AST 121 A The Discovery of Galaxies Spring 2015

Meeting Times: TH 9:30-10:45, F 2-4		**Classroom:** MAC 228 (lab in MAC 222)	
Instructor: Dr. Todd Timberlake		**Office:** MAC 338A	
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Office Hours:	M 8-9, 11-12	T 8-9	
	W 8-9, 1-2	H 1-4	
	F 8-9. 11-12	Other times by appointment	

Catalog Description Galactic astronomy from the Seventeenth Century to the early Twentieth Century. Examines changing ideas about the place of our solar system within the Milky Way galaxy and the existence of other galaxies. Emphasizes the historical development of new theories and how those theories were evaluated. Recommended for general-education requirement in science. 4 credit hours.

What This Course is REALLY About We are told that our Sun is just one of hundreds of billions of stars in our Milky Way galaxy, which is one of hundreds of billions of galaxies separated from each other by millions of light-years of empty space. These galaxies are rushing away from each other because of the expansion of the universe, which began with the Big Bang 14 billion years ago.

And yet . . .

No human being has ever traveled beyond the orbit of the Moon. No human artifact has ever left our solar system. All we know of the galaxies comes from examining light from the depths of space. How did we determine the size and shape of our galaxy, and our own location within it? How did we discover other galaxies and measure their distances from us? How did we find out that the universe is expanding and began with a "Big Bang?" What methods and assumptions did we use to arrive at this amazing picture of the universe? Can this picture be *trusted*?

This course explores the history of mankind's discovery of the galaxies, from the Ancient Greeks to the mid-20th century. The journey begins with speculations about the night sky, particularly the stars and the Milky Way, as visible to the naked eye. We will examine how new technologies like telescopes, spectroscopes, photometers, photographic cameras, and radio antennae provided astronomers with a wealth of new data about our universe. We will see how mathematics and physics were used to make sense of this data. We will study the ways in which theoretical insights into gravitation, light, star formation and evolution, and even the nature of space and time itself, helped astronomers develop an increasingly coherent picture of our universe. In short, we will trace out the path by which human beings discovered their place in the universe among the galaxies. If you've ever wondered *how* astronomers figured out all these amazing things about our universe, this is the course for you.

How I Will Teach I believe that the best way to teach is to give students interesting and educational things to do, and then let the students do them. My job is to provide you with interesting (I hope) things to do that will help you learn about the history of galactic astronomy and, through it, about our Universe and the nature of science. I will provide you with reading assignments and homework questions to be completed outside of class time, as well as group activities to be completed during class time. I will also help guide you through this work. But the whole thing falls apart if you don't do the work, both in and out of class. I expect you to learn a lot in this class, and you simply cannot learn anything significant without working for it. If you find this fact upsetting, you may take comfort in the fact that you also cannot teach anything significant without working for it: so I'm right in there with you. Let's work together and make this a great class.

What You Will Read The following book is *required* for this course:

- *The Scale of the Universe: Discovering Our Place Among the Galaxies* by Todd Timberlake. (Yes, I wrote it. But feel free to complain if you think it could be improved.)

Why You (Should) Want to Take This Course Most students who take this course will never take another astronomy course, nor will they use astronomy in their careers. So why should you take this course, aside from the obvious fact that it satisfies a General Education requirement? There may be any number of reasons why this course might be good for you, but here are the ones I think are most important for the majority of students who take this course:

- This course will give you an understanding of the large-scale character and structure of our universe. This understanding is an important component of basic scientific literacy, and frankly it is just something you should want to know about. After all, you live here.
- This course will help you appreciate the methods of science and give you a better understanding of what scientists do and why science is important. It will also help you understand the historical development of science, and how this development was influenced by (and influenced) human culture and technology. Learning about the methods and history of science will help you to understand why some of your tax dollars are spent on scientific research. It will also help you to distinguish scientific claims (backed by evidence) from psuedoscientifc claims (with little or no evidence), an important skill in a world filled with con artists trying to sell you psychic predictions and free-energy machines. Plus science is cool.
- This course will improve your ability to apply abstract concepts and mathematical arguments to solve problems. Astronomy is, and always has been, a mathematical science. You cannot really learn astronomy without doing some math. That said, this course will focus more on concepts than on mathematics, and when mathematics is used the emphasis will be on mathematical reasoning (particularly reasoning involving ratios and proportions) rather than repetitive calculation. Mathematical reasoning is a skill that is valuable for almost any profession.
- This course should give you an appreciation for the beauty and *elegance* of astronomy. Astronomy presents us with stunningly beautiful images (think of the photos taken by the Hubble Space Telescope), but it also presents us with a unified and coherent picture of the universe that astronomers have developed to explain astronomical phenomena. This picture, which was constructed in the minds of human beings, is more beautiful than any snapshot taken by the HST.

Cool Stuff You Will Do By the End of This Course If you successfully complete this course you will do lots of very cool things. Here are a few of them:

- You will describe the key observational, theoretical, and technological developments in the evolution of our modern understanding of galaxies and the universe.
- You will construct an evidence-based argument for, or against, a scientific theory relating to galaxies or the universe.
- You will construct a concept map to illustrate the connections between specific theories and observations.
- You will read and interpret scientific graphs.
- You will construct arguments, or solve a problems, using proportional reasoning.
- You will determine the distances to stars and galaxies using observational data.
- You will analyze the influence of religion and technology on the development of science in different historical periods.
- You will look at some cool stuff through a telescope.
- And more!

What You Can Do to Learn In this course there are many ways for you to learn, including:

Text Readings Read the assigned sections of the textbook *before* each class meeting.

Reading Quizzes For each reading assignment you will complete a short multiple-choice reading quiz on VikingWeb *before* class time. These quizzes are designed to ensure that you read the assigned sections of the text before we cover that material in class.

Classroom Activities/Labs Most class days will be devoted to in-class activities. For each activity you will work in a group of 2-5 students to examine some astronomical phenomenon or theory. The activities will often involve exploring computer simulations. Some activities are intended to allow you to observe, in the space of a few short sessions, astronomical phenomena that were observed by astronomers over many years. Other activities are designed to help you visualize the predictions made by certain astronomical theories. Still others are designed to walk you through the processes by which astronomers first calculated important astronomical quantities from minimal observational data. You will attend at least one night session at the observatory. The activities and labs are a critical part of this course, so you should participate fully in each one.

Lectures I will usually give a brief lecture at the beginning (or maybe the end) of each class to recap the results of the previous activity and discuss some points of particular significance. DO NOT expect these brief lectures to get you out of reading the textbook or completing the activities!

Classroom Discussions Some days we will spend class time discussing topics covered in the textbook. It is vitally important that each student read the assigned material so as to be prepared to contribute to the class discussion.

Homework There will be several homework assignments based on the material covered in the textbook. Many of the homework problems will involve some mathematical calculation. The homework will help you gain a deeper understanding of the material, or it may help you discover that you need to do some more work to understand certain topics. If you don't do the homework you won't know if you really understand or not . . . that is, until you take the test. And that's a bad time to find out that you don't understand.

One-On-One Teaching Don't hesitate to come by my office to get some extra help from me if you feel you need it. Feel free to just drop by during office hours. You can also make an appointment to see me if you want to meet outside of my normal office hours. Occasionally I will be called away during office hours for a committee meeting or something similar. I apologize in advance if that ever happens.

What I Expect From You I expect everyone to learn a lot and have fun in this course. In order to learn and have fun, here's what you need to do:

- Attend each class meeting and arrive on time. You need to be there, and the other members of your group need you to be there. Arriving late disrupts the work of your group.
- Participate fully in activities, labs, and discussions. Although the activities, labs, and discussions should be enjoyable and entertaining, that is not the primary reason I am asking you to do them. They are a vital part of your learning experience.
- Read the assigned chapters of the text and complete the online reading quiz before each class. When I wrote the book, I intended it to be read.
- Complete *all* assigned work on time. No late work will be accepted. If you are unable to complete an assignment on time for a valid reason you must explain your absence *in writing* to receive credit for make-up work. Feel free to do the make-up work anyway, but you will only receive credit if you give me a written explanation of your absence.
- Be respectful of me and of the other students in the class. This doesn't mean you cannot criticize someone's ideas (including mine), but you must give reasons for your criticism and you should never be insulting or demeaning to anyone. I promise to be respectful of you in return.
- Come talk to me outside of class if you are having trouble with anything. I don't bite - honest!
- Abide by Berry's policies on academic integrity (see the Viking Code). All work that you turn in must be your own. You may discuss labs, activities, and homework with other students but the work you turn in must be your own (or that of your group, for a group assignment). All other work must be done without assistance from anyone but the instructor. If you are found in violation of Berry's policies on academic integrity I will impose strict penalties (like an automatic "F" for the course), because that kind of behavior hurts you and all of the other students in the course (and it really hacks me off).

- Students with a disability who believe they may need accommodations in this course are encouraged to contact the Academic Support Center in Memorial Library (706.233.4080) as soon as possible to ensure that such accommodations are implemented in a timely fashion.

How I Will Determine Your Grade Your grade will be based upon the following criteria, weighted as indicated:

Tests 45 % (3 weighted equally)

Essays 15 % (3 weighted equally)

Homework 20 %

Reading Quizzes 10 %

Activities and Labs 10 %

You should expect to receive an "A" for a grade in the range 90-100, a "B" for a grade in the range 80-89, etc. I will determine pluses and minuses at the end of the semester by examining the distribution of grades.

Tests The first two tests will be given during lab periods, the third during the final exam period. The tests will cover material in the assigned readings, classroom and lab activities, and homework assignments. The tests will be designed to assess your understanding of scientific inquiry as illustrated by the material discussed in class, as well as your understanding of the concepts and arguments (including mathematical arguments and calculations) that played an important role in the development of this material. The tests will consist of short essay questions, multiple choice questions, and short-answer questions which may involve mathematical calculations.

Essays The essay assignments will be given a few days prior to each test and will be due about one week after the test (except for the final test). Each essay will be about 2 pages (double-spaced) in length. Essays must be written entirely on your own. Essays will focus on the historical development of the astronomical concepts discussed in the course, including cultural and technological factors that influenced that development.

Homework You must complete your homework on your own. You can discuss homework questions with other students (and with the instructor) but you cannot copy answers from someone else. Homework will be graded for correctness, with each problem/question receiving a score ranging from 0 (no answer or a meaningless answer) to 4 (correct answer).

Activities and Labs Each activity or lab is due at the end of the class period, or at the beginning of the next class period. Each student should turn in their copy of the activity worksheet. Activities and labs will be graded for completion, with each group member receiving a score of 0 (for members who did not participate in the activity), 1 (for members who participated in only a portion of the activity), or 2 (for members who participated in the entire activity).

Night Labs Night labs are tentatively scheduled for the nights of January 15 at 8 PM and Apr 20 at 10 PM. We will meet at the outdoor classrooms behind McAllister Hall, then carpool out to the observatory. Both nights we will do a tour of the constellations, as well as view some particular objects. In January we should see Jupiter, the Crab Nebula, the Orion Nebula, and the Andromeda Nebula (and maybe a comet!). In April we will see Jupiter (again), Saturn, a planetary nebula, and a globular cluster. You are required to attend both of these night labs, but if you have to miss one you can make it up by attending a Star Party. There will also be an opportunity at some point during the semester to observe sunspots (during the day in front of Krannert).

Course Schedule A tentative schedule of topics for the course is given below.

AST 121 Tentative Schedule			
Date	**Topic**	**Quiz**	**HW Due**
1/13	Introduction		
1/15	The Game of Science	Ch. 1	Syllabus
1/16	The Night Sky	App. A, 2.1	HW 0
1/20	Distance and Parallax	2.2, App. B	
1/22	Cosmos: Greece to Copernicus	2.3, 2.4	
1/23	Copernicus' Revolutions and the Stars	3.1, 3.2	HW 0 C
1/27	Universe: Finite or Infinite?	3.3	HW 1
1/29	Photometric Distances	3.4, App. C	
1/30	Uniformity of the Stars	3.5, 3.6	HW 2
2/3	Stellar Motions	4.1	
2/5	Dark Sky Riddle	4.2	HW 3
2/6	Models of the Universe	4.3-4.6	
2/10	Motion of the Sun	5.1-5.3	HW 4
2/12	Construction of the Heavens	5.4-5.7	
2/13	The Nebulae	6.1-6.4	HW 5
2/17	Spectroscopy	6.5	
2/19	Olber's Paradox	6.6-6.8	
2/20	**Test 1: Ch. 1-5**		
2/24	Photometry and Photography	7.1	
2/26	Radial Velocity and Binary Stars	7.2	HW 6
2/27	Spectral Classification	7.3.1	
3/3	The H-R Diagram	7.3.2	
3/5	Stellar Evolution	7.3.3-7.4	
3/6	Star Streams	8.1-8.3	HW 7
3/17	Kapteyn Universe	8.4-8.5	
3/19	Spiral Nebulae I	9.1-9.4	HW 8
3/20	Spiral Nebulae II	9.5-9.7	
3/24	Cepheid Variables	10.1	HW 9
3/26	The Big Galaxy	10.2-10.4	
3/27	**Test 2: Ch. 1-9**		
3/31	The Great Debate	Ch. 11	HW 10
4/2	Cepheids in Spirals	Ch. 12	HW 11
4/7	Galactic Rotation	13.1	
4/9	Absorption	13.2-13.4	HW 12
4/10	Relativity	14.1	
4/16	Relativistic Cosmology	14.2	HW 13
4/17	Expanding Universe	14.3-15.1	
4/21	Stellar Populations	15.2-15.5	HW 14
4/23	Spiral Structure	16.1-16.2	
4/24	The Big Bang	16.3-16.4	
4/28	The Modern View	Epilogue	HW 15/16
5/1	**Test 3: Ch. 1-16**		