COLUMBIA GRAMMAR & PREPARATORY SCHOOL

Advanced Science *Research*

A GUIDE FOR **STUDENTS**

Inspired by the pioneering work of Dr. Robert Pavlica

"If the teacher knows more about the topic than the student does, then the student doesn't know enough"
– Dr. Pavlica

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The Philosophy

The goal of the course is to immerse you into college-level STEM research. It is aimed at students who wish to pursue excellence and progress into advanced areas of original research. Emphasis is on both laboratory and bibliographic research. The course will develop and foster your commitment to long-term focused research that demonstrates initiative, perseverance, and creativity. You will learn and hone skills crucial to the practice of science, such as writing a research paper and giving a technical presentation to laypeople and experts.

A Message from Mr. Yashin

I'm glad that you're showing interest in ASR! Don't worry if you haven't been doing "sciency stuff" since kindergarten. Don't worry if you aren't known as a "science person." Don't worry if you're not sure whether you "have it in you" to become a student researcher.

If you are excited by the prospect of discovering a tiny sliver of the universe that nobody had ever known before or making something nobody else had, no matter how much time and toil it will take you—we want you. If you have a love for anything related to science, technology, or math in your heart, and the guts to do an incredible amount of high-level work to get where you want to get—we want you.

Messages from ASR Students

*"**You will never know if ASR is meant for you if you don't take a leap of faith in yourself and your abilities.***
I didn't think that science was really for me, or that research in high school was even possible, but I took a leap of faith in myself that I could at least try to do something that was totally unfamiliar—and I found out that even though it was hard, I enjoyed it."

*"**ASR is a class about passion and persistence, not innate ability**. Although every student in the program started at a different place in terms of scientific knowledge and writing/presenting ability, everyone has undergone tremendous growth.*
ASR is unlike your typical high school class; if you have the true motivation to contribute something meaningful to the world of science, it is most definitely possible with a lot of hard work and passion for whatever it is that you are studying. ASR is more than a class; it is a community. Everyone in the community supports one another and, even though we are each working on our own individual projects, we all collaborate, rather than compete against one another."

*"ASR is not your normal class. It's work, A LOT of work. But you're going to enjoy most of the work you do. **If you are even remotely interested, apply.** It is a community of some of the best people I know and the environment every day is such a wonderful thing to be a part of.*
There is no such thing as a "science person," but even if there was, I wouldn't be one of them. Literature and writing are my thing, but this class makes my day, every day I have it. I have learned so many life lessons here and I could not imagine my life without ASR.
*It's not for everyone, but at least apply if you're interested. Get your feet wet, see if you enjoy the application work and the summer assignment. **I remember being terrified to apply, but I am so glad that I did.** If you're unsure, apply so you at least have the option to decide whether it's for you. **Why not at least try?**"*

Frequently Asked Questions

Is ASR a class or an extracurricular program? What do you do in class?

ASR meets as a class just like any other year-long core class. You'd need to take it along with the required science classes. Roughly one third to one half of all class periods will be devoted to individual meetings with students, and you'll be able to work quietly on your own. The rest of class meetings will be devoted to presentations and lessons.

What will I be graded on?

Three things: knowledge (how well you can explain and answer questions about what you've been learning), responsibility (meeting deadlines, following assignment directions, etc.), and improvement (a goal you set for yourself). You will assess yourself before each monthly individual meeting and then discuss it with Mr. Yashin at the meeting.

Can I work on something that's technically not "science"?

Yes! Although "science" is in the name, you can also do a research project in math, engineering, programming, or even something closer to the humanities. Anything that involves analyzing data and drawing conclusions can be a project. You can make a mathematical model, invent and build a device, or write crafty code to do useful things.

Will the program find and contact a mentor for me?

No, but you will be taught how to find and contact potential mentors. Success is extremely likely with enough perseverance and flexibility.

Will I *have to* work in a lab?

No. Many legitimate, fascinating projects can be done at home, at school, or completely on your computer.

What if my project isn't successful? What if the results aren't interesting, or my invention fails?

That alone has no effect on the inherent quality of your project or your grade in ASR. Welcome to authentic STEM research, where results aren't known in advance! All that matters is that your research question(s) or engineering objective(s) are well-thought-out in advance and that you follow the best methodology.

What's the typical workload?

An average of 7-10 hours per week. Some parts of the year are busier than others, and sometimes you'll be able to move your ASR deadlines around to accommodate other classes.

Would I still have time for extracurriculars like sports and arts if I take ASR?

Yes! Many successful ASR students do it. You can ask Mr. Yashin to connect you to some such students.

When will I do most of my research?

This varies. At least one project needs to be done before the beginning of senior year, and most students do a lot of it during the summer after junior year. You can also choose to do it the summer after sophomore year. If you can do your project from home or school, you will have most of junior year to work on it.

What's the deal with summers?

The only requirement is for the summer before senior year: you must leave that summer open for substantial ASR work, and you will need to have two virtual meetings with Mr. Yashin: one individual and one with all rising seniors. You do not have to do anything ASR-related during the summer after sophomore year; however, there are numerous benefits to making substantial progress on your project that summer, and you'll have Mr. Yashin's support if you do so.

Program Overview

ASR students accomplish the following:

- They choose and explore a topic of interest. It may come from any area of basic or applied science, mathematics, medicine, or engineering. They develop bibliographic research skills using professional databases and other research tools.

- They find and study numerous journal articles, using textbooks and other articles to fill in their gaps in understanding so that they are able to explain every detail of each article and its significance.

- Once they have read a critical mass of literature on their narrowly-defined topic, they write a review article that outlines the background of the topic, the cutting edge of our understanding of it, and the outstanding problems.

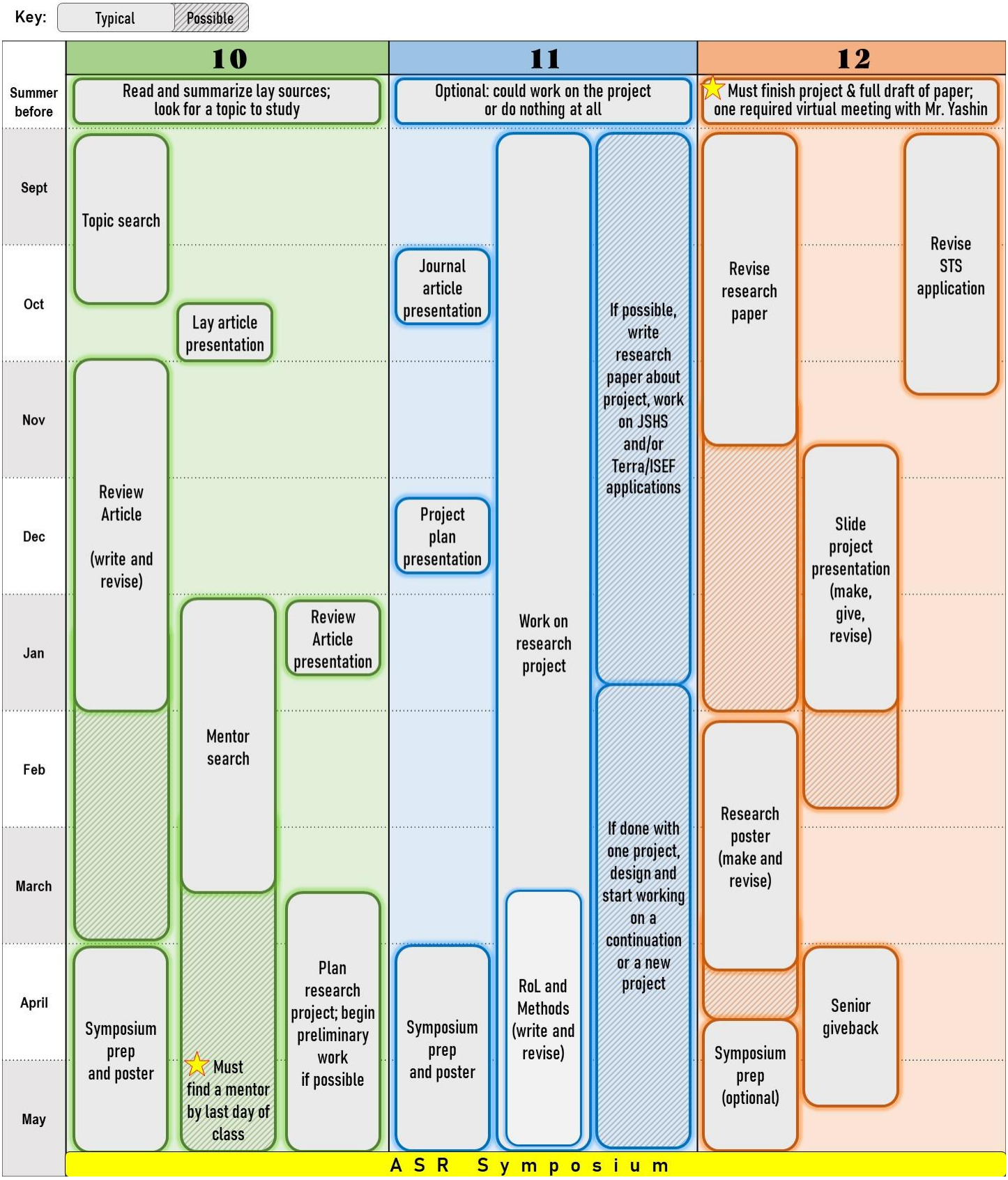
- Students contact a scientist who has completed research in the field they wish to study and ask the scientist to serve as a mentor to assist them in carrying out a research project in their area of interest.

- Students then engage in an original piece of research under the supervision of their research mentor and their ASR teacher. This may be the student's own project, or the student may assist the mentor in some meaningful manner. If the student works on the mentor's research, it is the student's responsibility to acquire sufficient knowledge and skills to become a genuine asset to their mentor. The minimum requirement for a project is that the student analyzes data, interprets the results, and makes conclusions, even if the data are provided by the mentor. We recognize the limited time that most researchers have, and we inculcate the study habits, high standards of scientific rigor, and personal responsibility required for research at the college level.

- We teach our students fundamental inferential statistics and expect competency in using the common statistical tests and interpreting their results. Most students complete their own data analyses or assist the mentor with theirs.

- Once they complete a research project, students write a professional research paper and make a presentation about it. They submit their project to science research competitions (see p. 9) to get experience with presenting to and being questioned by expert judges. Although submission to science research competitions is a requirement, it is not the goal of ASR. The only goals are quality research and quality learning.

The Three-Year Curriculum



APPLYING TO THE PROGRAM

You can apply to ASR in the spring of 9th grade. The application consists of two parts:
An essay showcasing your interest in STEM, and a three-minute live presentation of a popular science article, followed by a brief Q&A. Recommendations from your science and mathematics teachers are considered, but students from a wide range of ability levels and academic achievements are considered as long as they demonstrate determination, and strong personal responsibility. Once accepted, you will choose a tentative STEM area of interest (or a few).

Then, over the summer, you will read and summarize 12 science articles on your topic(s), from popular science magazines and books. This will help you to explore new areas and begin developing questions that appeal to you, and which may later turn into potential research projects! If you are already certain about your interest in a certain topic, you will be given the opportunity to go deeper into learning about that topic by reading review articles and other college-level material, filling in the gaps along the way.

10th GRADE

First, you will explore your research areas of interest and then gradually narrow them down to one. You will master researching skills using popular science magazines and college-level textbooks, as well as online research. The class meets every day, and you will have an individual meeting with the teacher approximately once a month to monitor progress and discuss the next steps.

You will then select approximately between five and ten journal articles on your chosen topic and use these articles to write a 20-to-40-page Review Article as an overview of the topic. The article is written to be understandable to both a layperson and a researcher, which will push your understanding of the subject, as well as your technical and expository writing skills, to a deeper level. The draft will go through as many revisions as is necessary until it is your best possible work, which usually takes a month or two.

You will also make a presentation about the current state of research in your field, based on your Review Article. The presentation includes an overview of the importance of the topic, an explanation of relevant fundamental concepts, an overview of several key journal articles, and avenues for further research on the topic.

Throughout the year, you will read approximately five journal articles per quarter, in addition to developing presentation skills, statistics knowledge, and an understanding of APA formatting and the formatting most commonly used in your field.

Once you complete the Review Article to the satisfaction of the ASR teacher, you will contact the authors of the journal articles that they have thoroughly read and are interested in to inquire about mentorship opportunities. With instructions and support, you will keep looking for research mentors and sending emails to potential mentors; you will be required to find a mentor by the last day of class to stay in ASR.

Once you find a mentor, you can start working together remotely and then in person, often in a laboratory, and possibly continuing into the summer. Depending on many factors, you may either start working on a research project in the spring of your 10th grade and continue through the summer or devote the spring and summer to gaining the knowledge and skills required to begin a research project. This will be determined jointly by you and your mentor. While devoting the summer after 10th grade to working on your research project has enormous benefits, it is not required.

You will give a presentation on your research topic and, if possible, your proposed research project at the ASR Symposium in May.

11th GRADE

You will devote most of your junior year to your research project, maintaining regular communication with your mentor every one to three weeks. During and outside of class, you will do whatever is necessary for your research, whether it's gaining the prerequisite knowledge or skills or designing and conducting the project itself and analyzing data.

There is a wide range of what 11th grade is like in ASR, depending on the requirements of your project and your drive. You may need to devote the entire year to the research project you will have begun the previous spring or summer. Or you may be able to complete a research project by the middle of 11th grade. In this case, you are encouraged to submit it to several science research competitions and non-competitive venues such as academic conferences, as suggested by your mentor. This will provide you with an excellent opportunity to hone your writing and presenting skills and to interact with judges. Afterwards, you will either expand significantly upon the first project (more than just getting more data) or start a new one, to be completed by the beginning of 12th grade.

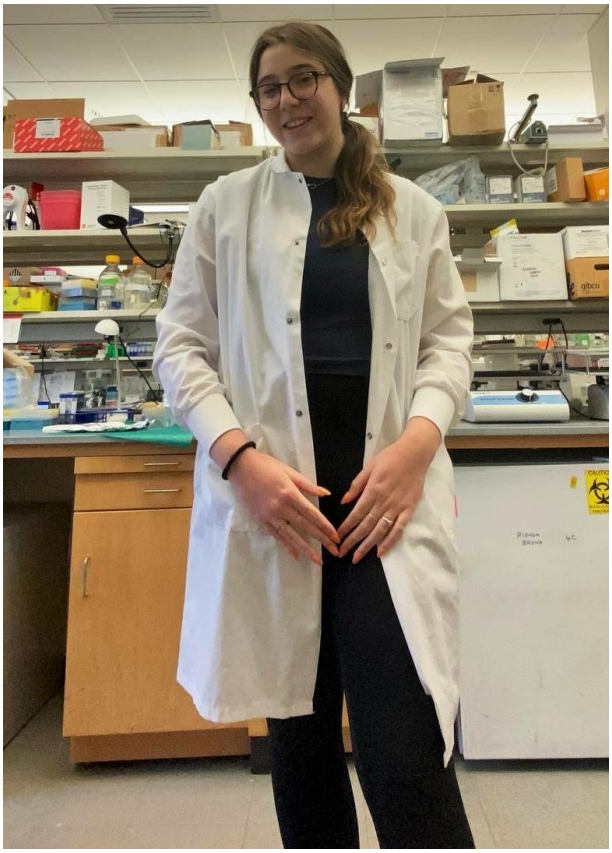
As a junior, you will continue to meet with the ASR teacher individually approximately once a month to discuss the ongoing research, attend classes on research topics, and learn lab skills, programming, etc., as needed. You will continue to hone your presentation skills by giving presentations to the class on the progress of your research, following a format similar to that of many research staff meetings. Juniors who plan to work with human subjects follow the approval guidelines of an Institutional Review Board to minimize risk. If needed, you will receive HIPAA and/or IACUC training to handle private subject data or to work with animals.

Toward the end of the 11th grade, you will present either your completed project or the ongoing one to the school community at the ASR Symposium in May, which all mentors, parents, and school faculty and staff are invited to attend. You will also write the Introduction/Review of Literature section of your senior research paper, for which you will receive instruction and opportunities for revision.

SUMMER AFTER 11th GRADE

You must keep this summer open for your ASR work. This summer (as well as 11th grade and, possibly, the summer before 11th grade—every student's path is unique) is dedicated to performing the study or experiments, collecting data, analyzing and interpreting the results, and writing the research paper. Many students spend part or all of this summer working directly with their mentor, although some conduct their research independently while maintaining regular communications with their mentor and ASR teacher.

By the first day of 12th grade, you are required to finish your research project and write a full draft of your research paper. You will receive instruction on how to write the paper in the last few weeks of the previous semester. You will meet once during the summer with your ASR teacher to discuss your research progress and your paper. You will also be required to learn and follow the guidelines issued by the Society for Science for advanced high school science research, including guidelines for animal care and hazardous materials handling.



You can do research in a lab like Morgan...

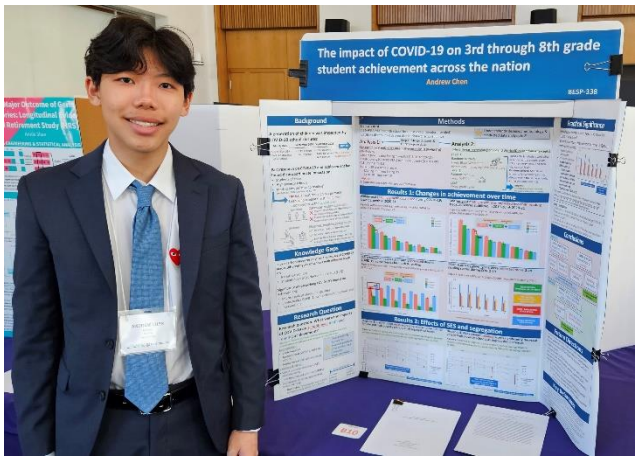
...or on a roof like Annika

12th GRADE

As a senior, you will continue to meet daily with the class and individually with the teacher about once a month to ensure that all goals and objectives are reached. You will revise your research paper and begin making a formal presentation of your research. Once your paper is approved by your teacher and your mentor, you will submit it to the Regeneron Science Talent Search (STS) and the International Science and Engineering Fair (ISEF), two of the most prestigious high school science competitions in the world. You will also submit it to the Junior Science and Humanities Symposium (JSHS).

Although participating in these research competitions is a requirement, it is not the goal of the program. The goals of the program are for you to learn valuable skills, do quality research, and share your work with the world. The competitions provide venues for you to do so, concrete goals to work toward, a nationally recognized set of standards to meet, and the opportunity for experts in the field to evaluate your work.

You will also be encouraged to find non-competitive venues for presenting your work. The presentations that students cherish the most often involve the challenge of presenting to your mentor's research group or at a professional conference. You will also present your work to the school community at our annual ASR Symposium in May.



Possible Research Areas

Source: Regeneron Science Talent Search

ANIMAL SCIENCES: Study of animals – ornithology, ichthyology, herpetology, entomology, animal ecology, paleontology, cellular physiology, circadian rhythms, animal husbandry, cytology, histology, animal physiology, invertebrate neurophysiology, studies of invertebrates, etc.

BEHAVIORAL AND SOCIAL SCIENCES: Human and animal behavior, social and community relationships – psychology, sociology, anthropology, archaeology, ethology, ethnology, linguistics, learning, perception, urban problems, public opinion surveys, educational testing, etc.

BIOCHEMISTRY: Chemistry of life processes – mechanisms of molecular biology and genetics, enzymes, photosynthesis, blood chemistry, protein chemistry, food chemistry, hormones, etc. Studies involve understanding life and cellular processes specifically at the molecular level.

BIOENGINEERING: Engineering principles applied to biology or medicine, such as bodily aids or replacements, medical/diagnostic devices, and drugs or other therapies using engineering to address a biological problem.

CELLULAR AND MOLECULAR BIOLOGY: Wide ranging field that studies cellular structure, function, biomolecule trafficking, signal transduction, genetic information flow, and cellular replication.

CHEMISTRY: Study of nature and composition of matter and laws governing it – physical chemistry, organic chemistry (other than biochemistry), inorganic chemistry, plastics, fuels, pesticides, metallurgy, soil chemistry, etc.

COMPUTATIONAL BIOLOGY AND BIOINFORMATICS: Studies that primarily focus on the discipline and techniques of computer science and mathematics as they relate to biological systems. This includes the development and application of data-analytical and theoretical methods, mathematical modeling and computational simulation techniques to the study of biological, behavioral, and social systems.

COMPUTER SCIENCE: Study and development of computer hardware, software engineering, internet networking and communications, graphics (including human interface), simulations/virtual reality or computational science (including data structures, encryption, coding and information theory), etc.

EARTH AND PLANETARY SCIENCE: Geology, mineralogy, physiography, cryosphere, ocean sciences, geomagnetism, hydrology, meteorology, climatology, speleology, seismology, tectonics, volcanology, planetary science, etc.

ENGINEERING: Technology; projects that directly apply scientific principles to manufacturing and practical uses – civil, mechanical, aeronautical, chemical, and electrical engineering; electronic, sound, automotive, marine, heating and refrigeration, transportation, environmental engineering, etc.

ENVIRONMENTAL SCIENCE: Study of ecology, sustainability, climate, and human impacts, including pollution from air, water or land sources and their control or remediation, etc.

GENOMICS: DNA microarray and deep sequencing studies; phylogenetic analysis of DNA or other biomolecules; analysis of human or other genomes, molecular evolution, etc.

MATERIALS SCIENCE: The structure, engineering properties, processing, and innovative uses of metals/alloys, polymers, ceramics, glasses, electronic materials, biomedical materials, composites, and other innovative materials at scales ranging from the atomic to the macroscopic, etc.

MATHEMATICS: Development of formal logical systems or various numerical and algebraic computations, and the application of these principles – calculus, geometry, abstract algebra, number theory, statistics, probability, etc.

MEDICINE AND HEALTH: Study of diseases and health of humans and animals – pharmacology, physiology, pathology, ophthalmology, oncology, cardiology, nephrology, endocrinology, pediatrics, dermatology, allergies, speech and hearing, nutrition, dentistry, etc.

PHYSICS: Theories, principles, and laws governing energy and the effect of energy on matter – solid state, optics, acoustics, particle, nuclear, atomic, superconductivity, thermodynamics, magnetism, quantum mechanics, biophysics, etc.

PLANT SCIENCES: Study of plant life – agriculture, agronomy, horticulture, forestry, plant taxonomy, plant physiology, plant pathology, plant genetics, hydroponics, algae, etc.

SPACE SCIENCE: Study of celestial bodies, their positions, motions, nature and evolution – astronomy

Examples of ASR Student Research

Research Area	Title of Student's Research Project
Behavioral and Social Sciences	The impact of the COVID-19 pandemic on 3rd-8th grade student academic performance
	Loneliness and well-being in mid and late adolescents: The role of resilience, hope, and wisdom as protective factors
Biochemistry	Single-molecule investigation of the interaction between MeCP2 and chromatin
Cellular and Molecular Biology	Mechanisms of lysosomal cross-correction in mucopolysaccharidosis type IIIC by gene-modified hematopoietic stem and progenitor cells
Chemistry	Developing photo-crosslinking peptide probes as substrate mimics to trap protein lysine methyltransferases
Computational Biology and Bioinformatics	Single cell analysis with CARM1 chemical probes reveals metastatic subpopulation of breast cancer cells
Computer Science	The impact of part-of-speech tagging on the accuracy of word sense disambiguation models
	Intra-procedural prostate MRI registration: A data-efficient Siamese neural network (SNN) design
Earth and Planetary Science	Improving our understanding of New York City's microclimates using a novel observational network
Environmental Science	Water retention of small-scale green roofs with edible vegetation
Medicine and Health	Does primary care availability mediate the relationship between rurality and lower life expectancy in the United States?
	Validating RNA-Seq results on the top differentially expressed genes that are upregulated in oncogenic GNAS R201C pancreatic ductal organoids
	Evaluating an AAV gene therapy in a bovine model of maple syrup urine disease
Space Science	Increasing the resolution of *Cassini* VIMS spectra

COME JOIN US!