Education is not the learning of facts, but the training of the mind to think.

- Albert Einstein
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Dear High School Science Research Pathways Teacher,

Welcome to the High School Science Research Pathways Program (HSSRP) Science Research Club Educator Guide. We are looking forward to supporting you as you launch your after-school Science Research Club this winter. This guide is designed to provide frameworks and resources that will help you create a club that engages and enriches the science experiences of your 9th and 10th grade students.

This guide includes:

- planning materials to help you map out milestones and activities from December through June;
- tools and resources to support students’ research, close reading, and communication learned from scientific literature and other resources;
- suggested activities to make the club engaging and fun for students; and
- information on the June Research Symposium, including specifics on what selected students in your club will need to prepare.

This guide is not a how-to or recipe for a Science Research Club – you’ll see that there is no step-by-step plan for you to follow. Instead, we hope that you’ll use this guide as a set of resources that you can pick and choose from as you decide how to set up your club. Since each school and group of students is unique, we want to make sure that you have the flexibility to create a club that meets the needs of your school and your students. Please feel free to adapt these activities as needed, and to include additional activities or resources from your own collection to add to your club – creativity and ingenuity is encouraged!

Our program team is looking forward to working with you as you launch your club this year. Please don’t hesitate to share questions, suggestions, or ideas with us.

Yours in research,

The High School Science Research Pathways Program Team
The purpose of the after-school Science Research Club is to give 9th and 10th grade students an opportunity to explore a scientific topic of interest, and to get a taste of some of the primary components of science research. Participating students will select and scope a scientifically valid research topic, which they will research through gathering and close reading of relevant articles from scientific journals and other periodicals. Students will closely analyze selected articles, and will synthesize their research into a literature review of their topic, that can be shared via written, visual, and oral reports and presentations. By giving students a low-risk opportunity to explore science research, the club enables the teacher and each participating student to make an informed decision about whether or not the student wants to commit to participating in a long-term science research program over the next two to three years.

As you begin to plan your club, you should map out your overall goals, taking time to think about the following:

**Who:** Who are the students you will be recruiting into the club, and what do you want these students to achieve as members of the club? How do you want club participants to grow as students and as scientists?

**What:** What are the major areas of focus that your club will have? What activities and resources – in addition to scientific articles – will you use to engage students and encourage them to be involved?

**When:** At what time and on what day of the week will your club meet? What scheduling constraints do you need to consider?

**Where:** Where in your school building will your club meet?

**How:** How will you take your ideas for the club and put them into action? How will you support your students in successfully scoping and researching their topics? How will you troubleshoot challenges as they arise? How will you leverage your school community, your fellow HSSRP teachers, and the HSS-RP program team to support you in the successful launch of your club?
Getting Buy-In and Support from Your School’s Faculty and Staff

Getting support from your school community is an important part of successfully launching your Science Research Club. Strategically engaging the stakeholders listed below so that they can act to support your club when needed is an important component of launching your club.

Administration
It is critical that your school’s administration – including your principal, AP(s), and programming staff – are aware of and supportive of your research club. In addition to providing space and resources for an after school activity, they can also support you in recruiting students to join the club, and in communicating to parents and families of interested students. Additionally, your school’s administration, particularly your science department leadership and programming staff, will play an important role in facilitating the creation of a research course in the upcoming school year.

Teacher Colleagues
Other teachers can support outreach about the club to share information to their students, recommend students in their classes (who you may not know) whom they think would be a good fit for the club, and can share ideas for hands-on activities or other ways to make the club relevant and interesting to participating students.

Other Staff
Other staff – including guidance counselors, deans, and coordinators of student activities – can also support you in identifying students to recruit to your club, and in supporting you with resources and space for your club. Additionally, coordinate with staff who lead or supervise other student extracurricular activities – coaches, club advisors, etc. – so that you can anticipate and manage potential conflicts that may arise for students who are involved in other extracurriculars. Finally, your school’s parent coordinator can support outreach to and communication with parents at your school.

Operational and Logistical Supports
Consider how different people in your school community can support you with club operations and logistics, including reserving space, gathering materials, supporting offsite field trips to research symposia and other events, and communications with students and families.
Recruitment and Engagement of Prospective Club Members

Strategically Marketing Your Club
Start recruiting students early in the school year – you should do initial outreach to students in late November, and follow up outreach in early January. We encourage you to take a multi-pronged approach, making sure to publicize the club broadly, and to do targeted outreach to students who have shown interest or potential to be successful in the club. Aim to recruit 20-35 students initially, to account for attrition and absences.

Upping the “Cool” Factor
- Convey to students that the Science Research Club is interesting and fun! Highlight how exciting it can be to delve into a question or topic that they’ve been curious about or that is interesting and relevant, and that THEY – not their teachers, parents, etc. – get to choose.
- Include some hands-on activities in your club’s sessions to get kids enthused and to model different ways that scientists gather data about the world around them. This is a great way to incorporate a hands-on activity that you might not have time to do in your regular curriculum or during the school day. Things like dissections, gel electrophoresis, a cool (but not dangerous) demo, some hands-on fieldwork outside, etc. are all activities that intrigue and excite students, and can build their repertoire of laboratory skills and techniques. Make sure that you highlight these activities in your marketing materials.
- Consider hosting a guest speaker at a club session – maybe a local scientist, an alumnus/a of the school, or a parent or friend of the school who is a scientist or who works in a scientifically-based profession.
- Work with colleagues in your department to nominate students to participate, and explain that being nominated to participate is an honor and a testament to a student’s potential to be successful. Giving the club an element of selectivity can make it more intriguing to students, and may capture the interest of students who overlook a flyer or poster.
- Emphasize that successful participation in the club can lead to acceptance into the High School Science Research Pathways Program, a three-year program in which students can complete an independent research project and may be able to enter science research competitions and/or earn college credits.
- And, any kind of food or snacks you can provide are always a draw.

Targeted Marketing: Finding the Right Students
- Encourage your colleagues who work with 9th and 10th grade students to identify and proactively reach out to students who have some intellectual curiosity and a willingness to do independent work.
- Communicate with other members of your school community who may have students in mind: administrators, guidance counselors, deans, paras, parent coordinators, PTA members, etc.
- Create outreach pamphlets or flyers for students and parents. If many parents at your school speak a language other than English, consider preparing some materials in that language as well.
Logistical Tips
• Consider other activities going on after school, especially those that may pose a scheduling conflict for students, and try to schedule the club on days that don’t conflict with other activities that many students may be participating in.
• Make sure that other teachers, coaches, after-school advisors, etc. know about the club and are aware of which students are participating.

Engaging and Communicating Expectations to Students
It is important to engage students so that they are both excited about the club, and aware of and ready to meet the expectations of the club.

• To build student excitement, consider highlighting the fact that this club offers them the opportunity to select and explore any scientific topic that sparks their interest and curiosity – they will have the opportunity to investigate and become their club’s resident expert in that area of science! Additionally, make sure to publicize that the Science Research Club will give them skills in research and project management that will be applicable to college-level academics and in the workplace.

• Make sure students are aware that the club is inclusive, and open to all students who demonstrate intellectual curiosity and a commitment to full participation in the club, regardless of prior GPA and/or placement in honors classes or programs.

• Use multiple forms of outreach to get the word out about your club. You may want to create an easy-to-notice flyer that can be posted in hallways, classrooms, and offices. A sample flyer that you can adapt for your club is included in this guide.

• Encourage your colleagues – particularly teachers, administrators, and guidance counselors – to nominate promising students to be in the club. Being tapped by a teacher indicates to a student that he/she has the potential to be a successful member of the club.

• Clearly articulate the expectations of club attendance, participation, and preparation of projects for the June Research Symposium to students so they are aware of the time and effort they will need to contribute to be a fully engaged member of the club. Resources to help students plan out and manage their time are included in the appendix. Most students will be new to the experience of managing a long-term project, and we encourage you to incorporate time into your club’s meetings to introduce your students to project and time management tools. You should consider having a participation agreement that outlines these expectations for students, and that students and parents can review and sign off on to confirm their understanding of the club’s policies.

• Many students find it difficult to select a single topic to research. Let students know that, in order to complete their literature review and preparation for the Research Symposium, they will need to make a final selection of a research topic by early March. Students may choose to explore a different topic once enrolled in the research course in the following school year.
Encourage your colleagues to nominate promising students to be in the club!

Engaging Parents

- Parent engagement is an important part of your club’s recruitment strategy. In addition to speaking with interested parents, preparing pamphlets and/or flyers for parents, and working with your colleagues to foster parental support, you may also want to outline for parents in writing the goals of the club and the High School Science Research Pathways Program. For example, you could have parents review and sign the club’s participation agreement that outlines expectations for students, and that ensures that students have parental permission to attend after-school club sessions and the culminating June Research Symposium.

- You may want to also offer a face-to-face session with parents to build interest and support, and to provide a place where they can ask questions and get response in real time. This could be an information session at a PTA meeting or at an open-school night, or an evening open house, and could take place either prior to or during the first few weeks of the club.

Outreach Materials for Students and Parents

Below are two examples of marketing materials that you can adapt for outreach. Full-page versions of these can be found starting on page 59 in the appendix.

The program overview below outlines the mission and goals of the High School Science Research Pathways after-school Science Research Club. You may use all or part of this overview to share information about the club with students, colleagues, administrators, parents, prospective mentors, etc.

The flyer example can be adapted to students or parents. In doing so, consider what elements of the club might resonate particularly with students and with parents, so that you can make sure to highlight 4-5 brief pieces of information that you think would be particularly relevant to each group.
Week-by-week planning (November-June)

As you begin to plan out your club, it is important that you plan with both long-term goals and week-by-week tasks in mind. This section of the guide, which focuses on club planning and implementation, includes an overview chart of club milestones and goals for the coming months. It also includes a project map that will allow you to plan out your club’s week-by-week activities and the actions that you, your students, and your school’s administration will be taking to support your students in successfully preparing for the Research Symposium.

The overview chart, Club Planning Documents for Teachers, provided on page 65 of the appendix provides a rough outline of what teachers, students, and parents should be doing over the course of the winter and spring sessions of the Science Research Club. Achieving these milestones in a timely fashion will help ensure that each club is well-prepared for the June Research Symposium. As you begin to plan out the week-by-week progression of your club, you will want to start thinking about specific activities to do with your students each week. A significant amount of time in the early part of the club should be devoted to activities that support students’ success in identifying, reading, and evaluating specific kinds of scientific literature. Additionally, the first few weeks of the club should also include time for students to identify potential topics, and then select and scope a science research topic of choice.

Once students have selected a topic, subsequent club sessions should focus on students identifying and selecting articles to compile into a literature review. Students should begin by using articles from valid periodicals (e.g. The New York Times Science Times, Scientific American) that are geared towards the general public as they work to broaden their background knowledge and to identify areas of active research within their topic of interest. They should then move on to finding relevant primary research articles from scientific journals (e.g. Cell, Proceedings of the National Academy of Sciences). Each student should aim to select and closely read and analyze at least three to four primary research articles and one review article on their topic of interest.

The final four to five weeks of the club should focus on students preparing literature reviews that may be presented to their peers in the club, as well as at the culminating Research Symposium. Students should work on outlining the structure and sequence of their literature reviews, planning and preparing their posters, and the club should select students who will represent them with posters at the Research Symposium. Students should also select a single club member who will prepare and deliver a
“TED-style” talk on their selected topic of research at the Research Symposium. However, we encourage you to augment your students’ research and Symposium preparation during club meetings with activities that extend beyond reading and interpreting scientific literature. The Resources and Activities, pages 52 to 55 of the appendix, can be used to support students’ collaborative, investigative, and technical skills. Feel free to use or adapt these, or to develop your own activities.

To help plan your week-by-week club agendas and activities, we encourage you to use a planning document like the one on page 67 of the appendix, which provides space for weekly planning from November through June.

Working With Scientific Literature and Conducting a Literature Review
A literature review encompasses multiple articles on a specified topic. For your club, each student should select and include five to ten articles on a specified topic. Articles may include a combination of the following:

General Audience-Focused Articles: These articles come from valid sources, such as newspapers, periodicals, or websites published by reputable sources (e.g. well-known newspapers or magazines, or websites of governments, universities, and research institutions) that focus on a scientific topic, but that are intended for the general population. These are good resources for students to use when they are doing initial research into a topic, as they often focus on more active research areas and can be helpful in narrowing a broad topic (e.g. autism, black holes) into a more specifically-scoped area of research. Examples of periodicals with these kinds of articles include The New York Times Science Times, Scientific American, Popular Science, The Economist, and Atlantic Monthly. This blog posting (http://blogs.scientificamerican.com/guest-blog/finding-good-information-on-the-internet/) from Scientific American provides some useful tools for verifying if a general audience article is indeed from a valid source.

Primary Research Articles:
Primary research articles come from peer-reviewed scientific journals that are intended for a scientific audience. Each article discusses a single investigation, and includes background information, materials and methodology, data, and an analysis and conclusion. Each primary article also has an abstract at the beginning that summarizes the article’s findings and implications; the abstract is a useful way to “pre-vet” the article and determine whether it is likely to be relevant and accessible enough to warrant reading the full article. Examples of peer-reviewed journals include Nature and The Journal of Cell Biology. Each student should have a minimum of three primary research articles in their literature review.

Review Articles: Review articles draw from multiple primary articles to provide an overview of recent developments in a specified area of scientific research. These articles are also published in peer-reviewed scientific journals, and can be distinguished from primary research articles in that they describe recent developments in an area of research, rather than the results and analysis of a single investigation. Review articles are essentially literature reviews themselves, and
they are an excellent way for students to get a sense of research development areas; they also include references to primary articles, which makes them a useful source for identifying additional research articles to review. Each student should have a minimum of one review article in their literature review.

**Student Organizational Techniques**

Students should spend the first few weeks of their project selecting and reading articles, which will in turn help them to identify a scope of research within their topic area of choice. Once students have closely read and annotated at least 5-6 selected articles, they may begin to start organizing information from these articles into an outline or graphic organizer so that they can structure their ideas, identify connections between different sources, and identify the main point or idea(s) that they want to convey in their literature review. This work of organizing their research and thinking will be helpful as they begin to plan out their deliverables for the Research Symposium and other culminating events.

There are a number of different activities that can be used to support students’ literacy and analysis of scientific texts. For example, students can use article review and discussion sheets with structured questions that support their understanding of major themes and supporting evidence in a given article. On pages 22 to 24 of the appendix there are three sample Article Review Sheets that are tailored to the three types of articles students will use – general audience-focused articles, primary research articles, and review articles. Additionally, the appendix also offers sample graphic organizers that students can use to structure the information that they have gathered, and provides group discussion guides that include questions and prompts to drive small group or club-wide conversations around selected articles.

**Suggested Activities to Keep Students Engaged**

While the Science Research Club primarily focuses on students’ exploration of a research topic through a review and synthesis of scientific literature, including interactive or “hands-on” activities is a great way to capture students’ interest and to increase the “cool” factor of a club. Interactive activities can include collaborative group work, exploring online simulations, or providing peer feedback on written work or presentations. In addition to being intriguing and appealing to kinesthetic learners, hands-on activities can complement articles students are reading by providing them with opportunities to carry out similar experimental techniques or simulations. We encourage you to structure your club in such a way that part of the time is spent doing research, reading, and writing, and part of the time is spent doing other more interactive activities. Additionally, to make the most of your limited amount of time, you may want to ask students to complete some work for the club on their own time as homework.

**Landmark Experiments and Case Studies**

You may also consider incorporating some famous or exciting experiments to capture students’ interest and to provide examples of the process of scientific discovery, and how multiple investigations and articles contribute to a discovery.
Some examples include:
• John Snow’s investigation into cholera transmission in 1850s London
• Charles Darwin’s development of the theory of evolution via natural selection
• Barry Marshall’s confirmation that *Helicobacter Pylori* bacteria cause stomach ulcers

You can also find articles to capture students’ interest in *The New York Times* (especially the Tuesday’s *Science Times*), the science sections of *The Economist*, the health and technology sections of *The Atlantic*, and through the website [www.sciencefriday.com](http://www.sciencefriday.com).

**Hands-On and/or Interactive Activities**

Consider incorporating hands-on activities that you’ve always wanted to do in your classroom – but haven’t had the time – to add some inquiry-based activities to your club. You can also incorporate activities that will help students expand their repertoire of technical skills for the laboratory, which students can then list on their resume or other outreach to prospective mentors. While ingenuity and creativity are encouraged, please make sure that all hands-on activities comply with New York City Department of Education Science Safety Manual standards.

So many choices ...

- **Dissections** – frog, fish, fetal pig, etc.
- **Gel electrophoresis** (use a forensics-style kit to make it really exciting)
- **Microbiology investigations** – preparation of agar plates, sample collection and plating, sterile technique
- **“Lab Olympics”** – students learn some basic laboratory skills (pipetting, labeling, creating a serial dilution, using triple-beam and digital balances, using a light microscope, measuring pH, selecting the right glassware for mixing, measuring, etc.) and show what they’ve learned in a team competition that rewards speed, accuracy, and safety
- **DNA extraction** from strawberries, bananas, thymus, etc.
- **Fieldwork in your community** – bird-watching, seining, water/air/soil quality analysis, transect sampling, exploring local geology, etc.
- **Cleaning water investigations** (filtration, determining the best way to separate a mixture, simulated oil spill cleanup)
- **Chromatography** with markers and/or spinach leaves
- **Dynamic demonstrations** (e.g. demonstrating nucleation through the bobbing raisins or Mentos/diet Coke geyser activities)
- **PhET Simulations** - online simulations of scientific phenomena
- **Field trips to science-rich cultural institutions** or to laboratories at a local college, university, hospital, or research institution.
Planning and Preparing for the Research Symposium
The STEM Matters NYC Research Symposium is the culminating event for the HSSRP Science Research Club. Taking place in early June, this event provides clubs members with an opportunity to share their work, and to see the work and accomplishments of other clubs.

Each Science Research Club will select three students to prepare tri-fold boards:
Clubs will select and submit three students’ research projects to represent their club at the Research Symposium. Each student will share their research in the form of a tri-fold board that provides an overview of literature on a student’s selected research topic, and will draw from five to ten articles the student has selected and reviewed over the course of the club. While students may use a combination of scientific journal articles and scientific articles written for a general audience, at least three selected articles should be primary literature articles from scientific journals that are based on specific experiments or investigations, and at least one article should be a review article.

Each student who prepares a tri-fold board should be prepared to present their board to Research Symposium attendees. As this board focuses on a literature review, it will have a slightly different structure from the classic “science fair”-style board. Please see Creating Great Boards and Other Visual Resources, page 57-58, of the appendix for additional information on setting up a tri-fold board.

Each Science Research Club will select one student to deliver an eight minute “TED-Style” Talk on his/her research topic:
Each research club will select one student speaker, who will present an overview of his/her research topic in an engaging “TED-Style” talk for an audience of Research Symposium attendees. Included below are examples of TED talks for you and your students to review.

TED Talk Playlists: Ted Under 20 (TED Talks from presenters under the age of 20)
TED-Ed Lessons: Check out the Science & Technology section for examples of how your students can present their research topics

Additional TED Talks can be found at http://www.ted.com, and we encourage your students to view a variety of talks to see both the diversity of TED Talk styles, as well as some of the common elements that all good TED Talks share. For example, while TED Talks vary in style and scope, all are well-rehearsed, easy to follow, and engaging. We encourage you to have ALL students in your club prepare a “TED-style” talk, and to then use popular vote or peer review to select a single speaker who will present at the Research Symposium.
Selecting Student Presenters for the Research Symposium

Being limited to three tri-fold boards and one student speaker means that only a fraction of you club members will be able to present their research at the Research Symposium, so you will need some kind of criteria to select which students present. While we leave the specifics of selection up to you, we encourage you to:

- consider students who have been particularly enthusiastic or creative with their project, have developed unusually sophisticated analyses and ideas, or who have really impressed you in the way that they have taken their research in a new and innovative direction;
- select students who have strong presentation skills, in terms of putting together a board, and in talking about their research; and
- involve all club members in the selection of their peer who will represent their club at the Research Symposium.

You may select three students to present boards and one student to deliver a TED-style talk, or you may select two students to present boards, and one student to present a board AND a TED-style talk. You will need to submit the names of your selected student presenters to the HSSRP program team approximately a month before the Research Symposium. We will share additional details about preparations and logistics, including buses, drop-off of tri-fold boards, and outreach information for parents and families a few weeks prior to the Research Symposium.

Please note that all of your Science Research Club students – whether presenting or not – and their families are encouraged to attend the Research Symposium. The Research Symposium will celebrate the accomplishments of all your club participants while providing your students an opportunity to network with their peers from other HSSRP program schools, so all club members – whether presenting or not – can benefit from and contribute to the Research Symposium.
From Club to Course: Linking Your Science Research Club to Next Year’s Course

The Science Research Club as a Preview to the Science Research Course
Your Science Research Club plays an important role in recruiting students for the Science Research Course that you will be leading in the following school year. Leading the Science Research Club enables you to gauge if:

- there is sufficient student interest in science research to launch a full course;
- science research is a program that is a strong fit for the students at your school; and
- you enjoy the process of advising on students’ scientific research.

Additionally, a Science Research Club that is successful in recruiting students and supporting their independent research can demonstrate the value of a comprehensive science research program to your school community, and can help to build support for launching a comprehensive science research program from administration, colleagues, and parents.

To that end, we urge you to consider ways that you can start planning for the course while you are leading your club. Not only will you be able to market the course to club members and their families during club meeting and/or parent engagement events, but you will also have a clearer picture of the contextual elements – student needs, library and research resources, classroom space, etc. - that you will need to consider what planning, marketing, and teaching your research course in the following school year.

Overview of Planning and Logistics for the Science Research Course
A brief timeline of activities pertaining to preparing and recruiting for your research course is outlined below. Please also see the Science Research Club timeline on page 65 of the appendix for more detailed recommendations on how to introduce the Science Research Course during club meetings and activities.

November-December: As you recruit students for your Science Research Club, make sure that they are aware that one of the purposes of the club is to explore their interest in taking a year-long Science Research Course that will begin in the following September. If your school is participating in SUNY Albany’s Science Research in the High School program, make sure that students know that they may be able to earn college credit through participation in the Science Research Course and independent summer research projects. Additionally, make sure that any colleagues assisting in student recruitment and/or nominating students are familiar with the course and the fact that the club can be a way for students to gauge their interest in committing to the Science Research Course in future years.

Finally, make sure that you are familiar with all programming timelines for the upcoming school year – this includes when elective course offerings are approved and/or confirmed, when students select next year’s courses, when course meeting times and locations are finalized, and when teacher schedules for the
upcoming year are finalized. Knowing the timing for these processes will help you to ensure that all logistics of the Science Research Course scheduling are completed in a timely fashion and in compliance with your school’s policies.

**January – March:** As your club continues, begin to informally assess students’ interest and initiative in the research club to help you identify students whom you want to proactively recruit to the course. Additionally, consider where students are in terms of progress in research and scientific literacy skills, and in their ability to identify and scope their research topic of choice. Gauging your students’ particular strengths and growth areas can inform the structure of your Science Research Course as you begin to plan out the course’s curriculum. You may also want to have an outreach session or nomination process for interested students who are not presently participating in the spring club due to after-school commitments or other conflicts.

You should also have an initial programming/scheduling conversation with your principal, AP, or other individual in your school who is responsible for programming to insure that you will be able to reserve space in both the building and in your teaching schedule to accommodate the research course in the upcoming school year.

**April – June:** As you approach late spring, make sure to have individual conversations with students whom you think are prospective candidates for the course, including students whom you definitely want to enroll and students who may be borderline candidates. Consider distributing course information to students and parents before the end of the school year. Additionally, we encourage you to create and distribute a brief summer assignment for students planning on taking the course to keep the momentum from club going over the summer.

**July – August:** Finish mapping out your Science Research Course curriculum for the upcoming school year, and finalize any outstanding scheduling or enrollment logistics. Create course expectations and policy documents for students and for their parents. You may want to schedule an intermediate or end-of-summer check-in with each student if you have asked students to complete a summer assignment. Finalize identifying or compiling any course materials you may need for the first 2-3 months of the course.

**September:** Launch your Science Research Course!
Creating a Multi-Year Research Program, and Incorporating College Credit through SUNY Albany’s University in the High School Program

As you develop a multi-year science research program, consider what long-term goals you would like your students to achieve after 2-3 years of enrollment in the program.

While not required, some schools may elect to participate in SUNY Albany’s University in the High School program, through which students can earn up to 12 college credits. Teachers who are interested in this opportunity should consult the SUNY Albany University in the High School website (http://www.albany.edu/uhs), which provides program details, including dates and fees of scheduled summer trainings that are required for teachers who want to become certified to teach a college credit-bearing course.

If you have elected to make your science research program a college credit-bearing program through SUNY Albany’s University in the High School (UHS) program, please make sure that you are aware of and adhering to all UHS policies and guidelines. An overview of these guidelines is available online (http://www.albany.edu/scienceresearch/guidelines.shtml).
Appendix

Resources for Finding and Selecting Articles
• Resources for Searching for Articles
• Journals and Databases that Are Accessible to Students
• Selecting Articles to Read More Closely

Resources for Close Reading, Annotation, and Analysis of Selected Articles
• Article Summary Guides
• Close Reading and Annotation Resources
• Group Discussion Resources and Additional Literacy Teaching Strategies

Resources for Understanding Scientific Terminology and Interpreting Data and Statistics
• Statistical Analysis Resources
• List of Commonly-Used Scientific Terms and Definitions

Resources for Communicating Scientific Research and Preparing for the Research Symposium
• Preparing a Literature Review and Presentation: Best Practices and Research Symposium Specifics
• Evaluation Rubric for Student “TED-Style Talk” Presentations
• Creating a Literature Review Board
• Preparing for the Research Symposium

Resources for Student Recruitment and Parent Outreach
• Mission and Goals Statement
• Sample Recruitment Flyers for Students and Parents
• Sample Student and Parent Contract

Resources for Monitoring Students’ Research Progress and Helping them to Stay Organized
• Best Practices and Things to Expect
• Two-Week Action Plan for Students

Additional Resources
• Club Planning Documents for Teachers
• Additional Articles
Resources for Finding and Selecting Articles

Selecting Articles to Read More Closely

Selecting appropriate research articles to include in a literature review for the High School Science Research Pathways Science Research Club can seem daunting to a student who is new to research. Many students will find that a search for their topic yields hundreds of different articles, and they may find that some of these articles are on very specific sub-topics, or include so much new terminology and/or complex mathematics or other analytics that they struggle to grasp even the main ideas of the article. The flow chart on the following page outlines a process by which students can select articles that are well-suited to including in their literature review – e.g., they are interesting, focused on the student’s topic of interest, and include methodologies, data, and analysis that the student can understand and interpret successfully. While this flowchart is geared towards searching for primary research articles from peer-reviewed scientific journals, it can be adapted to general audience or review articles.


This article provides an overview of strategies for finding scientific articles on a specific research topic via academic search engines, and lists a number of relevant search engines that are available to students. It also includes a section that outlines some of the ways that students can access a copy of a full article if they are not able to directly download it from an academic search engine.

Finding Good Information on the Internet (from www.scientificamerican.com):

This article provides an overview of resources for finding and interpreting scientific articles and articles that are intended for a more general audience. In particular, it outlines some strategies for assessing the validity of online information sources that are not peer-reviewed journals. This article is particularly useful for students who are in the early stages of their research, and are using general audience-focused articles to identify a research topic of interest.
Journals and Databases that are Accessible to High School Students

The databases listed below are open-access, meaning that the journal articles they offer are publicly available and free of charge.

**BioMed Central** ([www.biomedcentral.com](http://www.biomedcentral.com))
BioMed Central publishes 291 peer-reviewed open access journals. As the name suggests, most journals are focused on life sciences or medicine and health.

PubMed Central (PMC), is the U.S. National Library of Medicine’s digital archive of biomedical and life sciences journal literature, providing free access to the full text of articles.

**Directory of Open Access Journals** ([https://doaj.org](https://doaj.org))
DOAJ is an online directory that indexes and provides access to over 10,000 high quality, open access, peer-reviewed journals in all subjects and languages. Over 6000 journals are searchable at an article level. Students can search for topics by keyword, article title, or journal name.

**Highwire Press’ Free Online Full-text Articles** ([http://highwire.stanford.edu/lists/freeart.dtl](http://highwire.stanford.edu/lists/freeart.dtl))
HighWire Press offers over 7 million articles via links to specific journals’ websites. Many of the sites listed are either completely free, or offer archived articles (usually articles published over a year ago) or trial periods free of charge. (There are also links to partner sites that offer articles on a pay-per-view basis; students can gather the names of any pay-per-view articles and then search for them via a Google search to see if a free PDF is available online.)

**Open Science Directory** ([http://www.opensciedirectory.net/](http://www.opensciedirectory.net/))
The Open Science Directory IOC/IODE, provides a unique access point to all the journals contained in several different open-source programs. It is a good comprehensive source for finding databases other than those listed above.

**Google Scholar** ([https://scholar.google.com/](https://scholar.google.com/))
A useful database for researching scholarly articles in a variety of disciplines – includes both abstracts of articles and some full articles. Students can also create an email alert to be notified of new articles or publications in their area of research.

**Journal of Emerging Investigators and National High School Journal of Science** ([http://www.emerginginvestigators.org](http://www.emerginginvestigators.org) and [http://nhsjs.com](http://nhsjs.com))
These two journals are authored, reviewed and published by high school students. In addition to being open-source, they are helpful resources for gathering background knowledge of identifying possible research topics.

**NovelNY** ([http://novelnewyork.org](http://novelnewyork.org))
NovelNY, the New York Online Virtual Electronic Library, provides New York state residents with access to a vast array of databases, journals, magazines, and articles.
Selecting a Research Article:
A Step-by-Step Guide

01
TITLE

Read the title and abstract of the article.
Ask yourself, “Based on the information in the title and abstract, does this topic seem interesting and/or relevant to my research topic?”

Yes

No

02
HYPOTHESIS

Find and read the hypothesis or statement of purpose of the article (usually in the last paragraph of the introduction).
Ask yourself, “Based on the hypothesis or statement of purpose, do I understand what the experiment described in this article was investigating or testing? If yes, is the question investigated in this experiment relevant, interesting, and clearly defined?”

Yes

No

03
METHODOLOGY

Find and read the methodology section.
Ask yourself, “Are the methods clear and understandable? Based on my reading of the methodology, can I explain in my own words what the investigators did and why they set up their investigation in the way that they did?”

Yes

No

04
DATA

Review the data presented in the results section.
Ask yourself, “Do the charts, graphs, tables, or pictures presented contain clear, easy-to-understand data? Can I explain what is happening in most or all of the data charts or figures, and can I explain how the data presented in the results section related to the hypothesis or statement of purpose?”

Yes

No

05
CONCLUSION

Review the discussion and conclusion (you may want to review the conclusion first and then see if you can understand the discussion.)
Ask yourself, “Do I understand what is being discussed in the discussion and conclusion sections, and can I use the information provided in these sections to understand how or why the results of this experiment support or refute the hypothesis and/or answer the question posed in the statement of purpose?”

Continue
Resources for Close Reading, Annotation, and Analysis of Selected Articles

**Article Summary Guides**

Article summary guides for selected periodicals and articles that students find through their research can be used to help students find the main themes and ideas in a given article. They can also help students to identify key information or facts that they have gathered, and to raise questions or identify information that they still need to collect. There are three kinds of article review sheets:

**General Audience Articles:** This review sheet can be used for any article that is written for a general audience, rather than for the scientific community specifically. Sources include reputable newspapers, magazines, press releases, and websites.

**Primary Research Articles:** This review sheet can be used for any article that is published in a peer-reviewed scientific journal and that outlines the methodology, results, and analysis of a single research investigation.

**Review Articles:** This review sheet can be used for any article that is published in a peer-reviewed scientific journal and that synthesizes information from multiple primary research articles to offer a general review of a given topic.

**Close Reading and Annotation Resources**

The following resources support students’ close reading of scientific texts. In addition to providing sample questions to support comprehension of text and figures and specifics on annotation techniques, they also encourage the students to utilize all components of selected article, including the abstract, data, discussion, and conclusion sections.

**Additional Questions to Support Close Reading of Research Articles**

- Parts of a Journal Article
- Guide to Annotating Text
- Identifying Claims and Supporting Evidence
- Teachers Guide to Reading Primary Literature

**Group Discussion Resources and Additional Literacy Teaching Strategies**

These resources foster thoughtful group discussion of selected research articles.

- Group Article Share-Out
- Additional Literacy and Teaching Strategies in Science
General Audience Article Review Sheet

**Directions:** Select a general audience-focused article from a valid source, such as a well-known newspaper, magazine, or university or government website. Your article should be at least 3-4 paragraphs long, and should mention current research studies or trends.

Title of Article: ________________________________________________________________

Author: ______________________________________________________________________

Source (e.g. name of magazine, newspaper, or institution):_________________________

Date of Publication: ___________________________________________________________

Article Summary:

What new information did you find?

What new questions do you have after reading this article?

What information from this article will you include in your literature review?
Primary Research Article Review Sheet

Directions: Select a primary research article from a peer-reviewed scientific journal that provides a detailed overview and explanation of a specific scientific investigation.

Title of Article: ____________________________________________________________

Author: _________________________________________________________________

Name of Journal: _________________________________________________________

Volume/Edition/Date of Publication: _______________________________________

Article Summary:

What was research question that this article was investigating?

What new information did you find in the data section?

What new information did you find in the discussion and conclusion section?

What new questions do you have after reading this article?

What information from this article will you include in your literature review?
Review Article Review Sheet

Directions: Select a review article from a peer-reviewed scientific journal that draws on results from multiple primary review articles on a similar topic to provide an overview recent or current research trends in this topic.

Title of Article: ________________________________________________________________

Author: _____________________________________________________________________

Name of Journal: _____________________________________________________________________

Volume/Edition/Date of Publication: ________________________________________________

Article Summary:

What new information did you find?

What new questions do you have after reading this article?

What information from this article will you include in your literature review?
Close Reading and Annotation Resources

Additional Questions to Support Close Reading of Research Articles

The templates on the previous three pages are simply suggestions for how to encourage your students to investigate and explore different research articles. Based on your students’ needs, available time, and the number of articles that each student chooses to explore, you may find that you would like students to answer additional questions about a given article to show that they have reviewed it in depth. The list below contains additional close reading questions that you may want to include in article review sheets that your club uses.

INTRODUCTION

1. Was relevant background information – in the form of related theories, investigations, or literature - reviewed so that the gaps between the current knowledge and the research’s topic of interest were identified?

2. Was the objective and/or statement of purpose stated clearly? If not, could you figure out what objective and/or statement of purpose they were investigating and explain it in your own words?

3. Were the research questions and/or hypothesis that the investigation is testing clearly stated? If not, could you figure out what hypothesis or research question they were investigating and explain it in your own words?

4. What limitations of the study were noted and explained?

METHOD

1. What kind of research design (observational study, double-blind study, etc.) was used in this article? Why do you think that the researchers selected this type of study to investigate their selected research questions or hypothesis?

2. What steps did the researchers take to successfully set up their study in terms of selecting participants or samples, setting up control and experimental groups, etc. so that they effectively answered their research question and/or tested their hypothesis?

3. What unfamiliar terms, equipment, or procedures did you encounter when you read the methods section? Were you able to look up and define all unfamiliar terms in this section?
RESULTS

1. Explain how the results that are shared in this article link back to the purpose and hypothesis/research question outlined in the introduction of this investigation.

2. Which 2-3 tables, graphs, or other pieces of data shared in the results section are ones that you would consider including in your literature review? Why are these data pieces particularly useful?

3. Are pictures, illustrations, photographs or diagrams included in the results section? If so, why did the author include them in this specific study’s results?

4. What statistical techniques were used to look for patterns or assess the statistical significance and validity of the data collected? Do you feel that the author used appropriate statistical analyses, or would you recommend using alternative or additional statistical tools?

DISCUSSION & CONCLUSION

1. How does the author walk the reader through the explanation of WHY he/she got the results that were recorded? Were any aspects of the author’s thinking or discussion unclear?

2. Do the results and analysis support or refute the hypothesis presented in the introduction (Alternatively: Do the results and analysis address the research question(s) posed?)

3. Did the author/s relate their findings to one or more broader scientific theories and/or a larger body of previous research?

4. Did the authors suggest future research areas to investigate?

5. What are the strongest aspects of this study? How could this study be improved?
Parts of a Primary Research Article: What they are and How to Approach Reading Each of Them

Primary research articles are typically broken down into six sections: abstract, introduction, materials and methods, results, discussion, and references. A few journals have slightly different formats due to their space constraints or target audience. The most common alteration is to combine the results and discussion parts into a single section. Each part of the paper serves a unique purpose and can help your research project in a different way.

Abstract
The abstract is a summary of the paper. It usually highlights the main question(s) the authors investigated, provides the key results of their experiments, and gives an overview of the authors' conclusions. Reading the abstract will help you decide if the article was what you were looking for, or not, without spending a long time reading the whole paper. Abstracts are usually accessible for free either online at journals' websites or in scientific literature databases.

Introduction
The introduction gives background information about the topic of the paper, and sets out the specific questions to be addressed by the authors. The quantity and thoroughness of the background information will depend on both the authors' proclivities, and the guidelines for that specific journal. Throughout the introduction, there will be citations for previously published articles or reviews that discuss the same topic. Use these citations as recommendations for other articles you can refer to for additional background reading.

Reading the introduction is a test of whether or not you are ready to read the rest of the paper; if the introduction doesn't make sense to you, then the rest of the paper won't either. If you find yourself baffled by the introduction, try going to other sources for information about the topic before you tackle the rest of the paper. Good sources can include a textbook; online tutorials, reviews, or explanations; a review article or earlier primary research article (perhaps one of the ones cited in the introduction); or a mentor. If even after trying all these sources you're still confused, it may be time to consider a new topic.

Materials and Methods
The materials and methods section gives the technical details of how the experiments were carried out, including the types of controls used and where unusual resources (like a bacterial strain or a publicly available data set) were obtained. Reading the methods section is helpful in understanding exactly what the authors did. After all, if you don't understand their experiments, it will be impossible to judge the veracity of their results and conclusions! This section also serves as a "how-to" manual if you're interested in

(adapted from http://www.sciencebuddies.org/science-fair-projects/top_science-fair_how_to_read_a_scientific_paper.shtml; be sure to check this link out for additional resources!)
carrying out similar experiments, or even in repeating the same experiments as the authors did.

The materials and methods section is most commonly placed directly after the introduction. But if you can't find it there, check the end of the paper, just before the references, or look for a URL within the research article for a “supplementary information” section online.

Results
The results section is the real meat of a primary research article; it contains all the data from the experiments. The figures contain the majority of the data. The accompanying text contains verbal descriptions of the pieces of data the authors feel were most critical. The writing may also put the new data in the context of previous findings. However, often due to space constraints, authors usually do not write text for all their findings and instead, rely on the figures to impart the bulk of the information. So to get the most out of the results section, make sure to spend ample time thoroughly looking at all the graphs, pictures, and tables, and reading their accompanying legends!

Three types of information can be extracted from the results section: data from the experiments, ideas about how to improve the methods, and an understanding of how to represent similar data.

For example, a graph of the data might show that although the authors took time points every hour, there was no change at all until five hours into the experiment, and then the change was rapid. By interpreting their graph yourself and making this observation, you would be able to repeat the experiment, with differentially spaced time points, to resolve what actually happened during the fifth hour. And last, but not least, studying the figures will help you understand how to represent your own data in a way that is clear, accurate, and in keeping with the standards in that particular field of science.

Discussion
The discussion section is the authors' opportunity to give you their opinions. It is where they draw conclusions about the results. They may choose to put their results in the context of previous findings and offer theories or new hypotheses that explain the sum body of knowledge in the field. Or the authors may comment on new questions and avenues of exploration that their results give rise to. The purpose of discussion sections in papers is to allow the exchange of ideas between scientists. As such, it is critical to remember that the discussions are the authors' interpretations and not necessarily facts. However, this section is often a good place to get ideas about what kind of research questions are still unanswered in the field and thus, what types of questions you might want your own research project to tackle.

References
Throughout the article, the authors will refer to information from other papers. These citations are all listed in the references section, sometimes referred to
as the bibliography. Both review articles (often cited as "reviewed in...") and primary research articles, as well as books or other relevant sources, can be found in the references section. Regardless of the type of source, there will always be enough information (authors, title, journal name, publication date, etc.) for you to find the source at a library or online. This makes the reference section incredibly useful for broadening your own literature search. If you're reading a paragraph in the current paper and want more information on the content, you should always try to find and read the articles cited in that paragraph.

How to Proceed When Reading a Scientific Paper

Whether you're reading a review article or a primary research paper, you're likely to come across vocabulary and concepts with which you're unfamiliar. It's a good idea to have other resources on hand to look up those words and ideas. For example, a scientific dictionary is useful for checking unfamiliar vocabulary, and textbooks are excellent starting places to look up scientific concepts. Internet searches for tutorials or explanations about a specific method or concept can also be useful. And don't forget that people, like mentors and science teachers, can also be great resources when you're stuck.

You're likely to find that reading and understanding a scientific paper is an iterative process: read, look things up, re-read, etc. But if you find that you're spending hours looking up information and not making any progress, then it may be time to consider that this paper is not for you. If that's the case, try going to a more general paper (like a review or textbook entry) about the topic and then returning to the paper after you're more informed. And if that still doesn't help, it may be time to consider changing your topic.

Highlighting important data and making notes directly on a photocopy or printout of the paper can be a good ways to keep track of the information as you move through the paper. Taking notes will help you encapsulate what is important about the paper, and keep you focused on the task. You may even want to make a diagram or sketch in the margins to remind yourself how an experiment was done. These notes also provide a visual key to the pieces of data most relevant to you so that when you need to go back to the paper to remember a detail, it'll be easy for you to find it.

In all cases, start by reading the abstract; read it to make sure the paper is what you were looking for and is worth your time and effort. If the abstract indicates the paper is of interest to you, move on to the introduction. If you're already familiar with the paper's topic, you can just skim the introduction and materials and methods sections to make sure you're truly up-to-date. But if you aren't familiar with the topic, or if skimming reveals terms or concepts you don't understand, you'll need to read the introduction and then the methods section carefully, stopping to consult other resources or cited literature to augment your understanding.

Once you're sure you have a handle on the background information and an idea of how the experiments were performed, you're ready to tackle the results section. The first step is to examine each figure and table. Make sure to read the accompanying figure legend so you know what all the variables are, and refer back to the methods if you're unsure of how the data was collected. Try to analyze and draw your own conclusions from the figures. Then, once you've looked at all the figures, go back and read the results text. Since you've already been through the data on your own, you'll be better able to follow the authors' writing, and to decide if you agree with the conclusions they're making about the data.
Lastly, if you're interested in the authors' interpretations of the results, read the discussion. If you're already very familiar with the topic, you may find that reading the discussion is unnecessary. But for people just entering the field, discussions are a good place to get a glimpse of what the current competing theories and hypotheses are.

A Guide to Annotating Science Research Articles

The process of annotation – in which a reader marks up a text with underlining/highlights, symbols, and notes in the margins – is critical to developing skills in the close reading and interpretation of scientific texts, especially when seeking to identify main ideas and supporting evidence in primary research articles or review articles that include new terms, complex ideas, and dense, information-rich text. We encourage you to walk your students through the process of annotating a scientific article together as a group, and then support them in annotating the articles that they select for their individual research process. While students should have the freedom to develop an annotation process that works well for them, there are some best practices of annotation of scientific texts that all students in the club should be encouraged to adopt. This will create a consistency across students’ annotations — which will be helpful in group readings or discussions — and will help to insure that you understand your students’ thought processes when you review their annotated articles.

When Annotating a Scientific Article...

1. Read the article’s abstract and/or introduction to see if you can identify the main idea of the article. Make sure to write down or paraphrase the main idea in your own words somewhere near the title or abstract.

2. Use underlining or highlighting to note important words or main ideas. This helps to distinguish key terms and concepts from supporting text. It is a good rule of thumb that students highlight no more than one sentence at a time – many students are tempted to start highlighting the bulk of the text, which defeats the purpose using highlighting or underlining to differentiate particularly critical terms or statements.

3. If you encounter a passage of text that is unclear at the moment, mark it with a question mark (?) symbol so that you can return to it once you’ve completed reading the article to explore it more deeply. If a large passage of text is confusing, use a bracket in the margin to identify the beginning and end of the passage.

4. Circle any unfamiliar terms so that you can look them up later. Once you do, you may want to write in their definitions in the margins next to the text where they appear.

5. Use the margins to include notes, clarifying questions, and other responses to the text. Putting notes in the margins memorializes the thinking and respons-
es that you have formulated as you read
the text. Consider using the margins to
the left of the text to number paragraphs
or synopsize the text – this will make it
easier for you to search through the text
later on, and will build a de-facto outline
of the text. Use the margins to the right of
the text to include your responses to the
text – noting things that are surprising,
interesting, confusing, or that have con-
nections with other texts or ideas.

Other Resources for
Developing Students’
Annotation Skills

Hunter College Reading/Writing
Center: Annotating a Text
(http://www.hunter.cuny.edu/rwc/
repository/files/the-writing-process/
 invention/annotating-a-text.pdf/view?
searchterm=annotating%20a%20text):
This handout, prepared by the staff at
Hunter College’s Reading and Writing
Center, provides a succinct and stu-
dent-friendly overview of best practices
in annotating text, and also provides
some examples of annotate text.

Science in the Classroom (http://
scienceintheclassroom.org/):
A project of the American Association
for the Advancement of Science (AAAS),
this website offers an assortment of pre-an-
notated primary research articles from
Science (http://www.sciencemag.org/),
the AAAS’ flagship journal. Students can
use a “Learning Lens” function on the
right side of the page to uncover differ-
ent categories of annotations, including
glossary annotations for unknown words,
references to previous work, information
specifically related to the author’s work
and conclusions, and links to policy
implications and references. It is a great
way for students to explore some exam-
ple of annotated scientific text before
they begin to do their own annotating.
A detailed Teacher’s Resource provides
detailed information on how to use the
annotated articles and other resources
on the site.

Reading Techniques Help
Students Master Science
(http://www.scientificamerican.com/
article/reading-techniques-help-stu-
dents-master-science/): This Scien-
tific American Article describes some
techniques that support development of
literacy skills pertaining to scientific texts,
and includes links to specific techniques
and in-depth studies.

A list of annotation symbols:
Sharing a chart of annotation symbols
gives students a common language of
annotation, and also outlines some of the
different types of annotations that they
should make. You may already have a
chart that you use; if not, check with col-
leagues or online resources to view some
samples.

Your school’s ELA department
and/or librarian: Many ELA teach-
ers include annotating text as part of
their curriculum. Reach out to your ELA
teachers to see what kind of work they
have been doing with students – not only
may they have resources to share with
you, but you can also make sure that
the annotation skills that you are teach-
ing in your Science Research Club align
with what students are learning in other
classes – e.g., if the ELA teachers are
using a set of annotation symbols in their
classes, you may want to use the same set of symbols in your Science Research Club. Your school's librarian may also have annotation resources on hand, and s/he also may be able to direct you to additional annotation resources in your school's library or on online.

**Group Discussion and Reflection Resources**

Group discussion activities are valuable ways to build on your students’ individual research and reading of their articles, and are a good intermediate step to include as students segue from the research and reading portions of their work to beginning to prepare for the Research Symposium. Students can get feedback from peers on the quality and clarity of their presentation of articles, and can use questions from classmates to identify research areas to explore further, or to identify aspects of their presentation that should be more clearly explained. The roundtable conversation handout on the next page provides a template for structuring group discussions so that they stay on topic, use time effectively, and give all members of the group a chance to share their own work and to reflect/provide feedback on the work of others.

Additional resources in this section include a set of literacy strategies developed by Allyson Nusser (a literacy consultant who works with HSSRP teachers), and an article, Teachers’ Guide: Reading Primary Literature, which overviews a number of different strategies and assignments for building students’ capacity in working with the kinds of complex texts that they will encounter through their research.
Group Article Share-Out

**Directions:** Students should pair up with 2-3 fellow club members to form a group. Each student should bring one article that they would like to include in their literature review and the sheet below. Students should prepare the pre-work portion of the sheet in advance of the actual discussion with their peers.

**Pre-Work**

1. **Prepare a 3-5 minute synopsis of your article.** You should articulate the research question or hypothesis investigated, and should briefly describe the methodology used, the kind of data collected, and how the data was interpreted to answer the original research question and/or support or refute the hypothesis. Use the space below to write out or outline your synopsis.

2. **Identify any terms, concepts, or passages that you had difficulty understanding.** Share these with your discussion partners to see if they have any ideas or suggestions for how to approach these so that you can gain understanding.

3. **What are your next steps with this article?** Do you plan to re-read it? Use it as a jumping-off point for additional research? What questions to do you for your peers regarding your next steps?
# Discussion Activity

Students should take turns sharing their articles. Each student should have 3-5 minutes to share out his/her synopsis, while students listening fill in the charts below:

<table>
<thead>
<tr>
<th>Student Name:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Article Title:</td>
</tr>
<tr>
<td>Main Idea of this Article:</td>
</tr>
<tr>
<td>What I Understood from Presentation on this Article:</td>
</tr>
<tr>
<td>What was Confusing from the Presentation on this Article:</td>
</tr>
</tbody>
</table>

## How can I help my teammate with this article?

<table>
<thead>
<tr>
<th>Defining Terms:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understanding Ideas:</td>
</tr>
<tr>
<td>Asking Clarifying Questions:</td>
</tr>
<tr>
<td>Suggesting Next Steps:</td>
</tr>
</tbody>
</table>
# Literacy & Teaching Strategies to Use in Science
*(Adapted from several sources by Allyson Nusser)*

<table>
<thead>
<tr>
<th>Literacy Strategy</th>
<th>How It Works</th>
<th>When To Use It</th>
</tr>
</thead>
</table>
| **Read Aloud as Part of a Strategy Lesson**  
Teacher action | **Planning:**  
- Select short excerpt to read out loud and place on document camera. | Any time you want to think aloud about how you make sense of a text/demonstrate a strategy. |
|                  | **Implementing:**  
- You will likely read a bit, then think aloud, and repeat this cycle a few times.  
- Keep the modeling brief (approx. 5-7 minutes) so that students have time to practice. | |
| **Interactive Read Aloud**  
Teacher and Student activity | **Planning:**  
Select an engaging, high interest text that will introduce a topic or deepen students’ knowledge of a topic you are studying.  
- Read the text, planning out where you will pause to allow for interaction (teacher: student and student: student).  
- You may select an article or a science trade book. | To launch a new topic of study.  
To deepen students’ interest once they are well into a unit of study. |
|                  | **Implementing:**  
- Each time you pause in your reading, you will plan to do one of the following – think aloud; prompt students to turn and talk; prompt students to stop and jot or stop and sketch.  
- This will take longer than a strategy lesson. In a strategy lesson, you are using short excerpts of text for a very specific purpose. In interactive read aloud, you are giving students a shared experience with a text to build a deeper level of engagement with and understanding of content. Some trade books would need to be read in two to three 20-25 minute sessions. | |
| **Think aloud**  
Teacher action and Student activity | **Planning:**  
Plan ahead for what you will say and when you will say it. |  
- This method accompanies most, if not all, literacy strategy instruction.  
- In addition to being a tool used by the teacher to demonstrate thinking, it can be explicitly taught to students so that they can think aloud to peers during partner and group work.  
- Thinking aloud can be about a text being read but can also be about a hands-on activity or a concept that is being studied. |
|                  | **Implementing:**  
- Verbalize your thinking out loud to students.  
- Your goal is to make your thinking process visible to students. In a think aloud you may model various aspects of reading process, e.g., visualizing, voicing a confusion, paraphrasing a central idea, etc. | |
## Literacy & Teaching Strategies to Use in Science, con’t.
*(Adapted from several sources by Allyson Nusser)*

<table>
<thead>
<tr>
<th>Literacy Strategy</th>
<th>How It Works</th>
<th>When To Use It</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Turn and talk</strong></td>
<td>Planning: • Make sure that you model this explicitly before asking students to try it. Ask another teacher to do a “fishbowl” with you in front of the class. Implementing: • Give students brief time for a focused exchange with a partner. • This works best when it is a consistent classroom routine and students become accustomed to speaking with peers about texts and content in general. • At first prompts should be very specific, but over time, students will respond to open-ended prompts, as they will be accustomed to talking with peers about content.</td>
<td>After you have modeled a strategy, so that students can talk briefly about what they saw you do. When you want students to practice a strategy with the support of a partner. Any time you want students to verbalize their thinking about content – this can help them monitor their understanding.</td>
</tr>
<tr>
<td><strong>Text Coding</strong></td>
<td>Planning: • Use symbols to signify your thinking about the texts. (Examples include: * = “This seems important”? = “I’m confused...”) • Plan ahead where you will stop to code text. It should sound authentic to students – try to put yourself in the shoes of a student reader when you plan out how you will code text in front of students. Implementing: • Have a blank version of the text so that you can actually write your codes on the text in front of students using a document camera. • You may choose to add annotations explaining the codes.</td>
<td>When the text is complex for students. When students find it difficult to be metacognitive about their reading work.</td>
</tr>
<tr>
<td><strong>Reading with a guiding question</strong></td>
<td>Planning: • Craft a guiding question to accompany a text that suits your instructional purpose. • You may want to model this using a different text/question than the one(s) you will be giving to students, so that students can see the process of reading with a particular lens, but try it out on a different text. Implementing: • As you read from the text on the document camera, you may want to employ reading strategies you have already taught, such as paraphrasing and annotating. • Be sure to annotate (and possibly circle or underline) relevant parts, thinking aloud as you read text that is not relevant to your guiding question, noting such.</td>
<td>When the text contains a lot of information that is not directly relevant to the students’ purpose for reading. When students are reading to find evidence to support a scientific explanation.</td>
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<tr>
<td>Literacy Strategy</td>
<td>How It Works</td>
<td>When To Use It</td>
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| **Paraphrase**    | Planning:  
  - Decide how you will chunk the text – which chunks will you use to demonstrate paraphrasing? Which chunks will you ask students to try paraphrasing in guided practice? Which chunks will you ask students to paraphrase in independent practice?  
  - Plan for exactly what you will say in your paraphrase, taking care to use your own words to explain what that chunk of text is teaching you.  
  
  Implementing:  
  - Physically look away from the actual text and alter the tone of your voice to convey that you are in “thinking mode”. Do not ask students to write when you first introduce this strategy. Give them opportunities to practice this as a mental process multiple times before introducing annotating or paraphrasing in writing. | When the text is complex for students  
This “in the head” strategy will help them monitor their comprehension.  
Teach this as a mental process first (without writing). |
| **Chunking Text** | Planning:  
  - You will need to do this any time you are using a text and thinking aloud, whether it is to paraphrase or model any other strategy.  
  - Break the text apart into smaller parts in a way that makes sense – think of it as creating subtitles when there aren’t any.  
  - Allow for time to paraphrase, reread and ask/answer questions in a guided setting.  
  - For ELLs and struggling readers, the chunks should be smaller.  
  
  Implementing:  
  - On the document camera, only show the chunk(s) of text you are working with at the time (you may want to withhold individual copies from students during your modeling and guided practice to ensure they are all in the same place in the text). | When the text is complex for the students  
This is an effective strategy for ELL students.  
Students can be taught to chunk the text themselves as a way of managing a complex text independently. |
| **Rereading to fix up comprehension** | Planning:  
  - Identify parts of the text that are particularly difficult that you can anticipate students having trouble understanding – these are parts to use when modeling rereading.  
  
  Implementing:  
  - Physically model how you locate the beginning of the part that confused you, possibly even thinking aloud what you understood up to that point. Zoom in on the part and reread it slowly, pausing to define words for yourself. Model rereading slowly and closely, paraphrasing in the process. Show students how the second read repaired your understanding. | As a next step if one is unable to paraphrase the chunk of text they just read  
Rereading should become the automatic first step to repair confusion. This may seem obvious, but some students will continue to “read” text in spite of the fact that the meaning of the words broke down! |
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| **Annotate Text**  | **Planning:**  
  • This is the natural next step of paraphrasing. You may choose to revisit a text that you used to introduce paraphrasing as a mental process, adding writing during a subsequent lesson with the same text.  
  • Your annotations should be brief phrases based on your paraphrasing.  

**Implementing:**  
While you want to have this planned ahead of time, it is a good idea to physically show students how you annotate in the margins using a blank copy of the text. This way, you will paraphrase aloud as you annotate. | When the text is complex for students  
When students do not seem to react to what they read and you suspect they are merely “word calling”  
When students are reading to find evidence to support a scientific explanation |
| **Double entry journals** | **Planning:**  
  • Select parts of the text that explain key ideas and plan out your own double entry journal (summarize the ideas from the text on the right side, and respond with your own thinking on the left side – questions, confusions, reflections).  
  • This is a strategy to introduce after students are accustomed to paraphrasing and annotating text. Summarizing key ideas is more difficult, and students should have experience with those initial strategies before you introduce this.  

**Implementing:**  
Plan on introducing this in a guided way, first demonstrating how you select a part of the text to summarize (right side), and respond to (left side). After modeling this, give students a section of the same text to summarize and then respond to. After reviewing the strategy in this way several times, ask students to try it on their own while they are reading. | To encourage a higher level of engagement with the text  
To have an artifact of students’ thinking in response to text |
| **Visualizing**    | **Planning:**  
  • Select sections of text that require visualization to understand.  
  • Craft what you will say in your think aloud: “I’m picturing…. now I’m imagining…”  

**Implementing:**  
• Model visualizing one part of the text. Give students practice trying out visualizing other parts of the text, sharing their visualizations with partners. | When the text describes a scientific process that you want students to have a mental picture of |
## Literacy & Teaching Strategies to Use in Science, con’t.

*(Adapted from several sources by Allyson Nusser)*

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| Sketching my way through the text      | **Planning:**  
  • Select a text that describes stages of a process, steps, changes over time, or a group of related elements. Draw a series of simple sketches that illustrate this process.  

  **Implementing:**  
  • After modeling a series of sketches that illustrate the concepts described in a text (in front of students), invite students to try (using another appropriate section of text).  
  • An alternative is having students add on to a sequence of sketches that you started – you could do the first one or two steps, e.g., and they could do the remaining ones. | To help students visualize a phenomenon being described in the text                                                                                     |
| Student strategy (during reading)      |                                                                                                                                                                                                             |                                                                                                     |
| Moving Between the Text and the Graphics | **Planning:**  
  Mark up a text to show how the words connect to the photo or other graphic – draw arrows, annotate, etc.                                                                                              | When the text itself does not make connections between the words and graphics explicit.             |
Teachers’ Guide: Reading Primary Literature

By Ann McNeal, School of Natural Science, Hampshire College, Amherst MA 01002
(publication date unknown)

There are many advantages to having students read primary literature:

1. Articles have a vividness that is seldom found in a text, so students get excited by them.

2. Articles lend themselves to critical, analytical thinking.

3. Students feel smart and powerful when they read original sources.

4. Articles reveal the scientific process far better than secondary sources.

It is important to choose articles that are appropriate for your students, looking at conceptual depth, vocabulary, and accessibility of the experimental and statistical techniques. Of these considerations, vocabulary is perhaps the least important, especially if you follow the suggestions below for introducing students to the new words. It is amazing what students can and do read, if they are given the tools to do so. Conceptual depth refers to the difficulty of the concepts important to the article. For example, an article on transcriptional factors in white blood cells requires students to understand some molecular biology. Such an article could be perfect for a cell biology course, but might be too advanced for basic biology. In addition to the difficulty of the main ideas addressed, the article may present some experimental and statistical techniques that are just too hard to grasp. For example, articles on research in epidemiology, such as the relationship of heart attacks to diet, are often wonderfully accessible – except when the authors use logistical analysis. Or an article on evolutionary relationships among protein molecules might be quite readable – except for the PCR techniques. In both these cases, you could decide to use the article anyway, if you have carefully figured out how to present the difficult techniques in a reasonably palatable way.

In preparing your students to read articles for the first time, you will usually need to allocate a good amount of class time for the first article, but this experience should prepare them to be able to be a lot more independent in the future. This is the protocol that seems successful for the first-time readers of research articles.

Original Article URL: http://users.wfu.edu/gutholdm/Biophysics%20seminar/Teacher%20guide%20to%20reading%20primary%20literature%20.doc
Assignment #1

When you first assign an article, talk it up saying how powerful students will feel when they can read the original literature and how exciting it is to read the papers scientists write for one another. Acknowledge that it will not be easy, but reassure students that you have a system that will make it all right.

Briefly outline the four steps:

1. Skimming
2. Vocabulary
3. Comprehension
4. Reflection and analysis

All students need to have copies of the paper so that they may mark it up freely. Send them away with the first assignment to do: Step 1 – Skimming and part of Step 2 – Vocabulary. What they should do is underline or highlight every word and phrase they don’t understand. The next class period will be devoted to giving them an understanding of the vocabulary.

First Class Discussion – Vocabulary

Plan to spend the entire class period defining terms they do not understand. This will seem time-consuming but it will be completely worthwhile. Ask students to contribute words or phrases to be defined. Encourage everyone to name at least one term that needs defining – this helps to put them all on a more equal footing. (If students are asked to go and look up a term on the first paper, unless they are all at a high level, the exercise tends to split them further, with the more advanced students outstripping the others). It is useful to write all terms on the board first, as the students name them, and to organize them by category (e.g., technique words from Methods, anatomical terms, chemicals). After most of the words have been listed, you may want to ask them about some others that they might have ignored. Then choose whatever order seems best to you (doing simple terms first is often helpful) and define, define, explain, explain. Remember, you aren’t explaining the paper, just the vocabulary.

Assignment #2

The next assignment is to read the paper for comprehension. At this point you might want to assign students to answer some questions on the paper as well. The guidelines for students are as follows:

In the Introduction, note the overall context:

- What larger question is this a part of?
- The author’s summary and comments on the previous research
- The hypothesis of the paper and the ways this will be tested

In the Methods, try to get a clear picture of what was done at each step. What was actually measured? It is a good idea to make an outline and/or sketch of the procedures and instruments. Keep notes of your questions; some of them may be simply technical, but others may point to more fundamental considerations that you will use for reflection and criticism below.

The Results look carefully at the figures and tables, as they are the heart of most papers. A scientist will often read the figures and tables before deciding whether it is worthwhile to read the rest of the ar-
article. What does it mean to “understand” a figure? You understand a figure when you can redraw it and explain it in plain English words.

The Discussion contains the conclusions that the author would like to draw from the data. In some papers, this section has a lot of interpretation and is very important. In any case, this is usually where the author reflects the work and its meaning in relation to other findings and to the field in general.

Second Discussion – Comprehension
The second discussion can focus on comprehension of each section of the article. Students often avoid working with the figures and tables. Instead of whole class discussions of these, you might want to assign small groups of the students to spend ten minutes in class redrawing figures and tables and preparing to explain them to everyone else.

Assignment #3
To integrate their knowledge and think about the article more critically, the students need a third exposure to be able to analyze and reflect on the article. The student guidelines for this reading are as follows: (say to the students)

“After you understand the article and can summarize it, then you can return to broader questions and draw our own conclusions. It is very useful to keep track of your questions as you go along, returning to see whether they have been answered. Often, the simple questions may contain the seeds of very deep thoughts about the work.”

Here are some questions that may be useful in analyzing various kinds of research papers:

I) Introduction
a. What is the overall purpose of the research?
b. How does the research fit into the context of its field? Is it, for example, attempting to settle a controversy? Show the validity of a new technique? Open up a new field of inquiry?
c. Do you agree with the author’s rationale for studying the question in this way?

II) Method
a. Were the measurements appropriate for the questions the researcher was approaching?
b. Often, researchers need to use “indicators” because they cannot measure something directly – for example, using babies’ birth weight to indicate nutritional status. Were the measures in this research clearly related to the variables in which the researchers were interested?
c. If human subjects were studied, do they fairly represent the populations under the study?

III) Results
What is the one major finding?
Were enough of the data presented so that you feel you can judge for yourself how the experiment turned out?
Did you see patterns or trends in the data that the author did not mention?
Were there problems that were not addressed?
IV) Discussion

a. Do you agree with the conclusions drawn from the data?
b. Are these conclusions over-generalized or appropriately careful?
c. Are there other factors that could have influenced or accounted for the results?
d. Does this study ask more questions and therefore lead to other possible studies?
e. What would you think would be next steps in the research based on the conclusions of this study?

Third Discussion
– Reflection and Analysis

This is the opportunity to set the article in a larger context, to understand its relation to text material and to encourage students to think beyond the outlines of the article, examining other factors that that may not have been explored in the research. The questions above are a good basis for discussion. You may wish to break students into small groups to reflect on particular questions and present their ideas to the larger group. This discussion may take less than a full period. If students are advanced or if the article is relatively easy for them, you may combine the second and third assignments and discussions, but we have found that allowing ample time is key to allowing all students to reach a good level of understanding.

REFERENCES
As your students delve into primary scientific literature, they will encounter a variety of data and statistical analyses. Some of these terms may be confusing, particularly to students who have not taken a formal course in statistics. The next two pages include some websites and pages that offer useful, relevant, and high school student-friendly definitions and descriptions of statistical tools and terms. In addition to these resources, we also encourage you to reach out to your school’s math or statistics teachers to support students who may have questions about statistical analysis. Additionally, students should consider reaching out to an article’s author(s) if they have questions about a specific kind of analysis or term in an article.

Useful Sites:

The two sites below offer a variety of statistical analysis resources, many of which are discussed in more detail on the following page.

www.sciencebuddies.org
Excellent website that includes a number of articles on data analysis and presentation for high school students doing independent research projects.

www.explorable.com
Really useful reference site for best practices in science research. Aimed for psychology/social science researchers, but applicable to all areas of science. Lots of pages for different statistical terms – analytical tools, tests, descriptive statistics, etc. that your students may encounter in scientific literature.
Some useful webpages and links for specific statistics topics are listed below:

**Data Analysis:** This page provides helpful insight into data analysis best practices, including statistical analysis of data. Also has a bibliography which includes articles on how to select the right statistical test for a set of data, and how to deal with outliers.

**Summarizing Your Data:** This page provides an overview of descriptive statistics, and walks students through:
- measures of central tendency, such as the mean, median, and mode, which describe how data is clustered around an average or midpoint
- measures of dispersion, including the range, variance, and standard deviation, which all show how data is spread out across a range of values.

**Information on Variance and Standard Deviation:** Most high school students are familiar with basic measures of central tendency (mean, median, and mode) and dispersion (range), but most have not worked with variance or standard deviation. The resources below provide more information on what standard deviation and variance are, and the mathematical underpinnings of each. It’s important to reinforce to students that variance and standard deviation are essentially measuring the same thing, and that standard deviation is used more often because it’s an easier term to work with.
- Variance and Standard Deviation (from Science Buddies)
- Variance and Standard Deviation (from Math is Fun; lots of good explanations and examples!)

**Statistical Significance:** The links below discuss the meaning of statistical significance, and some of the terminology related to statistical significance that students may encounter.
- Statistically Significant Results: This page discusses how statistical significance can be used to test a hypothesis.
- Definition of Statistical Significance: Provides detailed description of statistical significance and critical values that are used to determine if data is statistically significant.
- Tests for Statistical Significance: This page provides summaries of commonly-used tests for statistical significance, which students may encounter in the articles they are reviewing.
List of Commonly-Used Scientific Terms and Definitions

(adapted from https://student.societyforscience.org/glossary-research-terms and http://libguides.usc.edu/content.php?pid=83009&sid=2772758)

Abstract - A brief summary of a research project and its findings.

Accuracy - a term used in survey research to refer to the match between the target population and the sample.

Aggregate - a total created from smaller units. For instance, the population of a county is an aggregate of the populations of the cities, rural areas, etc. that comprise the county. As a verb, it refers to total data from smaller units into a large unit.

Anonymity - a research condition in which no one, including the researcher, knows the identities of research participants.

Baseline - a control measurement carried out before an experimental treatment.

Bias - a loss of balance and accuracy in the use of research methods. It can appear in research via the sampling frame, random sampling, or non-response. It can also occur at other stages in research, such as while interviewing, in the design of questions, or in the way data are analyzed and presented. Bias means that the research findings will not be representative of, or generalizable to, a wider population.

Bibliography - A list of the books referred to in a research project. It usually appears at the end, or as a separate section, known as an appendix.

Claim - a statement, similar to a hypothesis, which is made in response to the research question and that is affirmed with evidence based on research.

Classification - ordering of related phenomena into categories, groups, or systems according to characteristics or attributes.

Conclusions - A brief summary of how the results of an experiment support or contradict a hypothesis.

Confidentiality - a research condition in which no one except the researcher(s) knows the identities of the participants in a study. It refers to the treatment of information that a participant has disclosed to the researcher in a relationship of trust and with the expectation that it will not be revealed to others in ways that violate the original consent agreement, unless permission is granted by the participant.

Confirmability - the findings of the study could be confirmed by another person conducting the same study.
Control - A duplicate setup, sample or observation treated identically to the rest of an experiment except for the variable being tested. And the control variable is meant to represent what’s normal or unchanged. For instance, if one wanted to see the effect of adding fertilizer to a plant’s soil, the control would be the growth of a plant with no fertilizer.

Control Group - the group in an experimental design that receives either no treatment or a different treatment from the experimental group. This group can thus be compared to the experimental group.

Controlled Experiment - an experimental design with two or more randomly selected groups [an experimental group and control group] in which the researcher controls or introduces the independent variable and measures the dependent variable at least two times [pre- and post-test measurements].

Correlation - a common statistical analysis, usually abbreviated as r, Correlation measures the degree of relationship between pairs of interval variables in a sample. The range of correlation is from -1.00 to zero to +1.00. Also, a non-cause and effect relationship between two variables.

Data Book (also Logbook) - A documentation of the work done during an experiment. It includes the findings, called data, collected during an experiment, as well as any observed responses, reactions and results.

Data - factual information [as measurements or statistics] used as a basis for reasoning, discussion, or calculation.

Data Mining - the process of analyzing data from different perspectives and summarizing it into useful information, often to discover patterns and/or systematic relationships among variables.

Data Quality - this is the degree to which the collected data [results of measurement or observation] meet the standards of quality to be considered valid [trustworthy] and reliable [dependable].

Demonstration Project - A project that retests an experiment already conducted by someone else. A demonstration project can also show how something works. Adding a variable to a demonstration can make it into an experiment.

Dependent Variable - a variable that varies due, at least in part, to the impact of the independent variable. In other words, its value “depends” on the value of the independent variable. For example, in the variables “gender” and “academic major,” academic major is the dependent variable, meaning that you're major cannot determine whether you are male or female, but your gender might indirectly lead you to favor one major over another.
Deviation - the distance between the mean and a particular data point in a given distribution.

Engineering Design - A process or series of steps that guide an engineer in solving problems. The process starts with identifying a problem. It ends with creating a solution to solve that problem.

Falsification - To change information or evidence to mislead.

Field Studies - academic or other investigative studies undertaken in a natural setting, rather than in laboratories, classrooms, or other structured environments.

Generalizability - the extent to which research findings and conclusions conducted on a specific study to groups or situations can be applied to the population at large.

Graph - A diagram that illustrates a relationship, typically between two variables. Each variable is measured along one of two axes, positioned at right angles.

HSSRP Science Research Teacher - The teacher who teaches your science research class and who oversees your overall student experiment. Your teacher will work closely with you and should be familiar with the student’s project and the student’s area of research.

Hypothesis (or Research Question) - A proposed explanation for a phenomenon; often times, a tentative explanation based on theory to predict a causal relationship between variables. In science, a hypothesis is an idea that hasn’t yet been rigorously tested. Once a hypothesis has been extensively tested and is generally accepted to be the accurate explanation for an observation, it becomes a scientific theory.

Independent Variable - the conditions of an experiment that are systematically manipulated by the researcher. A variable that is not impacted by the dependent variable, and that itself impacts the dependent variable. In the earlier example of "gender" and "academic major," (see Dependent Variable) gender is the independent variable.

Independent Research Project - An experiment designed, carried out and interpreted on one’s own.

Literature Search - An organized review of books, articles and published research on a specific topic.

Margin of Error - the permit table or acceptable deviation from the target or a specific value. The allowance for slight error or miscalculation or changing circumstances in a study.

Measurement - process of obtaining a numerical description of the extent to which persons, organizations, or things possess specified characteristics.
Mentor (also known as Research Advisor) - An experienced and trusted adviser who provides advice and counseling.

Methodology (or Research Methods) - A particular procedure or set of procedures. These may include the methods, techniques and instruments used in a research experiment.

Null Hypothesis - the proposition, to be tested statistically, that the experimental intervention has "no effect," meaning that the treatment and control groups will not differ as a result of the intervention. Investigators usually hope that the data will demonstrate some effect from the intervention, thus allowing the investigator to reject the null hypothesis.

Peer-Review - the process in which the author of a book, article, or other type of publication submits his or her work to experts in the field for critical evaluation, usually prior to publication. This is standard procedure in publishing scholarly research.

Principal Investigator - the scientist or scholar with primary responsibility for the design and conduct of a research project.

Probability - the chance that a phenomenon will occur randomly. As a statistical measure, it is shown as p [the "p" factor].

Random Sampling - a process used in research to draw a sample of a population strictly by chance, yielding no discernible pattern beyond chance. Random sampling can be accomplished by first numbering the population, then selecting the sample according to a table of random numbers or using a random-number computer generator. The sample is said to be random because there is no regular or discernible pattern or order. Random sample selection is used under the assumption that sufficiently large samples assigned randomly will exhibit a distribution comparable to that of the population from which the sample is drawn. The random assignment of participants increases the probability that differences observed between participant groups are the result of the experimental intervention.

Reliability - the degree to which a measure yields consistent results. If the measuring instrument [e.g., survey] is reliable, then administering it to similar groups would yield similar results. Reliability is a prerequisite for validity. An unreliable indicator cannot produce trustworthy results.

Representative Sample - sample in which the participants closely match the characteristics of the population, and thus, all segments of the population are represented in the sample. A representative sample allows results to be generalized from the sample to the population.

Results - A statement that explains or interprets the data produced in an experiment.
**Rigor** - degree to which research methods are scrupulously and meticulously carried out in order to recognize important influences occurring in an experimental study.

**Sample** - the population researched in a particular study. Usually, attempts are made to select a "sample population" that is considered representative of groups of people to whom results will be generalized or transferred. In studies that use inferential statistics to analyze results or which are designed to be generalizable, sample size is critical, generally the larger the number in the sample, the higher the likelihood of a representative distribution of the population.

**Sampling Error** - the degree to which the results from the sample deviate from those that would be obtained from the entire population, because of random error in the selection of respondent and the corresponding reduction in reliability.

**Scientific Method** - A sequence of steps followed in investigating natural phenomena.

**Scientific Research** - The organized investigation of questions raised by scientific theories and hypotheses.

**Scientific Theory** - In science, a theory is a well-supported model or explanation of a natural phenomenon. A scientific theory is based on observations, experiments and reason. Repeated experiments can confirm the validity of a scientific theory.

**Standard Deviation** - a measure of variation that indicates the typical distance between the scores of a distribution and the mean; it is determined by taking the square root of the average of the squared deviations in a given distribution. It can be used to indicate the proportion of data within certain ranges of scale values when the distribution conforms closely to the normal curve.

**Statistical Analysis** - application of statistical processes and theory to the compilation, presentation, discussion, and interpretation of numerical data.

**Statistical Bias** - characteristics of an experimental or sampling design, or the mathematical treatment of data, that systematically affects the results of a study so as to produce incorrect, unjustified, or inappropriate inferences or conclusions.

**Statistical Significance** - the probability that the difference between the outcomes of the control and experimental group are great enough that it is unlikely due solely to chance. The probability that the null hypothesis can be rejected at a predetermined significance level [0.05 or 0.01].

**Statistical Tests** - researchers use statistical tests to make quantitative decisions about whether a study's data indicate a significant effect from the intervention and al-
low the researcher to reject the null hypothesis. That is, statistical tests show whether the differences between the outcomes of the control and experimental groups are great enough to be statistically significant. If differences are found to be statistically significant, it means that the probability [likelihood] that these differences occurred solely due to chance is relatively low. Most researchers agree that a significance value of .05 or less [i.e., there is a 95% probability that the differences are real] sufficiently determines significance.

**Theory** - a general explanation about a specific behavior or set of events that is based on known principles and serves to organize related events in a meaningful way. A theory is not as specific as a hypothesis.

**Treatment** - the stimulus given to a dependent variable.

**Trial** - One of a number of repetitions of an experiment.

**Validity** - the degree to which a study accurately reflects or assesses the specific concept that the researcher is attempting to measure. A method can be reliable, consistently measuring the same thing, but not valid.

**Variable** - In research, something that can be changed or altered during an experiment. Each variable that is to be tested would represent a different test condition. For instance, if you were testing the effects of fertilizer on plant growth, the variable might be amount of fertilizer used: such as none, the normal amount, twice the normal amount and five times the normal amount.
While each club is limited to three or four students sharing their work at the Research Symposium, we encourage all members of the club to conduct a literature review that summarizes their selected research topic and the 5-10 articles that they have chosen.

A literature review is more than a summary; it is a critical review of the literature selected, that describes what progress has been made, and that identifies the gaps that exist. Some best practices in literature reviews are outlined below; these have been adapted from the article “Ten Simple Rules for Writing a Literature Review” (Pautusso, M., PLOS Computational Biology, Vol. 9, Issue 7, July 2013), an article that we encourage you and your students to review in its entirety.

**PLEASE NOTE:** Students are not required to write a full literature review paper as part of the Science Research Club. They only have to create a literature review outline, literature review poster, and “TED-style” oral presentation of their literature review. All students – regardless of whether or not they are presenting at the Research Symposium – should prepare these literature items.

- **Determine Your Scope:** A good literature review should be focused on a specific area of research (e.g. “A Review of Current Treatments for Glioblastoma” as opposed to “An Overview of Brain Cancer”), but should be broad enough in scope to be interesting and relevant to a larger scientific audience. Students should select some parameters around the scope of their literature review in terms of how far back their literature goes. How far back your literature goes may depend on the topic – for one topic, it may be appropriate to use a landmark paper from fifty years ago, while for a different topic only literature from the past decade may be relevant.

- **Tell a Story:** A literature review should have a structure that walks the reader through the “story” that the articles selected tell as a group. Whether an outline, a poster, or a paper, there should be a distinct progression or ideas, subtopics, or research progress over time. Encourage students to think of themselves as curators, selecting ideas, facts, or passages from different articles to create a literature review that is easy and interesting to follow.

- **Don’t be Afraid to be Critical:** A good literature review should identify both progress and gaps in research. While coverage of individual articles should be objective and should refrain from first-person and/or opinionated language (e.g. “I liked”), students should feel comfortable identifying gaps in research or suggesting future directions for investigations.
Evaluation Rubric for Student “TED-Style Talk” Presentations

The rubric on the following page can be used by students to evaluate one another’s presentations of literature review presentations. You will see that this rubric has been adapted to the “TED-style” talk that selected students will present at the June Research Symposium. Feel free to adapt this rubric as needed – you may want to adjust it based on students’ prior experience with oral presentations, or to adapt it to other developmental goals for students in your club.
Student Evaluation Rubric for “Ted-Style” Presentations

Speaker’s Name: ______________________________________________________________

Evaluated by: _________________________________________________________________

Title of Presentation: _______________________________________________________

Date: _____________________________________________________________________

Indicate the appropriate score for each criterion in the rubric below by circling the corresponding number:

1 = Poor/Needs Improvement;  
2 = Fair/ Some good elements, but definitely could be better  
3 = Good/High quality, just needs minor tweaks  
4 = Excellent/Exemplary

<table>
<thead>
<tr>
<th>Content &amp; Scientific Merit</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defines topic of research effectively</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>Conveys objective or goal of presentation</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>Explains background and importance of research effectively</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>Explains main ideas and/or arguments of presentation effectively</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>Connects ideas and information in a logical and easy-to-follow fashion</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>Cites at least 2-3 articles during presentation, and summarizes methodology and results</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>Defines unfamiliar terms and procedures, and explains any data and visuals that are presented</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>Talk is presented at a level of complexity appropriate for a high school audience</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>Summarizes main points of talk in conclusion</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>Identifies next steps in terms of future research or other initiatives</td>
<td>1 2 3 4</td>
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### Presentation Style

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<tbody>
<tr>
<td>Speaks clearly and at an understandable pace</td>
<td>1  2  3  4</td>
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<tr>
<td>Presentation is well-rehearsed (minimal reliance on notes or cues)</td>
<td>1  2  3  4</td>
</tr>
<tr>
<td>Engages audience through eye contact, modulation of voice, and body language</td>
<td>1  2  3  4</td>
</tr>
<tr>
<td>Uses available space (stage, room, board/screen effectively</td>
<td>1  2  3  4</td>
</tr>
<tr>
<td>Limited use of filler words (&quot;um&quot;, &quot;like&quot;, etc.,) or pauses</td>
<td>1  2  3  4</td>
</tr>
<tr>
<td>Talk is within time limit constraints – not too short or too long</td>
<td>1  2  3  4</td>
</tr>
<tr>
<td>Projects an enthusiastic and professional demeanor</td>
<td>1  2  3  4</td>
</tr>
<tr>
<td>Able to answer audiences questions professionally and confidently</td>
<td>1  2  3  4</td>
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</table>

### Structure and Clarity

<table>
<thead>
<tr>
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<th>Score</th>
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<tbody>
<tr>
<td>Accompanying slides or visuals are well-designed and informative</td>
<td>1  2  3  4</td>
</tr>
<tr>
<td>Text in slides is readable and succinct</td>
<td>1  2  3  4</td>
</tr>
<tr>
<td>Talk and visuals flow together to effectively tell a story about the research reviewed in the presentation</td>
<td>1  2  3  4</td>
</tr>
<tr>
<td>Data presented – tables, graphs, etc. – is clearly labeled, and speaker explains any hard-to-interpret data or visuals</td>
<td>1  2  3  4</td>
</tr>
<tr>
<td>All articles referenced during the presentation are cited in a bibliography at the end of the presentation</td>
<td>1  2  3  4</td>
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</tbody>
</table>

The 2-3 main takeaways that I got from this presentation are: ________________________________
________________________________________________________________________________________

2-3 things that you did especially well include: ________________________________
________________________________________________________________________________________

Things that I didn't completely understand include: ________________________________
________________________________________________________________________________________

2-3 recommendations for improvement include: ________________________________
________________________________________________________________________________________

Questions I still have include: ________________________________
________________________________________________________________________________________
Preparing for the Research Symposium
Overview of the June High School Science Research Pathways Research Symposium

Date: Early to mid-June
(exact date will be shared by January)
Time: 3:00PM-6:00PM
Research Symposium Location:
Armory on the Hudson*
216 Fort Washington Avenue
(at the corner of West 168th St.)
New York, NY 10032
*accessible via the 1 train to 168th St – Washington Heights or the A/C to 168 St.

I. Each Science Research Club will Select 3 (three) Students to Prepare Tri-Fold Boards:
Each research club will bring presentations of 3 (three) selected students’ research projects that they have prepared for the club.

Each research presentation should cover a students’ selected research topic, and should draw from 5-10 articles that the student has selected and reviewed over the course of the research club. While students may use a combination of scientific journal articles and scientific articles written for a general audience (e.g. NY Times Science Times, Scientific American), at least 3 selected articles should be primary literature articles from scientific journals that are based on specific experiments or investigations, and at least one article should be a review article from a scientific journal. Each student who prepares a tri-fold board should be prepared to present their board to Symposium attendees.

II. Each Science Research Club will select 1 (One) Student to deliver a 5 to 10-minute “TED-Style” Talk on his/her Research Topic:
Each research club will have one student speaker, who will present an overview of his/her research topic in an engaging “TED-Style” talk for an audience of Science Research Symposium attendees. We have included examples of Ted talks below for you and your students to review.

**TED Talk Playlists:** Ted Under 20 (TED Talks from presenters under the age of 20)

**TED-Ed Lessons:** Check out the Science & Technology section for examples of how your students can present their research topics

Many additional TED Talks can be found on [http://www.ted.com](http://www.ted.com), and we encourage your students to view a variety of talks to see both the diversity of TED Talk styles, as well as some of the common elements that all good TED Talks share. For example, which TED Talks vary in style and scope, all are well-rehearsed, easy to follow, and engaging. We encourage you to have ALL students in your club prepare a “TED-style” talk, and to then use popular vote or peer review to select a single speaker who will present at the research symposium.

**Selecting Student Presenters**
Being limited to three tri-fold boards and one student speaker means that only a fraction of you research club students will be able to present their research at the symposium, so you will need some kind of criteria to select which students present. While we leave the specifics of selection up to you, we encourage you to:

- consider students who have been particularly enthusiastic or creative with their project, have developed unusually sophisticated analyses and ideas, or who have really impressed you in the way that they have taken their research into a new and innovative direction.
• select students who have strong presentation skills, both in terms of putting together a board, and in talking about their research.
• involve all Science Research Club participants in the selection of peers who will represent their club at the research symposium.

You may select three students to present boards and one student to deliver a Ted talk, or you may select two students to present boards, and one student to present a board AND a Ted talk. You will need to submit the names of your selected student presenters to the HSSRP program team by mid-May. We will share additional details about registration and logistics specifics, including buses, transportation of tri-fold boards, and outreach information for parents and families as we get close to the date.

Please note that all of your Science Research Club students – whether presenting or not – and their families are welcome to attend the Research Symposium.

We look forward to seeing your students’ presentations at June Research Symposium! Please email STEM MattersNYC@schools.nyc.gov if you have questions about the Research Symposium.

Creating Great Boards and Other Visual Resources

This hand-out can be used to help students organize the different sections to be placed in their poster board. Specific details and requirements (technical and organization) are also provided to make sure that students come up with a presentable board.

<table>
<thead>
<tr>
<th>Introduction</th>
<th>TITLE</th>
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<tbody>
<tr>
<td></td>
<td>Author(s)</td>
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<tr>
<td></td>
<td>Results</td>
</tr>
<tr>
<td></td>
<td>Key Findings</td>
</tr>
<tr>
<td>Current Research</td>
<td>Table</td>
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<td></td>
<td>or Figure</td>
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<td>Table</td>
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<td></td>
<td>or Figure</td>
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<td></td>
<td>Results</td>
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<td></td>
<td>Analysis and Complications</td>
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<td></td>
<td>Future</td>
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<td></td>
<td>Directions</td>
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<td></td>
<td>Conclusion</td>
</tr>
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<td></td>
<td>References</td>
</tr>
</tbody>
</table>

More detailed hand-out on next page!
INTRODUCTION
Your introduction should provide an overview and background knowledge on the topic that you are researching, and should address the following questions in 1-2 full paragraphs:

- What is your topic?
- Is there a specific subtopic or area of research that your literature review is focused on?
- What are the basic (2-3 sentence) overview for your topic?
- Are there any terms, concepts, or processes that you need your audience to know in order to understand the rest of your poster?
- Why is this topic of interest to people?
- Why is this topic relevant and important?

CURRENT RESEARCH
Within 1-3 full paragraphs, address the questions below:

What are current topics of research in this field?
What kinds of experimental procedures and methods of data collection are used? Are there certain types of processes or materials that are commonly used in this area of research?
How do researchers measure or assess their data and results?
How do researchers analyze their data to make meaning of their results and identify next steps in their research?
What are the 2-3 main takeaways from the current research on the topic?

RESULTS: KEY FINDINGS
- Use bullet points to convey main points and to annotate diagrams
- Highlight key findings from current literature

RESULTS: ANALYSIS AND IMPLICATIONS
- Use bullet points to convey main points and to annotate diagrams
- Identify key trends and patterns in research
- Use 2-3 charts and diagrams to present information

CURRENT RESEARCH
Within 1-3 full paragraphs, address the questions below:

What are current topics of research in this field?
What kinds of experimental procedures and methods of data collection are used? Are there certain types of processes or materials that are commonly used in this area of research?
How do researchers measure or assess their data and results?
How do researchers analyze their data to make meaning of their results and identify next steps in their research?
What are the 2-3 main takeaways from the current research on the topic?

RESULTS: ANALYSIS AND IMPLICATIONS
- Use bullet points to convey main implications and open questions and to annotate diagrams
- Highlight gaps or unclear findings from current literature

FUTURE DIRECTIONS
Within 1-2 full paragraphs accomplish the following

- Build on and explain on possible future directions of this research
- Consider implications of prior research, and open questions or gaps of knowledge that can be investigated
- Explain these proposed areas of future research would contribute to this area of research and expand knowledge of this topic.

CONCLUSION
Explain the following in 1-2 paragraphs:

- Reiterate 1-2 key research questions
- Recap main areas of research and synopsis of research results to date (1-2 sentences)
- Identify outstanding questions, and which future directions of this research should be prioritized to address these questions
- Explain how this future area research could be explored

REFERENCES
- Only the papers referenced in the poster should be included here, and they should be numbered in their order of appearance
- Use a consistent format (e.g. APA format) for listing articles.
Resources for Student Recruitment and Parent Outreach

Mission and Goals Statement

High School Science Research Pathways Program Mission and Goals

Science research programs foster and nurture high school students’ learning by using research as a tool to build the necessary skills for students to become scientifically literate in the 21st century. The High School Science Research Pathways Program was designed to create or revive comprehensive, multi-year science research programs in NYCDOE high schools that do not presently have full research program in place.

The Science Research After-School Club provides 9th and 10th grade students with an opportunity to explore a scientific topic of interest and to get a taste of some of the primary components of science research, including selecting and scoping a research topic, searching for relevant literature, reading, analyzing, and making meaning of scientific literature, and synthesizing their research into written, visual, and oral reports and presentations that share out information about their data.

The Science Research After-School Club will meet from <<Time of Day>> on <<Day of Week>> in <<Location>>. The club will use meeting time for student members to work on the research topics that they have selected. In earlier sessions, they will focus on selecting and scoping a research topic and developing skills in reading and understanding scientific literature. In later sessions, they will focus on creating a literature review of their research topic that may be presented at the STEM Matters NYC Research Symposium and other events. Students who actively participate in the Science Research Club will develop college-level skills in scientific research, literacy, and communication, and will also strengthen their ability to plan and carry out a long-term project. Additionally, students will explore ethical aspects of science, including evaluating research claims for scientific validity, and in presentation of their original analysis and findings in a way that upholds academic integrity. Finally, the Science Research Club will integrate enrichment activities that may include hands-on investigations, explorations of current events in science, guest speakers, or field trips.

Students will prepare and present their research analysis to their classmates, and will receive feedback from their peers to help them to refine their research and results. They are also expected to participate in the STEM Matters NYC Research Symposium, which takes place on June <<Date>> at Armory on the Hudson, 216 Fort Washington Avenue, New York, NY, 10032, and serves as the culminating event for the club.

The Science Research After-School Club is also designed to help students and science research teachers make informed decisions about which students have the potential to be successful in a long-term science research program, that includes a three-year program of science research courses and may lead to the completion of a 2-year independent research project under the guidance of an outside research mentor. Participation in the Science Research Club is an excellent way to gauge a student’s interest in long-term science research, and helps a student and his/her teacher make an informed decision about the student’s participation in the longer-term science research program.
Sample Recruitment Flyer for Students and Parents

Below is an example of a flyer that was designed to recruit students to the Science Research After-School Club. Check it out!

![Sample Recruitment Flyer](image_url)
Sample Student and Parent Contract

High School Science Research Pathways Program
Club Student Contract (Sample)

Parents/Guardians: Please read and review with your student and submit a signed copy to your High School Science Research Pathways teacher.

1. High School Science Research Pathways Club: An after-school club that enables students to investigate scientific field of study that their choice and to prepare a review of current scientific literature on their topic. In addition to developing skills in researching and reading scientific literature, students may also use their experience in the club to determine if they would like to participate in a full-year science research course in the subsequent school year.

2. Student Commitment and Attendance Code: Participants must attend at least 80% of club meetings and must arrive on time and remain for the duration of the club session. Students should notify Science Research Club advisor of unavoidable absences in advance when possible, and should make sure to check in with their advisor within two days to make sure that they can make up whatever work time they missed.

3. Code of Conduct: Program participants are expected to actively participate in all aspects of the club, including individual research, group activities, and preparation for and/or attendance at the culminating STEM Matters NYC Research Symposium in June.

4. ZERO TOLERANCE: The following are considered “no tolerance.” Students who demonstrate these behaviors may be asked to withdraw from the High School Science Research Pathways club:

   a. **Missing more than two club sessions in a row without prior notification or immediate follow-up with the Research Club advisor:** Your progress in the club depends on you being present on a regular basis, and your advisor is counting on you to maintain your schedule of commitments!

   b. **Academic dishonesty:** Plagiarism, failing to cite/credit resources, and completing others’ work (or allowing others to complete your work) are behaviors that are not tolerated in any scientific community, including your school’s Science Research Club.

*Continued on next page.*
c. **Mis-using independent work time:** While the Science Research Club is meant to be a relaxed, collaborative environment where students are trusted to use time effectively, students are expected to hold themselves and their peers accountable for using time constructively. Using computers or other technology for personal purposes, socializing to the point of distraction, and leaving the research club meeting place for extended periods of time indicate that you are using time and resources constructively, and may result in dismissal from the club.

5. **Travel requirement:** Participants are expected to travel to the culminating Research Symposium with their advisor and fellow club members via bus or public transportation. Participants will be permitted to arrive/depart from the Research Symposium independently with parental/guardian consent as coordinated by the school.

6. Participants must have FUN during the program!

7. If participants encounter any problems, discomforts or just need someone to talk to about something please talk to the High School Science Research Pathways Program staff or teachers.

**STUDENT DECLARATION – Please ask the student to sign below.**

I have read this contract. I understand these rules as stated and will comply with them completely.

__________________________________________   ____________________  
Student Name and Signature      Date

**PARENT DECLARATION – Please ask a parent/guardian to sign below.**

I have read this contract. I understand these rules as stated and will support my student in complying with them completely.

__________________________________________   ____________________  
Parent Name and Signature       Date
Resources for Monitoring Students’ Progress and Helping them to Stay Organized
Best Practices and What to Expect

Student Materials
Each student should have a folder or binder in which to store materials for the Science Research Club, including copies of annotated articles, graphic organizers or other handouts from club activities, club information, including a syllabus and research symposium information, and any data sheets or other information from hands-on activities that you have done. You may want to keep students’ Research Club folders in your classroom or office so that they do not get lost between school and home.

Marking Good Use of Club Meeting Time
Most students will need significant support in planning out and undertaking different steps of their research project. In addition to needing help with searching for, selecting, and reading articles, students will also need assistance in accurately estimating just how much time each of these components will take. As mentioned previously, we do encourage you to incorporate some hands-on activities into your club, but do make sure to leave sufficient time during weekly club meetings to move students’ research work forward.

Mutual Accountability
Design activities that require students to hold themselves and their peers accountable. Students are more likely to stay on top of their responsibilities if they know that others are counting on their contributions. Group discussions and activities, presentations to classmates, peer review protocols, and other collaborative activities help students to hold one another accountable.

Link to College and Career
Highlight the similarities between the independent work done in the research club and the kind of work that college students and professionals do. Make sure that students are aware of the fact that the work they do in the club is great preparation for the kind of self-directed, independent work that they will encounter in college and the workplace. The time, efforts, and struggle that they put in now in terms of learning to map out a project and manage their time will pay off in their post-high school careers!

What to Expect
Most students will be new to the process of planning out a long-term project, and many will struggle with basic aspects of research, literacy, and presentation. That is OK, and to be expected! The club is structured so that students who attend regularly will have over 30 hours of time in a setting where they have immediate support from teachers and peers to scope, research, review, and prepare a presentation on their topic – even if they work slowly, they should be able to find and review the requisite 5-10 articles. If certain students are particularly struggling, consider tapping into the resources you use to differentiate instruction and support in your regular classes as you work to support these students. Finally, our program team is available to problem-solve and brainstorm ideas and solutions with you – please don’t hesitate to reach out if you have questions or need support.
Two Week Action Plan for Students

Planning a long-term project is a new experience for most high school students. The planning resources at the front of this guide can be adapted to your students. Additionally, you may want to ask students to use and update a two-week planning document like the one below to help them stay organized.

<table>
<thead>
<tr>
<th>Date/Day</th>
<th>Work Scheduled</th>
<th>Done/In Progress/Not Started</th>
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<tbody>
<tr>
<td>Day 1</td>
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<td>Day 14</td>
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Notes:

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## Additional Resources: Club Planning Documents for Teachers

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<thead>
<tr>
<th>Date or Time Period</th>
<th>Activities &amp; Milestones</th>
<th>What TEACHERS Should be Doing</th>
<th>What STUDENTS Should be Doing</th>
<th>What ADMINISTRATION Should be Doing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Late November</strong></td>
<td>Initial Club Planning &amp; Development of Recruitment Strategy</td>
<td>Working with administration/colleagues to map out preliminary logistics (day of week/time of day, club meeting location, preliminary marketing strategy). Developing recruitment strategy for recruiting interested &amp; able 9th/10th grade students.</td>
<td>Interested students should follow up with HSSRP teacher to gather more information and to learn more about the club and the HSSRP program.</td>
<td>Working with HSSRP teacher to map out strategy for Science Research Club; helping to secure necessary resources and advising/supporting on club recruitment/outreach to students and families as needed.</td>
</tr>
<tr>
<td><strong>December</strong></td>
<td>Final Club Planning and Marketing Campaign</td>
<td>Finalizing day of week, meeting time, location. Actively implementing recruitment strategy to recruit students for club. Doing additional outreach to parents and colleagues as needed.</td>
<td>Interested students should make sure that they are able to meet the commitments of the research club (e.g. that they do not have conflicts, that they have parental permission, etc.)</td>
<td>Working with HSSRP teacher to map out strategy for Science Research Club; helping to secure necessary resources and advising/supporting on club recruitment/outreach to students and families as needed.</td>
</tr>
<tr>
<td><strong>Mid-December to Early January</strong></td>
<td>Club Launch</td>
<td>First Meeting should occur before mid-winter break; should introduce students to the goals of the club, basics of science research, and use of articles to explore topics of interest.</td>
<td>Student attend initial launch meeting; bring questions and ideas. Students begin to brainstorm a list of topics to research.</td>
<td>Briefly visit first or second club meeting to meet student participants and to support club.</td>
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### Additional Resources: Club Planning Documents for Teachers, con’t

<table>
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<tr>
<td>January to Late February</td>
<td>Club Meetings to focus on basic research and literacy skills regarding scientific texts, and students will be introduced to journal articles via group readings of anthologized articles. Students are also introduced to topic selection to prep for end-of-year event.</td>
<td>Leveraging skills and best practices from autumn PD sessions to support students’ facility with dissecting a scientific journal article, using NovelNY and other databases to search for articles, and working with students to identify research topics that meet criteria of appropriate scope, depth, and student interest.</td>
<td>Students work with literature (e.g. article samples provided) to develop and refine skills in scientific literacy and literature interpretation. Students gain familiarity and comfort with databases and searching strategies, particularly as they identify a topic of interest and begin to search for related articles.</td>
<td>Continuing to check in with teacher and club regularly; connecting teacher with other research and literacy resources within the school.</td>
</tr>
<tr>
<td>March to Mid-April</td>
<td>Club Meetings focus on students’ research of self-selected topics. Students will use general audience and primary and secondary scientific journal articles.</td>
<td>Working with students on as-needed basis to support successful research (finding and interpreting appropriate primary and secondary sources); work on logistics of June research symposium (buses, permission slips, administrator support).</td>
<td>Students continue to research their topics through searches for and close reading of scientific articles. Students work with teachers and peers to troubleshoot and to refine/redirect area of research focus as needed.</td>
<td>Do a midpoint visit or check-in with the club. With the teacher, begin to identify students who would be good candidates for the science research course in the upcoming school year.</td>
</tr>
<tr>
<td>Late April - May</td>
<td>Club Meetings focus on synthesis of students' research and preparation of boards and presentations for June end-of-year research symposium.</td>
<td>Introducing and working with students to support successful analysis and synthesis of research, as demonstrated by oral and visual presentations; completing all logistics for June research symposium.</td>
<td>Students analyze and synthesize research findings to tell a cogent story/address a question or hypothesis, and begin to prepare presentation (oral and trifold board).</td>
<td>Supporting as needed with end-of-year research symposium.</td>
</tr>
<tr>
<td>June</td>
<td>Students participate in culminating Research Symposium.</td>
<td>Facilitating students' sharing out of research at June research symposium.</td>
<td>Students put final touches on presentations and boards; share out and celebrate research at research symposium.</td>
<td>(Optional) attending the end-of-year symposium.</td>
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<table>
<thead>
<tr>
<th>Date or Time Period</th>
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<td>Late April - May</td>
<td>Club Meetings focus on synthesis of students' research and preparation of boards and presentations for June end-of-year research symposium.</td>
<td>Introducing and working with students to support successful analysis and synthesis of research, as demonstrated by oral and visual presentations; completing all logistics for June research symposium.</td>
<td>Students analyze and synthesize research findings to tell a cogent story/address a question or hypothesis, and begin to prepare presentation (oral and trifold board).</td>
<td>Supporting as needed with end-of-year research symposium.</td>
</tr>
<tr>
<td>June</td>
<td>Students participate in culminating Research Symposium.</td>
<td>Facilitating students' sharing out of research at June research symposium.</td>
<td>Students put final touches on presentations and boards; share out and celebrate research at research symposium.</td>
<td>(Optional) attending the end-of-year symposium.</td>
</tr>
</tbody>
</table>
**Project Map: Activities and Responsibilities**

Identify the project activities, tasks, and responsibilities the HSSRP teacher, students, and administration will have for each week of the project. For administration, consider the things they may need to do to make all elements of your club – space, student recruitment, symposium attendance, etc. – possible. Be sure to plan for activities done during club meeting time, as well as work that the teacher, students, or administrators will be doing outside of when the club meets.

An electronic version of this chart is available at [http://spep.libguides.com/HSSRP](http://spep.libguides.com/HSSRP).

<table>
<thead>
<tr>
<th>Week</th>
<th>Project Activities and Milestones</th>
<th>Science Teacher Tasks and Responsibilities</th>
<th>Students Tasks and Responsibilities</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>November</td>
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<tr>
<td>December</td>
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# Project Map: Activities and Responsibilities

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</thead>
<tbody>
<tr>
<td>1st Week of January</td>
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<tr>
<td>2nd Week of January</td>
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<tr>
<td>3rd Week of January</td>
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<td>4th Week of January</td>
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<tr>
<td>Week</td>
<td>1st Week of February</td>
<td>2nd Week of February</td>
<td>3rd Week of February</td>
<td>4th Week of February</td>
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<td>Science Teacher Tasks and Responsibilities</td>
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<tr>
<td>Students Tasks and Responsibilities</td>
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<tr>
<td>Project Activities and Milestones</td>
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**Notes**
<table>
<thead>
<tr>
<th>Project Map: Activities and Responsibilities</th>
<th>2nd Week of March</th>
<th>3rd Week of March</th>
<th>4th Week of March</th>
<th>5th Week of March</th>
<th>1st Week of April</th>
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<tbody>
<tr>
<td>Science Teacher Tasks and Responsibilities</td>
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<td>Students Tasks and Responsibilities</td>
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<td>3rd Week of April</td>
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<tr>
<td>4th Week of April</td>
<td>Spring Break</td>
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<td>1st Week of May</td>
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<td>1st Week of June</td>
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<td>2nd Week of June</td>
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*Week of Research Symposium!*
Notes:
Additional Articles

Lauver, Sherri, *Attracting and Sustaining Youth Participation in After School Programs*, The Evaluation Exchange, Harvard Graduate School of Education, Volume X, Number 1, Spring 2004

*Sherri Lauver* from Harvard Family Research Project reviews implementation data from a range of evaluations to propose a set of strategies for recruiting and retaining youth participation in out-of-school time programs. Includes a bibliography with additional articles and resources.


While this resource is geared towards a broader range of experiential science programs for students of all ages, it includes a number of best practices in student recruitment and engagement that can be adapted to your Science Research Club. Additionally, as literature review, it includes a comprehensive list of research articles around science learning in afterschool setting.