

School of Law

University of Missouri – Columbia



**Legal Studies Research Paper Series
Research Paper No. 2006-40**

The Ambiguous Meaning of Human Conception

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UC Davis Law Review, Vol. 40, p. 199, (Nov. 2006)

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INTRODUCTION

Nearly all of the state and federal laws that protect early embryos from the moment of conception contain a fundamental ambiguity. Contrary to common belief, there is no “moment” of conception. Instead, conception is a forty-eight hour process, during which the haploid genomes of the sperm and egg gradually and precisely transform into the functioning diploid genome of a new human

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embryo. During that two-day period, many common clinical and laboratory activities take place, including the culling of unsuitable embryos, the freezing of others, and the testing of embryos for genetic abnormalities. The legal status of these activities will depend on the point in the process of conception chosen to trigger these laws.

In this Article, I argue that laws triggered by conception should not take effect until the process of conceiving a new diploid embryo is complete. This process occurs when the embryonic genome begins to function, roughly forty-eight hours after insemination, at the eight-cell stage. Prior to that point, a new human life is *being* conceived, but has not yet *been* conceived. Although many people will find this conclusion surprising, it is consistent with both the gradual nature of the transformation from gametes to embryo and with the goals that the authors of these laws sought to accomplish.

This Article proceeds as follows: Part I outlines the laws that have made human conception a legally important benchmark. Part II examines the embryological events that occur during the transformation from two haploid gametes to a single diploid embryo and notes the stages of this transformation that might serve as the legal “moment” of conception. Part III identifies the current treatments and research activities that occur during the process of conception and notes how they would fare under the various plausible definitions of conception. Part IV then evaluates the options and recommends that laws triggered by conception take effect when the diploid embryonic genome begins to function.

I. THE LEGAL BACKGROUND

State and federal lawmakers have enacted a number of laws which either explicitly or implicitly treat early embryos as persons from the moment of conception. Many states criminalize the killing of early embryos with feticide or fetal homicide statutes.¹ Others recognize a civil claim for damages against anyone who negligently causes the wrongful death of an early embryo, including fertility clinics.² Some

¹ E.g., ARIZ. REV. STAT. ANN. § 13-11103(A)(5) (2006) (discussing manslaughter); 720 ILL. COMP. STAT. ANN. § 5/9-1.2 (West 2000); MINN. STAT. §§ 609.2661-62 (2003); MO. REV. STAT. § 1.205 (2004); WIS. STAT. ANN. § 940.04(1) (West 2004). The Illinois statute has been upheld against both equal protection and due process challenges. *United States ex rel. Ford v. Ahitow*, 888 F. Supp. 909, 914 (1995), *rev'd on other grounds*, 104 F.3d 926 (7th Cir. 1997). Likewise, the Missouri statute has been upheld against a due process challenge. *Webster v. Reprod. Health Servs.*, 492 U.S. 490, 495 (1989).

² See generally *Strzelczyk v. Jett*, 870 P.2d 730 (Mont. 1994) (interpreting MONT.

ban the conception of cloned embryos for research³ or bar non-therapeutic research on embryos.⁴ The most sweeping state laws give early embryos all of the rights and protections conferred on children.⁵ In addition, researchers in infertility and embryology laboratories are unable to qualify for federal research grants if their work involves the destruction of early embryos.⁶ President George W. Bush also prohibited research funding for studies that use embryonic stem cells derived from any (post-conception) embryos destroyed after 2001.

Conception also triggers elevated ethical and professional scrutiny among many of the ethicists who do not believe that legal personhood begins at conception. Most of the governmental commissions that have studied the propriety of scientific research using early embryos have concluded that embryos less than two weeks old are not moral persons. They have also concluded, however, that early embryos deserve more respect than ordinary human tissue, such as skin cells or sperm.⁷ This “special respect” is warranted because of the early

CODE ANN. § 41-1-103 (2003)); Dee McAree, *Wrongful Death Suit Allowed Over Embryo*, NAT'L L.J., Feb. 18, 2005, <http://www.law.com/jsp/article.jsp?id=1108389933276> (discussing decision allowing wrongful death action for accidental discard of in vitro embryos).

³ E.g., ARK. CODE ANN. §§ 20-16-1001 to 1004 (2003).

⁴ E.g., FLA. STAT. ANN. § 390.0111(6) (West 2004); LA. REV. STAT. ANN. §§ 9:121-133 (2004); ME. REV. STAT. ANN. tit. 22, § 1593 (2004); MASS. ANN. LAWS ch. 112, § 12J(a) (LexisNexis 2003); MICH. COMP. LAWS §§ 333.2685-92 (2004); MINN. STAT. ANN. §§ 145.421-22 (West 2000); MISS. CODE ANN. § 97-3-37(1) (2004); N.D. CENT. CODE §§ 14-02.2-01 to -02 (2003); 18 PA. CONS. STAT. ANN. § 3216 (West 2000); R.I. GEN. LAWS § 11-54-1(a) (2004).

⁵ See LA. REV. STAT. ANN. § 14:2(7) (2006) (defining “person” in criminal code to include unborn child from moment of fertilization and implantation); MO. REV. STAT. § 1.205; McAree, *supra* note 2.

⁶ See Pub. L. No. 108-7, § 510(b), 117 Stat. 11, 344 (2003). This provision is contained in a rider which is attached annually to the National Institutes of Health appropriations bill. See Lars Noah, Commentary, *A Postmodern Take on the Human Embryo Research Debate*, 36 CONN. L. REV. 1133, 1141 n.34 (2004) (collecting citations to annual riders extending back to first one in 1996). In addition, federal funds cannot be used for research using stem cells derived from embryos created after 2001. For an excellent overview of the history and implementation of the Bush administration's stem cell policy, see generally O. Carter Snead, *The Pedagogical Significance of the Bush Stem Cell Policy: A Window into Bioethical Regulation in the United States*, 5 YALE J. HEALTH POL'Y L. & ETHICS 491 (2005).

⁷ However, some ethicists attach no special moral status to early embryos. For a description of this view, see PRESIDENT'S COUNCIL ON BIOETHICS, HUMAN CLONING AND HUMAN DIGNITY xxxviii-xxxix (2002) [hereinafter CLONING] (describing minority recommendations); JEFF MCMAHAN, THE ETHICS OF KILLING: PROBLEMS AT THE MARGINS OF LIFE 267 (2002) (concluding that one has no moral status until one develops capacity for consciousness). For a summary of the rationales of those who attach

embryo's potential to become a person. In this respect, an early embryo is biologically different from a sperm or egg. As a result, the American Society for Reproductive Medicine recommends that early embryos not be bought or sold, that researchers and infertility clinics use the smallest possible number of embryos, and that research using early embryos be limited to projects expected to yield important clinical data.⁸ In a dispute over the custody of frozen embryos, the Tennessee Supreme Court similarly concluded that early embryos, while not yet people, are owed "special respect."⁹

All of these ethical and legal restrictions operate only after "conception" or after "fertilization," terms that are usually used synonymously.¹⁰ Thus, the application of these legal and ethical restrictions to contraceptive and laboratory activities that occur after penetration of the egg by a sperm will depend on the point in the biological process of conception that is chosen by lawmakers to be the legal "moment" of conception.

intermediate status, see CLONING, *supra*, at 170-82 and sources cited *infra* note 8. See also PHILIP G. PETERS, JR., HOW SAFE IS SAFE ENOUGH? OBLIGATIONS TO THE CHILDREN OF REPRODUCTIVE TECHNOLOGY 70-74 (2004) (reviewing literature).

⁸ See, e.g., Ethics Comm., Am. Soc'y for Reprod. Med., *Donating Spare Embryos for Embryonic Stem-Cell Research*, 78 FERTILITY & STERILITY 957, 958 (2002) (regarding embryo prior to 14 days old as "a potential human being worthy of special respect"); accord AM. COLL. OF OBSTETRICIANS & GYNECOLOGISTS, ETHICS IN OBSTETRICS AND GYNECOLOGY 97 (2d ed. 2004) [hereinafter ACOG] (discussing professional guidelines calling for use of spare embryos first, barring sale and requiring both serious need to use human embryos and prospect of significant benefits from research).

⁹ *Davis v. Davis*, 842 S.W.2d 588, 597 (Tenn. 1992) (holding that pre-embryos are not people but are entitled to "special respect").

¹⁰ Laws using fertilization itself as a freestanding benchmark for the beginning of human life include, for example, ALA. CODE § 26-22-2(8) (2004); KY. REV. STAT. ANN. § 311.720(5) (West 2004); MASS. ANN. LAWS ch. 112, § 12K (LexisNexis 2004). In the Louisiana statutes dealing with uses of in vitro embryos, the ovum is protected from "fertilization" and an "embryo" is defined as a "fertilized human ovum . . . composed of . . . genetic material so unified and organized that it will develop . . ." LA. REV. STAT. ANN. § 9:121-22 (2004). Regarding ethicists, see LEON KASS, LIFE, LIBERTY AND THE DEFENSE OF DIGNITY: THE CHALLENGE FOR BIOETHICS 241-42 (2002). Also, the President's Council on Bioethics appears to use the term "fertilization" in the same way that I am using the word "conception" — to identify the point in human development when moral obligations first arise. See, e.g., PRESIDENT'S COUNCIL ON BIOETHICS, MONITORING STEM CELL RESEARCH 77 (2004) [hereinafter STEM CELLS]. Like the Council, the major embryology texts describe the process as one of "fertilization" rather than "conception." See, e.g., WILLIAM J. LARSEN, HUMAN EMBRYOLOGY 18 (3d ed. 2001) [hereinafter LARSEN] (describing process as fusion of sperm and oocyte membranes); KEITH L. MOORE & T.V.N. PERSAUD, THE DEVELOPING HUMAN: CLINICALLY ORIENTED EMBRYOLOGY 39-40 (7th ed. 2003); RONAN O'RAHILLY & FABIOLA MULLER, HUMAN EMBRYOLOGY & TERATOLOGY 31 (3d ed. 2001).

Surprisingly, however, “conception” lacks a precise and widely-accepted meaning among scientists and ethicists.¹¹ The definition of “fertilization” is similarly ambiguous.¹² Although most people share the belief that fertilization and conception occur when sperm and egg combine to form a *new human organism*, the consensus ends there. At one extreme sits the Louisiana legislature, which believes that conception occurs, and full legal personhood attaches, as soon as a sperm makes contact with the outside of the egg.¹³ At the other extreme are those who contend that conception is only complete when the early embryo implants in the uterus, roughly two weeks after insemination.¹⁴

In between these extremes are two more promising alternatives. The first alternative is offered by scholars who believe that conception occurs when the haploid genomes contributed by the egg and sperm combine to form the diploid embryonic genome, roughly twenty-four hours after insemination.¹⁵ This option, though credible, is inferior to the definition that conception occurs when the new embryonic genome begins to function. Activation of the new diploid genome, rather than assembly of the genome, completes the transformation from two functioning haploid gametes to a single diploid embryo.

Only rarely, however, have the new laws made a clear choice among these options.¹⁶ The failure to do so may reflect an unstated

¹¹ See Elizabeth Spahn & Barbara Andrade, *Mis-Conceptions: The Moment of Conception in Religion, Science, and Law*, 32 U.S.F. L. REV. 261, 295 (1998) (reviewing literature).

¹² See STEM CELLS, *supra* note 10, app. A at 163. Ideally, the two terms would be kept distinct, with fertilization referring to insemination of the egg by a sperm and conception referring to the point at which a new diploid life has been created. However, it is probably too late to reverse the tendency to use the terms as synonyms.

¹³ LA. REV. STAT. ANN. § 14:87D(4) (West, Westlaw through all 2006 First Extraordinary and Regular Sess. Acts) (“‘Conception’ means the contact of spermatozoan with the ovum.”).

¹⁴ See *infra* text accompanying notes 55-56.

¹⁵ See *infra* text accompanying notes 21-23, 84-85, 87-89.

¹⁶ When either term is defined, the definitions vary considerably from one statute to another. Some legislatures and ethicists have attempted to solve the problem by equating conception with fertilization. See, e.g., 720 ILL. COMP. STAT. ANN. § 510/2 (West 2004) (“‘Fertilization’ and ‘conception’ each mean the fertilization of a human ovum by a human sperm.”); MO. REV. STAT. § 188.015 (2004) (defining conception as fertilization of ovum of female by sperm of male); N.M. STAT. ANN. § 24-9A-1 (West 2005) (“[C]onception’ means the fertilization of the ovum”); OKL. STAT. ANN. tit. 63, § 1-730 (2004) (stating that conception means “the fertilization of the ovum of a female individual by the sperm of a male individual”); 18 PA. CONS. STAT. § 3203 (2004) (stating that conception and fertilization both occur when human spermatozoon is fused with human ovum); S.D. CODIFIED LAWS § 21-55-1 (2005)

assumption that conception occurs instantaneously when the egg is penetrated by a sperm. Yet that assumption vastly oversimplifies the complexity of the process needed to transform two separate haploid gametes into a single diploid organism. Experts widely agree that conception is a process, rather than a moment.¹⁷ In fact, it is a remarkably complex process that requires many steps and several days to complete. Only after the new diploid genome activates does the diploid stage of the human life begin.

II. THE SCIENCE

In scientific terms, the human life cycle alternates between two distinct stages: a diploid stage (human embryos, infants, and adults) and a haploid gametic stage (human eggs and sperm). During the diploid stage, all human cells have the full complement of nuclear DNA — two copies of the twenty-three distinct human chromosomes and, thus, a total of forty-six chromosomes. During the haploid stage, the diploid cells that give rise to egg and sperm go through a process called meiosis in which they shed half of their chromosomes, leaving only twenty-three unpaired chromosomes. When the gametes fuse, the process is reversed; two sets of twenty-three singleton chromosomes are matched up and eventually begin to function as a new diploid genome. With that transition, a new diploid organism comes into existence.

Laws restricting the handling of early embryos from the moment of conception reflect a desire to protect the entire diploid phase of the human life cycle. Yet, the creation of a diploid embryo from two

(stating that “conception” means “fertilization”). In addition, Nebraska defines conception as the “fecundation of the ovum by the spermatozoa.” NEB. REV. STAT. § 28-326 (2003). In one section of its laws, Louisiana defines life as beginning at conception but defines “conception” as occurring when the sperm contacts the ovum. LA. REV. STAT. ANN. § 14:87 (2004).

¹⁷ See, e.g., ACOG, *supra* note 8, at 96 (noting that fertilization is two-day process); MOORE & PERSAUD, *supra* note 10, at 31-32 (describing same process); STEM CELLS, *supra* note 10, at 76-77 (saying that it is process during which sperm and egg are transformed into third, new entity); STEM CELLS, *supra* note 10, app. A at 163 (stating that conception is more process than moment); O’RAHILLY & MULLER, *supra* note 10, at 31 (calling fertilization “a procession of events”); T.W. SADLER, LANGMAN’S MEDICAL EMBRYOLOGY 37 (8th ed. 2000) (calling fertilization “process”); Spahn & Andrade, *supra* note 11, at 278 (stating that conception is not suited to determination of “moment”); see also *Roe v. Wade*, 410 U.S. 113, 161 (1973) (discussing that conception is process). *But see* LA. REV. STAT. § 14:87D (2004) (defining “unborn child” as offspring from “moment of conception”); OKL. STAT. ANN. tit. 63, § 1-730 (West 2004) (stating “unborn child” means offspring from “moment of conception”).

haploid gametes is a remarkably complex and delicate process that takes several steps and multiple cell divisions to complete. During this period of transition, the development of the inseminated egg is not governed by either its original haploid genome or its forthcoming diploid genome. Instead, the transition is driven by materials in the cytoplasm of the egg. Thus, the period of transition is more aptly characterized as cytoplasmic than as haploid or diploid. This transitional cytoplasmic stage briefly bridges the boundary between more important haploid and diploid stages in the human life cycle.

Courts and legislatures will need to determine how far the gradual transformation from haploid to diploid organism must progress before the legal restrictions triggered by conception will take effect. An informed answer to that question requires an understanding of the biological process that transforms the haploid gametes into a diploid early embryo.

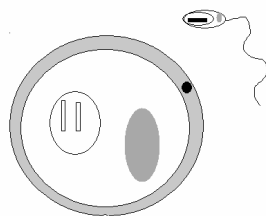
A. Insemination

The process of conception begins when a sperm attaches to the outer membrane of the egg (also called the “oocyte” or “ovum”) and begins to penetrate the egg’s outer cell wall.¹⁸ The egg still has forty-six chromosomes, rather than twenty-three, because it has not yet completed the transformation from a diploid precursor cell to a haploid ovum.¹⁹ See Figure 1 (not to scale).

¹⁸ See LARSEN, *supra* note 10, at 18 (discussing fusion of sperm and oocyte membranes); O’RAHILLY & MULLER, *supra* note 10, at 31; SADLER, *supra* note 17, at 39 (explaining second oocyte meiosis and penetration of sperm).

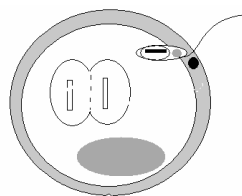
¹⁹ See LARSEN, *supra* note 10, at 18; Ann A. Kiessling, *What Is an Embryo?*, 36 CONN. L. REV. 1051, 1055-56 (2004). Only after the second division is the “secondary oocyte” transformed into the “definitive oocyte.” LARSEN, *supra* note 10, at 18. Due to the character of the two-stage meiotic division that the oocyte undergoes, its chromosomal structure at this late stage in the process is not yet reduced to the total number of chromosomes (23) required for conception, but also is no longer diploid in the conventional sense. It no longer has 23 pairs of mated chromosomes in which each of the mated chromosomes is genetically distinct from the other (i.e., diploid). Instead, its 46 chromosomes are comprised of 23 pairs of chromosomes in which each pair of chromosomes is genetically identical. Upon insemination, these two sets divide. One set of 23 maternal chromosomes remains in the egg nucleus and will become the maternal pronucleus. The other is contained in a “polar body” which will be ejected upon fertilization. See CLONING, *supra* note 7, at 66 (discussing ejection); Kiessling, *supra*, at 1057.

Figure 1. Oocyte with a double set of chromosomes (nuclear DNA). Sperm with a single set. Both have mitochondrial DNA (shaded) in their cytoplasm.



For a brief period of time after the entry of the sperm, the inseminated ovum contains both forty-six maternal chromosomes and twenty-three paternal chromosomes.²⁰ See Figure 2.

Figure 2. Sperm enters oocyte, triggering division of ovum's nuclear genome.



At this point, the inseminated egg contains all of the genes necessary for the development of a human embryo. As a result, some scientists and ethicists believe that conception is complete on entry of the sperm into the egg.²¹ Some state laws define conception in this way.²² This

²⁰ See LARSEN, *supra* note 10, at 18.

²¹ *Id.* (discussing that fertilization is complete because now diploid); STEM CELLS, *supra* note 10, at 77 (reporting that some authors have this view of fertilization); Robert John Araujo, *The Meaning of Person in the Context of Human Embryonic Cloning — Evolving Challenges for the Rule of Law in the International Order*, 1 U. ST. THOMAS L. REV. 39, 52 (2004) (“The development of each unique human being normally begins when egg and sperm have met.” (citing MOORE & PERSAUD, *supra* note 10, at 2)). Others may agree, but their terminology is more ambiguous. See, e.g., William L. Saunders, Jr., *Embryology: Inconvenient Facts*, FIRST THINGS, Dec. 2004, at 13 (“Every human being begins as a single-cell zygote.”); Patrick Lee & Robert George, *Embryology, Philosophy, & Human Dignity: Ronald Bailey Is Still Wrong*, NAT’L REV. ONLINE, Aug. 9, 2001, <http://www.nationalreview.com/comment/comment-lee080901.shtml> (“[A] distinct, living human individual comes to be with the

point may also be the one contemplated by state statutes which define fertilization as the “fusion” of sperm and egg.²³

The haploid chromosomes contributed by the egg and sperm are not immediately assembled into a new diploid genome. Instead, several preparatory steps happen. Those steps are directed by the maternal mitochondrial DNA and enzymes residing in the cytoplasm of the ovum. The sperm’s mitochondrial DNA does not play a role because it is destroyed as soon as the sperm enters the egg.²⁴ See Figure 3. Nor do the maternal and paternal chromosomes direct these preparatory steps. They are dormant and will remain inactive for roughly forty-eight hours. As a result, “initial development occurs independently of the embryonic genome and is under oocyte-derived (*i.e. maternal*) genetic control.”²⁵

Geneticist Alan Templeton explains that the nuclear DNA borne by the sperm and the egg is “chemically inactivated” during the initial hours of fertilization.²⁶ This change is accomplished by “methylating” the cytosine in the DNA, which silences the genes and makes it impossible for the cell to use the information contained in the genes. Consequently, “the initial zygotic genes cannot be expressed and therefore have no influence on development.”²⁷ The nuclear DNA contributed by mother and father are inactive during the period in which they are reassembled into a diploid genome. As a result, development is governed by instructions contained in the maternal

fertilization of the oocyte by the spermatozoan.”).

²² See, e.g., FLA. STAT. ANN. § 742.13 (West 2006) (“Fertilization’ means the initial union of an egg and sperm.”); 720 ILL. COMP. STAT. ANN. § 510/2 (5) (West 2006) (“Fertilization’ and ‘conception’ each mean the fertilization of a human ovum by a human sperm, which shall be deemed to have occurred at the time when it is known a spermatozoan has penetrated the cell membrane of the ovum.”).

²³ See ALA. CODE § 26-22-2(2) (2006) (fertilization is “the fusion of a human spermatozoon with a human ovum”); 18 PA. CONS. STAT. § 3203 (2004) (both fertilization and conception mean “the fusion of a human spermatozoon with a human ovum”).

²⁴ See CLONING, *supra* note 7, at 67; Kiessling, *supra* note 19, at 1057-58.

²⁵ O’RAHILLY & MULLER, *supra* note 10, at 38 (emphasis supplied). The nuclear DNA contributed by the both the mother and the father are not yet functioning. See *id.*, *supra* note 10, at 38-39; Kiessling, *supra* note 19, at 1051-52 (noting that human egg stores array of enzymes and other molecules which enable it to remodel chromosomes of sperm and then duplicate both sperm and egg chromosomes on its own).

²⁶ Alan R. Templeton, *When Does Life Begin? An Evolutionary Genetic Answer to a Central Ethical Question*, in *THE EMBRYO: SCIENTIFIC DISCOVERY AND MEDICAL ETHICS* 1, 12 (Shraga Blazer & Etan Z. Zimmer eds., 2005).

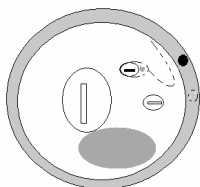
²⁷ *Id.*

cytoplasm.²⁸ Thus, this stage of the life cycle is more precisely characterized as cytoplasmic than as either haploid or diploid. As embryologists O’Rahilly and Muller observe, the forming embryo has not yet made the “transition from maternal to embryonic control”; that transfer will not occur until the new diploid embryonic genome begins to function.²⁹

B. Formation of the Pronuclei

The first step the inseminated egg takes toward the assembly and activation of the diploid genome is its ejection of the extra set of twenty-three chromosomes, leaving only the single set of twenty-three maternal chromosomes. See Figures 2 and 3. At this stage, the twenty-three maternal chromosomes and the twenty-three paternal chromosomes are stored separately, each in its own nucleus. See Figure 4.

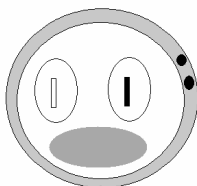
Figure 3. The membrane and mitochondria of the sperm degrade, leaving only the maternal mitochondria. One set of maternal chromosomes forms a polar body and is ejected. The other set forms the haploid maternal pronucleus.



²⁸ See Kiessling, *supra* note 19, at 1057-58. The mammalian egg is highly specialized. It stores an array of enzymes and other molecules which enable it to remodel the chromosomes of the sperm and then duplicate both sperm and egg chromosomes on its own. *Id.*

²⁹ O’RAHILLY & MULLER, *supra* note 10, at 39.

Figure 4. A second haploid pronucleus forms containing the sperm's chromosomes. Although the cell now has complementary sets of maternal and paternal chromosomes, they remain separate.

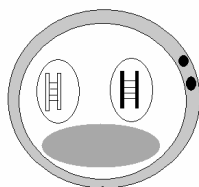


Each “pronucleus”³⁰ resembles a typical cell nucleus except that it contains only half the full complement of human chromosomes. Because the maternal and paternal chromosomes contained in the pronuclei are not yet active, the formation of the pronuclei and the next steps in preparation for genome assembly are engineered by enzymes in the maternal cytoplasm.

C. *Replication of Pronuclear DNA*

In the next stage of the process, each pronucleus duplicates its chromosomes.³¹ See Figure 5. Because the sperm head lacks the enzyme machinery that is needed to copy the paternal chromosomes,³² their duplication, like that of the chromosomes inside the maternal pronucleus, is governed by the maternal cytoplasm.

Figure 5. Maternal mitochondria instruct the DNA inside each pronucleus to replicate, resulting in enough DNA for two cells.



³⁰ See LARSEN, *supra* note 10, at 17; SADLER, *supra* note 17, at 39.

³¹ See LARSEN, *supra* note 10, at 18; MOORE & PERSAUD, *supra* note 10, at 36; SADLER, *supra* note 17, at 39; Kiessling, *supra* note 19, at 1058. The egg regulates this activity as the sperm head does not contain the necessary enzymes to copy the sperm chromosomes. See Kiessling, *supra* note 19, at 1058.

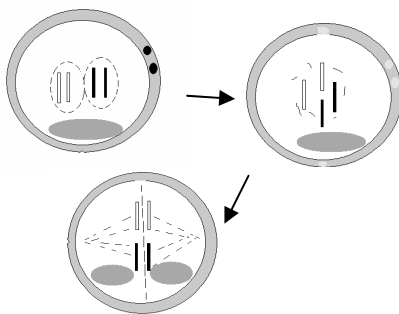
³² See Kiessling, *supra* note 19, at 1058. The nature of this enzyme reservoir is not well understood. *Id.*

After duplication, each pronucleus contains forty-six chromosomes. The combined total of ninety-two chromosomes is twice the number needed to make a single diploid embryonic cell. As a result, the eventual fusion of maternal and paternal pronuclei (“syngamy”) will be accompanied by cleavage of the inseminated egg into two cells (“cleavage”).

D. Syngamy and Cleavage

Next, the membranes surrounding the two pronuclei dissolve, ending the physical separation of the maternal and paternal chromosomes. The ninety-two chromosomes then migrate toward the center of the ovum and align themselves in anticipation of joinder.³³ See Figures 6 through 8.

Figures 6-8. The pronuclei migrate toward the center of the cell as the nuclear membrane degrades. Each pronuclei has two sets of chromosomes. The maternal and paternal chromosomes line up for fusion (syngamy) and for division into two cells (cleavage).



Once the chromosomes are properly aligned, the assembly of a diploid genome or syngamy begins.³⁴ Syngamy is accompanied by the first cell division, or cleavage.³⁵ See Figures 8 and 9.

Syngamy and cleavage usually occur about twenty-four hours after insemination.³⁶ After syngamy, the inseminated egg is called a

³³ See STEM CELLS, *supra* note 10, app. A at 163.

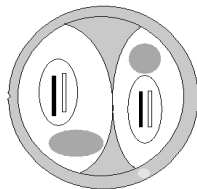
³⁴ See *id.* (discussing syngamy when DNA pair up).

³⁵ See LARSEN, *supra* note 10, at xviii, 18-20.

³⁶ See LARSEN, *supra* note 10, at xviii (stating cleavage occurs within 36 to 72 hours of insemination), 18-20 (discussing that syngamy is within 24 hours of

“zygote.” Each of the zygote’s two cells has a diploid embryonic genome.³⁷ See Figure 9.

Figure 9. Each cell has a diploid genome (two sets of matched chromosomes, one set from each parent). The genome is not yet transcribing its own proteins.



Because a diploid embryonic genome now exists, a number of authorities have concluded that syngamy and cleavage mark the point at which a new life is conceived.³⁸ Virginia law, for example, states that an embryo exists “from first cell division.”³⁹ In the United Kingdom, an embryo exists at “the appearance of a two cell zygote.”⁴⁰

insemination); STEM CELLS, *supra* note 10, app. A at 163 (explaining that syngamy happens 12 to 24 hours after ovulation).

³⁷ See O’RAHILLY & MULLER, *supra* note 10, at 33; Kiessling, *supra* note 19, at 1059.

³⁸ See LA. REV. STAT. ANN. § 9:121 (2006); ACOG, *supra* note 8, at 99 (noting fertilization ends at syngamy); O’RAHILLY & MULLER, *supra* note 10, at 31-33 (discussing that fertilization ends at cleavage); Spahn & Andrade, *supra* note 11, at 293 n.198 (stating that fertilization is complete at cleavage). Cf. MICH. COMP. LAWS § 333.16274 (2006) (finding human embryo is “a human egg cell with a full genetic composition capable of differentiating and maturing into a complete human being”).

³⁹ VA. CODE ANN. § 20-156 (2006) (“‘Embryo’ means the organism resulting from the union of a sperm and an ovum from first cell division until approximately the end of the second month of gestation.”).

⁴⁰ The United Kingdom’s Human Fertilisation and Embryology Act of 1990 states, “[F]ertilisation is not complete until the appearance of a two cell zygote.” 1990, c. 37, §§ 1, 11-16, available at http://www.opsi.gov.uk/acts/acts1990/Ukpga_19900037_en_1.htm. The conceptus is not an “embryo” until fertilization is complete. *Id.* Thereafter, it is covered by this Act. *Id.* Predictably, the term “embryo” has as many definitions as “conception.” See Kiessling, *supra* note 19, at 1065 n.33, 1068 n.72 (reviewing lay dictionaries, medical dictionaries, human embryology texts, law dictionaries, and state statutes). The definitions range from “conception” to “implantation.” Increasingly, commentators, courts, and legislators are using the term “pre-embryo” to describe the period from fertilization to implantation. *Id.* at nn.72-73. However, this has been criticized as a political decision, rather than a medical one. The Human Embryo Research Panel and the National Bioethics Advisory Commission used the term “preimplantation embryo” for the same stages. See NAT’L BIOETHICS ADVISORY COMM’N, ETHICAL ISSUES IN HUMAN STEM CELL RESEARCH, 85-86

In a dispute over the custody of frozen embryos, the Washington Supreme Court also concluded that an embryo exists from the first cell division.⁴¹ In addition, the Catholic Church and the President's Council on Bioethics appear to have concluded that syngamy constitutes the point at which conception has occurred.⁴²

E. Activation of the Embryonic Genome

At syngamy, however, the newly assembled embryonic genome is still dormant. Activation will not occur until its nuclear DNA has been demethylated and the genes begin transcribing DNA.⁴³ Many authorities believe that this occurs at about the eight-cell stage,⁴⁴ roughly forty-eight to seventy-two hours after insemination of the egg.⁴⁵ Others believe activation occurs much later. Ann Kiessling, for example, states that the embryonic genes begin synthesizing proteins at the thirty-two to sixty-four cell stage.⁴⁶ Templeton believes that the

(1999), available at <http://www.georgetown.edu/research/nrcbl/nbac/stemcell.pdf>; NAT'L INST. OF HEALTH, REPORT OF THE HUMAN EMBRYO RESEARCH PANEL D-7 (1994), available at http://osp.od.nih.gov/pdf/Volume1_revised.pdf. The President's Council on Bioethics defines an "embryo" as existing from fertilization. See CLONING, *supra* note 7, at 230.

⁴¹ The courts called this organism a "pre-embryo." See also, e.g., FLA. STAT. ANN. § 742.13 (12) (West 2006) ("Preembryo" means the product of fertilization of an egg by a sperm until the appearance of the embryonic axis"); ACOG, *supra* note 8, at 99 (defining "preembryo" as product of fertilization before 14 days and arrival of primitive streak).

⁴² See *infra* text accompanying notes 91-94.

⁴³ See Templeton, *supra* note 26, at 13.

⁴⁴ See LARSEN, *supra* note 10, at 21 (stating 8 cells at 72 hours); *id.* at 18-20 (explaining that there are 6 to 12 cells in 72 hours); O'RAHILLY & MULLER, *supra* note 10, at 39 (discussing 8-cell stage); Kiessling, *supra* note 19, at 1055 (stating that prior to genome activation, nuclear DNA contributed by both mother and father are not yet functioning). But see O'RAHILLY & MULLER, *supra* note 10, at 8 (suggesting that earlier activation is possible by stating that "the embryonic genome is not actually activated until two to eight cells are present"). The human egg stores an array of enzymes and other molecules which enable it to remodel the chromosomes of the sperm and then duplicate both sperm and egg chromosomes on its own. See Kiessling, *supra* note 19, at 1051-52; Templeton, *supra* note 26, at 12-13.

⁴⁵ See LARSEN, *supra* note 10, at 21 (discussing that there are 8 cells at 72 hours); *id.* at 18-20 (explaining development of 6 to 12 cells in 72 hours).

⁴⁶ See Kiessling, *supra* note 19, at 1060. Kiessling also states that "strong arguments can be made that fertilization is complete only when the sperm's genes are first activated," but she does not state her own conclusion. *Id.* at 1059.

new diploid genome is not sufficiently demethylated to influence development until the morula stage, roughly four to seven days after insemination when the embryo has hundreds of cells.⁴⁷ Thus, most scientists believe that the new embryonic genome takes control of embryonic development no sooner than the six- to eight-cell stage and possibly as long as several days later.

With activation of the embryonic genome, the transformation from two haploid gametes to a single diploid embryo reaches fruition. At that point, two independent organisms driven by haploid genetic engines have been transformed into a single organism that is powered by its own diploid genome.

Upon activation, the embryonic genome begins transcribing DNA into mRNA and translating mRNA into proteins. When it does, the new diploid genome assumes principal governance of the embryo's development. It takes over from the maternal enzymes that directed development during the transformation from the haploid to the diploid stages of the human life cycle.

This epigenetic event is accompanied by a change in the phenotype, or physical structure, of the embryo. Whereas the embryo did not grow in size prior to genome activation (the cells simply became successively smaller when they divided),⁴⁸ it begins to grow after reaching the eight-cell stage. It also changes in appearance. By the time it grows to thirty-two cells, "[t]he impression now conveyed is of a multicellular entity, rather than a loose packet of identical cells."⁴⁹ The cells are more adherent and tightly packed. Finally, and most importantly, the cells lose their "totipotency," or their ability to become any kind of tissue after the eight-cell stage. Until then, each cell of the pre-activation embryo can split off and become a new embryo. After activation, differentiation begins and a single cell is no longer sufficient to produce an embryo.⁵⁰

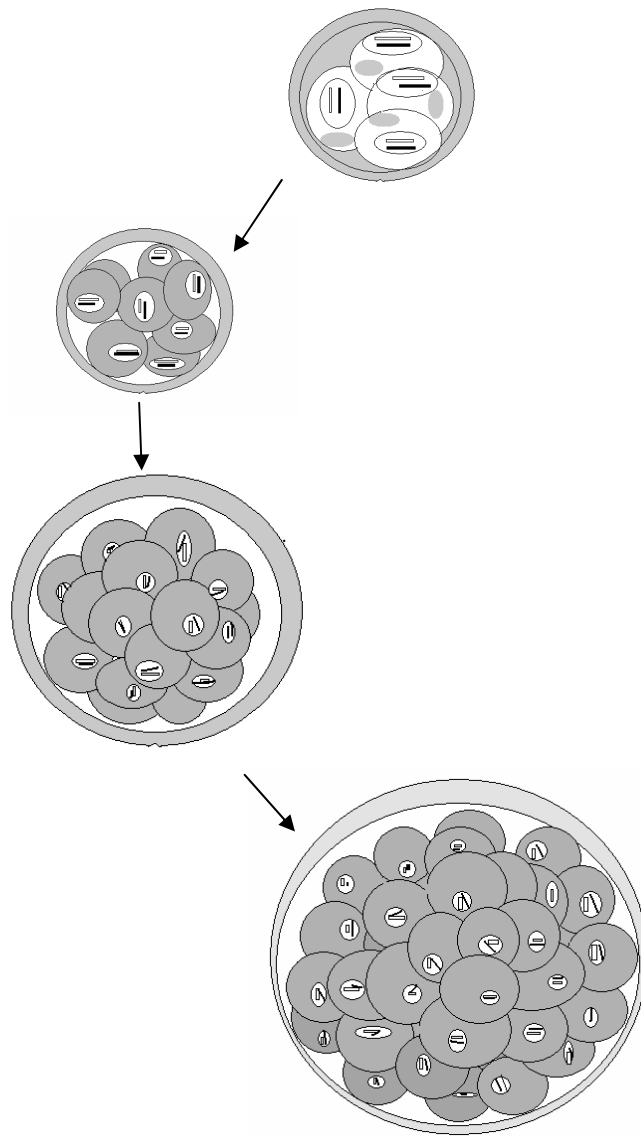
⁴⁷ Templeton, *supra* note 26, at 13.

⁴⁸ See Ethics Committee of the American Fertility Society, *Ethical Considerations of Assisted Reproductive Technologies*, 62 FERTILITY & STERILITY 1S, 29S (Supp. 1 1994).

⁴⁹ *Id.* at 30S.

⁵⁰ Late in the 8-cell stage or early in the 16-cell stage, the cells on the outside of the group become firmly attached to each other, while those on the inside remain more unconnected. C. R. AUSTIN, HUMAN EMBRYOS: THE DEBATE ON ASSISTED REPRODUCTION 10-11 (1989). In addition, the internal structure of these outer cells changes, commencing the first cell differentiation in the embryo. *Id.* at 11. These outer cells will become the placenta. *Id.* at 13. See also Alexandre Mauron, *Embryo and Fetus – I: Development from Fertilization to Birth*, in 2 THE ENCYCLOPEDIA OF BIOETHICS 707, 708 (Stephen G. Post ed., 3d ed. 2004) (noting that differentiation begins at 16-cell stage).

Figures 10-13. The early embryo divides into four diploid cells. Total embryo mass remains the same, so each division makes the cells smaller. The cells are loosely packed. The cells divide again, from four to eight. Total size remains the same. The embryonic genome activates and begins transcribing enzymes (indicated by dark shading of cells). It will govern development hereafter. The cells now start compacting, the organism starts to grow in overall size as the cells continue to divide, and the first cell differentiation begins at the sixteen-cell stage.



The physical changes that occur after the eight-cell stage are consistent with the hypothesis that activation of the new embryonic genome marks the conclusion of the transformation from haploid gametes to diploid early embryo and the beginning of independent embryonic existence.⁵¹ This shift in both genetic governance and developmental trajectory signals the end of the transition period during which development is governed by cytoplasmic maternal enzymes. It also signals the beginning of existence as a diploid organism.

F. Implantation

Implantation of the embryo in the uterus usually begins five or six days after insemination and finishes by the end of the second week.⁵² When it is complete, the possibility of the single embryo splitting into multiple embryos (“twinning”) ends.⁵³ In addition, the process of organ formation begins with the appearance of the primitive streak, the very early precursor of the spinal column.⁵⁴ A few authorities contend that the process of conception ends only when the embryo is implanted in the uterus.⁵⁵ Until the possibility of twinning ends,

⁵¹ See Carol A. Tauer, *Embryo and Fetus – II: Embryo Research*, in 2 THE ENCYCLOPEDIA OF BIOETHICS 707, 717 (Stephen G. Post ed., 3d ed. 2004) (describing, but not proposing, this view: “Arguably the embryo begins its own life distinct from that of the oocyte at the time that its own internal regulatory mechanism begins to function”).

⁵² See ACOG, *supra* note 8, at 99 (stating that implantation begins at day 5 to 7 and concludes by day 8 or 9); LARSEN, *supra* note 10, at 21 (noting starts on day 5); *id.* at xviii (discussing that process ends at days 7 to 12); MOORE & PERSAUD, *supra* note 10, at 41 (discussing implantation starts on day 5), 44 (explaining implantation done by day 14); O’RAHILLY & MULLER, *supra* note 10, at 40 (stating implantation starts on day 6).

⁵³ See ACOG, *supra* note 8, at 96.

⁵⁴ See, e.g., LARSEN, *supra* note 10, at xviii (noting primitive streak appears at day 13). Twinning can occur even after the preembryo’s cells are no longer identical and totipotent. See ACOG, *supra* note 8, at 96 (noting that twinning is possible even as primitive streak begins to form, although such twinning is often incomplete, resulting in conjoined twins).

⁵⁵ See MILLER-KEANE ENCYCLOPEDIA & DICTIONARY OF MEDICINE, NURSING & ALLIED HEALTH 406 (7th ed. 2003) (defining conception as “the onset of pregnancy, marked by implantation of the blastocyst; the formation of a viable zygote”); 1 OXFORD COMPANION TO MEDICINE 254 (1986) (defining conception as “the fertilization of an ovum by a spermatozoon and the implantation of the resulting zygote”); SLOANE-DORLAND ANNOTATED MEDICAL-LEGAL DICTIONARY 131 (Supp. 1992) (defining conception as “the onset of pregnancy, marked by implantation of the blastocyst”); Spahn & Andrade, *supra* note 11, at 294.

“there is no intrinsic one-to-one relationship between the zygote . . . and the born human.”⁵⁶

III. CONSEQUENCES OF THE CHOICE

The process of conception begins with insemination of the egg and arguably ends as late as implantation in the uterus. During this period of transition, many clinically important and socially controversial procedures take place. During the forty-eight hours needed for the fertilized egg to fashion a functioning genome, fertility clinics, obstetricians, and embryologists sort out unhealthy embryos, freeze and store embryos, discard some frozen embryos, destroy embryos in scientific research, and test embryos for genetic defects. Additionally, during the period between genome activation and implantation in the uterus, embryos are destroyed to obtain stem cells and birth control pills preclude implantation. In states that protect early embryos from the moment of conception, the legal status of all of these activities will turn on the stage of the process at which “conception” is deemed to occur.

One especially important activity which takes place during the process of conception is the testing of in vitro embryos for genetic abnormalities. Preimplantation genetic diagnosis (“PGD”) is performed by extracting a single cell from a four- to eight-cell embryo and then testing it for the presence of genes associated with serious genetic illness.⁵⁷ The testing process destroys the tested cell. When this test is performed, each cell in the embryo is still totipotent and, thus, has the capacity to develop into a separate child.⁵⁸

PGD extracts and destroys one of these totipotent cells. The legal status of that cell turns on the state’s definition of conception. If legal personhood begins at penetration of the egg by a sperm or at assembly of the dormant embryonic genome, then the extracted cell is itself a person and its destruction is a criminal act in a growing number of states.⁵⁹ If, however, conception does not occur until the embryonic

⁵⁶ Mauron, *supra* note 50, at 710.

⁵⁷ See MOORE & PERSAUD, *supra* note 10, at 40.

⁵⁸ See Ronald Bailey, *More Stubborn Facts*, NAT’L REV. ONLINE, Aug. 6, 2001, <http://www.nationalreview.com/comment/comment-bailey080601.shtml>.

⁵⁹ *Id.* Ronald Bailey uses this fact to argue against the extension of moral status to early embryos. Conservatives Patrick Lee and Robert George debated Bailey in a series of articles on the status of early embryos and did not expressly respond to his argument. Lee & George, *supra* note 21 (stating that twinning produces new individual, but not directly responding to Bailey’s contention).

genome begins to function or implantation occurs, then destruction of these totipotent cells is not prohibited.

An early definition of conception would also impede the routine practice of fertilizing many eggs and then culling the least robust embryos. Today, the rejected embryos are typically discarded. In states which impose restrictions from the time of conception, this practice can only continue if conception is deemed to occur on genome activation or at implantation.

In addition, robust but unused embryos are commonly frozen at the four-, six-, or eight-cell stage so that they can be used in the future. If infertility treatment ends before the supply is exhausted, the embryos are then donated or discarded. If legal conception does not occur until the genome begins to function, then the frozen embryos are not legal persons and can be disposed of as the parents dictate. In a state which adopts an earlier definition, however, each of these frozen embryos will have to be treated as if it were a child. In Missouri, for example, cautious clinics preserve every embryo indefinitely.⁶⁰

The definition chosen for conception will also affect the availability of surplus early embryos for use in fertility research. Under a late definition, embryos which have not yet completed conception could be used in research by embryologists and fertility specialists seeking to understand human infertility and other aspects of human reproduction. This issue arose in Australia during the mid-1980s, when researchers wanted to micro-inject sperm into an egg and observe the process of fertilization up to syngamy.⁶¹ They were allowed to do this experiment despite a state law that banned research on “fertilized” eggs. If “fertilization” had been defined as the insemination of the egg by a sperm, then this research would have been illegal.

Even in states which do not have a statute conferring personhood at conception, researchers who work on inseminated eggs will be unable to obtain federal funding if the federal government chooses an early definition. Current law prohibits the use of federal funds for research which creates embryos for research or which destroys them.⁶² Under

⁶⁰ For example, Louisiana and New Mexico statutes make this explicit. LA. REV. STAT. ANN. § 9:129 (2003); N.M. STAT. ANN. § 24-9A-1(D) (West 2004).

⁶¹ See PETER SINGER, *RETHINKING LIFE AND DEATH: THE COLLAPSE OF OUR TRADITIONAL ETHICS* 96 (1994).

⁶² See Pub. L. No. 108-7, § 510(b), 117 Stat. 11, 344 (2003). The rider is attached annually to the NIH appropriations bill. See Noah, *supra* note 6, at 1141 n.34 (collecting citations to annual riders extending back to first rider in 1996).

this statute, embryos exist from the time of fertilization, but fertilization has not yet been defined.⁶³

In some states, the definition of conception will determine when the loss of an embryo poses the risk of liability for wrongful death. An Illinois trial court recently startled the infertility industry by ruling that the careless loss of in vitro embryos gave rise to an action for wrongful death.⁶⁴ Years earlier, the Illinois State's Attorney for Cook County had set the stage for this ruling by arguing that a woman's attempt to destroy an embryo produced during in vitro fertilization was analogous to an elective abortion.⁶⁵ Each of these Illinois opinions reflects an implicit belief that conception occurs at insemination or syngamy, rather than at genome activation.

Characterization of pre-activation embryos as legal persons would also invalidate the contractual agreements that infertility clinics routinely ask parents to execute prior to in vitro fertilization. These agreements typically give instructions for the disposition or custody of unused embryos. However, the custody of children cannot be transferred by contract; instead, their custody must be awarded by a court after it makes a determination of the children's best interests.⁶⁶ The imposition of this child custody rule in disputes over the custody of unused embryos would reverse all of the existing cases, none of which have treated the frozen embryos as persons.⁶⁷

Even the stem cell debate could be affected. Embryonic stem cells are harvested after genome activation, but before the developmental stage at which in vivo embryos ordinarily implant. As a result, a life-

⁶³ Noah, *supra* note 6, at 1141 (“[H]uman embryo or embryos’ includes any organism . . . that is derived by fertilization, parthenogenesis, cloning or any other means from one or more gametes or human diploid cells.”) (emphasis provided).

⁶⁴ See McAree, *supra* note 2 (allowing wrongful death action for accidental discard of in vitro embryos).

⁶⁵ See Defendant Daley's Memorandum in Opposition to Plaintiff's Consolidated Motions for Preliminary Injunction, Summary Judgment, and Permanent Injunction at 25, *Smith v. Fahner*, No. 82C4324 (N.D. Ill. Oct. 13, 1982).

⁶⁶ The “best interest of the child” standard was first articulated by Judge Cardozo in *Finlay v. Finlay*, 148 N.E. 624, 626 (N.Y. 1925). Currently, the standard is employed by all fifty states. See, e.g., Jovana Vujovia, *Family Law Chapter: Child Custody and Visitation*, 5 GEO. J. GENDER & L. 477, 487 n.43 (2004) (listing all fifty state statutes applying standard to child custody).

⁶⁷ See, e.g., *York v. Jones*, 717 F. Supp. 421, 425-27 (E.D. Va. 1989); *A.Z. v. B.Z.*, 725 N.E. 2d 1051 (Mass. 2000); *J.B. v. M.B.* 783 A.2d 707 (N.J. 2001); *Kass v. Kass*, 696 N.E.2d 174 (N.Y. 1988); *Davis v. Davis*, 842 S.W.2d 588 (Tenn. 1992); *Litowitz v. Litowitz*, 48 P.3d 261 (Wash. 2002). The Washington and Tennessee decisions expressly rejected lower court rulings that had treated the embryos as persons.

begins-at-conception law will preclude the harvesting of embryonic stem cells unless application of the law is delayed until the embryo implants.

All of these activities will be greatly affected by the legal definition given to conception. Part IV evaluates the options.

IV. THE OPTIONS AND THE CONSIDERATIONS

Because the transition from the haploid genomes of the sperm and egg to the functioning diploid genome of an early embryo is gradual and extends over several days, the normative question is how far the process must advance before the living cells which undergo it are entitled to the protections and legal status assigned by laws triggered at conception. Although only a few scholars have attempted to answer this question, those who have done so have reached very different conclusions. Several possibilities have been suggested, including (1) penetration of the ovum by a sperm, (2) assembly of the new embryonic genome, (3) successful activation of that genome, and (4) implantation of the embryo in the uterus. Choosing among these options obliges us to identify the attributes that make early embryos morally different from sperm and egg and to identify the point in the process of transformation when those attributes appear.

There is no formal legislative history to guide the courts on this question. Indeed, most of the lawmakers who voted in favor of these statutes probably assumed that the transition occurs as the sperm penetrates the egg. Because that assumption is incorrect, the courts must look elsewhere for guidance.

Under these circumstances, the search for a rationale reasonably begins by examining the arguments made by the supporters of these life-begins-at-conception laws. The four attributes of the early embryo which are most commonly offered as a basis for recognizing life from the moment of conception are (1) the fertilized egg's potential to become a child (and thus an undisputed moral agent), (2) its self-directed development, (3) its genetic completeness, and (4) its individuality.⁶⁸ The attributes of genetic completeness and self-

⁶⁸ See, e.g., KASS, *supra* note 10, at 87-88 (noting genetic completeness, distinctness, and self-direction); Lee & George, *supra* note 21 ("This new organism directs its own growth, coordinating from within all of its elements and forces toward his or her own survival and maturation."); Saunders, *supra* note 21, at 13 (emphasizing genetic completeness, genetic distinctness, and self-direction).

direction implicitly acknowledge the importance of a functioning embryonic genome. In the text which follows, I explain why this implicit threshold should be made explicit.

A. Potential

Most ethicists who believe that early embryos are moral persons place great importance on the potential of the fertilized ovum to become a child.⁶⁹ Early embryos, they contend, deserve protection long before they develop any morally important functional capacities because they have the potential to develop those capacities in the future. Although scholars vigorously debate the sufficiency of this potential for elevated moral status, there seems little reason to doubt that it is a necessary condition for conception.

Locating the onset of this potential is an elusive project, however. Arguably, similar potential is created whenever a sperm and ovum are placed in the same petri dish. Because no one seriously argues that the selection of two gametes constitutes conception, potential alone seems insufficient to explain the normative role assigned to conception.

B. Individuality

The argument for making individuality a necessary condition for moral status is built on the reasonable premise that we cannot confer moral status on someone until there is a distinct “someone” on whom to confer it.⁷⁰ Supporters of early recognition of human personhood sometimes argue that an adult human is “the same individual” who was once an embryo.⁷¹ Patrick Lee and Robert George use this notion of personal identity to anchor their views about early embryos, arguing that a living person “was never a sperm or an egg” but all of us “were once embryos.”⁷² Every adult human being around us, they contend, is the same individual who, at an earlier stage of life, was a

⁶⁹ See, e.g., KASS, *supra* note 10, at 89-90.

⁷⁰ See STEM CELLS, *supra* note 10, at 76. The individuality criterion draws on notions of genetic distinctness and life history. See, e.g., Saunders, *supra* note 21, at 13. It is also closely tied to the notions of completeness and self-direction discussed *infra* at notes 83-90.

⁷¹ See STEM CELLS, *supra* note 10, at 76.

⁷² Patrick Lee & Robert P. George, *Reason, Science, & Stem Cells: Why Killing Embryonic Human Beings Is Wrong*, NAT'L REV. ONLINE, July 20, 2001, www.nationalreview.com/comment/comment-georgeprint072001.html.

human embryo. "From zygote to irreversible coma, each human life is a single person history."⁷³

As John Harris has observed, however, it is just as reasonable to claim that a person's individual life history begins when the gametes that produced her were created or when those gametes were selected and placed in a petri dish together.⁷⁴ Harris notes that the life story of Louise Brown, the first "test-tube baby," surely began with the harvesting of an egg from a mother.⁷⁵ The fertility technique called intracytoplasmic sperm injection ("ICSI") makes this point most cogently. In ICSI, a single sperm is preselected for manual injection into a single preselected egg.⁷⁶ Thus, the complete genetic identity of the resulting embryo is fixed before fertilization. ICSI procedure illustrates that genetic identity can be determined well before conception. As a result, genetic individuality does not capture exactly what we mean when we talk about a person's conception.⁷⁷

The individuality criterion is also vulnerable to another objection. The human embryo can subdivide into two or more embryos for roughly two weeks after insemination, a point noted by the Tennessee Supreme Court when it decided not to treat frozen embryos as legal persons.⁷⁸ While assembly of the embryonic genome fixes the genetic identity of any future children, it does not fix their number. Because each twin or triplet is surely a separate individual, individuality is not fixed before the period for twinning is over.

Several members of the President's Council on Bioethics sought to solve this problem by arguing that one child exists from the moment of genome assembly and that this child is joined by a second at twinning.⁷⁹ Yet, this description of twinning misses something important. The splitting of an early embryo is not, as this argument implies, like the removal of one of Adam's ribs to create Eve. Instead, it is more like tearing a paper doll down the middle. "Mary Jane," in

⁷³ CLONING, *supra* note 7, at 153 (discussing views of those Council members opposing therapeutic cloning).

⁷⁴ See JOHN HARRIS, *WONDERWOMAN AND SUPERMAN: THE ETHICS OF HUMAN BIOTECHNOLOGY* 61 (1992).

⁷⁵ *Id.*

⁷⁶ The same life history argument can certainly be made for any woman who was conceived from an egg that was damaged by her mother's preconception ingestion of DES.

⁷⁷ Although Lee and George are right to claim that a living person was never a sperm or an egg, each of us certainly was once a sperm *and* an egg.

⁷⁸ See *Davis v. Davis*, 842 S.W.2d 588, 592-95 (Tenn. 1992) (noting that eight-celled embryo has not yet reached singleness).

⁷⁹ See CLONING, *supra* note 7, at 155.

other words, is gone and has been replaced by “Mary” and “Jane.” Surely, neither Mary’s nor Jane’s existence *as an individual* began before the split.⁸⁰

If conception does not occur until the individuality of the future child is fixed, then it does not occur until the possibility of twinning has expired. That time expires two weeks after insemination, when implantation is finished and the primitive streak appears. Although a few authorities accept this implication and argue that conception is not complete until implantation occurs,⁸¹ most reject it in favor of syngamy or genome activation.

The principal problem with treating implantation as the end of conception is its inconsistency with our ordinary use of the word conception. Although individuality may be a reasonable threshold to impose before the extension of full moral personhood,⁸² it simply does not address the events that conception is meant to describe. That meaning, despite its ambiguities, has its locus in the transition from sperm and egg to embryo. Because fixed individuality occurs long after the transition to a diploid embryo is over, it is reasonable to conclude that the normative significance of conception is not tied to fixed individuality. As a result, complete individuality should not be considered a necessary condition for conception, even though it may be a legitimate requirement for moral personhood.

C. *Self-Direction*

Self-direction is widely and correctly considered an essential characteristic of the postconception human embryo.⁸³ The drive to develop into a child distinguishes early embryos from other diploid human cells, such as skin cells. Yet, self-direction alone is not enough to justify elevated moral and legal status. If it were, we would have to

⁸⁰ See HARRIS, *supra* note 74, at 62. For this reason, one philosopher who generally believes that individual life begins at fertilization makes an exception for embryos that twin. Bernard Williams offers a “modified zygotic principle” making an exception for twins. Their individual lives begin at splitting. *Id.* at 64. However, this seems an unsatisfactory after-the-fact method of determining ex ante obligations to individuals.

⁸¹ See *supra* notes 55-56.

⁸² This is probably the sense in which New Hampshire’s embryo research statute should be read. It does not apply during the first 14 days. N.H. REV. STAT. ANN. § 168-B:15(1) (2006). Similarly, the American Society of Reproductive Medicine and the American College of Obstetrician and Gynecologists both allow experimentation only during the first two weeks. See *supra* note 8.

⁸³ See STEM CELLS, *supra* note 10, at 76.

confer similar legal status on eggs and sperm. Each has a self-directed drive to mate, make babies, and, thereby, reproduce itself. Although the drive to develop into a child is an essential attribute of the human embryo and distinguishes it from other diploid body cells, that self-direction is not sufficient to explain the normative significance of conception.

D. Genetic Completeness

The embryo's genetic completeness distinguishes the early embryo from the haploid gametes which produced it.⁸⁴ Once the egg is genetically complete, notes William Saunders, "[e]ach human being is genetically the same human being at every stage, despite changes in his or her appearance."⁸⁵

Proponents of elevated moral status from the time of conception typically point out that early embryos combine genetic completeness with self-direction. They are right to argue that the combination of genetic completeness and internal propulsion has normative significance. This combination of attributes distinguishes early embryos from gametes (which are self-directed, but haploid) and from ordinary body cells (which are diploid, but not propelled to become an embryo).

A few experts believe that these two conditions are satisfied as soon as a sperm enters the ovum.⁸⁶ They base this conclusion on the fact that penetration of the ovum by a single sperm activates the ovum and begins a process of continuous development that, if successful, will result in the birth of a child.⁸⁷ Once the two cells have merged into one, the inseminated ovum contains all of the genetic raw material needed to build a new diploid genome and is internally propelled to do so.⁸⁸ At insemination, therefore, the future person's unique genetic code has been determined, even though it has not yet been assembled into a single diploid genome.

⁸⁴ In another sense, however, a sperm is a complete, integrated whole. Its mission is to create a future child. Thus, its distinguishing feature is not that it is incomplete in any biological sense (as, for example, an enucleated human cell would be), but that it is haploid.

⁸⁵ Saunders, *supra* note 21, at 13.

⁸⁶ See *supra* notes 20-22.

⁸⁷ See STEM CELLS, *supra* note 10, at 76-77 (reporting that some ethicists endorse this view).

⁸⁸ Cf. LARSEN, *supra* note 10, at 18 (claiming that fertilization ends on penetration because of genetic completeness).

Given this internal propulsion and the presence of all the needed genetic materials within the walls of the fertilized egg, supporters of this view do not see the embryo's lack of an assembled and functioning embryonic genome as critical. Instead, the eventual assembly and activation of the embryonic genome are seen as subsequent steps in a process commenced when a sperm enters the ovum. At this point, a genetically distinct and complete organism has "embarked upon its own distinctive development."⁸⁹

Yet the claims of genetic sameness and completeness vastly overstate the sharpness of the distinction between the haploid and diploid stages prior to assembly of the embryonic genome.⁹⁰ In the hours following insemination, the maternal and paternal chromosomes are segregated into separate nuclei. At this stage, the fertilized egg really has two haploid genomes, each in its own nucleus, not a diploid genome. In fact, there is no "embryonic genome" at this time. Instead, the embryo's development is being directed by maternal proteins and rDNA.

As a consequence, both conservative and liberal commentators have concluded that the entry of a sperm into the ovum is not sufficient to justify the conclusion that a new human life has been conceived. Instead, most would wait until the genome has been assembled. In effect, they acknowledge that the emerging embryo lacks sufficient self-direction and genetic completeness to deserve privileged moral and legal status before it has a diploid genome. Most probably also assume that the diploid genome will thereafter direct the embryo's development. Yet, scientists have learned that the newly formed diploid genome does not assume immediate control of the embryo's development. Instead, it remains dormant for two more cell divisions. Thus, the embryo does not become a diploid organism (i.e., one governed by a diploid genome) until it reaches at least the eight-cell stage.

E. Genome Assembly

Only with the assembly of the diploid embryonic genome does the embryo have the genetic machinery that will govern the rest of its existence. With syngamy, the maternal and paternal genes lose their separate character and become submerged in the new, unique, and diploid embryonic genome. Because syngamy marks the creation of a

⁸⁹ Saunders, *supra* note 21, at 13.

⁹⁰ However, Saunders is correct that the inseminated ovum is "genetically distinct from all other human beings" (except twins). *Id.*; accord KASS, *supra* note 10, at 87-88.

new diploid genome, it is certainly a plausible point at which to conclude that conception has occurred.

Thus far, genome assembly is the heavily favored choice. For example, the stem cell report issued by the President's Council on Bioethics states that fertilization is complete only when the two pronuclei are fused to form a new diploid genome.⁹¹ An appendix to that report states that individual human lives begin with formation of "a new complete genome" and that syngamy produces "an entity with an individual genome."⁹² William Hurlbut, a conservative member of the Council, has also written that "moral status must begin with the zygote."⁹³ The Catholic Church has quietly taken the same position. In its view, conception occurs at "the moment the zygote has formed," an event that takes place "when the nuclei of the two gametes have fused."⁹⁴

Yet, syngamy has a significant shortcoming. At syngamy, the newly assembled embryonic genome is not functioning. Until it is demethylated and begins producing proteins, the embryo's development is still governed by maternal proteins and rDNA, not by the newly assembled genome. Only with successful completion of the activation process will the transformation be complete.

⁹¹ See STEM CELLS, *supra* note 10, app. A at 163-65; see also *id.* at 76-77 (saying that some authors commence life at syngamy because there is new genome in new individual life embarking on path of continuous development). Like the Council, the major embryology texts describe the process as one of "fertilization" rather than "conception." Some of these texts state that fertilization ends upon successful penetration of the egg. See LARSEN, *supra* note 10, at 18. But most state that fertilization ends at syngamy and cleavage. See, e.g., MOORE & PERSAUD, *supra* note 10, at 39; O'RAHILLY & MULLER, *supra* note 10, at 31.

⁹² See STEM CELLS, *supra* note 10, app. A at 165. The Council also argues as follows: "Before fertilization, no new individual exists. After it, sperm and egg cells are gone — subsumed and transformed into a new, third entity capable of its own internally self-directed development." *Id.* at 76.

⁹³ CLONING, *supra* note 7, app. at 273 (statement of Dr. Hurlbut) (calling for "bright line at conception" also and, thus, apparently equating conception with fertilization).

⁹⁴ Congregation for the Doctrine of the Faith, Vatican, *Instruction on Respect for Human Life in Its Origin and on the Dignity of Procreation: Replies to Certain Questions of the Day* (1987), available at http://www.vatican.va/roman_curia/congregations/cfaith/documents/rc_con_cfaith_doc_19870222_respect-for-human-life_en.html (last visited Oct. 22, 2006). The guidance treats fertilization and conception as synonymous. *Id.*

F. *Activation of the Embryonic Genome*

The transformation of two haploid gametes into one diploid embryo concludes with activation of the embryonic genome. This event marks the end of cytoplasmic governance and the onset of diploid existence. During the cytoplasmic period, the haploid genomes contributed by sperm and egg were deactivated and their transformation was engineered by materials in the maternal cytoplasm. Cytoplasmic governance ends with activation of the embryonic genome.

Because the transition from a cytoplasmic organism to a diploid one occurs at activation of the embryonic genome, not at its assembly, lawmakers should treat genome activation as the time when a new diploid human life is conceived. Prior to that time, the post-syngamy embryo is merely a cytoplasmic organism *containing* a diploid genome, not a diploid organism *driven* by a diploid genome.

The transition into a diploid organism occurs when the embryo's nuclear DNA is demethylated and its genes begin transcribing DNA into mRNA and mRNA into proteins. This process seems to occur around the eight-cell stage, although it could occur later. With activation of the embryonic genome, the transformation from two haploid gametes to a single diploid embryo reaches fruition. Two independent gametes driven by haploid genomes have been transformed into a single organism powered by its own diploid genome. Put differently, the activation of the embryonic genome constitutes the embryo's emancipation from maternal governance.

This emancipation seems to be exactly what conservative ethicists have in mind when they explain why they ascribe significant moral status to early embryos. The President's Bioethics Council, for example, explained that the case for respecting early human embryos turns on the argument that an embryo is an "organic whole, a living member of the human species in the earliest stage of natural development, and that, given the appropriate environment, it will, by self-directed integral organic functioning, develop progressively to the next more mature stage and become first a human fetus and then a human infant."⁹⁵ Hurlbut also emphasizes the idea of overall organic unity, stating that the early embryo "is a self-sustaining and harmonious whole, a unified being with *an inherent principle of organization* that orders and guides its continuity of growth."⁹⁶ That

⁹⁵ STEM CELLS, *supra* note 10, at 76.

⁹⁶ William B. Hurlbut, *Altered Nuclear Transfer as a Morally Acceptable Means for the Procurement of Human Embryonic Stem Cells* (Dec. 2004) (unpublished paper), available at <http://www.bioethics.gov/background/hurlbut.html> (emphasis supplied).

inherent and life long principle of organization is provided by the diploid embryonic genome. Only a functioning diploid genome confers on humans the potential to develop the higher capacities that make humans morally distinct. The haploid and cytoplasmic stages in the human life cycle lack this potential.

Interestingly, the genetic and developmental significance of the shift from cytoplasmic to genomic control is simultaneously expressed in important phenotypic changes. Not only does the embryonic genome begin transcribing rDNA after activation, but the developmental trajectory of the embryo itself changes dramatically. At the eight- to sixteen-cell stage, the cells of the embryo begin to compact and the embryo shows its first signs of cell differentiation, as the cells start to separate into inner and outer layers. In addition, the embryo begins to grow in size. These physical changes confirm the biological significance of the transfer of developmental control from stored maternal proteins to the embryo's own genome. With this transfer, the process of conceiving a diploid organism ends. As a result, activation of the embryonic genome should be the time when legal conception occurs.

CONCLUSION

Conception marks the point at which the morally insignificant haploid stage of the human life cycle is succeeded by the morally important diploid stage.⁹⁷ The transformation from a pair of functioning haploid genomes to a single functioning diploid genome is a complex, multistep biological process. During the process, the inseminated ovum is functionally neither haploid nor diploid.

⁹⁷ However, it is not clear that lawmakers should define "fertilization" in the same way that they define "conception." In lay usage, fertilization probably is synonymous with insemination of the egg by a sperm. Because the term serves this simple descriptive purpose, it provides a poor vehicle for addressing the larger and ethically more crucial question of when the transformation from gamete to embryo has occurred. At present, however, policymakers and scholars often use the term fertilization for this larger purpose. The President's Council on Bioethics has already used the term "fertilization" to describe the process of creating an embryo from two gametes and, thus, to confront the larger social issue. Similarly, a number of state legislatures have equated conception with fertilization, thus putting the larger policy issue into play.

As long as legislatures use the term for this purpose and fail to define the term any further, courts will have to determine the legislature's meaning. If faced with such a challenge, courts ought to rule that fertilization, like conception, is not complete until activation of the embryonic genome.

Instead, it is passing through a transitional cytoplasmic state that serves as a bridge between the two genomic stages.

Lawmakers will have to decide how far the transformation from haploid to diploid must progress before the legal restrictions triggered by conception take effect. Two options are especially attractive. One occurs at syngamy when the diploid embryonic genome is constructed from the chromosomes contributed by the sperm and the egg. This construction occurs roughly twenty-four hours after penetration of the egg by a sperm.

Although syngamy appears to be the choice preferred by the members of the President's Council on Bioethics, it has a significant shortcoming. At syngamy, the newly assembled embryonic genome is dormant and the transformation from haploid to diploid has not yet finished. During this transformation, the chromosomes contributed by the egg and sperm are turned off and the transformation is orchestrated by mitochondrial enzymes stored in the egg's cytoplasm. This transitional period of cytoplasmic governance does not end until the embryonic genome is activated and the diploid stage commences. Prior to that, a diploid human life is being conceived, but has not yet been conceived. It is diploid in form, but not in function. That is not enough.