Description for the general public

In recent years, biomedical research has made huge progress in developing laboratory biofabricated human tissues for 3D *in vitro* modeling to study diseases and test new drugs. However, one major challenge remains: creating lab-grown muscles that work just like real human muscles. Muscles are essential for movement, metabolism, and overall health, but current lab-grown models are still too weak and immature to be truly useful for medical research, drug testing, or even bioengineered robotics.

One of the **biggest problems is how to make lab-grown muscles "train" and develop properly**. Just like in the human body, muscles in the lab need stimulation to grow stronger and function correctly. Traditionally, scientists have used two main types of stimulation: Electrical stimulation, which works like signals from the brain to the muscles. It uses small electric pulses to make muscle fibers contract and become stronger over time. Mechanical stimulation, which physically stretches and moves the muscle fibers, similar to what happens when muscles experience tension during exercise.

These methods have been useful in supporting muscle development, but they still fall short of achieving optimal results due to their lack of standardization and the difficulty in precisely controlling the parameters needed for proper muscle growth. They can also be difficult to control and don’t always work the same way across different experiments. Another problem is that scientists usually check muscle growth only at the end of an experiment, rather than tracking how the muscle changes over time. This makes it harder to adjust the conditions to improve muscle development.

To address these challenges, the **OPTI-MUS project (OPtomechanical Transduction for In vitro MUscle maturation and Strength refinement)** aims to develop an innovative bioreactor and an integrated workflow that uses light-based stimulation instead of electrical or mechanical force to **promote muscle growth in a more natural and controlled way**. The key idea is to leverage light-sensitive molecules (light transducers) that, when exposed to blue light, trigger muscle fiber contractions, mimicking how real muscles respond to nerve signals. The project will focus on three key experimental objectives: **i) developing biofabricated muscle constructs using genetically modified human muscle cells** that express a fluorescent protein to continuously monitor the muscle fibers organization and maturation; **ii)** designing and **optimizing a custom-designed bioreactor** that delivers precise photostimulation to enhance muscle strength and physiological properties; **iii) analyzing muscle function and maturation by examining biochemical and genetic markers**. This will allow researchers to fine-tune the entire biofabrication process, improving the reliability and scalability of engineered muscle tissues for various applications. Ultimately, OPTI-MUS project will generate engineered muscle constructs with **different types of muscle fibers, allowing the development of optimized muscle models**, from endurance-based muscles, like the soleus, to power-generating muscles, like the triceps. Importantly, different muscle fiber types are also affected differently by diseases. By replicating these differences *in vitro*, this project will provide a deeper understandingof muscle-specific disease mechanisms and facilitate the development of targeted therapeutic strategies. If successful, this research could revolutionize muscle tissue engineering, making it easier to test new drugs, study muscle diseases, and even create artificial muscles for robotics and medical applications.