Erkenn (2014) 79:999–1017
DOI 10.1007/s10670-013-9540-6

ORIGINAL ARTICLE

Understanding Embryos in a Changing and Complex World: A Case of Philosophers and Historians Engaging Society

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Received: 1 October 2013 / Accepted: 1 October 2013 / Published online: 16 October 2013

Abstract The case of embryo research provides insight into the challenges for historians and philosophers of science who want to engage social issues, and even more challenges in engaging society. Yet there are opportunities in doing so. History and philosophy of science research demonstrates that the public impression of embryos does not fit with our scientific understanding. In cases where there are competing understandings of the phenomena and public impacts, we have to negotiate social responses. Historians and philosophers of science can both inform and learn from engaging in the process, by helping to recognize underlying assumptions and by demonstrating changing ideas over time and what factors have caused the changes.

1 Introduction

Philosophers and historians of science have experienced various fashions concerning norms for how "pure" or how "engaged" a "proper" professional ought to be. Ironically, recent moves to study social contexts of science as inextricably connected with and even part of the science itself have brought surprising little actual engagement with society. At the same time that we acknowledge that society shapes science, the history and philosophy of science professions as a whole and individual scholars within them have not done much to inform or be informed by that society. Leaders of our professional organizations lament, for example, that it is often science writers and journalists who write the popular books that the public buys and loves. We complain that governments and agencies do not understand the way science works or the historical development of our current knowledge, and we

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lament when government agencies or foundations cut funding streams. We can see our colleagues in more socially-oriented science and technology studies (STS) areas taking up public roles. Yet, as professionals in philosophy and history of science, most of us do little ourselves in our professional capacities to engage socially.

Should we? Should professional philosophers and historians of science engage society in some way? And if so, in what way? And to what end? My own approach has been to take my understanding of history and philosophy of science to various public venues more or less passively, accepting invitations rather than pursuing an active campaign to attract offers. In particular, I advocate for grounding any social engagement in reasons rather than intuitions as a starting point, and I have sought to start with what we have learned from philosophical examination of underlying assumptions, for example, and of the historical way science develops conclusions from evidence and argument. It is not that we have no perspective or guidance for how to think through complex problems, but rather we can start from historical examples and show what lessons those relevant episodes offer, as well as why they are relevant. We can help to identify and analyze underlying assumptions and their implications. These are some particular ways to engage socially.

There are, of course, many quite different ways to engage social issues as well as to engage society more directly. I do not mean to suggest that every individual should engage in the same way, nor even that every individual should do so at all. Rather, given the individual local contexts and demands, each individual should choose whether and how to engage and in what ways and to what ends. Each should have the opportunity and support for doing so. Some scholars such as Allan Brandt or Robert Proctor have provided deep and rich histories of the tobacco industry, for example, and have played important roles in courts by directly tackling the industry's claims about what they knew and when they knew it.

Others such as Naomi Oreskes and Eric Conway have taken messages about climate change to the public, focusing on issues of building consensus or rejecting evidence for political purposes.[1] They have drawn on the historical record and on philosophical reflections to show that particular social positions follow from particular sets of starting, and often political or non-scientific, assumptions about the scientific evidence. In particular, they show that the tobacco industry distorted evidence in order to expand the market for smoking and to reduce liability for any injury that might result, just as climate deniers send a parallel message about what they would count as evidence. These "merchants of doubt," in Oreskes's and Conway's term, continue to suggest that the absence of absolute definitive proof is the same as saying that the issue remains in doubt and that we have no established scientific grounds for social action. Historians and philosophers taking on these issues are seeking to use their own professional fields to demonstrate what they see as misuse and abuse of scientific results.

Others, such as those with Arizona State University's Consortium for Science Policy and Outcomes (CSPO), focus on applications of science in the world. They explore what outcomes result from what science, and they seek to challenge assumptions that investment in science and technology always yields positive results. Sometimes the results are not positive for society, they argue. Assessing the

[1] Brandt (2007), Oreskes and Conway (2010), Skloot (2010), Proctor (2012).

social outcomes should therefore parallel studies of scientific outcomes. As they put it, CSPO "is an intellectual network aimed at enhancing the contribution of science and technology to society's pursuit of equality, justice, freedom, and overall quality of life. CSPO's DC office expands its capacity to help decision makers and institutions grapple with the immense power and complexity of science, technology and society."[2] This group follows Arizona State University's President Michael Crow in arguing that use-inspired research is "better" than curiosity-driven research alone precisely because it is socially informed and socially engaged. There is room for philosophers and historians as part of this group, but these fields have not yet played a central role.

Alternatively, still others seek to draw on STS perspectives to challenge the status quo and even to call for social and political change. The Science for the People group based in Cambridge, Massachusetts, in the 1970s sought to disrupt social assumptions and to use science for what they saw as good in an anti-war context, for example. Some senior academics, such as Everett Mendelsohn or Garland Allen, have become politically active themselves in respectively the Middle East or Cuba, drawing on their professional perspectives to inform their political action as well as the other way around. For some activists, "socially engaged" science studies thereby includes assumptions that we should overhaul a government that is flawed and should change the world for the better, with the conviction that we as historians and philosophers somehow know what that means and that we share goals and values. I do not agree that simply by virtue of being historians and philosophers of science we know better about the world and its goals, though we may have something to contribute in particular cases. Rather, we can bring to bear our perspectives and contextualizations to analyze and assess the underlying assumptions and the issues at stake in a particular case, and can thereby inform decision-making by helping ensure that decisions are at least not made in denial of known facts.

There is obviously room for these different approaches and for others, and the workshop that led to this collection of papers invited exploration of different approaches and different kinds of messages. The papers offer a variety of examples and arguments. Here I focus on one example as a kind of case study, that of understanding embryos as a socially important category in recent years. My own approach seeks to play a moderating role. It is based in a call for reasons, for discussions and social decisions based on reasons, and for looking to science as a very powerful site for reasons when it comes to understanding the natural world. Being socially engaged with history and philosophy of science, then, involves using the professional tools of these fields to help establish what is reasonable in the realm of embryos.

Recent policy debates related to embryos have depended on a number of assumptions about factual claims. Those facts relate to both history and science. And many of the assumptions are wrong, or even more dangerous half-truths that miss important complexities and lead to simple and misleading conclusions. This paper looks at historical and scientific issues related to embryos and at implications

[2] cspo.org. Accessed 20 April 2013.

of getting the story wrong. The example introduces opportunities—and a call—for members of the history and philosophy of science community to get involved in order to improve the quality of public debate. There are many ways to do this, some of them quite minimalist and simple and yet worth doing. I am definitely not suggesting that HPS scholars will gallop in on white horses to save the day from idiocy and incompetence of the otherwise ignorant masses. But we can play a role in bringing reason and reasons to the often politically infused discussions. I offer some examples of how to do this, while recognizing that there are many others, that these approaches will not appeal to everyone, and that perhaps most importantly we need to create a climate in which engagement is valued before many younger scholars will feel they can afford to become involved.

2 Embryos in Society

From Aristotle's study of chick eggs to *Roe v. Wade*, embryos remained largely invisible and in the background.[3] Only with the advent in 1978 of in vitro fertilization (IVF), and then cloning and stem cell research, have embryos entered public debate.[4] The resulting swirl of pro-life and pro-choice arguments about abortion have clearly colored the ways embryos are perceived. I contend that there is wide public confusion about what embryos really are and about how assumptions about embryos have changed over time and in what ways. This lack of the longer-term perspective and understanding of the context for current understanding, in the case of embryos, has led to bad policy as well as to confused individual decisions.

2.1 Embryos in Policy

One example occurred with the U.S. 112th Congress. The House of Representatives held a very public discussion, when Paul Broun, Vice Presidential Candidate Paul Ryan, and others introduced a bill named the "Sanctity of Human Life Act," or H.R. 212. There these advocates sought "To provide that human life shall be deemed to begin with fertilization" (or the functional equivalent through cloning or other manipulations) and asserted that at that point "every human being shall have all the legal and constitutional attributes and privileges of personhood."[5] With this bill, they sought to define what counts as a person, a life, and an embryo. The language reflected many public discussions about early life.

Of course, a bill by a subset of one house of Congress does not make law in the U.S. In the end, the House of Representatives did not vote on this bill, and it did not proceed further. Yet the very existence of the bill and reactions to it clearly reflect the view of some significant portion of the legislative branch of government, of some religious leaders, and of at least some substantial part of the public. Some

[3] See Aristotle (1979), and more generally Maienschein (2003).

[4] Edwards and Steptoe (1980).

[5] H.R. 212, 2011, http://thomas.loc.gov/cgi-bin/query/z?c112:H.R.212.

immediately dismissed the bill as an aberration. It should not be treated so dismissively, however, because the proposal evoked considerable discussion about the moral status of embryos. Discussion of that issue continues in the form of "personhood initiatives" in a number of states and at the national level. In part, the flurry of activity came because Paul Ryan's role as Vice Presidential candidate showed that such positions that might seem extreme could actually be placed centrally in public view. Yet, again, this particular bill represents a strong statement of popular positions, some based in intuition and belief and others in scientific understanding.

Underlying assumptions reflected in the proposed bill started in the same place as the Roman Catholic Pope Pius IX. In 1869, this Pope changed the accepted Catholic position to emphasize that life begins at the moment of "conception" from the previous view that an individual person begins with "quickening" at roughly forty days.[6] The proposed bill held that a life begins at fertilization, and at that point deserves the protections of a person. In the U.S., we have no federal laws defining embryos or personhood at early developmental stages, and the proposed bill sought to fill that gap.

The only existing relevant U.S. federal legislation about embryos comes with what is called the Dickey-Wicker Amendment. This is actually part of federal funding legislation and has become a recurring rider to omnibus funding bills for NIH, stating that NIH must not use federal funds for research "in which human embryos are destroyed, discarded, or knowingly subjected to risk of injury or death greater than allowed for research on fetuses in utero under 45 CFR 46.208(a)(2) and 42 U.S.C. 289 g(b)." In particular, a human embryo is defined as "any organism, not protected as a human subject under 45 CFR 46 as of the date of enactment of this Act, that is derived by fertilization, parthenogenesis, cloning, or any other means from one or more human gametes."[7] The intention clearly has been to protect "life" at all stages, though changing technologies and changing understandings of early developmental stages make it tricky to interpret what falls under this ruling as a recent case shows.

A recent federal district court case sought to bring a judgment that would have drawn importantly on Dickey-Wicker to restrict federal funding of human embryonic stem cell research, and along the way would also have reinforced a particular definition of human embryo. In the end, the ruling was overturned, but only after appeal. It is nonetheless worth looking at the case to see what was at stake, and why embryo cases can easily involve confusion. In this case of *Sherley v. Sebelius*, two researchers claimed that they studied stem cells that come from adults (defined as any stage after the embryonic stages) and brought suit against the National Institutes of Health. They wanted to stop federal funding for human embryonic stem cell research, arguing that spending funds for such research that they considered improper was harming their ability to gain funding for their own preferred work in a highly competitive climate. Initially Judge Royce Lamberth in the District of Columbia federal district court supported the researchers, concluding

[6] Pius IX (1869).

[7] Dickey-Wicker Amendment, Public Law 104-99, 110 Statute 34 (1996).

that research on adult stem cells was better science, and including in his reasoning the assumption that embryos deserve protection from research.

Judge Lamberth argued that Dickey-Wicker clearly applied to human embryonic stem cell research, which in his interpretation involves research on embryos. Defendants argued that the research itself occurs on stem cells and not on embryos as a whole, and that the stem cell lines were generated from embryos in labs that do not rely on federal funding and therefore are not governed by Dickey-Wicker. The case was ultimately overturned on appeal, on these grounds that the production of stem cells and the research on them could in fact be divided into two distinct types of work, the first of which involves embryo research and the second of which does not. NIH funding therefore continues for the second type of work. Yet the case, and Judge Lamberth's initial reasoning, shows the complexity of our understanding of the early stages of human development, and lack of clarity about just what embryos really are.[8]

A widely held public impression, and clearly what Arkansas Representative Jay Dickey and Mississippi Senator Roger Wicker made clear in proposing their legislation, is that what we call embryos are the earliest stages of human development and are the beginning stages in a sequence that leads to adults. This is true, in a literal sense. Yet Dickey, Wicker, and many others really meant more than the literal physical sense. They saw these earliest developmental stages as not fundamentally different in kind from later stages and concluded therefore that humans deserve protection at all stages of development—perhaps even the same protection.

There is an underlying assumption in the Dickey-Wicker amendment, and definitely in the proposed Sanctity of Life bill, that we know what embryos are and that they are younger and smaller versions of us. This intention is clear from the testimony and arguments leading to the legislation. Whether embryos should be considered "persons" and whether they deserve full protection as the "Sanctity of Life Act" of 2012 proposed hangs on the question of how these earliest stages relate to later stages. There is a biological fact of the matter that tells us a great deal about the developmental stages and their relations and help illuminate how we should understand embryos. And there is an historical set of facts about how the understanding of embryos has changed, and philosophical perspectives that help uncover underlying assumptions.

2.2 Embryos in Ethics

It is not that the biology should dictate what we decide socially, I argue, but rather that our decisions should be guided by reasons and should be at the least not in contradiction with accepted scientific knowledge. Bringing historical and philosophical knowledge to bear can help illuminate what is at issue, as well as how and why different people have held different views at different times for different purposes. In fact, historians and philosophers have an important role in helping to clarify the scientific interpretations for the larger public. If we are going to make

[8] Sherley v. Sebelius (2010, 2011).

decisions that conflict with the reasons and facts of science, we should have good grounds and an understanding of the context in which we are doing so. And we should understand that we are doing so.

I have argued elsewhere that there is a tendency in the case of public understanding of embryos to want to derive an "is" from an "ought."[9] We learn in elementary philosophy courses about David Hume's warning not to draw conclusions the other way around.[10] We cannot derive an ought from an is, or in other words just because something is the case does not tell us anything about what ought to be the case. The reverse is also true: we cannot derive an is from an ought. Just because we believe something is good does not make it true. Yet in some cases such as that of social understanding of embryos, we see Judge Lamberth, Dickey and Wicker, and those proposing the Sanctity of Life Act, along with many members of the public, doing in effect just this. They start with the assumption that a human organism ought to be protected at all stages of life, including the most vulnerable or embryonic stages, and they conclude that the organism is the same kind of continuous human being that deserves protection throughout.

This being is seen as having integrity (in that it is the same individual throughout life), autonomy (in that it is its own individual and not part of another organism), and individuality (in that it has defined qualities that distinguish it from others). Moral convictions drive much of this discussion, obviously, and that is understandable. Yet, the moral assumptions cannot dictate what the biological facts are. If we accept my conviction that social and political decisions should at the least not be in contradiction with the scientific facts, then this morally-driven attempts are problematic.[11]

Our best biological understanding of embryos shows that embryos do begin with fertilization, yes, but that the developmental stages are highly plastic and able to respond in very flexible ways to changing conditions. In fact, embryos can be taken apart and still develop into adult organisms, in which case one can become two or more. Or two different embryos can be stuck together and develop as one organism, in which case one plus one (or more) becomes one. We can take embryos apart, re-engineer them, and put them back together in new ways to develop as new organisms, in which case one becomes a quite different one. In other words, there are many different ways in which an organism at fertilization does not remain a clearly defined thing all the way through to the adult stage. Therefore, the biological facts raise serious questions about what we might mean by embryos and about their

[9] Maienschein (2013).

[10] Hume (1977).

[11] Wade (1999). That there is a significant public that makes assumptions that embryos, like persons, have integrity, autonomy, and individuality became clear to me in discussions in the 105th Congress, as my diaries from staff discussions show very clearly. In addition, recent debates and public discussions circle back to these concepts repeatedly, often invoking one or all of them as arguments for why we need to protect embryos more fully. Even those with more nuanced views often point to embryos as having at the least individuality and integrity of that single, whole self, which become autonomous over time. This is not the place for a detailed discussion of the complex philosophical or theological literature on the topic.

presumed continuity. Let us look more closely at some of the most important biological facts and then at the implications.

2.3 Biological Embryos

In the beginning of each individual human, under normal circumstances, an egg cell comes together with a sperm cell in the process of fertilization. Then the fertilized egg cell divides into two cells, then into four, then eight. Up to this point, each of the cells is considered totipotent, that is having the ability to become a whole organism. If these cells are separated either in a glass dish or inside the mother, they can each give rise to individuals—1, 2, 4, 8, or some other number up to eight depending on how the cells divide.[12]

At the eight-cell stage, cells begin dividing in different ways and go on to form what is called a blastocyst. This is made up a single layer of cells that will become the placenta and that surround an inner mass of pluripotent stem cells. They are called that because they have lost the capacity to become the whole but can now give rise to a number of different kinds of cells (plural rather than total capacity, in other words). This is the point in development at which the blastocyst can be opened and the pluripotent stem cells harvested for research or medical applications.

At this point in humans (typically about the five to no later than the 14 days stage), the embryo can survive and develop apparently normally in a laboratory dish. Then it must be transplanted, so that it can attach to the uterus and begin to exchange nutrients and waste materials. At this point, the embryo prepares to begin growing and undergoing differentiation of the cells into different types. It soon undergoes separation into different kinds of cells in three different kinds of germ layers, in a stage called gastrulation. Developmental biologist Lewis Wolpert has famously repeated frequently that that gastrulation, that time when differentiation and germ layer formation occurs, is the most important moment of development.

The developing organism is still an embryo at this point, as the organ systems are only beginning to develop. Only by 8 weeks, the time when all the organ systems are in place in rudimentary form, is the developing human labeled a fetus instead of an embryo. It remains a fetus until it separates from the mother and becomes independent through birth.

The stages of human development had been outlined by the early twentieth century and are laid out in the amazing series of preserved human embryos, known as the Carnegie stages. This series was developed initially in Germany by Wilhelm His, then the collection moved to the United States and was continued by Franklin Paine Mall at the Carnegie Institution of Washington Embryology Department.[13] The reason the series matters so much is that it shows the changes over time. Any viewer can see, laid out in preserved embryos, how unformed the earliest stages are. It is very difficult to see the very earliest blobs of matter as the same kind of thing as

[12] See Maienschein (2003); NIH on "stem cell facts," and developmental biology textbooks such as Gilbert (2013), for more information.

[13] Hopwood 2000); Maienschein et al. (2005). See also the website of the Human Development Anatomy Center, accessed November 2012, http://www.medicalmuseum.mil/index.cfm?p=collections.hdac.index.

the later stages. With time and development, however, the form becomes clear and it is easy to see the fetal stages as the same kind of thing as the baby after birth. Therefore, just visually, the series suggests a transformation of the kind of thing that is developing.

With the presentation of clear evidence that the form emerges only gradually, it was clear that the nature of the embryo and fetus change very fundamentally over time. Additional examples of injured and diseased embryos and fetuses showed how much the developing individual can be affected by conditions of the environment and other accidental factors. These biological facts about the development of stages have been known for more than a century. They show what is actually the case as a basic starting point—as we understand it now, and subject to revision, of course. Yet we recall that these understandings of what is do not tell us what ought to be. We will return to such questions later. First, however, we need to complicate the story with a look at recent biological understanding of embryos.

3 Recent Biological Discoveries and Their Implications

As suggested earlier, descriptions of organisms and of human persons in legal domains often focus on issues of what are popularly thought of as autonomy, integrity, and individuality. There is, of course, a rich traditional literature exploring metaphysical, religious, historical, and other social and political meanings of individual organisms. That literature is relevant for social and political discussions, but so are the biological studies of individuals. It is on those biological meanings that I am focusing here, since the biological understanding must be at the least part of the discussions.

Three main assumptions about biological organisms that have held until quite recently, then, are that the developing human is thought to have physical as well as mental autonomy. Second, the developing human is thought to have integrity, in that the person remains the same whole entity (at least with respect to the "essential" parts) throughout life. And third, it is thought to have individuality, in that the person is one distinctive and definable individual that is different from others. These characteristics are thought to hold for adult humans, under normal healthy circumstances. Efforts such as the Sanctity of Life Act, and other legislation at the state level regarding laws for abortion and embryo disposition reflect a widespread view that embryos have the same characteristics.

Yet accumulating biological knowledge demonstrates that embryos fail each of these three tests, with significant evidence accumulating in each case. This matters in the public arena, because we presumably want our definitions and social discussions at the least not to be in contradiction with scientific knowledge. Philosophers and historians of science have a role in helping to unpack the underlying assumptions and how they have changed over time, thereby showing the need for evolving social responses in light of evolving scientific knowledge. So, let us turn to the biology.

First, the embryo does not exhibit autonomy. Though the human embryo can survive in a glass dish in the laboratory for up to the first 14 days under the right

conditions, it cannot live in the dish after that.[14] Obviously, the embryo and fetus are dependent on a uterus for nutrition and development, because they are highly dependent on the surrounding environment. This much is familiar and not surprising. In fact, adults depend on their environment as well and are not completely independent of others. We consider them autonomous.

Yet in the early developmental stages, and especially for the embryo, there is much less autonomy. The picture used to be of an embryo and then fetus lying within a womb, with a surrounding protective barrier that gives it independence. Recent studies show that the embryo depends very much on interactions with the mother for gene regulatory signals, epigenetic imprinting, and other developmental cues. The embryo and fetus are heavily dependent on external stimuli in ways that make them really integrated with and not autonomous from the environment. It is only gradually that the fetus develops all its organ systems and begins to function as an integrated unit itself. Embryos, in this sense, are a very different kind of thing than adults or even than the later fetal developmental stages.

The second factor, integrity in the sense in which the parts hold together to make a whole that retains its wholeness, might seem clearer. We think we know that the fertilized egg cell divides and divides and continues dividing, so that one cell becomes one more larger and more complex organism. This process gives the impression that the same organism retains its integrity during all those divisions. Yes, we know that under some circumstances one cell divides into two, and the two separate to become twins or two different entities, each with its own integrity.

But no, the situation is not nearly so tidy. Actually the embryo has many ways that it can lose its integrity and still continue to live. Hans Driesch showed already in the late nineteenth century with sea urchin eggs that he could shake cells apart and create twins or quadruplets artificially. That ability simply to shake apart the pieces raised serious questions about the extent to which an embryo actually has integrity.[15] Jacques Loeb's work of the same time on artificial parthenogenesis of sea urchin eggs showed that the organism did not always even need fertilization to begin developing. That raised questions about the point at which the supposed integrity begins, and how.[16]

Experimental embryologist Ross Granville Harrison went further. He took neuroblast cells from a frog embryo and cultured them in a glass dish, where they grew out into nerve fibers. The first ever tissue culture experiment in 1907 showed that parts of the whole embryo could develop separately from the others. In the period of the 1890s through 1930s, Hans Spemann carried out additional experimental work and showed that it was possible to take cells, tissues, and even body parts from one organism and transplant them to another organism. In many cases, the transplanted pieces grow in what appears to be normal ways, just in a different organism than they started out in. Furthermore, Spemann showed that he could transplant particular pieces and induce the production of new embryos. For example, one frog embryo could organize a new embryo that would then be growing

[14] McGee and Caplan (1999).

[15] Driesch (1892).

[16] Loeb (1899).

out of its side. These examples, in which transplanted parts grow elsewhere challenge any traditional notion of integrity of an individual.[17]

Even worse for claims about integrity came Beatrice Mintz's work on chimeras in mice. She showed that it was possible to take two embryos and stick them together to become a new mouse, made up of two different genetic lineages and with two different sets of variations. In her earliest cases, the mice seemed perfectly normal except for having stripes because the two embryos she put together had different pigments. Mintz carried out a number of experiments, showing a variety of ways that cells from different embryos could be combined to create new individuals altogether.[18] In this case, one plus one (or more) still equals one. The embryos throughout definitely lack integrity.

Leroy Stevens showed lack of integrity in other ways in work culminating in the 1970s. His studies, also with mice, showed that some lineages develop teratomas, with tangles of hair, teeth, and other foreign tissues in the testicles. In sorting out why this occurs, Stevens identified and named cells as pluripotent stem cells that remain in the testicles and undergo differentiation in the wrong place and in the wrong sequence.[19]

Cloning through nuclear transfer, first carried out in frogs in the 1950s, also shows lack of integrity. When researchers popped the nucleus out of one host frog and replace that nucleus with that from a donor, they destroyed the integrity of the initial egg cell and created a new organism made up of different parts. In cases with somatic cell nuclear transfer, such as that with Dolly, they went further and eliminated the step of fertilization while introducing their own kind of recombination. Again, the concept of integrity of the embryo or of the organism in the earliest stages just does not make sense here.

Individuality is the third feature in consideration. For many people this has come to mean that the DNA has an individuality that defines, or at least shapes the resulting individual organism. Yet the cloning and chimera experiments mentioned above show that we can recombine genetic materials. Furthermore, the cytoplasm contains unique material so that various recent experiments with combining bits of mitochondria or other cytoplasmic material into an embryo are creating new combinations that challenge assumptions about individuality. Beyond genetics is epigenetics, or all the multitude of factors that involve interactions of genes and the environmental, as well as developmental constraints because of past environmental events. Environmental "disruptors" can redirect the sequence of steps that would have shaped the individual, for example. Embryos are only individuals in a very general sense, and they depend heavily on their environment to define what they become.

These are all examples from before birth. Another case occurs before birth but only becomes evident afterwards. For example, msylexia is a case of conjoined twins. This rare kind of failed individuality has achieved public attention in fiction, but it occurs naturally as well. Twinning may occur when cells separate from the

[17] Harrison (1910), Hamburger (1988).

[18] Mintz (1962).

[19] Stevens (1970).

rest of the developing individual. Or in some cases, two eggs have been fertilized and become partly conjoined. The connection does not lead to formation of one normal individual, however, but to two or two parts. An individual may have part of a twin embedded, perhaps without a head or other parts. This condition challenges understanding of what we mean by an individual.

A recent example raises new and different kinds of questions about what we mean by an individual that are only beginning to become apparent. Individuality on the popular view has meant one individual organism, which began at fertilization and continues developing through cell divisions until it becomes a complex adult organism. Yet it is becoming clear that each of us is really a community, and our behavior and our history is shaped by the vast and complex population of microbes that live within us. In fact, recent estimates suggest that only about 10 % of the cells that make up each one of us are actually human. As a result, the NIH has begun the Human Microbiome Project to explore these parasites, symbionts, and community dwellers. It is already clear that different bacterial colonists in our guts affect our weight and health in a variety of ways, for example, and we may not even be able to live without them.[20] Therefore, the individuality we imagine is really a more communal and constantly changing identity. What we eat, how much we weigh, our allergies, our behaviors: all are influenced by the community of microbes that we begin to accumulate when we are born.

Stem cell science raises even deeper questions about individuality. We have seen that at the blastocyst stage, it is possible to open the embryo and extract the pluripotent stem cells. They can be cultured to generate any kind of cells in the body, hence the idea of pluripotency.[21] Once they are removed from the blastocyst, that particular blastocyst is no longer able to develop further. This necessary death of the embryo as a whole is the source of ethical concern for many. Yet the ability of the pluripotent stem cells to differentiate has made them hugely valuable for research, with considerable hope for possible therapeutic use as well.

More recently, though, researchers have come up with techniques for inducing cells, including somatic cells, to become (or at least to act as if they were) pluripotent stem cells. These induced Pluripotent Stem Cells (iPSC) have had remarkable capacities that challenge many assumptions about what we mean by individuality. Shinya Yamanaka's lab showed that it is possible to take a body cell and reprogram it with just four (and perhaps fewer) genes added. The cell was some kind of differentiated cell, perhaps a skin cell, and now it becomes a pluripotent stem cell with the ability to become different kinds of cells. Researchers have even taken these cells and reprogrammed them to become germ cells, which are then fertilized and start a new cycle. Yamanaka received a Nobel Prize in 2012 for this work, along with John Gurdon for his work starting in the 1960s on cloning.

What this research shows is that an embryo is not just an inevitable sequence of events that begin with fertilization of an egg with a sperm. It is not the case that an individual starts at that point and carries on throughout all the stages of development and differentiation. Rather, even without human intervention, the embryo divides

[20] http://commonfund.nih.gov/hmp/.

[21] Shamblott (1998), Gearhart (1998), Thomson et al. (1998).

and separates into different cells. Two embryos, or an embryo with additional cells, or a cell with additional genes can come together and result in an entirely new individual. One can come to equal more than one; one plus one can equal one; and the one we start with can become a different one over time. Clearly, individuality, integrity, and autonomy are not attributes of embryos. Clearly also, philosophers and historians can join biologists in helping to articulate what actually is the case in order to inform discussions of what ought to be the case socially and politically.

4 Advocacy for Reasoned Decisions

Stem cell science intersects with society on the coat tails of hope. In 1998, immediately with the announcement of success in harvesting and culturing human embryonic stem cells came pronouncements about the potential benefits. Soon we might be able to culture stem cells to do precisely what we need for medical therapies, the hopeful proclaimed. If only we invest more money in research, and if only we do not impose stupid regulations, and if only we allow researchers to use all those spare embryos currently wasted in fertility clinics… then we could hope.

The NIH very quickly issued a report on Stem Cell Basics and has maintained a very useful website with updated information about the science, clinical trials, and public understanding. U.S. President George W. Bush's staff relied on those NIH reports in developing the U.S. guidelines, and the agency has worked to reach the range of different audiences interested in stem cell and related research. The National Academy of Science has sought to provide additional reflective perspective with Stem Cells and the Future of Regenerative Medicine in 2002, and the NIH published a report focused explicitly on possible applications with Regenerative Medicine in 2006.

All of this activity happened very quickly after stem cell research hit the popular press, which was at the same time as the publication of results. The initial reaction was polarization among those who saw the research as an attack on embryos, on the one hand, and those who saw the possibilities for medical treatments, on the other. The debates created a niche for public commentary.

To a significant extent, it was church leaders and bioethicists who jumped into the public arena. In a few cases, historians and/or philosophers of science joined in. But many did not even when they were asked to do so. In some cases, they could have contributed to helping unpack many of the underlying assumptions or to place the work that seemed radically new in historical and broader perspective. Many who did not speak up and declined invitations to participate report that they did not feel prepared. They did not feel expert enough to contribute meaningfully. And that is understandable. Yet sometimes it is important to jump in and become prepared, to take up the issues at hand because they are there right now and somebody will step in. The lesson here is: When the press calls, answer. Answer the questions, or refer the caller to somebody who can. This might seem rather minor or unimportant, but I have had a number of reporters comment that they do not like to talk to philosophers or other humanists, who seem to think that returning a call a few days later is good

enough. They need an answer now. We can be prepared to have something to say to them.

I was in a peculiar position because my own work has been precisely in this area. In 1997 and 1998, I was working as Senior Science Advisor to Congressman, Matt Salmon. This meant I had to be careful about public engagement, though I did talk to reporters and the news media in my capacity as a faculty member. But as a congressional staff member, I had the chance to work with staff members in other offices. I worked with a Florida staff that was about to propose to outlaw genetic duplication in response to the news stories about Dolly, the cloned sheep. They didn't realize that their proposed bill would have made mothers who have identical twins into criminals. In this case, the lesson is that we have to learn to serve as staff. Nothing I did during that time showed up with my name on it. I wrote a lot of memos and reports in the name of others, and I contributed to a lot of processes that led to decisions without my name involved. And that means that I was doing it right, since the political world is an arena where congressmen and higher level appointees have the voices and staff do not. There are many opportunities on Capitol Hill or in state capitols to become involved through internships or volunteer work, and to learn tremendously as well as to help think through important issues.

Yet we all know that we do not get academic credit for participating or creating without authorship, and this makes many university faculty members reluctant to get involved. Let me be clear that I never suffered and have no complaints. In fact, I remain proud of the work I did with others' names as authors rather than mine. But most junior faculty members cannot afford not to get some credit. Many have reported feeling pressured to do only those things that will give them clear credit, and that the only things that "count" for tenure or promotions must have the author's name and level of contribution clearly indicated. I have heard from senior colleagues that they would really like to give credit for socially engaged work, but they do not feel the system will allow them to. This needs to change if we want to grow history and philosophy of science that is fully socially engaged.

I also had the chance to explain to a group of theologians and science studies scholars gathered at the National Cathedral that only in 1869 did Pope Pius IX decree that life begins at conception; before that, the Catholic assumption was that an individual life begins at 40 days or "quickening." If the Church had changed its position before, then why not again? Furthermore, the Church position, and that of many other religious groups, assumes that the embryo that starts with the fertilized egg retains its individuality throughout development—but as we have seen, history shows that this is not scientifically true in all cases. History can be useful in giving us perspective, and philosophy can be useful in revealing underlying assumptions.

I was invited to that meeting because they wanted historical perspective, and I said yes because I have been very fortunate to have supportive administrators who have encouraged taking on such roles. We had lively discussions with mutual respect for the complexity of the diverse points of view. As historians and philosophers of science, we can play a role in informing discussions. In turn, we learn what assumptions people are making and why, which can inform our understanding of how to explain the philosophy or history and may also inform the research questions we ask. We should make it easier for those who receive such

invitations to say yes and to feel validated for doing so. History and philosophy of science can inform such discussions.

On a very practical and local level, I also had the opportunity to work with Arizona Court of Appeals Judge Kessler. In the case of Jeter v Mayo, the Jeters were claiming that the Mayo-Scottsdale fertility clinic had lost some of its fertilized embryos. Mayo did not deny this fact. Yet the Jeters claimed that this amounted to Mayo's having killed the potential persons that the embryos represent; this was, they asserted, a case of wrongful death. Judge Kessler, a relative of philosopher of science Sandra Mitchell (which matters because most judges do not seek advice from external scholars, and certainly not from philosopher/historians), is a very smart man and a careful scholar. He started with the assumption that we have known for a long time that embryos are not well-defined individuals equivalent to politically-protected persons. He determined that the history of science established that embryos have not been considered as persons, and destroying them has not been considered as murder. He saw that the underlying assumptions of those arguing that destroying an embryo is killing a person are philosophically problematic, given the historical and biological context. Drawing heavily on the scholarly evidence, he ruled that the case did not involve any form of murder because the embryos are not persons.[22] Again, the message is to answer the emails or return the phone calls when somebody you have never heard of asks for help.

Other venues do provide opportunities to have a voice and also to have authorship as well as authority. I have worked with the Federal Judicial Center, carrying out education programs for federal judges in their own courts. This has led to lecture invitations at the 9th, 10th, and 11th Circuit courts and the chance to talk to hundreds of judges and lawyers who probably know little about embryos, but who may well face cases in the future and remember what we discussed. In fact, when I spoke most recently to the Circuit Court at a meeting in Florida, I told them about Judge Royce Lamberth's ruling and that we were waiting for him to address the decision of a higher court that had thrown the case back to him.

In fact, he made the decision that afternoon, hours after I spoke about the issues involved. As I walked around the Disneyworld setting where the meeting was being held, I would see judges also relaxing between sessions. A number came up and thanked me, saying that they never even would have noticed the Lamberth case if we hadn't discussed it and they would not have understood the issues involved. A significant number also told me that they had believed before my talk that they were opposed to any kind of embryo research, but now that they understand the scientific facts better, they were rethinking how to interpret those facts. At the same time, a half dozen or so of the conservative judges had walked out in protest of the fact that I had been invited to speak about embryos as the opening and keynote speaker for the conference. So, we do not get everybody to listen, but we can learn from them about what the questions are for them as well as how to communicate more effectively about our own research results. And occasionally, if we are lucky, we can make a difference; sometimes that difference is even visible and has wider impact.

[22] For a summary, see Heathcotte (2005).

5 Consequently

I have offered here just some very simple examples of ways in which there is a role for history and philosophy of science in engaging society. We can inform the discussions in some cases, but this is not a matter of our being *the* experts with *the* knowledge that we need to give to an ignorant public so that they will come to the right political view. No, instead we have expertise in thinking through complex problems, in understanding scientific knowledge and being able to interpret that so that others can use the knowledge in their own decision-making processes. We can raise questions, challenge assumptions, and show historical contingencies that have led to particular choices that were not inevitable and that might be changed. This is a moderate view, one of advocating for reasons rather than a particular political result. Yet it does assume that the political results will benefit from being reasoned and that this is even possible.

Unfortunately, at the conference that led to this collection of papers and at other discussions about the role of social engagement for scholars, we hear repeatedly that younger scholars do not feel they can afford to do this kind of work if they are not going to get any credit for it. That means that those of us in senior positions need to work change our reward system so that those engaging the public get credit for doing so. It is difficult to change the academic system, of course, but our working to do so is especially important for junior scholars facing tenure decisions. Junior scholars need to learn to put their work engaging society on their academic cv, not just as service or outreach but as part of their research or teaching effort. Those of us in positions to make tenure decisions can do a better job of advising junior candidates and in making sure that their work is counted as part of their academic portfolio. We can do the work, encourage the work, and talk about it in ways that explain why this work as philosophers and historians is part of our academic work and is important.

I do not mean to suggest that every social or political act should count for academic credit; of course not. Rather, insofar as the work in the public arena is doing philosophical and historical work that is professionally informed, then it should "count." The National Science Foundation and other government agencies even insist on the importance of having broader impacts as part of doing scholarly work. Therefore, our working with departments and other units involved in personnel decisions is important to ensure that the stated tenure criteria include work outside the academy to have social impact is an important step. It is not helpful to hear senior scholars complain that they want to give their junior colleagues credit for their work, but it does not fit the established agenda. Ok, let's help change that agenda so that it is more inclusive of work that involves engaging socially based on the scholarly work in philosophy and history of science.

We can also do a better job with educating our graduate students. Too many academics insist that students should do their "pure" scholarship and focus on completing their coursework, research, and writing without getting distracted from their "proper" work. On this view, they should get their degrees, get a job, get tenure, and only then perhaps think of engaging wider audiences. But this is wrong if it stifles the creativity of young scholars who want to use their professional skills

to become socially engaged. We can help these students learn how to engage diverse audiences in order to understand and to present their own work better. We can think about broader impacts, not just because the National Science Foundation tells us to, but in order more effectively to engage society. Let's support those who want not just to talk about social issues, but also to talk about them in different venues and learn from the feedback they get.

Some of our colleagues have developed ways to engage effectively. Here are just four of these efforts to show the kinds of efforts underway. First, the American Association for the Advancement of Science, which they declare is the world's largest general scientific organization, developed a blog for members. Their membership numbers in the hundreds of thousands, so here was the potential for considerable impact. They invited ideas to get these blogs started. Manfred Laubichler jumped in and offered "Scientia," for the history and philosophy of science. In fact, that has become one of the most popular, most often viewed, and the blog theme that the AAAS has developed into video programs as well.

Second, also with the AAAS, Sandra Mitchell serves on the Program Committee. In this capacity, she has already helped place HPS related sessions on the annual program. Since the AAAS meets with science writers, the meeting has more coverage than any other single event. Placing HPS centrally within this group gives us a valuable venue for engaging scientists and society, looking at social issues and doing it socially. More of us engaged with AAAS can reach a wide audience.

Third, an international group has developed an informal network centered around digital HPS. The goal here is to share tools and resources to make our research better, and also to make it more accessible to those who can reach websites but not the original sources in libraries. So, the effort is both archiving and making available existing materials. And also going much further in developing new computational tools and methods that generate new knowledge. This movement has great potential for making work in HPS available to many more and different audiences that show why the research we do actually matters.

Perhaps most notably, the workshop that led to this set of papers also led to the formation of a Joint Caucus with the Philosophy of Science Association and the History of Science Society working together. This group held an informal meeting in San Diego in fall 2012 at the HSS and PSA meeting, and the room overflowed with energetic interest. Notably, the younger generation was especially keen to become involved. Many commented there and after that they worry that their advisors do not want them to stray into social engagement from the defined (and confined) academic path. That effort has led to an energetic group of scholars of all ages working to establish a web presence and other efforts that should become visible very soon. The Rotman Institute for Philosophy Engaging Science at the University of Western Ontario is also beginning to move confidently in the direction of social engagement. Some philosophers, and ethicists most commonly, have worked on public health issues and have benefitted from public funding in several countries to do so.

There are many other examples, including from the STS field more generally, and I hope that those I have left out will go to the websites emerging through AAAS, PSA, HSS, and other groups and contribute your own examples. Many

European efforts parallel these in the United States. Get involved and help others get involved by broadening the reward structure, especially for younger scholars. The future of History and Philosophy of Science as a socially engaged and publicly useful enterprise contributing to scientifically and socially informed public debate depends on you.

Acknowledgments Thanks to Angela Potochnik and the University of Cincinnati for bringing together a group to explore issues about how philosophy of science can engage social issues and society in particular. The research leading to the conference talk and this paper were supported by a number of grants from the National Science Foundation. Arizona State University, especially the Center for Biology and Society and the President's Office have provided significant support. My colleagues Richard Creath, Manfred Laubichler, a number of wonderful graduate students, and the participants at the conference have helped with lively discussions.

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