MARET | UPPER SCHOOL CURRICULUM SCIENCE

Requirements: *3 credits; one course each in biology, chemistry, and physics is strongly recommended*
Chair: *Laurel Reitman*

The upper school science program builds on the strong foundation of data analysis and experimental design skills established in Middle School. The upper school curriculum is designed to include a wide selection of courses in each discipline, geared to a wide range of abilities and interest levels in science. There are many ways that students may progress through the program; see the accompanying chart on page 33 for possible scenarios.

Three years of science are required, although most students complete four or more courses. It is the strong recommendation of the department that this requirement be met by one course in each of the three principle disciplines of biology, chemistry, and physics. Typically, the entering ninth grader will take Biology to begin the sequence. Any of the courses listed may be used to complete the requirement. Some of these courses focus on developing the advanced knowledge and laboratory techniques needed to excel in college science; others seek to provide the student with the breadth of knowledge and problem-solving skills needed to make intelligent decisions about the scientific issues faced by all citizens. The department is committed to providing both future science majors and non-majors with hands-on experience and instruction at a level that will be appropriately challenging for them.

The department is well prepared to meet the needs of the program with three fully equipped labs in the Upper School. Each course is laboratory-based and designed to encourage critical analysis and the application of mathematics at a level appropriate to the course. Computers are used to enhance data collection and analysis.

BIOLOGY

Biology

Biology, along with Shaping of the Modern World and Elements of Literature, is a core 9th grade course. As such, the course intentionally develops students' writing, research, and analytical thinking skills. The course emphasizes the skills required to succeed in Maret's upper school program in numerous disciplines. While this is typically a 9th grade course, some students may elect to take it in 10th grade to balance their academic load.

Evolution and ecology are the unifying themes to this introductory biology course. Students engage in activities, laboratory investigations, and discussions to develop their understanding of these major themes. The curriculum covers a wide range of topics including human biology and reproduction, genetics, biotechnology, evolution, cells, biochemistry, ecology, and biodiversity. Within each of these units, students collect and analyze data using a variety of tools, including computer-based lab probes, spreadsheets, and graphing software. Lab exploration includes basic microscopy, dissection, and a variety of labs that model biological processes. They then demonstrate their understanding of the material with research-based lab reports, models, and other projects.

Advanced Biology

Prerequisites: *Biology, Chem Study*

Advanced Biology is a rigorous and technically demanding course, taught on the college level, that requires a previous basic foundation in biology and chemistry. The overarching themes of Advanced Biology are Evolution and Homeostasis. This course is designed to be a comprehensive survey of general biology and covers the following topics: evolution/speciation/origins of life, biomolecules, cellular biology, metabolism, molecular genetics and heredity, molecular biology, biotechnology, biodiversity,

structure and function of organisms, ecology and organ systems using Homo sapiens as the model organism. The scientific method is demonstrated through special in-class exercises devoted to experimental design/data interpretation and select labs. The labs are designed to supplement and amplify the lecture material as well as instruct the student in laboratory skills such as experimental design, instrument use, technique, data collection, analysis and writing experimental conclusions. Six weeks of lab are devoted to Drosophila melanogaster crosses and the interpretation of the results. The goals of the class are three-fold: 1) to help students to understand biology in the context of evolution and homeostasis from the molecular to the organismal levels, 2) to develop their analytical thinking skills as a biologist, and 3) to help the student learn how to prepare properly for a college biology class.

CHEMISTRY

Chemistry in the Community (Chem Com)

This course emphasizes the impact of chemistry on our everyday lives. It is designed for students who plan to pursue non-science careers, yet it stresses the important role that chemistry will play in their personal and professional lives. Through class discussion, laboratory, decision-making and problem-solving exercises, the major concepts, basic vocabulary, and laboratory skills of chemistry are developed. Major units include water, chemical resources, petroleum, food, nuclear chemistry, air and climate, and health. The approach is much less quantitative than the Chem Study course. There is also a service learning component integrated into this course.

Chem Study

Prerequisites: *Recommendation of a current science teacher.*

This chemistry course involves a quantitative approach to chemistry. The emphasis is on the scientific method and a careful development of the theoretical aspects of chemistry from an experimental viewpoint. There is a heavy emphasis on problem-solving skills and the ability to deal mathematically with the theoretical material. The course is supplemented with laboratory experiments that require students to draw inferences from their data and to attempt to deduce some of the principles of chemistry before they are covered in lecture. Lab work counts for about 25 percent of the grade each trimester.

The topics covered include a study of basic stoichiometric relationships, thermochemistry, gases and their ideal behavior, the development of modern atomic theory from a historical perspective, the periodic table, bonding, kinetics, equilibrium, acid-base reactions, and oxidation-reduction reactions.

Advanced Chemistry

Prerequisites: *Biology, Chem Study*

The Advanced Chemistry course requires a solid foundation in the basics of chemistry. It is assumed that the material covered in the first year course is well understood. The course is taught at the college level and the topics included on the Advanced Placement exam are covered. Most students take the AP exam at the end of the course. The laboratory segment of the course is designed to teach essential lab techniques necessary in any college course. Students work independently, in small groups, and in pairs in the lab. Labwork constitutes about 35% of the course. The topics covered include an in-depth study of equilibrium, thermodynamics, kinetics and bonding, quantum mechanics, acid base chemistry, and electrochemistry. A briefer look at nuclear and organic chemistry is included. The laboratory work includes college experiments involving acid base titrations, qualitative analysis, a variety of separation techniques, gravimetric analysis, redox titrations, spectrophotometry, and synthesis reactions.

Advanced Topics in Chemistry (MSON)

(Spring Semester)

Prerequisite: *Chemistry*

This semester course explores real-world applications to chemistry that are often skimmed over or omitted in most chemistry courses. Possible topics include nuclear, medical, atmospheric, industrial, food, water, and consumer product chemistry. Learn how a nuclear power plant works, how fuels are chemically altered for vehicles, what chemicals are added to drinking water and why they are added, how ores are processed into useful products, and why a country's standard of living

can be determined by its production of chlorine or other important chemicals. We'll explore the periodic table for daily applications and technologies, from cell phones to photovoltaic cells to medical treatments. This course will be heavy in applications and theory, leaving out much of the problem-solving found in other courses.

Introduction to Organic Chemistry (MSON)

(Fall Semester)

Prerequisite: *Chemistry*

This semester course will provide useful background information in organic chemistry by covering topics not typically found in high school chemistry courses. The course will give insight into the importance of the chemistry of carbon compounds to our daily lives. Topics covered will include organic nomenclature, structural formulas, stereochemistry, bonding, reaction mechanisms, chemical transformations of functional groups, and instrumental isolation and detection techniques. Applications to the life sciences (chemistry of proteins, nucleic acids, medicines, and natural products), biochemical applications to medicine, industrial applications, and environmental applications will be explored. Completion of the course should make students more confident in their chemical background when entering college biology or chemistry courses.

PHYSICS

Physics with Algebra

Pre-requisite: *none*

This course uses a student-centered approach in teaching the fundamental ideas of physics and includes applications to everyday experiences. Students will develop a strong understanding of the topics under discussion via multiple methods: frequent and hands-on laboratory exercises and activities, problem solving using algebra, and group discussions of the concepts that students will already have seen in action. In their study of the physical universe, students will delve into many branches of physics, including matter and its motion, the nature of waves, light, and sound phenomena, as well as electricity and magnetism. This course will also offer ongoing support in note-taking and organization, skills that will be invaluable to the students for the remainder of their high-school science career.

Physics

Suggested math: *Completion of geometry*

This course presents a survey of some of the fundamental ideas of classical physics, including kinematics, Newtonian mechanics, energy, waves, static electricity, basic circuits, and magnetism. One of the main goals of the class is to explore how physics applies to everyday life, while strengthening structured problem-solving skills. The text is supplemented with worksheets that emphasize how mathematics can be used to model real-world phenomena and to describe the relationships between variables in a system. Frequent labs provide hands-on experience and develop documentation and data analysis skills.

Advanced Physics AB

Suggested math: *Calculus or AB Calculus concurrent or prior, or mathematics teacher's permission*

This course provides a survey of college-level physics for those students who are interested in pursuing science or medicine in college. Topics covered include the graphical description of motion, kinematics, two-dimensional motion, Newton's laws, conservation of energy, electrostatistics, and circuits. Students test their understanding of topics by making predictions about demonstrations, solving problems, and performing labs. Labs occur every two weeks and emphasize finding patterns in data and using computers to analyze the data.

Advanced Physics BC

Suggested math: *AB or BC Calculus concurrent or prior, or mathematics teacher's permission*

This course is a mathematically rigorous college-level introduction to physics for those students who are likely to pursue the sciences or engineering in college. The course is an introduction to classical mechanics, covering the analysis of motion, Newton's laws, projectiles, momentum, friction, springs, energy, gravity, and rotational motion. Many student choose to take the AP Physics C: Mechanics exam, providing one semester of college credit. Students test their understanding of topics by making predictions about

demonstrations, solving problems, and performing labs. Labs occur every two weeks and emphasize finding patterns in data and using computers to analyze the data. Tests during the second semester are cumulative in preparation for the AP.

ELECTIVES

Advanced Electricity and Magnetism

(Spring Semester; not offered 2017)

Prerequisite: *Concurrent enrollment in Advanced Physics BC*

Electromagnetic interactions form the foundation of biological processes, chemical reactions and the technology we use every day. This semester-long physics elective introduces the theory and applications of classical Electromagnetism. Topics include Coulomb's Law, electric fields, DC circuits, magnetic induction and electromagnetic waves. Problem solving will be a crucial component of this course and students will be expected to solve vector equations and move comfortably between graphical and algebraic representations of physics problems. Labs and lecture-demonstrations will be used throughout the course to help make abstract concepts and equations "visible". Relevant electromagnetic "real world" phenomena (such as lightning, fuse boxes and electric motors) will be examined and there will be one research project so that each student can delve deeply into an electromagnetic topic of their choice.

Advanced Environmental Science

Prerequisite: *Biology and Chemistry*

In this yearlong course, we will explore the ways humans impact and are impacted by the environment via a systems approach. Our goal will be to understand the science behind major environmental issues and to explore the question of how humans can live more sustainably on the planet. We begin with a review of ecology and evolution because they provide the background information necessary for evaluating many environmental issues. Other topics include human population, environmental health, energy (including fossil fuels, nuclear, and alternative sources), urbanization, water resources and their pollution, soil and agriculture, air pollution and global climate change. Students should take this course if they want to achieve a deeper understanding of current environmental topics and to improve their ability to decipher and rationally judge the environmental arguments we see so regularly in the press, in our lives, and the halls of Congress. The AP exam is an option at the completion of the course.

Biotechnology: Techniques and Applications

(Fall Semester)

Prerequisites: *Biology, Chem Study (or Chem Com and permission of instructor)*

This course is a junior/senior science elective that offers the students an opportunity to explore the world of biotechnology. The two main goals of this course are 1) to familiarize the student with the many techniques used in the biotechnology setting and 2) to provide the students with an understanding of how these techniques are used in scientific research. The class requires that the student be able to function relatively independently in the laboratory after directions and demonstrations are provided to them, and to complete follow-up work on their own. The course is broadly divided into the Molecular Biology of DNA and RNA followed by Proteins and Bioinformatics. Each lab is introduced by a classroom "chalk talk" followed by the lab and then concludes with analysis and discussion of the experimental results.The students learn hands-on how to perform the following techniques: extraction and electrophoresis of DNA and proteins, restriction digestion of DNA, amplification of DNA using the polymerase chain reaction, and the cloning of DNA. Furthermore, a unit on bioinformatics is included, and the topic of fluorescence, along with its many applications (e.g., microscopy, DNA sequencing, and microarrays) is covered in oral presentations given by the students. In addition to learning these techniques, the course includes an ongoing discussion of how these techniques are used to help solve a number of real world problems. Finally, each student will learn how to use the biomedical research bibliographic database PubMed to help them begin the transition from using online resources to the primary scientific literature, and will complete the course with either a final research paper or project accompanied by an oral presentation.

CSI: MSON—Forensic Science (MSON)
(Spring Semester)

Prerequisite: *Completion of Chemistry or Biology and Algebra II (or currently enrolled)*

This course is designed for those interested in learning the discipline of forensic science and crime scene investigation. Students will be introduced to some of the specialized fields of forensic science and topics will include blood spatter and pattern analysis, death, ballistics, trace and glass evidence, toxicology, entomology, anthropology, serology, and DNA fingerprinting. Students will explore the forensic analysis of substances such as glass, soil, hair, bullets, gun powder, blood and drugs. This class will include a mixture of laboratory experiments, demonstrations, and speakers who are experts in the field.

Fundamentals of Nuclear Science (MSON)
(Fall Semester)

Prerequisite: *Introductory course in Physics at the AP, IB or Honors level, and past or current calculus class.*

This course provides an overview of the field of nuclear science emphasizing the sources and properties of nuclear radiation and mechanisms of radiation interaction with matter. Specific topics include: basic nuclear physics, modern physics concepts related to nuclear science, atomic and nuclear models, attenuation of particle beams, photon and neutron interactions, nuclear structure and instability, radioactive decay processes and properties of radiation, nuclear reactions and energetics, particle accelerators, and fission and fusion processes.
Information will be presented by class lectures, reading assignments, discussions and research projects. There will be approximately two hours of homework for each class and will consist of problem solving and writing reports. Laboratory exercises will be performed in a virtual context analyzing authentic data. Lab reports must be submitted for each exercise. There will be several quizzes during the semester and will be taken online. A midterm and final exam will be given each semester. Understanding of course material will be assessed via homework, quizzes, exams, lab reports and a final project.

Genetics And Genomics: Diving Into The Gene Pool (MSON)
(Fall Semester)

Prerequisite: *Completion of Chemistry and Biology*

This course will emphasize classic Mendelian genetics, molecular genetics, and population and evolutionary genetics. The topics include structure and function of genes (and the genome), biological variation, and gene regulations. Subsequently, the course will explore what experimental research has taught us about genome analysis methods, and our use of this information in society. Topics include recombinant DNA technology, mathematical models and statistical methods for data analysis. Papers from the current and classic literature will supplement lecture material.

Gravitational Astrophysics
(Spring Semester)

Prerequisite: *Must have completed Algebra 2 & Trigonometry. Physics/Physics A/Adv Phys either completed or enrolled in concurrently.*

Gravity is the weakest of the four fundamental forces in nature, yet it has the dominant influence in our Universe. This semester long Physics elective will present the concepts and mathematics of Newton's Law of Universal Gravitation within the context of Astrophysics. Topics examined will include orbital motion of satellites and planets, structure of the sun, escape speed, black holes, the search for exoplanets and ocean tides on Planet Earth. Periodic experiments in the Physics Lab will be supplemented by "virtual" labs on the computer. Students will be expected to work independently on projects throughout the semester.

Health Physics and Nuclear Technology (MSON)
(Spring Semester)

Prerequisite: *Introductory course in Physics at the AP, IB or Honors level, and past or current calculus class.*

This is an overview course that provides broad subject-area coverage to introduce students to application of theory to practical aspects of nuclear science and technology in the world today with special emphasis on health physics. Specific topics include: the detection and measurement of ionizing radiation, the quantities of radiation dosimetry (the absorbed

dose, equivalent dose, and effective dose) used to evaluate human radiation risks, elementary shielding calculations and protection measures for clinical environments, the characterization and proper use of health physics instrumentation, and the regulatory and administrative requirements of health physics programs, principles of nuclear reactors, and nuclear technology in industry and research.
Information will be presented by class lectures, reading assignments, discussions and research projects. There will be approximately two hours of homework for each class and will consist of problem solving and writing reports. Laboratory exercises will be performed in a virtual context analyzing authentic data. Lab reports must be submitted for each exercise. There will be several quizzes during the semester and will be taken online. A midterm and final exam will be given each semester. Understanding of course material will be assessed via homework, quizzes, exams, lab reports and a final project.

Lab Research in Biology

(Spring Semester)
Pre-requisite: *Biology and Chem Study required. Advanced Bio (fall semester) or Biotechnology recommended.*

This laboratory-based class will be centered on introducing the student to the practical implementation of the scientific method as applied to an experiment of their own design. The class will use two invertebrates: *Caenorhabditis elegans* and *Drosophila melanogaster* as model eukaryotic organisms for study. An introduction to PubMed and the critical reading of primary literature will be combined with developing an understanding of the importance of a sound hypothesis followed by the design of an appropriately controlled experiment, preferably using one of the model organisms. The emphasis will be on the process that a working scientist must go through in order to conduct a valid study and less on application of specific techniques to solve a problem. The goal of each project will be to produce data that can be quantitatively analyzed for its biological implications rather than being a demonstration of a fundamental principle. Students should be able to take instruction well, be self-motivated, organized, and capable of maintaining an accurate record of their laboratory experience.

Meteorology (MSON)

(Spring Semester)

Prerequisite: *Chemistry, physics is helpful although not necessary*

Meteorology is the study of the Earth's atmosphere. Although weather is only one aspect of meteorology, it will be the main focus in this class. In this rigorous course the role of moisture, vertical motions, jet streams, mid-latitude cyclones, and frontal systems in producing our weather will be covered. Students will also study thunderstorms and tornadoes, Students are expected to spend up to six hours/week reading and doing homework outside of class.

Modern Physics (MSON)

(Spring Semester)

Prerequisite: *Physics or AP Physics 1; Co-requisite: AP Calculus AB*

This is a mathematically rigorous course in which students study contemporary physics. The course begins with Einstein's theory of relativity, and then takes on a chronological exploration of the development of quantum mechanics. Time travel, quantum tunneling, and the acceptance of seemingly impossible dualities mark highlights of this course.

Waves, Optics, and Sound

(Fall Semester)

Prerequisite: *Completion of Algebra 2 & Trigonometry, suggested 12th grade status; Physics or Physics A or Physics AB or BC concurrently*

This semester-long Physics elective introduces the theory and applications of waves, sound and optics. After an introduction to the mathematics of waves, the theory of longitudinal and standing waves will be used to study the properties of sound waves such as the Doppler Effect and musical instruments. The wave nature of light will then be studied along with some everyday examples of physical optics such as polarizing sunglasses and colorful soap bubbles. Finally, the ray model of light, which is the foundation of geometrical optics, will be used to explain the physics of mirrors and lenses as well as some of their applications such as contact lenses and

rainbows. Labs involving quantitative data analysis will be a significant component of this course and students will be expected to work independently on research projects (e.g. the physics behind a particular musical instrument, building a simple kaleidoscope) throughout the semester.

SUMMER ELECTIVE

Subtropical Zone Ecology

(Conducted in Florida; open to grades 10-12)

This is a six-week study of the marine subtropical ecology of the intertidal and neritic zones, with additional investigations of dune, mangrove, mud flat, and grass flat ecosystems. Marine flora and fauna are studied through direct observation while snorkeling and through analysis in the laboratory. Students are required to prepare and submit a field research project. Extensive reading and discussions of environmental philosophy, as well as visits by guest speakers, amplify and enrich the course experience. The course is conducted on Sanibel Island and in the Florida Keys, taking advantage of the unique ecological characteristics presented by each locale.

MIDDLE SCHOOL AND UPPER SCHOOL SCIENCE SEQUENCE

Three upper school science credits are required for graduation. One course each in biology, chemistry, and physics is strongly recommended. Most Maret students take four years of upper school science, and some juniors and seniors take two science courses concurrently.