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Coshow, 2017

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Editorial Team

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The President's Paragraph: Notes from HASTI's President

Preparing for the Eclipse

Craig Williams

In each issue of The Hoosier Science Teacher, we invite the president to share some thoughts as an introduction. In this issue, HASTI's current President Craig Williams shares his thoughts about challenges and opportunities in 2023-24 for science teachers in Indiana.

In my June President's Paragraph, I encouraged all of you to think about how to teach your students to ask good questions. As we reach the midpoint of the school year, how are you doing in this regard? Are you providing students with phenomena to investigate, rather than just presenting a scientific principle and giving them practice problems? Are you giving your students a chance to document their learning via journals, posters, and presentations and not just homework assignments and tests? Do you begin each class with the mindset that you will learn something new from the students, not just them learning from you?

There is a really big natural phenomenon that is just a few months away–the April 8th total eclipse. Maybe you haven't had a chance to prepare for this, and perhaps you are feeling overwhelmed. Don't worry–HASTI has put together resources for you! This is too big an event to skip over. Here are three things you can do now to be prepared.

The first thing is to make sure you are yourself educated. Maybe you feel like you know very little about eclipses. Don't worry! There are a collection of links posted at the **HASTI eclipse website** that can help you get started. IDOE has a comprehensive page with lots of **eclipse lesson plans** and activities for different age levels. NSTA has posted an **Eclipse Guide for Educators**.

In addition, there are some key things that you want to figure out. In your city or town, what is the start time of partiality? Will your location experience totality? If so, when will it start, and for how many minutes will it last? Has your school adopted a special schedule for the day?

The second thing that you can do, once you have educated yourself, is to talk to others! One of the things that has come up again and again in various eclipse related planning meetings is the importance of making sure your administrators are well informed. In the past, there have been documented instances of school administrators deciding at the last minute to hold all students inside during the time of an eclipse. The best course of action is not to make assumptions about your principal or administrator. On the one hand, don't assume that they will be reactionary and not allow any students outside on the day of the eclipse. On the other hand, don't assume that they are so enlightened that they would never dream of depriving students of the opportunity. Instead, take this opportunity to educate them about the importance of an eclipse, as well as its ability to inspire awe. Talk about the many ways that an eclipse can be viewed safely. There is a great guide for talking with administrators that is posted at **NSTA's Eclipse** page. Check it out!

Full listing of authors and contacts can be found at the end of this article.

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The third thing you can do now is figure out what equipment will be needed so your students can safely observe the eclipse. If you attend the upcoming HASTI/ICTM conference, you will receive a classroom set of glasses that can be used to observe the sun directly (when it is completely blocked by the moon, it can be safely viewed without glasses, but only for those few short minutes of totality). If you think you will need more than that for your students at your school, now is the time order. Don't wait until February or March–the companies such as American Paper Optics, Rainbow Symphony, and others may well be sold out!

Here is a list of approved eclipse glasses vendors!

We have links to videos on the HASTI page that shows how to create simple pinhole viewers as well. Come to the conference in February to talk to other teachers to get even more ideas.

Finally, I leave you with a challenge: at our HASTI/ICTM conference in February, connect with your colleagues from around the state in a way you have not tried before. If you have never stayed after the last talk of the day, I encourage you to come to the Exhibit Hall Sneak Peek on Sunday evening, or to the Board Game Night on Monday evening. We have a number of field trips available–give it a try! Another terrific opportunity to meet people and expand your network is to volunteer. We will need help at the check-in desk, hanging signs, moving projectors, and many other tasks. Helping is a way to meet new people and help out your organization. Whatever you do, I hope you find the upcoming conference enjoyable and enlightening. I hope to see you there!

Photo by Lisa Kern, 2017

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Poindexter, K. (2023)
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Column: Elementary Explorations
Earth & Space Science

Kristen Poindexter

Abstract

This article provides several suggestions for implemeting Earth and Space science activities into the K-5 classroom ahead of the 2024 solar eclipse. Additionally, several resources, including children's literature, downloads, and websites are provided with specific K-5 eclipse activites so that teachers can incorporate them into their classrooms.

With the Great American Eclipse approaching in 2024, I have started to compile activities that I can share with my Kindergarten students so that they can begin to understand simple eclipse concepts and also learn about earth and space science. It can be a struggle with how to teach younger children about earth & space science when many of the concepts are so abstract.

Kindergarten Science standard K-ESS2-1 asks teachers to help students document daily weather changes and note patterns over time. This standard is easy to include in a daily calendar routine in any grade level. We use the Weather Graph from Math Their Way (see resources below for link) to chart the weather daily. We post these in our classroom at the end of each month and discuss any changes we see in the weather. For example, from August to October, we noticed an increase in cloudy and rainy days, indicating a shift in the seasonal weather patterns.

First grade Science standard 1-ESS1-1, states: Use observations of the sun, moon, and stars to describe patterns that can be predicted. They can keep the moon or sun. journals to track the movement of the sun and moon in the sky and learn the basics of moon phases and how there is a pattern to the phases. Fifth graders expand on the work of this idea to meet standard 5-ESS1-2; represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. They also begin to learn about the distance of the sun and stars from Earth and how their brightness is partially dependent upon that distance. Mystery Science has a fantastic lesson about the distance of the Sun and planets from each other determines how much light reaches each planet. Students explore which fictitious plants would be able to grow in each planet zone based on the amount of light that reaches them.

Third graders take weather mapping to a new level when they learn about typical weather conditions in each season and how those are cyclical (3-EES2-1). It is also an opportunity for teachers to introduce the effects of climate change on what we have known as our typical weather patterns. They also begin to learn about climates in other parts of the world, laying the groundwork for discussions about how we can all work together to slow down climate change as weather patterns are changing world-wide. An example of this would be to examine the recent uptick in severity of hurricanes. Students could investigate how there are more major hurricanes that seem to be developing more quickly and cause more damage. Students could research the hurricanes (and other natural disasters that are affected by weather) to determine how weather patterns are changing over time.

Full listing of authors and contacts can be found at the end of this article.

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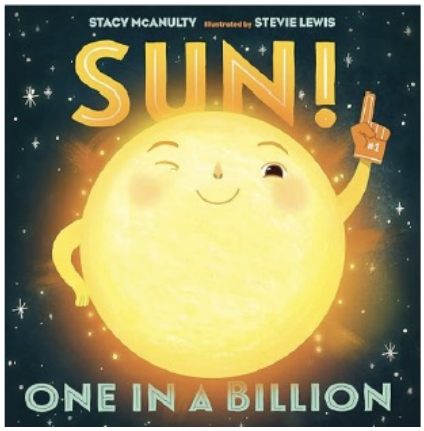

I use a wonderful series of children's literature that helps to share some background information about the Moon and Sun with children. Moon! Earth's best friend and Sun! One in a billion both authored by Stacy McAulty, give a child friendly glimpse into how scientists think they were created, what understandings we have about both planetary bodies, and how we interact with and need both of them! These books are wonderful for use at any grade level through fifth grade, as teachers can keep returning to them over the grade levels to revisit ideas as students understand more concepts.

Eclipse Resources

There are so many activities to teach elementary children about eclipses and although they may not fully understand what is happening during an eclipse, over time, they can put all their experiences and learning together. HASTI has created a page on our website where we are curating eclipse activities that have been vetted for accuracy from science teachers across the state. Check back often as we are constantly adding new resources. **HASTI Eclipse page**

Here are a few of my favorite solar eclipse activities that are appropriate for elementary students:

Generation Genius helps you create a simple model to demonstrate solar and lunar eclipses for children. Using a meter stick, some binder clips, toothpicks, and playdough, teachers and students can explore how the sun, moon and earth interact during a solar or lunar eclipse. A full lesson plan with video is included on the website.

Scholastic compiled a list of activities for the 2017 eclipse that are still relevant today. This list includes activities that can be done before or after an eclipse to help explain the phenomena that is happening.

Finally, the **NASA Jet Propulsion Laboratory** has created a huge list of activities, videos, and scenarios that help teachers and students better understand solar and lunar eclipses. In 2017 I used many of the K-5 activities and adapted them for different grade levels and they helped my students understand so much more. In addition, many of the activities tie into math standards, so there is practical application of math concepts as well!

Resources

Baratta-Lorton, M., & Baratta-Lorton, B. (2011). *Math Their Way Summary Newsletter*. Center for Innovation in Education. (*click on Blackline Masters to download*)

Mystery Science. (2023). *Could there be life on other planets?*

McAnulty S. & Lewis S. (2019). *Moon!: Earth's best friend*. (First Grade). Henry Holt and Company.

McAnulty S. & Lewis S. (2018). *Sun!: One in a billion.* (First Grade). Henry Holt and Company.

Generation Genius. (2023). *Solar eclipse model DIY.*

Heinecke, L. (2017, August 12). *7 activities to get kids excited for the solar eclipse*. Scholastic.

NASA/JLP-Caltech (2023). *STEM lessons for educators*.

HASTI. (2023). *Total solar eclipse*.

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Preparing to View the 2024 Total Eclipse Safely: A Video Article

Tom J. McConnell

Abstract
This "article" is a first for *The Hoosier Science Teacher* - a "video article." Because THST is an online digital that enables authors to include active hyperlinks, the editorial board has discussed including digital media other than traditional print. This article may provide an example for new and creative ways of publishing the scholarship and professional work we do as teachers of science. To view the "article, click the link below the introductory text below.

THST encourages authors to submit other video articles. You can submit an abstract and a link to a shared URL from a site like YouTube via the **THST Submissions** *page.*

The total solar eclipse coming in April, 2024, is naturally drawing a great deal of attention from scientists, science educators, and casual science enthusiasts. Indiana is expected a large contingent of visitors from around the world for the event. Science educators can use this exciting natural phenomenon as teaching tool, and we can all look forward to a once-in-a-lifetime experience.

A partial eclipse in 2017 taught us some lessons about solar eclipse viewing with a public audience. One of those lessons is that school administrators tend to react with extreme caution when eclipses occur. Principals and superintendents across the state directed teachers to not let students go outside during the eclipse to avoid potential injuries from viewing the eclipse without proper safety precautions.

As a life-long science educator, the author suggests a different approach. With proper planning and preparation, including educating our school administrators, the 2024 total eclipse can be a fun and educational… and safe! The tools to view and eclipse safely are easy to find, and there are excellent materials that even young children can make and use at school, at home, or at a public eclipse viewing event.

To help teachers and administrators learn more about how to prepare for safe eclipse viewing, the science education community at Ball State University offers a video article. You can view the article by clicking the following link to the YouTube video:

Preparing to View the 2024 Total Eclipse Safely: A Video Article

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Hougham, R., Bessler, B., Zocher, J., & Sams, W. (2023)
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Engaging Diverse Communities in a Community Science Fair

Justin Hougham,[1] Brad Bessler,[2] Joey Zocher[3], and Walter Sams[4]

Abstract

Prioritizing alternative ways to encourage student interest in STEM is necessary to increase the number of students that choose a career in STEM. The traditional classroom setting that includes direct instruction may inspire some students, but when there is a significant discrepancy of students from historically marginalized populations in STEM careers, determining what can be done differently and how it can be done differently, may be the questions that result in more representation from minoritized communities.

Origins of Science Strikes Back

Educators, administrators, and all-around nerds met in the fall of 2016 to begin planning a "Science Fair for All" with a Community Advisory group associated with a public charter school in Milwaukee, WI. Wouldn't it be cool for people to be able to engage in a science fair outside of educational affiliation? The original thought was to get a lot of likeminded organizations together to throw an event that would increase engagement with science and have an all-around good time. It wasn't long before conversations about the decline of science were on the table. Talking heads on TV "debunking" climate change, pundits taking hard lines against almost every branch of science to engage their base, get voters out of the woodwork, and increase their political clout were loudly present on many cable networks and social media websites. The idea of science seemed to be under attack. The title of Science Strikes Back came quickly and you could feel in the room that it was a hit.

The logo for Science Strikes Back (SSB) tells a story all its own. First is the obvious call back to a classic sci-fi film in which the main character has his hand cut off in an epic confrontation. Looking a little deeper though, there is a lot of significance in the title and logo choice. The hand holding an Erlenmeyer flask with an active reaction happening inside it is a direct reference to how some of the founders felt at that initial meeting. The immense potential transformative power of science work was being cut off at the wrist by counter-information and social media dissonance. The logo also brings a touch of taboo to the table by showing the exposed bone of a disembodied hand. Those of us around that table saw this chance to "strike back" against these forces to give students and other community members a reason to trust in science: relevance to their own lives and their own participation in the process.

After an hour or so of conversation, the skeleton was assembled. Folks from University of Wisconsin-Madison would spread out to different schools and organizations all over the Milwaukee area with lessons to engage groups in possible science fair projects. The host school, Escuela Verde, would drum up interest amongst their Project Based Learners and host the event with space assistance from their neighbors: The Urban Ecology Center and Velobhan Coffee. A late winter/early spring go time would be a fast turnaround, but it was certainly going to happen!

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We decided early on that our focus would be on diversity and environmentalism. All of the organizations involved were already in the trenches of anti-racism and environmental justice, so the fit was easy. This helped us know where to focus our recruitment efforts.

Science Strikes Back is different in a lot of ways, but it also leans on many of the conventions of traditional science fairs. We had categories to enter and prizes for winners. Our goal was to attract participants from all over the city, but we ended up with heavy participation from a few schools. We also wanted to keep it open to any age of participant- though we do most commonly see students in grades 6-12. Escuela Verde, being the host and having several staff members heavily involved, ended up providing the bulk of the participants. Since they are a Project Based Learning (PBL) school, this was a great fit. Seniors at Escuela Verde are required to submit a Youth Participatory Ecojustice Action Project (YPEAR). Many seniors would submit parts of their YPEAR capstones as SSB projects.

Science Fairs as a STEM Learning Venue

Prioritizing alternative ways to encourage student interest in STEM is necessary to increase the number of students that choose a career in STEM. The traditional classroom setting that includes direct instruction may inspire some students, but when there is a significant discrepancy of students from historically marginalized populations in STEM careers, determining what and how it can be done differently, may be the questions that result in more representation from minoritized communities. Recent data shows that 59% of White students received a Bachelor degree in STEM, while only 15% of Hispanic students and 9% of African American students received a degree (NCES, 2018).

Participation in a school event that can provide the opportunity for students to demonstrate their learning presents a unique opportunity that is not universally available to all schools. The "science fair" has become ubiquitous with what a school-related event may look like, but this opportunity is often limited to schools with bigger budgets and higher levels of funding (Grinnell, 2022). A recent longitudinal study indicated about 5% of 23,500 high school students surveyed participated in science competitions during high school (NCES, 2020). This data indicates that there remains an untapped opportunity for schools to consider when deciding if a STEM fair is purposeful or not, though recent research would suggest the former. Establishing a STEM fair within a school community has the ability to inspire student interest in STEM fields (Dabney, 2012; Grinnell, 2022; Koomen, 2021). STEM fairs also give students the chance to apply what they learn in their classrooms to a community setting by empowering them to share their scientific knowledge and passions with others. This participation in science activities outside of school hours more than once per year also increases the likelihood of students choosing a STEM-related career (Dabney, 2012). With more consideration being made to how the science event is structured, the more effective they may be in becoming equitable to diverse populations.

Historically, science fairs are student-focused with varying levels of support from families, teachers, experts, or mentors. A recent study by Grinnell et al. (2022) that surveyed students from populations underrepresented in STEM on their views of science and engineering fairs showed that the level of support from teachers, families, and science experts had an impact on STEM aspirations, but these supports differed greatly amongst different ethnicities. For example, when Black students participated in science and engineering competitions, their reports demonstrated that they were most likely to receive no help from parents, teachers, or scientists in comparison to students that identified as White, Hispanic, Asian and other (Grinnell et al., 2022). To make our community science fair more accessible and to fight back against these disparities we put several supports in place.

What Makes a Community Science Fair?

Participants can find any number of resources online for help in planning and performing a science fair project. We had the fortunate support of UW Extension and Upham Woods that would send out crews of educators to host project starting workshops for classrooms or after school groups. Many local schools also already host science fairs, so giving those students an opportunity to fine tune their earlier experience and bring it to another show is also a draw for participants. Some of the most unique and interesting projects, though, were those from families looking for a way to do something fun together. I remember a family whose project aimed to discover the best pancake recipe. What a fun way to spend a weekend with your kids! All while learning about how science works and getting the chance to share that research with people from all over the city!

How do you Judge a community science fair? That was a question to ponder. On one hand, you want there to be high stakes to drive participation, but in many

	Formative 1 2	Developing 3 4	Mature 5 6	Exemplary 7 8
Collaboration Mark Description: Team worked in a collaborative, mutually beneficial, way that helped address community needs.	-Project is determined and implemented with little involvement from community partners. -A shared vision and collaborative partnership has not been established or maintained.	-Partnerships are few in number, weak, or non-existent. - Project reflects a partial shared vision with minimal collaborative work between the partners. -Service is not reciprocal or of mutual benefit.	-Some communication and ongoing interaction with community partners is central to the project. -More opportunities could be provided to encourage the team to see community members as collaborative partners and resources, and not just recipients of service.	- Partnerships engage in frequent and regular communication, establish a shared vision and set common goals, and collaboratively worked on the project. -Partners share knowledge and understanding of community assets and needs, and view each other as valued resources.
Voice Mark Description: Team has a strong, original voice in planning and executing their project.	-Project has very limited original team input.	-Project is a spin-off of an already completed project. -One adult teammate offered strong guidance in organizing and completing project tasks.	-Project is original -Team works collaboratively to develop project plan and takes leadership in carrying out tasks.	-The team is engaged in generating ideas, identifying learning outcomes, and decision-making during planning, implementation, and evaluation of the project. -Project works with adults to create an environment that supports trust and open expression of ideas.
Meaningful *Mark Description: The team presented knowledge in such a way that was exciting, meaningful and understandable to the community.*	-Project demonstrates little evidence of new learning. -Little connection to the community. -Questions can not be readily answered.	-Project demonstrates some evidence of learning. -The action taken or research has little impact on the community. -Some of the questions can be answered.	-Project is exciting and demonstrates evidence of learning. -The action taken or research has an impact on the community. -Most questions can be answered with ease.	-Project is exciting and demonstrates clear evidence of learning. -The action taken or research has a meaningful and clear impact on the community. -All questions from review committee can be answered with ease.
Quality Mark Description: Product and methodology is a high quality.	-Poor product. -Information is disorganized. –Diagrams, illustrations or models are not accurate OR do not add to the reader's understanding of the topic. - Independent and dependent variables were not clear.	-OK product. -Information is organized - Diagrams, illustrations or models are neat and accurate and sometimes add to the reader's understanding of the topic. - Independent and dependent variables were mentioned.	-Good quality product. -Information is organized - Diagrams, illustrations or models are accurate and add to the reader's understanding of the topic. - Independent and dependent variables were clear.	-Professional quality product. -Information is very organized. -Diagrams, illustrations or models. - Independent and dependent variables were clear throughout.
Total points				

Figure 1. Customized Scoring Rubric

ways this event was designed as an anti-science fair. What parts do you embrace and what parts do you "Strike Back" against. Ultimately, we settled some of this in the rubric. Our rubric awarded points for diversity and cooperation amongst your team. If you were submitting a project on your own, you were at a disadvantage. The hope was that this would encourage people to get even more people involved. Though a great driver, the prestige aspect of winning the science fair was at odds with our hopes to bring down the ivory tower. Adding these non-academic rubric criteria was our way of saying there's more to this science fair than equations, science background knowledge, and academic clout. To give you a sense of the range of submissions, here are some example titles of project submissions in the past:

"Testing How Clothing Choices Impact the Behavior of Others Around Us"
"Who Stole the Cookies"
"The Benefits of BMX"
"Kombucha Krew"
"Pavement vs Grass"
"Light Pollution and Bats!"
"SLIME.411- Recipes"
"Are your Menorgs or Your Disorgs Winning?"

Judges ended up being a healthy mix of fun folks from all over the city. Education students looking to connect with schools, educators and staff from partnering organizations, and people who were just interested in the fair who may eventually enter in subsequent years. All judges met to go over the rubric to calibrate and make sure we were doing our best to be fair and impartial. This was actually a difficult task since the participants ranged from 3rd grade to professionals or PhD candidates. Once the rubric was covered, each judge was handed an iPad and a schedule to ensure that projects got equal coverage. Their rubrics were Google forms so that the results would be populated into a spreadsheet for easy scoring.

We had some hiccups the first year. There were submissions that didn't show up, or projects that changed their titles or set up in the wrong spot making it impossible for judges to find the correct groups to score. It was very helpful to have a few people dedicated to supporting the judges and the participants to make sure they had everything they needed and that things went as smoothly as possible. Behind the scenes we needed a person watching the rubrics as they were submitted in case something seemed off. We didn't want a project to

get an improper score due to user error or a mis-clicked prompt.

Judges then gather in a room to hammer out ties, agree on a best in show and in general discuss what they saw. At this time judges were having a Science Strikes Back experience of their own. What began as an opportunity to volunteer your time became an opportunity to be in touch with science, youth, and education. People were actually networking at this event. It became a way to connect with local orgs and each other. Some judges came back year after year.

This rubric was built over the years based on the curricular evaluation framework generated and co-created with the education team at Escuela Verde. They began with existing frameworks in PBL, specifically the EdVisions models. That team was also well versed in the YPAR and YPEAR research work by Joella Zocher mentioned above. This framework aligns very well with the goals of Science Strikes Back as it proposes that the inequities in education are not solely based on outside factors but instead are baked into the system of education, necessitating action to change the paradigm.

The 40 point rubric aims to offer opportunities for a project to succeed in a number of ways that a more traditional academic rubric might ignore. The five scoring categories are Collaboration, Voice, Meaningful, Quality, and one specific to the category the group submitted for. This has changed over the years, but an 8 point scale allows for two points of delineation for each indicator. Another challenge was lowering the entry point for judges. We didn't want a rubric that required an education background to understand because not all of our judges were educators. Throughout the years we've made changes and had tons of opportunities for judges to express their thoughts about scoring and the rubric. Every year we have and continue to make changes.

The specific aim of Science Strikes Back is to increase environmental literacy and agency among urban populations. Anecdotal feedback points to positive growth toward this goal, though the long-term impacts have yet to be measured (Zocher and Hougham, 2020). But the feeling in the room during this event speaks volumes. Observers, participants, and judges are buzzing with excitement, surprised and enlightened by projects created across a range of diverse presenters.

Lessons Learned

Can a similar science fair work for you? I would say emphatically: Yes! This project is moldable to suit so many potential fields, areas, and scales. Every year, as planning commences the folks behind Science Strikes Back think about growth and ways to reach out and make it bigger. There's also value in keeping it small, though. Whatever your desired scope, here are 9 things to do to get you started engaging your community in a similar event. Pick and choose the things that make sense to you and run with it!

1. Identify Partner Organizations - this can bring the person power and help drive your theming. Our partners were all environmental orgs so that was our driver. These can be organizations you are already working with, but it's also important to broaden your horizons and reach outside of your normal connections. You may want to engage some organizations to offer prizes for winners or gift bags for participants.
2. Get schools involved - if you have a school or two that will adopt this as a part of their curriculum that will guarantee participants and probably help with finding a host site. We rely on schools to provide the academic and safety context for their students leading up to the event.
3. Start gathering volunteer judges - reach out in as many ways as you can to get people interested. These folks may end up being interested in stepping up in deeper ways as well (see number 7)
4. Have organizations help with public submissions - some are already running studies that can be turned into science projects and some are looking for an easy way to do something like this.
5. Pick a date and find a venue - In our case we were linked to a school with a neighboring coffee shop and community center. This was perfect as it allowed us to spread out and with 3 host organizations it automatically expanded the reach we had.
6. Start working on a schedule - There should be ample time for judges (and public visitors) to check out the projects and allow for a bit of pageantry at the end to award prizes. We award top prizes for each category and overall best in show.

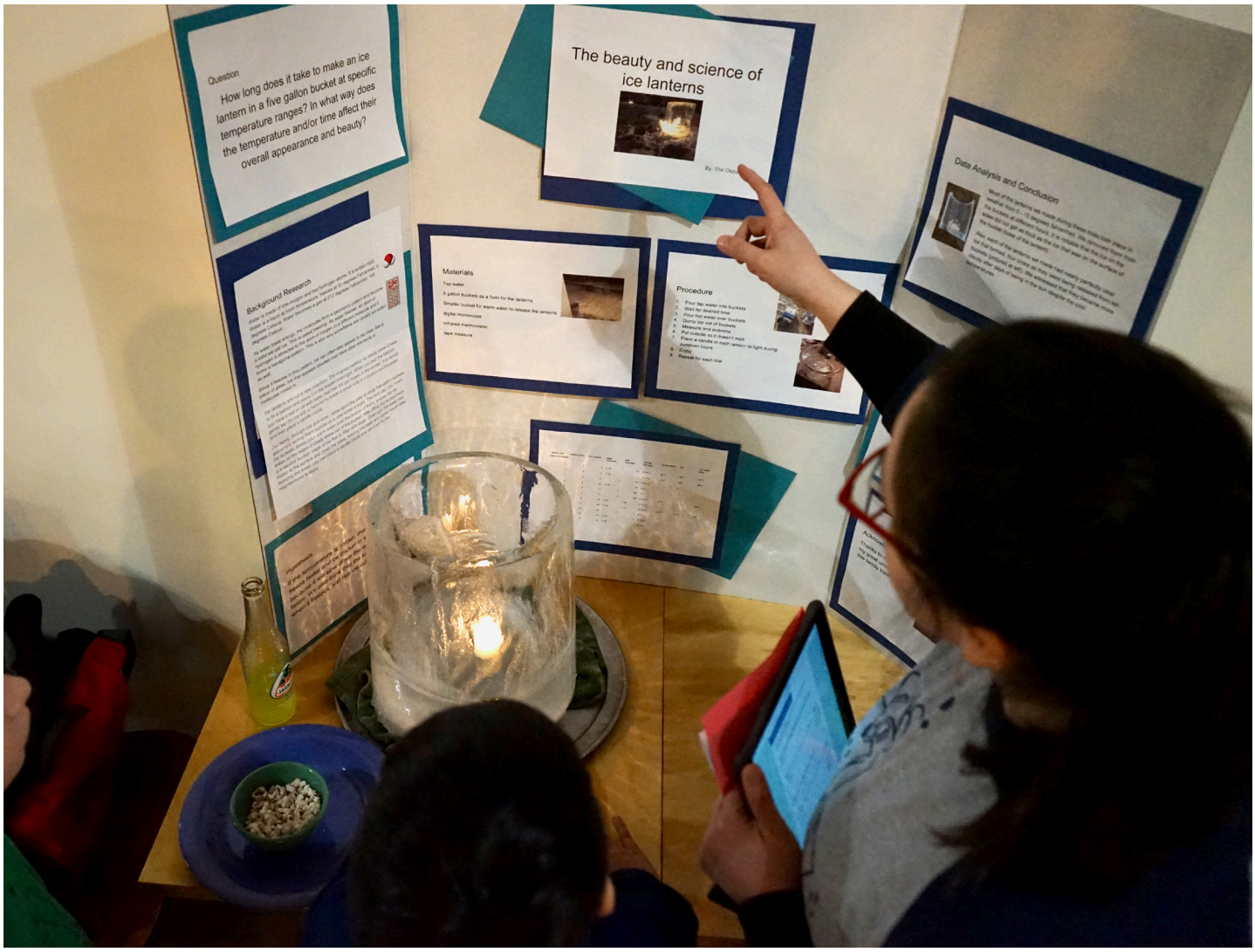

Fig. 2. Participant explaining her research

7. Establish a team with deliverable goals - Who is responsible for marketing the idea on social media? Who will manage participant entries? A few dedicated folks can make this event happen if you've got a good plan in place. We recommend placing someone in charge of the following elements: School/participant recruitment, social media and outreach, judge recruitment and judging, and someone with general oversight to make connections and host regular check-ins.
8. Decide what else you'd like going on during your event - Do you want to invite food vendors? Would local colleges like to have recruitment tables? There are all sorts of extra engagements you can add to an event like this. During COVID for example, we had to also navigate our own risk management and safety framework for holding the event in person. This was rolled up into our waiver for participation. We also have a photo release for the media we collect on the day-of.
9. To merch, or not to merch? With a name like Science Strikes Back, we decided a little bit of merch would go a long way to get the word out for subsequent years. T-shirts, mugs, journals, pins . . . it's an investment that hopes to increase interest next year and beyond.

Conclusion

Our experience with Science Strikes Back has been overwhelmingly positive. Over the past 6 years the event has continued to invite people who would not have thought to enter a science competition into the doors of organizations that have been able to establish new relationships with the science process. The event even survived the pandemic pivoting to a virtual model when presenting in public was not an option. Organizations keep coming back because they value the time and the payoff. On top of that, every year we get even more solid presentations from a diverse group of participants. By connecting multiple organizations' reach and participant base we are able to reach many more individuals than any one organization or school. This also means more meaningful new connections between participants (including judges, hosts and visitors/observers) that in our case has resulted in an increase in high quality connections. Engaging the community in the sciences is a great cause worth the time and effort. As we continue to see science's credibility being brought to task in a battle for social media clicks and network airtime, we need all of the resistance we can muster.

References

Dabney, K. P., Tai, R. H., Almarode, J., Miller-Friedmann, J., Sonnert, G., Sadler, P. M., & Hazari, Z. (2012). Out-of-School Time Science Activities and Their Association with Career Interest in STEM. *International Journal of Science Education, 2*(1), 63–79.

Grinnell, F., Dalley, S., & Reisch, J. S. (2022). High school science fair: Ethnicity trends in student participation and experience. *PLOS ONE, 17*(3).

Koomen, M. H., Hedenstrom, M., & Moran, M. A. (2021). Rubbing elbows with them: Building capacity in STEM through science and engineering fairs. *Science Education, 105*(3), 541–579.

National Center for Education Statistics. (n.d.). High School Longitudinal Study of 2009 (HSLS:09) - Overview.

S&E Degrees, By Race/Ethnicity of Recipients | NCSES | NSF. (n.d.).

Zocher, J. L., & Hougham, R. J. (2020). Implementing Ecopedagogy as an Experiential Approach to Decolonizing Science Education. *Journal of Experiential Education, 43*(3), 232–247.

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Open Access

The Great Hole in the Sky: Solar Eclipse, Radio Science and a Vision for Student Engagement

Joachim H. Ladwig

Abstract
The BNL Stars Amateur Radio club has come back to life after an entire generation of absense. We are active in several American Radio Relay League (ARRL) amateur events and NASA data collection activities. We plan to be active and growing our skills until 08APR24.

On October 14, 2023, across the Americas, residents experienced a spectacular eclipse opportunity. As much as it was an incredible cosmic, Keplerian, Sun-Moon-Earth geometric alignment event with potentially significant atmospheric ramifications, many folks felt that it was *merely annular* and just didn't get excited about it. I got excited. I'm excited about sharing science and truth be told, I'm getting to be a little more "radio-active." That's what's got me excited lately.

Fig 1. Time and Date.com Eclipse logo (with permission: Time and Date).

Out here in south central Indiana in the maximum shadow of *la luna* at 17:06 Zulu (Z) time we experienced a drizzly gray overcast sky with hints of a shark-bitten sun (at 49% occlusion) peeking through the cloud cover. Down south in Texas, across the I-10 corridor the landscape experienced near complete occlusion and an annular eclipse. Through two of my STEM teaching and learning networks I'd learned that both the National Aeronautics and Space Administration (NASA) and the American Radio Relay League (ARRL) wanted to know more about radio frequency propagation during a solar eclipse and they wanted citizen scientists to be their eyes and ears across the land. My colleagues and I set out to execute a joint venture to collect data for NASA and the ARRL; specifically, whether radio frequency propagation was affected by the passage of the solar shadow (the umbra and penumbra), and if so, which wavelengths are most affected.

Fig 2. Moments of totality during a solar eclipse. (NASA, 2023, CC 0)

We call a radio signal's radiation pattern, propagation. Radio frequency propagation patterns are affected by several technical factors addressed in the appendix. However, one of the key factors is ionospheric reflectivity which is constantly in flux across and around the entire globe. One particularly pronounced diurnal fluctuation comes with "the grey line" as it slides silently across the face of our blue planet turning day into night and hours later night into day. As my wise radio pal

Full listing of authors and contacts can be found at the end of this article.

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Pete (call sign KA1GHF) says, "...radio wave propagation gets to be kind of incredible *in the twilight zone*." This eclipse generated twilight zone is the focus of our citizen scientist data collection/investigation.

NASA's interest

NASA typically works its spacecraft at great distance or completely remote, all via propagating radio waves. They are excited about atmospheric phenomena too. They employ a data collection app for citizen scientists to engage with them, *Globe Observer*. Our middle/high school Civil Air Patrol (CAP) Cadets collected and submitted data to NASA using *Globe Observer* as part of their **CAP Solar Eclipse Mission** and will again on April 8th, 2024.

ARRL's interests

The American Radio Relay League–our national association for amateur radio—gets excited too because atmospheric science is what makes radio transceivers/antennas radiate like they do. ARRL is so excited they put out a call for citizen scientist solar eclipse data collectors, "radio-active" citizens like my amateur radio colleagues and me. They called it the *Solar Eclipse QSO Party* (SEQP) and it encompasses data collection efforts on April 8, 2024, as well. The SEQP is a national (even global) event with hundreds of stations submitting QSO (contact) reports for analysis soon thereafter.

On October 14, 2023, one of the busiest amateur radio days of the year we engaged our local CAP Composite Squadron (GLR-IN-002) cadets, the Bedford North Lawrence Stars Amateur Radio Club (W9BNL) membership, and the local amateur radio community (ARRL Indiana Section) for the event. In all 17 adults, middle school, and high school students gathered at the Monroe County Airport from 14:00 Z to 20:00 Z for our joint eclipse study. Our intent was to measure and report local weather conditions on the quarter hour, sample the 2-meter wavelength (VHF – see terms and definitions below) radio band propagation within line of sight and attempt to reach the Columbus Airport (Bartholomew County, 62 Km/38 miles). In addition, three high frequency (HF) radio stations worked various amateur radio bands (40/20/17/15/12/10 meter wavelength) under the drizzly sky making QSOs (radio contacts) across the USA and as far abroad as Australia, Brazil, Finland, the Slovak Republic, and Canada.

RRadio transmission signal strength and signal reports are given on a "clarity and loudness" scale. Clarity is rated from 5 to 1 and loudness is rated from 9 to 1, so a crystal clear and loud telephone-like signal would be rated at "5 by 9, 5 9, or a 59" while a scratchy, barely heard and barely copyable signal would rate at a "3 by 3, 3 3, or 33." A 4 4 signal is workable, but one must lean in and focus on the transmission. Serious amateur radio is an independent sport, one operator and their transceiver reaching to another operator on their transceiver. Better still, an operator and co-operator working a single transceiver with no extraneous chatter, just focusing on connecting with the operators on the other end of the radio waves. With a cooperating team there is a *mentor* and *apprentice*, a *teacher* and *student*, or the powerful team of a *radio operator* and *data logger/observer* when executing lifesaving tasking or world-wide contesting. When executing critical communications tasking this could be a three-operator team.

During the SEQP our initial reports provided evidence in support of some fluctuations in radio frequency propagation specifically with two stations. On the HF bands Station NØRDF (in ND) whose signal improved greatly from a signal report of "44" hours before occlusion to "59" at maximum solar occlusion and Station NF7E (in AZ) whose propagation AZ-to-IN was strong (59) at maximum occlusion while AZ-to-IN was weak (54). Four hours post-occlusion IN-toAZ propagation was strong (59) and IN-toAZ was weak (54).

With the passage of a large east-moving low pressure cell and local weather front, precipitation, wind velocity, and ambient temperature data varied from cool, calm, and dry early in the day to cooler, breezy, and drizzly at midday (maximum occlusion) which would have affected only VHF transmissions. VHF signals are very susceptible to absorption by atmospheric water and earth while HF signals (the lower the frequency the better) may literally pass through a rainforest with little or no measurable signal loss.

Resurrecting a school radio club (or starting one)

My path to school amateur radio club affiliation with the ARRL began in 2022 at the cajoling of a fellow Ham (amateur radio operator) and CAP Adult Member, Brad (call sign KD9TSY). He and I had been discussing how to grow a stronger emergency communications capability among our CAP squadron's middle and high school cadets. Modern students' experience with commercial radio and cell phones has diminished their understanding of the importance of alternative means of communication and given them a false sense of security for *when the lights go out*, during a natural disaster.

Telephonic device communication is 100% dependent on redundant infrastructure capacity until those back-up systems become overloaded or fail outright. One need only to recall the impossibility of reaching people in the affected areas during 9/11, Hurricane Katrina, or the tornado outbreak of March 31, 2023, that killed three Hoosiers in Sullivan County. Those hard-hit areas had redundant communication systems too, yet without notice they experienced telephone black outs for days, weeks, or months. With no way to prepare themselves those hundreds, thousands, or millions of Americans were left without communication or access to lifesaving public services. Each situation was absolutely tragic and people's lives were in upheaval, completely disconnected from the world with no way to reach loved ones from inside or from outside the catastrophe. An alternative communication method, amateur HF radio transceivers operating on battery/solar power, not infrastructure-dependent cell phones, are an answer to that disconnect.

Fig 4. Tornado outbreak of March 31 - April 1, 2023

Brad and I attended ARRL's June/Summer Field Day to check it out and I got interested. I was reeled in by the beckoning *dahdahdididit dididitdahdah* of the Morse Code key, the mashup of internationally accented callsigns drifting across the tent on the warm summer breeze, and the idea of using less wattage than an eco (green) light bulb to reach out to the world. Amateur radio was the answer! I got excited about possible ARRL-CAP connections and got FCC Technician licensed in July of 2022. I met new Ham pals from the Hoosier Hills Ham Club/W9GUS [as in Grissom] (BNL alumni and others) and we resurrected the old Bedford North Lawrence (BNL) High School Amateur Radio Club in August of 2022. The new BNL Stars Amateur RADio and ROCKetry Club became an affiliate ARRL school club in October of 2022. We were now an FCC licensed radio station with one licensed operator, me. How did this happen? I chose the one outreach project that caught my lapel and pulled me in for a better look.

As it turns out, the FCC allows unlicensed persons to operate radios under licensed operator control up to the privileges of the licensed control operator. The club wanted to talk DX (long distance intercontinental) so I studied, tested, and earned the expanded radio frequency band privileges of the FCC General license in December of 2022 as teachers do, over Christmas Break. I didn't have the equipment or the experience to talk to the world on the HF bands until March 23, 2023, when I called and reached Jay (call sign PJ2/AC7DC) in Curacao, off South America, from a picnic shelter in Clifty Falls State Park on 10 Watts of battery power. Now I was talking with the myriad international voices. I was thunderstruck and *electrified* in a good way!

Call sign	Worked	Date/Time	Band	Mode	Freq
KC9NVY	PJ2/AC7DC	2023-03-23 00:02:00	20M	SSB	14.22800

Fig 5. Exerpt from W9NVY's Logbook of the world, an ARRL tool.

The ARRL offers school club start-up grants and hosts a series of summer teacher technical institutes. To acquire these supports a school club sponsor must become FCC Technician licensed, join the ARRL, and apply for the programs with the help of the good people of ARRL's educational outreach desk. One's initial cash outlay to do all that over one summer can be as little as $150 with the incredible New Ham Jumpstart program, which provides free handheld radios and study tools. I took advantage of these over Summer 2023 to bring more technology (new radios, antennas, and piles of club training tools) and resources to the club. After TI-1 I studied hard to earn my FCC *Amateur Extra license,* full access to the amateur radio bands, and *much deeper* technical knowledge.

Food for Thought:

Monroe County is located in the heart of totality during the April 8, 2024, Total Solar Eclipse. Estimates suggest as many as 300,000 excited visitors and guests will triple the cellular access load and may disrupt this vital communication system.

Thereafter the club chose W9BNL as our personalized club callsign (a privilege of the Amateur Extra license) and we got very radio-active. We conducted three Field Day LITE events and got four students on the air during school hours. This year some have stayed on with the club and some have moved on, but we are bigger this year than last year. I am earning my radio chops and we're all learning how to radio in a big way. Kids are talking to faraway places, and I have made QSOs on every continent at odd hours of the day as I learn many lessons to help scaffold their learning. Big antennas are going up on the roof this month. With the help of some Hoosier Hills Ham Club hams (Pete/KA1GHF and Tim/KB9SNL) we are installing the school Ham shack and will assist our new FCC Technicians in setting up their own.

This Fall, W9BNL, the school radio club, really took off. We are twice as many as our first year and a dozen have been on the radios. We are building our skills and learning how to listen/talk to distant operators. Students have soldered and used their own homebuilt VHF antennas, studied electrical (DC series) circuits, conversed with southern Indiana hams via local VHF repeaters and simplex frequencies. On December 15, 2023, we conducted a Parks on the Air activation event at our nearby Spring Mill State. With the help of Jeremy/NQ8M, Mike/W9MDT, and Bryce/KD9YEY, the students made 103 QSOs with local operators as far as CT, FL, TX, WV, and CA. Students also DXed with Canada, Germany, and Switzerland on our tiny battery-powered HF transceiver.

Come the April 08, 2024 solar eclipse our town falls dead center under the longest and widest portion of solar eclipse totality. W9BNL will be on the air to participate in the total solar eclipse SEQP and make electrifying club history.

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Terms and Definitions

ARRL – The National Association for Amateur Radio®: An organization of amateur radio enthusiasts dedicated to promoting the appreciation, study, and use of radio frequencies globally for all its varied applications. Here I refer to the US chapter. Some of its applications include watching governmental regulations, community public service and emergency communication, international cooperation, and public service, etc. as well as numerous contesting opportunities.

FCC Amateur Radio Operator Licensing - The amateur radio license is a three-tiered, FCC regulated system in the USA.

Technician (the investigative level) gets operators on the air on the VHF and UHF bands, often with just a $30 - $50, pocketable handheld (H/T) radio and their randomly generated FCC callsign (C/S). Techs also have access to low power operation on two HF bands (6 and 10 meters). This first step is a tremendous discovery and learning time while providing some guardrails as one meets hundreds of Hams, discovers basic electrical theory, and attends their first HamFests (imagine a combination swap meet, family reunion, technology conference, and high-end industry trade show all under one giant roof). Discovery of all things radio begins at Technician; what facets of amateur radio interest them, who all *DOES* radio, and how to be a really good (dare I say professional?) amateur radio operator.

General (all purpose-level) requires more knowledge of the How-To's of amateur radio practice, safe/wise radio operations, and high-powered radios. General licensure grants operators access to portions of the traditional *short wave (HF) bands* which give operators a longer reach to the world from a simple, long wire antenna. The *General* provides a lifetime of fun and is the goal of many operators.

Amateur Extra (the BIG ticket) requires an operator to learn deeper electrical theory, antenna theory, and expects a deeper, more complex (nuanced) perspective of amateur radio operations. It is a badge of honor for some, the top ticket. These operators learn to maximize equipment capabilities and antenna tuning. Some build their own radios, tuners, antennas, etc. With the EXTRA ticket operators are granted access to all of the amateur frequency bands and participate as instructors and evaluators within their peer group. This can lead to career-level understanding of electromagnetic communications systems. Many astronauts, airline pilots, and industry professionals are FCC *Amateur Extra* radio operators.

CAP – The Civil Air Patrol: The Civil Air Patrol provides services to communities such as search and rescue, aerospace education outreach, and leadership training for all

ages. They also serve as an auxiliary of the US Air Force. They have a number of programs for teachers (primary and secondary school teacher programs that provide STEM kits and fly the teachers in CAP aircraft) and student participation. CAP offers an excellent classroom STEM resource program for Middle/High School students.

HF – High Frequency radio waves between 1.5 and 30 megahertz with wavelengths of 160 to 10 meters are the famous long range frequencies. HF radio waves make the journey between stations by either traveling along the surface of the Earth "*ground wave*," or by being returned to Earth after encountering the upper layers of the ionosphere as "*sky wave or skip*." The properties of the shortest waves (28 MHz) and the longest (1.5 MHz) waves are unique and produce notably different global propagation patterns. The ionosphere is known to change thickness when activated by diurnal changes in solar radiation levels, hence the inquiries about eclipse totality and radio wave propagation.

VHF – Very High Frequency radio waves between 30 and 300 megahertz with wavelengths of 10 to 1 meter. VHF radio waves are referred to as "line of sight" as they can be blocked by geographic features like hills and mountains. When conditions are ideal they also can refract (bend) through the ionosphere and so travel longer distances. FM radio, television, 2-way mobile radio systems like police and fire and hand-held walkie-talkies, all use VHF frequencies.

The direction of waves of all types can be changed by both diffraction and refraction. Diffraction is created by the construction and reinforcement of wavefronts after the wave encounters a reflection surface's corners or edges. Refraction is a more gradual bending of the wave because of changes in its velocity of propagation caused by changes in the medium through which the wave is traveling. HF signals traveling by sky wave are bent through the variably thick ionosphere and then "hop" (reflect) off the ground after ~2500 miles. When conditions are right there can be many ionospheric hops and an operator may even hear the incoming signal arriving via "the long path," the long way around the Earth from the sending station (Source: ARRL *Amateur Extra Class* License Manual, pp. 10-1 thru 10-4).

QSO – An exchange of signal strength information (3 3 to 5 9) and call signs from and to a contact made using radio by radio operators.

SEQP – Solar Eclipse QSO (radio contact) Party: An event created to provide data for a citizen's science project to determine the effect of the 2023 and 2024 solar eclipses over the United States on the distances HF and VHF radio frequencies can travel. While VHF is generally "line of sight", there is evidence that they propagate (travel) longer distances by refracting (bouncing) off the ionosphere during sunrise and sunset as the longer waves of HF frequencies more typically do. Our solar eclipse experiment is looking at possible extended refraction of the waves and variance in signal reports during eclipse events. There is previous evidence that the penumbra and umbra may affect the ionosphere in a way that extends radio contacts so we are going to find out!

Ham– a term for amateur radio operators. ARRL provides a source for the term here https://www.arrl.org/what-is-ham-radio

Field Day LITE - F*ield Day* is an operational, amateur radio event taking place "afield," distant and disconnected from buildings and vehicles and operating completely on battery power as practice for our support of civil catastrophes, etc. Field Day includes from one to 12 or more operators during a 24-hour, semi-annual (Winter: January and Summer: June event. There is generally some significant set-up and tear down. W9BNL's *Field Day LITE* takes place during a 45 minute Friday morning school club meeting session with the assistance of our local Hams and their portable equipment. The Hoosier Hills Ham Club (W9GUS, Tim/KB9SNL, Pete/KA1GHF) and Mike/W9MDT of Greene Cty fame frequently assist with these short opportunities to get our students out of the school building and ***On the Air***.

General terms

Umbra – the darkest part of the eclipse where the light of the Sun is totally blocked by the Moon's presence between the Sun and Earth.

Penumbra – the shadowed part of the eclipse where part of the Sun can still be observed. It is the region immediately surrounding the umbra and where Indiana observers were located during the 2017 eclipse.

Zulu – also known as UTC (Universal Coordinated Time) or GMT (Greenwich Mean Time). Zulu is the military application of the above and is based on the time at the Prime Meridian which goes through Greenwich, England. Eastern Standard Time (EST) is UTC+5, and it is a 24 hour time scale. So 12:00 midnight for us would be 05:00 Zulu or 05:00 UTC during Eastern Standard Time and 04:00 Zulu for daylight savings time (which we will be on when the next eclipse occurs).

"The grey line" – this is the Earth's terminator or the line where the light meets the darkness at sunrise and sunset. For additional information see NOAA - Terminator information or Time and Date's (visualized) terminator tracker.

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Ocular Hazards Associated with Eclipse Viewing

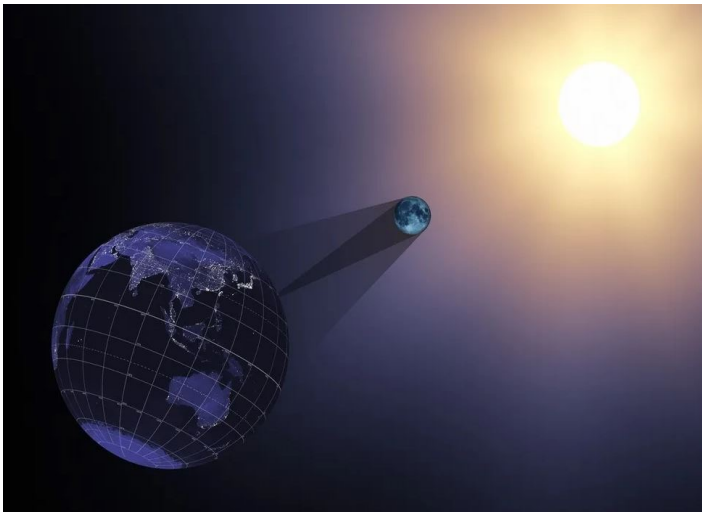
Arthur Bradley[1] and Todd Peabody[2]

Abstract

You have probably heard the warnings about direct viewing of an eclipse and the damage it can do to your eyes. What is the real threat, and how does sunlight during an eclipse pose a threat? In this article, reprinted from the 2017 Indiana University CelestFest website, hear from faculty at IU's School of Optometry about the medical information surrounding this topic.

On Monday, April 8, 2024, Indiana will experience a solar eclipse. The path of totality, or the area that will experience a full eclipse, will be only about 115 miles wide, arcing from the southwest to the northeast. Those outside the path of totality will experience a partial eclipse.

When the Moon passes between the Earth and the Sun, it casts a shadow onto the earth. Because of the large size of the Sun the shadow is only complete during umbra, the phase of the fully shaded inner region of the Sun which occurs during a total solar eclipse. This is the inner and darkest part of the Moon's shadow and the only time you can view the eclipse safely with your eyes. It lasts for only a few minutes depending on how close to the center of the path you are viewing from. The much larger shadow we refer to here is its penumbra, the outer and lightest part of the Moon's shadow. This is when only part of the sun's light is blocked. It is unsafe to look at any part of the Sun directly.



Shadow umbra, the dark inner shadow and penumbra, the lighter outer shadow. (NASA's Scientific Visualization Studio)

Photographs taken from deep space show this shadow moving across the planet at very high speed (between 1500 and 3000 km/hr). A NASA animation depicts how the Moon's shadow moves across the Earth during a total eclipse on August 21, 2017. The small darker circle of the umbra and the larger lighter circle of the penumbra can be seen. **Click here or on the image at the left to view an animation.**

This essay summarizes the ocular dangers posed by this solar eclipse.

Full listing of authors and contacts can be found at the end of this article.

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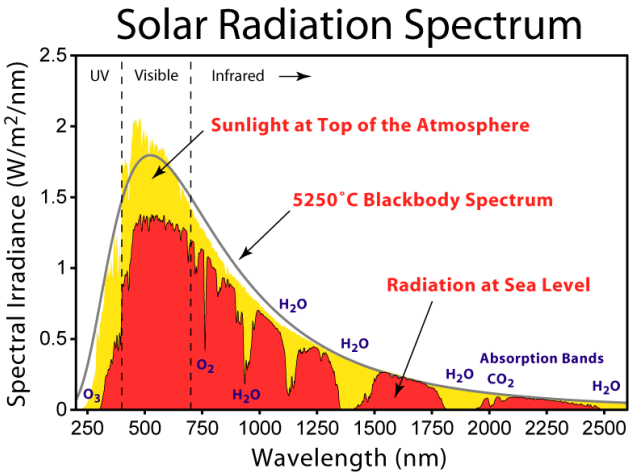
Those in the penumbra of the moon's shadow, viewing a partial eclipse, will be especially susceptible to eye damage during eclipse viewing.

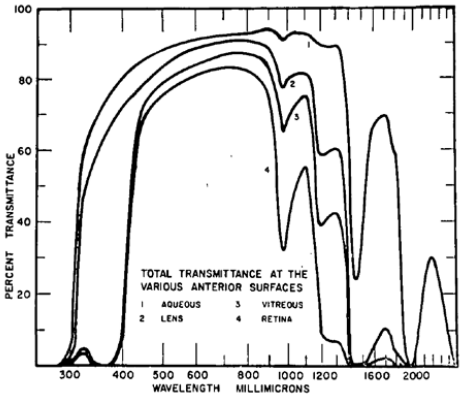
Michael Zeiler, GreatAmericanEclipse.com, by permission.

The Solar Spectrum

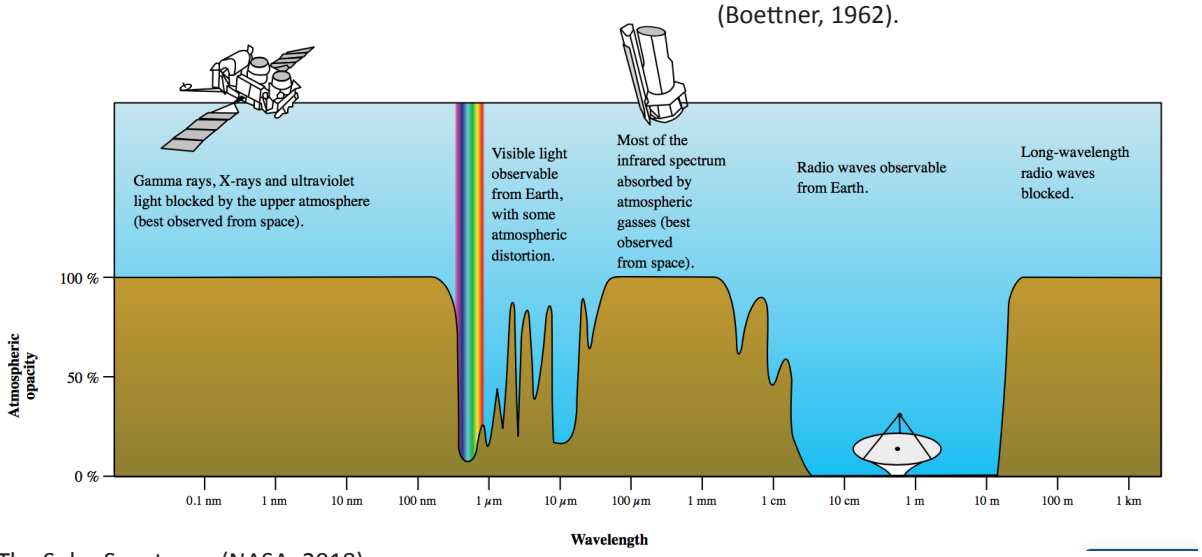
Acute solar damage to the retina occurs most frequently during solar eclipses. Worryingly, these sight threatening events occur in spite of an educated population, and children and young adults are most vulnerable (MacFaul, 1969). Typically, we avoid looking directly at the sun, because it is so bright, and generates a sense of discomfort. However, during an eclipse, people might look at the sun for many minutes, during which accumulating damage builds up in the retina. However, because there are no pain detectors in the retina, this damage goes un-noticed until much later when vision is impaired.



Due to availability in the solar spectrum, and the high transmission of our atmosphere, most animals on earth are visually sensitive to the 400 – 700 nm range of the electromagnetic spectrum. (Robert A Rhode, 2013)



In order for us to see this spectral range, the optical components of the eye must be transparent at these wavelengths, because the photo-detecting cells are at the back of the eye (the retina). The eye's optics are highly transparent between 450 and 800 nm (Boettner, 1962).



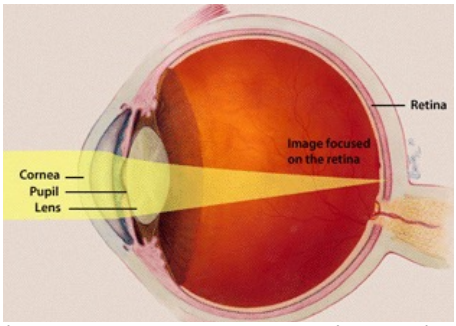
The Solar Spectrum. (NASA, 2018)

So, the spectral characteristics of the eye are nicely adapted to the realities of our solar spectrum, atmospheric transparency, and the need to create images at the back of the eye. However, although we have evolved to employ indirect solar radiation (reflected from objects in the environment) for vision, direct viewing of the sun can be damaging to the retina. For example, our laptop computer may have a luminance of 160 cd/m2, but the sun has a luminance of 1.6×109 cd/m2 at noon, or 10 million times brighter than your computer screen.

Intensity Amplification by optical systems including the eye

In addition to generating images, optical systems also amplify the intensity (flux density) of light. We are all familiar with this phenomenon from our childhood experienced using magnifying glasses to burn holes in paper by imaging the sun directly onto the paper. For example, a typical magnifying glass 5cm in diameter with a 20 cm focal length will increase the concentration of rays by a factor of about 800x between the lens and the solar image. This is typically sufficient to burn paper. Performing the same calculation for the human eye, we discover that for a large pupil (e.g. a nighttime pupil diameter of 7mm, or a dilated pupil following an eye exam) this amplification effect is >1000x, but of course, when looking at the sun, the pupil will normally shrink to about 2mm, but still the amplification is high, above 100X. Studies of rats have shown that solar and eclipse exposure when the pupil has been dilated by drugs dramatically increases the retinal damage (Thanos et al., 2001). The image of the sun on our retina has an area of about 0.017 mm^2, which is small enough to fit completely within the foveolar.

(BCCampus Pressbooks CC-BY 4.0)



(National Eye Institute, US Gov't Works)

Source of Retinal Damage

The above analogy of the microscope burning paper is useful, but misleading in one important way. Our retina is not a piece of dry paper in air, but biological tissue surrounded by water, blood and other heat conducting materials. Because of this, although heat is created in the pigment rich outer retina by the image of the sun, it is dissipated through heat conduction via the adjacent tissue, and when viewing the sun, the retinal temperature does not increase sufficiently to damage the retina (imagine using a magnifying lens to raise the temperature of paper in a glass of water). Passive heat conduction, and not active blood flow through the choroid is primarily responsible for heat dissipation, and solar imaging will not raise retinal temperature by the 10 degrees required to cause photocoagulation in the retina (Mainster, 1998).

Electromagnetic radiation can, however, cause damage in another way. If the small packages of energy (photons) that constitute light individually contain enough energy to dislodge electrons from the atoms that absorb them, they can cause direct molecular changes as their energy is absorbed. This type of light damage, unlike heat, cannot be dissipated, and it is much more likely to occur in tissue that is full of pigment, as is the outer retina. Short wavelength visible photons reach the retina and contain sufficient energy to create these electron changes. After viewing the sun, therefore, the pigment rich photoreceptors and pigment epithelial cells in the outer retina suffer most of the damage (Wu et al., 2006) because of the rhodopsin in the photoreceptor outer segments, and the melanin and lipofuscin in the retinal pigment epithelial cells. The chemical changes that occur generate free radicals, which in turn damage cell membranes and other cellular tissues. The high concentrations of pigment to absorb short wavelength photons in the outer retina, combined with the high levels of oxygen provided by the choroid for the normal high metabolism of photoreceptors, make the outer retina especially vulnerable to this photo-oxidative damage.

Lipid membranes are especially vulnerable to such oxidative damage, and the photoreceptor outer segments are full of lipid membranes. Also, unlike heat that dissipates, photochemical damage will simply accumulate with increased exposure. That is, the longer you look at the sun, the more retinal damage will ensue. Because

shorter wavelength photons are responsible for this photochemical damage in the retina, young eyes (and eyes with an artificial or fake lens) are more vulnerable because of higher short wavelength transmission by the lens.

Clinical Evidence of Eye Damage

Hospitals and eye clinics are often visited by patients suffering from vision loss after a solar eclipse (MacFaul, 1969; Atmaca et al., 1995; Wong et al., 2001), and in each case, the eye exam reveals that the retina has been damaged. Patients who viewed the sun for longer periods had more serious damage (Wong et al., 2001), that in many cases does not recover, causing small regions of blindness in the eye. In milder cases, there appears to be a recovery process, and the clinically observable signs of retinal damage disappear, and vision seems to recover (MacFaul, 1969; Atmaca et al., 1995). However, patients who initially present with visual acuities worse than 20/50 never recovered 20/20 acuity (Atmaca et al. 1995). Recovery is restricted to the 1 month after the lesion develops, with no additional recovery (or worsening) over future years. However, the ability to recover seems to vary significantly from one eye to another in an unpredictable way. Because the retinal lesions created by sun-viewing are small and generally located in the central fovea (Codenotti, et al. 2002)), retina close to the fovea can be healthy and thus visual acuity reductions are often small (Wong, et al. 2001). Also, visual acuity can return to 20/20 in spite of a permanent small foveal scotomas (MacFaul, 1969).

Surprisingly, these patients arrive at clinics in modern times in countries with sophisticated health systems that educate the population about the dangers of direct viewing of the sun during an eclipse. For example, after the 1999 solar eclipse in England, many patients suffered from retinal damage (Wong, et al. 2001). Most concerning are reports that children and young adults are more likely to experience damage. Especially concerning was that many patients viewing the solar eclipse in England in 1966 and Turkey in 1995 experienced retinal damage even though they had employed-some protective eye-wear that presumably was thought to provide adequate protection (MacFaul, 1969; Atmaca, et al. 1995). Imperfect use of the protective devices and ineffective filtering can both lead to retinal damage when viewing an eclipse. Use of ineffective protective devices and strategies can be, therefore, doubly dangerous because they provide the illusion of safety, may cause pupil dilation, and can prevent the avoidance behavior that normally protects us from solar damage to the retina by encouraging extended viewing.

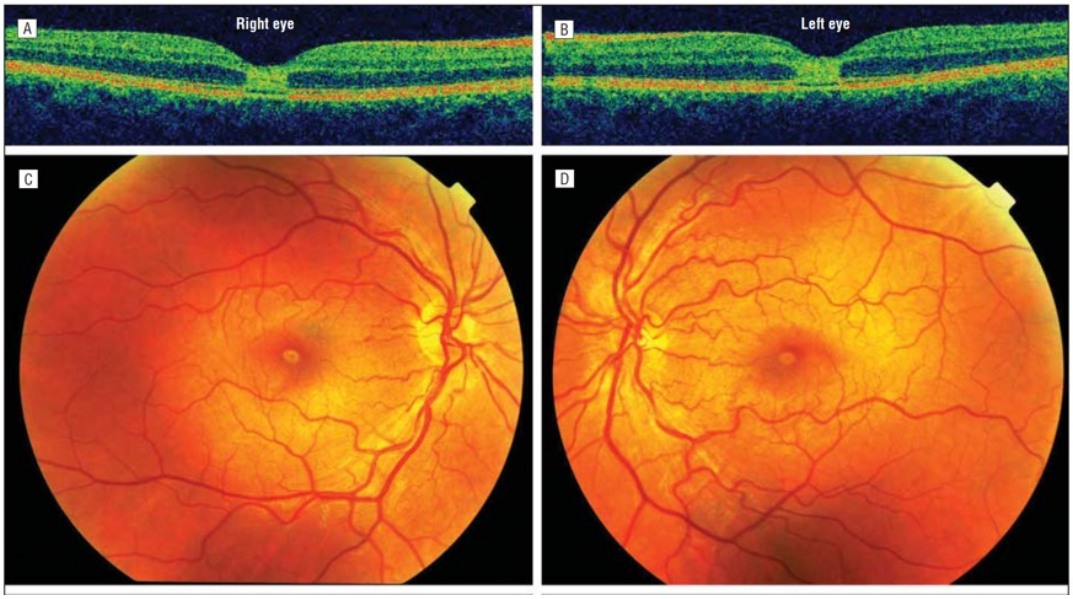
Because there are no pain receptors in the retina, damage can happen without the person being aware. History suggests that this will happen when people employ inadequate filters in an unsuccessful attempt to protect their eyes. For example, although certified sunglasses employ powerful UV blocking filters (e.g. no more than 5% of UV wavelengths <380 nm can be transmitted by these lenses), they can meet standards by transmitting between 3%-100% of visible light (EU standard EN 1836:2005). However, to meet established safety standards for comfortable and safe solar viewing, lenses/filters must transmit no more than 0.001% (1/100,000) of the incident light at all wavelengths. This difference emphasizes that even fairly "dark" sunglasses that transmit only 10% will be transmitting 10,000 times more light than is considered safe, leading the most crucial conclusion that **sunglasses must NEVER be used to view an eclipse!** Only specially manufactured "eclipse glasses" should be used (AAS Eclipse Safety Report, 2017). The AAS report reveals that "To date four manufacturers have certified that their eclipse glasses and hand-held solar viewers meet the ISO 12312-2 international standard for such products: Rainbow Symphony, American Paper Optics, Thousand Oaks Optical, and TSE 17." It is important to check updated reports for each solar eclipse viewing event.

Clinical signs of Solar Retinopathy

Macular edema, loss of foveal reflex, and lamellar macular holes have all been reported in cases of solar retinitis (McFaul, 1969).

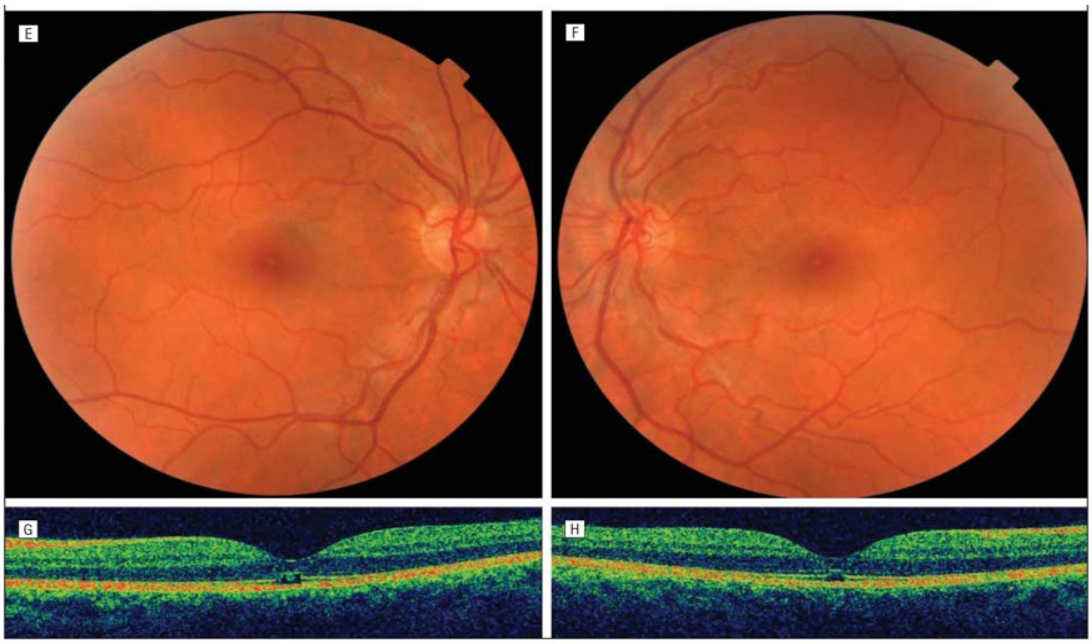
Case Study (Levy et al., 2012):

This case shows how the fundus and OCT (optical coherence tomography) images change over the first month following the acute exposure of the fovea to the sun's image, VA (visual acuity) 20/60 and 20/40 for Right and Left eyes.



These images show the foveal hyper-reflectivity of the outer retina. Note the apparent complete absence of cone cell nuclei (outer nuclear layer) and the cone outer-segments.

At a 3 month follow-up, the outer retina has locally reduced reflectivity, and VA had improved to 20/30.



Case study (Baisakhiya, Chaudhry et al. 2012):

A 21 year old male presented to the eye outpatient department (OPD) with complaints of blurred vision, central scotoma and metamorphopsia since one day after watching the solar eclipse through the radiographic film. The duration of exposure was 2 to 3 minutes. On examination the visual acuity was 6/60 in both the eyes. The Amsler grid revealed a central scotoma and metamorphopsia. The patient was treated with oral prednisolone tablets in dose of 1mg/kg of body weight for 1 week, which was then gradually reduced over a period of four weeks. The patient recovered during the first one month, with reduced metamorphopsia and recovered visual acuity with no residual ophthalmoscopically detectable damage to the macula.

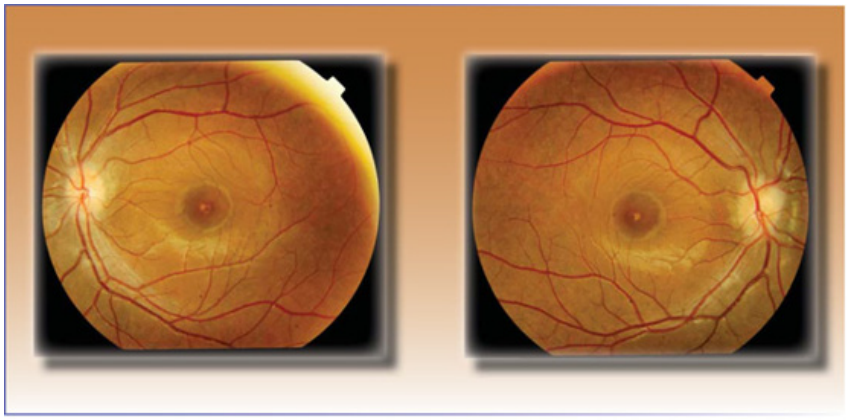


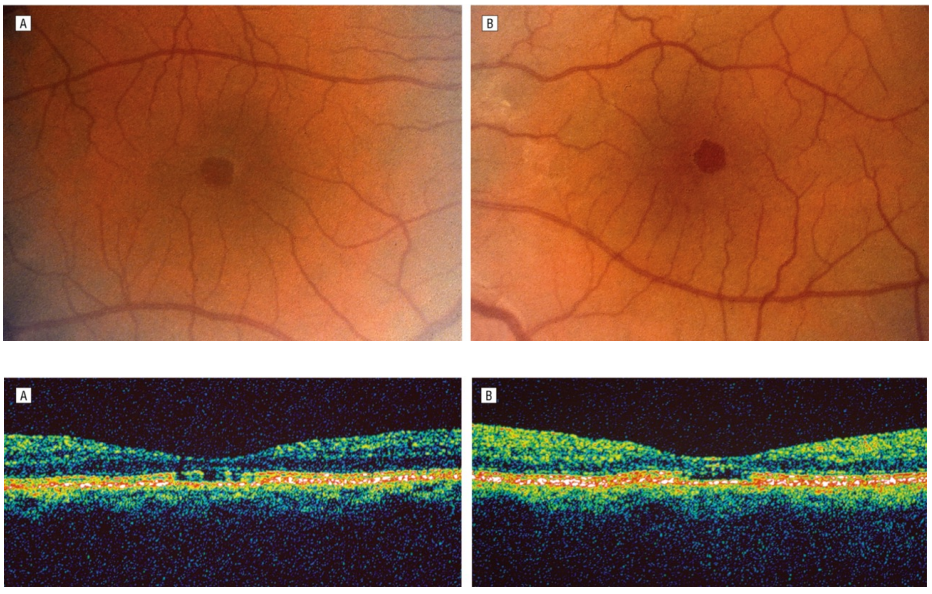
Figure 1: Fundus picture of left eye showing typical yellow white foveolar lesion on presentation.

Figure 2: Fundus picture of right eye showing typical yellow white foveolar lesion on presentation.

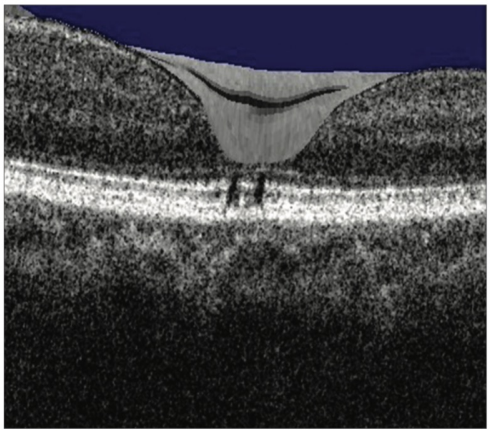
(Baisakhiya, et al. 2012)

Case Study (Steinkamp, et al. 2003):

Example of right and left eyes from man who repeatedly stared at sun.



Notice hyporeflectivity concentrated in outer photoreceptor and RPE layers.



A different case of repeated sun-gazing causing outer retinal (inner and outer segments of foveal cones) damage visualized with 3D OCT (Sheth, et al. 2013)

McFaul (1969) lists a series of case studies and treats with systemic steroids for most serious cases of macular edema following eclipse-gazing.

Pathophysiology of Solar Retinitis

A study of an enucleated eye from a patient with a malignant melanoma of the choroid provides some important insights into the retinal damage produced in human eyes by looking directly at the sun (Hope-Ross, et al. 1993). A patient volunteered to expose the retina to solar damage (10 minutes of looking directly at the sun) prior to enucleation. The fluorescein angiogram was normal in appearance with a very subtle but visible lesion in central fundus image.

Post enucleation histology showed dramatic changes in photoreceptors.

Fragmented discs in cone outer segments:

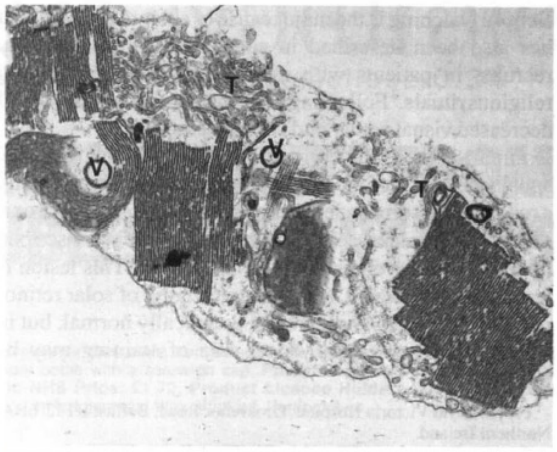


Fig. 4 (b). *Cone outer segment at higher magnification shows fragmentation of the disc membranes with vesicular (V) and tubular (T) profiles. × 24 450.*

(Hope-Ross, et al, 1993)

Swollen Inner segments and swollen mitochondria of photoreceptors

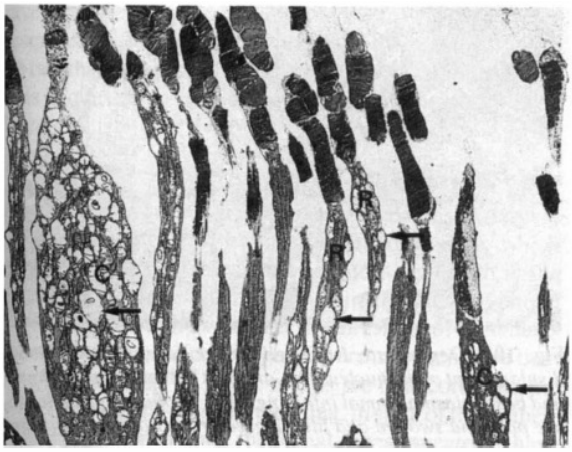


Fig. 6 (a). *Inner segments of rods (R) and cones (C) in the parafovea show swollen mitochondria (arrows). × 4000.*

These authors also noted many abnormalities in the foveal and parafoveal retinal epithelial cells, including large amounts of lipofuscin, and loss of apical microvilli.

Animal immunolabelling studies showed wound healing responses in the neuroglial cells (Muller cells) during the week after solar exposure of mice retinas (Thanos, et al. 2001).

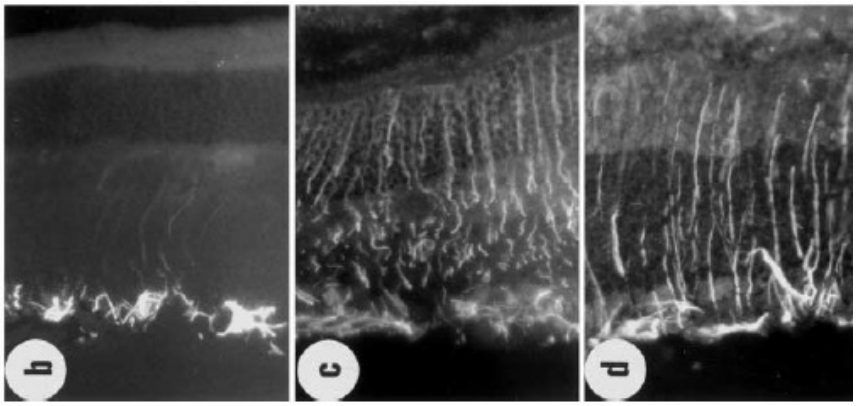


Fig. 4a–h Up-regulation of glial and vascular markers in the eclipse-exposed retina .b Control retina with glial fibrillary acidic protein (GFAP) expression in the astrocytes of the GCL. c, d GFAP is up-regulated in the Müller cells at 1 day post-exposure (c) and is more pronounced 6 days post-exposure (d).

Conclusions

The very optical characteristics of the eye that enable vision, make the retina susceptible to damage from direct viewing of the sun. Typically, humans do not view the sun directly, but a notable exception occurs during a solar eclipse. Attempting to protect the eye with inadequate filtering can exacerbate damage because of the false sense of safety promoting prolonged foveal viewing, and the fact that retinal damage is produced without any accompanying pain. Milder lesions do show clinical signs of recovery, and upregulation of Muller cell repair mechanisms may be responsible for recovery of damage caused by photo-oxidation in the outer retina. Many cases of foveal damage following eclipse viewing never recover fully, but there is some evidence to suggest that control of inflammation with corticosteroids may be an effective treatment strategy for retinal damage produced during eclipse viewing.

Sources of Information on Solar Eclipse Safety

AAS Solar Eclipse Safety Guidelines

AAO Eclipse Eye Safety

NASA's Eclipse Safety Page

References

Atmaca, L. S., Idil, A. & Can, D. (1995). Early and late visual prognosis in Solar Retinopathy. Graefes Arch Clin Exp Ophthalmol, 233(12), 801-804.

Baisakhiya, S., Chaudhry, M., Manjhi, P., Babber, M. & Mehta, C. (2012). Acute Solar Retinopathy. Delhi Journal of Ophthalmology, 23(4), 285-287.

Boettner, E. A. & Wolter, J. A. (1962). Transmission of the ocular media. IOVS 1(6), 776-783.

Codenotti, M., Patelli, F., & Brancato, R. (2002). OCT findings in patients with retinopathy after watching a solar eclipse. Ophthalmologica, 216(6), 463-466.

Hope-Ross, M. W., Mahon, G. J., Gardiner, T. A., & Archer, D. B. (1993). Ultrastructural findings in Solar Retinopathy. Eye (Lond) 7 (Pt 1), 29-33.

Levy, S., Sheck, L., & Guest, S. (2012). OCT appearances in Acute Solar Retinopathy. Arch Ophthalmol, 130(12), 1540.

MacFaul, P. A. (1969). Visual prognosis after Solar Retinopathy. Br J Ophthalmol, 53(8), 534-541.

Mainster, M. A. (1998). Solar eclipse safety. Ohthalmology, 105(1), 9-10.

Sheth, J., Vidhya, N. & Sharma, A. (2013). Spectral-domain optical coherence tomography findings in Chronic Solar Retinopathy. Oman J Ophthalmol, 6(3), 208-209.

Steinkamp, P. N., Watzke, R. C., & Solomon, J. D. (2003). OCT appearances in Acute Solar Retinopathy. Archives Ophthalmology, 121, 1798.

Thanos, S., Heiduschka, P., and Romann, I. (2001). Exposure to a solar eclipse causes neuronal death in the retina. Graefes Arch Clin Exp Ophthalmol, 239(10), 794-800.

Wong, S. C., Eke, T. & Ziakas, N. G. (2001). Eclipse burns: a prospective study of Solar Retinopathy following the 1999 solar eclipse. Lancet 357(9251): 199-200.

Wu, J., Seregard, S. & Algvere, P. V. (2006). Photochemical damage of the retina. Surv Ophthalmol 51(5), 461-481.

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HASTI Board of Directors (2023)
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HASTI Calendar of Events

HASTI Board of Directors

The HASTI website has a calendar of upcoming events to help you see upcoming meetings, conference and professional developments.

HASTI Events Page

To submit an event you would like to add to that list, email info and URL to thst@hasti.org

January 11, 2024 – Ninth Annual Indiana STEM Education Conference, Purdue University. 8:30 am to 3:30 pm.

January 20, 2024 – Winter Science Day, 10:00 am to noon, Corydon Capital State Historic Site, Corydon. Learn about the science of winter. $ Registration required.

January 27, 2024 – Learn about the Great North American Eclipse from eclipse professional Dan McGlaun at the Franklin branch of the Johnson County Public Library. 2:00 to 3 pm.

February 1-4, 2024 – Live Raptor Show #1, Paynetown State Recreation Area. This is part of the Eagles over Monroe event at Monroe Lake. Show begins at 1:00 PM. Registration is required by Jan 30. $5 per person.

February 9-10, 2024 – Indiana Region Junior Science and Humanities Symposium. Students (grades 9 – 12) compete for scholarships and recognition by presenting their original research efforts before a panel of judges and an audience of their peers. Hanover College.

February 10, 2024 – Eclipse: The Sun Revealed, Planetarium Show, 5:00 PM at the Charles W. Brown Planetarium, Ball State University, Muncie, IN. Repeats

February, 29, 2024 – Indiana Envirothon Northeast Regional Competition, Peabody Public Library, Columbia, Indiana. Contact Nadean Lamle, Northeast Regional Coordinator at nadean.lamle@in.nacdnet.net

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March 1, 2024 – Deadline for fifth grade **Arbor Day Poster Contest** hosted by the Indiana Department of Natural Resources. One submission per school.

March 2, 2024 – **Space Day** from 10 am to 4 pm at the Johnson County Armory in Franklin, Indiana. Enjoy activities like the SkyDome, eclipse demonstrations and presentations, Storytime from Space, a NASA artifact display, and a VR experience.

March 6, 2024 – **Indiana Envirothon Central Competition**, Franklin College Science Center, Franklin, Indiana. For more information contact Ben O'Neal at BONeal@franklincollege.edu

March 12. 2024 – **Indiana Envirothon Southwest Competition**, Warrick County 4H Center, Boonville, Indiana. Contact Southwest Regional Co-coordinators Susan King (susan.king@in.nacdnet.net) or Tina Boerner (Tina Boerner@in.nacdnet.net)

March 13, 2024 – **Indiana Envirothon North Central Regional Competition**, Camp Buffalo, Monticello, Indiana. Contact Amanda Heltzel, North Central Regional Coordinator at amanda.heltzel@in.nacdnet.net

March 13, 2024 – **Indiana Envirothon South Central Competition**, Lawrence County Fairgrounds, Bedford, Indiana. For more information contact Stephanie Baker, South Central Regional Coordinator, at stephanie.baker@in.nacdnet.net

March 14, 2024 – **Indiana Envirothon Northwest Competition**, Red Mill County Park, La Porte, Indiana. For more information contact Linda Schwab Northwest Regional Coordinator at lschwab@laporteco.in.gov

March 14, 2024 – **Indiana Envirothon East Central Competition**, Ball State University Environmental Education Center, Muncie, Indiana. Contact the registration coordinator LuAnne Holeva (Luanne.holeva@in.nacdnet.net) or the site contact Erica Oliver (elforstater@bsu.edu)

March 15, 2024 – **Indiana Envirothon West Central Competition**, Ivy Tech Community College, Terre Haute, Indiana. For more information contact Jan Came, West Central Regional Coordinator, at jan.came@usda.gov

March 23, 2024 – **Indiana Science Olympiad**. Purdue Northwest. Twenty-three competitions each for middle and high school teams.

April 4, 2024 – **First Thursdays Festival: Eclipse Themed**. Hosted by the Arts and Humanities Council. Indiana University, Arts Plaza, 5 – 8 PM.

April 6, 2024 – **Indiana University Science Fest**, Bloomington Campus, 9 am to 3 pm.

April 6-8, 2024 – **Festival Country Eclipse Festival 2024**. Live music, food trucks, hot air balloon, races, free eclipse glasses, and eclipse science will take place in Franklin, Greenwood, Johnson County Park, Edinburgh, and Whiteland. For more details go to

April 8, 2024 – **Holcomb Observatory and Planetarium**, Butler University, Total Eclipse Indiana 2024: Eclipse Viewing Festival. Noon to 4:30 PM. Eclipse related activities.

April 26, 2024 – **Eco-Science Challenge: Solutions for the Future**. Indiana students K-12. Indiana State Museum and Historic Sites in partnership with Earth Charter Indiana. Deadline for application is April 12, 2024.

June, 9-12, 2024 – **Rising Leaders Program**. Indiana University O'Neill School of Public and Environmental Affairs. Designed for high school students who want to understand the impact they can have on society. The application portal is open.

June 24-28 – **Summer Experience in Sustainability and the Environment (SESE)**. Indiana University Integrated Program in the Environment. Keep an eye on the website for the up-to-date information and application procedure and deadline beginning in January.

HASTI Board of Directors (2023)
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Freebies! Free resources for teachers

HASTI Board of Directors

This feature of THST will provide information for teachers about free resources, PD activities, and materials.
Look for this feature in each issue!

NSTA Solar Eclipse Guide for Educators: A Solar Eclipse Double-Header. Dennis Schatz and Andrew Fraknoi.

Solar Eclipse Double-Header in October 2023 and April 2024: What School Administrators and Other Education Leaders Need to Know. Dennis Schatz and Andrew Fraknoi

Customized Environmental field trips for high school students through the IU Integrated Program in the Environment. Contact Elspeth Hayden at haydene@indiana.edu

Free Planetarium Shows. **View the schedule of shows** at the Charles W. Brown Planetarium, Ball State University. Attend a public show, or schedule a FREE show for your class or organization.

Indiana DNR Total Solar Eclipse resources. Printable maps, downloable poster, location of parks for eclipse viewing and more. **Click Here!**

NASA Mars Exploration Posters to download and print.

NASA Goddard Space Flight Center, 2017

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