Physical Sciences

Core courses in the Physical Sciences benefit from a rich tradition of scientific discovery at the University of Chicago. The late University of Chicago professor and Nobel laureate Subrahmanyan Chandrasekhar, who predicted the existence of black holes based on theoretical considerations, described well the importance of science in our lives when he said, "Science is a perception of the world around us. Science is a place where what you find in nature pleases you."

Under the designation PHSC, the Physical Sciences Collegiate Division offers several sequences of courses from **Astronomy and Astrophysics**, **Chemistry**, **Geophysical Sciences**, **Molecular Engineering**, and **Physics**, tailored to provide an interesting and useful education for non-scientists in their goal of satisfying their Physical Sciences Core requirement. The goal of general education in the physical sciences is to engender the student's ability to understand and assess our knowledge of the physical world. One can argue that the fundamental tenet of liberal education at the University of Chicago is to cultivate an appreciation for critical inquiry and the basis for judgement. The physical sciences contribute to this mission in teaching the principles of experimentation, observation, and scientific inquiry. Chemistry and physics are advanced through laboratory experiments that study the structure of nature and build models which we extrapolate from those observations. Astronomy and geophysical sciences develop methods to make inferences about the world around us based on observations which cannot always be recreated in a laboratory.

Students are required to take an approved two- or three-course sequence in the physical sciences to satisfy the Core requirement. This requirement may be met by taking an introductory sequence in Chemistry, Geosciences, or Physics, or by taking any acceptable pairing of Physical Sciences (PHSC) courses, which generally have a broader focus than the disciplinary sequences. Students are encouraged to complete the Physical Sciences Core requirements in their first two years.

Students who seek to deviate from the combinations identified here must submit a petition (https://college.uchicago.edu/sites/default/files/documents/College%20Dean%20of%20Students/General%20Petition%20Form.pdf) to the Master of the Physical Sciences Collegiate Division. Email the completed petition to the College Academic Advising office at collegeadvising@uchicago.edu, (collegeadvising@uchicago.edu) addressed to Scott Snyder, PSCD Master.

Core Sequences for Science Majors

The following introductory sequences may be used to satisfy the Core requirement in the physical sciences for all students, although these tend to be taken by science majors or by students who have a particular need for science (namely, premeds). The sequences are:

CHEM 10100 & CHEM 10200	Introductory General Chemistry I and Introductory General Chemistry II [#]	200
CHEM 11100-11200	Comprehensive General Chemistry I-II [*#]	200
CHEM 12100 & CHEM 12200	Honors General Chemistry I and Honors General Chemistry II [#]	200
GEOS 13100 & GEOS 13200	Physical Geology and Earth History	200
PHYS 12100-12200	General Physics I-II [**]	200
PHYS 13100-13200	Mechanics; Electricity and Magnetism	200
PHYS 14100-14200	Honors Mechanics; Honors Electricity and Magnetism [*]	200

[*]For information, see the Placement Tests (http://collegecatalog.uchicago.edu/thecollege/examinationcreditandtransfercredit/) and Advanced Placement Credit (http://collegecatalog.uchicago.edu/thecollege/examinationcreditandtransfercredit/) sections elsewhere in this catalog.

[**]PHYS 12100 has the prerequisite of CHEM 11300.

[#]Students who have credit for CHEM 10100, 11100, or 12100 (either by taking the course or by AP credit) and do not wish to progress in the CHEM sequences above may satisfy the Core requirement with any of the following courses offered by the Department of Chemistry:

PHSC 12200 The Chemistry of Food and Cooking

PHSC 12400 The Chemistry of Big Problems

PHSC 12500 Molecular Mechanisms of Human Disease

PHSC 12900 The Chemistry of Artists' Materials

PHSC 13000 Exploring the Organic Chemistry of Medicinal Plants: From Field to Laboratory

Core Sequences for Non-Science Majors

There are several sequences in the physical sciences, each of which introduces a different discipline and different aspects of scientific knowledge. Physical Sciences (PHSC) courses fall mainly into five general categories that we might conveniently label as "**Physics**," "**Astronomy and Astrophysics**," "**Geosciences**," "**Molecular Engineering**," and "**Chemistry**." As a general rule, courses from two different categories may not be combined as a sequence unless otherwise specified below. It is strongly recommended that Core requirements be completed in the first two years. Some PHSC courses may restrict registration for students beyond the second year.

Physics

The PHSC courses and approved sequences in the **Physics** category are listed below. Other sequences are not permitted*.

PHSC 11600 & PHSC 11700	Physics for Future Presidents: Fundamental Concepts and Applications and Physics for Future Presidents: Energy and Sustainability	200
or PHSC 11800	Physics and Contemporary Architecture	
PHSC 11700 & PHSC 11800	Physics for Future Presidents: Energy and Sustainability and Physics and Contemporary Architecture	200
PHSC 11800 & PHSC 12600	Physics and Contemporary Architecture and Matter, Energy, Space, and Time	200
or PHSC 13400/13410	Global Warming: Understanding the Forecast	

* Students wishing to take a three-quarter Physical Sciences sequence may combine PHSC 11600-PHSC 11700 with any other Physical Sciences Core course.

Chemistry

Sequences of PHSC courses with a focus on **Chemistry** are listed below. The courses in these sequences can be taken in any order.

PHSC 12200 & PHSC 11600	The Chemistry of Food and Cooking and Physics for Future Presidents: Fundamental Concepts and Applications	200
or PHSC 11700	Physics for Future Presidents: Energy and Sustainability	
or PHSC 12400	The Chemistry of Big Problems	
or PHSC 12500	Molecular Mechanisms of Human Disease	
or PHSC 12900	The Chemistry of Artists' Materials	
or PHSC 13000	Exploring the Organic Chemistry of Medicinal Plants: From Field to Laboratory	
or PHSC 13400	Global Warming: Understanding the Forecast	
or PHSC 13410	Global Warming: Understanding the Forecast (Flipped Class)	
or PHSC 13600	Natural Hazards	
PHSC 12400 & PHSC 12500	The Chemistry of Big Problems and Molecular Mechanisms of Human Disease	200
or PHSC 12900	The Chemistry of Artists' Materials	
or PHSC 13000	Exploring the Organic Chemistry of Medicinal Plants: From Field to Laboratory	
PHSC 12500 & PHSC 12900	Molecular Mechanisms of Human Disease and The Chemistry of Artists' Materials	100
or PHSC 13000	Exploring the Organic Chemistry of Medicinal Plants: From Field to Laboratory	

Molecular Engineering

The PHSC courses in the **Molecular Engineering** category introduce students to the novel strategies and tools used by engineers to tackle modern challenges in human health, energy and sustainability, and materials science. The options below can be taken in any order. Courses may **not** be paired with those from other sequences to satisfy the Core requirement.

Two of the following:		200
PHSC 15100	Machine Learning and Artificial Intelligence for Molecular Discovery and Engineering	
PHSC 15200	Engineering for Human Health	

Note on Sequence in Molecular Engineering:

Students who have declared the major or minor in Molecular Engineering and are not taking courses to satisfy the Physical Sciences Core requirement are encouraged to enroll in the equivalent MENG-coded course.

Geophysical Sciences

The PHSC courses and approved sequences in the **Geosciences** category are listed below. The courses in these sequences can be taken in any order. *Under no circumstances may a student receive credit for both PHSC 10100 and PHSC 10800, or PHSC 13400 and PHSC 13410.*

PHSC 10100 & PHSC 11000	Origin and Evolution of the Solar System and the Earth and Environmental History of the Earth	200
or PHSC 11900	Getting Something for Nothing	
or PHSC 13400	Global Warming: Understanding the Forecast	
or PHSC 13410	Global Warming: Understanding the Forecast (Flipped Class)	
PHSC 10800 & PHSC 11000	Earth as a Planet: Exploring Our Place in the Universe and Environmental History of the Earth	200
or PHSC 11900	Getting Something for Nothing	
or PHSC 13400	Global Warming: Understanding the Forecast	
or PHSC 13410	Global Warming: Understanding the Forecast (Flipped Class)	
or PHSC 13600	Natural Hazards	
PHSC 11000 & PHSC 11900	Environmental History of the Earth and Getting Something for Nothing	200
or PHSC 13400	Global Warming: Understanding the Forecast	
or PHSC 13410	Global Warming: Understanding the Forecast (Flipped Class)	
or PHSC 13600	Natural Hazards	
PHSC 11900 & PHSC 13600	Getting Something for Nothing and Natural Hazards	200
or PHSC 13400	Global Warming: Understanding the Forecast	
or PHSC 13410	Global Warming: Understanding the Forecast (Flipped Class)	
PHSC 13600 & PHSC 13400	Natural Hazards and Global Warming: Understanding the Forecast	200
or PHSC 13410	Global Warming: Understanding the Forecast (Flipped Class)	

Astronomy and Astrophysics

The on-campus PHSC courses in the **Astronomy and Astrophysics** category include two logical progressions: one that applies physical principles based on terrestrial experiments to the cosmos at large, and one that concerns observed properties of important classes of astronomical objects.

PHSC 12600 & PHSC 12610	Matter, Energy, Space, and Time and Black Holes	200
or PHSC 12620	The Big Bang	
PHSC 12700 & PHSC 12710	Stars and Galaxies	200
or PHSC 12720	Exoplanets	

Students can build two- or three-quarter sequences most naturally from the two progressions above, but they may also mix the two in the following ways:

PHSC 12600 & PHSC 12710	Matter, Energy, Space, and Time and Galaxies	200
(galaxies are an example of structure that evolved from early conditions)		
PHSC 12700 & PHSC 12610	Stars and Black Holes	200
(black holes are an end state of stellar evolution)		
PHSC 12600 & PHSC 12700	Matter, Energy, Space, and Time and Stars	200

Students may also pair certain **Geosciences** and **Astronomy and Astrophysics** courses in approved sequences:

PHSC 10800 & PHSC 12710	Earth as a Planet: Exploring Our Place in the Universe and Galaxies	200
or PHSC 12720	Exoplanets	
or for students who wish to begin a sequence in Winter Quarter:		

PHSC 10100 & PHSC 12720	Origin and Evolution of the Solar System and the Earth and Exoplanets	200
PHSC 12710 & PHSC 12720	Galaxies and Exoplanets	200

Three-quarter sequences may be created by adding any Astro course numbered in the 12000s to an approved sequence also numbered in the 12000s. PHSC 10800 + PHSC 12710 + PHSC 12720 is the only three-quarter sequence possible for approved sequences numbered in the 10000s. Astronomy and Astrophysics courses numbered in the 18000s are **electives** and may **only** be applied to Core requirements in three-course sequences, combined with any approved two-quarter sequence above (including those in other categories).

Note on Approved Sequences in Astronomy and Astrophysics:

Students who have declared the minor in Astronomy and Astrophysics and are taking courses to complete that program are not required to follow the sequencing guidelines of the Core. Students who are not taking courses to satisfy the Physical Sciences Core requirement are encouraged to enroll in the equivalent ASTR-coded course.

General Education Courses

PHSC 10100. Origin and Evolution of the Solar System and the Earth. 100 Units.
This course examines the physical and chemical origins of planetary systems, the role of meteorite studies in this context, and a comparison of the Earth with neighboring planets. It then turns to chemical and physical processes that lead to internal differentiation of the Earth. Further topics include the thermal balance at the Earth's surface (glaciation and the greenhouse effect), and the role of liquid water in controlling crustal geology and evolution. (L) Note: This course includes a lab section, but the labs can be done at home at any time with no need for specialized equipment.
Instructor(s): A. Davis Terms Offered: Winter
Note(s): Under no circumstances may a student receive credit for both PHSC 10100 and PHSC 10800.

PHSC 10800. Earth as a Planet: Exploring Our Place in the Universe. 100 Units.
This course explores the diversity of bodies in our Solar System, and the physical and chemical processes that have shaped them over their histories. We will also discuss how these studies have carried us away from an Earth-centered view of the universe to one where Earth is just one of billions of planets that exist in our galaxy. Topics to be covered include: early observations of the Solar System and the laws of planetary motion, the formation and evolution of the Moon, the structure and geophysical evolution of the planets, and the search for habitable environments outside of Earth.
Instructor(s): F. Ciesla Terms Offered: Not offered in 2024-25
Note(s): Under no circumstances may a student receive credit for both PHSC 10100 and PHSC 10800.

PHSC 11000. Environmental History of the Earth. 100 Units.
This course considers how physical and biological processes determine environmental conditions at the surface of the Earth. The Spring Quarter version stresses how environments and life have changed over the 4.5 billion-year history of Earth (Webster). Topics include the methods of historical inference in geology; major transitions in the history of life, including the origin of life, the evolution of oxygen-producing photosynthesis, the origin of animals, and the series of massive extinctions that have repeatedly re-set ecosystems both on land and in the sea; and ecosystem evolution, including the environmental effects of human evolution. The Autumn Quarter version covers the same methodological ground but places greater stress on evaluating environmental and ecological changes within our present-day, increasingly human-dominated Anthropocene (Kidwell). In both versions, labs involve hands-on study of rock and fossil specimens, and analysis and interpretation of datasets drawn from the scientific literature and/or faculty research programs.
Instructor(s): M. Webster; S. Kidwell Terms Offered: Autumn Spring
Note(s): Due to significant overlap of course content, students may register for only one of PHSC 11000, BIOS 12117, or GEOS 13900/BIOS 13123

PHSC 11600. Physics for Future Presidents: Fundamental Concepts and Applications. 100 Units.
This algebra-based course presents an introduction to many of the foundational concepts of physics with applications to modern society. These concepts include energy and power, heat, sound, gravity, electromagnetism and light, nuclear physics and radioactivity, and Newton's laws.
Terms Offered: Autumn
Prerequisite(s): none

PHSC 11700. Physics for Future Presidents: Energy and Sustainability. 100 Units.
This course treats both the past and future of how the principles that govern the conversion of energy to useful work have impacted and will impact civilization. The principles of kinetic, potential, thermal, mechanical, and nuclear energies will be considered in the contexts of societal issues such as energy sustainability, modern technologies, war, information, food, and health.
Instructor(s): Peter Littlewood Terms Offered: Winter
Prerequisite(s): none

Note(s): PHSC 11600-11700 is an approved two-quarter sequence which will satisfy the general education requirement in the physical sciences.

PHSC 11800. Physics and Contemporary Architecture. 100 Units.
Architectural structures form the built environment around us and in many ways create the backbone of our civilization. They push the limits of form and function on the largest human scales, often leading to iconic masterpieces that symbolize the aesthetics as well as the technical achievements of a period. Many architectural advances have been made possible by breakthroughs in the science of materials, which then led to innovation in construction and fabrication techniques. This course will introduce the physics principles that have enabled some of the most innovative architecture of our time. This course will take key ideas and tools from physics and demonstrate their power and relevance in a broader context familiar from everyday experience. The course will challenge students to recognize physics concepts in the built structures that make up the urban environment we live in. Chicago is a most appropriate place for this study; it was the birthplace of the first skyscraper, and ever since it has played an internationally celebrated role in pushing the limits of the architectural state of the art. A long succession of renowned Chicago architects and structural engineers has turned this city into a premier laboratory for architectural innovation. Against this backdrop, the course will show how science, and physics in particular, delivers the conceptual foundations that drive current directions in architecture and open up new opportunities.
Instructor(s): Heinrich M. Jaeger; Sidney Nagel Terms Offered: Spring
Prerequisite(s): Some exposure to high-school physics is recommended
Note(s): The course will consist of two lectures per week plus a weekly hands-on workshop (lab) component. The Monday lectures will introduce the physics principles to be explored that week. The Thursday lectures will be delivered by distinguished guest speakers, including renowned architects and engineers. These lectures will be public lectures. They will relate to the physics principle introduced that Monday and explore its ramification within the broader context of contemporary architectural practice. The Thursday afternoon workshop component will involve team-based, hands-on construction projects to develop a better understanding and intuition of the physics principles introduced in the lectures and to obtain a sense of their real-life implications. The workshops will also provide an opportunity to interact with the guest lecturers. Attendance at Thursday lectures is required. This course meets the general education requirement in the physical sciences and may be paired with PHSC 11600, 11700, 12600, or 13400 in order to complete the requirement. This course can be taken for credit towards either the general education requirement in the physical sciences or the Architectural Studies minor, but not both. Students intending to receive physical sciences general education credit should register for PHSC 11800; students intending to receive credit towards the Architectural Studies Minor should register for ARCH 11800.
Equivalent Course(s): CHST 11800, ARCH 11800

PHSC 11900. Getting Something for Nothing. 100 Units.
We can learn an incredible amount about the physical world with simple tools of estimation. So-called Fermi problems involve estimating quantities of interest to within an order of magnitude, or factor of 10, on the "back of an envelope." There are leanable techniques that we can use to approach these problems. Developing these skills is incredibly useful for physical scientists because it allows us to quickly estimate whether an idea is worth pursuing with expensive resources and time. More generally, order-of-magnitude estimation can keep you from getting fooled by journalists and politicians, or give you a trading edge in a competitive market. Finally, Fermi problems are common in interviews for jobs in finance, consulting, and software. Students in this course will develop techniques to quickly estimate physical science quantities to within an order of magnitude.
Instructor(s): D. Abbot Terms Offered: Spring. This course will first be offered in Spring 2024.
Note(s): Physical Science Course Pairings (to complete the general education requirements): 1. PHSC 10100. Origin and Evolution of the Solar System and the Earth. 2. PHSC 10800. Earth as a Planet: Exploring Our Place in the Universe. 3. PHSC 11000. Environmental History of the Earth. 4. PHSC 13400. Global Warming: Understanding the Forecast. 5. PHSC 13410. Global Warming: Understanding the Forecast (Flipped Class) 6. PHSC 13600. Natural Hazards.
Equivalent Course(s): GEOS 25600

PHSC 12200. The Chemistry of Food and Cooking. 100 Units.
The goals of this course are for students to understand the everyday chemistry involved in food and cooking, gain science literacy, and critically evaluate food marketing. The first part of the course will explore the basics of food chemistry, establishing how the structure and properties of water, fats, proteins, and other macromolecules influence our eating and cooking experiences. We will also investigate the chemical components that contribute to color, flavor, and aroma in food. The rest of the course will examine consumer issues related to food science. What do the food labels organic, all-natural, and non-GMO actually mean from a chemistry perspective? What is the science involved in the plant-based meat industry? How can we use chemistry to be a more thoughtful consumer of food? Additional topics will be driven by student interest. The course will include a both a lecture and laboratory component. The laboratory sessions will involve case studies and application of lecture topics in a collaborative environment. Course assignments will include readings, class discussions, written papers, and a final presentation.
Instructor(s): Shaunna McLeod Terms Offered: Spring
Prerequisite(s): Some previous background in Chemistry is recommended
Note(s): In order to complete the Physical Sciences Core Requirement, this course may be paired with: PHSC 11600, PHSC 11700, PHSC 12400, PHSC 12500, PHSC13400, PHSC 13600

Equivalent Course(s): CHEM 12600

PHSC 12400. The Chemistry of Big Problems. 100 Units.
This course will discuss the chemistry of big problems that impact human life and society, such as the future accessibility of personal genetic sequence information, genetically modified organisms, or plastics and polymers and alternative sources of energy. We will use each of these topics as a window to grasp the underlying chemistry, reaction mechanisms, analytical methods, and quantitative chemical principles applied to major scientific issues that impact the world around us. Relevant examples will be considered in a discussion-oriented format to bring out chemical and analytical principles associated with big problems. The course will have a classroom lecture component as well as a laboratory component. The laboratory component will involve case studies and problem solving by application of analytical principles and independent work or teams of students. (L)
Instructor(s): Tian, B. Terms Offered: Autumn
Prerequisite(s): Some previous background in Chemistry is recommended.
Note(s): Note(s): In order to satisfy the general education requirements in the physical sciences PHSC 12400 may be combined with PHSC 12300 Chemistry for an Alternative Energy Source or PHSC 12500 Molecular Mechanisms of Human Disease. If a student does not wish to continue with CHEM 10100 Introductory General Chemistry, CHEM 11100 Comprehensive General Chemistry, or CHEM 12100 Honors General Chemistry sequence, they may take PHSC 12400 as the second course.,
Equivalent Course(s): CHEM 12400

PHSC 12500. Molecular Mechanisms of Human Disease. 100 Units.
This course will examine the molecular basis for a few specific instances of human disease. We will use each of these molecular case studies as a vehicle to demonstrate quantitative chemical principles such as thermodynamics, chemical equilibrium, chemical kinetics, diffusive dynamics, and DNA damage and repair. The goal of the course will be to use well-understood biological and medical examples to illustrate chemical principles and to give students a toolbox and techniques to understand molecular systems more broadly. The course will have a classroom lecture component as well as a laboratory component. The laboratory component will involve specific case studies and mechanistic proposals that represent exploratory independent work by teams of students. (L)
Instructor(s): G. Engel Terms Offered: Spring
Prerequisite(s): Some previous background in Chemistry recommended
Note(s): Note(s): In order to satisfy the general education requirements in the physical sciences PHSC 12500 may be combined with PHSC 123 Chemistry for an Alternative Energy Source or PHSC 12400 The Chemistry of Big Problems, If a student does not wish to continue with CHEM 10100 Introductory General Chemistry, CHEM 11100 Comprehensive General Chemistry, or CHEM 12100 Honors General Chemistry sequence, they may take PHSC 12500 as the second course.
Equivalent Course(s): CHEM 12500

PHSC 12600. Matter, Energy, Space, and Time. 100 Units.
A comprehensive survey of how the physical world works, and how matter, energy, space, and time evolved from the beginning to the present. A brief survey of the historical development of mathematics, physics, and astronomy leads to a conceptual survey of the modern theory of the physical universe: space and time in relativity; the quantum theory of matter and energy; and the evolution of cosmic structure and composition. The major theme of this course is the understanding of all nature, from the prosaic to the exotic, using powerful quantitative theory grounded in precise experiments. Although quantitative analysis will be an important part of the course, students will not be expected to employ mathematics beyond algebra. (L)
Instructor(s): Derek Buzasi Terms Offered: Autumn Spring. Available in Astronomy Paris Program in Spring 2026.
Equivalent Course(s): ASTR 12600

PHSC 12610. Black Holes. 100 Units.
The past decade has seen the stunning discovery of gravitational waves from black holes merging together, allowing physical theory to be tested in the most exotic and extreme environment in the universe. Black holes are mathematically the most perfectly understood of any physical structure, but their visible effects can be extraordinarily complex. This course will survey the physics of space and time; the nature of black holes, neutron stars, and white dwarf stars; their effects on surrounding matter and light; the astrophysical contexts in which they are observed; and frontier areas of research. The development of Albert Einstein's theory of General Relativity will be placed in historical context, including a review of observational confirmation of predictions of the theory. Experimental work will include use of a robotic telescope to observe circumstances related to extreme gravity, such as supernovae and the centers of giant galaxies that harbor super-massive black holes. Quantitative analysis will be an important part of the course, but mathematics beyond algebra will not be required. (L)
Instructor(s): Fausto Cattaneo (Summer Quarter); Derek Buzasi and Paolo Privitera (Winter Quarter) Terms Offered: Summer Winter
Prerequisite(s): PHSC 12600 or PHSC 12700
Equivalent Course(s): ASTR 12610

PHSC 12620. The Big Bang. 100 Units.
The Big Bang model describes the Universe on the largest scales and its evolution from the earliest observationally accessible times through the formation of the complex world we live in today. This powerful framework allows us to interpret a wide range of observations and to make detailed and precise predictions for new experiments. The key motivating observations include the expansion of the Universe and how it has changed with time; the existence of radiation indicating a hot and dense early phase; the abundance of the light elements; and how matter is organized over a wide range of physical scales. The model naturally incorporates dark matter and dark energy, two surprising and poorly understood components that govern the growth of structure over time. The course will explore the history of scientific cosmology and the evidence for the Big Bang model, its consequences for the earliest moments after the Big Bang, and its predictions for the eventual fate of the Universe. Labs will include a hands-on measurement of the relic cosmic microwave background radiation from the early universe and the use of astronomical data to verify key discoveries in the history of Big Bang cosmology. Quantitative analysis will be an important part of the course, but prior experience with mathematics beyond algebra will not be required. (L)
Instructor(s): Jamie Law-Smith Terms Offered: Spring. Available on campus and in Astronomy Paris Program in Spring 2026.
Prerequisite(s): Must have ASTR/PHSC 12600 Matter, Energy, Space and Time as the pre-requisite for ASTR/PHSC The Big Bang.
Equivalent Course(s): ASTR 12620

PHSC 12700. Stars. 100 Units.
Elements such as carbon and oxygen are created in fusion reactions at high temperatures and pressures in the deep interiors of stars, conditions that naturally arise in stars like the Sun. This course will outline the physical principles at work and the history of the development of the key ideas: how nuclear physics and the theory of stellar interiors account for how stars shine, why they live for such long times, and how the heavy elements in their cores are dispersed to form a new generation of stars. Gravity assembles stars out of more diffuse material, a process that includes the formation of planetary systems. The course shows how, taken together, these physical processes naturally lead to the ingredients necessary for the emergence of life, namely elements like carbon, nitrogen, and oxygen, and planets in stable orbits around long-lived stars. The course features quantitative analysis of data; any tools needed beyond pre-calculus algebra will be taught as part of the course. (L)
Instructor(s): Fausto Cattaneo (Summer Quarter); Damiano Caprioli (Autumn Quarter) Terms Offered: Autumn Summer
Equivalent Course(s): ASTR 12700

PHSC 12710. Galaxies. 100 Units.
Galaxies have been called island universes, places where stars are concentrated, where they are born, and where they die. The study of galaxies reaches back to the Renaissance; Galileo Galilei first pointed a telescope skyward in 1610 and confirmed a then 2000 year-old Greek conjecture about the nature of our own galaxy -- the Milky Way. This course will use extensive modern observational data from a wide range of telescopes to trace the modern picture for the formation and evolution of galaxies and the stars in them. Galaxies will then be used as markers of yet larger scale structures, in order to explore the influence of gravity over cosmic time. The object of study in this course is galaxies, and the narrative arc traced through that extensive data and understanding will highlight our profound discovery that most of the mass in galaxies (and the Universe as a whole) is in fact an exotic form of matter -- dark matter -- that we cannot directly see. Quantitative analysis will be an important part of the course in both laboratory work and lectures, but mathematics beyond algebra and some geometric understanding will not be required. This course will feature several observationally-oriented labs that will allow students to directly experience how some of the modern understanding of galaxies has arisen. (L)
Instructor(s): Hsiao-Wen Chen Terms Offered: Winter
Prerequisite(s): PHSC 10800, PHSC 12600 or PHSC 12700. PHSC 12710 can be taken as the first course in a sequence combined with PHSC 12720.
Equivalent Course(s): ASTR 12710

PHSC 12720. Exoplanets. 100 Units.
The discovery of planets in orbit around other stars is one of the newest developments in astronomy, which set off a race to characterize these "exoplanetary" systems. The architectures of planetary systems are set by the formation of the parent star and its protoplanetary disk, but they also encode subsequent evolution. We are now able to place our Solar System into the context of other worlds, and we find some aspects familiar and other aspects quite alien. A challenging next step is to find planets like the Earth in orbit around stars like the Sun. This course will review the techniques for discovery of planets around other stars, what we have learned so far about exoplanetary systems, and the driving questions for the future, including the quest for habitable environments elsewhere. Although quantitative analysis will be an important part of the course, students will not be expected to employ mathematics beyond algebra. (L)
Instructor(s): Derek Buzasi (Summer Quarter); Leslie Rogers and Daniel Fabrycky (Spring Quarter) Terms Offered: Spring Summer
Prerequisite(s): PHSC 10800, PHSC 10100, PHSC 12700 or PHSC 12710.
Equivalent Course(s): ASTR 12720

PHSC 12900. The Chemistry of Artists' Materials. 100 Units.
The goal of this course is to understand the fundamentals of molecular structure as applied to dyes, pigments, and other materials used in art and crafts. Students will gain general scientific literacy skills and engage with fundamental laboratory techniques in an inherently interdisciplinary way. The first part of the course will delve into molecular structure of organic dyes and inorganic pigments as well as principles behind how visible light interacts with these compounds to produce the colors we see. The fundamental set of techniques used to probe and explore these processes is called spectroscopy; these techniques will play a large role in the laboratory component. Throughout the rest of the course, a number of case studies of these principles will be investigated, including natural v. synthetic dyes and historical dye extraction processes, conservation and restoration of fine art, pigments and materials used in pottery, and the chemistry of stained glass. Additional topics will be driven by student interest. Course assignments will include readings, class discussions, homework sets, lab reports, and a final written pape
Instructor(s): Lant, Hannah Terms Offered: Autumn
Note(s): PHSC 12200 The Chemistry of Food and Cooking PHSC 12400 The Chemistry of Big Problems, and PHSC 12500 Molecular Mechanisms of Human Disease. Students who have credit for CHEM 10100, 11100, or 12100 by either taking the course or by AP credit (for CHEM 11100) and do not wish to take CHEM 10200, 11200, or 12200 may complete the general education requirement with any of the PHSC courses offered by the Department of Chemistry.
Equivalent Course(s): CHEM 12900

PHSC 13000. Exploring the Organic Chemistry of Medicinal Plants: From Field to Laboratory. 100 Units.
This course is designed to provide students with a unique and hands-on experience that combines ecology, ethnobotany, and organic chemistry, offering a comprehensive exploration of medicinal plants. Students will have the opportunity to visit Schulenberg Prairie at the Morton Arboretum to explore indigenous and folkloric medicinal plants, identify their medicinal properties, and then delve into the chemical structures that make these plants effective. The course will culminate in a lab component where students will utilize the knowledge gained to create their own herbal salve/balm, with a strong focus on the organic chemistry involved. The course will emphasize an exploration of the chemical basis of medicinal plants along with the significance of ecological restoration and sustainability in traditional medicinal plant harvesting and utilization.
Terms Offered: Summer
Equivalent Course(s): CHEM 13000

PHSC 13400. Global Warming: Understanding the Forecast. 100 Units.
The future of human civilization depends on its ability to avoid, or adapt to, climate change associated with fossil-fuel (carbon) emissions. With so much at stake, it is important that citizens of the world understand the science which forms the foundation of what is understood about global climate change. The learning objectives of this course are to develop understanding of: (1) the historical and pre-historical records of global climate change, (2) the Earth's carbon budget, (3) how the greenhouse effect determines temperature in Earth's atmosphere and at the land and sea surface, (4) how climate projections are made, and (5) how present-day activities, both in the scientific research realm and in the socio-economic/political realm are shaping what will happen in the future. Course activity is partitioned into lectures (given by the course instructor), weekly laboratory-section activity (run by graduate teaching assistants), outside reading, and occasional homework. Assessment leading to a course grade will focus primarily on student performance in completing laboratory exercises and on a midterm and final exam. (L)
Instructor(s): D. MacAyeal Terms Offered: Autumn
Equivalent Course(s): ENSC 13400, GEOS 13400

PHSC 13410. Global Warming: Understanding the Forecast (Flipped Class) 100 Units.
This course presents the science behind the forecast of global warming to enable the student to evaluate the likelihood and potential severity of anthropogenic climate change in the coming centuries. It includes an overview of the physics of the greenhouse effect, including comparisons with Venus and Mars; predictions and reliability of climate model forecasts of the greenhouse world. This course is part of the College Course Cluster program, Climate Change, Culture, and Society. This course covers the same material as PHSC 13400, but is organized using a flipped classroom approach in order to increase student engagement and learning.
Instructor(s): D. Abbot Terms Offered: Autumn Spring
Prerequisite(s): Some knowledge of chemistry or physics helpful.
Equivalent Course(s): ENSC 13410, GEOS 13410

PHSC 13600. Natural Hazards. 100 Units.
This course presents the current understanding of high-impact weather and geologic events and an introduction to risk assessment and mitigation. Topics include an overview of geography, statistics, and societal impacts of the world's natural hazards; physics and forecasts of hurricanes, extratropical cyclones, tornadoes, earthquakes, tsunamis, volcanic eruptions, droughts, floods and wildfires; climate change and extreme weather events; quantifying and managing risks. (L)
Instructor(s): N. Nakamura Terms Offered: Winter

PHSC 15100. Machine Learning and Artificial Intelligence for Molecular Discovery and Engineering. 100 Units.
The foundations of artificial intelligence can be dated back to Alan Turing's seminal 1950 paper in which the concept of "thinking machines" was first introduced and the 1956 Dartmouth Summer Conference in which the term artificial intelligence was first coined. The field has since passed through multiple epochs of development, and today artificial intelligence and machine learning are ubiquitous and enabling tools that pervade all corners of engineering discovery and practice. This course will survey the conceptual and historical basis of artificial intelligence and machine learning; the role, integration, and ethics of these approaches in modern engineering practice; the mathematical and algorithmic underpinnings of some popular machine learning techniques; and selected applications of these tools in particular applications in molecular engineering drawn from areas such as energy and sustainability, drug discovery, quantum science and information, materials science, and bioengineering.
Instructor(s): Andrew Ferguson Terms Offered: Autumn
Prerequisite(s): Quantitative analysis and numerical calculations will be an important part of the course, but mathematics beyond algebra will not be required and any necessary mathematics will be reviewed as part of the course.
Equivalent Course(s): MENG 15100

PHSC 15200. Engineering for Human Health. 100 Units.
This course is designed to introduce undergraduates to the types of clinical problems that engineers solve and the physical concepts they apply to solve them. Various types of devices - from genetically engineered bacteria to biosensors - will be discussed, and we will explore the physics and chemistry necessary to understand and design each of these devices. We will also discuss many of the more practical concerns that influence the development of therapies, including intellectual property, regulation, and clinical trial design. In addition, students will learn how to work effectively in groups and to communicate their findings in a professional manner.
Instructor(s): Terry Johnson Terms Offered: Winter
Equivalent Course(s): MENG 15200

Elective Courses

Courses numbered 18xxx can be used only as a third course in physical sciences to meet the Core requirement (of six courses total in the biological, physical, and mathematical sciences). Courses numbered 2xxxx do not satisfy the Core.

PHSC 18000. The Search for Extraterrestrial Life. 100 Units.
The origin of life is one of the biggest questions of modern science. While substantial progress has been made in understanding how life arose on our planet, such research represents just a single case study in how life originates and evolves. This course covers the search for life beyond Earth from the planets and moons of the Solar System to planets orbiting other stars and intelligent life that may have left its mark on macroscopic scales. The discovery of life beyond Earth would be transformative for our understanding of humanity's place in the universe. A range of ongoing and planned experiments have the potential to detect or put strong constraints on the existence of life during the next few decades. This class will mix traditional lectures with flipped classroom problem-solving sessions.
Instructor(s): Jacob Bean Terms Offered: Spring
Note(s): Can be used as a third course in physical sciences to meet the general education requirement (of six courses total in the biological, physical, and mathematical sciences). Not recommended for students who have taken ASTR/PHSC 12720 Exoplanets.
Equivalent Course(s): ASTR 18000

PHSC 18100. The Milky Way. 100 Units.
Within a largely empty universe, we live in a vast stellar "island" that we call the Milky Way. As we survey the stellar and interstellar components of the Milky Way-the distribution and motions of stars and interstellar gas, and how these dynamic, ever-changing components interact with each other during their life cycles inside the Milky Way-we will follow the path of ancient astronomers, wonder at their mistakes and prejudices, and form our own understanding.
Instructor(s): Nick Gnedin Terms Offered: Autumn
Prerequisite(s): Any two-course 10000-level general education sequence in chemistry, geophysical sciences, physical sciences, or physics. Can be used as a third course in physical sciences to meet the general education requirement (of six courses total in the biological, physical, and mathematical sciences).
Equivalent Course(s): ASTR 18100

PHSC 18200. The Origin and Evolution of the Universe. 100 Units.
This course provides a comprehensive introduction to modern cosmology. It will discuss how the fundamental laws of physics allow us to understand the origin, evolution, and large-scale structure of the universe. After a brief review of the history of cosmology, the course will cover the expansion of the universe, Newtonian cosmology, Einstein's Special and General Relativity, black holes, dark matter, dark energy, the Cosmic Microwave Background radiation, Big Bang nucleosynthesis, the early universe, primordial inflation, the origin and evolution of large-scale structure in the universe, and cosmic surveys that are probing inflation and cosmic acceleration.

Instructor(s): Austin Joyce Terms Offered: Autumn
Prerequisite(s): No pre-requisites. May not be taken if previous enrollment in ASTR/PHSC 12620 Big Bang.
Equivalent Course(s): ASTR 18200

PHSC 27010. Histories of Women in Science. 100 Units.
In the mid-1980s, only two female students drew women when asked what a scientist looked like and none of the male students in the study did. Only 8% of STEM workers in 1970 were women; in 2019 that number was still only 27%. This would seem to suggest that the history of women in science is a recent one. Yet historians of science have foregrounded women's involvement in fields ranging from early modern medicine to twentieth century astrophysics. This class introduces students to these histories, investigates how and why science came to be a gendered as male, and asks to what extent gendered values continue to inform modern conceptions scientific achievement or value. In so doing, this course also introduces students to feminist science studies and challenges students to reflect upon their own (gendered) experiences of science. Students are strongly encouraged to develop final research projects that draw upon their own interests, scientific expertise, and linguistic competencies. No prior experience with history is required for this course, although an enthusiasm for history is advised.
Instructor(s): Kristine Palmieri Terms Offered: Winter
Equivalent Course(s): HIPS 27011, GNSE 37011, CHSS 37011, KNOW 37011, HIST 27806, GNSE 23162

PHSC 28102. Science Communication: Producing a Science Video Story. 100 Units.
Students will gain skills in oral communication and will apply these skills to produce a video communicating primary research in a scientific area of the student's choice. The goal is effective, engaging communication of science to a general audience without sacrificing scientific accuracy or complexity. Students will work with faculty to write scripts and design visual and audio elements. The talks will be filmed and edited in collaboration with UChicago Creative, who will assist with visual aids and animation. Students will leave the course with a professionally produced video that they can use to advance their career and promote their topic. While this course naturally follows BIOS 28101, that course is not a pre-requisite.
Instructor(s): S. Serritella; S. Kron. Terms Offered: Spring
Prerequisite(s): Three quarters of a Biological Sciences Fundamentals sequence. Third- or fourth-year standing. This course does not satisfy the general education requirement in the physical sciences.
Equivalent Course(s): BIOS 28102, SCPD 11200

PHSC 28104. Science Communication: Crafting a Science Think Piece. 100 Units.
Science think pieces are an important genre of public writing. Think pieces are longform journalism typically ranging between 2,000 and 5,000 words that appear in print and online publications. Readers of all kinds turn to science think pieces to understand critical issues in STEM fields and get a big picture perspective. Science think pieces provide deep context, informed perspective, and expert synthesis of the most recent data and findings. They have the power to shape public opinion and influence science policy. This course guides students through the process of conceiving, developing, pitching, writing, and potentially publishing an engaging and persuasive science think piece. Through reading-inspired group discussions and instructor-led writing projects, the course introduces students to current theories and best practices of science communication as well as everyday processes in science journalism and public-facing science writing. Students will finish the course with a polished science think piece ready for submission to potential venues for publication. No prior knowledge of science communication is required.
Instructor(s): Jordan Bimm Terms Offered: Autumn Spring Winter
Prerequisite(s): Three quarters of physical or biological (including neuroscience) sciences. Third- or fourth-year standing or consent of instructor.
Equivalent Course(s): SCPD 11300, HIPS 11300

PHSC 28500. Effective Writing in the Sciences. 100 Units.
This course will help undergraduates majoring in the sciences write effectively in major-level coursework and thesis research. The course is in its pilot year; in future years, the course's graduates may be eligible to serve as teaching assistants in it. For this reason, although the course is mostly devoted to scientific writing, it will include a component on how to teach writing, potentially helping undergraduate science students obtain broader impacts opportunities in science communication. Our reading texts will range from lab reports and posters to advanced scientific work such as research articles, review articles, and grant proposals. We'll analyze how these documents are structured, discuss strategies for reading them efficiently, and discuss what makes them succeed (or not). We'll develop strategies for note- taking, drafting, and revision. Our ultimate purposes: communicating complex information clearly, articulating research questions, justifying the plausibility of methods, and explaining how new research contributes to the advancement of a field. All these writing tasks must ultimately be tailored to meet the needs of the many audiences that working scientists address, including not only researchers in the field but funding agencies, policymakers, and the general public."
Terms Offered: Summer

PHSC 29103. Science Communication: Building a Science Exhibit. 100 Units.
Students will work as a class to create an interactive physical exhibit that communicates a particular scientific topic to the public. The student-created exhibit will be displayed either on campus or across the city of Chicago. We will welcome guest speakers who are experts in data visualization, visual arts, and museum exhibits to demonstrate the variety of ways science can be communicated. Students will also take field trips to the local

museums to observe the different ways in which research and science communication work together. Students will critically analyze exhibits, evaluate how exhibits and approaches across the city are similar and different, and reflect on the variety of approaches. An advisory board of researchers from local Chicagoland museums will inform and review the final exhibits.
Instructor(s): P. Mason, S. Serritella Terms Offered: Spring
Prerequisite(s): Third- or fourth-year standing.
Note(s): This course does not meet the requirements for the Biological Sciences major. This course does not satisfy the general education requirement in the physical sciences.
Equivalent Course(s): BIOS 29103