Cellular reagents and OSH for education in Chile

Although molecular biology principles and general applications are being progressively incorporated in the national education curriculum, possibilities to experience first hand common techniques of the field are extremely limited for most high schools and universities in Chile. The reasons behind this lack of access to molecular biology tools are variable but common factors are the cost and logistics of obtaining biological reagents like enzymes. Indeed, they are manufactured in the Global North and imported under cold chain in a procedure that takes weeks to months to arrive for use. Access to the equipment is also prohibitive, as specialized tools are often proprietary, expensive and manufactured abroad, which becomes a problem when the equipment requires fixing, usually needing to send it abroad taking weeks to months to get it back. Altogether, these barriers make it difficult for non-research institutions to provide an educational perspective on molecular biology tools.

Considering the limitations described above, we decided to contribute by making the PCR reaction accessible for the classroom. To do that, we implemented the cellular reagent protocol (Open Bioeconomy Lab), in an attempt to provide higher autonomy to institutions interested in enzyme manufacturing. Producing the OpenVent DNA polymerase in pLysS bacteria, using directly the cell as a reagent in the reaction. This protocol brings the cost of the enzyme down to US$ 0.01 per 100 reactions, compared to US$ 18 in the case of the cheapest enzyme available in Chile, which means a difference of two orders of magnitude. We also activated a community of hardware developers in Chile and Argentina, who collaborated in the open-source creation of traditional equipment.

The Open-source hardware kit consists of a centrifuge based on a drone motor with a 3D printed base, designed by Nicolás Méndez (Universidad de Buenos Aires), used to collect the bacteria expressing the enzyme. A colorimeter made by Fernando Castro (Universidad Nacional de Cuyo) and Nicolás Méndez, in collaboration with IORodeo, for optical density measurement at 595 nm estimating cell density. To run the PCR reactions, we use the PocketPCR thermal cycler designed by Gaudi Labs. The electrophoresis uses a power supply designed by Wladimir Aralla (IOWlabs) and a low-cost Chinese chamber to which we change the platinum to a high purity 0,1 mm platinum wire. To visualize the gels, we use a transilluminator designed in collaboration with reGOSH, IOWlabs and Francisco Quero (University of Cambridge) based on the original from IORodeo, consisting of a 3D printed base, a SMD LEDs PCB and low-cost blue and orange lee filters.

As presented the kit is designed to perform PCR reactions in the classroom. Nonetheless, each component can and is encouraged to be applied for other practical work too, building a community-based kit where protocols are shared and new applications are provided for each equipment. For example, in our courses to third year biochemistry students we use both the PocketPCR and transilluminator for Gibson Assembly reactions.

Here we describe our work with high school teachers, researchers and undergrad students to produce *in situ* the OpenVent enzyme from plate protein expression and perform PCR reactions

at low-cost using our open source hardware ecosystem. We implemented five times the protocol in three regions of the country: Magallanes (Punta Arenas), Los Ríos (Valdivia) and Metropolitana (Santiago). Most of the participants had little to no previous experience in molecular biology. Yet, overall, **85%** of the groups (17/20 combining all activities) were successful in implementing at least one positive PCR reaction with cellular reagents. All the repositories of the aforementioned devices are publicly available, and some equipment can even be purchased in Latin America.