

# Science

## Requirements:

**Biology (SCI 210)**

**Chemistry (SCI 220) or Physics Through Inquiry (SCI 230),**

**Physics (SCI 311) or Physics Honors (SCI 312H)**

## Elective Courses Offered in 2021-22:

300-level

- Physics (SCI 311)
- Physics Honors (SCI 312H)
- Biotechnology (SCI 320)
- Human Anatomy and Physiology (SCI 321)
- Experiments in Physics and Chemistry (SCI 322)
- Science Research 1 (SCI 350)

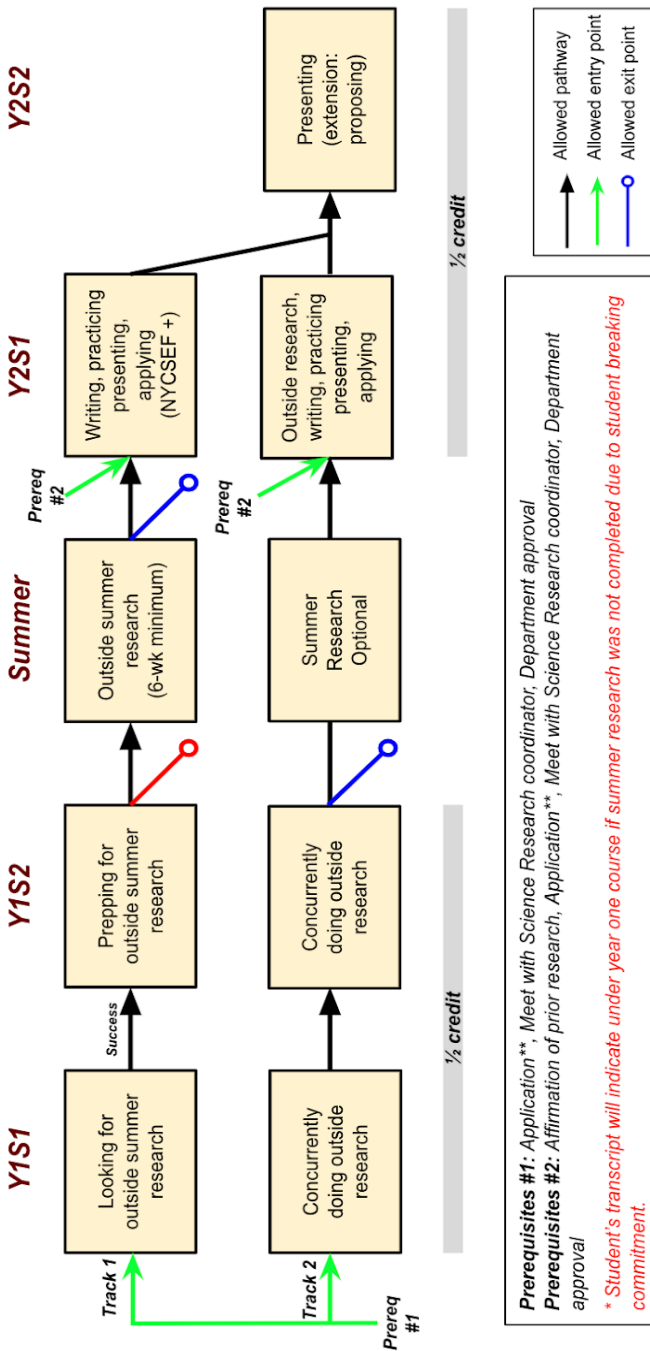
400-level

- Molecular Genetics, Cells and Physiology (SCI 410.01)
- Molecular Genetics, Evolution and Ecology (SCI 410.02)
- Organic Chemistry and Its Applications in Biochemistry (SCI 420)
- Atomic Structure, Reactivity and Applications of Chemistry (SCI 425)
- Physics with Calculus (SCI 430)
- Environmental Science (SCI 440)
- Science Research 2 (SCI 450S)

## **Courses Not Offered 2021-22**

- Topics in Biology (SCI 301)
- Selected Topics in Physics (SCI 310)

# HM Science Research Course Overview



**Prerequisites #1:** Application\*\*. Meet with Science Research coordinator, Department approval  
**Prerequisites #2:** Affirmation of prior research, Application\*\*, Meet with Science Research coordinator, Department approval

\* Student's transcript will indicate under year one course if summer research was not completed due to student breaking commitment.  
 \*\* Applications in all cases must be submitted during program planning the spring before course enrollment.

## Science

The Science Department believes (as Carl Sagan said) that science is more than a body of knowledge; it is a way of thinking and of skeptically interrogating the universe. The science curriculum is designed to build an understanding of science by doing science. Students learn to make observations through experiments, and they develop conceptual and analytical reasoning skills by relating observations to theories and by solving problems. We believe students should not only be knowledgeable about the ideas of science, but also have an understanding and appreciation of how we know what we know. Three introductory courses — Biology, Chemistry, and Physics — are taken by most students. These courses provide an overview of the core topics in each discipline, and emphasize developing the scientific literacy that is important for all students. All three introductory courses are required to take any of the 400 level electives. A variety of other upper-level electives allows students to explore topics of interest in more depth in both classroom and laboratory settings. In laboratory courses, one of the class meetings each week is a double laboratory period.

### **Requirements:**

Biology

One of the following: Chemistry, Physics Through Inquiry, Physics or Physics Honors

### **A note on 400-level Science classes:**

Students are rarely approved to take two 400 level science classes concurrently, especially when also registering for additional 400 level classes. Students who find themselves in this situation will require special permission and should be sure to speak with their grade dean.

### **Introductory Courses**

#### **SCI 210 - Biology**

*Full credit, meets 4 days/week, including one double lab period, usually taken in Grade 9.*

*Prerequisites: None*

The course provides a survey of the major areas of inquiry in biology including molecular biology, genetics, physiology, evolution, and ecology. Students design and test hypotheses, collect and analyze data, and draw conclusions during double laboratory periods every week to support their understanding of biological phenomena. Students also explore current research including cutting edge discoveries through reading, activities and discussion. Finally, at the end of the course, students will collaborate on a final laboratory or

data-based project and present their work to the class. This final project is a culmination of the skills developed throughout the course. It will highlight student understanding of experimental design and analysis of data to draw conclusions.

### **SCI 220 - Chemistry**

*Full credit, meets 4 days/week, including one double lab period, usually taken in Grade 10.*

*Prerequisites: None*

*Chemistry concerns the composition and properties of matter. The topics discussed in the classroom are explored through demonstrations and reinforced through weekly laboratories. Topics include atomic and electronic structure, bonding, reactions, stoichiometry, gas laws, states of matter, solutions, reaction kinetics, thermodynamics, equilibrium, acid/base chemistry, and electrochemistry. In addition to traditional assessments, students will also complete one research-based project per semester. Both projects will include student collaboration, inquiry, and presentation.*

### **SCI 230 - Physics Through Inquiry**

*Full credit, meets 4 days/week, including one double lab period. Can be taken in Grade 10 (before taking Chemistry in Grade 11) or later.*

*Prerequisites: Biology*

*Physics Through Inquiry is a laboratory-based introductory class where students will work collaboratively with their peers. Through experimentation, students will build and test scientific models of Newtonian mechanics, conservation of momentum and energy, thermodynamics, wave behavior, and light. A project at the end of each semester will focus on our society's use of energy and technology. The course will emphasize the development of analytical reasoning skills which will help students become more comfortable with applying mathematical reasoning to the scientific process.*

*Physics Through Inquiry (along with Biology and Chemistry) will serve as a prerequisite for all 400 level science courses other than SCI 404 (Physics with Calculus) and SCI 425 (Chemistry Concepts and Applications). SCI 404 and SCI 425 will still require Physics or Physics Honors as a prerequisite.*

### **SCI 311 - Physics**

*Full credit, meets 4 days/week, including one double lab period.*

*Prerequisites: Biology, Chemistry (recommended), usually taken in Grade 11.*

*Physics is an introductory, algebra-based course covering Newtonian mechanics, conservation of energy and momentum, electricity, waves, and modern physics. This course focuses on developing both a conceptual understanding of the basic principles of physics and*

problem-solving skills. Weekly laboratory work allows students to explore the concepts learned in class and gain experience designing and conducting experiments.

Students who have not completed Algebra II and Trigonometry require permission from the department; please consult with your advisor, your current science teacher, and/or the Department Chair about whether this is a suitable program choice. Students who elect to enroll in Physics before, or in place of, Chemistry must have completed Algebra II and Trigonometry.

### **SCI 312H - Physics Honors**

*Full credit, meets 5 days/week, including one double lab period.*

*Prerequisites: Biology, Chemistry (recommended), usually taken in Grade 11, departmental approval (see below).*

Physics Honors is an introductory, algebra-based, college-level physics course. Topics are studied in greater depth than in Physics, and some additional topics, which vary from year to year, are covered. The concepts developed in this course are applied in a broad range of contexts, and the problem-solving is designed to encourage creativity and to challenge students' conceptual and analytical reasoning abilities. Extensive use is made of advanced mathematical methods and students are expected to solve challenging problems with a high degree of independence. The laboratory work places a greater emphasis on independent work, projects, and computer modeling.

Students who have not completed Algebra II and Trigonometry require permission from the department - please consult with your advisor, your current science teacher, and/or the Department Chair about whether this is a suitable program choice. Students who elect to enroll in Physics before, or in place of, Chemistry must have completed Algebra II and Trigonometry.

Generally, students need to have earned grades of A- or better in all science and mathematics courses to be considered. All interested students must also complete a placement exercise in May, which is designed to assess the readiness of students for this course. Interested students are encouraged to talk with their current science teacher and/or the Department Chair prior to requesting Physics Honors. Given the significant demands of Physics Honors, the department does not generally give permission for concurrent enrollment in Physics Honors and a 400-level Science; students who are interested in doing so must discuss this with their current science teacher and the Department Chair before submitting their Course Request Sheet. Physics Honors may not be taken by students who have completed Physics.

**Elective Courses:****SCI 320 - Biotechnology**

*Full credit, meets 3 days/week, including one double lab period.*

*Prerequisites: Biology, Chemistry*

This is an upper-level course in Biology that introduces students to the cutting-edge techniques used in contemporary molecular biology research. As well as emphasizing hands-on laboratory experience, students are challenged to consider the bioethical issues associated with advancing technology. This course builds on foundational Biology and Chemistry concepts learned in the 9th and 10th grades to further understand the molecular biology behind topics like infectious disease and immunology, antibiotic resistance, genetically modified organisms, advances in cancer biology, and human evolution. Students will learn important techniques in molecular biology including gel electrophoresis, restriction enzyme digests, primer design, DNA amplification by polymerase chain reaction (PCR), nucleic acid extraction and purification, genetic engineering, bacterial/yeast transformations, DNA sequencing, and microarray analysis. Students will plan, conduct, analyze, and write reports or answer lab study questions on their own experiments. Students will also spend time exploring the historical, technical, and social issues influenced by advances in biotechnology by writing papers and making presentations to the class on these issues.

**SCI 321 - Human Anatomy and Physiology**

*Full credit, meets 4 days/week, including one double lab period.*

*Prerequisites: Biology, Chemistry*

This upper-level course in biology examines the structures and functions of cells, tissues, organs, and organ systems found in the human body. The class will go through the complexity of many features found in body systems, such as the microscopic anatomy of bones in the skeletal system, the sliding filament model of the muscular system, action potential propagation in the nervous system, and the cardiac cycle of the cardiovascular system. The class will emphasize the relationship between the physiological aspects of the organ systems to one another. Additionally, students will complete research projects and presentations, where they will be able to focus on a specific topic, disorder, disease, treatment, or surgery related to the body systems discussed in class. Possible research topics include common skin disorders, knee replacement surgery, muscular dystrophy, and the impact of specific drugs on neurons. Laboratory investigations will include performing a variety of dissections, measuring bodily activity, and modeling physiological processes.

**SCI 322 - Experiments in Physics and Chemistry**

*Full credit, meets 4 days/week, including one double lab period.*

*Prerequisites: Biology, Chemistry*

This course is designed for those students who are interested in exploring topics in Chemistry and Physics from an experimental perspective. This elective explores topics in a way that encourages independent thought and provides direct experience with scientific investigation. It also stresses presenting scientific findings in oral and written form. The course consists of five to seven units investigating topics such as analytical chemistry, chemical synthesis, organic chemistry, forensics, novel materials, mechanics, waves, sound, and light, analog and digital circuits, energy, and atmospheric science. In the second semester, students will pursue an independent project on a subject of interest to the student, selected in consultation with the teacher. Although some library-based research will be involved, the major emphasis of the course will be explorations that involve data collection and analysis in the chemistry and physics labs.

**SCI 410.01 - Molecular Genetics, Cells and Physiology**

*Full credit, meets 4 days/week, including one double lab period.*

*Prerequisites: B+ or better in Biology, Chemistry, and Physics Through Inquiry or Physics or Physics Honors, departmental approval required. A grade of B+ or better in Biology is required. Particularly outstanding and interested students may be permitted to take Physics concurrently.*

Molecular Genetics and Cell Physiology is an advanced biology course. During the first half of the course, we will learn about modern molecular genetics, from the classic experimental events that identified the proteins involved in DNA replication and repair, to cutting-edge assays and gene sequencing. Then, our focus will shift to the cell, the foundational building block for all living things, and we will learn about cellular structure and processes. This course will address cell structure, energy metabolism, cellular signaling, physiology of various types of cells including neurons, as well as the endocrine and immune system cellular responses. The course will draw upon a solid foundation of basic chemical knowledge and integrate it into the understanding of how cells function within multicellular organisms. The course will include topics that will span both prokaryotic and eukaryotic organisms, but will focus on multicellular eukaryotic organisms. *Note: Students who take SCI 410.01 will not be permitted to take SCI 410.02 due to overlap of course content.*

**SCI 410.02 - Molecular Genetics, Evolution and Ecology**

*Full credit, meets 4 days/week including one double lab period.*

*Prerequisites: B+ or better in Biology, Chemistry, and Physics Through Inquiry or Physics or Physics Honors, departmental approval required. A*

grade of B+ or better in Biology is required. Particularly outstanding and interested students may be permitted to take Physics concurrently. Molecular Genetics, Evolution and Ecology is an advanced biology course. During the first half of the course, we will learn about modern molecular genetics, from the classic experimental events that identified the proteins involved in DNA replication and repair, to cutting-edge assays and gene sequencing. The second half of the course focuses on the processes and evidence of evolution as a means to study biological diversity and ecosystem structure. We will build a comprehensive understanding of the fundamentals of life history, behavior, population dynamics, ecosystem processes and how evolution shapes ecological relationships. We will make connections between species diversity and ecosystem function in order to understand the importance of conserving biodiversity. Conceptual learning will be supported by hands-on inquiry-driven investigations that emphasize experimental design, data analysis and scientific communication. *Note: Note: Students who take SCI 410.02 will not be permitted to take SCI 410.01 due to overlap of course content.*

### **SCI 420 - Organic Chemistry and its Applications in Biochemistry**

*Full credit, meets 4 days/week, including one double lab period.*

*Prerequisites: B+ or better in Biology, Chemistry, and Physics Through Inquiry or Physics or Physics Honors, departmental approval required.*

*Particularly outstanding and interested students may be permitted to take Physics concurrently. A grade of B+ or better in Chemistry is required.*

This rigorous, advanced elective course focuses on chemistry that bridges the fundamentals of carbon-based chemistry and biological applications. Students will have the opportunity to engage with advanced organic and biochemistry material in a collaborative environment and be challenged to think independently and creatively. The organic focused semester will build a foundation in Lewis acid-base theory, organic nomenclature, stereochemistry, and reaction mechanisms. In the biochemistry semester, students will focus on how the structure and function of macromolecules in biological systems interact. Students will explore the biochemical requirements and mechanisms of biological pathways. Many of the laboratory experiments are multi-week projects and require students to think critically while introducing essential organic chemistry and biochemistry laboratory skills.



**SCI 425 – Atomic Structure, Reactivity and Applications of Chemistry**

*Full credit, meets 4 days/week, including one double lab period.*

*Prerequisites: B+ or better in Biology, Chemistry, and Physics Through Inquiry or Physics or Physics Honors, departmental approval required (see below).*

This course is comparable to an introductory college course in general chemistry. The course will emphasize the conceptual and quantitative understanding of how compounds and molecules interact and the design and execution of sophisticated inquiry-based chemistry experiments to support that understanding. This course will also focus on making connections to real-world applications of chemistry. Topics may include Lewis acid-base chemistry, buffer systems, atmospheric and ocean chemistry, and batteries. Semester I will focus on chemical structure and bonding, and semester II will focus on chemical equilibrium, free energy and reaction kinetics. Strong problem-solving skills are required to master this course.

Approval requirements: In addition to approval by the department, students must be enrolled in or have completed Precalculus. Particularly outstanding and interested students may be permitted to take Physics concurrently.

**SCI 430 - Physics with Calculus**

*Full credit, meets 5 days/week, including one double lab period.*

*Prerequisites: Biology, Chemistry, and Physics or Physics Honors, department approval (see below).*

Physics with Calculus is a calculus-based treatment of physics concepts in mechanics and in electricity and magnetism. All calculus techniques are discussed before they are applied. Topics discussed include Newton's laws, conservation of energy, momentum and angular momentum, gravitation, rotational dynamics, oscillations, electric and magnetic fields (including Gauss's law and Ampere's law), static and moving charges, circuits, and electromagnetism (including Faraday's law). Ideas from introductory physics are amplified and more broadly applied, and new ideas are introduced. Laboratory investigations involve a variety of experimental techniques and methods of data analysis. Analysis of experimental error is emphasized and formal laboratory reports are required periodically. Students have substantial freedom in designing their own experiments, and many experiments are carried out over several weeks. A final project may be assigned.

Approval requirements: In addition to approval by the department, students must be enrolled in or have completed Calculus AB, Calculus (MATH 401), Calculus BC Honors, or Calculus Honors (MATH 422). Math grades are also considered.

**SCI 440 - Environmental Science**

*Full credit, meets 4 days/week, including one double lab period.*

*Prerequisites: B+ or better in Biology, Chemistry, and Physics Through Inquiry or Physics or Physics Honors, departmental approval required. Particularly outstanding and interested students may be permitted to take Physics concurrently.*

As a species, we have had a profound impact on our planet, impacting which species are alive today, the flow of water, the temperature and even the geology. As humans, we have created many problems, yet we must also create solutions. In this course, students will use scientific principles to understand how the systems of our planet function, how humans impact them and how to develop creative solutions. In this laboratory-based class, students will practice the process of science, learning how scientists have figured out what we know. Students will develop their skills in data analysis, and draw conclusions from the data they collect. Interdisciplinary in nature, this course incorporates elements of biology, chemistry, physics, geology and anthropology, building on students' past science experiences with this real-world context.

Approval requirements: Students must have a B+ average across all science courses.

**Science Research at HM**

The goal of the Science Research Program at Horace Mann School is to prepare and support students through a science research experience. This support begins by providing students with the understanding of scientific method and skills necessary to perform research and continues through the research experience. Finally, students are supported as they present their research at local science competitions and symposiums and write a full research paper. A map of the different tracks is included in the Program of Studies. Students may choose track 1 (T1) by searching for an outside lab experience for the summer between Science Research I and Science Research II and will be coached through that process. Students who have already secured a steady research experience outside of Horace Mann may choose track 2 (T2), and will work consistently outside of school on their research project while also working with the Science Research curriculum. Students of all tracks will be mixed within the same section, and will learn the same curriculum, with appropriate differentiation to help each student meet their science research goals. The course is scheduled every other day, with class meetings occurring once per week. Other scheduled periods will be used for one-on-one or small group meetings and experimentation.

Approval requirements: Selection is at the discretion of the department. Before submitting their Course Request sheet on May 4, 2021, interested students must meet with the Science Research Coordinator and submit an application to the program.

**SCI 350 - Science Research 1: Research Theory and Skills**

*One-half credit, meets every other day*

*Prerequisites: Selection is at the discretion of the department. Before submitting their Course Request sheet on May 4, 2021, interested students must meet with the Science Research Coordinator and submit an application to the program.*

The curriculum of year one is focused on reading scientific literature, gathering background information on a science research project, to converse about the scientific research of others, specifying research interests, and developing research projects. An overview of the scientific method and practice of science research will be studied. Students will also learn how to build a resume, interview, and write emails to outside labs as they are supported in finding outside research opportunities. Some discussions will also center around ethics and science research.

**SCI 450S - Science Research 2: Analysis and Presentation of Research**

*One-half credit, meets every other day*

*Prerequisites: Selection is at the discretion of the department. Before submitting their Course Request sheet on May 4, 2021, interested students must meet with the Science Research Coordinator and submit an application to the program.*

Students enrolled in year two would focus on written and oral presentations of their research. They will enter various competitions and symposiums, with the course requiring entry only into NYCSEF (New York City Science and Engineering Fair). In addition, discussions about the scientific method and practice of research, data analysis, and research ethics will continue. Students will informally mentor year one students. For T1 students, experimentation must have taken place the summer prior to this course. For T2 students, experimentation will occur through at least the fall of the course.

**Courses Not Offered in 2021-22****SCI 301 - Advanced Topics in Biology****[Course not offered 2021-2022]***Full credit, meets 4 days/week, including one double lab period**Prerequisites: Biology, Chemistry*

This is a second course in biology for students who wish to explore some topics in biology in greater detail and with greater freedom than in a traditional textbook-oriented course. A majority of class time will be spent in laboratory experiments, discussion, and presentations, rather than lecture. Students will design and conduct experiments and lead discussions on scientific articles, while incorporating aspects of other areas of study, such as engineering, ecology, physiology, physics, chemistry, and history. The course will focus on various topics of interest in biology, which will vary from year to year. Past topics include: the biology of food; biomimicry; urban ecology and biodiversity; exercise physiology; and bacteriology and microbiology.

**SCI 310 - Selected Topics in Physics****[Course not offered 2021-2022]***Full credit, meets 4 days/week**Prerequisites: Biology, Chemistry*

The class is intended to work as a seminar, emphasizing cooperative and collaborative learning as a means of carrying out research. Thus, there are no tests or quizzes except as diagnostic exercises. Assessment is based on contributions to class discussion as well as presentations and projects, individually and in small groups throughout the year. The informal tone of the course therefore demands a genuine interest in and dedication to both the material and the sincere learning dynamic. This course does not fulfill the Physics prerequisite for 400-level Science courses.

Each semester, students will explore one or more paired themes—a foundational one followed by a broader application to something more wide-ranging, which may include social, political, or even philosophical aspects. Some examples of thematic combinations are: Astronomy and Cosmology, Sound and Music, Energy and Climate Change, Technological Development and Ethics, Chaos Theory and Predictability. Students are encouraged to pursue topics within these themes that matter to them.