A revolution in vaccine development—but will we all benefit?

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Credit: AI-generated image (disclaimer)

By manipulating the "instruction manuals" that control cell function in our bodies, we will soon be able to combat many diseases, including the new coronavirus outbreak. However, in the worst scenario, such innovations will only benefit the rich.

Recently, it was reported that a vaccine against the new coronavirus could be ready for testing on animals within one month, and on humans within three months. This process normally takes several years, but innovative vaccine technology can do the job at record speeds.

The new technology makes use of mRNA (short for messenger RNA), which carries nucleic acids—the chemical "building blocks" of life. Messenger RNA acts as a "working copy" of the genes (made of DNA) that our bodies have to read in order to make the proteins that control the life processes taking place in our cells. RNA represents a family of molecules that is structurally similar to DNA.

Research into mRNA is being carried out at breakneck speed, but is largely in the hands of a small number of private sector pharmaceutical companies. This is troublesome from a public health perspective.

Extremely expensive

As is the case with currently available medicines that contain other forms of RNA, vaccines and drugs based on mRNA could be extremely expensive to produce.

If everyone, including the poorest in society, is going to take part in the health revolution promised by mRNA technology, research must take place across all sectors and should not be restricted to private enterprise.

But this will require the public sector, both in Norway and globally, to invest in this technology.

Major scope for improvement

Let's be clear. The vaccines we use today represent a solid foundation

for global health.

The development of a traditional antiviral vaccine usually begins with the isolation of the whole or parts of a pathogenic virus, which is then caused to be more or less inactive. It is then injected into the body in order to stimulate a required immune response.

This strategy has worked since the end of the 18th century, when the first smallpox vaccine was developed.

But a lot has happened since then. According to the private foundation established by Bill and Melinda Gates to support vaccine development, vaccines have saved the lives of 122 million children in the years between 1990 and 2017.

However, there is still major scope for improvement.

Goodbye to allergic reactions

Current approaches to vaccine development are complicated processes characterized by a lot of uncertainty and a great deal of testing—all of which takes time.

Moreover, viruses used in vaccines must be designed to achieve exactly the appropriate level of virulence that stimulates the desired immune response. If the stimulation is too mild, the vaccine will have no effect. If it is too strong, the recipient will become ill.

Many of our current vaccines also contain traces of the compound formalin, which in some few cases cause allergic reactions. But formalin can be eliminated if we use mRNA-based vaccines.

So what is the secret?

Instruction manual for the cells in our bodies

Messenger RNA is effectively an "instruction manual" that our cells refer to in order to make proteins. Proteins are essential for the assimilation and processing of nutrients in our bodies, as well as the breakdown of harmful substances and bodily renewal.

Most common medicines act by changing protein functions. However, these changes are commonly imprecise—with side-effects that can be anything from insignificant to life-threatening.

Messenger RNA is made up of four nucleic acid components abbreviated to A, U, C and G. The configuration of these components is read by the cells like the instructions in a cooking recipe. If the mRNA instructions cannot be read, its message will have no effect and so no side-effects will develop. But if the message is read correctly, the body will make exactly the right kinds of proteins it needs—no more and no less, at the right time and in the right place.

Vaccines and other medicines based on this process thus open the door to amazing possibilities.

Protein-encoding virus fragments packaged in synthetic molecules

As soon as the genetic make-up of a new virus has been mapped, we can code its key fragments into a synthetic mRNA molecule and deliver it to the body as a vaccine.

The body uses the instructions in the vaccine to make a new protein. The immune system reacts, but its protective response progresses without any risk of infection. In this way, the body makes itself ready to combat the

virus when it makes its appearance.

The challenge we face is thus two-fold. Firstly, the manufacture and management of mRNA is a demanding process. Secondly, it has proved difficult to deliver the genetic "working copies" intact to the locations within our cells where they are most needed. However, scientists have overcome these problems by packaging mRNA molecules into lipid-based nanocapsules—thus opening the way for the treatment of a whole range of diseases.

Combating cancer

The list of potential applications ranges from drugs to combat cancer, hereditary genetic disorders and neurological diseases, to vaccines against infections.

At SINTEF, we are working on the use of nanoparticulate mRNA in the treatment of so-called triple negative breast cancer, which is one of the most lethal forms of the disease. This work is part of a project called EXPERT that is funded by the EU with NOK 150 million.

In nanoparticle-based solutions of this type, the mRNA fragment can easily be replaced without the drug distributing itself differently within the body. Thus, when we obtain new facts about a given disease, the path to an effective drug treatment can be short.

Public sector involvement

The flipside of this story is the high costs associated with RNA drug treatments, and this is where the challenge lies. By consolidating global public sector investment in research in this field, it may be possible to prevent the monopolization of mRNA drug manufacture by market-

driven private enterprise.

Only in this way can mRNA technology be applied for the benefit of all—in line with UN sustainability goals.

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