Research on Human Cloning: Playing God or Saving Lives?

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Contents

List of abbreviations

ART	Assisted reproductive technology
ES cells	Embryonic stem cells
HC	Human cloning
IPS cells	Induced pluripotent stem cells
IVF	In vitro fertilization
MRT	Mitochondrial replacement therapy
RC	Reproductive cloning
SCNT	Somatic cell nuclear transfer
TC	Therapeutic cloning

Introduction: When science fiction threatens to become scientific reality

While attending a wedding in 1996, an unusual message was delivered to Mrs. Karen Mycock: "She's been born and she has a white face and furry legs". A weird birth announcement for a weird birth. The reason why Mrs. Mycock was informed is because she belongs to a researcher team at the Scottish Roslin Institute of Animal Genetics. This small but significant message was delivered to announce one of the most discussed events of the 20th century: the birth of Dolly the sheep, the first mammal clone in history (The Economist 2017)

Dolly's existence put the cloning issue immediately under public spotlight. The result was a contentious ethical, political and medical controversy surrounding one key question: Should we allow human cloning? (Nerlich et al. 2001: 38) Two opposing positions emerged: on the one end of the spectrum are primarily religious leaders and social thinkers who saw in Dolly the reincarnation of evil, a sort of Pandora's box that should never have been opened. On the other end are mainly scientists and experts who regarded Dolly as a scientific Holy Grail, as a dream of curing life-threatening diseases coming true (ibid: 47).

Since the very beginning of this debate, Frankenstein and other science fiction icons have continuously served as the "imaginary hook onto which chains of arguments about these issues were attached". Scientific reality threatened to catch up with science fiction, with clones we know from books and films now turning into blood and flesh (ibid: 38 f.) This has prompted governments from all around the world to answer in legislative policy terms. Under President Bush, the Human Cloning Production Act was passed in 2001, thus banning all public funding for research on human cloning. Given the contending character of this debate, the question addressed in this paper is: **To what extent should we ban research on human cloning?**

In order to answer this question, the first part of this essay will provide preliminary information about the "cloning" procedure in order to clarify what *is* possible with this technology – and

what is not. This background is necessary to understand the moral and scientific implication of cloning, a debate that will be addressed in the second part of the essay.

In this paper, I shall argue that we should not ban research on human cloning all together. While reproductive cloning, which amounts to "playing God", is indeed morally questionable, therapeutic cloning has great live-saving potentials. Research on what we indiscriminately call "human cloning", or nuclear-transferring techniques, should therefore be regulated but not banned.

I) The scientific preliminaries: Defining "clone" and understanding "cloning"

To have a qualified debate, it is important to first understand from a scientific perspective what clones are and how they are created. The first part of this section will therefore trace back the origins of the term and explore the occurrence of natural clones. The second part will explain the procedures to artificially create clones and present major mile stones in the history of cloning science.

1.1 The origins of the term "clone"

„Cloning is a process through which an exact copy of an organism is asexually reproduced by splitting embryo cells". (Khare/Khetal 2016: 1) In other words, "clones" are genetically identical individuals. The term originates from the Greek word "clonos" (κλώνος), which literally means "twig". Initially, it was used to describe the agricultural practice of growing a new tree using the twigs instead of the seeds of the original tree.

That the same principle could be applied to all living beings was already realized in ancient times. As early as in the sixth century AD, the philosopher Joannes Philoponus estimated that "[i]f someone cuts a twig from a walnut tree in Athens and plants it in Patras [200 km away], two or three years later it will bear nuts that are the same in every aspect, in size and taste and colour and every other character, with the ones from the walnut tree in Athens. […] So, if the

resemblances between the plants do not originate because the seed comes from the entire body, as it was proved, but for some other reason, […] the same applies to animals as well." Here Philoponus was refering to Aristotle's work, who - long before Mendel was born, explained in his book *On Animal Generation* that there are different means of passing on the characteristics of plants, animals and humans to later generations apart from sexual intercourse:

> "Children are like their more remote ancestors from whom nothing has come, for the resemblances recur at an interval of many generations, as in the case of the woman in Elis who had intercourse with an Ethiop; her daughter was not an Ethiop but the son of that daughter was. The same thing applies also to plants. […] If again something creates this composition later, it would be this that would be the cause of the resemblance, not the coming of the semen from every part of the body."

In our contemporary time, we call Aristotle's "something" the DNA. The philosopher somehow understood that there exists an information which is responsible for the characteristics of living beings, and that reproductive seeds and semen are but mediums to transmit this information. In biology, we observe natural "cloning" when organisms like bacteria, molecules, insects and plants propagate asexually. For what concerns humans, natural clones sharing the same genetic material are called identical twins. (Diamandopoulos/Goudas 2000)

1.2 The application of "cloning" methods

The term "clone" to describe identical beings was first coined by J. B. S. Haldane in 1963 after the first animal, a tadpole, was cloned in the 1950s (Nerlich et al. 2001: 40) As of today, the two most important cloning techniques are somatic-cell nuclear transfer (SCNT) and induced pluripotent stem cells (IPS cells).

1.2.1 Somatic cell nuclear transfer (SCNT)

The first nuclear transfer was performed by Hans Spemann in 1928, and he assumed that this technique could be used to "clone" higher organisms (Nerlich et al. 2001: 40) Somatic-cell nuclear transfer (SCNT) involves the fusion of two distinct components. One is an egg cell, or

oocyte, which had its nucleus[1] (the part which contains the DNA) removed – making it a "neutral" or "enucleated egg". The other is the nucleus of a somatic cell (an adult body cell such as a skin or liver cell). The somatic cell is provided by a donor whose genetic information is supposed to be copied. Once the nucleus of the somatic cell is transferred to the host egg cell with a micropipette, the resulting unicellular entity can be fused and incited to divide by electronic stimulation. The egg is thus "tricked" into becoming an embryo possessing the same genetic profile as the original somatic cell donor. The embryo can subsequently develop and grow either in a surrogate mother or artificially under laboratory conditions. (Hochedlinger/Jaenisch 2003 in Cunningham 2013: 825)

Using nuclear transfer in 1996, Dr. Ian Wilmut and Dr. Keith Campbell of the Scottish Roslin Institute have given life to Dolly the sheep, the first successful mammal clone. Three animals were involved in Dolly's creation. First, the somatic cell with an intact gene-bearing nucleus was taken from the udder of a white-faced ewe. Secondly, the egg, which was then enucleated, was provided by a black-faced ewe. And finally, the surrogate mother who took the embryo to term was another black-faced ewe. The newborn lamb was white-faced, thus proving that it was a clone of the white-faced Finn Dorset sheep that had donated its udder cells for the experiment. (Wilmut et al. 1997 in Nerlich et al. 2001: 41 ff) The lamb was named Dolly because the cells used to make it were derived from mammary tissue, which reminded Dr. Wilmut of the impressing bosom of singer Dolly Parton (Wilmut in Nerlich et al. 2001: 47) The one crucial thing to understand about Dolly the sheep is that, without involving sperms, a healthy lamb was created simply by using the nucleus[2] of an adult body cell to "fertilize" an oocyte which had its own nucleus removed. This means that an oocyte will react on the nucleus of any cell the way

[1] Nucleus, DNA, nuclear genome, genome or genetic information are all synonymous terms. They all refer to the genetic material of any cell, be it a somatic cell (any differentiated, adult body cell), gametes (sperms and eggs) or stem cells (undifferentiated cells that can become any specialized cell like blood cells, skin cells etc.)

[2] Nucleus, nuclear genome, genome etc. are synonymous terms. They all refer to the key genetic information of a cell, be it a somatic cell (any differentiated, adult body cell), gametes (sperms and eggs) or stem cells (undifferentiated cells that can become any specialized cell like blood cells, skin cells etc.)

it would on sperm cells. (Latham 2005) At this point, it is interesting to note that, since no sperm cells were needed for such a nuclear transfer, it was able for three female sheep to provide all the necessary ingredients to bring a female baby lamb into being.

Dolly embodies the "holy grail" for the reproductive science community. In 1952 Robert Briggs and Thomas King already used nuclear transfer to create tadpoles, the first cloned animal in history. It was however assumed that cloning could only be done with embryonic cells and that reproducing higher mammals was impossible. Dolly was also significant because her existence proved that the genetic information from an adult body cell, programmed to perform a specific function, can be reprogrammed to develop into an entire new organism. Since Dolly's birth, SCNT was used to successfully clone about 20 other species. The list includes for instance camels, mice, cats, dogs, wolves and pigs. (Nerlich et al. 2001: 40 ff.) SCNT was the first cloning method discovered since the 1920s. However, a new technology which might make SCNT obsolete was pioneered in 2006. It is called the induced pluripotent stem cells method.

1.2.2 Induced pluripotent stem cells (IPS cells)

Stem cells are undifferentiated cells that have the potential to differentiate into specialized cells and to propagate indefinitely. In other words, they can grow to become any part of the human body (i.e. skin, blood, heart, neurons, sperms, eggs, liver cells etc.). This potential of stem cells is called pluripotency. (Nisbet 2004: 131 ff) Naturally occurring pluripotent stem cells are embryonic stem cells (ES cells). Induced pluripotent stem cells (IPS cells) were initially specialized cells which are artificially reprogrammed back into stem cell stage. The technique to generate IPS cells was discovered by Dr. Shinya Yamanaka in 2006. (Pera/Trounson 2013: 159 f.) After hearing about Dolly's birth, Dr. Yamanaka realized that there must exist certain chemical factors within eggs which had the power to "rejuvenate" the DNA of an adult body cell. Henceforth, the biologist was determined to find them. In 2006, he succeeded in discovering four of such "reprogramming" factors, which could, when coordinated

simultaneously, transform specialized cells back into pluripotent stem cells. The tremendous medical signification of this discovery won Yamanaka a Nobel Prize in 2012. For instance, in the case of a patient suffering from a heart disease, the technique could be used to convert some of the patient's skin cells back into stem cells which can then, in turn, grow into a cloned heart for the patient. Since the heart matches the patient's genetic profile perfectly, there is no longer the risk that the transplant will be rejected by his/her immune system (The Economist 2017).

IPS cells can also be used to clone entire organisms, for instance by using tetrapoid complementation assay. This means that two diploid[3] somatic cells will be fused and stimulated to divide with an electric jolt to produce a tetraploid embryo. Such an embryo can now be combined with an IPS cell derived from the body cell of a donor to create the donor's clone. A researcher team has recently replicated genetically identical mice by applying this technique. (Boland et al., 2009 in Lo et al 2010:16) In theory, human IPS cells could be injected into a human tetraploid embryo to create a clone of the IPS cell donor. (Lo et al 2010: 16)

IPS cells also open up new possibilities in the domain of assisted reproductive technology (ART). In mice, it is now possible to convert IPC cells originating from skin cells into sperms and eggs. If this technique, also called in vitro gametogenesis or IVG, could be applied to humans, it would allow people suffering from infertility to have children. It also means that same-sex couples will be able to have shared biological children, for example with a sperm derived from one woman inseminating another woman's natural egg. Conversely, an oocyte derived from one man's body cell can be fertilized by another's natural sperm (albeit a surrogate mother is still needed to bring the embryo to term). In theory, this would also allow for one person to provide both gametes. Since human beings have two copies of every gene, but eggs and sperms each only get one, the offspring would not be a genetical clone of the parent. But

[3] Every cell is diploid, meaning that it possesses each chromosome (X and Y) in duplicate.

there is no need for panic, this sort of inbreeding is not feasible in practice and would be banned by any legislative body (The Econonomist 2017).

Considering the potential use of these technologies, it is of little surprise that concerns about the morality and safety of cloning procedures were raised. The section above attempted to answer all preliminary questions concerning the meaning of clones and the process of cloning. It is now time to address the harder question of whether research on human cloning should be permitted.

II) The ethical and legal debate: allowing or banning research on human cloning?

New technologies like human cloning pose manifold risks, which is why moral and safety problems should be carefully considered. However, in order to have an informed and constructive debate, it is important to refer to facts instead of succumbing to "fictions, fantasies and fears". The first part of this section will consider the dangers posed by cloning technologies before evaluating the current bans on human cloning. The second part will clear up some common stereotypes about clones, consider the medical benefits of cloning techniques and, given their live-saving potential, argue for a more balanced legislative approach away from a total ban towards a partial ban permitting therapeutic cloning.

2.1. The danger of playing God

2.1.1. Going down the path of moral disgrace

Under the Third Reich, the Nazis attempted to create an Aryan super-race. Eugenics, literally meaning "good genes", was an official state policy. During the war, 12 000 blue-eyed blond babies from occupied territories were captivated, Germanized and given to Nazi foster parents. In so-called "breeding clinics", suitable men and women were encouraged to mate in order to produce "racially pure" babies for the Third Reich (Dailymail 2009). Had the Nazis known how

to clone human beings, they would have tried to populate the whole world with the *Herrenrasse*. Thinking of similar scenarios, some have immediately objected to human reproductive cloning out of fear that human genetic engineering for eugenic purposes could be reintroduced into our society. Another concern is that human clones could be used to harvest "spare organs". (Nerlich et al. 2001: 40) Additionally, it was argued that asexual reproduction, i.e. by using IPC cells to create an embryo, constitutes a violation of cultural norms and of natural or divine laws (The President's Council on Bioethics, 2002 in Lo 2010: 16 f.) The Vatican, for instance, stated that humans should be born "in a human way and not in a laboratory" (The Economist 2017) These are however more distant fears because the cloning of humans has not been possible – yet.

Another concern is related to the moral status of embryos. Some oppose all form of research on human embryos because they think that, no matter their age, these embryos have a right to human dignity and respect. Embryos are like hollow balls with stem cells inside. They must be broken open to harvest these stem cells for therapeutic purposes (Lo et al. 2010: 17) This is why research on embryos is problematic because 'it is immoral to create human embryos for purposes that are foreign to the embryos' own well-being and that necessarily require their destruction'' (President's Council on Bioethics 2002 in Cunningham 2013: 828) This criticism is only addressed at SCNT, as IPS cells are not derived from embryos but from adult body cells.

There also exists the possibility to create human-animal chimeric embryos using SCNT. These embryos are created by injecting a human nucleus into a non-human animal egg. These are tissue engineering projects which aim at growing "human cell-derived organs" in animals for transplantation purposes. The existence of such organisms, however, raise serious ethical concerns because they blur the boundary between human and animals, thus challenging the notion of human identity and human dignity. The technique has so far been used to create the Vatican mouse (with a human ear grown on its back) or pig-human hybrids. (Rashid et al. 2014; Matsunari in Mizuno et al 2015: 1; Nerlich 2001: 42 f.) A part from the ethical problems

mentioned above, there exist also practical safety concerns regarding the use of cloning techniques.

2.1.2. Recognizing the risk of unintended outcomes

The uncertain consequences of new scientific technologies such as cloning are the source for great societal concern. Social theorists like Ulrich Beck, talking about a "risk society", warned of the unforeseeable dangers posed by techno-scientific uncertainties of contemporary modern society. (Beck 1992 in Jensen 2008: 123) For instance, women have to undergo risky surgeries in order to donate their eggs for cloning research purposes. Again, these concerns are only related to SCNT and not to IPS cell research as no oocytes are required for the latter. (United Nations General Assembly, 2005 in Lo et al 2010: 17)

There are also manifold risks for the cloned embryo. Studies on animal clones reported birth defects, pre- or neonatal deaths, reprogramming and imprinting errors and health risks to the pregnant mother. (The President's Council on Bioethics, 2002 in Lo et al 2010: 1) In the case of Dolly, 277 successful nuclear transfers only yielded 29 embryos, out of which only one has developed into a normal sheep. For the creation of Prometea, the first cloned horse, 814 attempts were needed. (Economist 2017) This suggests that reproductive cloning is still a risky and unsafe procedure. (Lo et al. 2010: 17)

Bioethicists thus maintain that we do not know enough about genetic science, such as cloning and gene editing, to calculate long term consequences. Cloning, considered to be an unsound technology, was thus often compared to the invention of the nuclear bomb (Nerlich et al 2001: 49) One of the opponents to cloning, Dr. Blackwelder, worries about whether we "really think that we have enough knowledge to remake millions of years of evolution of living organisms with less than one century worth of scientists who try to understand what is going on" (Blackwelder 2015)

2.1.3. Banning human cloning all together

The social, religious and medical concerns outlined above have prompted legislative bodies to react sharply to cloning technologies. Especially after Dolly's birth, the prospect of using SCNT to clone human beings has triggered a contentious public debate. Many countries and supra-national bodies decided that safety and moral problems can only be addressed with a ban on human cloning (National Bioethics Advisory Commission, 1997; National Research Council and Institute of Medicine, 2002; The President's Council on Bioethics, 2002 in Lo 2010: 16 ff)

In 2001, the US Congress under President Bush passed a bill prohibiting federal funding for all kind of research on human cloning. The ban directly affected stem cell research as embryonic stem cells were derived from embryos using SCNT (Cunningham 2013: 828). Back then, President Bush expressed his opposition towards stem cell research by saying that the "idea of growing human beings for spare parts, or creating life for our convenience" was unethical. (Bush 2001) During the 2004 US presidential campaign, the subject of stem cell research and therapeutic cloning reemerged. John Kerry, a presidential candidate back then, brought up the issue to public attention during his speeches. (Kerry 2004 in Jensen 2008: 124)

International institutions have also expressed their opposition to human cloning. In 2005, the United Nations Organization passed a resolution banning human cloning of all sorts because "they are incompatible with human dignity and the protection of human life". (United Nations General Assembly, 2005 in Lo et al 2010: 17). The ban is, however, non-binding and UNO member states are free to decide on their national legislation regarding the issue. (Khare/Khetpal 2016: 1) Members of the European Parliament also called on EU member states to "enact binding legislation prohibiting all research on human cloning and providing criminal sanctions for any breach." The Council of Europe thus decided to prohibit human cloning, defined as "the creation of a human being sharing the same nuclear gene set as another being". The European Parliament also passed a resolution in 1997 to reassert that "the cloning of human

beings […] cannot under any circumstances be justified or tolerated by any society, because it is a serious violation of fundamental human rights and is contrary to the principle of equality of human beings as it permits a eugenic and racist selection of the human race, it offends against human dignity and it requires experimentation on humans." (in Harris 2016: 7) At the present, approximately 46 countries have declared a ban on human cloning (CGS 2017)

Given the risks inherent in the cloning technology, it is indeed important to establish laws to prevent immoral abuses and to avoid unintended consequences. However, in order to choose the appropriate legislative framework, it is equally important to weigh the risks against the benefits of research on human cloning in order to make qualified judgements about what to make of the technology.

2.2. The need to save lives

The following section will first distinguish between two different uses of human cloning: reproductive and therapeutic cloning. Then, it will be shown how popular images forged by cloning fiction can cloud judgements about cloning science. Having cleared up those stereotypes, we will be able to better understand the potential benefits offered by techniques like SCNT and IPS cells creation. Taking into consideration their live-saving potential, it will become evident that a more balanced legislative approach – allowing cloning for therapeutic while banning cloning for reproductive purposes – is needed.

2.2.1. Knowing the difference between reproductive and therapeutic cloning

Dolly is the most famous sheep of all time. A poll conducted in Great Britain shows that more than half of the 1018 respondents knew who she was. 65 per cent also knew that she was created from a somatic cell. The most discussed aspect of her birth was however the potential use of SCNT to clone humans, despite repeated assertion of the Roslin Institute that Dolly was not created to promote research on human cloning.

As a matter of fact, most people do not really know the difference between reproductive and therapeutic cloning. In 2002, only 2 out of 5 US Americans were either "very clear" or "somewhat clear" on the distinction between the two cloning applications. (Nisbet 2004: 135) "*[T]herapeutic cloning* [TC] […] refers to the use of SCNT to clone a human embryo from which stem cells can be derived for therapies or cures" while *"reproductive cloning"* [RC] is understood as the use of SCNT to clone a human embryo, which is subsequently implanted and brought to term culminating in live birth." (Jensen 2008: 125) Whereas therapeutic cloning is usually seen as a positive medical progress, reproductive cloning is considered as still being a long way off or even impossible to achieve. (Nerlich et al. 2001: 38). Advocates of therapeutic cloning usually put emphasis on these differences with the aim of fighting against negative connotations of the term "human cloning". They use therefore preferably terms like "stem cell cloning", "medical cloning" or "nuclear transfer". Meanwhile, opponents of all forms of human cloning (especially anti-abortion activists) try to blur this distinction intentionally. This is a tactic to achieve a legislative ban on all form of human cloning instead of a comprehensive partial ban that only prohibits reproductive cloning. Despite the efforts of scientists to carefully distinguish the two concepts, public suspicion towards "human cloning" remains considerably high. This is partly due to a persistent common imagination of "clones" within the public sphere which has been shaped by popular books and films published during the 20th century. (Jensen 2008: 125)

2.2.2. Understanding the impact of dystopian "fictions, fantasies and fears"[4]

Following the publishing of the Dolly paper by the journal *Nature*, a sort of "myth" surrounding the topic of clones emerged. Dolly stood for every thinkable demonic image associated with clones ranging from the "creation of a super race or a race of slaves" through "cloning an army of Hitlers" and up to "multiplication of famous people" (Nerlich et al. 2001: 45) Scientists tried

[4] The title is inspired by Nerlich et al. 2001, "Fictions, fantasies, and fears: The literary foundations of the cloning debate"

to convince the public that Dolly was simply a cuddly sheep – an unsuccessful attempt at the time. (Hodgson 1998: 30 in Nerlich et al. 2001 :47)

However, this kind of public debate was to some extent predictable. The press coverage about Dolly was mixed with science fiction, often citing books and films such as *Frankenstein, Brave New World, The Stepford Wives, Boys from Brazil, Multiplicity* or *Gattaca* to explain the Dolly event. This conflation has made it very easy for the wider public to establish links between science fiction and scientific reality. Unfortunately, this contributed to fostering false beliefs about clones among the general public and to increasing their "fears about an increasing process of biological hybridisation which blurs the boundaries between humans, plants, animals, and machines and threatens people's sense of humanity. (Nerlich et al. 2001: 37) For instance, in Aldous Huxley's 1932 *Brave New World*, we find an early presentation of "test tube embryos" which are grown in vitro. During the time, the theme of identical monster armies and that of the desire for immortality emerged. In 1951, the novel *Midwich Cuckoos* by John Wyndham was published, telling the story of a village whose inhabitants, after being put to deep sleep by a strange gas, suddenly wake up to see all their young women becoming pregnant. Nine months later, blond babies with strange powers were born, causing stranger accidents to happen in the village. The myth that clones have supernatural powers emerged during this time. In 1978 the film *Boys from Brazil* dealt with the theme of an Adolf Hitler being cloned in the deep jungles of South America by former Nazis. After the publication of the Dolly-article in 1997, *Gattaca* came out in the cinemas and painted "a vision of a dystopian future in which prospective parents can obtain genetic profiles of their *in vitro* embryos and, based on that information, decide which to implant. In effect, they will be able to choose – to some extent – the kind of children they will have". (Nerlich 2001: 40 ff.) Finally, in 2005, Kazuo Ishiguro's novel *Never let me go* explored the theme of human clones being used as commodities, a sort of "spare parts stocks". (Carroll 2010). All in all, these and other works have continuously shaped a common

understanding of "clones" which will eventually serve as basis for any discussion surrounding the subject of clones, as Nerlich explained:

> "These images were the foundations for the development of some fundamental metaphors, according to which CLONES ARE COPIES that have inferior value, CLONES ARE PLANTS/ANIMALS that can be farmed and harvested, CLONES ARE PRODUCTS, CLONES ARE MACHINES, BODY PARTS OF CLONES ARE SPARE PARTS that can be bought and sold, exchanged for better ones, and so on" (Nerlich 2001: 45)

As such, it was difficult for people to see clones "just as babies", just as one of the other 400000 natural human clones that are born every year – namely identical twins. (Harris 2016: 8) These dystopian images about clones have considerable impacts on policies and public opinion, as Jensen would point out:

> "The doom scenarios portrayed in popular films helped to frame the public policy debate around the a priori conclusion that reproductive cloning must be banned. […] Extended discussion was often unnecessary: Merely mentioning such films sufficed to immediately communicate an entire narrative about human cloning. […] [Unfortunately,] popular films have hyped the risks of human cloning to the point that the dystopias they envision are often deeply misleading and far removed from any scientifically plausible and realistic scenario […] this reinforces public uncertainty and undercuts the possibility of different societal groups (e.g. religious, scientific, and patient advocacy groups) engaging in a constructive dialogue on important issues such as those related to human cloning research." (Jensen 2008: 137 ff.)

2.2.3. Considering the potential benefits of scientific progress

Examples from the past show that scientific progress always had to deal with misleading popular beliefs before rationality overtakes fears and fiction, thus triggering a process of normalisation. This was for instance the case with the Black Death or with AIDS. Eventually, people started to realize that AIDS "is just a virus". At the end of the 1990s, the public was not confronted by an unknown disease, but by a sudden scientific progress that could possibly cure live-threatening diseases: the prospect of human cloning using SCNT (Nerlich et al. 2001: 37). Cloning was depicted as "freakish" and its journey towards "familiarity" was a long and hard

one. Other medical advances which went through a similar process is in vitro fertilization (IVF). In 1978, Baby Louise Brown was born as the first human baby being conceived in vitro. Religious arguments against scientists "playing God" were immediately voiced, and the IVF debate prepared future arguments for the cloning debate. Just recently, the 38 year-old Mrs. Louise Brown pondered: "When I was born they all said it shouldn't be done and that it was messing with God and nature but it worked and obviously it was meant to be" (Brown in Harris 2016: 7f.) There are some similarities between the case of Louise Brown and that of Dolly. First, both were perceived as being born under "synthetic" conditions. Secondly, there is the claim that their right to "genetic identity" was violated. In both cases, the public initially believed that they were somehow abnormal, as if they were not a normal female human and a normal ewe.(Harris 2016: 7ff.) Religious voices were quick to remind the public that such asexual procreation techniques threaten to "usurp" god's position. (Weasel/Jensen 2005: 1)

Adding to this hostile atmosphere against cloning are also the bogus claims of some scientists about having successfully cloned human beings. One year after Dolly's disclose, Clonaid (a company secretly founded by a religious cult) announced that it would set up "human cloning clinics". (Nerlich 2001: 43)

Other objections to genetic editing, cloning or IVF are not so much grounded in moral assumptions but more in the safety risks posed by these practices. However, Harris' counter-argument is that "uncertainty is the defining feature of knowledge-intensive societies and applies, quite obviously, to any procedure contemplated in humans for the first time. If impractically high precautionary thresholds were decisive we would not have vaccines, nor IVF, nor any other advance. Nothing is entirely safe. We have to decide what's "safe enough" given the balance of risks and benefits. Sometimes this decision must be left to those who wish to use the procedure and on whom the risk falls […]" (Harris 2016: 11)

Meanwhile, what has really happened to cloning techniques 20 years after Dolly's birth? Fact is, there are still no existing human clones at the present, and this will remain the case because human reproductive cloning is explicitly forbidden under international law. Instead, SCNT and IPS cells have been successfully applied to generate stem cells for therapeutic purposes. While embryonic stem cells derived from SCNT have been considerably criticized, the process of creating induced pluripotent stem cells do not involve the destruction of embryos. Consequently, stem cells researchers no longer need to acquire 'surplus' human embryos that were collected for *in vitro* fertilization for the creation of stem cells. (Pera/Trounson 2013: 159 f.) IPS cells hence allows scientists to circumvent the moral and legal problems of embryonic stem (ES) cell research. Furthermore, tissues grown from IPS cells will perfectly match the patient's genetic profile, thus reducing the risk of rejection during the transplantation. (Lo et al 2010: 1) In 2010, stem cell therapy has been used to treat spinal injury for the first time. Moreover, IVF-derived ES cells were also recently used to create insulin-producing cells, a material that can treat type 1 diabetes. However, these sorts of "handcrafted" stem cell therapies are still very costly because it is difficult to find public funding for research and progress has been slowed down by harsh legislations. A stem cell therapy involving the extraction of adult stem cells from bone marrow costs $ 665 000 nowadays. (The Economist 2017)

Another example for medical progress is mitochondrial replacement therapy (MRT), also called the "three parent technique". This technology can prevent babies from inheriting lethal genetic diseases by replacing the faulty mitochondrion of the embryo with that of a third person before IVF. In 2015, the UK was the first country to legalise this technique. (Harris 2016: 6) Another breakthrough is the CRISPR Cas-9, also called the "molecular scissor". This technique permits to replace faulty genes with intact ones, a kind of "copying and pasting" of DNA sequences, ultimately opening up the possibility of curing innumerous genetic diseases. Using this method, it has been possible to restore eyesight to blind rats. (The Guardian 2016) However, opponents

warn of the potential misuse of these techniques to create "designer babies" by artificially modifying and inserting DNA-sequences (The Guardian 2017)

Conclusion: An informed debate away from science fiction and towards scientific reality

Few subjects are as controversial as human cloning. 20 years after Dolly's birth, research on all kinds of human cloning is still prohibited in many countries. This essay has argued that, while it is important to recognize the risks associated to new technologies such as human cloning, states should not ban research on human cloning all together. A distinction should be made between reproductive human cloning, which is conducted to create whole human beings, and therapeutic cloning, which is pursued to find cures for diseases. Governments should clearly ban reproductive cloning but allow the therapeutic sort. Some states, such as the United Kingdom, have opted for such a "partial" ban, while France, Germany and the US still opt for a "total" ban. Studies have shown that, similarly to the case of abortion laws, the socio-religious belief and the level of income per head of a population determine whether a state will adopt a total ban or a partial ban on human cloning research (Stabile 2006, Isasi/Knoppers 2006: 1 f.)

Because of the great potential benefit therapeutic cloning has for mankind, governments should allow research on human clones for medical purposes. Opposition to human cloning is often fuelled by pre-determined stereotypes cumulating from a century of cloning science fiction. It is therefore important to consider the benefits of cloning techniques from the angle of scientific reality and to rehabilitate therapeutic cloning. Moreover, a total ban is not a good way to deal with existing risks. There is nothing to stop someone from trying out the technology outside of the legislative framework. A ban might create black markets and incite researchers to emigrate to countries where regulations are lax. (Lo et al. 2010: 20) It is therefore "better to control and regulate human cloning than to try to ban it". (The Economist 2003) Cloning techniques promise great potential for medical progress, such as the treatment of heart diseases, fibrosis,

haemophilia, infertility, Alzheimer's, Parkinson's and so on. (Nerlich 2001: 45) In order to reduce the costs for potential patients, the technology deserves to be funded by the government.

Knowledge is always a double-edged sword. But that does not mean that knowledge should not be pursued. As Harris states, "we have to balance possible unknown future risks with known future dangers" (like the certain death resulting from life-threatening diseases) (Harris 2016: 11) In a Brecht play, Galileo mentions similar thoughts:

> "A human race which shambles around in a pearly haze of superstition and old laws, too ignorant to develop its own powers, will never be able to develop those powers of nature which [scientists] are revealing to it. To what end are you working? Presumably for the principle that science's sole aim must be to lighten the burden of human existence" (in Harris 2016: 16)

Without any doubt, Pierre and Marie Curie did not know that their discovery of radioactive atoms will lay out the ground work for Einstein to create the nuclear bomb. At the same time, it also allowed for many people to survive cancer thanks to the invention of the chemo therapy. In the end, the issue at stake can be boiled down to one question: is it the means (technique) or the ends (purpose) that is responsible for evil outcomes?

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