The Influence of Geology and Substrate on Plant Life in Northeastern North America

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7f. Critical zone processes: their role in ecology and evolution

Within a given climate, geology plays a central role in the distribution and ecology of plant species and their associated biota. The most significant causes of localized or unusual plant distributions are discontinuities in geology. Abrupt changes in geologic conditions can also set the stage for processes generating plant diversity. The study of plants growing on unusual geologies and substrates has contributed much to ecological and evolutionary theory. While much attention has been paid to the influences of geology and substrate on plant life worldwide, such literature for eastern North America is scant. The work we are currently pursuing on the flora of serpentine and granite outcrops, seabird guano deposits, and metal-enriched mine tailings in Maine suggests a unique substrate effect on the regional flora at taxonomic, physiological, and community levels. Our research highlights the need to better document the floras of other under-explored substrates of the region, including limestone, dolomite, and gypsum, and soils overlying metal-enriched geologies, including mine tailings and waste rock piles. These island-like habitats with unusual chemical and physical soil features can provide unique settings for the assembly of distinct plant communities, consisting of rare and endemic species and physiologically distinct ecotypes of more regionally common species. Such edaphically-restricted plants and their associated biota can provide ample opportunities for descriptive and experimental studies in ecology and evolution, ranging from cellular and organismal to population, community, and ecosystem levels.

Bioremediation of Heavy Metals using Transgenic Microalgae

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Microalgae account for most of the biologically sequestered trace metals in aquatic environments. Their high metal binding affinities coupled with efficient metal uptake and storage systems make them efficient metal chelators. These factors combined with their large surface: volume ratios aid them bind up to 10% of their biomass as metals. In addition to essential trace metals required for metabolism, microalgae can efficiently sequester toxic heavy metals which often compete with essential trace metals for binding and uptake into cells. We have developed transgenic approaches to further enhance the heavy metal specificity and binding capacity of microalgae with the objective of using these microalgae for the treatment of heavy metal contaminated wastewaters and sediments. These transgenic strategies have included the over expression of enzymes whose metabolic products ameliorate the effects of heavy metal-induced stress and expression of heavy metal chelating protein such as Metallothionein (MT) to sequester heavy metals. The most effective strategies have substantially reduced the toxicity of heavy metals allowing transgenic cells to grow at wild-type rates in the presence of lethal concentrations of heavy metals. In addition, the metal binding capacity of transgenic algae has been increased five-fold relative to wild-type cells. Recently, fluorescent heavy metal biosensors have been developed for expression in transgenic *Chlamydomonas reinhardtii*. These fluorescent biosensor strains can be used for the detection and quantification of bioavailable heavy metals in aquatic environments. Furthermore, we discuss strategies for utilizing these transgenic algae for applications including sequestration of heavy metals in aquatic sediments.

Figure 1: Unicellular green alga *Chlamydomonas reinhardtii*

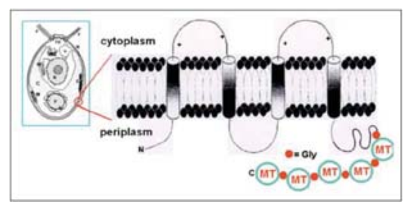

Figure 2: Cartoon depicting algal cell membrane engineered to express surface exposed Metallothionein (MT) units

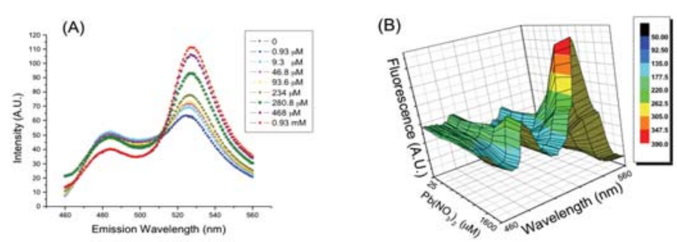

Figure 3: (A) *In vitro* metallothionein fluorescent biosensor showing increased heavy metal lead (Pb) concentration specific response (527nm/485nm).
(B) Intracellular expression of fluorescent biosensor in transgenic algae showing dose dependent response to added Pb.