

# Teaching Statement

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Nature reveals herself to be endlessly creative and relentlessly logical. She is elegantly minimalist at the core, but abounds with every whimsy, variety, and complexity of implementation at the surface of our senses. Perhaps it follows that the student of nature ought to mirror her traits, the better to understand her ways. It seems common however for students to exit high school having misdiagnosed (in either direction!) their aptitude for mathematics and the sciences. The goal of science, and particularly physics, is the unified description of an ever expanded web of phenomena by an ever reduced set of assumptions. The rote skills of memorization, absorption of facts, and adherence to fixed sequential procedures which have led to prior academic success are devalued in this setting. One is better served by the dynamic skills of pattern recognition, detective-like problem analysis, and the ability to widely generalize a relatively narrow base of core knowledge. The greatest obstacle to excellence in science education seems not to be delivery of raw content, but developing the essential methods of creative and logical thought, and nurturing the confidence to seek a presently unknown solution.

In my first years at Sam Houston State it was a regular duty to help cover the popular service level Planetary Astronomy course. I was surprised by what an enjoyable experience this became. Although I have had plenty of opportunity to instruct physics courses, both at the upper and lower division, there is something about my experience in the astronomy courses which encapsulates my philosophy of the teaching of natural science in a particularly succinct and apt manner. Indeed, astronomy is a wonderfully rich example of applied physics, and naturally provides a panoramic view of mankind's long struggle to comprehend his surroundings. It is a chance to convey not only the deep truths discovered, but also the subtexts of how careful observation and testing led us there and of which techniques and perspectives were beneficial, while others led only to dead ends. Free from a focus on specialized calculations or exercises, the subject is uniquely suited to a "big picture" perspective. It leads us through the detailed naked-eye observations of Tycho Brahe, to the distillation of this sprawling record into Kepler's three concise principles, to the discovery of sensible laws explaining why the planets choose such paths by the great Isaac Newton. Surely modern physics must count its lineage from that moment of realization that the agents of motion in the Heavens are one and the same with those acting on our

Earth, and that the strains of a Universal Gravitation hold but a single grip on both. There is an ironic warning in history's judgment of Ptolemy, whose epicycles were the leading explanation of retrograde motion for one and a half millennia, insulating the disastrous dogma of Geocentrism with an unrivaled predictive power. There is a lesson in good taste from Copernicus, who realized that this illusion of complexity was only the consequence of viewing a simple (nearly) circular orbit from another planet, one among many, also in motion about the Sun. We now see our place more clearly again, with the Sun as one among a couple hundred billion stars of the Milky Way, itself one of a couple hundred billion galaxies, each holding perhaps as many stars again. Relativity advises that a universe whose laws apply for just a single frame of reference is truly beyond comprehension, and that the notions of absolute rest or absolute centrality are without meaning. The subject of astronomy is not limited however to the great expanses above our heads. Accurately decoding the mysteries carried in the ancient light that reaches our telescopes requires us to also know something of that light's nature as an electro-magnetic wave. Consisting of many varied wavelengths, we realize that a full spectrum of detectors (gamma, x-ray, infrared, microwave and radio) is necessary to complete the narrow picture visible to our eyes. As for any wave, this "light" experiences dispersion, refraction, diffraction, and a Doppler shift from which is measured speed of approach or recession. Blackbody spectra can tell a star's temperature, and teach us along the way that sometimes light behaves as a particle. The identifying "fingerprints", unique to a given element or molecule, of discrete absorption and emission spectra are a window into the atom, ten-billion times smaller than ourselves, where "particles" such as the electron act like waves. So reminiscent of a planetary system, yet so very different, this is a land where deeper rules play, washed out to our clumsy bodies much as the pointillist strokes of a Seurat blur with distance into a continuous image. We cannot "see" the atom, because we are made of atoms. We cannot expect the atom to obey the rules of our intuition, for they are merely the side effects of functions carried out at the lower layer. Ten thousand times smaller, the nucleus exists. And far smaller yet are the scales relevant to the Universe's earliest moments, where cosmology and particle physics strongly intermingle. Measurements of our "fundamental" constants hint that the bottom layer, if such a thing exists, is many more times smaller than our bodies than the visible Universe is larger. Before this great Universe we are in awe, but we are not diminished. Perhaps even, we are her greatest machine – one capable of comprehending and appreciating her great wonders. This is the perspective on what science is, how science progresses, and how scientists think, which I attempt to share with my students, both specialized and non-specialized.