The Classroom Astronomer Newsletter #25 - May 10-11, 2022

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the classroom astronomer
The Astronomy Education Newsletter

The Classroom Astronomer Newsletter #25 - May 10-11, 2022

Sky Lessons: Using the May 16-16 Total Lunar Eclipse and a Ball to Find the Moon's Distance and Size; Communicating Science Discoveries and Astronomy Education Results with Poetry.

May 10

Cover Photo - The Shadow of Earth

In This Issue:

Welcome to Issue 25 of *The Classroom Astronomer* Inbox Magazine! - *We Are One Year Old!!*

Doing some things different this issue.

1. We're letting all subscribers, paid and free, see the article on what to do with a total lunar eclipse, specifically, how to find the Moon's size and distance by tracking the Moon through the Umbra. If it is Greek to you, well, the ancient Greek's figured it out millennia ago, and you can too. You can even go to our Substack website and read it online!
2. In fact, we're letting the whole issue go for free to anyone who wants to see it.
3. Because this is our 25th issue, and we're one year old on May 15th, we're going to celebrate by eclipsing <ahem> our usual subscription rate to $25.00 from now until May 20th If you use the code **TCAONEYEAR** at our Substack.com site, or click this button below:

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Some folks think the universe is the sheer poetry of Nature…and it is. But as teachers, a lot of our students don't get it—they aren't science geeks like teachers often are. So let's be artsy and teach them to learn with science communication….with poetry! As in writing it, and reporting their findings poetically. That's the other article in this issue.

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Key websites: **Homepage** for *The Classroom Astronomer,* with its index to all Inbox Magazine issues' contents, by celestial object, educational subject area, grade level or venue, and with complete Tables of Contents:

http://www.classroomastronomer.com .

Not a subscriber? Become one by putting your email in the box below (and then you'll have access to the Archive of all past issues!). But do it before the 20th when the regular rate returns….:

The Classroom Astronomer Newsletter

The Classroom Astronomer Newsletter (TCA) [Inbox Magazine] is all about astronomy education, for the general public, K-12, university, home schoolers.

By Dr. Larry Krumenaker

The ultimate home of our Universe — **Hermograph Press** — has its homepage at: www.hermograph.com and its Store, for educational materials and books, is at: www.hermograph.com/store . This issue features

Hermograph's Materials for Education and Fun! Get 20% off until the June Solstice with the E-Coupon **TCASpring20!**

Thanks for subscribing!

Publisher -- Dr. Larry Krumenaker

Sky Lesson - Measuring the Moon's Size and Distance During a Total Lunar Eclipse with Earth's Shadow and a Tennis Ball

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The following exercise is from the original The Classroom
Astronomer Magazine December 2010 issue, updated for the May
2022 lunar eclipse.  We will be using this to find the Moon's
distance during the lunar eclipse!
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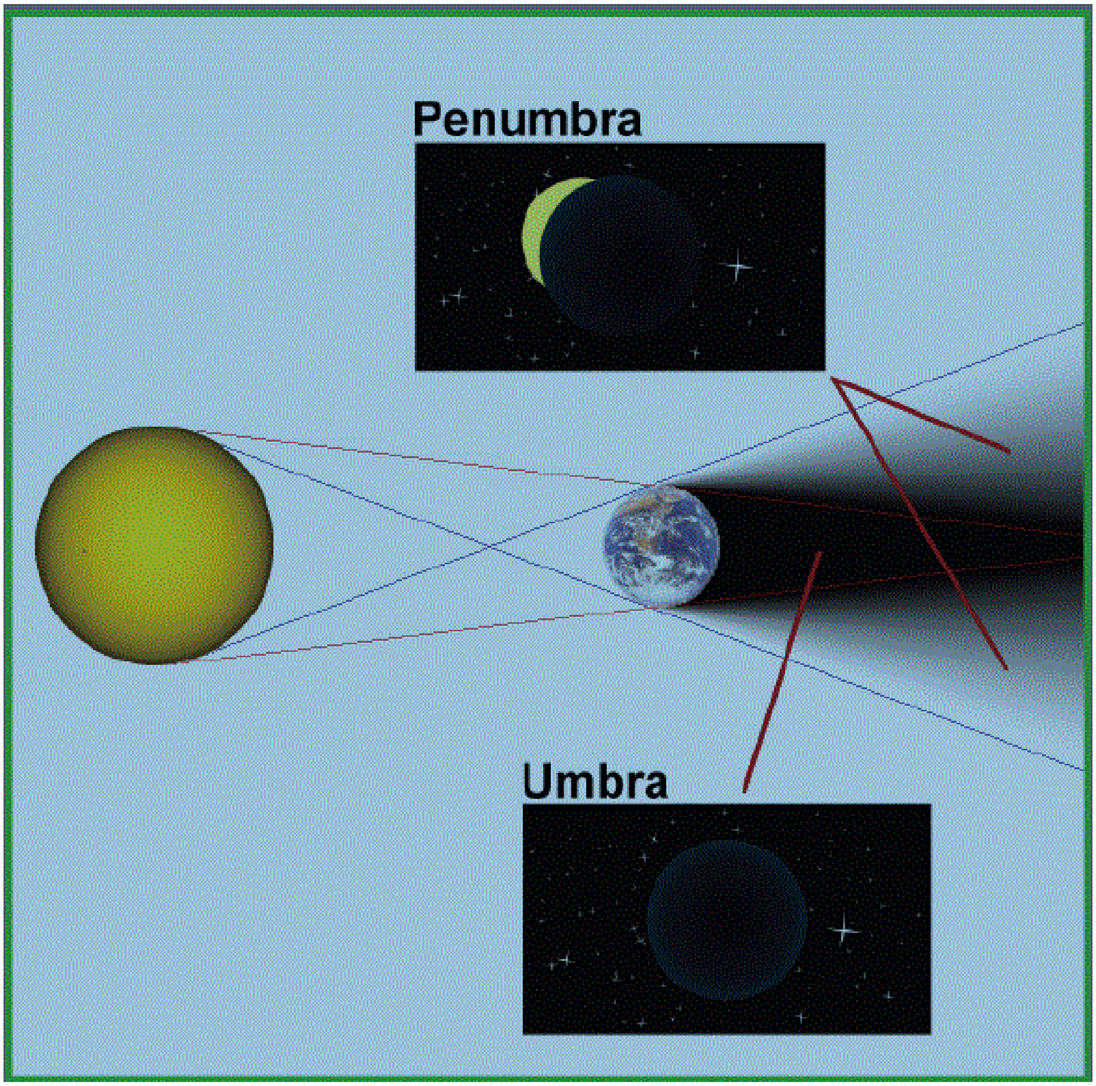
This technique can be done anyplace where the Moon can be watched through the beginning partial, total, and end partial phases of the eclipse. It can be recorded by drawing or photography.

The shadow of any spherical object in the solar system consists of a dark central cone called the Umbra and an outer shadow zone surrounding the cone called the Penumbra, where some sunlight shines directly into that space. The umbral shadow edges may appear sharp to the unaided eye but it isn't as sharp as it seems. This will cause some uncertainty in the measures, an important point all budding scientists should learn--no measurement is ever infinitely precise. We are attempting to measure the diameter of the umbral shadow at the distance of the Moon when it gets eclipsed this time. The Moon's distance varies because of its elliptical orbit. The Earth's shadow length also varies; the cone can be longer or shorter depending on whether we are close to the Sun or farther, though not as extremely as the Moon’s.

The farther way the Moon is, the smaller the cross section of the umbra it cuts through. So, measuring the ratio of the size of the Moon in our sky to the size of the umbral shadow cross section in degrees during totality gives us a way to find the distance to the Moon at that time.



Courtesy Wikipedia Commons

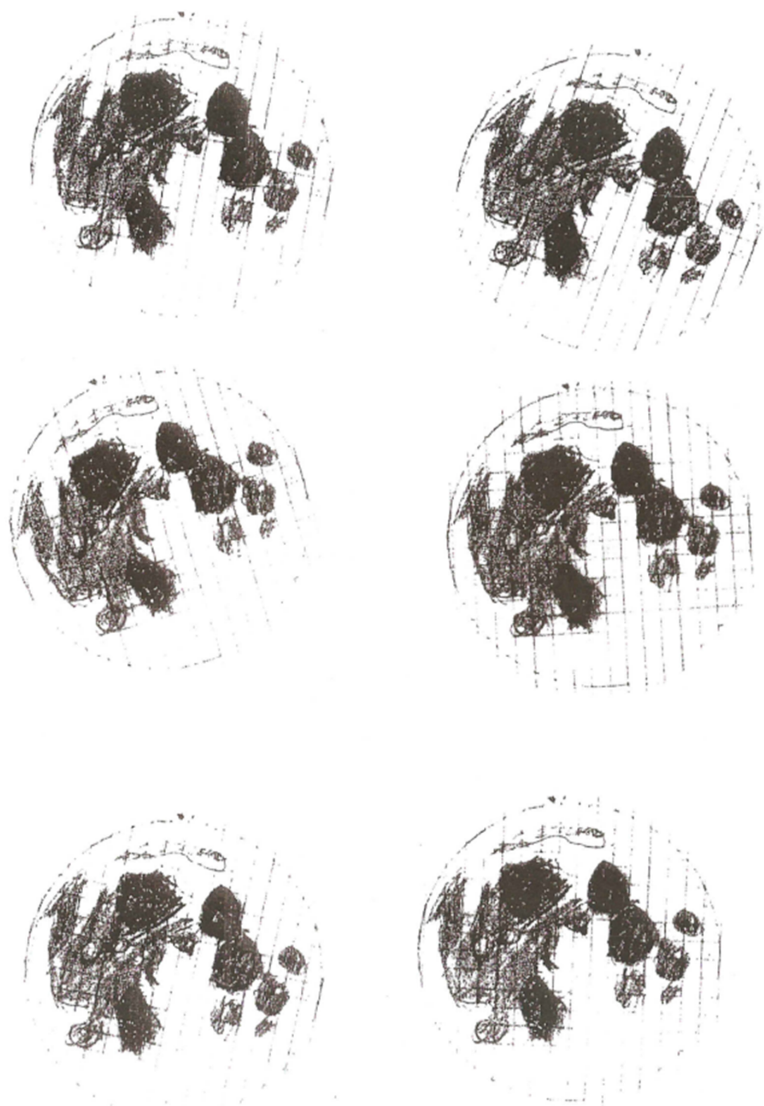
Here’s what you will do to measure the Moon using the Shadow technique:

1. Take drawings or photographs of the Moon as it moves through the Earth's umbra (central) shadow.
2. After the eclipse ends, put your photographs or drawings on a timeline along the edge of a piece of graph paper (preferably).
3. Here's the challenging part: Using a drawing compass and adjusting its size AND where the 'center point' should be, find the circle that BEST fits the circular edge of the shadow as the Moon moved through the umbra.
4. Measure the diameter of your estimated shadow cross section in millimeters, and the diameter of a Moon image, dividing the first by the second to get a ratio value somewhere between 2.5 and 3.0. You will use this to find the Moon's distance and size.

Before The Eclipse

1. You MUST be within the zones where you can see all the total phases and at least some of the partial phases in order to do the Shadow Method.

2. Download the Moon drawing sheet and copy it to paper.



This is just an excerpt of the full sheet. See the upside-down three-toed footprint on the right (west side)? When you line up your drawings, that footprint should ALWAYS be to the right!

3. Print also the timeline sheet attached to the drawing sheet (see below for its image) and use or adapt this to another piece of paper. **The Moon moves its own diameter every hour so each hour mark MUST BE wide enough to just appear on the left and right edges of any Moon drawing image.**

Extra Credit but Worth Doing:
An interesting experiment to try near Sunset or Sunrise on a day before the eclipse happens is to **measure the ratio of the diameter of a spherical object (a tennis ball, a marble, a globe) and the length of its umbral shadow cone.** The umbra of the ball is easy to see on a screen when the screen is a meter or yard away from the ball but as the screen gets further away, the umbra fades into the growing penumbra (this is why we do this late or early in the day, we need the horizontal distance a shadow will go when the sun is low in the sky!) *One should find that, when you average several measures, the ratio of shadow-cone-length to sphere-diameter is pretty much the same no matter what kind of sphere you use!* The ratio is just a bit over 100. In fact, the actual equation should be:
Equation 1: Shadow Cone Length L = 108 x Diameter of sphere.
You can then scale this up to the size of Earth and calculate its shadow size to be
L(Earth) = 856,000 miles from Earth.

During The Eclipse

You must begin drawing the edge and coverage of the shadow on the Moon circles just as the partial phases begin, and end just after the partial phases end. **We suggest you make your observations every 30 minutes; overlaps are okay. Your drawings should draw the shadow edge as it appears over the lunar seas that you see with the naked eye (or low-power binoculars) and with the shadowed part shaded in.** It is very easy and tempting to draw the eclipse as it appears in the sky relative to the *horizon* but this would be wrong!!! Observers should rotate their sheet of paper with Moon images to *match the Moon* as it appears, particularly as to which maria (seas) are "up". Record the times of observations on a white part of the Moon circle. We suggest you NOT cut out the circles until after the eclipse.

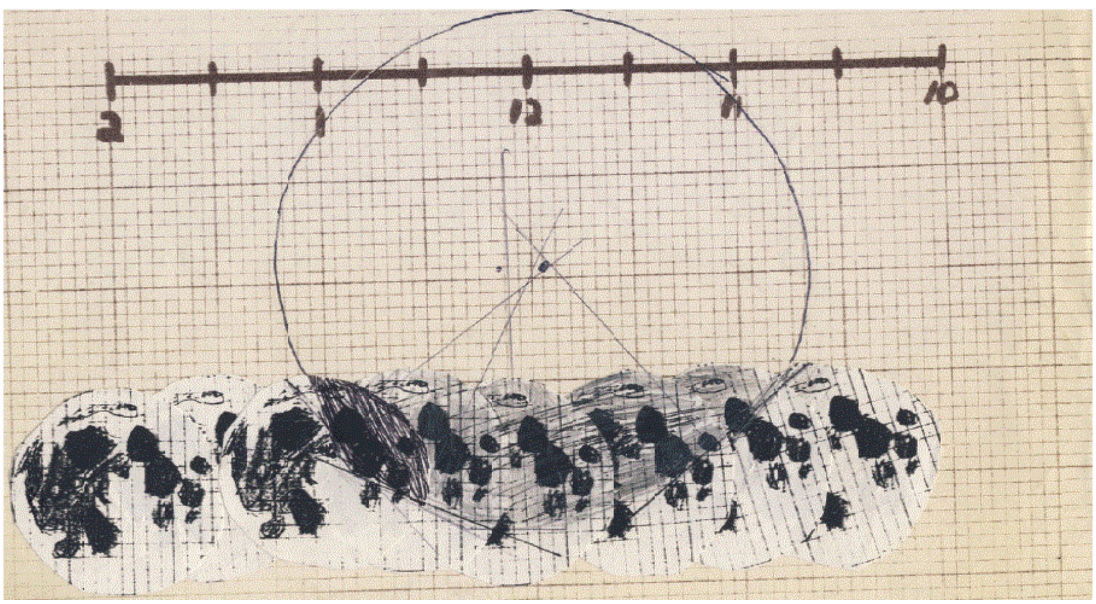
(You can also take individual photos during the eclipse and print them and cut them out and put them on a timeline. There are some photographers who can take a series of photographs on the same image (sheet of film or stored CCD image and show the circular outline of the umbral shadow, like our **Cover Photo**).

After The Eclipse

1. Cut out and put the Moon drawings on the paper with the time line. Mark your hours and half-hours on the timeline as appropriate for your time zone. If you drew the Moon every thirty minutes you should have Moon images overlapping. This is a good thing; you will be able to "average out" some of your drawing discrepancies.

   Note that though the Moon's features may appear to rotate as the Moon moves across the sky, they actually do not and all your lunar seas should always line up exactly the same way on the timeline - the seas that seem to form a three-toed footprint should *always* be on the right (west) side of each drawing.

2. You should see that the edge of the Earth's shadow has a circular form, but you will only see part of the circle. Your next job is to make the circle that best fits the visible shadow edge arcs. This may require several attempts to get it done well; you are doing a BEST FIT and it won't be exact or going through all parts of the arc perfectly. We find that if you make tangents around the drawn large circular edge at several places, and then use a T-square to get perpendiculars to the tangent lines, you will find they roughly converge near a point. Adjusting your drawing compass in size and center location place, you will eventually find your 'best fit' circle.



Here are the Moon circles placed on a timeline paper. Notice that all of them have the "footprint" facing to the right (west). Also, see the tangent lines along the edge of the shadow and the perpendiculars from them that helped locate the center of the umbral cone cross-section....

3. Measure the Moon image diameter and the best-fit shadow circle diameter in millimeters. Divide the second value by the first; you should get a ratio between 2.5 and 3.0 (usually around 2.7). Calculate the shadow circle

diameter in degrees by knowing the Moon is ~0.5 degrees and multiplying that by the ratio you just determined (e.g. 0.5 x 2.7 = 1.35).

Activity 1 — The Moon's Distance.

Any object has an angular size in radians equal to its diameter in miles divided by its distance from us in miles. Now, as the distance gets larger, the shadow cone cross section (XSD) will get smaller. It starts at 7926 miles at the bottom of the cone (at Earth), goes to zero at the end, and thus has an proportionally intermediate size between the extremes. For example, fly 25% of the 856,000 miles away and you'll find Earth's shadow's cross section is 100-25%, or 75%, the size of Earth, down to 5945 miles across. This we can call **Equation 2: XSD = 7926 x (1-f),** where f is how far into the shadow cone you are from Earth —above it was 25%. Conversely if you can measure the size of the cross section in miles, you can determine how far away you are! That's where the Moon and its eclipse comes in. The ancient Greeks knew to use them to find the Moon's distance.

We've measured the size of the umbra, (typically it is 1.33 degrees, close to the value in our example above). In the box below we take that basic definition of angular size of an object and substitute Equation 2 on top and Equation 1 on the bottom, and generate Equation 3, the f equation at the end of the chain of mathematics. That is what we need.

$$\text{Angular Size (A)} = \frac{\text{XSD (cross sectional diameter)}}{\text{Distance to Cross Section}} = \frac{7926 \times (1-f)}{7926 \times 109 \times f} \Rightarrow f = \frac{1}{[(A * 108)+1]} \quad \text{(Eq. 3)}$$

Let's take a **typical** scenario. The shadow cone cross section size we found to be 1.35 degrees. (If you did the tennis-ball extra credit assignment, use that value you found, otherwise, use 108, and your umbra size from your observations and the circle you made!) To convert any degree value to radians, divide it by 57.3 degrees per radian; this makes the angular size of the shadow .0233 radians. Plugging this value for A into Equation 3 gets us *f* = 1/ [(0.0233 x 108]+1) or 0.282, 28% of the way from Earth to the end of the cone. Multiply *f* by the shadow length 856,000 miles makes the Moon about 241,000 miles away. We have found the Moon's distance!

Use THIS eclipse's observed values to get your data. Above is just a routine example.

Activity 2 — The Moon's Diameter

This is simpler. Knowing that the Moon (and the umbral cross section) is, say, 28% of the way out, the size of the shadow we see on the Moon is (from Equation 2): 7926 * 1-*f*, or 7926 x (1-.28), yielding **5706** miles across.
As the shadow is 2.67 times the Moon's size, the Moon must be 5706 / 2.67, or 2137 miles across, about 1% smaller than its actual 2160-mile size! We clearly can determine size and distance of the Moon to within a few percent accuracy! Use your eclipse values to get the March 2022 values.

The best science technique is to get a group to do this, and do statistics, i.e. get a mean value and graph the spread, and see how close to known values you get, and remember, the Moon's orbit IS elliptical so it won't be the average Earth-Moon distance. But the Moon's diameter doesn't change <g>.

How clever those ancient Greek astronomers were!

Galactic Times Inbox Magazine Issue #23 Highlights

TCA's sister publication. Twice a month, on the 1st and mid-month, with the following columns usually, plus occasional other articles. Here is what was in the most recent issue. *Subscribe to it here! It's Free!*·

- **Cover Photo** — *Total Eclipse in View*
- **Welcome to Issue 23**
- **This Just In —**
  * *A Roundup of Mars Discoveries*
  * *DNA in Meteorites + Water on Europa = 2010?*
- **Sky Planning Calendar —**
  * **Moon-Gazing -** *Moon Goes from Dark, past Mercury, into Dark Shadow*
  * **Observing—Plan-et** —
  \- *An Exclamation Point in the Morning, with Jupiter on Both Ends*
  \- *Meteors and (Almost two) Comets*
  * **Border Crossings**
  * **The May 15-16th Total Lunar Eclipse (Cover Story)**
- **Astronomy in Everyday Life** - *Lunar Eclipses are in the Shadows of Solar Eclipses*

Astronomical Teachniques

From Science to Stanzas, Astronomy Education Poetically Written, Part 1

Within the cradle of a burning core,
You wither down and find yourself well worn;
As untold pressures crush and shape and bore,
Your substance is assaulted, broke and torn.
Then just as you think you can take no more,
Through flames and righteous heat you are reborn;
An all-consuming diamond in the sky,
Extinguishing all other lights nearby.

The above is a report about the Ottava Rima, inspired by recent research that has discovered that the birth of stars from dense clouds of gas and dust may not be happening in the manner that has long been assumed. Clearly it is not written in the drier style of news releases or journal reports. It is more rhythmic, colorful, draws a picture in the mind. But it is just as scientifically accurate as the research report…and an example of another way to communicate scientifically.

There are famous stanzas with astronomical imagery. Robert Frost wrote one about a telescope called the Star-Splitter, though the poem itself began with lines about Orion rising up over a horizon of mountains. Or Tennyson's Pleiades rising as a "swarm of fire-flies tangled in a silver braid." But could you reach people with poems on black holes? Or a graph of Kepler's Third Law? Or get students to write their lab results poetically more accurately than in prose? Would the story of the lives of stars be more comprehensible to some if it was done as a set of quatrains?

Educators of all kinds are science communicators as much as news media and NASA Goddard press release writers. We could write lightly in conversation, or deeply in technicalese, but couldn't we also try to explain what's going on in poetry? Is there not a way for right-brains and left-brains to meet? The student and public audiences are non-scientists as much as the readers as magazines or blogs (or Substack newsletters).

True confession time: Yours truly majored in astronomy in college, yes. But one of his two minors was…mythology. After all, astronomy is rich in Greek myths; I was curious to know more. And the coursework included writing myths in prose and poems (in high school I had been the student newspaper's poetry guy but I had never really gotten any training in it). I got more interested in the above issue—science communication poetry—when I saw a book by British professors Sam Illingworth and Stephen Paul Wren, *A Celestial Crown of Sonnets* (Penteract Press, 24pp, 4-Euros) 'which tells the story of astronomy with (a round of sonnets) with each sonnet focusing on a different historically significant astronomer. (The 14 sonnets in Shakespearean style) have the last line of the sonnet become the first line of the proceeding one.' Illingworth also has widely written about using poetry for science communication, that is, writing about current science news and discoveries in poetic forms. Climate change. Animal behavior. Archaeological findings. The starting poem of this story is from a piece by Dr. Illingworth.

Couldn't some of Illingworth's ideas be transferrable to astronomy education?

In email exchanges with him, and in perusing aanother of his books, *Science Communication Through Poetry*, I've come with a 'first draft' of ideas of using poetry and poems in astronomy classes and outreach. Illingworth's first ideas of how to help science teachers use poetry as a way to discuss and investigate astronomy with their students might be the following approach:

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1. Listen to the students and ask them what aspects of
astronomy they were interested in.
2. Wrote some list poems to explore these ideas and generate
some word banks.
3. Maybe invite a speaker in on a certain topic or encourage
independent research.
4. Use this research / speaker to form the basis of the topic
for a poem.
5. Introduce a poetic form to concentrate on. Maybe a haiku or
a nonet or a sonnet.
6. Ask the students to write a poem on that topic using that
form. And encourage them to break poetic rules if they so
wish.
7. Invite the students to share their poems and use it to help
generate further discussion.
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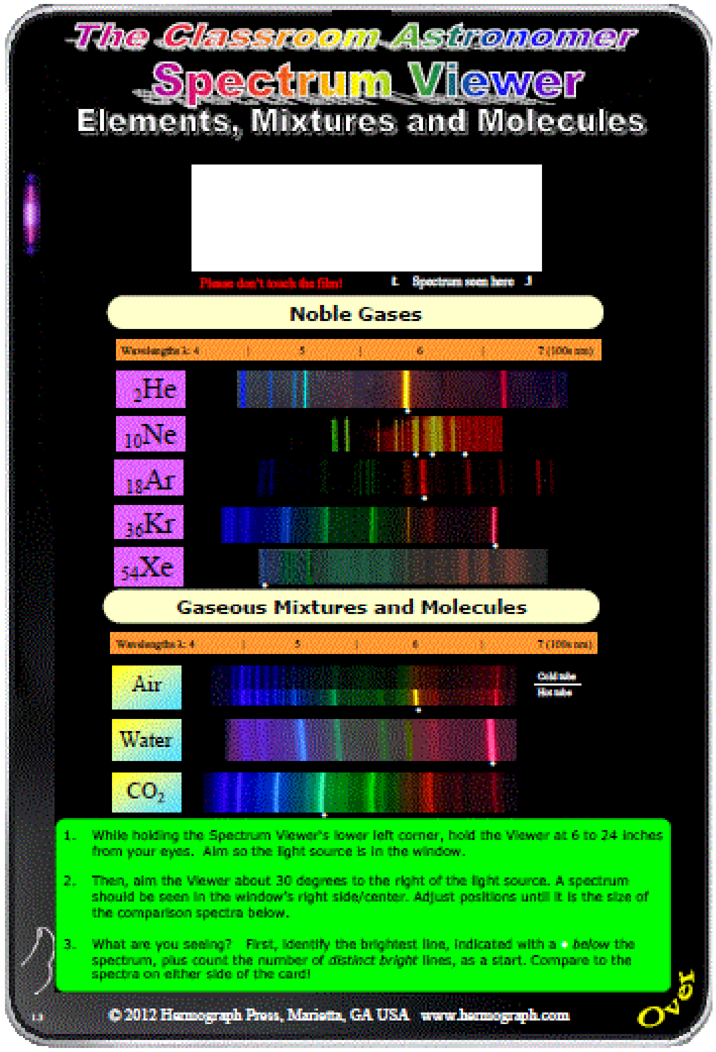
In the next issue of *The Classroom Astronomer*, we'll look at some of these poetic forms in detail, and some examples with which to use them.

Don't forget the 20% off Hermograph Sale, including Spectrum Viewers for gas tubes, until the Solstice! See details near the top of the issue!



Questions, suggestions, comments? Email them to: Dr. Larry Krumenaker

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