What does the word Mycorrhizae Mean?

"Mycor" is the Latin word for 'fungus', and "rhizae" means "roots". So, the term Mycorrhizae perfectly describes the mutually beneficial relationship between a plant and the specialized fungi that support its roots in healthy, undisturbed soil ecology. Both the plant host and the fungi benefit in this unique relationship. It is the classic example of a mutually beneficial symbiosis between 2 very dissimilar organisms. So to be clear, the word Mycorrhiza is not the name of a specific genus or species of fungi (in the way that the word 'Acer' is applied to all Maples) but rather mycorrhiza is a descriptive term for this unique type of fungi. And mirroring the great diversity of plant species that we see above the ground, there are hundreds of species of mycorrhizal fungi associated with plant roots below the ground in undisturbed natural landscapes.

Some fungi might be described as Parasites (if they obtain their food at the expense of their host), while other fungi are called Saprophytes; these fungi obtain their energy by digesting dead plant materials. Unlike green plants, fungi can't photosynthesize energy from sunlight and carbon dioxide – so just like us, they need to find food from other sources. The unique thing about mycorrhizal fungi is that they obtain energy by trading with their plant host. Plants give mycorrhizae energy (surplus to their own needs) in the form of Exudates in exchange for water and nutrients that the fungi are uniquely equipped to source out in soils. A perfect partnership.

How do Mycorrhizal Fungi Help Roots?

After hundreds of millions of years of adaptation to the task, mycorrhizal fungi have become very good at assisting roots in their quest for water and nutrients in soils. The mushrooms in a forest (or the ones that we eat on a pizza) have a very rapid metabolic rate – simply put – fungi grow crazy-fast. In fact, tiny fungal filaments (called hyphae) grow hundreds of times faster than roots do. Mycorrhizal hyphae combine rapid growth, a tiny diameter (that can squeeze into tight spots that roots are far too big to get into), and a dense branching structure. For roots, mycorrhizal fungi serve as a rapidly deployed sponge-like structure that continuously rebuilds itself as the plant host requests more assets from the soil. Fully-formed mycorrhizal networks can expand the net absorptive capacity of roots by a hundred to a thousand times over. In a healthy undisturbed ecosystem, there can be over a mile of mycorrhizal hyphae in just a teaspoon-full of soil.

Beyond getting into every available space in the soil around roots, mycorrhizae also deploy powerful acid-like enzymes that solubilize (dissolve) essential mineral nutrients that they find in soil and transport these (now plant-available) nutrients back to the root through the hyphal pipeline. Organic nitrogen, phosphorus, iron and other essential soil nutrients are typically "tightly bound" to the organic matter, clay, rock and various aggregates in soils. And so, the nutrient acquisition and transfer of hard-to-find or tightly-bound nutrients into the plant's root system is an essential function that mycorrhizae play in natural, undisturbed soil ecosystems. This is basically how plants get fed in the natural world – nobody is out there fertilizing or watering. Plants have developed a network of supporting organisms that sustain them; mycorrhizal fungi are an essential part of that network of soil microbes. In natural environments, plants orchestrate and power this nutrient and water acquisition process (select and sustain an army of beneficial microbes) using surplus energy that they manufacture through photosynthesis. Plants photosynthesize up to 40% more stored carbohydrates (sugars, starches, etc.) than they actually need to grow – and they 'give away' this surplus (collectively called 'Exudates') to get work done by microbes in the soil environment – including mycorrhizae. Fully 1/3 of the carbohydrate compounds that plants produce through photosynthesis are traded to mycorrhizal fungi in exchange for work these highly specialized microbes perform in soil.

Where are Mycorrhizae Naturally Abundant in Soils?

In wild, undisturbed ecosystems soils are packed with incredibly dense networks of beneficial mycorrhizal fungi. High fungal density in soil is, in fact, the hallmark of plant communities that have reached the apex (or climax) of plant succession; a point in undisturbed natural settings where the diversity of plants becomes stabilized, leaving only a few species which dominate the geography. In Canada, we have several unique and still untouched examples of undisturbed forests where plant succession has reached its climax; wonderful places like Clayoquot Sound on the west coast of Vancouver Island, or Wolf Lake in the Temagami Highlands of Ontario. The microbial life in the soils under these beautiful landscapes has also evolved to a type of climax; these soils are dominated by dense networks of mycorrhizal fungi which support the green canopy above, whereas disturbed, or early succession soils are typically dominated by bacteria. Urban soils are in fact the least likely place to find significant levels of beneficial soil fungi – bacteria abound in these soils. And the early succession plants (that thrive in bacterial soils) are easy to find in urban environments too; these are the fast-growing, heavy seed producing annual plants - many of which we call 'weeds'. Remember, mycorrhizal fungi require a host plant to exist; they can only obtain the carbon that that they need to survive by providing a higher successional plant host with what it needs – access to soil water and nutrients. Take away the higher succession plant hosts (perennials, shrubs, trees and evergreens) and the mycorrhizae will not be fed, and they will fade from the soil.

So, What Happens when Synthetic Fertilizers are Applied to a 'Natural System'?

The relationship between green plants and the virtually countless microbes in the soil that sustain them has been developing and evolving over millions of years. Plants have learned to trade their surplus photosynthetic capital to obtain essential nutrients through a complex relationship with communities of soil microbes and higher soil organisms. Nutrients in the natural environment are not typically 'laying around' in a highly soluble (plant available) form - if they were, they would leach out of the soil and wash downstream with the next rainfall. In nature, nutrients are typically tightly bound to mineral aggregates and clay (the parent materials of soil), and plants employ 'specialist microbes' to extract and capture these bound nutrients without risk of them washing away. Nature has perfected a highly-efficient, closed-loop system. The application of synthetic fertilizers essentially short-circuits this process; plants suddenly find their roots saturated with highly plant-available, reactive nutrients - and as a result - they simply stop 'asking for help' from soil microbes like mycorrhizae. The upshot of the sustained application of high-potency synthetic fertilizers is a steady decline in soil microbial life - soils simply become 'empty media' lacking in all but foraging bacteria and latent pathogens. And in the end, the plants in soil systems disrupted by the application of highly reactive fertilizers ultimately become dependent on the continued application of synthetic fertilizers. The 2014 report by the International Joint Commission [IJC] "A Balanced Diet for Lake Erie" makes it clear how much damage can be done when synthetic fertilizers are continuously applied to farm fields (and Landscapes). Download the IJC 2014 Report 'A Balanced Diet for Lake Erie'

To break this cycle, beneficial microbes like mycorrhizae must be restored to soils. Soil health and plant success can be restored to a natural, sustainable balance.