Pittsburgh Regional Science and Engineering Fair (PRSEF) 2021

Teachers' and Students' Handbook

Contents

Announcement: Due to the unprecedent public health challenges we are facing and out of concern for the safety of our students, judges and volunteers, PRSEF 2021 will be a virtual fair. The virtual fair is being developed by Carnegie Science Center staff and the PRSEF Judge Advisory Committee, who have extensive experience in science fair management. The principles of conducting a science fair are the same regardless of if the fair is held virtually or in-person. The information provided herein is applicable generally.

Important Dates and Deadlines

Pittsburgh Regional Science and Engineering Fair (PRSEF) Wednesday, March 24, 2021

2021 Student Registration Deadlines

School Registration Opens – September 1, 2020

School Registration Closes – November 13, 2020

Student Registration Deadline for projects requiring preapproval – November 20, 2020

Note- All projects involving human subjects, non-human vertebrate animals, potentially hazardous chemicals, activities and devices require pre-approval

Student Registration Deadline – January 8, 2021

Student Registration Deadline for schools with science fairs – February 5, 2021

Abstract Submission Deadline – February 5, 2021

Regeneron ISEF Student Deadlines (9th – 12th grade only):

One copy of the student's research paper and application must be mailed to Carnegie Science Center, Attn: PRSEF Director, One Allegheny Avenue, Pittsburgh PA 15212 – February 28, 2021

One copy of the student's research paper must be emailed to PRSEF@CarnegieScienceCenter.org – February 28, 2021

Final paperwork must be submitted to Regeneron ISEF by winners – April 2, 2021

Student must attend ISEF prep session – April 2021

Regeneron ISEF will be held in May 2021; Location TBD

Note: Student must be a PRSEF participant and complete the appropriate paperwork to apply for Regeneron ISEF

See Appendix 1 Science Fair Timelines for additional information

Who, what, why, how?

Who can compete?

Any student in grades 6-12 who resides in Allegheny, Armstrong, Beaver, Bedford, Blair, Butler, Cambria, Clarion, Clearfield, Fayette, Greene, Indiana, Jefferson, Lawrence, Mercer, Somerset, Venango, Washington, or Westmoreland counties in Pennsylvania or in Garrett County, Maryland is welcome to compete at PRSEF.

Why do a research project?

Scientific research helps us to understand the world around us and make it a better place. Through their research students can explore topics which are relevant to them or their community, increase awareness of those issues, explain phenomena in the world around them, advance technology and enrich the lives of those around them. By exploring the world around them through scientific investigation and independent research students gain the skills of

- Critical thinking and observation
- Data analysis
- Perseverance
- Public speaking and communication
- Creativity and problem solving
- Confidence
- Collaboration

In ALL aspects of a student's life, the knowledge and skills gained by completing a science or engineering research project will always be with them personally and professionally. **These are important for any career path**.

Participating in science fair helps students to develop their own STEM identity. Science fairs make science research more accessible to students who may not previously have been able to picture themselves as scientists and can spark a lifelong love of inquiry and experimentation. Interviews with judges, mentorship from local scientists and the interest of their science teacher demonstrate to students that adults value them and their work. Science fair projects are also an effective way for students to solve problems in their community and make their voices heard.

Scientific research is also fun and highly satisfying! STEM clubs or research classes allow students to work together and be part of a team, create a sense of community and camaraderie, and normalize the experience of pre-collegiate research. Science fairs give young scientists a sense of belonging and teamwork.

Please see Appendix 2 How Student Science Research Projects Provide Support for Meeting PA State Science Standards and Assessment Anchors.

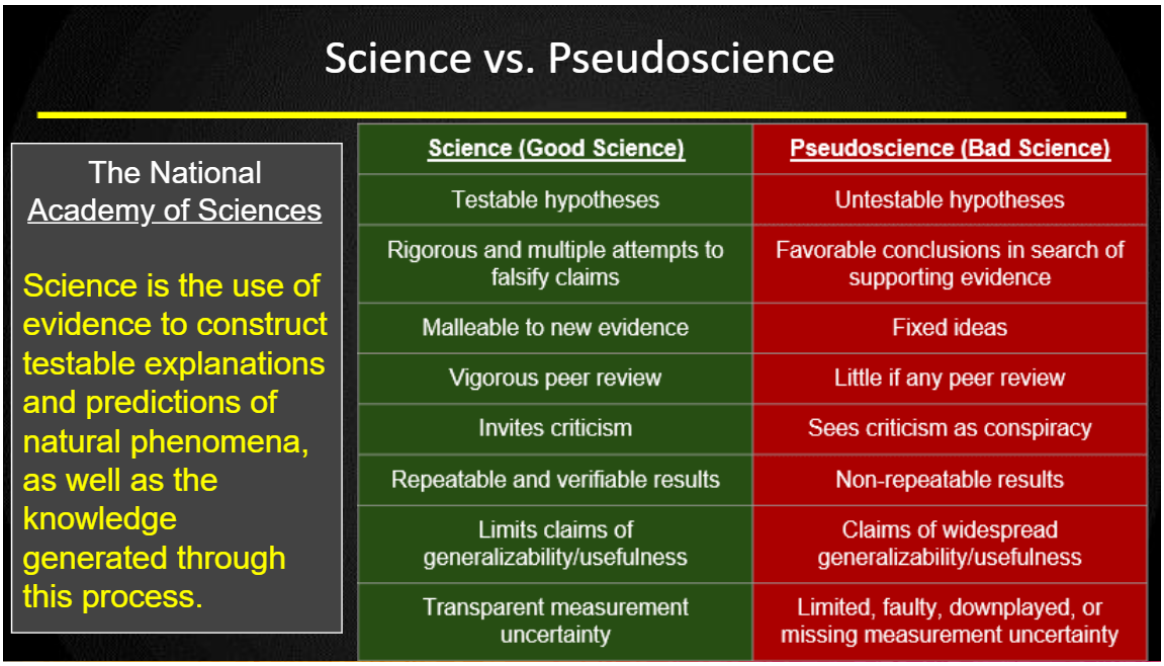
What is a Research Project?

A research project is when you use a step-by-step approach, like the scientific method, to answer a question or solve a problem.

Good scientists, both young and old, follow a similar approach to study what they see in the world. Research is the process by which people create new knowledge about themselves or the world in which they live in order to answer a question or solve a problem. When choosing your topic, give careful thought to how your research might enhance the world and its inhabitants. Questioning is probably the most important part of scientific creativity and is often followed by an "if...then" statement. Questioning usually leads to experiments or observations.

All students should strive to conduct original research and open-ended investigation which is hypothesis-driven. Original research does not seek to repeat or confirm experiments which have already been done, but rather aims to answer a new question. In an open-ended investigation, a student will conduct a series of experiments where the results of one experiment lead to the next question in a repeated fashion.

Students should learn to be skeptical of all research results, especially their own. A good experiment may or may not answer the questions asked, but almost always leads to fresh questions requiring new experiments or observations. The final hypothesis is often developed after the researcher has run a number of preliminary experiments, analyzed a body of results, and reached a tentative conclusion. The results of a student's work must be measurable and, in most cases, quantifiable.



Some projects do not look like what we usually think of when we hear the term "science fair project".

Engineers create things that never were or improve on a previous design. An engineering project should state the engineering goals, the development process and the evaluation of improvements.

Computer science projects involve creating and writing new algorithms to solve a problem or improve an existing algorithm. Simulations, models or "virtual reality" are other areas on which to conduct research.

Mathematics projects involve proofs, solving equations, etc. Math is the language of science and is used to explain existing phenomena or prove new concepts and ideas.

Theoretical projects involve a thought experiment, development of new theories and explanations, concept formation or designing a mathematical model.

Social sciences projects which do not involved an experiment or data are not appropriate for competition at PRSEF.

How do I participate at PRSEF?

Students Should Complete the Following Steps Involved in a Research Project

1. Pick a topic of interest. Use the ideas in Appendix 3 Projects to Avoid for guidance. Some ideas about where to find topics for science fair projects include:

    - The community – what problems do you see, what are you curious about
    - Nature – nearby parks, forests, farms and waterways can provide interesting topics
    - Current events
    - Water analysis of local streams - algae blooms, erosion, salinity
    - Science News for Students, Science News for High Schools, and Science News – all publications of the Society for Science and the Public
    - Science News archived educator guides - available for free at sciencenews.org
    - Society for Science and the Public blog - https://www.societyforscience.org/blog/
    - Sustainable development goals published by the United Nations at https://sustainabledevelopment.un.org/
    - The Earth Deconstructed Project
    - Work done by local universities or businesses
    - Published literature

    Publicly available open source data sets can also be a good source of ideas for a project. Some you might want to explore include:

    - USGS Earth Explorer geological and geographic data
    - NASA image data
    - NASA Geosciences data
    - Infrared astronomy data – IPAC
    - Work done by local Geographic Information Systems professionals
    - Data about weather conditions at https://www.WeatherSTEM.com and https://data.noaa.gov/datasetsearch
    - Websites like https://animaldiversity.org/ with information about specific animal species
    - CDC disease data
    - US Census bureau (demographics, populations, voting)
    - The human microbiome project
    - Genetic stock collections
    - World Bank Open Data

- World Health Organization
- Google Public Data Repository
- Registry of Open Data on AWS
- FiveThirtyEight
- US government open data
- freeCodeCamp
- UNICEF
- Kaggle
- LODUM
- UCI Machine Learning Repository

2. Ask a question or identify/define a problem related to the chosen topic.
3. Search for and review published materials related to the question or problem. Visit Appendix 4 Links to Recommended PRSEF Resources, Appendix 5 PA Power Library, Appendix 6 Science Projects Research Ideas from Sponsors, Appendix 7 Recommended Chemistry Resources, and **Access PA Power Library** or www.wlnonline.org/PRSEF for appropriate resources. To determine if an internet resource is reliable check the tips at www.wlnonline.org/PRSEF or https://acscareers.wordpress.com/2013/08/05/its-on-the-internet-it-must-be-true/. Students should do this in November to be ready for PRSEF in March.
4. Develop a research plan. All research plans must include: rationale, research question/engineering goal, hypothesis/expected outcome, procedure, risk analysis and bibliography with at least 5 (five) major references (e.g. science journals, books, articles, internet sites). Sources will be checked and must be well documented. See www.wlnonline.org/PRSEF and Appendix 8 A General Guide for Scientific References for guidelines regarding formatting references. **Urls alone are not acceptable as references to scientific resources.** Reference pages must be written in a recognized professional format (MLA, APA etc.)
5. Teachers: Before registering students for the fair, work with them to choose a category for each project. See Appendix 9 Project Categories for a complete list of categories. Choosing the correct category ensures that the project is evaluated by judges who are appropriate subject matter experts and will increase the chances of a project being recognized with an award.
6. Teachers: Register the project and student online at www.PRSEF.STEMisphere.org and complete Form 1. This will generate all of the required forms for the project. If you are unsure that the forms were generated correctly, use the rules wizard at https://ruleswizard.societyforscience.org/ to help you determine which forms should be required or contact PRSEF@CarnegieScienceCenter.org. Be sure to read Guide to the Scientific Review before completing the forms. The following forms must be submitted for **ALL** projects:
   - Form 1: Checklist for Adult Sponsor
   - Form 1A: Student Checklist
   - Research Plan (page 2 of Form 1A)
   - Form 1B: Approval Form
   - Form 3: Risk Assessment Form
7. Complete, sign and submit the forms at www.PRESF.STEMisphere.org. At a minimum, this part of the process will require participation by the adult sponsor, student, and parent. Other adults may also be involved depending upon type of project. Once the project has been reviewed, you

will receive an email either requesting additional information or approving the research project. When you receive a confirmation notice of approval—START YOUR RESEARCH!

8. Challenge and test the hypothesis through experimentation (data collection) and analysis or build and test an engineering model.

   For students who are completing an engineering project, sites like TinkerCAD, Adafruit.com and Arduino may be helpful. Appropriate resources provided to PRSEF by science fair teachers Vince Joralemon and Mike Carapezza can be found at: TinkerCad Worksheets (https://www.tinyurl.com/tinkercadworksheets), Engineering Design Worksheets (https://www.tinyurl.com/edpworksheets2020) and Arduino Activities (https://www.tinyurl.com/arduinoworksheets). Students should do this in January to be ready for PRSEF in March. Note: Keep track of all data in a project data book.

9. Examine and organize the data. Evaluate the results of the experiment or engineering project and reach conclusions based on the data. Use the statistics suggestions in Appendix 10 Using Statistics for ideas about how to analyze data.

10. Write an abstract and add it to your registration file before February 5. Sponsor, affiliate sponsor and scholarship and judges will use abstracts to select the students they are interested in interviewing on fair day. A high-quality abstract will earn you more interviews. See the section *Abstracts, Presentation Boards and Research Papers* for more information.

11. Prepare a report and/or presentation board (junior and intermediate divisions) or write a research paper (senior division). See the section *Abstracts, Presentation Boards and Research Papers* for more information.

12. Prepare and upload your fair day document and project gallery video presentation- see the section *Abstracts, Presentation Boards and Research Papers* and the PRSEF rulebook for more information.

Teachers: All students must be registered and have submitted the required forms at www.PRSEF.STEMisphere.org on or before January 8, 2021 unless the school has a science fair in which case the deadline is extended to February 5, 2021.

Teachers: In mid-March, fair day logistics will be emailed to you to share with the students.

Tips For Teachers

Bring in help – Invite local scientists from industry or academia into your classroom to talk to students about their work. Students benefit greatly from knowing that there are adults in the science community who care about them and their research. If you are working with minority students, a scientist who shares their background and heritage – who looks like them - is even more inspirational. Scientists in academia and industry are often looking for partnerships and outreach to fulfill requirements of their grants. You can contact individuals in management at local universities and companies to help you find scientists who have grant obligations.

Broaden your reach - If you can't find anyone local, track down role models through social media or the internet and ask them to visit your classroom virtually. Local Geographic Information Systems professionals who can be found at https://www.gisci.org/Recertification/GISPRegistry.aspx can be a great resource.

Create community – Science is a team sport and groups of students working on related projects or toward a similar goal (like attending PRSEF) benefit from the same sense of community which a sports team would benefit if you create the community. You can create a feeling of belonging by giving students a time and space to gather and collaborate. Host a community night during which families, friends, local business owners and other students can see student work. Invite students from lower grades to see your students' projects and allow the older students to plan science demonstrations for the younger students. Encourage students to work in the community to find inspiration for project ideas and support for their ideas.

Encourage summer research – There are numerous summer research programs for high school students in the Pittsburgh area. Encourage your students to apply to these programs to give them a head start on their projects.

Communicate, communicate, communicate – Students need lots of reminders to stay on track, especially when a project takes place over such a long period of time. Use class announcements, hard copy messages to parents, the Remind app for texting, YouTube videos with instructions, emails to parents and any other method you can think of to keep students on track. The more varied the communication is, the more likely you are to reach everyone.

Engage parents – The parents of student researchers are most likely not scientists themselves; they might not even know anyone who is a scientist. They do not need to understand the intricacies of the project (or even much of the vocabulary), but they can still help with transportation to and from local labs or after-school STEM club meetings, listen to the students practice their presentations, supervise progress toward due dates and milestones, and offer encouragement. If a parent believes that their child can be a scientist, the child is more likely to believe it themselves.

Be flexible – Students are so busy with other activities, after-school jobs, family obligations, and homework! Try to offer multiple times and options for them to work with you on their project. If they can't attend the club meeting after school because they don't have a ride home if they miss the bus, offer to meet with them before homeroom or make yourself available by phone.

Use free resources from Society for Science and the Public – Explore www.ScienceNews.org and www.SocietyForScience.org under Outreach and Equity. You can find free Science News (high school) and Science News for Students (middle school) articles, archived educator guides from Science News, e-newsletters, an online community of science teachers and the advocate program for special support for underrepresented and low income student populations.

Use the technology which is available – Students do not need to work in a university level lab to do great science. Simple model organisms like pill bugs, bean beetles, planarians, fruit flies, brine shrimp, onions, garlic, herbs, lichen, and legumes among others can be used to do very interesting science fair projects. The model organism does not need to be complex; it just needs to match the research question. The most important parts of the project are not the complexity of the technology used, but the uniqueness of the question, the creativity of method, and the reliance on iterative use of the scientific method.

Encourage your students to publish their work - Reach for the stars! The following journals publish pre-collegiate research. Submitting student research to them will give them access to professional peer review.

- National High School Journal of Science
- Journal of Student Research
- Journal of Student Science and Technology
- Journal of Emerging Investigators

Need more help? Ask the Science Fair Director! Send an email to PRSEF@CarnegieScienceCenter.org or call 412-237-1534. We are always here to help support you and your students.

Abstracts, presentation boards and research papers

Abstracts

After finishing research and experimentation, students are required to write a (maximum) 250-word, one-page abstract. An abstract should include: (a) purpose of the experiment, (b) procedures used, (c) data, and (d) conclusions. It also may include any possible research applications. Projects do not need to be completed to submit an abstract. You can simply state that experimentation is continuing, and results will be available on fair day. Only minimal reference to previous work may be included. The abstract should focus on work done since the last PRSEF and should not include: a) acknowledgments, or b) work or procedures done by the mentor.

It is in the student's best interest to submit an abstract prior to the fair. Sponsor award judges and other special award judges have access to student abstracts prior to competition day to determine which projects address their special areas and are eligible for their prize. In addition, category judges review abstracts prior to interviews for a summary of the research. Abstracts must be submitted online at STEMisphere.org/PRSEF by the adult sponsor or the student.

A completed abstract MUST be submitted online on or before February 5, 2021.

Abstract Samples –

Project Title: *What Type of Trash Makes the Most Biogas*
Fossil fuels are becoming a rare resource because they are nonrenewable. My experiment provides us with an alternative way to produce gas. I wanted to find out which type of organic material produces the most biogas. To do that, I pureed apples, blueberries, onions, and lettuce, put them in bottles filled to the top with water, and sealed the top with a balloon. Then, every day for a week, I measured the circumference of the balloon. After the one week, the apples ended up producing the most biogas, rejecting my hypothesis that the blueberries would produce the most biogas.

Project Title: *Landfill Chemistry*
Landfills are a major problem and this study evaluated ways to increase the decomposition rate of newspaper, a common ingredient. Eight simulated landfills were built, and the rate of the decomposition of newspaper was tested by adding various agents: "yeast with Yeast Energizer,"

"Campden Tablets," and "Amalayse Enzyme." Microbial growth and biodegradability of the newspaper were then examined. Newspaper treated with Alpha Amylase underwent a significant increase in decomposition as compared with untreated samples and the other agents. Future studies are being planned in an effort to increase the decomposition rate of plastics and organic garbage.

Project Title: *Cetuximab_DHA Antitumor Effect*
Cetuximab is EGFR-specific antibody treatment for head and neck cancers. Since only 10-20% of patients respond clinically, there is an interest in enhancing cetuximab's efficacy. Docosahexaenoic Acid (DHA) is an omega-3 fatty acid that can inhibit tumor progression. The effects of combining DHA and cetuximab on cell proliferation, EGFR expression, and antibody dependent cell-mediated cytotoxicity (ADCC) were studied in vitro. Combination treatment better reduced proliferation, and DHA upregulated phospho-EGFR while combination treatment mitigated this effect. Pre-treatment of tumor cells with DHA increased ADCC by healthy donor effector cells. These findings show co-administration enhances the antitumor effects the treatments had alone.

Presentation Boards

Junior and Intermediate Division students must submit a PDF document (2.5MB or less in size) containing the information which would have been included on a poster at the fair: title, rationale, research question, hypothesis, procedure, results and data analysis, conclusions. The PDF file may include images of your poster board (if you created one) or presentation slides describing your project.

Images of three-dimensional demonstration materials, abstracts, and research papers are not required, but may also be included. Take photographs of important parts/phases of your experiment to use in your project submission file. You must have signed consent forms from human test subjects pictured in photographs. All photos must have a credit line of origin ("Photograph taken by..." or "Image taken from..." or "Graph/Chart/Table taken from…"). All images MUST BE properly cited.

Judges highly recommend including excerpts of information from a data book which you used to record accurate and detailed notes. Good notes show consistency and thoroughness to the judges, help to make a logical and winning project and are useful when summarizing your work in a research paper or on a presentation board.

Tips for Presentation Boards

- A Good Title - Your title should be simple, accurate and an attention-grabber. It should make the observer want to know more.
- Organization - Make sure your display is logically presented and easy to read. A glance should permit anyone (particularly the judges) to quickly locate the title, experiments, results, and conclusions. When you arrange your display, imagine that you are seeing it for the first time. When you assemble your pdf file, make sure that the logical flow of your poster isn't lost.
- Eye-catching - Make your project stand out. You could do this by including photographs, using neat, colorful headings, charts, and graphs. Pay special attention to the labeling of graphs, charts, diagrams, and tables - each item must have a descriptive title. Anyone should be able to understand the visuals without further explanation.
- Ask adults for advice when needed.

- Your goal is to make the observer want to know more. Make it easy for interested judges to assess your study and the results. Use clear and concise elements. Headings should stand out. Draw graphs and diagrams clearly and label them correctly.

Research Paper (Required for Regeneron ISEF and for Senior Division PRSEF students)

Senior Division students must submit a research paper. This document must be a PDF file 2.5MB or less in size. The paper must include an abstract, rationale, research question, hypothesis, procedure, results, data analysis, and conclusions. Research papers may include excerpts from a project data book and any other relevant written materials.

A research paper helps organize data as well as thoughts. A good paper should resemble a paper which could be published in a scientific journal. Check www.wlnonline.org/PRSEF for examples of scientific journals and what the papers there contain. The research paper should be no more than 20 pages long. Relevant data tables should be included in appendices. The appendices are not included in the 20-page limit.

Elements of the research paper

- **Title Page and Table of Contents** – The title page and table of contents allows the reader to follow the organization of the paper quickly.
- **Abstract** – Summary of your experiment in 250 words.
- **Introduction** – The introduction sets the scene for your report. The introduction includes the purpose, your hypothesis, problem or engineering goals, an explanation of what prompted your research, and what you hoped to achieve.
- **Materials and Methods** – Describe in detail the methodology used to collect your data or make your observations, design apparatus, etc. Your report should be detailed enough so that someone could repeat the experiment from the information in your paper. Include detailed photographs or drawings of self-designed equipment. Only include this year's work.
- **Results** – The results include data and analysis. This should include statistics, graphs, etc.
- **Discussion** – The discussion section is the essence of your paper. Tell your readers exactly what you did and thought. Compare your results with theories, published data, commonly held beliefs, and expected results. Discuss possible errors. How did the data vary between repeated observations of similar events? How were results affected by uncontrolled events? What would you do differently if you repeated this project? What other experiments should be conducted?
- **Conclusion** – Briefly summarize your results. Be specific. Do not generalize. Never introduce anything in the conclusion that has not already been discussed. This is a good place to discuss practical applications.

- **Appendix including acknowledgments** – Credit those who assisted you, including individuals, businesses, and educational or research institutions. Note any financial or material donations. Do not list teachers, parents, schools, etc. by name. Relevant data tables may also be included in an appendix.
- **Bibliography** – Include any documentation not your own (i.e., books, journal articles). See an appropriate reference in your discipline, www.wlnonline.org/PRSEF or Appendix 8 A General Guide for Scientific References for format (ie. APA, MLA or Chicago Manual of Style) to learn more about how to format your bibliography. Urls alone are not acceptable references.

Fair Day Interviews

Communicating your science is a skill which must be developed just like your wet lab techniques. When talking about your project to others you should:

- Explain why your project is important not only to you but also to the person you are talking to, your community or society as a whole. Using a who, what, when, where, why, how approach is helpful for introducing the most important points.
- Be clear and avoid using complicated technical terms which the other person might not understand. Explain to your audience what your findings mean and what broader applications they might have.
- Be honest - even if your results did not support your hypothesis or if you don't know the answer to a question. Acknowledge the limitations of your current project when asked. Telling a judge that you don't know the answer to a question and then suggesting ways you might be able to find that answer is strongly encouraged.
- Remember that you are the expert on your work. Nobody knows your project better than you do (even the judges), but they are interested in learning more and need for you to teach them.
- Practice, practice, practice. The more times you present your work and the more varied your audiences are, the better you will get at communicating your science. It doesn't matter if your audience knows a lot about science or not – post your talk on social media (with your parent's permission), ask younger scout troops if you can present to them for a badge, tell your parents, siblings, aunts, uncles, teachers, neighbors and friends about your work and try to answer their questions in simple terms.
- Bring your ideas, knowledge and enthusiasm.

Fair Day Schedule

Fair Day Schedule – Wednesday, March 24, 2021

8:00 am – 8:30 am
Orientation

8:40 am – 12:20 pm
Morning Interview Session

12:20 pm – 1:00pm
Lunch break

1:00pm - 3:00 pm
Afternoon Interview Session

The online project gallery and engaging content from our sponsoring organizations will be available throughout the day. Further details will be published closer to the event.

Virtual Science Fair Awards Ceremony – Thursday, March 25, 2021 - 6:30 pm – 8:30 pm

Rules of Participation

See 2021 PRSEF guidelines and 2021 ISEF guidelines for full details.

Ethics Statement: Scientific fraud and misconduct are not condoned at any level of research or competition. This includes plagiarism, forgery, use or presentation of other researcher's work as one's own and fabrication of data. Fraudulent projects will fail to qualify for competition in affiliated fairs and Regeneron ISEF. PRSEF reserves the right to revoke recognition of a project subsequently found to have been fraudulent.

- You must not have reached age 20 on or before May 1, 2021.
- Must be in grades 6-12.
- You must live in one of the following counties: **PENNSYLVANIA:** Allegheny, Armstrong, Beaver, Bedford, Blair, Butler, Cambria, Clarion, Clearfield, Fayette, Greene, Indiana, Jefferson, Lawrence, Mercer, Somerset, Venango, Washington, Westmoreland or **MARYLAND:** Garrett.
- Team Projects (2 or 3 students) are permitted in all divisions. All team members must attend grades which are assigned to the same division. For example, a sixth grader (junior division) cannot work with a seventh grader (intermediate division). All team members must be present on Fair Day.
- Pittsburgh Regional Science & Engineering Fair is the ONLY science fair in Western PA which is affiliated with the Regeneron International Science & Engineering Fair. Please note for students new to your school (moving from other regions), a student may compete in only one ISEF affiliated fair in any one school year.
- The project must be solely the work of the exhibitor(s) in research, construction and design of the exhibit. Parents or sponsors may only advise. (Supervision and assistance with the use of power tools is exempt.)
- All work must be done within the 12 consecutive months and must begin no sooner than the January of the year prior to competition year (work for projects competing at PRSEF in 2021 must begin in sooner than January 2020). Continuation projects which rely on previous work and include a new research question or method of collecting/analyzing data are acceptable. Only work done during the current fair year may be presented in the competition. Form 7 must be completed for continuation projects.
- **Note:** Teachers that sponsor students from different schools (ie. Intermediate, high school) must register each school separately.
- Each student MUST HAVE an adult sponsor (parent /teacher/mentor) who is ultimately responsible for the health and safety of the student conducting the research and of any human or animal subjects. An adult sponsor may be a teacher, parent, university professor or scientist who has a solid background in science and will closely supervise the student's research.
- All students (in all divisions) conducting research involving vertebrate animals, human subjects, tissue, recombinant DNA, microbes, and pathogenic or controlled substances, must fill out special approval certification forms (See 2021 PRSEF Guidebook BEFORE starting the project. Paperwork deadline for these projects is November 20, 2020.

- **Human Participant Studies -** Projects involving the consumption, ingesting, tasting, applying, absorbing of any substance will be accepted with the approval of both the local Institutional Review Board (IRB) on Form 4 and of the PRSEF Scientific Review Committee (SRC). Research completed at a Regulated Research Institution and approved by the institute's IRB on Form 4 does not need PRSEF SRC approval. **PRSEF's SRC reserves the right of final approval of all other projects submitted to the competition. See** Human Participants **for more information**
- **Bacteria Projects:** Many students collect bacteria in a home environment. This is acceptable as long as the collected bacteria are immediately transported to a lab with the appropriate level of biosafety containment and petri dishes remain sealed throughout the rest of the experiment. See Potentially Hazardous Biological Agents for more information.
- **Mold Projects:** Many students observe mold growth on food. This is acceptable as long as the experiment is terminated at the first evidence of mold.
- High school seniors that are enrolled in college courses are eligible provided they are also enrolled in high school and will receive their diploma in the academic year in which they participate in PRSEF.
- Students MUST attend judge interviews during the official judging time on fair day. Teachers, adult sponsors, parents etc. may not coach the student during the judge interviews with the exception of assistance resolving technical issues with connecting to the judge call. ONLY students, judges, and official PRSEF volunteers/staff are permitted to participate in the judging calls.
- The Category Award Selection Procedure has been designed to ensure all projects are evaluated on a consistent basis and ranked appropriately with regard to receiving awards. The decisions of the judges, determined on the day of the fair, are final. See Appendix 12 Category Award Selection Procedure for details.

Judging and Category Award Selection Procedure

Students should be ready to talk in depth about their research. They should be able to have a conversation about their work and results. Students should practice explaining their research to parents, friends, teachers, and especially people who don't understand their research. They should tell everyone to ask them at least three questions.

Judges look for well thought-out research. They consider how significant the project is in its field, as well as how thorough the student was in conducting their research. Did they leave something out? Did they start with four experiments and finish only three?

Judges recognize students who can speak freely and confidently about their work. They are not interested in memorized speeches, but prefer simply to TALK with students about the project to see if they have a good grasp of their research from start to finish. Note cards are permitted, but students should not read from them. Besides asking the obvious questions, judges often ask questions to test students' insight into their project, such as, "What was your role?" or "What didn't you do?" and "What would be your next step?"

Judges expect the student to demonstrate that they did the work themselves.

Some students who compete at PRSEF have had opportunities to work in industrial research or teaching hospital labs. Students, parents and judges have expressed concern about equity in judging

these projects in competition with those done in more traditional places, i.e., home or school labs. PRSEF strives to maintain a level playing field.

Research is usually an activity that proceeds faster when ideas are exchanged and techniques are shared. This is especially true whenever the ideas shared are in part generated by a specialist or scientist working actively in the field in question. A student stands to gain considerable knowledge by association with these professionals and also usually has access to the latest research equipment. ***To this point, however, it is essential that the judge determine how the student connected with the lab. A student who chose the project and created the lab situation will be more highly rated than one who was led to those choices by someone of influence. The judge is evaluating the creativity of the student, not the mentor.***

The student researcher shall convince the judges of the following:

- ***The student did all of the work***. All of the work reported must be done by the student. It is unacceptable to present other's work, and any project doing that will be disqualified.
- ***A higher level of science is expected***. Whenever work is done in these labs it is expected to be more complex and advanced. In and of itself, this shall not influence a judge's evaluation. More complex science is usually presented in these cases; this is as expected and does not influence the rating.
- ***The student has a complete understanding of the work reported***. Each judge shall thoroughly test the student's knowledge of the subject. If a judge is not familiar with the science of the project a Category Chair shall be notified and other judges assigned. Here especially, judges shall not be satisfied with "canned" presentations.
- ***The student made use of the tools available***. The judge shall determine how effectively the student used resources available in the lab.

When deciding which of these projects to advance for Category awards, judges shall consider the judges' rubric attributes (See Appendix 12 Judges' Rubrics) and reward projects that have scored well against those criteria. Just as judges are not unduly influenced by a flashy poster, they should not automatically assume that these are better science projects.

See Appendix 11 Category Award Selection Procedure for details about the judging and award selection process.

Science Fair Awards

Pittsburgh Regional Science and Engineering Fair (PRSEF) awards fall into several different categories.

Category Awards - Awards are distributed based on the number of entries in each category. Multiple second, third and fourth place awards may be awarded. Only one first place will be awarded in each category.

Senior Division (Grades 9 – 12)

$300 – First Place
$150 – Second Place
$75 – Third Place
$25 – Fourth Place

Intermediate Division (Grades 7 – 8)

$150 – First Place
$75 – Second Place
$35 – Third Place
$20 – Honorable Mention

Junior Division (Grades 6)

$75 – First Place
$50 – Second Place
$30 – Third Place
$15 – Fourth Place

Note: Teams will split the award money equally among team members.

Regeneron International Science and Engineering Fair (ISEF) Awards

Senior Division, Grades 9 – 12
Each student researcher entering an exhibit may apply for participation in the International Science and Engineering Fair (ISEF). Senior division student researchers will be chosen from the applicants and will win an all-expenses paid trip to compete at ISEF.

Junior and Intermediate Division (Grades 6 – 8)
Category Award Winners (1st, 2nd & 3rd places) are nominated to advance to Broadcom MASTERS competition, a program of Society for Science and the Public.

Sponsor Awards

Companies which sponsor PRSEF may award a $50 prize to a student of their choosing. Sponsors use their own criteria to select projects. Some look for projects from their special field of interest. See Appendix 6 Science Project Research Ideas from our Sponsors for more information.

Affiliate Sponsor Awards - PRSEF is a regional science fair affiliated with the International Science & Engineering Fair (ISEF). Affiliated sponsor awards are presented at PRSEF based on criteria received from ISEF.

Scholarships - Senior Division PRSEF participants (9th-12th grade) are eligible to be judged and receive scholarships from participating colleges and universities. More than 100 scholarships are expected to be awarded.

Perseverance Awards

Honorary Scientist
Eleventh and twelfth grade students with five or more years of active participation.

Associate Scientist
Eleventh and twelfth grade students with three or four years and tenth grade students with four or five years of active participation.

Junior Scientist
Eighth and ninth grade students with three or four years of active participation.

Merit Awards - Category Judges select the students who exhibit excellence in Creativity, Presentation, or Scientific Method. Students will receive a certificate of excellence that signifies his or her outstanding performance in one of these areas.

Conditions of Awards
All cash awards will be paid in the year they are awarded, if the student has provided the necessary documentation (W9 forms) to process payment. Awards not distributed within one year of the award date will be subject to forfeiture. Internal Revenue Service (IRS) regulations require that Carnegie Institute file IRS Form 1099 for Miscellaneous Income for recipients of award monies which total $600 or more during a calendar year. Award recipients will receive their copy of Form 1099 from Carnegie Institute in January of the year following the year award payments are made.

Sponsors
The Pittsburgh Regional Science & Engineering Fair is presented by Covestro, FedEx Ground and leading corporations, foundations, professional societies and universities in this region.

Appendix 1 Science Fair Timeline

Steps to a Successful Project	Suggested Time Required
CHOOSE a topic/explore your world—almost anything can be the basis for a science project	1 week
RESEARCH your topic at the library to find background information on the general topic to narrow the topic	1-2 weeks
FORMULATE a question to explore the topic, DESIGN an experiment to answer the question and WRITE a research plan	2 weeks
COMPLETE required forms at PRSEF.STEMisphere.org	1 week
GATHER materials to do the experiment	1 week
BEGIN the experiment, OBSERVE and record data	Varies depending on the experiment
ORGANIZE recorded data into charts, graphs, tables	2 weeks
ANALYZE data using quantitative methods and form conclusions	2 weeks
PREPARE display and presentation	1-2 weeks

Important Dates to Remember

Item	Due Date
School Registration and Fee	Friday, November 13, 2020
Student Registration Forms (includes Form 1, 1A, Student's Research Plan, 1B, and 3)	November 20, 2020 for pre-approval projects (human participants, bacteria, vertebrate animals) January 8, 2021 for projects without pre-approval or a school science fair February 5, 2021 for schools with school science fairs
Student's Abstract entered online	On or before Friday, February 5, 2021
Submit Preliminary Application to PRSEF for Regeneron International Science & Engineering Fair (ISEF) 9^{th}-12^{th} grade students only	February 28, 2021
PRSEF Competition	Wednesday, March 24, 2021
PRSEF Awards Ceremony	Thursday, March 25, 2021

Visit www.pittsburghsciencefair.org for recommended websites and project ideas from our sponsors.

Appendix 2 How Student Science Research Projects Provide Support for Meeting PA State Science Standards and Assessment Anchors

Richard Close
Director of Outreach Delaware
Valley Science Fairs

There has been much discussion and debate regarding the value of students doing student science research projects. In doing science research projects students follow what is known as the "Inquiry Cycle" (similar to but significantly different from the old "scientific method"). The Inquiry Cycle has 8 parts:

1) the student identified question to be solved,
2) background research,
3) experimental design(procedure) to follow,
4) data taking through completion of the procedure,
5) analysis of data,
6) conclusions based on empirical evidence from the experiment,
7) dissemination of the findings to peer group/ professional scientists and
8) new question(s) raised from dissemination.

This sets the stage for another research question as new questions are raised from others and the process repeats itself.

From this it can be seen that logical problem solving is practiced by the student if they follow these steps. But how does this help the students meet the Pennsylvania Science and Technology Standards? How are they prepared for the PSSA Assessments that will be starting in Spring, 2007? To see, let's look at the State Science Standards and the newly released

"Assessment Anchors" and "Eligible Content" that will drive the PSSA Science Assessment. There are 8 major areas that the standards are divided into. These standards comprise what the students of Pennsylvania are expected to know and be able to do in the areas of Science, Technology and Environmental Education.(These are found at the PDE website.) The areas identified are:

1) Unifying Themes of Science
2) Inquiry and Design
3) Biological Sciences
4) Physical Science, Chemistry and Physics
5) Earth Sciences
6) Technological Education
7) Technological Devices
8) Science, Technology and Human Endeavor

Standards 1, 2, 6, 7 and 8 bring in new areas of thinking for the students. They will be highlighted to demonstrate that by **having students doing student science research, they will have opportunities to learn, practice and "hone" their skills and knowledge in these areas.**

Standards 3, 4 and 5 -- Biological Sciences, Physical Science, Chemistry and Physics, and Earth Sciences are the content-driven standards. These areas key on facts and concepts of science disciplines. Portions of the content of the various science disciplines, as identified in standards 3, 4 and 5, would be addressed in science research project as the students 1) do the background research for the problem or area under consideration and 2) perform the experimentation—"doing the science" that reveals the content identified in the content standards. A student researcher must know and understand the underlying, foundational concepts—the knowledge--- identified in these standards so that they can understand and extend the learning from the research project. As can be seen standards 3, 4 and 5 are compatible with rather than in opposition to the inquiry and process standards 1, 2 6, 7 and 8.("**Knowledge** -- facts, principles, theories and laws verifiable through scientific inquiry by the world community of scientists; includes physics, chemistry, earth science and biological sciences.")[1]

In **Standard 1---Unifying Themes of Science**--- students are challenged to be able **to identify the concepts of systems, model design, patterns, scale and change** in the natural world. This is a key area that student researchers develop as they complete their experimental design(through systems and "scale usage") and make their observations through quantitative data measurement. Then by analysis and interpretation the researcher develops their skills in seeing patterns, change and model design to answer their initial research question. **The research project gives the students a real life opportunity to see how these unifying themes in science can be observed through their own experimentation and inquiry.**

In **standard 2**, **Inquiry and Design**, students are challenged to "develop appropriate scientific experiments: raising questions, formulating hypotheses, testing, controlled experiments, recognizing variables, manipulating variables, interpreting data, and producing solutions."[1]

In addition they are to "apply the elements of scientific inquiry to solve problems by:

- Generating questions about objects, organisms and/or events that can be answered through scientific investigations.
- Evaluating the appropriateness of questions.
- Designing an investigation with adequate control and limited variables to investigate a question.
- Conducting a multiple step experiment.
- Organizing experimental information using a variety of analytic methods.
- Judging the significance of experimental information in answering the question.
- Suggesting additional steps that might be done experimentally."[1]

[1] **Academic Standards for Science and Technology,** Pennsylvania Department of Education, 2002.

Where will students have the opportunity to have these rich, scientific experiences on an ongoing basis--not a once a week, "guided inquiry", cookbook lab that most science texts provide**? Students and teachers will find that through the completion of a long-term student science research project they will be continually experiencing these scientific process skills while still dealing with the content and knowledge demanded by the state and national science standards.**

Standard 6 and 7 deals with **Technology Education** and **Technological Devices**. Depending on the project selected the student will have a greater or lesser amount of learning about technology, technological tools and technological problem solving. However, since almost all projects use computers and measurement devices, there is a portion of the standards that science research projects work with. Such standard indicators as "select and safely apply appropriate tools, materials and processes necessary to solve complex problems" and "apply advanced tool and equipment manipulation techniques to solve problems"[1] point to the student use and understanding of measurement and to the use of technology to solve problems, which is done during student science research projects. In addition, the standards statement "apply basic computer operations and concepts" challenges students to use computers in their problem solutions, **something that is done as they complete their student science research project.**

Standard 8 encompasses **Science, Technology and Human Endeavors**. This area requires the student to be able to analyze and apply solutions of science to real world conditions. Standard statements such as:

> 1) Analyze the relationship between societal demands and scientific and technological enterprises,
>
> 2) Analyze how human ingenuity and technological resources satisfy specific human needs and improve the quality of life and
>
> 3) Evaluate possibilities consequences and impacts of scientific and technological solutions require students to be able to apply their science learning to real world situations and conditions. This aspect too is part of student-driven science research. The student scientist is required to apply their investigation and project to a real world application. For many students, this is a first time experience of taking something they have "discovered" and think through how to apply this learning to a practical situation or condition. Rarely will students be asked to apply learning like this. Often textbook learning requests an application but seldom do teachers have students think about how their investigative discovery could apply to a real life situation. **Once again, the student science research project provides the means for standards-driven learning.**

The new PA Science Assessment Anchors provide teachers and students "eligible content" that the PSSA Science Assessment could incorporate in the assessment, starting in 2007. A few of the following are areas of "eligible content" that are strongly dealt with through the performance of student science research projects:

---

[1] **Academic Standards for Science and Technology,** Pennsylvania Department of Education, 2002.

- Evaluate the appropriateness of research questions (e.g., testable vs. not-testable).
- Explain how specific scientific knowledge or technological design concepts solve practical problems
- Analyze or compare the use of both direct and indirect observation as means to study the world
- Use appropriate quantitative data to describe or interpret change in systems
- Critique the elements of an experimental design (e.g., raising questions, formulating hypotheses, developing procedures, identifying variables, manipulating variables, interpreting data, and drawing conclusions) applicable to a specific experimental design.

- Critique the elements of the design process (e.g. identify the problem, understand criteria, create solutions, select solution, test/evaluate and communicate results) applicable to a specific technological design.
- Use data to make inferences and predictions, or to draw conclusions, demonstrating understanding of experimental limits.
- Critique the results and conclusions of scientific inquiry for consistency and logic.
- Communicate results of investigations using multiple representations.
- Evaluate appropriate methods, instruments, and scale for precise quantitative and qualitative observations
- Analyze and predict the effect of making a change in one part of a system on the system as a whole.
- Use appropriate quantitative data to describe or interpret a system
- Compare the accuracy of predictions represented in a model to actual observations and behavior.
- Describe or interpret recurring patterns
- Analyze stationary patterns and physical patterns of motion to make predictions or draw conclusion

  (taken from **Assessment Anchors for Science and Technology,** Pennsylvania Department of Education, 2004.)

These along with any of the content pieces that the student science research project deals with demonstrates once again the great value of having students meet the standards as well as preparing for the state science assessment **by using the science research project platform.**

In Closing

Knowledge of what science is incorporates carefully developed and integrated components:

- **Nature of Science**
- **Unifying themes of science**
- **Inquiry**
- **Process skills**
- **Problem solving**
- **Scientific thinking**

As you can see from the above summarization from the Pennsylvania Science & Technology Standards, students must learn science by doing. Inquiry is the key component for understanding science. How do students experience this? **By doing science as real scientists!** Where do they get the experiences like this? **By doing science research!** What platform allows this to happen on an ongoing, long-term basis? **Student Science Research Projects!**

Appendix 3 Top Projects to Avoid

Science Project Topics to Avoid	Why
Any topic that boils down to a simple preference or taste comparison. For example, "Which tastes better: Coke or Pepsi?"	Such experiments don't involve the kinds of numerical measurements we want in a science fair project. They are more of a survey than an experiment.
Most consumer product testing of the "Which is best?" type. This includes comparisons of popcorn, bubblegum, make-up, detergents, cleaning products, and paper towels.	These projects only have scientific validity if the Investigator fully understands the science behind why the product works and applies that understanding to the experiment. While many consumer products are easy to use, the science behind them is often at the level of a graduate student in college.
Any topic that requires people to recall things they did in the past.	The data tends to be unreliable.
Effect of colored light on plants	Several people do this project at almost every science fair. You can be more creative!
Effect of music or talking on plants	Difficult to measure.
Effect of running, music, video games, or almost anything on blood pressure	The result is either obvious (the heart beats faster when you run) or difficult to measure with proper controls (the effect of music).
Effect of color on memory, emotion, mood, taste, strength, etc.	Highly subjective and difficult to measure.
Any topic that requires measurements that will be extremely difficult to make or repeat, given your equipment.	Without measurement, you can't do science.
Graphology or handwriting analysis	Questionable scientific validity.
Astrology or ESP	No scientific validity.
Any topic that requires dangerous, hard to find, expensive, or illegal materials.	Violates the rules of virtually any science fair.
Any topic that requires drugging, pain, or injury to a live vertebrate animal.	Violates the rules of virtually any science fair.
Any topic that creates unacceptable risk (physical or psychological) to a human subject.	Violates the rules of virtually any science fair.
Any topic that involves collection of tissue samples from living humans or vertebrate animals.	Violates the rules of virtually any science fair.

Source: http://www.sciencebuddies.org/science-fair-projects/project_question.shtml#examples

What Makes a Good Science Fair Project Question?	For a Good Science Fair Project Question, You Should Answer "Yes" to Every Question
Is the topic interesting enough to read about, then work on for the next couple months?	Yes / No
Can you find at least 3 sources of written information on the subject?	Yes / No
Can you measure changes to the important factors (variables) using a number that represents a quantity such as a count, percentage, length, width, weight, voltage, velocity, energy, time, etc.? Or, just as good, are you measuring a factor (variable) that is simply present or not present? For example, Lights **ON** in one trial, then lights **OFF** in another trial, **USE** fertilizer in one trial, then **DON'T USE** fertilizer in another trial.	Yes / No
Can you design a "fair test" to answer your question? In other words, can you change only one factor (variable) at a time, and control other factors that might influence your experiment, so that they do not interfere?	Yes / No
Is your experiment safe to perform?	Yes / No
Do you have all the materials and equipment you need for your science fair project, or will you be able to obtain them quickly and at a very low cost?	Yes / No
Do you have enough time to do your experiment more than once before the science fair?	Yes / No
Does your science fair project meet all the rules and requirements for your science fair?	Yes / No
Have you checked to see if your science fair project will require SRC (Scientific Review Committee) approval?	Yes / No
Have you avoided the bad science fair project topic areas listed in the "Science Project Topics to Avoid" table?	Yes / No

Source: http://www.sciencebuddies.org/science-fair-projects/project_question.shtml#checklist

Appendix 4 Links to Recommended PRSEF Resources

Determining Reliable Internet Sources

If a publication is listed in a reputable source, like those below, you can be assured that they are accurate and legitimate:

NASA Headquarters Library

NASA Jet Propulsion Laboratory Video Series
How to do a Science Fair Project

Rubber, Plastic and More - Top Science Project Ideas

Carnegie Library Science & Technology Resources
Articles, Databases & More

Access PA POWER Library
(A research database) Requires a library card

International Science and Engineering Fair

The World-Wide Web Virtual Library: Science Fairs

Broadcom MASTERS Program

Discovery Young Scientists Challenge

Neuroscience for Kids

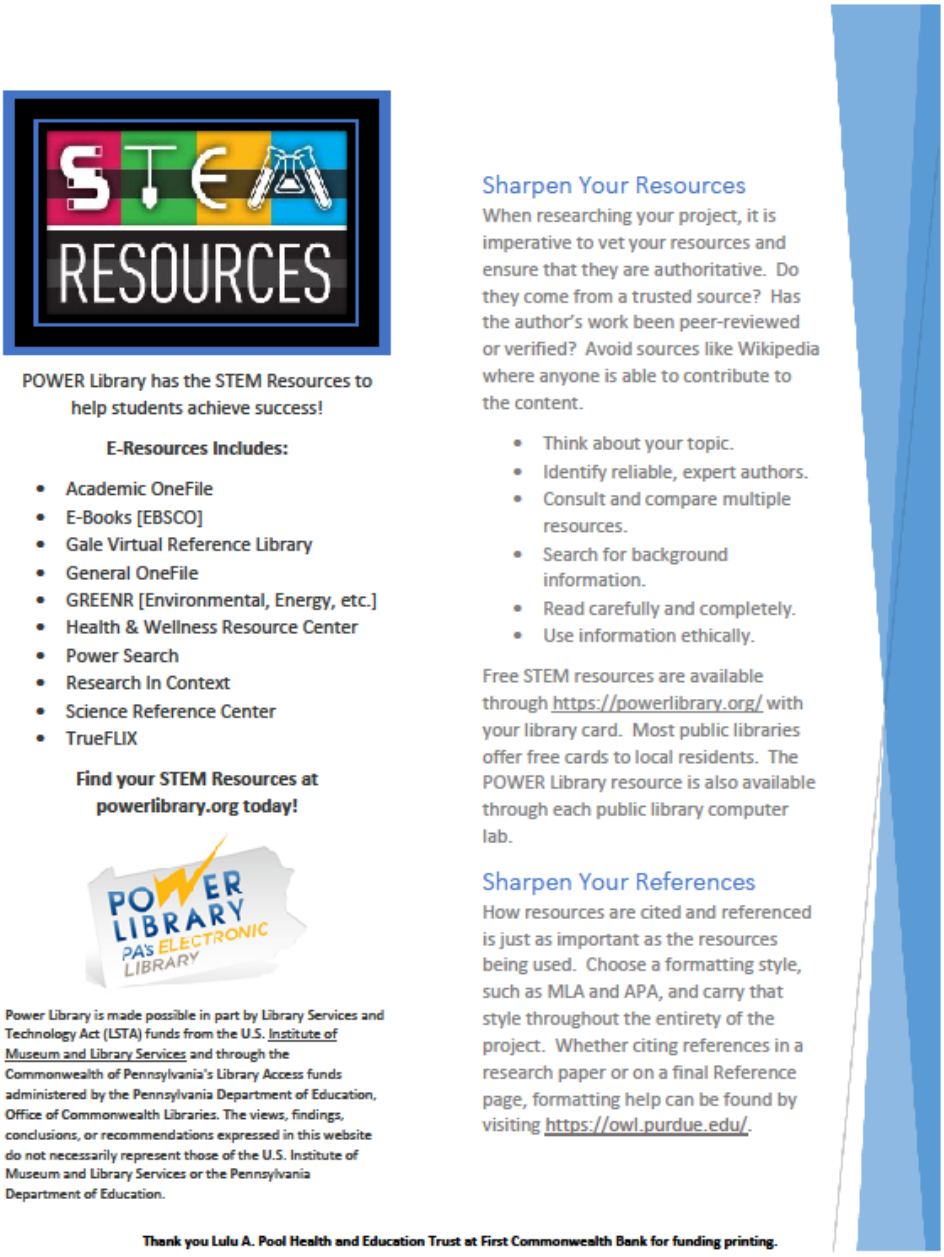
PubMed
A database of all published biomedical literature

Google Scholar
References to scholarly literature

See also, Appendix 7 Recommended Chemistry Resources

Appendix 5 PA Power Library

The Westmoreland County Library has compiled an excellent website full of high-quality sources and information about how to conduct a literature review and format a references page. This webpage can be found at www.wlnonline.org/PRSEF.



STEM RESOURCES

POWER Library has the STEM Resources to help students achieve success!

E-Resources Includes:

- Academic OneFile
- E-Books [EBSCO]
- Gale Virtual Reference Library
- General OneFile
- GREENR [Environmental, Energy, etc.]
- Health & Wellness Resource Center
- Power Search
- Research In Context
- Science Reference Center
- TrueFLIX

Find your STEM Resources at powerlibrary.org today!

POWER LIBRARY PA's ELECTRONIC LIBRARY

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Sharpen Your Resources

When researching your project, it is imperative to vet your resources and ensure that they are authoritative. Do they come from a trusted source? Has the author's work been peer-reviewed or verified? Avoid sources like Wikipedia where anyone is able to contribute to the content.

- Think about your topic.
- Identify reliable, expert authors.
- Consult and compare multiple resources.
- Search for background information.
- Read carefully and completely.
- Use information ethically.

Free STEM resources are available through https://powerlibrary.org/ with your library card. Most public libraries offer free cards to local residents. The POWER Library resource is also available through each public library computer lab.

Sharpen Your References

How resources are cited and referenced is just as important as the resources being used. Choose a formatting style, such as MLA and APA, and carry that style throughout the entirety of the project. Whether citing references in a research paper or on a final Reference page, formatting help can be found by visiting https://owl.purdue.edu/.

Thank you Lulu A. Pool Health and Education Trust at First Commonwealth Bank for funding printing.

Appendix 6 Science Project Research Ideas from our Sponsors

Our sponsors are a very important part of the Pittsburgh Regional Science & Engineering Fair. To increase the number of projects to be considered for a Sponsor Award, Sponsors have supplied us with project criteria to encourage students to conduct research related to the sponsor's field of interest.

Research Projects Related to Air & Water Pollution
Air & Waste Management of Western PA Section will present two student awards related to air and water pollution.

Research Projects Related to ALCOSAN
will present an award to one Senior Division student research project that proves in what way(s) pollution affects the environment. It is required that the project presents the different types of pollution, as well as their effects. The research project must demonstrate high-level thinking and reasoning, knowledge of the subject area, and a concern for water quality.

Research Projects Related to Allegheny County Health Department
Three students will be awarded in the areas of environmental health, air pollution and public health.

Research Projects Related to Allegheny County Medical Society Alliance
One Science Fair student and teacher award in the field of medicine/biology presented in honor ACMS Alliance members. Winning projects should promote healthy living, improve public health and/or the advancement of medicine.

Research Projects Related to Allegheny County Medical Society Foundation
Two awards will be presented to students with projects in a topic related to Medicine. Projects should demonstrate ideas that could improve health care for patients in the future or promote quality improvement in a medically related area. The project should demonstrate knowledge of the subject area and how it relates to the field of Medicine.

Research Projects Related to American Society for Quality
American Society for Quality will present an award to a student who applies quality techniques to his/her project. The judging criteria are: the students' ability to eloquently and accurately describe their project and a theme of quality within the project, which often involves the use of statistical methods for high school students or the inclusion of quantitative reasoning for middle school students.

Research Projects Related to American Society of Civil Engineers
The American Society of Civil Engineers, ASCE, Pittsburgh Section will present two Science Fair student awards in civil engineering. Projects involving dams and waterways will be considered since they are an integral part of our region. An award in the Junior Division and Senior Division will be presented.

Research Projects Related to ASM International, Golden Triangle Chapter
An award will be presented to one Science Fair student project in the field of materials science and engineering. The winning project will be chosen based on the following: a) project must be based on some aspect of materials-related concepts, for example: solidification processing, heat treatment, mechanical testing, corrosion, etc.; b) clarity of presentation; c) demonstration of a clear understanding of the scientific method; d) aesthetics - project layout, neatness, readability, etc.

Research Projects Related to The Aviation Foundation
Two student awards will be selected as follows: i) *Aviation Weather Prediction* - How to predict ceiling, visibility, wind and temperature needed by pilots. ii) *Unique Aircraft Design* – Develop an unusual design for an aircraft. Determine any advantages of this design.

Research Projects Related to Braskem America
Braskem America will present two awards to students with projects that demonstrate innovation with a focus on sustainability. We have a special interest in the areas of polymers, plastics, engineering, and chemistry.

Research Projects Related to Bridges
Two (2) students awards for bridge related projects sponsored by the Association for Bridge Construction and Design.

Research Projects Related to Carnegie Mellon University, Leonard Gelfand Center for Service Learning and Outreach.
Carnegie Mellon will present three student and sponsoring teacher awards. The Leonard Gelfand Center presents three awards annually. These are selected by Carnegie Mellon faculty or students and focus on the judges' area of research.

Research Projects Related to Chemistry
The Pittsburgh Section of the American Chemical Society will award students for projects that demonstrate creativity and knowledge in topics related to chemistry.

Research Projects Related to Duquesne University - Bayer School of Natural and Environmental Sciences
The Bayer School of Natural and Environmental Sciences at Duquesne University will award three students for their projects based on the areas of biology, chemistry, environmental science, forensics, and physics. Creativity, ingenuity and a strong understanding of the scientific method should be demonstrated.

Research Projects Related to Electrical Power:
Eaton will present awards for projects in the field of engineering relative to electrical power distribution, which demonstrate creativity and knowledge in topics related to energy efficiency, circuit protection, renewable power, electrical safety or power quality.

Research Projects Related to Electrical and Electronics Engineering - IEEE Award
The Institute of Electrical and Electronics Engineers (IEEE) will present The Institute of Electrical and Electronics Engineers (IEEE) will present two awards in the field of electrical and electronics engineering. Winning projects will demonstrate significant knowledge of electrical principles, electronics, robotics, computer design, software development or mathematical techniques. Students are encouraged to submit projects to the Science Fair categories such as Engineering, Robotics, Computer, Physical Science, etc. to be considered for these awards.

Research Projects Related to Innovation Works
Innovation Works will make awards based on the potential to commercialize technology to solve real-world problems. The technology can be based in any scientific or engineering discipline (robotics,

energy, life sciences, information technology, materials science, etc.) as long as there is a demonstrable need and the scientific research addresses the need with a solution that could be mass produced and marketed.

Research Projects Related to National Association of Corrosion Engineers, Pittsburgh Section
NACE International's Pittsburgh Section will present awards for the studies of corrosion mitigation that help protect people, assets, and the environment from the adverse effects of corrosion. Select an industry (Pipelines; Bridges; Drinking and Waste Water; Department of Defense; etc) and identify the threats of corrosion, the consequences of a corrosion event, and provide recommendations of mitigation measures for improvement. Creativity, ingenuity and a strong understanding of corrosion should be demonstrated.

Research Projects Related to Industrial Hygiene
The Pittsburgh section of the American Industrial Hygiene Association will present two awards in the field of Industrial Hygiene. Winning projects will be based on how well the student understands the health & safety industry which focuses on issues such as indoor air quality, exposure to chemicals, noise, heat/cold, vibrations, and repetitive motion.

Research Projects Related to Mining, Mining Engineering or the Field of Geology or Mineralogy
The Society for Mining, Metallurgy, and Exploration (SME) Pittsburgh Section would like to present an award to a project related to the application of mining and mining engineering or the fields of geology or mineralogy.

Research Projects Related to Neuroscience
Projects related in any way to the nervous system will be judged on their use of sound scientific methods and reasoning, and the quality of results obtained. This award is sponsored by the Department of Neuroscience, University of Pittsburgh.

Research Projects Related to Paints, Coatings and Related Materials
PPG will present six (6) awards for projects involving chemistry, physics, engineering, or material science which demonstrate creativity and knowledge in topics related to fiberglass, glass, coatings, paints, plastics, inks, adhesive, color, optically transparent material, polymers or chemicals. Two awards in each division (6th, 7th-8th, 9th-12th).

Research Projects Related to Pittsburgh Geological Society
PGS will present two awards. Awards will be presented for earth science / geoscience projects that examine how the geologic basis of our environment relates to everyday life. Ideas for project topic areas include the following. A rock stratagraphic column is a good place to start as it sets the framework for your investigation. Mineral resources are an important part of the Pennsylvania economy and the legacy of historic mining still causes problems of acid mine drainage, mine subsidence and hazardous materials contamination. Coal, oil, and gas development can interact with rural and urban development and affect both the quality and quantity of surface and groundwater resources. The current Marcellus shale gas drilling demonstrates the importance of that resource and its associated environmental controversies to the community you live in. Landslides destroy houses, close roads and disrupt utilities. The recognition of causes is an important municipal planning tool. Knowledge of the various types of rock and their properties are aspects of mineralogy, geochemistry, geophysics, geotechnical engineering and the durability of building materials, even gravestones. Fossils are important to understanding the role of evolution in a changing historical landscape and understanding differences in depositional

environments. Western PA even has volcanic rocks. Projects are not limited to Pennsylvania problems. Listen / read the news, look at an outcrop, let your mind wonder to the question Why!

Research Projects Related to Pittsburgh Intellectual Property Law Association (PIPLA)
PIPLA will award two students for projects that demonstrate creative ideas resulting in new and functional processes or devices. Projects in Engineering/Robotics, among others, will be considered.

Research Projects Related to Psychoanalysis
Pittsburgh Psychoanalytic Center will make an award(s) that offers a way of understanding ourselves, our relationships and how we conduct ourselves in the world. Winning projects could include the following topics: Dreams, the Unconscious, Development, Relationships, Trauma, or Anxiety/Defense.

Research Projects Related to Sigma XI - Carnegie Mellon University
Sigma XI - Carnegie Mellon University awards a student in any discipline of science or mathematics for a project that shows innovation, diligence, relevance to everyday life and quantitative analysis. We have a special interest in experiment design and use of statistical methods to interpret results.

Research Projects Related to Spectroscopy
An award will be presented by the Spectroscopy Society of Pittsburgh to the six Science Fair student projects in spectroscopy or its components, including optics, lenses, prisms, mirrors, lasers, dispersion, interference. Three awards will be selected from Senior and three from Intermediate/Junior Divisions. Winning projects will involve topics dealing with spectroscopy and will have completed all components of the PRSEF project (lab notebook, report and poster).

Research Projects Related to Society for Mining, Metallurgy, and Exploration
The Pittsburgh Section of the Society for Mining, Metallurgy, and Exploration (SME) would like to present their award to a project related to the application of mining and mining engineering or the fields of geology or mineralogy. Creative or innovative uses of modern technology, such as electronics, computerization, and/or robotics, in mining, mineral exploration, geology, mining equipment, miner safety, or mine rescue would merit strong consideration for a prize award.

Research Projects Related to Society of Military Engineers

What is the current condition of the nation's electrical generation and transmission grid and how will carbon reduction mandates, decreased electrical generation by coal, aging infrastructure, and alternative energy sources such as solar and wind affect the reliability of the power grid and the cost of electricity?

Given the impact of aging infrastructure nationwide, and the importance of maintenance to extend the service life, students could evaluate the infrastructure condition in their municipality, the budgets in place to maintain or replace infrastructure, and explore what planning options should be considered for maintenance and replacement of the municipality's infrastructure.

Research Projects Related to Society of Women Engineers
An award will be presented to one middle school female student and one high school female student for research projects showing practical applications of engineering principles (civil, chemical, industrial,

mechanical, electrical, environmental, biomedical, software, etc.). Winning projects will demonstrate a creative, yet practical, application of the selected engineering discipline.

Research Projects Related to Sustainable Materials

Covestro will present two awards in each division for projects focused on polymer materials and Circular Economy design principles. The winning project will take a future-facing look at expanding the long-term benefits of polymer technologies in areas such as recycling/reuse, energy efficiency and outreach. Solutions based on chemistry, environmental science and engineering will be considered.

Research Projects Related to The Webb Law Firm

The Webb Law Firm will award two students for projects that demonstrate creative ideas resulting in new and functional processes or devices. Projects in Engineering/Robotics, among others, will be considered.

Research Projects Related to the Impacts of Thermo Fisher Scientific

Thermo Fisher Scientific will present awards to projects whose finding and knowledge thereof could have impact in making the world healthier, cleaner, or safer. Subject matters may be related (but are not limited) to laboratory work in the fields of biology, chemistry, water quality, or safety for consumer or industrial markets.

Research Projects Related to Thiel College

Thiel College will present awards to projects in the fields of Behavioral and Social Science, Biology, Environment, and Medicine & Health

Appendix 7 Recommended Chemistry Resources

PRSEF Chemistry Category Judges' Preferred Bibliographic Resources

Charles B. Greenberg, Ph.D., Category Co-chair

A. About the "Science Enterprise" Generally

1. Krieger, Melanie Jacobs, *How to Excel in Science Competitions, Revised and Updated,* Enslow Publishers, Berkeley Heights, N.J. (1999).

2. Dashefsky, H. Steven, *High School Science Fair Experiments*: *Environmental Science*, McGraw-Hill, New York (1994). [Senior Chemistry level].

3. Bortz, Fred, *Revolutionary Discoveries of Scientific Pioneers*, 8 volumes, Rosen Publishing Group, New York (2014).

4. Gribbon, John, *The Scientists: A History of Science Told Through the Lives of Its Greatest Inventors,* Random House, New York (2002).

5. Greenberg, Charles, *Scientific Enterprise,* Pittsburgh Legacy Lewis and Clark: http://www.lc.pitt.edu, University of Pittsburgh (2002).

B. Intermediate School Chemistry

See Senior Chemistry below too and explore to your grade-appropriate comfort level for each subject. For example, the Encyclopedia Britannica, which is listed as reference #7 for Senior Chemistry, will also often serve Intermediate School Chemistry. So, do not hesitate to browse, and then move on to the next resource.

1. American Chemical Society, *Chemistry for Life*: http://www.middleschoolchemistry.com. [Protons, Neutrons and Elements; Finding Volume; Why Does Water Dissolve Salt?; The Periodic Table; Molecules in Motion]

2. Environmental Protection Agency, *A Students Guide to Global Climate Change:* https://www3.epa.gov/climatechange//kids/index.html.
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3. Gardner, Robert, Tocci, Salvatore, & Rainis, Kenneth G., *Ace Your Chemistry Science Project: Great Science Fair Ideas*, Enslow Publishers, Berkeley Heights, N.J. (2010). [Organized into five chapters: "Chemical Properties," "Acids and Bases," "Temperature," "Volume and Pressure."]

4. Mebane, Robert C. & Rybolt, Thomas R., *Adventures with Atoms and Molecules: Chemistry Experiments for Young People,* Enslow Publishers, Berkeley Heights, N.J. (1998).

5. Mebane, Robert C. & Rybolt, Thomas R., *Everyday Material Science Experiments," series: Air & Other Gases; Metals; Plastic & Polymers; Salts & Solids; Water & Other Liquids,* Twenty-First Century Books, New York (1995*).*

6. Museum of Science & Industry, Chicago, *Online Science, including goReact; Analyze Candy Using Chromatography; See the Colors in Leaves; Create Gas; Make Ice Cream; Make Recycled Paper; Make Slime:* https://www.msichicago.org/experiment/hands-on-science/candy-chromatography/.

7. Smithsonian Science Education Center, *Middle School Teaching Resources: https://ssec.si.edu/.* [Subjects include electricity, energy, optics, properties of matter, weather and climate.]

C. Senior Chemistry *(but not excluding Intermediate Level resources)*

1. American Museum of Natural History, *Power of Poison*: https://www.amnh.org/exhibitions/the-power-of-poison.

2. Bourne, Jr., Joel K., *Green Dreams*, National Geographic (October 2007): https://www.cbsd.org/cms/lib/PA01916442/Centricity/Domain/1622/Article%20I2%20-%20Green%20Dreams.pdf.

3. Carbon Dioxide Information Analysis Center: http://cdiac.ornl.gov.

4. Carnegie-Mellon University/National Science Digital Library (NSDL), *Resources to Teach and Learn Chemistry*: http://www.chemcollective.org/find.php. [Subjects include stoichiometry, thermochemistry, kinetics, equilibrium, acid-base chemistry, solubility, oxidation-reduction and electrochemistry, analytical chemistry lab techniques, and physical chemistry.]

5. Carson, Rachel, *Silent Spring,* Houghton Mifflin Harcourt, Boston (2002). [The classic book about how chemical pollutants impact life on earth; free download at https://archive.org/details/fp_Silent_Spring-Rachel_Carson-1962.]

6. Chemical Education Digital Library: http://www.chemeddl.org. [Access Periodic Table Live!, Models 360, ChemPRIME and more for searches.]

7. Encyclopedia Britannica, *Chemistry*: https://www.britannica.com/science/chemistry. [Broad coverage; if you are not a subscriber, just ignore the ads, which are the price for free access to the site.]

8. Environmental Protection Agency, *Data and Issues*: http://www.epa.gov.

9. Gardner, Robert & Shore, Edward A., *Math & Science in Nature, Finding Patterns in the World Around Us,* Scholastic Library Publishing, New York (1994). [Useful for applying statistical analyses to experimental data.]

10. Gay, Kathlyn, *Water Pollution,* Scholastic Library Publishing, New York (1990).

11. Gay, Kathlyn, *Air Pollution,* Scholastic Library Publishing, New York (1990).

12. Government Science, numerous topics: http://www.science.gov/index.html.

13. Kirk-Othmer Encyclopedia of Chemical Technology, 4th (or 5th) Edition, 27 volumes plus K-O Concise Encyclopedia of Chemical Technology, John Wiley & Sons, New York (1991-99). [Excellent resource, but affordable only by major public libraries, universities and corporate libraries. See Carnegie Library of

Pittsburgh, University of Pittsburgh Library, or Carnegie-Mellon University Library: free print reference; online with password access.]

14. Miodownik, *Stuff Matters,* Houghton Mifflin Harcourt, Boston (2014). [About various materials such as steel, glass, paper, textiles and more.]

15. National Science Foundation, *Classroom Resources for Chemistry and Materials*: http://www.nsf.gov/news/classroom. (*Lots and lots of excellent, user-friendly video resources for Intermediate and Senior levels on Chemistry & Materials, Earth & Environment, Nanoscience and more. A great place to start your bibliographic search.)*

16. National Renewable Energy Laboratory, *Alternate Energy and Biofuels*: https://www.nrel.gov/workingwithus/re-biofuels.html.

17. National Science Digital Laboratory: https://nsdl.oercommons.org/ [Browse the resource categories.]

18. Royal Society of Chemistry, *Learn Chemistry*: http://www.rsc.org/learn-chemistry/resource. [Lots of online videos on numerous subjects.]

19. Sandia National Laboratories, *Energy and Climate:* http://energy.sandia.gov. [Renewable Systems such as fuel cells and biomass, as well as the Combustion Research Facility, are linked.]

20. Spectroscopy Society of Pittsburgh: http://www.ssp-pgh.org/educational-software-video. [Access to free educational software]

21. Stwertka, Albert, *A Guide to the Elements, Revised Edition,* Oxford University Press, London, (1998).

22. Woods Hole Oceanographic Institution: *Ocean Chemistry*: http://www.whoi.edu/main/topic/ocean-chemistry; *Climate & Ocean:* http://www.whoi.edu/main/topic/climate-ocean.

Appendix 8 A General Guide for Scientific References

Students are required to list at least 5 (five) major references (e.g. science journals, books, articles, internet sites will be checked and must be well documented) in their research plans. Referencing sources correctly is crucial for purposes of academic integrity and of students' future success in higher educational pursuits.

Below are examples of what types of information to include in references, descriptions of what that information entails and how to find it, and formatting requirements for those references.

Basic Reference Structure:

Author(s), title, journal name, journal identifying information (year date, volume, issue, page(s)), web address (if any), date accessed (if web based)

Anatomy of a reference:

Author: The names of the people who wrote the reference. If this is an anonymous publication, such as a report from a government agency, you would list the government agency.

Title: the name of the article. If this was a report from a government agency, the name of the report. It this was a news item, even from web source, this is the headline. If this is a web item, it's the title at the beginning.

Journal name: the name of the book or journal. If this was a news item, it would be the newspaper, or the web-based news site, with the date.

Web address: If the source was obtained from the web, then this is the exact URL which would bring up the content cited. If this is a print journal or a print newspaper which you are viewing on-line, then you don't need to reference the web address, because this exists on paper.

Date accessed: This is the date on which you viewed the material you are citing. This is important because information on websites can be edited at any time.

Examples of different types of sources:

Book: Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., & Trow, M. (1994). *The new production of knowledge*. London, United Kingdom: Sage., pp 3-4

Article in Edited Volume: Bricmont, J. (1996). Science of chaos or chaos in science? In P. R. Gross, N. Levitt, & M. W. Lewis (Eds.), *The flight from science and reason* (Annals of the New York Academy of Sciences, Volume 775, pp. 131-175). New York, NY: The New York Academy of Sciences.

Journal Article: Ormerod, R. J. (1998). Beyond internal OR groups. *Journal of Operational Research Society*, *49*(4), 420-429. N.B., If an article is from a print journal, you don't need to add a URL, even if you read the article on line.

Journal Article (Online): Vukotich, C. J., Jr., Cousins, J., & Stebbins, S. (2014). Building sustainable research engagements: Lessons learned from research with schools. *Journal of Research Practice*, *10*(1), Article M1. Retrieved from http://jrp.icaap.org/index.php/jrp/article/view/381/324 (1/10/17)

Web Page (No Date): Banathy, B. H. (n.d.). *The evolution of systems inquiry* (Part 1). Retrieved December 1, 2013, from http://www.isss.org/primer/evolve1.htm

Web Page (No Author): *JRP Focus Areas*. (2013, January 14). Retrieved January 7, 2017, from http://jrp.icaap.org/miscfiles/jrp_focus_areas.html

NOTES:

Listing only a URL is never acceptable.

Wikipedia is not an acceptable academic reference; however, Wikipedia uses standard references, which you can use in your literature search. While Wikipedia is often accurate, it may contain information or references which are not reliable.

Academic references should be of high quality and should be peer reviewed. Please check http://flinders.libguides.com/evaluate or https://www.wlnonline.org/PRSEF for information about how to evaluate a source and its legitimacy.

Appendix 9 Project Categories

Individuals and team projects of the same scientific discipline will compete in the same category. Students will select a project category and type (individual/team) during registration. A team consists of 2 or 3 members who are all in grade levels which allow them to compete in the same division. For example, a seventh grader and an eighth grader would both be in the intermediate division and may work together; however, a sixth grader and a seventh grader would be in two different divisions and may not work together.

Junior Division - Grade 6

Behavioral and Consumer Sciences These projects will explore consumer products and the science of how people respond to the world around them. The areas include: Consumer Related (Consumer Product Testing, Consumer Product Design and Enhancements, Comparisons and Evaluation of Commercially Available Products), Behavioral Science Related (Psychology, Human and Animal Behavior, Learning and Perception, Educational and Testing, Surveys),

Biological Sciences These projects will explore living things, including plants, animals and humans, and the things which affect them. The area includes**:** Life Science Related (Biology, Botany & Zoology, Photosynthesis, Plant Growth, Biochemistry, Genetics & Inherited Traits), Health Related (Nutrition, Human and Animal Behavior, Allergies, Exercise, Studies of Animal/Human Health)

Chemistry These projects will explore chemistry, which includes study of any kinds of chemicals. These areas include: Chemistry Related (Organic & Inorganic Chemistry, Chemical Compounds, Household Chemicals (chemistry focus, not functional emphasis), Chemical Engineering) **Note**: If the project focuses on the biological impact/effect of the chemical, then the project should be placed in the biological category.

Physical Sciences & Engineering These projects will explore physics which includes our mechanical world, and engineering, which includes building things and solving problems: **Physics Related (**States of Matter, Optics and Photography, Sound and Acoustics, Heat, Cold and Thermal, Conductivity, Pressure and Vacuum, Electricity and Magnetism, Friction, Inertia, Gravity, Density), **Engineering Related (**Mechanical Engineering, Transportation, Buildings and Bridges, Planes, Trains, Boats and Cars, Sports, Robotics, Computers, Energy Production, Conversion and Storage, Alternative Energy, such as Wind and Solar)

Intermediate Division - Grade 7 and 8

Behavioral and Social Science: human and animal behavior, social and community relationships - psychology, sociology, anthropology, archaeology, ethnology, ethnology, linguistics, learning, perception, urban problems, reading problems, public opinion surveys, educational testing, etc.

Biology: botany, zoology, genetics, biochemistry, including hormones, molecular biology, molecular genetics, enzymes, photosynthesis, blood chemistry, protein chemistry, food chemistry, etc.

Chemistry: inorganic, organic, physical materials, plastics, fuels, pesticides, metallurgy, etc.

Consumer Science: projects in the areas of consumer product testing and design.

Computer Science/Math: development of computer hardware, software engineering, Internet, simulations; statistics, calculus, geometry, abstract algebra, number theory, probability, etc.

Earth / Environment: pollution and sources of control, ecology, geology, mineralogy, oceanography, meteorology, climatology, geology, seismology, etc.

Engineering / Robotics: technology; projects that apply scientific principles to manufacturing and practical uses - civil, mechanical, aeronautical, chemical, heating and refrigerating, transportation, electrical, photographic, sound, automotive, marine, etc.

Medicine & Health/Microbiology: bacteriology, virology, fungi, bacterial genetics, etc.; study of diseases and health of humans and animals - dentistry, pharmacology, pathology, ophthalmology, nutrition, sanitation, pediatrics, dermatology, allergies, speech and hearing, etc.

Physics and Astronomy: solid state, optics, acoustics, particle, nuclear, plasma, superconductivity, fluid and gas dynamics, magnetism, quantum mechanics, biophysics, astronomy etc.

Senior Division - Grades 9 - 12

Behavioral and Social Science: human and animal behavior, social and community relationships - psychology, sociology, anthropology, archaeology, ethnology, ethnology, linguistics, learning, perception, urban problems, reading problems, public opinion surveys, educational testing, etc.

Biology: botany, zoology, genetics, biochemistry, including hormones, molecular biology, molecular genetics, enzymes, photosynthesis, blood chemistry, protein chemistry, food chemistry, etc.

Chemistry: inorganic, organic, physical materials, plastics, fuels, pesticides, metallurgy, etc.

Computer Science / Math: development of computer hardware, software engineering, Internet, simulations; statistics, calculus, geometry, abstract algebra, number theory, probability, etc.

Earth / Environment: pollution and sources of control, ecology, geology, mineralogy, oceanography, meteorology, climatology, geology, seismology, etc.

Engineering / Robotics: technology; projects that apply scientific principles to manufacturing and practical uses - civil, mechanical, aeronautical, chemical, heating and refrigerating, transportation, electrical, photographic, sound, automotive, marine, etc.

Medicine & Health / Microbiology: bacteriology, virology, fungi, bacterial genetics, etc.; study of diseases and health of humans and animals - dentistry, pharmacology, pathology, ophthalmology, nutrition, sanitation, pediatrics, dermatology, allergies, speech and hearing, etc.

Physics / Astronomy: solid state, optics, acoustics, particle, nuclear, plasma, superconductivity, fluid and gas dynamics, magnetism, quantum mechanics, biophysics, astronomy, etc.

Appendix 10 Using Statistics

As a tool to strengthen the use of statistical techniques in science fair projects, students should consider using the following statistical techniques (only if statistics are applicable) in presenting and analyzing data collected for their projects:

Junior Division

Graphical Presentation:

- Multiple samples
- Plotting data on graphs
  - X-Y charts
  - Pie charts
  - Bar charts

Intermediate Division

Statistical Analysis:

- Measure with dot plot
- Non-linear plots
- Numerical summaries
  - Median, mean
  - Percentiles, standard deviation

Senior Division

Hypothesis Testing:

- Z-test, T-test, Chi Square and when to use each
- Normal Distribution
- Linear Regression
- Least-squares curve fit

Statistical Advice for a Project

- A general rule for sample size is 10 minimum per case. When comparing 2 groups use at least 8 samples each. Seek a minimum of 4 samples per group when comparing many groups.
- Present all of the raw data obtained from the experiment and use statistical techniques to analyze them. Present the results of the analysis. Draw conclusions based upon the results of the analysis.
- Describe and explain any experimental data you obtained but that you chose not to use. Explain why you chose not to use the data.
- Using computer programs to plot and analyze data is acceptable. However, make sure that you know how the programs analyze data – a judge may ask you to explain it.

Where to look for more information about statistics

- Your library will have several references on statistics and statistical techniques to help you with your project. The math department at your school is also a great resource.
- A good resource for explaining the importance of statistics and uncertainty can be found at https://www.nature.com/articles/nmeth.2613.
- https://www.DataClassroom.com is a valuable tool for teachers who want to add statistical techniques to their curriculum.
- Guidelines for evaluating and expressing uncertainty can be found at https://www.nist.gov/pml/nist-technical-note-1297 and https://www.dit.ie/media/physics/documents/GPG11.pdf

Appendix 11 Category Award Selection Procedure

Although there are many ways to reach a decision on category award winners, the following two procedures are simple and avoid the issue of disparity in judges' numerical scoring.

1. Judges review abstracts and view project submissions online.
2. Judges interview students in their virtual conference room.
3. After interviews are completed, each judge group should select the best 1 or 2 projects they reviewed. If the judges feel that none of the projects in their group are worthy of an award, they should discuss this with their co-chair. Likewise, the judges may feel that there are more than 2 projects in their group which deserve further consideration. This too should be discussed with the co-chair.
4. The top 1 or 2 projects from each judge group are then presented to the whole group for final award judging. The total number of projects advanced to be judged by the whole group will depend on the number of projects and awards in the category.
5. Each judge records the selected project numbers on the Award Selection Form. See Appendix 7 Award Selection Form.
6. As a group, all of the judges for the category review the top projects. At this time, one of the judges shall present each project to the panel for discussion. Judges may also listen to the students interview if it was recorded or view the project submission files. **Not all projects advanced will be recognized with an award.**
7. When the group review is completed, each judge ranks the projects, giving their first choice 1 point, the second 2 points and so on. Discussion is encouraged.
8. The ranking scores from each judge are added and the award winners are determined based on the composite scores. The first place winner is the project with the lowest score, and so on.
9. Judges caucus to discuss the results and confirm that the project with the lowest score is the one which the group agrees is the best project. They repeat that procedure for the other award winners. Category chair judges shall resolve ties if the selection appears to be at an impasse.
10. Based on the number of entries in each category, multiple second, third and 4th place awards may be awarded. **Only one first place will be awarded in each category**. Judges will follow the Final Category Ranking form to determine how many awards to select. See Appendix 8 Sample Final Category Ranking Form.

Alternate Procedure

7. After the projects have all been presented to the group, the best of the category shall be chosen by a vote. The group discusses each of the projects and, via a virtual show of hands, asks who among the judges feels that this particular project is worthy of 1st place. The project receiving the most votes is the 1st place selection for the category.
8. The group discusses each of the remaining projects and, via a virtual show of hands, asks who among the judges feels that what projects are worthy of 2nd place, 3rd place and 4th place. Based on the number of entries in each category, multiple second, third and honorable mention awards may be awarded. Only one first place will be awarded in each category. Judges will follow the Final Category Ranking form to determine how many awards to select.

Appendix 12 Judging Rubrics

These rubrics were developed in order to provide constructive feedback to the students. These will be used by Category Judges to determine winners in each category. Please note that this will only be one judge's assessment of the strengths and weaknesses of the student's work given in order to improve future projects. It will not indicate how well the student performed with respect to other PRSEF participants. Each student will be interviewed by at least two category judges.

Some rubrics are tailored for specific applications. Point scores are used as a judging tool. Rubrics less the point values will be provided to the students' teachers after PRSEF. The Category Judge Selection Procedure (See Appendix 11) has been designed to ensure all projects are evaluated on a consistent basis and ranked appropriately with regard to receiving awards. The decisions of the judges, determined on the day of the fair, are final.

Senior/Intermediate Division Rubric

PRSEF USE ONLY
Student Name_____
Teacher_____
School_____

Project #_____ Feedback Form – Senior/Intermediate Division

The purpose of this form is to provide one judge's assessment of the strengths and weaknesses of the presenter's work in order to improve future projects. It does not indicate how well the presenter performed with respect to other PRSEF participants.

Judging Criteria	Outstanding	Above expectations	At Expectations	Areas for Improvement	Points
Scientific thought	❑ Hypothesis is relevant, testable, and **novel** ❑ Conclusion is **fully** supported by data	❑ Hypothesis is relevant, testable, and **approached in a new way** ❑ Conclusion is **largely** supported by data	❑ Hypothesis is relevant, testable, & **new to the student; research beyond simple internet search** ❑ Conclusions **may overstate** what is supported by the data	❑ Choose a scientific question appropriate to grade level of the student and is testable ❑ Provide data that support the conclusion	____/20
Experimental methods	❑ Variables and controls **clearly** defined & complete ❑ **Multiple trials**, with multiple samples, performed ❑ Well planned, **documented**, & carefully executed ❑ **Thorough** work notebook	❑ Variables and controls defined & **complete** ❑ At least **2 independent** trials with multiple samples performed ❑ Well planned & **carefully** executed ❑ **Adequate** work notebook	❑ Variables and controls defined but **may be incomplete** ❑ **Single** trial with multiple samples performed ❑ **Appropriate** but execution **incomplete** ❑ **Weak** notebook	❑ Define variables and provide controls ❑ Perform multiple trials with multiple samples ❑ Use an experimental method that is appropriate ❑ Prepare and present a notebook	____/20
Analytical approach	❑ Data **completely** supports conclusions ❑ Data limitations **defined** ❑ Statistical **analysis is appropriate** & correctly executed	❑ Data **adequate** to support conclusion ❑ Data limitations **not fully understood** ❑ Statistical analysis **correctly executed**	❑ Data **consistent** with conclusions **but not convincing** ❑ Limitations of data **not addressed** ❑ Statistical analysis **included**	❑ Present data that support conclusions ❑ Understand and describe the limitation of the data ❑ Apply correct and appropriate statistical analysis	____/20
Visual Presentation	❑ **Primarily graphs or tables, scientific question, conclusions, & brief descriptions of methods** ❑ Data presentation is **clear and concise** ❑ Material is well organized and reader needs **no assistance**	❑ Text and visually displayed information **balanced** on poster ❑ **Proper use** of graphs/tables for data presentation ❑ Material is organized and reader needs **minimal assistance**	❑ Text **outweighs** visually displayed information ❑ **Some use** of graphs/tables for data presentation ❑ Material is organized so the reader can navigate **with help**	❑ Revise the poster to balance text and visually displayed information ❑ Organize the material to assist the reader	____/20
Oral Presentation	❑ Well prepared, reflects a deep understanding of the question and **relevance to a broad audience** ❑ **Responds readily** to questions ❑ Can reason from findings **independently** to suggest further investigations	❑ Well prepared, reflects a **deep** understanding of the question ❑ **Familiarity** of background appropriate to experience level ❑ Can reason from findings, **with help**, to suggest further work	❑ Well prepared, reflects an **adequate** understanding of the question ❑ **Limited** familiarity of background appropriate to experience level ❑ **Able to suggest** further research	❑ Provide a complete description of the question ❑ Become more familiar with the background material ❑ Provide at least one suggestion for further research	____/20
Judge's Constructive Comment/Suggestion. **If TEAM Project, include comments on TEAMWORK:**					**Judge's Initials**

SrIntProjects2013

Junior Division Rubric

PRSEF USE ONLY
Student Name_____
Teacher_____
School_____

Project # _____ Feedback Form – Junior Division

The purpose of this form is to provide one judge's assessment of the strengths and weaknesses of the student's work in order to improve future projects. It does not indicate how well Student performed with respect to other PRSEF participants.

Judging Criteria	Outstanding	Above expectations	At Expectations	Areas for Improvement	Points
Concept Formation	☐ Concept independently developed and **novel**	☐ Concept **independently** developed	☐ Concept developed **with some assistance**	☐ Student should develop concept based upon personal interests	__/20
	☐ Hypothesis **original**, stated clearly, and reinforced by **scholarly** references	☐ Hypothesis stated clearly and reinforced by **additional** research	☐ Hypothesis **stated clearly**	☐ State hypothesis more clearly; reinforce with additional research	
Conduct of Experiment	☐ Student independently recognized need for controls, used them correctly, **and recognized additional controls**	☐ Student **independently** recognized need for controls and used them correctly	☐ **With some assistance** student recognized need for controls and used them correctly	☐ Learn more about experimental control and correct use	__/20
	☐ Data presented clearly **with limitations indicated**	☐ Data presented **clearly**	☐ Data **presented**	☐ Clarify data and discuss limitations	
	☐ Conclusions are based on **multiple** experiments with many replications **of each experiment**	☐ Conclusions are based on a **single** experiment with **many** replications	☐ Conclusions are based on a single experiment with **few** replications	☐ Perform more replications in experiment and gather additional data	
Validation of Hypothesis	☐ Data more than adequate to support the conclusions **and clearly presented**	☐ Data **more than** adequate to support conclusions	☐ Data **just adequate** to support conclusions	☐ Obtain additional data to better support conclusions	__/20
	☐ Interpreted data correctly, clearly described interpretation, and **applied appropriate statistical techniques**	☐ Interpreted data correctly and **clearly described interpretation**	☐ Interpreted data **correctly**	☐ Review data and reconsider the interpretation, clarify interpretation	
	☐ Recognizes limitations of data **and options to improve**	☐ **Recognizes** limitations of data	☐ Presented data with **minimal consideration** of limitations	☐ Review data collection method and describe limitations	
	☐ Describes **a well-organized plan** for further research in field studied	☐ Cites **several** examples for further research in field studied	☐ Cites **one** example for further research in field studied	☐ Consider opportunities for further research in field studied	
Visual Presentation	☐ **Primarily** graphs or tables, hypothesis, conclusions, and **brief** description of methods	☐ Text and visually displayed information are **balanced**	☐ Text **outweighs** visually displayed information	☐ Revise poster to balance text and visually displayed information	__/20
	☐ **Extensive** use of graphs / tables for data presentation **which are clear and concise**	☐ **Extensive** use of graphs / tables for data presentation	☐ **Some** use of graphs / tables for data presentation	☐ Use graphs / tables to present data	
	☐ Material is **well** organized and reader needs **no** assistance to understand	☐ Material is organized and reader needs **minimal** assistance to understand	☐ Material is organized so reader can navigate **with help**	☐ Organize material to assist reader	
Oral Presentation	☐ Student can clearly and **spontaneously** discuss the project and explain the hypothesis, procedure, and conclusions	☐ Student can **clearly** discuss the project and explain the hypothesis, procedure, and conclusions	☐ Student **can discuss** the project and **explain** the hypothesis, procedure, and conclusions	☐ Become more familiar with the project's hypothesis, procedure, and conclusions	__/20
	☐ Handles **all** questions well; leads judge through the discussion	☐ Handles **most** questions well; **leads** judge through the discussion	☐ Student handles **most** questions well; **follows** the judge's lead through the discussion	☐ Become more comfortable with describing the project and answering questions about it	
Judge's Constructive Comment/Suggestion:					**Judge's Initials**
If TEAM Project, include comments on TEAMWORK:					

JrDiv 2013

Engineering and Robotics Senior Division Rubric

PRSEF USE ONLY
Student Name_____
Teacher_____
School_____

Project #_____ Engineering/Robotics Feedback Form – Senior & Intermediate Division

The purpose of this form is to provide one judge's assessment of the strengths and weaknesses of the presenter's work in order to improve future projects. It does not indicate how well the presenter performed with respect to other PRSEF participants.

Judging Criteria	Outstanding	Above expectations	At Expectations	Areas for Improvement	Points
Engineering Approach	❑ Problem scope is **well-defined** and serves a **clear** purpose	❑ Problem **limited** in scope and **serves a purpose**	❑ Problem scope **too limited or broad** with **no clear** purpose	❑ Clarify and limit the problem scope	___/35
	❑ Proposed solution is **novel**	❑ Proposed solution represents a **new approach to an old design**	❑ Proposed solution is **new** to student	❑ Propose a solution that has not been tried before	
	❑ Project addresses **all** aspects of the problem	❑ Project addresses **most** aspects of the problem	❑ Project addresses only **one** aspect of the problem	❑ Revise the project to more clearly address the problem	
	❑ **Can reason** from findings to suggest further work	❑ Can reason from findings, **with help,** to suggest alternative solutions	❑ **Not able** to suggest modifications to current plan	❑ Become familiar with limitations of the solution and how they relate to limits of the design	
Procedural Plan	❑ Design process **appropriate & thorough**	❑ Design process appropriate, **expert advice would improve**	❑ Design process appropriate but is **incomplete**	❑ Revise the design process to more clearly address design limitations	___/15
	❑ Design process **well-supported** in notebook	❑ Design process **documented** in notebook	❑ Design notebook includes **minimal data** to support design	❑ Prepare and present the design notebook	
	❑ Construction feasible **and** cost effective	❑ Construction is feasible **or** cost-effective	❑ Construction feasible **but not cost effective**	❑ Revise the construction to be more appropriate and adequate	
Analytical approach	❑ Rationale for solution clear, appropriate, **and well supported**	❑ Rationale for solution **is clear and appropriate**	❑ Rationale for solution provided, but **lacks clarity and appropriateness**	❑ Revise the rationale for the solution to be more clear and appropriate	___/10
	❑ Mathematical approach included, appropriate statistical analysis correctly executed **and well understood**	❑ Mathematical approach is included, **appropriate statistical analysis correctly executed**	❑ Mathematical approach **limited in scope,** but is included	❑ Describe the mathematical approach	
Visual Presentation	❑ Poster is **primarily** graphs or tables, scientific question, conclusions, & brief descriptions of methods	❑ Text and visually displayed information **balanced** on poster	❑ **Text outweighs** visually displayed information	❑ Revise the poster to balance text and visually displayed information	___/20
	❑ **Clear and concise** data presentation	❑ **Proper use** of data presentation (graphs/tables)	❑ **Some use** of graphs/tables for data presentation	❑ Use graphs and tables for presenting data	
	❑ Material is well organized and reader needs **no assistance**	❑ Material is organized and reader **needs minimal assistance**	❑ Material is organized so the reader can navigate through it **with help**	❑ Organize the material to assist the reader	
	❑ Documentation reflects **comprehensive** understanding of design limitations	❑ Documentation reflects **understanding** of design limitations	❑ Documentation reflects **incomplete** understanding of design limitations	❑ Provide documentation	
Oral Presentation	❑ Well prepared, **reflects a deep understanding** of underlying engineering principles and relevance to a broad audience	❑ **Well prepared**, reflects a deep understanding of the question	❑ **Prepared**, reflects an understanding of the question	❑ Become more familiar with the question and provide a more complete presentation	___/20
	❑ **Responds readily to questions** on engineering principles	❑ **Familiarity** with engineering principles	❑ **Limited** familiarity with engineering principles	❑ Become more familiar with the engineering principles and the rationale for the selected design	
	❑ Understands how the project can be useful **and the difficulties** that might be encountered in construction	❑ **Understands how** the project can be useful but **may not appreciate** the difficulty of construction	❑ **Believes** the project could be useful	❑ Provide an example of an application	

Judge's Constructive Comment/Suggestion:

Judge's Initials

If TEAM Project, include comments on TEAMWORK:

Engineering/Robotics 2013

PRSEF USE ONLY
Student Name_____
Teacher_____
School_____

Project # _____Engineering Feedback Form – Junior Division

The purpose of this form is to provide one judge's assessment of the strengths and weaknesses of the student's work in order to improve future projects. It does not indicate how well Student performed with respect to other PRSEF participants.

Judging Criteria	Outstanding	Above expectations	At Expectations	Areas for Improvement	Points
Engineering Approach	□ Project scope independently developed and **novel**	□ Project scope **independently** developed	□ Project scope developed **with some assistance**	□ Student should develop project scope based upon personal interests	__/20
	□ Solution stated clearly, and reinforced by **scholarly** references	□ Solution stated clearly and reinforced by **additional** research	□ Solution **stated clearly**	□ State solution more clearly; reinforce with additional research	
Procedural Plan	□ Design process is **appropriate and thorough**	□ Design process appropriate, **expert advice would improve**	□ Design process appropriate but is **incomplete**	□ Revise the design process to more clearly address design limitations	__/20
	□ Design process **well-supported** in notebook	□ Design process **documented** in notebook	□ Design notebook includes **minimal data** to support	□ Prepare and present the design notebook	
	□ Construction feasible **and** cost effective	□ Construction is feasible **or** cost-effective	□ Construction feasible **but not cost effective**	□ Revise the construction to be more appropriate and adequate	
Analytical Approach	□ Rationale for solution clear, appropriate, **and well supported**	□ Rationale for solution **is clear and appropriate**	□ Rationale for solution provided, but **lacks clarity and appropriateness**	□ Revise the rationale for the solution to be more clear and appropriate	__/20
	□ Mathematical approach included, appropriate statistical analysis correctly executed **and well understood**	□ Mathematical approach is included, **appropriate statistical analysis correctly executed**	□ Mathematical approach **limited in scope,** but is included	□ Describe the mathematical approach	
Visual Presentation	□ **Primarily images (or schematics)** graphs or tables, problem statement, solution, and **brief** description of methods	□ Text and visually displayed information are **balanced**	□ Text **outweighs** visually displayed information	□ Revise poster to balance text and visually displayed information	__/20
	□ **Extensive** use of graphs / tables for data presentation **which are clear and concise**	□ **Extensive** use of graphs / tables for data presentation	□ **Some** use of graphs / tables for data presentation	□ Use graphs / tables to present data	
	□ Material is **well** organized and reader needs **no** assistance to understand	□ Material is organized and reader needs **minimal** assistance to understand	□ Material is organized so reader can navigate **with help**	□ Organize material to assist reader	
Oral Presentation	□ Student can clearly and **spontaneously** discuss the project and explain the problem, procedure, and solution	□ Student can **clearly** discuss the project and explain the problem, procedure, and solution	□ Student **can discuss** the project and **explain** the problem, procedure, and solution	□ Become more familiar with the project's problem, procedure, and solution	__/20
	□ Handles **all** questions well; leads judge through the discussion	□ Handles **most** questions well; **leads** judge through the discussion	□ Student handles **most** questions well; **follows** the judge's lead through the discussion	□ Become more comfortable with describing the project and answering questions about it	
Judge's Constructive Comment/Suggestion:					**Judge's Initials**
If TEAM Project, include comments on TEAMWORK:					

Computer Science Senior and Intermediate Division Rubric

PRSEF USE ONLY
Student Name_____
Teacher_____
School_____

Project #_____ Computer Science Feedback Form – Senior & Intermediate Division

The purpose of this form is to provide one judge's assessment of the strengths and weaknesses of the presenter's work in order to improve future projects. It does not indicate how well the presenter performed with respect to other PRSEF participants.

Judging Criteria	Outstanding	Above expectations	At Expectations	Areas for Improvement	Points
Scientific thought	❑ Objective is clear, **ambitious** and practical	❑ Objective is clear and **practical**	❑ Objective is **clear but limited**	❑ Clarify and limit the objective	_____/20
	❑ Approach to problem is **novel**	❑ Approach to problem is **new to the student**	❑ Approach to problem is **well-understood**	❑ Reevaluate the approach to the problem to prevent potential failures	
Programming methodology	❑ Appropriate choice of computer language and **effective use** of language features	❑ Appropriate choice of computer language and language features sometimes **used** to advantage	❑ Appropriate choice of computer language but language features **not used** to advantage	❑ Improve the choice of computer language and improve use of features of computer language	_____/20
	❑ Program and data structure **well-fitted** to problem	❑ Program and data structure **adequate** for the problem	❑ Program and data structure **sufficient** to solve the problem	❑ Redesign the program or data structures to prevent failures	
	❑ Coding **standards and conventions** used	❑ Code commented **adequately** and with **good** variable naming	❑ Code comment **limited** and with **mediocre** variable naming	❑ Comment the code and use descriptive variable names	
Analytical approach	❑ User interface is **effective**	❑ User interface is **adequate**	❑ User interface is **weak**	❑ Redesign the user interface to prevent confusion	_____/20
	❑ Processing algorithms correct and **efficient**	❑ Processing algorithms correct with **limited attention** to efficiency	❑ Processing algorithms correct but **no consideration** for efficiency	❑ Correct the processing algorithms to produce expected results	
Visual Presentation	❑ Poster contains **concise summary** of algorithms, results, and sample input and output, including special cases	❑ Poster contains **adequate** information	❑ Poster contains **too much or too little detail**	❑ Clarify the poster	_____/20
		❑ Algorithms are **described**	❑ Algorithms are **not sufficiently** described	❑ Present the algorithms and correctly describe them	
		❑ **Adequate samples** of input and output presented	❑ **Missing some** important input and output conditions	❑ List input and output conditions with samples	
	❑ **Complete** diagrammatical description of program structure	❑ **Limited** diagrammatical description of program structure	❑ **Limited attempt** at description of program structure	❑ Describe the program structure	
	❑ Material is well organized and reader needs **no assistance**	❑ Material is organized and reader needs **minimal assistance**	❑ Material is organized so the reader **can navigate with help**	❑ Organize the material to assist the reader	
Oral Presentation	❑ Well prepared, reflects a deep understanding of the program and **how objective satisfied**	❑ Well prepared, reflects a **deep** understanding of the program	❑ Well prepared, with a **superficial** understanding of the program	❑ Provide a complete description of the program	_____/20
	❑ **Responds readily** to questions	❑ **Familiarity** of background appropriate	❑ **Limited familiarity** with background	❑ Become more familiar with the background material	
	❑ Can **reason from experience** to suggest further improvements and extensions	❑ Can **suggest** further improvements	❑ Suggestions for improvements are **very simple**	❑ Suggest at least one potential improvement	
Judge's Constructive Comment/Suggestion:					**Judge's Initials**
If TEAM Project, include comments on TEAMWORK:					

Mathematics Senior and Intermediate Division Rubric

PRSEF USE ONLY
Student Name_____
Teacher_____
School_____

Project #_____ Mathematics Feedback Form – Senior & Intermediate Division

The purpose of this form is to provide one judge's assessment of the strengths and weaknesses of the presenter's work in order to improve future projects. It does not indicate how well the presenter performed with respect to other PRSEF participants.

Judging Criteria	Outstanding	Above expectations	At Expectations	Areas for Improvement	Points
Scientific thought	▫ Objective is clearly-stated with mathematical content **2-3 years beyond school level**	▫ Objective is clearly-stated with mathematical content **1-2 years beyond school level**	▫ Objective is **clearly-stated** with mathematical content at the school level	▫ Choose an objective that is at or above the grade level of the student and correct the objective	____/20
	▫ **Appropriate** mathematical language		▫ **Some use** of mathematical language	▫ Use mathematical language that is appropriate	
Supporting evidence	▫ **Results placed in** historical context		▫ **Some** historical background	▫ Provide historical background	____/20
	▫ **Examples** illustrate result	▫ **At least one** example to illustrate result		▫ Provide examples to illustrate result	
	▫ **Counter examples** show argument fails if hypotheses are omitted				
Analytical approach	▫ Step-by-step argument **without** gaps	▫ Step-by-step argument with **only minor gaps**	▫ **Poorly-structured** but correct argument	▫ Revise the argument to support conclusions	____/20
	▫ **Appropriate** references to the literature	▫ References possibly **incomplete**	▫ Key references **missing**	▫ Provide references	
Visual Presentation	▫ Poster contains **concise** summary of results, steps of argument and illustrations of supporting evidence	▫ Poster **not sufficiently concise**, possibly missing some steps	▫ Poster contains **too much** detail	▫ Revise the poster to summarize the results and the steps of the argument and to provide supporting evidence	____/20
	▫ **Multiple** examples Illustrate argument	▫ **Example** to illustrate argument	▫ Possibly **incomplete** example illustrating argument	▫ Provide a complete example illustrating the argument	
	▫ Material is well organized and reader needs **no assistance**	▫ Material is organized and reader needs **minimal assistance**	▫ Material is organized so the reader can navigate through it **with help**	▫ Organize the material to assist the reader	
Oral Presentation	▫ Well prepared, reflects a deep understanding of the question **and relevance** to a broad audience	▫ Well prepared, reflects a **deep understanding** of the question	▫ Well prepared, but reflects a **lack of familiarity** with some steps in argument.	▫ Become more familiar with the question and provide a more complete presentation	____/20
	▫ **Responds readily** to questions	▫ **Familiarity** with background appropriate to experience level	▫ **Limited familiarity** with background appropriate with experience level	▫ Become more familiar with the background material	
	▫ Can reason from findings to suggest further investigations	▫ Can reason from findings, **with help**, to suggest further work	▫ Suggestions for further work are **very simple**	▫ Suggest at least one example of further work	
Judge's Constructive Comment/Suggestion:					**Judge's Initials**
If TEAM Project, include comments on TEAMWORK:					

Math 2013