MID-PROTEROZOIC RECORDS OF ATMOSPHERIC OXYGEN. N. J. Planavsky[1], D. B. Cole[1], C. T. Reinhard[2], T. W. Lyons[3]. [1]Yale University, New Haven, CT (noah.planavsky@yale.edu), [2]Georgia Tech, Atlanta, Georgia, [3]University of California, Riverside.

Introduction: There is widespread and vigorous debate about the relative roles that environmental and biological factors played in driving broad-scale evolutionary trends. For animals, one of the major and long unresolved questions is whether their relatively late appearance and diversification was linked to a change in environmental oxygen levels or if this dramatic shift in the structure and complexity of the biosphere simply reflects the timing of genetic innovation, independent of any environmental control. This debate has lingered, and now arguably stagnated, in part because of poor quantitative constraints on oxygen levels during the majority of the Proterozoic—i.e., the billion-year interval preceding the rise of animals. Metazoan physiologies are associated with absolute minimum oxygen requirements: larger body sizes, mobility, and sophisticated ecologies such as predation are accompanied by higher metabolic oxygen demands. However, there are very few independent constraints on mid-Proterozoic (1.8-0.8 billion years ago (Ga)) atmospheric oxygen levels prior to the appearance of animals. Traditionally, there are only very crude lower estimates for mid-Proterozoic atmospheric O_2 levels (e.g., > ~1% PAL). Without improved constraints on Proterozoic atmospheric oxygen concentrations, little progress can be made in assessing possible causal links between environmental change and animal evolution. Further, as the possibility of detecting the atmospheric composition of terrestrial exoplanets moves from the realm of science fiction to science we have become increasingly focused on determining what Earth would look like if analyzed remotely over its long history. Beyond just providing a record of Earth's atmospheric composition, our goal is to determine how biological evolution has shaped surface oxygenation. A better understanding of our own planet's atmospheric evolution will improve the framework we use to interpret exoplanetary atmospheres. Current poor constraints on pO_2 also make it impossible to reconstruct the history of atmospheric biosignatures on Earth.

In this talk we will present a critical review of currently utilized pO2 toolkit and briefly explore how these records link to remotely detectable atmospheric biosignatures on our terrestrial planet. We will focus on Cr isotopes and the possibility of trapping direct atmospheric gases. We will make a case that the Cr isotope record provides strong evidence for low mid-Proterozoic atmospheric oxygen levels and that extreme caution is needed when using fluid inclusions to track Earth's oxygenation. Lastly, we will highlight that the Earth has not, as typically envisioned, undergone a unidirectional rise in atmospheric oxygen.