and will continue to expand without interruption. The HeLa cell line was the first human cell line to be established in the 1950s, derived from the cervical cells of one Henrietta Lacks, who died from cervical cancer shortly after the cell culture was established; the HeLa line is now used in laboratories throughout the world, and has four hundred times the body mass of the woman whose cells were used in its establishment.<sup>22</sup> A stem cell line displays even more vitality, in the sense that the cells retain their pluripotency, their ability to generate new kinds of tissues. As Thomas Okarma, president and CEO of Geron Corporation, has observed: “Because of pluripotency and infinite self-renewal, hES cells [*human embryonic stem cells*] are perhaps the most extraordinary cells ever discovered. Their discovery certainly qualifies as one of the major breakthroughs in biomedicine.”<sup>23</sup>

20. CMOEG, *Stem Cell Research* (above, n. 15).

21. Wolpert, *Triumph of the Embryo* (above, n. 18).

22. Catherine Waldby, “Henrietta’s Rache” (Henrietta’s revenge), *Triebwerk* (October 1998): 763.

23. Thomas Okarma, “Human Embryonic Stem Cells: A Primer on the Technology and Its Medical Applications,” in Holland, Lebacqz, and Zoloth, *Human Embryonic Stem Cell Debate* (above, n. 17), pp. 3–13, on p. 5.

So what is killed when a blastocyst's cells are immortalized? One answer to this is a certain kind of humanist imperative: the imperative that the trajectory of human biological life preserves identity across time. This could be described as a biographical idea of human life, where the narrative arc that describes identity across time has been extended to include the earliest moments of ontogeny. Here the embryo is retrospectively constituted as the originary moment of a being able to enter into the human community and into culture. Certainly this way of regarding the embryo is evident in the assertion that embryos should be the bearers of full human rights, as the starting point for civil individuals. It is evident, more touchingly, among couples in IVF programs who often give names to and talk to their newly implanted embryos, willing them to become viable pregnancies and produce an infant.<sup>24</sup>

Another thing that is killed is what we would term a biographical biology. What we mean by this is a biological account of ontology based on a normative model of embryological development, one which assumes that the human body emerges ineluctably from the embryological processes. The process of normalization applies, as we will see in a moment, to the resulting human body as well as to its developmental production. Biographical biology proposes a stable developmental sequence in which human being unfolds steadily from the fertilized ovum, in a process of maturation. Biology here is goal-directed, and its goal is the production of a fully human subject. It is not difficult to detect such a biographical biology in some aspects of embryology. However, the discipline of embryology has also historically acted to complicate deterministic tendencies in molecular biology and genetics.<sup>25</sup> In what follows we want to examine the tension in some embryology texts between a biographical biology and an antidevelopmental biology that is more useful for thinking about the life and status of embryonic stem cell lines.

### Biographical Embryology

Embryology is, generally speaking, a developmental narrative concerned with processes that begin with fertilization and produce the embryo and fetus. In this sense it sets out a path of normative development in which the zygote unfolds according to predetermined stages—the twenty-three Carnegie embryonic stages that de-

24. Gaylene Becker, *The Elusive Embryo: How Men and Women Approach New Reproductive Technologies* (Berkeley: University of California Press, 2000), pp. 121–122.

25. Evelyn Fox Keller, *Refiguring Life: Metaphors of Twentieth-Century Biology* (New York: Columbia University Press, 1995).

scribe particular developmental milestones: the free blastocyst, the attaching blastocyst, implantation, the appearance of the primitive streak, and so on, followed by more gradual fetal development.<sup>26</sup> These stages convey a stable order of progressive development in which each structure throws up its successor, and the formation of the human body can be securely traced back and forth through time. In general, embryology is committed to multifactorial explanations to account for the complexity of embryological development, but with very rare exceptions, embryology textbooks habitually attribute the primary control of development to genetics, and embryological teaching tends to reflect that perspective.<sup>27</sup> So, for example, here is the introductory statement in a widely used embryology textbook.

Human embryology is the study of the human embryo and fetus. . . . The descriptive science of human embryology is basically developmental anatomy. . . . Development includes growth (an increase in the mass of tissue) and differentiation, by which is meant increasing complexity. . . . Development is under the control of the genome, which operates at several levels of organization.<sup>28</sup>

Similarly, a nonspecialist introduction to embryology states:

Embryonic development presents a fundamental problem of biological organization. From the single cell, the fertilized egg, come large numbers of cells . . . that consistently give rise to the structures of the body. How do these multitudes of cells become organised into the structures of, for example, our body—nose, eyes, limbs, and brain? What controls their individual behavior so that a global pattern emerges? And how are the organizing principles, as it were, embedded or encoded within the egg? The answer lies in cell behavior and how this behavior is controlled by genes. Genes control development.<sup>29</sup>

As Susan Oyama has demonstrated, developmental biology utilizes the idea of a genetic program in embryology and elsewhere as a guarantee of biological stability and linear, progressive processes. She argues that all privileging of genetic causality over other kinds of de-

26. Ronan Rahilly and Fabiola Muller, *Human Embryology and Teratology*, 3rd ed. (New York: Wiley-Liss, 2001), pp. 82–104.

27. In a recent essay, Anne Fausto-Sterling has demonstrated how an introductory embryology course could be revised to reflect the complex, conditionally and culturally imbricated nature of embryological development. Such an alternative science pedagogy would introduce embryology as the multidetermined, multidirectional, emergent and *contingent* ontogenesis that we describe here. See Anne Fausto-Sterling, "Science Matters, Culture Matters," *Perspectives in Biology and Medicine* 46:1 (2003): 109–124.

28. Rahilly and Muller, *Human Embryology and Teratology* (above, n. 26), p. 7.

29. Wolpert, *Triumph of the Embryo* (above, n. 18), p. 2.

developmental dynamics is a kind of preformationism,<sup>30</sup> where all information regarding the form of the embryo, and indeed the adult body, is already contained in the genes, simply awaiting expression. Hence, in genetically driven embryology, the trajectory of development is predetermined, and the preexisting form of the zygote is in some sense the same as the adult form of the body. As Oyama puts it:

[Biologists] assign formative relevance only to the DNA, where the encoded representation of the phenotype (or of the instructions for building it) is thought to reside. . . . Maturation, conceived causally rather than descriptively, is seen as a force bringing basic characteristics into being, without requiring . . . more than minimal environmental influence. Maturation is seen as driven and guided by the genes which "initiate and guide development."<sup>31</sup>

This privileging of the human genetic program as the driver of embryological processes dovetails with what John Fischer terms the potentialist position in bioethics, which upholds the existence of full human rights for the embryo and fetus. As he summarizes this position, "the development of the embryo inside the female body can be seen as a mere unfolding of a potential that is inherent in it."<sup>32</sup> The privileging of a genetic program for embryonic development has the effect of securing a preexisting identity in the genetic component of the embryo, as blueprints for development which are expressed in ontogenesis. This identity is human, as in the human genome; individual, as in the particular genetic constitution of that conception; and *normate*, as in "the constructed identity of those who, by way of the bodily configurations and cultural capital they assume, can [possess] authority and wield the power it grants them."<sup>33</sup> Ontogeny then becomes a developmental process that securely preserves that identity through time, taking it from one stage of actualization to the next to eventually produce the infant, the child, and the adult.

30. Preformationism is an ancient explanation for biological development, in which all the features of the mature organism are present in the fertilized egg in miniature. Aristotle is attributed with formulating the idea of epigenesis against that of preformation; in the former, development is understood to emerge gradually as one structure gives way to another, while in preformationism the structures all preexist and coexist.

31. Susan Oyama, *The Ontogeny of Information: Developmental Systems and Evolution* (Cambridge: Cambridge University Press, 1985), p. 26.

32. J. Fisher, "Why Potentiality Does Not Matter: A Reply to Stone," *Canadian Journal of Philosophy* 24:2 (1994): 261 (citing Peter Singer and Karen Dawson "IVF Technology and the Argument from Potential," *Philosophy and Public Affairs* 17 (1988): 89).

33. Rosemary Garland Thomson, *Extraordinary Bodies: Figuring Physical Disability in American Culture and Literature* (New York: Columbia University Press, 1997), p. 8.

A deviation from this developmental pathway produced the subject of the branch of embryology known as teratology, from the Greek *teratos*, monster. As Margrit Shildrick demonstrates in her study of monstrosity, the figure of the monster has historically been used to define and stabilize the borders of what counts as proper human life and the hierarchy of being that places healthy white male bodies at the apex of the human, and cedes lesser human status to those—women, nonwhites, the disabled—whose bodies do not conform to this norm.<sup>34</sup> Ironically, the very same stem cell research that is abjured by the Bush administration because it interrupts the human developmental ontology is also being heralded by some disability rights activists for the potential it holds to redirect abnormal development.

Teratology, however, also produces studies that can help to perturb the teleological version of ontogeny and ontology that we have sketched above. It shows the multitude of developmental pathways generated in embryonic development, and indeed the statistical rarity of the linear progressive pathway described above. So, for example, studies of abnormal blastogenesis find that 22 percent of conceptions do not progress to the establishment of an embryo, that 20 percent of clinically recognized pregnancies spontaneously abort, and that the majority of these are due to chromosomal and cytological abnormality.<sup>35</sup> A laboratory analysis of 3,912 spontaneously aborted embryos found nodular embryonic tissue, cylindrical embryos without limb buds, fragmented and unorganized embryonic tissues, embryos with neural tube defects, limb abnormalities, and phenotypically normal but genetically abnormal embryos.<sup>36</sup> Other blastogenic abnormalities include conjoined twins, anomalies of placenta and umbilical cord formation, fistulas, and malformations of internal organs.<sup>37</sup>

While such studies of embryo pathology on the one hand may seem to shore up the norm of a secure developmental pathway for

34. Margrit Shildrick, *Embodying the Monster: Encounters with the Vulnerable Self* (London: Sage, 2002).

35. Dagmar Kalousek, "The Effect of Confined Placental Mosaicism on the Development of the Human Aneuploid Conceptus," in *Blastogenesis: Normal and Abnormal*, ed. J. Opitz and N. Paul (New York: Wiley-Liss, 1993), pp. 39–51.

36. Dagmar Kalousek, T. Pantzar, M. Tsai, and B. Paradice, "Early Spontaneous Abortion: Morphologic and Karyotypic Findings in 3,912 Cases," in Opitz and Paul, *Blastogenesis* (above, n. 35), pp. 53–62.

37. J. Opitz, "Blastogenesis and the 'Primary Field' in Human Development," in Opitz and Paul, *Blastogenesis*, pp. 3–38.

the viable embryo, insofar as they suggest the nonviability of entities that do not follow this pathway, the *laboratory* source of those studies biases the sample, since they are focusing on those entities that were spontaneously aborted and thus never reached viability. Between the normate human being produced by the normalized developmental process, and the abnormal (teratogenic/monstrous) miscarriage, however, exists a variety of alternative developmental trajectories, from trisomy 21, to Turner's syndrome, to xy gonadal dysgenesis. When these alternate trajectories, and the beings they produce, are factored into a broader and more accurate definition of *human*, they affirm the contingency of ontogenesis, its open-endedness. This open-endedness is readily acknowledged in embryology textbooks even while the genetic role is framed as primary. So, for example, Lewis Wolpert states:

In humans, the development of identical twins or more dramatically quintuplets . . . illustrates the absence of a fixed pattern in the egg. Surprisingly, identical twins rarely arise from the separation into two cells at the two-cell stage. Instead the separation occurs much later when the embryo is made up already of many hundreds of cells. This means that in human embryos even when there are several hundred cells present the fate of the cells is not fixed.<sup>38</sup>

This open-endedness of ontogenesis is, in the case of some embryology texts, drawn on to act as a critique of gene-centrism. So the study of blastogenesis cited above states, for example, that a strict doctrine of gene action is not compatible with a properly epigenetic account of ontogeny:

At every succeeding stage of [embryonic development] novelty is created unpredictably from the preceding parts and events and not directly coded for in the genes. Genes probably do not, directly, "control" development or code for "developmental programs" but rather "act as suppliers of the material needs of development and, in some instances, as context-dependant catalysts of cellular changes." . . . There is, therefore, not a simple 1:1 correspondence between gene product and morphological event.<sup>39</sup>

The antidevelopmental implications of a properly ontogenetic, rather than classically epigenetic, account of ontogeny are fully explored in Oyama's text *The Ontogeny of Information*. Oyama's account of the process offers a useful framework for thinking about the ontological status of embryonic stem cell lines. Her object is a critique of the use of information as teleological explanation for the forma-

38. Wolpert, *Triumph of the Embryo* (above, n. 18), p. 36.

39. Opitz, "Blastogenesis and the 'Primary Field'" (above, n. 37), p. 5.

tion of embryos. Most genetic accounts of ontogenesis are preformationist by default, she argues: they are committed to the idea that the formative process of ontogenesis is preexistent in the embryonic genome, that "it exists before its utilization or expression,"<sup>40</sup> and that the essence of embryonic form resides there and gradually unfolds. Against this teleological approach she posits a contingent ontogenesis:

It is ontogenesis, the inherently orderly but contingent coming into being, that expresses what is essential about the emergence of pattern and form without trapping us in infinite cognitive regress (where was the pattern before it got here?). . . . [Developmental information] neither preexists its operations nor arises from random disorder. It is neither necessary, in an ultimate sense, nor a function of pure chance, though contingency and variation are crucial to its formation and its function. Information is a difference that makes a difference, and what it does or what it means is thus dependent on what is already in place and what alternatives are being distinguished.<sup>41</sup>

If ontogenetic development is contingent and emergent, then embryos do not have a predestined biological fate, or a biological identity that is preserved or lost through particular developmental pathways. Oyama notes the tendency to ascribe stability and predictability of development to the genotype, and variation of development to environmental effects on the phenotype, so that any deviation from a norm is attributed not to biological processes proper but to a contingent "environment." She argues that stability and variation are both products of dynamic processes, and that the equation of stability with the unfolding of preexisting biological identity in the genome "reflects and perpetuates the belief that variation is deviation from an internal ideal."<sup>42</sup>

For Oyama, ontogeny is not then the unfolding of a preexisting essence, but rather, to use Françoise Jacob's famous description of evolution, a process of "bricolage." Ontogeny does not work from a preexisting plan or genomic identity, but rather by improvising with existing sets of conditions, materials, and states of organization. It is opportunistic, taking incremental advantage of the material afforded by the embryo in whatever state it is. Oyama gives an account, following Thomas Elsdale, of the morphogenetic behavior of cultured cells, where form arises from random energetic inputs and mutual constraints by the parts:

40. Oyama, *Ontogeny of Information* (above, n. 31), p. 2.

41. *Ibid.*, p. 3.

42. *Ibid.*, p. 21.

What is crucial about the cell movements is that they are relatively small in magnitude, spontaneous and individual, and not organised at the aggregate level. Their interaction produces constraints on further movement such that an organised array results. Though they result from random movements, the arrays of cell sheets at right angles to each other are not themselves “chance” phenomena. Nor are they necessary, in the sense of being fated by a plan in the cell. . . . They become necessary however, given an assemblage of particular kinds of cells under particular conditions.<sup>43</sup>

She notes that a change of conditions, such as the introduction of an enzyme, will change the array that results, not because some pre-given natural developmental processes have been perverted but because the conditions have changed and such interdependent changes are “the essence of development.”<sup>44</sup> Once tissue arrays of various kinds are formed they can enter into higher-level interactions, which then further modify and produce cell activity.

If these kinds of emergent, multicausal, and dynamic processes are placed at the center of ontogenetic processes, it leads us to re-think the notion of biological potential, Oyama argues. As long as potential is thought of as the capacity for achieving a singular end, it will commit biology to teleological ways of understanding development. Potential should be thought of not as predetermined, but rather as

possibilities for further alterations in a given structure. . . . It is multiply, progressively determined, with new varieties of causes and consequences emerging at different hierarchical levels and with time.<sup>45</sup>

If one particular developmental trajectory is not privileged, it follows from Oyama’s argument that the resultant human being cannot be categorized as simply normal or abnormal. Neither the developmental trajectory that results in type I diabetes, nor the developmental trajectory producing a proliferation of stem cells that could ultimately be used to cure type I diabetes by replacing faulty islet cells with fully functioning ones, would be alien to the new redefinition of human life. But the boundaries of human life itself, by this logic, might be called into question.

### Stem Cells and Embryonic Life

Where does this idea of potential leave the claim that the human potential of embryos is destroyed in the production of stem cell

43. *Ibid.*, p. 118.

44. *Ibid.*, p. 119.

45. *Ibid.*, p. 120.



lines? It suggests that we must radically rethink the meaning of “human potential” in this context. Stem cell lines are produced by intervening at a particular moment in the process of embryonic self-organization and redirecting some of the forces involved in this organization. Their purpose is precisely to harness and temporally control the potential specific to this level of ontogeny, the potential of undifferentiated yet pluripotent cells to gradually commit to particular cellular types. Stem cell lines are intended to capture this potential in a form that will be therapeutically useful, able eventually to be introduced into adult bodies where they can, it is hoped, rebuild damaged tissue or supplement deficiencies. They may be therapeutically useful precisely because they are human tissues in the histological sense, in the same way that a human heart can be transplanted from one person to another, but (as yet) baboon hearts cannot.

In this sense we would argue that stem cell lines do not “destroy the human potential of the embryo”; rather, it is precisely the human potential at that level of embryonic organization that they use. They modify and redirect this potential into a viable form of living system that is histologically human, although its morphology bears no relationship to the human organism. Human stem cell lines participate in human status insofar as humans are acknowledged as “integrated colon[ies] of amoeboid beings,”<sup>46</sup> as concatenations of heterogeneous cells whose apparent coherence at the level of gross anatomy rapidly disappears at the level of cellular dynamics.

### Ontogeny and Phylogeny

When genetic engineering is combined with stem cell therapy, in the practice known as interspecific transplantation, or xenotransplantation, the notion of being histologically human, like the notion of having the potential to become human, is transcended. Instead, the marginal tissue produced by these engineered stem cells raises questions—and anxieties—not only about the biographic trajectory of identity, but about an identity’s species integrity as well. Although still experimental, interspecies transplantation is not a new procedure. As long ago as 1997, a young man with fulminate hepatic failure, or sudden liver death, underwent a form of xenotransplantation: in a process known as “extracorporeal perfusion,” his blood was cycled for six hours through an externally maintained pig’s liver that was bathed in saline and had been genetically altered so that it did not provoke an immune response, while he waited for a liver transplant. Since then, experimental xenotransplantation has

46. Keith Ansell Pearson, *Viroid Life: Perspectives on Nietzsche and the Transhuman Condition* (New York/London: Routledge, 1997), p. 124.

been carried on in the United States to treat neurodegenerative diseases. In 2000, it was reported, "researchers at Diacrin have been able to successfully transplant fetal pig neuronal cells into the human brain for the treatment of Parkinson's disease and stroke."<sup>47</sup> The United States Food and Drug Administration halted all experiments in xenotransplantation out of fear that porcine retroviruses could be transmitted to human beings.<sup>48</sup> However, such experimentation still proceeds elsewhere.

For example, at the 19th International Congress of the Transplantation Society (2002), researchers reported that a new technique of transplanting a combination of islet cells and testicular-derived Sertoli cells from fetal pigs achieved reduced insulin dependency in a small number of type I diabetics between eleven and seventeen years old. The children were thus able to live a *more normal* life, but only by virtue of assimilating within themselves nonhuman living tissues. The procedure was carried out by U.S. physicians on Mexican patients according to medical procedures approved in Mexico but not yet in the United States. The company that bred the pigs, and produced the combination of islet and Sertoli cells called "DiaVcell," obtained regulatory approval for the technology in Mexico, and has applied for it in two additional countries. But according to one source, earlier in 2002 "the company came under fire by the US government for moving ahead with their technology too quickly."<sup>49</sup>

Xenotransplantation forces the confrontation with an ontology that extends past phylogeny, transgressing boundaries of species, as well as legal and national boundaries.<sup>50</sup> Although the tissues or organs of other species are not generally classified as waste or abandoned, but rather are viewed as valuable therapeutic resources, they are treated within mainstream medicine as objects rather than subjects. Yet such techniques beg the question of the tipping point in species definition: what *amount* of tissue from another species would

47. Arlene Judith Klotzko, "IBC's Fifth Annual International Conference on Xenotransplantation," *Medscape Surgery* 2:1 (2000), at <http://www.medscape.com/viewarticle/408761> (October 8, 2002).

48. Bryn Nelson, "Alive with Help from a Pig's Liver," *Newsday*, August 20, 2002, at [www.newsday.com/news/printedition/health/ny-dsspdn2831024aug20.story?coll=ny](http://www.newsday.com/news/printedition/health/ny-dsspdn2831024aug20.story?coll=ny) (August 20, 2002).

49. Susan L. Smith, "Newsmakers, Paradigm Shakers: Highlights from the XIX International Congress of the Transplantation Society; August 25–30, 2002; Miami, Florida," *Medscape*, at <http://www.medscape.com/viewarticle/441013> (October 10, 2002).

50. Juan Dominguez-Bendala, Camillo Ricordi, and Luca Inverardi, "Stem Cells and Their Clinical Application," *Transplantation Proceedings* 34:5 (August 2002): 1372–1375.

be necessary for the ontology of the individual to be redefined? To put the question another way: what relations exist between a reconceptualization of ontogeny and a reconceptualization of phylogeny?

The well-known phenomenon of microchimerism—the fact that in xenotransplantation donor cells persist in the blood of transplant recipients—has been demonstrated clinically. A study of 160 patients who were treated therapeutically with pig tissues revealed that “[p]ersistent low-level microchimerism . . . was observed in the circulation of 23 patients.”<sup>51</sup> Despite the phenomenon of microchimerism, can genetically engineered tissues pass the immunological barrier between species? Such appears recently to have occurred with experimental use of the “DiaVcell” combination of pig islet-cell xenografts. As David White of the University of Western Ontario, who followed the progress of the Mexican children subjected to the treatment, was reported to have explained: “Patients initially mount an attack against the pig islets, but then the response fades,” probably because “the Sertoli cells that are transplanted along with the islets are actually turning off the immune response to pigs.”<sup>52</sup> If the risk of immunological rejection posed by xenotransplantation can be overcome, then sociocultural and rhetorical rather than biomedical negotiations insure that the incorporation of tissues of another species into the body of a human patient does not threaten his or her identity as a human being, even when the tissue is being grafted into the *brain*, as was the case in the Diacrin Parkinson’s disease therapeutic trials in 2000.

Thus the ontological status of the embryo is not the only thing in question. The ontological status of the graft recipient must be negotiated, when the graft involves genetically engineered stem cells from another species. And the ontological status of the illnesses to which biomedical technology responds is equally challenged, in an endless regression, as the division between veterinary and human

51. Robin A. Weiss, “Xenotransplantation: Pausing to Reflect,” *Hospital Practice: Advances in Medicine for Primary Care Physicians* 10:71, at [www.hosppract.com/issues/2000/10/weiss.htm](http://www.hosppract.com/issues/2000/10/weiss.htm) (November 8, 2002).

52. Claudette Allerdycy, “Transplantation of Pig Islet Xenografts Without Immunosuppressants Shows Some Success,” *DI zone*, Reuters, August 28, 2002, at [http://www.druginfozone.org/news/Aug02/Aug02\\_news181.html](http://www.druginfozone.org/news/Aug02/Aug02_news181.html) (October 19, 2002). “Sertoli cells are large cells extending from the basal lamina to the lumen of seminiferous tubules” (“Perikaraya of Sertoli Cells,” *Atlas of Histology*, College of Medicine at Urbana-Champaign, at <http://www.med.uiuc.edu/histo/small/atlas/objects/1152.htm> [November 8, 2002]). They produce the “blood-testis barrier” that is necessary to prevent systemic immune rejection during the process of spermatogenesis. See Dr. Thomas Caceci, “VM 8054 Veterinary Histology Example: Sertoli Cells,” at <http://education.vetmed.vt.edu/Curriculum/VM8054/Labs/Lab27/EXAMPLES/EXSERTOL.HTM> (November 8, 2002).

medicine, or between zoonoses (diseases humans can catch from animals) and what have recently been dubbed *humanooses*, is called into question.<sup>53</sup> This increasingly permeable, increasingly *constructed* barrier between human and animal presents us with another form of life to negotiate, whose boundary lies not between silicon and carbon, but rather between steps in the evolutionary ladder—or the branching developmental tree—of phylogenetic life forms. Stem cell technologies thus challenge both the temporal and spatial boundaries of human life, both our biography and our biological niche, giving a much broader meaning to the questioning of embryonic *personhood*.

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53. Gregory G. Dimijian, "Pathogens and Parasites: Strategies and Challenges," *Baylor University Medical Center Proceedings* 13 (2000): 19–29.