The race is on to find a vaccine for COVID-19. The good news is that many of the world’s largest vaccine companies are developing promising vaccine candidates using ethically-derived cells. The bad news is that many of the leading vaccine candidates for the 2019 novel coronavirus (SARS-CoV2) are being developed using fetal cell lines that were originally derived from the tissues of aborted babies in the 1970s and 80s.

With more than 6.2 million reported cases so far and more than 375,000 deaths worldwide, the burden of disease from the 2019 novel coronavirus continues to mount. And so does the urgency to find a cure. From big pharma to small biotech companies and universities, researchers have been pushing out dozens of vaccine candidates and have fast-tracked promising vaccine candidates to clinical trials in record time. Pharmaceutical companies are sprinting to have a vaccine ready by the end of the year or by early 2021.

According to a tracker from the World Health Organization, there are now more than 120 vaccine candidates in development. Of these, 10 vaccine candidates have already advanced to clinical trials to test the vaccine candidate’s safety and efficacy. Several more candidates are expected to begin clinical trials before the end of the year.

Fetal Stem Cells Being Used

Several COVID-19 vaccine frontrunners, including those being developed by Moderna, Oxford University/AstraZeneca, CanSino Biologics/Beijing Institute of Biotechnology, and
Inovio Pharmaceuticals, are using a human fetal kidney cell line called HEK-293 to develop their trial vaccines. HEK-293 was originally derived from kidney tissue taken from a baby girl who was aborted in the Netherlands in 1972 and later developed into a cell line in a lab in 1973.

Additionally, Janssen, the pharmaceutical division of consumer product giant Johnson & Johnson, is using the human fetal cell line PER.C6 to develop its vaccine. The PER.C6 fetal cell line was derived from retinal tissue taken from an 18-week-old baby boy who was aborted in the Netherlands in 1985 and later converted into a fetal cell line in 1995.

The U.S. government has made grants totaling nearly $2 billion in support of the development of COVID-19 vaccines using fetal cell lines. Most of this funding has been awarded through the Biomedical Advanced Research and Development Authority (BARDA), a division within the U.S. Department of Health and Human Services (HHS).

BARDA has awarded a $1.2 billion grant for AstraZeneca to fund research for the trial vaccine it is jointly developing with Oxford University. BARDA has also made grants for up to $483 million for Moderna’s vaccine and $456 million for Janssen Research and Development, LLC of Johnson & Johnson. Inovio has also received an unspecified grant for developing its vaccine candidate from the Defense Advanced Research Projects Agency (DARPA) at the Department of Defense.

On June 1st, BARDA issued a $628 million task order under a preexisting government contract with Emergent BioSolutions Inc. to accelerate development and manufacturing capacity for COVID-19 vaccines and drug treatments. Emergent BioSolutions is currently working with Janssen of Johnson & Johnson to manufacture their trial vaccines. BARDA’s funding for Emergent, however, was not awarded specifically for scaling up production of J&J’s vaccine candidate.

Worse still, the U.S. Centers of Disease Control and Prevention (CDC) has been producing samples of the SARS-CoV2 virus for biotech and pharmaceutical companies to use for vaccine research using fetal HEK-293T cells (a decedent cell line of HEK-293).

Moderna is also receiving substantial research assistance for its COVID-19 vaccine from the National Institute of Allergy and Infectious Diseases (NIAID) which helped develop the vaccine and conduct clinical trials. NIAID is a division of the National Institutes of Health (NIH) led by Dr. Anthony Fauci.

Ethically-Produced COVID-19 Vaccines in the Pipeline
While many COVID-19 vaccines are being developed with fetal cell lines, a number of promising vaccine candidates, such as those being developed by Novavax, Sanofi Pasteur, GlaxoSmithKline (GSK), and Sinovac, are using ethically-derived cell lines.

Of particular note, rival pharmaceutical giants Sanofi Pasteur and GSK have teamed up in an unprecedented partnership to jointly develop a vaccine for SARS-CoV2. Sanofi Pasteur will be bringing to the table an ethically produced antigen for the vaccine and GSK will be contributing an adjuvant—an immune response booster that improves the effectiveness of a vaccine.

U.K.-based GSK and France-based Sanofi are the world’s #1 and #3 largest vaccine producers respectively by total revenue in 2017 according to FiercePharma.

A vaccine being developed by Maryland-based Novavax is using an ethically-derived invertebrate cell line Sf9 to produce protein nanoparticle antigens that make its vaccine work.

In animal studies, Novavax’s candidate demonstrated that the vaccine produces antibodies to the SARS-CoV2 spike protein and produces neutralizing antibodies capable of isolating and destroying the SARS-CoV2 virus. Novavax’s vaccine has already been approved for a fast-tracked phase I/II stage clinical trial. Results for the vaccine candidate’s safety profile and immunogenicity (the ability to induce an effective immune response in the body) are expected by July.

Sinovac, a China-based biotech company, is also working on an ethically-derived vaccine candidate called PiCoVacc. PiCoVacc uses a purified inactivated SARS-CoV2 as an antigen. Sinovac’s antigen is ethically grown in Vero (monkey kidney) cells. Sinovac’s vaccine is currently undergoing expedited phase I/II clinical trials.

Pharmaceutical giant Merck also recently jumped into the COVID-19 vaccine race with an announcement on May 26th that the company will be pursuing 3 vaccine candidates. Merck was the first company to develop a proven vaccine for Ebola. Merck’s Ebola vaccine was granted regulatory approval by the FDA last December.

As of the writing of this article, it is still too early to tell whether Merck’s COVID-19 vaccines will use fetal cell lines or ethically derived cells.

But one of Merck’s vaccine candidates for COVID-19 being developed in partnership with the International AIDS Vaccine Initiative (IAVI) will be utilizing the same platform Merck used in successfully developing its Ebola vaccine (V290). The company’s Ebola vaccine is
manufactured using a cell line ethically derived from the kidney cells of an African green monkey.

Another vaccine candidate being developed by Merck through Themis, a biotech company recently acquired by Merck, is seeking to use the live measles vaccine as a viral vector. Merck’s measles vaccine is produced using chicken egg [Note: Merck’s MMR vaccine (measles-mumps-rubella) is manufactured using human fetal cell line WI-38 which was derived from the lung cells of an aborted baby].

How Do Vaccines Work?

Cell lines are often used in vaccine production to grow viral proteins that make the vaccine work.

Vaccines produce immunity by training immune cells to fight off infection by exposing them to weakened or dead viruses or an isolated protein from the virus (or a synthetic look-alike). Providing immune cells the chance to fight off weakened viruses or viral fragments prepares the body to identify and neutralize the virus if encountered in the future.

Weakened viruses, inactivated viruses, and viral proteins used in a vaccine to produce immunity are called antigens. Antigens are any protein or molecule that triggers an immune response in the body, causing immune cells to produce antibodies. Antibodies are proteins the body’s immune cells produce to bind with and tag viruses and harmful bacteria with markers that help the immune system identify and destroy pathogens.

Traditionally, vaccines are manufactured by growing antigens in animal, plant, or fungi cells or tissues such as embryonated chicken eggs, yeast, or monkey kidney cells. After the antigens have been grown in these cells, the antigens are harvested, purified, and then added to a solution that is later injected or ingested as a vaccine.

Sometimes, however, vaccine manufacturers will use human fetal cells instead of animal cells to grow the antigens for their vaccines.

Several COVID-19 vaccines under development, such as those being developed by Oxford University, CanSino Biologics, and Johnson & Johnson, are utilizing a technology known as “non-replicating viral vector” vaccines.

Unlike traditional vaccines which involve injecting antigens into the body that were previously grown in chicken eggs or petri dishes, viral vector vaccines grow the antigens in a person’s own cells.
In viral vector vaccines, a segment of DNA from the SARS-CoV2 virus is spliced into the genome of a benign carrier virus. The viral vector is also genetically modified to prevent the virus from replicating. When injected into the body, the viral vectors carry coronavirus DNA to the body’s cells that provide the cells with instructions on how to make antigens.

In order to make these vaccines, vaccine manufacturers must grow a sufficient number of these genetically-modified viral vectors to induce immunity. Viral vector vaccines being developed by Oxford University, CanSino Biologics, and Johnson & Johnson are currently using fetal cell lines from aborted babies to grow their viral vectors.

A number of COVID-19 vaccine candidates under development are utilizing completely new vaccine platforms that require no cells at all. Several biotech and pharmaceutical companies are racing to develop vaccines that contain no viral proteins at all but only messenger RNA (mRNA) or DNA plasmids that provide the body’s cells with instructions on how to produce antigens.

Although no mRNA or DNA plasmid vaccine has yet received regulatory approval for normal use, the technology is promising. Experimental mRNA vaccines in recent years have shown promising results in clinicals trials and in animal studies. mRNA vaccines could have distinct advantages over traditional vaccines because they can be developed much faster,
cheaper, with a higher potency, and they can even be created without samples of the pathogen. The genome sequence is all that is needed to create these vaccines, slashing the amount of time it takes to produce a vaccine.

Additionally, mRNA- and DNA-based vaccines have the benefit that no fetal cells (or any cells for that matter) are needed to produce them.

Moderna is developing a mRNA COVID-19 vaccine candidate (mRNA-1273) in collaboration with NIAID. Meanwhile, Inovio Pharmaceuticals is developing a DNA plasmid vaccine for SARS-CoV2 (INO-4800).

Despite the fact that no fetal cell lines are needed to produce DNA plasmid vaccines, Inovio has chosen to test the immunogenicity and efficacy of its vaccine candidate using human fetal kidney cells (HEK-293T), sadly tainting what could otherwise have been a promising vaccine candidate.

As for Moderna’s vaccine, NIAID claims to have helped Moderna develop mRNA-1273.

In February, NIAID scientists working in collaboration with researchers at the University of Texas at Austin (UT) successfully identified and isolated the SARS-CoV2 spike (S) protein and its receptor binding domain using previous research it had on similar coronaviruses such as those which cause severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome (MERS). However, the scientists in this study used human fetal kidney cells (HEK-293) to culture the SARS-CoV2 virus before isolating the S protein. The results from this study were later published in the peer-reviewed journal Science.

In a news release on February 19th, NIAID claimed that the study “supports NIAID’s approach to a gene-based vaccine for COVID-19.” In the same new release, NIAID also mentioned that it was working with Moderna to produce a mRNA vaccine, presumably using the findings from its study using HEK-293 cells to help identify the genetic sequence for mRNA vaccine.

Moral and Ethical Issues with Using Fetal Cell Lines to Develop Vaccines

The use of fetal cell lines for vaccine production has long stirred significant controversy among ethicists and people of faith, particularly among Catholics and Protestants that have deep religious and moral objections against the use of cell lines that were originally derived from aborted babies.

The Catholic Church has long vocally opposed the development of vaccines using unethically
derived fetal cell lines. The Congregation for the Doctrine of the Faith’s 2008 Instruction *Dignitas Personae* states that the use of fetal cell lines for developing vaccines “gives rise to various ethical problems with regard to cooperation in evil and with regard to scandal” and that “everyone has the duty to make known their disagreement and to ask that their healthcare system make other types of vaccines available.”

Although it is not widely known or clearly disclosed by pharmaceutical companies, fetal cell lines have been used for decades in the development and manufacture of many widely used vaccinations including measles/mumps/rubella (MMR), rubella, varicella (chickenpox), polio, hepatitis A, rabies, and shingles. For some vaccines, such as MMR, chickenpox, and hepatitis A, no ethically-produced alternatives exist in the U.S.

**Why Are Fetal Cells Ever Used to Manufacture Vaccines?**

Although alternative ethically-derived cell lines exist for vaccine development, pharmaceutical companies often prefer to use fetal cell lines because the characteristics of fetal cell lines are well known and because they do not contain significant contaminating viruses or bacteria that are often found in cells derived from animals.

For example, the polio vaccine in the mid-20th century was once manufactured using primary cell cultures harvested from the kidneys of monkeys. However, it was later discovered that the vaccines were often contaminated with a common monkey virus known as Simian Virus 40 (SV40). Although SV40 is harmless to humans, the incident alarmed vaccine manufacturers. Since then, vaccine developers have relied more heavily on cell lines rather than cell cultures taken from live animals.

To provide a more contemporary example, the FDA is currently investigating whether there is any potential from harm in using primate cells for vaccines and biologics. Simian foamy viruses (SFV) are widespread among non-human primates and it is known that these viruses are sometimes able to cause infection in humans. Although no one is ever known to have become sick as a result of SFV, the FDA is investigating whether there could be long-term effects due to this.

With cell lines, it is possible for researchers to know the characteristics and inherent flaws in the cells they are working with. Cell lines have been rigorously inspected by scientists across the industry for contaminating virus DNA or genetic mutations, whereas tissues taken directly from live animals may have unknown contaminants that may potentially be
harmful to humans.

But why use fetal cell lines instead of animal cell lines or embryonated chicken eggs which have an excellent track record and have been used for decades to manufacture vaccines? Many vaccines, including vaccines for the seasonal flu, are grown in embryonated chicken eggs.

However, there is a potential for supply issues when using chicken eggs to manufacture vaccines. If, for instance, there were a widespread outbreak affecting chickens that causes the supply of eggs to suddenly drop, it could impact the ability for manufacturers to make vaccines quickly. The supply issue could especially present problems in the event of a pandemic such as the current COVID-19 pandemic where the ability to produce hundreds of millions of vaccines quickly is paramount.

More significantly however, some viruses, such as chickenpox for instance, do not grow well in animal cells. In such cases, there are few other options available other than using human cell lines for vaccine production.

Researchers also often prefer to use human cells for experiments testing the effect of drugs or vaccines because they more closely resemble how a drug will work in humans.

But if human cells are better for manufacturing certain vaccines, why are fetal cell lines derived from aborted babies used instead of ethically-derived adult cells?
Fetal cells are often preferred to adult cells because there are a limited number of splittings (passages) cells can undergo before they age and eventually die off. Fetal cell lines can be put through more passages than adult cells would and they are less prone to cell aging and senescence (when cells in a culture no longer divide and start dying off). Fetal cells are also less likely to be contaminated with human viruses or with genetic mutations or alterations that naturally occur as cells age.

Certain fetal cell lines such as PER.C6 are uniquely designed for manufacturing non-replicating viral vector vaccines. The viral vectors are genetically modified to prevent replication in the human body by deleting a portion of the viral vector’s genome. PER.C6 cells are designed to fill in this deleted genome gap. In this way, vaccine manufacturers can replicate viral vectors for their vaccines in the lab but such viruses are incapable of producing an ongoing infection in the body.

However, there is no need to derive cell lines from aborted babies. Human cell lines for vaccines could easily be produced in an ethical manner if they are derived from adult cells. Cell lines could be derived from tissue discarded during surgery or from organs donated after death. If fetal cells are needed, there are thousands of stillbirths and neonatal deaths in the U.S. every year. There is no reason why cell cultures cannot be derived from tissue donated from prematurely-born infants that, despite the best medical technology, aren’t able to survive and die of natural causes while in a hospital setting. In these scenarios, developing a cell line would be no different from an ethical perspective than donating organs.

There is also the possibility that cell lines could be developed using cells ethically derived from human umbilical cord, cord blood, or placental tissue—tissues and organs that hospitals routinely discard as medical waste.

And ethical alternatives for human cell lines specially designed for producing viral vector vaccines may soon be available to vaccine manufacturers.

The John Paul II Medical Research Institute in collaboration with Cellular Engineering Technologies (CET) is currently in the process of developing an ethically-derived adult human cell line specially designed for growing viral vectors for vaccines that could replace ethically-fraught cell lines like HEK-293 and PER.C6.

But even so, it is not necessary for viral vector vaccines to be manufactured using fetal cell lines. Merck’s Ebola vaccine, for instance, is a viral vector vaccine that is grown in monkey
kidney cells.

Immortalized adult human cell lines that were ethically derived from the cancer cells of cancer patients have also been available to researchers for decades. Immortalized human cancerous cell lines have some of the benefits of fetal cell lines in that they are high passage cells (in fact cancerous cell lines divide infinitely). However, the genetic mutations in these cell lines often change too much and there is concern that these cells could be contaminated with oncogenic viruses (i.e. viruses that induce the formation of cancerous tumors). There is fear that DNA from oncogenic viruses could find their way into vaccines if these cell lines are used for manufacturing vaccines.

However, fetal cell lines such HEK-293 and PER.C6 are also tumorigenic. There is concern that these cell lines too could be infected with oncogenic viruses or oncogenic DNA.

Although rigorous purification processes are used when manufacturing vaccines, purification is an arduous process and it is practically impossible to filter out all contaminants. The FDA is currently researching tests and methods to better determine whether certain cell lines are safe enough for vaccine production.

For the current ongoing COVID-19 pandemic, there is no reason for vaccines to be developed using unethically-derived fetal cell lines. Many of the world’s largest vaccine companies, including Sanofi, GSK, Merck, and Novavax, have demonstrated that it is possible to develop promising vaccine candidates using ethically-derived cells such as Vero, Sf9, and perhaps even embryonated chicken egg. Ethical alternatives exist.

If pharmaceutical companies are not willing to use ethical alternatives, then they must be required to.

Previous version of this article incorrectly stated that the mRNA sequence in Moderna’s vaccine was produced using HEK-293 cells. mRNA vaccines such as Moderna’s are manufactured cell-free. Rather, Moderna’s vaccine was developed collaboration from NIAID. NIAID had conducted research using HEK-293 to isolate and study the SARS-CoV-2 spike protein. This article was updated to reflect these facts.