Rochester Academy of Science™

BULLETIN

"An organization of people interested in the Natural Sciences"

September 2023; Vol. 77, #8

President's Message

Fall Paper Session

This Fall, on Saturday, November 4th, we will host the **49th Annual RAS Fall Scientific Paper Session**. The paper session will be held at *Rochester Institute of Technology*.

We are pleased that Dr. Roger Easton, Jr. has accepted our invitation to deliver the keynote address as our 2023 Larry King Memorial Lecturer. His specialty is using advanced imaging technologies to recover long lost texts from ancient manuscripts which are faded or used recycled parchment. He will speak on "The New Golden Age of Manuscript Studies".

Dr. Roger Easton, Jr., of the Chester F. Carlson Center for Imaging Science at the College of Science, Rochester Institute of Technology.

Some of the examples of such recovered documents are truly exciting. Take the case of the Greek astronomer *Hipparchus*. (c. 190 – c. 120 BCE). Besides inventing trigonometry and discovering the precession of the equinoxes, he created the earliest known star chart, cataloguing the coordinates of the stars. Although his models for the motion of the Sun and Moon survive, his star chart had been long lost. In 2017, part of it was found when a medieval manuscript was analyzed to recover the text that had been lost when scraped clean to reuse the parchment pages. One page was measurements in degrees for the constellation Corona Borealis. The date of the observations—about 129 BCE—can be determined by the difference in the star positions then compared to the present due to precession, which takes 26,000 years to complete one cycle.

For more information on the RAS paper session and to register go to rasny.org/paper-session.

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ASRAS at Rochester Fringe Festival

ASRAS is helping RMSC put on the FREE Astro-Fringe **event as part of** the Rochester Fringe Festival on Sept 22 & 23 at 6pm for 4 hours at Parcel 5, 285 E Main St, Rochester, NY 14604. The objective is a record setting number of telescopes, so bring yours. You'll be able to get a close look at the Moon, Saturn, Jupiter, and more with all these telescopes! There will be food trucks, music, and space-themed hands-on activities.

Michael Grenier, RAS President

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New Psychology Section proposed

RAS Member Cory Crane and associates are now organizing a proposed RAS section dedicated to psychological and behavioral science. Cory writes that this proposed section intends to tap into the various domains of psychology (i.e., Clinical, Cognitive, Developmental, Industrial / Organizational, and Social) to appeal broadly to those interested in human perception and behavior. The proposed Psychological Sciences Section plans to hold regular meetings with experiential activities accessible to lay audiences, such as guest lectures and exhibitions that highlight the integration of technology and other advances, in order to heighten interest and facilitate the exchange of knowledge. Sample section activities can include skills-based workshops (e.g., healthy interpersonal relationships), game nights (e.g., the psychology of gambling), pop-culture character analysis (e.g., understanding Walter White), discussion of critical thinking (e.g., evaluating sources of data), and review of recently published manuscripts.

Cory is a clinical psychologist and an associate professor in Behavioral Health within the College of Health Sciences and Technology at the Rochester Institute of Technology. His clinical and research focus is on the assessment and treatment of addictive diseases as well as associated conditions. Cory notes that the proposed section seeks representation from local colleges, universities, and community organizations. Student engagement is a top priority with targeted advertisements, outreach, and student representatives elected within high schools. Psychological Sciences may draw many new members to the RAS and some likely have interests in our existing sections. Our bylaws permit establishing a new section upon written petition of ten active members. If you are interested in this proposed new section and would like to lend your name to the petition of organization, please contact Cory at cacihst@rit.edu.

Events for September 2023

NOT MEETING IN SEPTEMBER
Anthropology Members
Fossil Members

Sept. 6 Wed: Astronomy Board Meeting
7:00 p.m. Farash Center in Ionia. ASRAS members are welcome. Contact: Anthony Golumbeck at semp@use.startmail.com.

Sept. 8 Fri: Astronomy Members Meeting
7:30 p.m. – 10:00 p.m. Education building at the Ionia Farash Observatory site. Jennifer Indovina from RIT will speak about how astronauts transition back to earth after long duration space missions. Contact: Anthony Golumbeck at semp@use.startmail.com.

Sept. 10 Fri: Astronomy Members Open House
12:00 p.m. – 3:00 p.m. Farash Center, Ionia. Come help out and learn how to operate the telescopes. Contact: Anthony Golumbeck at semp@use.startmail.com.

Sept. 13 Wed: Herbarium Workshop
The Life Sciences section will hold a workshop at the RAS Herbarium, located in the basement of the Rochester Museum and Science Center (RMSC). We will be continuing to organize plant specimens in preparation for digitizing, hopefully later this year. If you plan to attend, please send an RSVP to Elizabeth Pixley. At RMSC go to the front desk to meet other participants. For more information, contact Elizabeth Pixley, herbarium curator (334-0977 or eypixley@gmail.com).

Sept. 15 Fri: Public Observing at Farash Center
7:30 p.m. - 11:00 p.m. Public is welcome. Members come and help visitors observe through our telescopes. Contact: Anthony Golumbeck at semp@use.startmail.com.

Sept. 15 Fri: RIT Photonics Lab Tour
Contact Dave Bishop at dbishopx@gmail.com if interested.

Sept. 20 Wed: RAS Board Meeting
7:00 p.m. – 9:00 p.m. at Landmark Society Warner Castle. Zoom option available. For details, contact Michael Grenier at mgrenier@frontiernet.net.

Sept. 26 Tues: Mineral Section Meeting
7:00 p.m.- Meet at NEQALS building, 1030 Jackson Road, Webster. Join us for a social gathering and a program to be determined. Members will receive a notice. Contact: Jutta Dudley, juttasd@aol.com.

ONGOING EVENTS EVERY MONTH:

STRASENBURGH OBSERVATORY
ASRAS will operate the telescope at Strasenburgh Planetarium on mostly clear Saturday nights. But, the telescope will be CLOSED Sept 9 for a planetarium event. Contact: Jim Seidewand (585) 703-9876.

OUTSIDE RAS EVENTS:

Sept. 16 Sat: 25nd ANNUAL IONIA FALL FESTIVAL
ASRAS will do outreach at this event. For details see https://www.ioniaumc.org/events.html. Contact: Anthony Golumbeck at semp@use.startmail.com.

Rochester Research in Review.

(These are Hot Links which when clicked lead to the press release on the Science Daily website.)

Super Radar: Breakthrough radar research overcomes a nearly century-old trade-off between wavelength and distance resolution

Sea urchins are struggling to 'get a grip' as climate change alters ecosystems

Meteor in the Milky Way from the favorable, moonless Perseid Meteor shower this year. Taken Sun, Aug 13. **Nick Lamendola**

Genomic Editing

by Michael Grenier

The following research project, which was awarded an RAS student grant, relies on gene editing. Following is a summary for those unfamiliar with the process.

First, bacteria are frequently attacked by viruses and can be killed by them. They survive by recognizing and destroying the virus. One way, used by close to half of all known bacteria, is to copy a stretch of that virus' DNA or RNA into their own DNA, in a section known as the CRISPR sequences. CRISPR is an acronym, short for Clustered Regularly Interspaced Short Palindromic Repeats of DNA base pairs. That stretch of DNA is unique to that specific virus and it can be used to recognize whenever that virus invades. Because it is part of the bacteria's DNA, it is passed on to its descendants, which can thereby recognize that virus invader the first time it intrudes.

Recognition is only the first step in defeating the virus invader. Once recognized, it must be destroyed. The bacteria also possess an enzyme, often Cas9, which can literally chop the virus into pieces, rendering it harmless. Cas is an acronym for this enzyme (CRISPR-associated). The complete function requires that the enzyme be attached to the CRISPR sequence, so that when the sequence is matched to the corresponding stretch of base pairs in the virus, Cas9 will cut it there. End of virus.

For a short (1 m 39 sec) illustrative YouTube video from the Mayo Clinic, click here CRISPR Explained.

In August 2012, Jennifer Doudna and Emmanuelle Charpentier and their teams published their finding that the CRISPR-Cas9 complex could be programmed with a guide RNA to edit genomic DNA. ("A programmable dual-RNA-guided DNA endonuclease in adaptive bacterial immunity". *Science*. 337 (6096): 816–821.) They found that with the proper guide RNA sequence, any gene could be cut at any point. They also found that by using the natural repair mechanisms in DNA, they could make various edits. A single cut is repaired by the broken ends reattaching. Due to the gain or loss of a few base pairs of amino-acid based nucleotides on each end, a cut made in a protein-coding stretch (called an exon) will make that exon inoperable. That inactivates that gene. A cut made at each end of an exon enables that exon to be removed (deleted). That is the case for any stretch of nucleotides the worker wants to remove. Lastly, it is possible to insert a new stretch of nucleotides either at the single cut or in replacing a removed segment. An entire gene can be removed, or added, or replaced.

This seminal paper is considered one of the most significant discoveries ever in biochemistry. Three years after the discovery, the American Association for the Advancement of Science named the CRISPR genome-editing method its "Breakthrough of the Year." The lead researchers Emmanuelle Charpentier and Jennifer Doudna were awarded the 2020 Nobel Prize in Chemistry for developing these techniques. They were the first two women to share a Nobel Prize without a male awardee.

The CRISPR gene-editing technique is so significant because it is very precise, cheap, and easy to use. Joy Wang and Jennifer Doudna noted earlier this year (*Science*, 20 Jan 2023, Vol 379, Issue 6629) that, "(CRISPR) genome editing, coupled with advances in computing and imaging capabilities, has initiated a new era in which we can not only diagnose human diseases and even predict individual susceptibility based on personal genetics but also act on that information. Likewise, we can both identify and rapidly alter genes responsible for plant traits, transforming the pace of agricultural research and plant breeding. The applications of this technology convergence are profound and far reaching." With it we can create new medicines and agricultural products, control pathogens and pests, and may be able to treat inherited genetic diseases and cancers.

2022-2023 Undergraduate Student Research Grant Award Winner

Investigating the role of TET2 in human erythropoiesis using CRISPR/Cas9

By Charly Campanella, St. John Fisher University. Advisor: Zachary Murphy, Ph.D.

[Winner - $400 2023 Undergraduate Student Research Grant Award from RAS. This research will continue through the 2023-2024 school year.]

Figure 1. Charly Campanella (photo courtesy of author)

Abstract: Erythropoiesis is the biological process involving the creation of erythrocytes, or red blood cells. Red blood cells are made continuously in the body, and they provide the body's tissues with oxygen. Red blood cells go through a specific process of maturation in order to lose their nuclei and take on their normal biconcave morphology. The protein hemoglobin is found inside red blood cells and binds oxygen molecules within the body. The cells then transport the oxygen throughout the body to different organs. Disruption of erythropoiesis can lead to diseases such as anemia and myelodysplastic syndrome (MDS). Anemia is characterized by reduced transport of oxygen throughout the body, while MDS involves the bone marrow being unable to produce the correct mature red blood cells. Ten-Eleven Translocation-2 (TET2) is a gene that is suggested to be related to MDS, and it may play a role in the proper functioning of erythropoiesis. Studies have shown the possibility of a lack of TET2 playing a role in the progression of MDS in patients [3,6,16,19]. TET2's function is currently unknown, but previous publications suggest that its function may be related to erythropoiesis.

A guide RNA is a piece of RNA that functions as a guide for RNA- or DNA-targeting enzymes, with which it forms complexes. Very often these enzymes will delete, insert or otherwise alter the targeted RNA or DNA (*Wikipedia*).

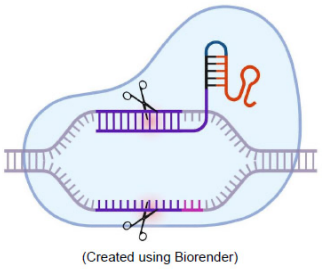

Figure 2. sgRNA designs - Specific oligo sequences were designed for exons 3, 7, and 11 on the TET2 gene using CRISPRcan.org

To determine the relationship between erythropoiesis and TET2, specific "single guide RNA molecules" (sgRNAs) were designed to target exons 3, 7, and 11 of TET2. These sgRNAs and CRISPR/Cas9 were inserted into cells with lipofectamine and monitored in a cell culture room. The alteration of TET2 sequences was observed in the cells, and the resulting phenotypes and genotypes were recorded. If TET2 is necessary for erythropoiesis, and beginning, middle, and ending exons of TET2 are targeted, erythropoiesis will not function properly and the morphology of the cells will differ from the normal biconcave phenotype.

Background and aims: Erythropoiesis is a crucial process in humans. It involves the production of erythrocytes, also known as red blood cells. Erythrocytes' primary function is to carry oxygen through the body. Erythrocytes are generated from precursors, known as erythroblasts, starting with a proerythroblast that progressively matures to an erythrocyte. As the erythroblasts continue to mature, the cell becomes smaller, the nucleus condenses, and the organelles are removed. Erythrocytes, unlike many other cells, are without a nucleus as the nucleus is removed in the final stage of maturation resulting in the biconcave morphology of the cells.

The human body makes about 2 million red blood cells every second. Once these cells are mature, they have limited abilities to repair any mistakes due to their lack of nucleus or organelles. If the red blood cells do not mature properly they cannot function properly. The biconcave morphology is a crucial part of maturation and red blood cell function and if the morphology or physiology is abnormal oxygen will have a challenging time interacting with the protein hemoglobin, found in red blood cells. This lowers the amount of oxygen that can be transported throughout the body and can cause anemia. Anemia is a decreased ability of the body to deliver oxygen. Anemia can be caused by the destruction of erythrocytes, the loss of erythrocytes, functional deficiency of erythrocytes, a decrease in hemoglobin, or a decrease in hematocrit (ratio of erythrocyte volume to blood volume). Since many red blood cells are made per second, small changes can occur resulting in anemia and one third of the population has experienced anemia. Diseases in one group of cancers associated with a lack of properly functioning erythrocytes are called myelodysplastic syndromes (MDS) [19]. MDS is characterized by a decrease in the number of erythrocytes due to bone marrow failure, the site of erythrocyte production, resulting in a decreased amount of oxygen carried throughout the body. Over time, some patients progress from having MDS to having acute leukemia [19]. TET2 is one gene that is believed to be related to MDS [10]. Researchers have noted that in some patients with MDS, the TET2 gene is mutated or completely deficient [5,10]. This gene is located on chromosome four and the role of TET2 is not exactly known. Researchers have speculated that TET2 and erythropoiesis may be connected [3,5,10]. The TET family includes genes TET1, TET2, and TET3. The TET family plays a role in DNA methylation, which alters the DNA by the addition of a methyl group. The TET proteins are methylcytosine dioxygenases and they also have a function that is related to histone modification [6].

The relationship between MDS and TET2 could possibly explain the role of TET2 mutations in bone marrow failure. TET2 could also be important for the formation of erythrocytes in the bone marrow, which is why a deficiency of the gene is sometimes apparent in patients with MDS. The

goal of this project is to target three exons in the beginning, middle, and end of the TET2 gene for genome editing in order to observe the potential phenotype of the cells in an effort to understand the role of TET2 in erythropoiesis.

Project Goals: Immortalized human cell lines play a role in helping researchers understand certain pathologic processes. CRISPR/Cas9 technology is used to target and disrupt exons 3, 7, and 11 of TET2.

Aim 1: Design and synthesize sgRNA targeting TET2 to genetically alter specific regions of the TET2 gene.

Aim 1a: Design sgRNA(s) that disrupt the transcription start site and early coding region to prevent TET2 transcription. The websites of cripsrscan.org and benchling.com were used to design the sgRNA(s).

Aim 1b: Design sgRNA(s) that disrupt throughout the TET2 gene to see if it is required for function in erythroid cells. Three sgRNAs needed to be designed in order to target each exon.

Aim 2: Optimize and perform transfection of sgRNA and Cas9 into human erythroid cells lines in order to generate models of TET2 loss and mutation

Aim 2a: Optimize the use of ribonucleoprotein complexes to perform CRISPR/Cas9 in K562 and KITCAT human erythroid cells lines. The K562 and KITCAT cells are specific types of human erythroid models. The Cas9 and sgRNA were inserted into cells with lipofectamine and the cells were monitored in a cell culture room.

Aim 2b: Use Sanger sequencing and trace deconvolution software to analyze efficiency of CRISPR in erythroid cells. Sanger sequencing is a technique that is used to sequence DNA. The DNA of interest is used for a polymerase chain reaction, in which DNA polymerase adds dNTPs to a growing DNA strand. Growth is terminated with the addition of a fluorescent ddNTP. The DNA fragments are then separated by size with gel electrophoresis. The sequence of nucleotides can be determined by identifying the fluorescent ddNTPs in fragments of a specific size.

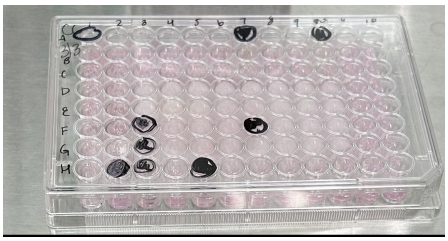

Figure 3. The monocultures that were in a 96 – welled plate. The black circles on some of the wells indicated the presence of cells.

Research plan: The sgRNA(s) were designed using crisperscan.org and benchling.com for exons 3, 7, and 11 on the TET2 gene. Once the sgRNA(s) were sequenced, the sgRNA and Cas9 were transfected into K562 and KITCAT cells with lipofectamine. The cells were monitored over the span of two weeks and the phenotypes and genotypes were observed.

Progress to date: An sgRNA targeting exon 3 of TET2 was designed using crisprscan.org and benchling.com. The sgRNA was synthesized with the EnGen SgRNA Synthesis kit and the dsDNA template was used to make the sgRNA. Once the sgRNA was synthesized, it was purified and the concentration of the RNA yield was observed with a nanodrop spectrophotometer. The health of K562 cells was observed over the span of three to four weeks in a cell culture room. Once the cells had a viability around 90%, the purified sgRNA and Cas9 were transfected into the cells with lipofectamine. One well of the cells had the sgRNA and Cas9, while the other well of the cells acted as the control, containing buffer and Cas9. The cells were monitored for 2 weeks and some of the cells were analyzed under a microscope after being stained with undiluted Giemsa Stain. Cells from both the experimental and control groups were isolated and PCR screened.

The experimental cells were growing at a faster rate than the control cells and they had higher viability.

Successful design and generation was confirmed by determining RNA concentrations on the nanodrop spectrophotometer.

The gel electrophoresis did not show any of the control or experimental bands. The gradient PCR showed that there was DNA present, but the primers were not working.

The number of live amplified cells increased for both the experimental cells in both the Fall and the Spring.

Some monocultures grew faster than others, suggesting that TET2 could be linked to cancer.

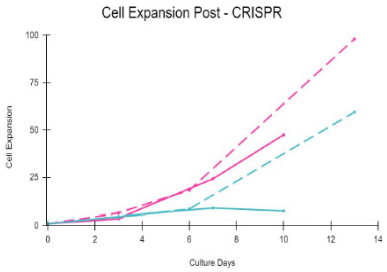

Figure 4. The expansion of the post – CRISPR cells over a span of 12 days. The pink dotted line represents the experimental cells from the fall (2022). The pink solid line represents the experimental cells from the spring (2023). The light blue dotted line represents the controls cells from the Fall (2022). The light blue solid line represents the control cells from the Spring (2023).

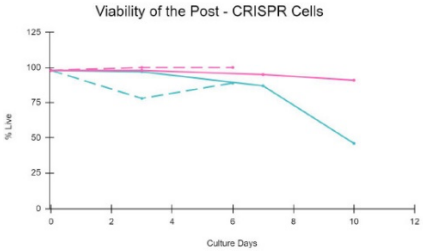

Figure 5. The percent of viable cells after interacting with the CRISPR. The same lines and colors from Figure 4 are used here.

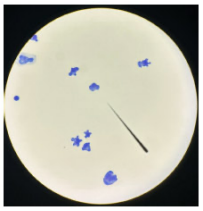

Figure 6.

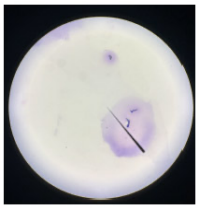

Figure 7.

Figure 6 shows the image of control cells (2023) under 400X total magnification. Figure 7 shows the image of experimental cells (2023) under 400X total magnification.

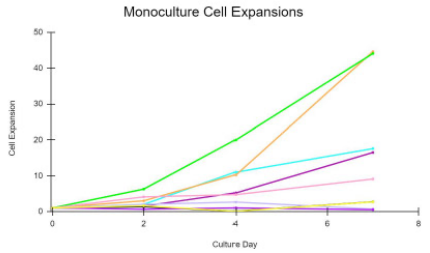

Figure 8. The cell expansion of each monoculture line over the span of 7 days. The monocultures were labeled A1 (light blue line), A7 (orange line), A10 (dark purple line), F3 (lime green line), F7 (black line), G3 (lilac line), H2 (light purple line), H3 (pink line), and H5 (yellow line).

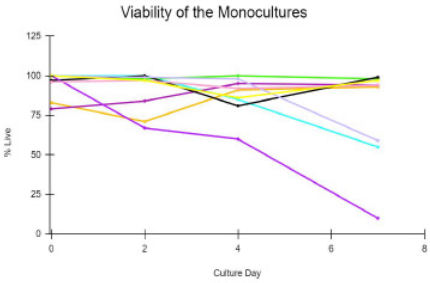

Figure 9. The viability of the cells for the monocultured lines (have same color lines as Figure 8).

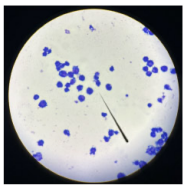

Figure 10.

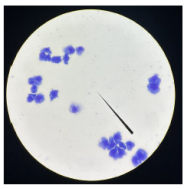

Figure 11.

Figure 10 shows the cells from A7 at 400X total magnification. Figure 11 shows the cells from F3 at 400X total magnification. Figure 12 shows the cells from F7 at 400X total magnification.

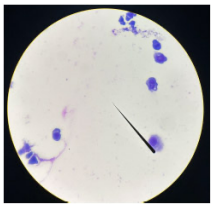

Figure 12.

Future Plans

- Sequence exon 3 to determine the efficiency of sgRNA for exon 3 and test the sgRNA.
- Look at the phenotype and genotype of the cells to determine how they differ.
- Troubleshoot possible primers that can be used for the PCR
- Freeze the cells from the monocultures and observe their phenotypes
- Carry out similar molecular techniques for exons 7 and 11
- Determine the roles of different exons and see what happens to the cells when each exon is mutated or deleted

Expected Results/Hypothesis:

Previous experiments and publications have discussed a possible relationship between TET2 and MDS [3,6,16,19]. MDS is related to erythropoiesis because MDS is caused by bone marrow failure [16]. Erythropoiesis takes place in the bone marrow, and without proper biological interactions, it can cause diseases like MDS. Mutations in TET2 could cause erythrocytes to develop incompletely and alter their ability to function. This would reduce the amount of oxygen carried throughout the body, and overall lead to other biological issues due to the necessity of oxygen to sustain life. When TET2 expression is reduced in erythrocytes via knockdown, the morphology and growth of erythroid cells should be impacted. It has previously been shown that some MDS patients express mutations in TET2 [3,6,19]. It can therefore be hypothesized that the morphology of red blood cells is impacted by TET2. Additionally, high levels of TET2 may be found in bone marrow tissue since MDS is characterized by bone marrow failure. It is expected that mutations of TET2 would cause red blood cells to not mature properly. Their final morphology would therefore be expected to differ from the normal biconcave morphology.

Because the function of red blood cells is dependent on their final morphology, cell growth would also be impacted. Millions of cells are produced every second, and it is crucial that these cells mature correctly. Their morphology determines the capacity and rate of oxygen molecules that can bind to hemoglobin. If the biconcave morphology is altered in any way, cell growth will decrease over time. This can then lead to larger biological problems for patients with a deficiency of TET2. While other genes and proteins may contribute to the process of red blood cell formation, TET2 may play a central role in normal erythropoiesis.

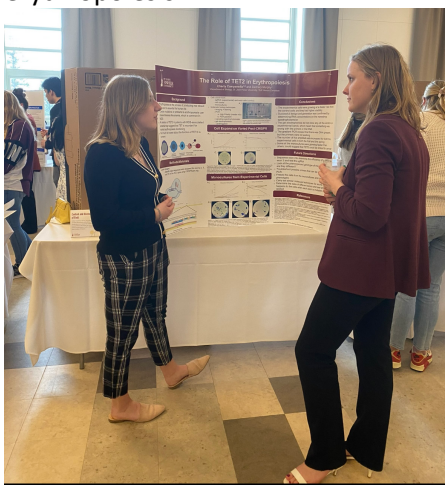

Figure 13. Ms. Campanella (left) presenting at St. John Fisher. (photo courtesy of author)

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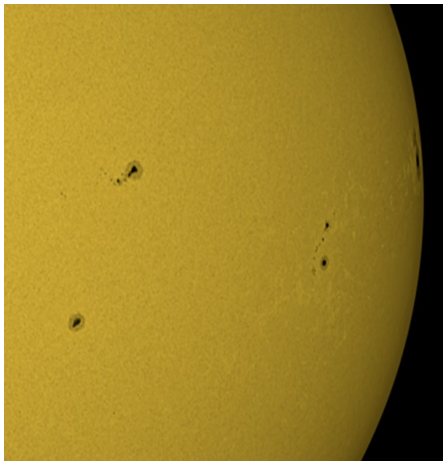
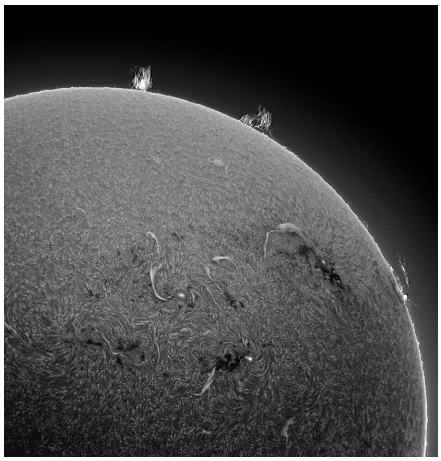


Sun in white light photo: taken Sun, Aug 6, **Kevin Lyons**.



Sun in H-alpha light, N up, E right, surface has light/dark reversed: taken same day, Sun, Aug 6. **Doug Kostyk.**

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