



## CHAPTER 19

# Opening Pandora's Box: The Ethics of Xenotransplantation—A Biotechnology Exemplar<sup>1</sup>

**Rosalie Starzomski**

*“We must learn to balance the material wonders of technology with the spiritual demands of our human nature.” (Naisbitt, 1984, p. 36)*

**AS THE 21ST CENTURY UNFOLDS**, society is in the midst of a profound revolution in biotechnology<sup>11</sup>—a revolution that is radically altering our view of who we are as human beings, as well as our conceptions of health and health care (Lee, 2016; Nuffield Council of Bioethics, 2012; Stevens, 2016; Susumu, 2011). The seeds of this revolution were planted when Canadians Frederick Banting and Charles Best first discovered insulin for the treatment of diabetes in 1921, thereby launching the field of biotechnology. Since Watson and Crick’s historic discovery of the double helix of DNA in 1953

(Lemonick, 2003), remarkable strides have been made in biotechnology, and in the last few decades, the “biotech” industry has emerged as the cutting-edge industry of this century. The identification of the human genome, and the breakthroughs that have arisen in the world of genetics, have resulted in significant changes regarding conceptions about disease and disability.<sup>3</sup> In addition, society is faced with a myriad of new health care technologies emerging from research in areas such as artificial intelligence (AI), genetics, human reproduction, nanotechnology, regenerative medicine, robotics, and xenotransplantation (Association for the Advancement of Blood and Technologies, 2023; Anjum et al., 2021; Daar, 2002; Hobson, 2016; Holland et al., 2001; Hovatta et al., 2010; Jarry, 2022; Kaul et al., 2020; Mnyusiwalla, 2003; Skloot, 2010).<sup>4</sup> The implications of this biotechnological reframing are vast. Today, developments are occurring at such a rapid rate that there is often insufficient societal discussion about the ethical and social implications of the scientific advancements being made. Further, this rapidly expanding evolution of diverse forms of biotechnology is having an increasingly profound effect on health care delivery, including nursing practice.

Science fiction writers have for a long time shed light on some of the value conflicts that can be generated by technological developments. Sometimes it appears that, as a society, we are prepared “to boldly go where no one has gone before” (as described in the *Star Trek* science fiction television programs, movies, and books), often with minimal critique of the direction in which we are moving. However, whereas *Star Trek* provided opportunities for the show’s writers and actors to examine the moral dimensions of featured technological “wonders,” as a society, we have not always reviewed the social and ethical consequences of biotechnological developments prior to their implementation (Midgely, 2000; Rappert, 2008). Thus, the diffusion of biotechnology into the health care system continues in many situations without the thoughtful reflection that is needed.

My goal in this chapter is to consider the ethical and societal challenges that are often pushed to the margins as we “boldly go where no one has gone before” by discussing xenotransplantation as an exemplar of biotechnological development. Xenotrans-

plantation, the transfer of living cells, tissues, or organs from one species to another for medical purposes, has arisen as one solution to increase the number of organs available for transplantation (Carrier et al., 2022; Fischer & Schneike, 2022). Many of the issues, concerns, and troublesome questions that emerge about whether xenotransplantation should be part of the therapeutic armamentarium to treat end-stage organ failure are also evident in other domains of biotechnological development. In what follows, I offer approaches to advancing dialogue and debate about the ethical and societal concerns that are emerging as part of the discussion about the development of xenotransplantation, particularly strategies to enhance nursing leadership in the area. I also illustrate what advanced practice nurse leaders need to consider when assisting patients to make difficult choices. Further, I discuss ways that advanced practice nurse leaders can be active and effective agents of change in regard to public policy in collaboration with governments and other stakeholders.

## **Biotechnology: Promises and Pitfalls**

Biotechnological changes come in many forms,<sup>5</sup> and most share common features with respect to ethics. These features include corporate involvement in development and diffusion of technology, a rapid proliferation of the technology, public pressure to make the biotechnology available, scientific progress with uncertainty, and inadequate attention to societal values.

Even though there may be little question that the capabilities and promises of biotechnology may be of benefit to society, there are concerns about the consequences of biotechnological innovation (O'Mathuna, 2007; Scheufele et al. 2007). For example, a worldwide pandemic and public health crisis brought about by SARS-CoV-2, instances of bovine spongiform encephalopathy (BSE, also known as mad cow disease), and avian flu have added to the fears about biotechnology and the crossover of viruses and other pathogens from animals and birds to humans (Health Canada, 2007, 2010, 2023; Kluger, 1997; Silva, 2010). These developments have resulted in more emphasis being placed on the need for exten-

sive societal discussion about the use of new technologies prior to their implementation.

Biotechnological development and decisions about how to use new technology have largely been under the control of “experts”—including researchers, governments, vested interest groups, and corporations—and have been highly politicized. Today, there is widespread agreement among a number of authors with diverse areas of expertise that societal input is required in the debate about the ethical issues that have surfaced in regard to biotechnology. Input from members of the public is required when making decisions about what type of research ought to be pursued, and also in the development of coherent public policy about the application of the innovations that emerge from the research. The call for public involvement regarding biotechnology policy and research comes from many sectors, and for many years has been a theme in health care system reviews, as well as in meetings to discuss biotechnology (Government of Canada, 2017; Nuffield Council on Bioethics). Although support exists for the idea that decisions about the research, use, and outcomes of biotechnology have major implications for society, input from members of the public has not always been sought. Further, in addition to the pivotal role members of the public could hold in determining the future direction for biotechnology, a substantial role is available for advanced practice nurse leaders and all health care providers (HCPS) to not only understand the ethical and societal concerns that surround the technology, but also to become involved in the ongoing debate about the manner in which to proceed with specific innovations (Canadian Nurses Association [CNA], 2006; National Academies of Sciences, Engineering, and Medicine; National Academy of Medicine; Committee on the Future of Nursing 2020–2030, 2021).

Involvement in decision making about biotechnology is paramount for the public, advanced practice nurse leaders, and all HCPS in order to ensure that important societal values and expert knowledge are infused throughout the decision-making process. To illustrate how this can and should occur, I turn to a discussion of the perplexing ethical and societal implications of biotechnology. Using xenotransplantation as an illustrative case, I first

provide an Ethics in Practice scenario to contextualize the discussion. I then review developments in the area, and the benefits and concerns linked to xenotransplantation, especially as these developments apply to pathogen transmission and informed consent. In addition, I elaborate on some of the challenges that arise in regard to corporate, research, and regulatory issues related to xenotransplantation. Next, I discuss public participation in biotechnology policy development, and provide an example of a comprehensive approach used when attempting to obtain citizen input into whether Canada should proceed with xenotransplantation. In conclusion, I discuss ways in which advanced practice nurse leaders can influence change in regard to biotechnological development and implementation.

#### **ETHICS IN PRACTICE 19-1**

### *Xenotransplantation: An Illustration of the Benefits and Challenges of Biotechnology*

Judith is a nurse practitioner working within the transplant program in an urban quaternary care hospital, and with other members of the transplant team is responsible for the assessment, education, and support of potential kidney transplant recipients. One of Judith's patients, Theo, is a 47-year-old married teacher and father of two adult children. Theo has been receiving hemodialysis for ten years and has been on the transplant waiting list for over five years. Judith has met with Theo and his family several times and has developed a trusting relationship with them.

Unfortunately, Theo has developed a number of complications from chronic renal failure, including severe peripheral neuropathy. He has exhausted all possibilities of receiving an organ from a living donor, as the family members who have been tested are not compatible donors, and no friends have come forward to offer him a kidney. In desperation, Theo put a message on a social media site asking people to respond if they could donate a kidney to him. Because of the number of negative responses he received, Theo removed the request after a few months. He has been unsuccessful in obtaining an organ from a non-living donor, partly because he has a high level of panel-reactive antibodies, and with the waiting list growing, and the number of organs available for transplantation from non-living donors decreasing, Theo realizes he could be waiting for some time to receive a kidney transplant. Theo's only daughter is getting married in several months and he does not believe he will survive to attend her wedding and walk her down the aisle. He is quite despondent and is feeling absolutely

desperate about obtaining a transplant. He has even considered going to a developing country to buy a kidney on the black market, but cannot afford the cost. Recently, he has heard that xenotransplant human clinical trials are being conducted in his country, and he wants to be a volunteer. Theo's wife does not support the idea, as she is concerned about what could happen to him, and she is also worried about the possibility of transmission of viruses to her and their children. Theo's good friend and neighbour also heard about a potential xenotransplant and believes that Theo is being irresponsible and putting his whole community at risk.

Since Judith has been instrumental in helping Theo to make health care decisions in the past, he has approached her for advice about his idea. He also wants her to help him find a way to be a subject in a xenotransplant clinical trial in another country if he cannot find a trial in his own country.

### **REFLECTIVE QUESTIONS**

1. *What role does Judith have in providing advice to Theo?*
2. *How can Judith ensure that Theo has the information required to make an informed choice about xenotransplantation?*
3. *What are the benefits and risks associated with xenotransplantation that Theo should consider?*
4. *What are Judith's responsibilities as an advanced practice nurse in ensuring that patients and families in her care understand the risks, benefits, and implications of new biotechnologies such as xenotransplantation?*
5. *What are Judith's responsibilities to the community regarding biotechnological innovations within the realm of her practice?*

In the sections that follow, I review several of the ethical and societal issues related to xenotransplantation emanating from Ethics in Practice 19-1. Further, by addressing some of the questions posed above, I will identify ways in which Judith can demonstrate nursing leadership in the area of biotechnology.

## Ethical and Societal Implications in the Development of Xenotransplantation

Solid organ, tissue, and cell transplantation have progressed from being impossible to becoming commonplace, with millions of people worldwide benefiting from transplants over the years (Canadian Institutes for Health Information, 2023; Molzahn et al., Murray, 1992; Starzomski, 2002, 2021; United Network for Organ Sharing, 2023). With this success comes an increased demand for donor organs at a time of severe shortage, resulting in a growing number of individuals worldwide who die while waiting for suitable organs to become available.

Xenotransplantation has been proposed as one way to alleviate the shortage of organs, tissues, and cells available from non-living donors, and to reduce the need for living humans to donate organs—a surgical process that is not without risk (Schneider & Seebach, 2008, 2010; Soulillou, 2011). Significant ethical and societal implications of biotechnology are reflected in the debates that have surfaced around xenotransplant technology—debates that raise fundamental questions about social justice, informed consent, the relationships of people with one another as humans, human relationships with other species, the roles of researchers and corporations, and the role of expert and public stakeholders in making decisions about biotechnology development and implementation (Carrier et al. 2022; Fischer & Schnieke, 2022; Hughes, 2007; Johnson, 2022; Reardon, 2022; Shapiro, 2008).

The science of xenotransplantation has evolved over the past several decades, spurred on by major developments in genetics, transforming xenotransplantation into a treatment that has the potential to be clinically feasible. Most clinical developments in xenotransplantation have been in the area of cell transplantation, although there is growing emphasis on xenotransplant technology for solid organ transplantation. The need for an appropriate ethical framework is paramount if this clinical application is to be viable.

Although with xenotransplantation there is the potential to supply cells to treat such disorders as Parkinson's disease and diabetes, and to supply tissues such as skin and bone for transplant purposes, my emphasis in this chapter is on the use of xenotrans-

plantation in the field of solid organ transplantation. While xenotransplantation can occur between animal species, I will centre my review on transplantation of solid organs from animals to humans.

A major problem in the clinical application of xenotransplantation has been finding a suitable source animal from which to retrieve organs that will not be rejected by the human recipient (Carrier et al., 2022; Fischer & Schnieke, 2022). In the early days of xenotransplantation, the source animals were generally non-human primates. An example of such a case was that of newborn Baby Fae, one of the first humans to receive a xenograft (an organ from a donor of a different species than the recipient). The case received much media attention in 1984 when Baby Fae received a heart transplant from a baboon to treat a condition often fatal in the first days of life called hypoplastic left heart syndrome—a condition in which the left atrium and ventricle are seriously underdeveloped. She died a few weeks post-transplant amid considerable controversy about the cause of her death, since her heart did not show evidence of cellular rejection (McCormick, 1985; National Institutes of Health, 1985; Veatch, 2000). In the midst of the analysis and disputes after her death, xenotransplantation trials in humans were stalled because of the concerns related to possible organ rejection.

Non-human primates have been removed from consideration as source animals for xenotransplantation, partly because of the high risk of unknown infections being transmitted from them to humans, as demonstrated by the human immunodeficiency virus (HIV) pandemic (Allan, 1996; Cozzi et al., 2009). Further, major animal rights concerns exist regarding the use of non-human primates for research because of the close genetic link of these animals to humans (Johnson, 2022; Rollin, 2003, 2020; Singer, 1992). Also, their long gestation period raises concern that insufficient numbers of animals could be bred to meet the need for organs.

Currently, the source animals of choice for xenotransplantation are transgenic<sup>6</sup> pigs. Source animals, such as pigs, can be altered by genetic engineering, including genetic technologies like clustered regularly interspaced short palindromic repeats (CRISPR), to minimize rejection, thus optimizing organ function and providing potential advantages to the recipients (Carrier et al., 2022; Fischer et al., 2016; Fischer & Schnieke, 2022). While some risks are reduced

with the use of pigs as source animals because of their greater phylogenetic distance from humans, and the ability to breed them quickly in pathogen-free, closed environments, the risks associated with unknown infectious agents cannot be quantitatively assessed. Because of the difficulties, few solid organ xenotransplants have been conducted worldwide. Most of the transplants done to date have been for short-term bridging purposes—that is, while critically ill human recipients waited for human organs to become available.

This situation is changing, however, as scientific developments in the area of xenotransplantation are accelerating. It is now possible to clone pigs, and scientists are altering genetic systems in order to reproduce litters of piglets with organs that the human immune system will not reject. Companies have cloned pigs and “knocked out” the specific gene that has been implicated in transplant rejection, thereby moving the possibility of successful xenotransplantation closer to reality. Recently, a pig heart was transplanted into a human in the United States (US) through a “one-off” approval by the United States Food and Drug Administration (FDA) on grounds of compassionate use for a patient in a critical situation where no other options were available to the patient (Johnson, 2022; Sade & Mukherjee, 2022). In addition, in the US, Montgomery et al. (2022) described the results of two cases of pig-to-human kidney transplants in neurologically dead recipients. As a result of the rapidly increasing scientific development in this area, many countries in the world have been working to create appropriate regulatory frameworks for xenotransplant human clinical trials and the therapeutic application of the technology, a topic I will take up later in this chapter.

## Natural Law

Xenotransplantation, similar to other types of biotechnological innovation, is the focus of much controversy and debate, raising complex ethical, social, legal, and economic issues (Caplan & Parent, 2022). The issues raised by xenotransplantation reflect the diversity of values, beliefs, and attitudes held by members of society about vital questions regarding who we are as humans, and our role in the natural ecological order of our planet (Rollin, 2020). Such questions

are also important when discussing other forms of biotechnology within areas such as AI, genetics, human reproduction, nanotechnology, regenerative medicine, and robotics.

Societal beliefs, attitudes, and values about the nature of xenotransplantation are diverse. Some opponents of xenotransplantation suggest that the technology raises a problem of natural law because the intermixing of biological material from different species violates fundamental morality, impacting directly on who we are as humans (Canadian Public Health Association [CPHA], 2001; Veatch, 2000). Some who support xenotransplantation propose that although the transplantation of organs from one species to another is cause for concern at first, it does not involve any more of a violation of natural law than does transplantation of an organ from one person to another, as long as the animal is treated with respect (CPHA; Veatch).

This diversity of societal opinion about the nature of xenotransplantation was clearly articulated by participants in a study where focus groups were held with 34 consumer and HCP groups to determine their attitudes and beliefs about a number of ethical issues related to organ transplantation, including xenotransplantation (Starzomski, 1997). In the following quotes, taken from transcripts of the focus group discussions, participants expressed their thoughts about xenotransplantation. For instance, one critical care nurse expressed her concern about xenotransplantation when she said,

I'm a Christian, and I believe that death all along is natural; we are not immortal, and I see it as the final course of life, isn't it? And that's why, when you mentioned the pigs, I go no way! Because that is going to the mad scientist stage, and it's just beyond [imagination].

Providing a different view, an advanced practice nurse said, in her interview,

I would support it [xenotransplantation] as long as we are using, in real valued things, a lower-order animal like a pig (and I think there is still enough research done to know they already are lower-order animals) versus finding out later that they are actually smarter than we are, like the

whales kind of thing. So, if there were some scientific assurances that that is the case then somehow I could bring myself to accept that. ...

It sounds like a good idea, we eat them [animals] anyway, so we're not that sentimental about them. I wouldn't like to see them terribly exploited, but we exploit all over the place.

These opinions, generated by reflection on personal values, underscore several of the germane concerns related to xenotransplantation. What follows is a review of some of the benefits and challenges related to xenotransplantation, including further exploration of many of the issues that have been raised in the discussion about biotechnology.

## **Benefits and Challenges of Xenotransplantation**

Although xenotransplantation has the potential to benefit many people, a number of societal and ethical concerns must be addressed if this technology is to move forward in a manner that optimizes its potential to benefit people while at the same time minimizing risk. I review the major benefits of xenotransplantation and discuss some of the potential problems that work against these benefits. Given the limited scope of this chapter, I will not address one of the concerns raised by xenotransplantation—that is, the rights of the animals who will be the donors if xenotransplantation becomes a reality (CPHA, 2001; Haddow et al., 2010; Singer, 1992). For readers who would like to have more information about this topic, I include references that provide further background with respect to the animal rights challenges related to xenotransplantation.<sup>7</sup>

Many potential benefits have been identified if xenotransplantation were to become a therapeutic treatment for end-stage organ failure. These include the following:

- The potential to eliminate the shortage of organs, tissues, and cells, as facilities would be established to produce pigs to serve as sources that would be available when required.

- In some jurisdictions where human organ donation has not been accepted because of ethical or ethnocultural concerns, xenotransplantation might provide an acceptable alternative.
- With ready access to organs, recipient selection criteria could be broadened, and the ethical dilemmas surrounding transplant allocation would diminish, as everyone who needed an organ could theoretically receive one.
- Xenotransplants could be done in an early, controlled fashion before the complications of diseases affected patients.
- Xenotransplants could offer advantages similar to those associated with the use of human living donor organs. For example, the transplant surgery could be pre-scheduled; pre-treatment of recipients would be possible; the quality of the organs would be known; the organs would be out of the body for a limited amount of time, thereby preventing rejection; and the effects of neurological death on organ quality could be avoided.
- Finally, xenografts might not be susceptible to the human autoimmune diseases or viral infections that caused organ failure initially in some patients, and which often limit the survival of organ transplants from human donors (Council of Europe, 2003; Gunzburg & Salmons, 2000; Nuffield Council on Bioethics, 1996; Sykes et al., 2003).

In this review of the possible benefits of xenotransplantation, I show that biotechnology has the *potential* to provide therapeutic advantages in health care delivery. Benefits similar to the ones described above exist for other biotechnologies. For instance, by using successful gene therapy and cloning technology, HCPs could make treatments available that are tailored to an individual's genetic profile, thus preventing further disease and disability.

Although xenotransplantation offers benefits, a number of scientific and ethical barriers exist that must be addressed to ensure that advances in biotechnology are developed in a manner that optimizes their potential to benefit society. At the same time, it is important to consider how to minimize risk for individuals and communities.

## Risk of Pathogen Transmission

One of the significant societal and ethical concerns involved in xenotransplantation is the worry about the risk of transmission of animal pathogens to humans and the subsequent consequences for society. As with all mammals, pigs have viruses that are active, latent, or represented only by a partial genetic sequence embedded in the pig genome. It is difficult to assign exact numbers to the risk, but many experts agree that it is possible that pig endogenous retroviruses (PERVs) could be transmitted to human xenograft recipients (Carrier et al., 2022; Fischer & Schnieke, 2022).

The possibility has arisen that, under specific conditions, PERVs can be carried in tissue that is transplanted, and can infect human cells. Because PERVs could be transmitted to human xenograft recipients, it is further possible that such infections could be passed from recipients to other humans, and to members of society at large. Some authors have indicated that these fears are not unfounded by suggesting that technology in antibody screening for potential xenozoonoses<sup>8</sup> is fraught with problems and needs further study. Although investigators disagree about the magnitude of the risk, few dismiss it, and many agree that it is sufficient to merit serious concern (Caplan & Parent, 2022; Carrier et al., 2022; Fischer & Schnieke, 2022).

Further complicating the issue of disease transmission is the reality that if researchers were aware of a particular virus or pathogen, they might be able to develop a test to determine if the pathogen was present. However, if it were a pathogen that had not yet been recognized, it would be impossible to determine if an animal were pathogen-free. This is a very serious concern, as precedents exist for the survival, replication, and spread of animal viruses to humans with subsequent human-to-human transmission. For example, some scientists believe that HIV might have originated in monkeys before spreading to humans (Allan, 1996). In addition, some epidemiologists believe that the H1N1 virus (Spanish flu) that killed close to 50 million people worldwide in the early part of the 20th century might have been triggered by genes of avian origin (Jordan et al., 2019). It is also thought that the H5N1 influenza virus that struck Hong Kong in 1997, killing 18 people, was

spread from ducks to chickens to humans. Experts indicate that if the outbreak had not been stopped in time, it would have caused a pandemic (Evanson, 2000).

In 2002 and 2003, severe acute respiratory syndrome (SARS), caused by a coronavirus called SARS-associated coronavirus (SARS-CoV), and thought to have moved from bats to humans, quickly spread to many countries, infecting over 8,000 people and killing 774 (Centers for Disease Control and Prevention, 2017). Other situations linked to the jump of pathogens from animals to humans include the Ebola and Lassa fever outbreaks in Africa (Nnaji et al., 2021). In the case of SARS-CoV-2 (COVID-19), there is speculation that the virus might have emerged from animals in a wet market in China, although others believe that it might have emerged from a laboratory setting (Khullar, 2023).

Many gaps exist in our knowledge of the potential risks of disease transmission if xenotransplantation were to become a reality. Risks cannot be eliminated based on current evidence, and the uncertainty about the safety of xenotransplantation continues to be a significant obstacle to its implementation. Cloning and genetic modification techniques to address disease transmission are still in process. Further scientific information may close the gap somewhat, but it may never be possible to say with absolute certainty that the risk is absent. Xenotransplantation falls into the category of experimental treatment where, although the risk is perhaps low, and the benefits to humans substantial, the consequences for humanity could be catastrophic (Caplan & Parent, 2022). As one member of the public in the 1997 study by Starzomski said,

You know at this point, I think it [xenotransplantation] is a good idea, but where will it lead? I'm not sure, and I don't think any of us know where DNA manipulation is going to lead. It could be really scary stuff, and we need the answers to the questions, I suppose, to think about it at this point. I worry about the transmission of disease. What will happen to our world if we get another bug like HIV?

## Concerns About Informed Consent

The tension between individual and societal rights is part of the difficult ethical debate about xenotransplantation. While participants often accept risks arising from experimental treatment, believing them to be balanced by the potential benefits, one important distinction between xenotransplantation and other treatments is that xenotransplantation may put individuals other than the recipient at risk of contracting disease. The concept of informed consent for individual patients is a central principle in Western health care delivery. When faced with health care decisions, the patient is informed of the various alternatives for treatment and the relative risks and benefits of each option. Given that scientists in the area of xenotransplantation cannot answer all the questions about possible risks, a potential patient would be put in a very difficult situation if they were considering being a participant in a clinical trial. In addition to consenting to the procedure, participants would have to consent to lifelong surveillance, including medical monitoring and follow-up. They would also have to consent to the archiving of their biological specimens when appropriate. Further, they would need to inform intimate contacts of potential risk, thus causing many privacy concerns for potential recipients (American Medical Association, 2017; FDA, 2016a, 2016b).

As evident in Ethics in Practice 19-1, the risk is not restricted to the individual who is receiving the xenotransplant, but is also of concern to close contacts, family members, and indeed the community at large. Xenotransplantation raises the problematic challenge of applying the principle of informed consent to an entire community, since the community as a whole would be potentially exposed to the risk (Hughes, 2007). The risk posed to the community by possible zoonosis after xenotransplantation requires that some form of “community consent” is necessary before solid organ animal-to-human xenotransplantation takes place. As the relevant community is global, and there are no existing agencies with the appropriate credentials sufficient to establish this consent, this presents obstacles to the implementation of xenotransplantation (World Health Organization, 2003).

In Ethics in Practice 19-1, Judith, the advanced practice nurse, will have to ensure that Theo has information about the risks of xenotransplantation and, as part of her responsibility, ensure that information is conveyed to Theo's family as well. To gain support in this work, Judith could access information about xenotransplantation, such as national standards and guidelines, which she could explain and interpret for Theo and his family. Even though Theo is not currently enrolled in a clinical trial, Judith might find it useful to review information available about the role of the nurse in research (as described in Chapter 2) to help determine what could and should be conveyed to Theo and his family.

But what of the larger community? What is Judith's responsibility to it? Viruses and other infectious agents do not respect national borders. The 2003 cases of SARS and BSE have made that evident and, more recently, the COVID-19 pandemic has made it clear that viruses know no boundaries. Along with other HCPS and health care researchers, advanced practice nurse leaders have a responsibility to ensure that information about issues such as xenotransplantation, genetics, and regenerative medicine that are within the realm of their practice are discussed in the community. Further, it is essential that informed representatives of the public are given an opportunity to participate actively and meaningfully in the decisions about whether, and under what conditions, society is exposed to the risks associated with these and other biotechnological developments. If it is unethical to impose a health care risk on a patient, it is also unethical to expose the public to a risk without first considering societal opinion. Strategies for advanced practice nurse leaders to become involved in the community at large in order to facilitate discussion about biotechnological advances will be discussed in more detail later in this chapter.

## **Corporate and Research Influences on Xenotransplantation**

Xenotransplantation is a big business, and it poses challenging problems from the perspective of business and corporate ethics, as well as research ethics. The economic implications are considerable, and many pressures are brought to bear by stakeholders for whom

these considerations are at the forefront. For example, the market for organ and tissue transplants in the US is thought to be worth billions of dollars, thus providing a huge potential market for biotechnology companies. Many companies have invested heavily in the area of xenotransplantation and are eager to see their investments be profitable (Loring et al., 2022).

When considering the diffusion of new biotechnologies, it is important to ask questions about who is likely to benefit from the various types of biotechnology, and who is likely to suffer from them (Sherwin, 2000). It remains to be seen whether or not xenotransplantation and other technologies, such as gene therapies, will be accessible to the poor and disadvantaged. In the past, pharmaceutical and medical technologies have been readily available in the Western world but not accessible to over half of the world's population, who do not have access to even basic health care (MacNeill & Jacobs, 2019). Furthermore, issues regarding conflict of interest and research ethics have had an impact on how companies choose to study new technologies and make them available globally (Neufeld et al., 2001).<sup>9</sup>

Because many Western governments have been unwilling to allow xenotransplant clinical trials, corporations and some investigators moved to other countries to pursue research and human clinical trials (BBC News, 2002; Sykes & Cozzi, 2006). Clinical trials in some countries, conducted under weak safety rules, opened the door for "international xenotourism," where desperate patients have bypassed tight regulations for treatment in some developed countries. Failure to implement international regulations, or loose interpretation of standards, have the potential to adversely affect already disadvantaged groups and populations, and possibly give rise to worldwide risks.

Although some countries do not have the appropriate regulatory authorities to develop and maintain suitable guidelines to safeguard patients and their contacts, pressure from international bodies has sometimes influenced practice. For example, a number of years ago, clinical trials in children with Type 1 diabetes were conducted in Mexico. People from other countries came to Mexico for islet cell xenotransplants, but the trials were shut down

when it was found that international ethical standards were not upheld (Cook et al., 2011).

It can be argued that in developing countries, biotechnology research is inappropriate when people are living without the basics of preventive care, maternal and child health services, and other fundamental health care needs (Veatch, 2000). Xenotransplantation raises significant questions of international justice since there is the potential to place the lives of citizens of poor nations at risk to benefit the citizens of wealthy nations (Sparrow, 2009).<sup>10</sup>

Another challenging problem that falls within the corporate and research realm is the lack of access to data from international clinical trials of xenotransplantation. Usually, such data, and any adverse reactions resulting from treatment, is confidential, and may only be made public at the discretion of the sponsor, something that generally only happens if positive outcomes are observed. Therefore, corporate and research issues and concerns must be part of the public debate about biotechnology. There is a need for members of the public and HCPs to work together with corporations and investigators to ensure that they are able to meet their ethical and social responsibilities. Shareholders, and society as a whole, must hold corporations and researchers accountable in future work related to xenotransplantation, as well as innovations coming from research in areas of biotechnology.

## **Regulatory Concerns**

There are a variety of approaches used to regulate xenotransplantation research in different jurisdictions around the world. In Canada, xenotransplantation studies are currently being carried out using laboratory animals only. These pre-clinical or experimental trials do not involve human patients and are not regulated by Health Canada. Xenotransplants for humans are considered therapeutic products and can only be used in clinical trials if authorized by Health Canada (Health Canada, 2010); to date, no such authorization for human xenotransplant trials has been given. For Health Canada, one of the principles guiding the identification and evaluation of risks related to xenotransplantation has been the Government of Canada's proposed precautionary approach or

principle. This is an approach used to manage threats of serious or irreversible harm when there is scientific uncertainty (Fovargue & Ost, 2010; Government of Canada, 2001). In the US, xenotransplant human clinical trials are approved and are tightly controlled. All experiments using animal tissues must be cleared through the FDA (FDA, 2016a, 2016b).

As scientific knowledge about xenotransplantation increases, there is still no consistency across the world about the status of xenotransplantation, or how regulatory frameworks are developed and implemented. Countries worldwide have been implementing a wide range of decisions about xenotransplantation research and clinical trials, from outright bans and moratoriums to more relaxed safety rules (Cheng, 2015; Health Canada, 2010; Tallacchini, 2008). Some authors have suggested that what is needed is a coordinated international effort by the World Health Organization aimed at harmonizing xenotransplantation protocols in accordance with the best available scientific data and with the highest ethical and regulatory standards, to ensure that clinical xenotransplantation trials will be conducted with minimal risk to society.

The Ethics Committee of the International Xenotransplant Association (Sykes et al., 2003) suggested that trials on humans should only be performed with oversight from a governmental regulatory agency with guidelines similar to those developed in Western countries. The committee proposed that the trials should include information about the source animals, as well as monitoring procedures for xenotransplant research subjects and, where deemed appropriate, their close contacts. In addition, the group suggested the development of a national repository for holding specimens from human subjects in countries in which clinical trials are conducted and, if a repository was not possible, then specimens should be properly obtained, tracked, analyzed, and stored. The committee went on to recommend that in the absence of such oversight and monitoring, clinical xenotransplantation should not occur. The committee proposed that the International Xenotransplant Association take leadership in facilitating the development of universally accepted procedures, standards, and guidelines about xenotransplantation since many countries around the world were beginning xenotransplant programs. Like others involved in xeno-

transplantation, the committee raised the concern that without such co-operation, efforts of countries to minimize the potential risks would be jeopardized, because of concerns about xenotourism; that is, the potential travel of individuals who received a xenotransplant in a country without regulatory guidelines (or close contacts of those individuals).

Although the issues discussed here are focused on xenotransplantation, they are also applicable to other biotechnologies, where similar regulations are required and are being discussed in many countries. Clearly, decisions about biotechnology require broad societal discussion and debate.

## **Public Participation in Decisions About Xenotransplantation**

Members of the public are often overlooked as participants in the discussions about biotechnology (Abelson et al., 2010; Lenaghan, 1999). In order to ensure that the required values and perspectives are represented, multiple voices are needed in the debate about biotechnology, with a prominent position for members of the public. The idea of public and HCP involvement in decision making is supported, but how can this become a reality? Many people have been proponents of the public becoming more involved in decision making about technological diffusion into society and health care (Iverson & Bach, 2002; Kögel & Marckmann, 2020). Decades ago, Winner (1993) proposed broad involvement in decision making about technology, and pointed out that there was no moral community or public space in which technological issues were topics for deliberation and common action.

Brunger and Cox (2000), in their discussion about genetics and ethics, suggested strategies for widening the space of public debate about technology, including providing the public with information about the production, distribution, and application of knowledge; legitimizing lay knowledge; attending to a multiplicity of voices; welcoming dissent as a sign that all voices are being heard; allowing the debate to be transparent in public; and promoting the accountability of government, industry, and science to the public. Other authors have proposed several conditions that must be met

for meaningful public participation to occur in health care decision making, including assuring that consumers have adequate information; that there are a majority of consumers in the decision-making group; that there is a strong mandate from the community with formal and informal access to constituents; and that people selected to represent communities are confident enough not be intimidated or dominated by the so-called experts within the group (Abelson et al., 2010; Montesanti et al., 2017; Starzomski, 2002). What follows is a description of a public consultation process in which these strategies were evident in the discussion about whether Canada should proceed with xenotransplantation and, if so, under what conditions. This example stands as one of the most comprehensive processes ever undertaken in Canada to involve the public in decision making about the implementation of biotechnological developments.

In 2000, Health Canada provided funding to the CPHA to strike a Public Advisory Group (PAG) to conduct an arm's length public consultation to hear the views and concerns of Canadians about xenotransplantation. The PAG was given the task of reporting back to the federal minister of health with recommendations about whether Canada should proceed with xenotransplantation. Members of the PAG represented a diversity of perspectives, regions, and interests. The process they designed included several options for Canadians to voice their opinions, including a telephone survey of 1,519 randomly selected adults; opportunities to submit letters, faxes, and emails to the CPHA office and website; a "have your say" questionnaire (which was located on the CPHA website and also mailed to 3,700 organizations); and regional citizen forums (sometimes also called citizen juries) of between 15 and 23 demographically representative citizens. These citizen forums were held in six major cities across Canada. The forums were moderated by a bilingual professional facilitator who travelled to each city, and included opportunities for panellists to have discussions with experts and review resource material in the area of xenotransplantation. In addition, during each forum, prior to the private panellists' meeting, time was allocated for members of the general public to participate in the discussion (CPHA, 2001; Einseidel & Ross, 2002).

Before the two-and-a-half-day forums were held, the members of the citizen juries were asked to complete a questionnaire to determine their attitudes and beliefs about xenotransplantation. Many participants held a positive view, but after discussing the risks and concerns during the forums, the majority changed their thinking, concluding that Canada should not proceed with xenotransplantation at that time: 34% said no; 19% said no with qualifications; and 46% said yes with qualifications. It appeared from these results that the more Canadians learned about xenotransplantation, the more concerned they became. Although not absolutely opposed to xenotransplantation, the forum participants favoured a precautionary approach, expressing concerns about uncertain health risks, an insufficient level of scientific knowledge in the area of xenotransplantation, and inadequate regulations (CPHA, 2001; Wharry, 2002).

In contrast to the citizen jury experience, in the telephone survey of 1,519 Canadian adults, 70% were not very, or not at all, knowledgeable about xenotransplantation and yet, of this number, 65% supported clinical trials. These findings must be interpreted cautiously, as they illustrate some of the problems that occur when public opinion polls (where participants have little information about the issues) are used to solicit opinions about complex areas such as xenotransplantation. The final report of the PAG included the results of the complete public consultation process. It was delivered to the minister of health and subsequently released publicly in 2002 (CPHA, 2001). In the report, the CPHA did not close the door on xenotransplantation, but rather called for more research into potential risks, suggesting that those who wish to proceed with xenotransplantation need to determine the level of risk and demonstrate how the benefits of the procedure would outweigh those risks. In addition, among the recommendations, the CPHA suggested that non-human pre-clinical research would be acceptable, as this could provide more information about the viability of xenotransplantation. There was also a call for more stringent and transparent legislation and regulation covering all aspects of xenotransplant clinical trials. Further, it was recommended that Health Canada consider alternatives, such as disease prevention, the development of mechanical substitutes, and pursuit of stem cell research to

expand the human donor pool. Finally, the authors of the report suggested that efforts should continue to further the knowledge and public discussion of xenotransplantation, and that the citizen forum model be considered for future consultations on complex and poorly understood health-related policy issues.

The consultation process described here for xenotransplantation is a model for other areas where innovations in biotechnology are occurring. Regardless of the particular approach taken, if public consultation of this sort is to be effective, it is crucial that participants be well informed. All sides of the issue must be presented without attempts to steer the dialogue, allowing the public participants to arrive at their own conclusions. However, even with possible flaws (Wright, 2002), the CPHA process to solicit public opinion about xenotransplantation stands as one of the only comprehensive experiments in Canada to engage the public in discussion about decisions regarding the diffusion of a new biotechnology into the health care system.

The practice of public consultation in biotechnology does not mean, however, that a few public representatives set policy. Such groups are not representative of the whole population and are not selected to represent the entire community. In the example described above, the PAG report was presented to the minister of health to inform the decisions that must be made by policymakers and the political representatives to whom citizens delegate such authority. The CPHA experience has provided valuable information about including the values of the public in decision making and engaging citizens in the debate about biotechnology development in Canada.

Health Canada notes on its website that xenotransplantation is currently not prohibited in Canada. However, as the live cells, tissues, and organs from animal sources are considered to be therapeutic products, xenotransplantations are subject to the requirements of the *Food and Drugs Act*, the Food and Drug Regulations or the Medical Devices Regulations (Health Canada, 2010). To conduct a human clinical trial, a sponsoring company or research institute would have to apply to Health Canada for approval before proceeding. At the time of writing this chapter, no human

clinical trial involving xenotransplantation has yet been approved by Health Canada.

The public must be involved in all facets of societal development. In particular, in creating policy about biotechnology, it is clear that public values are essential in making ethical choices that will benefit the community. Good health care decisions are not possible until the public has the opportunity to help choose the goals, priorities, and means that guide policy development.

There is a major role for nurses in ensuring that diverse voices are heard in discussions about biotechnology (Care et al., 2014). In the Ethics in Practice 19-2 scenario, an advanced practice nurse leader is presented with a challenge when promoting appropriate stakeholder engagement in making decisions about new biotechnological developments in cancer care.

In what follows, I discuss the implications for advanced practice nurse leaders in helping to open the moral space required for discussion about the ethical and societal implications of biotechnology. The debate becomes all the more vital and complex with the introduction of ever-more-powerful biotechnologies that may offer potential benefits to individuals, but may be counterbalanced by potential risks to individuals or to large populations.

## **ETHICS IN PRACTICE 19-2**

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### **A Community Biotechnology Challenge**

Frank is a clinical nurse specialist working in a cancer centre in a large city and has been asked to join a committee examining cancer treatments that combine targeted and immune therapies to kill treatment-resistant cancer cells. At the first meeting, Frank is worried that ethical questions have not been raised about the overall effectiveness of treatments, given their side effects and their impact on patients' quality of life. Furthermore, he is concerned that the cancer patient community has not been involved in discussions about if and how these treatments might be used. When Frank's concerns are raised in the committee, a number of the committee members suggest that these worries are unfounded, as researchers have demonstrated that all the therapies are useful.

**REFLECTIVE QUESTIONS**

1. *Who should be involved in the discussion about implementation of new biotechnological treatments in cancer care at the micro, meso, and macro levels of the health care system?*
2. *How should Frank proceed in addressing his concerns?*
3. *What supports could Frank access to help him with the issues he has raised?*
4. *How could Frank and the committee engage with cancer patients and their families in getting input about targeted and immune therapies?*

## **Opening Moral Space for Discussion about Biotechnology: Implications for Nurses**

In a rapidly changing world, we are inundated with information about the “good, the bad, and the ugly” of biotechnological innovations, as we seek to interpret the vast amount of data that we are exposed to on a daily basis. Kingwell (2002) suggested that as conscientious citizens, we struggle to stay on top of what is happening in our technologically dominated complex world, and advised that we need to prepare ourselves for a “bumpy ride” as we try to determine where we are headed. Further, Saul (2001) pointed out that there are severe limitations to what we can understand in the face of constant technological change. He reminded us that “[i]n fact, with the explosion of technology over the last quarter-century, the percentage of what we understand versus what we know has probably slipped back to where it was a century ago” (p. 30).

As nurses, how do we sort through the information that is available, organize ourselves for the “bumpy ride,” and ensure that we are prepared to deal with the societal and ethical implications of biotechnology? It is a difficult undertaking, as the line between science and science fiction has become blurred, a plethora of information is available, and many conflicting points of view exist. We only have to review recent newspaper and magazine headlines to emerge with a sense of the complexity of the information

provided for our perusal and the variety of perspectives and opinions that are presented to the public.

In this book, and elsewhere, there has been a call to expand social, environmental, and political thinking in nursing, and a call for a focus on the common good, a term used to describe the well-being of the community at large based on shared goals and common purposes (Starzomski & Rodney, 1997). Nurses need to be involved in understanding and facilitating broad societal discussion of issues related to transplantation and biotechnology as these technologies can influence profound change in the human capacity to control diseases and human reproduction (Care et al., 2014; CNA, 2006, 2017; National Academies of Sciences, Engineering, and Medicine et al., 2021; Starzomski, 2021). One of the most significant challenges that advanced practice nurse leaders will face in the future will be to find the balance between maximizing the benefits of using biotechnology in health care, while at the same time ensuring a humanistic, relational focus for care.

The Canadian Nurses Association has made claims about the importance of the involvement of nurses and the public in making policy decisions about biotechnology. In several position statements, documents, briefs, as well as in their 2017 *Code of Ethics for Registered Nurses*, the CNA expresses support for including nurses in discussions about technology at all levels of the health care system. They suggest that nurses must be involved in all aspects of technology use, including identifying the need for such use, developing and implementing technology, and evaluating the impact on client care. CNA policy statements, such as those related to technology, primary care, and leadership, all include some reference to supporting a nursing role in discussions about technology development and implementation (CNA, 1992, 1995, 2002, 2006). Further, the CNA has shown national leadership in the area of biotechnology by promoting the involvement of expert nurses on committees and councils where decisions about biotechnology are made.<sup>11</sup>

Understanding the scope of biotechnology can be overwhelming. It is neither practical nor possible for every nurse to keep abreast of all the ethical and societal developments; nor is it possible to speak out on every issue, as the issues are numerous and priorities vary. However, advanced practice nurse leaders can act as

expert navigators of biotechnology and become information brokers for their patients and colleagues, while ensuring that the core values of nursing are maintained. Further, there is a need for advanced practice nurse leaders to examine the impact of biotechnological changes on nursing recruitment, nursing work design, and the nursing workforce. An understanding of nursing ethics can prepare advanced practice nurse leaders to deal with the challenges confronting them when addressing the use of biotechnology in health care. A background in nursing ethics can also enable advanced practice nurse leaders to critically examine the issues and influence change in the use of biotechnology when needed. It is essential that in this work, advanced practice nurse leaders engage in discussions with diverse HCPS and members of the public to ensure that the best decisions are being made.

Returning to Ethics in Practice 19-1, Judith faced a number of ethical challenges. In reflecting further on the ideas presented so far in this chapter, the micro-, meso-, and macro-level strategies that follow would be useful for Judith to consider as she develops her plan about how to support Theo and his family.

Micro-level strategies include

- Becoming educated about biotechnological developments and the associated societal and ethical implications.
- Ensuring that patients and families are informed about options, risks, and benefits when considering therapeutic biotechnological interventions.
- Helping to educate other nurses, HCPS, and members of the public about biotechnology.
- Ensuring that ethical and societal issues about biotechnological developments are part of educational curricula, conferences, and symposia for nurses and other HCPS.
- Engaging in advocacy to help patients and families have opportunities to express their views regarding biotechnological interventions.

Meso-level strategies include

- Participating in both clinical and research ethics committees where issues about biotechnology are being discussed.
- Conducting research examining the ethical and societal implications of biotechnology.
- Ensuring that ethical and societal issues about biotechnological developments are part of hospital, community, regional board, and health authority discussions.

Macro-level strategies include

- Participating in national committees, debates, and forums about health care and biotechnology.
- Working with provincial professional associations and organizations to ensure that there is public dialogue about biotechnological concerns.
- Using methods such as citizens' juries, consensus conferences, town hall meetings, and social media to engage the public and HCPs in debates about biotechnological issues.
- Participating with professional associations to ensure that nurses are represented in the federal government and provincial/territorial legislatures where laws are being made that govern biotechnology.

There is no doubt that, in the future, decisions about biotechnology will continue to demand the involvement of advanced practice nurses, all HCPs, and the public. These decisions will be complex and difficult, and no one societal group or set of voices will be adequate to make the choices that are needed. Although, as a society, we may not always have the answers to questions related to choices about biotechnology, a collaborative effort will provide the best method to ensure that wise choices are made for future biotechnological developments and their implementation.

## **Future Directions: The Tip of the Iceberg**

The use of biotechnology raises major issues—issues about ethics, choice, trust, democracy, and globalization. Innovations in biotech-

nology are encumbered with intended and unintended social, political, and economic values. I have argued throughout this chapter that policies surrounding xenotransplantation, and other emerging biotechnological interventions, must be developed by those who consider the importance of balancing opportunity and risk. Further, I have advocated for an expansion in the debate about biotechnology that includes members of the public, advanced practice nurse leaders, all nurses, and other HCPs in discussions about the societal and ethical issues facing us in the realm of biotechnology.

Public involvement in decisions about biotechnology is complex. While there is no consensus about how to include the public in meaningful ways in the development of healthy public policy, in this chapter I have presented several methods that I believe move us in the right direction. Clearly, we need to be sensitive to the contexts where public participation is being sought, in order to ensure that citizens are able to avail themselves of opportunities to be informed and involved (Abelson et al., 2010; Maxwell et al., 2003; Mitton et al., 2009). This is an area where “one size does not fit all” (Martin et al., 2002).

Although the future of collaborative dialogue and debate on issues of biotechnology is by no means assured, there are promising signs of progress. As discussed throughout this chapter, researchers, as well as governmental and non-governmental organizations, are focusing more attention on biotechnological issues. The xenotransplantation public consultation process in Canada was one example of a move in that direction. It is important to seek meaningful societal participation regarding the issues facing us in biotechnology, in order to make the best possible choices about future technological opportunities that are coming our way.

By its very nature, science alone will not give us answers with absolute certainty and can only tell us about the likelihood of the benefits and dangers posed by biotechnology. As citizens, we will need to continue to review the science and to make decisions based on our value systems, as the current ethical challenges in biotechnology are really just “the tips of icebergs.” The future possibilities in biotechnology are beyond our imaginations, and for many may seem like science fiction.<sup>12</sup> Research in areas such as AI, genetics, human reproduction, nanotechnology, robotics, regenerative medi-

cine, and xenotransplantation may offer opportunities to address some of our health care concerns; but, in the future, the success of these approaches will depend not only on scientific development, but also careful consideration of the related ethical and societal issues.

Before us is a period of remarkable biotechnological innovation. We have added more innovations that influence life and death to our armamentarium. Will we use biotechnology to preserve our humanity and improve our quality of life, as exemplified in the optimistic future portrayed in *Star Trek*? Or, will we choose a more pessimistic future such as that portrayed in Aldous Huxley's *Brave New World* (1932), where humans have really become the tools of their tools? The manner in which we develop and use biotechnology today is a harbinger of what we can become as a society tomorrow. We must choose wisely, keeping in mind that the wisdom we need for tomorrow comes from understanding the present and learning from the past.

### **QUESTIONS FOR REFLECTION**

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1. *Think about your work setting and your role within your family and community. How can you facilitate discussion about the biotechnological innovations that affect you in those spheres of your life?*
2. *How can advanced practice nurse leaders hold decision makers accountable about whose best interests are being served by various biotechnologies?*
3. *What social justice issues arise in everyday nursing practice from decisions about biotechnology?*
4. *How can public input be obtained about the use of biotechnological developments in areas such as AI, genetics, human reproduction, nanotechnology, regenerative medicine, robotics and xenotransplantation?*

## Endnotes

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- 1 This chapter is adapted and revised from: Starzomski, R. (2013). Opening Pandora's box: The ethical challenges of xenotransplantation: A biotechnology exemplar. In J. L. Storch, P. Rodney, & R. Starzomski (Eds.), *Toward a moral horizon: Nursing ethics for leadership and practice* (2nd ed., pp. 448–472).
- 2 Biotechnology is the application of science and engineering to the use of living organisms or their constituent parts with the intent to modify human health and the human environment (Dahms, 2004).
- 3 Please see Chapter 14 (Disabilities and Health Care) and Chapter 17 (Genetics and Identity) in this book for more details.
- 4 Nanobiotechnology is a branch of science which includes structures or functional materials at the nanoscale that are produced by employing both physical and chemical methods (Hobson, 2016). Regenerative medicine may be defined as the process of replacing or “regenerating” human cells, tissues or organs to restore or establish normal function” (Association for the Advancement of Blood and Technologies, 2023).
- 5 Please see Chapter 17 (Genetics and Identity) and Chapter 18 (Digital Health Technologies) for many examples of how new technologies are being used in health care.
- 6 “Transgenic refers to an organism or cell whose genome has been altered by the introduction of one or more foreign DNA sequences from another species by artificial means” (National Human Genome Research Institute, 2023, para. 1).
- 7 Please see Prater (2021), Weintraub (2022), and Kwisda et al. (2020).
- 8 A zoonosis is an infectious disease that has jumped from a non-human animal to humans (Centers for Disease Control and Prevention (2021).
- 9 For more information, refer to Chapter 9 (Promoting Health Equity) and Chapter 20 (Global Health Ethics) in this book.
- 10 Although further discussion of these global issues is beyond the scope of this chapter, please see Chapter 1 (Nursing Ethics) for a more comprehensive discussion of the principle of social justice and Chapter 20 for an in-depth discussion of ethics and global health.
- 11 The author of this chapter was nominated by the CNA to sit on Health Canada's Expert Advisory Committee on Xenograft Regulation and was a member of that group for several years.
- 12 For enlightening perspectives on biotechnological development, see *Klara and the Sun*, a novel by Kazuo Ishiguro (2021) and Margaret Atwood's (2003) book *Oryx and Crake*—a novel about xenotransplantation.

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