Hnrs PS2030: Exploring Key Concepts in the Physical Sciences
Are we Alone? The Science of Astrobiology

Professor	Stacy Palen	**Meeting Time**	MWF 10:30-11:20
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Email	spalen@weber.edu	**Texts**	Sagan, Carl: The Demon-Haunted World: Science as a Candle in the Dark Coursepack available at the bookstore

The Point: (What are we trying to do? What are the learning outcomes?)

- The physical sciences are one of the touchstones of our technological society. Everyone should know a little of this material, if they are to make reasoned decisions in life.
- No science stands alone, and it is often at the intersections that we find the most interesting, fruitful avenues of inquiry. All the sciences, working together, make better science.
- Science is beautiful, fun and interesting. No, really. It is. Every person should know that too! We'll explore the scientific aesthetic, through this intersection of several different sciences.

This course will investigate the nature of science by asking (and trying to answer) a particular question: Are We Alone? The effort to answer this question is called 'Astrobiology', and it is an interdisciplinary investigation involving physics, astronomy, chemistry, geology, and microbiology.

Formal learning outcomes for this (and other Natural Science General Education courses) are listed on this webpage: http://www.weber.edu/AcademicAffairs/natural_sciences.html and at the end of this document. In the material below, I will reference these learning outcomes by group and subnumber. So that Foundations of the Natural Sciences Learning Outcome 2 will be denoted *F2*. Physical Sciences Learning Outcome 4 will be denoted *P4*.

In this course, we will read six primary texts in astrobiology, devoting ~3 weeks to each one. During those three weeks, we will be carrying out hands-on and thought experiments, carrying out calculations, writing essays, and using every other tool we can bring to bear to try to really understand how science is done, as well as how science impacts our culture and the human condition.

The papers we will be reading are:

1. To organize our thoughts:
   a. The Drake Equation by Frank Drake (*F2, F3, F4, P1, P2*)
   b. Sagan, Carl and Druyan, Ann The Demon-Haunted World: Science as a Candle in the Dark, Ballantine Books, 1997 (*F1, F3, F4*)
2. All about the discovery of 51 Pegasi b:
   a. Mayor, Queloz, et al.; 51 Peg; IAUC 6251 (the discovery announcement of 51 Peg b in October 1995) (*P1, P3, P4*)
   b. Landsman, Simon, et al.; 51 Peg; IAUC 6268 (IUE follow-up observations of 51 Peg in November 1995) (*F3, P1, P3, P4*)

c. Marcy and Butler: AAS: The Planet around 51 Pegasi BAAS, 27, 1379 (poster abstract confirming discovery in December 1995) (*F3, P1, P3, P4*)
d. Sagar, Ram; Discovery of a planetary system around 51 Pegasus BASI 1996 (*F3*)
e. Boss, A. P.; Forming a Jupiter-like Companion for 51 Pegasi LPI, 27, 1996 (*F3, P1, P2, P3, P4*).
f. Lin, D. et al.; Orbital migration of the planetary companion of 51 Pegasi to its present location, Nature, 1996 (*F1, F3, F4, P1, P2, P3, P4*)

3. All about habitability
   a. Lowell, Percival The Habitability of Mars, Nature, 1908 (*F1, P1*)
   b. deVera, et al. The Adaptation Potential of Extremophiles to Martian Surface Conditions and its Implications for the Habitability of Mars, EGUGA, 2012 (*F1, P1*)
4. All about remote sensing
   a. Payne, Cecilia "Astrophysical Data Bearing on the Relative Abundance of the Elements" PNAS 1925 (*F1, F2, F4, P1, P2, P3*)
5. What happens when you get it "wrong"?
   a. Wolfe-Simon, et al. Did nature also choose arsenic? IJAsB, 2009 (*F1, F2, F3, F4*)
   b. Whatever is the latest article attacking this idea. (*F1, F2, F3, F4*)

The Points: (How am I going to figure out how we're doing?)

- **Activities:** Each week, usually on Friday, we will do an activity in class, about the material from the current week. This can be as simple as measuring the distances to objects using parallax, or as complex as detecting dark matter from the rotation curves of galaxies. The purpose of these activities varies, from exploring a difficult conceptual concept from a new angle, to giving you a sense of what the scientific data and process look like. The majority of these activities will be completed entirely during class time. (30%)
- **Homework:** Each week, due on Wednesday, we will have homework assignments due. Some of these will be quantitative (graph, calculate or measure), and some will be qualitative (explain, compare and contrast, research). Some will be a little of both. The purpose of these assignments is to give you a chance to spend a little more time with the background material, so that you can explore subtleties that you might otherwise miss. (30%)
- **Projects:** In some weeks, we will have short student presentations covering the non-technical aspects of the course. These will be group projects, and are expected to be short---ten minutes maximum. Each student will present at least once. These short projects will be presented on Wednesdays. The purpose of these projects is to give you some experience doing 'research' into the topic in a less directed manner. Generally, you will be asked to answer a particular question---hopefully one that you might have running around in your head anyway. (10%)
- **Paper:** The culminating project is a paper about one of the pillars of Big Bang cosmology (by the end of day one, you will understand what this means!). You will be expected to *synthesize* the information in class with information from other sources, and to *evaluate* the scientific evidence. A discussion of alternative interpretations is appropriate in some cases, but the focus should be on the accepted scientific interpretation. I expect that a *thorough*, *well-reasoned* and *insightful* assessment can not be written in fewer than fifteen pages. The purpose of this paper is to 'put it all together', to step back and look at the subject from a little distance, and see how it fits into the larger picture. (30%)

Week	Monday	Wednesday	Friday	Learning Outcomes Addressed this Week
8/29	Introduction, syllabus, why this class, etc	A brief history of the Universe	Activity: The Drake Equation	(*F1, F2, F3, F4, P1*)
9/5	Labor Day	A brief history of Science	Activity: Scientific Method	(*F1, F4*)
I9/12	The Demon-Haunted World I	The Demon-Haunted World II	Presentations: The Demon-Haunted World III	(*F3, F4*)
9/19	Stellar spectra	Stellar spectra	Activity: Emission and Absorption	(*F4, P1, P2, P3*)
9/26	Stellar spectra	Stellar spectra	Presentations: Stars and atoms	(*F4, P1, P2, P3, P4*)
10/3	Stellar spectra	Stellar spectra	Activity: R*	(*F4, P1, P2, P3, P4*)
10/10	51 Peg: Doppler Shift	51 Peg: discovery	Activity: 51 Peg	(*F4, P1, P3, P4*)
10/17	51 Peg: extra-solar planet catalog	51 Peg: extra-solar planet catalog	Fall Break	
10/24	Extremophiles	Extremophiles	Field trip to Great Salt Lake	(*F1, F2, F3*)
10/31	Extremophiles	Extremophiles	Activity: Microbial life and death: What does it mean to die?	(*F1, F2, F4, L1, L2, P1, P3*)
11/7	Extremophiles	Extremophiles	Activity: Great Salt Lake Halophiles	(*F1, F2, F4, L1, L2, P1, P3*)
11/14	Astro-geology	Astro-geology	Activity: Latest data from Mars Science Laboratory	(*F3, F4, P1, P3, P4*)
11/21	Astro-geology	Astro-geology	Thanksgiving	
11/28	Earliest life on Earth	Earliest life on Earth	Activity: Extracting DNA	(*F2, F4, L1, L3*)
12/5	When it all goes wrong.	When it all goes wrong.	Presentations: When it all goes wrong.	(*F3*)
12/12	Finals week---no class	Finals week---no class	Finals week---no class	

And finally, any student requiring accommodations or services due to a disability must contact Services for Students with Disabilities in room 181 of the Student Services Center. SSD can also arrange to provide course materials (including this syllabus!) in alternative formats if necessary.

Foundations of the Natural SciencesLearning Outcomes

After completing the natural sciences general education requirements, students will demonstrate their understanding of general principles of science:

Nature of science. Scientific knowledge is based on evidence that is repeatedly examined, and can change with new information. Scientific explanations differ fundamentally from those that are not scientific.

Integration of science. All natural phenomena are interrelated and share basic organizational principles. Scientific explanations obtained from different disciplines should be cohesive and integrated.

Science and society. The study of science provides explanations that have significant impact on society, including technological advancements, improvement of human life, and better understanding of human and other influences on the earth's environment.

Problem solving and data analysis. Science relies on empirical data, and such data must be analyzed, interpreted, and generalized in a rigorous manner.

The Physical SciencesLearning Outcomes

Students will demonstrate their understanding of the following feature of the physical world:

Organization of systems: The universe is scientifically understandable in terms of interconnected systems. The systems evolve over time according to basic physical laws.

Matter: Matter comprises an important component of the universe, and has physical properties that can be described over a range of scales.

Energy: Interactions within the universe can be described in terms of energy exchange and conservation.

Forces: Equilibrium and change are determined by forces acting at all organizational levels.