So Much Knowledge, So Little Time

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I once had the opportunity to visit a forensic laboratory conducting genetic analyses. Our guide proudly showcased their newly acquired pipetting station – a device used to prepare reaction mixtures in very small volumes, in the thousandths of a microliter. I joked that in our lab this work is done by a student, who is much cheaper. However, costs are much less important where accuracy is concerned. Even an extremely meticulous student or an experienced lab technician will never be as precise as a machine that can prepare several hundred reactions without any errors in just a few minutes.

These days when it comes to lab work, most of the tasks previously performed by technicians are now being done by all sorts of machines. Observing blood smears under the microscope is a thing of the past, as a flow cytometer will determine its composition much faster and more accurately. Nobody calculates statistical tests with a calculator and hardly anyone can still use a logarithmic slider or a laboratory scale with weights. Hardly anybody buys generic reagents to prepare mixtures for themselves – now the reagents come in specific patent-protected kits designed for a strictly defined purpose (such as for extracting DNA from saliva).

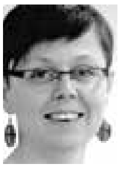
Does this mean that scientists will be losing their jobs to machines? For now this certainly isn't the case. It is primarily routine tasks that are becoming automated, as automation requires a suitable device not only to be designed and constructed, but also to be correctly calibrated, in other words "taught" the characteristics of the samples studied. It is a time-consuming and expensive process, which is why the solutions available on the market are almost exclusively designed for use with model species such as mice, yeast or fruit flies. Biologists interested in other study species still have to check for themselves whether a certain solution is useful in their work. Can the kit to determine the hormone concentration in the blood of lab mice be used for gerbils? What is the blood composition of gerbils if no one has ever tested it before? What are the normal and abnormal hormonal levels in this species? Often, rather than testing the usefulness of a new commercial product in a unique study, it is easier to analyze the samples manually, as was always done in the past, by preparing reactions and reading their results on a less advanced but more universal equipment.

Automation is therefore inextricably linked to the cost-effectiveness of specific methods. In small research groups or teams of scientists exploring many different non-model species, the effort put into developing procedures that can then be automated may simply not be worth it. One needs to take into account the time needed to learn the specifics of the new machine and adjust its parameters to the needs of the project. Also, if a relatively small sample is to be tested, using a large machine can simply be too expensive. Sometimes it is easier to view several hundred smears under the microscope in search of interesting blood parasites than to try to figure out how to use a cytometer for this purpose. In this type of research, it is the scientists and their creative approach to the technical problems appearing with every new species that are much more important than the speed with which these procedures can be performed.

There is another side to the evolving automation of laboratory work. It took ten years, the work of about one hundred labs, and a multitude of scientists to sequence the first human genome. These days it can be done by a single person in just a few days. It is becoming easier to generate volumes of data, but it is increasingly difficult to analyze them, not only due to their quantity, but also their complexity. Sometimes it takes a lot of effort to understand the results produced by a machine. If we want to perform a certain analysis, it takes computation time to process terabytes of data and find an answer to a biological question. This is why many researchers no longer collect their own data but instead base their work entirely on the information available in public repositories, which contain such things as sequences of single genes, as well as whole genomes or protein characteristics. This is reminiscent of the planet described in Stanisław Lem's *Observation on the Spot*, where researchers had amassed so much data that they needed all available computers to search through the discs and memories, and where new fields of science had to determine what was truly not yet known, and what had already been researched and forgotten.

One of the basic techniques in molecular biology, called PCR, is used to obtain multiple copies of a tested gene by means of polymerase, a DNA replicating enzyme. For the reaction to work, the reaction mixture must be regularly treated with three different temperatures. Currently, the entire process takes place in a machine called a thermocycler. Previously, the test tubes were simply physically transferred between water baths set to various temperatures.

When I talk about it in lectures, I imagine students who once performed the job of this device. I imagine them with a stopwatch in hand carefully transferring the samples every few seconds from one water bath to the other, over and over again for one and a half to two hours. The name of the inventor of the PCR reaction went down in science history, but we never mention the engineer who constructed the first thermocycler. I, however, think of him very fondly, as I do of other anonymous inventors of the devices used every day in the lab, because their inventions have freed researchers from performing robotic work, and allowed us to focus on what we do best, developing new ideas. And no robot has replaced us in this area, at least not just yet*.



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works at the Faculty of Biology at the University of Warsaw. She studies the evolution of the parasite-host relationship in natural conditions. She also assists in conservation biology projects and studies of genetic variability in wolves and squirrels. In 2010 she received a START scholarship from the Foundation for Polish Science. Editor of *Academia's* Biological Sciences section.

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* If you are worried about losing your job to machines, we suggest you visit the website willrobotstakemyjob.com or www.replacedbyrobot.info, where you can calculate your risk of being replaced by a robot. For biologists, it is currently estimated at 1.5-6%. So I guess we can sleep soundly for now?