Case - Artemisinin

Description

Part of the Genomics, Ethics, and Society course, this scenario looks at issues of genomics and synthetic biology through the true case of the artificial production of artemisinic acid - a substance used in the production of anti-malarial drugs.

Body

In May 2010, scientists at the J. Craig Venter Institute created the first artificially synthesized cell (Gibson et al., 2010). This cell was constructed by inserting the genome from the bacterium Mycoplasma mycoides into the cell of the bacterium Mycoplasma caprocolum. The genome of M. mycoides was chemically synthesized by computer, based on previous sequencing of the M. mycoides genome. Once the genome was inserted, M. mycoides subsequently took over the M. caprocolum host and began replicating M. mycoides genes.

This cell was not fully synthetic, however, because it used previously existing biological organisms. A fully synthetic cell would be created out of purely artificial parts, without any use of biological materials. Some scientists predict that fully synthetic cells (and perhaps more complex synthetic organisms) will be achieved within the next decade (Bedau et al., 2010).

Creating fully synthetic cells would be an enormous scientific breakthrough (Bedau, 2011; Boldt & Müller, 2008; Khalil & Collins, 2010; Kaebnick, 2013). It would also potentially provide more efficient control over organisms that are already being used for human benefit. For instance, scientists have identified a way to artificially produce artemisinic acid, which is a precursor for artemisinin, the primary ingredient in a widely-used anti-malarial drug (Gibson et al., 2008; Ro et al., 2006).

Researchers found that by inserting the genome of the sweet wormwood plant, the traditional source for artemisinin, into yeast (S. cerevisiae), the yeast produced an abundance of artemisinic acid—enough to significantly reduce the cost of anti-malaria drugs.

Accomplishing this increase in artemisinic acid was a painstaking process that might be done more efficiently if we did not have to rely on biological organisms. Wormwood and yeast could be removed from the process if an artificial life form could be created that performed the same functions. This would likely be more cost-effective.

However, many scientists and ethicists are concerned about the implications of synthetic organisms. One major concern frequently expressed is that there is a moral difference between manipulating previously existing organisms and creating entirely new organisms. Both activities might seem controversial, but creating new organisms especially so.

For instance, some have argued that acquiring the capacity to create life raises challenging philosophical and ethical questions (Deplazes-Zemp, 2012; Kaebnick, 2013). While we have been modifying organisms and directing their reproduction for a long time, we have not been able to create organisms of other species, either those that already exist or those not found in nature. One concern might be that having the capacity to create synthetic organisms will lead us to “commodify life,” and think it is ours to control as we wish. Another is that synthetic organisms have no evolutionary history (Norton 2010)

Others claim that the processes that create and are constitutive of life have “intrinsic value,” and that for humans to create artificial life may be to infringe on this value (Link, 2013; Preston, 2008; Sandler, 2012). The M. mycoides created by Venter’s lab, for instance, was designated a success primarily because it was able successfully to replicate itself. Self-replication is perhaps the most essential process in evolutionary history. By manipulating the property of self-replication, and in some cases granting it to artificially created matter, it might be argued that we are failing to respect the intrinsic value of life as well as its long evolutionary history.

As with many other types of genetically modified substances, there are also concerns that artificial self-replicating organisms could be released (either intentionally or accidentally) and reproduce outside of the lab. Scientists have taken various precautions to prevent this, including limiting the number of times an artificial organism can reproduce and inserting markers into artificial organisms so they can be easily found outside of the lab. However, it is possible that these precautions would not be implemented in future artificial organisms.

There are also concerns that this technology could be misused. For instance, some scientists worry that it could lead to the development of artificial infectious diseases that might be used for bioterrorist acts. This is especially troublesome given the rise of at-home genomics kits and the widespread availability of the basic materials needed to create synthetic organisms.

- ***Suppose you are a scientist working to create synthetic artemisinic acid for medical purposes. What sort of precautions would you implement? What ethical issues do you think are raised by your project?***

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