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Of Xenotransplantation and Animal Futures: Science-Market Conviviality and the Engineering of Hope

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Abstract: *The active, optimistic involvement of xenoengineering companies in the lucrative business of producing transgenic pigs as sources of xeno-organs for solving the shortage of transplantable human organs, the ethical problems involved in inflicting pain on animals in such xenoexperiments and the financial unviability of such alternatives for public use, calls for critical, sociological attention. Financial investments and market projections are inherent to the forces that enable and give direction to scientific innovations like xenotransplantation. The mutual show of trust between the technoscience experts and financial investors in the xenotransplants venture shows how convivial science and market are in the hopeful venture of seeking solution to organ crisis through production of genetically engineered pigs which are human compatible, and are variously called "galsafe" pigs or "perv free" piglets. These are hybrids and attractive commodities to be sold on the market, which xenoengineering companies produce to gain control of human biological future. Yet in these hopeful anthropocentric, humanist ventures the troubling question of fate of the animals in xenoexperiments and the hybrids-the cloned pigs, from which xeno-organs will be harvested for transplantation, is reluctantly set aside.*

Keywords: Xenotransplantation, xenoengineering, xenoexperiments, xeno-organs, market, technoscience, conviviality, hope, hybrids, life.

Prolegomenon: Xenoexperiments! A Controversy and the Problematic

In May 2000, *Uncaged Campaigns*, a British animal rights activist group came up with series of leaked documents that testified to the involvement

of *Imutran*, a xenotransplants engineering company in Britain, in transplanting pig organs in monkeys and baboons for experimental trial. The documents revealed that from 1990s till 2000, over 420 monkeys and 50 baboons had succumbed to death as result of the trials of *Imutran*. The average duration of survival of such animals under trial was barely 13 days. The *Uncaged Campaigns* put up the documents on the web along with a special report on xenotransplantation[1]-induced animal violence titled "Diaries of Despair", trying to draw attention of the British government to the urgent need to stop xenoexperiments[2] and set up a committee to conduct enquiry into the matter. According to the *Frontline* report[3] which made this controversy public, *Imutran* manipulated the context which led to the removal of the documents from the web on grounds of confidentiality and breach of copyright. However, by that time, the incident had already gained public attention via widespread media coverage, generating panic about violence against animals. The *British Daily Express* came up with an article in September 2000[4], revealing the misinformation produced by *Imutran* about its achievements in the field. *Imutran's* defense was however that the animals did not suffer as result of the trials. *Imutran* also managed to get a court order issued so that circulation of content pertaining to its involvement in violence against animals is forbidden.[5]

The *Daily Express* report particularly focused on a baboon by the label x201M which was one of the targets of xenotransplantation trials carried out by *Imutran*. According to the report, baboon x201M's heart was removed and the heart of a genetically engineered pig was implanted in its place. The baboon allegedly survived for thirty-nine days in that condition. *Imutran* published a paper in the *Journal of Heart and Lung Transplantation* showcasing its success in cross-species transplantation using the instance of baboon x201M, and claimed that the baboon remained agile, with the transgenic pig heart fitted to its body. The *Daily Express* however contradicted the claim by bringing to light that *Imutran's* own log records reflected contradictory details - that baboon X201M suffered from severe weakness as outcome of the xeno-procedure. By the time the baboon passed away, the pig heart had become thrice the size of the baboon as result of inflammation possibly.[6] Dan Lyon of *Uncaged Campaigns* narrated the notoriety of the incident to *Daily Express* emphasizing on what had exactly happened to the poor baboon. Here I quote Dan Lyon from an interview to the *Daily Express* correspondent[7]:

> One of the most unfortunate animals had a piglet heart transplanted into his neck. It was a particularly disturbing example, I think, because for several days he was holding the heart. It was swollen. It was seeping

> blood; it was seeping pus as a result of the infections that often occur in the wound site. He suffered from body tremors, vomiting, diarrhea. And the animal just sat there. *I think living hell is really the only sort of real way you can get close to describing what it must be like to have been that animal in that situation.* (Emphasis mine)

In the same interview when Dan Lyons was asked whether such experiments are justified or not, to which he said that such acts can never be justified for they involve "deliberate infliction of pain, suffering and death on someone else." Lyons particularly spoke against animal trial for he believed that any success in human organ transplantation can be made only by recourse to human trial. In contrast to xeno-organs, human organs, Lyons stated are far safer and reliable means to handle organ failure and transplantation, rather than, in his own words, "incarcerating an animal, cutting it up, and killing it, and then transplanting the non-human organ into a human being." Because xeno-organs are commercial products engineered by companies, he argued, the profit-making imperative inevitably makes its way into the enterprise.[8]

The xeno-researchers interviewed by the *Frontline* however had their own defense in favour of animal trials. For instance, Robert Michler, the chief of Cardiothoracic Surgery at the *Ohio State University Medical Center*, someone directly involved in transplanting the piglet heart in baboon X201M's body, said that it is impossible to proceed with xenotransplantation without conducting animal experiments first. For any therapy to be applied to humans, Michler stated, its efficacy and safety should be tested on the animals first. Michler explicitly prioritized human life over the animals, which for him are the means to human ends and their welfare concerns only derivative. In fact he blatantly said: "Human life is what I am designed to help and it's something that I understand in a very intimate way."[9]

In the same *Frontline* report, Alan H. Berger, Executive Director of *Animal Protection Institute* and member of the *Secretary's Advisory Committee on Xenotransplantation*, while discussing the financial viability of xenotransplantation exclaimed that when the question is about spending money for healthcare, the priority should be the benefit of society at large. Because xenotransplantation is way expensive and only a privileged few could have access to it, Berger stated that it is not worth spending healthcare funds in this domain. Rather the same amount of money could be used to improve health conditions in general, aiming to prevent illness rather than curing them *pre-factum*. From consumer point of view, Berger said that xenotransplantation costs would be "astronomical", amounting to $20 billion a year, according to a 1996 estimate provided by the *Institute of Medicine*.

Berger further observed that if the industry is so expensive, offering xenotransplantation would mean that the cost has to be borne by the government and private medical insurances, which in turn would result in additional burden for the government and increase in premium of private medical insurances. As regards projection of price of xeno-organs, Berger stated that such organs would be "frighteningly" expensive, ranging between $10,000 to $50,000 dollars. The complete xenotransplants package would be between $125,000 to $450,000 dollars.[10]

But, why do I begin this particular controversy? I do this because in many ways it introduces the reader to a host of complex issues of which I seek to engage the active involvement of xenoengineering companies in the lucrative business of producing *transgenic* pigs[11]or xeno-organs[12], the ethical problems involved in inflicting pain on animals in xenoexperiments and the financially unviable cost of such alternatives for public use, and so on. The controversy and its aftermath calls for critical attention not only because of the claims and counter-claims pertaining to it, but also owing to the larger issues such an instance raise by way of putting into flux the whole of idea of biology and by pointing to the fact that we are at a moment of history of biology where biology is constituted more of what it *could be*, rather than what it is. Biology emanates from the foundational schism between humans and animals, man and nature and so on (Franklin2007) These schisms may continue to hold conceptual relevance in disciplines but in practice biology today is more concerned with complex hybrids (Lock 2009, 2001; Haraway 2004; Latour 1993) rather than pure essences. The study of *transgenesis*[13] therefore brings us face-to-face with processes that have put life and vital processes at the brink of hybridization, through what Sarah Franklin (1997) as identified as unprecedented "biological control", hoping for better life (also see Rose 2007; Foucault 1973) and rehabilitative animal futures. This compels me to ask two questions: What sustains the hope (as enabling factors) associated with these illusions? What imperatives propel the attempts to realize these hopes?

To answer these questions, I look at a xenoengineering company as a case for analyzing how financial investments and market projections are inherent to the forces that give direction to scientific innovations like xenotransplantation. I pursue a critical analysis of various press releases of the company, as way of tracking its history and the present by way of their achievement-claims about xenoengineering feats and market collaborations via the voices of the techno-scientific-cum-managerial experts. Such press releases constitute a discursive space, in and through

which I track the conviviality between the scientific claims and market promises of xenotransplantation, and the mutual show of trust between the techno-science experts and the financial investors in the xenotransplants venture. Grappling this conviviality becomes relevant against enunciations like that of Alan H. Berger[14] who pose questions relating to the financial viability of xenotransplants technology and its highly classist character, or the *Uncaged Campaigns* in the Britain, which brings under public scrutiny the violent experiments of xenoengineering companies, thriving on the rhetoric of fostering human life (Foucault 1980), while engaging in deductive attitude towards animals.

Xenoengineering and New Biological Futures: Case Study of Revivicor

Revivicor[15] is a Virginia-based bio-engineering and pharmaceutical company that emerged as a "spin-out"[16] from U.K.-based PPL Therapeutics,[17] one which engineered the cloned sheep Dolly. *Revivicor* aims at, as declared in their website, "curing human diseases through regenerative medicine." As a bio-engineering company *Revivicor* aims to offer "superior-quality, high-volume, alternative tissue source as a solution for the critical shortage of human-compatible tissues, cells and organs" through the creation of genetically engineered pigs-an approach which derives from the cloning technology of PPL Therapeutics. The pigs so engineered by *Revivicor* are to be used as viable substitutes to human kidney and heart for a longer duration of support, and human liver for a short span of time.

Towards this end, *Revivicor* has successfully engineered pigs, whose organs and tissues are resistant to human "immune response to cross-species transplantation" which is also known as *hyperacute rejection*[18]- the rejection of foreign organ or tissue or cell by the human immune response system. What demarcates pigs from humans is that they have sugar called the *galactosyltransferase*[19](popularly known as "Gal" in the biomedical parlance) on their cell surface. This trait is foreign to human bodies and the possibility of rejection of such cells loom large when transplanted into human bodies as their introduction triggers severe immune response. To avert this, the strategy of *Revivicor* has been to genetically engineer pigs in which the "Gal" has been inactivated or "knocked out"[20]rendering them safe for transplantation in human bodies.[21]

But that's not all – the inactivation of "Gal", though the most important clinically speaking to achieve pig-to-human xenotransplantation, there are

other enzymes too that may trigger human immune response. To meet that end, *Revivicor* has introduced via genetic engineering a human gene in the pig system to generate a protein called CD64[22] which dilutes human immune response. Revivicor's strategy of inactivating the "Gal" gene and generating the human protein in pig cells in the production of genetically engineered pigs, with the aim to launch successful pig-to-human xeno-transplantation derive from purportedly successful pig heart transplantation experiments in primates, which enhanced the survival of the latter by more than six months. The integrated inactivation of "Gal" gene and generation of CD64 protein approach to pig-to-human organ transplantation has the potential to reduce, the cost and side effects of immunesuppression[23] in *allotransplantation.*[24] [25]

This is a brief introduction to *Revivicor*. Next in order is an analysis of various press releases of the company between 1998 and 2010 which help us trace the timeline of its achievements-claims, through the voice of the technoscientific-cum-managerial experts who have run the company during this period.

In January 23, 1998, Dr. David Ayares, then the Chief Operating Officer and Vice President of Research of PPL Therapeutics (then Revivicor was yet to emerge), announced the birth of the first calf, using the same technique of cloning, scientifically known as "somatic cell nuclear transfer",[26] through which Dolly and Polly were genetically engineered by the PPL. The calf was named "Mr. Jefferson" because it was born on the President's Day in the State of Virginia. Dr. Julian Cooper, another Chief Operating Officer at the PPL, hailed the birth of the calf as "an important step towards using transgenic cattle to produce large quantities of cost effective therapeutics quickly." But he was quick to add that "Mr. Jefferson" was not *transgenic* cattle *per se*, but was engineered through "nuclear transfer",[27] which has the potential to introduce minute genetic changes and modifications toward developing less costly treatments for various diseases.[28] "Mr. Jefferson" was soon to be obscured from scientific and public imagination, by newer clonal achievements. Just within two years, in March 14, 2000, there was a press release on the part of, once again, Dr. Ayares, then Vice President of Research and Development and Dr. Ron James, the Managing Director of the PPL Therapeutics, that on March 5, 2000, they have achieved "a major step towards successful production of xeno organs for human use" via the production of five cloned piglets using adult cells through cloning. Evidently proud of the achievement, as it marks a significant "step" ahead, Dr. Ayares and Dr. James emphatically claim:[29]

> The successful cloning of these pigs is a major step in achieving PPL's xenograft objectives. It opens the door for making modified pigs whose organs and cells can be transplanted into humans; the only near term solution to solving the world wide organ shortage crisis. Pigs are preferred species for xenotransplantation on scientific and ethical grounds. Clinical trials could start in as little as four years and analysts believe the market could be world $6 billion for solid organs alone, with as much again possible for cellular therapies, e.g. transplantable cells that produce insulin for treatment of diabetes.

Trying to explain why this was path-breaking compared to genetic engineering of Dolly or "Mr. Jefferson", Dr. Ayares and Dr. James further claim, foregrounding how the "intractable" has been overcome through their technique:[30]

> Nuclear transfer in pigs has proved to be more difficult than for other livestock … because pig reproductive biology is inherently more intractable …

Then they go on to suggest that the method used for producing Dolly was different from the method that has been deployed to produce the five female piglets, which involved many new, "inventive" steps for which the PPL personnel have applied for patents. Funding in part came from the National Institute for Standards and Technology, under the Government of United States. In face of the "intractability" of porcine reproductive biology that Dr. Ayares and Dr. James foreground, which is also a way of positing that it is no mean an achievement, they argue that the objective that brought them the NIST funding was that of "knocking-out" a specific pig gene and that PPL was empirically able to achieve that end by inactivating the "alpha 1-3 gal transferase".[31] Dr. Alan Colman, the Research Director at PPL claims in the press release:[32]

> … PPL has built up the technical expertise and intellectual property to be the first to produce the type of pig which should become the industry standard for xenotransplantation – a pig that lack the alpha 1-3 gal transferase gene.

Dr. Ayares adds in the same press release that initially they thought only three or four fetuses would survive but to their "surprise" even the fifth one started developing. Showcasing the "challenging" achievement of the PPL personnel, Dr. Ayares states:[33]

> Solving nuclear transfer in pigs was quite a challenge, so our ultimate challenge was all the more rewarding. This was a great team effort by all at PPL.

According to Dr. Ayares, the pig xenograft produced by PPL team has substantially reduced the risk of four types of already known *graft rejection*[34] and the researchers at PPL are on their way to, apart from the "Gal knock-out" they have already achieved, add new genes in pigs cell in order to make them resistant to two or three more causes of *graft rejection*. The press release also states that they are hopeful that the modified pig cells will "tolerize" the recipient and rule out rejection.[35] The attempt to "tolerize" the recipient in the PPL framework works through acts which de-porcine and renders human the cloned pigs and also at the same time, although in a lesser degree, re-humanizes the recipient after a new porcine framework.

Dr. James, the Managing Director of PPL seemed confident and hopeful about the biomedical and scientific, and the market promises of the latest technique they have devised which "knock-outs" genes and adds new ones as part of the same project, to facilitate unhindered xenograft transplantation in humans. Dr. James says:[36]

> We are unaware of any other group that has as comprehensive an approach to xenotransplantation as PPL. All the known technical hurdles have been overcome…. An end to the chronic organ shortage is now in sight…. We are now looking at various ways to fund our xenograft program, including discussion with potential market partners.

This is all about the project that PPL Therapeutics and its scientific-managerial apparatus had in their mind when they embarked upon the project of producing cloned pigs, and the project culminated in success when in January 2, 2002, PPL's press release declared the world's first production of genetically "knocked-out" pigs – engineered through the process of "nuclear transfer" combined with PPL's own patented technology of *gene targeting*[37] This, according to PPL, is a "key milestone … in the area of xenotransplantation."[38] Emphasizing why market players should invest in PPL Therapeutics, the press release proposes to have a "spin-out" partner that will co-function with PPL to carry forward and generate returns from PPL's achievements in the field of xenotransplantation. And given PPL's demonstration of its own achievements in the field, the release seemed hopeful that companies will be willing to co-function and co-fund its unprecedented, promising research initiatives. They were hopeful that clinical trials will begin soon, as the market analysis projects that xenografted solid organs would have a market worth $5 million in the near future. The market for PPL's products is projected as lucrative, which is why Dr. Ayares

convincingly says in this release, alluding to the market potential of pigs which are less porcine and more close to humans:[39]

> The birth of these pigs is a milestone in our xenograft program and should spark renewed vigour from both the scientific and investment communities.

Dr. James, the then Director of PPL adds as a gesture of trying to publicize PPL's scientific breakthrough through open invitation to market partners and investors as basis of marching ahead collectively towards further revolutions in the field of biomedicine. Dr. James says:[40]

> Today's announcement is a natural breakpoint for PPL to spin out the valuable technology it has developed thus far. … finding a third party at this particular time to take forward this very exciting area of science, which addresses major markets, will ensure that PPL's shareholders gain maximum value, while protecting the Company's limited cash resources needed to bring its lead product, reAACT, to market as quickly as possible.

Dr. Colman, the Research Director of PPL also emphasizes on the potential of their xenotransplantation program to "revolutionize the transplant industry."[41] This revolutionary potential of the xenotransplants industry is associated with the achievement of biological conditions which can facilitate reproduction among cloned pigs – the necessary means for generating "animal capital" (Franklin 2007) through reproduction. This press release was basically meant to announce the birth of female piglets, which marks the realization of half a step towards future breeding of such pigs.[42]

In April 1, 2002, the PPL declared the birth of male "knock-out pigs" which marks the beginning of an era of production of genetically engineered pigs through the reproduction of male and female "knock-out" pigs.[43] In August 22, 2002, Dr Ayares, the then continuing Chief Operating Officer and Dr. Geoff Cook, then the Chief Executive Officer of PPL Therapeutics confirmed in a press release that they have created doubly "knocked-out" pigs in which the pig sugar or "Gal" genes have been "doubly" deleted. They confidently declare that:[44]

> Because both copies of the gene have been inactivated, tissues from these pigs have been shown to be completely devoid of pig sugar that causes hyperacute rejection to take place.

Unprecedented scientific achievements of PPL generated confidence and the confirmed reproducibility of cloned pigs created possibilities of market ventures involving takeovers and acquisitions. After a year, when PPL therapeutics has been renamed as *Revivicor*, as result of the "spin-out" of

the former, an urgent press release on July 8, 2003, self-declared itself as a leading global enterprise producing "therapeutic products" for xenotransplantation.[45] In June 9, 2005, they declared that they have purchased the intellectual property (IP) rights and the tangible assets of an Australia-based xenotransplantation company named *XenoTrans Ltd.* (XTL). Elaborating the scientific promise and commercial profitability of the acquisition as step towards production of porcine biological equivalences for human use, Dr. Ayares says in the urgent release:[46]

> The acquisition of the XTL assets, combined with our IP and expertise in pig cloning technology positions Revivicor well for successful commercialization of a variety of therapeutic products derived from pigs… providing a solution for the adequate supply of equivalent human tissues.

The support for market expansion through investment and funding does not only come from the private players but also from the U.S. government, which also facilitates the market for porcine biological equivalences. In another immediate press release in November 3, 2010, Revivicor declared it is one among the few fortunate companies to receive federal grants under the *Qualifying Therapeutic Discovery Project*, under the aegis of the *Life Sciences Committee*, *NewVa Corridor Technology Council*.[47] These federal grants were made available in the form of a "tax credit program" as part of the *Patient Protection and Affordable Care Act of 2010* with aim to provide fillip to the biotechnological and pharmaceutical companies which produce unique medicines and introduce competitiveness in life and biomedical sciences in the United States. Applauding Revivicor's selection for federal grant, Dr. Ayares says in the release:[48]

> As a small biotech company with limited resources, in this economic climate, programs like QTDP are essential to move technology forward at a competitive pace.

A study of the press releases of *Revivicor*, during 2003 to 2005, shows that the company was receiving grants and purchasing intellectual property licenses from other companies – indicating its active market presence. In July 8, 2003, Revivicor prestigiously declared that it has received a substantial grant of $1.9 million, the third one in line, under the *Advanced Technology Program of National Institute of Standards and Technologies*, under the United States Department of Commerce for developing "perv free"[49] xenografts. This project aimed to produce xenografts that do not have the "pervs" – the *pig endogenous retroviruses,*[50] which will generate public acceptance of xenotransplantation. The release however notes that there is no evidence which show that "pervs" can affect humans, but owing to

wider "theoretical" belief that there is a risk of transmission of pig virus via xenografts, research is much needed.[51]

Another big announcement came in November 16, 2004 which declared *Revivicor's* acquisition of rights via licensing to use *Geron Corporation's* "nuclear transfer technology" to produce xenografts for human transplantation as well as for therapeutic use. In return of the acquisition of licensing rights, *Geron Corporation* will receive "equity interest" and "royalty" from *Revivicor's* continuing and future ventures. Dr. Ayares reaction to these lucrative market interactions, in his own words:[52]

> These licenses involve an important milestone in the implementation of Revivicor's business strategy.

Dr. David J. Earp, the chief patent counsel and senior Vice-President of Business Development of Geron Corporation said in response, which is symbolic of the science-market conviviality production of cloned pigs generates:[53]

> Geron has granted a number of licenses for this technology to companies that are positioned to be leaders in their fields. We are pleased that these licenses to our technology will help enable Revivicor's product development and commercialization plans.

Apart from the mutual show of confidence and trust between marker partners in scientific research, there is also a disclaimer in the same press release regarding the optimistic claims made in the press release. There is a caveat that potential investors are made aware of the risks that are involved in such ventures. Both confidence and risks relating to the market are voiced in the press releases, but nonetheless scientific confidence gets over-represented viz-a-viz the market risks. But that's no denial of risk either. Rather acceptance of risk, however subtle, brings to the fore how deeply such ventures are steeped in market ideology.

Wrapping Up! Porcine Futures and the 'Others' of Hope

Not only *Revivicor*, there are other xenoengineering companies like *eGenesis,*[54] whose scientific and managerial-cum-administrative team makes every possible effort to let the world know about their achievements. The media also takes great interest in these unprecedented, futuristic contributions. In a newspaper article entitled 'Why Pig Organs Could Be the Future of Transplants'[55] published in *Time*, in February 15, 2018, the author talks about how engendering human tissues in a laboratory setting is

no longer a fiction. With the advent of new genetic engineering technology such as CRISPR,[56] manipulation of human tissues has become a scientific fact. The newspaper report also states in a positive tone of evaluation that that while some find such development disconcerting, these are "not as Frankenstenian as it seems." A *New York Times* report[57] published in May, 24, 2018, states that researchers are "mindful that there may be ethical concerns …. But … the importance of savings human lives is worth the ethical risk…." Another newspaper report that speaks of CRISPR and *eGenesis* in a very positive light is a *Guardian* report[58] published in April 3, 2019. The report quotes William Westlin, Executive Vice President for Research and Development, *eGenesis*, who foregrounds the spectacular character of xenotransplants and the biomedical urgency to apply them by saying:[59]

> I think this is a magical point in the field of [animal transplants]. It is no longer a question of if. It's just a question of when.

Elaborating how the promise of endless supply of organs and other biological materials from the pigs is no longer a distant dream, the newspaper report quotes Dr. David Cooper, who co-directs the xenotransplantation programme at University of Alabama, Birmingham:[60]

> Transplant-ready pigs could do far more than just provide organs. Eventually, they could be used to produce the islet cells – clusters of hormone-producing pancreatic cells – needed by people with diabetes. Pig blood could be used to give transfusions to trauma patients and people with chronic diseases like sickle cell anemia, who often develop antibodies against human blood cells because they have had so many transfusions. Even dopamine producing cells could be made by pigs, and transplanted into patients with Parkinson's diseases.

Deeply convinced of the benefits of CRISPR technology and *eGenesis* contribution in this respect, Dr. Cooper further says:[61]

> It'll revolutionize medicine when it comes in. …You would have these organs available whenever you want them…. If somebody's had a heart attack, you could take their heart out and put a pig heart in on that spot. There is huge potential here.

There is constant emphasis on the spectacular promises and magical achievements of CRISPR and *eGenesis's* deployment of it to achieve successful xenotransplantation in the media articulations presented above. But that's not all; the *Guardian* report also takes into account that there is great resistance to the "road ahead" through the intervention of animal rights activists. Researchers are sometimes apprehensive about how the

society will receive or accept xenotransplantation, even if they save human lives. They do not make public the location of their labs for fear of animal welfare activists is what the *Guardian* report states. Speaking in a positive tone, Dr. Cooper convincingly says that his desperately ill patients would be happy to get a pig organ as long as it works. In response to the opposition and negativity it has generated, Dr. Cooper says, "When it hits you personally and you are going to die, I think your attitude changes."[62] This argument of Dr. Cooper is continuous with an apparently different, adventurous *eGenesis* slogan, "We are empowered. We are entrepreneurial."[63] The *eGenesis* xenotransplantation program is projected as an empowering in that it helps humans take control of their destiny and CRISPR makes it achievable, but it is human inhibition unless at the throes of a crisis like organ failure or unnecessary animal rights' group resistance that smothers such empowering, life-fostering moves. Dr. Cooper thinks that the opposition to these developments is undermining the public utility of these technologies towards greater good.[64]

A close look at *Revivicor* and *eGenesis* invites us to reflect on the nature of relation that obtains between financial investments and market projections on the one hand and scientific innovation and research on the other. Press releases I have used as *texts* for analysis unequivocally point to the fact scientific initiatives are essentially business-like, and scientists are entrepreneurs of hope. Scientific innovation requires financial investment and market involvement, without which scientific research and practice would rather be too limited in terms of nature and scale. The hope-full, promising products scientific research and practice has to offer also offers a lucrative market for investment. This results in collaborations, conviviality, and strengthening of market forces by mutual participation in procuring, buying and acquiring of licenses and patents. And with this is involved a kind of organizational posturing on the part of techno-scientific-cum-managerial apparatus of xenoengineering companies, which tendentiously foreground the unprecedented "control" contemporary genetic engineering in general and xenoengineering in particular has come to achieve and exercise on the so-called "intractability" of biology, thereby facilitating a transition to a new tractable biology and therefore new porcine futures. Xenoengineering business and its scientific apparatus plays around with what Franklin (2007) calls the "plasticity" of biology. This playing around with the "plastic" biology in the discourses of *Revivicor* and *eGenesis*, unfolds in the form of "Gal" inactivation or "perv knock-outs" in the cloned pigs, or production of "Galsafe" pigs or "perv free" piglets, leading to the engendering of hybrids, which embody the promise of porcine futures.

Scientific practitioners and financial investors become aspiring market partners in this play of producing hybrids for better futures, seeking to achieve "revolutionary" goals, eulogizing and supporting each other through public show of mutual trust and concerted action.

The "plastic" biology that is at the centre of all machinations involved herein, is no longer simply the biology of DNAs, genes and cells, although the imaginaries simulated by the discursive enunciations indicate that research and investment initiatives relating to xenoengineering have the DNAs, genes and cells at the centre of their discourses as concrete materialities, my point is that their discourses thrive more at the level of the magical rather than purely material, for they constantly invoke images of magic and spectacle to explain what they have achieved or can achieve in future. Language has a significant role in pushing the cellular materiality to the level of the magical. Xenoengineering offers an animal solution to organ scarcity – which in turn helps imagining an animal or porcine future to be more specific. The power that biomedical sciences exercise over life, aiming to foster it, render it productive is reflected in the control such power exercises and the intervention such control necessitates. At the centre of such control is the hope for a better biological future. However, the hope xenoengineering offers to the humanity, concomitantly has pain, physical harm and violence in the animal register, something which is disavowed in the anthropocentric-scientific register of things. Even in face of opposition from animal rights activists, xenoengineering thrives, for a utilitarian science presumes the higher moral worth of humans viz-a-viz animals-the other of the human. Moreover, the animals xenoengineering companies produce are hybrids, which are not pure essences. In the vocabulary of xenoengineering scientists and industrialists, they are "galsafe" pigs or "perv free" piglets. They have attractive names, for they are lucrative commodities to be traded or sold on the market.

Evelyn Fox Keller (2000) emphasizes on the power of words in science for they enable communication with the larger public and function as instrument of persuasion. If the hybrids enable science communicate with and persuade the scientific public, the market and society at large of the promises of xenotransplantation, they are able to do so only because inherent to the persuasion is the logic of hope. Persuasion via hybrids becomes meaningful only because they operate within an anthropocentric discourse of hope for better life at present and in future through the animal route. This is more than evident in the discourses of *Revivicor* and the *eGenesis*. The troubling question of fate of the animals in xenoexperiments and the hybrids-the

cloned animals, from which xeno-organs will be harvested, is however reluctantly set aside in these hopeful discourses of xenoengineering companies.

Notes

1. Xenotransplantation is the transplantation of organs across species barrier. If animal organs are transplanted in human bodies, then that would be a case of xenotransplantation. Xenotransplantation aims to solve the shortage of transplantable human organs as the only solution to human organ failure by offering animal alternatives.
2. Xenoexperiments are experiments where organs are transplanted across species barrier. The transplantation of a cloned piglet's heart in the body of baboon X201M is a case of xenoexperiment.
3. https://www.pbs.org/wgbh/pages/frontline/shows/organfarm/
4. A summary of the report is available in the *Frontline* report.
5. https://www.pbs.org/wgbh/pages/frontline/shows/organfarm/rights/controversy.html
6. Ibid.
7. https://www.pbs.org/wgbh/pages/frontline/shows/organfarm/interviews/lyons.html
8. Ibid.
9. https://www.pbs.org/wgbh/pages/frontline/shows/organfarm/rights/views.html
10. https://www.pbs.org/wgbh/pages/frontline/shows/organfarm/interviews/berger.html
11. Transgenic pigs are genetically modified pigs with foreign gene inserted in their bodies.
12. Xeno-organs are organs produced through genetic and xenoengineering.
13. Transgenesis is a process of genetic modification through insertion of foreign gene in the genome.
14. https://www.pbs.org/wgbh/pages/frontline/shows/organfarm/interviews/berger.html
15. https://www.revivicor.com/about.html
16. A spin-out is basically a process of corporate realignment.
17. It is the biotechnology company that produced the cloned sheep, Dolly.
18. Hyperacute rejection is rejection of graft within twenty-four hours of transplantation due to violent immunological reaction.

19. These are enzymes that act as a xenoantigen and triggers hyperacute rejection in pig-to-human transplantation.
20. Knock out is common expression in genetic engineering parlance, for inactivation or removal.
21. https://www.revivicor.com/technology.html
22. CD64 is a glycoprotein.
23. Immunesuppression is the suppression of body's internal immune system.
24. Allotransplantation is the scientific term for human-to-human organ transplantation.
25. https://www.revivicor.com/technology.html
26. Somatic cell nuclear transfer or SCNT is a strategy for producing an embryo using a body cell and an egg cell.
27. Same as SCNT.
28. https://www.revivicor.com/MrJefferson.htm
29. https://www.revivicor.com/clonedpigsrelease.htm
30. Ibid.
31. These are pig enzymes which hasten rejection of xenografts by humans.
32. https://www.revivicor.com/clonedpigsrelease.htm
33. Ibid.
34. Graft Rejection is the rejection of transplant by the immune system of the recipient body.
35. https://www.revivicor.com/clonedpigsrelease.htm
36. Ibid.
37. Gene targeting is the strategy of altering gene or sequence at a particular location.
38. https://www.revivicor.com/KOrelease.htm
39. Ibid.
40. Ibid.
41. Ibid.
42. Ibid.
43. https://www.revivicor.com/MaleKOrelease.htm
44. https://www.revivicor.com/PPLDKOPigRelease.html
45. Ibid.
46. https://www.revivicor.com/XTL%20Revivicor%20press%20Release%20final.htm
47. https://www.revivicor.com/NCTC%20Press%20Release.pdf
48. Ibid.

49. Perv free refers to a condition devoid of pig endogenous retroviruses.
50. Pig endogenous retroviruses are a specific type of retrovirus in pig genome transferred through inheritance.
51. https://www.revivicor.com/pressrelease8july2003.htm
52. https://www.revivicor.com/ATP%20Polyclonal%20Antibody%20Grant%20-%2030Sept04.htm
53. https://www.revivicor.com/Revivicor%20Geron%20License%20Agreement%20Press%20Release.htm
54. https://www.egenesisbio.com/
55. https://time.com/5159889/why-pig-organs-could-be-the-future-of-transplants/
56. CRISPR stands for clustered regularly interspaced short palindromic repeats. It is a genome-editing technology.
57. https://www.nytimes.com/2018/05/24/science/using-medicine-and-science-to-improve-the-quality-of-life.html.
58. https://www.theguardian.com/science/2019/apr/03/animal-global-organ-shortage-gene-editing-technology-transplant?
59. Ibid.
60. Ibid.
61. Ibid.
62. Ibid.
63. Ibid.
64. Ibid.

References

Foucault, Michel. 1980. *The History of Sexuality, Volume I: An Introduction*. New York: Vintage Books.

Foucault, Michel. 1973. *The Birth of the Clinic: An Archaeology of Medical Perception*. (Trans. A. M. Sheridan). London and New York: Routledge.

Franklin, Sarah. 2007. *Dolly Mixtures: The Remaking of Genealogy*. Durham: Duke University Press.

Haraway, Donna. 2004. *The Haraway Reader*. New York and London: Routledge.

Keller, Evelyn Fox. 2000. *The Century of the Gene*. Cambridge: Harvard University Press.

Latour, Bruno. 1993. *We Have Never Been Modern*. (Trans. Catherine Porter). Cambridge: Harvard University Press.

Lock, Margaret. 2009. 'Demoting the Genetic Body', *Anthropologica*, Vol.51, No.2: 159-172.

Lock, Margaret. 2001. 'The Tempering of Medical Anthropology: Troubling Natural Categories', *Medical Anthropology Quarterly*, Vol.15, No. 4: 478-492.

'Organ Farm: Could Pig-to-Human Transplants Revolutionize Medicine? A Report on the Promises, Risks and Controversy' *Frontline*, March, 2001. Stable URL:https://www.pbs.org/wgbh/pages/frontline/shows/organfarm/ (accessed on July, 27, 2021).

Park, Alice. 2018. 'Why Pig Organs Could Be the Future of Transplants', *Time*, February 15. Stable URL:https://time.com/5159889/why-pig-organs-could-be-the-future-of-transplants/ (accessed on July, 27, 2021).

Rose, Nikolas. 2007. *The Politics of Life Itself: Biomedicine, Power and Subjectivity in the Twenty-first Century*. New Jersey: Princeton University Press.

'Using animal organs in humans: It's just a question of when', *The Guardian*, April 3, 2019. Stable URL: https://www.theguardian.com/science/2019/apr/03/animal-global-organ-shortage-gene-editing-technology-transplant?utm_source=STAT+Newsletters&utm_campaign=82a7657beb-MR_COPY_01&utm_medium=email&utm_term=0_8cab1d7961-82a7657beb-150659881 (accessed on July, 27, 2021).

'Using Medicine and Science to Improve the Quality of Life', *The New York Times*, May 24, 2018. Stable URL:https://www.nytimes.com/2018/05/24/science/using-medicine-and-science-to-improve-the-quality-of-life.html (accessed on July, 27, 2021).