This presentation will discuss the climate change challenge and how it needs to be addressed by closing the resource loop. More specifically, a parallel will be drawn between what we have done since the beginning of the industrial era and what nature can teach us on addressing waste recovery. We will see that nature, by design, reutilizes all the resources since the resources on the planet are finite: there is no incoming feed of new material from the Universe to replace what has been consumed. However, energy is abundant, free and available everywhere through solar radiation. This is why evolution was more favorable to systems that could work together at recycling all atoms, without primarily favoring the energy efficiency of those systems. This is in direct contrast to our industrialized world where energy has a cost, because it is resource–derived, which forces us to be primarily energy efficient. In most cases, recovering waste requires work to reorganize the matter and our focus on energy efficiency immediately discards any attempts or processes that would require energy to convert waste.

Billions of years of evolution show that the best and yet most efficient system for closing the loop of carbon requires energy and is called photosynthesis. Perhaps this tells us that the “holy grail” technology everybody is looking for, which would use minimal energy to recycle material, might not be possible. Certainly, this should guide our approach towards recycling.

So now that we admit work is needed to recycle, what do we do? How does Nature approach waste recovery from a process standpoint? We will observe the mechanism by which waste is recovered and conclude that recycling occurs at the atomic or molecular level. Large structures, like celluloses, lignin, etc., are decomposed into smaller molecules. This happens through multiple reactions until the final molecules obtained are re-usable for protein or sugar synthesis.

To develop processes which recycle waste, we can no longer work in silos. It is essential i) to work with a detailed and overall vision, ii) to collaborate with people from different disciplines, iii) to innovate by effectively using the non-established and courageous nature of our graduate students.

As an application example, we will talk about a recent successful industry-university collaboration incorporating lessons from Nature to address plastic waste and tire recovery. We will introduce the Pyrowave and Ecolomondo technologies. Pyrowave uses microwave-assisted pyrolysis on a small scale to form monomer and waxes from waste plastics. Through conventional pyrolysis, Ecolomondo produces oil and carbon black from its industrial units. Both technologies convert waste, one to monomer and the other to carbon black, which can be recycled again into polymer synthesis and new tires.