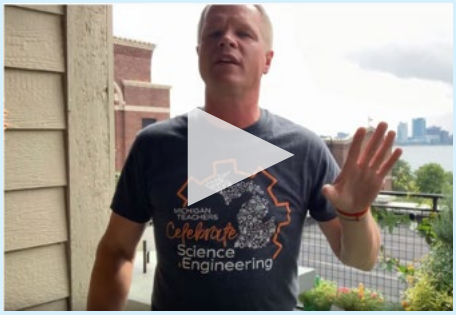
MSTA Newsletter

A publication of the Michigan Science Teachers Association • Volume 71.3 • SUMMER 2019

In this Issue

From the President's Desk

Message from the MSTA President, Brian Peterson:



From the Desk of Your Executive Director

Betty Crowder and Robby Cramer, MSTA Co-Executive Directors

We hope you have enjoyed a perfect summer whether you spent time traveling, gardening, enjoying your family, studying, reading, observing or exercising. The important thing is taking time for yourself. As you read this, you are already in the throes of the opening of school year so summer memories may be fading. Please keep in mind those special summer moments and try to duplicate those moments throughout your busy school year. One way you may do this is by finding inspiration in a new adventure – the Michigan Science Teachers Association.

If you haven't already discovered MSTA, you may ask, "I think I am a member so why should I become more involved in this professional organization? Between my colleagues at school and Google, I have nearly everything I need." For one thing, professional organizations can take you beyond "the basics," and connect you with like-minded, passionate educators. There are so many benefits - from networking, to the feel-good aspect of volunteering, to developing lasting personal and professional relationships plus it may just give you the boost you need in your career!

Being a member is not the same as engaging as a member. It is likely that most of you are members of MSTA because you attended our conference. That is commendable! Our conference is the best thing we do! Beyond the conference, however, we would like you to consider taking your relationship with MSTA to the next level. There are numerous reasons why:

Reason #1: Networking
You will enhance your professional (and personal) network because connecting to a group gives you a sense of security and trust. You will learn about "breaking news" in science education in the state, learn about best practices or new ideas, and meet and brainstorm with peers who share your interests and passion. You may find a mentor or be able to mentor others to help with professional goals.

continued on page 2

From the Executive Director

continued from page 1

Reason #2: Career
It may enhance your career by giving you access to extensive resources plus listing your involvement in a professional organization on your resume is impressive!

Reason #3: Stay Inspired, Get Involved
Learn to love what you do! You may not even know that you love something, until you try. There is no quicker pick-me-up than becoming involved with something you feel passionate about. (www.aicpa.org) That something may just be MSTA. We have over 50 board members who can attest to the value of serving this organization. Attend a meeting, volunteer at the conference, present at the conference, volunteer for a committee, write articles for the newsletter or journal, join the board – the sky's the limit! Most importantly, we guarantee you will make new friends and develop long-lasting personal and professional relationships! Here's a start! If you are interested in helping with the conference, please contact our chair, Holly McGoran holly_mcgoran@msta-mich.org or assistant chair, Rich Bacolor rich_bacolor@msta-mich.org. If you are interested in writing an article for the newsletter or publishing in the journal, please email Betty Crowder betty_crowder@msta.mich.org. Or if you have general questions, please go to our website www.msta-mich.org or contact Betty. We look forward to hearing from you or seeing you at one of our upcoming meetings!

WMU is accredited by the Higher Learning Commission (HLC).

Mallinson Institute for Science Education
Western Michigan University

100% Online MA in Science Education and/or DI Certification

- ✓ Flexible course scheduling – no cohort
- ✓ Year-round classes, including summers
- ✓ Asynchronous classes
- ✓ No thesis, project or teaching required
- ✓ 30 credits to MA degree completion

WMU is one of the **10 Best Online Master's** in Science Education

BEST ONLINE PROGRAMS Master's in Science Education

SCAN ME

www.wmich.edu/science/masters

Follow MSTA on

Visit www.msta-mich.org for the latest information.

NEW! GLOBAL SOUNDSCAPES

Immerse your students in the amazing sounds of our planet with the new Global Soundscapes film in MiSci's Toyota Engineering Theater!

Through giant screen images, surround sound, and live presentation, Global Soundscapes takes you on an ear-opening journey into the science of sound and the emerging field of soundscape ecology.

Now booking for fall field trips! Visit Mi-Sci.org or call 313.577.8400.

GLOBAL SOUNDSCAPES

MISSION TO RECORD THE EARTH

MI.Science.Center mi_sci mi_sci

The Michigan Science Center is a 501(c)(3) nonprofit organization.

Technology and Data: Use Simple Tools to Calculate Terminal Velocity

By Andrew Frisch, Farwell Schools

The Engineering Practices within the Next Generation Science Standards require the use of technology to collect data that can then be mathematically evaluated to recognize patterns to make predictions. All that being said; we, science teachers, need to get tools into our students' hands, so they can use them to make measurements. Then they will write those measurements down as data to see what can be figured out.

Technology is the use of tools. Not all tools need to be electronic, some of the best technology is simple, hand-held, and available. Paper, pencils, rulers or meter sticks, timers, electronic scales, and calculators can go a long way. These tools allow students to collect real data, in real time that can used as the basis of many mathematical concepts.

This is a description of a lesson plan that was developed in the RET program within the College of the Engineering and Technology at Central Michigan University. The materials are readily available and there are extensions that could be applied to make the mathematical relationships and computations quite advanced.

Lesson Plan: Use Coffee Filters to Determine Terminal Velocity.

Background:

In Physical Science and Physics classes, the five forms of energy (PS3.A) and energy transfers (PS3.B) are covered as Disciplinary Core Ideas.

As an object fall towards the earth, it reaches terminal velocity when the force of air resistance is equal to its weight. The terminal velocity varies based on the surface area and weight of the falling object.

Falling times of coffee filters at various heights will be measured to ensure they are falling at a terminal velocity, then the terminal velocity will be calculated, to determine the relationship between mass and its terminal velocity. Extensions into other falling objects and calculating the coefficient of friction are possible.

Materials:

Use the "Raining Coffee Filters" lab sheet to provide structure to the lesson.

Extensions:

1) Use Styrofoam spheres of various diameters to repeat the lab sheets. This time it will be called, "Raining Styrofoam Balls". The data should be used to find the relationship between terminal velocity and radius. (Hint: terminal velocity is related to surface area, which is radius squared, while weight is related to volume, which is radius cubed.)

2) Use the coffee filters and challenge the students to make the coffee filter fall slowly as possible and land within a given circular target place on the floor. Students can manipulate the shape of the filter and the height of the fall, but they only get one test trial and it must hit the target.

continued on page 5

Technology and Data: Raining Coffee Filters *continued from page 4*

Raining Coffee Filters Name_____

Purpose: To describe (graph and calculate) the motion of a falling object.

Materials: Meter stick, five (5) coffee filters, tape, and stop watch.

Procedure:
- Work with a partner; one will be "the dropper" and the other "the timer".
- Using the meter stick, measure and mark with the tape heights of 100 cm, 150 cm, 200 cm, 250 cm.
- Begin with one coffee filter. Drop and record the time it takes for one coffee filter to fall 100 cm. (This is called hang time.)
- Drop the same coffee filter two more times for a total of three times and calculate the average time for one coffee filter at 100 cm. Use the average time as its "hang time".
- Repeat this one coffee filter drop at the other heights of 150 cm, 200 cm, and 250 cm. Again do all heights three times, calculate the average, and use the average as the hang time.
- Once all of the data has been collected and recorded by dropping one coffee filter, repeat all of the drops from all of the marked heights this time using three (3) coffee filters stacked on one another.
- Once all the data has been collected and recorded by dropping three coffee filters, repeat all of the drops from all of the marked heights this time using five (5) stacked coffee filters.
- After all the data has been collected and calculated, create three separate graphs. Title them: Hang Time of One Coffee Filter at Various Heights, *Hang Time of Three Coffee Filter at Various Heights, and Hang Time of Five Coffee Filter at Various Heights*.
- Set up each graph with the appropriate X and Y axis, label them and determine appropriate intervals.
- Complete the questions.

Data:

One coffee filter

	100 cm	150 cm	200 cm	250 cm
Hang time 1				
Hang time 2				
Hang time 3				
Average				

Three coffee filters

	100 cm	150 cm	200 cm	250 cm
Hang time 1				
Hang time 2				
Hang time 3				
Average				

Five coffee filters

	100 cm	150 cm	200 cm	250 cm
Hang time 1				
Hang time 2				
Hang time 3				
Average				

continued on page 6

Technology and Data: Raining Coffee Filters *continued from page 4*

Data Analysis:
Create a graph for each data set with the distance of each fall as the independent variable and the hang time is the dependent variable. Draw the line of best fit.

Questions:

1. Are the graphs linear or non-liner?

2. Calculate the slope of each graph.

   a. Slope of one filters graph.

   b. Slope of three filters graph.

   c. Slope of five filters graph.

3. What does the slope represent?

4. Do the filters continue to accelerate throughout the fall or do they reach terminal velocity? Explain your answer.

5. What are the forces acting on the coffee filters?

6. Use the forces acting on the filters to explain the motion of the coffee filters as they fall. (Use the answers given in question 5 to explain question 4.)

Ready for the *Next Generation!*

CEREAL CITY SCIENCE™
by BCAMSC

Designed for the Next Generation Science Standards, Cereal City Science units engage students in sense-making of phenomena or designing of solutions through integrated curriculum of physical science, life science, earth science, engineering, and technology. The STEM-based units are equipped with everything needed to implement three-dimensional learning in Kindergarten through Middle School classrooms.

Curriculum Features:

- Figuring out phenomenon through modeling
- Common Core State Standards for ELA and Mathematics integration
- Tools for formative and summative assessment
- Teacher Guide, Student Journals, and Answer Key
- Materials for up to 32 students

Your partner in science instruction – Cereal City Science supports Kindergarten through Middle School educators with professional learning opportunities including Unit Training, Next Generation Science Exemplar (NGSX), Science Leadership Corps and follow-up "Kit Chats." Educators are immersed in modeling, science concepts, sense-making, and pedagogical strategies in full-day, in-person trainings and workshops.

Learn more at cerealcityscience.org

Macroscopic Representations of Magnetism, Solubility, and Polarity

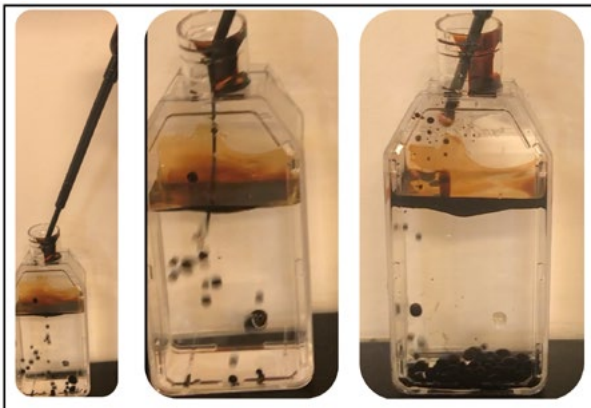
By Larry Kolopajlo, Chemistry Department, Eastern Michigan University

The visual sides of physics and chemistry are essential in effective science teaching. In this newsletter piece the reader will be shown engaging ways of teaching magnetism, solubility and polarity. Predict-Observe-Explain (POE) Cycles are a good way to guide student thinking.

The first example is demonstrating solubility by using a ferrofluid. Ferrofluid demos would be a great way to celebrate National Nanotechnology Day on Oct. 9. A ferrofluid is a colloidal mixture of iron(III) oxide (Fe_2O_3) and surfactant in a light hydrocarbon oil. The particles of iron(III) oxide, from a mineral like magnetite, are between 1 and 10 nm in size. The surfactant prevents the nanoparticles from forming large globules. Students can observe the brown-black color of the ferrofluid, classify it as a liquid, and do some simple physical property experiments. There are many safety precautions to be followed. For example, because ferrofluids cause skin irritation and leave a brown stain, gloves and aprons should be worn, and surface areas must be protected. Students should also wear goggles.

Demonstrating the insolubility of ferrofluid in water

Ask students to predict what happens when a ferrofluid is added to water. Using a pipet, slowly add ferrofluid to water. Have a student volunteer perform the experiment projecting it to a screen. Photos shown below demonstrate that ferrofluids are insoluble in water. Next, perform the experiment using mineral oil as solvent. Ask students to use the "Like-Dissolves-Like" rule to classify ferrofluid as polar or nonpolar.

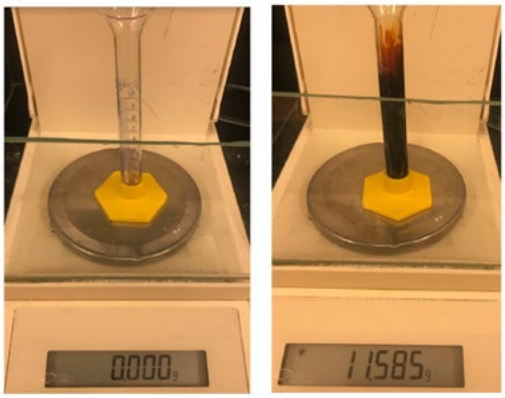


Ferrofluid in water
Ferrofluid is hydrophobic.

Density of a ferrofluid

This experiment may sacrifice a graduated cylinder, but it works as a density experiment:

Determine the density of a ferrofluid



$$Density = \frac{11.585\ g}{10.0\ mL} = 1.16\ \frac{g}{mL}$$

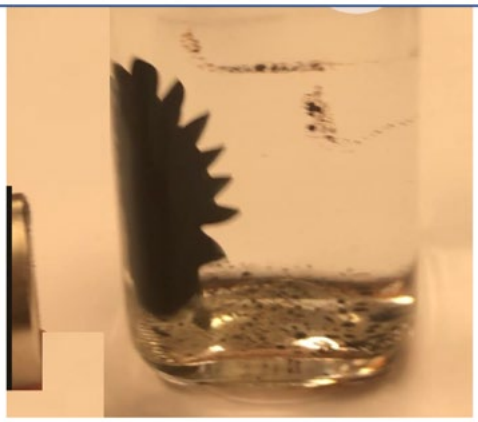
continued on page 10

Macroscopic Representations of Magnetism, Solubility, and Polarity *continued from page 8*

Magnetism

A neodymium magnet brought next to ferrofluid-water mixture can attract the ferrofluid, showing its well-known magnetic field spikes.

Have students work in pairs to create a "blooming magnet" like the one shown below. All participants should wear gloves, aprons, and goggles!

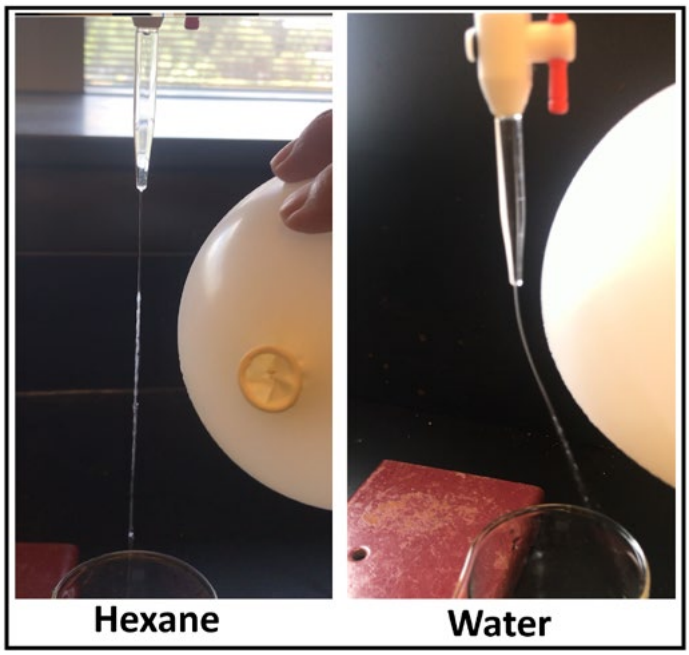


A neodymium magnet (on the left) attracts ferrofluid in water.

Magnetic spikes from ferrofluid on bolt attached to a neodymium magnet

Testing the polarity of water and hexane

Fill two burets with water and hexane respectively. Charge a balloon by rubbing it with fur or on a student's hair. Ask students to predict what will happen when a charged balloon is brought next to streams of both liquids. Open the buret stopcock and bring the balloon next to the water stream; it will bend towards the balloon. Try the same experiment with hexane and observe no deflection. Have students draw particle models explaining the experimental results, that hexane is nonpolar and water is polar.



Summary

Although ferrofluids are usually used to teach magnetism, they can also be used to teach chemistry concepts like colloids, solubility and polarity. Students can draw models to explain their results. Edifying discussions can follow.

Michigan Space Grant Consortium

Affiliates

Calvin College

Eastern Michigan University

Grand Valley State University

Hope College

Michigan State University

Michigan Technological University

Oakland University

Saginaw Valley State University

University of Michigan

Wayne State University

Western Michigan University

K12 Educator Incentive Mini-Grants

Building capabilities to engage classrooms in hands-on, educational activities in science, technology, engineering, and mathematics (STEM)

Support for teachers to attend STEM education conferences and workshops

Support for expanded STEM curricular materials and supplies

Additional Grant Opportunities for School Systems and Nonprofits

Main Office 734-764-8327 ▪ Ann Arbor ▪ mi.spacegrant.org

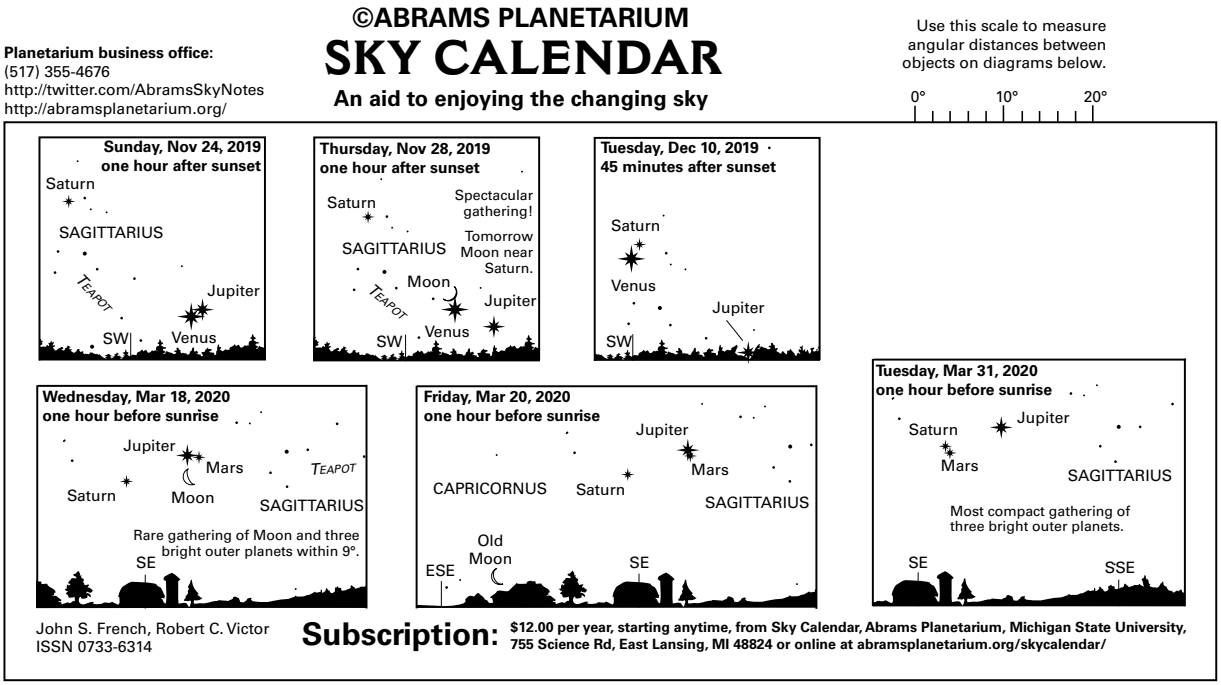
Follow the naked-eye planets through the 2019-20 school year, September 2019 through August 2020, until a very special event on December 21, 2020

by Robert C. Victor

Dawn and dusk twilight sky maps by Robert D. Miller. Sky Calendar illustrations courtesy of Abrams Planetarium, Michigan State University. Graphs of planet rising and setting times for School Year 2019-2020 by Jeffrey L. Hunt.

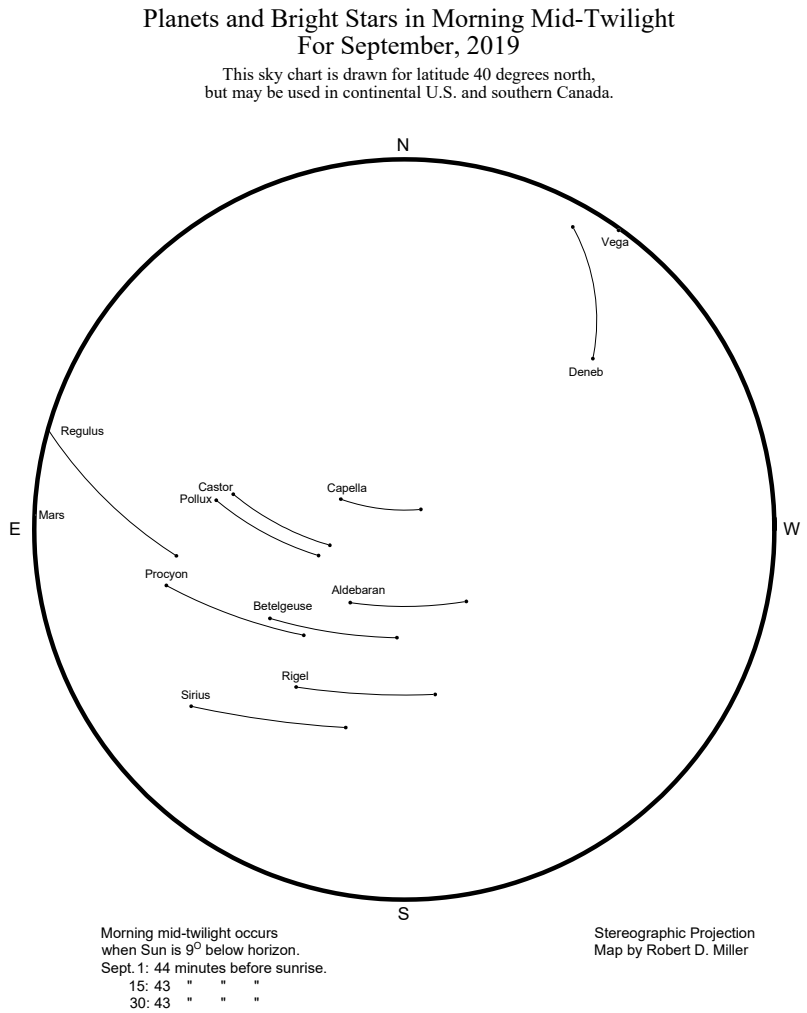
Teachers are encouraged to gather their students for at least one early evening session early in autumn 2019, before Jupiter and Saturn sink low in the southwest twilight glow. Otherwise, the next good views of Jupiter and Saturn will be at predawn sessions in March through early June 2020 (Mars joining Jupiter-Saturn in a compact gathering March 20-31), or at evening sessions in summer and autumn 2020. Venus slowly emerges from the evening twilight glow in autumn 2019, forming striking naked-eye pairs with Jupiter on November 23-24, and with Saturn on December 10. Venus climbs higher in western sky at dusk until March-April 2020, when it will set four hours after sunset. Venus will be at its best for telescopic viewing in the evening sky from late March until late in May 2020, showing half through crescent phases, ever thinner while growing ever larger in apparent size as Venus approaches inferior conjunction between Earth and Sun on June 3, 2020. Jupiter and Saturn return to the evening sky just 6 degrees apart in July 2020, will move apart slightly until late August, then gradually come together until December 21, 2020, for their closest pairing since nearly four centuries ago.

Here is a selection of some of the most striking gatherings of solar system bodies during the school year 2019-2010, in November-December 2019 at dusk, and in March 2020 at dawn.



The full version of this article, with a complete set of morning and evening twilight sky maps for each month through August 2020, appears online at www.abramsplanetarium.org/msta/

Follow the Naked Eye *continued from page 11*



Robert D. Miller's all-sky chart, "Planets and Bright Stars in Evening Mid-Twilight -- September 2019" provides a ready visual representation of where to find the brightest objects at dusk. The simplified chart depicts positions of only the naked-eye planets, and the stars of first magnitude or brighter, at the moment the Sun is 9° below the horizon; we call this "mid-twilight". From lower Michigan in September, that occurs about 45 minutes after sunset. Daily planet positions are plotted as dots, labeled every 7th day (1, 8, 15, 22, 29). Positions of bright stars above the horizon at mid-twilight during the month are represented by continuous trails.

Observe at the same stage of twilight each day, and you'll notice the stars, and the slow-moving planets Jupiter and Saturn, trekking westward across the sky in the course of any month, a consequence of Earth's annual revolution around the Sun. Star positions on the first and last day of the month are each indicated by a dot.

This chart shows bright Jupiter in SSW at dusk, and Saturn in SSE to S, some 29° to 26° east (left) of Jupiter in the course of September. The brightest stars visible are Arcturus, in the west at dusk and getting lower as the month progresses, and Vega, passing from east to west of overhead. Other bright stars visible are Altair and Deneb, completing the Summer Triangle with Vega, and the red supergiant star Antares, the heart of the Scorpion, 7° to 10° to the lower right of Jupiter.

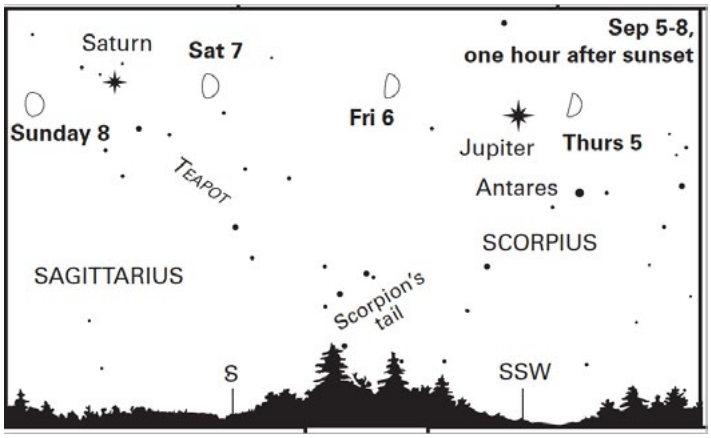
September's evening planets are both very impressive for telescopic viewing, Jupiter with dark cloud belts parallel to its equator and four moons discovered by Galileo, and Saturn with its beautiful rings. In 2019, these showpiece planets will remain available for early evening viewing well into autumn. Make plans to hold observing sessions early in this school year, the sooner the better, before these planets sink low into the western twilight glow! We hope you and your students get to enjoy many of the planetary highlights of the coming school year.

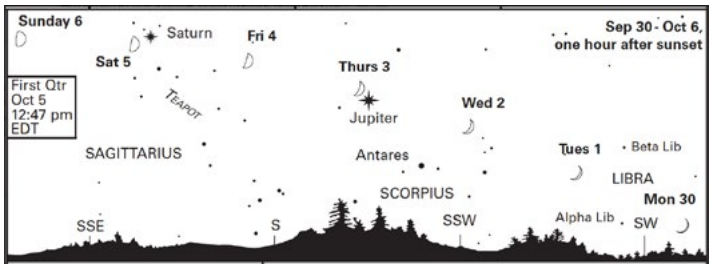
Highlights of September through December 2019 – planets in evening sky

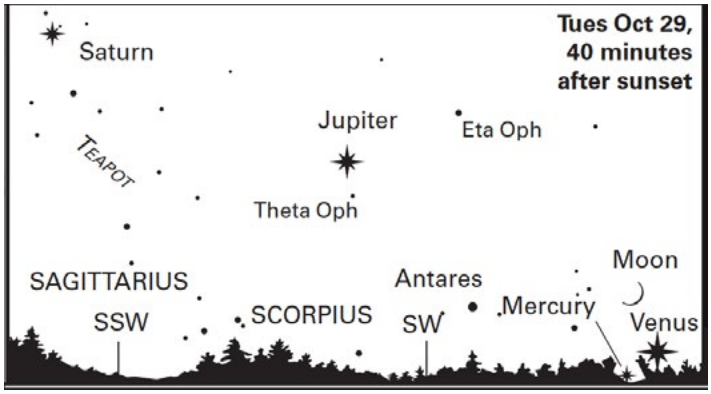
Moon-planet pairings, Sept.-Dec. 2019: The Moon forms pairs or gatherings with planets and bright zodiacal stars every month. Here are some of the most eye-catching of the evening events for the rest of 2019, which are illustrated on the Abrams Planetarium *Sky Calendar*. Angular distances of planets from the Moon are given for observers in Michigan at mid-twilight.

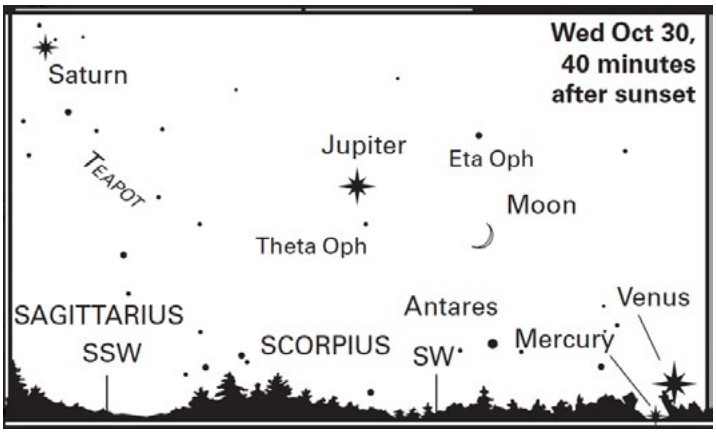
continued on page 13

Follow the Naked Eye *continued from page 12*









Sept. 5-8, 2019: Watch Moon pass Antares, Jupiter, Saturn. Notable pairings are with Jupiter on Sept. 5 (4.0˚), and Saturn on Sept. 7 (6.6˚) and Sept. 8 (5.9˚). < ***See diagram for Sept. 5-8, 2019.*** >

Oct. 2-5: Moon again passes Antares, Jupiter, Saturn. On Oct. 3, Moon is 1.8˚ from Jupiter; on Oct. 5, 2.0˚ from Saturn. < ***See diagram for Sept. 30-Oct. 6, 2019.*** >

Venus will first become easily noticed in evening twilight in October 2019. It will become ever more engaging to follow the two brightest planets, Venus and Jupiter, as the gap between them narrows, from 30˚ on Oct. 26, to 20˚ on Nov. 4, to 10˚ on Nov. 14.

Oct. 29-Nov. 2: Moon makes yet another pass by the planets, this time including Venus. Here are daily descriptions, with individual diagrams for the first three evenings:

On Oct. 29, Venus is within 5˚ lower right of the Moon. < ***See diagram for Oct. 29, 2019.*** >

On Oct. 30: Jupiter 9˚ to Moon's upper left. < ***See diagram for Oct. 30, 2019.*** >

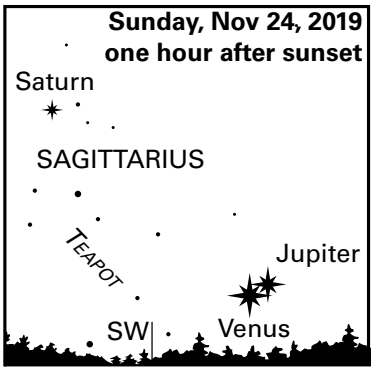
Oct. 31: Jupiter 4˚-5˚ to Moon's lower right. < ***See diagram for Oct. 31, 2019.*** >

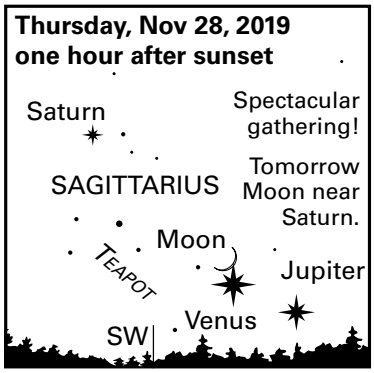
Nov. 1: Saturn 5˚ upper left of Moon.

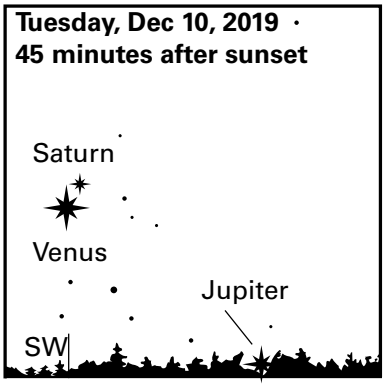
Nov. 2: Saturn 8˚ lower right of Moon; Moon has moved east of the planet gathering.

continued on page 14

Follow the Naked Eye *continued from page 13*







During Nov. 19-28, Venus-Jupiter will appear no more than 5° apart! Be sure to catch them forming their spectacular closest pair as Venus passes 1.5° south of Jupiter on Nov. 23 and 24, the Saturday and Sunday evenings of the weekend before Thanksgiving. < ***See diagram for Nov. 24, 2019.*** > On Sunday, Nov. 24, Saturn will be 19° upper left of the bright pair.

On the latter half of Thanksgiving Week, **a crescent Moon** adds beauty to the scene: On Wednesday Nov. 27, Moon is 7° lower right of Jupiter and 11° lower right of Venus. **On Thanksgiving, Nov. 28, Moon will be within 2°** upper left of Venus (**another event not to miss!) and 6°** upper left of Jupiter. Saturn will be within 13° upper left of Moon. Four solar system bodies within 19°! < ***See diagram for Nov. 28, 2019.*** > On Friday Nov. 29, Saturn will be within 2° upper right of the Moon.

Spreading to nearly 5° apart by Thanksgiving, Nov. 28, Venus-Jupiter continue to separate, to nearly 10° on Dec. 3, and 15° on Dec. 8. **Venus-Saturn appear no more than 5° apart during Dec. 7-14, and form their closest pairings on Dec. 10 and 11,** as Venus passes within 1.9° south of Saturn. Jupiter on Dec. 10 appears 17° to the lower right of the Venus-Saturn pair. By then, Jupiter is just above the horizon in mid-twilight and sets less than an hour after sunset. < ***See diagram for Dec. 10, 2019.*** >

When the waxing crescent Moon reappears in the southwest at dusk on Dec. 27, Jupiter will be invisible, in conjunction on the far side of the Sun (this time, actually behind the solar disk!), while the 1.7-day crescent Moon will appear 13° lower right of Venus and within 6° upper left of Saturn. By then, binoculars may be essential for spotting Saturn low in the twilight glow.

In a spectacular event on the next evening, Dec. 28, the lunar crescent appears within 2.6° lower right of Venus at dusk, and moves to within 2° of the bright planet by moonset. On the next evening, Dec. 29, the Moon will be 9° upper left of Venus at dusk.

Highlights of January through August 2020 – evening sky:

Venus will be visible evenings through late May 2020. Mercury has favorable appearances at dusk in Jan.-Feb. and May-June. We will welcome the return of Jupiter and Saturn to the southeast evening sky in July 2020.

Venus is spectacular in the early months of 2020. Venus continues in the evening sky into 2020, getting higher until late in March, near the date of its *greatest elongation* 46° from the Sun, March 24. The monthly pairings of Venus with the crescent Moon on Jan. 27- 28, Feb. 27, Mar. 28, and Apr. 26 will all be wide, 6°-8° apart, but they can still be used to easily spot Venus in the daytime. **At dusk, Venus can help viewers locate Mercury during some of its apparitions:** Find our solar system's innermost planet within 30° lower right of Venus during Jan. 23-Feb. 17, and as close as 24° during Feb. 4-11. On May 21, a few days before departing from the evening sky, Venus will pass about one degree from emerging Mercury.

From March until late in May 2020, Venus will be of increasing interest for observation with telescopes and binoculars, even in the daytime, as it changes through half and crescent phases, while the planet draws ever closer to Earth. At greatest elongation on March 24, Venus appears half full. Venus brightens for another five weeks, until late in April, when Venus appears in crescent phase, just over one-quarter illuminated. The crescent continues to get ever thinner and grow in apparent diameter to nearly one arcminute, at *inferior conjunction* on June 3, 2020. Since Venus passes within half a degree north of the Sun's center on that occasion, it'll be unsafe

continued on page 15

Follow the Naked Eye *continued from page 14*

to attempt observation for several days before and after that date. While still in the evening sky during April and May 2020, Venus has striking conjunctions with stars in Taurus, the Bull. On Apr. 3, use your binoculars to watch Venus pass within 0.3° of 3rd-magnitude Alcyone (Eta Tauri), the brightest member of the beautiful Pleiades (Seven Sisters) star cluster. The passage will be fascinating to watch for several evenings, as Venus shifts eastward by nearly 1° per day. On April 14th, Venus makes a wide pass 10° north of Aldebaran. On May 9-12, Venus pauses 1.5° lower left of Beta Tauri, or Elnath, the tip of Taurus' northern horn. The event is termed a *quasi-conjunction,* because Venus approaches the star, but does not move past it. Venus instead begins to retrograde (move westward against the stars), and plunge ever more rapidly toward the setting Sun.

Before Venus is lost in the solar glare, **Mercury** passes *superior conjunction* on the far side of the Sun on May 4, 2020 and emerges within a week. Look for Mercury to lower right of Venus, by 15° on May 14, by 9° on May 17, and 5° on May 19. Mercury appears only 1.1° south (lower left) of Venus on May 21. That evening, a telescope will show the planets in the same field, Venus as a very thin crescent, its disk 0.9 arcminute in diameter, 5 percent illuminated, and Mercury, in the background, a tiny 0.1 arcminute across and in gibbous phase, 69 percent lit. On May 23, a young, thin, 2-percent crescent Moon joins them, and all three will fit within a 6.5° binocular field! Even on May 27, just one week before Venus' inferior conjunction, you can still see Venus! Moments after the Sun has set and is safely hidden below the horizon. Venus will be over 8° up in WNW and 10.6° upper left of the recently-set Sun, and, viewed with binoculars or a telescope, displaying a crescent, 2 percent illuminated. **Venus departs, but Mercury climbs to its highest in the twilight glow around May 30, and reaches greatest elongation 24° from Sun on June 3.** A week later, on June 10, Mercury is 12° below the Twin stars Pollux and Castor, forming an isosceles triangle with them, and thereafter fades quickly and drops out of sight, leaving the early evening sky devoid of planets for a few weeks. Mercury's inferior conjunction occurs on June 30.

By early July 2020, Jupiter and Saturn will return to the early evening sky, rising in ESE just 6° apart, before evening mid-twilight. Earth will overtake Jupiter and Saturn within a week apart, as the two planets reach opposition and all-night visibility on July 14 and 20, respectively. The planets will remain close companions in the evening sky all summer and fall, spreading to 8.3° apart in late August 2020, and coming back together for a rare, spectacularly close pairing, only 0.1° apart, on December 21, 2020. Jupiter overtakes Saturn about every 20 years, only a few times in a human lifetime, but this event will be their closest pairing since 1623, during the life of Galileo, and the closest until the year 2080.

Here are a few of the highlights of the morning sky during school year 2019-2020.

Refer to the **morning twilight chart for September 2019. < See chart N201909A. >**

Notice the stars are in roughly the same positions they will occupy in the evening sky a few months hence. Getting up before dawn is a good way to preview the evening sky of the coming season! Our morning charts show the sky at mid-twilight, when the Sun is 9° below the eastern horizon, but you may want to begin your predawn sky watches at least 1½ hours before sunup, to include some dark sky time.

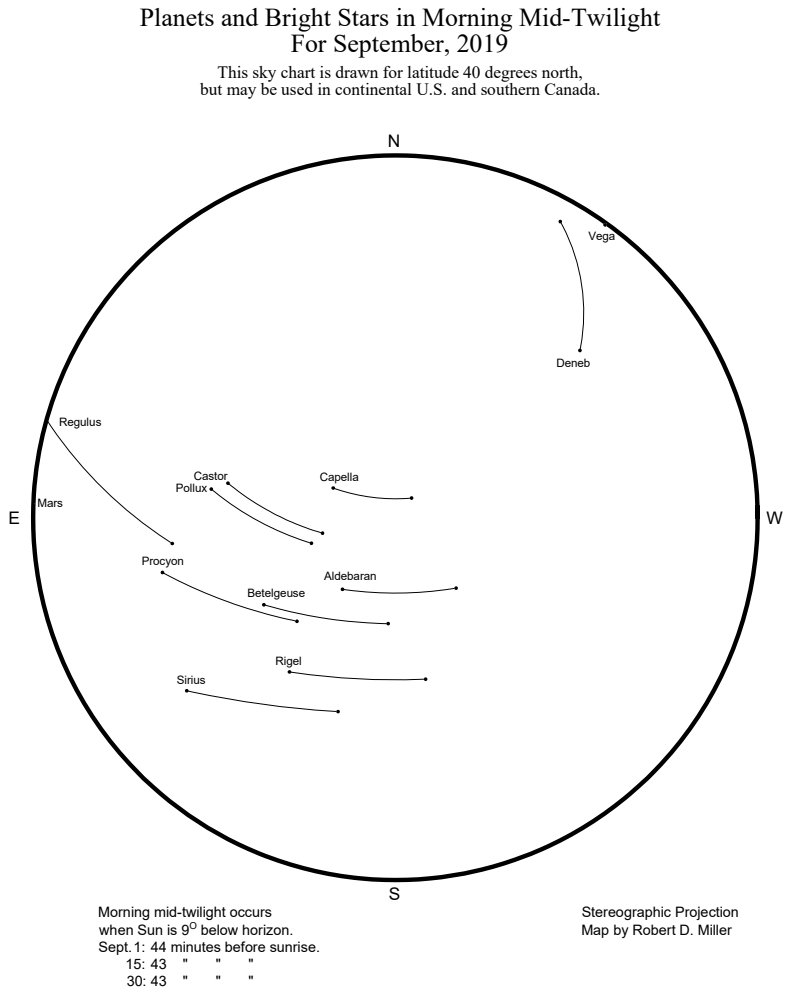
In the last four months of 2019, for naked-eye morning planet viewing, we're limited to two: **Mercury** during a foray into the eastern twilight glow, a favorable one, in November-December, after the transit of Mercury across the Sun's disk on Nov. 11; and **Mars,** after its emergence into the eastern morning sky in October. Mars begins its apparition at mag. +1.8, as faint as it ever gets, improving only slowly at first, and reaching a spectacular mag. –2.6 at opposition in October 2020, when it will outshine Jupiter.

But the most beautiful feature of the morning sky in the closing months of 2019 is the large number of bright stars, of the constellations Orion, Taurus, Gemini, Canis Major and Canis Minor, Auriga, and the Hyades and Pleiades star clusters in Taurus. The stars you'll enjoy before dawn in September through December are the same ones you'll see in the same places in evening twilight during February through May.

And an advantage of daylight saving time, is that the late sunrises we get in autumn before we change back to standard time in early November will enable us to view a dark morning sky without the hardship of getting up very early by the clock.

continued on page 16

Follow the Naked Eye *continued from page 15*



Use the morning twilight charts for following these constellations' bright stars from east to west from September into December, and to locate any visible planets. Keep in mind that Mercury is always faint near the start of its morning apparitions, so you may have to wait until several days after the date of its first appearance on a morning chart.

Follow the waning Moon across the morning sky each month, watching for its conjunctions with planets and with these bright zodiacal stars: Aldebaran in Taurus, Pollux and Castor in Gemini, Regulus in Leo, Spica in Virgo, and Antares in Scorpius. The dates the Moon is in the sky at morning mid-twilight in late 2019 are Sept. 14-27, Oct. 13-27, Nov. 12-25, and Dec. 11-24. Within each set of dates, **on Sept. 22, Oct. 21, Nov. 19, and Dec. 19, the Moon is at or nearest to Last Quarter phase, when it's half full and 90° from the Sun, and will show wonderful surface detail through binoculars and telescopes!** Even at a daytime session at your school, schedule a session within a day or two of Last Quarter phase as the first activity of the morning. Thread a *single* polarizing filter into the low-power eyepiece of your telescope, aim the telescope at the Moon, and rotate the eyepiece in its tube until the sky foreground is made as dark as possible. (You'll be using the filter to cross-polarize against the polarized light of the blue sky.) This greatly improves the contrast of Moon against the sky, and allows you to see wonderful lunar detail even in the daytime. This works best when the Moon is close to 90° from the Sun (and so half full), on a day when the sky is a deep blue, without much haze. You can order threaded polarizing filters from Orion Telescopes and Binoculars; their website is www.telescope.com

Transit of Mercury on Nov. 11, 2019 (a daytime event): Our solar system's innermost planet passes directly in front of the Sun on the morning of Monday, Nov. 11. (Note that's a federal holiday, therefore not a school day.) To observe this transit of Mercury safely, one should use a telescope to project an image of the Sun, or use a filter designed for direct solar observing, securely installed at the front end of the telescope. Do not use any of those unsafe, eyepiece solar filters often provided with inexpensive telescopes; those should be regarded as throwaways! Unlike during a solar eclipse, or during the transits of Venus in 2004 and 2012, hand-held filters used with unaided eye will *not* show the tiny disk of Mercury, which will be only 10 arcseconds across, less than 1/180 of the half-degree solar diameter, and only one-sixth of the apparent diameter of Venus at its most recent transit in 2012. From Michigan on Nov. 11, 2019, the transit of Mercury gets underway a few seconds after 7:36 a.m. EST. That's

continued on page 17

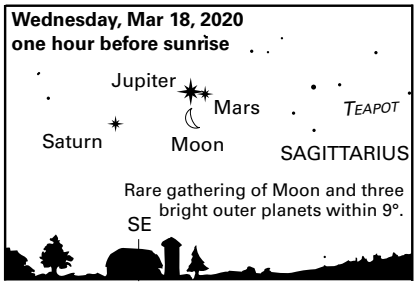
Follow the Naked Eye *continued from page 16*

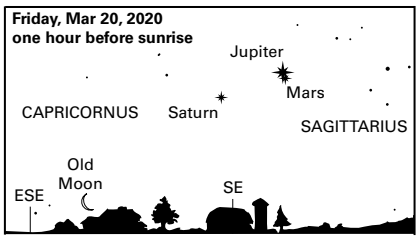
not far from the time of sunrise, and so the event won't be seen well until the Sun rises higher in the sky. Mercury appears at its minimum distance NNE of the center of the solar disk at 10:20 a.m. EST. For observers in Michigan, the leading edge of Mercury's tiny dark silhouetted disk reaches the solar limb about 15 seconds before 1:03 p.m., and takes only about 1.7 minutes more until egress from the disk is complete. After this transit of Mercury on Nov. 11, there won't be another visible in Michigan until May 7, 2049.

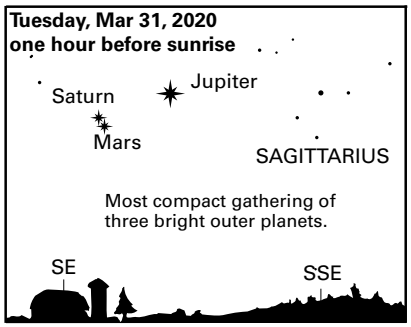
After the Nov. 11 transit, Mercury enters the morning sky, brightening to mag. +1.1 by Nov. 18, and to mag. +0.1 by Nov. 21. Than Mercury lingers about 10° lower left of faint Mars Nov. 21-29. Mercury reaches greatest elongation, 20° from Sun, on Nov. 28. Brightening slowly as it heads toward the far side of the Sun, Mercury remains visible for about the first three weeks of December, but sinks into bright twilight.

With Mercury's departure, Mars becomes the only planet visible at dawn, until Jupiter emerges from the ESE morning twilight glow in third week of January 2020; Saturn follows in first week of February, 11° lower left of Jupiter.

In predawn skies of March 2020, there will be a compact gathering of the three bright outer planets. Jupiter appears to pass Saturn at intervals of about 20 years (the next time will occur on Dec. 21, 2020), the longest interval between conjunctions for any pair of naked-eye planets. So seeing Jupiter-Saturn appear within a few degrees of each other, though lasting for several months, is uncommon. Having Mars pass between the two giants while they're only a few degrees apart is even more remarkable.







In a truly rare sight on March 18, a 30-percent crescent Moon is inside the compact gathering of three bright outer planets, about 2° below Mars and Jupiter (which are 1.3° apart), and 7° right of Saturn. The gathering of Saturn, Moon, Jupiter, and Mars spans only 8.3°. < ***See diagram for Mar. 18, 2020.*** > By March 19, the 21-percent crescent Moon will be nearly 7° lower left of Saturn, and so outside the 3-planet gathering.

Mars passes 0.7° S of Jupiter on March 20, 2020, with Saturn 7.1° east of the pair. < ***See diagram for Mar. 20, 2020.*** >

Mars passes 0.9° S of Saturn on March 31. Jupiter is then within 6.3° west of the pair. This is the most compact arrangement of the three bright outer planets between the years 2000 and 2040. < ***See diagram for Mar. 31, 2020.*** >

Mars moves on, and on the morning of April 15, the red planet is 9.5° east of Saturn, and 15.0° east of Jupiter. Jupiter-Saturn have closed to within 5.5° of each other, and the Moon, a fat 45-percent crescent, is within the 15°-wide planet grouping, and 3° below Saturn. Jupiter is 90° west of the Sun, so Spaceship Earth is heading directly toward Jupiter. As our home planet follows its orbit around the Sun and overtakes the three slower moving planets, each will take a turn at opposition, Jupiter and Saturn within a week apart in July, and Mars in October. Morning sky watchers can follow these planets drifting toward the western horizon until their oppositions. The gap between Jupiter and Saturn will be less than 5° during April 28-June 6, 2020 (minimum separation, 4.7° on May 18) and then widen as Jupiter retrogrades faster than Saturn.

With the opposition of Jupiter on the night of July 13, 2020, and Saturn on the night of July 20, it becomes convenient to follow those two planets at dusk for the rest of 2020. In the evening sky, watch Jupiter and Saturn continue to separate until August 28 (8.3° apart), and then come back together for their spectacular close pairing on December 21, 2020, when

continued on page 18

Follow the Naked Eye *continued from page 17*

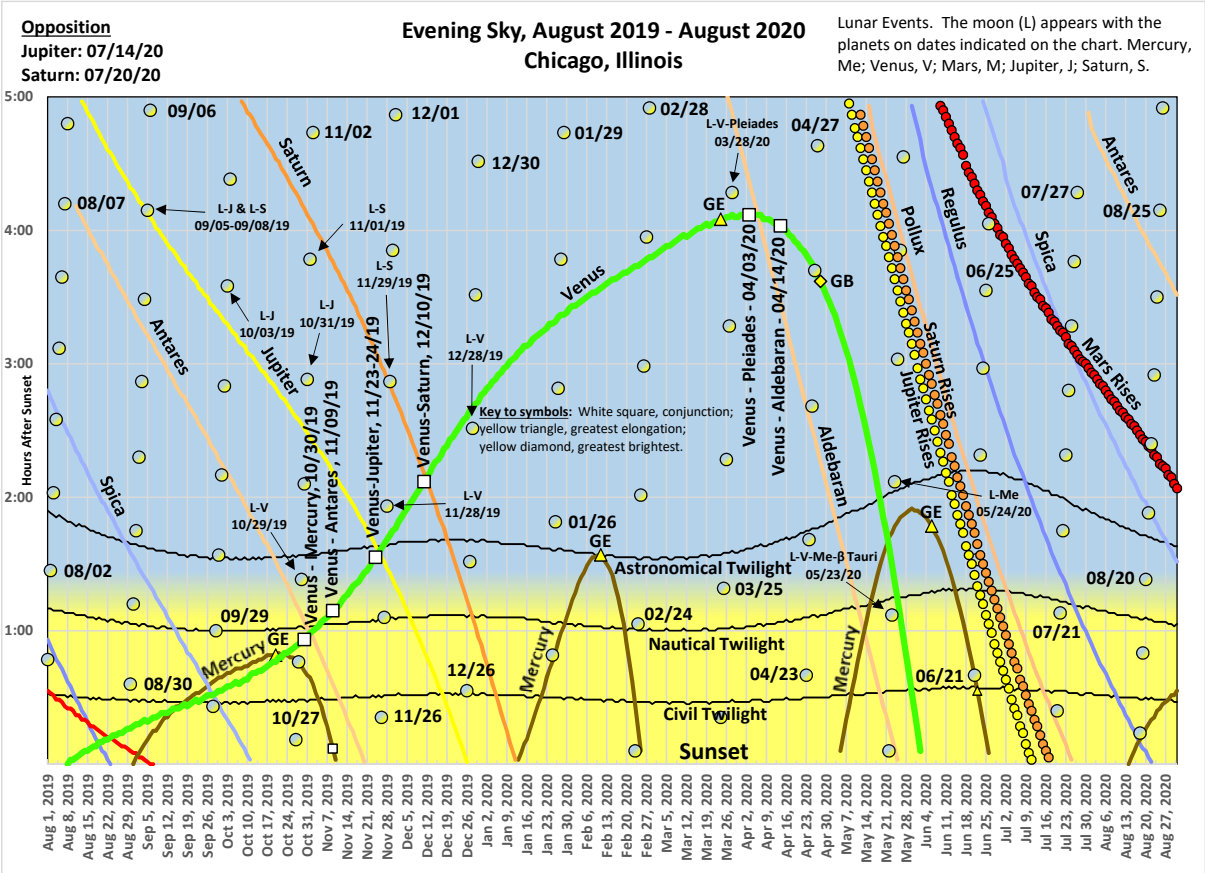
they'll be just 0.1 degree apart. For a preview of how close that is, observe the naked-eye double star Mizar and Alcor at the bend of the handle of the Big Dipper; they are 0.2 degree apart. Observe that double star with unaided eye and binoculars in summer and early autumn, before the Big Dipper gets low. Imagine Jupiter and Saturn on December 21, 2020 at just half that separation!

Before the Jupiter-Saturn pairing on Dec. 21, Mars reaches opposition on Oct. 13, 2020, in the eastern sky at dusk, and visible all night. Thereafter, the red planet will remain an evening object, fading, until it sinks into the western twilight glow around the end of July 2021. Venus can be followed in the morning sky from mid-June, 2020 through late January, 2021.

Abrams Planetarium publishes a monthly ***Sky Calendar*** with an ***evening sky map***. The calendar will illustrate many of the events described in this article. Subscriptions are $12 per year at www.abramsplanetarium.org/skycalendar/ for three printed issues mailed quarterly. A sample issue of *Sky Calendar* and its evening sky map are posted on that website.

To help plan your evening planet viewing sessions between August 2019 and August 2020, download **Jeffrey Hunt's graphic summary of Moon and planet setting times relative to times of sunset,** exact for Chicago, but quite useful over a wide area of the U.S., including Michigan. Open circles show setting times of the waxing Moon for several evenings after New.

Here is the graph of evening planet visibility: **< See diagram, Chicago_SY_19-20_pm_setting.pdf. >**
[Exact for Chicago, Illinois]



All moon dots, and the curves for planets and stars, indicate setting times in relation to sunset, except for the three planet curves labeled to indicate times of rising, also in relation to sunset.

continued on page 19

Follow the Naked Eye *continued from page 18*

This graph of evening planet setting times shows the departure of Jupiter and Saturn in December 2019; the very favorable appearance of Venus visible as much as four hours after sunset in March-April 2020, followed by its rapid departure from the evening sky in May; and favorable appearances of Mercury in January-February and May-June 2020, when it sets longest after sunset.

In addition to a full set of evening and morning twilight sky charts for each month through August 2020, we include a graph of morning planet visibility, showing Moon and planet rising times relative to times of sunrise, in the full version of this article, at www.abramsplanetarium.org/msta/
The graph of morning planet rising times shows the gradual emergence of Mars before dawn in autumn 2019; the very favorable appearance of Mercury in November-December 2019; the emergence of Jupiter and Saturn into visibility in January-February 2020; and the sudden rise of Venus into predawn prominence in June-July 2020.

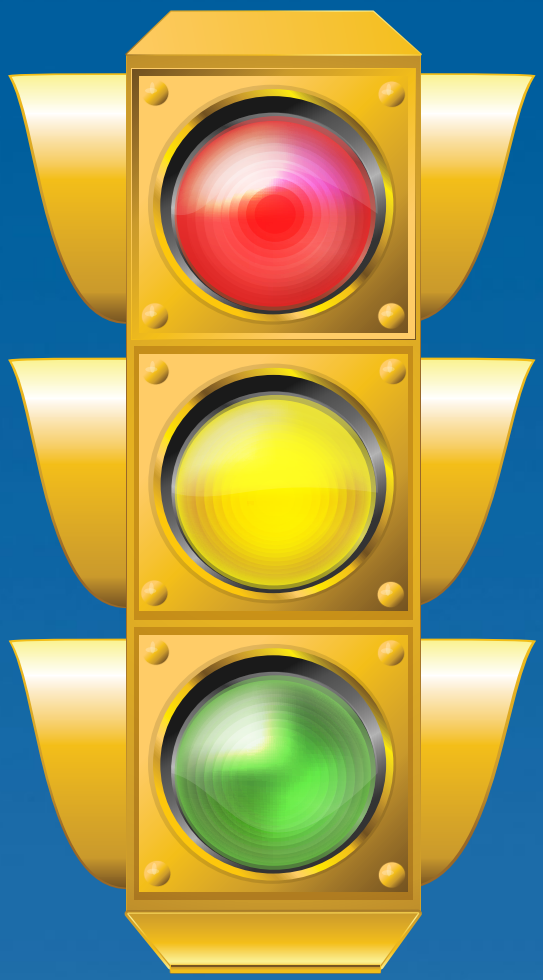
Here's wishing you an abundance of clear evenings and mornings to enjoy the sky!

Robert C. Victor was Staff Astronomer at Abrams Planetarium, Michigan State University. Now retired, he often collaborates with John S. French on the Sky Calendar, and enjoys providing sky watching opportunities for a variety of groups, mostly in the California desert and in Michigan.

Robert D. Miller did graduate work in Planetarium Science and later astronomy and computer science at Michigan State University and remains active in research and public outreach in astronomy.

Dr. Jeffrey L. Hunt, a retired planetarium director now living in the Chicago area, has taught astronomy and sky watching to all ages. He studied astronomy education at Abrams Planetarium at Michigan State University. Jeff writes an astronomy blog at jeffreylhunt.wordpress.com and can be followed on Twitter at @jeff_hunt.

THE BEST SIDE JOB YOU'LL EVER HAVE!



Hiring awesome teachers to teach kids how to drive

- Great pay
- After-school and summer opportunities
- Rewarding experience
- Free certification

OFFICIAL DRIVING SCHOOL

248.548.8000

OFFICIALDriving School.com/instructors