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## Transplacental and Molecular Migrations: Methyl Isocyanate Gas and Reproductive Bioeconomies in Bhopal

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### Abstract

In this article, the feminist and postcolonial frameworks of distributed reproduction and frontstaging a chemical are used to further explore the concept of global fertility chains. In particular, these approaches are used to trace reproductive bioeconomies that are traveling at the molecular and physiological levels and that link the chemical compound methyl isocyanate (MIC) involved in the 1984 Bhopal gas tragedy to the recent growth of reproductive technologies and surrogacy services in the very same city of Bhopal. The goal of this paper is to identify and contextualize the vertical and horizontal transmission of MIC-mediated chemical toxicity through different generations of human and nonhuman actors, and to understand how this toxicity connects to reproductive bioeconomies as we continue to map out global fertility chains and give particular importance to matters of place, scale, and biological borders. Distributed reproduction allows us to rethink the scope of reproduction and make legible the colonial infrastructures that support the molecular and physiological transmission of toxicities. Frontstaging the chemical MIC allows us to trace the specific pathways of colonial legacies that have assumed unfettered access to raw materials and biolabor extracted from the soil, plants, animals, and humans in Bhopal. The paper explores the role that the chemical MIC plays as a catalyst for the transplacental migration of biopolitics—thereby contributing to an extended appreciation of global fertility chains at new molecular and physiological scales.

### Keywords

Bhopal, toxicity, colonialism, reproductive technologies, surrogacy, molecular, bioeconomies

### Introduction

The Bhopal gas tragedy occurred on December 3, 1984, in the early morning hours at the Union Carbide Corporation’s pesticide plant in the city of Bhopal. One of the chemicals used to produce Union Carbide’s pesticide Sevin was the compound methyl isocyanate (MIC). There is of course controversy around the cause of the accident, but what is known is that workers at the plant that night were cleaning pipelines around a MIC holding tank. As they had likely done countless times before, water was used to wash away the grime from the pipes. On that particular occasion, however, water leaked into the holding tank where the MIC was housed. This caused a highly exothermic reaction (a chemical reaction that is accompanied by the release of heat), which resulted in the emission of forty tons of MIC gas into the night air in a matter of hours (Bhargava et al. 2010). According to the Government of Madhya Pradhesh, vapors of the MIC gas lofted throughout the night air, reportedly killing about three thousand people from the toxic fumes (Bhopal Gas Tragedy Relief and Rehabilitation 2017). Independent and non-governmental agencies claim, however, that this number is grossly underestimated and that closer to eight thousand people died during the first week following exposure to MIC gas (International Campaign for Justice in Bhopal 2019a).

Survivors of the tragedy remember their bodies being turned inside-out on the night of the disaster (International Campaign for Justice in Bhopal 2019c). The citizens in the surrounding area of the plant were not trained to evacuate or to protect themselves in the case of such a disaster. The majority of those who were affected by the initial exposure to toxic fumes were the poorest of the poor, living in slums around the Union Carbide plant (Fortun 2001). Those who were able to escape the deadly fumes by car were later noted to have had better survival rates and experienced fewer long-term health problems. Those without vehicles had attempted to run away from the fumes on foot, inhaling the toxic air. In the wake of the explosion, the toxic MIC gas, which was heavier than the surrounding air, settled low to the ground, thereby likely exposing smaller children to even higher concentrations of toxic fumes than were the adults. The direction of the wind and the density of MIC gas mattered that night.

It is reported that thousands of animals died in the immediate surrounding areas of the chemical plant and that leaves on the surrounding trees of the Union Carbide plant turned yellow and fell to the ground (Broughton 2005). Humans who died immediately were reported to have brought up bodily fluids and were foaming at the mouth (Eckerman 2005). The chemical also acted as a severe irritant of the eye so that tears flowed constantly. The International Campaign for Justice in Bhopal (2019b) claims that in the years that have followed, the Union Carbide disaster has in fact caused permanent health issues for more than five hundred thousand people. This estimate includes not only the immediate deaths resulting from the MIC gas leak, but also deaths caused by the effects of ongoing water and soil contamination resulting from the inadequate environmental cleanup efforts in the aftermath of the gas leak. Drinking water is still contaminated in some parts of the city that were directly affected by the gas back in 1984 (Bhopal Medical Appeal 2014a). Decades after the initial chemical reaction that led to the death and biological harm of so many, MIC continues to leave its imprint and influence the organization of life and death of insects, plants, nonhuman animals, and humans. As we now know, MIC gas took part in a highly exothermic reaction that lasted only a matter of seconds, but to this day, continues to serve as a catalyst for further biological, biochemical, and biopolitical reactions in Bhopal. Thus my bafflement, when just over a decade ago, I came across an article that, while highlighting several “hot spots” of reproductive tourism in India, also reported that some of cheapest surrogates available in the world at that time could be found in the city of Bhopal (Sehgal 2008).

In this paper, I frontstage MIC to better understand the molecular and physiological processes of reproductive labor and reproductive bioeconomies that are unfolding in Bhopal. I should make clear, however, that this article is not about Indian surrogacy. Scholars such as Amrita Pande (2014), Sayantani Dasgupta and Shamita Das Dasgupta (2014), Sharmila Rudrappa (2015), Sayani Mitra (2015), Kalindi Vora (2009, 2015) and more have written on this topic with far more expertise and insight than what is offered in this article. Together, these works provide a crucial body of literature for the reader who is interested in learning more specifically about surrogacy within India and within broader global contexts. Rather, in this article I am interested in contributing to ongoing conversations on colonial legacies and reproductive bioeconomies by developing a contextualized and situated materialist account of the organic compound MIC and its role in fastening and extending global fertility chains. In defining the concept of global fertility chains, Sigrid Vertommen, Vincenzo Pavone, and Michal Nahman explain that global fertility chains consist of “multiple sociotechnical actors that are transnationally connected” and that a crucial dimension of utilizing a global fertility chain framework includes analyzing a “networked input-output structure comprising multiple actors at multiple scales” (2021, 120 and 115). Integrating a postcolonial lens, they further note that a characteristic of global fertility chains is their “embeddedness in global geographies of uneven development” where questions of “space, scale, territories, localities, mobility, and borders in the reproductive bioeconomy” matter (Vertommen, Pavone, and Nahman 2021, 126). In this article, I argue that the organic chemical MIC can be thought of as a sociotechnical actor operating at a scale that is often overlooked, but nonetheless one that contributes to the infrastructure of global fertility chains. I further argue that global fertility chains can be connected and traced across countries and geopolitical borders, as well as mapped more locally by examining intra-actions (Barad 2007) that include molecular and physiological surrogates-fetus borders such as the placenta. Frontstaging MIC exposes the biologically embodied reach of global fertility chains and traces the colonial legacies of reproductive bioeconomies at both macro and molecular scales. As such, surrogacy in Bhopal provides a flashpoint for examining the ontological politics of reproduction that are in part being catalyzed by this chemical today.

### Distributed Reproduction in Bhopal and Frontstaging MIC

I have been sitting with this information for far too many years now, trying to make legible the multitude of questions that emerged for me regarding the availability, impacts, and aftermath of surrogacy services in Bhopal. Apparently, the current typical rate for surrogacy services in the United States ranges between USD$60,000 and $150,000 (American Fertility 2020). In 2008 the average cost for a surrogate in the US was approximately $70,000. The 2008 article that brought my attention to surrogacy in Bhopal reported that a “37-year old Russian came to Bhopal because she could limit her [surrogacy] expenses to merely $4,500 [USD] as opposed to the prohibitive $35,000 – 45,000 [USD] in her own country” (Sehgal 2008).

Had commissioning individuals and couples around the world, who were eager to have children, forgotten what had happened in Bhopal in 1984? Had they used the internet to conduct their research on affordable surrogacy services? Did Bhopal, India, appear as a top destination for their reproductive needs? If so, did they then conduct any follow-up research and type in the word *Bhopal* on its own into their search engines? If so, did they not come across the Bhopal gas tragedy? Did they not see the crucial medical and health advocacy work that has been going on in the city since the mid-1990s through the Sambhavna Clinic, or the fundraising and political awareness efforts made by the International Campaign for Justice in Bhopal, an organization that began just days after the gas explosion? Or, could it be that they already knew about the Bhopal gas tragedy, and despite learning about the toxicity of MIC, they decided that their desire to have a child outweighed any possible risk associated with hiring a surrogate in Bhopal? Could it have further been that their understanding of surrogacy had led them to believe that as long as the DNA or gametes came from somewhere else, their commissioned fetus would remain “untouched” by the surrogate’s biology? For Hindu couples in India, who were hiring Bhopali surrogates that belonged to a lower caste, was “untouchability” no longer an issue? Was it possible that they viewed the surrogate as merely a vessel for their own sperm and eggs or some other highly coveted DNA with a proper caste? These questions are ones that came into clear focus for me years ago. There has also been a separate set of questions that, to this day, I still cannot articulate clearly but continue to try to pose. These questions are below and I thank the reader in advance for allowing me to practice asking these questions in the space of this paper.

Was it possible that by hiring a Bhopali woman to serve as a surrogate, who in turn may have been exposed to MIC, a commissioning individual or couple (non-Indian, non-resident Indian, or Indian) had already arrived at the understanding that as humans we must learn to live with toxicity? Had they already accepted the fact that we must learn how to live in compromised times? Had they already reconciled themselves to “toxic interdependencies” but without an ethical awareness of interpellating such interdependencies through disability justice and queer relationality frameworks as suggested by feminist philosopher Alexis Shotwell (2016)? Were they ready to overlook the possible sedimentation of MIC in the soil and water in Bhopal? Back in 2008, had they already anticipated the work of feminist anthropologist Anna Tsing? In her book *The Mushroom at the End of the World* (2015), Tsing states, “To live with precarity requires more than railing at those who put us here (although that seems useful too, and I’m not against it). We might look around to notice this strange new world, and we might stretch our imaginations to grasp its contours. This is where mushrooms help. Matsutake’s willingness to emerge in blasted landscapes allows us to explore the ruin that has become our collective home” (2015, 3). Had the commissioning individual or couple gone the way of the mushroom and decided to work within the ruins of colonial devastation, environmental disasters, and industrial contamination? Did they knowingly and willingly invest in “biocapital” and a “promissory future” where foetuses are forced into emergence through the extraction of reproductive labor from surrogate bodies—despite all the contradictions of life, death, and toxicity in Bhopal (Sunder Rajan 2007)?

Along with my collaborators Banu Subramaniam and Sushmita Chatterjee, I have previously attempted to reconcile the impossibility of some of these questions by placing them through the analytic lenses of reproductive justice, feminist theory, and feminist and postcolonial STS (Roy and Subramaniam 2016; Chatterjee, Roy, and Subramaniam 2022). In this paper, I draw specifically on what feminist historian of science Michelle Murphy describes as “distributed reproduction” and the “chemical infrastructures of reproduction” (2013) to think about the role that the chemical MIC plays in “assisting” or altering reproduction in the context of Bhopal. Murphy suggests that we think about distributed reproduction as a way of reframing what counts as reproduction itself by stating, “Why should reproduction end at our bodies? How to participate in and challenge the ontological politics of ‘reproduction’? What is the place of industrial chemicals in reproduction? What is the place of industrial chemicals in reproduction if we now live in an era which some scientists have named the anthropocene—a historical period when all life, all ecosystems, and the entire planet has been rearranged by human activity?” (2013, 1).

Although my approach to studying the action of MIC is also informed by critical theory in posthumanisms and feminist materialisms, the concept of distributed reproduction is extremely useful here to think about global fertility chains and the flow of reproductive bioeconomies at a more molecular scale. It allows me to think with fresh eyes and examine the biological and genetic traces that are being left behind by the chemical MIC in both human maternal and fetal molecular reproductive environments, as well as nonhuman and dispersed reproductive life. Murphy further suggests that thinking about distributed reproduction allows us to keep in mind that infrastructures, including chemical ones, aid in “social sedimentations such as colonial legacies, the repetition of gendered norms in material culture, or the persistence of racialization” (2013, 1).

I am prompted also by what film, media, and science studies scholar Rahul Mukherjee has described as “forced intimate relationships with…chemicals” (2016, 849). In his own work on Bhopal and the production of chemical publics, he conducts a “frontstaging of non-humans” (853) in order to think about the contributions made by the chemicals. Through his use of frontstaging, Mukherjee offers what I consider to be a rich methodological approach that puts a spin on the well-honed STS practice of “following the chemical.” The frontstaging of nonhumans allows us to decenter the liberal humanist understanding of the autonomous human subject as the sole and central starting point of inquiry—a perspective commonly found in Western and European colonial thought. And although I recognize the importance feminists and others have placed on asking identity-based questions that emerge from placing historically disenfranchised humans at the center of inquiry (including work on surrogacy), this paper is trying to do something different. As I have described above, MIC continues to bring environmental and chemical events from the past into contact with new forms of matter, biotechnologies, and biocapitalism. I want to argue here that the chemical MIC itself can be thought of as a sociotechnical actor that has a hand in carving out our reproductive futures. Frontstaging MIC therefore opens a line of inquiry that is less familiar but may be more helpful in examining and challenging the specific ontological politics of reproduction taking place in Bhopal. It may also help to address the multitude of questions I have posed above that ultimately impact both humans and non-humans alike.

#### **Macro and Molecular Physiologies of MIC**

In a piece published in the anthology *Mattering: Feminism, Science and Materialism* (2016) edited by Victoria Pitts-Taylor, Banu Subramaniam and I have articulated several key methodologies to thinking about questions of ontology and materialisms. Among these methodologies are resisting the urge for any easy translation between privileged Western knowledge practices and those deemed unscientific, incoherent, or incommensurable; recognizing the situatedness and developing molecular materialist accounts of the world that are cognizant of matter across scales; articulating local points of interest within larger networks; and detecting contact zones of empire (Roy and Subramaniam 2016). In the case of MIC, it is important to acknowledge therefore that this chemical agent was initially produced and activated in Bhopal by both global and local capitalist and neoliberal economic practices. Initially intended for the production of pesticides in India, the contact zones of empire for MIC has now been extended to global fertility chains and to the flows of biocapital through surrogate bodies. At both macro and molecular levels, MIC now plays a role in rewriting the value of life and death by “effac(ing) the boundaries between the spheres of production and reproduction, labor and life, the market and living tissues” (Cooper 2008, 9).

In the case of the Bhopal gas tragedy, frontstaging MIC and developing a multi-scalar materialist account involves shifting the focus of analysis, at least for a moment, from macro questions of human agency and the circulation of capacities of production and consumption on the human scale to a less explored set of relations. These relations bring forward the modes of distributed reproduction that occur on a minor or molecular scale. My intention is not to disregard the surviving humans of the gas tragedy, or to dismiss the impacts of reproductive technologies and reproductive bioeconomies on the lives of surrogate women who currently participate in these arrangements. Nor do I intend to dismiss the crucial questions of human agency and “vital energies” of humans that are required for the flows of biocapital (Vora 2015). My intention, rather, is to expand our understanding of the ontological politics of reproduction in Bhopal. By tracing the transplacental migrations of MIC and creating a map of the biocolonial legacies of this compound, the remainder of this paper brings into sharper focus: (1) the biological rupture of Bhopali survivors’ reproductive bodies, their genetics, and their bodily fluids due to MIC exposure; and (2) the biological sedimentation of global fertility chains through MIC-mediated intra-actions involving fetal and surrogate bodies.

#### **Biological Ruptures: Living and Dying with MIC Exposure**

In her influential book *Advocacy after Bhopal: Environmentalism, Disaster, New Global Orders* (2001) cultural anthropologist and STS scholar Kim Fortun addresses the role and impact of scientific representations of the Bhopal disaster. In her assessment of living with environmental health risks in Bhopal, Fortun states,

The desperate need for paper proof of victimization has become part of the legacy of Bhopal, as has a need for new idioms through which disaster can be represented, both textually and socially. What counts as expertise has been complicated. Scientific inputs have been crucial to direct diagnostic and therapeutic agendas, but also to validate legal arguments. Science has also been unsettled—by the rigorously nonlinear, unpredictable, cumulative effects of toxic chemicals. The science needed to underwrite fair distributions of compensation in Bhopal is a different science than that which can remedy the suffering of individuals. (xvi)

Fortun’s analysis reminds us that the project of examining the biological effects of MIC in Bhopal is complicated. It requires that we not only prepare ourselves to become unsettled by the scientific literature (or lack thereof), but more importantly that we learn to pay attention to the so-called unscientific, incoherent, or incommensurable that “unsettles” science. It requires a *different* science—one that actively pursues epistemic decentering of what traditionally counts as scientific evidence and who gets to count as a scientific knower. In the accounts that follow, the distributed reproduction mediated by MIC is traced by bringing forward and giving the floor to multiple modes of scientific expertise, emerging from the voices of different communities of knowers.

***Survivors of the gas tragedy are tracing MIC-mediated ruptures of human health themselves****.* Those who survived the explosion at the Union Carbide plant know that MIC did not just disappear and can in fact be traced within their bodies (Bhopal Medical Appeal 2014b). It is clear from survivor accounts that MIC and its metabolites have left their mark and continue to intra-act with the hormones, tissues, DNA (both somatic and gametic), and reproductive capacities of the Bhopali population. In the surviving human population in Bhopal, evidence of the world’s worst industrial chemical disaster comes in the form of abnormally high cancer rates, respiratory problems, and excessive reproductive harm occurring at many different biological levels. The population of Bhopal continues to experience alarmingly high rates of stillbirths, miscarriages, and incidences of children born with genetic dispositions that are deemed as disorders or “abnormalities” by the medical community. Due to the initial exposure to MIC gas during the explosion, and due to the further exposure of residual chemical contaminants in the soil and ground water left after the disaster, the status of reproductive health in particular continues to be an issue for both survivors of the Bhopal tragedy, as well as new generations of local residents.

The Bhopal Medical Appeal houses both the Sambhavna Trust and Clinic (established in 1996) and the Chingari Trust and Rehabilitation Center (founded in 2006) in Bhopal. The non-profit and community-based organization has produced a great deal of scientific knowledge and expertise on the biological effects of MIC through participatory research methods. Survivors and health advocates have reported that the occurrence of genetic mutations is all too common amongst children of survivors and refer to the high incidence rates of cleft lip and missing palate as evidence. The Sambhavna Clinic, for example, which provides free medical care to the survivors through allopathy, ayurveda, and yoga, suggests that the “indiscriminate prescription of steroids, antibiotics and psychotropic drugs is compounding the damage caused by the gas exposure” (Sarangi 2001, 93). They claim that birth defects in the children of survivors of the gas leak are far too prevalent and that many of these birth defects are due to the gas exposure of their parents as well as the cocktails of pharmaceutical drugs that were introduced into the population soon after the disaster.

***Women in Bhopal are tracing the MIC-mediated ruptures of gendered social relations***. Women who survived the gas tragedy, as well as women who were born after the gas tragedy, have expertise in tracing the chemical. Rashida Bee, a survivor of the Bhopal gas tragedy and co-founder of the Chingari Trust and Rehabilitation Center, explains the broader repercussions of all of these reproductive health issues. In the independent documentary film *The Bhopal Chemical Disaster*: *20 Years without Justice* (2004), made by the attorney Sanford Lewis for the International Campaign for Justice in Bhopal, Bee explains that reproductive health issues have made the lives of women in Bhopal extremely difficult. In a culture that values a woman’s worth through her reproductive capabilities, she explains that much of the social and economic difficulty that Bhopali women face is related to their reproductive health status. She states,

Women now have abnormal period intervals of fifteen days to as much as three months. Some girls do not start their periods until they are age twenty and other women as young as thirty have menopausal symptoms…When the girls who were children at the time of the tragedy become of marriageable age, it is difficult to find a decent groom for them as no one wants to be wedded to a gas survivor. The girl comes laden with a history of medical problems creating a burden on the groom to provide for her through her life. (Lewis 2004)

Bee also explains that if a woman does get married, she may not have children, which stigmatizes her and lessens her worth as a wife. Bee further states that if a Bhopali woman does have children, they may be “deformed” [*sic*] as impairments develop in the fetus. She emphatically repeats that no parent wants their son to marry to a girl from Bhopal. Yet, as was reported in 2008, Bhopali women who did manage to marry and have a child, and/or women in the surrounding areas of Bhopal, became candidates for providing low-cost surrogacy services.

***Social activists, health advocates, and community members at the Bhopal Medical Appeal are tracing MIC-mediated ruptures of women’s reproductive physiology***. It is known that women who were in their reproductive years during the time of the gas disaster immediately started to experience the effects of MIC poisoning on their bodies. Unfortunately, many of the studies conducted on women’s reproductive health by the Indian government were cancelled and only a handful of documented studies can be found in peer-reviewed scientific journals on the topic. Studies on the reproductive health of the next generation of Bhopali women coming into reproductive age were also terminated, but an early unpublished study titled “An Epidemic of Gynecological Disorder,” written by the activists and researchers Drs. Rani Bang and Mira Sadgopal in 1985, revealed that pregnant or not, women who lived in Bhopal were at a much higher risk of developing pelvic infections. These infections have been correlated with higher rates of incidence of other reproductive health issues such as menstrual cycle problems, dysmenorrhea, and endometriosis. In her book *The Bhopal Saga: Causes and Consequences of the World’s Largest Industrial Disaster*, Swedish activist and general practitioner Ingrid Eckerman verified these findings and noted that very soon after the disaster, “a total of 36 wards were marked as being ‘gas affected,’ with an estimated population in 1984 of 520,000. Of these 520,000 exposed people, 200,000 were below 15 years of age and 3,000 were pregnant women” (2005, 94). As Eckerman states, these women experienced multiple symptoms, including “high proportions of leucorrhoea, pelvic inflammatory disease, cervical erosion,…excessive menstrual bleedings and suppression of lactation…The impressions from Sambhavna 2003 is that menstrual irregularities after the first year of menarche, profuse menstruations and premature menopause are more common among gas victims and their daughters” (111). In 2009 a review of clinical and experimental findings from the Bhopal gas tragedy also verified Bang and Sadgopal’s findings, reporting that “menstrual abnormalities, vaginal discharge and premature menopause have emerged as common problems among Bhopal MIC exposed women and their female offspring/girl children” (Mishra et al. 2009, 196). Not only has the chemical affected the immediate survivor population, but also in line with chemical infrastructures that “assist” or alter reproduction in a distributed sense as Murphy puts it, MIC is “transforming life in inter-generational time” (2013, 1).

***Pharmacologists and epidemiologists are tracing MIC-mediated reproductive toxicity***. In 1985, following the accident, the Indian Council of Medical Research (ICMR) set up a unit called the Bhopal Gas Disaster Research Center. The unit closed down after six years, but in the interim had come up with a number of important findings. Thankfully, environmental medicine and community-based health researcher, V.R. Dhara (2000) reported on the ICMR’s work in his doctoral thesis, “The Bhopal Gas Leak: Lessons from Studying the Impact of a Disaster in a Developing Nation.” Dhara shared a number of incredibly important but unsettling scientific accounts of the status of reproductive health in Bhopal, including the conclusion drawn by the ICMR that there was sustained and increased trends of spontaneous abortion rates amongst survivors as compared to the control population (Dhara et al. 2002, 487). A recent ICMR report suggests that the rate of birth defects in the gas-affected population remains high to this day (Mishra 2019).

Unfortunately, in the years that followed the gas explosion, the Indian government withheld much of its findings on the health impacts of the disaster. However, in 1992, the International Medical Commission on Bhopal was formed in an effort to acquire more information and assess the long-term health effects and health-related needs of the victims of the accident. With Dhara as one of its expert members on toxic substances and disease, the commission revealed a list of conditions, which they deemed as the most pertinent MIC-mediated long-term health issues faced by the survivors. These conditions included reproductive toxicity and genotoxicity (Dhara and Dhara 2002, 399).

As mentioned, unfortunately many of the studies done on women’s reproductive health by the Indian government were cancelled and hardly any documented studies can be found in peer-reviewed scientific journals on the topic. However, a report released in 1987 by pharmacologist and activist Daya R. Varma showed that women who were pregnant at the time of the gas leak experienced spontaneous abortion rates that were ten times higher than the normal population. As Varma states in his abstract,

Although press reports indicate that the leakage of methyl isocyanate (MIC) on December 3, 1984, in Bhopal has led to an increase in spontaneous abortions, stillbirths, infant mortality, and fetal abnormalities, no clinical or experimental studies on the reproductive toxicity of MIC were reported in scientific journals for several months after the accident. We therefore conducted, 9 months after the accident, a preliminary survey of 3270 families in Bhopal and experimental studies on the effects of MIC in pregnant mice. It was found that 43% of pregnancies in women residing near the Union Carbide pesticide plant did not result in the birth of a live child. Likewise, exposure of mice to relatively low concentrations of MIC (9 and 15 ppm) for 3 hr caused complete resorption in more than 75% of animals. A decrease in fetal and placental weights was observed at 2 to 15 ppm MIC. In general, the experimental findings in mice corroborate the epidemiological data from Bhopal. The mechanism of the fetal toxicity of MIC remains to be established. (1987, 153)

Based on Varma’s study, Dhara further clarified the effects of MIC on pregnant women. In an epidemiological survey, he stated that “in a sample of 865 women who lived within 1 km of the plant and who were pregnant at the time of the gas leak, 43% of the pregnancies did not result in a live birth. Of the 486 live births, 14% of babies died in the first 30 days as compared to a death rate of 2.6% to 3% for previous deliveries in the 2 years preceding the accident in the same group of women” (Dhara 2000, 32). These findings indicate that women who were in the first trimester of their pregnancy during the time of the leak were at much higher risk of spontaneous abortion. Women who were able to carry their fetuses to term experienced many pregnancy related complications. There were increased factors of risk in fetuses brought to term as many of the women themselves had also experienced MIC-mediated respiratory problems and stress and had to take several different medications that are normally avoided by pregnant women. These medications included several rounds of antibiotics, bronchodilators, and analgesics (Dhara 2000, 32).

Molecular biologists in the Global South and Global North can trace MIC’s role in necropolitics at the level of genes and proteins. Enough time has now passed to observe long-term molecular and genetic effects of methyl isocyanate exposure. Yet once again, many of the scientific studies on the genetics of the population of survivors that had been initiated soon after the disaster were terminated. Of the very few studies that can be accessed, several cite the presence of chromosomal aberrations. These aberrations appear in the form of “breaks and gaps” or ruptures in the DNA of cells such as lymphocytes (Dhara 2000, 34). Dhara reports, “Cytogenetic studies were done 3 years after exposure on a sample of 40 male and 43 female exposed persons. Results from this study showed statistically higher frequencies of chromosomal aberrations in the exposed group as compared to 46 age and sex-matched unexposed controls. The aberrations were in the form of breaks, gaps, dicentrics, rings, tri and quadri-radial configurations and were more pronounced in female subjects” (35). The incidence of spontaneous abortions may also be related to issues of genotoxicity. The direct effects of MIC on gamete development and zygote formation have not been studied in sufficient detail. Of the studies that do appear on the effects of MIC on gametes, only male germ cell and sperm mutagenicity are examined. An in vitro study conducted by G.V. Raghuram and colleagues, using a male mouse spermatogonial cell line, showed that MIC causes DNA damage, oxidative stress, and apoptosis. Chromosomal aberrations were also reported in the form of “telomere anomaly, aneuploidy and variable amplification of microsatellite repeats” (Raghuram et al., “Molecular Characterization,” 2010, 213). Another study by this group, that examined a mouse ovarian epithelial cell line, reported that MIC exposure resulted in ovarian carcinogenesis through persistent DNA damage. This damage included “telomeric dysfunction due to premature senescence and plausible association with chromosomal and microsatellite instability” (Raghuram et al., “Molecular Mechanisms,” 2010, 377). These studies demonstrate the effects of MIC-mediated distributed reproduction at the molecular level.

### The Biological Sedimentation of Global Fertility Chains Mediated by MIC

As MIC continues to exert its effects on the reproductive biology of women, men, and children in Bhopal, remarkably, there is a growing market of human “*in vivo* labor” (Waldby and Cooper 2014, 7) involved in the production of biocapital that has also developed in this city. This market relies on the promissory futures that can be extracted from the remaining reproductive potential found in this very same population and location. While commenting more broadly about medical tourism in India, Amit Sengupta, founder and advocate of the People’s Health Movement in India, stated, “While the private sector has always been prominent as a source of medical care, neoliberal policies have created conditions for its rapid growth…Thus, while women from across the world flock to India to take advantage of the booming market for assisted reproductive technologies, a very large number of Indian women are denied basic health care” (2011, 313–14). Interestingly, the story of *in vivo* labor occurring specifically in Bhopal remains relatively underexplored. Just as Sengupta pointed out, survivors of the Bhopal gas tragedy are denied basic reproductive health care. Meanwhile, biotechnologies of reproduction and the artificial reproductive technologies (including IVF, gamete intrafallopian transfer (GIFT), intracytoplasmic sperm injection (ICSI), pre-implantation genetic screening, and gestational surrogacy) that are not primarily geared toward helping the survivors themselves are growing steadily in the city of Bhopal (Sengupta 2011). This contradiction between reproductive harm and promissory reproductive futures comes to some of us perhaps as no surprise at all. Even before the influx of artificial reproductive technologies (ARTs) and surrogacy services became prevalent in Bhopal, Fortun (2001) also discussed the status of reproductive health in *Advocacy after Bhopal*. She writes,

Disaster harbors particular contradictions for women. Bhopal is no exception. In the wake of disaster, women have gained access to public space and, in some cases, to wage-earning work. But they have also borne an unequal share of the effects of disaster. Many have husbands who can’t, or won’t, earn. Many are responsible for the care of sick children, spouses, siblings, and parents. Many are sick themselves. Many have faced the social stigmas of reproductive disorder. All must deal with a medical establishment that systematically discounts the particular problems of women’s health. (2001, 150)

In the case of Bhopal, it is clear that some women have indeed gained access to public spaces and to wage-earning work through the reproductive tourism industry and specifically through the surrogacy services that they have provided. In this last section, I examine how we can trace the migration of biopolitics by following MIC’s chemistry and its intra-actions with surrogate bodies, fetal bodies, and placentas.

***The transnational chemistry of MIC connects plants, pesticides, and placentas***. In their article “Twice Poisoned Bhopal,” Chandana Mathur and Ward Morehouse (2002) explain the various elements that were necessary for the perfect storm of bodies, environments, and technologies that resulted in the chemical disaster in Bhopal. They and others have developed a link between the colonial legacies of the MIC gas explosion and the Green Revolution that took place in India during 1960s and ’70s. The Indian government-sanctioned Green Revolution initiative introduced the need for high-yielding seeds, chemical fertilizers, and therefore the need for pesticides. Although it has been argued that the Green Revolution was “developed by Indians for Indians…not at the behest of Western powers, but rather in a determined effort to break free of them” (Bandyopadhyay 2021), this response to a colonial legacy, however, in turn, spurred the demand for the production of pesticides. This demand, coupled with the perceived expendability of the poor residents of Bhopal, provided the perfect conditions for Union Carbide (an American-owned company) to build its manufacturing plant in Bhopal in 1970. As Mathur and Morehouse suggest, the Bhopali people faced the “head-on impact of world historical and political economic processes” (2002, 69). In reference to the actual Union Carbide plant itself, they note, “The design of the Bhopal plant, as well as the policies related to its maintenance and operation, were in keeping with the double standard often applied by transnational corporations in their Third World outposts, where environmental, worker, and community safety issues may be seen as less pressing than at home…The Indian State’s unwillingness to discourage foreign private investment has been a crucial factor in the continuing injustice in Bhopal” (2002, 69). The colonial legacy that made it possible for the transnational chemistry of the “Green Revolution” to take place in India is the same legacy that supports the expansion of global fertility chains to include Bhopal. Today, the need for raw materials in the production of reproductive bioeconomies has manifested itself in the increase of *in vivo* human labor in Bhopal through the growth of ART clinics and surrogacy services in this city. Interestingly, today many of the companies offering reproductive biotechnology services are owned and operated by Indian doctors and cater to Indian couples. None of their websites mention the Bhopal gas tragedy.1

***MIC leaves a trace of racialized and gendered labor in surrogate bodies.*** Embraced by the coming together of neoliberal politics in India and the global spread of reproductive technology-mediated biocapitalism, reproductive tourism and surrogacy services have in fact spread at an amazing rate across all of India, including the city of Bhopal. Of course, reproductive tourism, fertility outsourcing, and transnational commercial surrogacy services have also exploded across the globe over the past two decades (Hudson et al. 2011; Nahman 2016; Vertommen, Pavone, and Nahman 2021; Weis 2021). An extensive review of the literature conducted in 2011 suggested that while cross-border reproductive care services were likely increasing around the globe, a significant number of US patients sought reproductive cares services offered in India (and Asia more broadly), including surrogacy services, egg donation, and IVF (Hudson et al. 2011). In fact, in 2015, while referring to India’s $2.3 billion reproductive tourism industry, a prominent reproductive tourism journal referred to India as the “surrogacy capital of the world” (*International Medical Travel Journal* 2015). This may be due to the fact that in 2002, India became the first country to legalize commercial surrogacy. As a sociotechnical actor, MIC may in fact be associated with the “low cost” associated with surrogacy services in Bhopal.

As my colleagues and I have discussed elsewhere (Chatterjee, Roy, and Subramaniam 2022), although it appears that there will soon be strict regulations on reproductive tourism and commercial surrogacy services offered in India, other ARTs involving different forms of *in vivo* and *in vitro* human reproductive labor will continue to be offered to both Indian citizens and international commissioning couples. In fact, there is a fear that once surrogacy services become strictly regulated, this will drive the use of surrogacy services and other ARTs underground, thereby opening the doors for further exploitation of women who participate in this labor. This is particularly relevant in the context of Bhopal, where IVF clinics promoting “test-tube” babies are growing and where the cheapest surrogates for hire were once found in India.

Arguing that modern-day surrogacy arrangements in India can be better understood in the context of racialized and gendered labor and colonial geopolitics, feminist and postcolonial STS scholar Kalindi Vora suggests in her book *Life Support: Biocapital and the New History of Outsourced Labor* (2015) that surrogate women should be viewed as biological and affective producers, the extraction of whose “vital energies” is required for biocapital. Describing surrogacy clinics in northern India (but not Bhopal specifically), she has framed the Indian surrogate woman as a type of biological worker and suggests that it is common for surrogates to come from poor economic backgrounds. They make great sacrifices and travel far distances to find employment. In most cases, surrogates are required to be married and to have had children of their own. This proves to the medical staff of the clinic and to potential clients that she is capable of carrying all the way through with a pregnancy, and thereby will likely fulfill her end of the contract. It also means, however, that the surrogate woman leaves behind her children while carrying out her reproductive work. Most clinics have housing arrangements for their surrogates and provide simple living quarters for them. The surrogate mother’s health is also monitored and close attention is given to her diet. Furthermore, she is removed from immediate sources of physical and mental stress (Vora 2009). This way, the fetus or “investment” can be closely monitored.

I am attentive to this wave of recent feminist and postcolonial scholarship that links racialized and gendered labor as well as colonial geopolitics to transnational and commercial surrogacy practices. As Bronwyn Parry’s article in this special section discusses the expansion of fertility clinics in India into smaller cities, so too have Dasgupta and Das Dasgupta, pointing out that surrogacy services and the “outsourcing” of wombs are occurring throughout India in metropolitan or large cities, but also increasingly in the smaller cities such as Bhopal. They suggest that, “with growing medical tourism, the smaller cities are not only becom[ing] more accessible, but have also become a steady source of gamete donors and surrogates. Further, the clinics in smaller towns (even with limited infrastructure and expertise) have tie ups with clinics in large cities, and flying embryologists and visiting experts have become the standard practice in the operations of ARTs. The fertility industry in India is witnessing both vertical and horizontal expansion; both across and within cities” (Dasgupta and Das Dasgupta 2014, 2–3). It is evident that assisted reproduction and reproductive labor in Bhopal are unfolding not apart from but in direct relation to global circuits of capital and racialized and gendered labor that are in turn supported by the neoliberal Indian state. This is the same state that opened its doors to foreign investment several decades ago, including multinationals such as the Union Carbide Corporation that produced a pesticide, which in turn required the mass production of the compound MIC.

***Placentas serve as a MIC-mediated contact zone of empire***. In order to trace MIC-mediated distributed reproduction in an immediate contact zone of empire, I want to end this paper by focusing in on MIC’s molecular impacts on the placenta—a local point of interest that is created when a surrogate woman and a growing fetus intra-act in the context of Bhopal. For example, a 1988 study conducted in pregnant female mice exposed to [14C] radiolabeled MIC showed that this compound accumulated in several tissues, including the uterus, placenta, and fetus (Ferguson et al. 1988). A 1990 study, which examined the direct effects of MIC exposure on fetal growth, later suggested that the fetal toxicity of MIC was “partly independent of maternal toxicity and may result from its transfer across the placenta and interaction with fetal tissues” (Varma et al. 1990, 1).

In light of current research that links the exposure of environmental agents to epigenetic influences mediated by human placental development and pathology, it is crucial that we reconsider these earlier findings that demonstrated an impact of MIC on placental tissue beyond decreased placental weights. Given the concern of intergenerational transmission and epigenetic effects of MIC gas, perhaps the question is not just what is MIC writing onto the bodies of gas victims, but what genetic editing processes is MIC orchestrating in placental DNA? Are there epigenetic effects of MIC that directly influence the function and expression of proteins and signaling mechanisms not just within reproductive cells and tissues overall, but within the placenta itself? Although a link between in utero exposure to MIC gas and human fetal growth has been established, studies examining the status of DNA methylation in human placentas following exposure to methyl isocyanate have not yet been conducted.

***Microchimerism and the vertical transmission of MIC-mediated neoliberal politics.*** MIC, known to be a highly irritant chemical, is absorbed horizontally through the skin and reacts with various liquids and mucous membranes in the body. In the past several years, there has been a handful of studies that clearly show MIC’s ability to penetrate through tissues, react with proteins in the body, and initiate genetic and epigenetic “reprogramming” through DNA methylation and histone modifications. For example, a retrospective review of cytogenetic studies on MIC published by Samarth, Gandhi, and Maudar raises the concern of epigenetic effects of MIC gas and the possibility of “vertical transmission of genetic aberrations” (2013, 325).

If this is indeed the case, we should be asking what is happening at a molecular level within a placenta when a surrogate woman and a donor-gamete assembled fetus meet one another in the aftermath of the Bhopal gas tragedy and the continued environmental presence of MIC-induced toxicity. What does the “vertical transmission of genetic aberrations” mean in the context of surrogate and commissioned fetus encounters in Bhopal? Also, we must ask, can a life be transformed by reverse-vertical transmissions through the placenta—that is, from the fetus to the surrogate? Recent evidence of fetal microchimerism indicates that pregnancy-derived fetal cells do not just passively reside in the bloodstream of pregnant women but can form small populations of cells with different genetic backgrounds that exist for long periods of time in maternal tissues, including the heart, lungs, kidney, spleen, liver, and brain (Chan et al. 2012; Rijnink et al. 2015).

### Conclusion

In this article, I have attempted to use the framework of distributed reproduction to connect the different materialities produced by the world’s worst industrial chemical disaster, along multiple scales, to the concept of global fertility chains. As Vertommen, Pavone, and Nahman have stated, “global fertility chains do not exist in a vacuum but materialize in particular institutional, socio-spatial, and cultural environments” (2021, 15). I have used a methodology of frontstaging the chemical MIC to trace the intersecting contours of toxicity, reproductive health, and surrogacy services in Bhopal. I want to leave you now with two potential molecular scenarios and another set of unanswered questions. The scenarios emphasize why we must not forget about the Bhopal gas tragedy while thinking about reproductive technologies and surrogacy practices in the city of Bhopal, why we must continue to be unsettled by the different bodies of knowledge being produced by the survivors of the tragedy, and why we must continue to unsettle science until we have the answers to some of these questions.

First, in the context of surrogacy practices in Bhopal, what can we make of the biological evidence that indicates the transmission of hormones and proteins from the surrogate mother, through to the placenta, and into the fetal environment? If a surrogate body has been impacted by MIC, what, if any, imprint can this chemical leave on a commissioned fetus through placental transmission? With a variety of knowledge bases, from survivor histories to epigenetic analyses, can we better understand the vertical and horizontal transmission of chemical toxicities at various environmental scales, and on different generations of human and nonhuman actors?

Second (and this is the more difficult scenario to imagine), what can we begin to ask if we consider more carefully scientific research that indicates the movement of fetal DNA into maternal plasma, particular in the case of surrogate women in Bhopal? In many reproductive tourism arrangements in India, embryos implanted into Indian surrogate women were obtained from the commissioning couple and/or sperm and egg banks. Given that many of the embryos used in ARTs and surrogacy arrangements in Bhopal were created through the conjugated nuclear material provided by North American and European germ cell donors, can it be imagined that a MIC-mediated chemical infrastructure and distributed reproduction is rupturing our ideas of fixed, racialized, and gendered biologies? As a response to increased flows of reproductive bioeconomies, is MIC creating a molecular and genetic transcript of translocated biopolitics whereby a reproductive laborer’s hormones and proteins enter into fetal bodies while a mixture of consumer DNA is expressed in maternal surrogate blood and tissues? Given that we now know that fetal/maternal bodies are enmeshed beyond the time and space of the placenta, if fetal DNA and cells enter into the surrogate woman’s plasma and tissues, are we ready to trace these biophysical markers of transnational chemistries and their colonial legacies? If so, will we be ready to meet the materializations of toxic interdependencies through feminist, postcolonial, (de/anti)colonial, disability justice, and queer relationality frameworks?

The answers to these questions may lie in the distant future. Rearranging the ontological politics of MIC-mediated distributed reproduction does not necessarily resolve the contradictions that are harbored by the Bhopal gas tragedy. It does however allow us to develop more situated accounts of life, death, and reproduction in Bhopal and, in a way, learn how to better encounter these contradictions.

### Note

1 IVF and surrogacy services in Bhopal are advertised online at several major centers, including the International Infertility Institute India and Bhopal Test-tube Baby Center (<http://www.ivfgo.com/>), the Malti Hospital and Test Tube Baby Center (<http://www.maltihospital.com/>), and the Vijaya Maternity and Test Tube Baby Center (<http://www.vijayamaternity.com/about.php>).

### References

American Fertility. 2020. *Costs of Surrogacy in the USA*. <https://americanfertility.com/costs-surrogacy-usa/>.

Bandyopadhyay, Ritajyoti. 2021. “Growing Democracy: How India’s Green Revolution Enfranchised the Rural Poor.” *The Breakthrough Institute*. Retrieved from <https://thebreakthrough.org/journal/no-14-summer-2021/growing-democracy-india-farmer>.

Bang, Rani, and Mira Sadgopal. 1985. “An Epidemic of Gynecological Disorder.” Unpublished study.

Barad, Karen. 2007. *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning*. Durham, NC: Duke University Press.

Bhargava, Arpit, Ram Prakash Punde, Neelam Pathak, Sunil Dabadghao, Prabha Desikan, Aruna Jain, Kewal Krishan Maudar, and Pradyumna Kumar Mishra. 2010. “Status of Inflammatory Biomarkers in the Population that Survived the Bhopal Gas Tragedy: A Study after Two Decades.” *Industrial Health* *48*: 204–208. <https://doi.org/10.2486/indhealth.48.204>.

Bhopal Gas Tragedy Relief and Rehabilitation. 2017. “The Aftermath.” <http://www.bgtrrdmp.mp.gov.in/profile.html>.

The Bhopal Medical Appeal. 2014a. “Bhopal’s Second Poisoning.” <https://www.bhopal.org/second-poisoning/bhopal-second-poisoning/>.

———. 2014b. “Union Carbide’s Chemical Trail.” <https://www.bhopal.org/second-poisoning/union-carbides-chemical-trail/>.

Broughton, Edward. 2005. “The Bhopal Disaster and Its Aftermath: A Review.” *Environmental Health: A Global Access Science Source* 4 (6): 1–6. <https://doi.org/10.1186/1476-069X-4-6>.

Chan, William F. N., Cécile Gurnot, Thomas J. Montine, Joshua A. Sonnen, Katherine A. Guthrie, and J. Lee Nelson. 2012. “Male Microchimerism in the Human Female Brain.” *PLOS ONE* 7 (9): 1–7. <https://doi.org/10.1371/journal.pone.0045592>.

Chatterjee, Sushmita, Deboleena Roy, and Banu Subramaniam. 2022. “Spectres of Biological Politics: Conversations within and across South Asia.” In *Birth Controlled: Selective Reproduction and Neoliberal Eugenics in South Africa and India*, edited by Amrita Pande. Manchester: Manchester University Press.

Cooper, Melinda. 2008. *Life as Surplus: Biotechnology and Capitalism in the Neoliberal Era*. Seattle: University of Washington Press.

Dasgupta, Sayantani, and Shamita Das Dasgupta. 2014. *Globalization and Transnational Surrogacy in India: Outsourcing Life*. Lanham, MD: Lexington Books.

Dhara, V. Ramana. 2000. “The Bhopal Gas Leak: Lessons from Studying the Impact of a Disaster in a Developing Country.” PhD diss., University of Massachusetts Lowell.

Dhara, V. Ramana. and Rosaline Dhara. 2002. “The Union Carbide Disaster in Bhopal: A Review of Health Effects.” *Archives of Environmental Health* 57 (5): 391–404. <https://doi.org/10.1080/00039890209601427>.

Dhara, V. Ramana, Rosaline Dhara, Sushma D. Acquilla, and Paul Cullinan. 2002. “Personal Exposure and Long-Term Health Effects in Survivors of the Union Carbide Disaster at Bhopal.” *Environmental Health Perspectives* 10 (5): 487–500. <https://doi.org/10.1289/ehp.02110487>.

Eckerman, Ingrid. 2005. *The Bhopal Saga: Causes and Consequences of the World’s Largest Industrial Disaster*. Hydrabad, Andhra Pradesh: Universities Press.

Ferguson, J. S., A.L. Kennedy, M.F. Stock, W.E. Brown, and Y. Alarie. 1988. “Uptake and Distribution of 14Cduring and following Exposure to [14C] Methyl Isocyanate.” *Toxicology and Applied Pharmacology* 94 (1): 104–17. <https://doi.org/10.1016/0041-008X(88)90341-9>.

Fortun, Kim. 2001. *Advocacy after Bhopal: Environmentalism, Disaster, New Global Orders*. Chicago: University of Chicago Press.

Hudson, Nicky, Lorraine Culley, Eric Blyth, Wendy Norton, Frances Rapport, and Allan Pacey. 2011. “Cross-Border Reproductive Care: A Review of the Literature.” *Reproductive Biomedicine Online*, no.22, 673–85. <https://doi.org/10.1016/j.rbmo.2011.03.010>.

International Campaign for Justice in Bhopal. 2019a. “The Death Toll.” <https://www.bhopal.net/what-happened/that-night-december-3-1984/the-death-toll/>.

———. 2019b.“Fact Sheet.” <https://www.bhopal.net/wp-content/uploads/2019/11/Factsheet-Bhopal35-English.pdf>.

———. 2019c. “In Their Words.” <https://www.bhopal.net/what-happened/that-night-december-3-1984/the-death-toll/>.

*International Medical Travel Journal*. 2015. “India Introduces Legislation to Ban Surrogacy Tourism.” December 7, 2015. <https://www.imtj.com/news/india-introduces-legislation-ban-surrogacy-tourism/>.

Lewis, Sanford, dir. 2004. *The Bhopal Chemical Disaster: 20 Years without Justice.* Strategic Video Productions. <https://www.youtube.com/watch?v=0csW97x8d24>.

Mathur, Chandana, and Ward Morehouse. 2002. “Twice Poisoned Bhopal: Notes on the Continuing Aftermath of the World’s Worst Industrial Disaster.” *International Labor and Working Class History*, no. 62, 69–75. <https://www.jstor.org/stable/27672806>.

Mishra, Manish Chandra. 2019. “Birth Defects Remain High in Bhopal Gas Survivors 35 Years after the Disaster.” *DownToEarth*, November 28, 2019. <https://www.downtoearth.org.in/news/environment/birth-defects-remain-high-in-bhopal-gas-survivors-35-years-after-disaster-67979>.

Mishra, Pradyumna K., Ravindra M. Samarth, Neelam Pathak, Subodh K. Jain, Smita Banerjee, and Kewal K. Maudar. 2009. “Bhopal Gas Tragedy: Review of Clinical and Experimental Findings after 25 Years.” *International Journal of Occupational Medicine and Environmental Health* 22 (3): 193–202.

Mitra, Sayani. 2015. “When Surrogacy Fails: The Biopolitics and Hidden Risks of the Industry in India.” *Open Democracy* (London), December 16, 2015. <https://www.proquest.com/docview/1749275291?accountid=10747>.

Mukherjee, Rahul. 2016. “Toxic Lunch in Bhopal and Chemical Publics.” *Science, Technology, and Human Values* 41 (5): 849–75.

Murphy, Michelle. 2013. “Distributed Reproduction, Chemical Violence, and Latency.” *The Scholar and Feminist Online*. <http://sfonline.barnard.edu/life-un-ltd-feminism-bioscience-race/distributed-reproduction-chemical-violence-and-latency/>.

Nahman, Michal Rachel. 2016. “Reproductive Tourism: Through the Anthropological ‘Reproscope.’” *Annual Reviews of Anthropology*, no. 45, 417–32. <https://doi.org/10.1146/annurev-anthro-102313-030459>.

Pande, Amrita. 2014. *Wombs in Labor: Transnational Commercial Surrogacy in India*. New York: Columbia University Press.

Raghuram, Gorantla Venkata, Neelam Pathak, Deepika Jain, Hemant Pandey, Hariom Panwar, Subodh Kumar Jain, Smita Banerjee, and Pradyumna Kumar Mishra. 2010. “Molecular Characterization of Isocyanate-Induced Male Germ-Line Genomic Instability.” *Journal of Environmental Pathology, Toxicology, and Oncology* 29 (3): 213–34. <https://doi.org/10.1615/JEnvironPatholToxicolOncol.v29.i3.50>.

Raghuram, Gorantla Venkata, Neelam Pathak, Deepika Jain, Hariom Panwar, Hemant Pandey, Subodh Kumar Jain, and Pradyumna Kumar Mishra 2010. “Molecular Mechanisms of Isocyanate Induced Oncogenic Transformation in Ovarian Epithelial Cells.” *Reproductive Toxicology*, no. 30, 377–86. <https://doi.org/10.1016/j.reprotox.2010.05.087>.

Rijnink, Emilie C., Marlies E. Penning, Ron Wolterbeek, Suzanne Wilhelmus, Malu Zandbergen, Sjoerd G. van Duinen, Joke Schutte, Jan A. Bruijn, and Ingeborg M. Bajema. 2015. “Tissue Microchimerism Is Increased during Pregnancy: A Human Autopsy Study.” *Molecular Human Reproduction* 21 (11): 857–64. <https://doi.org/10.1093/molehr/gav047>.

Roy, Deboleena, and Banu Subramaniam. 2016. “Matter in the Shadows: Feminist New Materialism and the Practices of Colonialism.” In *Mattering: Feminism, Science and Materialism*, edited by Victoria Pitts-Taylor, 23–42. New York: NYU Press.

Rudrappa, Sharmila. 2015. *Discounted Life: The Price of Global Surrogacy in India.* New York: NYU Press.

Samarth, Ravindra M., Puneet Gandhi, and Kewal K. Maudar. 2013. “A Retrospective Review of Cytogenetic Studies on Methyl Isocyanate with Special Reference to the Bhopal Gas Tragedy: Is the Next Generation Also at Risk?” *International Journal of Occupational Medicine and Environmental Health* 26 (3): 324–36. <https://doi.org/10.2478/s13382-013-0110-6>.

Sarangi, Satinath. 2001. “An Industrial Disaster Becomes a Medical Nightmare.” *Indian Journal of Medical Ethics* 9 (3): 93. <https://ijme.in/wp-content/uploads/2016/11/773-5.pdf>.

Sehgal, Priti. 2008. “Reproductive Tourism Soars in India.” *AlterNet*, November 16, 2008. <https://www.alternet.org/2008/11/reproductive_tourism_soars_in_india/>.

Sengupta, Amit. 2011. “Medical Tourism: Reverse Subsidy for the Elite.” *Signs: Journal of Women in Culture and Society* 36 (2): 312–19. <https://doi.org/10.1086/655910>.

Shotwell, Alexis. 2016. *Against Purity: Living Ethically in Compromised Times*. Minneapolis: University of Minnesota Press.

Sunder Rajan, Kaushik. 2007. *Biocapital: The Constitution of Postgenomic Life.* Durham, NC: Duke University Press.

Tsing, Anna Lowenhaupt. 2015. *The Mushroom at the End of the World: On the Possibility of Life in Capitalist Ruins*. Princeton, NJ: Princeton University Press.

Varma, Daya R. 1987. “Epidemiological and Experimental Studies on the Effects of Methyl Isocyanate on the Course of Pregnancy.” *Environmental Health Perspectives*, no.72, 153–57. <https://doi.org/10.1289/ehp.8772153>.

Varma, Daya R., Ian Guest, Smith, S., Mulay, S. 1990. “Dissociation between Maternal and Fetal Toxicity of Methyl Isocyanate in Mice and Rats.” *Journal of Toxicology and Environmental Health* 30 (1): 1–14. <https://doi.org/10.1080/15287399009531405>.

Vertommen, Sigrid, Vincenzo Pavone, and Michal Nahman. 2021. “Global Fertility Chains: An Integrative Political Economy Approach to Understanding the Reproductive Bioeconomy.” *Science, Technology, and Human Values* 47 (1): 1–34. <https://doi.org/10.1177/0162243921996460>.

Vora, Kalindi. 2009. “Indian Transnational Surrogacy and the Commodification of Vital Energy.” *Subjectivity*, no. 28, 266–78. <https://doi.org/10.1057/sub.2009.14>.

———. 2015. *Life Support: Biocapital and the New History of Outsourced Labor*. Minneapolis: University of Minnesota Press.

Waldby, Catherine, and Melinda Cooper. 2014. *Clinical Labor: Tissue Donors and Research Subjects in the Global Bioeconomy*. Durham, NC: Duke University Press.

Weis, Christina. 2021. “Changing Fertility Landscapes: Exploring the Reproductive Routes and Choices of Fertility Patients from China for Assisted Reproduction in Russia.” *Asian Bioethics Review*, no. 13, 7–22. <https://doi.org/10.1007/s41649-020-00156-w>.

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